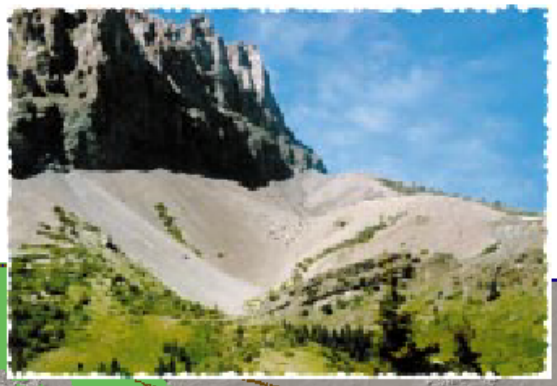
Current Vegetation Map of Northern Idaho and Western Montana



Cover Type:
Rock & Scree

Ground Truth Plots

Landsat TM Scenes

MONTANA

CONTINENTAL DIVIDE

National Forest Lands Administered by Region 1

Sampled Quads

Row 28

Row 29

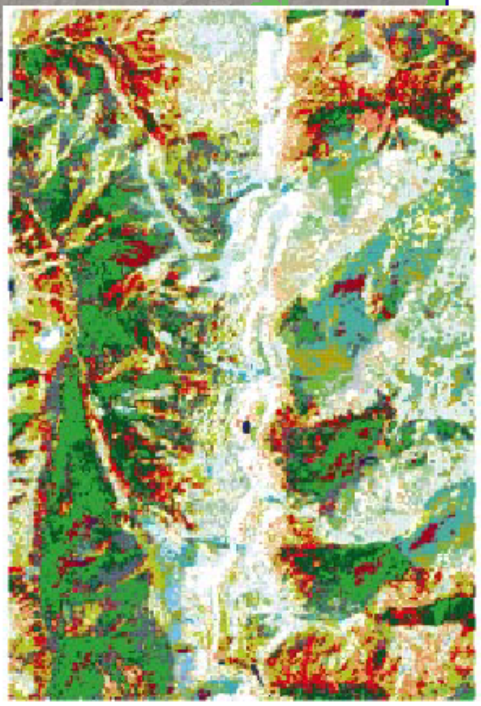
Path 42

Path 41

Path 40

Project Area

IDAHO



Three Sisters Quad

March 1996

The Wildlife Spatial Analysis Lab
The University of Montana

Northern Region
USFS

MAPPING EXISTING VEGETATION AND LAND COVER ACROSS WESTERN MONTANA AND NORTHERN IDAHO

FINAL REPORT
Contract #: 53-0343-4-000012

Submitted to:
U.S. Department of Agriculture
Forest Service, Northern Regional Office
Missoula, MT

Principal Investigator
Roland L. Redmond

Post-Doctoral Scholar
Zhenkui Ma

Digital Image Analysts
Troy P. Tady and J. Chris Winne

GIS Analysts
Jim Schumacher and Judy Troutwine

Cartographer
Steven W. Holloway

Data/Systems Administrators
Charles P. McGuire and Ronald L. Righter

Graduate Student Researchers
L. Guy McWethy David W. Schirokauer
Polly C. Thornton Claudine Tobalske

Student Research Assistants
Willard Gustafson Jodi Handley John Hinshaw
Ashley Jones Steven Stegman Anne Vander Meer

Other Research Personnel
Melissa M. Hart Kathleen P. McLaughlin Wendy A. Williams

Wildlife Spatial Analysis Lab
Montana Cooperative Wildlife Research Unit
The University of Montana
Missoula, MT 59812

12 June 1996

ABSTRACT

We constructed a digital map of existing vegetation and land cover across northern Idaho and western Montana, covering more than 26 million hectares (nearly 65 million acres) and requiring all or parts of 18 Landsat TM scenes. Information was stored in a raster database comprised of a series of ARC/INFO grids (one per TM scene). This database was built through a two-stage classification involving both unsupervised and supervised procedures. First, for each TM scene, an unsupervised classification of pixels was conducted. This pixel classification, based on Euclidean distance calculations, was designed to maintain patterns observed in a color composite of channels 4, 5, and 3. The resultant spectral classes were then regrouped and merged to 2 ha MMU (>22 pixels). Next, a raster database was constructed in ARC/INFO: base regions (or raster polygons) were delineated, and attributes for each region were collected (including majority aspect values and mean values for TM channels 1-7, elevation, and slope). Meanwhile, 7.5 minute quadrangles were selected for field sampling in 1994-95 by the U.S. Forest Service, Northern Region. These ground-truth plots were combined with plots from pre-existing sources and passed to our lab, where they underwent a series of logical and positional tests to verify their accuracy and utility for supervised classification purposes. In all, 17,854 plots were compiled in the ground-truth database. Plots in each TM scene that passed all tests were separated into two data sets: 20% of the plots by cover type were set aside for use in accuracy analysis, and 80% were used as training data in a supervised classification which assigned cover type labels using the NEAREST MEMBER OF GROUP classifier. This process was repeated for size class, but for some scenes the NEAREST MEAN classifier was used to assign labels. Training and test data sets were also built for canopy cover; however, labels were assigned using decision rules based on an examination of modified NDVI values for ground-truth plots. Decision rules were also used for manual modifications specific to each scene. In addition, some cover types were labeled through visual interpretation of imagery, such as urban areas, agricultural lands, and clouds. Using fuzzy sets, separate assessments of accuracy were conducted for land cover type, size class, and canopy cover attributes. After labeling was complete, adjacent TM scenes were ‘virtually’ edge-matched such that when files are physically merged, seamless output is generated. Riparian vegetation was mapped through a separate process, and is maintained in a separate database. Using digital elevation data, predicted riparian zones were delineated, then spectral classes were selected to represent riparian vegetation within the zones at 30 m pixel resolution.

ACKNOWLEDGEMENTS

This project involved a close collaboration between the U.S. Forest Service, Northern Region and The University of Montana. As such, many different individuals played active and vital roles. We begin with those from the Forest Service. Wendel Hann had the vision and determination to get the project underway, and Martin Prather provided the leadership and guidance to see it through to completion. We are grateful to their Unit Directors, Jim Hagemeier and Doug Glevanik, as well as to members of several Regional Leadership Teams for their willingness to support such an effort. Dave Atkins devoted much of his time during the last two years managing the day-to-day interactions between our respective organizations. Both he and Martin Prather deserve special acknowledgement for effectively managing a very complex organizational effort. Without their clear thinking, trust, and pleasant demeanor, our collaboration would not have borne fruit. Cecilia McNichol and Ken Brewer assisted Wendel to get us off to a quick start. At this stage, three key people were hired to serve as coordinators between our lab and field crews at each forest, Chip Fisher, Kristen Loken, and Marcy Mahr. Their understanding and commitment to this project was unwavering for almost 18 months during which time they perservered under sometimes challenging conditions and situations. Another key group of people was assembled under Dave Atkins' and Anne Rys-Sikora's leadership for data entry. This sometimes thankless job was performed diligently by Gerri Deleo and Pat Mikota. Field data were processed, formatted, and transferred to us by Dave Browder, John Caratti, Mike Jensen, and Rosa Nygaard. Biophysical data related to landform boundaries were provided by John Nesser. Dick Roullier and Bill Tanke were instrumental in acquiring all 7.5 minute DEM's and Cartographic Feature Files available for the study area from the Geometronic Service Center. Also, Bill Tanke and Tim Gray helped to provide for a smooth transfer of digital data from our lab to the Northern Region, Management Systems Unit. This project was handled by three different Contracting Officers -- Jim Hamilton, Roger Thomas, and Dallas Summerfield, all of whom dealt with contract issues promptly, courteously, and in a fair and reasonable manner.

A number of Forest Service personnel also deserve special mention for coordinating and carrying out project responsibilities on individual forests. From the Northern Region these include: Art Zack (Idaho Panhandle), Pat Green (Nez Perce), Sonny Castille (Clearwater), Dan Leavell (Kootenai), Maria Mantas (Flathead), Nora Leetch (Lolo), Janet Johnson and Linda

Pietarinen (Bitterroot), John Joy (Deer Lodge), Lee Harry and Dan Svoboda (Beaverhead), Lois Olsen (Helena), Tim Horn (Lewis and Clark), Julie Neff-Shea (Gallatin), and Jeff DiBenedetto (Custer). Outside Region 1, Bill Rush (Boise NF) and Dave Dyer (BLM, Boise District Office) helped to provide ground-truth data from in and around the Targhee, Boise, Payette, Wallowa-Whitman, and Colville National Forests. Carl Wright (Colville) took the time to review and help us refine a preliminary classification for a portion of the Newport District.

Many other people deserve special mention for actively assisting us with this project. These include Carl Key, Richard Meineke, and Laurie Kurth at Glacier National Park; Larry Rau and Sally Sovey at the BLM, Headwaters District Office; Jim Byer, Dan Dupuis, Sam Morigeau, and Art Soukalla at the Confederated Salish & Kootenai Tribes; Frank Roberts at the Coeur d'Alene Tribe; and Andy Hansen, Robin Patten, Matt Kraska, and John Wilson at Montana State University.

Last but not least, we come to those who helped and supported us at The University of Montana. We begin with Ray Murray, Ken Hubbard, Pat Bristol, and Sheila Hoffland in the Office of Research Administration. Ray Murray and Ken Hubbard deserve special mention; the former for helping to consolidate and upgrade workspace in the lab, and the latter for advice and guidance with contract negotiations and amendments. At the Montana Cooperative Wildlife Research Unit, Joe Ball's commitment was unwavering, and Virginia Johnston provided considerable administrative assistance, especially in the first few months of the project. Additional administrative help came from Margaret Bachmeier, Carol Gilworth, and Sandy Russo in Business Services, as well as from Sue Brown and Angela Priest in Human Resources. Finally, we wish to acknowledge colleagues in the Computer Science Department who made significant contributions to the MERGE program, as well as to our ability to successfully manage and process the many gigabytes of data required for this project; in particular, these include Professors Ray Ford and Alden Wright, and graduate students, Jin Guo and Kim Hastings.

To all the individuals named above, and to many others, be they friends, loved ones, or anonymous administrators and field assistants whose contributions were more subtle but no less important, we extend our sincere thanks and gratitude. A project of this scope, magnitude, and duration could not have been accomplished so smoothly and successfully without you.

TABLE OF CONTENTS

ABSTRACT i
ACKNOWLEDGEMENTS ii
TABLE OF CONTENTS iv
LIST OF TABLES vi
LIST OF FIGURES vii
INTRODUCTION 1
PROJECT AREA 3
METHODS 6
Creating a Database of Existing Vegetation and Land Cover 6
Mapping Inputs 8
Landsat TM Imagery 8
Digital Elevation Data 8
Digital Hydrography 11
Ground-truth Data 11
Processing Steps 14
Unsupervised Classification of Pixels 14
Collection of Data for Supervised Classifications 20
Ground-truth Data Processing Pipeline 24
Setting up the Raster Database 26
Training Data Analysis 27
Supervised Classification of Regions 30
Manual Modifications 33
Edge Matching 37
Accuracy Assessment 44
Quality Control 47
Mapping Riparian Vegetation 48
Introduction 48
Delineation of Riparian Zones 48
Selection of Riparian Spectral Classes 50
Distinguishing Agricultural and Riparian Classes 52
Post-classification Processing 53
Limitations 54
RESULTS AND DISCUSSION 55
Mapping Trends in the Project Area 55
Cover Type 55
Lifeform 60
Canopy Class 60
Size Class 60
Comments 61
Accuracy Assessment 66
Cover Type 72
Size Class 72
Canopy Cover 73
Data Limitations 73
TM Data 73
Map Unit Definition 75
Ground-truth Data 76
Conclusions 78

TABLE OF CONTENTS

REFERENCES 79
APPENDIX A. Montana and Idaho Vegetation and Land Cover Classification System . . A.1
APPENDIX B. Constructing a Digital Elevation Database B.1
APPENDIX C. Compiling and Editing a Digital Hydrographic Database C.1
APPENDIX D. Selecting Representative Training Sites for Supervised Classification . . . D.1
APPENDIX E. Processing Pipeline for Ground-truth Plots E.1
APPENDIX F. Scene Summary Reports (in two separate volumes) F.1
APPENDIX G. Draft Manuscript, Color Palette G.1
APPENDIX H. Draft Manuscript, Mapping Vegetation across Large Geographic Areas . H.1
APPENDIX I. Land Cover Attributes for Northern Idaho and Western Montana I.1
APPENDIX J. Interpreting Error Matrices J.1

LIST OF TABLES

1. Eighteen Landsat TM scenes used in construction of a digital database of existing vegetation and land cover across northern Idaho and western Montana.
2. Pixel values, or digital numbers for hypothetical spectral classes. Such values are contained in the color palettes that were used to drive unsupervised classifications of satellite image data.
3. Number of 7.5 minute quadrangles selected for field sampling using criteria below.
4. Plots in the ground-truth database, summarized by TM scene.
5. Dominance matrix establishing relationships between each pair of adjacent Landsat TM scenes; used for edge-matching purposes.
6. Fuzzy matrix used in assessing classification accuracy among cover types. 5 = perfect match; 4 = good; 3 = acceptable; 2 = understandable, but wrong; 1 = absolutely wrong.
7. Percentages and area (ha) of land cover types found in the project area, the states of Idaho and Montana, and Forest Service lands.
8. Percentages and area (ha) of life forms in the project area, the states of Idaho and Montana, and Forest Service lands.
9. Percentages and area (ha) of canopy classes in the project area, the states of Idaho and Montana, and Forest Service lands.
10. Percentages and area (ha) of size classes in the project area, the states of Idaho and Montana, and Forest Service lands.
11. Percentages of forest cover types by size class for the project area and Forest Service lands, obtained by combining attributes of the land cover type and size class grids.
12. Accuracy levels for cover type classifications by TM scene; assessed using fuzzy set analysis.
13. Accuracy levels for size classifications by TM scene; assessed using fuzzy set analysis.
14. Accuracy levels for canopy classifications by TM scene; assessed using fuzzy set analysis.

LIST OF FIGURES

1. Project area.
2. Major steps in constructing digital databases of existing vegetation and land cover, elevation, and hydrography for northern Idaho and western Montana. Processing path for riparian classification indicated by dashed line.
3. Location of 18 Landsat TM scenes.
4. Availability of 7.5 minute digital elevation models across northern Idaho and western Montana.
5. Ground-truth plots.
6. RGB color cube. The unsupervised algorithm relies on Euclidean distances calculated between pixel values within this color space.
7. Two-pass unsupervised classification procedure. Output files can be regrouped and merged to the desired minimum mapping unit, then used as base units in a GIS database.
8. Steps in the unsupervised classification process, illustrated for the central Swan Valley, Montana.
9. Sampled quads.
10. Example of the information shown on spectral quad maps used in field sampling.
11. Ground-truth data processing pipeline.
12. Steps in processing training data for each TM scene.
13. Classification of land cover types for the central Swan Valley, Montana.
14. Classification of tree and shrub size for the central Swan Valley, Montana.
15. Classification of tree and shrub canopy cover for the central Swan Valley, Montana.
16. Landsat TM scenes: overlap & dominance.
17. Edge-matching method.
18. Classification of land cover types for the Bitterroot National Forest; all data extracted from Landsat TM scene P41/R28.
19. Classification of land cover types for the Lolo National Forest; data extracted and edge-matched from five Landsat TM scenes.
20. Classification of riparian vegetation cover types within predicted riparian zone for the Salmon Prairie vicinity of the central Swan Valley, Montana.
21. Classification of land cover types for northern Idaho and western Montana; data extracted and edge-matched from eighteen Landsat TM scenes.
22. Classification of life forms for northern Idaho and western Montana; data extracted and edge-matched from eighteen Landsat TM scenes.
23. Classification of size classes for northern Idaho and western Montana; data extracted and edge-matched from eighteen Landsat TM scenes.

INTRODUCTION

This report describes the assembly and contents of several digital databases produced to map existing vegetation and land cover in a standardized and consistent manner across nearly 26.2 million hectares (64.8 million acres) in northern Idaho and western Montana. This work resulted from an ambitious, complex, and successful collaboration between the U.S. Department of Agriculture, Forest Service and The University of Montana. As originally envisioned, these databases were to be used to support interagency, scientific regional characterizations of the Upper Columbia and Upper Missouri Basins. They are ideally suited for analyses at the regional, subregional, and landscape levels, as well as for support of nearly all management disciplines, including timber, wildlife, fisheries, and recreation.

The report is organized as follows. General descriptions of the project area, methods, and results are presented, followed by a discussion of the strengths and limitations of the methods and resulting databases. Complete descriptions of the vegetation classification scheme and attributes are provided in Appendices A and I, respectively. Additional methodological details are described in Appendices B - E, as well as G, H, and J. More detailed results and comments for each individual TM scene are found in Appendix F.

Delivered with this written report are digital files containing elevation and hydrographic data, arranged in tiles that correspond to standard U.S. Geological Survey 1:100,000 scale quadrangles (1˚ latitude by 2˚ longitude blocks; n = 122 for elevation and 107 for hydrography). For each of the 18 TM scenes within the project area, the following digital files are also included:

1) Unsupervised classification, unregrouped spectral classes (30 m pixel resolution);
2) Unsupervised classification, regrouped spectral classes (30 m pixel resolution);
3) Unsupervised classification, regrouped spectral classes, merged to 2 ha (5 ac) minimum mapping unit (MMU);
4) Supervised classifications of land cover types, as well as size and canopy cover for forest and shrub types (2 ha MMU);

5) The zone in which riparian vegetation is predicted to occur; and
6) Supervised classification of riparian cover types within the predicted zone (30 m pixel resolution).

The supervised classifications of cover type, size, and canopy are stored in raster databases (ARC/INFO grids) created for each of the 18 Landsat TM scenes. Each of the 18 grids is roughly 50 megabytes in size (range ~40 -55 Mb), and has an average of 290,000 *regions*, or raster polygons (range ~228,000 -359,000). Each region is analogous to a stand; it has a unique identifier (VALUE) and more than 30 attribute descriptors like LIFEFORM, COVERTYPE, SIZECLASS, and CANOPYCODE, stored in a file called a value attribute table (VAT). An additional, and similar, riparian database was created for each TM scene. File sizes for riparian grids tend to be smaller because they have fewer attributes; however, because riparian data are maintained at 30 m MMU, these grids may contain nearly as many regions. Attributes for both databases can be accessed, updated, and manipulated through the INFO (or ORACLE) database or through the GRID module of ARC/INFO.

PROJECT AREA

The project area covers approximately 26.2 million hectares (64.8 million acres) in the eastern Columbia and western Missouri River Basins. It is a vast and structurally complex area that includes portions of northeastern Washington, northern Idaho, western Montana, and northwestern Wyoming (Figure 1). It straddles the Continental Divide from the U.S./Canada border to below Yellowstone National Park in Wyoming, and from the Palouse Prairie in eastern Washington to the northern Great Plains in central Montana. West of the Continental Divide, the project area boundary follows the Canadian border to the west side of the Pend Oreille River Valley in northeastern Washington. From there it turns south to the Idaho/Washington border near Mt. Spokane, and follows this border south through the eastern Palouse Prairie to near Lewiston, Idaho. From there it continues south along the Salmon River before turning east to take in the Gospel Hump and northern portion of the Frank Church River of No Return Wilderness Areas. South of Salmon, Idaho, the boundary turns southeast again, passing through the Lemhi Range, then east across the upper Snake River Plain, and back to the Continental Divide near the southeast corner of Yellowstone National Park. Major river systems draining the mountains west of the Continental Divide include the Clark Fork, Flathead, and Kootenai in western Montana, and the Coeur d'Alene, Clearwater, Salmon and upper Snake in Idaho, and the Pend Oreille in northeastern Washington. East of the Continental Divide, the project area boundary follows the Canadian border east to the eastern border of the Blackfeet Reservation. From there it proceeds southeast along the East Front of the Rocky Mountains to the Teton River. It then turns east and wraps around the Highwood, Little Belt, Big Snowy, Crazy, and Beartooth Mountains, and all of Yellowstone National Park. Major tributaries to the Missouri River that drain the project area include the Marias, Teton, Sun, Beaverhead, Madison, Jefferson, Gallatin, Musselshell, and Yellowstone Rivers. Elevations range from 230 m (700 ft) above sea level east of Lewiston to nearly 4200 m (12,799 ft) at the summit of Granite Peak in the Beartooth Mountains.

The area is sparsely populated and predominately forested. Much of the land is administered by the U.S.D.A. Forest Service through 21 National Forests split among four different regions (1, 2, 4, and 6). The U.S. Department of Interior also administers substantial holdings that are shared among the National Park Service, the Bureau of Land Management, and

the Fish and Wildlife Service. Other important land management authorities include the states of Idaho and Montana, as well as the Blackfeet, Coeur d'Alene, Confederated Salish and Kootenai, and Nez Perce Tribes. Land management practices across the area vary from being relatively simple and straightforward in some remote areas of rock, snow, and ice, to being complex and sometimes controversial in and around places like Yellowstone and Glacier National Parks.



Figure 1. Project Area

METHODS:
CREATING A DATABASE OF EXISTING VEGETATION AND LAND COVER

To map existing vegetation and land cover across northern Idaho and western Montana, we employed a two-stage classification process, unique to this lab, which integrates remote sensing and GIS technology. In the first stage, land cover patterns are derived from a color composite of TM data using an unsupervised classification algorithm, and adjacent pixels of the same spectral class are grouped into contiguous areas termed *regions* (Appendix G). The second stage incorporates a supervised classification algorithm within ARC/INFO GIS software to label all regions according to existing vegetation and land cover type (Appendix H). The first stage is analogous to a process of manually digitizing polygon boundaries based on spectral patterns; literally, ***what you see*** on-screen ***is what you get*** in the output file. Similarly, the second-stage, supervised classification is analogous to a process of manually labeling polygons, but uses digital attribute values for each region to determine the proper labels. In manual labeling techniques, non-digital attributes are typically assimilated from analysts' knowledge, aerial photo interpretation, and/or field validation (Scott *et al*., 1993).

Euclidean distance (Equation 1) is central to our entire mapping process. This measure is used to assess similarities between input pixels and spectral classes in the unsupervised classification, as well as similarities between input regions and cover types in the supervised classification. For the unsupervised classification, X represents a known spectral group and Y

$$D_{xy} = \sum_{i=1}^{M} (X_i - Y_i)^2 \qquad (1)$$

an unknown pixel; for the supervised classification, X is a known cover type in the training data set and Y is an unknown region to be classified.

Naturally, this overview of the classification process is greatly simplified. In practice, numerous interdependent steps are required to produce the desired land-cover databases (Fig. 2). Several digital databases were compiled as inputs to the classification process, and checkpoints were implemented at various stages to ensure accurate and consistent products.

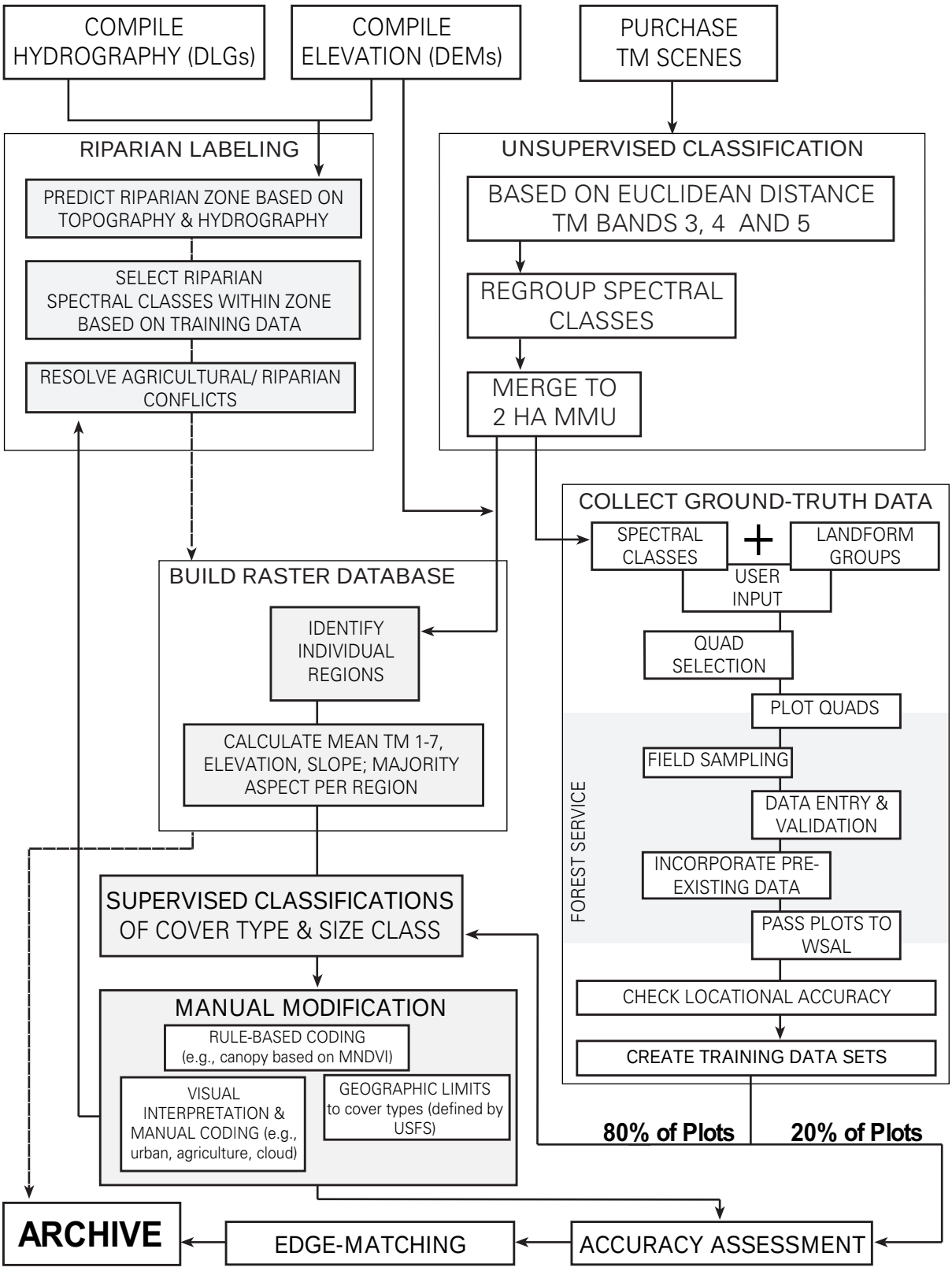


Figure 2. Major steps in constructing digital databases of existing vegetation and land cover, elevation, and hydrography for northern Idaho and western Montana. Processing path for riparian classification indicated by dashed line.

Analyses were conducted on IBM RS/6000 workstations running AIX (version 3.2). Primary commercial software packages included: ARC/INFO (versions 6.1.1-7.0.3), ERDAS (version 7.5), and IMAGINE (version 8.1). In addition, for many major processing steps, we constructed customized software written in FORTRAN and C (such as VIMAP, copyright 1994-96, Zhenkui Ma), or scripts written in Arc Macro Language (AML).

MAPPING INPUTS

Landsat TM imagery, digital elevation models (DEMs), digital hydrography, and ground-truth plots were the primary data layers incorporated in the mapping process. Data acquisition and database construction are outlined below. Details are provided in related appendices, as well as in digital metadata documents.

Landsat TM Imagery

For northern Idaho and western Montana, we purchased 18 TM scenes (Fig. 3, Table 1), making efforts to obtain the most recent, cloud-free imagery available. All scenes were collected during the growing season, mid-June to late September, and most are dated 1991-1993. Three data types were available for purchase: system-corrected, precision-corrected, and terrain-corrected data. After evaluating these options, terrain-corrected TM scenes with mosaic quality were selected because these gave the most accurate geographic locations for land features in western Montana (Root Mean Square Error of 18 and 30 m in the x and y directions, respectively, for P41/R27; J. Troutwine, unpubl. data). Hughes/STX Corporation terrain-corrected 15 of the TM scenes (Table 1) using proprietary techniques and ground control points. The remaining three scenes were obtained from and terrain-corrected by the EROS Data Center (Sioux Falls, SD). All scenes were projected into an Albers Equal-Area Conic projection, NAD27 datum. Final pixel size was 30 m^2.

Digital Elevation Data

Elevation, slope, and aspect information were derived from digital elevation data. U.S. Geological Survey (USGS) 7.5' DEMs were used wherever possible. However, some quadrangles, particularly on the study area periphery, were not available in digital form. These areas were patched with three arc-second data (from the Defense Mapping Agency, source scale 1:250,000), which had previously been resampled to 30 m^2 pixels and co-registered to

Table 1. Eighteen Landsat TM scenes used in construction of a digital database of existing vegetation and land cover across northern Idaho and western Montana.

SCENE	DATE	NAME	Source	Analyst	% Cloud	Received	Checked	Classified	No. Classes	Regrouped & Filtered	No. Classes	Merged	Quads Selected
P43/R26	09/25/93	Priest Lake, ID	MRLC	Tady	0	08/29/94	08/94	08/31/94	64	09/01/94	33	09/01/94	09/02/94
P43/R27	08/08/93	Coeur d'Alene Lake/Spokane	MRLC	Tady	0	07/30/94	08/94	08/03/94	66	08/03/94	39	08/03/94	08/04/94
P42/R26	08/14/92	Lake Koocanusa/Eureka	H-STX	Tady	2	05/31/93	10/93	02/24/94	60	02/25/94	30	02/25/94	07/08/94
P42/R27	08/14/92	Thompson Falls/Noxon Res	H-STX	Tady	0	05/31/93	10/93	02/23/94	53	02/23/94	29	02/23/94	04/05/94
P42/R28	06/14/93	Dworshak Res/Kooskia, ID	MRLC	Ma	10	07/30/94	08/94	08/02/94	61	08/03/94	31	08/03/94	08/04/94
P41/R26	09/06/91	Glacier National Park	H-STX	Ma	1	05/10/93	09/93	03/02/94	70	03/03/94	36	03/04/94	04/28/94
P41/R27	07/20/91	Missoula/Flathead Lake	H-STX	Ma	1	05/31/93	09/93	06/20/93	71	09/10/93	31	09/10/93	04/18/94
P41/R28	07/20/91	Selway/Bitterroot	H-STX	Ma	1	05/31/93	09/93	02/15/94	73	02/15/94	30	02/15/94	04/21/94
P41/R29	06/04/92	Salmon River, ID	H-STX	Tady	1	05/31/93	10/93	12/22/93	85	12/22/93	25	01/03/94	06/01/94
P40/R27	07/31/92	East Front/Choteau	H-STX	Tady	2	06/07/93	09/93	02/10/94	76	02/11/94	33	02/11/94	06/30/94
P40/R28	07/29/91	A-P/Georgetown Lake	H-STX	Winne	2	08/05/93	09/93	07/06/93	69	07/07/93	18	11/18/93	05/23/94
P40/R29	07/31/92	Beaverhead Mtns/Big Hole	H-STX	Tady	0	05/31/93	08/93	08/23/93	64	08/24/93	25	09/10/93	05/25/94
P39/R27	07/06/91	Highwood Mtns/Benton Lk	H-STX	Winne	1	05/03/93	09/93	09/16/93	54	02/08/94	27	02/08/94	05/25/94
P39/R28	07/22/91	Canyon Ferry Lake/Bozeman	H-STX	Winne	2	05/10/93	09/93	08/03/93	57	08/05/93	27	04/28/94	05/02/94
P39/R29	08/09/92	Centennial Valley	H-STX	Winne	1	05/31/93	09/93	10/15/93	63	10/15/93	28	10/18/93	05/02/94
P38/R27	07/31/91	Judith Mountains/Winifred	H-STX	Ma	1	05/03/93	09/93	04/24/94	69	04/25/94	37	04/27/94	05/24/94
P38/R28	07/31/91	Crazy Mountains	H-STX	Ma	1	05/03/93	09/93	02/17/94	75	02/18/94	33	02/18/94	05/06/94
P38/R29	07/15/91	Yellowstone National Park	H-STX	Ma	5	05/03/93	09/93	02/17/94	75	02/22/94	31	02/22/94	05/25/94

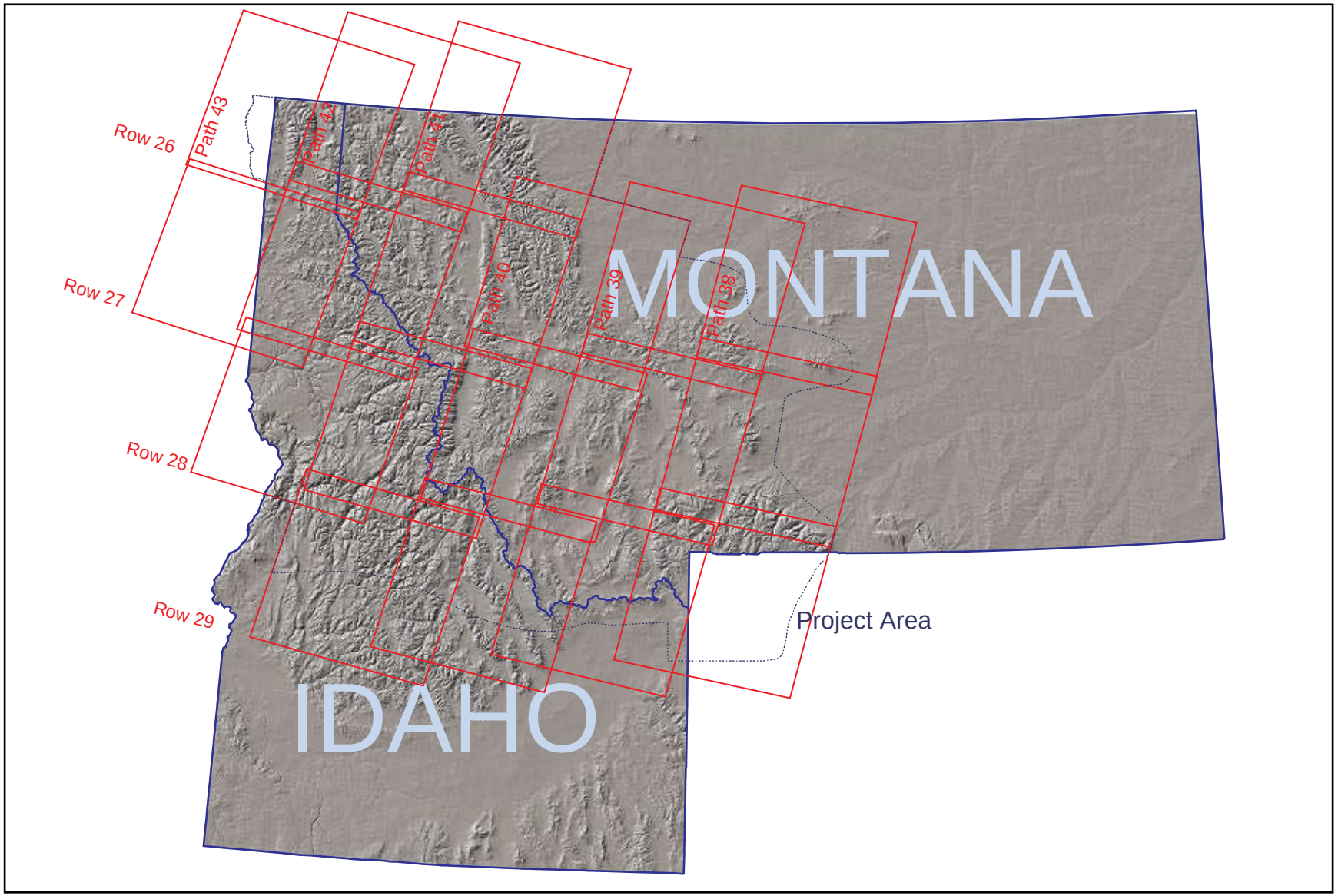


Figure 3. Location of 18 Landsat TM Scenes

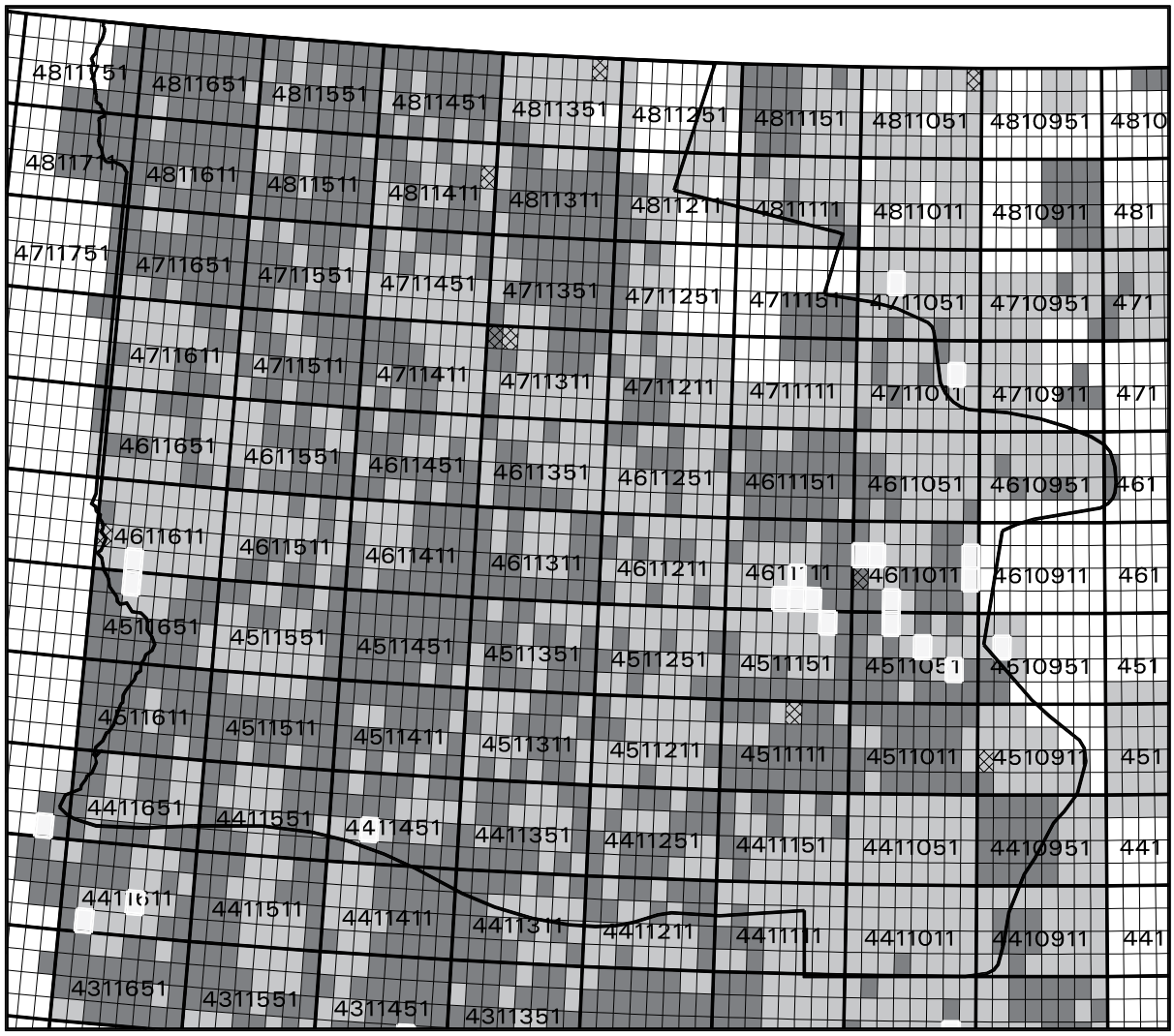
the TM scenes either by Hughes/STX or EROS Data Center. Digital elevation data were stored in tiles corresponding to the spatial extent of the USGS 1:100,000 quadrangles. In all, 7.5' DEMs were acquired for 3,203 quadrangles, and used in compiling 102 DEM tiles (Fig. 4). Each DEM tile is roughly 10 megabytes in size. For more details, refer to Appendix B.

Digital Hydrography

USGS 1:100,000 digital line graphs (DLGs) were acquired for the project area. When compared with recently published USGS topographic maps, inconsistencies were observed, such as missing features, miscoded features, and superfluous features in the digital version. We learned through consultation with USGS that the hardcopy maps were more reliable and accurate, and thus we edited the DLGs to reflect information on the hardcopy maps. No physical changes were made to the original information contained in the DLGs; however, new attributes were added to flag miscoded, superfluous, and newly added features so that users could quickly modify the DLGs to match the hardcopy maps if necessary. Individual DLGs were then appended to create separate coverages for each TM scene, although data were archived and delivered in tiles corresponding to the USGS 1:100,000 quadrangles. In all, 107 DLGs were examined, and 50 required some degree of editing. In comparison with the DEM tiles, hydrography tiles are relatively small, well under one megabyte apiece. See Appendix C for further information.

Ground-truth Data

Plots were acquired from the U.S. Forest Service, Northern Region (Fig. 5). ASCII files containing plot information were converted to ARC/INFO point coverages, then sorted and stored in separate coverages for each TM scene. To maximize the training data available for use in supervised classification, plots that fell in multiple scenes were maintained in multiple coverages. Additional training data were collected from USFS personnel during reviews of preliminary classifications, and were compiled from other sources where available (e.g., aerial photos or forest stand maps). More information on the sampling scheme behind ground-truth data collection, and the manner in which plots were processed, is provided in later sections, as well as in Appendices D and E.



* ?Outside study area : Either unavailable or not purchased

Figure 4: Availability of 7.5 minute digital elevation models across northern Idaho and western Montana.

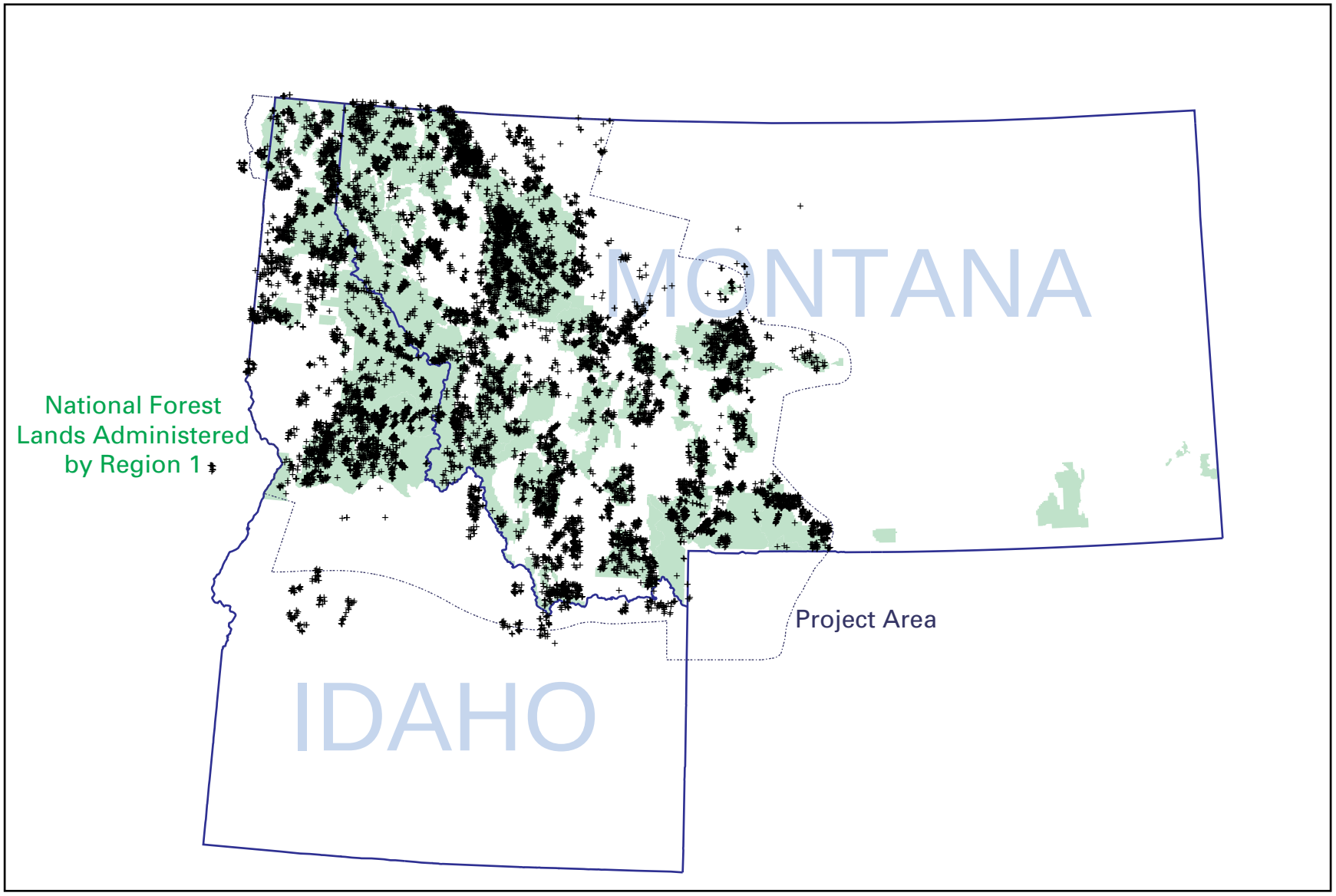


Figure 5. Ground Truth Plots

PROCESSING STEPS

Unsupervised Classification of Pixels

The two-pass, unsupervised classification procedure was designed by Zhenkui Ma to replicate the patterns observed in a color composite of TM imagery (channels 4, 5, and 3 assigned to red, green and blue). Again, what you see on-screen is what you get in the classified output file. If the colors of a classified image appear similar to the color composite from which it is drawn, important patterns presumably have been retained through the classification process. Spectral classes are defined based on Euclidean distance; the algorithm essentially is searching for the shortest distance between points in multivariate space, or in this case, the distance between RGB values for different pixels. Color similarity thus determines spectral class.

In the first pass of the unsupervised classification, a color palette file (Table 2), which maps spectral values for the three TM channels to RGB values (Fig. 6), was created by randomly sampling pixels to represent patterns evident in the color composite and thus to define spectral classes. In the second pass, Euclidean distances were calculated between pixels in the input image and spectral classes in the color palette; input pixels were assigned to the nearest spectral class as measured by Euclidean distance. More detailed discussion of methodology is provided in Appendix G. The following steps in the unsupervised classification, carried out using ERDAS and VIMAP software, were repeated for each of the 18 TM scenes (Fig. 7):

1. ***Create Color Palette*:**
    a. The criterion value for Euclidean distance (D_c) was set; new spectral classes were defined based on this cutoff value. The skip factor, or percentage of pixels to be sampled from the input image, was also input to determine how many random passes would be used. We employed a skip factor of 20 (lines), 20 (pixels).
    b. One pixel was randomly selected from the input image, and its values for channels 4, 5, and 3 were saved in a color palette file. This pixel served as a seed for the color palette; its values automatically defined the first spectral class.
    c. Pixels were randomly sampled from the image data, and Euclidean distance was calculated between each pixel from the input image and pixel(s) from the color palette. Generally, 50-80 pixels were sampled.

d. New spectral classes were defined by adding input pixels to the color palette when the smallest Euclidean distance value calculated between an input pixel and any other pixel already in the color palette exceeded the cutoff value specified in 1a.
e. Steps 1c and 1d were repeated until all randomly sampled pixels had been examined. Pixels in the color palette were then used as representative spectral classes for an unsupervised classification.

2. ***Classify the input image using the newly-created color palette:***
   a. The input image was classified by assigning pixels to classes to which their spectral values were closest in terms of Euclidean distance.
   b. To make a color map file with enhanced contrast, pixels in the color palette were stretched with the same parameters used for displaying the color composite. This step generated a new color palette, or color map file, for displaying the classified image.
   c. The classified image (8-bit data) was visually compared to the color composite (24-bit data displayed with a 24-bit graphics card). If color differences were observed between the classified image and the color composite, a pixel from each missing spectral class was randomly selected and added to the color palette. Steps 2a-2c were repeated until satisfactory results were obtained.

The color composite (Fig. 8a) and unsupervised classification output (Fig. 8b) are illustrated for the central Swan Valley, northwestern Montana. Spectral classes were next regrouped to reach a more manageable number of classes, and to better reflect some land cover type patterns (Fig. 8c). Typically, the number of classes was reduced from approximately 60-80 to 30-40. To regroup classes, pixels were clustered in the color palette (the stretched version created in Step 2b). Euclidean distance was then used to group pixels in the color palette based on their positions in RGB color space. The grouped pixels were then used to determine the colors for displaying the classified image. After visually comparing the classified image to the color composite (with a 24-bit graphics card), pixel groupings in the color palette were manually adjusted as necessary. Once the grouped color palette produced a satisfactory display of the original classified image, spectral groups in the classified image were physically regrouped to correspond with the revised color palette. The regrouped image was then subjected to a majority filter using a 3 x 3 window. At the time in which the unsupervised classifications were being conducted, this step was necessary to reduce data

dimensionality prior to the merging step described below. Improvements in hardware and software have since rendered the regrouping and filtering steps unnecessary; however, they were implemented for all 18 TM scenes within the project area.

After regrouping and filtering, we refer to each contiguous area of pixels assigned to the same spectral class as a ***region*** (again, analogous to a polygon, but in raster format). Regions less than the selected MMU of 2 ha, or 22 pixels (30 m * 30 m * 22 = 19,800 m^2 = 1.98 ha), were eliminated in a rule- and object-based merging process (Ford et. al., 1993; Guo, 1993; Ma, 1995). The 2 ha MMU was enforced for all spectral classes except those corresponding to water; to aid in future riparian evaluations (e.g., wildlife habitat assessments), an early decision was made to maintain individual 30 m^2 pixels for these classes. The merging process centered around construction of a similarity matrix used to control the incorporation of small regions into larger neighbors. This matrix was built based on the TM channel values for the input spectral groups. The merging process first identified regions smaller than the MMU, listed neighboring regions, then examined similarities between small regions and their neighbors. Small regions were then merged with larger neighbors having the most similar spectral values. Once the merging process was finished, region shapes and sizes were established, and were not changed in subsequent steps (Fig. 8d). These regions serve as the base units in our raster database. At this point, all steps in the entirely digital unsupervised classification were complete. To assign labels to these base regions through the supervised classification process, collection of ground-truth data was necessary.

Table 2. Pixel values, or digital numbers, for hypothetical spectral classes. Such values are contained in the color palettes that were used to drive unsupervised classifications of satellite image data.

RED	GREEN	BLUE	COLOR GROUP	SPECTRAL CLASS
255	0	0	red	bright red
10	0	0	red	darker red
255	255	0	yellow	bright yellow
50	50	0	yellow	darker yellow
255	255	255	gray	bright/white
10	10	10	gray	darker/black
255	160	140	pink	bright pink
205	110	90	pink	darker pink

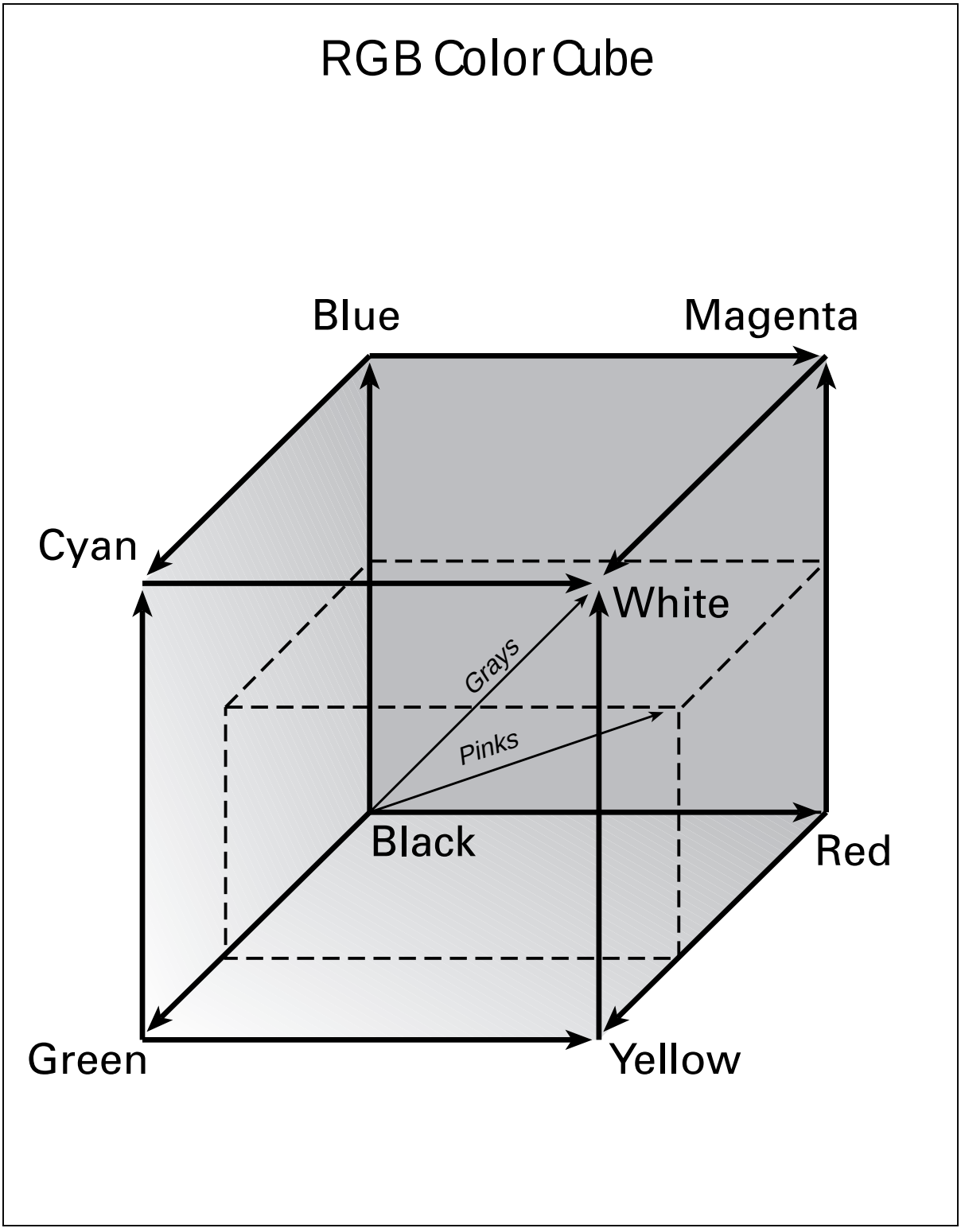


Figure 6. RGB Color Cube.

The unsupervised algorithm relies on Euclidean distances calculated between pixel values within this color space.

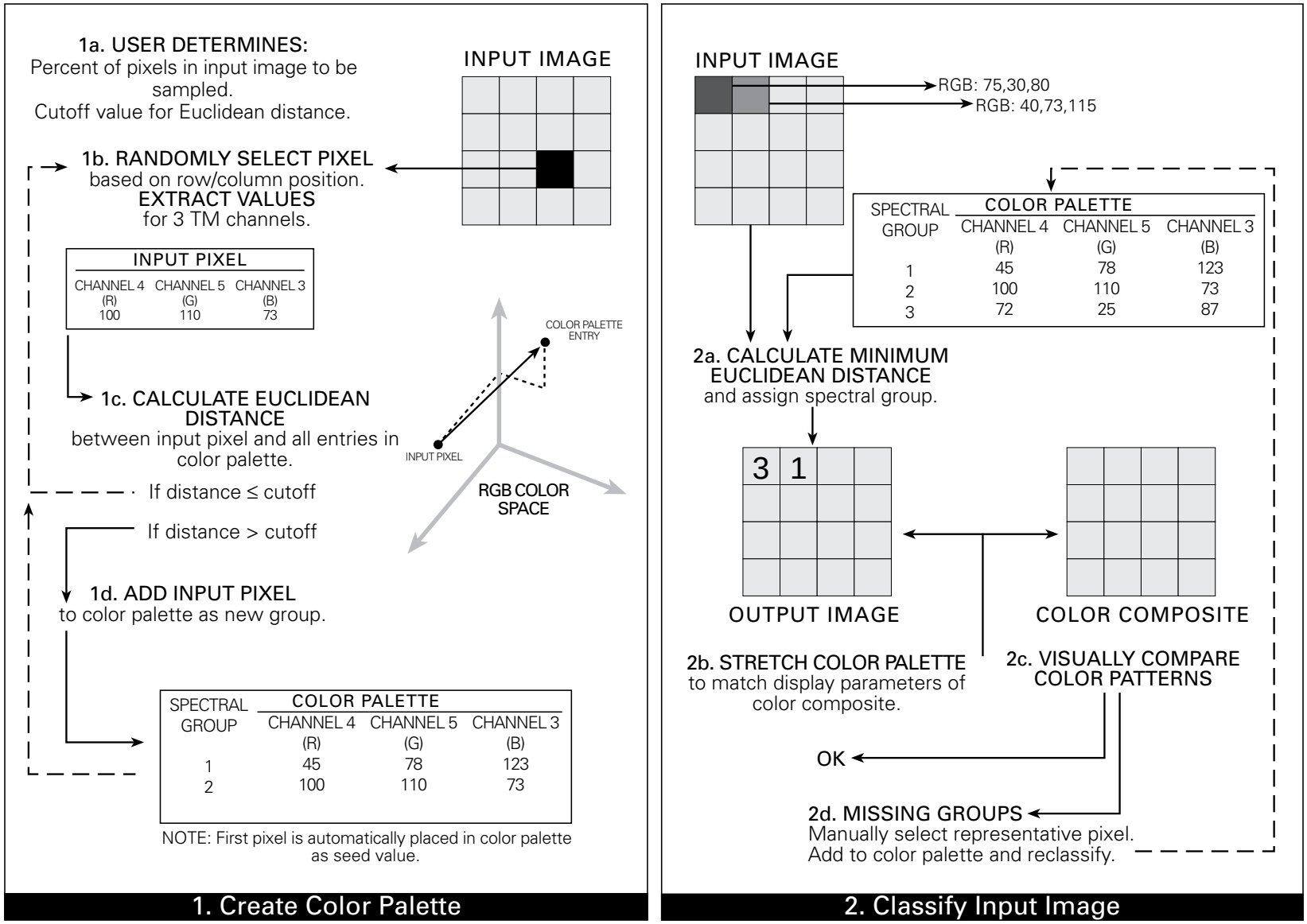
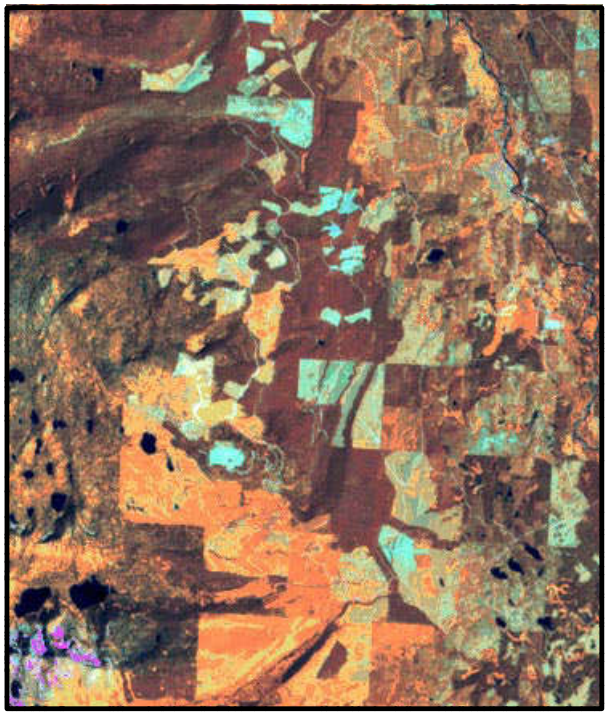


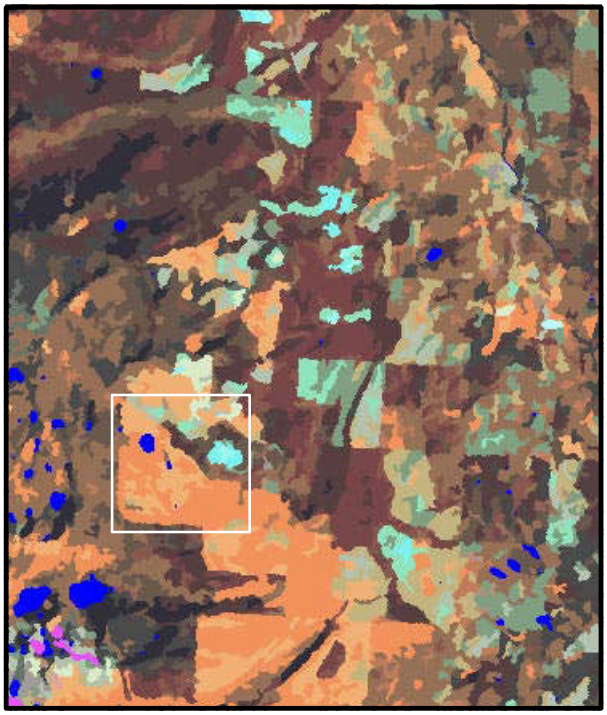
Figure 7. Two-pass unsupervised classification procedure. Output files can be regrouped and merged to the desired minimum mapping unit, then used as base units in a GIS database.



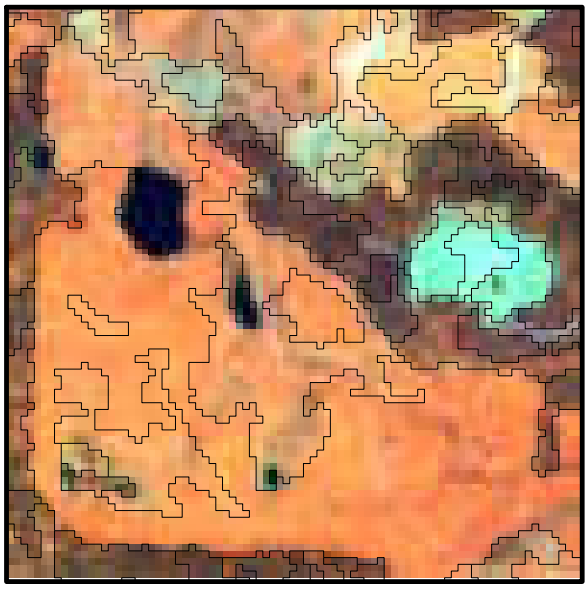
(a) Color composite of TM channels 4,5,3 (R G B).



(b) Unsupervised classification of TM channels 3,4,5.



(c) Classification regrouped and merged to 2 ha minimum mapping unit, with area of enlargement *(d)* outlined.



(d) Enlargement showing polygons derived from *(c)*, overlaid on *(a)*.



Figure 8. Steps in the unsupervised classification process, illustrated for the central Swan Valley, Montana.

Collection of Training Data for Supervised Classifications

Compilation of a training dataset is a critical step in classifying existing vegetation, because the resultant map can only be as good as the training data used to develop it. In order to collect sufficient ground-truth data for classifying existing vegetation and land cover, the U.S. Forest Service Northern Region conducted an extensive two-season field sampling effort in northern Idaho and western Montana. A stratified sampling scheme (Appendix D), similar to that described by Warren et al. (1990), was adopted for the first season: For each TM scene, spectral classes were examined according to landform group (Table D-1). USGS 7.5' quadrangles were selected for field sampling based on high spectral diversity, presence of rare spectral classes, and/or presence of poorly represented classes. After these criteria were applied, additional quadrangles were selected to improve the overall geographic distribution of samples. After the first field season, the number of plots collected for each cover type in the classification scheme was tallied. Quadrangle selection for the second field season was then targeted toward sampling cover types for which insufficient plots had been previously collected (see Appendix D for criteria). In all, 671 quadrangles were selected for sampling across the entire project area (Fig. 9, Table 3).

Once quadrangles were selected for sampling, field maps were prepared for each quadrangle, displaying spectral classes (polygons at 2 ha MMU), with hydrography and roads overlaid for reference. In the second season, field maps were modified slightly: Spectral classes at 30 m resolution were plotted, with boundaries for 2 ha MMU polygons overlaid for reference, along with hydrography and roads (Fig. 10). This improvement allowed field crews to locate their plots in homogeneous areas within polygons as indicated by the 30 m data. After receiving the maps, field crews then sampled the 2 ha MMU polygons using ECODATA methodology (Keane et al. 1990). To maximize positional accuracy, plot coordinates were determined based on differentially-corrected GPS locations whenever possible.

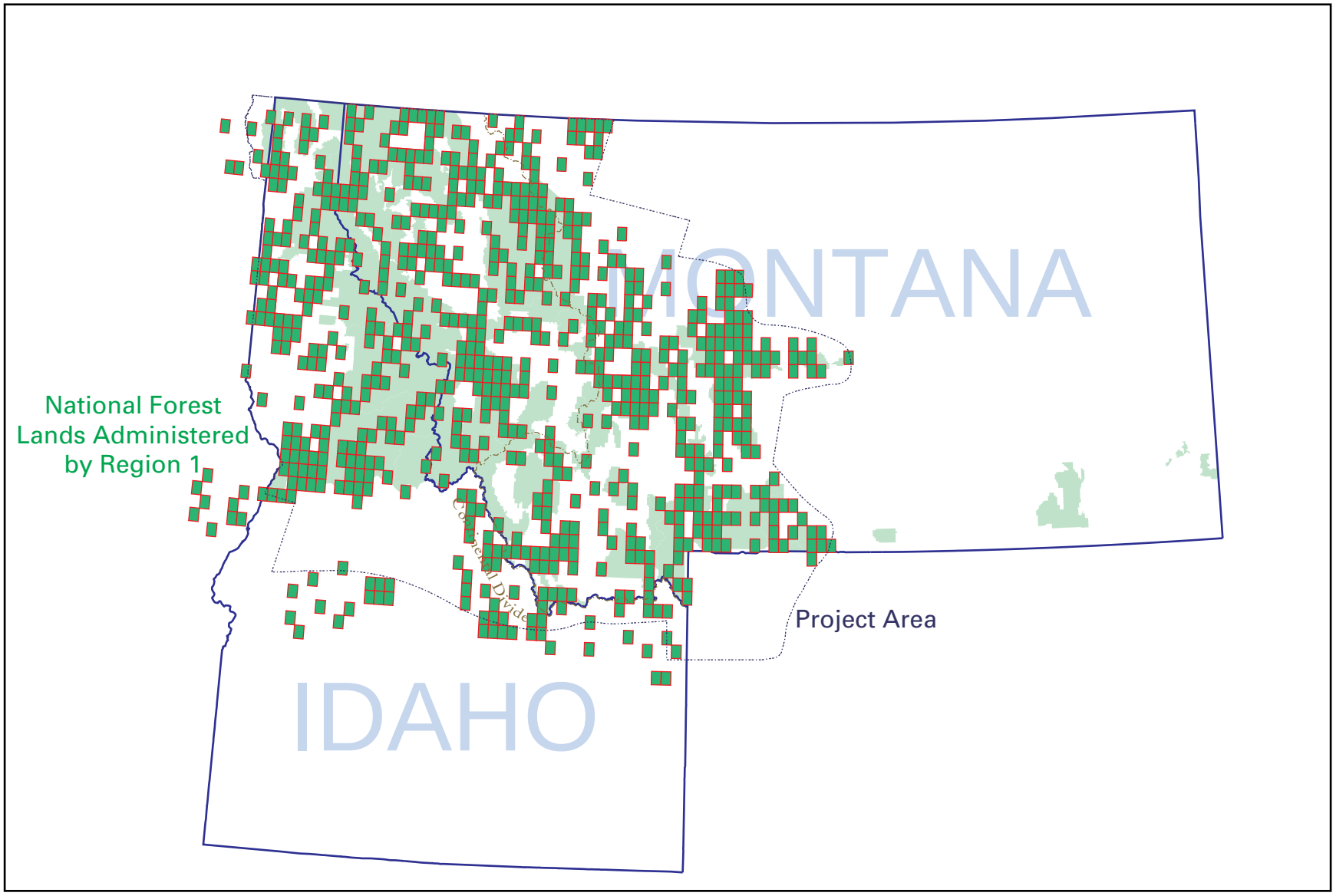


Figure 9. Sampled Quads

Table 3. Number of 7.5 minute quadrangles selected for field sampling using criteria below.

TM Scene	Name	Diversity	Rarity	Forest Service	Under Represented	Geographic Distribution	Cover Type	TOTALS
P43/R26	Priest Lake, Idaho	14	1	3	2	4	6	30
P43/R27	Coeur d'Alene Lake/Spokane	0	3	0	2	0	18	23
P42/R26	Lake Koocanusa/Eureka	9	3	2	3	4	14	35
P42/R27	Thompson Falls/Noxon Res	15	14	10	3	5	7	54
P42/R28	Dworshak Res/Kooskia	17	9	0	3	2	7	38
P41/R26	Glacier National Park	8	15	3	3	3	19	51
P41/R27	Missoula/Flathead Lake	17	10	7	11	2	15	62
P41/R28	Selway/Bitterroot	19	14	7	3	1	10	54
P41/R29	Salmon River	10	0	0	0	0	0	10
P40/R27	East Front/Choteau	13	14	5	6	3	11	52
P40/R28	A-P/Georgetown Lake	14	1	2	0	1	4	22
P40/R29	Beaverhead Mtns/Big Hole	17	3	0	2	0	0	22
P39/R27	Highwood Mtns/Benton Lk	8	10	0	2	1	15	36
P39/R28	Canyon Ferry Lake/Bozeman	17	3	11	3	2	7	43
P39/R29	Centennial Valley	19	6	3	3	0	0	31
P38/R27	Judith Mountains/Winifred	3	11	0	2	0	9	25
P38/R28	Crazy Mountains	12	5	5	4	1	16	43
P38/R29	Yellowstone National Park	11	10	3	1	1	14	40
	TOTALS	223	132	61	53	30	172	671

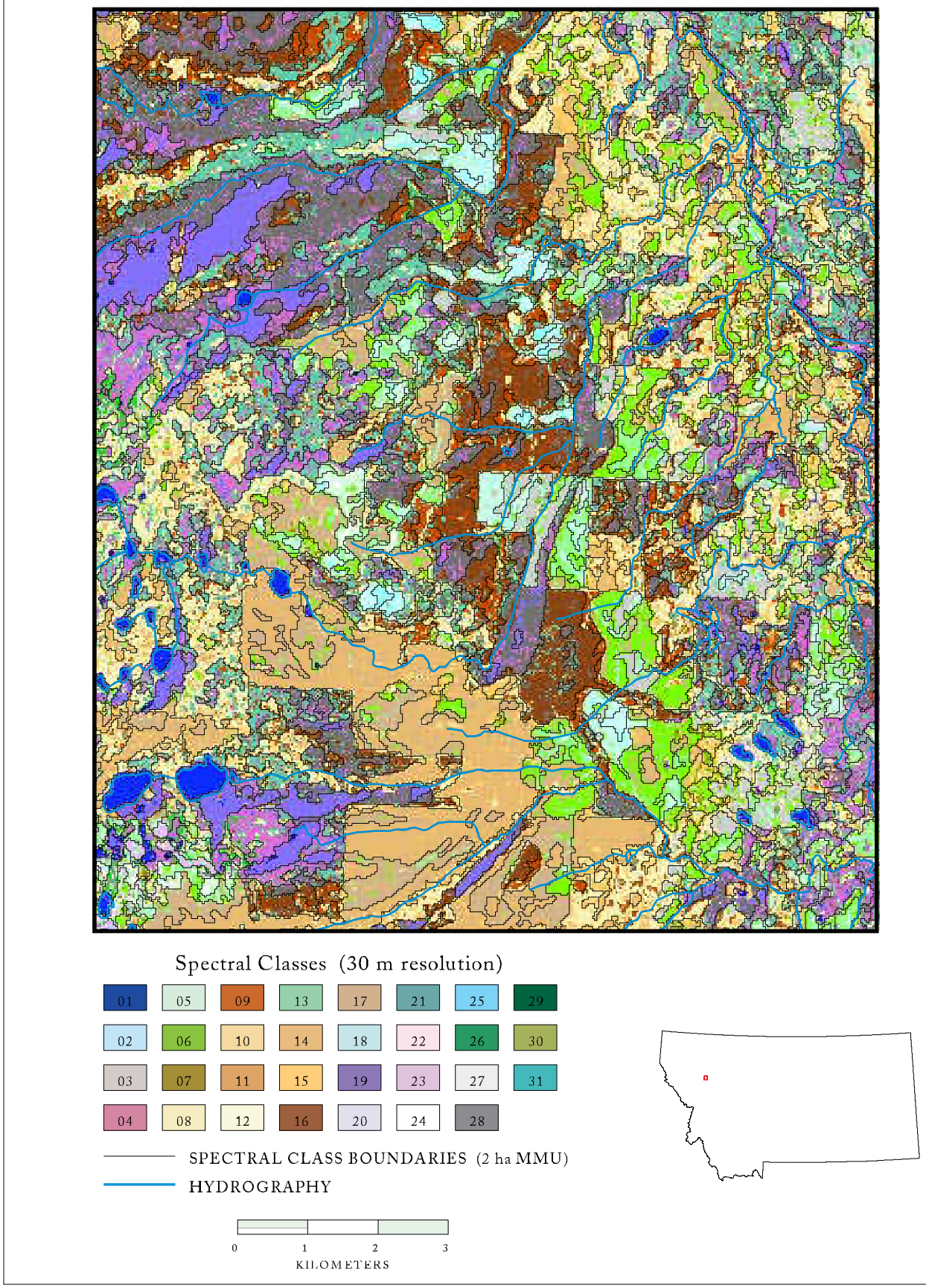


Figure 10. Example of the information shown on spectral quad maps used in field sampling.

Ground-truth Data Processing Pipeline

After field plots were obtained from the Forest Service in digital format, they were subjected to a series of logical and positional checks (Fig. 11, Appendix E). A total of 17,854 unique plots were compiled in the ground-truth database (Table 4). Of these, 2,451 fell in the area of overlap between three scenes, 8,613 fell in the overlap between two scenes, and 6,790 were located in a single scene. ARC/INFO point coverages with numerous attributes were then created and manipulated to obtain training datasets for each TM scene. Because of the overlap between scenes, individual plots may be stored in multiple training set coverages, such that a total of 31,369 plots were available. These scene-based plot coverages were then passed to the image analysts for use in the supervised classification process (described below).

Size classes assigned to plots required additional review before they could be used as training data. Because many of the forest cover plots had multiple tree size class groups present, the size class group with the highest Dominance Index (average height * group cover) was assigned for each plot. Recall that field sampling was targeted toward cover types; some emphasis was placed on canopy cover levels, but not size classes (C. Fisher, pers. comm.). Training data was thus readily available for cover type and canopy cover, but size class underwent a *post hoc* assignment, meaning that most forest plots did not offer good size class representations for training purposes. Therefore, data were high-graded in a stringent manner that led to the elimination of many plots. First, for forest types, plots were eliminated if they did not have both ≥20% forest cover and a live size class assigned in the field. Remaining plots were labeled using rules determined by the Forest Service; plots that met the following criteria were identified using a script written in AML (Arc Macro Language):

1) Seedling/sapling (SE/SA, ≤4.9" dbh): ≥20% seedling and/or sapling cover, AND combined total SE/SA cover >66% of total tree cover, AND pole + medium cover <3%, AND large + very large tree cover = 0%.
2) Pole tree (PT, 5.0-8.9" dbh): >20% PT cover, AND total PT cover >66% of total tree cover.
3) Medium tree (MT, 9.0-20.9" dbh): >20% MT cover, AND total MT cover >66% of total tree cover.
4) Large/very large tree (LT/VLT, ≥21.0" dbh): ≥20% combined LT/VLT cover, AND combined total LT/VLT cover >66% of total tree cover.

For shrub types, plots had to have ≥20% shrub cover. Assignments were similar:

1) Low shrub (<2.4'): low shrub cover > 66% of total shrub cover.
2) Medium shrub (2.5-6.5'): medium shrub cover >66% of total shrub cover.
3) Tall shrub (>6.5'): tall shrub cover >66% of total shrub cover.

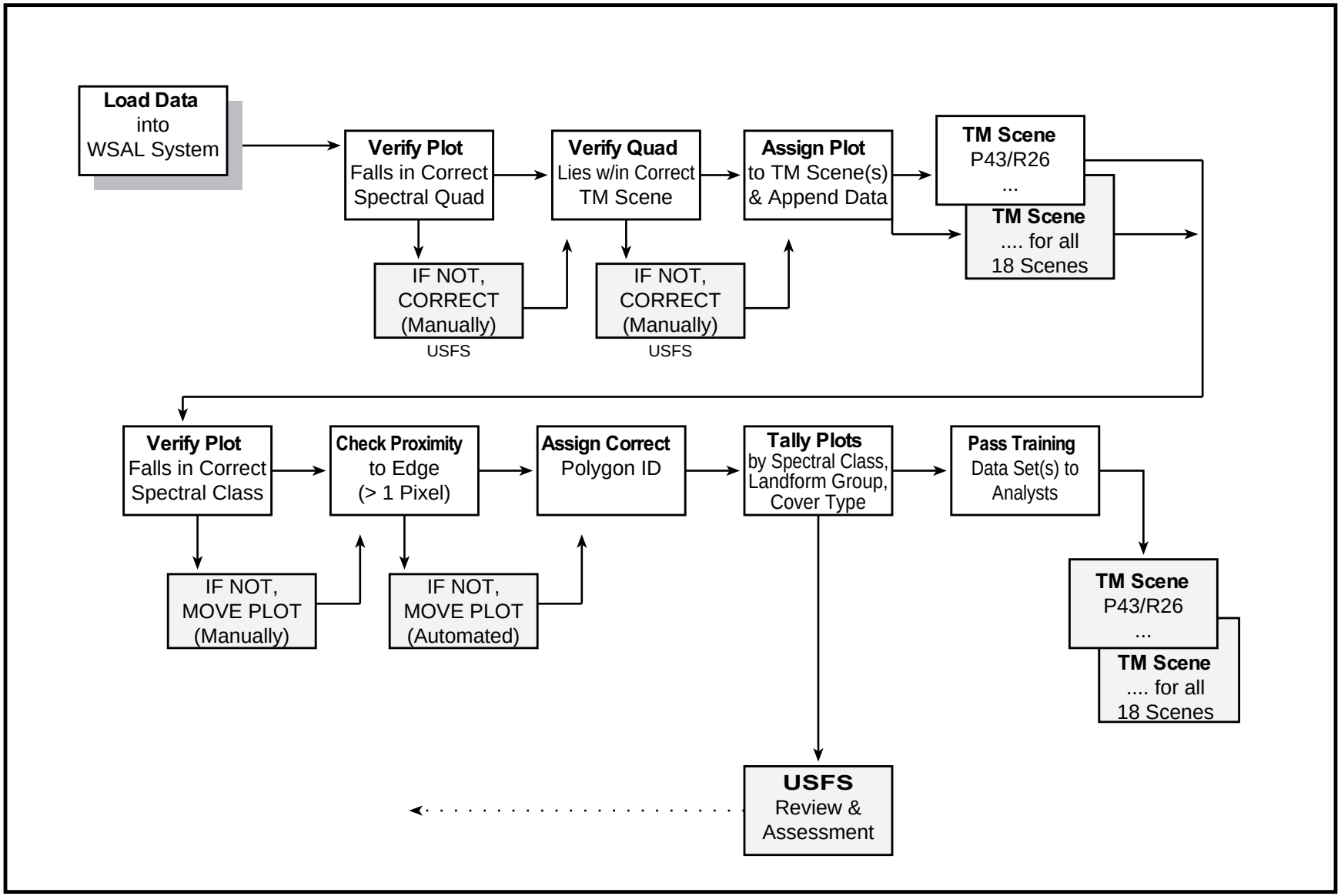


Figure 11. Ground-Truth Data Processing Pipeline

Table 4. Plots in the ground-truth database, summarized by TM scene.

Scene	1994-95 Field Data	Existing Data	Total Plots
P43/R26	730	323	1053
P43/R27	1111	14	1125
P42/R26	1115	877	1992
P42/R27	2281	306	2587
P42/R28	1234	594	1828
P41/R26	947	705	1652
P41/R27	1935	1690	3625
P41/R28	1666	1329	2995
P41/R29	224	20	244
P40/R27	1751	1093	2844
P40/R28	1393	633	2026
P40/R29	918	69	987
P39/R27	853	261	1114
P39/R28	1927	443	2370
P39/R29	1512	268	1780
P38/R27	272	193	465
P38/R28	1418	332	1750
P38/R29	838	94	932
Total	22125	9244	31369

Setting up the Raster Database

The supervised classification, where regions are assigned labels based on ground-truth data, required a raster database containing multiple TM and ancillary attributes. Logically, then, classifications could not take place until such databases (or scene grids) had been constructed for each TM scene. Once a classified and merged image was created through the unsupervised classification process, the resultant file was converted from ERDAS GIS to ARC/INFO

GRID format, thus maintaining its raster file structure. Each scene grid contained roughly 300,000 regions. Next, for each scene grid, a value attribute table (VAT) was built to contain statistics by region for spectral and biophysical (TM and DEM) data (Ma and Redmond, 1992). In addition to the mean values for TM channels 1-7, mean elevation and slope values for each region were calculated and stored within the attribute table. Because mean values were unlikely to offer representative measures for aspect (e.g., when averaged, northeast and northwest slopes would be recorded as south), we classified aspect into eight groups and stored majority values for each region. We also calculated a version of modified NDVI (normalized difference vegetation index) adapted from Nemani et al. (1993):

MNDVI = (TM4 - TM3) / (TM4 + TM3 + 1) * (256 / (TM5 + 1)) * 100

Spatial attributes (hectares, perimeter length, and xy coordinates) were also calculated and recorded. The latter two were derived by converting the raster file to vector format; these attributes were automatically created in the conversion, then their values were transferred back to the raster file. See Appendix I for a complete description of database attributes.

Training Data Analysis

As mentioned above, the supervised classifications could not occur until raster databases were constructed. Even more importantly, the supervised classifications would not be possible without the input of high-quality data to 'train' the computer in which labels should be assigned to each region. Thus, the analysts next examined the scene-based plot coverages created during the ground-truth processing pipeline stage (Fig. 12). Plots expected to cause problems were identified. If problems could not be resolved, the associated plots were eliminated from the training set. Examples include multiple plots with different vegetation types in a single polygon, and plots with low or unknown locational accuracy. Each analyst examined the data for the same set of problems, but in a slightly different order. Generally, plots were set aside if they had cover type codes that would be manually rather than digitally labeled; these included urban, agricultural, and water cover types, but the specific set of excluded types varied by TM scene. Riparian plots also were set aside for use in a separate classification of riparian vegetation (see later section for methods). In addition, plots were eliminated if they represented cover types that were determined by USFS personnel to be minor scene components, and thus not desirable for mapping purposes (lists on file at Lolo National Forest).

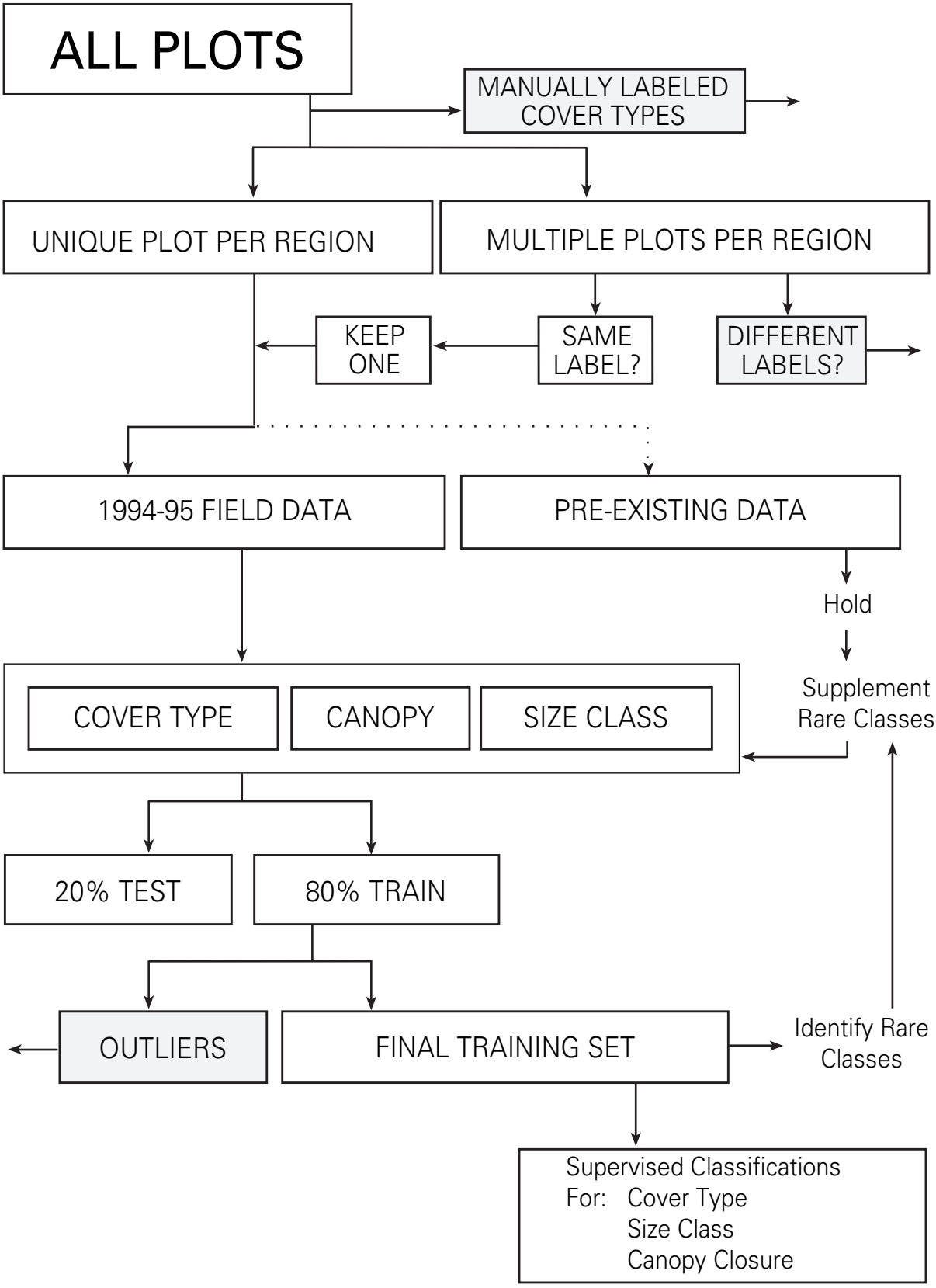


Figure 12. Steps in processing training data for each TM scene.

Plots were also overlayed with the regions, or raster polygons, created through the unsupervised classification process. In many cases, multiple plots occurred within one region: some regions stretched across large areas, but their contiguity was not evident on field maps; other regions crossed quadrangle boundaries, and were sampled in more than one quadrangle; other regions contained both 1994-95 and pre-existing data. Yet other duplicates were created within the area of overlap between TM scenes. Whatever the reason, if multiple plots fell within a single region, but were assigned different cover type codes, they were treated as 'bad duplicates'. Most were by necessity deleted, but in situations where cover type codes were quite similar, and/or most plots suggested that a region should be labeled with a given code, one plot was kept to represent the region. Careful treatment of 'bad duplicates' was necessary because these plots would have created confusion during the supervised classification (see below). Similarly, if multiple plots fell within a region, but all had the same cover type codes, one of the plots was kept and the others discarded. 'Good duplicates' such as these would not have created confusion during the supervised classification; however, the attribute values would have been extracted twice from the same polygon, creating many unnecessary calculations and increasing processing time.

Once all problems with duplicates had been resolved, ground-truth data collected for this project during 1994-95 were separated from pre-existing data. Pre-existing data (including ECODATA and TSMRS) were set aside. Later, these data were used in a restricted manner, varying by scene, as supplemental training or test data for cover types that were poorly represented by 1994-95 plot data (see criteria, Appendix D). Because pre-existing data were sampled for other purposes and often at other scales, their locational accuracy with regard to our region boundaries was suspect. Poorer results were obtained for early supervised classifications using all pre-existing data than for classifications where they were used sparingly; thus, a decision was reached to treat them in the manner described here.

From the remaining set, 20% of the plots for each cover type were set aside for assessing classification accuracy. The other 80% comprised the potential training set for cover type classification. These plots were subjected to further spectral examination. Outliers were identified for each cover type by examining plots in relation to TM and ancillary data for the regions in which they fell. Plots were inspected both visually and in relation to statistical measures like Euclidean distance and standard deviation. Outlier or otherwise questionable plots were eliminated from the training set. Separate test and training sets for tree and shrub

size classes were created using this process as well.

Training data analysis did not truly end until supervised classifications were complete. To assess the quality of training data at various stages of the entire process, we used a bootstrap method. This approach involved removing each training plot from the data set in turn, and using the remaining plots to classify that single plot. A matrix then was generated from the classified output files to evaluate potential confusion among training plots. Diagonal elements in the 'confusion' matrix represent the number of plots properly classified; misclassified plots (omission and commission errors) were further evaluated and in some cases dropped altogether from subsequent analyses. Note that even if plots were correctly classified by others, they still may have been deleted; clusters of problem plots were fairly common. Confusion matrices for cover type based on the final training set are provided for each TM scene in Appendix F.

Supervised Classification of Regions

Once the raster database and training data sets were in place for a given TM scene, supervised classifications were conducted to assign cover type and size class labels to each region. This proved to be an iterative process. Multiple classifications may have been conducted for a single attribute, with intermediate modifications to training data, until satisfactory results were obtained. Furthermore, 'classifications within classifications' may have been conducted. For example, for mesic upland shrub types west of the Continental Divide, rough elevation breaks were defined to partially separate cover types 3202 and 3203 using simple decision rules, but to complete the process, additional classifications were conducted to separate the two within an intermediate elevation zone. Also in this manner, mixed mesic forest (4221) was divided into a number of subcodes (e.g., 4226, western red cedar - grand fir forest) where training data were available. Once cover types had been classified, all regions labeled 4221 were subjected to additional classification so that subcodes could be assigned.

The algorithm used to classify regions is a supervised, nonparametric classification called the NEAREST MEMBER of GROUP (NMG). The mathematical description of NMG is:

> An unknown region Y belongs to group i if
> $ED(Y,X_i) < ED(Y,X_j)$ for $j <> i$
> where ED is Euclidean distance, X_i and X_j are supervised training data, and X_i is any one of the known training regions for group i.

With NMG, Euclidean distances are calculated between each unknown (i.e., unsampled) region and every training region in the data set; thus, all training regions are treated independently, and have an equal chance of affecting the assignment of labels. Each region is assigned a label corresponding to the group that contains the training region closest to the unknown region in terms of Euclidean distance.

The first step in each supervised classification was to overlay training plots with regions in the raster database, and extract the necessary attributes from each region for use in the classification. For each training plot, an attribute was added to identify the exact region in which it fell. Attribute tables were then related for the training plot and raster files, and the attribute values desired for each classification were exported into a training data file (ASCII format), sorted by group (cover type or size class). To classify cover types (Fig. 13), we used mean values for TM channels 1-7 and elevation. Because TM values range from 0-255, well below typical values for elevation (m), elevation was rescaled by dividing the raw value by 25 so that it would not be accorded extra weight in the classification. In separate classifications of forest and shrub size classes, only TM data were incorporated; presumably, elevation should not influence size class as it could cover type. In addition to creating ASCII files for training data, similar files were created by exporting a matching set of attributes for every region in the raster database. Using VIMAP software, the file of training data was compared with the file of regions to be classified, and every region was classified using the NMG algorithm. The NMG algorithm used Euclidean distances derived as follows:

$$(TM1_{train} - TM1_{unknown})^2 + (TM2_{train} - TM2_{unknown})^2 + \ldots (TM7_{train} - TM7_{unknown})^2 + (ELE_{train} - ELE_{unknown})^2$$

Distances between attribute values were squared to : 1) avoid mixing positive and negative values, and 2) magnify the amplitude of distances, thus helping to distinguish differences among groups. Attribute values thus played the primary role in determining which labels should be assigned to each region; these were the values between which Euclidean distances were calculated.

Three cover type labels were assigned to each region, in decreasing order of likelihood (or rather, increasing Euclidean distance). Labels were maintained without any modifications in the raster database as COV_CODE_1, COV_CODE2, and COV_CODE3 (Appendix I). Along with these cover type labels, the actual Euclidean distance values (rescaled by dividing ED by 1000) were recorded as well (COV_PROB_1, COV_PROB_2, COV_PROB_3). Smaller values indicated a higher likelihood of correct classification: even if a cover type proved to be incorrect for a given region, a very small ED value would indicate that, based on the training data available, the assigned label offered the best possible fit. These ED values were used in evaluating classification results by looking at the relative differences between all three values for individual regions, and various combinations of values across regions. ED values were also instrumental in making some modifications to cover type labels. Only the smallest Euclidean distance (COV_PROB_1) was maintained in the raster database. After the cover type classification was complete, a new attribute called COVERTYPE was added and populated with values from COV_CODE_1; this attribute was later manipulated through manual modifications. If COVERTYPE equals COV_CODE_1, no modifications were made.

Often, for size classifications (Fig. 14), the NEAREST MEAN classifier offered better results, and was used rather than NMG. NEAREST MEAN is a special case of NMG, where only one set of attribute values is used to represent each group (e.g., size class). Typically, NEAREST MEAN is best in situations where groups are quite distinct; when groups have a high degree of overlap, this classifier can be problematic, because means are not likely to adequately represent such variation. As a further modification, whenever sufficient training plots were available, size class data were stratified by canopy cover (as classified from MNDVI; see below). Separate classifications of size then were conducted for each canopy class. Attribute values were extracted for the training data as described above; mean values were derived and used in another set of Euclidean distance calculations. Separate attributes were created for tree and shrub size classes; all regions in the database, regardless of their assigned cover types, were assigned both tree and shrub size classes (TREESIZE and SHRUBSIZE). By so doing, we ensured that if cover types were modified such that lifeforms changed, size classes would still be available. Later, once cover type labels were finalized, we created a new attribute called SIZECLASS, which contained unique values for each tree and shrub class, and was only populated for regions carrying tree and shrub cover types.

Manual Modifications

Once supervised classifications had been conducted, manual modifications proved simple within the raster database structure. Three basic types of manual modifications were used: attribute recoding based on decision rules, geographic limits (defined by the Forest Service for some cover types), or visual interpretation of Landsat TM imagery. All cover type modifications were applied to the COVERTYPE attribute only.

As an example of a rule-based modification, we used MNDVI in conjunction with training data to classify canopy cover for forest and shrub types (Fig. 15). We used this method rather than a supervised classification because considerable variation was observed in the training data for canopy cover. MNDVI offered an objective alternative because its derivation emphasizes variation in middle infrared wavelengths (measured by TM5) which are known to be associated with canopy closure (Butera, 1986; Baret *et al*., 1988; Spanner *et al.*, 1990). Separate histograms showing frequency distributions for MNDVI were plotted and examined for forest, mesic shrub, and xeric shrub training regions (Appendix F). Breakpoints for low, medium, and high canopy cover were determined based on the distribution modes. A decision rule was then used to assign canopy classes to regions with tree and shrub cover types based on those breakpoints. Other decision rules were used to subdivide or recode cover types based on elevation or other attributes; mesic shrub types, water, snow, and rock were commonly manipulated in this manner (see Appendix F for specific rules by scene).

Geographic limits were also applied to cover type distributions as per instructions provided by the Forest Service (in the form of small-scale, hardcopy maps, on file at Lolo National Forest). If a region was labeled ponderosa pine (COV_CODE_1 = 4206), but fell outside the defined limits of this type, the value from COV_CODE_2 was transferred to COVERTYPE. Each analyst employed a slightly different way of identifying which regions fell outside geographic limits.

Visual interpretation was used to distinguish between land use and land cover types -- a task not typically feasible within a totally digital environment. Again, specific methods varied by analyst for identifying land use (agricultural and urban areas). However, for nearly all TM scenes, the raster files were vectorized, and region boundaries were overlayed with raw TM imagery (using a color composite of channels 4, 5, and 3). A script was written in AML to allow GIS technicians to view the imagery, then rapidly recode selected regions. We used this method to classify not only urban and agricultural lands, but also clouds and cloud shadows.

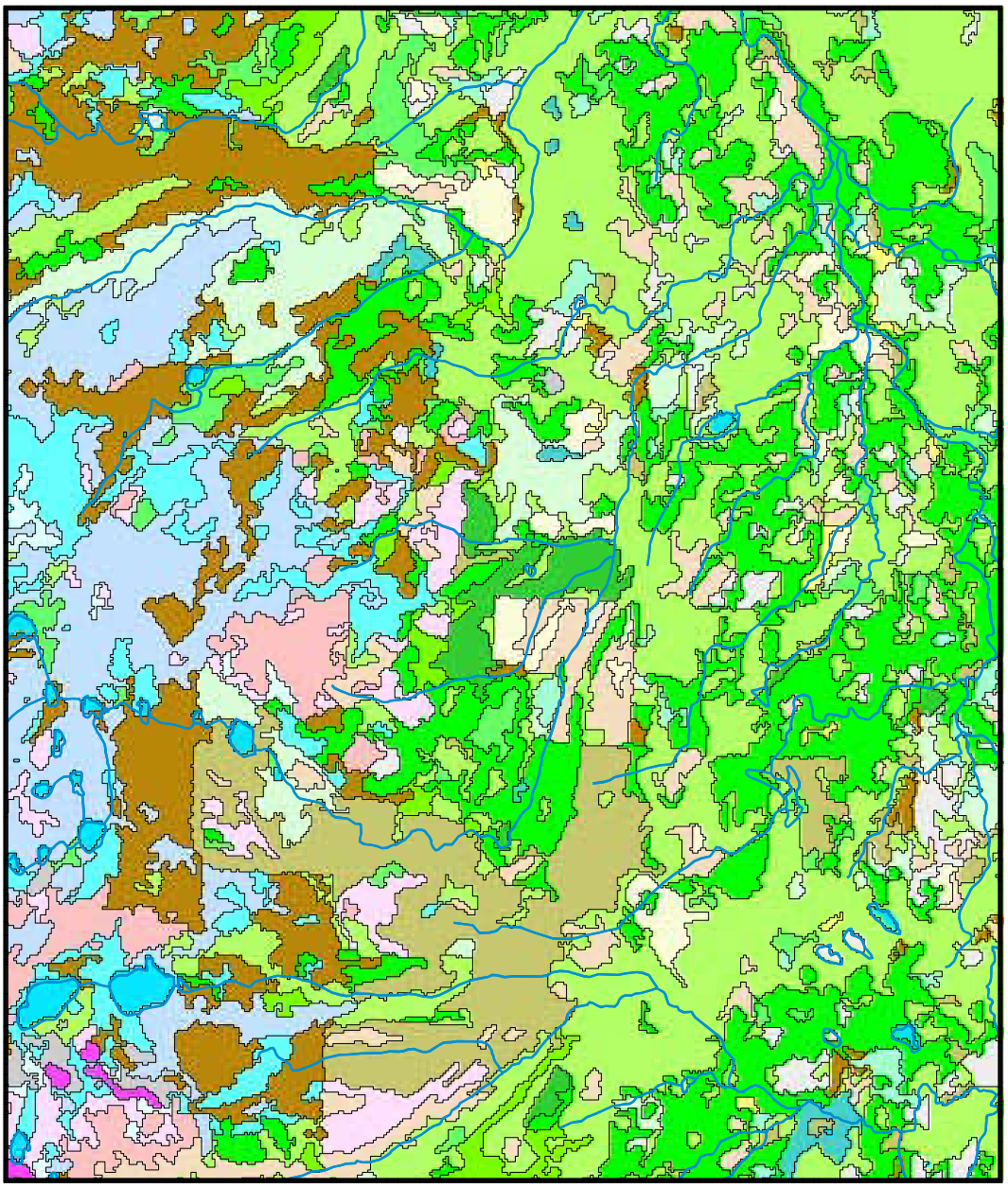


Figure 13. Classification of land cover types for the central Swan Valley, Montana.

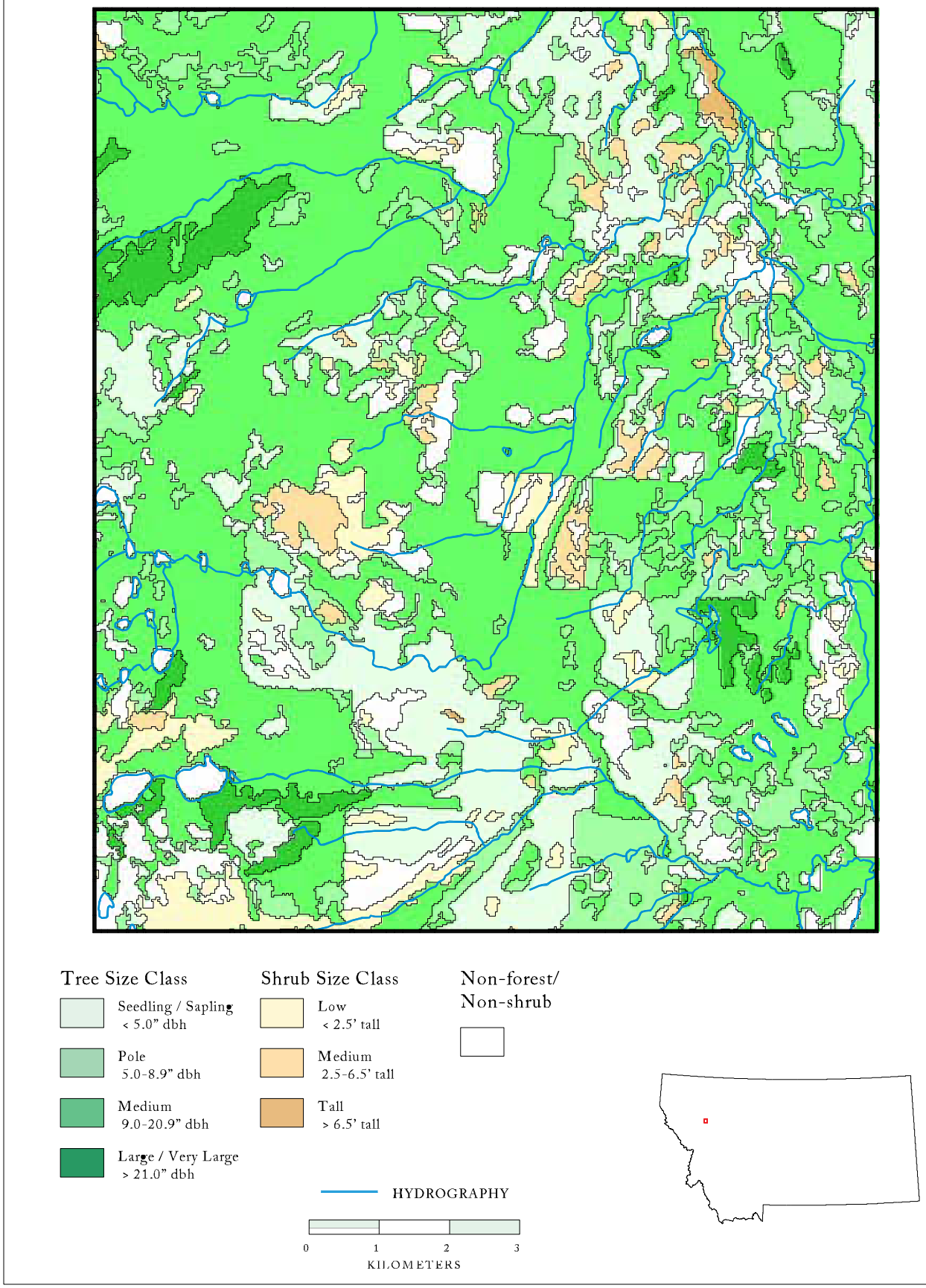


Figure 14. Classification of tree and shrub size for the central Swan Valley, Montana.

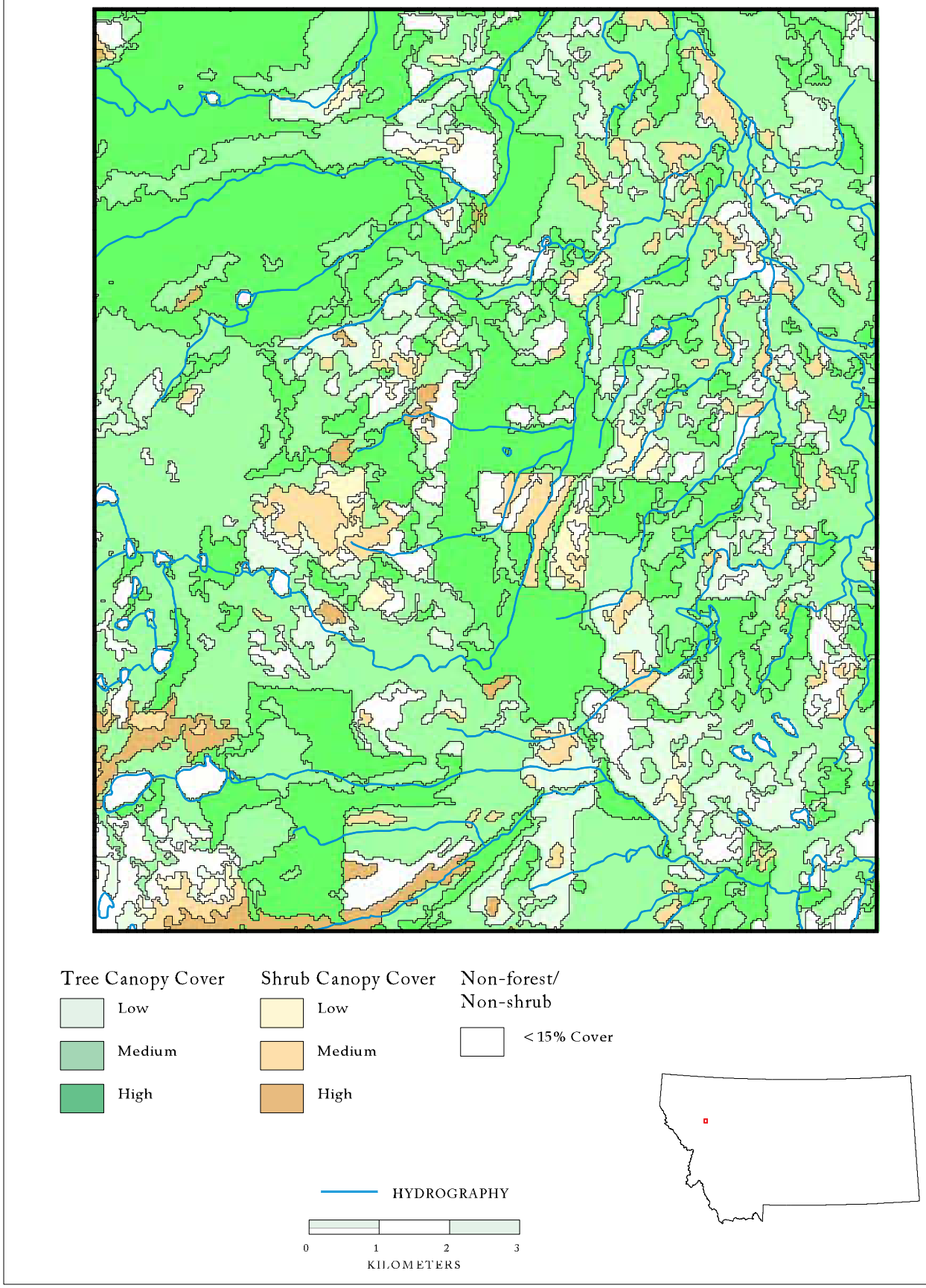


Figure 15. Classification of tree and shrub canopy cover for the central Swan Valley, Montana.

Edge-matching

We employed a simple solution for seamlessly edge-matching classified data from adjacent scenes once the raster database had been constructed. This 'cookie cutter' method was designed to preserve the integrity of individual scene classifications, and to minimize the perception of an 'edge' between adjacent overlapping scenes. It allows each image to be processed independently using all available spectral information, then edge-matched to its neighbors based on natural boundaries observed from land cover patterns. Through this method, adjacent scenes are 'virtually' edge-matched. Rather than physically deleting regions, they are simply flagged to indicate whether or not they should be used. As a result, the original data can always be retrieved, and new edge-matching schemes can be devised and implemented at any time.

Edge-matching occurs only within overlapping areas for adjacent scenes (Fig. 16). Before edge-matching could begin, each scene within the mapping area had to be evaluated and a dominance matrix established to consider relationships among all adjacent scene pairs (Table 5). Factors like the distribution of cloud cover, the image acquisition date, and classification accuracy levels for each scene were carefully weighed in determining which scenes should take precedence over others. Once this scheme was established, the following sequence of steps was implemented for each pair of adjacent scenes, starting with scenes that were dominant on the most sides as defined in the matrix:

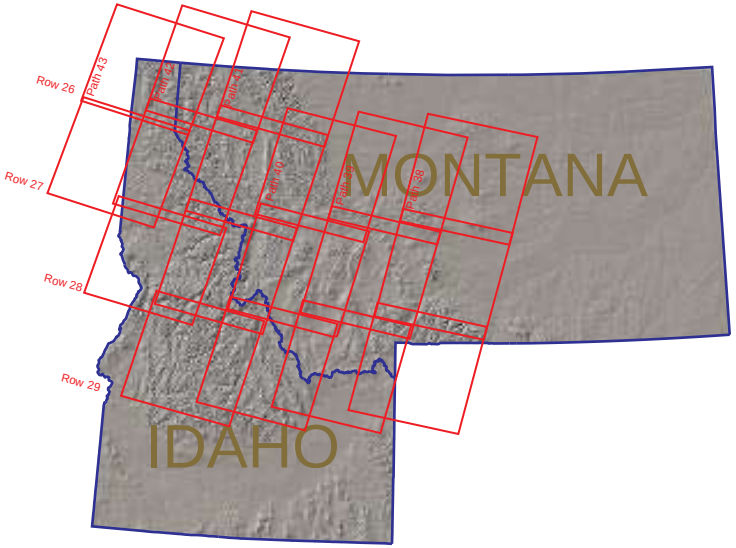
1. Based on the dominance matrix, one scene was identified as dominant, the other subordinate.
2. A selection area was drawn on the dominant scene on-screen; at least one of its sides had to fall within the overlap area. All regions on the dominant scene that fell at least partially within the boundaries of the selection area were identified. Shapes of selection areas varied; some boundaries were drawn to avoid clouds or include other specific features. Two files were used as reference in drawing selection areas: the image produced through the unsupervised classification process (classified, regrouped, and merged), and vector files showing the scene boundaries (so that the area of overlap would be evident). Selection areas were drawn for all sides on which the scene was dominant (north, east, south, or west) at one time.

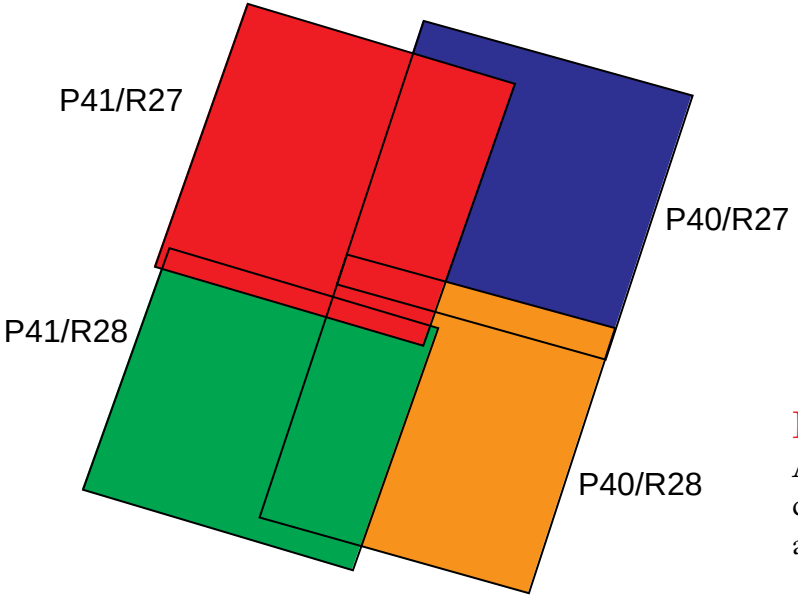
3. A new, intermediate attribute called EDGE was added to the raster database. All regions on the dominant image that fell at least partially within the selection area were assigned EDGE = 1. Regions completely outside of the area were assigned EDGE = 0 to indicate that these regions will be dropped in any physical edge-matching processes. When the two scenes are combined, the dominant scene acts as a cookie cutter; its regions replace underlying areas in the subordinate scene.

Natural boundaries between TM scenes were generated through the above processes (Fig. 17), laying the groundwork for seamless output across northern Idaho and western Montana. Because 'virtual' edge-matching has been completed, data can be cut and archived into more manageable tile units, such as 1:100,000 scale quadrangles (1˚ latitude by 2˚ longitude), or into specific units that can be either ecological or administrative in nature (e.g., a watershed versus a National Forest, Figs. 18, 19). An ARC/INFO script, called CLIPPER, was written in AML for this purpose and provided to the USFS Northern Regional Office.

Overlap:

Landsat TM scenes within the study area overlap roughly 40% by row and 20% by path.





Dominance:

Areas within the overlap are ordered by dominance. Four scenes from the 18 in the study area are shown at left, layered by their order of dominance.

Figure 16. Landsat TM Scenes: Overlap & Dominance

Table 5. Dominance matrix establishing relationships between each pair of adjacent Landsat TM scenes; used for edge-matching purposes.

	P38/R27	P38/R28	P38/R29	P39/R27	P39/R28	P39/R29	P40/R27	P40/R28	P40/R29	P41/R26	P41/R27	P41/R28	P41/R29	P42/R26	P42/R27	P42/R28	P43/R26	P43/R27
P38/R27	-1	0	-2	0	0	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
P38/R28	1	-1	0	0	0	7	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
P38/R29	-2	1	-1	-2	0	4	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
P39/R27	2	6	-2	-1	3	-2	4	7	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
P39/R28	5	2	6	0	-1	3	8	4	7	-2	-2	-2	-2	-2	-2	-2	-2	-2
P39/R29	-2	0	0	-2	0	-1	-2	0	0	-2	-2	-2	-2	-2	-2	-2	-2	-2
P40/R27	-2	-2	-2	0	0	-2	-1	0	-2	8	0	0	-2	-2	-2	-2	-2	-2
P40/R28	-2	-2	-2	0	0	6	1	-1	3	-2	0	0	7	-2	-2	-2	-2	-2
P40/R29	-2	-2	-2	-2	0	2	-2	0	-1	-2	-2	0	4	-2	-2	-2	-2	-2
P41/R26	-2	-2	-2	-2	-2	-2	0	-2	-2	-1	0	-2	-2	0	0	-2	-2	-2
P41/R27	-2	-2	-2	-2	-2	-2	2	6	-2	1	-1	3	-2	8	4	7	-2	-2
P41/R28	-2	-2	-2	-2	-2	-2	5	2	6	-2	0	-1	3	-2	8	4	-2	-2
P41/R29	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-2	0	-1	-2	-2	8	-2	-2
P42/R26	-2	-2	-2	-2	-2	-2	-2	-2	-2	2	0	-2	-2	-1	0	-2	4	0
P42/R27	-2	-2	-2	-2	-2	-2	-2	-2	-2	5	0	0	-2	1	-1	3	8	0
P42/R28	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	-2	0	-1	-2	0
P43/R26	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	-2	-1	0
P43/R27	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	5	2	6	1	-1

KEY:

-2 = TWO GRIDS NOT ADJACENT
-1 = DIAGONAL AXIS CELLS (SAME GRID)
0 = GRID B DOMINATES GRID A
1 = GRID A DOMINATES GRID B FOR NORTHERN EDGE
2 = GRID A DOMINATES GRID B FOR EASTERN EDGE
3 = GRID A DOMINATES GRID B FOR SOUTHERN EDGE
4 = GRID A DOMINATES GRID B FOR WESTERN EDGE
5 = GRID A DOMINATES GRID B FOR NORTHEAST CORNER
6 = GRID A DOMINATES GRID B FOR SOUTHEAST CORNER
7 = GRID A DOMINATES GRID B FOR SOUTHWEST CORNER
8 = GRID A DOMINATES GRID B FOR NORTHWEST CORNER

Edge-Matching Method

When an area to be classified and mapped extends beyond the boundaries of a single digital image, one must contend with how to edge-match adjacent images. Seamless edge-matching is desireable when any planning or assessment units, such as National Forests, counties, watersheds, or individual states, extend across multiple images. The cookie-cutter method is designed to preserve the integrity of individual image classifications and to minimize the perception of an "edge" between adjacent overlapping data sets. When adjacent images must be fitted together (as for the Montana land-cover map), multiple edge-matching operations must be performed.

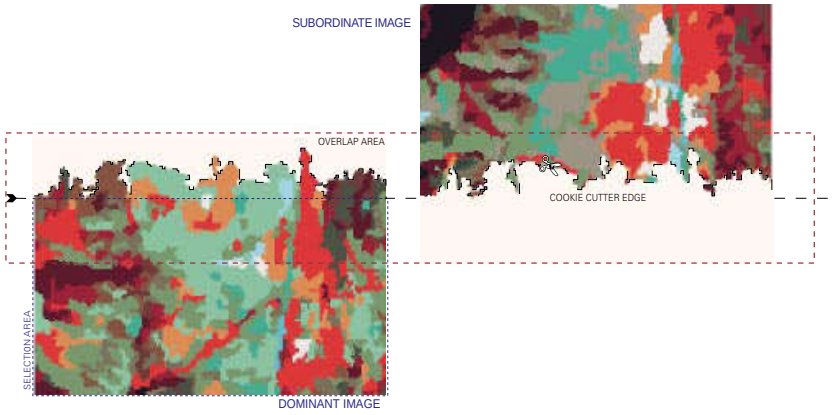
Cookie Cutter Method

The cookie cutter involves several GIS operations to perform the edge-matching. The result is an invisible boundary which follows natural patterns delineated in at least one of the images.

1 Select one image as dominant based on user specifications.

2 Draw a selection area on the dominant image; at least one of its sides must fall within the overlap area. This area is used to identify all polygons on the dominant image that lie at least partially within its boundaries. The MMU of the polygons must be small enough such that when selected they will not exceed the overlap area. The selection area can be any shape, and its boundaries can be drawn to avoid or include clouds or other features. Starting with scenes that are most dominant, selection areas are drawn for all necessary sides at the same time.

3 Create a new item in the GIS database called EDGE. All polygons on the dominant image at least partially within the selection area are assigned EDGE=1. Polygons outside the area are assigned EDGE=0 and will be dropped in the edge-matching process. The selected polygons (EDGE=1) are shown on the dominant image below.



4 Merge the dominant image with the subordinate one. In the process, the dominant image acts as a "cookie cutter", replacing the underlying portion of the subordinate image as shown to the right.



Figure 17. Edge-Matching Method

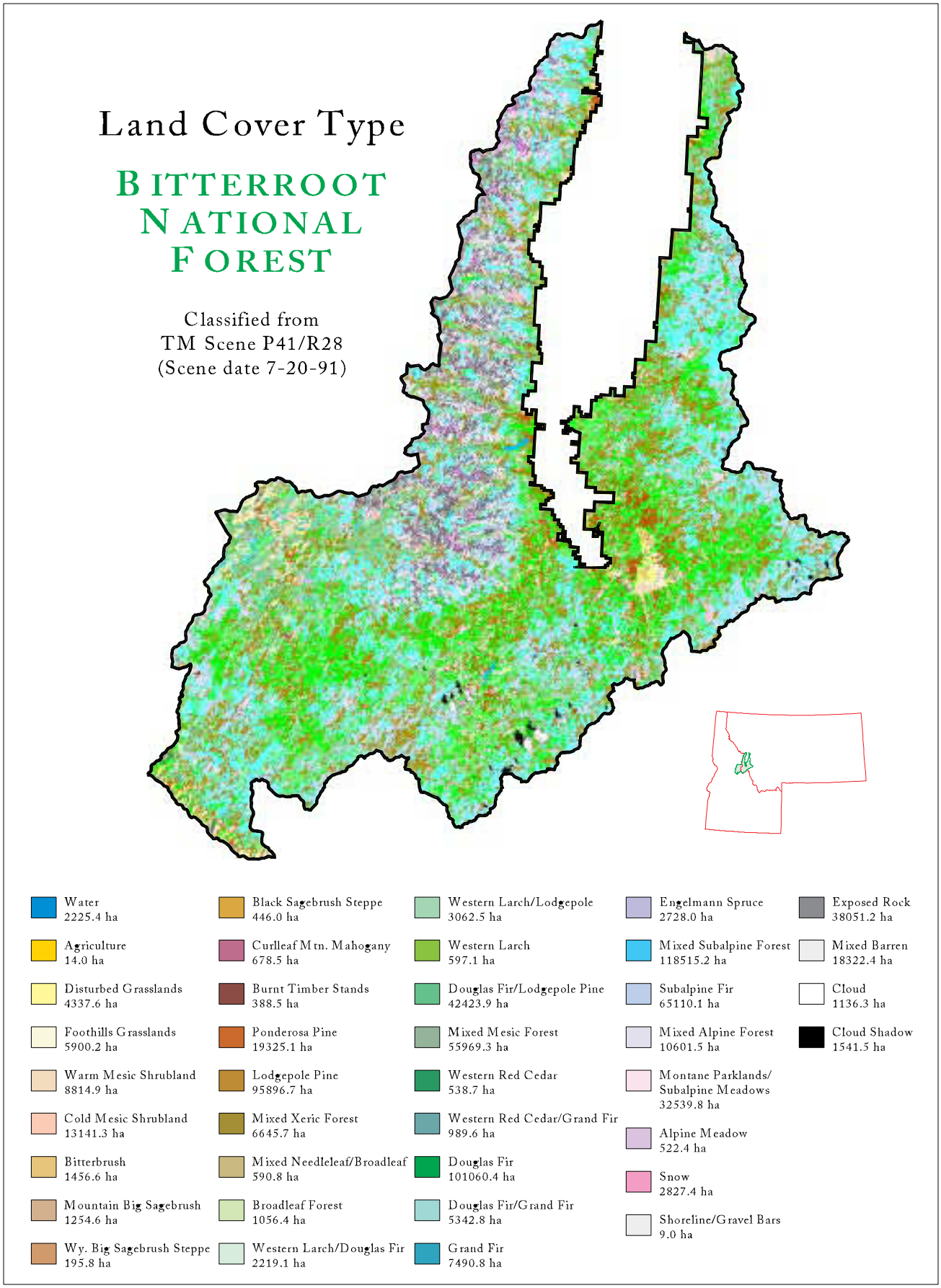


Figure 18. Classification of land cover types for the Bitterroot National Forest; all data extracted from Landsat TM Scene P41/R28.

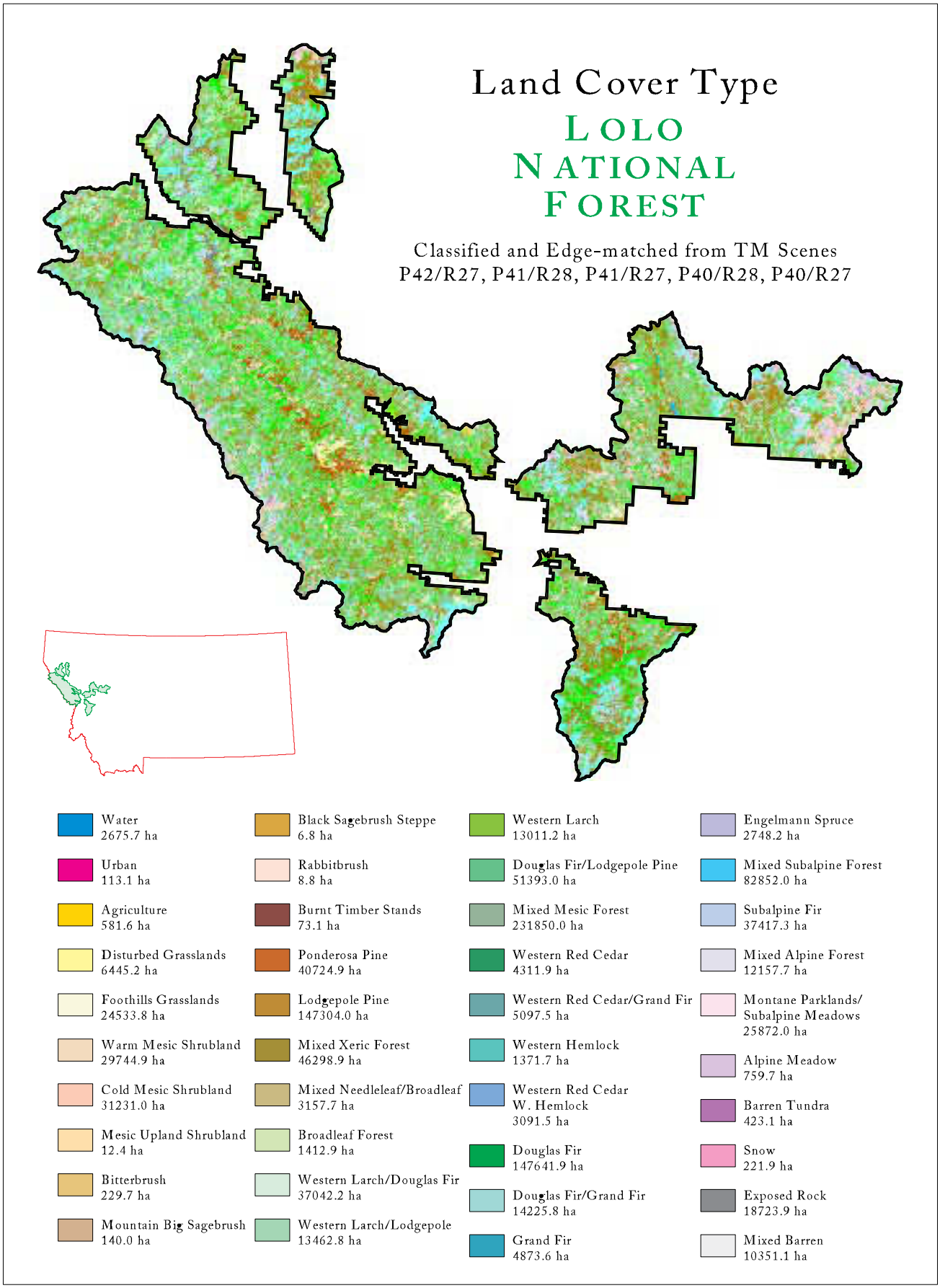


Figure 19. Classification of land cover types for the Lolo National Forest; data extracted and edge-matched from five Landsat TM Scenes.

Accuracy Assessment

Because the land cover classification scheme employed for Montana is complex (more than 90 cover types; see Appendix A), and many types overlap to varying degrees, map accuracy was evaluated using fuzzy sets (Gopal and Woodcock, 1994). A fuzzy matrix, derived from two-way tabulation of cover types, was constructed to evaluate the acceptability of various misclassification possibilities (Table 6). Acceptability was ranked through scores assigned to each cell in this matrix. For example, confusion between Douglas-fir (*Pseudotsuga menziesii*) and Douglas-fir/lodgepole pine (*Pinus contorta*) was determined to be less troublesome than confusion between Douglas-fir and foothills grassland. Acceptability was rated on a scale from 1 to 5, as outlined by Gopal and Woodcock (1994): 1) absolutely wrong; 2) understandable, but wrong; 3) acceptable; 4) good; 5) perfect match. When evaluating cover types according to this scheme, the following logic was applied (D. Atkins, pers. comm.):

- If cover type codes matched exactly, a score of 5 was assigned;
- If the codes did not match exactly, but the types shared a dominant species in the cover type name, a score of 4 was given (i.e., 4225 Douglas-fir - grand fir received score 4 if it was classified either 4212 Douglas-fir or 4207 grand fir);
- If the cover type was a commonly-occurring species in a mixed type, it received a score of 3 (i.e., 4203 lodgepole pine is a common component of 4220 mixed subalpine forest, and thus the confusion between these types is scored 3);
- If the cover type fell within the correct lifeform, but was not similar to the species in the label, it was assigned a score of 2 (i.e., 4206 ponderosa pine and 4208 subalpine fir);
- If the lifeform was mismatched, a score of 1 was given.

By rating acceptability in this manner, accuracy assessments could be conducted at both the acceptable and ideal levels, thus offering more information than traditional approaches.

Separate assessments of accuracy were conducted for cover type, size class, and canopy cover. Plots from the test data sets were overlayed with the raster database; plot attributes were compared with classification results, and scores of 1-5 were drawn from the fuzzy matrix. Producer and user accuracies were assessed both individually (for scores 5, 4, 3,

2, and 1 in ‘match matrices’) and cumulatively (for scores 5+4+3+2+1 in ‘accumulate matrices’); Appendix F contains both matrices for each scene. For standard definitions of accuracy and general guidelines on interpreting error matrices, see Appendix J; Lachowski et al. (1995) also offers information on accuracy assessment and error matrices.

Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type was estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates were summed for each cover type, and the results divided by 1000 to yield an overall area-weighted producer’s accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

Table 6. Fuzzy matrix used in assessing classification accuracy among cover types.

	1000	2000	3101	3102	3103	3104	3201	3202	3203	3301	3304	3305	3306	3308	3309	3312	3313	3314	4101	4102	4201	4203	4205	4206	4207	4208	4210	4211	4212	4214	4215	4219	4220	4221	4222	4223	4225	4226	4227	4228	4229	4301	5000	6101	6102	6103	6201	6202	7100	7200	7300	7400	7600	7800	7900	8101	9101	9200
1000	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2000	1	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3101	1	1	5	3	2	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3102	1	1	3	5	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3103	1	1	2	2	5	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3104	1	1	3	3	2	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3201	1	1	1	1	1	1	5	4	4	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3202	1	1	1	1	1	1	4	5	3	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3203	1	1	1	1	1	1	4	3	5	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3301	1	1	1	1	1	1	2	2	2	5	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3304	1	1	1	1	1	1	2	2	2	2	5	3	4	4	3	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3305	1	1	1	1	1	1	2	2	2	2	3	5	4	3	3	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3306	1	1	1	1	1	1	2	2	2	2	3	4	5	3	3	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3308	1	1	1	1	1	1	2	2	2	2	4	4	4	5	3	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3309	1	1	1	1	1	1	2	2	2	2	3	3	3	3	5	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3312	1	1	1	1	1	1	2	2	2	2	3	3	3	3	3	5	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3313	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3314	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4101	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4102	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4201	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	5	2	2	2	2	3	2	2	2	2	2	3	4	4	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4203	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	5	2	2	2	2	2	2	2	2	2	2	3	3	3	2	4	2	2	2	4	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4205	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	5	2	2	2	2	2	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4206	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	5	2	2	2	2	2	2	2	2	2	3	4	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4207	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	5	2	2	2	2	2	2	2	2	3	4	4	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4208	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3	2	2	2	2	5	2	2	2	2	2	3	3	3	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4210	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	5	3	2	2	2	2	2	3	2	2	2	4	4	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4211	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	5	2	2	2	2	2	3	2	2	2	3	4	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4212	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	5	2	3	2	3	3	4	4	4	2	2	2	4	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4214	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	5	2	2	2	2	4	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4215	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	3	2	2	5	2	3	3	2	2	2	2	2	2	4	4	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4219	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3	3	2	2	2	3	2	2	2	2	2	5	3	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4220	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	4	3	2	2	2	3	2	2	3	2	2	3	5	2	2	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4221	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3	3	2	2	3	3	2	3	3	2	2	2	2	5	2	3	4	4	4	4	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4222	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	3	2	2	2	2	3	3	2	2	2	2	5	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4223	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	3	3	2	5	3	2	2	4	4	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4225	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	4	2	2	2	3	2	2	2	2	4	2	3	5	3	3	3	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4226	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	4	2	3	3	2	2	2	2	2	4	2	2	3	5	4	3	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4227	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	2	2	2	2	2	4	2	2	3	4	5	3	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4228	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	2	2	2	2	2	3	2	3	4	2	4	3	3	5	4	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4229	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3	4	2	4	3	3	3	4	5	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4301	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	2	2	2	2	3	2	3	2	2	2	2	2	3	3	3	3	3	3	3	3	3	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5000	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6101	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	2	3	2	2	1	1	1	1	1	1	1	1	1	1
6102	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	5	3	2	2	1	1	1	1	1	1	1	1	1	1
6103	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	5	2	2	1	1	1	1	1	1	1	1	1	1
6201	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	5	2	1	1	1	1	1	1	1	1	1	1
6202	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	5	1	1	1	1	1	1	1	1	1	1
7100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	3	3	3	3	3	2	1	1	1
7200	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	5	3	3	3	3	2	1	1	1
7300	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	5	3	4	3	2	1	1	1
7400	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	5	2	2	3	1	1	1
7600	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	4	2	5	3	2	1	1	1
7800	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	5	3	3	1	1
7900	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3	2	2	2	5	1	1	1
8101	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	3	1
9101	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1
9200	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1

Key: 5 = perfect match; 4 = good; 3 = acceptable; 2 = understandable, but wrong; 1 = absolutely wrong.

Quality Control

As a last step, the raster databases for each scene were examined for consistency and completeness, using an AML to standardize final products and make them more convenient to use. To reduce file size, large background polygons (described below) were deleted from each TM scene grid, and the value attribute table was reordered to reflect this change. Because TM scenes are diagonal, and raster file systems deal with rectangles, each background polygon filled in the smallest possible square around the legitimate data values for that scene. The TM scenes were originally imported into ERDAS; this software package uses 0 to define NODATA, whereas ARC/INFO treats 0 as a legitimate value distinct from NODATA. Thus, when files were transferred to ARC/INFO, large meaningless background polygons were created.

In addition to deleting background polygons, attribute names were made more intuitive, attribute order was logically reorganized, and extraneous attributes were deleted; Appendix I outlines the resultant database. Key attributes were queried to ensure that their values matched a list of acceptable possibilities. A new attribute for size class, combining both tree and shrub information, was created: only tree and shrub regions received size class values (1-4 for tree and 5-7 for shrub); all others received values of 0. Regions falling completely outside of the study area boundary were identified. Their attributes for LIFEFORM, COVERTYPE, CANOPYCODE, and SIZECLASS were reassigned 0 values; all other attributes for these regions were untouched. This step was taken because training data were collected only within the study area boundaries; thus, classification results cannot reliably be extrapolated to outlying areas. However, the raw classification results for entire scenes are still available to users for future examination and manipulation.

METHODS: MAPPING RIPARIAN VEGETATION

Introduction

Because riparian vegetation often occurs in small patches associated with wet conditions, much information about its distribution was lost in the process of merging 30 m pixels to 2 ha MMUs. To rectify this situation, we developed a method to classify and label riparian vegetation separately for each scene, using unregrouped spectral values for individual pixels, and a variable width buffer around water features to estimate where riparian vegetation was likely to occur. First, using hydrographic features and digital elevation data, riparian zones were predicted for a Landsat TM scene. Next, within the predicted riparian zone, spectral classes were selected by examining field data and spectral class characteristics, and then assigned to a riparian vegetation class (Fig. 20). Five classes were initially defined: Grass-Forb Riparian/Wetland, Shrub Riparian/Wetland, Needleleaf Dominated Riparian, Broadleaf Dominated Riparian, and Needleleaf-Broadleaf Riparian. Broad as these classes are, they failed to capture the continuum of riparian vegetation observed in the field. Two more vegetation classes were required to reasonably categorize all selected spectral classes: Mixed Grass-Forb-Shrub Riparian/Wetland, and Mixed Riparian, which may include trees and any other riparian vegetation class.

Delineation of riparian zones

Boundaries of riparian zones near water features were modeled using USGS 7.5' digital elevation models (DEMs), where available, and USGS 1:100,000 scale digital hydrographic features. Our goal was to approximate lowlands adjacent to all lakes and streams (both intermittent and perennial).

Given the uncertainty of absolute elevation values in DEMs, we developed a sturdy, yet feasible approach to riparian delineation. For each 30 m stream or lake shore segment, we delineated adjacent lands with elevations <5 m higher than the elevation value of the stream segment. To accomplish this, each 30 m segment was given an elevation value, which was derived from the same location in the corresponding DEM. Then we compared the elevation value between a given stream cell and cells extending out perpendicularly from it. If the difference was <5 m, the cell was included in the riparian zone (Fig. 20).

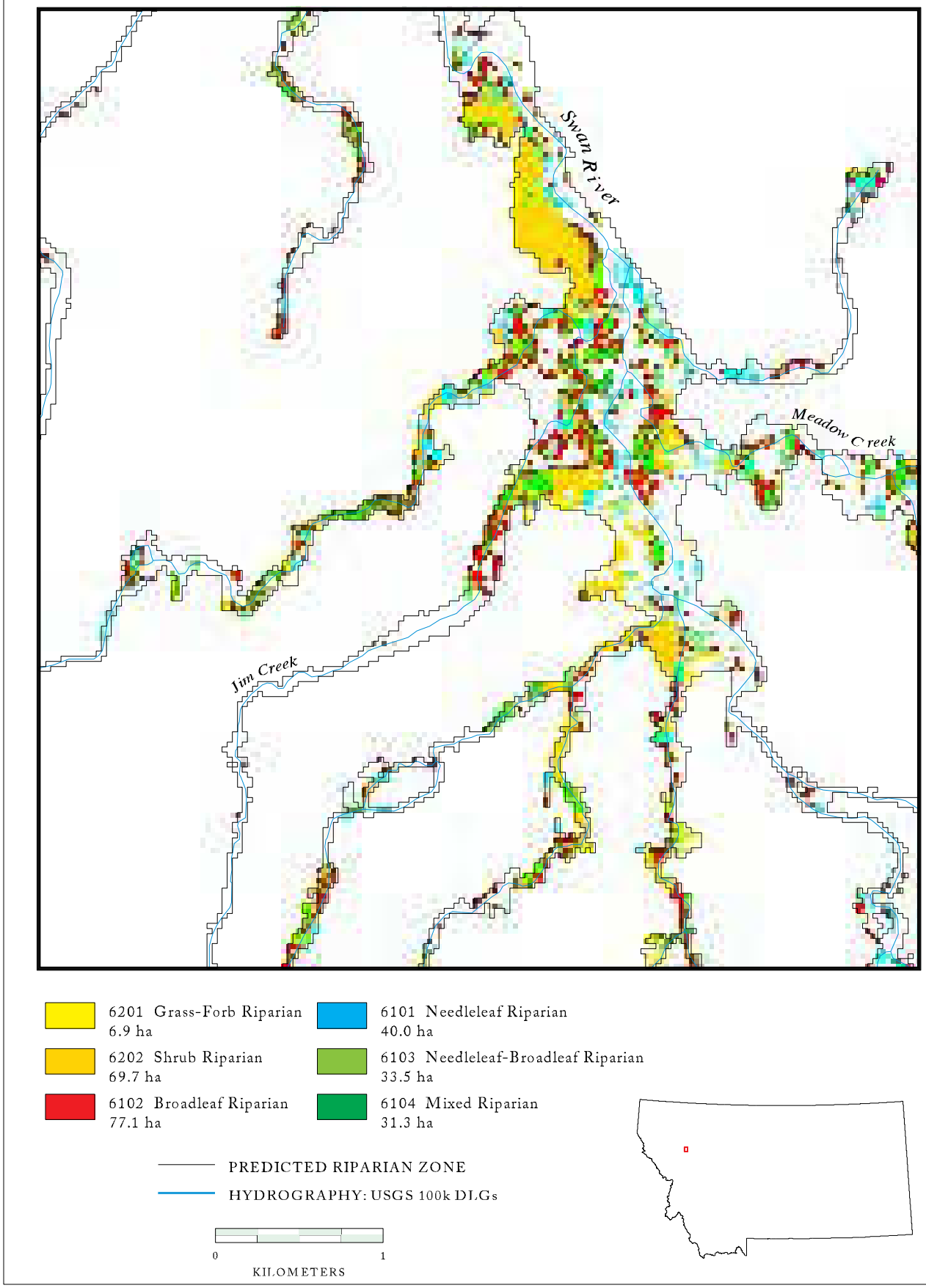


Figure 20. Classification of riparian vegetation cover types within predicted riparian zone for the Salmon Prairie vicinity of the central Swan Valley, Montana.

The nature of the hydrographic data required a modified procedure. When streams are digitized, curves are represented by a series of straight line segments of variable length that only estimate shape and flow direction. This creates a potential problem for predicting riparian zones: adjacent land areas extending perpendicularly from actual stream segments are not necessarily the same areas found perpendicular to the digitized line segments. To address this concern, we delineated the small catchment area for each 30 m stream or lake shore segment as representing the land area adjacent to that segment. The catchment area for each of these segments is found by creating a flow-direction grid, then inputting that along with the stream segment elevation grid into the watershed command. The segment elevations act like identifiers, so each cell or series of connected cells (as along a lake shore) acts as the pour point, or pour out area, of a small watershed. The area adjacent to and descending towards a cell more accurately represents the areas near that cell that may be labeled as riparian vegetation. After this, differences in elevation were calculated. The resulting riparian zone boundaries appeared to be well-matched to low lying areas near streams.

Selection of riparian spectral classes

The USFS provided training data, acquired through field sampling and aerial photo interpretation, for riparian classification. As one would expect, both the locational and class accuracies of these plots varied according to their method of collection and the scale at which they were collected. Thus, the training data were considered a strong indication of site vegetation, but not absolute verification for each and every site that was sampled.

Training data points were overlaid with spectral classes in order to assign spectral class values to each point. Here, locational errors in the ground-truth data mingled with inaccuracies in the registration of the TM scenes. Although our terrain-corrected imagery is the most accurately georeferenced data available, we know that the planimetric accuracy, as measured by root mean square error, was within one 30 m pixel, which means that some error undoubtedly was introduced in matching training data points to single pixels.

Once each training data point was assigned a spectral class from the unregrouped image, we determined whether or not the point fell within the calculated riparian zone; a new attribute was assigned values of 0 for outside and 1 for inside the zone. We focused more attention on vegetation class values for points within the zone than those outside of the zone.

However, vegetation classes for outside points also were used: some points represent riparian vegetation that are near water features not found on 1:100,000 scale maps or that fall just outside the estimated riparian zone. In such cases, these outside points still offer valid information to support decisions made within the zone. For a given spectral class, points outside of the zone may indicate whether that class represents riparian vegetation, or a certain lifeform (e.g., trees versus grass), or a typical species composition (e.g., needleleaf versus broadleaf forest).

To evaluate how the vegetation classes indicated by ground-truth data corresponded with the spectral classes derived from TM imagery, we totaled points by vegetation class for each spectral class. Five examples from TM scene P42/R27 follow:

1. Spectral class 3 was matched to three plots with Shrub Riparian/Wetland vegetation, two plots with Broadleaf Dominated Riparian vegetation, and two plots with Grass-Forb Riparian/Wetland vegetation. Although clearly linked with riparian vegetation, this class was not strongly tied to one of the five initial riparian vegetation classes, and so was labeled Mixed Riparian.
2. Spectral class 6 matched 13 plots with agricultural vegetation, one plot at a Shrub Riparian/Wetland site, and one plot in an Urban or Developed Land area. Dominated by agricultural vegetation, the class was not selected to represent riparian vegetation.
3. Spectral class 9 was matched to one plot each of Aspen, Irrigated Crop, Mesic Upland Shrubland, and Needleleaf Dominated Riparian. No clear pattern emerged, and the class was not labeled as a riparian type.
4. Spectral class 7 matched 10 plot locations: one Broadleaf Dominated Riparian, one Douglas-fir, one Grass-Forb Riparian/Wetland, one Lodgepole Pine, one Mixed Needleleaf-Broadleaf, two Needleleaf Dominated Riparian, and three Shrub Riparian/Wetland. A majority of the points indicated riparian vegetation within this class, so an attempt was made to assign the class to one of the four riparian vegetation classes. The conclusion was Needleleaf Dominated Riparian, based not only on the riparian points, but also on the other conifer points and characteristics of the spectral class throughout the scene. It is worth noting that the definitions for the riparian vegetation classes specify percentages of coverage by the dominant

vegetation (see Appendix A, Classification of Existing Vegetation), so that the presence of Shrub Riparian/Wetland points need not disqualify the conclusion.

5. Spectral class 35 matched four plots: one Foothills Grassland, one Irrigated Crop, and two Shrub Riparian/Wetland. After examining both plot information and spectral class characteristics, we labeled the class Shrub Riparian/Wetland.

In practice, it was not realistic to separate analysis of spectral classes by their characteristics from analysis of ground-truth data. The intent was to assign only one riparian class label to each spectral class. When analysts examined data on-screen, color and spatial distribution relative to topography and hydrographic features were factors in defining the overall riparian class represented by the spectral class. For every TM scene, analysts reviewed each spectral class that was identified as representing riparian vegetation, and determined that conclusions were warranted based on the color and spatial distribution of that class. On-screen analysis proved especially valuable for classes containing very few training plot locations. Some spectral classes were ruled out due to their color and distribution across the TM scene, even though a plot indicated that some riparian vegetation was represented by the class. In one instance, the conclusion favored Shrub Riparian/Wetland even though only 1 of 5 riparian plots indicated that conclusion. Thus, analysts' interpretations of imagery played an integral role in mapping riparian vegetation. These are all documented for each spectral class in each TM scene in Appendix F.

When selecting spectral classes, our interpretations were guided by a decision to err on the side of underestimating rather than overestimating the amount of riparian vegetation within a TM scene. However, we have provided two products through this process: riparian vegetation, and the predicted riparian zone. If the former is an underprediction, the latter may be viewed as an overprediction. In future applications, either or both may be used depending on the user's objectives.

Distinguishing agricultural and riparian classes

Because color patterns for agricultural areas can be nearly identical to those representing riparian areas, further interpretation was required to reconcile labeling inconsistencies between the 30 m and 2 ha MMU databases. Without this step, riparian vegetation would have been

overestimated in agricultural areas. After agricultural lands (> 2 ha) were manually identified and riparian spectral classes selected, riparian areas that overlapped agricultural areas were modified in a two-stage procedure. Much of this process was automated within ARC/INFO using an AML to implement user-defined rules. However, in most cases, analysts made final decisions based on visual interpretation.

In the first stage, individual 2 ha MMU regions labeled as agriculture were flagged for editing if >50% of their area overlapped with 30 m pixels designated as riparian. Typically, the number of regions flagged did not exceed 2500. Selected agricultural regions were then displayed on-screen in a sequence of editing windows. Overlapping areas were outlined; these could be parts of either riparian regions or agricultural polygons. The background view included the agricultural portions of the unregrouped image, so that shifts in color across the agricultural polygons (2 ha) were visible. As additional cues in determining the pattern of predicted riparian cover types, colored label points within the overlapping areas indicated the riparian classes. The boundaries of the predicted riparian zone and hydrographic features were also displayed for reference. As a general rule, if an agricultural region fell within a riparian zone, but no color change was evident near a water feature, then the overlapping riparian pixels were flagged for deletion. If colors did change in association with water features in the zone, then the overlapping pixels were retained and considered to be riparian, unless the color clearly indicated a non-vegetated cover type, e.g., a sand or gravel bar.

The second stage was targeted toward agricultural regions that fell only partly within the predicted riparian zone. For these regions, the proportion inside was compared to the proportion outside the riparian zone. If <10% of the region was inside, the overlap was automatically flagged for removal; if it was >10% but <20%, the area was edited by analysts in a manner similar to that in the first stage.

Post-classification processing

After all evaluations of riparian spectral classes were completed, further processing in ARC/INFO was required to complete construction of the raster database. In a process parallel to the one used to build the general land cover database, each riparian region was overlaid with TM and ancillary data to derive mean values for each TM channel, elevation, and slope, and also majority values for aspect. Unlike the land cover regions, with boundaries based on

spectral classes from the unsupervised classification, regions in the riparian database were defined by the vegetation codes assigned through supervised classification. Once completed, raster databases were archived for each scene, along with the predicted riparian zone.

Limitations

Integrating riparian information with the rest of the land cover information in a single database would certainly have been preferable. Unfortunately, construction of a GIS database at the 30 m MMU necessary to preserve riparian information was not -- and is not -- feasible given current hardware and software capabilities. Once the land-cover database was constructed at the 2 ha MMU, attributes were assigned values based on the shape of each region. If the 30 m MMU riparian data were replaced into the 2 ha MMU database, attribute values would become invalid for regions that changed shape because they were adjacent to, and thus partially replaced by, riparian regions. Attributes could be revised of course, but such a step would be unwise because classifications of cover type, canopy cover, and size class hinge on these attribute values. Thus, operating within the constraints of this project, it was necessary to maintain a separate database for riparian vegetation. Any inconvenience resulting from this procedure should be offset by the resulting improved product.

RESULTS & DISCUSSION

We created an ARC/INFO raster database of existing vegetation and land cover across northern Idaho and western Montana, covering more than 26 million hectares. In so doing, we compiled digital databases of topography and hydrography, and classified all or part of 18 Landsat TM scenes. Specific results for each TM scene are presented in Appendix F as frequency tables that summarize the number of regions and total hectares mapped for each cover type, size class, and canopy cover level. Results for the entire project area are highlighted below; these are followed by a discussion of the accuracy assessments for individual TM scenes.

MAPPING TRENDS IN THE PROJECT AREA

Cover type

According to our results, foothills grasslands (3101) is the dominant cover type in the project area (14.19%; Table 7, Fig. 21). The dominant shrub is mountain big sagebrush (3305; 4.66%), and Douglas-fir (4212) is the most common forest type (9.19%). Lodgepole pine (4203; 8.12%), mixed subalpine forest (4220; 7.51%) and mixed mesic forest (4221; 6.75%) are the only other forest types occupying more than 5% of the landscape. The relative importance of cover types changes when the percentages are calculated by state: foothills grasslands, for example, are more common in western Montana than in northern Idaho (19.33% versus 6.05%). Forest cover types also differ between the two states, with more Douglas-fir and mixed mesic forest in Idaho. National Forest lands are dominated by forest types, especially lodgepole pine (12.66%), Douglas-fir (11.76%), mixed subalpine forest (12.89%), and mixed mesic forest (10.71%).

Seven riparian cover types are found in the study area (Table 8), occupying 3.21% of the land area. Needleleaf-dominated riparian forest (6101) and shrub-dominated riparian (6202) are most prevalent in the project area, as well as in individual states and on National Forest lands.

Table 7. Percentages and area (ha) of land cover types found in the project area, in northern Idaho and in western Montana, and on National Forest lands.

Cover Type[a]	Project Area		Northern Idaho		Western Montana		National Forest Lands	
	Percent	Hectares	Percent	Hectares	Percent	Hectares	Percent	Hectares
1000	0.19	50755	0.22	17892	0.20	32780	0.01	652
2000	6.82	1788377	5.57	454592	8.01	1331002	0.10	10498
3101	14.19	3722554	6.05	493858	19.33	3213185	2.68	280514
3102	1.00	262713	0.29	23926	1.44	238771	0.17	18109
3104	3.50	918354	2.52	205354	3.99	662871	5.15	538847
3201	1.59	416705	0.99	80463	2.00	331832	0.61	63399
3202	2.01	528137	3.97	324119	1.16	193131	2.81	294182
3203	0.75	195969	0.74	60325	0.81	135101	1.54	161642
3301	0.29	76196	0.55	44801	0.19	31392	0.07	6828
3303	0.01	3146	0	0	0.02	3146	0.00	205
3304	0.08	20688	0.02	1915	0.11	18773	0.02	1821
3305	4.66	1222274	2.74	223227	5.83	969189	1.34	139720
3306	0.62	162057	1.23	100176	0.33	55492	0.06	6612
3307	0.57	148310	1.40	114068	0.21	34241	0.01	669
3308	0.52	135935	1.12	91470	0.27	44466	0.02	2568
3312	0.00	515	0.00	14	0.00	501	0.00	8
3313	0.03	6641	0	0	0.04	6641	0.00	374
4101	1.00	261743	0.50	40813	1.24	205962	0.34	35579
4102	0.37	98104	0.27	21943	0.45	75346	0.29	30832
4201	0.50	130120	0.45	36399	0.53	87877	1.01	105489
4203	8.12	2130938	6.71	547357	7.58	1259001	12.66	1324700
4205	0.50	131117	0.51	41750	0.50	82811	0.26	26999
4206	2.99	784573	4.11	335622	2.68	445689	2.34	245340
4207	1.16	303864	3.30	269680	0.15	25324	1.91	199479
4208	2.27	596101	3.03	247473	1.95	324572	4.01	419562
4210	0.61	160270	1.27	103371	0.22	37354	1.05	109809
4211	0.33	86287	0.74	60352	0.13	21764	0.55	57179

[a] Cover type codes are defined in Appendix A.

Table 7 (continued). Percentages and area (ha) of land cover types found in the project area, in northern Idaho and in western Montana, and on National Forest lands.

Cover Type[a]	Project Area		Northern Idaho		Western Montana		National Forest Lands	
	Percent	Hectares	Percent	Hectares	Percent	Hectares	Percent	Hectares
4212	9.19	2410320	11.52	940346	8.43	1400808	11.76	1230223
4214	0.27	71143	0.43	34992	0.22	35786	0.02	1710
4215	0.67	174692	0.83	67942	0.58	96065	1.20	126069
4219	3.45	904295	1.58	128939	2.74	455085	4.05	424290
4220	7.51	1969627	6.23	508486	7.52	1249805	12.89	1349088
4221	6.75	1770673	10.65	869545	5.25	873310	10.71	1120217
4222	3.00	787198	3.18	259691	3.12	518927	2.49	260191
4223	2.99	784928	4.02	327957	2.59	431274	4.14	433474
4224	0.38	98826	0.07	5328	0.06	9259	0.04	4340
4225	1.13	296973	2.94	239922	0.32	53989	1.62	169521
4226	0.94	247347	2.83	230732	0.10	16604	1.21	126402
4227	0.42	111221	0.74	60650	0.24	40099	0.75	78826
4228	0.40	104857	0.51	41304	0.37	61795	0.83	86332
4229	1.13	295390	0.85	69008	1.35	224681	2.10	219295
4301	0.47	122035	0.81	66161	0.29	48990	0.53	55167
5000	1.24	325195	1.2	98634	1.08	179501	0.76	79672
6102	0.01	3151	0	0	0.02	3151	0	0
7300	3.01	788651	1.74	141724	3.71	616930	3.46	361920
7400	0.04	10082	0.01	882	0.05	8676	0.08	8279
7500	0.02	5699	0	0	0.03	5699	0.01	736
7800	1.34	351674	0.84	68590	1.63	270426	1.15	120539
7900	0.03	7929	0.01	565	0.04	7363	0.01	700
8100	0.28	74153	0.06	5279	0.30	49789	0.46	48087
9100	0.20	52031	0.30	24798	0.15	24368	0.24	25494
9800	0.25	64599	0.21	17281	0.23	37816	0.25	25934
9900	0.22	56982	0.15	11843	0.19	32025	0.25	26273

[a] Cover type codes are defined in Appendix A.

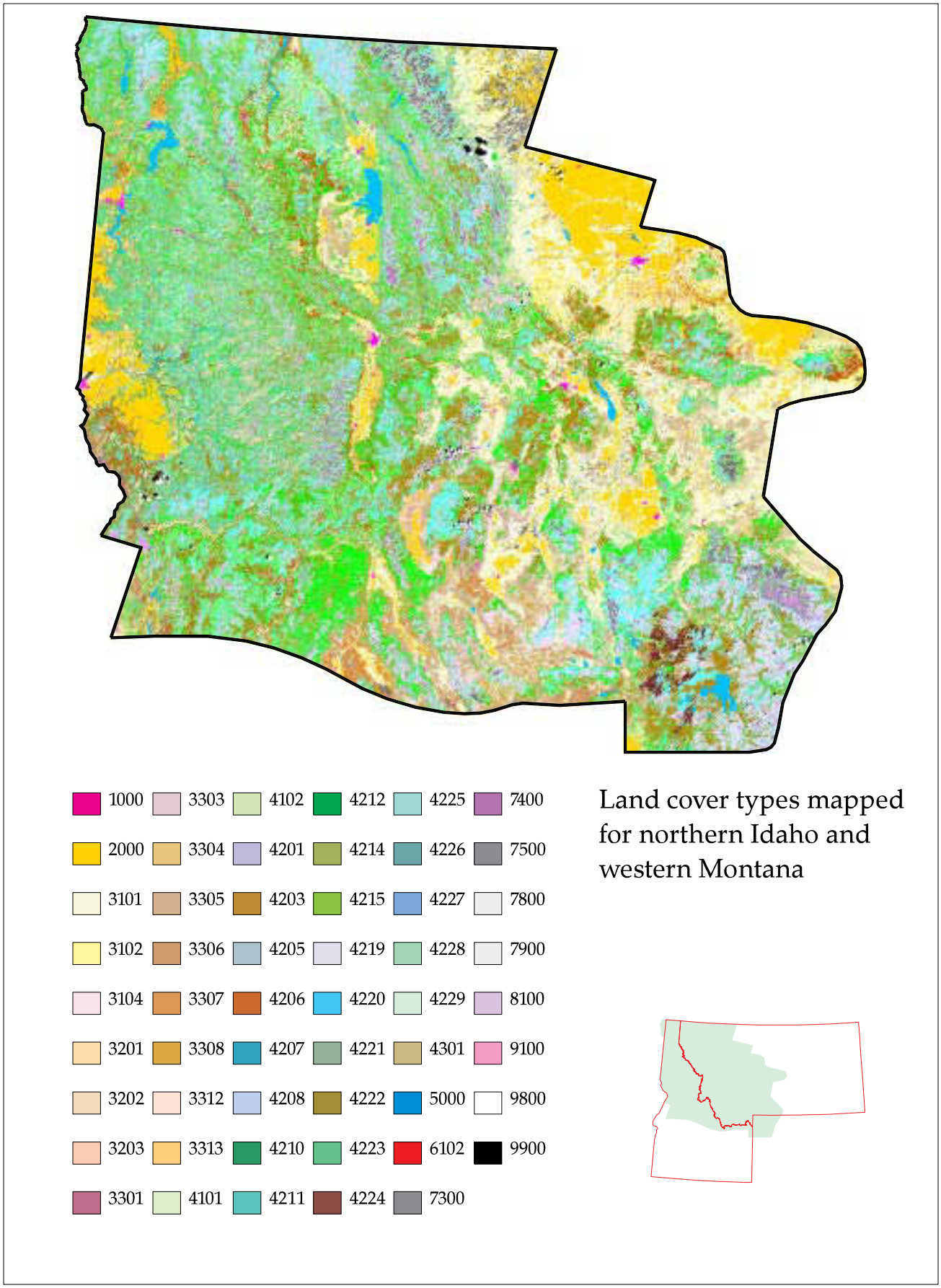


Figure 21. Classification of land cover types for northern Idaho and western Montana; data extracted and edge-matched from eighteen Landsat TM scenes.

Table 8. Percentages and area (ha) of riparian land cover types in the project area, in northern Idaho and in western Montana, and on National Forest lands.

Cover Type[a]	Project Area (3.21% riparian)		Northern Idaho (1.98% riparian)		Western Montana (2.58% riparian)		National Forest Lands (1.67% riparian)	
	Percent	Hectares	Percent	Hectares	Percent	Hectares	Percent	Hectares
6101	19.57	165010	30.03	48613	18.57	79599	38.13	66519
6102	9.49	80043	5.75	9300	9.50	40719	5.76	10042
6103	8.76	73886	9.63	15583	6.02	25830	10.69	18647
6104	16.58	139825	14.93	24163	16.42	70402	14.61	25488
6201	12.66	106734	10.95	17714	12.91	55370	8.63	15059
6202	27.53	232204	24.40	39482	31.72	135984	19.93	34761
6203	5.41	45635	4.30	6933	4.86	20843	2.25	3926

[a] Cover type codes are defined in Appendix A.

Table 9. Percentages and area (ha) of lifeforms in the project area, in northern Idaho and in western Montana, and on National Forest lands.

Lifeform	Project Area		Northern Idaho		Western Montana		National Forest	
	Per-cent	Hectares	Per-cent	Hect-ares	Per-cent	Hect-ares	Per-cent	Hectares
Non-vegetated	6.5	1713601	4.68	382214	7.31	121558	6.21	650204
Agriculture	6.82	1788377	5.57	454592	8.01	133100	0.10	10498
Herb	18.98	4977775	8.92	728419	25.06	416461	8.46	885558
Shrub	11.12	2916577	12.75	1040583	10.97	182391	6.48	678034
Tree	56.56	14835806	68.07	5555775	48.65	808533	78.74	8240124

Lifeform

More than half of the project area is tree-covered (56.56%; Table 9, Fig. 22); herbaceous types, dominated by foothill grasslands, occupy the next largest area (18.98%). Only 6.53% of the project area is non-vegetated. The distribution differs between states, and reflects cover type composition: again, western Montana has more herbaceous cover (25.06%), whereas northern Idaho is more forested (68.07%). National Forest lands are largely dominated by forest (78.74%).

Canopy class

Logically, percentages in the various canopy classes are related to those in the lifeform categories: non-vegetated, agriculture, and herbaceous lifeforms are summed to make the 'n/a' canopy class, which comprises almost one-third of the project area (32.33%; Table 10). Medium canopy class is most common for trees (28.93%, i.e., one-half of the tree lifeform class), whereas shrubs predominantly fall in the low canopy class (6.78%). The same pattern can be found for individual states, but with higher percentages in the tree classes for Idaho, against more 'n/a' for Montana (because of the importance of herbaceous cover in this state). Tree canopy cover for the National Forest lands is dominated by the medium class (43.37%), followed by the high class (22.35%).

Size class

Medium trees are the dominant size class at all four levels examined, ranging from 24.50% in western Montana, to 41.62% for National Forest lands (Table 11, Fig. 23). Pole trees are more abundant on National Forest lands than on the overall project area (22.58% versus 16.21%). Northern Idaho has a higher percentage of large and very large trees than western Montana (9.95% versus 2.06%). Differences in size classifications are evident among TM scenes (Fig. 23).

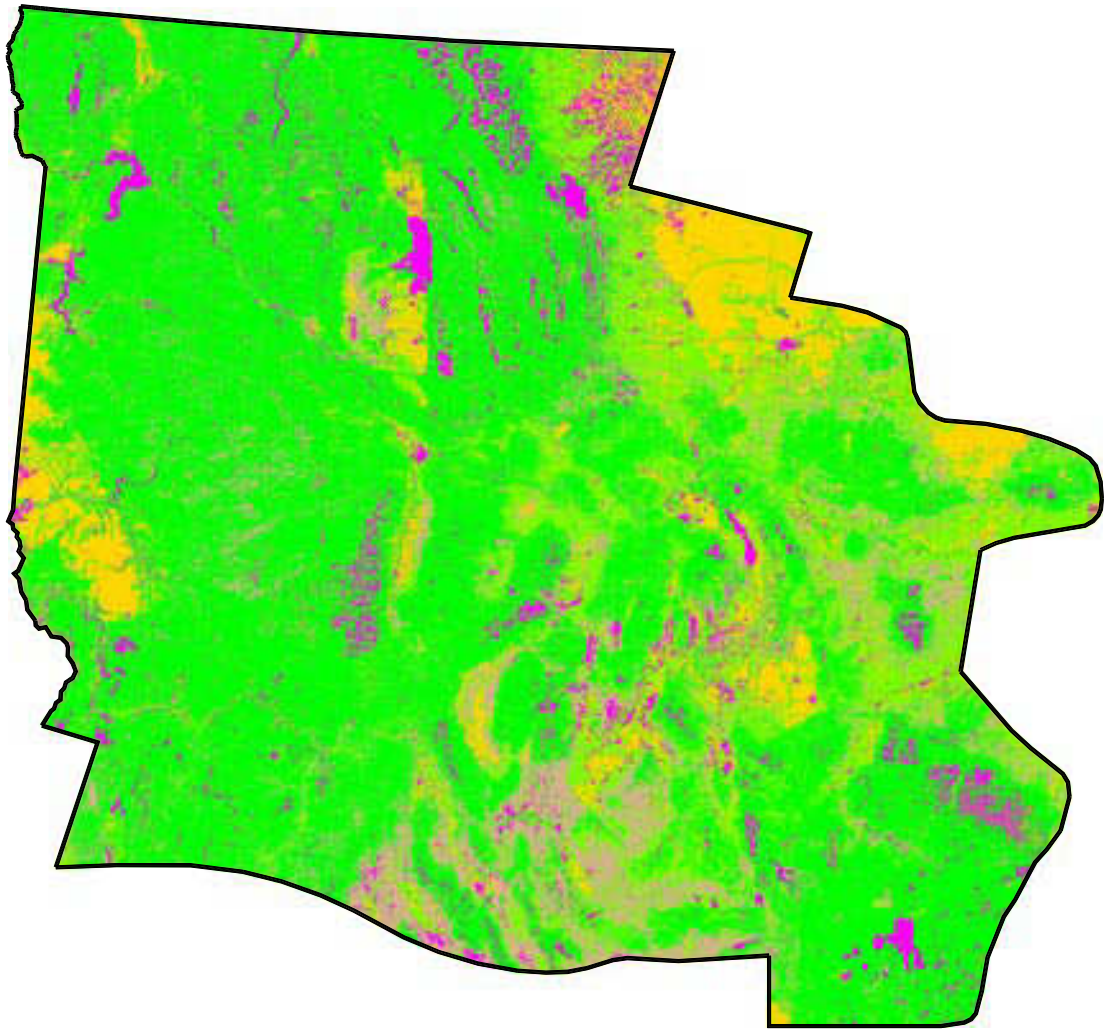
Cover types are not equally distributed among the four size classes (Table 12). In the project area, several cover types have >25% of their area in the seedling/sapling class; these include aspen (4101), broadleaf forest (4102), limber pine (4205), ponderosa pine (4206), Rocky Mountain juniper (4214), mixed xeric forest (4222), and Douglas-fir-grand fir forest (4225). The pole class is important for lodgepole pine (4203; 37.15%) and limber pine

(41.46%). Thirteen of the 25 forest types have >50% of their area in the medium class (up to 75.75% for western hemlock 4211, and to 83.50% for standing burnt and dead timber 4224). Finally, forest types with the largest proportions in the large/very large class include Engelmann spruce (4201; 11.69%), grand fir (4207; 26.33%), western red cedar (4210; 16.47%), mixed mesic forest (10.51%), Douglas-fir-lodgepole forest (4223; 16.10%), and western red cedar-grand fir forest (4226; 22.51%). These percentages differ slightly when only National Forest lands are considered (e.g., higher percent of grand fir and western red cedar-grand fir forest in the large/very large class), but remain in the same order of magnitude.

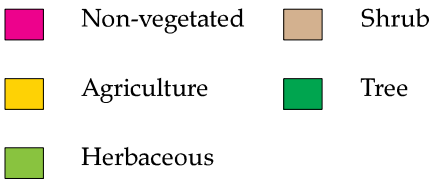
Comments

The project area, located mostly in western Montana and northern Idaho, is dominated by forests, shrublands, and grasslands; agriculture occupies only a small percentage of the area. Differences between Montana and Idaho, notably in terms of the importance of herbaceous versus tree cover, also are partially an artifact of project area boundaries: the project area includes a portion of the plains of eastern Montana, where grasslands and cultivated lands are important cover types; on the other hand, the Idaho part is mostly mountainous and forested. As could be expected, National Forest lands are predominantly forested. The size class analysis reveals the relative rarity of large and very large trees, and the predominance of pole and medium trees in the landscape. Combining attributes to obtain new summaries (e.g., forested cover types by size class) offers interesting insights on the characteristics of particular cover types, especially for relatively rare types that are swamped in overall percentages.

It is important to note that these results are dependent upon the amount and quality of training data available during the classification process. For example, the large proportion of grand fir (4207) in the large/very large tree category (26.33%) may be due to the availability of a greater number of training plots for this forest type compared to other forest types. The unequal number of training sites per cover type and scene also explains why ‘seams’ between individual TM scenes can sometimes be identified (e.g., Figure 23). Limitations inherent to the amount and quality of training data are discussed further below.



Life forms mapped for northern Idaho and western Montana



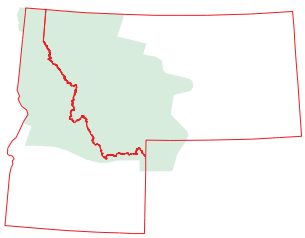


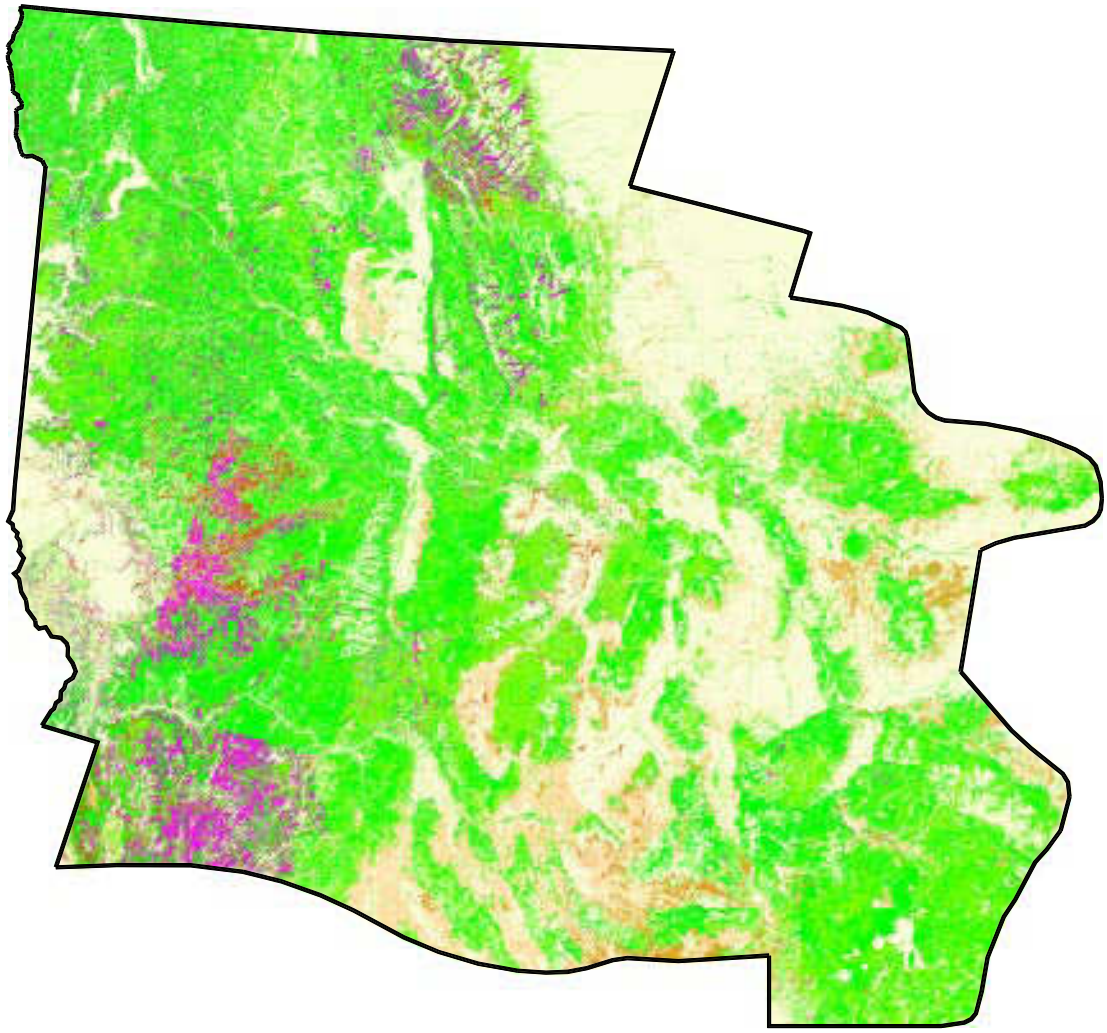
Figure 22. Classification of life forms for northern Idaho and western Montana; data extracted and edge-matched from eighteen Landsat TM scenes.

Table 10. Percentages and area (ha) of canopy classes in the project area, in northern Idaho and in western Montana, and on National Forest lands.

Canopy Class	Project Area		Northern Idaho		Western Montana		National Forest Lands	
	Percent	Hectares	Percent	Hectares	Percent	Hectares	Percent	Hectares
n/a	32.33	8479766	19.18	1565233	40.38	6711211	14.78	1546261
Tree, low	14.08	3692971	13.69	1117468	11.89	1976458	13.02	1362990
Tree, medium	28.93	7589565	35.22	2874421	25.35	4212598	43.37	4538240
Tree, high	13.55	3553269	19.16	1563885	11.41	1896282	22.35	2338893
Shrub, low	6.78	1777287	7.75	632258	6.68	1109682	2.71	284094
Shrub, medium	3.75	983816	4.45	362849	3.66	607504	3.14	328160
Shrub, high	0.59	155473	0.56	45475	0.64	106723	0.63	65779

Table 11. Percentages and area (ha) of size classes in the project area, in northern Idaho and in western Montana, and on National Forest lands.

Size Class	Project Area		Northern Idaho		Western Montana		National Forest	
	Percent	Hectares	Percent	Hectares	Percent	Hectares	Percent	Hectares
n/a	32.33	8479766	19.18	1565233	40.38	6711211	14.78	1546261
Seedling/sapling	8.29	2174723	11.88	969509	6.69	1111826	9.50	993780
Pole tree	16.21	4251309	14.62	1192894	15.40	2559496	22.58	2363288
Medium tree	27.80	7293611	32.23	2630503	24.50	4071828	41.62	4355478
Large/very large	4.25	1116161	9.35	762868	2.06	342187	5.04	527577
Low shrub	6.54	1715464	6.87	560496	6.83	1135730	2.91	304081
Medium shrub	3.15	825884	2.62	213760	3.52	584998	1.79	187780
Tall shrub	1.43	375228	3.26	266353	0.62	103181	1.78	186172



Size classes mapped for northern Idaho and western Montana



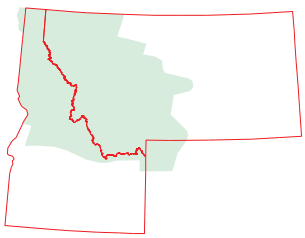


Figure 23. Classification of size classes for northern Idaho and western Montana; data extracted and edge-matched from eighteen Landsat TM scenes.

Table 12. Percentages of forest cover types by size class for the project area and for National Forest lands.

Cover type[a]	%		% Pole		% Medium		% Large/very	
	Project	NF	Project	NF	Project	NF	Project	NF
4101	48.48	31.33	30.99	48.01	20.35	20.08	0.18	0.58
4102	25.11	29.68	33.23	34.05	37.09	35.90	4.58	0.37
4201	8.22	7.04	16.05	16.37	64.04	64.32	11.69	12.26
4203	8.42	8.49	37.15	37.56	49.44	51.26	4.98	2.69
4205	31.08	16.05	41.46	41.79	27.45	42.16	0.02	0
4206	25.74	24.04	21.99	24.58	48.98	47.88	3.29	3.51
4207	22.90	15.71	21.83	23.05	28.94	27.13	26.33	34.11
4208	16.19	15.02	18.19	17.19	57.17	62.46	8.46	5.34
4210	8.06	8.40	17.24	19.77	58.23	58.47	16.47	13.37
4211	3.73	3.54	16.26	17.22	75.75	74.55	4.26	4.69
4212	11.56	10.53	25.96	25.03	57.17	59.99	5.31	4.45
4214	49.97	74.91	2.32	8.98	46.70	8.96	1.01	7.16
4215	17.55	19.26	26.37	25.48	53.75	53.42	2.33	1.84
4219	11.12	12.29	46.75	42.33	38.78	41.36	3.35	4.02
4220	7.78	7.83	32.06	32.79	51.33	55.63	8.83	3.75
4221	16.42	15.03	21.79	22.19	51.28	53.10	10.51	9.68
4222	25.53	19.05	31.41	34.55	37.54	44.22	5.53	2.17
4223	7.97	10.09	33.55	32.05	42.38	50.44	16.10	7.41
4224	13.97	3.66	2.53	41.95	83.50	54.39	0	0
4225	32.85	22.12	20.20	24.41	38.31	41.82	8.64	11.65
4226	22.96	9.43	26.23	21.39	28.29	29.93	22.51	39.25
4227	10.92	9.71	15.38	16.04	65.62	66.10	8.07	8.14
4228	10.65	10.74	18.72	16.64	65.53	67.43	5.10	5.19
4229	13.94	14.68	20.53	21.66	62.56	60.61	2.97	3.05
4301	16.56	20.54	26.59	27.63	51.91	44.07	4.93	7.75
All forest	8.29	9.50	16.21	22.58	27.80	41.62	4.25	5.04

[a] Cover type codes are defined in Appendix A.

ACCURACY ASSESSMENT

Classification accuracies for cover type, size class, and canopy cover are reported by scene in Tables 13, 14, and 15, as well as in Appendix F. Both Level 5 (exactly right) and Level 3 (acceptable) producer's accuracies are reported. Note, however, that Level 3 accuracies have little meaning for size class and canopy cover; only a few classes were mapped, and hence the use of fuzzy set analysis is less appropriate for them than it is for cover type. As overall measures for each scene, two accuracy figures are presented. The first is simply an average of the percent correct for each class, and the second is area-weighted (50.49% versus 62.5% exactly right for P43/R26). Area-weighted measures are useful because they relate to the proportion of the overall map that is correct rather than simply the proportion of the plots correctly classified. Thus, a cover type that occupies a large area and has been well mapped will carry more weight than a rare cover type that has been poorly mapped, or vice versa.

Not surprisingly, accuracy levels vary greatly among scenes. Results should be viewed with caution; in particular, attention should be focused on the number of test plots available for each type. In many cases, these numbers are quite low, and may lead to accuracy levels that are not true representations of accuracy across the entire TM scene.

Although it is tempting to calculate an overall measure of accuracy for the project area by averaging the summary measures per scene, the result would have little meaning and in some regards may even be improper. First of all, if we simply averaged the percent correct per scene, the resultant figure would not account for the area occupied by each cover type, size class, or canopy level. Furthermore, averaging the area-weighted summary figures is improper because it precedes edge-matching and thus does not correct for the area of overlap between scenes. The area occupied by many types would be overestimated, and the results would be incorrectly skewed. Also relating to overlap between scenes, it is possible that plots used for training in one scene may have been used for testing purposes in another. While this is entirely logical, and even efficient, for our scene-based classifications, it could inflate overall accuracy calculations. To calculate an overall measure of accuracy, it would be necessary to:

1) Put all ground-truth plots for each scene into one file;
2) Eliminate plots used for both training and test purposes, and extract the remaining test plots;
3) Overlay test plots with an edge-matched grid for the entire project area;
4) Conduct an accuracy assessment using fuzzy set analysis;
5) Calculate an area-weighted accuracy measure.

This is not a trivial task, and its completion was beyond the scope of this project.

Table 13. Producer's accuracy levels, assessed using fuzzy set analysis, for cover type classifications by TM scene.

	P43/R26			P43/R27			P42/R26			P42/R27			P42/R28			P41/R26			
	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	
COVER TYPE																			COVER TYPE
3101	8	75	87.5	20	60	60	15	60	60	28	60.71	67.86	18	11.11	22.22				3101
3102	2	0.00	100				9	22.22	22.22	6	0.00	83.33	3	33.33	66.67				3102
3103																			3103
3104	2	50	50							18	33.33	55.56	27	37.04	40.74				3104
3201													37	32.43	40.54	6	0.00	16.67	3201
3202	7	71.43	71.43	13	46.15	46.15				15	46.67	46.67	5	0.00	0.00	64	28.12	40.62	3202
3203	2	0.00	50	2	0.00	0.00				7	42.86	42.86				58	8.62	27.59	3203
3301													2	0.00	0.00				3301
3302																			3302
3303																			3303
3304																			3304
3305										2	50	50							3305
3306																			3306
3307																			3307
3308																			3308
4101																4	0.00	0.00	4101
4102	2	100	100	1	0.00	100	2	50	50							10	40	40	4102
4201										1	0.00	0.00				13	0.00	53.85	4201
4203	2	50	50	2	0.00	50	2	50	100	47	42.55	51.06	33	18.18	66.67	47	29.79	85.11	4203
4205																2	50	50	4205
4206	2	100	100	7	28.57	57.14	2	100	100	14	64.29	71.43	12	25	50				4206
4207	2	50	50	7	0.00	42.86				15	20	46.67	29	31.03	68.97				4207
4208	5	80	80	1	0.00	100	5	0.00	80	18	50	72.22	5	40	40	67	16.42	64.18	4208
4210	2	100	100	1	100	100				4	25	50	4	0.00	75				4210
4211	2	0.00	100	3	33.33	66.67				17	29.41	47.06							4211
4212	10	60	70	14	35.71	64.29	18	11.11	66.67	78	38.46	82.05	24	4.17	62.5	19	10.53	63.16	4212
4213																			4213
4214																			4214
4215				2	0.00	50	2	0.00	50	10	20	80	1	0.00	0.00	7	57.14	85.71	4215
4219	4	75	100				5	40	60							38	13.16	86.84	4219
4220	1	100	100	2	0.00	100	2	50	50	11	36.36	81.82	21	9.52	52.38	74	16.22	68.92	4220
4221	24	25	83.33	25	32	80	30	23.33	53.33	100	38	76	54	31.48	75.93	57	36.84	66.67	4221
4222	2	50	50	3	66.67	66.67	2	0.00	100	9	22.22	77.78	4	0.00	25	1	0.00	0.00	4222
4223	2	50	100	2	0.00	50	3	0.00	33.33	9	44.44	77.78	6	0.00	66.67	6	16.67	83.33	4223
4224																			4224
4225	2	50	100	3	33.33	100	1	0.00	100	10	30	70	13	7.69	69.23	1	0.00	0.00	4225
4226	1	0.00	100	4	75	100				16	50	87.5	14	7.14	57.14				4226
4227	5	20	100	10	0.00	100				8	75	87.5							4227
4228	2	0.00	50	2	50	100	4	0.00	75	10	90	100				1	0.00	100	4228
4229	2	0.00	100				6	16.67	66.67	6	100	100				8	12.5	75	4229
4301	5	60	80	2	0.00	50	5	20	40	3	0.00	33.33	2	0.00	50	11	0.00	54.55	4301
7100																			7100
7200																			7200
7300	3	100	100	2	50	50	5	100	100	12	50	66.67	6	0.00	0.00	24	66.67	66.67	7300
7400																			7400
7500																2	0.00	0.00	7500
7600																			7600
7700																			7700
7800	2	100	100				6	16.67	33.33	5	60	60				8	0.00	37.5	7800
7900																2	0.00	50	7900
8100																1	0.00	0.00	8100
Sum	103	50.49	82.52	118	36.44	65.25	124	28.23	58.87	479	42.17	70.15	320	20.94	54.69	531	21.66	59.51	Sum
Sum (weighted)		62.5	83.6		43.63	63.45		30.64	63.77		44.17	71.23		19.88	53.35		22.14	60.42	Sum (weighted)

Notes: Vegetation key code is listed in Appendix A. Urban, agricultural, water, riparian, snow, cloud, and barren classes were not included in accuracy tests. Cover types 3309 through 3401 (7 Xe
Shrubland types) are not listed as no TM scenes contain them. Key: NP = number of plots used to assess accuracy; %5 = percentage absolutely correct (Level 5); %3 = percentage acceptable (L

Table 13 (continued). Producer's accuracy levels, assessed using fuzzy set analysis, for cover type classifications by TM scene.

	P41/R27			P41/R28			P41/R29			P40/R27			P40/R28			P40/R29			
COVER TYPE	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	COVER TYPE
3101	31	29.03	45.16	27	18.52	40.74	5	100	100	131	45.8	45.8	18	27.78	77.78	19	47.37	63.16	3101
3102	4	0.00	0.00	7	14.29	28.57	1	0.00	100	2	50	50	3	66.67	100				3102
3103																			3103
3104	130	15.38	26.92	70	8.57	24.29							3	33.33	66.67	7	57.14	57.14	3104
3201	5	0.00	40	7	0.00	42.86	2	50	50				4	50	50	1	100	100	3201
3202	119	17.65	24.37	91	43.96	48.35	1	0.00	0.00	4	50	75							3202
3203	123	14.63	28.46	29	17.24	27.59				1	0.00	100							3203
3301				2	0.00	0.00	1	100	100				3	66.67	66.67	3	66.67	66.67	3301
3302																			3302
3303																			3303
3304	1	0.00	0.00	2	0.00	0.00							3	66.67	66.67				3304
3305	6	66.67	66.67	1	0.00	0.00				2	100	100	16	68.75	68.75	19	42.11	57.89	3305
3306																60	60	80	3306
3307																			3307
3308				1	0.00	100	1	100	100							5	40	80	3308
4101													4	50	50	2	100	100	4101
4102										5	80	80							4102
4201	10	0.00	70	8	12.5	37.5													4201
4203	88	31.82	71.59	107	28.97	66.36	1	100	100	94	31.91	73.4	15	46.67	73.33	4	25	25	4203
4205	1	0.00	0.00							5	40	40				2	50	50	4205
4206	23	8.7	39.13	42	30.95	50	3	66.67	66.67				7	42.86	57.14				4206
4207	6	16.67	50	51	25.49	60.78	1	0.00	100										4207
4208	53	11.32	62.26	37	16.22	40.54				16	25	68.75	1	0.00	0.00				4208
4210	5	0.00	40	13	30.77	53.85													4210
4211																			4211
4212	127	20.47	77.17	95	36.84	69.47	3	100	100	105	13.33	59.05	26	42.31	73.08	17	82.35	88.24	4212
4213																			4213
4214																1	0.00	0.00	4214
4215	18	0.00	61.11	2	0.00	50				3	66.67	66.67							4215
4219	51	13.73	62.75	28	0.00	78.57				2	50	50	4	75	100	2	100	100	4219
4220	78	19.23	69.23	110	27.27	75.45				10	10	60	2	50	50	2	50	50	4220
4221	129	42.64	82.95	77	25.97	72.73	3	100	100	71	23.94	54.93	3	66.67	66.67				4221
4222	22	0.00	40.91	38	5.26	44.74	1	100	100	20	10	30	6	33.33	50	2	100	100	4222
4223	18	11.11	83.33	28	7.14	71.43	1	100	100	6	16.67	83.33	5	40	100	2	50	50	4223
4224				0.00	0.00	0.00													4224
4225	4	0.00	100	16	12.5	62.5	1	0.00	100										4225
4226	5	0.00	60	23	17.39	52.17													4226
4227																			4227
4228	17	0.00	70.59							6	16.67	50							4228
4229	22	4.55	86.36	1	0.00	0.00				13	0.00	69.23							4229
4301	11	0.00	90.91	1	0.00	0.00				2	0.00	100							4301
7100																			7100
7200																			7200
7300	46	47.83	47.83	37	29.73	37.84	2	0.00	0.00	51	31.37	37.25	13	46.15	69.23	11	18.18	18.18	7300
7400													1	100	100				7400
7500				0.00	0.00	0.00													7500
7600																			7600
7700																			7700
7800	29	3.45	17.24	20	0.00	25				24	4.17	16.67	3	33.33	33.33	5	40	40	7800
7900				1	0.00	0.00													7900
8100										2	50	50				1	100	100	8100
Sum	531	24.97	64.48	972	23.72	55.44	27	70.37	77.78	575	28.17	54.26	140	47.14	70	110	52.73	61.82	Sum
Sum (weighted)		20.14	53.89		24.07	57.87		93.39	93.39		33.57	58.84		45.1	69.9		57.46	62.86	Sum (weighted)

Notes: Vegetation key code is listed in Appendix A. Urban, agricultural, water, riparian, snow, cloud, and barren classes were not included in accuracy tests. Cover types 3309 through 3401 (7 Xe
Shrubland types) are not listed as no TM scenes contain them. Key: NP = number of plots used to assess accuracy; %5 = percentage absolutely correct (Level 5); %3 = percentage acceptable (L

Table 13 (continued). Producer's accuracy levels, assessed using fuzzy set analysis, for cover type classifications by TM scene.

	P39/R27			P39/R28			P39/R29			P38/R27			P38/R28			P38/R29			
COVER TYPE	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	COVER TYPE
3101	31	80.65	90.32	68	69.12	80.88	31	38.71	80.65	16	37.5	37.5	79	43.04	55.7	14	42.86	64.29	3101
3102	2	50	50										1	0.00	100				3102
3103																			3103
3104	7	57.14	57.14	8	62.5	75	20	70	80	4	50	75	10	40	60	2	0.00	0.00	3104
3201	7	100	100	7	14.29	14.29				2	50	50	4	0.00	0.00	1	0.00	0.00	3201
3202													4	0.00	25	1	0.00	0.00	3202
3203													1	0.00	0.00				3203
3301				3	33.33	33.33	1	0.00	0.00										3301
3302																			3302
3303	0.00	0.00	0.00																3303
3304													2	0.00	0.00				3304
3305	2	50	50	18	38.89	38.89	40	55	92.5				7	28.57	28.57	8	50	50	3305
3306				3	33.33	66.67	6	50	83.33							2	100	100	3306
3307																			3307
3308				3	0.00	66.67	4	25	100							1	0.00	100	3308
4101	2	100	100	4	50	50	4	75	75	3	66.67	66.67	9	66.67	66.67	6	33.33	33.33	4101
4102													1	0.00	100	5	0.00	20	4102
4201	2	100	100										5	0.00	80	3	66.67	66.67	4201
4203	10	90	90	15	20	40	6	33.33	50	17	5.88	52.94	44	20.45	70.45	15	53.33	73.33	4203
4205	1	100	100	1	0.00	100	4	25	25	2	50	50	5	0.00	0.00	1	100	100	4205
4206	12	83.33	83.33	5	40	100				8	62.5	75	10	0.00	10				4206
4207																			4207
4208	1	100	100	3	33.33	33.33	1	0.00	100				5	0.00	60	3	0.00	33.33	4208
4210																14			4210
4211																1			4211
4212	20	75	85	42	52.38	80.95	31	48.39	80.65	19	15.79	42.11	81	46.91	80.25		21.43	64.29	4212
4213																			4213
4214	1	100	100	5	0.00	20	2	0.00	0.00				2	0.00	0.00		0.00	0.00	4214
4215																			4215
4219	2	100	100	5	20	40	5	20	40	3	0.00	66.67	9	33.33	66.67	6	66.67	83.33	4219
4220	7	85.71	85.71	8	50	87.5	6	33.33	100	1	0.00	100	12	25	66.67	8	37.5	87.5	4220
4221													2	0.00	50	1	0.00	0.00	4221
4222	8	100	100	9	66.67	88.89	3	0.00	66.67	3	0.00	33.33	16	6.25	62.5	4	25	50	4222
4223	2	100	100	5	20	100	1	0.00	100				9	11.11	77.78	4	0.00	75	4223
4224																0.00	0.00	0.00	4224
4225																			4225
4226																			4226
4227																			4227
4228																			4228
4229																			4229
4301													1	0.00	100	1	0.00	0.00	4301
7100																			7100
7200																			7200
7300	14	50	50	17	88.24	94.12	15	73.33	93.33				24	54.17	58.33	6	0.00	0.00	7300
7400							3	33.33	33.33										7400
7500																0.00	0.00	0.00	7500
7600																			7600
7700																			7700
7800	2	50	50	4	0.00	25	7	42.86	42.86				9	0.00	11.11	1	0.00	0.00	7800
7900																			7900
8100				3	33.33	33.33	3	0.00	0.00				2	0.00	0.00	2	0.00	50	8100
Sum	133	78.36	82.09	236	50.85	69.49	193	47.15	77.2	78	26.92	51.28	363	32.78	60.06	110	30.77	52.14	Sum
Sum (weighted)		81.36	86.97		52.25	71.27		44.99	80.06		No weight			35.41	54.86		43.66	66.01	Sum (weighted)

Notes: Vegetation key code is listed in Appendix A. Urban, agricultural, water, riparian, snow, cloud, and barren classes were not included in accuracy tests. Cover types 3309 through 3401 (7 Xe
Shrubland types) are not listed as no TM scenes contain them. Key: NP = number of plots used to assess accuracy; %5 = percentage absolutely correct (Level 5); %3 = percentage acceptable (L

Table 14. Producer's accuracy levels, assessed using fuzzy set analysis, for size class classifications by TM scene.

	P43/R26			P43/R27			P42/R26			P42/R27			P42/R28			P41/R26		
	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3
SHRUB																		
1	1.00	100.00	100.00	1.00	100.00	100.00	3.00	100.00	100.00	14.00	71.43	85.71	4.00	25.00	25.00	7.00	57.14	100.00
2	1.00	100.00	100.00	2.00	50.00	100.00	1.00	100.00	100.00	9.00	22.22	100.00	6.00	16.67	100.00	38.00	15.79	100.00
3	1.00	100.00	100.00	1.00	0.00	100.00	1.00	100.00	100.00	5.00	0.00	60.00	1.00	100.00	100.00	15.00	66.67	93.33
Sum	3.00	100.00	100.00	4.00	50.00	100.00	5.00	100.00	100.00	28.00	42.86	85.71	11.00	27.27	72.73	60.00	33.33	98.33
Sum (weighted)		100.00	100.00		28.67	100.00		100.00	100.00		41.70	83.10		58.84	62.54		62.10	96.60
TREE																		
1	4.00	25.00	75.00	5.00	40.00	80.00	9.00	11.11	55.56	26.00	34.62	50.00	9.00	66.67	77.78	71.00	12.68	54.93
2	5.00	20.00	100.00	4.00	25.00	100.00	8.00	50.00	100.00	32.00	15.62	100.00	4.00	0.00	75.00	59.00	28.81	74.58
3	21.00	85.71	95.24	29.00	51.72	93.10	16.00	43.75	68.75	123.00	73.98	91.06	27.00	48.15	85.19	12.00	50.00	83.33
4	2.00	50.00	100.00	1.00	100.00	100.00	12.00	0.00	50.00	12.00	0.00	66.67	2.00	0.00	100.00	1.00	0.00	100.00
Sum	32.00	65.62	93.75	39.00	48.72	92.31	35.00	34.29	71.43	193.00	54.40	85.49	42.00	45.24	83.33	143.00	22.38	65.73
Sum (weighted)		69.90	93.00		45.80	94.40		38.00	73.90		54.55	86.99		46.75	83.22		22.90	76.80

	P41/R27			P41/R28			P41/R29			P40/R27			P40/R28			P40/R29		
	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3
SHRUB																		
1	18.00	88.89	94.44	10.00	40.00	60.00	1.00	100.00	100.00	10.00	50.00	90.00	13.00	69.23	100.00	22.00	86.36	100.00
2	6.00	50.00	83.33	3.00	33.33	100.00	2.00	0.00	100.00	6.00	33.33	100.00	5.00	40.00	100.00	6.00	0.00	100.00
3	n/a	n/a	n/a	2.00	100.00	100.00	1.00	100.00	100.00	3.00	33.33	66.67	2.00	50.00	100.00	5.00	0.00	0.00
Sum	24.00	79.17	91.67	15.00	46.67	73.33	4.00	50.00	100.00	19.00	42.11	89.47	20.00	60.00	100.00	33.00	57.58	84.85
Sum (weighted)		79.07	91.65		66.60	89.20		78.50	100.00		40.26	95.30		55.54	100.00	1000.00	79.00	100.00
TREE																		
1	25.00	56.00	64.00	18.00	44.44	50.00	2.00	100.00	100.00	15.00	53.33	93.33	24.00	83.33	91.67	3.00	33.33	33.33
2	34.00	0.00	94.12	10.00	30.00	90.00	1.00	100.00	100.00	26.00	57.69	100.00	16.00	43.75	93.75	3.00	33.33	100.00
3	81.00	83.95	92.59	39.00	51.28	79.49	5.00	40.00	40.00	17.00	17.65	88.24	29.00	62.07	93.10	4.00	0.00	75.00
4	9.00	33.33	100.00	6.00	16.67	66.67	n/a	n/a	n/a	2.00	100.00	100.00	3.00	100.00	100.00	n/a	n/a	n/a
Sum	149.00	57.05	88.59	73.00	43.84	72.60	8.00	62.50	62.50	60.00	46.67	95.00	72.00	66.67	93.06	10.00	20.00	70.00
Sum (weighted)		74.40	91.50		45.25	73.97		87.40	87.40		41.40	94.20		55.64	93.61		7.80	74.60

	P39/R27			P39/R28			P39/R29			P38/R27			P38/R28			P38/R29		
	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3
SHRUB																		
1	6.00	66.67	100.00	22.00	90.91	95.45	12.00	91.67	100.00	n/a	n/a	n/a	7.00	42.86	100.00	8.00	62.50	100.00
2	3.00	66.67	100.00	6.00	33.33	100.00	9.00	55.56	100.00	n/a	n/a	n/a	2.00	0.00	100.00	4.00	0.00	100.00
3	n/a	n/a	n/a	1.00	100.00	100.00	3.00	33.33	33.33	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sum	9.00	66.67	100.00	29.00	79.31	96.55	24.00	70.83	91.67	n/a	n/a	n/a	9.00	33.33	100.00	12.00	41.67	100.00
Sum (weighted)		66.60	100.00	1000.00	81.20	96.40		75.70	95.30	n/a	n/a	n/a		25.00	100.00		42.40	100.00
TREE																		
1	6.00	33.33	66.67	15.00	46.67	86.67	14.00	42.86	50.00	n/a	n/a	n/a	8.00	37.50	50.00	8.00	0.00	50.00
2	29.00	37.93	100.00	15.00	53.33	100.00	40.00	45.00	97.50	n/a	n/a	n/a	7.00	42.86	100.00	7.00	28.57	100.00
3	36.00	66.67	86.11	11.00	45.45	90.91	96.00	76.04	96.88	n/a	n/a	n/a	11.00	72.73	90.91	6.00	33.33	66.67
4	n/a	n/a	n/a	2.00	0.00	50.00	2.00	50.00	50.00	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sum	71.00	52.11	90.14	43.00	46.51	90.70	152.00	64.47	92.11	n/a	n/a	n/a	26.00	53.85	80.77	21.00	19.05	71.43
Sum (weighted)		55.20	89.50		48.40	93.80		64.70	94.20	n/a	n/a	n/a		61.00	90.70		23.70	74.30

NP = number of plots used to assess accuracy; %5 = percentage absolutely correct (Level 5); %3 = percentage acceptable (Level 3).

Table 15. Producer's accuracy levels, assessed using fuzzy set analysis, for canopy classifications by TM scene.

	P43/R26			P43/R27			P42/R26			P42/R27			P42/R28			P41/R26		
	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3
SHRUB																		
1	2	100.00	100.00	3	66.67	100.00	1	100.00	100.00	5	20.00	40.00	7	57.14	100.00	5	100.00	100.00
2	4	25.00	100.00	6	83.33	100.00	5	80.00	100.00	16	56.25	93.75	9	66.67	100.00	3	0.00	100.00
3	4	25.00	75.00	6	0.00	50.00	3	33.33	100.00	6	0.00	83.33	4	0.00	75.00	5	0.00	20.00
Sum	10	40.00	90.00	15	46.67	80.00	9	66.67	100.00	27	37.04	81.48	20	50.00	95.00	13	38.46	69.23
Sum (weighted)		54.90	93.80		79.20	100.00		55.94	100.00		39.96	77.42		59.80	100.00		99.40	100.00
TREE																		
1	13	69.23	92.31	17	17.65	64.71	41	14.63	73.17	52	23.08	80.77	47	34.04	93.62	30	43.33	90.00
2	34	64.71	100.00	31	58.06	100.00	43	67.44	100.00	89	57.30	94.38	44	72.73	100.00	28	32.14	92.86
3	26	34.62	96.15	25	68.00	96.00	15	53.33	100.00	50	52.00	96.00	8	12.50	100.00	6	33.33	50.00
Sum	73	54.79	97.26	73	52.05	90.41	99	43.43	88.89	191	46.60	91.10	99	49.49	96.97	64	37.50	87.50
Sum (weighted)		59.20	97.90		56.50	93.70		58.00	97.20		49.90	93.00		55.80	98.60		37.50	84.00

	P41/R27			P41/R28			P41/R29			P40/R27			P40/R28			P40/R29		
	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3
SHRUB																		
1	12	50.00	66.67	16	75.00	81.25	2	100.00	100.00	11	72.73	100.00	29	58.62	89.66	17	76.47	94.12
2	9	55.56	88.89	13	38.46	84.62	2	0.00	0.00	10	60.00	100.00	12	16.67	100.00	10	10.00	100.00
3	1	0.00	100.00	5	0.00	40.00	n/a	n/a	n/a	5	20.00	100.00	3	0.00	33.33			
Sum	22	50.00	77.27	34	50.00	76.47	4	50.00	50.00	n/a	57.69	100.00	44	43.18	88.64	27	51.85	96.30
Sum (weighted)		43.80	81.50		59.26	82.58		51.70	51.70		69.20	100.00		42.10	87.60	1000	71.4	94.60
TREE																		
1	44	45.45	84.09	75	46.67	85.33	7	57.14	85.71	57	31.58	89.47	29	20.69	100.00	7	28.57	100.00
2	74	43.24	97.30	73	60.27	98.63	6	0.00	100.00	51	68.63	100.00	45	93.33	100.00	16	50.00	100.00
3	13	69.23	100.00	16	25.00	100.00	2	100.00	100.00	11	54.55	100.00	6	0.00	100.00	1	0.00	100.00
Sum	131	46.56	93.13	164	50.61	92.68	15	40.00	93.33	119	49.58	94.96	80	60.00	100.00	24	41.67	100.00
Sum (weighted)		51.35	95.40		49.80	95.20		50.45	89.61		59.70	98.20		78.00	100.00		29.10	100.00

	P39/R27			P39/R28			P39/R29			P38/R27			P38/R28			P38/R29		
	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3	NP	%5	%3
SHRUB																		
1	6	33.33	83.33	16	87.50	100.00	24	70.83	91.67	n/a	n/a	n/a	7	85.71	100.00	9	77.78	100.00
2	4	50.00	100.00	13	23.08	100.00	12	41.67	100.00	n/a	n/a	n/a	2	100.00	100.00	1	0.00	50.00
3	1	0.00	100.00	1	100.00	100.00	1	0.00	100.00	n/a	n/a	n/a	n/a	n/a	n/a	1	0.00	100.00
Sum	11	36.36	90.91	30	60.00	100.00	37	59.46	94.59	n/a	n/a	n/a	9	88.89	100.00	11	46.67	73.33
Sum (weighted)		35.80	97.30		76.00	100.00		62.50	94.00		n/a	n/a		92.40	100.00		65.27	100.00
TREE																		
1	30	63.33	90.00	57	49.12	94.74	14	42.86	100.00	n/a	n/a	n/a	16	87.50	100.00	21	52.38	90.48
2	27	66.67	100.00	51	56.86	100.00	30	30.00	100.00	n/a	n/a	n/a	43	44.19	76.74	32	62.50	84.38
3	6	33.33	66.67	22	54.55	90.91	5	80.00	80.00	n/a	n/a	n/a	20	5.00	60.00	19	10.53	78.95
Sum	63	61.90	92.06	130	53.08	96.15	49	38.78	97.96	n/a	n/a	n/a	79	43.04	77.22	72	45.83	84.72
Sum (weighted)		62.50	92.60		54.45	96.90		57.60	90.10		n/a	n/a		65.40	88.30		54.90	86.80

NP= number of plots used to assess accuracy; %5= percentage absolutely correct (Level 5); %3= percentage acceptable (Level 3).

Cover Type

Several factors may limit the accuracy of cover type classifications, not the least of which is the detailed classification scheme which was adopted for the project. When attempting to map a large number of cover types, some of them very similar, confusion between types becomes probable. The numerous mesic conifer types offer a ready example. The potential for problems was compounded when a limited number of plots were available for some cover types in a given scene; those plots available did not necessarily represent the full range of variation observed on the ground for those cover types. Furthermore, some cover types cannot reliably be distinguished using TM data. For example, confusion was common between low-density forest and shrub or grassland types. Even a large number of training plots may not help in such situations. The error matrices provided in Appendix F illustrate confusion among cover types as observed from the training data.

Size Class

Accurate discrimination of forest and shrub size classes may be limited by similar factors. Perhaps most importantly, field sampling was targeted toward cover types, and to a lesser degree, on canopy cover levels, meaning that training data were readily available for these attributes. On the other hand, we did not explicitly sample for all size classes within all cover types and canopy levels. Furthermore, size class underwent a *post hoc* assignment because many forested plots had multiple size class groups. Most forested plots did not offer good size class representations for training purposes, and had to be high-graded. This reduced the potential training set by many plots (especially for large and very large trees, ≥21" dbh), and eliminated nearly all ' gray areas' along the size class continuum. Included in the 'gray area' category were multi-storied stands, which we were not able to distinguish from single-storied stands in size classifications. The limited number of training plots for stands dominated by large/very large trees was especially problematic; although the Nearest Mean classifier yielded better results than Nearest Member of Group for most scenes, it still relied on mean values. Undoubtedly, mean values derived from very few plots are more suspect than those calculated from many plots. For some scenes, training data were insufficient to classify all size classes that could reasonably be expected to occur within the area. On the other hand, there was no shortage of medium tree (9.0-20.9" dbh) plots in the training set, reflecting the

dominance of this size class in the landscape overall. The skewed distribution of size classes may have influenced the resultant classifications. In addition, size class was confounded with stand density; we tried to compensate for this by stratifying size classifications by canopy cover, but results, though improved, were still imperfect. In general, size classification results were surprisingly unsatisfactory. Although the manner in which size classes were assigned to training plots played a major part, we also may have reached the limits of TM data to discriminate between different vegetative characteristics, given the complex array of cover types and size classes in the Northern Rockies. Other methods, such as interpretation of radar data, should be explored.

Canopy Cover

Because canopy cover was classified using a rule-based approach, results can be quickly modified where necessary. However, in general, results proved more satisfactory than those for size class. By basing canopy cover assignment on MNDVI, we drew upon an objective alternative to standard supervised classifications; again, the derivation of MNDVI emphasizes variation in middle infrared wavelengths (measured by TM5) which are known to be associated with canopy closure (Butera, 1986; Baret *et al*., 1988; Spanner *et al.*, 1990). It is worth noting that, although all training plots were uniformly divided into low (<40%), medium (40-69%), and high (≥70%) canopy cover, specific MNDVI breakpoints varied by TM scene (see Appendix F). Thus, low canopy in one scene may differ slightly from low canopy in another.

Data Limitations

In general, many factors can influence the accuracy of classifications derived from Landsat TM data (see Congalton, 1991; Congalton and Green 1993; Lachowski et al., 1995). These range from limitations associated with input data, including TM imagery or ground-truth data, to errors introduced in the classification process. We discuss these in some detail below.

TM Data

Given both the spatial and spectral resolutions of TM data, not all vegetation patterns can be delineated or classified accurately. For instance, we typically find variation in the

spectral composition of 30 meter pixels representing the same cover type. If variation within a cover type is greater than the variation among different cover types, then these cover types necessarily will be confused spectrally with others. In the case of ponderosa pine, its spectral signature varied widely within scenes, depending on tree size and density, as well as the presence and amount of understory grass or shrubs. This contributed to spectral overlap between the ponderosa pine cover type and certain non-forest types, and undoubtedly led to lower classification accuracies, not just for cover types, but also for lifeform and size class.

Time of year and atmospheric conditions affect the quality of TM data and any resulting classifications. Information about existing vegetation and land cover is best obtained from TM data acquired at certain times of the year. For existing vegetation, acquisition times close to the peak of the growing season are undoubtedly best, although to distinguish particular vegetation cover types, such as western larch, spring or fall images might be best. Sun angle and atmospheric conditions also can adversely affect the quality of TM imagery. For example, in September the sun is lower in the sky and casts more shadows in steep, mountainous terrain than earlier in the season. Similarly, smoke or haze can interfere with spectral reflectance patterns and thereby limit the variation available in TM data. In the western U.S., hazy atmospheric conditions commonly occur in late August and September as a result of wildfires. For all these reasons, mid-summer (July or early August) should be the ideal time to acquire TM data for this project area. Although TM scenes were not always available for this time of year, we were fortunate to be able to obtain relatively high quality scenes and to have them all terrain-corrected. The poorest quality image that we had to work with was the one for P42/R28; this was extensively covered by haze which limited the spectral variation available for classification. Image clarity, on the other hand, can contribute to improved classification results, even when other factors are limiting. For example, in spite of the above stated preference for mid-summer acquisition dates, we point to the good classification results for P43/R26, a scene that was acquired in late September, 1993. These results were possible only because the image was very clear, and we were able to compensate for the relatively low sun angle with supplementary training data from the Idaho Panhandle and Colville National Forests.

Reflectance data from the TM thermal channel (band 6) were missing from three scenes covering northern Idaho and northeastern Washington -- P43/R26, P43/R27, and

P42/R28. These scenes were obtained from the Multi-Resolution Land Characterization Consortium archive at the USGS EROS Data Center. Because our supervised classification method used mean values for all seven TM channels, the lack of thermal information for these scenes hindered our ability to distinguish among general cover types, like water, rock, grass, shrub, and forest, that we know absorb, radiate, and reflect heat differently. For the other 15 scenes, we observed general patterns of association between thermal values and cover classes, such as low values for water, moderate ones for forest, and relatively high ones for grass, shrub, and rock. Similarly, cover types occurring on south and west facing slopes tended to have higher thermal values than cover types on north and east facing slopes. Thus, we feel that the absence of thermal data for the three TM scenes reduced the power of our classification method and may have reduced the resulting map accuracies as well. On the other hand, we again point to the high accuracies for P43/R26 and reiterate the ability of high quality training data to compensate for certain data limitations.

Map Unit Definition

Our unsupervised classification process sometimes produced large regions that contained multiple cover types, each of which were undoubtedly larger than the 2 ha MMU. These occurred as a result of spectral classes being regrouped and pixels then being merged solely on the basis of spectral similarity. Although we recognized the potential for this to occur early on, we were prevented by hardware and software limitations from solving the problem until midway through the project. At that point, it was too late to go back and reprocess all 18 TM scenes. We now point out the potential benefits of either incorporating topographic similarity with spectral similarity in the delineation of MMU boundaries, or maintaining a higher number of spectral classes rather than regrouping. This would help ensure that two or more patches of relatively homogeneous but different vegetation that occurred on adjacent aspects would be split by the merging process. As it stands now, if one large region spans more than one aspect and includes different spectral classes, its label will be derived from its mean spectral and topographic values which may correspond to values associated with a totally different type, or the average values may represent some strange new values. If data from plots placed in these large, heterogeneous patches are used for training, then the associated errors will be perpetuated throughout the supervised classification and lead to many incorrect

labels. On the other hand, if these large patches are not sampled, misclassification errors will be fewer and limited just to the occurrence of these patches.

Conversely, the mapping process also yielded regions smaller than the 2 ha MMU. First, spectral classes corresponding to water were preserved at 30 m resolution in the merging process. This did not guarantee that they would -- or even should -- be labeled water in the supervised classification. Such instances are especially common on steep, north-facing slopes that appear shadowed on the TM imagery. Although there are numerous regions of this sort, they occupy little area overall. Second, along edges, regions smaller than 2 ha may have been created and maintained. The edge-matching process in particular reshaped and/or subdivided many regions on subordinate scene edges. In addition to creating 'remnant' polygons smaller than the MMU, this process also created some non-contiguous regions wherever subordinate regions were subdivided by overlapping dominant ones. Any attempt to rectify these would have changed the region attributes; because these are the attributes we used in the classification process, we opted to leave the database intact, to be fixed by individual users if desired.

Ground-truth Data

First, even though we tried from the outset to devise an unbiased sampling methodology, the actual field sampling procedures ended up being biased in favor of cover types that were forested and more readily accessible to Forest Service field crews than types occurring either in remote, inaccessible areas, or on privately owned lands. This is evident from the fuzzy set accuracy matrices which show relatively few test plots for certain cover types that were in fact quite common. For example, the foothills grassland type was abundant but poorly sampled on P38/R28 because it occurred primarily on private lands. If more plot data were available for these cover types that were not sampled in proportion to their abundance, our accuracy assessments undoubtedly would have been higher.

Second, during the 1994 field season, we produced spectral quads which showed all regions 2 ha and larger as homogeneous landscape units. As a result, field crews using these maps were unable to distinguish between homogeneous and heterogeneous patches, and to avoid sampling the latter. For the second field season, 1995, all spectral quads were plotted to show both the regrouped spectral classes at 30 m resolution and the 2 ha MMU polygons. This enabled field crews using these more detailed spectral quads to better locate plots in more

uniform patches of ground cover than they could in 1994. Consequently, plot data collected in 1995 probably contributed to fewer classification errors than those collected in 1994.

Third, we were very selective in our use of training data for each TM classification; but it was not possible to examine and check those plots (20% by cover type) held aside for accuracy assessment. This could have important implications for how one interprets the accuracy results. Several examples will help illustrate this issue.

The accuracy of ground-truth plots, both in terms of their location and content, will directly affect classification accuracies. Again, we tried to identify plots with potential errors early in the processing pipeline. If these errors could not be corrected, then individual plots were eliminated. Undoubtedly, however, some errors were missed. If these ended up in the training data set, they could still be detected by further quality control measures. If they were not detected and used for training, however, their effects would be distributed throughout the classification and result in a lower map accuracy. On the other hand, if these errors ended up in the test data set, we could not detect them, and the final stated accuracy would be lower than the true map accuracy.

It was inevitable that more plots would be available for some scenes than for others. To maximize the use of all available data, either for classification or accuracy assessment, we tried to use data from plots that were located on multiple scenes. However, because adjacent scenes sometimes were acquired at different times, in different years, or under different environmental or atmospheric conditions, this was not always appropriate. When these plots were selected for training two or more adjacent image classifications, they were removed if they did not meet certain filtering criteria. But as noted above, we could not identify and similarly remove such outliers from the test data sets.

All TM scenes were acquired between 1991 and 1993, whereas the field sampling occurred in 1994 and 1995, and some pre-existing field data were collected as far back as the mid-1980's. For stable, slow changing cover types, these temporal differences should not cause classification problems, unless land use suddenly changed. Again, our training data analysis was designed to catch gross inconsistencies between field and satellite data, but we certainly did not eliminate all errors.

Related to the topics of plot location and patch uniformity, some pre-existing field data were collected for purposes and at scales that do not match the 30 m spatial resolution of TM

data. Even though single 30 m pixels might represent relatively pure cover types on the ground, it is important to remember that we were classifying patches 2 ha and larger. Thus, when 30 m pixels are combined into these larger mapping units, both training and test data must match this scale. Once again, we tried to minimize this potential conflict in the classification process by careful analysis of the training data and removal of questionable plots. However, the data held aside for the accuracy assessment contained more plots that were collected prior to this project (and hence for other purposes); these were more likely to have been collected with the intention of sampling vegetation units that were either smaller or larger than those captured by our 2 ha MMU. Consequently, test data of this type (i.e., ECODATA plots collected prior to 1994, TSMRS, or other existing data) could not be adequately screened and undoubtedly contributed to some of the lower than expected accuracy results. For this reason, we feel that most cover type accuracies are conservative.

CONCLUSIONS

In spite of the limitations discussed above, we maintain that our two-stage procedure for mapping large areas was a suitable and effective approach for a project of this magnitude. By providing an integrated GIS database, users can query and process information contained in many layers in a cost-efficient manner and at a controlled level of accuracy. Furthermore, all stated accuracies represent conservative estimates, and users should find the GIS databases to be more accurate and useful than these figures might otherwise indicate. Where inaccuracies are real, the nature of the database makes modifications relatively simple and straightforward. Although the database covers a large geographic area, the full scene units have been maintained for archival, online storage, and eventual updating with new TM imagery. Being relatively small (~50 megabytes each), these full scene databases can be retrieved quickly and processed efficiently. Thus, many problems arising from conventional classifications of Landsat images across large areas have been resolved through methodology developed for this project.

REFERENCES

Baret, F., G. Guyot, A. Begue, P. Maurel, and A. Podaire. 1988. Complementarity of middle infrared with visible and near-infrared reflectance for monitoring wheat canopies. *Remote Sensing of Environment,* 26: 213-225.

Brown, J. F., T. R. Loveland, J. W. Merchant, B. C. Reed, and D. O. Ohlen. 1993. Using multisource data in global land cover characterization: concepts, requirements, and methods. *Photogrammetric Engineering and Remote Sensing,* 59(6): 977-987.

Butera, C. 1986. A correlation and regression analysis of percent canopy closure and TM spectral response for selected forested sites in San Juan National Forest, Colorado. *I.E.E.E. Transactions on Geosciences and Remote Sensing*, GE-24, 122-129.

Congalton, R. G. 1988. A comparison of sampling schemes used in generating error matrices for accessing the accuracy of map generated from remote sensing data. *Photogrammetric Engineering and Remote Sensing* , 54(5): 593-600.

Congalton, R.G. 1991. A review of assessing the accuracy of classifications of remotely sensed data. *Remote Sensing of Environment* 37: 35-46.

Congalton, R.G., and K. Green. 1993. A practical look at the sources of confusion in error matrix generation. *Photogrammetric Engineering and Remote Sensing,* 59(5): 641-644.

Crist, E. P., and R. C. Cicone. 1983. Investigation of Thematic Mapper data dimensionality and features using field spectrometer data. *Proceedings of the Seventeenth International Symposium on Remote Sensing of Environment,* Vol. III, pp. 1313-1322.

Davis, F.W., P.A. Stine, and D.M. Stoms. 1994. Distribution and conservation status of coastal sage scrub in southwestern California. *Journal of Vegetation Science,* 5(5):743-756.

ERDAS. 1991. **Field guide**, Second Edition, Version 7.5, Printed in the United States of America, 394 p.

Environmental Systems Resource Institute. 1991. **Cell-based modeling with GRID**. Version 6.0, Printed in the United States of America.

Ford, R., Z. Ma, R. L. Redmond. 1993. Aggregation of image classification units for mapping large areas. The 1993 Northwest ARC/INFO Users Conference, Whitefish, Mont.

Guo, J. 1993. An object-oriented model with efficient algorithms for identifying and merging raster polygons. M.S. Thesis, Department of Computer Science, The University of Montana, Missoula, Mont.

Gopal, S., and C. Woodcock. 1994. Theory and methods for accuracy assessment of thematic maps using fuzzy sets. *Photogrammetric Engineering and Remote Sensing* , 60(2): 181-188.

Heckbert, P., 1982. Color image quantization for frame buffer display. *Computer Graphics*, 16(3): 297-307.

Heuvelink, G. B. M., P. A. Burroughs, and A. Stein. 1989. Propagation of errors in spatial modelling with GIS. *International Journal of Geographical Information Systems*, 3(4): 303-322.

Hixson, M., D. Scholz, N. Fuhs, and T. Akiyama. 1980. Evaluation of several schemes for classification of remotely sensed data. *Photogrammetric Engineering and Remote Sensing*, 46(12):1547-1553.

Justice, C., and J. Townshend. 1982. A comparison of supervised and unsupervised classification procedures on LANDSAT MSS data for an area of complex surface conditions in Basilicata, southern Italy. *Remote Sensing of Environment*, 12:407-420.

Keane, R. E., M. E. Jensen, and W. J. Hann. 1990. ECODATA and ECOPAC: analytical tools for integrated resource management. *The Compiler*, 8(3):24-29, 31, 33-37.

Lachowski, H., P. Maus, M. Golden, J. Johnson, V. Landrum, J. Powell, V. Varner, T. Wirth, J. Gonzales, S. Bain. 1995. Guidelines for the use of digital imagery for vegetation mapping. USDA: Forest Service, Gen. Tech. Rep. EM-7140-25, Washington, D.C.

Lillesand, T. M. and R. W. Kiefer. 1987. **Remote Sensing and Image Interpretation**, 2nd ed., John Wiley & Sons, New York, New York, 721 p.

Ma, Z., 1995. Using a rule-based merging algorithm to eliminate 'salt-pepper' and small regions of classified image. *Proceedings of the Ninth Annual Symposium on Geographic Information Systems,* Vol. II, pp. 834-837.

Ma, Z. and C. E. Olson. 1989. Spectral matching in supervised classification of terrain features. *IGARSS '89,* Vol. II, pp. 638-640.

Ma, Z. and C. E. Olson. 1989. A measurement of spectral overlap among cover types. *Photogrammetric Engineering and Remote Sensing,* 55(10): 1441-1444.

Ma, Z. and C. E. Olson. 1990. Accuracy evaluation of computed classified thematic map with a systematic cluster sampling scheme. *IGARSS '90,* Vol. III, pp. 2379-2382.

Ma, Z. and R. L. Redmond. 1992. Building attribute tables for raster GIS files with ARC/INFO. Gap Analysis Technical Bulletin, The University of Idaho, Moscow, Idaho.

Ma, Z. and R. L. Redmond. 1995. Tau coefficients for accuracy assessment of classification of remote sensing data. *Photogrammetric Engineering and Remote Sensing,* 61(4): 435-439.

Nemani, R., L. Pierce, S. Running, and S. Band. 1993. Forest ecosystem processes at the watershed scale: sensitivity to remotely-sensed leaf area index estimates. *Int. J. Remote Sensing,* 14(13): 2519-2534.

Russ, J. C. 1992. **The Image Processing Handbook**. CRC Press, Boca Raton, Florida, 445 p.

Scott, J. M., F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'erchia, T. C. Edwards, Jr., J. Ulliman, and R. G. Wright. 1993. Gap analysis: a geographic approach to protection of biological diversity. *Wildlife Monographs* no. 123, 41 p.

Skidmore, A.K., and B.J. Turner. 1988. Forest mapping accuracies are improved using a supervised nonparametric classifier with SPOT data. *Photogrammetric Engineering and Remote Sensing,* 54(10): 1415-1421.

Spanner, M. A., L. L. Pierce, D. L. Peterson, L. E. Band, and S. W. Running. 1990. Remote sensing of temperate coniferous forest leaf area index: The influence of canopy closure, understorey vegetation and background reflectance. *International Journal of Remote Sensing*, 11: 95-111.

Thompson, M. 1987. Maps for America. U.S. Geological Survey. 265 p.

Tom, C. H., and L. D. Miller, 1984. An automated land-use mapping comparison of the Bayesian MAXIMUM LIKELIHOOD and linear discriminant analysis algorithms. *Photogrammetric Engineering and Remote Sensing*, 50(2):193-207.

U.S. Forest Service. June 1976. Subsection map for western Montana. USDA Forest Service, R. Max Peterson, chief. Maps compiled and on file at Northern Regional Office, Missoula, Mont.

U.S. Forest Service. January 1980. Subsection map for northern Idaho. USDA Forest Service, R. Max Peterson, chief. Maps compiled and on file at Northern Regional Office, Missoula, Mont.

U.S. Forest Service. August 1981. Subsection map for central Montana. USDA Forest Service, R. Max Peterson, chief. Maps compiled and on file at Northern Regional Office, Missoula, Mont.

U.S. Forest Service. 1992. Subsection map for eastern Montana. USDA Forest Service, F. Dale Robertson, chief. Maps compiled and on file at Northern Regional Office, Missoula, Mont..

U.S. Geological Survey. 1989. Digital line graphs from 1:100,000-scale maps, data user guide 2. U.S. Geological Survey. 88 p.

U.S. Geological Survey. 1989. U.S. geodata -- digital line graphs. U.S. Geological Survey. 1 p.

Warren, S. D., M. O. Johnson, W. D. Goran, and V. E. Diersing. 1990. An automated, objective procedure for selecting representative field sample sites. *Photogrammetric Engineering and Remote Sensing*, 56(3): 333-335.

APPENDIX A:
Montana & Idaho Vegetation & Land Cover Classification System
Modified for the Upper Columbia Basin Assessment, March 1996

This vegetation and land cover classification system for Montana and Idaho was developed for the ground-truthing component of the Forest Service Upper Columbia Basin Assessment. This system was modified from the Montana GAP Analysis to aid in the preliminary classification of unsupervised Landsat TM imagery at a mid-scale level of 1:100,000.

Each cover type in the hierarchical classification system is given a four-digit code. The first digit of the class codes are based on the USGS standard (Anderson, 1986) for assigning satellite imagery land cover types (1=urban, 4=forests, etc.).

Lists of representative plant species or field conditions follow each class code. The classification categories and the rules for making the assignment are intended to be exclusive. The list of species or description below a particular cover type is not all-encompassing but meant to give a representation of what might be encountered. Some of the species listed are marked with asterisks (*), which indicates they are used in the rule set for determining the assignment of a cover type label.

Each plant common name is accompanied by a six-letter code derived from the scientific name. Nomenclature follows Hitchcock & Cronquist (1973). Species listed under vegetation types are suggestive species only intended to describe existing habitats. Three codes require special consideration: 3102, Disturbed Grasslands and 3202 and 3203, Warm Mesic and Cold Mesic Shrublands (respectively), are field conditions in which listed species **must** be present.

Criteria are provided to assist crews in assessing vegetation and land type cover using estimates of canopy cover for life forms and/or specific species types. Canopy cover is defined as an expression of the percentage of the total natural spread of foliage of an individual species, including interstitial spaces of branches. This classification system defines classes based ont he distinction between absolute and relative canopy cover. Values in parentheses refer to fields on the Northern Region ECODATA form.

Categories of classification are defined as:

- **Grasslands & Shrublands** <15% forested (<20 GF F93 TreeCover).
  Grasslands ≥15% herbaceous (≥20 GF F104-F105 HerbCover).
  <15% shrub (<20 GF F100 ShrubCover).
  Shrublands ≥15% shrub (≥20 GF F100 ShrubCover).

- **Forest Land** ≥15% forested (≥20 GF F93 TreeCover).
  Upland areas, not adjacent to open water, may have a perched water table and hydric soils.
  Broadleaf (>75% broadleaf and <25% needleleaf relative to total canopy cover).
  Needleleaf (>75% needleleaf and <25% broadleaf relative to total canopy cover).
  Mixed Broadleaf & Needleleaf Forest (≥25% and ≤75% broadleaf and ≥25% and ≤75% needleleaf relative to total cover).

- **Riparian & Wetland Areas** (adjacent to running or standing water or influenced by very saturated soils).
  Forested Riparian or Wetland (≥15% Broadleaf or Needleleaf forest)
  Non-Forested Wetland <15% forested (<20 GF F93 TreeCover)

- **Barren Land** (<20 GF F93 TreeCover, <20 GF F100 ShrubCover, <20 GF F104-F105 HerbCover)

Montana and Idaho Vegetation & Land Cover Classification System
Modified for the Upper Columbia Basin Assessment, March 1996

NOTE: Vegetation cover types are not always listed in numerical order.

1 URBAN OR DEVELOPED LAND (1000)

2 AGRICULTURAL (2000)

21 Cropland & Pasture

2101 Dry-land crop type
Small grains
Fallow lands
Shelter belts

2102 Irrigated crop type
Row crops (i.e., corn, beans, beets)
Alfalfa
Hay

2103 Dry-land pasture type
Crested wheatgrass
Russian wildrye
Other dry-land pastures

2104 Irrigated pasture type
Irrigated meadow/pasture

22 Orchard, Groves, Nurseries
23 Feed lots
24 Other Agricultural Lands

3 NON-FORESTED LAND
Grasslands and Shrublands <15% Forested (<20 GF F93 TreeCover)

31 Grasslands
<15% total shrub cover
(<20 GF F100 Shrub Cover)

3101 Foothills Grasslands
Bluebunch Wheatgrass (AGRSPI)
Thickspiked Wheatgrass (AGRDAS)
Western Wheatgrass (AGRSMI)
Needle&Thread (STICOM)
Blue Grama (BOUGRA)
Bluegrasses (POA spp)
Idaho Fescue (FESIDA)
Rough Fescue (FESSCA)
Bent grasses (AGROSTIS spp)
Reedgrasses (PHRAGMITES spp)
Cinquefoil (POTENTILLA spp)
Pussy-toes (ANTENNARIA spp)
Sticky Geranium (GERVIS)
Lupine (LUPINUS spp)
Arrowleaf Balsamroot (BALSAG), etc.

≥30% exotic species relative to total cover	**3102**	**Disturbed Grasslands** Cheatgrass (BROTEC) Japanese Brome (BROJAP) Knapweed (CENMAC) Black medic (MEDLUP) Yellow sweet-clover (MELOFF) Spurge (EUPESU) St. John's-wort (HYPPER) Common Dandelion (TAXOFF) Field Pennycress (THLARV) Hound's-tongue (CYNOFF) Bull Thistle (CIRVUL)
	3103	**Herbaceous Clearcut**
locally determined elevation break	**3104**	**Montane Parklands & Subalpine Meadows** Pinegrass (CALRUB) Elk Sedge (CARGEY) Northwestern Sedge (CARCON) Beaked Sedge (CARROS) Smooth Woodrush (LUZHIT) Beargrass (XERTEN) Columbia Brome (BROVUL) Hood's Sedge (CARHOO) Parry's Rush (JUNPAR) Green Fescue (FESVIR) Showy Oniongrass (MELSPE) Broadleaf Arnica (ARNLAT) Heart-leaf Arnica (ARNCOR) Subalpine Daisy (ERIPER) Fan-leaved Daisy (ERIFLA) Five-stamened Mitrewort (MITPEN) Fireweed (EPIANG), etc.

3200-3400 Shrublands ≥15% total shrub cover (≥20 GF F100)

a) Calculate dominance index (% canopy cover x height) for mesic and xeric shrub types. If dominance index for mesic shrubs > dominance index for xeric shrubs go to MESIC SHRUBLANDS. If dominance index for xeric shrubs > dominance index for mesic shrubs go to XERIC SHRUBLANDS.
b) If dominance index for mesic and xeric shrub types is equal make call based on individual or forest personnel knowledge. If unable to make call enter 3401 (other shrublands).

32 Mesic Shrubland

1) If east of the Rocky Mountain Front use code 3201 for all mesic shrublands.
2) If west of the Rocky Mountain Front use codes 3202 and 3203 for all mesic shrublands.
   a) Determine the dominance index and sum for all warm, then all cold mesic shrubs on the plot. Dominance for warm mesic species > dominance for cold mesic species = 3202. Dominance for cold mesic species > dominance for warm mesic species = 3203.
   b) If dominance index for warm and cold species is equal make call based on your knowledge or forest personnel knowledge. If unable to make call enter code 3401 (other shrubland).
   c) If species on plot are not those that are specifically listed enter code 3401 (Other Shrubland).

East of Continental Divide (used only in 1995 sampling) **3201** **Mesic Upland Shrubland**

Alder (ALNUS spp)
Big Tooth Maple (ACEMAC)
Bearberry (ARCUVA)
Black Hawthorn (CRADOU)
Bunchberry (CORCAN)
Ceanothus (CEAVEL)
Canada Buffaloberry (SHECAN)
Chokecherry (PRUVIR)
Columbia Clematis (CLECOL)
Common Prince's Pine (CHIUMB)
Dwarf Bilberry (VACMYR)
Dwarf Huckleberry (VACCAE)
Globe Huckleberry (VACGLO)
Grouse Whortleberry (VACSCO)
Ocean Spray (HOLDIS)
Pipsissewa (CHIMEN)
Raspberry (RUBIDA, RUBPAR)
Rocky Mountain Maple (ACEGLA)
Rose (ROSA spp)
Shiny-leaf Spiraea (SPIBET)

West of Continental Divide **3202** **Warm Mesic Shrubland**

Alder (ALNUS spp.)
Rocky Mtn Maple (ACEGLA)
Bigtooth Maple (ACEGRA)
*Western Serviceberry (AMEALN)
*Creeping Oregon Grape (BERREP)
Bunchberry (CORCAN)
Red-osier Dogwood (CORSTO)
*Ocean-spray (HOLDIS)
*Twinflower (LINBOR)
*Devil's Club (OPLHOR)
Pachistima (PACMYR)
*Mockorange (PHILEW)
*Ninebark (PHYMAL)
*Chokecherry (PRUVIR)
*Baldhip Rose (ROSGYM)
*Woods Rose (ROSWOO)
*Blue Elderberry (SAMCER)
Red Elderberry (SAMRAC)
*Canada Buffaloberry (SHECAN)
*Shiny-leaf Spiraea (SPIBET)
*Common Snowberry (SYMALB)
Creeping Snowberry (SYMMOL)
*Western Snowberry (SYMOCC)
*Mountain Snowberry (SYMORE)

West of Continental Divide

3203 Cold Mesic Shrubland
*Labrador Tea (LEDGLA)
*Fool's Huckleberry (MENFER)
*Red Mountain Heath (PHYEMP)
*Dwarf Huckleberry (VACCAE)
*Globe Huckleberry (VACGLO)
*Big Huckleberry (VACMEM)
*Grouse Whortleberry (VACSCO)
*Alder (ALNUS spp.)

33 Xeric Shrubland

1) Calculate dominance index for individual species and enter appropriate code based on greatest dominance index value.
   a) If no one species is dominant, make call based on individual or forest personnel knowledge. If unable to make call enter 3401 (other shrublands).

3301 Curlleaf Mountain Mahogany (CERLED)
Curlleaf mountain mahogany-sagebrush

3302 Gambel Oak (QUEGAM)
(* in S ID only)

3303 Skunkbrush Sumac (RHUTRI)

3304 Bitterbrush (PURTRI)
Bitterbrush-rough fescue (PURTRI-FESSCA)
Bitterbrush-Idaho fescue (PURTRI-FESIDA)
Bitterbrush-sagebrush

3305 Mountain Big Sagebrush (ARTTSV)
(* at higher elevations SW to WC MT)
Mountain big sagebrush-bluebunch wheatgrass (ARTTSV-AGRSPI)
Mountain big sagebrush-grassland
Low sagebrush (ATRARB)

3306 Wyoming Big Sagebrush Steppe (ARTTSW)
(* hot, dry sites S MT)
Wyoming big sagebrush (ARTTSW)
Wyoming big sagebrush-western wheatgrass (ARTTSW-AGRSMI)
Wyoming big sagebrush-grassland
Sand sagebrush (ARTFIL)

3307 Basin Big Sagebrush Shrubland (ARTTST)
Basin big sage (ARTTST)
Fourwing saltbrush (ATRCAN)
Shadscale (ATRCON)
Basin big sagebrush-grassland

3308 Black Sagebrush Steppe (ARTNOV)
Three-tip sagebrush (ARTTRP)
Sand sagebrush (ARTFIL)

3309 Silver Sage (ARTCAN)

3310 Salt-Desert Shrub

(* associated w/moist, salty, alkaline bottom land)
Saltsage (ATRNUT)

3311 Greasewood (SARVER)
Greasewood (SARVER)
Greasewood-sagebrush
Greasewood-saltsage

3312 Rabbitbrush
Green rabbitbrush (CHRVIS)
Rubber rabbitbrush (CHRNAU)

3313 Creeping Juniper (JUNHOR)
Creeping juniper-sun sedge (JUNHOR-CARHEL)

3314 Shrub-Dominated Clearcut

34 Other Shrubland **3401 Other Shrubland**

4 FOREST UPLANDS ≥15% total forest cover (>20 GF F93 TreeCover)

* non-riparian forest not adjacent to surface water, but may be associated with a perched water table and hydric soils.

1) If >75% broadleaf and <25% needleleaf (relative to total cover) go to 41 Broadleaf.
2) If ≥25% and ≤75% of broadleaf species and ≥25% and ≤75% of needleleaf species (relative to total cover) go to 43 Mixed Needle/Broadleaf Forest.
3) If >75% needleleaf and <25% broadleaf (relative to total cover) go to 42 Needleleaf.

41 Broadleaf Forest
1) If Aspen (POPTRE) is ≥66% relative cover enter code 4101.
2) If Aspen (POPTRE) is <66% relative cover enter code 4102.

4101 Aspen (POPTRE)
Aspen grove
Aspen-Conifer mix

4102 Broadleaf Forest
Black Cottonwood (POPTRI)
Paper Birch (BETPAP)
Green Ash (FRAPEN)
Box Elder (ACENEG)
Red Alder (ALNRUB)
Bur Oak (QUEMAC) (* in SE MT only)

42 Needleleaf Forest

1) If a single species is >66% relative cover enter code for species listed 4201-4215.
2) If no one species is >66% relative cover go to 2-species dominant cover types, 4223, 4225-4229.
   a) Select possible appropriate code and calculate relative dominant cover for the two specific species listed. If the combined total is >80% relative cover enter the correct code.
   b) If the combined total is <80% relative cover go to mixed forest types, 4219-4222.
      b1) Mixed types are based on >10% relative dominant cover of key (*) indicator species and in the order of listed types as follows:
      mixed alpine
      mixed mesic
      mixed subalpine
      mixed xeric
      b2) If percent values for relative dominant cover do not indicate any code, select an appropriate code based on individual or forest personnel knowledge.
      b3) If unable to determine vegetation type, enter code 42.

4201 Engelmann Spruce (PICENG)

4203 Lodgepole Pine (PINCON)

4205 Limber Pine (PINFLE)

4206 Ponderosa Pine (PINPON)

4207 Grand Fir (ABIGRA)

4208 Subalpine Fir (ABILAS)

4210 Western Red Cedar (THUPLI)

4211 Western Hemlock (TSUHET)

4212 Douglas-Fir (PSEMEN)

4213 Pinyon-Juniper (PINMOO)-JUNOST)

4214 Rocky Mountain Juniper (JUNSCO)

4215 Western Larch (LAROCC)

4219 Mixed Whitebark Pine Forest
(previously **Mixed Alpine Forest**)

* ≥10% relative cover
* Whitebark Pine (PINALB)
* Alpine Larch (LARLYA)
Lodgepole Pine (PINCON)
Engelmann Spruce (PICENG)

	4221	**Mixed Mesic Forest**
* ≥10% relative cover		* Western Red Cedar (THUPLI) * Western Hemlock (TSUHET) Douglas-Fir (PSEMEN) Engelmann Spruce (PICENG) * Western Larch (LAROCC) * Grand Fir (ABIGRA) Lodgepole Pine (PINPON) White Spruce (PICGLA) Western White Pine (PINMON) * Pacific Yew (TAXBRE)
	4220	**Mixed Subalpine Forest**
* ≥10% relative cover		* Subalpine Fir (ABILAS) * Mountain Hemlock (TSUMER) Douglas-Fir (PSEMEN) Engelmann Spruce (PICENG) White Spruce (PICGLA) Lodgepole Pine (PINCON)
	4222	**Mixed Xeric Forest**
* ≥10% relative cover		* Ponderosa Pine (PINPON) * Rocky Mountain Juniper (JUNSCO) * Limber Pine (PINFLE) (* east of Rocky Mtn Front) Douglas-Fir (PSEMEN) Lodgepole Pine (PINCON)
≥80% relative cover	**4223**	**Douglas-Fir-Lodgepole Forest** (PSEMEN-PINCON)
≥80% relative cover	**4225**	**Douglas-Fir-Grand Fir Forest** (PSEMEN-ABIGRA)
≥80% relative cover	**4226**	**Western Red Cedar-Grand Fir Forest** (THUPLI-ABIGRA)
≥80% relative cover	**4227**	**Western Red Cedar-W. Hemlock Forest** (THUPLI-TSUHET)
≥80% relative cover	**4228**	**Western Larch-Lodgepole Forest** (LAROCC-PINCON)
≥80% relative cover	**4229**	**Western Larch-Douglas-Fir Forest** (LAROCC-PSEMEN)
<15% live tree cover	**4224**	**Standing burnt and dead timber**

43 Mixed Needleleaf/Broadleaf
≥25% and ≤75% of broadleaf species and ≥25% and ≤75% of needleleaf species (relative cover).

	4301	**Mixed Needleleaf/Broadleaf Forest**

5 WATER

51 Rivers & Streams

52 Lakes

53 Reservoirs

6 RIPARIAN & WETLAND AREAS

Adjacent to running or standing water, or obviously influenced by very saturated soils.

61 Forested Riparian or Wetland

≥15% Forested (<20 GF F93 TreeCover)

>2/3 relative cover	**6101**	**Needleleaf Dominated Riparian Forest** needleleaf forest Douglas-Fir (PSEMEN) Western Red Cedar (THUPLI) Engelmann Spruce (PICENG), etc.
≥2/3 relative cover	**6102**	**Broadleaf Dominated Riparian Forest** broadleaf forest Aspen (POPTRE) Black Cottonwood (POPTRI) Green Ash (FRAPEN) Box Elder (ACENEG), etc.
	6103	**Needleleaf-Broadleaf Riparian Forest**

≥25% and <66% broadleaf, ≥25% and <66% needleleaf (relative cover)

6104 **Mixed Riparian** (Forest & Non-forest)

62 Non-Forested Riparian or Wetland

<15% total forest cover (<20 GF F93 TreeCover)

<15% total shrub cover (<20 GF F100 ShrubCover)	**6201**	**Graminoid & Forb Dominated** Wet to moist meadow grasslands Tufted hairgrass-reedgrass (DESCSP-CALASP) Inland saltgrass-alkali sacaton Common reed (PHRAGMITES) Sedges (CAREX spp) Kentucky bluegrass (POAPRA) Cattail marshes (TYPHA spp), etc.

≥15% total shrub cover (≥20 GF F100 ShrubCover)	**6202**	**Shrub Dominated Riparian** Willows (SALIX spp) Twinberry (LONINV) Utah Honeysuckle (LONUTA) Black Hawthorn (CREDOU) Wild Plum (PRUAME) Red-osier Dogwood (CORSTO) Water Birch-Dogwood (BETOCC-CORSTO) Sitka Alder (ALNSIN) Mountain Alder (ALNINC) Water Birch (BETOCC) Shrubby Cinquefoil (POTFRU) Rose (ROSA spp) Currant (RIBES spp) Raspberry (RUBUS spp) Thimbleberry (RUBUS spp) Buffaloberry (SHECAN) Tamarisk (TAMCHI), etc.
	6203	**Mixed Non-forest Riparian**

7 BARREN LAND

<15% total forest cover (<20 GF F93 TreeCover),
<15% total shrub cover (<20 GF F100 ShrubCover),
<15% total herbaceous cover (<20 GF F104-F105 HerbCover)

71 Dry Salt Flats

72 Sandy Areas, Blowouts

73 Exposed Rock (GF F43 LF=R)	**7300**	**Exposed rock** Cliff Rock outcrop Talus or scree slope Barren/special feature

74 Barren Alpine Tundra (* locally determined elevation break)

75 Mines, Quarries & Gravel pits

76 Badland breaks (* in Dakotas and along Rocky Mountain Front)

77 Clearcut	**7701**	**Bare Clearcut** Mostly litter and duff on surface, >10% bare mineral soil, burned or unburned.
78 Mixed Barren	**7800**	**Mixed Barren Land** (* foothills and subalpine areas; locally determined elevation break to distinguish from other classes like 7400)

79 Shoreline and stream gravel bars

8 ALPINE MEADOW
high elevation, low-vegetation, above treeline
* locally determined elevation break

81 Alpine Meadow	**8101**	**Alpine Meadow**
≥15% total herbaceous cover		Bentgrasses (AGROSTIS spp)
(≥20 GF F104-F105 HerbCover)		Sheep Fescue (FESOVI) DRYAS, SILENE, OXYTROPIS, SEDUM spp
<15% total shrub cover (<20 GF F100 ShrubCover)		Alpine moss-lichen-forb associations

9 SNOW, ICE, CLOUD, or CLOUD SHADOW

9100	**Perennial Snow or Ice**
9800	**Cloud**
9900	**Cloud Shadow**

APPENDIX B: Constructing a Digital Elevation Database

— L. Guy McWethy

Introduction

In the process of creating maps of existing vegetation and land cover through classification of Landsat TM imagery, the lab has assembled an extensive digital elevation database. We have collected most of the 7.5‘ (1:24,000 scale) digital elevation models (DEMs) available from the United States Geological Survey (USGS) for western Montana, northern Idaho, and adjacent parts of Washington, Oregon, and Wyoming. We currently have digital elevation data for approximately 3100 7.5‘ quadrangles in the study area. These data were either purchased directly from the USGS or provided by other agencies (e.g., the U.S. Forest Service, Bureau of Land Management, National Park Service, Fish and Wildlife Service, and Montana Department of Natural Resources and Conservation).

Throughout this appendix, the term quadrangle refers to a 7.5‘ quadrangle as defined by the USGS and references a certain geographic area. The term DEM refers to a digital file with data covering a specific 7.5‘ quadrangle. Therefore we can refer to multiple DEMs for a single quadrangle, but not vice versa. The term 'quad' is also used as an abbreviation of quadrangle.

Assembling data from multiple sources led to acquisition of multiple, non-identical copies of DEMs for some quadrangles. Among the 3100 quads covering the study area, we had more than one DEM file for 853 quads. It was necessary to compare all multiple DEM files to identify non-identical copies, and then to evaluate these carefully to select the best copy for further processing.

Information about individual DEM files and spatial coverage of DEMs available in the lab was stored and updated in three INFO relational databases:

1. The quads database (*dem24kcovt*) contains spatial information about each 7.5‘ quadrangle, along with information about its availability at WSAL and USGS. The number of DEM copies for each quadrangle and, if more than one copy was available, information about the copy selected, were stored in the quads database.
2. All the header information from each individual DEM file at the lab was stored in the dem database (*dems_received*). Each DEM file was assigned a unique

identification number, and logged as coming from a specific source and batch.

3. Specific information about each batch (number of DEM files, source agency, date received, etc.) was stored in a batch database (*dems_batch*).

These three databases were updated as new batches were received and choices were made between DEM files for the same quad. The quads database also was revised throughout the project as new DEMs became available from the USGS.

With such a large study area and the requisite large number of DEM files to be managed, we decided to merge the 7.5‘ DEM data into tiles covering an area coincident with the USGS 1:100,000 scale maps (henceforth referred to as 100K tiles). These tiles were projected into the Albers Equal Area Conic Projection using the following projection parameters:

Units = meters
Spheroid = Clarke 1866
Datum = NAD27
1st Parallel = 46 degrees
2nd Parallel = 48 degrees
Central Meridian = -109.5 degrees
Latitude of Projection's Origin = 44.25 degrees
False Easting = 600,000 meters
False Northing = 0

To ensure that these tiles would fit together seamlessly with their neighbors, a total of 60 quads were processed together for each tile -- the 32 quads actually contained within the tile, plus the immediately surrounding 28 quads. Finally, to guarantee sufficient overlap among adjacent tiles such that no slivers of missing data would exist, the actual extent of data coverage for each tile was expanded outward by 90 meters (3 pixels) before clipping. Although the processing time and storage space required for preparing tiles in this manner were greater, we felt that this was outweighed by the benefits of having DEM tiles that would fit together seamlessly to cover larger areas, such as TM scenes or National Forests. In fact, the 100K tiles were assembled together for each TM scenes, and these full-scene DEM files were used in the classification process to obtain elevation, slope, and aspect data for every raster polygon

in the database.

Steps used to create the 100K DEM tiles are documented below. All work was performed using ARC/INFO (version 7.0.3) in conjunction with standard UNIX commands and utilities on IBM RS/6000 workstations. The documentation has been split into four steps: pre-processing the incoming raw data files, creating patches for missing and corrupted data, creating the 100K tiles, and merging the 100K tiles into files coincident with TM scenes.

Pre-processing Incoming 7.5' DEM ASCII Files

Pre-processing converts the raw data (as it is received) into a format compatible with ARC/INFO. Several checks to assure quality are performed on the data, and comparisons are made between non-identical copies of data covering the same quadrangle. Steps are as follows:

1. Receive the data, either over the network via FTP, on a CD-ROM disk, or on magnetic media. The shipment usually included a file listing the file names with the corresponding quadrangle names and states; alternatively, we received some files with names that indicated the spatial position of the quad that they represented. In the first case, the relational database in INFO was searched by quad name and state to obtain the correct filename. ARC/INFO scripts (AMLs) were written and implemented to do this. In the second case, files were renamed to match the USGS standard names.

2. Un-block the data into the proper record structure for ARC/INFO. This was done either directly with the UNIX 'dd' command, or by using the DEMREAD command in ARC, depending on the organization providing the data and the computer platform used to process particular batches.

3. Log in the newly received DEMs as a specific batch. An AML (*log_dem_batch.aml*) recorded selected header information, as well as user-specified information about the batch and the individual DEMs received into the three separate INFO databases.

4. Update the quadrangle relational database to indicate the receipt of the new quads.

5. Move the new DEM files into the correct directory using the AML (*copy_new_demdata.aml*). These directories were organized by longitudinal strip and named

accordingly (dem<longitude strip>). Each file was named according to the 9-character Forest Service convention of using the quadrangle's lower right (SE) corner coordinate (2 character latitude degrees, 2 character latitude minutes, 3 character longitude degrees, 2 character longitude minutes) followed by the string 'dem'.

6. Any duplicates received were checked to ensure that the best version available was transferred to the proper directory for later processing. The AML, *check_identical_dems.aml* , automatically compared all copies of the same DEM file to determine if they were identical. Two additional AMLs, *id_lowerright_from_fndem.aml* and *misguided_dem.aml*, checked DEMs that were geographically misplaced or labeled incorrectly. Other checks were performed to 1) select processing level 2 DEMs over level 1 DEMs, 2) evaluate the amount and degree of striping, 3) look for anomalies such as spikes, pits, or rips, 4) check for missing lakes by overlaying 100K scale USGS hydrography, and 5) identify differences between two or more copies and decide which was more accurate.

Creating Patches for Missing or Problem Quadrangles

Some 7.5‘ quads did not have any DEM data available, and we found approximately 10 DEMs that contained major errors that needed to be repaired manually. Any tiles that were missing one or more quads were filled by clipping and inserting three arc-second DEM data from the Defense Mapping Agency to which our TM data had been registered. The Hughes/STX Corporation, which provided 15 of our 18 TM scenes, claims to have used some 7.5' data to guide and improve its resampling of the three arc second DEMs to 30 m pixels. But because its terrain-correction process was proprietary, no further details were available.

1. When 7.5' DEM data could not be found for a given quad, patches were created from the Hughes/STX or EROS Data Center DEMs using the AML, *clipa_100K_quad.aml,* that extracted individual 7.5‘ quads and converted them to ARC/INFO grid files. These files were stored in the directory 'd.patches', and the quads database was updated to indicate that HSTX data were used for this quad (item "stx-filled" set to 1).

2. Any DEM quadrangles containing errors (zeros, bad spikes, etc.) were manually corrected. The actual procedure varied according to the specific problem. After identification, the major steps included: 1) read the ASCII file into an ARC/INFO grid; 2) correct the

problem (remove spikes, pits, or bad data); 3) convert back to ASCII DEM file, 4) rename original file and save corrected one, and 5) update the quads database to indicate that this quad was repaired (item "repaired_ascii" set to 1).

Creating the 100K Tile

The following steps were incorporated into an AML, *tile_7min_dems.aml.* to create seamless 100K tiles.

1. Identify all quadrangles needed to complete the specified tile. A maximum of 60 quads were used to create a single 100K tile. These included 32 core quads plus the surrounding 28 quads. The latter were needed to fill in the rectangular region in the Albers projection and to ensure a seamless fit when adjacent tiles were edge-matched. Because the ARC/INFO MERGE command could only accept 49 files at a time, the 60 quads were divided into groups. Logical groupings were quads that occurred in the same UTM zone, and ones that were patched (because these were already projected into Albers). If one group still contained more than 49 quads, it was split into two smaller groups and the quads in each were merged into separate files that were merged together in a later step. In this manner, up to four separate groups could be created.

2. Read each ASCII DEM file into an ARC/INFO Grid. These raw data were assumed to be in the Universal Transverse Mercator (UTM) projection. The AML checked that the datum and elevation units were correctly defined, and attempted to correct them if one or both were not. If the datum was not defined, it was assumed to be NAD27. If the input datum was specified as not being NAD27, the quad was re-projected NAD27. If the input elevation data were in feet, they were converted to meters. Next, for all DEM files in the tile, any change in elevation between adjacent pixels that exceeded 50 m was identified as a pit or spike, and its elevation value was replaced with the average value of the 8 surrounding pixels. Then, the UTM lattice grid for all the DEMs was stored in integer format for subsequent processing. After all data anomalies were fixed, but before re-projection to Albers, the 32 quads comprising the core of a 100K tile were stored as a separate UTM grid and archived.

3. Merge each group of quads (see 1 above) together. If any group included quads that were converted to NAD27, any null values in the merged file were filled to ensure that any

holes between datum shifts would not be expanded or distorted by the projection process.

4. Project each merged file into Albers. Note that quads were merged before this projection step to minimize the possibility that gaps would be expanded between quads in adjacent groups. Also, quads that were patched and projected in step 1 above did not need to be projected again here and were held aside.

5. Merge all groups of projected files (including patched quads) together into the final tile.

6. Fill in any null values left between merged quads. These were interpolated by averaging elevation values for the 3X3 pixel neighborhood around the hole.

7. Store final tiles in directories defined by one-degree longitudinal strips. Tile names were based on the USGS naming convention for 100K maps, by using the NHQ codes preceded by BC and followed by DEM. The 'B' indicated the 100K spatial extent, and the 'C' indicated the 24K scale of the input data. The NHQ code was 7 characters: 2 character latitude, 3 character longitude, and 1 character each for latitude and longitude of the lower right corner. These last characters indicated the relative position from the lower left corner of the one degree block. For example, the file for the lower 100K tile of the 48° latitude and 115° longitude block would be called BC4811511DEM, and it would be stored in a directory called d.115 along with all other tiles from this longitude strip.

Creating the TM Scene DEM File

Overlap between each TM scene and the boundaries of each 100K tile were calculated to create lists of all tiles covering each TM scene. These lists were used to merge all the tiles together to create full-scene DEMs with the AML, *extract_dem_4poly*. ARC/INFO polygon files were used to clip the merged tiles to the boundaries of the TM scenes. These polygon files were created using the corner coordinates reported in the headers of the TM data. Because these corners may not precisely indicate the extent of every TM scene, polygon boundaries were expanded out by three pixels in every direction to avoid missing any data along the scene edges.

APPENDIX C: Compiling and Editing a Digital Hydrographic Database

— Wendy A. Williams

In compiling a digital database of hydrography across northern Idaho and western Montana, our goal was to acquire the most detailed and accurate data available across this large geographic area. Thus, we turned to the 1:100,000 (100k) hydrography digital line graph (DLG) data produced by the United States Geological Survey (USGS) (see Thompson, 1987; USGS, 1989; USGS, 1990). These data are reported to be digital representations of cartographic data derived from USGS 1:100,000 scale (30x60 minute) quadrangles. When compared to current, corresponding USGS 1:100,000 scale quadrangle format maps (topographic maps), however, many of these 100k DLG data files contained inconsistent hydrographic information. These inconsistencies were of concern to us because the DLG data were being used in conjunction with satellite imagery to model riparian habitat, and any inaccuracies would affect the modeling output. After consulting with the USGS, we learned that the recently published hardcopy topographic maps were the most reliable and accurate source for this 1:100,000 scale cartographic information. Thus, we used the hardcopy maps as references when evaluating and editing the DLG data; steps in this process are described below.

Acquire 1:100,000 DLG Hydrography

DLG data for hydrography were obtained from the USGS FTP site, 'ftp -i edcftp.cr.usgs.gov'. Each 100k quad was represented by 8 USGS DLG character format (*opt.gz) files. These files were transferred in two sets, four east and four west files representing 30x30 minute sections of the quad.

The 8 *opt.gz files were then converted into ARC/INFO coverages. This process included: 1) unzipping the 8 DLG character format files; 2) converting each file into an ARC/INFO coverage using the DLGARC command; 3) cleaning and building the coverages; 4) appending the 8 coverages into one complete 100k quad coverage; and 5) projecting the coverage into the Albers Conic Equal-Area coordinate system, using the same parameters as for all other data sets used in this project.

Verify Hydrography

Precision of each 100k DLG coverage was verified by direct comparison to a recent version of its 1:100,000 scale USGS topographic map (see Table C-1 for dates). To do this, a map composition of each DLG coverage was made in ARCPLOT, and plotted to match the size and coordinate system of the 100k topographic map. This plot was then overlayed onto its corresponding USGS topographic map and the hydrography was compared. Hydrography on the DLG plot that was miscoded, missing, or superfluous, with respect to the topographic map, was marked. Specifically, miscoded hydrography carried incorrect attribute data; for example, perennial streams may have been assigned the intermittent attribute code, and vice versa. Superfluous hydrography were those streams, lakes, etc., displayed on the DLG plot, but not printed on the USGS topographic map. Missing hydrography were streams and lakes present on the topographic map that were not on the DLG plot. All missing hydrography was traced onto the DLG plot.

If the plotted line segments from the DLG data matched those on the USGS topographic map exactly, the coverage was placed into the system repository for later use. If inconsistencies were found between the two, the DLG coverage was edited. Generally, when DLGs were prepared in the 1970s but the paper edition bore a 1990s date, more editing was required (Table C-1). A total of 107 DLG coverages were evaluated; 50 of these were edited.

Edit Hydrography

All editing, including digitizing, was done on-screen in ARCEDIT, using a mouse to enter arcs for any new hydrographic features. A coverage of 100k contour lines was made from digital elevation model (DEM) data using the LATTICECONTOUR command; contour line intervals were specified to be consistent with those on the corresponding USGS topographic map. This contour coverage, used as a background display to the DLG coverage in ARCEDIT, allowed for precise digitizing when hydrography additions were required. Where 7.5 minute DEM data were available, they were used in constructing the contour coverage; holes created by missing 7.5 minute quads were patched with three arc-second data resampled to 30 m^2 resolution by Hughes/STX. If accurate 7.5 minute DEM data were not available to build a contour line coverage, corresponding satellite imagery was used when

editing hydrography. This alternative procedure was only necessary for four DLG coverages (Table C-1).

All streams and lakes added to a DLG coverage were coded with the standard, appropriate attributes, and also were assigned a supplementary attribute item (within the arc attribute table, or .aat; see below) that flagged these features as "new" additions to the DLG coverage. Miscoded hydrography was also flagged as such, via the supplementary attribute item. Most miscodes found were of streams that reflected the converse of their true perennial or intermittent attribute. If hydrography was miscoded other than in a "perennial vs. intermittent" manner, another supplementary attribute item, in addition to the flag item, was added to include the correct code. All superfluous DLG hydrography was also flagged in this manner.

Supplementary attribute items of missing, miscoded and superfluous hydrography were coded as follows:

ITEM CODE	DEFINITION
Major5 = 333	hydrography addition to the DLG coverage
Major5 = 777	miscoded hydrography, typically the converse of true perennial vs. intermittent
Minor5 = ___	if miscoded other than "perennial vs. intermittent", correct hydrography attribute entered
Major5 = 888	superfluous hydrography; not present on USGS topographic map

Hydrography additions through on-screen digitizing were the only physical changes made to the DLG coverage. These additions included arcs digitized to correct stream shape and length. Because the true source of the USGS DLG hydrography is somewhat unclear, the original information was preserved in the form that it was acquired from the anonymous FTP site: no streams or lakes were physically deleted, and no changes were made to the codes assigned to the standard DLG attributes. However, inconsistencies in the DLG coverages have been flagged using new attributes; now, users can quickly alter each coverage to match the USGS 1:100,000 scale topographic map if needed. For example, in modeling riparian vegetation, analysts may choose to delete superfluous streams, or leave them in the coverage.

Create Hydrography Coverages for Each TM Scene

Finally, DLG hydrography coverages were projected back into the Albers coordinate system, renamed to reflect that they had been edited, and stored in the system repository. Overlap between 100k coverages and TM scenes was identified, and lists of the coverages within each scene were prepared. Next, 100k coverages within each TM scene were appended and clipped to the scene boundaries. Quad boundaries (Major1 = -99999) were deleted from the appended coverages to create seamless hydrography coverages for each scene. At this point, the hydrography coverages for each TM scene were ready to serve as inputs for riparian vegetation modeling.

Table C-1 summarizes the status of the source hydrography information used in creating each DLG coverage, the edition of the topographic map used in evaluating the DLG accuracy, and the degree to which each DLG coverage was edited.

Footnotes used in the table represent the following information:

* Year the USGS topographic map was photoinspected.

** Accuracy checked using a BLM 100k topographic map.

*** Edited using a satellite image (as opposed to contour map) as backcoverage.

TOTAL HYDROGRAPHY COVERAGES CHECKED:	107
TOTAL HYDROGRAPHY COVERAGES EDITED:	50
TOTAL FEATURES ADDED:	3241
TOTAL FEATURES RECODED:	1471
TOTAL FEATURES FLAGGED (SUPERFLUOUS):	7829

Table C-1. Editing hydrographic features for USGS 1:100,000 digital line graphs (continued on the following four pages).

100K QUAD NAME	STATE	SOURCE DATE	USGS TOPO EDITION	ADDED FEATURES	RECODED FEATURES	SUPERFLUOUS FEATURES
ARCO	ID	1979	1988	4	1	7
ASHTON	ID, WY, MT	1976	1989	23	-	16
BELT	MT	1984	1984	-	-	-
BIG SNOWY MOUNTAINS***	MT	1979	1993	225	87	137
BIG TIMBER	MT	1979	1979	-	-	-
BIGHORN CRAGS	ID, MT	1982	1992	-	-	-
BILLINGS	MT	1979	1989	-	-	-
BOISE	ID, OR	1981	1981	1	-	-
BONNERS FERRY	ID, MT	1983	1983	-	-	-
BORAH PEAK	ID, MT	1978	1989	131	45	665
BOZEMAN	MT	1975	1992	367	331	1952
BUTTE NORTH	MT	1975	1975, 1990*	1	26	10
BUTTE SOUTH	MT	1975	1994	78	13	35
CANYON FERRY DAM	MT	1975	1975, 1991*	-	-	-
CARTER MOUNTAIN	WY	1980	1980	-	-	-
CHALLIS	ID	1982	1982	-	-	-
CHEWELAH	WA, ID	1984	1984	-	-	-
CHOTEAU	MT	1984	1984	-	-	-

* Year the USGS topographic map was photoinspected.
** Accuracy checked using a BLM 100k topographic map.
*** Edited using a satellite image (as opposed to a contour map) as backcoverage.

Table C-1. Editing hydrographic features for USGS 1:100,000 digital line graphs (continued).

100K QUAD NAME	STATE	SOURCE DATE	USGS TOPO EDITION	ADDED FEATURES	RECODED FEATURES	SUPERFLUOUS FEATURES
CIRCULAR BUTTE	ID	1980	1980	2	2	8
CLARKSTON	WA, ID	1981	1981	-	-	-
CODY	WY, MT	1980	1980	4	-	-
COEUR D'ALENE	ID, MT	1977	1978**	92	167	596
COLVILLE	WA, ID	1978	1984	-	-	-
CONNELL	WA	1983	1983	-	-	3
CONRAD	MT	1984	1984	-	-	-
COULEE DAM	WA	1983	1983	-	-	-
CUT BANK	MT	1984	1984	-	-	-
DEADWOOD RIVER	ID	1982	1982	-	-	-
DEARBORN RIVER	MT	1975	1993	1	-	1335
DILLON	MT	1983	1983	-	-	-
DODSON	MT	1984	198-	-	-	
DUBOIS	ID, MT	1983	1983	-	3	-
ELK CITY	ID	1981	1981**	-	-	-
ELLISTON	MT	1975	1975, 1990*	1	-	-
ENNIS	MT, WY	1975	1989	201	46	645
ENTERPRISE	OR	1986	1986	-	-	-
FORT BENTON	MT	1984	1984	-	-	-
GARDINER	MT, WY	1975	1992	444	167	421
GRANGEVILLE	ID,WA	1980	1980	-	-	-
GREAT FALLS NORTH	MT	1976	1976, 1990*	-	1	4
GREAT FALLS SOUTH	MT	1976	1976, 1991*	-	-	-

Table C-1. Editing hydrographic features for USGS 1:100,000 quads (continued).

100K QUAD NAME	STATE	SOURCE DATE	USGS TOPO EDITION	ADDED FEATURES	RECODED FEATURES	SUPERFLUOUS FEATURES
HAMILTON	MT, ID	1980	1980**	-	-	-
HARLOWTON***	MT	1979	1993	68	-	14
HEADQUARTERS	ID, MT	1982	1982	-	-	-
HEBGEN LAKE	MT, ID, WY	1975	1993	838	143	645
HUNGRY HORSE RESERVOIR	MT	1981	1981	-	36	-
IDAHO CITY	ID	1982	1982	-	-	-
JACKSON LAKE	WY	1981	1981	-	1	-
KALISPELL	MT	1981	1981	-	-	44
KOOSKIA	ID	1981	1981	-	-	-
LEADORE	ID, MT	1980	1980**	-	-	-
LEWISTOWN	MT	1978	1978, 1991*	3	-	134
LIBBY	MT	1979	1978, 1991*	2	-	6
LIMA	MT, ID	1979	1987	7	-	311
LIVINGSTON	MT	1978	1992	108	145	321
LONESOME LAKE	MT	1984	1984	-	-	-
McCALL	ID, OR	1978	1980	2	-	-
MISSOULA EAST	MT	1984	1984	-	-	-
MISSOULA WEST	MT, ID	1981	1980	-	-	-
MUSSELSHELL***	MT	1978	1993	354	104	315
NESPELEM	WA	1984	1984	-	-	-
NEZ PERCE PASS	ID, MT	1981	1981	-	-	-
OROFINO	ID,WA	1981	1981	-	-	-
PHILIPSBURG	MT	1976	1993	5	4	4

Table C-1. Editing hydrographic features for USGS 1:100,000 digital line graphs (continued).

100K QUAD NAME	STATE	SOURCE DATE	USGS TOPO EDITION	ADDED FEATURES	RECODED FEATURES	SUPERFLUOUS FEATURES
PISTOL CREEK	ID	1982	1982	-	-	-
PLAINS	MT	1980	1980	-	1	-
POLSON	MT	1980	1980	-	-	-
POTLATCH	ID	1981	1981	-	-	6
PULLMAN	WA, ID	1982	1982	-	-	-
RED LODGE	MT, WY	1978	1989	90	97	31
REPUBLIC	WA	1984	1984	-	1	-
REXBURG	ID, WY	1978	1988	2	-	17
RIGGINS	ID, OR	1987	1987	1	3	176
RINGLING	MT	1979	1993	-	-	-
RITZVILLE	WA	1982	1982	-	-	-
ROCKY BOY	MT	1985	1985	-	-	-
ROSALIA	WA, ID	1984	1984	-	-	-
ROUNDUP	MT	1979	1979	-	-	-
SAINT MARIES	ID	1981	1981	-	-	-
SAINT MARY	MT	1981	1981	114	-	8
SALMON	ID, MT	1981	1981	-	-	-
SANDPOINT	ID, MT	1984	1984	-	-	-
SEELEY LAKE	MT	1979	1993	12	1	29
SPOKANE	WA, ID	1974	1987	1	1	97
SUN VALLEY	ID	1978	1992	-	-	-
SWAN PEAK	MT	1978	1978	13	-	2
THE RAMSHORN	WY	1978	1978	-	-	-

Table C-1. Editing hydrographic features for USGS 1:100,000 digital line graphs (continued).

100K QUAD NAME	STATE	SOURCE DATE	USGS TOPO EDITION	ADDED FEATURES	RECODED FEATURES	SUPERFLUOUS FEATURES
THOMPSON FALLS	MT, ID	1978	1992	115	30	104
TOWNSEND	MT	1976	1976, 1991*	-	-	-
VALIER	MT	1984	1984	-	-	-
WALLACE	ID, MT	1978	1994	2	9	1
WALLOWA	OR	1982	1982	-	-	-
WARREN	ID	1981	1981	-	-	-
WEISER	ID, OR	1980	1980	-	-	-
WHITE SULPHUR SPRINGS	MT	1984	1984	-	-	-
WHITE CLOUD PEAKS	ID	1982	1982	-	-	-
WHITEFISH RANGE	MT	1981	1981	-	-	-
WINNETT***	MT	1978	1986, 1991*	1460	256	572
WINNIFRED	MT	1984	1984	-	-	-
WISDOM	MT, ID	1978	1994	5	4	26
YAAK RIVER	MT	1979	1979, 1990*	-	-	-
YELLOWSTONE PARK, N.	WY, MT	1983	1983	-	-	-
YELLOWSTONE PARk, S.	WY	1982	1982	-	-	-
ZORTMAN	MT	1984	1984	-	-	-

APPENDIX D: Selecting representative training sites for supervised classification of Landsat TM data

— Judy M. Troutwine

For each of the 19 TM scenes originally slated for classification (P42/R29 was dropped at a later date), covering northern Idaho and western Montana, our unsupervised classification resulted in more than 300,000 raster polygons 2 ha or larger and representing from 18 to 39 different spectral classes. Design of an efficient and cost-effective sampling scheme for collecting representative training data thus became a critical challenge; our approach is similar to one described by Warren et al. (1990), although it was developed without reference to this source. For the first field season, we stratified each TM scene by spectral class and landform group, then selected 7.5' quads for field sampling based on the diversity of spectral class/landform group (SpecLand) combinations, and the presence of rare and/or under-represented combinations within each quad. Additional quads were selected to satisfy requests from individual National Forests, and to improve the geographic distribution of quads to be sampled across the study area. For the second field season, quads were targeted toward presence of cover types that were not adequately sampled after the first season. Details are provided below.

Stratifying TM Scenes by Spectral Class and Landform Group

The first logical step in quad selection was to stratify the TM scenes by spectral class. Because the same spectral class can represent different vegetation or land cover in different locations, we sought to further stratify the landscape using biophysical parameters which directly influence vegetation patterns. For this, we turned to a classification of landforms based on topography, climate, soils, and parent materials developed by the Forest Service (USDA:FS 1976, 1980, 1981, 1992). Working with Forest Service scientists at the Northern Regional Office, we aggregated these landforms into 12 broad groups across the study area (Table D-1). These landform groups were sufficiently well distributed across individual TM scenes to provide adequate stratification, yet sufficiently aggregated to constrain the number and complexity of SpecLand combinations to a manageable and useful level. The number of combinations ranged from 114 to 282 for each scene, with an arithmetic average of 200 SpecLand combinations per scene.

Table D-1. Landform/subsection groups used for stratification of TM scenes (USDA: FS 1976, 1980, 1981, 1992).

I.	Mountains and foothills			
	A.	Primarily noncalcareous		
		1.	Coarse-grained parent materials	
			a. Dissected mountain slopes, ridges, draws, benches, & breaklands (M1, M8, M12, M13, M19, M20, M22, M25, M27)	1[a]
			b. Dissected mountain slopes w/ rounded ridges, trough walls, benches, moraines, valleys, cirques, talus, & moraine lakes (M3, M9, M10, M17, M28, M29, M30, M31, M32, ML)	2
			c. Rolling hills and dissected benches (F1, F2, F3, F4)	3
		2.	Fine-grained parent materials	
			a. Dissected mountain slopes w/ rounded ridges, trough walls, alpine glacial cirques, & small valley moraines, earthflows (F7, M6, M14, M15, M16, M18, M21, M23, M24, M26, M33, M36, M40)	4
	B.	Primarily calcareous		
		1.	Fine, soft-grained parent materials	
			a. Dissected mountain slopes, steep to rolling ridges, draws, benches, trough walls, & cirques (F5, F6, M2, M4, M5, M7)	5
	C.	Primarily basalt		
		1.	Dissected mountain slopes, steep to rolling ridges, draws, benches, trough walls, & cirques	8
II.	Valleys			
	A.	Primarily noncalcareous		
		1.	Flood plains, terraces, benches, ground moraines, alluvial fans, & lake beds (A2, A3, B1, B2, B3, B4, B5, B6, B7, B8, B50)	6
	B.	Primarily basalt		
		1.	Flood plains, terraces, benches, & plateaus	9
III.	Plains			
	A.	Primarily calcareous		
		1.	Fine-grained parent materials	
			a. Rolling plains & benchlands, and dissected breaklands (P1, P2, P3, P4, P5, P6, P7, P8, P13, P14, P18, P19, P20, P22, P23)	7
			b. Clayey, lacustrine plains (P9, P11, P12, P21)	10
	B.	Primarily basalt (P13A, P14A)		11
	C.	Glacial till plains (P4A, P4B, P4C, P10, P15, P16, P17)		12

[a] Landform Group assigned by Wildlife Spatial Analysis Lab, University of Montana

Selecting 7.5' Quads for Field Sampling

Next, we had to decide how to sample these different SpecLand combinations. It was contractually agreed that about 40 of the 230 or more 7.5' quads on each scene would be identified and plotted for field sampling, and WSAL set a goal of selecting 3-5 quads per SpecLand combination. Because all quads had between 11 and 94 SpecLand combinations, this goal seemed attainable -- especially if priority could be given to the quads expected to have the highest landscape diversity based on the number of SpecLand combinations within their bounds. This approach also would help to optimize field crews' efforts. Since a scene's boundary sliced across quads located on its periphery, only those quads with at least 75% of their area within the scene were included in the pool of possible quads to be visited for that scene. Those excluded from one scene could still be selected from neighboring, overlapping scenes. This was a cost-saving measure for both WSAL and the Forest Service.

The criterion of using only the most diverse quads, though, did not ensure that all SpecLand combinations were represented adequately, or that all landform groups or even a scene's geographic extent were well-represented. A combination of criteria evolved; we used diversity as a base, but completeness of representation was also a target. Additionally, the cooperating National Forests were given input as to quads which they felt to be of interest in their work or which had particular merit in vegetation mapping.

A practical sequence of analysis became apparent. Evaluation was facilitated by creating a raster representation for each scene (ARC/INFO grid), with several attributes for each 30 m^2 cell, including spectral class, landform group, and the 7.5' quad in which the cell is located. Once such a 'master' grid was prepared, deriving information about the spectral classes and landform groups within each quad became a straightforward matter. First, quads were ranked by their diversity (number of SpecLand combinations). For each scene, the 20 quads with the highest diversity scores were selected; absolute scores varied by scene depending on the results of the unsupervised classification and the distribution of the landform groups on each scene. Note that a quad may be covered by as many as three scenes where they overlap; adjacent images may have been taken on different days in the same year or in different years. If such quads were highly diverse on one scene, then they were usually highly diverse on another, even though the number of classes resulting from the unsupervised

classification varied among adjacent scenes.

Then, quads containing 'rare' SpecLand combinations (occurring on fewer than five quads) were located. Up to five quads were selected, though in some cases there was only one quad containing a particular SpecLand combination. Next, the Forests' own quad selections were incorporated. At that point, the total selection set for each scene was checked for completeness in terms of SpecLand representation on that scene, followed by a programmed search for quads containing under-represented combinations. Up to three quads were selected for each under-represented combination. Here again, the diversity ranking was used so that the most diverse quads were selected. Redundancy was eliminated at each step by recursively checking quads previously selected by the program for the presence of the SpecLand combination targeted in the current search before adding another quad to the selection set.

We reduced the number of selected quads from five to three for under-representation partly because of field time and cost constraints, and partly because the number of quads selected tended to surpass the target of 40 quads per scene. We also recognized that, even for well-represented SpecLand combinations, crews would be unlikely to visit every SpecLand combination on every quad. Further, we assumed that some under-represented SpecLand combinations would be sampled through 'windshield' plots taken as crews traveled from one sampling area to another, or through aerial photo interpretation.

Lastly, the selected quads for each scene were displayed over the classified image for evaluation of their spatial distribution by WSAL and Forest Service personnel. Additional quads were selected to improve the geographic distribution of areas to be sampled. Crews were informed of the reasons why each quad was selected -- diversity, rarity, under-representation, Forest selection, geographic distribution, and combinations thereof -- and sampling procedures varied accordingly for these different quads. In all, field maps (spectral quads) were prepared for 671 7.5’ quads; the number of 7.5’ quads selected for each reason is outlined in Table D-2.

As the season progressed, it became apparent that additional field work would be needed the next year, and that modifications to the sampling scheme would be possible, driven by summaries and assessments of work completed in the first year. Between field seasons, the number of plots collected for each type in the classification scheme for existing vegetation

and land cover (Appendix A) was tallied. After reviewing the plot data collected in 1994, modifications were made to the original sampling strategy. Stratification by landform group had not proved useful, and was abandoned altogether. Further, we switched from sampling by spectral class to sampling by cover type, because the former method caused oversampling of some cover types and undersampling of others. Quad selection for the second field season was thus targeted toward sampling cover types for which the number of plots available was not considered sufficient for conducting supervised classifications. After weighing the desired level of classification accuracy against the limited time available for field sampling and classification, plot minimums were determined for cover type groups (Table D-3). Additional 7.5' quads were then selected for 1995 sampling, drawing on knowledge of the distribution of those cover types that required supplementa plot data to meet the targeted numbers for each TM scene.

Table D-2. Number of 7.5 minute quadrangles selected for field sampling using criteria below.

TM Scene	Name	Diversity	Rarity	Forest Service	Under Represented	Geographic Distribution	Cover Type	TOTALS
P43/R26	Priest Lake, Idaho	14	1	3	2	4	6	30
P43/R27	Coeur d'Alene Lake/Spokane	0	3	0	2	0	18	23
P42/R26	Lake Koocanusa/Eureka	9	3	2	3	4	14	35
P42/R27	Thompson Falls/Noxon Res	15	14	10	3	5	7	54
P42/R28	Dworshak Res/Kooskia	17	9	0	3	2	7	38
P41/R26	Glacier National Park	8	15	3	3	3	19	51
P41/R27	Missoula/Flathead Lake	17	10	7	11	2	15	62
P41/R28	Selway/Bitterroot	19	14	7	3	1	10	54
P41/R29	Salmon River	10	0	0	0	0	0	10
P40/R27	East Front/Choteau	13	14	5	6	3	11	52
P40/R28	A-P/Georgetown Lake	14	1	2	0	1	4	22
P40/R29	Beaverhead Mtns/Big Hole	17	3	0	2	0	0	22
P39/R27	Highwood Mtns/Benton Lk	8	10	0	2	1	15	36
P39/R28	Canyon Ferry Lake/Bozeman	17	3	11	3	2	7	43
P39/R29	Centennial Valley	19	6	3	3	0	0	31
P38/R27	Judith Mountains/Winifred	3	11	0	2	0	9	25
P38/R28	Crazy Mountains	12	5	5	4	1	16	43
P38/R29	Yellowstone National Park	11	10	3	1	1	14	40
	TOTALS	223	132	61	53	30	172	671

Table D-3. Minimum numbers of plots per cover type group targeted for each TM scene in 1995 sampling efforts. Numbers differed for scenes entirely within and scenes only partially within the project area boundaries. A 15-plot minimum was intended to provide 10 plots for training data and 5 for accuracy assessment. See Appendix A for a full list of cover types.

COVER TYPES	FULL SCENE	PARTIAL SCENE
Urban, agriculture, and water[a]	10	10
Grass/forb (3100)	20	15
Shrub (3200, 3300)	25	15
Forest (4100, 4200)	30	15
Forest riparian	30	15
Shrub riparian	25	15
Grass/forb riparian	15	15
Salt flats, dunes	10	10
Exposed rock	20	15
Mixed barren	20	15
Stream gravel bar	10	10
Tundra	15	15

[a] Manually labeled types; plots collected for purposes of accuracy assessment only.

APPENDIX E: Processing Pipeline for Ground-truth Plots

— J. Chris Winne

Here, documentation is provided on the ground-truth data pipeline from data input through to the beginning of supervised classification. Data were provided to the WSAL by the USFS on diskette, with each diskette consisting of a set of files containing comma delimited data. Separate files were provided for, at the least, existing data, field data with non-differentially corrected GPS locations, and all other field data. We defined batches for each set of data received based on the processing steps required. At a minimum, field and existing data were sorted into separate batches. In all, twenty-five batches of data were processed, containing 21,462 plots. However, of these, only 20,189 unique key-ids were input to the system. Of these plots, 17,854 plots passed all quality control tests, and were input to the classification process. Including overlap between TM scenes, 31,369 plot locations were available.

The initial processing step involved importing the ASCII file or files into an INFO data file. The plots were put through a series of tests to ensure data integrity and accuracy, with emphasis on locational accuracy. Data collected specifically for this project in 1994 and 1995 was handled somewhat differently than pre-existing data from other sources, where less opportunities existed to evaluate quality.

1994-95 FIELD DATA

Input Checking

1. An ARC/INFO script was used to ensure that each plot was located in the correct 7.5' quad based on its latitude and longitude values.
2. Scene-ids were validated to ensure that all plots were located in the correct TM scenes.
3. Quad nhqcodes were checked to ensure that the quad specified by the nhqcode was actually plotted for the specified scene.
4. Input plots were compared with those already received to avoid duplicate plots in the database. This check was implemented later in the project period after the passing of duplicate plots was discovered.

Following these checks, the INFO file was converted into an ARC/INFO point coverage, and projected at double-precision to an Albers Equal Area Conical Projection. This coverage was then split into separate coverages based on scene-id, and copied into the 'truth' workspace.

Manual Correction

An ARC/INFO script with a menu interface was written to implement the process of correcting mismatches between the spectral value assigned in the field and the spectral value corresponding to the actual coordinates when digital overlays were conducted. The spectral value as recorded in the field was compared with the spectral value extracted from the unsupervised classification that had been merged to 5 acre (2 ha) minimum mapping unit (MMU). If these values were the same, it was assumed that the plot was correctly located. Those plots with mismatches were flagged for visual inspection. USFS Zone Coordinators (Chip Fisher, Kristen Loken, and Marcy Mahr) examined and decided how to resolve each mismatch. The program provided three options to the user: moving the plot to its true location; changing the field spectral value to match the spectral value at the plot's true location; or discarding the plot if its true location could not be resolved.

The digital plot location was compared with the location marked on the spectral quad that was used in the field. Again, three actions could be taken, the criteria for which are incorporated in an attached USFS document entitled: Guidelines for Point Manipulation via Arc System: 1) If the coverage location was wrong (meaning that the latitude/longitude coordinates incorrectly placed the plot), the plot could be moved to its proper location. 2) If the plot location was correct, but the field spectral value was not, the spectral value could be changed to match the digitally-derived value. 3) If the plot could not be properly placed, it could be removed from the database. Actions taken were documented in the database, and any changed values were recorded.

Incorporation to Database

After all mismatches in the database were dealt with, the full scene coverages were merged into one file. Given the pattern of overlap among adjacent TM scenes, each plot could

fall within the boundaries of as many as three different scenes. Every scene in which each plot fell was identified by overlaying plot locations with scene boundaries, then the coverage was again split into different coverages by scene. This split was based, however, on scenes where plots were located rather than scenes for which plots were collected, with the result that a plot could occur in more than one coverage.

Buffer Routine to Check Plot Locations Relative to Region Edges

The final processing step involved assessing plot locations in each scene coverage relative to the boundaries of the regions (or raster polygons) in which they fell. Because of the potential for projection-related problems with plots located near region edges, if a plot did fall near an edge, it was moved toward the center of the region. The criteria for moving any plot included ensuring that the 30m spectral class was the same as the 5 acre, if appropriate. Riparian plots were not moved, although the distance and direction to the nearest 'good' location was calculated.

EXISTING DATA

Existing data were processed somewhat differently because there were fewer options for quality control. There was no spectral map to tie the plot to a specific region; additionally, the plots usually did not come with scene-id or nhqcode attributes. Thus, only the buffer routine was employed to assess plot locations; however, unlike 1994-95 plots, these plots were not moved. After plots were imported into an ARC/INFO coverage, they were split into scene coverages based on plot location. These plots were tested as to their location within regions of the 5 acre merged grid. Plots more than one pixel from the region edge were accepted for use in classification; conversely, plots within one pixel of the edge were discarded. Additionally, because of the 30 m MMU of the riparian classification, all riparian plots were accepted, regardless of their positions within regions. Their positions relative to region edges were, however, recorded in the database.

CREATION OF COVERAGES BY TM SCENE

Once all other processing steps were completed, both 1994-95 and existing data plots were stripped of their attributes. Because changes to the database were frequent, a master database of information was maintained. The attributes were reattached prior passing the data to image analysts for use in supervised classifications. Note that some plots were determined inappropriate for classification use at other levels than these documented here (e.g., by the Forest Service). Plots were finally compared to a database of deleted plots, and good plots were appended to scene-based plot coverages.

ITEMS ADDED IN THE MANUAL CORRECTION PROCESS

The following items, found within the point attribute tables (PATs) for the scene coverages, apply only to 1994-95 field data:

ORIG_X, ORIG_Y: If the plot was moved by the Zone Coordinators, this is the original location (based on latitude, longitude values passed by USFS).

ORIG_FLD_SPEC: If the SPEC_CLAS_FLD value was changed by the Zone Coordinators, this is the original value as passed by the USFS.

ERROR_CODE: This is a code that documents the actions taken by the Zone Coordinators. It is a binary code and can take values from 0-7. If odd, the plot was moved by the Zone Coordinators. If values 2, 3, 6, 7, the field spectral value was changed. If the value is 4 or greater, the plot was tossed.

COMMENT: Comments added by Zone Coordinators on any special circumstances.

ITEMS ADDED BY THE BUFFER ROUTINE

This routine, designed to move plots away from region edges, calculated a number of variables relating to the heterogeneity of plot location in both the 5 acre merged grid and the 30m recoded grid. Riparian plots (6000) were not moved; however, heterogeneity information was recorded for plot location. These items, found within the PATs for the scene coverages, apply to both 1994-95 field data and to existing data:

VARIETY5: The number of spectral classes in a 3x3 window around the plot within the 5 acre grid. This is for the plot location following placement of plot by Zone Coordinators.

SPEC5: The value of the pixel in the current scene within which the plot lies, from the 5 acre grid. If the plot has been moved, this is for the new location.

VARIETY30: The number of spectral classes in a 3x3 window around the plot within the 30 m (recoded) grid. If the plot has been moved, this is for the new location.

SPEC30: The value of the pixel in the current scene prior to moving by the buffer routine. This is extracted from the 30 m (recoded) grid.

SPEC30N: The new value of the pixel after moving by the routine in the scene within which the plot lies. This is extracted from the 30 m (recoded) grid.

MAJ30: The majority value of a 3x3 window of the 30 m grid centered on the pixel in which the plot falls. This value is prior to any moving by the buffer routine.

MAJ30N: The majority value of a 3x3 window of the 30 m grid centered on the pixel in which the plot falls, after moving by the buffer routine.

NUM_SPEC5: The number of SPEC5 within a 3x3 window of the 30 m (recoded) grid.

NUM_SPEC30: The number of SPEC30 within a 3x3 window of the 30 m (recoded) grid.

EUC_DIST: Distance from the original plot location to the nearest location which passes criteria.

XCOORD_M: If the plot was moved, the x-coord location prior to moving.

YCOORD_M: If the plot was moved, the y-coord location prior to moving.

MOVE_CRIT: This can have several values, listed here in decreasing order of homogeneity. Riparian field season ground-truth plots will have these fields filled in, but will not have been moved.

NoMove: VARIETY5 is equal to 1 and NUMSPEC5 is equal to 9. (30m and 5 acre classifications are both homogeneous in 3x3 window).

30m3x3: If SPEC5 is equal to SPEC30 or SPEC5 is equal to MAJ30, the plot is moved to a position in which SPEC30N and SPEC5 are equal, and the new VARIETY5 and VARIETY30 are equal to 1. It takes this value if SPEC5 is equal to either SPEC30 or MAJ30.

30mCent: The plot is moved to a point which has SPEC5 equal to SPEC30N, and VARIETY5 equal to 1. No 30m3x3 location available.

5ac3x3: Plot has been moved to a location in which VARIETY5 is equal to 1.

CantMove:No homogeneous 3x3 area exists within the 5 acre merged region .

ECOPLOT: The plot is not part of the current ground-truthing effort, but is rather an `Existing' data plot. All non-riparian plots should have VARIETY5 equal to 1; those without a homogeneous 3x3 area around the plot location were not included in the final ground-truth file.

EUC_DREC: The direction in degrees in which the plot is moved.

NUM_MAJ30: The number of values of MAJ30 within the plot location prior to moving by buffer routine.

APPENDIX F:
Scene Summary Reports

TM scenes are in the following order:

P43/R26	Priest Lake, Idaho
P43/R27	Coeur d'Alene Lake/Spokane
P42/R26	Lake Koocanusa/Eureka
P42/R27	Thompson Falls/Noxon Reservoir
P42/R28	Dworshak Reservoir/Kooskia, Idaho
P41/R26	Glacier National Park
P41/R27	Missoula/Flathead Lake
P41/R28	Selway/Bitterroot
P41/R29	Salmon River, Idaho
P40/R27	East Front/Choteau
P40/R28	Anaconda-Pintlar/Georgetown Lake
P40/R29	Beaverhead Mountains/Big Hole
P39/R27	Highwood Mountains/Benton Lake
P39/R28	Canyon Ferry Lake/Bozeman
P39/R29	Centennial Valley
P38/R27	Judith Mountains/Winifred
P38/R28	Crazy Mountains
P38/R29	Yellowstone National Park

Summaries for each scene are in the following order:

1. Analyst's Summary
2. Error Matrix for Cover Type Training Plots (table)
3. MNDVI Histograms
    a. Tree canopy cover classes
    b. Shrub canopy cover classes
    c. Mesic shrub canopy cover classes (few scenes)
4. Accuracy Assessment Tables
    a. Cover type
    b. Tree size class
    c. Shrub size class
    d. Tree canopy closure
    e. Shrub canopy closure
5. Frequency Tables
    a. Cover type
    b. Canopy class
    c. Size class
    d. Life form
6. Color Figure: Classification of Land Cover Type for TM Scene
7. Description of Cover Types Mapped in Each TM Scene
8. Riparian Classification

TM SCENE P43/R26

Image Analyst: Troy P. Tady

Training Data Analysis

In all, 1053 ground-truth plots were available for labeling P43/R26 (see table, next page). The data were initially checked over the full scene to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 55) were removed from further analysis. The data were then examined by cover type to determine whether or not plots were collected for this project or for other purposes (e.g., pre-existing ECODATA, TSMRS, etc.). The following classes were manually labeled: urban, agriculture, water, snow, riparian, mines/quarries/gravel pits, sandy areas and shoreline/gravel bars. Points with these VEG_CLASS_CODEs were not used in the digital classification as either training or test data. Classes also excluded as per USFS decisions were: 3201, 4201, and 8101. The aspen (4101) cover type was combined with the general broadleaf forest class (4102) because adequate training data for these two classes were not available. The disturbed grasslands (3102) class was combined with foothills grassland (3101) because of negligible spectral differences between the two classes.

Of the remaining plots (n = 525), 20% were randomly selected from each cover type. These plots (n = 105) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

For the remaining 80% of this "filtered" data set (n = 420), plots were subjected to further spectral examination. Outliers were eliminated for each cover type based on knowledge of general spectral patterns for various ground features. Pre-existing ECODATA points (n = 85) were used as training data for the following classes: 4211, 4225, 4226, 4227, 4228, and 4229. ECODATA points were used as training data supplements for tree and shrub size classes, but were not used as accuracy test data points. Insufficient training data plots were available for one cover type, 4102 broadleaf forest (4 plots; when combined with 4101, 7 plots).

Training data for this and most of the other cover types were supplemented from data gathered during a Forest Service review session with Idaho Panhandle National Forest personnel, as well as from personal knowledge of individuals familiar with areas in the scene. A total of about 350 new training data plots were obtained through these review sessions.

Total plots in ground-truth file	1053	
Total 1994-95 field plots	730	
Plots sampled for P43/R26		387
Plots sampled for other scenes		343
Pre-existing plots (ECODATA, TSMRS, etc.)	323	
Plots with codes included in the classification	818	
Plots discards	293	
Pre-existing plots		238
'Bad duplicates'		37
'Good duplicates'		18
Potential training plots	525	
20% test		105
80% training		420
Supplemental plots	350	(+/-)
Total plots for training-- cover type	875	(+/-)
-- size class	181	
-- canopy cover	428	

Land Cover Types

Land cover types were labeled through a digital classification of 6 TM channels available for this scene (1, 2, 3, 4, 5, and 7) plus rescaled elevation (raw elevation value divided by 25). The digital classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2 , and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were assigned directly to the COVERTYPE field in the database attribute table. Further modifications were carried out using spectral class values (SPECTRAL_CLASS, or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000. Urban.	Manually identified and recoded by Troy Tady.
2000. Agriculture.	Manually identified and recoded by Steve Stegman.
3101. Foothills Grassland.	All grass types occurring below 1067 m (3500 ft) were relabeled as Foothills Grassland.
3104. Montane Parkland & Subalpine Meadow.	All grass types occurring at and above 1067 m (3500 ft) were relabeled as Montane Parkland & Subalpine Meadow.
3202. Warm Mesic Shrubland.	Shrub types were labeled as Warm Mesic Shrubland if they occurred below 1341 m (4400 ft). If they occurred between 1341 m (4400 ft) and 1646 m (5400

		ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
3203.	Cold Mesic Shrubland.	Shrub types were labeled as Cold Mesic Shrubland if they occurred above 1646 m (5400 ft). If they occurred between 1341 m (4400 ft) and 1646 m (5400 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
4102.	Broadleaf Forest.	This class was well represented by the 7 combined 4101 and 4102 training plots. Confusion with taller shrub types may be expected, however.
4203.	Lodgepole Pine.	At lower elevations in northern Idaho and eastern Washington, lodgepole distributions conformed data obtained from the Idaho Panhandle and Colville National Forests.
4206.	Ponderosa Pine.	The Idaho Panhandle and Colville National Forests provided additional training data for this type. The resulting distributions matched well with known Ponderosa Pine occurrences for this area, especially at low elevation and in river bottom lands.
4207.	Grand Fir.	Confusion between Grand Fir and Mixed Mesic Forest (4221) was evident in the training data and is reflected in the cover type accuracy assessment. This confusion is understandable because grand fir species component in the 4221 class tends to be very large in northern Idaho, and the species does not normally occur in monoculture stands.
4208.	Subalpine Fir.	Supplemental data for Subalpine Fir were provided by the Colville National Forest. Confusion with other high elevation cover types was evident in some areas of the scene.
4210.	Western Red Cedar.	Timber stand maps provided by the Idaho Panhandle National Forest were used to supplement the training set.
4211.	Western Hemlock.	Supplemental data for Western Hemlock were provided by the Idaho Panhandle National Forest. Seven ECODATA plots were also added to the training set. General mapped distribution for this class seems to match actual ground occurrences very well.
4212.	Douglas-fir.	No modifications.
4215.	Western Larch.	During the USFS review sessions, Western Larch was found to be confused with some shrub and broadleaf

		classes in younger plantations. Larch training data were supplemented by the Idaho Panhandle National Forest to help resolve this.
4219.	Mixed Whitebark Pine Forest.	Supplemental data for Mixed Whitebark Pine Forest were provided by the Idaho Panhandle National Forest for the Bonners Ferry District. General distribution for this class seems reasonable.
4220.	Mixed Subalpine Forest.	Supplemental data for Mixed Subalpine Forest were provided by the Colville and Idaho Panhandle National Forests. Very little confusion was noted between the Mixed Mesic Conifer (4221) class and the Mixed Subalpine Forest class, which seems to indicate that elevational breaks in the training data were representative of vegetational changes along the elevation gradient.
4221.	Mixed Mesic Forest.	See subclasses: 4211, 4225, 4226, 4227, 4228, 4229. The cover type accuracy assessment shows good results for 4221 subclasses, which are generally fairly difficult to delineate and label.
4222.	Mixed Xeric Forest.	No modifications. No supplemental data.
4223.	Douglas-fir - Lodgepole Pine.	No modifications.
4225.	Douglas-fir - Grand Fir.	Two ECODATA plots were added to the training data set to label this class.
4226.	Western Red Cedar - Grand Fir.	Only one ECODATA plot was available to supplement the training data set for this class.
4227.	Western Red Cedar - Western Hemlock.	Eleven ECODATA plots were used to supplement the training data set for this class.
4228.	Western Larch - Lodgepole Pine.	Two ECODATA plots were added to the training data set to label this class.
4229.	Douglas-fir - Western Larch.	Only one ECODATA plot was available to supplement the training data set for this class.
4301.	Broadleaf - Needleleaf Forest.	No modifications.
5000.	Water.	All regions with spectral class (LINK) = 1 and slope $\leq 5^{o}$ were labeled as water. Generally, water was more spectrally distinct than most other cover types, but in high mountainous terrain, it was confused with cliff shadows. A 5° slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate elevation and slope values, such that their slope may be greater than 5°.

		This would result in the misclassification of some small ponds or lakes.
7300.	Rock.	Supplemental plots were obtained to provide a better representation of spectral variation in the 7300 class. The following decision rule was used to aid in accurately mapping 7300: If 7300 and elevation <800 m , then 7800.
7400.	Barren Alpine Tundra.	An elevation cutoff of 8000 ft (2438 m) was used to separate 7400 from 7800. 7400 occurs only at elevations <8000 ft (2438 m).
7800.	Mixed Barren.	7800 occurs at ≥8000 ft (2438 m); see 7400.
9800.	Clouds.	Manually identified by Troy Tady.
9900.	Cloud Shadows.	Manually identified by Troy Tady.

A total of 32 classes were labeled in the full TM scene. These included two grass types, two shrub types, twenty forest types, plus eight non-vegetated or manually labeled classes. Cover types are mapped in Figure F-1.

Size Classes

Seven size classes were mapped -- four for forest cover types (seedling/sapling, pole, medium, and large/very large tree) and three for shrub cover (low, medium, and tall). Six TM spectral channels were used for the size classification (elevation was not included). The Nearest Member of Group (NMG) classifier was used for both tree and shrub size classes. Tree size classes were stratified based upon the three canopy cover classes described above.

Canopy Cover Classes

Canopy cover labels (CANOPY_CODE = low, medium, or high) were assigned to tree and shrub classes based on MNDVI values. These values were plotted as frequency histograms for all coniferous forest types (Figure F-1a), as well as for 3200 class shrub types (Figure F-1b). The histograms were examined to determine break points based upon the distribution modes (see table below). Regions with MNDVI values falling below the lower break point were assigned to a low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class.

	MNDVI BREAKPOINTS	
CANOPY COVER	Tree	Shrub
Low	<330	<220
Medium	≥330 and ≤725	≥220 and ≤310
High	>725	>310

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications.

CLASSIFICATIONS FOR P43/R26	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	26	84%	63%
Tree Size Class	4	93%	70%
Tree Canopy Class	3	98%	59%
Shrub Size Class	3	100%	100%
Shrub Canopy Class	3	94%	55%

Comments

Significant sources of supplementary data were probably responsible for the relatively high accuracy of the cover type classification. General distributions for most cover type classes (see *Land Cover Types*, above) were acceptable when viewed with the US Forest

Service representatives from the Idaho Panhandle National Forest. Furthermore, image maps for the Colville National Forest were constructed and used in the field to add approximately 200 points for the northwest portion of the contract area in scene P43/R26. These plots provided needed information for land cover types in western portions of the Idaho Panhandle National Forest where data were lacking.

Supplemental plots for tree size class were acquired using vegetation maps prepared by the Idaho Panhandle National Forest. These maps were very useful in helping to better define tree size classes and, in offering more training plots, made possible the stratification of tree size data by canopy cover.

The MNDVI breaks used to define tree canopy cover classes were fairly obvious from histograms generated from the Forest Service ground truth data set. The high accuracy value seems to reflect a good correlation between the MNDVI breaks and the canopy cover data provided by the Forest Service.

A large training set was not available for the shrub size classification. It should be noted that the 100% accuracy value reflects agreement between only three test data points (one point for each canopy class) and the classified data.

Shrub canopy classes, derived from MNDVI values were difficult to assess given the non-representative range of variation for MNDVI contained within the Forest Service ground truth plots. Several attempts were made to adequately define shrub canopy classes using various MNDVI breaks. The accuracy listed for shrub canopy cover seems to indicate a good correlation between the MNDVI breaks used and some of the more representative plots in the Forest Service ground truth set.

Special recognition goes to personnel on the Colville National Forest, Newport Ranger District, for their time, knowledge, and aid in providing additional land-cover data.

Error Matrix For Cover Type Training Plots
Scene P43/R26

PLOT COVER TYPES	CLASSIFIED COVER TYPES																		
	3101	3201	4102	4203	4206	4207	4208	4210	4212	4215	4219	4220	4221	4222	4223	4301	7301	7800	SUM
3101	64	15	0	0	3	0	0	0	0	0	0	0	1	1	0	2	6	3	95
3201	12	39	2	2	7	0	2	0	0	1	0	0	4	0	0	1	0	4	74
4102	1	1	2	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	7
4203	1	3	0	21	0	0	2	1	4	1	0	0	5	0	1	1	0	0	40
4206	0	2	0	0	38	0	0	0	0	0	0	0	0	1	0	1	0	0	42
4207	0	0	0	1	0	17	1	2	1	1	0	0	0	0	2	3	0	0	28
4208	1	0	0	2	0	2	34	0	0	2	0	4	5	0	4	0	0	0	54
4210	0	0	0	1	1	4	1	19	6	3	0	0	12	0	1	1	0	0	49
4212	0	0	0	3	0	0	1	4	36	1	0	0	10	0	1	2	0	1	59
4215	0	1	0	0	0	2	0	2	2	36	0	0	1	1	0	1	0	0	46
4219	0	0	0	0	0	0	2	0	0	0	15	3	1	0	0	0	0	0	21
4220	0	0	0	0	0	1	5	1	0	1	1	37	2	0	0	0	1	0	49
4221	1	5	0	7	3	5	8	13	9	4	2	3	51	2	3	10	0	3	129
4222	0	2	0	1	2	0	0	0	0	0	0	0	1	0	0	0	0	0	6
4223	0	0	0	1	0	0	3	0	0	2	0	0	2	0	31	0	0	0	39
4301	1	4	0	1	0	1	0	2	1	2	0	0	11	0	0	29	1	0	53
7301	6	2	0	1	1	0	0	0	0	0	0	4	0	0	1	0	9	0	24
7800	1	3	0	0	1	0	0	0	1	0	0	1	2	0	0	0	1	8	18
SUM	88	77	4	41	57	32	59	44	60	54	18	52	108	5	44	52	19	19	833

% AGREEMENT	58.34
TAU WITH EQUAL PROBABILITY	0.559
TOTAL DIAGONAL ELEMENTS	486
TOTAL TRAINING PLOTS IN DATA SET	833

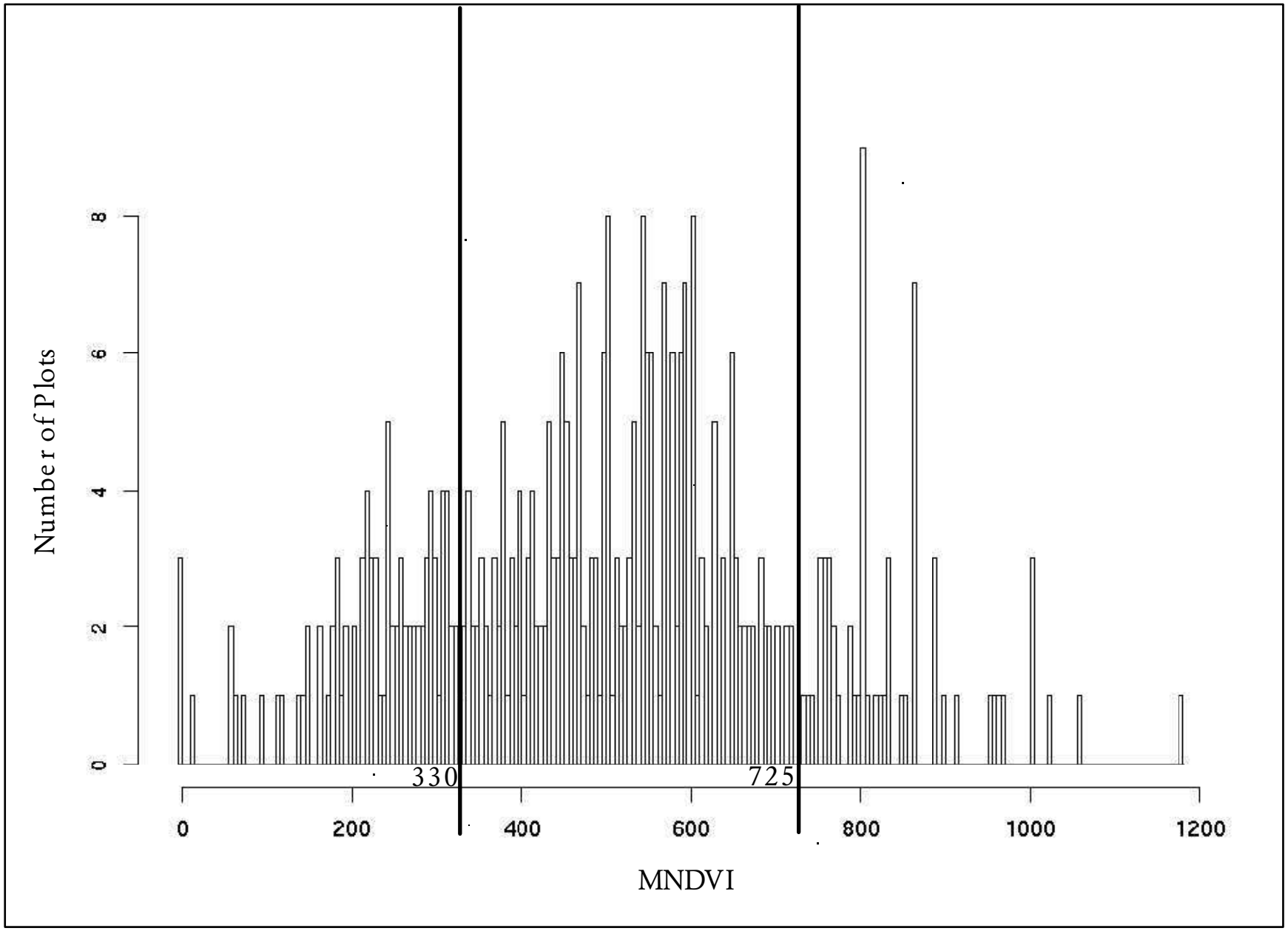


Figure F-1a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P43/R26

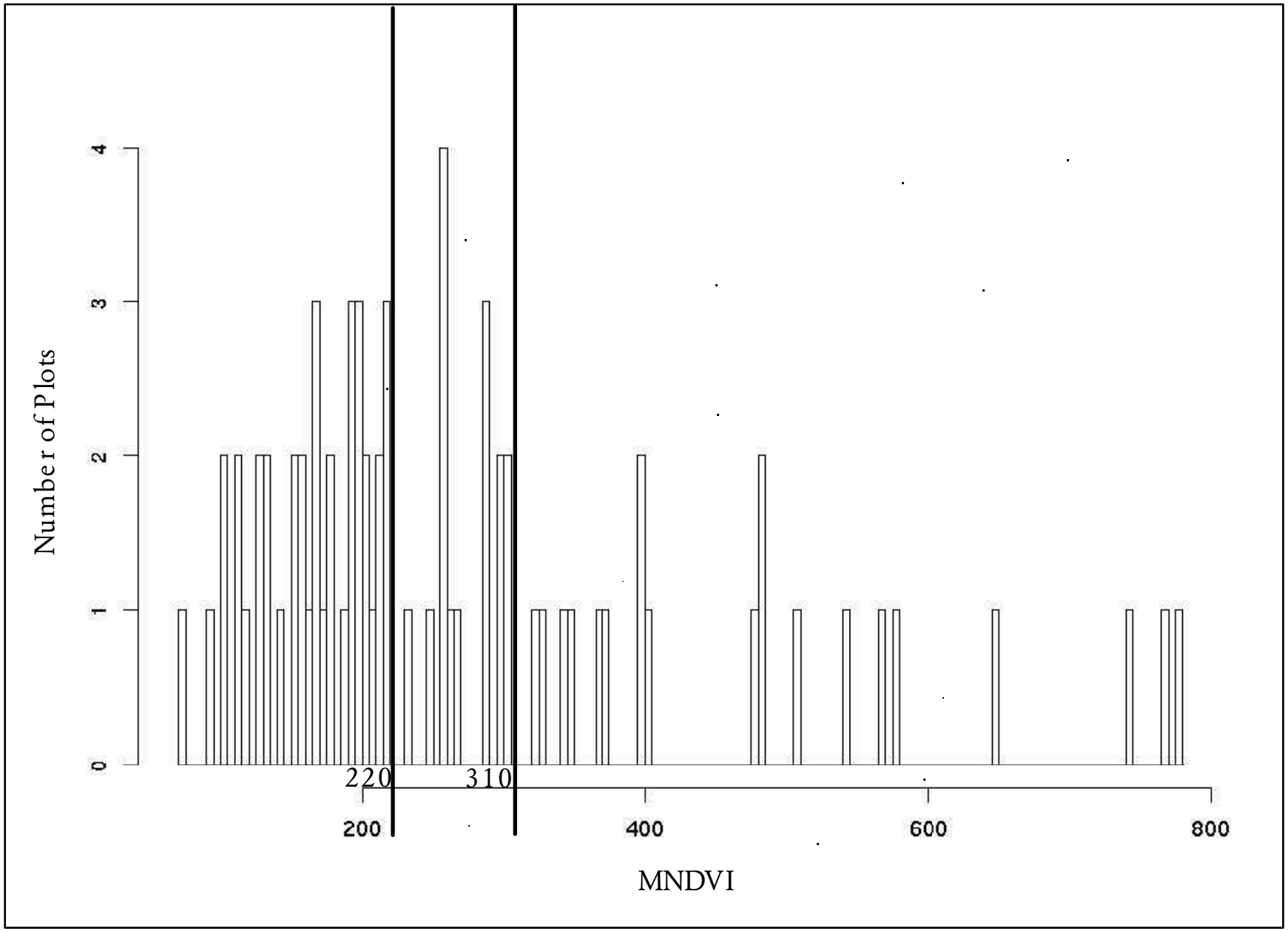


Figure F-1b. Breaks between shrub canopy cover classes in relation to MNDVI values: TM scene P43/R26

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3102	3104	3202	3203	4102	4203	4206	4207
3101	6(5)	0(3)	1(3)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3102	2(3)	0(5)	0(2)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3104	0(3)	0(3)	1(5)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)
3202	0(1)	0(1)	0(1)	5(5)	0(3)	0(1)	1(1)	0(1)	0(1)
3203	0(1)	0(1)	0(1)	1(3)	0(5)	0(1)	0(1)	0(1)	0(1)
4102	0(1)	0(1)	0(1)	0(1)	0(1)	2(5)	0(2)	0(2)	0(2)
4203	0(1)	0(1)	0(1)	1(1)	0(1)	0(2)	1(5)	0(2)	0(2)
4206	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	2(5)	0(2)
4207	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	1(5)
4208	0(1)	0(1)	1(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)
4210	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)
4211	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)
4212	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)
4219	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)	0(2)	0(2)
4220	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)	0(2)	0(2)
4221	0(1)	0(1)	0(1)	2(1)	0(1)	0(2)	1(3)	1(2)	1(3)
4222	1(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(3)	0(2)
4223	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)	0(2)	0(2)
4225	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(4)
4226	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(4)
4227	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)
4228	0(1)	0(1)	0(1)	1(1)	0(1)	0(2)	0(3)	0(2)	0(2)
4229	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)
4301	0(1)	0(1)	0(1)	0(1)	0(1)	0(3)	0(2)	0(2)	0(3)
7300	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7800	0(2)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	9(0)	0(0)	3(0)	10(0)	0(0)	2(0)	3(0)	4(0)	2(0)

Accuracy Assessment Tables for P43/R26 -- Cover Type

RF/CF	4208	4210	4211	4212	4219	4220	4221	4222	4223
3101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3104	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3202	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3203	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4102	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4203	0(2)	0(2)	0(2)	0(2)	0(3)	0(3)	0(3)	0(2)	0(4)
4206	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(3)	0(4)	0(2)
4207	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(3)	0(2)	1(2)
4208	4(5)	0(2)	0(2)	0(2)	0(3)	0(3)	0(3)	0(2)	0(2)
4210	0(2)	2(5)	0(3)	0(2)	0(2)	0(2)	0(3)	0(2)	0(2)
4211	0(2)	0(3)	0(5)	0(2)	0(2)	0(2)	1(3)	0(2)	0(2)
4212	0(2)	2(2)	0(2)	6(5)	0(2)	0(3)	1(3)	0(4)	0(4)
4219	0(3)	0(2)	0(2)	0(2)	3(5)	1(3)	0(2)	0(2)	0(2)
4220	0(3)	0(2)	0(2)	0(3)	0(3)	1(5)	0(2)	0(2)	0(3)
4221	0(2)	1(3)	2(3)	1(3)	0(2)	0(2)	6(5)	0(2)	0(3)
4222	0(2)	0(2)	0(2)	0(3)	0(2)	0(2)	0(2)	1(5)	0(2)
4223	0(2)	0(2)	0(2)	0(3)	0(2)	0(3)	1(3)	0(2)	1(5)
4225	0(2)	0(2)	0(2)	0(3)	0(2)	0(2)	0(4)	0(2)	0(3)
4226	0(2)	0(3)	0(3)	0(2)	0(2)	0(2)	0(4)	0(2)	0(2)
4227	0(2)	0(3)	1(3)	0(2)	0(2)	0(2)	3(4)	0(2)	0(2)
4228	0(2)	0(2)	0(2)	0(2)	0(2)	0(3)	1(4)	0(2)	0(4)
4229	0(2)	0(2)	0(2)	1(3)	0(2)	0(3)	0(4)	0(2)	0(4)
4301	0(2)	1(3)	0(2)	1(2)	0(2)	0(3)	0(3)	0(3)	0(3)
7300	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7800	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	4(0)	6(0)	3(0)	10(0)	3(0)	2(0)	13(0)	1(0)	(0)

Accuracy Assessment Tables for P43/R26 -- Cover Type

RF/CF	4225	4226	4227	4228	4229	4301	7300	7800	SUM
3101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	8(0)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(0)
3104	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(0)
3202	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	7(0)
3203	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(0)
4102	0(2)	0(2)	0(2)	0(2)	0(2)	0(4)	0(1)	0(1)	2(0)
4203	0(2)	0(2)	0(2)	0(4)	0(2)	0(2)	0(1)	0(1)	2(0)
4206	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)	2(0)
4207	0(4)	0(4)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)	2(0)
4208	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)	5(0)
4210	0(2)	0(4)	0(4)	0(2)	0(2)	0(2)	0(1)	0(1)	2(0)
4211	0(2)	0(3)	1(4)	0(2)	0(2)	0(2)	0(1)	0(1)	2(0)
4212	0(4)	0(2)	0(2)	0(2)	0(4)	0(2)	0(1)	0(1)	10(0)
4219	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)	4(0)
4220	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)	1(0)
4221	2(4)	0(4)	2(4)	2(4)	2(4)	1(2)	0(1)	0(1)	24(0)
4222	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)	2(0)
4223	0(3)	0(2)	0(2)	0(4)	0(4)	0(2)	0(1)	0(1)	2(0)
4225	1(5)	0(3)	0(3)	1(3)	0(3)	0(2)	0(1)	0(1)	2(0)
4226	0(3)	0(5)	1(4)	0(3)	0(3)	0(2)	0(1)	0(1)	1(0)
4227	0(3)	0(4)	1(5)	0(3)	0(3)	0(2)	0(1)	0(1)	5(0)
4228	0(3)	0(3)	0(3)	0(5)	0(4)	0(2)	0(1)	0(1)	2(0)
4229	1(3)	0(3)	0(3)	0(4)	0(5)	0(2)	0(1)	0(1)	2(0)
4301	0(3)	0(3)	0(3)	0(3)	0(3)	3(5)	0(1)	0(1)	5(0)
7300	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	3(5)	0(3)	3(0)
7800	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(3)	2(5)	2(0)
SUM	4(0)	0(0)	5(0)	3(0)	2(0)	5(0)	3(0)	2(0)	103(0)

Diagonal Elements = 52; Total Test Points = 103
Percentage Agreement = 50.49; Kappa = 0.469; Tau w/equal Prob = 0.485

2 points do not belong to groups listed in the test data and were treated as misclassifications. Default score for these 2 points = 1

Accuracy Assessment Tables for P43/R26 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	6	75.00	0	0.00	1	12.50	0	0.00	1	12.50
3102	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00
3104	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
3202	5	71.43	0	0.00	0	0.00	0	0.00	2	28.57
3203	0	0.00	0	0.00	1	50.00	0	0.00	1	50.00
4102	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4206	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4207	1	50.00	0	0.00	0	0.00	1	50.00	0	0.00
4208	4	80.00	0	0.00	0	0.00	0	0.00	1	20.00
4210	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4211	0	0.00	1	50.00	1	50.00	0	0.00	0	0.00
4212	6	60.00	0	0.00	1	10.00	2	20.00	1	10.00
4219	3	75.00	0	0.00	1	25.00	0	0.00	0	0.00
4220	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4221	6	25.00	8	33.33	6	25.00	2	8.33	2	8.33
4222	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4223	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
4225	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
4226	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
4227	1	20.00	3	60.00	1	20.00	0	0.00	0	0.00
4228	0	0.00	1	50.00	0	0.00	0	0.00	1	50.00
4229	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00
4301	3	60.00	0	0.00	1	20.00	1	20.00	0	0.00
7300	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	52	50.49	14	13.59	19	18.45	6	5.83	12	11.65

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	6	75.00	6	75.00	7	87.50	7	87.50	8	100.00
3102	0	0.00	0	0.00	2	100.00	2	100.00	2	100.00
3104	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
3202	5	71.43	5	71.43	5	71.43	5	71.43	7	100.00
3203	0	0.00	0	0.00	1	50.00	1	50.00	2	100.00
4102	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4203	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4206	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4207	1	50.00	1	50.00	1	50.00	2	100.00	2	100.00
4208	4	80.00	4	80.00	4	80.00	4	80.00	5	100.00
4210	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4211	0	0.00	1	50.00	2	100.00	2	100.00	2	100.00
4212	6	60.00	6	60.00	7	70.00	9	90.00	10	100.00
4219	3	75.00	3	75.00	4	100.00	4	100.00	4	100.00
4220	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4221	6	25.00	14	58.33	20	83.33	22	91.67	24	100.00
4222	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4223	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
4225	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
4226	0	0.00	1	100.00	1	100.00	1	100.00	1	100.00
4227	1	20.00	4	80.00	5	100.00	5	100.00	5	100.00
4228	0	0.00	1	50.00	1	50.00	1	50.00	2	100.00
4229	0	0.00	0	0.00	2	100.00	2	100.00	2	100.00
4301	3	60.00	3	60.00	4	80.00	5	100.00	5	100.00
7300	3	100.00	3	100.00	3	100.00	3	100.00	3	100.00
7800	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
SUM	52	50.49	66	64.08	85	82.52	91	88.35	103	100.00

Accuracy Assessment Tables for P43/R26 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	6	66.67	0	0.00	2	22.22	0	0.00	1	11.11
3102	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3104	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
3202	5	50.00	0	0.00	1	10.00	0	0.00	4	40.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4102	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
4206	2	50.00	0	0.00	0	0.00	1	25.00	1	25.00
4207	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
4208	4	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4210	2	33.33	0	0.00	2	33.33	2	33.33	0	0.00
4211	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00
4212	6	60.00	0	0.00	2	20.00	1	10.00	1	10.00
4219	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4220	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
4221	6	46.15	4	30.77	3	23.08	0	0.00	0	0.00
4222	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4223	1	50.00	0	0.00	0	0.00	1	50.00	0	0.00
4225	1	25.00	2	50.00	1	25.00	0	0.00	0	0.00
4226	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4227	1	20.00	4	80.00	0	0.00	0	0.00	0	0.00
4228	0	0.00	2	66.67	1	33.33	0	0.00	0	0.00
4229	0	0.00	2	100.00	0	0.00	0	0.00	0	0.00
4301	3	60.00	0	0.00	0	0.00	1	20.00	1	20.00
7300	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	52	51.49	14	13.86	19	18.81	6	5.94	10	9.90

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	6	66.67	6	66.67	8	88.89	8	88.89	9	100.00
3102	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3104	1	33.33	1	33.33	2	66.67	2	66.67	3	100.00
3202	5	50.00	5	50.00	6	60.00	6	60.00	10	100.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4102	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4203	1	33.33	1	33.33	2	66.67	2	66.67	3	100.00
4206	2	50.00	2	50.00	2	50.00	3	75.00	4	100.00
4207	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
4208	4	100.00	4	100.00	4	100.00	4	100.00	4	100.00
4210	2	33.33	2	33.33	4	66.67	6	100.00	6	100.00
4211	0	0.00	0	0.00	3	100.00	3	100.00	3	100.00
4212	6	60.00	6	60.00	8	80.00	9	90.00	10	100.00
4219	3	100.00	3	100.00	3	100.00	3	100.00	3	100.00
4220	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
4221	6	46.15	10	76.92	13	100.00	13	100.00	13	100.00
4222	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4223	1	50.00	1	50.00	1	50.00	2	100.00	2	100.00
4225	1	25.00	3	75.00	4	100.00	4	100.00	4	100.00
4226	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4227	1	20.00	5	100.00	5	100.00	5	100.00	5	100.00
4228	0	0.00	2	66.67	3	100.00	3	100.00	3	100.00
4229	0	0.00	2	100.00	2	100.00	2	100.00	2	100.00
4301	3	60.00	3	60.00	3	60.00	4	80.00	5	100.00
7300	3	100.00	3	100.00	3	100.00	3	100.00	3	100.00
7800	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
SUM	52	51.49	66	65.35	85	84.16	91	90.10	101	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	39	75.00	0	0.00	6	12.50	0	0.00	6	12.50
3102	0	0.00	0	0.00	0	100.00	0	0.00	0	0.00
3104	15	50.00	0	0.00	0	0.00	0	0.00	15	50.00
3202	39	71.43	0	0.00	0	0.00	0	0.00	16	28.57
3203	0	0.00	0	0.00	2	50.00	0	0.00	2	50.00
4102	8	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	32	50.00	0	0.00	0	0.00	0	0.00	32	50.00
4206	22	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4207	15	50.00	0	0.00	0	0.00	15	50.00	0	0.00
4208	80	80.00	0	0.00	0	0.00	0	0.00	20	20.00
4210	67	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4211	0	0.00	9	50.00	9	50.00	0	0.00	0	0.00
4212	43	60.00	0	0.00	7	10.00	14	20.00	7	10.00
4219	42	75.00	0	0.00	14	25.00	0	0.00	0	0.00
4220	98	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4221	30	25.00	40	33.33	30	25.00	10	8.33	10	8.33
4222	4	50.00	0	0.00	0	0.00	0	0.00	4	50.00
4223	19	50.00	0	0.00	19	50.00	0	0.00	0	0.00
4225	7	50.00	0	0.00	7	50.00	0	0.00	0	0.00
4226	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
4227	9	20.00	27	60.00	9	20.00	0	0.00	0	0.00
4228	0	0.00	7	50.00	0	0.00	0	0.00	7	50.00
4229	0	0.00	0	0.00	15	100.00	0	0.00	0	0.00
4301	16	60.00	0	0.00	5	20.00	5	20.00	0	0.00
7300	20	100.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	20	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	625	62.81	84	8.44	123	12.36	44	4.42	119	11.96

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	39	75.00	39	75.00	45	87.50	45	87.50	51	100.00
3102	0	0.00	0	0.00	0	100.00	0	100.00	0	100.00
3104	15	50.00	15	50.00	15	50.00	15	50.00	30	100.00
3202	39	71.43	39	71.43	39	71.43	39	71.43	55	100.00
3203	0	0.00	0	0.00	2	50.00	2	50.00	4	100.00
4102	8	100.00	8	100.00	8	100.00	8	100.00	8	100.00
4203	32	50.00	32	50.00	32	50.00	32	50.00	65	100.00
4206	22	100.00	22	100.00	22	100.00	22	100.00	22	100.00
4207	15	50.00	15	50.00	15	50.00	30	100.00	30	100.00
4208	80	80.00	80	80.00	80	80.00	80	80.00	100	100.00
4210	67	100.00	67	100.00	67	100.00	67	100.00	67	100.00
4211	0	0.00	9	50.00	19	100.00	19	100.00	19	100.00
4212	43	60.00	43	60.00	51	70.00	65	90.00	72	100.00
4219	42	75.00	42	75.00	56	100.00	56	100.00	56	100.00
4220	98	100.00	98	100.00	98	100.00	98	100.00	98	100.00
4221	30	25.00	70	58.33	100	83.33	111	91.67	121	100.00
4222	4	50.00	4	50.00	4	50.00	4	50.00	8	100.00
4223	19	50.00	19	50.00	39	100.00	39	100.00	39	100.00
4225	7	50.00	7	50.00	14	100.00	14	100.00	14	100.00
4226	0	0.00	1	100.00	1	100.00	1	100.00	1	100.00
4227	9	20.00	36	80.00	45	100.00	45	100.00	45	100.00
4228	0	0.00	7	50.00	7	50.00	7	50.00	13	100.00
4229	0	0.00	0	0.00	15	100.00	15	100.00	15	100.00
4301	16	60.00	16	60.00	22	80.00	27	100.00	27	100.00
7300	20	100.00	20	100.00	20	100.00	20	100.00	20	100.00
7800	20	100.00	20	100.00	20	100.00	20	100.00	20	100.00
SUM	625	62.50	709	70.90	836	83.60	881	88.10	1000	100.00

Accuracy Assessment Tables for P43/R26 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	4	SUM
1	1(5)	2(3)	1(1)	0(1)	4(0)
2	1(3)	1(5)	3(3)	0(1)	5(0)
3	1(1)	0(3)	18(5)	2(3)	21(0)
4	0(1)	0(1)	1(3)	1(5)	2(0)
sum	3(0)	3(0)	23(0)	3(0)	32(0)

Diagonal Elements = 21; Total Test Points = 32
Percentage Agreement = 65.62; Kappa = 0.307; Tau w/equal Prob = 0.542

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	25.00	0	0.00	2	50.00	0	0.00	1	25.00
2	1	20.00	0	0.00	4	80.00	0	0.00	0	0.00
3	18	85.71	0	0.00	2	9.52	0	0.00	1	4.76
4	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
SUM	21	65.62	0	0.00	9	28.12	0	0.00	2	6.25

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	25.00	1	25.00	3	75.00	3	75.00	4	100.00
2	1	20.00	1	20.00	5	100.00	5	100.00	5	100.00
3	18	85.71	18	85.71	20	95.24	20	95.24	21	100.00
4	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
SUM	21	65.62	21	65.62	30	93.75	30	93.75	32	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
2	1	33.33	0	0.00	2	66.67	0	0.00	0	0.00
3	18	78.26	0	0.00	4	17.39	0	0.00	1	4.35
4	1	33.33	0	0.00	2	66.67	0	0.00	0	0.00
SUM	21	65.62	0	0.00	9	28.12	0	0.00	2	6.25

Accuracy Assessment Tables for P43/R26 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	33.33	1	33.33	2	66.67	2	66.67	3	100.00
2	1	33.33	1	33.33	3	100.00	3	100.00	3	100.00
3	18	78.26	18	78.26	22	95.65	22	95.65	23	100.00
4	1	33.33	1	33.33	3	100.00	3	100.00	3	100.00
SUM	21	65.62	21	65.62	30	93.75	30	93.75	32	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	35	25.00	0	0.00	69	50.00	0	0.00	35	25.00
2	18	20.00	0	0.00	74	80.00	0	0.00	0	0.00
3	626	85.71	0	0.00	70	9.52	0	0.00	35	4.76
4	20	50.00	0	0.00	20	50.00	0	0.00	0	0.00
SUM	699	69.76	0	0.00	233	23.25	0	0.00	70	6.99

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	35	25.00	35	25.00	104	75.00	104	75.00	139	100.00
2	18	20.00	18	20.00	92	100.00	92	100.00	92	100.00
3	626	85.71	626	85.71	695	95.24	695	95.24	730	100.00
4	20	50.00	20	50.00	39	100.00	39	100.00	39	100.00
SUM	699	69.90	699	69.90	930	93.00	930	93.00	1000	100.00

Accuracy Assessment Tables for P43/R26 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	1(5)	0(3)	0(1)	1(0)
2	0(3)	1(5)	0(3)	1(0)
3	0(1)	0(3)	1(5)	1(0)
SUM	1(0)	1(0)	1(0)	3(0)

Diagonal Elements = 3; Total Test Points = 3
Percentage Agree = 100.00; Kappa = 1.000; Tau of Equal Prob = 1.000

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
2	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	3	100.00	3	100.00	3	100.00	3	100.00	3	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
2	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	3	100.00	3	100.00	3	100.00	3	100.00	3	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	276	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	255	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3	469	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	1000	100.00	0	0.00	0	0.00	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	276	100.00	276	100.00	276	100.00	276	100.00	276	100.00
2	255	100.00	255	100.00	255	100.00	255	100.00	255	100.00
3	469	100.00	469	100.00	469	100.00	469	100.00	469	100.00
sum	1000	100.00	1000	100.00	1000	100.00	1000	100.00	1000	100.00

** CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	0
1	4(5)	2(3)	1(1)	10(0)
2	0(3)	1(5)	2(3)	3(0)
3	0(1)	0(3)	2(5)	2(0)
0	4(0)	3(0)	5(0)	15(0)

Diagonal Elements = 7; Total Test Points = 15
Percentage Agreement = 46.67; Tau w/equal prob = 0.200

3 points did not belong to groups listed in the test data and were treated as mis-classifications. Default score for these 3 points = 1

Accuracy Assessment Tables for P43/R26 -- Shrub Size Class

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	40.00	0	0.00	2	20.00	0	0.00	4	40.00
2	1	33.33	0	0.00	2	66.67	0	0.00	0	0.00
3	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	7	46.67	0	0.00	4	26.67	0	0.00	4	26.67

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	40.00	4	40.00	6	60.00	6	60.00	10	100.00
2	1	33.33	1	33.33	3	100.00	3	100.00	3	100.00
3	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
SUM	7	46.67	7	46.67	11	73.33	11	73.33	15	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	1	33.33	0	0.00	2	66.67	0	0.00	0	0.00
3	2	40.00	0	0.00	2	40.00	0	0.00	1	20.00
SUM	7	58.33	0	0.00	4	33.33	0	0.00	1	8.33

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	100.00	4	100.00	4	100.00	4	100.00	4	100.00
2	1	33.33	1	33.33	3	100.00	3	100.00	3	100.00
3	2	40.00	2	40.00	4	80.00	4	80.00	5	100.00
SUM	7	58.33	7	58.33	11	91.67	11	91.67	12	100.00

Accuracy Assessment Tables for P43/R26 -- Shrub Size Class

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	108	40.00	0	0.00	54	20.00	0	0.00	108	40.00
2	86	33.33	0	0.00	172	66.67	0	0.00	0	0.00
3	472	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	666	66.60	0	0.00	226	22.60	0	0.00	108	10.80

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	108	40.00	108	40.00	163	60.00	163	60.00	271	100.00
2	86	33.33	86	33.33	257	100.00	257	100.00	257	100.00
3	472	100.00	472	100.00	472	100.00	472	100.00	472	100.00
SUM	666	66.60	666	66.60	892	89.20	892	89.20	1000	100.00

Accuracy Assessment Tables for P43/R26 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	9(5)	3(3)	1(1)	13(0)
2	6(3)	22(5)	6(3)	34(0)
3	1(1)	16(3)	9(5)	26(0)
SUM	16(0)	41(0)	16(0)	73(0)

Diagonal Elements = 40; Total Test Points = 73
Percentage Agreement = 54.79; Kappa = 0.272; Tau w/equal Prob = 0.322

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	69.23	0	0.00	3	23.08	0	0.00	1	7.69
2	22	64.71	0	0.00	12	35.29	0	0.00	0	0.00
3	9	34.62	0	0.00	16	61.54	0	0.00	1	3.85
SUM	40	54.79	0	0.00	31	42.47	0	0.00	2	2.74

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	69.23	9	69.23	12	92.31	12	92.31	13	100.00
2	22	64.71	22	64.71	34	100.00	34	100.00	34	100.00
3	9	34.62	9	34.62	25	96.15	25	96.15	26	100.00
SUM	40	54.79	40	54.79	71	97.26	71	97.26	73	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	56.25	0	0.00	6	37.50	0	0.00	1	6.25
2	22	53.66	0	0.00	19	46.34	0	0.00	0	0.00
3	9	56.25	0	0.00	6	37.50	0	0.00	1	6.25
SUM	40	54.79	0	0.00	31	42.47	0	0.00	2	2.74

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	56.25	9	56.25	15	93.75	15	93.75	16	100.00
2	22	53.66	22	53.66	41	100.00	41	100.00	41	100.00
3	9	56.25	9	56.25	15	93.75	15	93.75	16	100.00
SUM	40	54.79	40	54.79	71	97.26	71	97.26	73	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	115	69.23	0	0.00	38	23.08	0	0.00	13	7.69
2	404	64.71	0	0.00	220	35.29	0	0.00	0	0.00
3	73	34.62	0	0.00	129	61.54	0	0.00	8	3.85
SUM	592	59.20	0	0.00	387	38.70	0	0.00	21	2.10

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	115	69.23	115	69.23	153	92.31	153	92.31	166	100.00
2	404	64.71	404	64.71	624	100.00	624	100.00	624	100.00
3	73	34.62	73	34.62	202	96.15	202	96.15	210	100.00
SUM	592	59.20	592	59.20	979	97.90	979	97.90	1000	100.00

Accuracy Assessment Tables for P43/R26 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	2(5)	0(3)	0(1)	2(0)
2	3(3)	1(5)	0(3)	4(0)
3	1(1)	2(3)	1(5)	4(0)
SUM	6(0)	3(0)	1(0)	10(0)

Diagonal Elements = 4; Total Test Points = 10
Percentage Agreement = 40.00; Kappa = 0.167; Tau w/equal Prob = 0.100

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	1	25.00	0	0.00	3	75.00	0	0.00	0	0.00
3	1	25.00	0	0.00	2	50.00	0	0.00	1	25.00
SUM	4	40.00	0	0.00	5	50.00	0	0.00	1	10.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
2	1	25.00	1	25.00	4	100.00	4	100.00	4	100.00
3	1	25.00	1	25.00	3	75.00	3	75.00	4	100.00
SUM	4	40.00	4	40.00	9	90.00	9	90.00	10	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	33.33	0	0.00	3	50.00	0	0.00	1	16.67
2	1	33.33	0	0.00	2	66.67	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	4	40.00	0	0.00	5	50.00	0	0.00	1	10.00

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	33.33	2	33.33	5	83.33	5	83.33	6	100.00
2	1	33.33	1	33.33	3	100.00	3	100.00	3	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	4	40.00	4	40.00	9	90.00	9	90.00	10	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	399	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	88	25.00	0	0.00	264	75.00	0	0.00	0	0.00
3	62	25.00	0	0.00	124	50.00	0	0.00	62	25.00
SUM	549	54.95	0	0.00	388	38.84	0	0.00	62	6.21

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	399	100.00	399	100.00	399	100.00	399	100.00	399	100.00
2	88	25.00	88	25.00	352	100.00	352	100.00	352	100.00
3	62	25.00	62	25.00	187	75.00	187	75.00	249	100.00
SUM	549	54.90	549	54.90	938	93.80	938	93.80	1000	100.00

Scene P43/R26 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	196276.0	1707238.8	54.0
1000	39.0	2857.0	0.1
2000	3467.0	47084.2	1.5
3101	5646.0	33263.2	1.1
3104	4260.0	32542.6	1.0
3202	11365.0	70786.2	2.2
3203	944.0	7378.2	0.2
4102	1317.0	7015.7	0.2
4203	10798.0	91292.1	2.9
4206	4363.0	27604.0	0.9
4207	4421.0	35116.5	1.1
4208	14164.0	125394.8	4.0
4210	11695.0	102404.3	3.2
4211	2724.0	34119.8	1.1
4212	13028.0	104734.4	3.3
4215	7630.0	61141.4	1.9
4219	7604.0	36143.2	1.1
4220	10788.0	116095.4	3.7
4221	18481.0	175375.3	5.5
4222	989.0	6092.3	0.2
4223	5829.0	44357.4	1.4
4225	1996.0	17794.9	0.6
4226	119.0	934.9	0.0
4227	6205.0	73072.4	2.3
4228	1566.0	18409.0	0.6
4229	2181.0	22874.2	0.7
4301	5634.0	37495.6	1.2
5000	789.0	79602.6	2.5
7300	2618.0	24298.9	0.8
7400	4.0	18.5	0.0
7800	2400.0	19208.7	0.6

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	196276.0	1707238.8	54.0
Not tree/shrub	19223.0	238875.8	7.6
Shrub 1	5440.0	31760.0	1.0
Shrub 2	4339.0	28523.9	0.9
Shrub 3	2530.0	17880.5	0.6
Tree 1	28026.0	156887.5	5.0
Tree 2	81287.0	713731.9	22.6
Tree 3	22219.0	266848.3	8.4

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	196276.0	1707238.8	54.0
Not tree/shrub	19223	238875.8	7.6
Tree 1	19732.0	162741.2	5.1
Tree 2	12074.0	115096.1	3.6
Tree 3	94122.0	818073.6	25.9
Tree 4	5604.0	41556.7	1.3
Shrub 1	4228.0	24458.8	0.8
Shrub 2	2972.0	18674.4	0.6
Shrub 3	5109.0	35031.2	1.1

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	196276.0	1707238.8	54.0
A	3467.0	47084.2	1.5
H	9906.0	65805.8	2.1
N	5850.0	125985.7	4.0
S	12309.0	78164.4	2.5
T	131532.0	1137467.6	36.0

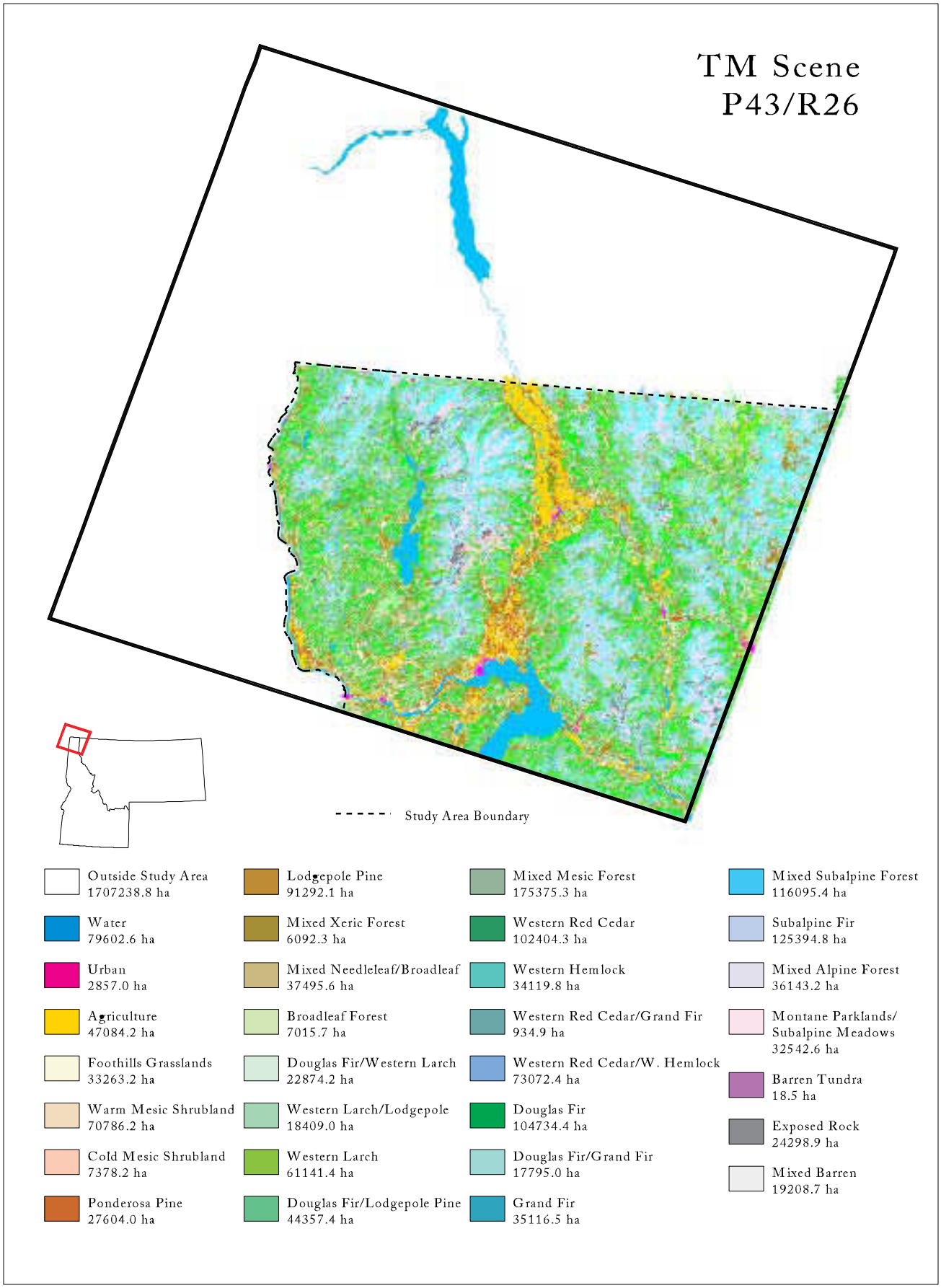


Figure F-1. Classification of land cover types for TM Scene P43/R26.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P43/R26

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4201: ENGELMANN SPRUCE FOREST

Conifer forest dominated by Engelmann spruce (Picea engelmannii) ranging from 2840 to 5480 feet in elevation. The average canopy cover is 33%, ranging from 3-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western larch (Larix occidentalis), and western red cedar (Thuja plicata) with average percent cover ≥6% and ≤11% and frequency of occurrence ≥15% and ≤85%.

Primary associated shrub species with ≥31% and ≤77% frequency of occurrence in Engelmann spruce stands: sitka alder (Alnus sinuata), Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea), swamp current (Ribes lacustre), thimbleberry (Rubus parviflorum), red elderberry (Sambucus racemosa), and big huckleberry (Vaccinium membranaceum).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤54% frequency of occurrence in Engelmann spruce stands: **graminoids**: Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), small-winged sedge (Carex microtera), dropping woodreed (Cinna latifolia), blue wildrye (Elymus glaucus), small-flowered woodrush, and nodding trisetum (Trisetum cernuum); **forbs**: heart-leaf arnica (Arnica cordifolia), queen's cup beadlily (Clintonia uniflora), sweetscented bedstraw (Galium triflorum), one-sided wintergreen (Pyrola secunda), trefoil foamflower (Tiarella trifoliata), green false hellebore (Veratrum viride), and pioneer violet (Viola glabella); **ferns**: ladyfern (Athyrium filix-femina), mountain wood-fern (Dryopteris austriaca), oak-fern (Gymnocarpium dryopteris), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

2) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 2175 to 5200 feet in elevation. The average canopy cover is 44% ranging from 20-70% total cover and frequency of occurrence equal to 96%. Primary associated tree species include western larch (Larix occidentalis), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover equal to 3% and frequency of occurrence ≥30% and ≤37%.

Primary associated shrub species with ≥26% and ≤48% frequency of occurrence in lodgepole pine stands: creeping Oregon grape (Berberis repens), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤44% frequency of occurrence in lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens); **forbs**: heart-leaf arnica (Arnica cordifolia), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), white-flowered hawkweed (Hieracium albiflorum), pink wintergreen (Pyrola asarifolia), pioneer violet (Viola glabella), and beargrass (Xerophyllum tenax); **ferns**: oak-fern (Gymnocarpium dryopteris) and brackenfern (Pteridium aquilinum); **moss**: none.

3) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 2142 to 3680 feet in elevation. The average canopy cover is 34% ranging from 10-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include lodgepole pine (Pinus contorta), Douglas-fir (Pseudotsuga menziesii), and western red cedar (Thuja plicata) with average percent cover ≥1% and ≤10% and frequency of occurrence ≥11% and ≤78%.

Primary associated shrub species with ≥11% and ≤33% frequency of occurrence in ponderosa pine stands: kinnikinnick (Arctostaphylos uva-ursi), ocean-spray (Holodiscus discolor), mockorange (Philadelphus lewisii), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and dwarf huckleberry (Vaccinium caespitosum).

Primary associated graminoid, forb, fern, and moss species with ≥11% and ≤22% frequency of occurrence in ponderosa pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), western fescue (Festuca occidentalis), and rough fescue (Festuca scabrella)**; forbs**: aster (Aster spp.), arrowleaf balsamroot (Balsamorhiza sagittata), fireweed (Epilobium angustifolium), penstemon (Penstemon spp.), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: moss (moss spp.).

4) 4207: GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) ranging from 3180 to 4660 feet in elevation. The average canopy cover is 46% ranging from 30-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Douglas-fir (Pseudotsuga menziesii), western red cedar (Thuja plicata), and western hemlock (Tsuga heterophylla) with average percent cover ≥4% and ≤15% and frequency of occurrence ≥44% and ≤78%.

Primary associated shrub species with ≥11% and ≤78% frequency of occurrence in grand fir stands: rocky mountain maple (Acer glabrum), Utah honeysuckle (Lonicera utahensis), mountain-lover (Pachistima myrsinites), sticky current (Ribes viscosissimum), common snowberry (Symphoricarpos albus), globe huckleberry (Vaccinium globulare), and big huckleberry (Vaccinium membranaceum).

Primary associated graminoid, forb, fern, and moss species with ≥11% and ≤33% frequency of occurrence in grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris) and elk sedge (Carex geyeri); **forbs**: trail-plant (Adenocaulon bicolor), wild ginger (Asarum caudatum), queen's cup beadlily (Clintonia uniflora), hooker fairy-bell (Disporum hookeri), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentalis), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), oak-fern (Gymnocarpium dryopteris), and brackenfern (Pteridium aquilinum); **moss**: none.

5) 4208: SUBALPINE FIR FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 3440 to 7880 feet in elevation. The average canopy cover is 41% ranging from 20-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and western white pine (Pinus monticola) with average percent cover ≥2% and ≤6% and frequency of occurrence ≥11% and ≤44%.

Primary associated shrub species with ≥11% and ≤61% frequency of occurrence in

subalpine fir stands: menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), cascade mountain-ash (Sorbus scopulina), sitka mountain-ash (Sorbus sitchensis), globe huckleberry (Vaccinium globulare), big huckleberry (Vaccinium membranaceum), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤73% frequency of occurrence in subalpine fir stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), bluebunch wheatgrass (Elymus spicatus), and smooth woodrush (Luzula hitchcockii); **forbs**: broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), western rattlesnake-plantain (Goodyera oblongofolia), Brewer's mitrewort (Mitella breweri), one-sided wintergreen (Pyrola secunda), trefoil foamflower (Tiarella trifoliata), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), brittle bladder-fern (Cystopteris fragilis), spinulose wood-fern (Dryopteris spinulosa), oak-fern (Gymnocarpium dryopteris), stiff clubmoss (Lycopodium annotinum), clubmoss (Lycopodium spp.), brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

6) 4210: WESTERN RED CEDAR FOREST

Conifer forest dominated by western red cedar (Thuja plicata) ranging from 1850 to 4760 feet in elevation. The average canopy cover is 50% ranging from 10-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), Douglas-fir (Pseudotsuga menziesii), and western hemlock (Tsuga heterophylla) with average percent cover ≥3% and ≤14% and frequency of occurrence ≥31% and ≤62%.

Primary associated shrub species with ≥15% and ≤46% frequency of occurrence in western red cedar stands: rocky mountain maple (Acer glabrum), bunchberry (Cornus canadensis), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), devil's club (Oplopanax horridum), thimbleberry (Rubus parviflorum), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤46% frequency of occurrence in western red cedar stands: **graminoids**: sedge (Carex spp.) and elk sedge (Carex geyeri); **forbs**: wild ginger (Asarum caudatum), queen's cup beadlily (Clintonia uniflora), sweetscented bedstraw (Galium triflorum), clasping-leaved twisted-stalk (Streptopus amplexifolius), trefoil foamflower (Tiarella trifoliata), white trillium (Trillium ovatum), and pioneer violet (Viola glabella); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), mountain wood-fern (Dryopteris austriaca), male fern (Dryopteris filix-mas), field horsetail (Equisetum arvense), oak-fern (Gymnocarpium dryopteris), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

7) 4211: WESTERN HEMLOCK FOREST

Conifer forest dominated by western hemlock (Tsuga heterophylla) ranging from 2400 to 4450 feet in elevation. The average canopy cover is 59% ranging from 20-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), Douglas-fir (Pseudotsuga menziesii), and western red cedar (Thuja plicata) with average percent cover ≥5% and ≤14% and frequency of occurrence ≥25% and ≤75%.

Primary associated shrub species with ≥10% and ≤15% frequency of occurrence in western hemlock stands: sitka alder (Alnus sinuata), common prince's pine (Chimaphila umbellata), Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea),

huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare), and big huckleberry (Vaccinium membranaceum).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤20% frequency of occurrence in western hemlock stands: **graminoids**: brome (Bromus spp.) and Columbia brome (Bromus vulgaris); **forbs**: queen's cup beadlily (Clintonia uniflora), hawkweed (Hieracium), one-sided wintergreen (Pyrola secunda), starry solomon-plume (Smilacina stellata), trefoil foamflower (Tiarella trifoliata), round-leaved violet (Viola orbiculata); **ferns**: oak-fern (Gymnocarpium dryopteris) and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

8) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 1700 to 5200 feet in elevation. The average canopy cover is 40% ranging from 20-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western larch (Larix occidentalis), and ponderosa pine (Pinus ponderosa), with average percent cover ≥4% and ≤6% and frequency of occurrence ≥27% and ≤ 30%.

Primary associated shrub species with ≥23% and ≤33% frequency of occurrence in Douglas-fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), creeping Oregon grape (Berberis repens), ocean-spray (Holodiscus discolor), mountain-lover (Pachistima myrsinites), mallow ninebark (Physocarpus malvaceus), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤39% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), beaked sedge (Carex rostrata), blue wildrye (Elymus glaucus), bluebunch wheatgrass (Elymus spicatus); **forbs**: trail-plant (Adenocaulon bicolor), wild ginger (Asarum caudatum), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: brittle bladder-fern (Cystopteris fragilis), stiff clubmoss (Lycopodium annotinum), clubmoss (Lycopodium spp.), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

9) 4215: WESTERN LARCH FOREST

Conifer forest dominated by western larch (Larix occidentalis) ranging from 2442 to 5120 feet in elevation. The average canopy cover is 26% ranging from 10-4
0% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), lodgepole pine (Pinus contorta), and western red cedar (Thuja plicata) with average percent cover ≥4% and ≤11% and frequency of occurrence equal to 44%.

Primary associated shrub species with ≥33% and ≤56% frequency of occurrence in western larch stands: rocky mountain maple (Acer glabrum), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), thimbleberry (Rubus parviflorum), Canada buffaloberry (Shepherdia canadensis), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥11% and ≤33% frequency of occurrence in western larch stands: **graminoids**: Columbia brome (Bromus vulgaris), blue wildrye (Elymus glaucus), common timothy (Phleum pratense), and nodding trisetum (Trisetum cernuum); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica

(Arnica latifolia), sweetscented bedstraw (Galium triflorum), white-flowered hawkweed (Hieracium albiflorum), pioneer violet (Viola glabella), round-leaved violet (Viola orbiculata), and beargrass (Xerophyllum tenax); **ferns**: male fern (Dryopteris filix-mas) and brackenfern (Pteridium aquilinum); **moss**: none.

10) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albicaulis), codominant species is alpine larch (Larix lyallii), and ranging from 5360 to 7360 feet in elevation. The average canopy cover for PINALB is 11% ranging from 1-30% total cover and frequency of occurrence equal to 85%. The average canopy cover for LARLYA is 13% ranging from 1-30% total cover and frequency of occurrence equal to 60%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥8% and ≤16% and frequency of occurrence ≥5% and ≤100%.

Primary associated shrub species with ≥5% and ≤75% frequency of occurrence in mixed whitebark pine stands: common juniper (Juniperus communis), menziesia (Menziesia ferruginea), yellow mountain-heath (Phyllodoce glanduliflora), white rhododendron (Rhododendron albiflorum), dwarf huckleberry (Vaccinium caespitosum), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤55% frequency of occurrence in mixed whitebark pine stands: **graminoids:** sedge (Carex spp.), elk sedge (Carex geyeri), and smooth woodrush (Luzula hitchcockii); **forbs**: wholly pussy-toes (Antennaria lanata), broadleaf arnica (Arnica latifolia), aster (Aster spp.), glacier lily (Erythronium grandiflorum), white-flowered hawkweed (Hieracium albiflorum), silvery lupine (Lupinus argenteus), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**; none.

11) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 3880 to 6600 feet in elevation. The average canopy cover of ABILAS is 27% ranging from 1-70% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii), with average percent cover ≥19% and ≤20% and frequency of occurrence ≥15% and ≤85%.

Primary associated shrub species with ≥27% and ≤73% frequency of occurrence in mixed subalpine stands: sitka alder (Alnus sinuata), Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea), white rhododendron (Rhododendron albiflorum), thimbleberry (Rubus parviflorum), globe huckleberry (Vaccinium globulare), huckleberry (Vaccinium spp.), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤39% frequency of occurrence in mixed subalpine fir stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), smooth woodrush (Luzula hitchcockii), and nodding trisetum (Trisetum cernuum); **forb**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), starry solomon-plume (Smilacina stellata), trefoil foamflower (Tiarella trifoliata), green false hellebore (Veratrum viride), pioneer violet (Viola glabella), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), oak-fern (Gymnocarpium dryopteris), stiff clubmoss (Lycopodium annotinum), clubmoss (Lycopodium spp.), polypody (Polypodium spp.), brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

12) 4221: MIXED MESIC FOREST

Conifer forest dominated by western red cedar (Thuja plicata), codominant species are grand fir (Abies grandis), western larch (Larix occidentalis), and western hemlock (Tsuga heterophylla), and ranging from 1793 to 5800 feet in elevation. The average canopy cover for THUPLI is 20% ranging from 1-80% total cover and frequency of occurrence equal to 76%. The average canopy cover for ABIGRA is 13% ranging from 1-70% total cover and frequency of occurrence equal to 60%. The average canopy cover for LAROCC is 12% ranging from 1-40% total cover and frequency of occurrence equal to 68%. The average canopy cover for TSUHET is 17% ranging from 1-70% total cover and frequency of occurrence equal to 58%. Primary associated tree species include subalpine fir (Abies lasiocarpa), western white pine (Pinus monticola), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥6% and ≤14% and frequency of occurrence ≥34% and ≤62%.

Primary associated shrub species with ≥15% and ≤34% frequency of occurrence in mixed mesic stands: rocky mountain maple (Acer glabrum), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤22% frequency of occurrence in mixed mesic stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), ross sedge (Carex rossii), and smooth woodrush (Luzula hitchcockii), **forbs**: broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), starry solomon-plume (Smilacina stellata), trefoil foamflower (Tiarella trifoliata), pioneer violet (Viola glabella), round-leaved violet (Viola orbiculata), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), brackenfern (Pteridium aquilinum); **moss**: none.

13) 4222: MIXED XERIC FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) and ranging from 2060 to 3680 feet in elevation. The average canopy cover is 21% ranging from 10-30% total cover and frequency of occurrence equal to 100%. Primary associated tree species include lodgepole pine (Pinus contorta), black cottonwood (Populus trichocarpa), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥10% and ≤25% and frequency of occurrence ≥8% and ≤100%.

Primary associated shrub species with ≥9% and ≤46% frequency of occurrence in mixed xeric stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), ocean-spray (Holodiscus discolor), Utah honeysuckle (Lonicera utahensis), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤50% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), bluebunch wheatgrass (Elytrigia spicata), bluebunch wheatgrass (Elymus spicatus), and Idaho fescue (Festuca idahoensis); **forbs**: heart-leaf arnica (Arnica cordifolia), aster (Aster spp.), hooker fairy-bell (Disporum hookeri), common St. John's-wort (Hypericum perforatum), lomatium (Lomatium spp.), lupine (Lupinus spp.), and starry solomon-plume (Smilacina stellata); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

14) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) and ranging from 2320 to 5240 feet in elevation. The average canopy cover for PINCON is 24% ranging from 10-40% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 28% ranging from 10-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western larch (Larix occidentalis), and western white pine (Pinus monticola) with average percent cover ≥1% and ≤5% and frequency of occurrence ≥36% and ≤50%.

Primary associated shrub species with ≥21% and ≤50% frequency of occurrence in Douglas-fir-lodgepole pine stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤36% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens) and ross sedge (Carex rossii); **forbs**: aster (Aster spp.), queen's cup beadlily (Clintonia uniflora), Virginia strawberry (Fragaria virginiana), western rattlesnake-plantain (Goodyera oblongofolia), clover (Trifolium spp.), violet (Viola spp.), round-leaved violet (Viola orbiculata), and beargrass (Xerophyllum tenax); **ferns**: clubmoss (Lycopodium spp.) and brackenfern (Pteridium aquilinum); **moss**: none.

15) 4225: DOUGLAS FIR-GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) and Douglas-fir (Pseudotsuga menziesii) and ranging from 2250 to 5100 feet in elevation. The average canopy cover for ABIGRA is 24% ranging from 10-60% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 29% ranging from 10-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western larch (Larix occidentalis), western white pine (Pinus monticola), and western red cedar (Thuja plicata), with average percent cover ≥2% and ≤9% and frequency of occurrence ≥27% and ≤33%.

Primary associated shrub species with ≥20% and ≤47% frequency of occurrence in Douglas-fir-grand fir stands: rocky mountain maple (Acer glabrum), ocean-spray (Holodiscus discolor), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), mallow ninebark (Physocarpus malvaceus), thimbleberry (Rubus parviflorum), and globe huckleberry (Vaccinium globulare),

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤39% frequency of occurrence in Douglas-fir-grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris), orchard-grass (Dactylis glomerata), and blue wildrye (Elymus glaucus); **forb**: trail-plant (Adenocaulon bicolor), common pearly-everlasting (Anaphalis margaritacea), spotted knapweed (Centauria maculosa), western goldthread (Coptis occidentalis), common St. John's-wort (Hypericum perforatum), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

16) 4227: WESTERN RED CEDAR-WESTERN HEMLOCK FOREST

Conifer forest dominated by western red cedar (Thuja plicata) and western hemlock (Tsuga heterophylla) ranging from 2399 to 4820 feet in elevation. The average canopy cover for

THUPLI is 36% ranging from 10-70% total cover and frequency of occurrence equal to 100%. The average canopy cover for TSUHET is 40% ranging from 10-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western larch (Larix occidentalis), and western white pine (Pinus monticola) with average percent cover ≥4% and ≤5% and frequency of occurrence ≥27% and ≤51%.

Primary associated shrub species with ≥8% and ≤35% frequency of occurrence in western red cedar-western hemlock stands: sitka alder (Alnus sinuata), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), and globe huckleberry (Vaccinium globulare),

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤20% frequency of occurrence in western red cedar-western hemlock stands: **graminoids**: Columbia brome (Bromus vulgaris) and nodding trisetum (trisetum cernuum); **forbs**: queen's cup beadlily (Clintonia uniflora), western rattlesnake-plantain (Goodyera oblongofolia), pink wintergreen (Pyrola asarifolia), one-sided wintergreen (Pyrola secunda), starry solomon-plume (Smilacina stellata), trefoil foamflower (Tiarella trifoliata), and pioneer violet (Viola glabella); **ferns**: ladyfern (Athyrium filix-femina), oak-fern (Gymnocarpium dryopteris), stiff clubmoss (Lycopodium annotinum), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: none.

17) 4228: WESTERN LARCH-LODGEPOLE FOREST

Conifer forest dominated by western larch (Larix occidentalis) and lodgepole pine (Pinus contorta) ranging from 2246 to 5812 feet in elevation. The average canopy cover for LAROCC is 18% ranging from 3-30% total cover and frequency of occurrence equal to 100%. The average canopy cover for PINCON is 23% ranging from 10-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western red cedar (Thuja plicata), and western hemlock (Tsuga heterophylla) with average percent cover ≥4% and ≤17% and frequency of occurrence ≥42% and ≤58%.

Primary associated shrub species with ≥25% and ≤50% frequency of occurrence in western larch-lodgepole pine stands: sitka alder (Alnus sinutata), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), Canada buffaloberry (Shepherdia canadensis), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤25% frequency of occurrence in western larch-lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens) and spike trisetum (Trisetum spicatum); **forbs**: heart-leaf arnica (Arnica cordifolia), queen's cup beadlily (Clintonia uniflora), western rattlesnake-plantain (Goodyera oblongofolia), white-flowered hawkweed (Hieracium albiflorum), western twayblade (Listera caurina), pink wintergreen (Pyrola asarifolia), and round-leaved violet (Viola orbiculata); **ferns**: oak-fern (Gymnocarpium dryopteris) and brackenfern (Pteridium aquilinum); **moss**: none.

18) 4301: MIXED NEEDLELEAF/BROADLEAF FOREST

Mixed needleleaf and broadleaf forest dominated by western red cedar (Thuja plicata) and ranging from 2275 to 5473 feet in elevation. The average canopy cover is 24% ranging from 1-70% total cover and frequency of occurrence equal to 86%. Primary associated tree species include grand fir (Abies grandis), paper birch (Betula papyrifera), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥9% and ≤23% and frequency of

occurrence ≥69% and ≤76%.

Primary associated shrub species with ≥17% and ≤35% frequency of occurrence in mixed needleleaf and broadleaf stands: rocky mountain maple (Acer glabrum), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), bald-hip rose (Rosa gymnocarpa), thimbleberry (Rubus parviflorum), and shiny-leaf spiraea (Spiraea betulifolia).

Primary associated graminoid, forb, fern, and moss species with ≥10% and ≤20% frequency of occurrence in mixed needleleaf and broadleaf stands: **graminoids**: brome (Bromus spp.), Columbia brome (Bromus vulgaris) pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), and blue wildrye (Elymus glaucus); **forbs**: trail-plant (Adenocaulon bicolor), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), mountain sweet-cicely (Osmorhiza chilensis), starry solomon-plume (Smilacina stellata), and round-leaved violet (Viola orbiculata); **ferns**: oak-fern (Gymnocarpium dryopteris) and brackenfern (Pteridium aquilinum), Oregon woodsia (Woodsia oregana); **moss**: none.

P43/R26 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	9, 10, 63
6102	Broadleaf Dominated Riparian	None identified for scene
6103	Needleleaf-Broadleaf Riparian	8, 35, 37
6104	Mixed Riparian (trees + any other)	6, 7
6201	Grass-Forb Riparian/Wetland	None identified for scene
6202	Shrub Riparian/Wetland	12, 14
6203	Mixed Grass-Forb-Shrub Riparian	None identified for scene

---

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 2
Color: White; RGB 255 255 255.
Distribution: Occurs in clusters and patches at low and high elevations.
Comment: Outside the riparian zone, training sites indicate herbaceous, shrub, and coniferous vegetation. Visual cues suggest agriculture and subalpine meadow.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
2	1	Urban & Developed Land
3	1	Irrigated Crop
4	1	Dry-land Pasture
5	2	Foothills Grassland
6	1	Needleleaf-Broadleaf Riparian

Spectral Class 4
Color: Brown; RGB 106 76 82.
Distribution: Widely distributed across the image, except locations at lowest and highest elevations; ranges from light to medium density.
Comment: Needleleaf cover types dominate training data outside the zone; riparian (6201, 6202, 6102) and Mixed Needleleaf-Broadleaf cover types are included. Appears to represent Mixed Mesic vegetation; too high to be riparian.
Conclusion: Not riparian.

7	1	Douglas-fir
8	1	Needleleaf Dominated Riparian
9	1	Broadleaf Dominated Riparian
10	2	Shrub Riparian/Wetland

Spectral Class 6
Color: Mauve; RGB 178 129 133.
Distribution: Light density at middle to upper elevations across the image.
Comment: Outside the riparian zone, needleleaf cover types were most recorded; several points indicate riparian vegetation (6102, 6101, 6201).
Conclusion: 6104.

12	2	Urban & Developed Land
13	1	Mixed Mesic Forest
14	1	Needleleaf Dominated Riparian
15	2	Broadleaf Dominated Riparian

Spectral Class 7
Color: Light brown; RGB 144 107 112.
Distribution: Light density at middle elevations across the image.
Comment: About 20% of training sites outside the zone represent riparian vegetation (6102, 6101, 6103, 6201, 6202). Coniferous cover types are most prevalent, with Mixed Needleleaf-Broadleaf and Broadleaf Forest also present.
Conclusion: 6104.

16	1	Urban & Developed Land
17	1	Mesic Upland Shrubland
18	1	Broadleaf Forest
19	1	Mix Needleleaf-Broadleaf
20	1	Rivers & Streams
21	1	Needleleaf Dominated Riparian
22	1	Needleleaf-Broadleaf Riparian

Spectral Class 8
Color: Brick red; RGB 173 76 102.
Distribution: Light to medium density at middle elevations.
Comment: Outside the riparian zone, coniferous cover types were most recorded; Mixed Needleleaf-Broadleaf, and riparian (6101, 6102, 6103) cover types were also recorded.
Conclusion: 6103.

23	1	Broadleaf Dominated Riparian

Spectral Class 9
Color: Brown black; RGB 96 49 82.
Distribution: Light to high density at middle elevations.
Comment: Conifers dominate observations for training sites outside the zone; riparian (6101, 6201) and Mesic Upland Shrubland are included. Appears to represent Mixed Mesic Forest and shadows.
Conclusion: 6101.

24	1	Mixed Mesic Forest
25	1	Needleleaf Dominated Riparian

Spectral Class 10
Color: Dark rust; RGB 140 53 82.
Distribution: Occurs primarily at middle elevations; generally light density, but also high density on some slopes.
Comment: Most training sites outside the zone represent conifers; a few indicate Mixed Needleleaf-Broadleaf vegetation; riparian cover types (6202, 6101) are also present. Visual cues indicate Mixed Mesic Forest and Western Red Cedar.
Conclusion: 6101.

26	1	Western Red Cedar
27	2	Mixed Mesic Forest
28	1	Shrub Riparian/Wetland

Spectral Class 12
Color: Olive; RGB 77 103 112.
Distribution: Very light density at all elevations; some near water bodies.
Comment: Conifers, shrubs, and herbaceous and riparian vegetation (6202) make up observations outside the zone.
Conclusion: 6202.

29	1	Douglas-fir
30	2	Shrub Riparian/Wetland

Spectral Class 14
Color: Light olive; RGB 115 129 133.
Distribution: Similar to Spectral Class 12.
Comment: Upland shrubs and riparian vegetation (6202, 6102, 6103) are equally represented in training data outside the zone: Conifers comprise the group most frequently recorded: Rock, mines, and barren land are minimally represented.
Conclusion: 6202.

31	4	Shrub Riparian/Wetland

Spectral Class 16
Color: Dark tan; RGB 226 164 133.
Distribution: Small clusters at middle to upper elevations.
Comment: The eleven training sites for this class are characterized by shrubs, conifers, and

riparian (6101, 6103) vegetation. There are no training sites located within the riparian zone. Color and locations suggest upland shrubs.
Conclusion: Not riparian.

Spectral Class 18
Color: Dark gray; RGB 63 53 92.
Distribution: Shadows.
Comment: Needleleaf cover types are most prevalent among training sites outside the zone; one site represents riparian vegetation (6201).
Conclusion: Not riparian.

34	1	Engelmann Spruce
35	2	Subalpine Fir
36	1	Mixed Subalpine Forest
37	1	Mixed Mesic Forest
38	2	Needleleaf-Broadleaf Riparian
39	2	Grass-Forb Riparian/Wetland
40	2	Shrub Riparian/Wetland

Spectral Class 19
Color: Gray; RGB 149 167 184.
Distribution: Very light density at most elevations.
Comment: Training sites outside the zone indicate coniferous, shrub, and Mixed Needleleaf-Broadleaf cover types. Appearance suggests shrub and grass vegetation.
Conclusion: Not riparian.

41	1	Foothills Grassland
42	1	Douglas-fir
43	1	Shrub Riparian/Wetland

Spectral Class 20
Color: Light tan; RGB 241 194 133.
Distribution: A rare class. Very light density at most elevations; some small clusters at middle to upper elevations.
Comment: Of six training points outside the zone, three represent Mixed Mesic Forest; one point refers to Needleleaf-Broadleaf Riparian vegetation. No recorded sites fall within the zone. Appears to represent rocks and subalpine forest.
Conclusion: Not riparian.

Spectral Class 21
Color: Bisque; RGB 255 225 194.

Distribution: High density at some low elevation locations; occasional small clusters at all elevations.
Comment: Grasslands, agriculture, and conifers characterize training sites; one point represents riparian vegetation (6201). Visual cues indicate agriculture and subalpine forest.
Conclusion: Not riparian.

44	2	Foothills Grassland
45	1	Grass-Forb Riparian/Wetland

Spectral Class 22
Color: Terracotta; RGB 231 107 112.
Distribution: Light to medium density at some mid-elevation locations; very little at low elevations.
Comment: Training sites indicate conifers, Aspen, grass, and Needleleaf-Broadleaf Riparian vegetation. Visual cues suggest a mixture of nonriparian, needleleaf and broadleaf forest types.
Conclusion: Not riparian.

46	1	Foothills Grassland

Spectral Class 23
Color: Dark purple; RGB 63 27 71.
Distribution: Shadows.
Comment: Coniferous cover types dominate training data outside the zone; riparian vegetation (6101) comprises about 12% of the sites.
Conclusion: Not riparian.

47	1	Mixed Mesic Forest
48	3	Needleleaf Dominated Riparian

Spectral Class 24
Color: Light olive; RGB 188 175 122.
Distribution: Very light density across the image, at middle to upper elevations.
Comment: There are just four training sites for this class, all outside the zone and indicating coniferous vegetation.
Conclusion: Not riparian.

Spectral Class 31
Color: Dull red; RGB 197 103 112.
Distribution: Light to medium density at middle elevations.
Comment: Coniferous cover types dominate training data, all of which are outside the zone: Aspen, Mixed Needleleaf-Broadleaf, and Needleleaf Dominated Riparian are minimally represented: Three points indicate shrubs. Appears to be mixed conifers and shrubs, but too dry to be riparian.

Conclusion: Not riparian.

Spectral Class 33
Color: Light taupe; RGB 202 194 163.
Distribution: Very light density, with some small clusters, at most elevations.
Comment: Conifers, Aspen, shrub, grass, and riparian vegetation (6101, 6103) are included in training data.
Conclusion: Not riparian.

56	1	Irrigated Crop

Spectral Class 34
Color: Mauve pink; RGB 255 179 184.
Distribution: Clusters at some low and mid-elevation locations.
Comment: Herbaceous vegetation, shrub, Broadleaf Forest, fir, Mixed Needleleaf-Broadleaf forest, and riparian vegetation (6201) were observed outside the zone. Appears to be mesic shrubland.
Conclusion: Not riparian.

57	1	Grass-Forb Riparian/Wetland

Spectral Class 35
Color: Dark gray red; RGB 140 80 102.
Distribution: Light to high density at middle elevations across the image; very little at lower elevations.
Comment: Needleleaf, riparian (6101, 6103, 6102, 6201), and mixed needleleaf-broadleaf cover types were recorded for training sites outside the zone.
Conclusion: 6103.

58	1	Needleleaf Dominated Riparian
59	1	Broadleaf Dominated Riparian
60	2	Needleleaf-Broadleaf Riparian
61	1	Shrub Riparian/Wetland

Spectral Class 37
Color: Light red; RGB 231 137 133,
Distribution: Occurs in clusters at middle elevations, primarily along river corridors.
Comment: Conifers, Aspen, and Mixed Needleleaf-Broadleaf cover types make up recorded observations, all outside the zone.
Conclusion: 6103.

Spectral Class 39
Color: Dull brown; RGB 149 145 133.
Distribution: Light density across the image, at all but the highest and lowest elevations.
Comment: Needleleaf, shrub, and riparian (6202, 6201) vegetation were recorded. Visual cues indicate sparse conifers, especially seedlings and saplings in harvested areas.
Conclusion: Not riparian.

62	1	Grass-Forb Riparian/Wetland
63	2	Shrub Riparian/Wetland

Spectral Class 40
Color: Blue black; RGB 0 0 92.
Distribution: Water bodies.
Comment: Obviously water.
Conclusion: Not riparian.

64	2	Rivers & Streams
65	4	Lakes
66	1	Shoreline & Gravel Bars

Spectral Class 41
Color: Pale olive sage; RGB 212 225 184.
Distribution: Very light density at all but the highest elevations.
Comment: Herbaceous, needleleaf, and shrub vegetation characterize training sites outside the zone; one site represents riparian vegetation (6201). Appears to represent dry grasses.
Conclusion: Not riparian.

67	2	Dry-land Pasture
68	1	Foothills Grassland
69	2	Grass-Forb Riparian/Wetland

Spectral Class 44
Color: Mauve; RGB 188 156 173.
Distribution: Very light density across the image.
Comment: Conifers are most prevalent in training data: Upland and riparian shrubs and Mixed Needleleaf-Broadleaf vegetation are minimally included. All recorded observations were made outside the riparian zone.
Conclusion: Not riparian.

Spectral Class 46
Color: Grape; RGB 120 99 173.
Distribution: A rare class. Very light density at highest and lowest elevations.
Comment: The two training sites for this class both indicate coniferous vegetation. Appears to

represent high elevation cover types and rock.
Conclusion: Not riparian.

72	1	Mixed Xeric Forest
73	1	Needleleaf Dominated Riparian

Spectral Class 49
Color: Gray blue; RGB 115 148 184.
Distribution: Very light density across the image; some near rivers.
Comment: Of just four training sites outside the zone, two were recorded as conifers, one as shrub, and one as sand.
Conclusion: Not riparian.

75	1	Broadleaf Dominated Riparian

Spectral Class 62
Color: Brown; RGB 130 103 102.
Distribution: Some near water features at lower elevations, but primarily light to medium density at middle to higher elevations.
Comment: Conifers are most prevalent at sites observed outside the zone; herbaceous and riparian (6201, 6102, 6103) vegetation were also observed. Visual cues indicate Lodgepole Pine and
Ponderosa Pine.
Conclusion: Not riparian.

82	1	Engelmann Spruce
83	1	Lodgepole Pine
84	1	Douglas-fir
85	1	Mixed Mesic Forest
86	1	Broadleaf Dominated Riparian
87	1	Needleleaf-Broadleaf Riparian
88	1	Grass-Forb Riparian/Wetland

Spectral Class 63
Color: Maroon; RGB 91 53 92.
Distribution: Shadows.
Comment: Needleleaf cover types dominate training data for sites outside the zone; three sites represent riparian vegetation (6101, 6202).
Conclusion: 6101.

89	1	Douglas-fir
90	1	Mixed Mesic Forest
91	1	Needleleaf Dominated Riparian

TM SCENE P43/R27

Image analyst: Troy P. Tady

Training Data Analysis

In all, 1118 ground-truth plots were available for labeling P43/R27 (see table next page). The data were initially checked over the full scene to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 34) were removed from further analysis. The data were then examined by cover type to determine whether or not plots were collected for this project or for other purposes (e.g., pre-existing ECODATA, TSMRS, etc.). The latter "existing data" were used only as supplementary accuracy test points. The following classes were excluded from the digital classification process and from selection of accuracy test points: urban, agriculture, water, snow, riparian, mines/quarries/gravel pits, clearcuts, sandy areas and shoreline/gravel bars. The aspen (4101) cover type was combined with the general broadleaf forest class (4102) due to a lack of adequate training data for each separate class. The disturbed grassland (3102) class was combined with foothills grassland (3101) due to negligible spectral differences between the two classes.

Of the remaining plots, 20% were randomly selected from each cover type. These plots (n = 124) were held aside in a separate data file for use in the accuracy assessment. Later, ECODATA points, which were not used as training data, were added to this point set (n = 124 + 8 = 132). The same test data extraction was used for size and canopy closure, although without the use of existing data points.

Plots in the remaining 80% of the data were subjected to further spectral examination. Outliers were eliminated for each cover type based on knowledge of general spectral patterns for various ground features. Insufficient training data plots were available for the following cover types:

3104 Subalpine Meadow	- 0 plots
4220 Mixed Subalpine Forest	- 3 plots
4223 Douglas-Fir - Lodgepole Pine	- 12 plots

Training data for these and most of the other cover types were supplemented from data gathered during several forest service review sessions as well as from personal knowledge of individuals familiar with areas within the scene. A total of 109 new training data plots were obtained through various review sessions.

Total plots in ground-truth file	1118	
Total 1994-95 field plots	1110	
Plots sampled for P43/R27		190
Plots sampled for other scenes		920
Pre-existing plots (ECODATA, TSMRS, etc)		8
Plots with codes included in the classification	660	
Plot discards	34	
Pre-existing plots		8
'Bad duplicates'		0
'Good duplicates'		26
Potential training plots	626	
20% test		124
80%		502
Supplemental plots	109	(+/-)
Total plots for available for training	735	(+/-)
Total plots used for training --cover type	462	
size class	223	
canopy	467	

Land Cover Types

A digital classification of TM channels 1, 2, 3, 4, 5, & 7 (6 was not available) plus rescaled elevation (raw elevation value divided by 25) produced three intermediate cover type labels in descending order of likelihood: COV_CODE1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were used and assigned directly to the COVERTYPE field in the database attribute table. Further modifications were carried out using spectral class values (SPECTRAL_CLASS or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000. Urban.	Manually identified and recoded by Troy Tady, Will Gustafson, and Colin Davis.
2000. Agriculture.	Manually identified and recoded by Troy Tady, Will Gustafson, and Colin Davis.
3101. Foothills Grassland.	All grass types occurring below 1067 m (3500 ft) were relabeled as Foothills Grassland.

3104.	Montane Parkland & Subalpine Meadow.	All grass types occurring above 1067 m (3500 ft) were relabeled as Montane Parkland & Subalpine Meadow (3104).
3202.	Warm Mesic Shrubland.	All regions west of the Continental Divide (all areas in this scene) that were classified as a 3200 level shrub type were labeled as Warm Mesic Shrubland if they occurred below 1341 m (4400 ft). If they occurred between 1341 m (4400 ft) and 1646 m (5400 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
3203.	Cold Mesic Shrubland.	All regions west of the Continental Divide (in this case, the entire scene) that were classified as a 3200 level shrub type were labeled as Cold Mesic Shrubland if they occurred above 1646 m (5400 ft). If they occurred between 1341 m (4400 ft) and 1646 m (5400 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
4102.	Broadleaf Forest.	Aspen (4101) and Broadleaf Forest (4102) points were combined into the Broadleaf Forest (4102) class.
4201.	Engelmann Spruce	Although the USFS vegetation limit criteria specify that Engelmann Spruce cover types are a minor component of scene P43/R27; two 4201 plots included as Mixed Mesic Forest (4221). VEG_CODE_SUBs were used in the classification.
4203.	Lodgepole Pine.	Confusion between Lodgepole Pine (4203) and Mixed Mesic Forest (4221) resulted in the addition of 18 supplemental Lodgepole Pine (4203) plots and the transfer of 7 Mixed Mesic Forest (4221) plots to Lodgepole Pine (4203).
4206.	Ponderosa Pine.	No modifications.
4207.	Grand Fir.	Confusion between Grand Fir (4207) and Mixed Mesic Forest (4221) resulted in the deletion of 5 Mixed Mesic Forest (4221) plots.
4208.	Subalpine Fir.	Six supplemental plots added.
4210.	Western Red Cedar.	15 supplemental plots added.
4211.	Western Hemlock.	Eight supplemental plots added.

4212.	Douglas-Fir.	No modifications.
4215.	Western Larch.	No modifications.
4220.	Mixed Subalpine Forest.	12 supplemental plots added.
4221.	Mixed Mesic Forest.	Point deletions for VEG_CODE_SUB = 4221.
4222.	Mixed Xeric Forest.	No modifications.
4223.	Douglas-Fir - Lodgepole Pine.	Nine supplemental plots added.
4225.	Douglas-Fir - Grand Fir.	Seven supplemental plots added.
4226.	Western Red Cedar-Grand Fir.	Ten supplemental plots added.
4227.	Western Red Cedar-Western Hemlock.	Eight supplemental plots added.
4228.	Western Larch-Lodgepole Pine.	Seven supplemental plots added.
4229.	Western Larch-Douglas-Fir.	Six supplemental plots added.
4301.	Mixed Needleleaf-Broadleaf.	No modifications.
5000.	Water.	All regions with spectral class (LINK) = 1 and slope ≤5˚ were labeled as water. Generally, water was more spectrally distinct than most other cover types, but in high mountainous terrain, it was confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate elevation and slope values such that their slope may be >5 ˚. This would result in the misclassification of some small ponds or lakes.
7300.	Rock.	No modifications.
7800.	Barren.	No modifications.

9800. Cloud. Manually modified by Will Gustafson.

9900. Cloud Shadow. Manually modified by Will Gustafson.

A total of 31 classes were labeled in the full TM scene. These included two grass types, two shrub types, twenty forest types, plus seven non-vegetated or manually labeled classes. Cover types are mapped in Figure F-2.

Size Classes

Seven size classes were mapped -- four for forest cover types (seedling/sapling, pole, medium, and large/very large) and three for shrub cover types (low, medium, and tall). Six TM spectral channels were used for the size classification (elevation was not included). Plots for size class were stratified based on 3 canopy cover classes for forest cover types and 3 canopy cover classes for shrub cover types (see below). A Nearest Mean Classifier was used to classify size for forest and shrub cover types (this method proved more effective than the Nearest Member of Group (NMG) or Gaussian Maximum Likelihood (GML) classifiers).

Canopy Cover Classes

Canopy cover labels (CANOPYCODE = low, medium, or high) were assigned to tree and shrub classes based on Modified Normalized Distribution Vegetation Index (MNDVI) values. These values were plotted as frequency histograms for all forest types (Figure F-2a) as well as for the mesic shrub types (3202 & 3203; Figure F-2b). The histograms were examined to determine break points based on the distribution modes (see table below). Regions with MNDVI values falling below the lower break point were assigned to a low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class.

	MNDVI BREAKPOINTS	
CANOPY COVER	Tree	Shrub
Low	<260	<142
Medium	≥260 and ≤460	≥142 and ≤314
High	>460	>314

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not

representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications.

CLASSIFICATIONS FOR P43/R27	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	22	63%	44%
Tree Size Class	4	94%	46%
Tree Canopy Class	3	94%	57%
Shrub Size Class	3	100%	29%
Shrub Canopy Class	2	100%	79%

Error Matrix For Cover Type Training Plots
Scene P43/R27

CLASSIFIED COVER TYPES

PLOT COVER TYPES	3101	3201	4102	4203	4206	4207	4208	4210	4212	4215	4220	4221	4222	4223	4301	7301	7800	SUM
3101	61	12	1	1	4	0	0	0	0	0	0	1	1	0	1	2	3	87
3201	18	28	1	1	2	0	0	0	1	0	0	2	0	0	0	0	0	53
4102	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4203	1	0	0	2	0	0	0	1	2	2	1	7	0	2	0	0	0	18
4206	5	4	1	0	7	0	0	0	3	1	0	2	2	0	0	0	0	25
4207	0	0	0	0	0	0	1	2	0	0	0	8	2	0	0	0	0	13
4208	0	0	0	0	0	1	3	0	0	2	1	4	0	0	0	0	0	11
4210	0	0	0	1	0	2	0	7	0	0	0	1	0	1	1	0	0	13
4212	0	1	0	3	2	4	1	0	12	1	1	3	3	2	2	0	0	35
4215	0	0	0	1	1	0	1	1	1	2	1	2	1	1	0	0	0	12
4220	0	0	0	0	0	0	1	0	1	0	10	1	0	0	0	0	0	13
4221	0	2	0	7	2	7	3	1	9	2	1	64	3	5	4	0	1	111
4222	0	2	0	0	7	2	0	0	2	1	0	2	5	0	0	0	0	21
4223	0	0	0	2	0	0	0	1	1	2	0	6	0	0	1	1	0	14
4301	1	0	0	0	1	1	0	1	1	0	0	5	1	1	1	0	0	13
7301	3	1	0	0	0	0	0	0	0	0	0	0	0	1	0	4	1	10
7800	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	7	12
SUM	92	51	3	18	26	17	10	14	33	13	15	109	18	13	10	8	12	462

% AGREEMENT	46.1
TAU WITH EQUAL PROBABILITY	0.428
TOTAL DIAGONAL ELEMENTS	213
TOTAL TRAINING PLOTS IN DATA SET	462

F. p43/r27. 7

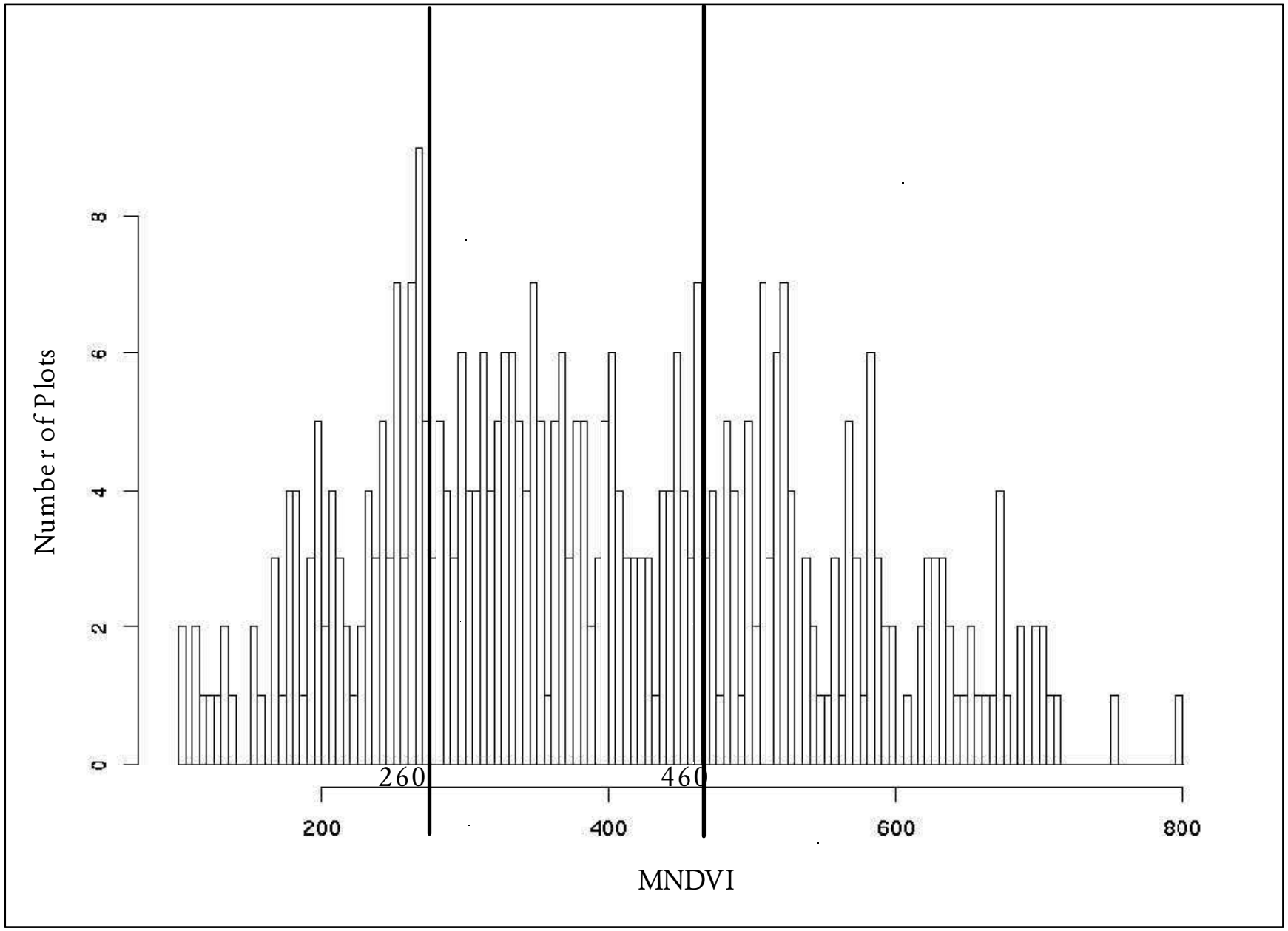


Figure F-2a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P43/R27

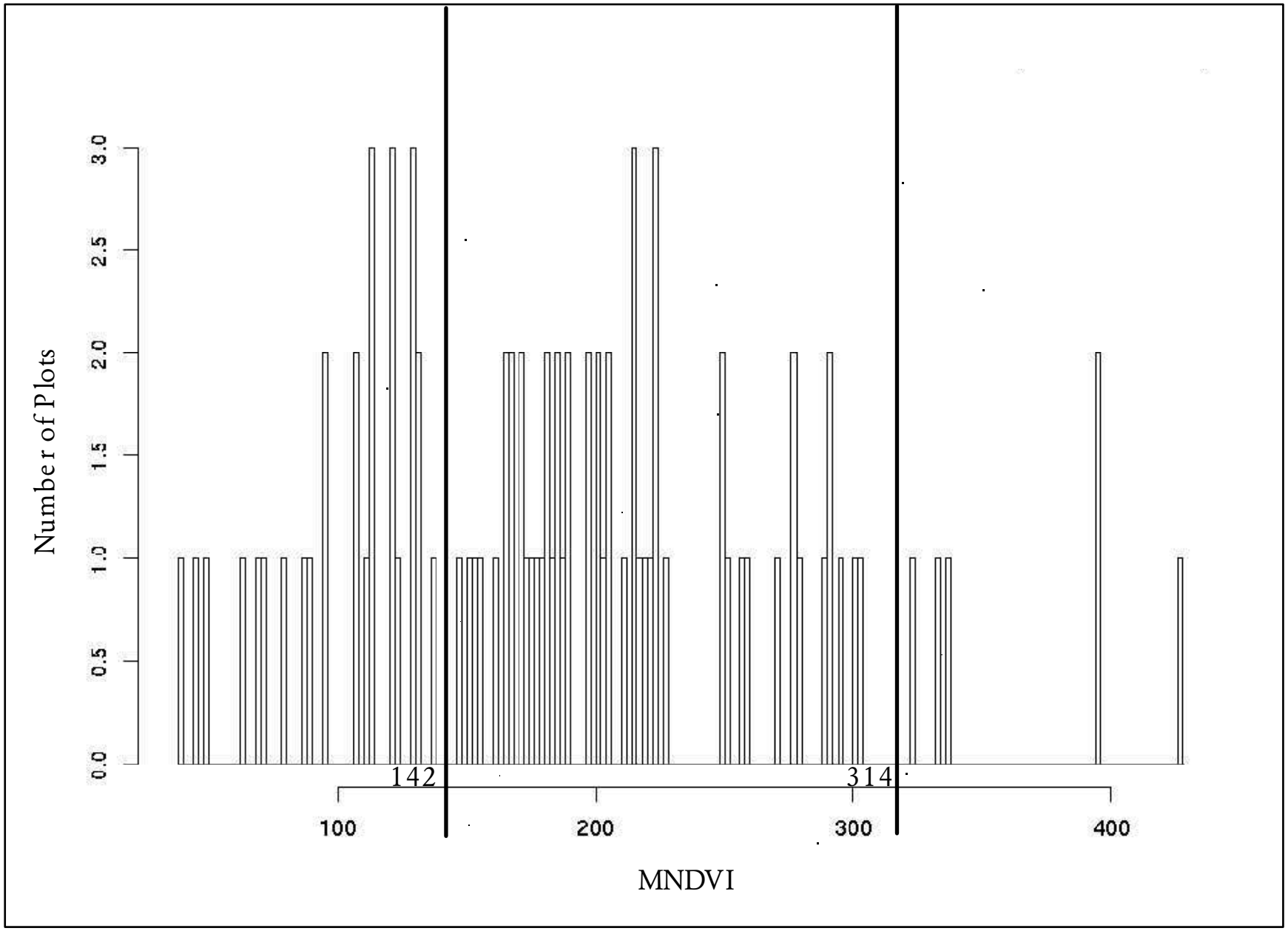


Figure F-2b. Breaks between shrub canopy cover classes in relation to MNDVI values: TM scene P43/R27

Accuracy Assessment Tables for P43/R27 -- Cover Type

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3202	3203	4102	4203	4206	4207	4208	4210
3101	12(5)	4(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)
3202	0(1)	6(5)	0(3)	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)
3203	0(1)	0(3)	0(5)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4102	0(1)	0(1)	0(1)	0(5)	0(2)	0(2)	0(2)	0(2)	0(2)
4203	0(1)	0(1)	0(1)	0(2)	0(5)	0(2)	0(2)	0(2)	0(2)
4206	0(1)	2(1)	0(1)	0(2)	0(2)	2(5)	0(2)	0(2)	0(2)
4207	0(1)	2(1)	0(1)	0(2)	0(2)	0(2)	0(5)	0(2)	1(2)
4208	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)	0(5)	0(2)
4210	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)	0(2)	1(5)
4211	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)	1(2)	1(3)
4212	2(1)	0(1)	0(1)	0(2)	0(2)	1(2)	1(2)	0(2)	0(2)
4215	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	1(2)	0(2)	0(2)
4220	0(1)	0(1)	0(1)	0(2)	0(3)	0(2)	0(2)	1(3)	0(2)
4221	1(1)	1(1)	0(1)	0(2)	0(3)	0(2)	2(3)	0(2)	0(3)
4222	0(1)	0(1)	0(1)	0(2)	0(2)	0(3)	0(2)	0(2)	0(2)
4223	0(1)	0(1)	0(1)	0(2)	0(3)	0(2)	0(2)	0(2)	0(2)
4225	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	1(4)	0(2)	0(2)
4226	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(4)	0(2)	0(3)
4227	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)	0(2)	1(3)
4228	0(1)	0(1)	0(1)	0(2)	0(3)	0(2)	0(2)	0(2)	0(2)
4301	1(1)	0(1)	0(1)	1(3)	0(2)	0(2)	0(3)	0(2)	0(3)
7300	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	16(0)	16(0)	0(0)	1(0)	2(0)	4(0)	5(0)	2(0)	4(0)

RF/CF	4211	4212	4215	4220	4221	4222	4223	4225	4226
3101	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
3202	0(1)	0(1)	0(1)	0(1)	2(1)	1(1)	0(1)	0(1)	1(1)
3203	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4102	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4203	0(2)	0(2)	0(2)	0(3)	1(3)	1(2)	0(4)	0(2)	0(2)
4206	0(2)	1(2)	0(2)	0(2)	1(3)	1(4)	0(2)	0(2)	0(2)
4207	0(2)	1(2)	0(2)	0(2)	3(3)	0(2)	0(2)	0(4)	0(4)
4208	0(2)	0(2)	0(2)	1(3)	0(3)	0(2)	0(2)	0(2)	0(2)
4210	0(3)	0(2)	0(2)	0(2)	0(3)	0(2)	0(2)	0(2)	0(4)
4211	1(5)	0(2)	0(2)	0(2)	0(3)	0(2)	0(2)	0(2)	0(3)
4212	0(2)	5(5)	1(3)	0(3)	3(3)	0(4)	0(4)	0(4)	1(2)
4215	0(2)	0(3)	0(5)	0(3)	1(3)	0(2)	0(2)	0(2)	0(2)
4220	0(2)	0(3)	0(2)	0(5)	0(2)	0(2)	0(3)	0(2)	0(2)
4221	0(3)	7(3)	2(3)	2(2)	8(5)	0(2)	1(3)	0(4)	0(4)
4222	0(2)	0(3)	0(2)	0(2)	1(2)	2(5)	0(2)	0(2)	0(2)
4223	0(2)	1(3)	1(2)	0(3)	0(3)	0(2)	0(5)	0(3)	0(2)
4225	0(2)	0(3)	0(2)	0(2)	0(4)	0(2)	1(3)	1(5)	0(3)
4226	0(3)	0(2)	0(2)	0(2)	1(4)	0(2)	0(2)	0(3)	3(5)
4227	0(3)	0(2)	0(2)	0(2)	0(4)	0(2)	0(2)	0(3)	0(4)
4228	0(2)	0(2)	1(3)	0(3)	0(4)	0(2)	0(4)	0(3)	0(3)
4301	0(2)	0(2)	0(2)	0(3)	0(3)	0(3)	0(3)	0(3)	0(3)
7300	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	1(0)	15(0)	5(0)	3(0)	22(0)	5(0)	2(0)	1(0)	5(0)

Accuracy Assessment Tables for P43/R27 -- Cover Type

RF/CF	4227	4228	4301	7300	SUM
3101	0(1)	0(1)	1(1)	1(1)	20(0)
3202	0(1)	0(1)	1(1)	0(1)	13(0)
3203	0(1)	0(1)	0(1)	0(1)	2(0)
4102	0(2)	0(2)	1(4)	0(1)	1(0)
4203	0(2)	0(4)	0(2)	0(1)	2(0)
4206	0(2)	0(2)	0(2)	0(1)	7(0)
4207	0(2)	0(2)	0(2)	0(1)	7(0)
4208	0(2)	0(2)	0(2)	0(1)	1(0)
4210	0(4)	0(2)	0(2)	0(1)	1(0)
4211	0(4)	0(2)	0(2)	0(1)	3(0)
4212	0(2)	0(2)	0(2)	0(1)	14(0)
4215	0(2)	0(4)	0(2)	0(1)	2(0)
4220	0(2)	0(2)	0(2)	0(1)	1(0)
4221	0(4)	0(4)	1(2)	0(1)	25(0)
4222	0(2)	0(2)	0(2)	0(1)	3(0)
4223	0(2)	0(4)	0(2)	0(1)	2(0)
4225	0(3)	0(3)	0(2)	0(1)	3(0)
4226	0(4)	0(3)	0(2)	0(1)	4(0)
4227	0(5)	0(3)	0(2)	0(1)	1(0)
4228	0(3)	1(5)	0(2)	0(1)	2(0)
4301	0(3)	0(3)	0(5)	0(1)	2(0)
7300	0(1)	0(1)	0(1)	1(5)	2(0)
SUM	0(0)	1(0)	4(0)	2(0)	118(0)

Diagonal Elements = 43; Total Test Points = 118
Percentage Agreement = 36.44; Tau w/equal Prob = 0.334

2 points not belong to groups listed in the
test data and treated as mis-classification
Default score for these 2 points = 1

Accuracy Assessment Tables for P43/R27 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	12	60.00	0	0.00	0	0.00	0	0.00	8	40.00
3202	6	46.15	0	0.00	0	0.00	0	0.00	7	53.85
3203	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4102	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
4203	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00
4206	2	28.57	1	14.29	1	14.29	1	14.29	2	28.57
4207	0	0.00	0	0.00	3	42.86	2	28.57	2	28.57
4208	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4210	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4211	1	33.33	0	0.00	1	33.33	1	33.33	0	0.00
4212	5	35.71	0	0.00	4	28.57	3	21.43	2	14.29
4215	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00
4220	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4221	8	32.00	0	0.00	12	48.00	3	12.00	2	8.00
4222	2	66.67	0	0.00	0	0.00	1	33.33	0	0.00
4223	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00
4225	1	33.33	1	33.33	1	33.33	0	0.00	0	0.00
4226	3	75.00	1	25.00	0	0.00	0	0.00	0	0.00
4227	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4228	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
4301	0	0.00	0	0.00	1	50.00	0	0.00	1	50.00
7300	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
SUM	43	36.44	4	3.39	30	25.42	14	11.86	27	22.88

Accuracy Assessment Tables for P43/R27 -- Cover Type

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	12	60.00	12	60.00	12	60.00	12	60.00	20	100.00
3202	6	46.15	6	46.15	6	46.15	6	46.15	13	100.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4102	0	0.00	1	100.00	1	100.00	1	100.00	1	100.00
4203	0	0.00	0	0.00	1	50.00	2	100.00	2	100.00
4206	2	28.57	3	42.86	4	57.14	5	71.43	7	100.00
4207	0	0.00	0	0.00	3	42.86	5	71.43	7	100.00
4208	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4210	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4211	1	33.33	1	33.33	2	66.67	3	100.00	3	100.00
4212	5	35.71	5	35.71	9	64.29	12	85.71	14	100.00
4215	0	0.00	0	0.00	1	50.00	2	100.00	2	100.00
4220	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4221	8	32.00	8	32.00	20	80.00	23	92.00	25	100.00
4222	2	66.67	2	66.67	2	66.67	3	100.00	3	100.00
4223	0	0.00	0	0.00	1	50.00	2	100.00	2	100.00
4225	1	33.33	2	66.67	3	100.00	3	100.00	3	100.00
4226	3	75.00	4	100.00	4	100.00	4	100.00	4	100.00
4227	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4228	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
4301	0	0.00	0	0.00	1	50.00	1	50.00	2	100.00
7300	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
SUM	43	36.44	47	39.83	77	65.25	91	77.12	118	100.00

Accuracy Assessment Tables for P43/R27 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	12	75.00	0	0.00	0	0.00	0	0.00	4	25.00
3202	6	37.50	0	0.00	0	0.00	0	0.00	10	62.50
3203	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4102	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4203	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4206	2	50.00	0	0.00	0	0.00	1	25.00	1	25.00
4207	0	0.00	1	20.00	2	40.00	2	40.00	0	0.00
4208	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00
4210	1	25.00	0	0.00	2	50.00	1	25.00	0	0.00
4211	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4212	5	33.33	0	0.00	8	53.33	2	13.33	0	0.00
4215	0	0.00	0	0.00	4	80.00	1	20.00	0	0.00
4220	0	0.00	0	0.00	1	33.33	2	66.67	0	0.00
4221	8	36.36	1	4.55	9	40.91	1	4.55	3	13.64
4222	2	40.00	1	20.00	0	0.00	1	20.00	1	20.00
4223	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00
4225	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4226	3	60.00	0	0.00	0	0.00	1	20.00	1	20.00
4227	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4228	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4301	0	0.00	1	25.00	0	0.00	1	25.00	2	50.00
7300	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
SUM	43	37.07	4	3.45	30	25.86	14	12.07	25	21.55

Accuracy Assessment Tables for P43/R27 -- Cover Type

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	12	75.00	12	75.00	12	75.00	12	75.00	16	100.00
3202	6	37.50	6	37.50	6	37.50	6	37.50	16	100.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4102	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4203	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4206	2	50.00	2	50.00	2	50.00	3	75.00	4	100.00
4207	0	0.00	1	20.00	3	60.00	5	100.00	5	100.00
4208	0	0.00	0	0.00	1	50.00	2	100.00	2	100.00
4210	1	25.00	1	25.00	3	75.00	4	100.00	4	100.00
4211	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4212	5	33.33	5	33.33	13	86.67	15	100.00	15	100.00
4215	0	0.00	0	0.00	4	80.00	5	100.00	5	100.00
4220	0	0.00	0	0.00	1	33.33	3	100.00	3	100.00
4221	8	36.36	9	40.91	18	81.82	19	86.36	22	100.00
4222	2	40.00	3	60.00	3	60.00	4	80.00	5	100.00
4223	0	0.00	0	0.00	2	100.00	2	100.00	2	100.00
4225	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4226	3	60.00	3	60.00	3	60.00	4	80.00	5	100.00
4227	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4228	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4301	0	0.00	1	25.00	1	25.00	2	50.00	4	100.00
7300	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
SUM	43	37.07	47	40.52	77	66.38	91	78.45	116	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	222	60.00	0	0.00	0	0.00	0	0.00	148	40.00
3202	43	46.15	0	0.00	0	0.00	0	0.00	50	53.85
3203	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4102	0	0.00	2	100.00	0	0.00	0	0.00	0	0.00
4203	0	0.00	0	0.00	14	50.00	14	50.00	0	0.00
4206	18	28.57	9	14.29	9	14.29	9	14.29	18	28.57
4207	0	0.00	0	0.00	15	42.86	10	28.57	10	28.57
4208	0	0.00	0	0.00	7	100.00	0	0.00	0	0.00
4210	10	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4211	5	33.33	0	0.00	5	33.33	5	33.33	0	0.00
4212	24	35.71	0	0.00	19	28.57	14	21.43	10	14.29
4215	0	0.00	0	0.00	8	50.00	8	50.00	0	0.00
4220	0	0.00	0	0.00	5	100.00	0	0.00	0	0.00
4221	37	32.00	0	0.00	55	48.00	14	12.00	9	8.00
4222	31	66.67	0	0.00	0	0.00	16	33.33	0	0.00
4223	0	0.00	0	0.00	6	50.00	6	50.00	0	0.00
4225	8	33.33	8	33.33	8	33.33	0	0.00	0	0.00
4226	28	75.00	9	25.00	0	0.00	0	0.00	0	0.00
4227	0	0.00	0	0.00	8	100.00	0	0.00	0	0.00
4228	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
4301	0	0.00	0	0.00	9	50.00	0	0.00	9	50.00
7300	11	50.00	0	0.00	0	0.00	0	0.00	11	50.00
SUM	438	43.89	28	2.81	169	16.93	96	9.62	267	26.75

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	222	60.00	222	60.00	222	60.00	222	60.00	370	100.00
3202	43	46.15	43	46.15	43	46.15	43	46.15	93	100.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4102	0	0.00	2	100.00	2	100.00	2	100.00	2	100.00
4203	0	0.00	0	0.00	14	50.00	28	100.00	28	100.00
4206	18	28.57	27	42.86	36	57.14	45	71.43	63	100.00
4207	0	0.00	0	0.00	15	42.86	25	71.43	35	100.00
4208	0	0.00	0	0.00	7	100.00	7	100.00	7	100.00
4210	10	100.00	10	100.00	10	100.00	10	100.00	10	100.00
4211	5	33.33	5	33.33	10	66.67	15	100.00	15	100.00
4212	24	35.71	24	35.71	43	64.29	57	85.71	67	100.00
4215	0	0.00	0	0.00	8	50.00	17	100.00	17	100.00
4220	0	0.00	0	0.00	5	100.00	5	100.00	5	100.00
4221	37	32.00	37	32.00	92	80.00	105	92.00	115	100.00
4222	31	66.67	31	66.67	31	66.67	47	100.00	47	100.00
4223	0	0.00	0	0.00	6	50.00	13	100.00	13	100.00
4225	8	33.33	16	66.67	24	100.00	24	100.00	24	100.00
4226	28	75.00	38	100.00	38	100.00	38	100.00	38	100.00
4227	0	0.00	0	0.00	8	100.00	8	100.00	8	100.00
4228	1	50.00	1	50.00	3	100.00	3	100.00	3	100.00
4301	0	0.00	0	0.00	9	50.00	9	50.00	19	100.00
7300	11	50.00	11	50.00	11	50.00	11	50.00	23	100.00
SUM	438	43.63	467	46.51	637	63.45	734	73.11	1004	100.00

Accuracy Assessment Tables for P43/R27 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	4	SUM
1	2(5)	2(3)	1(1)	0(1)	5(0)
2	1(3)	1(5)	2(3)	0(1)	4(0)
3	2(1)	9(3)	15(5)	3(3)	29(0)
4	0(1)	0(1)	0(3)	1(5)	1(0)
SUM	5(0)	12(0)	18(0)	4(0)	39(0)

Diagonal Elements = 19; Total Test Points = 39
Percentage Agreement = 48.72; Tau w/equal Prob = 0.316

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	40.00	0	0.00	2	40.00	0	0.00	1	20.00
2	1	25.00	0	0.00	3	75.00	0	0.00	0	0.00
3	15	51.72	0	0.00	12	41.38	0	0.00	2	6.90
4	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	19	48.72	0	0.00	17	43.59	0	0.00	3	7.69

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	40.00	2	40.00	4	80.00	4	80.00	5	100.00
2	1	25.00	1	25.00	4	100.00	4	100.00	4	100.00
3	15	51.72	15	51.72	27	93.10	27	93.10	29	100.00
4	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	19	48.72	19	48.72	36	92.31	36	92.31	39	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	40.00	0	0.00	1	20.00	0	0.00	2	40.00
2	1	8.33	0	0.00	11	91.67	0	0.00	0	0.00
3	15	83.33	0	0.00	2	11.11	0	0.00	1	5.56
4	1	25.00	0	0.00	3	75.00	0	0.00	0	0.00
SUM	19	48.72	0	0.00	17	43.59	0	0.00	3	7.69

Accuracy Assessment Tables for P43/R27 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	40.00	2	40.00	3	60.00	3	60.00	5	100.00
2	1	8.33	1	8.33	12	100.00	12	100.00	12	100.00
3	15	83.33	15	83.33	17	94.44	17	94.44	18	100.00
4	1	25.00	1	25.00	4	100.00	4	100.00	4	100.00
SUM	19	48.72	19	48.72	36	92.31	36	92.31	39	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	43	40.00	0	0.00	43	40.00	0	0.00	22	20.00
2	78	25.00	0	0.00	235	75.00	0	0.00	0	0.00
3	258	51.72	0	0.00	207	41.38	0	0.00	34	6.90
4	79	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	458	45.85	0	0.00	485	48.55	0	0.00	56	5.61

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	43	40.00	43	40.00	86	80.00	86	80.00	108	100.00
2	78	25.00	78	25.00	314	100.00	314	100.00	314	100.00
3	258	51.72	258	51.72	465	93.10	465	93.10	499	100.00
4	79	100.00	79	100.00	79	100.00	79	100.00	79	100.00
SUM	458	45.80	458	45.80	944	94.40	944	94.40	1000	100.00

Accuracy Assessment Tables for P43/R27 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	1(5)	0(3)	0(1)	1(0)
2	1(3)	1(5)	0(3)	2(0)
3	0(1)	1(3)	0(5)	1(0)
SUM	2(0)	2(0)	0(0)	4(0)

Diagonal Elements = 2; Total Test Points = 4
Percentage Agreement = 50.00; Tau w/equal Prob = 0.250

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
3	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
SUM	2	50.00	0	0.00	2	50.00	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
2	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
3	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
SUM	2	50.00	2	50.00	4	100.00	4	100.00	4	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
2	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	2	50.00	0	0.00	2	50.00	0	0.00	0	0.00

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
2	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	2	50.00	2	50.00	4	100.00	4	100.00	4	100.00

Accuracy Assessment Tables for P43/R27 -- Shrub Size Class

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	195	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	92	50.00	0	0.00	92	50.00	0	0.00	0	0.00
3	0	0.00	0	0.00	621	100.00	0	0.00	0	0.00
SUM	287	28.70	0	0.00	713	71.30	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	195	100.00	195	100.00	195	100.00	195	100.00	195	100.00
2	92	50.00	92	50.00	185	100.00	185	100.00	185	100.00
3	0	0.00	0	0.00	621	100.00	621	100.00	621	100.00
SUM	287	28.67	287	28.67	1001	100.00	1001	100.00	1001	100.00

Accuracy Assessment Tables for P43/R27 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	3(5)	8(3)	5(1)	17(0)
2	3(3)	18(5)	10(3)	31(0)
3	1(1)	7(3)	17(5)	25(0)
SUM	7(0)	33(0)	32(0)	73(0)

Diagonal Elements = 38; Total Test Points = 73
Percentage Agreement = 52.05; Tau w/equal Prob = 0.281

1 points not belong to groups listed in the
test data and treated as mis-classification
Default score for these 1 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	17.65	0	0.00	8	47.06	0	0.00	6	35.29
2	18	58.06	0	0.00	13	41.94	0	0.00	0	0.00
3	17	68.00	0	0.00	7	28.00	0	0.00	1	4.00
SUM	38	52.05	0	0.00	28	38.36	0	0.00	7	9.59

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	17.65	3	17.65	11	64.71	11	64.71	17	100.00
2	18	58.06	18	58.06	31	100.00	31	100.00	31	100.00
3	17	68.00	17	68.00	24	96.00	24	96.00	25	100.00
SUM	38	52.05	38	52.05	66	90.41	66	90.41	73	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	42.86	0	0.00	3	42.86	0	0.00	1	14.29
2	18	54.55	0	0.00	15	45.45	0	0.00	0	0.00
3	17	53.12	0	0.00	10	31.25	0	0.00	5	15.62
SUM	38	52.78	0	0.00	28	38.89	0	0.00	6	8.33

Accuracy Assessment Tables for P43/R27 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	42.86	3	42.86	6	85.71	6	85.71	7	100.00
2	18	54.55	18	54.55	33	100.00	33	100.00	33	100.00
3	17	53.12	17	53.12	27	84.38	27	84.38	32	100.00
SUM	38	52.78	38	52.78	66	91.67	66	91.67	72	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	24	17.65	0	0.00	63	47.06	0	0.00	47	35.29
2	276	58.06	0	0.00	200	41.94	0	0.00	0	0.00
3	265	68.00	0	0.00	109	28.00	0	0.00	16	4.00
SUM	565	56.50	0	0.00	372	37.20	0	0.00	63	6.30

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	24	17.65	24	17.65	86	64.71	86	64.71	134	100.00
2	276	58.06	276	58.06	476	100.00	476	100.00	476	100.00
3	265	68.00	265	68.00	375	96.00	375	96.00	390	100.00
SUM	565	56.50	565	56.50	937	93.70	937	93.70	1000	100.00

Accuracy Assessment Tables for P43/R27 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	2(5)	1(3)	0(1)	3(0)
2	1(3)	5(5)	0(3)	6(0)
3	3(1)	3(3)	0(5)	6(0)
SUM	6(0)	9(0)	0(0)	15(0)

Diagonal Elements = 7; Total Test Points = 15
Percentage Agreement = 46.67; Tau w/equal Prob = 0.200

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	66.67	0	0.00	1	33.33	0	0.00	0	0.00
2	5	83.33	0	0.00	1	16.67	0	0.00	0	0.00
3	0	0.00	0	0.00	3	50.00	0	0.00	3	50.00
SUM	7	46.67	0	0.00	5	33.33	0	0.00	3	20.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	66.67	2	66.67	3	100.00	3	100.00	3	100.00
2	5	83.33	5	83.33	6	100.00	6	100.00	6	100.00
3	0	0.00	0	0.00	3	50.00	3	50.00	6	100.00
SUM	7	46.67	7	46.67	12	80.00	12	80.00	15	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	33.33	0	0.00	1	16.67	0	0.00	3	50.00
2	5	55.56	0	0.00	4	44.44	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	7	46.67	0	0.00	5	33.33	0	0.00	3	20.00

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	33.33	2	33.33	3	50.00	3	50.00	6	100.00
2	5	55.56	5	55.56	9	100.00	9	100.00	9	100.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	7	46.67	7	46.67	12	80.00	12	80.00	15	100.00

Accuracy Assessment Tables for P43/R27 -- Shrub Canopy Closure

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	164	66.67	0	0.00	82	33.33	0	0.00	0	0.00
2	628	83.33	0	0.00	126	16.67	0	0.00	0	0.00
3	0	0.00	0	0.00	0	50.00	0	0.00	0	50.00
SUM	792	79.20	0	0.00	208	20.80	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	164	66.67	164	66.67	246	100.00	246	100.00	246	100.00
2	628	83.33	628	83.33	754	100.00	754	100.00	754	100.00
3	0	0.00	0	0.00	0	50.00	0	50.00	0	100.00
SUM	792	79.20	792	79.20	1000	100.00	1000	100.00	1000	100.00

Scene P43/R27 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	148543.0	1778282.2	56.7
1000	975.0	9629.2	0.3
2000	10753.0	132845.8	4.2
3101	15966.0	113575.3	3.6
3104	530.0	3323.7	0.1
3202	10338.0	74017.4	2.4
3203	493.0	2816.6	0.1
4102	472.0	3401.8	0.1
4201	436.0	1711.1	0.1
4203	5369.0	64728.9	2.1
4206	5852.0	54393.6	1.7
4207	4808.0	78950.0	2.5
4208	1770.0	17191.3	0.5
4210	2837.0	21911.0	0.7
4211	2652.0	34420.0	1.1
4212	13341.0	127692.6	4.1
4215	2681.0	34441.3	1.1
4220	1756.0	10650.4	0.3
4221	23609.0	240734.5	7.7
4222	7769.0	66050.3	2.1
4223	4352.0	26849.3	0.9
4225	4023.0	53467.4	1.7
4226	5913.0	78153.0	2.5
4227	3225.0	16187.2	0.5
4228	581.0	6525.9	0.2
4229	898.0	11512.1	0.4
4301	3760.0	27838.3	0.9
5000	1744.0	33786.4	1.1
7300	649.0	3858.5	0.1
7800	983.0	5465.1	0.2
9800	2.0	1492.5	0.0
9900	2.0	1942.3	0.1

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	148543.0	1778282.2	56.7
Not tree/shrub	31604.0	305918.8	9.7
Shrub 1	3303.0	20018.2	0.6
Shrub 2	7528.0	56815.7	1.8
Tree 1	12677.0	81148.1	2.6
Tree 2	53732.0	428898.1	13.7
Tree 3	29695.0	466763.9	14.9

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	148543.0	1778282.2	56.7
Not tree/shrub	31604.0	305918.8	9.7
Tree 1	13544.0	119384.3	3.8
Tree 2	25928.0	350504.3	11.2
Tree 3	38765.0	433618.0	13.8
Tree 4	17867.0	73303.5	2.3
Shrub 1	2687.0	15696.6	0.5
Shrub 2	4781.0	34922.6	1.1
Shrub 3	3363.0	26214.8	0.8

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	148543.0	1778282.2	56.7
A	10753.0	132845.8	4.2
H	16496.0	116899.0	3.7
N	4355.0	56173.9	1.8
S	10831.0	76834.0	2.4
T	96104.0	976810.1	31.1

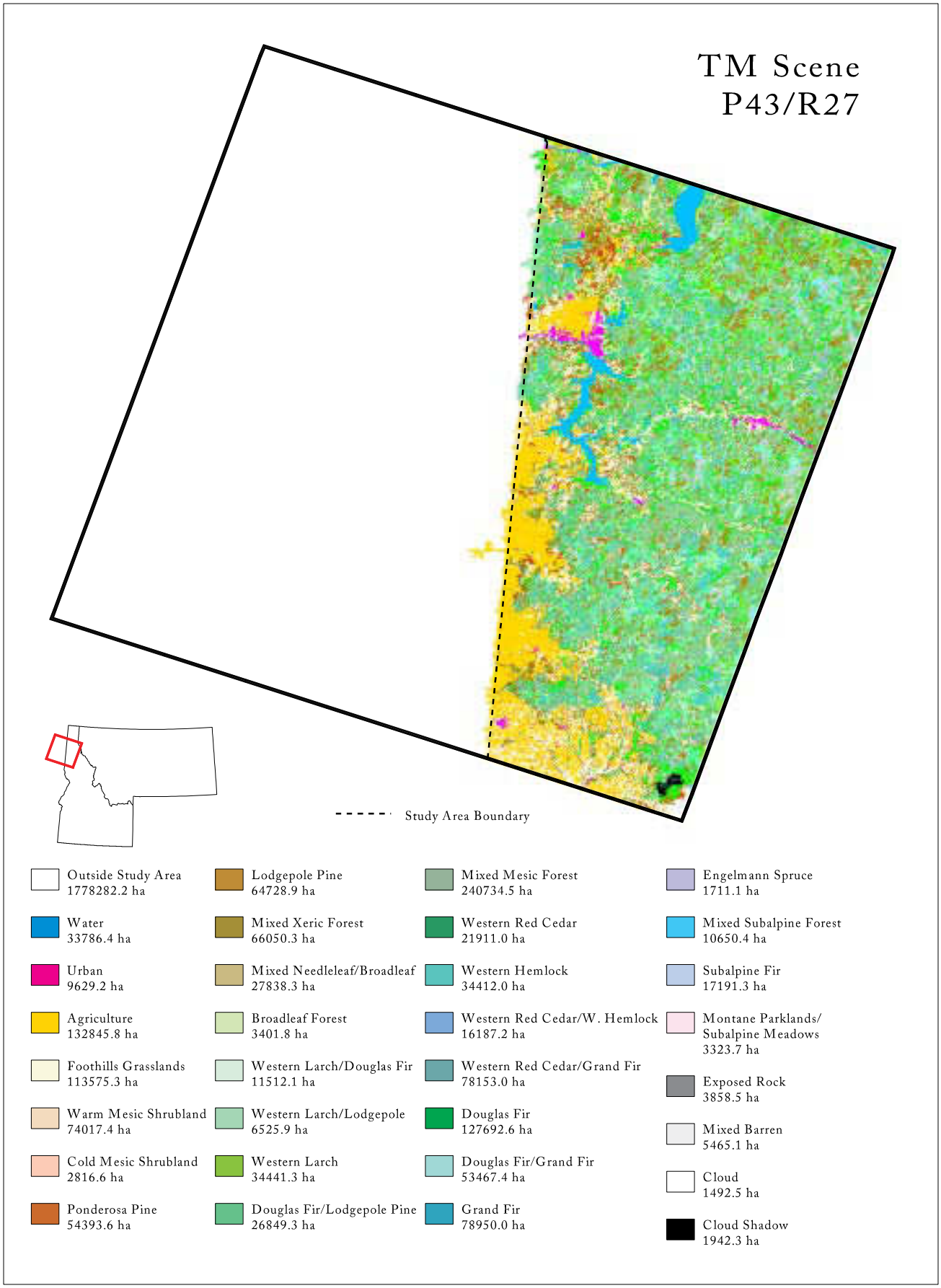


Figure F-2. Classification of land cover types for TM Scene P43/R27.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P43/R27

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 2175 to 4990 feet in elevation. The average canopy cover is 53% ranging from 10-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western white pine (Pinus monticola), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥1% and ≤5% and frequency of occurrence ≥40% and ≤73%.

Primary associated shrub species with ≥13% and ≤27% frequency of occurrence in lodgepole pine stands: mountain balm (Ceanothus velutinus), mountain-lover (Pachistima myrsinites), willow (Salix spp.), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤53% frequency of occurrence in lodgepole pine stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), and sedge (Carex spp.); **forbs**: queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), fireweed (Epilobium angustifolium), lupine (Lupinus spp.), strawberry bramble (Rubus pedatus), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

2) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 2180 to 4155 feet in elevation. The average canopy cover is 35% ranging from 10-70% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western larch (Larix occidentalis), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤11% and frequency of occurrence ≥4% and ≤52%.

Primary associated shrub species with ≥4% and ≤76% frequency of occurrence in ponderosa pine stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), black hawthorn (Crataegus douglasii), ocean-spray (Holodiscus discolor), mallow ninebark (Physocarpus malvaceus), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤16% frequency of occurrence in ponderosa pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Japanese brome (Bromus japonicus), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), orchard grass (Dactylis glomerata), bluebunch wheatgrass (Elymus spicatus), and bluegrass (Poa spp.); **forbs**: common pearly-everlasting

(Anaphalis margaritacea), balsamroot (Balsamorhiza sagittata), glacier lily (Erythronium grandiflorum), and sierran peavine (Lathers nevadensis); **ferns**: none; **moss**: none.

3) 4207: GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) ranging from 2175 to 4720 feet in elevation. The average canopy cover is 451 ranging from 20-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western red cedar (Larix occidentalis), Douglas-fir (Pseudotsuga menziesii), and western hemlock (Tsuga heterophylla) with average percent cover ≥3% and ≤8% and frequency of occurrence ≥32% and ≤73%.

Primary associated shrub species with ≥22% and ≤57% frequency of occurrence in grand fir stands: rocky mountain maple (Acer glabrum), ocean-spray (Holodiscus discolor), twin flower (Linnaea borealis), mallow ninebark (Physocarpus malvaceus), thimbleberry (Rubus parviflorum), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤30% frequency of occurrence in grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), and orchard grass (Dactylis glomerata); **forbs**: trail-plant (Adenocaulon bicolor), arnica (Arnica spp.), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: common Christmas-fern (Polystichum munitum) and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

4) 4210: WESTERN RED CEDAR FOREST

Conifer forest dominated by western red cedar (Thuja plicata) ranging from 2115 to 3640 feet in elevation. The average canopy cover is 53% ranging from 30-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), Douglas-fir (Pseudotsuga menziesii), and western hemlock (Tsuga heterophylla) with average percent cover ≥4% and ≤11% and frequency of occurrence ≥40% and ≤100%.

Primary associated shrub species with ≥10% and ≤30% frequency of occurrence in western red cedar stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), twin flower (Linnaea borealis), mockorange (Philadelphus lewisii), thimbleberry (Rubus parviflorum), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤38% frequency of occurrence in western red cedar stands: **graminoids**: none; **forbs**: trail-plant (Adenocaulon bicolor), wild ginger (Asarum caudatum), queen's cup beadlily (Clintonia uniflora), glacier lily (Erythronium grandiflorum), starry solomon-plume (Smilacina stellata), and false bugbane (Trautvetteria caroliniensis); **ferns**: common Christmas-fern (Polystichum munitum) and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

5) 4211: WESTERN HEMLOCK FOREST

Conifer forest dominated by western hemlock (Tsuga heterophylla) ranging from 2260 to 4450 feet in elevation. The average canopy cover is 60% ranging from 20-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western white pine (Pinus monticola), and western red cedar (Thuja plicata) with average percent cover ≥2% and ≤10% and frequency of occurrence ≥33% and ≤83%.

Primary associated shrub species with ≥8% and ≤17% frequency of occurrence in western hemlock stands: rocky mountain maple (Acer glabrum), sitka alder (Alnus sinuata), bunchberry (Cornus canadensis), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤14% frequency of occurrence in western hemlock stands: **graminoids**: none; **forbs**: arnica (Arnica spp.), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), starry solomon-plume (Smilacina stellata), and trefoil foamflower (Tiarella trifoliata); **ferns**: northern maidenhair (Adiantum pedatum) and oak-fern (Gymnocarpium dryopteris); **moss**: moss (moss spp.).

6) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 2180 to 4840 feet in elevation. The average canopy cover is 46% ranging from 10-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), ponderosa pine (Pinus ponderosa), and western hemlock (Tsuga heterophylla) with average percent cover ≥4% and ≤7% and frequency of occurrence ≥15% and ≤ 58%.

Primary associated shrub species with ≥14% and ≤46% frequency of occurrence in Douglas-fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), ocean-spray (Holodiscus discolor), mountain-lover (Pachistima myrsinites), mallow ninebark (Physocarpus malvaceus), Scouler willow (Salix scouleriana), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤19% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), orchard grass (Dactylis glomerata), blue wildrye (Elymus glaucus), and bluebunch wheatgrass (Elymus spicatus); **forbs**: trail-plant (Adenocaulon bicolor), showy aster (Aster conspicuus), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), common St. John's-wort (Hypericum perforatum), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

7) 4221: MIXED MESIC FOREST

Conifer forest dominated by grand fir (Abies grandis), codominant species are western larch (Larix occidentalis), western red cedar (Thuja plicata), and western hemlock (Tsuga

heterophylla), ranging from 1999 to 5280 feet in elevation. The average canopy cover for ABIGRA is 18% ranging from 1-50% total cover and frequency of occurrence equal to 82%. The average canopy cover for LAROCC is 11% ranging from 1-60% total cover and frequency of occurrence equal to 51%. The average canopy cover for THUPLI is 14% ranging from 1-50% total cover and frequency of occurrence equal to 49%. The average canopy cover for TSUHET is 21% ranging from 1-70% total cover and frequency of occurrence equal to 41%. Primary associated tree species include lodgepole pine (Pinus contorta), western white pine (Pinus monticola), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥11% and ≤16% and frequency of occurrence ≥29% and ≤75%.

Primary associated shrub species with ≥9% and ≤21% frequency of occurrence in mixed mesic stands: rocky mountain maple (Acer glabrum), ocean-spray (Holodiscus discolor), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), mallow ninebark (Physocarpus malvaceus), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤15% frequency of occurrence in mixed mesic stands: **graminoids**: cheatgrass (Bromus tectorum), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), orchard grass (Dactylis glomerata), and Kentucky bluegrass (Poa pratensis); **forbs**: trail-plant (Adenocaulon bicolor), arnica (Arnica spp.), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), fireweed (Epilobium angustifolium), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

8) 4222: MIXED XERIC FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) and ranging from 2280 to 4040 feet in elevation. The average canopy cover is 23% ranging from 1-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥23% and ≤30% and frequency of occurrence ≥7% and ≤100%.

Primary associated shrub species with ≥7% and ≤57% frequency of occurrence in mixed xeric stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), ocean-spray (Holodiscus discolor), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤28% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), purple reedgrass (Calamagrostis purpurascens), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), slender hairgrass (Deschampsia elongata), bluebunch wheatgrass (Elymus spicatus); **forbs**: trail-plant (Adenocaulon bicolor), heart-leaf arnica (Arnica cordifolia), bull thistle (Cirsium vulgare), glacier lily (Erythronium grandiflorum), sweetscented bedstraw (Galium triflorum), sierran peavine (Lathers nevadensis), and false bugbane (Trautvetteria caroliniensis; **ferns**: brackenfern (Pteridium aquilinum); **moss**: none.

9) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) and ranging from 2145 to 5400 feet in elevation. The average canopy cover for PINCON is 30% ranging from 20-40% total cover and frequency of occurrence equal to 93%. The average canopy cover for PSEMEN is 30% ranging from 10-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western larch (Larix occidentalis), and western white pine (Pinus monticola) with average percent cover ≥2% and ≤6% and frequency of occurrence ≥21% and ≤71%.

Primary associated shrub species with ≥21% and ≤57% frequency of occurrence in Douglas-fir-lodgepole pine stands: ocean-spray (Holodiscus discolor), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), mallow ninebark (Physocarpus malvaceus), thimbleberry (Rubus parviflorum), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤21% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), and Kentucky bluegrass (Poa pratensis); **forbs**: trail-plant (Adenocaulon bicolor), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

10) 4225: DOUGLAS FIR-GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) and Douglas-fir (Pseudotsuga menziesii) and ranging from 2470 to 4600 feet in elevation. The average canopy cover for ABIGRA is 28% ranging from 10-50% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 27% ranging from 10-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western larch (Larix occidentalis), western white pine (Pinus monticola), and western hemlock (Tsuga heterophylla) with average percent cover ≥2% and ≤5% and frequency of occurrence ≥21% and ≤32%.

Primary associated shrub species with ≥14% and ≤57% frequency of occurrence in Douglas-fir-grand fir stands: rocky mountain maple (Acer glabrum), ocean-spray (Holodiscus discolor), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), mallow ninebark (Physocarpus malvaceus), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare),

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤21% frequency of occurrence in Douglas-fir-grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris) and pinegrass (Calamagrostis rubescens); **forb**: trail-plant (Adenocaulon bicolor), queen's cup beadlily (Clintonia uniflora), horseweed (Conyza canadensis), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

11) 4226: WESTERN RED CEDAR-GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) and western red cedar (Thuja plicata) and ranging from 2300 to 4340 feet in elevation. The average canopy cover for ABIGRA is 41% ranging from 10-60% total cover and frequency of occurrence equal to 100%. The average canopy cover for THUPLI is 29% ranging from 10-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western larch (Larix occidentalis), Douglas-fir (Pseudotsuga menziesii), and western hemlock (Tsuga heterophylla) with average percent cover ≥4% and ≤5% and frequency of occurrence ≥43% and ≤64%.

Primary associated shrub species with ≥7% and ≤36% frequency of occurrence in western red cedar-grand fir stands: rocky mountain maple (Acer glabrum), bunchberry (Cornus canadensis), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), mallow ninebark (Physocarpus malvaceus), thimbleberry (Rubus parviflorum), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤21% frequency of occurrence in western red cedar-grand fir stands: **graminoids**: none; **forbs**: broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), glacier lily (Erythronium grandiflorum), starry solomon-plume (Smilacina stellata), and American vetch (Vicia americana); **ferns**: oak-fern (Gymnocarpium dryopteris) and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

12) 4301: MIXED NEEDLELEAF/BROADLEAF FOREST

Mixed needleleaf and broadleaf forest dominated by grand fir (Abies grandis) and ranging from 2100 to 3640 feet in elevation. The average canopy cover is 20% ranging from 3-50% total cover and frequency of occurrence equal to 75%. Primary associated tree species include paper birch (Betula papyrifera), Douglas-fir (Pseudotsuga menziesii), and western red cedar (Thuja plicata) with average percent cover ≥11% and ≤28% and frequency of occurrence ≥50% and ≤75%.

Primary associated shrub species with ≥17% and ≤33% frequency of occurrence in mixed needleleaf and broadleaf stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), common prince's pine (Chimaphila umbellata), ocean-spray (Holodiscus discolor), thimbleberry (Rubus parviflorum), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤17% frequency of occurrence in mixed needleleaf and broadleaf stands: **graminoids**: none; **forbs**: spotted knapweed (Centauria maculosa), queen's cup beadlily (Clintonia uniflora), starry solomon-plume (Smilacina stellata), tansy (Tanacetum spp.), and common tansy (Tanacetum vulgare); **ferns**: common scouring-rush (Equisetum hyemale) and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp).

P43/R27 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	7, 31
6102	Broadleaf Dominated Riparian	28, 59
6103	Needleleaf-Broadleaf Riparian	6
6104	Mixed Riparian (trees + any other)	20, 66
6201	Grass-Forb Riparian/Wetland	None identified for scene
6202	Shrub Riparian/Wetland	8, 11, 37, 62
6203	Mixed Grass-Forb-Shrub Riparian	44

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 2
Color: White; RGB 255 255 255.
Distribution: A small class, occurring in clusters at lower elevations.
Comment: There are just two training sites outside the zone for this spectral class. One indicates Urban & Developed Land, and the other represents the cover type Mines, Quarries, Gravel Pit. Appears to represent barren land.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
1	1	Broadleaf Dominated Riparian

Spectral Class 6
Color: Brown; RGB 136 114 81.
Distribution: Light to medium density spackle at middle elevations; some along streams at lower elevations.
Comment: As a group, conifers have the highest combined frequency among cover types outside the riparian zone; shrubs and grassland are next in dominance. Several sites represent Aspen or Mixed Needleleaf-Broadleaf cover types. Riparian cover types (6102, 6101, 6103) are minimally included.
Conclusion: 6103.

5	1	Ponderosa Pine & Savannah
6	1	Broadleaf Dominated Riparian
7	1	Grass-Forb Riparian/Wetland
8	4	Shrub Riparian/Wetland

Spectral Class 7
Color: Dark brown; RGB 122 75 55.
Distribution: Medium to high density at middle elevations.

Comment: Conifers dominate training sites outside the zone; also present are riparian (6101, 6103, 6201), Mixed Needleleaf-Broadleaf, Mesic Upland Shrubland, agricultural, and Aspen cover types.
Conclusion: 6101.

9	1	Foothills Grassland
10	1	Broadleaf Forest
11	1	Needleleaf Dominated Riparian
12	2	Broadleaf Dominated Riparian
13	1	Needleleaf-Broadleaf Riparian

Spectral Class 8
Color: Light, warm brown; RGB 185 137 89.
Distribution: Light to medium density at middle elevations; some at lower elevations.
Comment: Herbaceous cover types, including agriculture, are most prevalent outside the zone; shrub, coniferous and riparian (6201, 6101, 6102, 6103) characterize the remaining sites.
Conclusion: 6202.

14	1	Dry-land crop
15	1	Irrigated Crop
16	1	Dry-land Pasture
17	4	Foothills Grassland
18	1	Broadleaf Dominated Riparian
19	2	Grass-Forb Riparian/Wetland
20	1	Shrub Riparian/Wetland

Spectral Class 9
Color: Brown black; RGB 80 43 64.
Distribution: High density at middle to upper elevations.
Comment: Needleleaf cover types dominate training data outside the zone; several points represent riparian vegetation (6101, 6202). Visual cues indicate shadows and coniferous vegetation. Conclusion: Not riparian.

21	1	Irrigated Crop
22	1	Dry-land Pasture
23	1	Mixed Mesic Forest
24	2	Needleleaf Dominated Riparian
25	1	Broadleaf Dominated Riparian
26	1	Grass-Forb Riparian/Wetland

Spectral Class 11
Color: Rust; RGB 189 103 64.
Distribution pattern: Medium to high density at upper elevations; light density at some lower and middle elevation locations.
Comment: Needleleaf and shrub cover types characterize training data outside the zone; riparian (6102, 6103, 6201), grassland, and pasture are included.
Conclusion: 6202.

28	1	Urban & Developed Land
29	1	Irrigated Pasture
30	1	Foothills Grassland
31	1	Mesic Upland Shrubland
32	1	Ponderosa Pine & Savannah
33	1	Needleleaf Dominated Riparian
34	3	Broadleaf Dominated Riparian
35	1	Needleleaf-Broadleaf Riparian
36	3	Shrub Riparian/Wetland

Spectral Class 14
Color: Dark red; RGB 171 66 60.
Distribution: Medium density at highest elevations; light density at middle elevations.
Comment: Needleleaf cover types are most prevalent outside the zone; one site represents riparian (6103) vegetation. Appears to be Mixed Mesic forest.
Conclusion: Not riparian.

Spectral Class 18
Color: Salmon pink; RGB 252 131 140.
Distribution: Clusters at lower elevations.
Comment: Herbaceous cover types are indicated by the four training sites outside the zone, one of which is mixed Ponderosa and Savannah. Color and locations indicate agricultural land.
Conclusion: Not riparian.

40	1	Grass-Forb Riparian/Wetland

Spectral Class 19
Color: Light, cool brown; RGB 210 152 149.
Distribution: Light density at lower elevations.
Comment: Agriculture, grassland, and coniferous vegetation are equally represented by training data outside the zone. Appears to represent urban areas.
Conclusion: Not riparian.

41	1	Urban & Developed Land
42	1	Dry-land Pasture

Spectral Class 20
Color: Red orange; RGB 255 111 85.
Distribution: Numerous clusters in agricultural areas; medium density clusters at highest elevations.
Comment: Coniferous and herbaceous vegetation are about equally represented by training sites outside the zone; four sites indicate riparian vegetation (6102, 6103, 6201).
Conclusion: 6104.

43	1	Irrigated Pasture
44	1	Foothills Grassland
45	1	Aspen
46	1	Grass-Forb Riparian/Wetland
47	2	Shrub Riparian/Wetland

Spectral Class 23
Color: Medium green; RGB 77 129 102.
Distribution: Medium density on the Channel Scablands south and west of Spokane; light to medium density in some other low elevation areas.
Comment: Herbaceous vegetation were most recorded outside the zone; shrub and barren cover types were also recorded. Color and distribution suggest dry grass and sage cover types.
Conclusion: Not riparian.

49	1	Urban & Developed Land
50	1	Grass-Forb Riparian/Wetland

Spectral Class 24
Color: Blue black; RGB 0 41 72.
Distribution: A rare class. Very light density along edges of water bodies and at middle elevations.
Comment: Urban, coniferous, and water cover types are minimally included in training data outside the zone.
Conclusion: Not riparian.

51	1	Urban & Developed Land
52	4	Rivers & Streams
53	1	Lakes
54	1	Grass-Forb Riparian/Wetland
55	1	Mixed Barren Land
56	1	Shoreline & Gravel Bars

Spectral Class 25
Color: Gray; RGB 133 128 136.
Distribution: Small clusters on foothills and upper low elevation locations; high density in Spokane.
Comment: Herbaceous vegetation is most prevalent outside the zone, with urban, coniferous, shrub, and riparian (6202) vegetation included. Visual cues indicate urban areas.
Conclusion: Not riparian.

57	2	Foothills Grassland
58	1	Grass-Forb Riparian/Wetland

Spectral Class 26
Color: Kelly green; RGB 87 174 132.
Distribution: High density in sinuous patterns at lowest elevations; light density in some other low elevation areas.
Comment: Herbaceous vegetation, including agricultural, dominates training data outside the zone. Appears to represent agricultural and dry grass areas.
Conclusion: Not riparian.

59	1	Grass-Forb Riparian/Wetland

Spectral Class 27
Color: Blue gray; RGB 80 98 136.
Distribution: Light to medium density in settled areas.
Comment: A number of cover types are minimally included among training sites outside the zone: urban, Dry-land crop, grasslands, Exposed Rock, Mines, and Mixed Barren Land. Color and pattern indicate hard surfaces, especially in urban areas.
Conclusion: Not riparian.

60	1	Dry-land crop
61	1	Mesic Upland Shrubland
62	1	Grass-Forb Riparian/Wetland

Spectral Class 28
Color: Dark pink; RGB 220 94 128.
Distribution: Clusters in agricultural areas, sparsely distributed.
Comment: The two training sites outside the zone represent Dry-land crop and Mesic Upland Shrubland. The high red component, as well as locations along particular lakes, imply broadleaf riparian vegetation.
Conclusion: 6102.

63	2	Dry-land crop

Spectral Class 31
Color: Dark olive; RGB 91 101 72.
Distribution: Light to medium density at upper low elevations.
Comment: Conifers, shrub, and grassland characterize training sites outside the zone. Appears to be Ponderosa Pine riparian vegetation.
Conclusion: 6101.

64	1	Ponderosa Pine & Savannah
65	2	Grass-Forb Riparian/Wetland

Spectral Class 32
Color: Black; RGB 28 23 43.
Distribution: High density at upper elevaions; light density at lower mid-elevations.
Comment: Coniferous cover types dominate training data outside the zone; two points represent riparian vegetation (6101). Visual cues indicate conifers and water.
Conclusion: Not riparian.

66	1	Mixed Mesic Forest
67	3	Lakes
68	1	Needleleaf Dominated Riparian

Spectral Class 37
Color: Light orange; RGB 255 173 102.
Distribution: A rare class. Sparsely distributed small clusters at all elevations; some near water features.
Comment: Herbaceous vegetation was obseved somewhat more frequently than other cover types outside the zone; urban and shrub were included.
Conclusion: 6202.

70	1	Irrigated Pasture
71	1	Foothills Grassland

Spectral Class 38
Color: Bright orange; RGB 255 150 68.
Distribution: Small clusters in agricultural areas and some mid-elevation locations.
Comment: Agriculture, shrubs, and conifers characterize training sites outside the zone.
Conclusion: Not riparian.

72	1	Irrigated Crop
73	1	Dry-land Pasture
74	1	Foothills Grassland
75	1	Grass-Forb Riparian/Wetland

Spectral Class 44
Color: Gold; RGB 203 169 98.
Distribution: Sparsely distributed small clusters at all elevations.
Comment: Herbaceous and shrub cover types were the most recorded outside the riparian zone; one site represents riparian vegetation (6202).
Conclusion: 6203.

82	1	Urban & Developed Land
83	2	Dry-land crop
84	1	Irrigated Crop
85	1	Grass-Forb Riparian/Wetland

Spectral Class 46
Color: Blue black; RGB 0 2 60.
Distribution: Water bodies.
Comment: Water features dominate training data outside the zone.
Conclusion: Not riparian.

87	1	Urban & Developed Land
88	3	Rivers & Streams
89	12	Lakes
90	3	Reservoirs
91	1	Grass-Forb Riparian/Wetland
92	1	Sandy Areas, Blowouts

Spectral Class 47
Color: Bright pink; RGB 252 133 213.
Distribution: A rare class. Occasional sites in agricultural areas.
Comment: There are not training sites for this spectral class. Visual cues do not give a strong indication of any particular cover type.
Conclusion: Not riparian.

Spectral Class 51
Color: Dark lavender; RGB 182 109 170.
Distribution: A small class. Light density in agricultural areas.
Comment: The single training site outside the zone indicates Dry-land crop. Appears to represent urban and agricultural areas.
Conclusion: Not riparian.

Spectral Class 53
Color: Light moss green; RGB 168 184 128.
Distribution: Light to medium density at lower mid-elevations; some along streams.
Comment: Agricultural land and grasslands are most prevalent among training sites outside the zone.
Conclusion: Not riparian.

95	1	Dry-land crop
96	2	Dry-land Pasture
97	1	Foothills Grassland

Spectral Class 55
Color: Yellow; RGB 238 203 119.
Distribution: A rare class. Occassional clusters at low and middle elevations.
Comment: The four training sites outside the zone all indicate herbaceous vegetation.
Conclusion: Not riparian.

98	1	Dry-land Pasture
99	1	Irrigated Pasture

Spectral Class 56
Color: Bright, cool red; RGB 255 73 102.
Distribution: A small class. Sparsely distributed clusters in agricultural areas.
Comment: All three training sites outside the zone represent herbaceous vegetation, two of which indicate agricultural land.
Conclusion: Not riparian.

100	1	Dry-land crop

Spectral Class 58
Color: Salmon; RGB 255 167 166.
Distribution: A small class. Medium density in agricultural areas.
Comment: The single training site for this class, which is outside the riparian zone, represents Irrigated Crop.
Conclusion: Not riparian.

Spectral Class 59
Color: Gray red; RGB 168 88 106.
Distribution: A small class. Light density at middle elevations; some clusters in agricultural areas.
Comment: Needleleaf and grass vegetation were observed outside the zone. Visual cues suggest broadleaf riparian vegetation.
Conclusion: 6102.

101	1	Dry-land Pasture
102	1	Broadleaf Dominated Riparian
103	2	Shrub Riparian/Wetland

Spectral Class 62
Color: Dark red; RGB 206 62 55.
Distribution: A small class, Some small clusters at high elevations.
Comment: Agriculture, shrubs, and conifers are minimally included in training data outside the zone.
Conclusion: 6202.

Spectral Class 63
Color: Very dark brown; RGB 98 45 51.
Distribution: A large class. High density at middle to upper elevations.
Comment: Needleleaf cover types dominate training sites outside the riparian zone; two sites represent Mixed Needleleaf-Broadleaf forest, and several represent riparian vegetation (6101, 6103).
Conclusion: Not riparian.

104	1	Mix Needleleaf-Broadleaf
105	1	Broadleaf Dominated Riparian

Spectral Class 64
Color: Dark, warm brown; RGB 143 73 55.
Distribution: Light to medium density at middle to upper elevations.
Comment: Coniferous vegetation is most prevalent outside the zone; riparian (6102, 6101, 6201) and Mixed Needleleaf-Broadleaf vegetation are included.
Conclusion: Not riparian.

106	1	Mixed Mesic Forest
107	1	Needleleaf Dominated Riparian
108	2	Needleleaf-Broadleaf Riparian
109	1	Shrub Riparian/Wetland

Spectral Class 66
Color: Very dark olive; RGB 101 90 81.
Distribution: Medium density on foothills and some valley locations; light density at middle elevations, with some linear pattern.
Comment: Coniferous cover types dominate training data outside the zone; one point refers to riparian vegetation (6101).
Conclusion: 6104.

111	2	Irrigated Crop
112	1	Disturbed Grasslands
113	1	Ponderosa Pine & Savannah
114	1	Mixed Mesic Forest
115	1	Broadleaf Dominated Riparian

TM SCENE P42/R26

Image Analyst: Troy P. Tady

Training Data Analysis

In all, 1992 ground-truth plots were available for labeling P42/R26 (see table next page). The data were initially checked over the full scene to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 20) were removed from further analysis. The data were then examined by cover type to determine whether or not plots were collected for this project or for other purposes (e.g., pre-existing ECODATA, TSMRS, etc.). The latter "existing data" were used only as supplementary training plots for some cover types. The following classes were manually labeled if they occurred in the scene and if data were available: urban, agriculture, water, snow, riparian, burns, mines/quarries/ gravel pits, clearcuts, sandy areas and shoreline/gravel bars. Plots with these VEG_CLASS_CODEs were not used in the digital classification as either training or test data. The following classes were also excluded because they were determined to be minor scene components as per USFS decisions: 3201, 3304, and 8101. The aspen (4101) cover type was combined with the general broadleaf forest class (4102) due to a lack of adequate training data for each separate class. The disturbed grassland (3102) class was combined with foothills grassland (3101) because of negligible spectral differences between the two classes.

Of the remaining plots, 20% were randomly selected from each cover type. These plots (n = 152) were held aside in a separate data file for use in the accuracy assessment. Pre-existing ECODATA points were used as training data for the following classes: 4201, 4207, 4210, 4225, 4226, 4227, 4228, and 4229. ECODATA points were not used as accuracy test data points. The same process was used to separately extract test points for size classes and for canopy cover classes. ECODATA points were not used as training data supplements for tree and shrub size classes or as accuracy test data points. For the remaining 80% of this "filtered" data set, plots were subjected to further spectral examination. Outliers were eliminated for each cover type based on knowledge of general spectral patterns for various ground features. Insufficient training data plots were available for the following cover types:

4101 Broadleaf Forest	- 16 plots (when combined with 4102, 12 plots)
4207 Grand Fir	- 3 plots
4211 Western Hemlock	-16 plots
4225 Douglas-fir - Grand Fir	- 5 plots
4226 W.Red Cedar - Grand Fir	- 8 plots

Training data for some of these and most of the other cover types were supplemented from data gathered during a Forest Service review session with the Kootenai National Forest as well as from personal knowledge of individuals familiar with areas within the scene. A total of about 240 new training data plots were obtained through various review sessions.

Total plots in ground-truth file	1992	
Total 1994-95 field plots	1115	
Plots sampled for P42/R26		747
Plots sampled for other scenes		368
Pre-existing plots (ECODATA, TSMRS, etc.)	877	
Plots with codes included in the classification	1632	
Plot discards	79	
Pre-existing plots		59
'Bad duplicates'		0
'Good duplicates'		20
Potential training plots	771	
20% test		152
80% training		619
Supplemental plots	240	(+/-)
Total plots for available for training	859	(+/-)
Total plots used for training--cover type	572	
size class	161	
canopy	598	

Land Cover Types

Land cover types were labeled through a digital classification of TM channels 1-7 plus rescaled elevation (raw elevation value divided by 25). The digital classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were used and assigned directly to the COVERTYPE field in the database attribute table. Further modifications were carried out using spectral class values (SPECTRAL_CLASS or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000. Urban.	Manually identified and recoded by Will Gustafson.
2000. Agriculture.	Manually identified and recoded by Will Gustafson.
3101. Foothills Grassland.	All grass types occurring below 1067 m (3500 ft) were relabeled as Foothills Grassland.
3104. Montane Parkland & Subalpine Meadow.	All grass types occurring at and above 1067 m (3500 ft) were relabeled as Montane Parkland & Subalpine Meadow.

3202.	Warm Mesic Shrubland.	Shrub types were labeled as Warm Mesic Shrubland if they occurred below 1341 m (4400 ft). If they occurred between 1341 m (4400 ft) and 1646 m (5400 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland. Confusion with most tree classes was evident in the original shrub class data. Plot investigations revealed major mislabeling errors for both tree and shrub plots. This problem was corrected by examining MNDVI, NDVI, and various spectral values to determine plots not representing their cover type label.
3203.	Cold Mesic Shrubland.	Shrub types were labeled as Cold Mesic Shrubland if they occurred above 1646 m (5400 ft). If they occurred between 1341 m (4400 ft) and 1646 m (5400 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland. Confusion with most tree classes was evident in the original shrub class data (see 3202).
4102.	Broadleaf Forest.	This class was well represented by the 16 combined 4101 and 4102 training plots. Confusion with taller shrub types may be expected, however.
4203.	Lodgepole Pine.	Lodgepole pine distributions in northern Idaho and northwestern Montana were not well represented from data obtained from the Kootenai NF. General distributions, however, seemed reasonable for the area when viewed by Kootenai representatives.
4201.	Engelmann Spruce.	Understandable confusion with Mixed Subalpine Forest (4220) was noted although general distribution for Engelmann Spruce seems reasonable for the area.
4206.	Ponderosa Pine.	Ponderosa pine data were supplemented with data provided by the Kootenai NF. General distribution at low elevations and in river bottoms seems to indicate likely Ponderosa Pine occurrences for this area.
4207.	Grand Fir.	Confusion between Grand Fir and Mixed Mesic Forest (4221) was evident in the training data and is also reflected in the cover type accuracy assessment. This confusion is understandable since Grand Fir monoculture stands are relatively rare while the Grand Fir species component in the 4221 class tends to be very large in N Idaho and NW Montana. The small number

		of Grand Fir plots available for P42/R26 certainly underestimates Grand Fir distribution in the area. Grand Fir data were supplemented with one ECODATA plot.
4208.	Subalpine Fir.	Confusion with shrub cover types was evident in some areas of the scene (see *Discussion)*. An investigation of ground truth points showed numerous locational or labeling errors in the ground truth data, where very sparsely vegetated areas were labeled as Subalpine Fir (see also 4221).
4210.	Western Red Cedar.	Seven ECODATA plots were used to supplement the Western Red Cedar classification. Information for this class was generally scarce for P42/R26. No supplemental data were provided through the Forest Service reviews for this class.
4211.	Western Hemlock.	Little information for Western Hemlock was available for P42/R26. No supplemental data were available.
4212.	Douglas-fir.	Douglas-fir training data with unusually low MNDVI values were removed from the training data set. This reduced confusion with tall shrub types (see *Discussion)*.
4215.	Western Larch.	During the USFS review sessions, Western Larch was found to be confused with some shrub and broadleaf classes in younger plantations. Larch data were supplemented by the Kootenai NF to help correct this.
4219.	Mixed Whitebark Pine Forest.	Supplemental data for Mixed Whitebark Pine Forest was provided by the Kootenai NF and the Panhandle NF for parts of the Bonners Ferry District. General distribution for this class seems reasonable although come confusion is evident with the Mixed Subalpine Forest (4220) class. An elevational minimum of 5000 ft (1524 m) was used to help alleviate this problem.
4220.	Mixed Subalpine Forest.	Supplemental data for Mixed Subalpine Forest was provided by the Kootenai NF and Panhandle NF. Very little confusion was noted between the Mixed Mesic Conifer (4221) class and the Mixed Subalpine Forest class, which seems to indicate that elevational breaks in the training data were representative of vegetational changes along the elevation gradient. Confusion was evident, however, between Mixed Subalpine Forest plots and shrub plots in the original training data. Outliers

		were removed from the data set to help alleviate this problem (see *Discussion).*
4221.	Mixed Mesic Forest.	See subclasses: 4201, 4211, 4225, 4226, 4227, 4228, 4229 (and also *Discussion).*
4222.	Mixed Xeric Forest.	No modifications. No supplemental data.
4223.	Douglas-fir - Lodgepole Pine.	No modifications.
4225.	Douglas-fir - Grand Fir.	Two ECODATA plots were added to the training data set to classify Douglas-fir - Grand Fir.
4226.	Western Red Cedar - Grand Fir.	Three ECODATA plots were added to the training data set to classify Western Red Cedar-Grand Fir.
4227.	Western Red Cedar - Western Hemlock.	Eight ECODATA plots were added to the training data set to classify Western Red Cedar-Western Hemlock.
4228.	Western Larch - Lodgepole Pine.	Ten ECODATA plots were added to the training data set classify Western Larch-Lodgepole pine.
4229.	Douglas-fir - Western Larch.	Fourteen ECODATA plots were added to the training to classify Douglas-fir - Western Larch. A large amount of supplemental information for 4229 was obtained from the Kootenai NF.
4301.	Broadleaf - Needleleaf Forest.	No modifications.
5000.	Water.	All regions with spectral class (LINK) = 1 and slope ≤5˚ were labeled as water. Generally, water was more spectrally distinct than most other cover types, but in high mountainous terrain, it was confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate elevation and slope values such that their slope may be greater than 5˚. This would result in the misclassification of some small ponds or lakes. Some manual modification was applied to major rivers where the spectral class and slope criteria were not applicable for various topographic reasons.
7300.	Rock.	Supplemental data plots were obtained to provide a better representation of spectral variation in the 7300 class. The following decision rule was used to aid in accurately mapping 7300: If 7300 and NDVI <150 , then 3101.

7400.	Barren Alpine Tundra.	An elevation cutoff of 7000 ft (2133 m) was used to separate 7400 from 7800. 7400 occurs only at elevations ≥7000 ft (2133 m).
7800.	Mixed Barren.	See 7400 (occurs at <7000 ft (2133 m)).
9800.	Clouds.	Manually identified and recoded by Will Gustafson.
9900.	Cloud Shadows.	Manually identified and recoded by Will Gustafson.

A total of 33 classes were labeled in the full TM scene. These included two grass types, two shrub types, twenty-one forest types, plus eight non-vegetated or manually labeled classes. Cover types are mapped in Figure F-3.

Size Classes

Seven size classes were mapped -- four for forest cover types (seedling/sapling, pole, medium, and large/very large) and three for shrub cover (low, medium, and tall). The seven TM spectral channels were used for the size classification (elevation was not included). The Nearest Member of Group (NMG) classifier was used for both tree and shrub size classes. Tree size classes were stratified based upon three canopy cover classes (see below).

Canopy Cover Classes

Three canopy cover labels (CANOPYCODE = low, medium, or high) were assigned to tree and shrub classes based on Modified Normalized Distribution Vegetation Index (MNDVI) values (modified from Nemani et al. 1993). These values were plotted as frequency histograms for all forest types (Figure F-3a) as well as for one shrub type (Figure F-3b). The histograms were examined to determine break points based upon the distribution modes (see table below). Regions with MNDVI values falling below the lower break point were assigned to a low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class.

	MNDVI BREAKPOINTS	
CANOPY COVER	Tree	Shrub
Low	<180	<110
Medium	≥180 and ≤400	≥110 and ≤200
High	>400	>200

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications.

CLASSIFICATIONS FOR P42/R26	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	19	64%	31%
Tree Size Class	4	74%	38%
Tree Canopy Class	3	97%	58%
Shrub Size Class	3	100%	100%
Shrub Canopy Class	3	100%	56%

Comments

General distributions for most cover type classes seemed acceptable when viewed with the US Forest Service representatives from the Kootenai NF. Analysis of the original training data, however, revealed severe problems with lifeform-level mislabeling of plots. When the initial classification was run using the Forest Service training data (without supplemental plots) grass and agricultural areas were classified as 4221, 4220, and 4212. Likewise, shrub areas were classified as a 4200 cover type class. The initial classification also revealed an inadequate sample for 3100 class plots. Grass types were initially greatly underestimated by the Forest Service training plot data. Supplemental plots for grass locations fixed this problem. These problems were not encountered to such a degree for any of the six other scenes classified by T. Tady. Although these problems were fixed in the training data set, they cannot be remedied in the test data set. For this reason, twenty-nine of the 152 test plots used in the accuracy assessment were discarded as these plots labeled tree polygons on sites with no vegetation at all. Even with this consideration, the accuracy values for cover type reflect the poor quality of some of the cover type data set. Some classes are not represented in the accuracy assessment figures due to the problems mentioned above. In some cases, none of the randomly selected test plots for a specific cover type class were of useful quality.

Accuracy values for tree size class reflect the problems mentioned above for cover type classes. A large test set was not available for the shrub size class accuracy assessment. It should be noted that the 100% accuracy value reflects agreement between only five test data points and the classified data.

The MNDVI breaks used to define tree and shrub canopy cover classes were fairly obvious from histograms generated from the Forest Service ground truth data set. The histograms, however, illustrated the problems previously mentioned. Tree and shrub MNDVI distributions were uncommon relative to most other scenes. The higher accuracy (relative to cover type) values for both tree and shrub canopy cover demonstrate the ability to readjust MNDVI values for mislabeled points into a more representative distributions for various ground features. Better correlation between the readjusted MNDVI breaks and the canopy cover data provided by the Forest Service was noted because of the more robust and generalized nature of the canopy cover classes (i.e., few classes with a wide range of variation).

Shrub canopy classes, derived from MNDVI values, were difficult to assess given the non-representative range of variation for MNDVI contained within the Forest Service ground truth plots. As mentioned above, attempts were made to adequately define shrub canopy classes using readjusted MNDVI breaks. The accuracy listed for shrub canopy cover seems to indicate a good correlation between the MNDVI breaks used and some of the more representative plots in the Forest Service ground truth set.

Error Matrix For Cover Type Training Plots
Scene P42/R26

CLASSIFIED COVER TYPES

PLOT COVER TYPES	3101	3201	4102	4201	4203	4206	4207	4208	4210	4212	4215	4219	4220	4221	4222	4223	4301	7301	7800	SUM
3101	57	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4	5	70
3201	3	39	0	0	0	0	0	0	0	0	0	0	4	2	0	0	2	0	3	53
4102	0	0	3	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	7
4201	0	0	0	4	0	0	0	0	0	0	0	1	5	7	0	0	0	0	1	18
4203	0	1	0	0	18	0	0	0	1	0	1	0	2	5	1	0	0	0	0	29
4206	0	2	0	0	0	10	0	0	1	1	0	0	0	1	2	0	2	1	1	21
4207	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2
4208	0	0	0	0	0	0	0	4	1	0	0	1	4	1	0	0	0	0	0	11
4210	0	1	0	0	0	1	0	0	5	0	0	0	0	4	0	0	2	0	0	13
4212	0	1	0	0	0	3	0	0	1	19	2	0	3	14	0	2	0	0	0	45
4215	0	0	1	1	0	0	0	0	0	3	4	0	1	5	0	0	0	0	0	15
4219	1	0	0	1	0	0	0	1	0	0	0	15	4	1	0	0	0	0	1	24
4220	0	3	0	5	2	0	0	4	0	1	0	3	22	3	0	0	0	0	0	43
4221	0	1	0	4	3	1	0	0	5	14	5	1	5	76	1	0	4	1	2	123
4222	0	0	1	0	1	2	0	0	0	2	0	0	0	2	5	0	2	0	1	16
4223	0	0	0	0	1	0	0	1	0	2	0	0	1	2	0	1	1	0	0	9
4301	0	1	0	0	0	1	0	0	2	1	1	0	1	5	1	0	7	0	0	20
7301	6	1	0	0	0	2	0	0	0	0	0	2	0	1	0	0	0	20	2	34
7800	7	5	1	0	2	0	0	0	0	0	0	0	0	1	0	0	0	1	2	19
SUM	74	58	6	15	28	21	0	10	16	43	14	23	52	132	10	3	21	27	19	572

% AGREEMENT	54.37
TAU WITH EQUAL PROBABILITY	0.519
TOTAL DIAGONAL ELEMENTS	311
TOTAL TRAINING PLOTS IN DATA SET	572

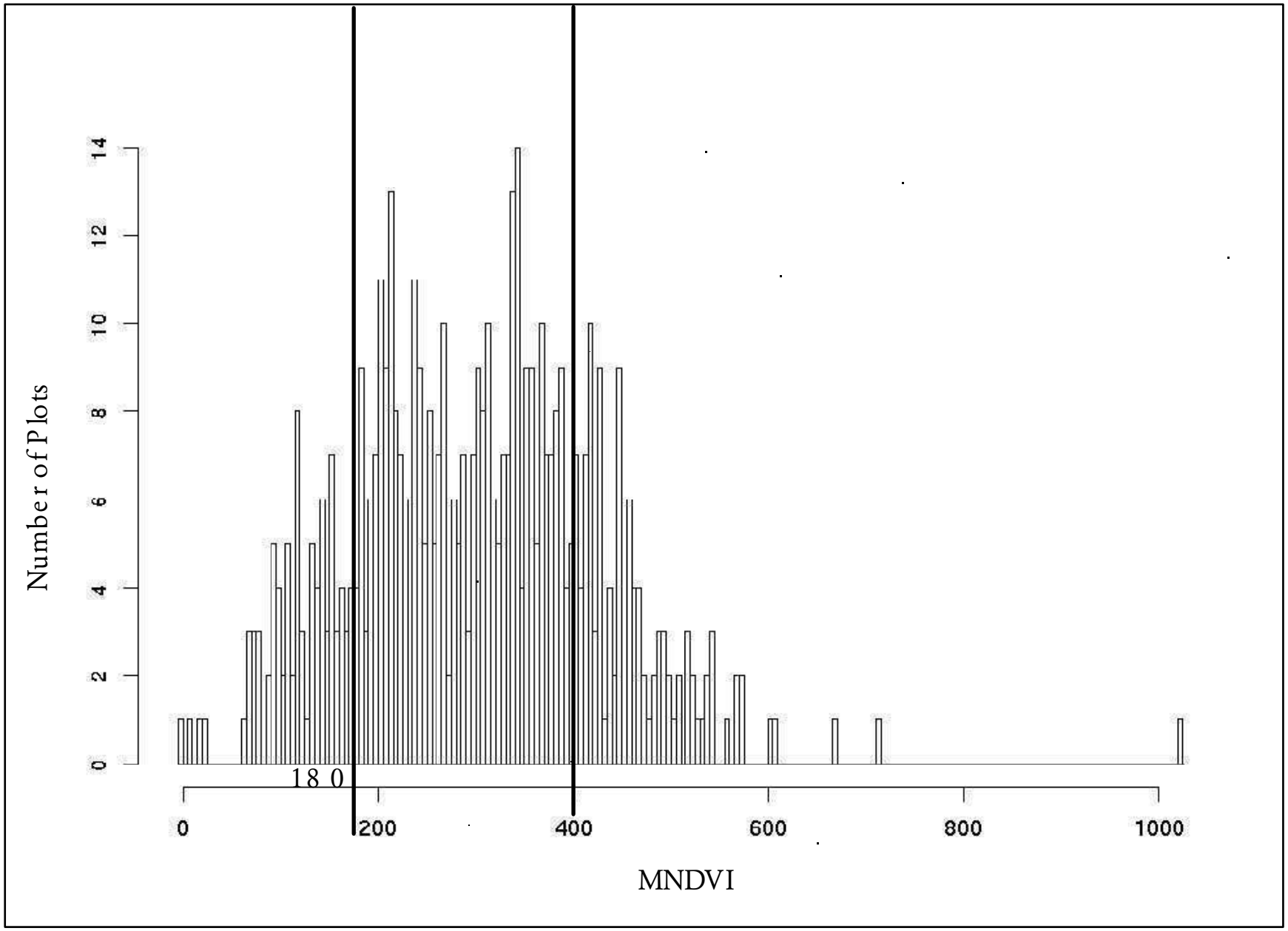


Figure F-5b. Breaks between mesic shrub canopy coverclasses in relation to MNDVI values: TMscene P42/R28

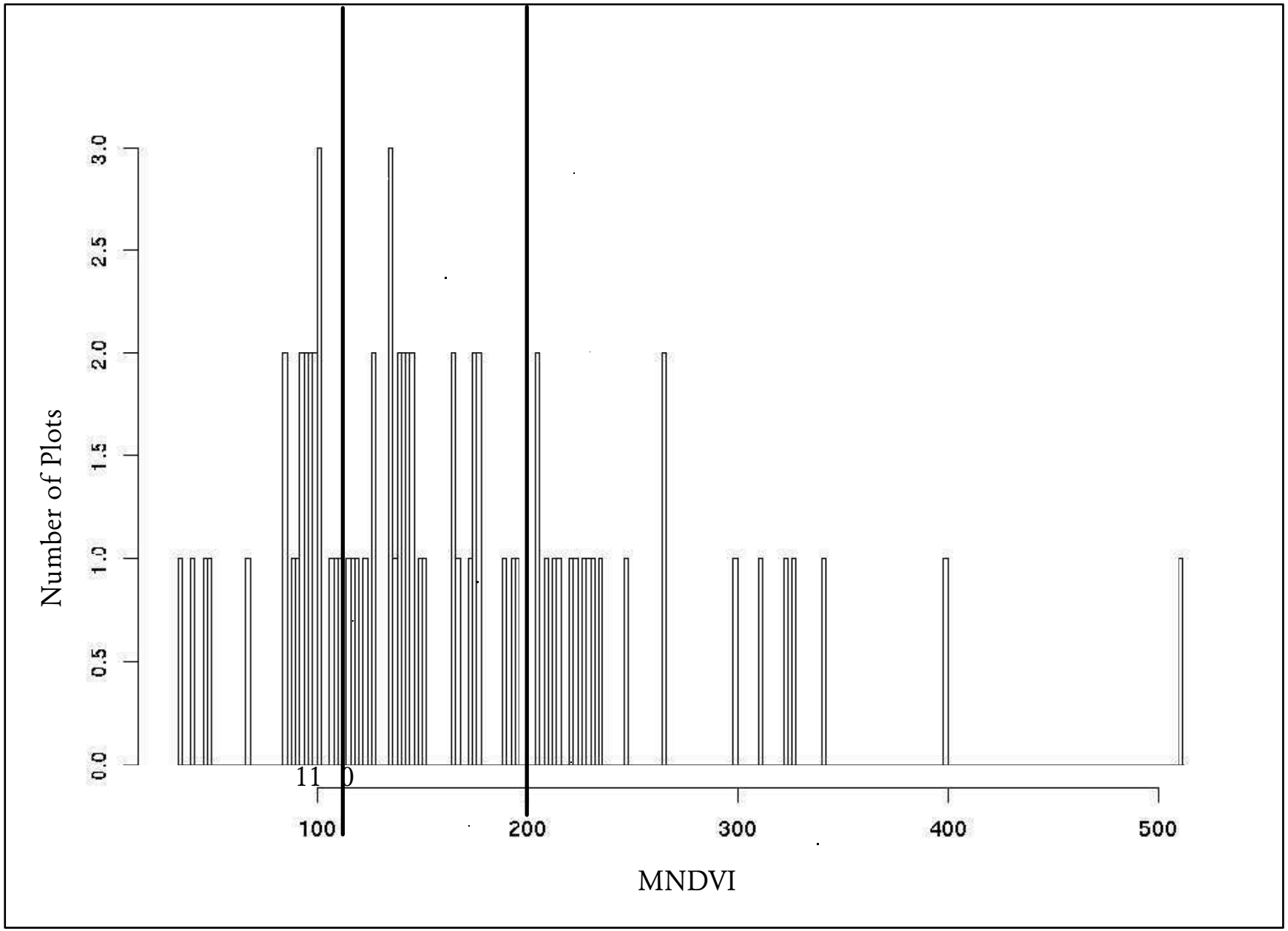


Figure F- 3b. Breaks between shrub canopy cover classes in relation to MNDVI values: TMsceneP42/R26

CONFUSION (FUZZY) MATRIX (P42R26)

RF/CF	3101	3201	4102	4203	4206	4208	4212	4215	4219
3101	9(5)	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3201	1(1)	2(5)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4102	0(1)	0(1)	1(5)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4203	0(1)	0(1)	0(2)	1(5)	0(2)	0(2)	0(2)	0(2)	0(3)
4206	0(1)	0(1)	0(2)	0(2)	2(5)	0(2)	0(2)	0(2)	0(2)
4208	0(1)	0(1)	0(2)	0(2)	0(2)	0(5)	0(2)	0(2)	2(3)
4212	0(1)	0(1)	0(2)	0(2)	0(2)	1(2)	2(5)	1(3)	0(2)
4215	0(1)	1(1)	0(2)	0(2)	0(2)	0(2)	0(3)	0(5)	0(2)
4219	0(1)	0(1)	0(2)	0(3)	0(2)	1(3)	0(2)	0(2)	2(5)
4220	0(1)	0(1)	0(2)	0(3)	0(2)	0(3)	0(3)	0(2)	0(3)
4221	0(1)	0(1)	2(2)	1(3)	1(2)	0(2)	2(3)	0(3)	1(2)
4222	0(1)	0(1)	0(2)	0(2)	2(3)	0(2)	0(3)	0(2)	0(2)
4223	0(1)	0(1)	0(2)	0(3)	0(2)	1(2)	0(3)	0(2)	0(2)
4225	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)	1(3)	0(2)	0(2)
4228	0(1)	0(1)	0(2)	0(3)	0(2)	0(2)	0(2)	1(3)	0(2)
4229	0(1)	0(1)	0(2)	0(2)	1(2)	0(2)	0(3)	1(3)	0(2)
4301	0(1)	0(1)	0(3)	0(2)	1(2)	0(2)	1(2)	0(2)	0(2)
7300	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7800	0(2)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
SUM	10(0)	5(0)	4(0)	2(0)	8(0)	3(0)	6(0)	3(0)	5(0)

RF/CF	4220	4221	4222	4223	4225	4228	4229	4301	7300
3101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(1)
3201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4102	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	1(2)	0(4)	0(1)
4203	0(3)	0(3)	0(2)	0(4)	0(2)	1(4)	0(2)	0(2)	0(1)
4206	0(2)	0(3)	0(4)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)
4208	1(3)	1(3)	0(2)	0(2)	0(2)	0(2)	1(2)	0(2)	0(1)
4212	1(3)	3(3)	3(4)	1(4)	0(4)	1(2)	1(4)	2(2)	0(1)
4215	0(3)	1(3)	0(2)	0(2)	0(2)	0(4)	0(4)	0(2)	0(1)
4219	0(3)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)
4220	1(5)	0(2)	0(2)	0(3)	0(2)	0(2)	0(2)	0(2)	0(1)
4221	3(2)	7(5)	1(2)	1(3)	0(4)	0(4)	5(4)	3(2)	0(1)
4222	0(2)	0(2)	0(5)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)
4223	1(3)	0(3)	0(2)	0(5)	0(3)	0(4)	0(4)	0(2)	0(1)
4225	0(2)	0(4)	0(2)	0(3)	0(5)	0(3)	0(3)	0(2)	0(1)
4228	0(3)	1(4)	1(2)	0(4)	0(3)	0(5)	1(4)	0(2)	0(1)
4229	0(3)	0(4)	0(2)	1(4)	0(3)	1(4)	1(5)	0(2)	0(1)
4301	0(3)	0(3)	0(3)	1(3)	0(3)	0(3)	0(3)	1(5)	0(1)
7300	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	5(5)
7800	0(1)	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(3)
SUM	7(0)	13(0)	7(0)	4(0)	0(0)	3(0)	10(0)	6(0)	8(0)

Accuracy Assessment Tables for P42/R26 -- Cover Type

RF/CF	7800	SUM
3101	1(1)	15(0)
3201	0(1)	9(0)
4102	0(1)	2(0)
4203	0(1)	2(0)
4206	0(1)	2(0)
4208	0(1)	5(0)
4212	0(1)	18(0)
4215	0(1)	2(0)
4219	0(1)	5(0)
4220	0(1)	2(0)
4221	0(1)	30(0)
4222	0(1)	2(0)
4223	0(1)	3(0)
4225	0(1)	1(0)
4228	0(1)	4(0)
4229	0(1)	6(0)
4301	0(1)	5(0)
7300	0(3)	5(0)
7800	1(5)	6(0)
SUM	2(0)	124(0)

Diagonal Elements = 35; Total Test Points = 124
Percentage Agreement = 28.23; Kappa = 0.234; Tau w/equal Prob = 0.242

18 points not belong to groups listed in the
test data and treated as misclassification
Default score for these 18 points = 1

Accuracy Assessment Tables for P42/R26 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	9	60.00	0	0.00	0	0.00	0	0.00	6	40.00
3201	2	22.22	0	0.00	0	0.00	0	0.00	7	77.78
4102	1	50.00	0	0.00	0	0.00	1	50.00	0	0.00
4203	1	50.00	1	50.00	0	0.00	0	0.00	0	0.00
4206	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4208	0	0.00	0	0.00	4	80.00	1	20.00	0	0.00
4212	2	11.11	5	27.78	5	27.78	4	22.22	2	11.11
4215	0	0.00	0	0.00	1	50.00	0	0.00	1	50.00
4219	2	40.00	0	0.00	1	20.00	0	0.00	2	40.00
4220	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4221	7	23.33	5	16.67	4	13.33	11	36.67	3	10.00
4222	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00
4223	0	0.00	0	0.00	1	33.33	1	33.33	1	33.33
4225	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4228	0	0.00	2	50.00	1	25.00	1	25.00	0	0.00
4229	1	16.67	2	33.33	1	16.67	1	16.67	1	16.67
4301	1	20.00	0	0.00	1	20.00	2	40.00	1	20.00
7300	5	100.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	1	16.67	0	0.00	1	16.67	0	0.00	4	66.67
SUM	35	28.23	15	12.10	23	18.55	22	17.74	29	23.39

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	9	60.00	9	60.00	9	60.00	9	60.00	15	100.00
3201	2	22.22	2	22.22	2	22.22	2	22.22	9	100.00
4102	1	50.00	1	50.00	1	50.00	2	100.00	2	100.00
4203	1	50.00	2	100.00	2	100.00	2	100.00	2	100.00
4206	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4208	0	0.00	0	0.00	4	80.00	5	100.00	5	100.00
4212	2	11.11	7	38.89	12	66.67	16	88.89	18	100.00
4215	0	0.00	0	0.00	1	50.00	1	50.00	2	100.00
4219	2	40.00	2	40.00	3	60.00	3	60.00	5	100.00
4220	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4221	7	23.33	12	40.00	16	53.33	27	90.00	30	100.00
4222	0	0.00	0	0.00	2	100.00	2	100.00	2	100.00
4223	0	0.00	0	0.00	1	33.33	2	66.67	3	100.00
4225	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4228	0	0.00	2	50.00	3	75.00	4	100.00	4	100.00
4229	1	16.67	3	50.00	4	66.67	5	83.33	6	100.00
4301	1	20.00	1	20.00	2	40.00	4	80.00	5	100.00
7300	5	100.00	5	100.00	5	100.00	5	100.00	5	100.00
7800	1	16.67	1	16.67	2	33.33	2	33.33	6	100.00
SUM	35	28.23	50	40.32	73	58.87	95	76.61	124	100.00

Accuracy Assessment Tables for P42/R26 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	9	90.00	0	0.00	0	0.00	0	0.00	1	10.00
3201	2	40.00	0	0.00	0	0.00	0	0.00	3	60.00
4102	1	25.00	0	0.00	0	0.00	2	50.00	1	25.00
4203	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
4206	2	25.00	0	0.00	2	25.00	3	37.50	1	12.50
4208	0	0.00	0	0.00	1	33.33	2	66.67	0	0.00
4212	2	33.33	0	0.00	3	50.00	1	16.67	0	0.00
4215	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00
4219	2	40.00	0	0.00	2	40.00	1	20.00	0	0.00
4220	1	14.29	0	0.00	3	42.86	3	42.86	0	0.00
4221	7	53.85	1	7.69	5	38.46	0	0.00	0	0.00
4222	0	0.00	3	42.86	0	0.00	2	28.57	2	28.57
4223	0	0.00	2	50.00	2	50.00	0	0.00	0	0.00
4225	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4228	0	0.00	2	66.67	0	0.00	1	33.33	0	0.00
4229	1	10.00	7	70.00	0	0.00	2	20.00	0	0.00
4301	1	16.67	0	0.00	0	0.00	5	83.33	0	0.00
7300	5	62.50	0	0.00	1	12.50	0	0.00	2	25.00
7800	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
SUM	35	33.02	15	14.15	23	21.70	22	20.75	11	10.38

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	9	90.00	9	90.00	9	90.00	9	90.00	10	100.00
3201	2	40.00	2	40.00	2	40.00	2	40.00	5	100.00
4102	1	25.00	1	25.00	1	25.00	3	75.00	4	100.00
4203	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
4206	2	25.00	2	25.00	4	50.00	7	87.50	8	100.00
4208	0	0.00	0	0.00	1	33.33	3	100.00	3	100.00
4212	2	33.33	2	33.33	5	83.33	6	100.00	6	100.00
4215	0	0.00	0	0.00	3	100.00	3	100.00	3	100.00
4219	2	40.00	2	40.00	4	80.00	5	100.00	5	100.00
4220	1	14.29	1	14.29	4	57.14	7	100.00	7	100.00
4221	7	53.85	8	61.54	13	100.00	13	100.00	13	100.00
4222	0	0.00	3	42.86	3	42.86	5	71.43	7	100.00
4223	0	0.00	2	50.00	4	100.00	4	100.00	4	100.00
4225	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4228	0	0.00	2	66.67	2	66.67	3	100.00	3	100.00
4229	1	10.00	8	80.00	8	80.00	10	100.00	10	100.00
4301	1	16.67	1	16.67	1	16.67	6	100.00	6	100.00
7300	5	62.50	5	62.50	6	75.00	6	75.00	8	100.00
7800	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
SUM	35	33.02	50	47.17	73	68.87	95	89.62	106	100.00

Accuracy Assessment Tables for P42/R26 -- Cover Type

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	20	60.00	0	0.00	0	0.00	0	0.00	13	40.00
3201	0	22.22	0	0.00	0	0.00	0	0.00	0	77.78
4102	9	50.00	0	0.00	0	0.00	9	50.00	0	0.00
4203	26	50.00	26	50.00	0	0.00	0	0.00	0	0.00
4206	60	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4208	0	0.00	0	0.00	30	80.00	8	20.00	0	0.00
4212	8	11.11	21	27.78	21	27.78	17	22.22	8	11.11
4215	0	0.00	0	0.00	15	50.00	0	0.00	15	50.00
4219	36	40.00	0	0.00	18	20.00	0	0.00	36	40.00
4220	94	50.00	0	0.00	0	0.00	0	0.00	94	50.00
4221	17	23.33	12	16.67	10	13.33	26	36.67	7	10.00
4222	0	0.00	0	0.00	62	100.00	0	0.00	0	0.00
4223	0	0.00	0	0.00	8	33.33	8	33.33	8	33.33
4225	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4228	0	0.00	22	50.00	11	25.00	11	25.00	0	0.00
4229	19	16.67	37	33.33	19	16.67	19	16.67	19	16.67
4301	12	20.00	0	0.00	12	20.00	25	40.00	12	20.00
7300	0	100.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	6	16.67	0	0.00	6	16.67	0	0.00	24	66.67
SUM	307	30.79	118	11.84	213	21.36	123	12.34	236	23.67

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	20	60.00	20	60.00	20	60.00	20	60.00	34	100.00
3201	0	22.22	0	22.22	0	22.22	0	22.22	0	100.00
4102	9	50.00	9	50.00	9	50.00	19	100.00	19	100.00
4203	26	50.00	53	100.00	53	100.00	53	100.00	53	100.00
4206	60	100.00	60	100.00	60	100.00	60	100.00	60	100.00
4208	0	0.00	0	0.00	30	80.00	38	100.00	38	100.00
4212	8	11.11	30	38.89	51	66.67	68	88.89	76	100.00
4215	0	0.00	0	0.00	15	50.00	15	50.00	30	100.00
4219	36	40.00	36	40.00	54	60.00	54	60.00	90	100.00
4220	94	50.00	94	50.00	94	50.00	94	50.00	188	100.00
4221	17	23.33	29	40.00	38	53.33	64	90.00	72	100.00
4222	0	0.00	0	0.00	62	100.00	62	100.00	62	100.00
4223	0	0.00	0	0.00	8	33.33	17	66.67	25	100.00
4225	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4228	0	0.00	22	50.00	33	75.00	45	100.00	45	100.00
4229	19	16.67	56	50.00	74	66.67	93	83.33	111	100.00
4301	12	20.00	12	20.00	25	40.00	49	80.00	62	100.00
7300	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00
7800	6	16.67	6	16.67	12	33.33	12	33.33	36	100.00
SUM	307	30.64	427	42.61	639	63.77	764	76.25	1002	100.00

Accuracy Assessment Tables for P42/R26 -- Tree Size Class

CONFUSION (FUZZY) MATRIX (P42R26)

RF/CF	1	2	3	4	SUM
1	1(5)	4(3)	3(1)	1(1)	9(0)
2	1(3)	4(5)	3(3)	0(1)	8(0)
3	5(1)	4(3)	7(5)	0(3)	16(0)
4	0(1)	1(1)	1(3)	0(5)	2(0)
SUM	7(0)	13(0)	14(0)	1(0)	35(0)

Diagonal Elements = 12; Total Test Points = 35
Percentage Agreement = 34.29; Kappa = 0.032; Tau w/equal Prob = 0.124

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	11.11	0	0.00	4	44.44	0	0.00	4	44.44
2	4	50.00	0	0.00	4	50.00	0	0.00	0	0.00
3	7	43.75	0	0.00	4	25.00	0	0.00	5	31.25
4	0	0.00	0	0.00	1	50.00	0	0.00	1	50.00
SUM	12	34.29	0	0.00	13	37.14	0	0.00	10	28.57

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	11.11	1	11.11	5	55.56	5	55.56	9	100.00
2	4	50.00	4	50.00	8	100.00	8	100.00	8	100.00
3	7	43.75	7	43.75	11	68.75	11	68.75	16	100.00
4	0	0.00	0	0.00	1	50.00	1	50.00	2	100.00
SUM	12	34.29	12	34.29	25	71.43	25	71.43	35	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	14.29	0	0.00	1	14.29	0	0.00	5	71.43
2	4	30.77	0	0.00	8	61.54	0	0.00	1	7.69
3	7	50.00	0	0.00	4	28.57	0	0.00	3	21.43
4	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	12	34.29	0	0.00	13	37.14	0	0.00	10	28.57

Accuracy Assessment Tables for P42/R26 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	14.29	1	14.29	2	28.57	2	28.57	7	100.00
2	4	30.77	4	30.77	12	92.31	12	92.31	13	100.00
3	7	50.00	7	50.00	11	78.57	11	78.57	14	100.00
4	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	12	34.29	12	34.29	25	71.43	25	71.43	35	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	21	11.11	0	0.00	85	44.44	0	0.00	85	44.44
2	133	50.00	0	0.00	133	50.00	0	0.00	0	0.00
3	226	43.75	0	0.00	129	25.00	0	0.00	162	31.25
4	0	0.00	0	0.00	12	50.00	0	0.00	12	50.00
SUM	380	38.08	0	0.00	359	35.97	0	0.00	259	25.95

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	21	11.11	21	11.11	106	55.56	106	55.56	192	100.00
2	133	50.00	133	50.00	266	100.00	266	100.00	266	100.00
3	226	43.75	226	43.75	355	68.75	355	68.75	517	100.00
4	0	0.00	0	0.00	12	50.00	12	50.00	25	100.00
SUM	380	38.00	380	38.00	739	73.90	739	73.90	1000	100.00

Accuracy Assessment Tables for P42/R26 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX (P42R26)

RF/CF	1	2	3	SUM
1	3(5)	0(3)	0(1)	3(0)
2	0(3)	1(5)	0(3)	1(0)
3	0(1)	0(3)	1(5)	1(0)
SUM	3(0)	1(0)	1(0)	5(0)

Diagonal Elements = 5; Total Test Points = 5
Percentage Agreement = 100.00; Kappa = 1.000; Tau w/equal Prob = 1.000

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	5	100.00	0	0.00	0	0.00	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	100.00	3	100.00	3	100.00	3	100.00	3	100.00
2	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	5	100.00	5	100.00	5	100.00	5	100.00	5	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	5	100.00	0	0.00	0	0.00	0	0.00	0	0.00

Accuracy Assessment Tables for P42/R26 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	100.00	3	100.00	3	100.00	3	100.00	3	100.00
2	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	5	100.00	5	100.00	5	100.00	5	100.00	5	100.00

MATCH MATRIX (weighted producer) (assuming1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	485	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	412	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3	103	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	1000	100.00	0	0.00	0	0.00	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	485	100.00	485	100.00	485	100.00	485	100.00	485	100.00
2	412	100.00	412	100.00	412	100.00	412	100.00	412	100.00
3	103	100.00	103	100.00	103	100.00	103	100.00	103	100.00
SUM	1000	100.00	1000	100.00	1000	100.00	1000	100.00	1000	100.00

Accuracy Assessment Tables for P42/R26 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX (P42R26)

RF/CF	1	2	3	SUM
1	6(5)	24(3)	11(1)	41(0)
2	1(3)	29(5)	13(3)	43(0)
3	0(1)	7(3)	8(5)	15(0)
SUM	7(0)	60(0)	32(0)	99(0)

Diagonal Elements = 43; Total Test Points = 99
Percentage Agreement = 43.43; Kappa = 0.141; Tau w/equal Prob = 0.152

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	14.63	0	0.00	24	58.54	0	0.00	11	26.83
2	29	67.44	0	0.00	14	32.56	0	0.00	0	0.00
3	8	53.33	0	0.00	7	46.67	0	0.00	0	0.00
SUM	43	43.43	0	0.00	45	45.45	0	0.00	11	11.11

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	14.63	6	14.63	30	73.17	30	73.17	41	100.00
2	29	67.44	29	67.44	43	100.00	43	100.00	43	100.00
3	8	53.33	8	53.33	15	100.00	15	100.00	15	100.00
SUM	43	43.43	43	43.43	88	88.89	88	88.89	99	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	85.71	0	0.00	1	14.29	0	0.00	0	0.00
2	29	48.33	0	0.00	31	51.67	0	0.00	0	0.00
3	8	25.00	0	0.00	13	40.62	0	0.00	11	34.38
SUM	43	43.43	0	0.00	45	45.45	0	0.00	11	11.11

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	85.71	6	85.71	7	100.00	7	100.00	7	100.00
2	29	48.33	29	48.33	60	100.00	60	100.00	60	100.00
3	8	25.00	8	25.00	21	65.62	21	65.62	32	100.00
SUM	43	43.43	43	43.43	88	88.89	88	88.89	99	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	15	14.63	0	0.00	62	58.54	0	0.00	28	26.83
2	421	67.44	0	0.00	203	32.56	0	0.00	0	0.00
3	144	53.33	0	0.00	126	46.67	0	0.00	0	0.00
SUM	580	58.06	0	0.00	391	39.14	0	0.00	28	2.80

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	15	14.63	15	14.63	77	73.17	77	73.17	105	100.00
2	421	67.44	421	67.44	624	100.00	624	100.00	624	100.00
3	144	53.33	144	53.33	271	100.00	271	100.00	271	100.00
SUM	580	58.00	580	58.00	972	97.20	972	97.20	1000	100.00

CONFUSION (FUZZY) MATRIX (P42R26)

RF/CF	1	2	3	SUM
1	1(5)	0(3)	0(1)	1(0)
2	0(3)	4(5)	1(3)	5(0)
3	0(1)	2(3)	1(5)	3(0)
SUM	1(0)	6(0)	2(0)	9(0)

Diagonal Elements = 6; Total Test Points = 9
Percentage Agreement = 66.67; Kappa = 0.386; Tau w/equal Prob = 0.500

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	4	80.00	0	0.00	1	20.00	0	0.00	0	0.00
3	1	33.33	0	0.00	2	66.67	0	0.00	0	0.00
SUM	6	66.67	0	0.00	3	33.33	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
2	4	80.00	4	80.00	5	100.00	5	100.00	5	100.00
3	1	33.33	1	33.33	3	100.00	3	100.00	3	100.00
SUM	6	66.67	6	66.67	9	100.00	9	100.00	9	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	4	66.67	0	0.00	2	33.33	0	0.00	0	0.00
3	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
SUM	6	66.67	0	0.00	3	33.33	0	0.00	0	0.00

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
2	4	66.67	4	66.67	6	100.00	6	100.00	6	100.00
3	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
SUM	6	66.67	6	66.67	9	100.00	9	100.00	9	100.00

Accuracy Assessment Tables for P42/R26 -- Shrub Canopy Closure

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	67	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	311	80.00	0	0.00	78	20.00	0	0.00	0	0.00
3	182	33.33	0	0.00	363	66.67	0	0.00	0	0.00
SUM	560	56.00	0	0.00	441	44.10	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	67	100.00	67	100.00	67	100.00	67	100.00	67	100.00
2	311	80.00	311	80.00	389	100.00	389	100.00	389	100.00
3	182	33.33	182	33.33	545	100.00	545	100.00	545	100.00
SUM	560	55.94	560	55.94	1001	100.00	1001	100.00	1001	100.00

Scene P42/R26 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	134713.0	1422108.4	41.8
1000	475.0	6020.9	0.2
2000	2522.0	53353.1	1.6
3101	4586.0	49571.5	1.5
3104	6550.0	59365.5	1.7
3202	7494.0	62081.1	1.8
3203	4076.0	41154.9	1.2
4102	2907.0	32386.8	1.0
4201	9866.0	102421.1	3.0
4203	7461.0	72318.9	2.1
4206	6790.0	62310.6	1.8
4207	298.0	3061.4	0.1
4208	4880.0	40832.5	1.2
4210	4806.0	70748.7	2.1
4211	828.0	8184.0	0.2
4212	11917.0	135756.6	4.0
4215	4753.0	36146.2	1.1
4219	8191.0	72685.7	2.1
4220	18360.0	204901.1	6.0
4221	9573.0	119259.3	3.5
4222	8412.0	90858.4	2.7
4223	3609.0	46665.9	1.4
4225	158.0	1926.2	0.1
4226	753.0	9043.7	0.3
4227	3942.0	43941.6	1.3
4228	5440.0	57940.7	1.7
4229	15726.0	207879.6	6.1
4301	9192.0	108790.6	3.2
5000	2307.0	47084.2	1.4
7300	5143.0	47457.5	1.4
7400	114.0	686.1	0.0
7800	6258.0	52541.6	1.5
9800	2308.0	18293.9	0.5
9900	2432.0	12844.3	0.4

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	134713.0	1422108.4	41.8
Not tree/shrub	32695.0	347218.6	10.2
Shrub 1	1251.0	11809.0	0.3
Shrub 2	6316.0	46631.3	1.4
Shrub 3	4003.0	44798.8	1.3
Tree 1	16693.0	128523.3	3.8
Tree 2	94223.0	971528.9	28.6
Tree 3	26946.0	428007.2	12.6

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	134713.0	1422108.4	41.8
Not tree/shrub	32695.0	347218.6	10.2
Tree 1	29464.0	301198.9	8.9
Tree 2	36045.0	391733.9	11.5
Tree 3	70584.0	797577.6	23.5
Tree 4	1769.0	37549.0	1.1
Shrub 1	6547.0	57355.9	1.7
Shrub 2	4059.0	37725.7	1.1
Shrub 3	964.0	8154.5	0.2

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	134713.0	1422108.4	41.8
A	2522.0	53353.1	1.6
H	11136.0	108937.0	3.2
N	19037.0	184928.5	5.4
S	11570.0	103236.0	3.0
T	137862.0	1528059.4	44.9

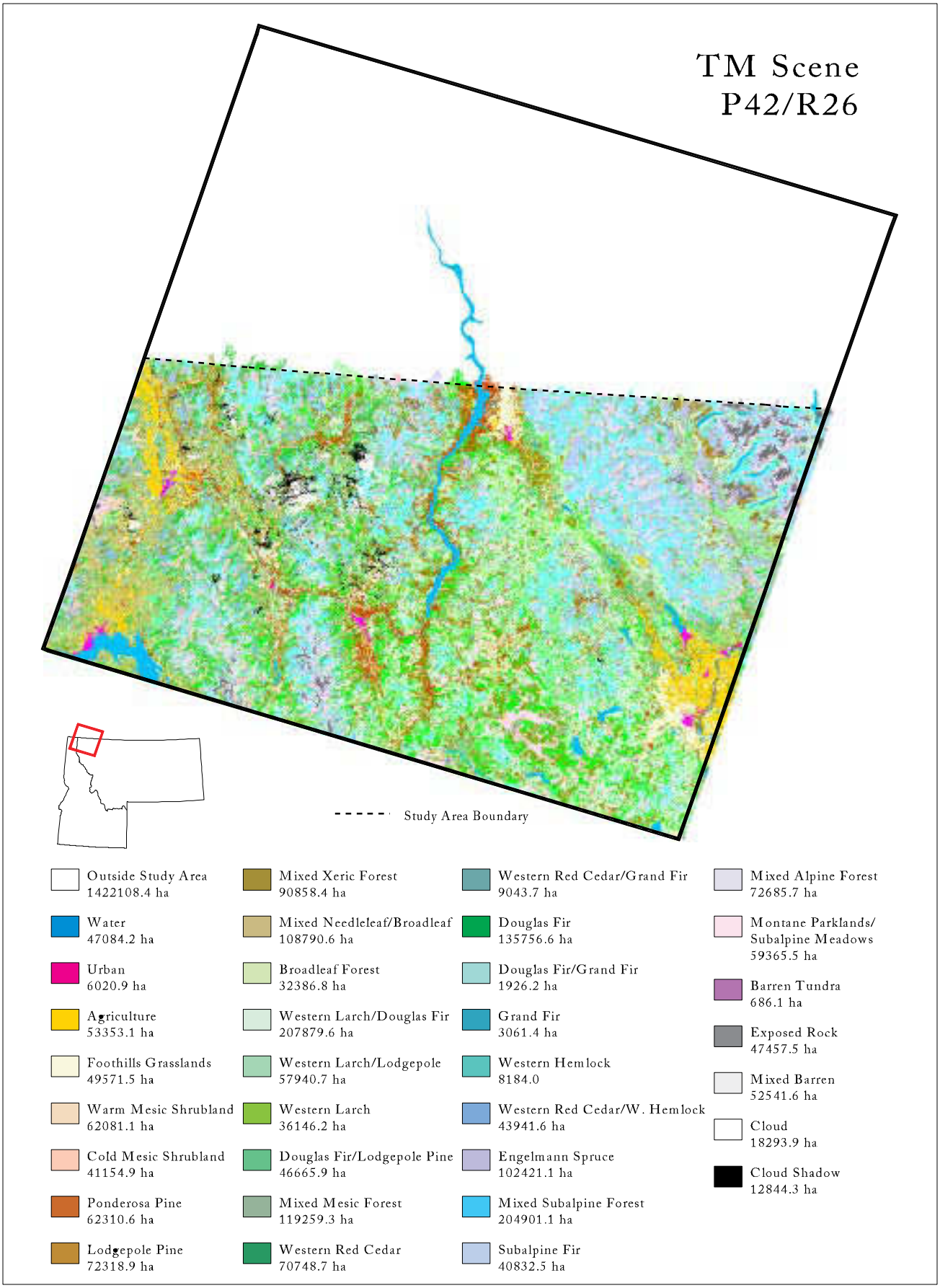


Figure F-3. Classification of land cover types for TM Scene P42/R26.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P42/R26

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4102: BROADLEAF FOREST

Broadleaf forest dominated by paper birch (Betula papyrifera) and ranging from 2211 to 4246 feet in elevation. The average canopy cover is 39% ranging from 20-50% total cover and frequency of occurrence equal to 73%. Primary associated tree species include lodgepole pine (Pinus contorta), aspen (Populus tremuloides), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤30% and frequency of occurrence ≥36% and ≤55%.

Primary associated shrub species with ≥27% and ≤46% frequency of occurrence in broadleaf stands: rocky mountain maple (Acer glabrum), common prince's pine (Chimaphila umbellata), ocean-spray (Holodiscus discolor), thimbleberry (Rubus parviflorum), Canada buffaloberry (Shepherdia canadensis), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥9% and ≤27% frequency of occurrence in broadleaf stands: **graminoids**: Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), blue wildrye (Elymus glaucus), wildrye (Elymus spp.), roughleaf ricegrass (Oryzopsis asperifolia); **forbs**: wild sarsaparilla (Aralia nudicaulis), heart-leaf arnica (Arnica cordifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), bedstraw (Galium spp.), shiny-leaf spiraea (Spiraea betulifolia), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: none.

2) 4201: ENGELMANN SPRUCE FOREST

Conifer forest dominated by Engelmann spruce (Picea engelmannii) ranging from 3000 to 6500 feet in elevation. The average canopy cover is 30%, ranging from 3-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), western larch (Larix occidentalis), and lodgepole pine (Pinus contorta), with average percent cover ≥4% and ≤12% and frequency of occurrence ≥16% and ≤81%.

Primary associated shrub species with ≥28% and ≤75% frequency of occurrence in Engelmann spruce stands: sitka alder (Alnus sinuata), red-osier dogwood (Cornus stolonifera), Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), cascade mountain-ash (Sorbus scopulina), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥10% and ≤80% frequency of occurrence in Engelmann spruce stands: **graminoids**: Columbia brome

(Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), orchard-grass (Dactylis glomerata), smooth woodrush (Luzula hitchcockii), and nodding trisetum (Trisetum cernuum); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), clasping-leaved twisted-stalk (Streptopus amplexifolius), western meadowrue (Thalictrum occidentale), and trefoil foamflower (Tiarella trifoliata); **ferns**: ladyfern (Athyrium filix-femina), mountain wood-fern (Dryopteris austriaca), oak-fern (Gymnocarpium dryopteris), brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

3) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 2469 to 6741 feet in elevation. The average canopy cover is 41% ranging from 10-80% total cover and frequency of occurrence equal to 99%. Primary associated tree species include subalpine fir (Abies lasiocarpa), western larch (Larix occidentalis), and lodgepole pine (Pinus contorta), with average percent cover equal to 4% and frequency of occurrence ≥44% and ≤59%.

Primary associated shrub species with ≥28% and ≤50% frequency of occurrence in lodgepole pine stands: sitka alder (Alnus sinuata), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤49% frequency of occurrence in lodgepole pine stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), rough fescue (Festuca scabrella), and Drummond's rush (Juncus drummondii); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), western rattlesnake-plantain (Goodyera oblongofolia), white-flowered hawkweed (Hieracium albiflorum), and beargrass (Xerophyllum tenax); **ferns**: male-fern (Dryopteris filix-mas), oak-fern (Gymnocarpium dryopteris), clubmoss (Lycopodium) mountain holly-fern (Polystichum lonchitis), and brackenfern (Pteridium aquilinum); **moss**: none.

4) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 2142 to 4312 feet in elevation. The average canopy cover is 36% ranging from 10-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western larch (Larix occidentalis), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤35% and frequency of occurrence ≥14% and ≤79%.

Primary associated shrub species with ≥7% and ≤29% frequency of occurrence in ponderosa pine stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), ocean-spray (Holodiscus discolor), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤57% frequency of occurrence in ponderosa pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), timber oatgrass (Danthonia intermedia), Idaho fescue (Festuca idahoensis), rough fescue (Festuca scabrella), and western fescue (Festuca occidentalis); **forbs**: common yarrow (Achillea millefolium), spreading dogbane (Apocynum androsaemifolium), wild sarsaparilla (Aralia nudicaulis), aster (Aster spp.), balsamroot (Balsamorhiza sagittata), silky lupine (Lupine sericeus), and penstemon (Penstemon spp.); **ferns**: none; **moss**: none.

5) 4208: SUBALPINE FIR FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 3400 to 7040 feet in elevation. The average canopy cover is 36% ranging from 1-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), and lodgepole pine (Pinus contorta), with average percent cover ≥3% and ≤5% and frequency of occurrence ≥14% and ≤58%.

Primary associated shrub species with ≥16% and ≤65% frequency of occurrence in subalpine fir stands: Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), cascade mountain-ash (Sorbus scopulina), sitka mountain-ash (Sorbus sitchensis), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤66% frequency of occurrence in subalpine fir stands: **graminoids**: Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), and smooth woodrush (Luzula hitchcockii); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), one-sided wintergreen (Pyrola secunda), trefoil foamflower (Tiarella trifoliata) and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), spinulose wood-fern (Dryopteris spinulosa), oak-fern (Gymnocarpium dryopteris), stiff clubmoss (Lycopodium annotinum), clubmoss (Lycopodium), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

6) 4210: WESTERN RED CEDAR FOREST

Conifer forest dominated by western red cedar (Thuja plicata) ranging from 1850 to 4800 feet in elevation. The average canopy cover is 53% ranging from 20-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), Engelmann spruce (Picea engelmannii), and western hemlock (Tsuga heterophylla) with average percent cover ≥5% and ≤13% and frequency of occurrence ≥27% and ≤53%.

Primary associated shrub species with ≥20% and ≤33% frequency of occurrence in western red cedar stands: rocky mountain maple (Acer glabrum), alder (Alnus spp.), menziesia (Menziesia ferruginea), devil's club (Oplopanax horridum), thimbleberry (Rubus

parviflorum), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤33% frequency of occurrence in western red cedar stands: **graminoids**: mountain brome (Bromus carinatus), Columbia brome (Bromus vulgaris), Dewey's sedge (Carex deweyana), and sedge (Carex spp.); **forbs**: sweetscented bedstraw (Galium triflorum), white-flowered hawkweed (Hieracium albiflorum), mountain sweet-cicely (Osmorhiza chilensis), clasping-leaved twisted-stalk (Streptopus amplexifolius), western meadowrue (Thalictrum occidentale), and white trillium (Trillium ovatum); **ferns**: ladyfern (Athyrium filix-femina), male-fern (Dryopteris filix-mas), field horsetail (Equisetum arvense), and oak-fern (Gymnocarpium dryopteris); **moss**: none.

7) 4211: WESTERN HEMLOCK FOREST

Conifer forest dominated by western hemlock (Tsuga heterophylla) ranging from 2680 to 4720 feet in elevation. The average canopy cover is 64% ranging from 20-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), Engelmann spruce (Picea engelmannii), and western red cedar (Thuja plicata) with average percent cover ≥4% and ≤11% and frequency of occurrence ≥31% and ≤81%.

Primary associated shrub species with ≥13% and ≤25% frequency of occurrence in western hemlock stands: rocky mountain maple (Acer glabrum), menziesia (Menziesia ferruginea), devil's club (Oplopanax horridum), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), globe huckleberry (Vaccinium globulare), and big huckleberry (Vaccinium membranaceum).

Primary associated graminoid, forb, fern, and moss species with ≥13% and ≤44% frequency of occurrence in western hemlock stands: **graminoids**: Columbia brome (Bromus vulgaris); **forbs**: baneberry (Actaea rubra), wild ginger (Asarum caudatum), queen's cup beadlily (Clintonia uniflora), hooker fairy-bell (Disporum hookeri), one-sided wintergreen (Pyrola secunda), trefoil foamflower (Tiarella trifoliata), and violet (Viola spp.); **ferns**: ladyfern (Athyrium filix-femina), mountain wood-fern (Dryopteris austriaca), male-fern (Dryopteris filix-mas), oak-fern (Gymnocarpium dryopteris), stiff clubmoss (Lycopodium annotinum), and common Christmas-fern (Polystichum munitum); **moss**: none.

8) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 1700 to 6053 feet in elevation. The average canopy cover is 36% ranging from 1-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western larch (Larix occidentalis), lodgepole pine (Pinus contorta), and ponderosa pine (Pinus ponderosa), with average percent cover ≥3% and ≤5% and frequency of occurrence ≥22% and ≤55%.

Primary associated shrub species with ≥19% and ≤37% frequency of occurrence in Douglas-fir stands: rocky mountain maple (Acer glabrum), western serviceberry

(Amelanchier alnifolia), creeping Oregon grape (Berberis repens), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤12% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), brome (Bromus spp.), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), and rough fescue (Festuca scabrella); **forbs**: raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), showy aster (Aster conspicuus), fireweed (Epilobium angustifolium), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: oak-fern (Gymnocarpium dryopteris) and brackenfern (Pteridium aquilinum); **moss**: none.

9) 4215: WESTERN LARCH FOREST

Conifer forest dominated by western larch (Larix occidentalis) ranging from 2973 to 5225 feet in elevation. The average canopy cover is 32% ranging from 10-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii), with average percent cover ≥3% and ≤6% and frequency of occurrence ≥44% and ≤71%.

Primary associated shrub species with ≥29% and ≤56% frequency of occurrence in western larch stands: sitka alder (Alnus sinuata), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤41% frequency of occurrence in western larch stands: **graminoids**: bentgrass (Agrostis spp.), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), beaked sedge (Carex rostrata), and blue wildrye (Elymus glaucus); **forbs**: broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), hooker fairy-bell (Disporum hookeri), fireweed (Epilobium angustifolium), white-flowered hawkweed (Hieracium albiflorum), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: male-fern (Dryopteris filix-mas), ground cedar (Lycopodium complanatum), and brackenfern (Pteridium aquilinum); **moss**: none.

10) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albicaulis), codominant species is alpine larch (Larix lyallii), and ranging from 5560 to 7622 feet in elevation. The average canopy cover for PINALB is 11% ranging from 1-30% total cover and frequency of occurrence equal to 94%. The average canopy cover for LARLYA is 13% ranging from 1-30% total cover and frequency of occurrence equal to 30%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥5% and ≤18% and frequency of occurrence ≥13% and ≤100%.

Primary associated shrub species with ≥6% and ≤85% frequency of occurrence in mixed whitebark pine stands: common juniper (Juniperus communis), Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea), cascade mountain-ash (Sorbus scopulina), globe huckleberry (Vaccinium globulare), dwarf bilberry (Vaccinium myrtillus), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤68% frequency of occurrence in mixed whitebark pine stands: **graminoids:** spreading wheatgrass (Agropyron scribneri), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), Drummond's rush (Juncus drummondii), and smooth woodrush (Luzula hitchcockii); **forbs**: arnica (Arnica spp.), broadleaf arnica (Arnica latifolia), fireweed (Epilobium angustifolium), glacier lily (Erythronium grandiflorum), white-flowered hawkweed (Hieracium albiflorum), bracted lousewort (Pedicularis bracteosa), one-sided wintergreen (Pyrola secunda), and beargrass (Xerophyllum tenax); **ferns**: field horsetail (Equisetum arvense); **moss**; none.

11) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 3515 to 6760 feet in elevation. The average canopy cover is 22% ranging from 1-70% total cover and frequency of occurrence equal to 99%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥10% and ≤15% and frequency of occurrence ≥36% and ≤94%.

Primary associated shrub species with ≥17% and ≤68% frequency of occurrence in mixed subalpine stands: sitka alder (Alnus sinuata), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), cascade mountain-ash (Sorbus scopulina), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤59% frequency of occurrence in mixed subalpine fir stands: **graminoids**: brome (Bromus spp.), Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), and smooth woodrush (Luzula hitchcockii); **forb**: broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), one-sided wintergreen (Pyrola secunda), western meadowrue (Thalictrum occidentale), and trefoil foamflower (Tiarella trifoliata); **ferns**: ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), oak-fern (Gymnocarpium dryopteris), lycopodium (Lycopodium spp.), mountain holly-fern (Polystichum lonchitis), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

12) 4221: MIXED MESIC FOREST

Conifer forest dominated by western larch (Larix occidentalis), codominant species are grand fir (Abies grandis), western red cedar (Thuja plicata), and western hemlock (Tsuga heterophylla), ranging from 1793 to 6175 feet in elevation. The average canopy cover for

LAROCC is 12% ranging from 1-40% total cover and frequency of occurrence equal to 90%. The average canopy cover for ABIGRA is 15% ranging from 1-70% total cover and frequency of occurrence equal to 26%. The average canopy cover for THUPLI is 21% ranging from 1-80% total cover and frequency of occurrence equal to 45%. The average canopy cover for TSUHET is 14% ranging from 1-70% total cover and frequency of occurrence equal to 26% Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥9% and ≤13% and frequency of occurrence ≥54% and ≤71%.

Primary associated shrub species with ≥20% and ≤34% frequency of occurrence in mixed mesic stands: rocky mountain maple (Acer glabrum), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤18% frequency of occurrence in mixed mesic stands: **graminoids**: brome (Bromus spp.), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), and western fescue (Festuca occidentalis); **forbs**: broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), white-flowered hawkweed (Hieracium albiflorum), one-sided wintergreen (Pyrola secunda), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), oak-fern (Gymnocarpium dryopteris), lycopodium (Lycopodium spp.), brackenfern (Pteridium aquilinum); **moss**: none.

13) 4222: MIXED XERIC FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) and ranging from 2060 to 4690 feet in elevation. The average canopy cover is 17% ranging from 10-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western larch (Larix occidentalis), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥10% and ≤17% and frequency of occurrence ≥14% and ≤100%.

Primary associated shrub species with ≥14% and ≤32% frequency of occurrence in mixed xeric stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), mountain balm (Ceanothus velutinus), ocean-spray (Holodiscus discolor), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤55% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), western fescue (Festuca occidentalis), and Alaska oniongrass (Melica subulata; **forbs**: spreading dogbane (Apocynum androsaemifolium), wild sarsaparilla (Aralia nudicaulis), spotted knapweed (Centauria maculosa), fireweed (Epilobium angustifolium), common St.

John's-wort (Hypericum perforatum), lupine (Lupinus spp.), and western meadowrue (Thalictrum occidentale); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

14) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) and ranging from 2320 to 5680 feet in elevation. The average canopy cover for PINCON is 21% ranging from 10-40% total cover and frequency of occurrence equal to 97%. The average canopy cover for PSEMEN is 22% ranging from 10-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), western larch (Larix occidentalis), and western red cedar (Thuja plicata), with average percent cover ≥4% and ≤12% and frequency of occurrence ≥10% and ≤62%.

Primary associated shrub species with ≥28% and ≤62% frequency of occurrence in Douglas-fir-lodgepole pine stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), mountain-lover (Pachistima myrsinites), and shiny-leaf spiraea (Spiraea betulifolia).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤69% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), and tufted hairgrass (Deschampsia cespitosa), common spikesedge (Eleocharis palustris), rough fescue (Festuca scabrella), and roughleaf ricegrass (Oryzopsis asperifolia); **forbs**: common yarrow (Achillea millefolium), heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), woods strawberry (Fragaria vesca), Virginia strawberry (Fragaria virginiana), white-flowered hawkweed (Hieracium albiflorum), and beargrass (Xerophyllum tenax); **ferns**: field horsetail (Equisetum arvense), lycopodium (Lycopodium spp.), and brackenfern (Pteridium aquilinum); **moss**: none.

15) 4227: WESTERN RED CEDAR-WESTERN HEMLOCK FOREST

Conifer forest dominated by western red cedar (Thuja plicata) and western hemlock (Tsuga heterophylla) ranging from 2730 to 4400 feet in elevation. The average canopy cover for THUPLI is 37% ranging from 10-60% total cover and frequency of occurrence equal to 100%. The average canopy cover for TSUHET is 38% ranging from 20-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western larch (Larix occidentalis), and western white pine (Pinus monticola), with average percent cover ≥2% and ≤4% and frequency of occurrence ≥31% and ≤62%.

Primary associated shrub species with ≥15% and ≤46% frequency of occurrence in western red cedar-western hemlock stands: rocky mountain maple (Acer glabrum), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), mountain-lover (Pachistima myrsinites), huckleberry (Vaccinium spp.), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥16% and ≤26% frequency of occurrence in western red cedar-western hemlock stands: **graminoids**: none; **forbs**: queen's cup beadlily (Clintonia uniflora), western rattlesnake-plantain (Goodyera oblongofolia), pink wintergreen (Pyrola asarifolia), one-sided wintergreen (Pyrola secunda), starry solomon-plume (Smilacina stellata), trefoil foamflower (Tiarella trifoliata), and pioneer violet (Viola glabella); **ferns**: ladyfern (Athyrium filix-femina), oak-fern (Gymnocarpium dryopteris), Anderson's sword-fern (Polystichum Anderson), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: none.

16) 4228: WESTERN LARCH-LODGEPOLE FOREST

Conifer forest dominated by western larch (Larix occidentalis) and lodgepole pine (Pinus contorta) ranging from 2246 to 5812 feet in elevation. The average canopy cover for LAROCC is 15% ranging from 10-20% total cover and frequency of occurrence equal to 100%. The average canopy cover for PINCON is 19% ranging from 3-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤5% and frequency of occurrence ≥35% and ≤60%.

Primary associated shrub species with ≥25% and ≤35% frequency of occurrence in western larch-lodgepole pine stands: sitka alder (Alnus sinutata), western serviceberry (Amelanchier alnifolia), common prince's pine (Chimaphila umbellata), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤30% frequency of occurrence in western larch-lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), ross sedge (Carex rossii), blue wildrye (Elymus glaucus), Kentucky bluegrass (Poa pratensis), and spike trisetum (Trisetum spicatum); **forbs**: broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), white-flowered hawkweed (Hieracium albiflorum), western meadowrue (Thalictrum occidentale), false spikenard (Smilacina racemosa), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: none.

17) 4229: WESTERN LARCH-DOUGLAS FIR FOREST

Conifer forest dominated by western larch (Larix occidentalis) and Douglas-fir (Pseudotsuga menziesii) ranging from 2433 to 5260 feet in elevation. The average canopy cover for LAROCC is 18% ranging from 3-50% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 24% ranging from 10-50% total cover and frequency of occurrence equal to 98%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta), and with average percent cover ≥4% and ≤6% and frequency of occurrence ≥19% and ≤42%.

Primary associated shrub species with ≥22% and ≤36% frequency of occurrence in western larch-Douglas-fir stands: rocky mountain maple (Acer glabrum), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤64% frequency of occurrence in western larch-Douglas-fir stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), blue wildrye (Elymus glaucus), showy oniongrass (Melica spectabilis), roughleaf ricegrass (Oryzopsis asperifolia), and fowl bluegrass (Poa palustris); **forbs**: wild sarsaparilla (Aralia nudicaulis), heart-leaf arnica (Arnica cordifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), one-sided wintergreen (Pyrola secunda), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: none.

18) 4301: MIXED NEEDLELEAF/BROADLEAF FOREST

Mixed needleleaf and broadleaf forest dominated by paper birch (Betula papyrifera) and ranging from 2280 to 5473 feet in elevation. The average canopy cover is 19% ranging from 3-50% total cover and frequency of occurrence equal to 65%. Primary associated tree species include western larch (Larix occidentalis), Douglas-fir (Pseudotsuga menziesii), and western red cedar (Thuja plicata) with average percent cover ≥10% and ≤19% and frequency of occurrence ≥54% and ≤65%.

Primary associated shrub species with ≥26% and ≤42% frequency of occurrence in mixed needleleaf and broadleaf stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤28% frequency of occurrence in mixed needleleaf and broadleaf stands: **graminoids**: bentgrass (Agrostis spp.), brome (Bromus spp.) Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus); **forbs**: trail-plant (Adenocaulon bicolor), common pearly-everlasting (Anaphalis margaritacea), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), western meadowrue (Thalictrum occidentale), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), oak-fern (Gymnocarpium dryopteris), clubmoss (Lycopodium spp.), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp).

P42/R26 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	21
6102	Broadleaf Dominated Riparian	None identified for scene
6103	Neeleleaf-Broadleaf Riparian	32, 40
6104	Mixed Riparian (trees + any other)	None identified for scene
6201	Grass-Forb Riparian/Wetland	25
6202	Shrub Riparian/Wetland	4, 17, 18
6203	Mixed Grass-Forb-Shrub Riparian	27

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 3
Color: Tan; RGB 196 152 124.
Distribution: Widely distributed at most elevations; some near streams.
Comment: Appears to be upland shrub distribution pattern. Mesic Upland Shrub dominates the training data points outside of the zone, with Mixed Mesic Forest next in frequency.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
5	1	Subalpine Meadow
6	1	Mesic Upland Shrubland
7	1	Mixed Subalpine Forest
8	1	Douglas-fir-Lodgepole
9	4	Broadleaf Dominated Riparian
10	2	Needleleaf-Broadleaf Riparian
11	2	Shrub Riparian/Wetland

Spectral Class 4
Color: Medium orange; RGB 255 152 98.
Distribution: Somewhat clustered along hillsides; some at lower elevations.
Comment: Color and pattern indicate shrub, riparian within the calculated zone. Mesic Upland Shrub dominates the training data points outside of the zone, with Mixed Mesic Forest next in frequency.
Conclusion: 6202.

12	1	Shrub Riparian/Wetland

Spectral Class 5
Color: Dark brown; RGB 102 64 85.
Distribution: Widely distributed, though somewhat aggregated in some areas; mostly

shadowed slopes; some near streams but not linear in pattern.
Comment: Appears to be primarily Mixed Mesic Forest. Outside the calculated zone, Mixed Mesic Forest is prevalent in the training data, with Douglas-fir also strongly represented.
Conclusion: Not riparian.

13	1	Douglas-fir
14	2	Mixed Mesic Forest
15	2	Needleleaf Dominated Riparian
16	1	Needleleaf-Broadleaf Riparian
17	1	Grass-Forb Riparian/Wetland

Spectral Class 6
Color: Medium gray; RGB 110 118 124.
Distribution: Widely distributed spackle; occurs near streams but is not linear.
Comment: Appears to be primarily Mixed Xeric Forest. Conifers and shrubs are most represented by training data points outside the zone.
Conclusion: Not riparian.

18	1	Dry-land Pasture
19	1	Mixed Subalpine Forest
20	1	Mixed Mesic Forest
21	1	Mixed Xeric Forest
22	1	Rivers & Streams
23	2	Broadleaf Dominated Riparian
24	3	Grass-Forb Riparian/Wetland
25	1	Shrub Riparian/Wetland

Spectral Class 7
Color: Red-brown; RGB 153 95 111.
Distribution: Southerly slopes at middle to upper elevations; some near streams and in river valleys.
Comment: Appears to be conifer, with possibly some riparian vegetation. If selected though, the riparian vegetation would be overestimated. Mixed Mesic Forest dominates points outside the zone.
Conclusion: Not riparian.

26	1	Foothills Grassland
27	2	Douglas-fir
28	1	Needleleaf Dominated Riparian
29	1	Broadleaf Dominated Riparian
30	1	Needleleaf-Broadleaf Riparian
31	2	Grass-Forb Riparian/Wetland

Spectral Class 8
Color: Black; RGB 51 52 85.
Distribution: Mid-elevation shadows; some gulley pattern.
Comment: Appears to be Douglas-fir and Alpine Fir. Douglas-fir and Mixed Mesic Forest were recorded most frequently outside the zone.
Conclusion: Not riparian.

32	1	Mesic Upland Shrubland
33	2	Mixed Subalpine Forest
34	2	Mixed Mesic Forest
35	1	Needleleaf Dominated Riparian
36	1	Exposed Rock

Spectral Class 10
Color: Light brown; RGB 169 129 111.
Distribution: Fairly uniformly distributed spackle; not in barren or dry areas; some near streams.
Comment: Color is not appropriate for Broadleaf vegetation. One training data point is not sufficient information. Mixed Mesic Forest and Mesic Upland Shrub have the highest training data representation outside of the zone.
Conclusion. Not riparian.

41	1	Urban & Developed Land
42	1	Dry-land Pasture
43	1	Subalpine Fir
44	2	Mixed Mesic Forest
45	1	Mixed Xeric Forest
46	5	Broadleaf Dominated Riparian

Spectral Class 11
Color: Dark gray; RGB 86 98 105.
Distribution: Spackle, more dense in some middle to lower elevation areas.
Comment: Appears to be upland conifer. Outside the zone, Mixed Mesic Forest and Lodgepole Pine have the highest point frequencies.
Conclusion: Not riparian.

47	1	Western Larch
48	1	Mixed Subalpine Forest
49	1	Mixed Mesic Forest
50	1	Needleleaf Dominated Riparian
51	2	Shrub Riparian/Wetland

Spectral Class 12
Color: Light tan; RGB 184 196 157.
Distribution: Somewhat sparse, but widely distributed in localized denser neighborhoods; some near streams; some in clearcuts. Mesic Upland Shrub, then Mixed Mesic Forest, are most represented by data points outside the zone.
Comment: Appears to be dry grass.
Conclusion: Not riparian.

52	2	Urban & Developed Land
53	1	Dry-land crop
54	1	Foothills Grassland
55	1	Subalpine Meadow
56	1	Mesic Upland Shrubland
57	1	Douglas-fir
58	2	Grass-Forb Riparian/Wetland
59	1	Shrub Riparian/Wetland

Spectral Class 13
Color: Mint green; RGB 153 216 196.
Distribution: Light density spackle; some in clearcuts and transition areas from lower slopes to flats; some near river.
Comment: Color and distribution indicate very dry grasses. Outside the zone, Mesic Upland Shrub and Foothills Grassland dominate observations.
Conclusion: Not riparian.

63	1	Foothills Grassland
64	1	Mesic Upland Shrubland
65	1	Mixed Mesic Forest
66	1	Broadleaf Dominated Riparian
67	1	Needleleaf-Broadleaf Riparian
68	1	Grass-Forb Riparian/Wetland
69	2	Shrub Riparian/Wetland
70	1	Exposed Rock

Spectral Class 15
Color: Medium gray; RGB 149 167 163.
Distribution: Mostly middle to lower elevations; light but widespread spackle.
Comment: Appears to be somewhat dry grass. Mixed Mesic Forest and Mesic Upland Shrub have highest data frequencies for this spectral class outside the zone.
Conclusion: Not riparian.

71	1	Douglas-fir

72	1	Mixed Alpine Forest
73	2	Broadleaf Dominated Riparian
74	1	Grass-ForbRiparian/Wetland
75	2	Shrub Riparian/Wetland
76	1	Mixed Barren Land

Spectral Class 16
Color: Black; RGB 0 54 78
Distribution: Sparse, low density; mostly in middle to upper elevations, but some near streams in lower elevations.
Comment: The class is clearly dominated by cloud shadows and water features. No vegetation class stands out as dominant outside the zone; Mixed Alpine Forest, Subalpine Fir, Mixed Mesic Forest, and Exposed Rock are represented.
Conclusion: Not riparian.

77	1	Broadleaf Dominated Riparian

Spectral Class 17
Color: Dark orange; RGB 208 121 98.
Distribution: Middle to upper elevations; some near river.
Comment: Color and distribution indicate shrub riparian vegetation. Mesic Upland Shrub and Mixed Mesic Forest have highest frequency values outside the zone.
Conclusion: 6202.

78	1	Foothills Grassland
79	1	Needleleaf Dominated Riparian

Spectral Class 18
Color: Light-medium orange; RGB 255 188 131.
Distribution: Mostly upper elevations, and some at lower elevations/near river.
Comment: This classes clearly represents Shrub Riparian vegetation. Mesic Upland Shrub dominates training data outside the zone.
Conclusion: 6202.

80	1	Dry-land crop
81	2	Mesic Upland Shrubland
82	4	Shrub Riparian/Wetland

Spectral Class 19
Color: Pale green; RGB 208 255 203.
Distribution: Appears to be dry/barren areas at various elevations.

Comment: Visual inspection of pattern and particular locations indicate clear cuts/barren and limber pine. Mesic Upland Shrub and Foothills Grassland are about equally represented outside the zone.
Conclusion: Not riparian.

83	1	Irrigated Crop
84	2	Foothills Grassland
85	1	Shrub Riparian/Wetland

Spectral Class 20
Color: Light blue; RGB 157 234 255.
Distribution: Low density, at all elevations.
Comment: Color and many locations for this class indicate harvested agriculture fields. Training data points outside the zone include several "hard surface" cover types, such as mines and sandy areas, but especially Urban & Developed Land.
Conclusion: Not riparian.

86	1	Sandy Areas, Blowouts

Spectral Class 21
Color: Dark red; RGB 141 59 85.
Distribution: Some scattered, some connected conifer stands.
Comment: This looks like some cedar, some of which is probably riparian. Mixed Mesic Forest dominates training data outside the zone.
Conclusion: 6101.

87	1	Western Red Cedar
88	2	Needleleaf Dominated Riparian

Spectral Class 23
Color: Medium gray green; RGB 129 196 183.
Distribution: Middle to lower elevations, some near streams.
Comment: Color and distribution pattern indicate drier grasses. Mesic Upland Shrub and Mixed Barren Land are about equally represented outside the zone.
Conclusion: Not riparian.

90	1	Urban & Developed Land
91	1	Foothills Grassland
92	1	Mix Needleleaf-Broadleaf
93	1	Broadleaf Dominated Riparian
94	1	Exposed Rock

Spectral Class 24
Color: Black; RGB 27 31 65
Distribution: Shadows.
Comment: Even if a spectral class within shadows contains some riparian vegetation, it cannot be a reliable indicator, since the shadow will also cover other vegetation classes. Mixed Subalpine Forest dominates training data frequencies outside the zone.
Conclusion: Not riparian.

95	1	Grass-Forb Riparian/Wetland

Spectral Class 25
Color: Tawny tan; RGB 216 178 124.
Distribution: Some in clearcuts or edges of open areas; some in mid-elevation slopes.
Comment: Significant red component and distribution pattern indicate Grass-Forb Riparian vegetation. Mesic Upland Shrub is most prevalent in training data outside the zone.
Conclusion: 6201.

96	1	Foothills Grassland
97	1	Engelmann Spruce
98	1	MixedMesicForest
99	1	Broadleaf Dominated Riparian

Spectral Class 27
Color: Yellow-orange; RGB 255 216 144.
Distribution: Open places at all elevations, not barren.
Comment: Appears to be grasses at lower elevations and forbs or shrubs at higher elevations. Mesic Upland Shrub dominates points outside the zone.
Conclusion: 6203.

103	1	Dry-land Pasture
104	1	Grass-Forb Riparian/Wetland
105	1	Shrub Riparian/Wetland

Spectral Class 29
Color: Midnight blue; RGB 0 5 98.
Distribution: Large lakes and other water features. Largely Urban & Developed Land outside the zone.
Conclusion: Not riparian.

106	1	Mesic Upland Shrubland
107	3	Rivers & Streams
108	5	Lakes

109	1	Reservoirs
110	1	Needleleaf-Broadleaf Riparian
111	2	Shoreline & Gravel Bars

Spectral Class 31
Color: Olive green; RGB 204 227 150.
Distribution: Open spots at all elevations; not barren.
Comment: Appears to be dry grass and shrub. Mesic Upland Shrub has the highest frequency outside the zone.
Conclusion: Not riparian.

114	1	Foothills Grassland
115	1	Grass-Forb Riparian/Wetland

Spectral Class 32
Color: Raspberry; RGB 192 85 105.
Distribution: Middle elevation, some large stands.
Comment: Clearly Needleleaf-Broadleaf vegetation in distribution, with red component indication riparian vegetation. Mixed Mesic Forest dominates points outside the zone.
Conclusion: 6103.

116	1	Western Red Cedar
117	1	Mix Needleleaf-Broadleaf
118	1	Needleleaf-Broadleaf Riparian

Spectral Class 34
Color: Dark purple; RGB 67 54 92.
Distribution: Shadows.
Comment: Locations suggest conifer stands. Color and training data points support the visual interpretation. Mixed Mesic Forest dominates training data points outside the zone.
Conclusion: Not riparian.

119	1	Engelmann Spruce
120	1	Douglas-fir
121	2	Mixed Subalpine Forest
122	2	Mixed Mesic Forest
123	1	Needleleaf Dominated Riparian
124	1	Needleleaf-Broadleaf Riparian

Spectral Class 36
Color: Light blue-purple; RGB 161 180 242.
Distribution: Light density, some in urban and agriculture areas.

Comment: Scene-wide, this class appears to be dominated by cloud edges, with urban next in line. Outside the zone, Urban & Developed Land is the most frequent cover type for this class.
Conclusion: Not riparian.

126	2	Urban & Developed Land
127	1	Needleleaf-Broadleaf Riparian
128	2	Shoreline & Gravel Bars

Spectral Class 40
Color: Brown; RGB 126 85 72.
Distribution: Relatively dense, widely distributed, and denser in some areas; mostly middle to upper elevations, but some in lower elevations; well represented within the riparian zone.
Comment: In some areas, the spectral class is clearly goes up draws, along hillsides. The red component is also significant. Here, Mixed Mesic Forest is the dominant vegetation class.
Conclusion: 6103.

130	1	Foothills Grassland
131	2	Mixed Mesic Forest
132	1	Rivers & Streams
133	1	Broadleaf DominatedRiparian
134	1	Needleleaf-Broadleaf Riparian
135	1	Grass-Forb Riparian/Wetland

Spectral Class 45
Color: Light green; RGB 169 252 196.
Distribution: Open spots at all elevations; not barren.
Comment: Appears to be dry grass, some in clear cuts. Outside the zone, Foothills Grassland and Mesic Upland Shrubland are about equally represented by the training data points.
Conclusion: Not riparian.

140	1	Grass-Forb Riparian/Wetland
141	1	Shrub Riparian/Wetland
142	1	Mixed Barren Land

Spectral Class 60
Color: Mauve; RGB 200 160 203.
Distribution: Mostly lower elevations; some agriculture and urban areas; otherwise sparse.
Comment: Appears to be mostly haze, as well as some urban areas. No vegetation class dominates this spectral class outside the zone, but Foothills Grassland, Sandy Areas, Grand Fir, and Exposed Rock are represented.
Conclusion: Not riparian.

151	1	Broadleaf Dominated Riparian

TM SCENE P42/R27

Image Analyst: Troy P. Tady

Training Data Analysis

In all, 2599 ground-truth plots were available for labeling P42/R27 (see table next page). The data were initially checked over the full scene to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 186) were removed from further analysis. The data were then examined by cover type to determine whether or not plots were collected for this project or for other purposes (e.g., pre-existing ECODATA, TSMRS, etc.). The latter "existing data" were used only as supplementary accuracy test plots (n = 129).

The following classes were excluded from the digital classification process: urban, agriculture, water, snow, riparian, mines/quarries/gravel pits, clearcuts, burns, sandy areas, and shoreline/gravel bars. Classes were also excluded because they were determined to be minor scene components as per USFS decisions: 3304, 3312, 3314, 4201, and 8101. Plots with these VEG_CLASS_CODEs were not used in the digital classification as either training data or test data. The aspen (4101) cover type was combined with the general broadleaf forest class (4102) because adequate training data for these two classes were not available. The disturbed grasslands (3102) class was combined with foothills grassland (3101) due to negligible spectral differences between the two classes.

Of the remaining plots, 20% were randomly selected from each cover type. These plots (n = 305) were held aside in a separate data file for use in the accuracy assessment. Pre-existing ECODATA plots were not used as training data, but 125 of them were used as test plots in addition to the 20% value listed above.

For the remaining 80% of this "filtered" data set, plots were subjected to further spectral examination. Outliers were eliminated for each cover type based on knowledge of general spectral patterns for various ground features. Insufficient training data plots were available for one cover type, 3104 subalpine meadow (2 plots).

Training data for this and most of the other cover types were supplemented from data gathered during several forest service review sessions with the Kootenai, Panhandle, and Lolo National Forests as well as from personal knowledge from individuals familiar with areas within the scene. A total of 130 new training data plots were obtained through various review sessions.

Total plots in ground-truth file	2599	
Total 1994-95 field plots	2252	
Plots sampled for P42/R27		1193
Plots sampled for other scenes		1059
Pre-existing plots (ECODATA, TSMRS, etc.)	347	
Plots with codes included in the classification	1865	
Plot discards	338	
Pre-existing plots		120
'Bad duplicates'		186
'Good duplicates'		32
Potential training plots	1527	
20% test		305
80% training		1259
Supplemental plots	130	(+/-)
Supplemental ECODATA for test plots	129	
Total plots available for training	1389	(+/-)
Total plots used for available training--cover type	937	
size class	877	
canopy	1153	

Land Cover Types

Land cover types were labeled through a digital classification of TM channels 1-7 plus rescaled elevation (raw elevation value divided by 25). The digital classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were used and assigned directly to the COVERTYPE field in the database attribute table. Further modifications were carried out using spectral class values (SPECTRAL_CLASS, or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000. Urban.	Manually identified and recoded by Troy Tady.
2000. Agriculture.	Manually identified and recoded by Troy Tady. MNDVI values were used to easily delineate large area of plowed farm fields in the southwestern portion of the scene.
3101. Foothills Grassland.	All grass types occurring below 1067 m (3500 ft) were relabeled as Foothills Grassland.

3104.	Montane Parkland & Subalpine Meadow.	All grass types occurring at and above 1067 m (3500 ft) were relabeled as Montane Parkland & Subalpine Meadow.
3202.	Warm Mesic Shrubland.	Shrub types were labeled as Warm Mesic Shrubland if they occurred below 1341 m (4400 ft). If they occurred between 1341 m (4400 ft) and 1646 m (5400 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
3203.	Cold Mesic Shrubland.	Shrub types were labeled as Cold Mesic Shrubland if they occurred above 1646 m (5400 ft). If they occurred between 1341 m (4400 ft) and 1646 m (5400 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
3304.	Bitterbrush.	Geographically confined using Forest Service vegetation distribution limits.
3305.	Mountain Big Sage.	Geographically confined using Forest Service vegetation distribution limits.
4102.	Broadleaf Forest.	Labeling of the Broadleaf Forest class was difficult due to the lack of adequate training plots. No supplemental data were available for this class.
4201.	Engelmann Spruce.	No modifications.
4203.	Lodgepole Pine.	Ten supplemental data plots were acquired for this class during the Forest Service review sessions. General distribution patterns seem reasonable.
4206.	Ponderosa Pine.	Sixty-one supplemental data plots were acquired for this class during the Forest Service review sessions. General distribution patterns seem very good.
4207.	Grand Fir.	Confusion between Grand Fir and Mixed Mesic Forest (4221) was evident in the training data and is reflected in the cover type accuracy assessment. This confusion is understandable since Grand Fir monoculture stands are relatively rare while the Grand Fir species component in the 4221 class tends to be very large in North Idaho.
4208.	Subalpine Fir.	No modifications.
4210.	Western Red Cedar.	Only one supplemental training plot was acquired for this class during the Forest Service review sessions.

4211.	Western Hemlock.	No modifications.
4212.	Douglas-fir.	The xeric to mesic transitions in the areas covered by P42/R27 made Douglas-fir a difficult class to label in some areas. High variation within the class adds to potential confusion with other cover type classes.
4215.	Western Larch.	Only one supplemental training plot was acquired for this class during the Forest Service review sessions.
4220.	Mixed Subalpine Forest.	No modifications.
4221.	Mixed Mesic Forest.	See subclasses: 4201, 4211, 4225, 4226, 4227, 4228, 4229.
4222.	Mixed Xeric Forest.	Eight supplemental training plots were acquired for this class.
4223.	Douglas-fir - Lodgepole Pine.	Only one supplemental training plot was acquired for this class.
4225.	Douglas-fir - Grand Fir.	Four supplemental training plots were acquired for this class.
4226.	Western Red Cedar - Grand Fir.	No modifications.
4227.	Western Red Cedar - Western Hemlock.	Seven supplemental training plots were acquired for this class.
4228.	Western Larch - Lodgepole Pine.	Good general distribution was observed for this class.
4229.	Douglas-fir - Western Larch.	Four supplemental training plots were acquired for this class.
4301.	Broadleaf - Needleleaf Forest.	No modifications.
5000.	Water.	All regions with spectral class (LINK) = 1 and slope ≤5˚ were labeled as water. Generally, water was more spectrally distinct than most other cover types, but in high mountainous terrain, it was confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate elevation and slope values such that their slope may be greater than 5˚.

		This would result in the misclassification of some small ponds or lakes.
7300.	Rock.	No modifications.
7500.	Mines/Gravel Pits/Quarries.	Manually labeled and recoded by Troy Tady.
7800.	Mixed Barren.	No modifications.
7900.	Shoreline/Gravel Bars.	Manually labeled and recoded by Troy Tady.
9200.	Melted Snow.	All regions classified as Melted Snow were recoded either to Exposed Rock (7300) if their slope was >5˚, or to Snow (9000) if their slope was ≤5˚.

A total of 34 classes were labeled in the full TM scene. These included two grass types, five shrub types, twenty forest types, plus seven non-vegetated or manually labeled classes. Cover types are mapped in Figure F-4.

Size Classes

Seven size classes were mapped -- four for forest cover types (seedling/sapling, pole, medium, and large/very large) and three for shrub cover (low, medium, and tall). The seven TM spectral channels were used for the size class classification (elevation was not included). Considerably more points were available to estimate population parameters for each size class then were available for each cover type. A Gaussian Maximum Likelihood (GML) classifier (see Lillesand and Kiefer 1987) was used to classify live size classes for shrub cover types. The GML classifier was not used for tree size classes as a Nearest Member of Group (NMG) classifier proved more effective.

Canopy Cover Classes

Canopy cover labels (CANOPYCODE = low, medium, or high) were assigned to tree and shrub classes based on Modified Normalized Distribution Vegetation Index (MNDVI) values. These values were plotted as frequency histograms for all forest types (Figure F-4a) as well as for two different shrub types (mesic versus xeric; Figure F-4b). The histograms were examined to determine break points were decided based on the distribution modes (see table below). Regions with MNDVI values falling below the lower break point were assigned to a low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class. The low number of points available for the xeric (3300) shrub classes required that mesic and xeric shrub points be combined for this scene.

	MNDVI BREAKPOINTS	
CANOPY COVER	Tree	Shrub
Low	<200	<100
Medium	≥200 and ≤400	≥100 and ≤200
High	>400	>200

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications.

CLASSIFICATIONS FOR P42/R27	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	27	71%	44%
Tree Size Class	4	87%	55%
Tree Canopy Class	3	93%	50%
Shrub Size Class	3	83%	41%
Shrub Canopy Class	3	77%	40%

Comments

The primary problem with conifer forest types, as indicated by individual Cover Type accuracy values, was separating and labeling subcodes falling under the mixed mesic conifer (4221) class. Confusion between these classes (4225, 4226, 4227, 4228, and 4229) is usually high. The absence of large amounts of training data for these sub codes combined with the spectral similarity of these classes will always cause misclassifications among these conifer types. Generally, however, distribution patterns seemed to be good to acceptable for most of the mapped cover types when examined during the Forest Service review sessions.

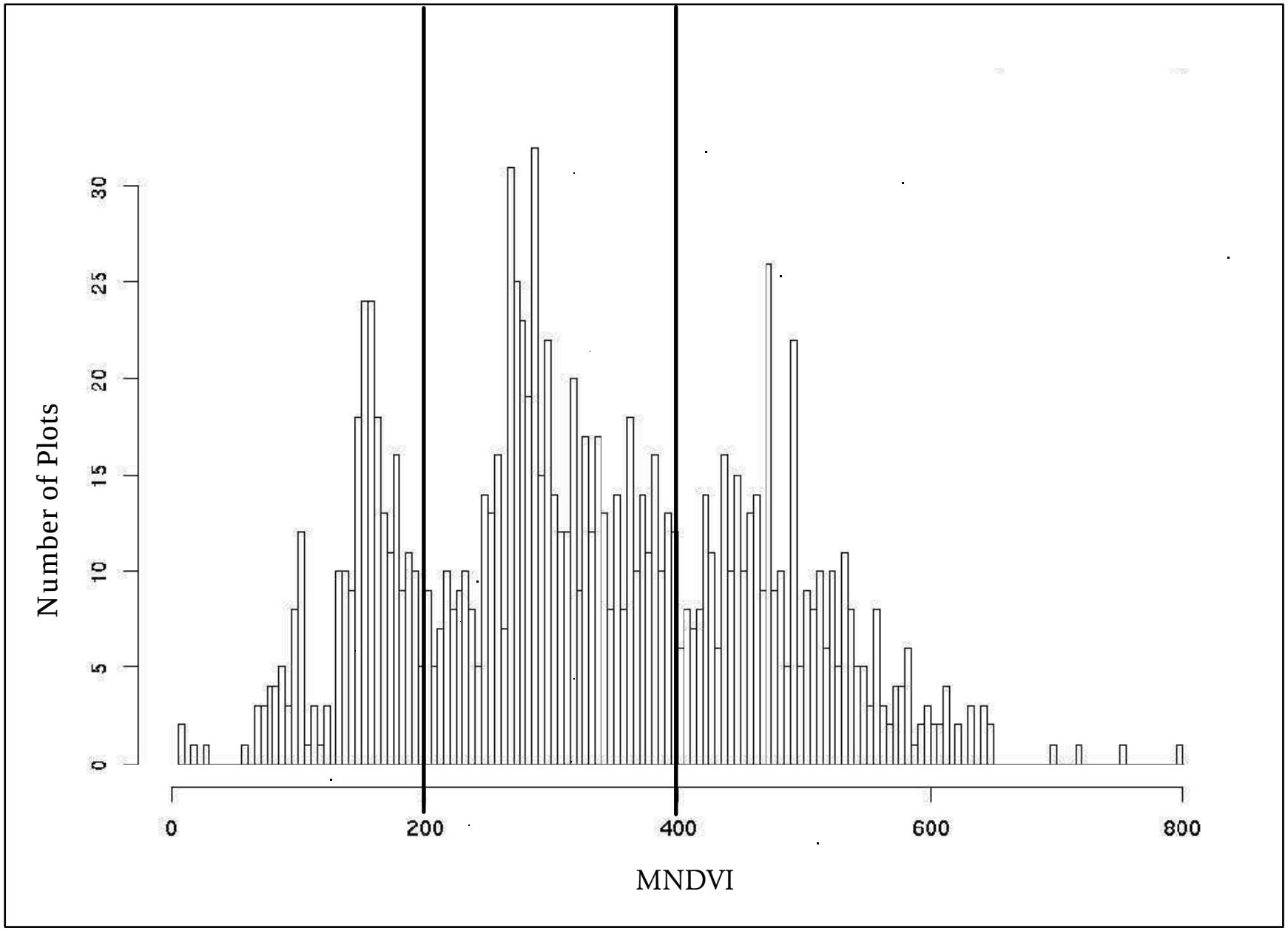
Error Matrix For Cover Type Training Plots
Scene P42/R27

CLASSIFIED COVER TYPES

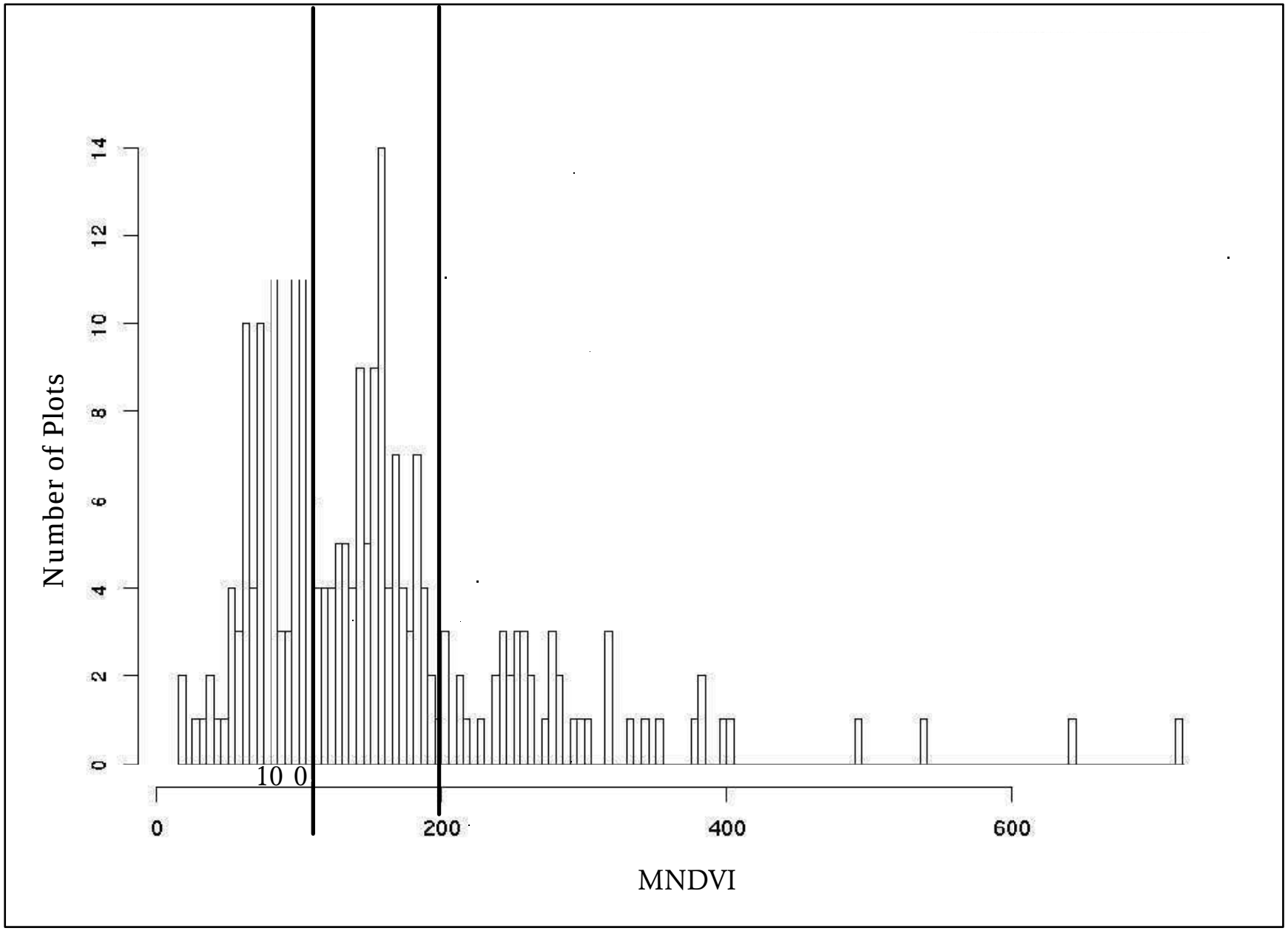
PLOT COVER TYPES	3101	3104	3201	3304	3305	3312	4102	4203	4206	4207	4208	4210	4212	4215	4220	4221	4222	4223	4301	7301	7800	SUM
3101	92	0	13	0	5	0	1	0	2	0	0	0	0	1	0	1	0	0	0	2	8	125
3104	0	3	2	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	7
3201	16	2	22	0	0	0	0	2	9	1	3	0	4	0	0	5	7	1	0	7	4	83
3304	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2
3305	3	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
3312	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4102	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	0	0	0	0	0	5
4203	0	0	1	0	0	0	0	28	0	0	2	0	2	1	1	9	1	0	0	0	0	45
4206	6	0	3	0	0	0	0	0	14	0	0	0	3	0	0	6	4	0	0	0	0	36
4207	0	0	2	0	0	0	0	0	0	3	0	0	5	1	0	16	0	0	1	0	0	28
4208	0	0	2	0	0	0	0	6	0	0	6	1	2	0	4	9	0	0	0	0	0	30
4210	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	6	0	0	1	0	0	10
4212	0	0	4	2	0	0	0	1	2	6	0	1	39	2	3	43	6	0	1	0	0	110
4215	0	0	1	0	0	0	0	1	0	0	1	0	3	2	0	5	0	0	1	0	0	14
4220	0	0	0	0	0	0	0	2	0	0	7	0	0	0	7	4	0	2	0	1	0	23
4221	0	1	8	1	0	0	1	7	5	13	8	7	41	8	2	166	7	4	1	1	0	281
4222	0	0	2	0	0	0	0	0	8	0	0	0	5	0	0	8	7	1	1	0	0	32
4223	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	5	2	2	0	0	0	14
4301	1	0	0	0	0	0	0	0	1	2	0	1	2	0	0	3	0	0	2	0	0	12
7301	8	1	12	0	0	0	0	2	0	0	0	0	1	0	2	3	0	0	0	15	2	46
7800	8	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	11	25
SUM	136	7	75	3	9	2	2	49	42	26	29	10	114	16	21	291	35	10	8	27	25	937

F.P42/R27. 8

% AGREEMENT	43.36
TAU WITH EQUAL PROBABILITY	0.427
TOTAL DIAGONAL ELEMENTS	425
TOTAL TRAINING PLOTS IN DATA SET	937



FigureF-4a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P42/R27



FigureF-4a. Breaks between tree canopy cover classes in relation to MNDVI values: TMsceneP42 / R27

Accuracy Assessment Tables for P42/R27 -- Cover Type

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3102	3104	3202	3203	3305	4201	4203	4206
3101	17(5)	0(3)	2(3)	3(1)	0(1)	0(1)	0(1)	1(1)	2(1)
3102	5(3)	0(5)	0(2)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)
3104	4(3)	0(3)	6(5)	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)
3202	3(1)	0(1)	3(1)	7(5)	0(3)	0(2)	0(1)	1(1)	0(1)
3203	0(1)	0(1)	1(1)	0(3)	3(5)	0(2)	0(1)	0(1)	0(1)
3305	1(1)	0(1)	0(1)	0(2)	0(2)	1(5)	0(1)	0(1)	0(1)
4201	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(5)	0(2)	0(2)
4203	0(1)	0(1)	0(1)	1(1)	1(1)	0(1)	2(2)	20(5)	0(2)
4206	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(2)	0(2)	9(5)
4207	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(2)	0(2)	0(2)
4208	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	1(3)	1(2)	0(2)
4210	1(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(2)	0(2)	0(2)
4211	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(2)	2(2)	1(2)
4212	1(1)	0(1)	0(1)	4(1)	0(1)	0(1)	0(2)	0(2)	3(2)
4215	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	1(2)
4220	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(4)	2(3)	1(2)
4221	3(1)	0(1)	0(1)	7(1)	1(1)	0(1)	0(3)	2(3)	4(2)
4222	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(3)
4223	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	1(3)	0(2)
4225	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)
4226	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)
4227	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)
4228	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)	0(2)
4229	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)
4301	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)
7301	0(1)	0(1)	0(1)	2(1)	1(1)	0(1)	0(1)	0(1)	0(1)
7800	0(2)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
SUM	37(0)	0(0)	13(0)	27(0)	9(0)	2(0)	3(0)	30(0)	22(0)

Accuracy Assessment Tables for P42/R27 -- Cover Type

RF/CF	4207	4208	4210	4211	4212	4215	4220	4221	4222
3101	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	1(1)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3104	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
3202	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3203	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3305	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4201	0(2)	0(3)	0(2)	0(2)	0(2)	0(2)	0(4)	0(4)	0(2)
4203	0(2)	2(2)	0(2)	6(2)	4(2)	1(2)	0(3)	3(3)	1(2)
4206	1(2)	0(2)	0(2)	0(2)	1(2)	0(2)	0(2)	1(3)	0(4)
4207	3(5)	0(2)	0(2)	1(2)	4(2)	1(2)	0(2)	4(3)	1(2)
4208	0(2)	9(5)	0(2)	0(2)	1(2)	0(2)	2(3)	1(3)	0(2)
4210	0(2)	0(2)	1(5)	0(3)	0(2)	0(2)	0(2)	1(3)	0(2)
4211	1(2)	0(2)	1(3)	5(5)	2(2)	0(2)	2(2)	2(3)	0(2)
4212	1(2)	0(2)	0(2)	0(2)	30(5)	1(3)	0(3)	21(3)	2(4)
4215	0(2)	1(2)	0(2)	0(2)	0(3)	2(5)	0(3)	6(3)	0(2)
4220	0(2)	2(3)	0(2)	0(2)	1(3)	0(2)	4(5)	1(2)	0(2)
4221	2(3)	2(2)	0(3)	2(3)	11(3)	2(3)	0(2)	38(5)	2(2)
4222	0(2)	0(2)	0(2)	0(2)	5(3)	0(2)	0(2)	2(2)	2(5)
4223	0(2)	0(2)	0(2)	0(2)	1(3)	1(2)	0(3)	0(3)	0(2)
4225	0(4)	0(2)	0(2)	0(2)	1(3)	3(2)	0(2)	3(4)	0(2)
4226	0(4)	0(2)	0(3)	0(3)	1(2)	0(2)	0(2)	3(4)	0(2)
4227	0(2)	0(2)	0(3)	0(3)	1(2)	0(2)	0(2)	1(4)	0(2)
4228	0(2)	0(2)	0(2)	0(2)	0(2)	1(3)	0(3)	0(4)	0(2)
4229	0(2)	0(2)	0(2)	0(2)	0(3)	0(3)	0(3)	0(4)	0(2)
4301	0(3)	0(2)	0(3)	0(2)	1(2)	0(2)	0(3)	1(3)	0(3)
7301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)
7800	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	8(0)	17(0)	2(0)	14(0)	65(0)	12(0)	9(0)	89(0)	9(0)

Accuracy Assessment Tables for P42/R27 -- Cover Type

RF/CF	4223	4225	4226	4227	4228	4229	4301	7301	7800	SUM
3101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	28(0)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	6(0)
3104	0(1)	0(1)	0(1)	0(1)	2(1)	0(1)	0(1)	3(1)	0(1)	18(0)
3202	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	15(0)
3203	0(1)	1(1)	0(1)	0(1)	1(1)	0(1)	0(1)	1(1)	0(1)	7(0)
3305	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(0)
4201	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)	1(0)
4203	1(4)	2(2)	1(2)	1(2)	0(4)	0(2)	0(2)	1(1)	0(1)	47(0)
4206	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	1(1)	0(1)	14(0)
4207	0(2)	0(4)	0(4)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)	15(0)
4208	0(2)	0(2)	0(2)	0(2)	1(2)	0(2)	0(2)	1(1)	0(1)	18(0)
4210	0(2)	0(2)	0(4)	0(4)	0(2)	0(2)	0(2)	0(1)	0(1)	4(0)
4211	0(2)	0(2)	0(3)	0(4)	0(2)	0(2)	0(2)	0(1)	0(1)	17(0)
4212	3(4)	4(4)	1(2)	1(2)	3(2)	3(4)	0(2)	0(1)	0(1)	78(0)
4215	0(2)	0(2)	0(2)	0(2)	0(4)	0(4)	0(2)	0(1)	0(1)	10(0)
4220	0(3)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)	11(0)
4221	3(3)	4(4)	4(4)	3(4)	3(4)	2(4)	1(2)	2(1)	0(1)	100(0)
4222	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)	9(0)
4223	4(5)	0(3)	0(2)	1(2)	0(4)	1(4)	0(2)	0(1)	0(1)	9(0)
4225	0(3)	3(5)	0(3)	0(3)	0(3)	0(3)	0(2)	0(1)	0(1)	10(0)
4226	0(2)	3(3)	8(5)	0(4)	0(3)	0(3)	1(2)	0(1)	0(1)	16(0)
4227	0(2)	0(3)	0(4)	6(5)	0(3)	0(3)	0(2)	0(1)	0(1)	8(0)
4228	0(4)	0(3)	0(3)	0(3)	9(5)	0(4)	0(2)	0(1)	0(1)	10(0)
4229	0(4)	0(3)	0(3)	0(3)	0(4)	6(5)	0(2)	0(1)	0(1)	6(0)
4301	0(3)	0(3)	0(3)	0(3)	0(3)	0(3)	0(5)	0(1)	0(1)	3(0)
7301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	6(5)	2(3)	12(0)
7800	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(3)	3(5)	5(0)
SUM	12(0)	17(0)	14(0)	13(0)	19(0)	12(0)	2(0)	15(0)	5(0)	479(0)

Diagonal Elements = 202; Total Test Points = 479
Percentage Agreement = 42.17; Tau w/equal Prob = 0.399

2 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 2 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	17	60.71	0	0.00	2	7.14	0	0.00	9	32.14
3102	0	0.00	0	0.00	5	83.33	0	0.00	1	16.67
3104	6	33.33	0	0.00	4	22.22	0	0.00	8	44.44
3202	7	46.67	0	0.00	0	0.00	0	0.00	8	53.33
3203	3	42.86	0	0.00	0	0.00	0	0.00	4	57.14
3305	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4201	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4203	20	42.55	1	2.13	3	6.38	20	42.55	3	6.38
4206	9	64.29	0	0.00	1	7.14	2	14.29	2	14.29
4207	3	20.00	0	0.00	4	26.67	7	46.67	1	6.67
4208	9	50.00	0	0.00	4	22.22	3	16.67	2	11.11
4210	1	25.00	0	0.00	1	25.00	0	0.00	2	50.00
4211	5	29.41	0	0.00	3	17.65	8	47.06	1	5.88
4212	30	38.46	12	15.38	22	28.21	9	11.54	5	6.41
4215	2	20.00	0	0.00	6	60.00	2	20.00	0	0.00
4220	4	36.36	0	0.00	5	45.45	2	18.18	0	0.00
4221	38	38.00	16	16.00	22	22.00	9	9.00	15	15.00
4222	2	22.22	0	0.00	5	55.56	2	22.22	0	0.00
4223	4	44.44	1	11.11	2	22.22	2	22.22	0	0.00
4225	3	30.00	3	30.00	1	10.00	3	30.00	0	0.00
4226	8	50.00	3	18.75	3	18.75	2	12.50	0	0.00
4227	6	75.00	1	12.50	0	0.00	1	12.50	0	0.00
4228	9	90.00	0	0.00	1	10.00	0	0.00	0	0.00
4229	6	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4301	0	0.00	0	0.00	1	33.33	1	33.33	1	33.33
7301	6	50.00	0	0.00	2	16.67	0	0.00	4	33.33
7800	3	60.00	0	0.00	0	0.00	0	0.00	2	40.00
SUM	202	42.17	37	7.72	97	20.25	73	15.24	70	14.61

Accuracy Assessment Tables for P42/R27 -- Cover Type

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	17	60.71	17	60.71	19	67.86	19	67.86	28	100.00
3102	0	0.00	0	0.00	5	83.33	5	83.33	6	100.00
3104	6	33.33	6	33.33	10	55.56	10	55.56	18	100.00
3202	7	46.67	7	46.67	7	46.67	7	46.67	15	100.00
3203	3	42.86	3	42.86	3	42.86	3	42.86	7	100.00
3305	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4201	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4203	20	42.55	21	44.68	24	51.06	44	93.62	47	100.00
4206	9	64.29	9	64.29	10	71.43	12	85.71	14	100.00
4207	3	20.00	3	20.00	7	46.67	14	93.33	15	100.00
4208	9	50.00	9	50.00	13	72.22	16	88.89	18	100.00
4210	1	25.00	1	25.00	2	50.00	2	50.00	4	100.00
4211	5	29.41	5	29.41	8	47.06	16	94.12	17	100.00
4212	30	38.46	42	53.85	64	82.05	73	93.59	78	100.00
4215	2	20.00	2	20.00	8	80.00	10	100.00	10	100.00
4220	4	36.36	4	36.36	9	81.82	11	100.00	11	100.00
4221	38	38.00	54	54.00	76	76.00	85	85.00	100	100.00
4222	2	22.22	2	22.22	7	77.78	9	100.00	9	100.00
4223	4	44.44	5	55.56	7	77.78	9	100.00	9	100.00
4225	3	30.00	6	60.00	7	70.00	10	100.00	10	100.00
4226	8	50.00	11	68.75	14	87.50	16	100.00	16	100.00
4227	6	75.00	7	87.50	7	87.50	8	100.00	8	100.00
4228	9	90.00	9	90.00	10	100.00	10	100.00	10	100.00
4229	6	100.00	6	100.00	6	100.00	6	100.00	6	100.00
4301	0	0.00	0	0.00	1	33.33	2	66.67	3	100.00
7301	6	50.00	6	50.00	8	66.67	8	66.67	12	100.00
7800	3	60.00	3	60.00	3	60.00	3	60.00	5	100.00
SUM	202	42.17	239	49.90	336	70.15	409	85.39	479	100.00

Accuracy Assessment Tables for P42/R27 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	17	45.95	0	0.00	9	24.32	0	0.00	11	29.73
3102	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3104	6	46.15	0	0.00	2	15.38	0	0.00	5	38.46
3202	7	25.93	0	0.00	0	0.00	0	0.00	20	74.07
3203	3	33.33	0	0.00	0	0.00	0	0.00	6	66.67
3305	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4201	0	0.00	0	0.00	1	33.33	2	66.67	0	0.00
4203	20	66.67	0	0.00	5	16.67	3	10.00	2	6.67
4206	9	40.91	0	0.00	0	0.00	10	45.45	3	13.64
4207	3	37.50	0	0.00	2	25.00	3	37.50	0	0.00
4208	9	52.94	0	0.00	2	11.76	5	29.41	1	5.88
4210	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
4211	5	35.71	0	0.00	2	14.29	7	50.00	0	0.00
4212	30	46.15	0	0.00	19	29.23	15	23.08	1	1.54
4215	2	16.67	0	0.00	4	33.33	6	50.00	0	0.00
4220	4	44.44	0	0.00	2	22.22	2	22.22	1	11.11
4221	38	42.70	7	7.87	40	44.94	3	3.37	1	1.12
4222	2	22.22	2	22.22	0	0.00	4	44.44	1	11.11
4223	4	33.33	4	33.33	3	25.00	0	0.00	1	8.33
4225	3	17.65	8	47.06	3	17.65	2	11.76	1	5.88
4226	8	57.14	4	28.57	0	0.00	2	14.29	0	0.00
4227	6	46.15	3	23.08	0	0.00	3	23.08	1	7.69
4228	9	47.37	3	15.79	0	0.00	4	21.05	3	15.79
4229	6	50.00	6	50.00	0	0.00	0	0.00	0	0.00
4301	0	0.00	0	0.00	0	0.00	2	100.00	0	0.00
7301	6	40.00	0	0.00	0	0.00	0	0.00	9	60.00
7800	3	60.00	0	0.00	2	40.00	0	0.00	0	0.00
SUM	202	42.35	37	7.76	97	20.34	73	15.30	68	14.26

Accuracy Assessment Tables for P42/R27 -- Cover Type

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	17	45.95	17	45.95	26	70.27	26	70.27	37	100.00
3102	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3104	6	46.15	6	46.15	8	61.54	8	61.54	13	100.00
3202	7	25.93	7	25.93	7	25.93	7	25.93	27	100.00
3203	3	33.33	3	33.33	3	33.33	3	33.33	9	100.00
3305	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4201	0	0.00	0	0.00	1	33.33	3	100.00	3	100.00
4203	20	66.67	20	66.67	25	83.33	28	93.33	30	100.00
4206	9	40.91	9	40.91	9	40.91	19	86.36	22	100.00
4207	3	37.50	3	37.50	5	62.50	8	100.00	8	100.00
4208	9	52.94	9	52.94	11	64.71	16	94.12	17	100.00
4210	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
4211	5	35.71	5	35.71	7	50.00	14	100.00	14	100.00
4212	30	46.15	30	46.15	49	75.38	64	98.46	65	100.00
4215	2	16.67	2	16.67	6	50.00	12	100.00	12	100.00
4220	4	44.44	4	44.44	6	66.67	8	88.89	9	100.00
4221	38	42.70	45	50.56	85	95.51	88	98.88	89	100.00
4222	2	22.22	4	44.44	4	44.44	8	88.89	9	100.00
4223	4	33.33	8	66.67	11	91.67	11	91.67	12	100.00
4225	3	17.65	11	64.71	14	82.35	16	94.12	17	100.00
4226	8	57.14	12	85.71	12	85.71	14	100.00	14	100.00
4227	6	46.15	9	69.23	9	69.23	12	92.31	13	100.00
4228	9	47.37	12	63.16	12	63.16	16	84.21	19	100.00
4229	6	50.00	12	100.00	12	100.00	12	100.00	12	100.00
4301	0	0.00	0	0.00	0	0.00	2	100.00	2	100.00
7301	6	40.00	6	40.00	6	40.00	6	40.00	15	100.00
7800	3	60.00	3	60.00	5	100.00	5	100.00	5	100.00
SUM	202	42.35	239	50.10	336	70.44	409	85.74	477	100.00

Accuracy Assessment Tables for P42/R27 -- Cover Type

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	28	60.71	0	0.00	3	7.14	0	0.00	15	32.14
3102	0	0.00	0	0.00	0	83.33	0	0.00	0	16.67
3104	6	33.33	0	0.00	4	22.22	0	0.00	8	44.44
3202	26	46.67	0	0.00	0	0.00	0	0.00	30	53.33
3203	5	42.86	0	0.00	0	0.00	0	0.00	7	57.14
3305	3	50.00	0	0.00	0	0.00	0	0.00	3	50.00
4201	0	0.00	0	0.00	0	0.00	0	0.00	6	100.00
4203	22	42.55	1	2.13	3	6.38	22	42.55	3	6.38
4206	29	64.29	0	0.00	3	7.14	6	14.29	6	14.29
4207	6	20.00	0	0.00	8	26.67	13	46.67	2	6.67
4208	17	50.00	0	0.00	7	22.22	6	16.67	4	11.11
4210	1	25.00	0	0.00	1	25.00	0	0.00	2	50.00
4211	6	29.41	0	0.00	4	17.65	10	47.06	1	5.88
4212	48	38.46	19	15.38	35	28.21	14	11.54	8	6.41
4215	3	20.00	0	0.00	9	60.00	3	20.00	0	0.00
4220	13	36.36	0	0.00	17	45.45	7	18.18	0	0.00
4221	61	38.00	26	16.00	36	22.00	15	9.00	24	15.00
4222	9	22.22	0	0.00	22	55.56	9	22.22	0	0.00
4223	9	44.44	2	11.11	4	22.22	4	22.22	0	0.00
4225	19	30.00	19	30.00	6	10.00	19	30.00	0	0.00
4226	22	50.00	8	18.75	8	18.75	5	12.50	0	0.00
4227	14	75.00	2	12.50	0	0.00	2	12.50	0	0.00
4228	18	90.00	0	0.00	2	10.00	0	0.00	0	0.00
4229	35	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4301	0	0.00	0	0.00	3	33.33	3	33.33	3	33.33
7301	9	50.00	0	0.00	3	16.67	0	0.00	6	33.33
7800	4	60.00	0	0.00	0	0.00	0	0.00	3	40.00
SUM	413	44.08	77	8.22	178	19.00	138	14.73	131	13.98

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	28	60.71	28	60.71	31	67.86	31	67.86	46	100.00
3102	0	0.00	0	0.00	0	83.33	0	83.33	0	100.00
3104	6	33.33	6	33.33	10	55.56	10	55.56	19	100.00
3202	26	46.67	26	46.67	26	46.67	26	46.67	56	100.00
3203	5	42.86	5	42.86	5	42.86	5	42.86	12	100.00
3305	3	50.00	3	50.00	3	50.00	3	50.00	6	100.00
4201	0	0.00	0	0.00	0	0.00	0	0.00	6	100.00
4203	22	42.55	23	44.68	26	51.06	48	93.62	51	100.00
4206	29	64.29	29	64.29	32	71.43	38	85.71	45	100.00
4207	6	20.00	6	20.00	13	46.67	26	93.33	28	100.00
4208	17	50.00	17	50.00	24	72.22	29	88.89	33	100.00
4210	1	25.00	1	25.00	2	50.00	2	50.00	5	100.00
4211	6	29.41	6	29.41	10	47.06	19	94.12	20	100.00
4212	48	38.46	68	53.85	103	82.05	117	93.59	125	100.00
4215	3	20.00	3	20.00	11	80.00	14	100.00	14	100.00
4220	13	36.36	13	36.36	30	81.82	36	100.00	36	100.00
4221	61	38.00	87	54.00	123	76.00	137	85.00	162	100.00
4222	9	22.22	9	22.22	31	77.78	40	100.00	40	100.00
4223	9	44.44	11	55.56	15	77.78	20	100.00	20	100.00
4225	19	30.00	37	60.00	43	70.00	62	100.00	62	100.00
4226	22	50.00	30	68.75	38	87.50	43	100.00	43	100.00
4227	14	75.00	16	87.50	16	87.50	18	100.00	18	100.00
4228	18	90.00	18	90.00	20	100.00	20	100.00	20	100.00
4229	35	100.00	35	100.00	35	100.00	35	100.00	35	100.00
4301	0	0.00	0	0.00	3	33.33	5	66.67	8	100.00
7301	9	50.00	9	50.00	12	66.67	12	66.67	18	100.00
7800	4	60.00	4	60.00	4	60.00	4	60.00	7	100.00
SUM	413	44.17	490	52.41	666	71.23	800	85.56	935	100.00

Accuracy Assessment Tables for P42/R27 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	4	SUM
1	9(5)	4(3)	13(1)	0(1)	26(0)
2	7(3)	5(5)	20(3)	0(1)	32(0)
3	11(1)	16(3)	91(5)	5(3)	123(0)
4	1(1)	3(1)	8(3)	0(5)	12(0)
SUM	28(0)	28(0)	132(0)	5(0)	193(0)

Diagonal Elements = 105; Total Test Points = 193
Percentage Agreement = 54.40; Tau w/equal Prob = 0.392

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	34.62	0	0.00	4	15.38	0	0.00	13	50.00
2	5	15.62	0	0.00	27	84.38	0	0.00	0	0.00
3	91	73.98	0	0.00	21	17.07	0	0.00	11	8.94
4	0	0.00	0	0.00	8	66.67	0	0.00	4	33.33
SUM	105	54.40	0	0.00	60	31.09	0	0.00	28	14.51

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	34.62	9	34.62	13	50.00	13	50.00	26	100.00
2	5	15.62	5	15.62	32	100.00	32	100.00	32	100.00
3	91	73.98	91	73.98	112	91.06	112	91.06	123	100.00
4	0	0.00	0	0.00	8	66.67	8	66.67	12	100.00
SUM	105	54.40	105	54.40	165	85.49	165	85.49	193	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	32.14	0	0.00	7	25.00	0	0.00	12	42.86
2	5	17.86	0	0.00	20	71.43	0	0.00	3	10.71
3	91	68.94	0	0.00	28	21.21	0	0.00	13	9.85
4	0	0.00	0	0.00	5	100.00	0	0.00	0	0.00
SUM	105	54.40	0	0.00	60	31.09	0	0.00	28	14.51

Accuracy Assessment Tables for P42/R27 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	32.14	9	32.14	16	57.14	16	57.14	28	100.00
2	5	17.86	5	17.86	25	89.29	25	89.29	28	100.00
3	91	68.94	91	68.94	119	90.15	119	90.15	132	100.00
4	0	0.00	0	0.00	5	100.00	5	100.00	5	100.00
SUM	105	54.40	105	54.40	165	85.49	165	85.49	193	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	36	34.62	0	0.00	16	15.38	0	0.00	52	50.00
2	29	15.62	0	0.00	157	84.38	0	0.00	0	0.00
3	480	73.98	0	0.00	111	17.07	0	0.00	58	8.94
4	0	0.00	0	0.00	40	66.67	0	0.00	20	33.33
SUM	545	54.55	0	0.00	324	32.43	0	0.00	130	13.01

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	36	34.62	36	34.62	52	50.00	52	50.00	104	100.00
2	29	15.62	29	15.62	186	100.00	186	100.00	186	100.00
3	480	73.98	480	73.98	591	91.06	591	91.06	649	100.00
4	0	0.00	0	0.00	40	66.67	40	66.67	60	100.00
SUM	545	54.55	545	54.55	869	86.99	869	86.99	999	100.00

Accuracy Assessment Tables for P42/R27 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	10(5)	2(3)	2(1)	14(0)
2	2(3)	2(5)	5(3)	9(0)
3	2(1)	3(3)	0(5)	5(0)
SUM	14(0)	7(0)	7(0)	28(0)

Diagonal Elements = 12; Total Test Points = 28
Percentage Agreement = 42.86; Tau w/equal Prob = 0.143

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	10	71.43	0	0.00	2	14.29	0	0.00	2	14.29
2	2	22.22	0	0.00	7	77.78	0	0.00	0	0.00
3	0	0.00	0	0.00	3	60.00	0	0.00	2	40.00
SUM	12	42.86	0	0.00	12	42.86	0	0.00	4	14.29

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	10	71.43	10	71.43	12	85.71	12	85.71	14	100.00
2	2	22.22	2	22.22	9	100.00	9	100.00	9	100.00
3	0	0.00	0	0.00	3	60.00	3	60.00	5	100.00
SUM	12	42.86	12	42.86	24	85.71	24	85.71	28	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	10	71.43	0	0.00	2	14.29	0	0.00	2	14.29
2	2	28.57	0	0.00	5	71.43	0	0.00	0	0.00
3	0	0.00	0	0.00	5	71.43	0	0.00	2	28.57
SUM	12	42.86	0	0.00	12	42.86	0	0.00	4	14.29

Accuracy Assessment Tables for P42/R27 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	10	71.43	10	71.43	12	85.71	12	85.71	14	100.00
2	2	28.57	2	28.57	7	100.00	7	100.00	7	100.00
3	0	0.00	0	0.00	5	71.43	5	71.43	7	100.00
SUM	12	42.86	12	42.86	24	85.71	24	85.71	28	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	361	71.43	0	0.00	72	14.29	0	0.00	72	14.29
2	56	22.22	0	0.00	197	77.78	0	0.00	0	0.00
3	0	0.00	0	0.00	145	60.00	0	0.00	97	40.00
SUM	417	41.70	0	0.00	414	41.40	0	0.00	169	16.90

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	361	71.43	361	71.43	433	85.71	433	85.71	506	100.00
2	56	22.22	56	22.22	253	100.00	253	100.00	253	100.00
3	0	0.00	0	0.00	145	60.00	145	60.00	241	100.00
SUM	417	41.70	417	41.70	831	83.10	831	83.10	1000	100.00

Accuracy Assessment Tables for P42/R27 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	12(5)	30(3)	8(1)	52(0)
2	8(3)	51(5)	25(3)	89(0)
3	2(1)	22(3)	26(5)	50(0)
SUM	22(0)	103(0)	59(0)	191(0)

Diagonal Elements = 89; Total Test Points = 191
Percentage Agreement = 46.60; Tau w/equal Prob = 0.199

7 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 7 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	12	23.08	0	0.00	30	57.69	0	0.00	10	19.23
2	51	57.30	0	0.00	33	37.08	0	0.00	5	5.62
3	26	52.00	0	0.00	22	44.00	0	0.00	2	4.00
SUM	89	46.60	0	0.00	85	44.50	0	0.00	17	8.90

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	12	23.08	12	23.08	42	80.77	42	80.77	52	100.00
2	51	57.30	51	57.30	84	94.38	84	94.38	89	100.00
3	26	52.00	26	52.00	48	96.00	48	96.00	50	100.00
SUM	89	46.60	89	46.60	174	91.10	174	91.10	191	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	12	54.55	0	0.00	8	36.36	0	0.00	2	9.09
2	51	49.51	0	0.00	52	50.49	0	0.00	0	0.00
3	26	44.07	0	0.00	25	42.37	0	0.00	8	13.56
SUM	89	48.37	0	0.00	85	46.20	0	0.00	10	5.43

Accuracy Assessment Tables for P42/R27 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	12	54.55	12	54.55	20	90.91	20	90.91	22	100.00
2	51	49.51	51	49.51	103	100.00	103	100.00	103	100.00
3	26	44.07	26	44.07	51	86.44	51	86.44	59	100.00
SUM	89	48.37	89	48.37	174	94.57	174	94.57	184	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	35	23.08	0	0.00	87	57.69	0	0.00	29	19.23
2	247	57.30	0	0.00	160	37.08	0	0.00	24	5.62
3	217	52.00	0	0.00	184	44.00	0	0.00	17	4.00
SUM	499	49.90	0	0.00	431	43.10	0	0.00	70	7.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	35	23.08	35	23.08	121	80.77	121	80.77	150	100.00
2	247	57.30	247	57.30	407	94.38	407	94.38	432	100.00
3	217	52.00	217	52.00	402	96.00	402	96.00	418	100.00
SUM	499	49.90	499	49.90	930	93.00	930	93.00	1000	100.00

Accuracy Assessment Tables for P42/R27 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	1(5)	1(3)	0(1)	5(0)
2	5(3)	9(5)	1(3)	16(0)
3	0(1)	5(3)	0(5)	6(0)
SUM	6(0)	15(0)	1(0)	27(0)

Diagonal Elements = 10; Total Test Points = 27
Percentage Agreement = 37.04; Tau w/equal Prob = 0.056

5 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 5 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	20.00	0	0.00	1	20.00	0	0.00	3	60.00
2	9	56.25	0	0.00	6	37.50	0	0.00	1	6.25
3	0	0.00	0	0.00	5	83.33	0	0.00	1	16.67
SUM	10	37.04	0	0.00	12	44.44	0	0.00	5	18.52

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	20.00	1	20.00	2	40.00	2	40.00	5	100.00
2	9	56.25	9	56.25	15	93.75	15	93.75	16	100.00
3	0	0.00	0	0.00	5	83.33	5	83.33	6	100.00
SUM	10	37.04	10	37.04	22	81.48	22	81.48	27	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	16.67	0	0.00	5	83.33	0	0.00	0	0.00
2	9	60.00	0	0.00	6	40.00	0	0.00	0	0.00
3	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
SUM	10	45.45	0	0.00	12	54.55	0	0.00	0	0.00

Accuracy Assessment Tables for P42/R27 -- Shrub Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	16.67	1	16.67	6	100.00	6	100.00	6	100.00
2	9	60.00	9	60.00	15	100.00	15	100.00	15	100.00
3	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
SUM	10	45.45	10	45.45	22	100.00	22	100.00	22	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	56	20.00	0	0.00	56	20.00	0	0.00	169	60.00
2	344	56.25	0	0.00	229	37.50	0	0.00	38	6.25
3	0	0.00	0	0.00	89	83.33	0	0.00	18	16.67
SUM	400	40.04	0	0.00	374	37.44	0	0.00	225	22.52

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	56	20.00	56	20.00	113	40.00	113	40.00	282	100.00
2	344	56.25	344	56.25	573	93.75	573	93.75	612	100.00
3	0	0.00	0	0.00	89	83.33	89	83.33	107	100.00
SUM	400	39.96	400	39.96	775	77.42	775	77.42	1001	100.00

Scene P42/R27 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	2736.0	30887.4	0.9
1000	431.0	7836.4	0.2
2000	4013.0	105313.4	3.1
3101	14583.0	155369.4	4.6
3104	8140.0	63021.1	1.9
3202	20782.0	189210.2	5.6
3203	5242.0	39909.0	1.2
3304	394.0	5733.4	0.2
3305	541.0	21101.4	0.6
3312	170.0	1517.0	0.0
4102	1238.0	7312.9	0.2
4201	1204.0	19135.4	0.6
4203	14274.0	173809.4	5.1
4206	10674.0	150626.3	4.4
4207	9613.0	95782.3	2.8
4208	10409.0	112280.9	3.3
4210	1406.0	16774.8	0.5
4211	3522.0	68724.4	2.0
4212	38659.0	426420.4	12.5
4215	6597.0	48319.5	1.4
4220	12991.0	123877.6	3.6
4221	55889.0	550000.1	16.2
4222	7466.0	135718.6	4.0
4223	6284.0	66410.7	2.0
4225	17440.0	209796.2	6.2
4226	13682.0	147665.8	4.3
4227	7576.0	62866.3	1.8
4228	4569.0	68537.4	2.0
4229	7348.0	119155.6	3.5
4301	3032.0	27260.2	0.8
5000	2980.0	68660.5	2.0
7300	9771.0	60391.9	1.8
7500	3.0	32.8	0.0
7800	2969.0	22011.5	0.6
7900	4.0	6.4	0.0

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	2736.0	30887.4	0.9
Not tree/shrub	42894.0	482643.3	14.2
Shrub 1	7686.0	72401.2	2.1
Shrub 2	16773.0	157566.9	4.6
Shrub 3	2670.0	27502.8	0.8
Tree 1	29065.0	396906.6	11.7
Tree 2	124436.0	1143625.3	33.6
Tree 3	80372.0	1089942.8	32.0

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	2736.0	30887.4	0.9
Not tree/shrub	42894.0	482643.3	14.2
Tree 1	29261.0	273252.1	8.0
Tree 2	47089.0	490415.4	14.4
Tree 3	141869.0	1707959.3	50.2
Tree 4	15654.0	158847.8	4.7
Shrub1	13114.0	130276.9	3.8
Shrub 2	6930.0	65018.2	1.9
Shrub 3	7085.0	62175.8	1.8

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	2736.0	30887.4	0.9
A	4013.0	105313.4	3.1
H	22723.0	218390.6	6.4
N	16158.0	158939.4	4.7
S	27129.0	257470.9	7.6
T	233873	2630474.6	77.3

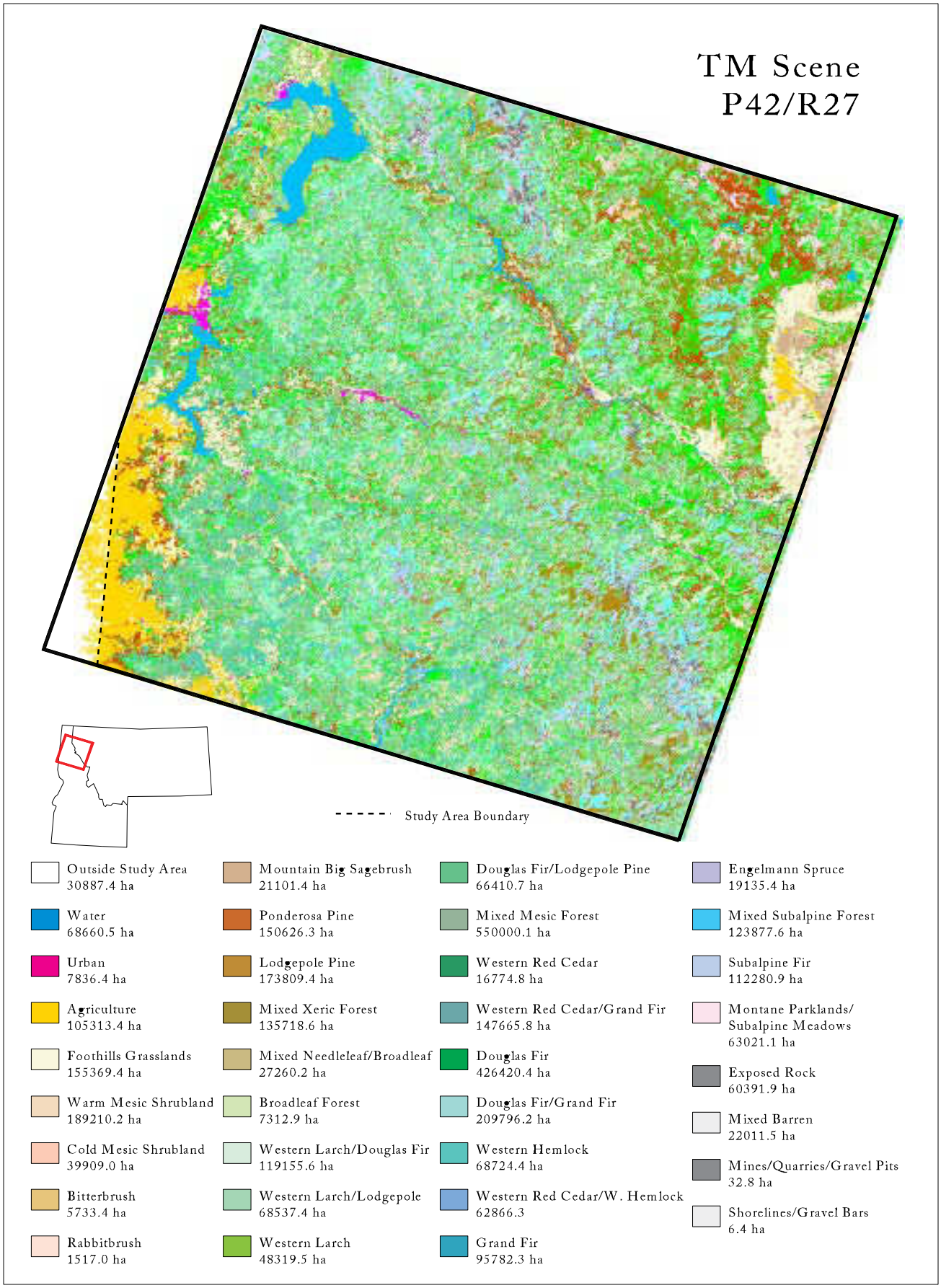


Figure F-4. Classification of land cover types for TM Scene P42/R27.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P42/R27

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 2309 to 6910 feet in elevation. The average canopy cover is 40% ranging from 10-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), subalpine fir (Abies lasiocarpa), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤5% and frequency of occurrence ≥29% and ≤44%.

Primary associated shrub species with ≥20% and ≤57% frequency of occurrence in lodgepole pine stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), mountain-lover (Pachistima myrsinites), scouler willow (Salix scoulerinana), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤68% frequency of occurrence in lodgepole pine stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), rough fescue (Festuca scabrella), and smooth woodrush (Luzula hitchcockii); **forbs**: Piper's anemone (Anemone piperi), heart-leaf arnica (Arnica cordifolia) western goldthread (Coptis occidentalis), fireweed (Epilobium angustifolium), bracted lousewort (Pedicularis bracteosa), pyrola (Pyrola spp.), and beargrass (Xerophyllum tenax); **ferns**: clubmoss (Lycopodium) and brackenfern (Pteridium aquilinum); **moss**: none.

2) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 2180 to 5160 feet in elevation. The average canopy cover is 35% ranging from 10-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western larch (Larix occidentalis), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤7% and frequency of occurrence ≥20% and ≤70%.

Primary associated shrub species with ≥8% and ≤55% frequency of occurrence in ponderosa pine stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), mountain balm (Ceanothus velutius), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥10% and ≤68% frequency of occurrence in ponderosa pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), orchard grass (Dactylis glomerata), bluebunch wheatgrass (Elymus spicatus), common timothy (Phleum pratense), and bluegrass (Poa spp.); **forbs**: common pearly-everlasting

(Anaphalis margaritacea), spreading dogbane (Apocynum androsaemifolium), balsamroot (Balsamorhiza sagittata), spotted knapweed (Centauria maculosa), glacier lily (Erythronium grandiflorum), sierran peavine (Lathers nevadensis), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

3) 4207: GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) ranging from 1920 to 4720 feet in elevation. The average canopy cover is 48% ranging from 10-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Douglas-fir (Pseudotsuga menziesii), western red cedar (Thuja plicata), and western hemlock (Tsuga heterophylla) with average percent cover ≥5% and ≤8% and frequency of occurrence ≥27% and ≤68%.

Primary associated shrub species with ≥18% and ≤54% frequency of occurrence in grand fir stands: rocky mountain maple (Acer glabrum), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), mallow ninebark (Physocarpus malvaceus), thimbleberry (Rubus parviflorum), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤23% frequency of occurrence in grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), orchard grass (Dactylis glomerata), and bluebunch wheatgrass (Elymus spicata); **forbs**: trail-plant (Adenocaulon bicolor), wild ginger (Asarum caudatum), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), sweet-scented bedstraw (Galium triflorum), starry solomon-plume (Smilacina stellata); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), brittle bladder-fern (Cystopteris fragilis), spinulose wood-fern (Dryopteris spinulosa), oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: none.

4) 4208: SUBALPINE FIR FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 3440 to 7120 feet in elevation. The average canopy cover is 40% ranging from 20-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), western white pine (Pinus monticola), and mountain hemlock (Tsuga mertensia) with average percent cover ≥2% and ≤5% and frequency of occurrence ≥13% and ≤31%.

Primary associated shrub species with ≥10% and ≤65% frequency of occurrence in subalpine fir stands: sitka alder (Alnus sinuata), mountain-lover (Pachistima myrsinites), red mountain-heath (Phyllodoce empetriformis), cascade mountain-ash (Sorbus scopulina), sitka mountain-ash (Sorbus sitchensis), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤77% frequency of occurrence in subalpine fir stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), green fescue (Festuca viridula), and smooth woodrush (Luzula hitchcockii); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), one-sided wintergreen (Pyrola secunda), trefoil foamflower (Tiarella trifoliata), California false hellebore (Veratrum californicum), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), brittle bladder-fern (Cystopteris fragilis), stiff clubmoss (Lycopodium annotinum), and brackenfern (Pteridium aquilinum); **moss**: none.

5) 4210: WESTERN RED CEDAR FOREST

Conifer forest dominated by western red cedar (Thuja plicata) ranging from 1640 to 5220 feet in elevation. The average canopy cover is 53% ranging from 10-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western white pine (Pinus monticola), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤15% and frequency of occurrence ≥41% and ≤94%.

Primary associated shrub species with ≥19% and ≤41% frequency of occurrence in western red cedar stands: rocky mountain maple (Acer glabrum), bunchberry (Cornus canadensis), twin flower (Linnaea borealis), devil's club (Oplopanax horridum), thimbleberry (Rubus parviflorum), pacific blackberry (Rubus ursinus), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤38% frequency of occurrence in western red cedar stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), sedge (Carex spp.), elk sedge (Carex geyeri), bearded fescue (Festuca subulata), and woodrush (Luzula spp.); **forbs**: wild ginger (Asarum caudatum), queen's cup beadlily (Clintonia uniflora), hooker fairy-bell (Disporum hookeri), western rattlesnake-plantain (Goodyera oblongofolia), mountain sweet-cicely (Osmorhiza chilensis), starry solomon-plume (Smilacina stellata), trefoil foamflower (Tiarella trifoliata), and round-leaved violet (Viola orbiculata); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), spinulose wood-fern (Dryopteris spinulosa), oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), brackenfern (Pteridium aquilinum), Oregon woodsia (Woodsia oregana); **moss**: none.

6) 4211: WESTERN HEMLOCK FOREST

Conifer forest dominated by western hemlock (Tsuga heterophylla) ranging from 2260 to 4450 feet in elevation. The average canopy cover is 61% ranging from 20-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), Douglas-fir (Pseudotsuga menziesii), and western red cedar (Thuja plicata) with average percent cover ≥5% and ≤9% and frequency of occurrence ≥25% and ≤71%.

Primary associated shrub species with ≥19% and ≤41% frequency of occurrence in western hemlock stands: rocky mountain maple (Acer glabrum), sitka alder (Alnus sinuata), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), devil's club (Oplopanax horridum), huckleberry (Vaccinium spp.), and globe huckleberry (Vaccinium globulare),

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤38% frequency of occurrence in western hemlock stands: **graminoids**: Columbia brome (Bromus vulgaris); **forbs**: wild ginger (Asarum caudatum), queen's cup beadlily (Clintonia uniflora), hooker fairy-bell (Disporum hookeri), sweet-scented bedstraw (Galium triflorum), mountain sweet-cicely (Osmorhiza chilensis), starry solomon-plume (Smilacina stellata), and trefoil foamflower (Tiarella trifoliata); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), mountain wood-fern (Dryopteris austriaca), stiff clubmoss (Lycopodium annotinum), oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

7) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 2180 to 5664 feet in elevation. The average canopy cover is 40% ranging from 10-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), lodgepole pine (Pinus contorta), and ponderosa pine (Pinus ponderosa), with average percent cover ≥3% and ≤7% and frequency of occurrence ≥23% and ≤36%.

Primary associated shrub species with ≥12% and ≤38% frequency of occurrence in Douglas-fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), creeping Oregon grape (Berberis repens), twin flower (Linnaea borealis), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤12% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), bluebunch wheatgrass (Elymus spicatus), and rough fescue (Festuca scabrella); **forbs**: common yarrow (Achillea millefolium), heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), starry solomon-plume (Smilacina stellata), and western meadowrue (Thalictrum occidentale); **ferns**: brittle bladder-fern (Cystopteris fragilis), clubmoss (Lycopodium spp.), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.) and (Rhytidiopsis robusta).

8) 4215: WESTERN LARCH FOREST

Conifer forest dominated by western larch (Larix occidentalis) ranging from 2350 to 5630 feet in elevation. The average canopy cover is 48% ranging from 10-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii), with average percent cover ≥4% and ≤12% and frequency of occurrence ≥44% and ≤83%.

Primary associated shrub species with ≥11% and ≤50% frequency of occurrence in western larch stands: rocky mountain maple (Acer glabrum), kinnikinnick (Arctostaphylos uva-ursi), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), mallow ninebark (Physocarpus malvaceus), thimbleberry (Rubus parviflorum), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥6% and ≤22% frequency of occurrence in western larch stands: **graminoids**: pinegrass (Calamagrostis rubescens) and sedge (Carex spp.); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), western goldthread (Coptis occidentalis), fireweed (Epilobium angustifolium), glacier lily (Erythronium grandiflorum), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: none.

9) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa), codominant species is mountain hemlock (Tsuga mertensia), and ranging from 4197 to 7180 feet in elevation. The average canopy cover of ABILAS is 21% ranging from 1-70% total cover and frequency of occurrence equal to 100%. The average canopy cover of TSUMER is 22% ranging from 1-60% total cover and frequency of occurrence equal to 70%. Primary associated tree species include Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), and lodgepole pine (Pinus contorta) with average percent cover ≥2% and ≤12% and frequency of occurrence ≥16% and ≤66%.

Primary associated shrub species with ≥6% and ≤58% frequency of occurrence in mixed subalpine stands: twin flower (Linnaea borealis), red mountain-heath (Phyllodoce empetriformis), thimbleberry (Rubus parviflorum), cascade mountain-ash (Sorbus scopulina), globe huckleberry (Vaccinium globulare), big huckleberry (Vaccinium membranaceum), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤82% frequency of occurrence in mixed subalpine fir stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), Parry's rush (Juncus parryi), field woodrush (Luzula campestris), and smooth woodrush (Luzula hitchcockii); **forb**: broadleaf arnica (Arnica latifolia), arrowleaf groundsel (Senecio triangularis), starry solomon-plume (Smilacina stellata), trefoil foamflower (Tiarella trifoliata), California false hellebore (Veratrum californicum), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), oak-fern (Gymnocarpium dryopteris), running-pine (Lycopodium clavatum), common Christmas-fern (Polystichum munitum), rock sword-fern (Polystichum scopulinum), and brackenfern (Pteridium aquilinum); **moss**: none.

10) 4221: MIXED MESIC FOREST

Conifer forest dominated by grand fir (Abies grandis), codominant species are western larch (Larix occidentalis), western red cedar (Thuja plicata), and western hemlock (Tsuga heterophylla), ranging from 1999 to 6200 feet in elevation. The average canopy cover for

ABIGRA is 14% ranging from 1-60% total cover and frequency of occurrence equal to 78%. The average canopy cover for LAROCC is 12% ranging from 1-50% total cover and frequency of occurrence equal to 60%. The average canopy cover for THUPLI is 16% ranging from 1-70% total cover and frequency of occurrence equal to 31%. The average canopy cover for TSUHET is 25% ranging from 1-70% total cover and frequency of occurrence equal to 25% Primary associated tree species include lodgepole pine (Pinus contorta), western white pine (Pinus monticola), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥10% and ≤15% and frequency of occurrence ≥37% and ≤78%.

Primary associated shrub species with ≥8% and ≤31% frequency of occurrence in mixed mesic stands: rocky mountain maple (Acer glabrum), kinnikinnick (Arctostaphylos uva-ursi), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), common snowberry (Symphoricarpos albus), globe huckleberry (Vaccinium globulare), and big huckleberry (Vaccinium membranaceum).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤45% frequency of occurrence in mixed mesic stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), rough fescue (Festuca scabrella), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis)**; forbs**: arnica (Arnica spp.), broadleaf arnica (Arnica latifolia), spotted knapweed (Centauria maculosa), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), brittle bladder-fern (Cystopteris fragilis), spinulose wood-fern (Dryopteris spinulosa), oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), brackenfern (Pteridium aquilinum), and Oregon woodsia (Woodsia oregana); **moss**: moss (moss spp.).

11) 4222: MIXED XERIC FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) and ranging from 2060 to 5140 feet in elevation. The average canopy cover is 22% ranging from 1-98% total cover and frequency of occurrence equal to 91%. Primary associated tree species include grand fir (Abies grandis), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥17% and ≤22% and frequency of occurrence ≥12% and ≤93%.

Primary associated shrub species with ≥7% and ≤37% frequency of occurrence in mixed xeric stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), mountain balm (Ceanothus velutinus), twin flower (Linnaea borealis), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤28% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), slender hairgrass (Deschampsia elongata), blue wildrye (Elymus glaucus), and Idaho fescue (Festuca idahoensis); **forbs**: common yarrow (Achillea millefolium), spotted knapweed (Centauria maculosa), bull thistle

(Cirsium vulgare), western goldthread (Coptis occidentalis), glacier lily (Erythronium grandiflorum), sweetscented bedstraw (Galium triflorum), silvery lupine (Lupinus argenteus); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

12) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) and ranging from 2145 to 5860 feet in elevation. The average canopy cover for PINCON is 21% ranging from 10-40% total cover and frequency of occurrence equal to 98%. The average canopy cover for PSEMEN is 23% ranging from 10-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), subalpine fir (Abies lasiocarpa), and western larch (Larix occidentalis) with average percent cover ≥3% and ≤6% and frequency of occurrence ≥22% and ≤44%.

Primary associated shrub species with ≥22% and ≤46% frequency of occurrence in Douglas-fir-lodgepole pine stands: sitka alder (Alnus sinuata), western serviceberry (Amelanchier alnifolia), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤63% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), and Kentucky bluegrass (Poa pratensis); **forbs**: common yarrow (Achillea millefolium), heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), white-flowered hawkweed (Hieracium albiflorum), one-sided wintergreen (Pyrola secunda), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: none.

13) 4225: DOUGLAS FIR-GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) and Douglas-fir (Pseudotsuga menziesii) and ranging from 2200 to 4920 feet in elevation. The average canopy cover for ABIGRA is 29% ranging from 3-60% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 28% ranging from 3-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western larch (Larix occidentalis), western white pine (Pinus monticola), and western hemlock (Tsuga mertensia) with average percent cover ≥2% and ≤5% and frequency of occurrence ≥20% and ≤26%.

Primary associated shrub species with ≥16% and ≤55% frequency of occurrence in Douglas-fir-grand fir stands: rocky mountain maple (Acer glabrum), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), mallow ninebark (Physocarpus malvaceus), thimbleberry (Rubus parviflorum), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare),

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤22% frequency of occurrence in Douglas-fir-grand fir stands: **graminoids**: Columbia brome

(Bromus vulgaris), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri) beaked sedge (Carex rostrata), orchard grass (Dactylis glomerata), blue wildrye (Elymus glaucus); **forb**: trail-plant (Adenocaulon bicolor), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), mountain sweet-cicely (Osmorhiza chilensis), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: northern maidenhair (Adiantum pedatum), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: none.

14) 4226: WESTERN RED CEDAR-GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) and western red cedar (Thuja plicata) and ranging from 1715 to 5370 feet in elevation. The average canopy cover for ABIGRA is 35% ranging from 10-60% total cover and frequency of occurrence equal to 100%. The average canopy cover for THUPLI is 30% ranging from 3-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western white pine (Pinus monticola), Douglas-fir (Pseudotsuga menziesii), and western hemlock (Tsuga mertensia) with average percent cover $\geq$2% and $\leq$5% and frequency of occurrence $\geq$28% and $\leq$63%.

Primary associated shrub species with $\geq$23% and $\leq$45% frequency of occurrence in western red cedar-grand fir stands: rocky mountain maple (Acer glabrum), bunchberry (Cornus canadensis), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), thimbleberry (Rubus parviflorum), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with $\geq$3% and $\leq$38% frequency of occurrence in western red cedar-grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris), sedge (Carex spp.), beaked sedge (Carex rostrata), drooping woodreed (Cinna latifolia), orchard grass (Dactylis glomerata), small-flowered woodrush (Luzula parviflora), common timothy (Phleum pratense); **forbs**: wild ginger (Asarum caudatum), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), starry solomon-plume (Smilacina stellata), white trillium (Trillium ovatum), and round-leaved violet (Viola orbiculata); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), spinulose wood-fern (Dryopteris spinulosa), oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum), and Oregon woodsia (Woodsia oregana); **moss**: moss (moss spp.).

15) 4227: WESTERN RED CEDAR-WESTERN HEMLOCK FOREST

Conifer forest dominated by western red cedar (Thuja plicata) and western hemlock (Tsuga heterophylla) ranging from 2280 to 4000 feet in elevation. The average canopy cover for THUPLI is 34% ranging from 10-70% total cover and frequency of occurrence equal to 100%. The average canopy cover for TSUHET is 40% ranging from 10-70% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western white pine (Pinus monticola), and Douglas-fir (Pseudotsuga menziesii) with average percent cover $\geq$3% and $\leq$9% and frequency of occurrence $\geq$16% and $\leq$58%.

Primary associated shrub species with ≥11% and ≤47% frequency of occurrence in western red cedar-western hemlock stands: rocky mountain maple (Acer glabrum), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), sticky current (Ribes viscosissimum), red raspberry (Rubus idaeus), and big huckleberry (Vaccinium membranaceum).

Primary associated graminoid, forb, fern, and moss species with ≥16% and ≤26% frequency of occurrence in western red cedar-western hemlock stands: **graminoids**: nodding trisetum (trisetum cernuum); **forbs**: trail-plant (Adenocaulon bicolor), queen's cup beadlily (Clintonia uniflora), hooker fairy-bell (Disporum hookeri), western rattlesnake-plantain (Goodyera oblongofolia), one-sided wintergreen (Pyrola secunda), starry solomon-plume (Smilacina stellata), and round-leaved violet (Viola orbiculata); **ferns**: oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

16) 4228: WESTERN LARCH-LODGEPOLE FOREST

Conifer forest dominated by western larch (Larix occidentalis) and lodgepole pine (Pinus contorta) ranging from 2320 to 6000 feet in elevation. The average canopy cover for LAROCC is 18% ranging from 1-60% total cover and frequency of occurrence equal to 100%. The average canopy cover for PINCON is 17% ranging from 1-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), subalpine fir (Abies lasiocarpa), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤6% and frequency of occurrence ≥41% and ≤77%.

Primary associated shrub species with ≥14% and ≤36% frequency of occurrence in western larch-lodgepole pine stands: sitka alder (Alnus sinutata), kinnikinnick (Arctostaphylos uva-ursi), twin flower (Linnaea borealis), cascade mountain-ash (Sorbus scopulina), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤55% frequency of occurrence in western larch-lodgepole pine stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), timber oatgrass (Danthonia intermedia), Idaho fescue (Festuca idahoensis), and Kentucky bluegrass (Poa pratensis); **forbs**: common yarrow (Achillea millefolium), common pearly-everlasting (Anaphalis margaritacea), raceme pussy-toes (Antennaria racemosa), broadleaf arnica (Arnica latifolia), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: none.

17) 4229: WESTERN LARCH-DOUGLAS FIR FOREST

Conifer forest dominated by western larch (Larix occidentalis) and Douglas-fir (Pseudotsuga menziesii) ranging from 2240 to 5480 feet in elevation. The average canopy cover for LAROCC is 16% ranging from 10-30% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 24% ranging from 10-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), lodgepole pine (Pinus contorta), and ponderosa pine (Pinus

ponderosa) with average percent cover ≥3% and ≤4% and frequency of occurrence ≥26% and ≤52%.

Primary associated shrub species with ≥11% and ≤26% frequency of occurrence in western larch-Douglas-fir stands: rocky mountain maple (Acer glabrum), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), twin flower (Linnaea borealis), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and huckleberry (Vaccinium spp.).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤53% frequency of occurrence in western larch-Douglas-fir stands: **graminoids**: pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), and fowl bluegrass (Poa palustris); **forbs**: common yarrow (Achillea millefolium), heart-leaf arnica (Arnica cordifolia), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: none.

18) 4301: MIXED NEEDLELEAF/BROADLEAF FOREST

Mixed needleleaf and broadleaf forest dominated by Douglas-fir (Pseudotsuga menziesii) and ranging from 2100 to 3640 feet in elevation. The average canopy cover is 15% ranging from 3-40% total cover and frequency of occurrence equal to 75%. Primary associated tree species include grand fir (Abies grandis), paper birch (Betula papyrifera), and western red cedar (Thuja plicata) with average percent cover ≥10% and ≤23% and frequency of occurrence ≥45% and ≤70%.

Primary associated shrub species with ≥15% and ≤30% frequency of occurrence in mixed needleleaf and broadleaf stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), red-osier dogwood (Cornus stolonifera), twin flower (Linnaea borealis), thimbleberry (Rubus parviflorum), willow (Salix spp.), and shiny-leaf spiraea (Spiraea betulifolia).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤25% frequency of occurrence in mixed needleleaf and broadleaf stands: **graminoids**: brome (Bromus spp.) and sedge (Carex spp.); **forbs**: trail-plant (Adenocaulon bicolor), wild sarsaparilla (Aralia nudicaulis), spotted knapweed (Centauria maculosa), western goldthread (Coptis occidentalis), cow-parsnip (Heracleum lanatum), starry solomon-plume (Smilacina stellata), and common tansy (Tanacetum vulgare); **ferns**: common scouring-rush (Equisetum fluviatile) and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp).

P42/R27 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	7, 15, 19
6102	Broadleaf Dominated Riparian	13
6103	Needleleaf-Broadleaf Riparian	43
6104	Mixed Riparian (trees + any other)	3, 25, 53
6201	Grass-Forb Riparian/Wetland	48, 37
6202	Shrub Riparian/Wetland	10, 29, 35, 42, 51
6203	Mixed Grass-Forb-Shrub Riparian	17, 26

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 2
Color: White; RGB 255 255 255.
Distribution: Low elevation agriculture areas; some near streams.
Comment: The color is more consistent with dry-land agriculture than with riparian vegetation. Field observations outside the calculated riparian zone for this spectral class were dominated by cropland.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
2	1	Dry-land crop
3	3	Irrigated Crop
4	1	Dry-land Pasture
5	3	Foothills Grassland
6	1	Grass-Forb Riparian/Wetland

Spectral Class 3
Color: Light sage-brown color; RGB 146 155 147.
Distribution: Widely distributed small regions (spackle).
Comment: Color and distribution indicate mixed riparian vegetation. Training data outside the zone was also mixed, with conifers, shrubs, and grasslands recorded most often.
Conclusion: 6104.

7	1	Mixed Xeric Forest
8	2	Broadleaf Dominated Riparian
9	3	Grass-Forb Riparian/Wetland
10	2	Shrub Riparian/Wetland

Spectral Class 4
Color: Navy-purple; RGB 38 36 77.

Distribution: Middle elevations in dark shadows.
Comment: Some riparian points within the calculated zone appeared to be near an island or in the center of a widened river approaching a confluence. Others appear to be in mountain shadows near streams. The color can represent muddy water.
Conclusion: Not riparian.

11	3	Lakes
12	1	Needleleaf Dominated Riparian
13	2	Grass-Forb Riparian/Wetland
14	1	Sandy

Spectral Class 5
Color: Tartan blue; RGB 0 61 96.
Distribution: Some linear pattern.
Comment: Color and distribution pattern are indicative of mixed barren land; when in riparian zone, class may represent gravel/sand bars.
Conclusion: Not riparian, based on color and point frequencies.

15	2	Rivers & Streams
16	3	Lakes
17	1	Grass-Forb Riparian/Wetland
18	1	Mixed Barren Land (gravel bar?)

Spectral class 6
Color: Light orange; RGB 255 197 159.
Distribution: Low agriculture areas.
Comment: Plots and distribution indicate the class is associated primarily with irrigated agriculture. Outside the zone, agriculture, Mesic Upland Shrubland, and needleleaf cover types were most observed.
Conclusion: Not riparian.

19	1	Urban & Developed Land
20	2	Irrigated Crop
21	1	Dry-land Pasture
22	1	Irrigated Pasture
23	1	Grass-Forb Riparian/Wetland
24	1	Shrub Riparian/Wetland

Spectral Class 7
Color: Light raspberry; RGB 171 83 102.
Distribution: Dense spackle in some areas; middle to higher elevations; some in low areas

near streams.
Comment: Color and distribution appears to be strongly associated with conifer tree types.
Conclusion: 6101.

25	1	Lodgepole Pine
26	1	Douglas-fir
27	1	Mix Needleleaf-Broadleaf
28	1	Needleleaf Dominated Riparian
29	1	Broadleaf Dominated Riparian
30	1	Needleleaf-Broadleaf Riparian
31	1	Grass-Forb Riparian/Wetland
32	1	Shrub Riparian/Wetland

Spectral Class 8
Color: Teal blue; RGB 75 148 159.
Distribution: Light density at lower elevations, but some clusters occur in open areas at any elevation.
Comment: Appears to be upland shrub cover types.
Conclusion: Not riparian.

33	1	Broadleaf Forest
34	1	Rivers & Streams
35	2	Grass-Forb Riparian/Wetland
36	1	Mixed Barren Land

Spectral Class 9
Color: Light grape; RGB 130 97 128.
Distribution: Fairly dense spackle. Not linear, but occurs in some low areas near streams.
Comment: The color and distribution do not suggest riparian vegetation.
Conclusion: Not riparian.

37	1	Irrigated Crop
38	1	Disturbed Grasslands
39	1	Mesic Upland Shrubland
40	1	Mixed Mesic Forest
41	1	Needleleaf Dominated Riparian

Spectral Class 10
Color: Light grass green; RGB 205 226 172.
Distribution: Generally located at lower elevations, near streams or agriculture or in clearcuts.
Comment: Appears to be Shrub Riparian/Wetland.
Conclusion: 6202.

42	1	Dry-land crop
43	2	Dry-land Pasture
44	1	Foothills Grassland
45	1	Grass-Forb Riparian/Wetland
46	1	Mixed Barren Land

Spectral Class 12
Color: Dark gray-brown; RGB 79 49 70.
Distribution: Thick spackle in shadows; not linear.
Comment: Based on color and distribution, this class appears to represent Mixed Mesic Forest.
Conclusion: Not riparian.

47	2	Western Red Cedar
48	1	Douglas-fir
49	5	Mixed Mesic Forest
50	1	Rivers & Streams
51	3	Needleleaf Dominated Riparian
52	1	Needleleaf-Broadleaf Riparian

Spectral Class 13
Color: Soft red; RGB 222 97 102.
Distribution: Medium to higher southeast and east slopes; not linear.
Comment: Color and location suggest Alder and thick clusters of shrubs.
Conclusion: 6201.

53	2	Broadleaf Dominated Riparian

Spectral Class 15
Color: Dark red; RGB 134 58 83.
Distribution: Dense spackle; middle to higher slopes; not linear.
Comment: Color and distribution indicate Needleleaf Dominated Riparian vegetation.
Conclusion: 6101.

57	1	Dry-land Pasture
58	1	Grand Fir
59	1	Western Red Cedar
60	4	Needleleaf Dominated Riparian
61	2	Broadleaf Dominated Riparian

Spectral Class 17
Color: Dark tan; RGB 192 151 128.
Distribution: Some linear pattern.
Comment: Color and distribution suggest non-forest, mixed shrub/grass riparian.
Conclusion: 6203.

67	1	Needleleaf Dominated Riparian
68	4	Shrub Riparian/Wetland

Spectral Class 18
Color: Pale sea green; RGB 167 255 223.
Distribution: Found in low elevation open areas, some being near streams.
Comment: Appears to be agricultural vegetation.
Conclusion: Not riparian.

69	1	Urban & Developed Land
70	3	Dry-land crop
71	8	Irrigated Crop
72	4	Dry-land Pasture
73	2	Irrigated Pasture
74	1	Foothills Grassland
75	1	Broadleaf Dominated Riparian
76	2	Grass-Forb Riparian/Wetland
77	1	Mixed Barren Land

Spectral Class 19
Color: Medium brown-gray; RGB 130 129 140.
Distribution: Light spackle and clearcuts; some linear and gulley pattern; some in river flats.
Comment: Color and distribution suggests that the class represents needleleaf dominated riparian vegetation where it occurs within the calculated zone.
Conclusion: 6101.

78	1	Urban & Developed Land
79	1	Irrigated Crop
80	1	Foothills Grassland
81	1	Mesic Upland Shrubland
82	2	Mixed Mesic Forest
83	1	Needleleaf Dominated Riparian

Spectral Class 20
Color: Olive; RGB 209 199 134.
Distribution: Sparse; some in river flats; difficult to see.

Comment: The distribution suggests association with disturbed sites with low vegetation; where it occurs within the zone, it may represent sparse vegetation along water's edge, but probably not worth notice.
Conclusion: Not riparian.

84	1	Broadleaf Dominated Riparian
85	2	Grass-Forb Riparian/Wetland
86	1	Bare Clearcut

Spectral Class 21
Color: Olive drab; RGB 138 180 159.
Distribution: Some mid-low slopes on sides of gullies; some other linear pattern.
Comment: Distribution indicates close association with disturbed sites (powerline corridor, clear cuts, some agriculture).
Conclusion: Not riparian.

87	1	Dry-land Pasture
88	1	Mesic Upland Shrubland
89	1	Mixed Subalpine Forest
90	1	Grass-Forb Riparian/Wetland
91	1	Shrub Riparian/Wetland
92	1	Irrigated Crop

Spectral Class 23
Color: Dark gray; RGB 84 85 96.
Distribution: Light-medium density spackle; not linear, but some in valley bottoms.
Comment: Color usually associated with conifer forest; distribution and plot data indicate stronger association with upland than with riparian forest types.
Conclusion. Not riparian.

96	1	Foothills Grassland
97	1	Douglas-fir
98	2	Mixed Mesic Forest
99	1	Douglas-fir/Lodgepole
100	2	Needleleaf Dominated Riparian

Spectral Class 24
Color: Sea green; RGB 105 197 191.
Distribution: Transitional mid to low slopes and some valleys.
Comment: The green color usually represents dry grass types rather than wetlands (see also class 50).
Conclusion: Not riparian.

101	1	Urban & Developed Land
102	1	Foothills Grassland
103	1	Grass-Forb Riparian/Wetland

Spectral Class 25
Color: Terracotta; RGB 196 119 102.
Distribution: Mid-elevation slopes; light spackle; not linear; some in stream areas.
Comment: Appears to represent primarily Shrub Riparian/Wetland, and Grass-Forb Riparian/Wetland, as well as needleleaf and broadleaf cover types.
Conclusion: 6104.

104	1	Mix Needleleaf-Broadleaf
105	2	Needleleaf-Broadleaf Riparian

Spectral Class 26
Color: Medium orange; RGB 247 158 121.
Distribution: Occurs at some river flat locations.
Comment: Color and distribution pattern suggest non-forest, mixed shrub/grass riparian vegetation.
Conclusion: 6203.

106	1	Irrigated Crop
107	1	Foothills Grassland
108	1	Mesic Upland Shrubland
109	1	Aspen
110	4	Broadleaf Dominated Riparian
111	1	Grass-Forb Riparian/Wetland
112	5	Shrub Riparian/Wetland

Spectral Class 29
Color: Orange; RGB 255 136 96.
Distribution: Agricultural area; not linear.
Comment: Color and distribution suggest shrub dominated riparian vegetation.
Conclusion: 6202.

122	1	Mixed Mesic Forest
123	1	Broadleaf Dominated Riparian
124	1	Needleleaf-Broadleaf Riparian
125	1	Grass-Forb Riparian/Wetland
126	1	Shrub Riparian/Wetland

Spectral Class 30
Color: Light mauve; RGB 222 199 217.
Distribution: Some agricultural areas; some other low-lying areas and gulleys; some upper slopes.
Comment: Color and distribution pattern indicate association with urban and developed areas.
Conclusion: Not riparian.

127	1	Urban & Developed Land
128	1	Foothills Grassland
129	1	Grass-Forb Riparian/Wetland

Spectral Class 31
Color: Pale blue; RGB 142 192 255.
Distribution: Tends to occur near agriculture areas.
Comment: Distribution pattern and training data points indicate barren areas along roads.
Conclusion: Not riparian.

130	1	Dry-land crop
131	1	Foothills Grassland
132	1	Grass-Forb Riparian/Wetland
133	2	Mines,Quarries,Gravel Pits

Spectral Class 35
Color: Tan; RGB 196 175 159.
Distribution: Light spackle; nearly uniformly distributed.
Comment: Color and distribution indicate shrub type; some confusion with agriculture.
Conclusion: 6202.

141	2	Irrigated Pasture
142	1	Foothills Grassland
143	2	Shrub Riparian/Wetland

Spectral Class 37
Color: Light lime yellow-green; RGB 230 248 191.
Distribution: Light density, with some clusters in open areas, such as clearcuts, along rivers, agricultural areas, and high elevations.

Comment: Falls in some wetter areas, with some linear pattern. Also, clusters are smaller in area than would be expected agricultural fields. Appears to be Grass-Forb Riparian/Wetland.
Conclusion: 6201.

145	2	Dry-land Pasture
146	1	Irrigated Pasture
147	2	Foothills Grassland
148	1	Mesic Upland Shrubland
149	1	Shrub Riparian/Wetland

Spectral Class 38
Color: Sky blue; RGB 100 170 255.
Distribution: Occasional clusters at lower elevations near water; also spackle above timberline.
Comment: Looks like urban clusters at lower elevations.
Conclusion: Not riparian.

150	3	Urban & Developed Land
151	1	Needleleaf-Broadleaf Riparian

Spectral Class 39
Color: Red; RGB 247 78 89.
Distribution: A sparse class, found mostly on mid-elevation slopes.
Comment: Appears to be mid-elevation shrubs.
Conclusion: Not riparian.

Spectral Class 41
Color: Grape; RGB 146 148 210.
Distribution pattern: Light density; located in some urban areas, clearcuts, and smaller open areas.
Comment: Appears to be dry grass and barren areas along roads.
Conclusion: Not riparian.

153	2	Foothills Grassland
154	2	Ponderosa Pine & Savannah
155	1	Rivers & Streams
156	1	Shrub Riparian/Wetland
157	2	Mines,Quarries,Gravel Pits

Spectral Class 42
Color: Orange-yellow; RGB 255 226 166.
Distribution: Light to medium density in open areas at all elevations, some in agriculture areas.
Comment: Appears to be Shrub Riparian/Wetland.
Conclusion: 6202.

158	1	Urban & Developed Land
159	2	Irrigated Crop
160	1	Dry-land Pasture
161	2	Irrigated Pasture
162	1	Grass-Forb Riparian/Wetland

Spectral Class 43
Color: Dark red; RGB 205 68 89.
Distribution: Light to dense spackle on mid-elevation slopes.
Comment: Appears to be mostly a Needleleaf-Broadleaf Riparian cover type. There are no training data points within the riparian zone for this spectral class. Points outside the zone were recorded mostly as conifer, and one shrub plot.
Conclusion: 6103.

Spectral Class 46
Color: Light lilac; RGB 247 223 255.
Distribution: Sparsely distributed small clusters in some low elevation areas such as near agriculture and urban; some light density spackle at higher elevations.
Comment: Appears to be dry land agriculture. Observations recorded outside the zone include agriculture, Foothills Grassland, Mesic Upland Shrubland, and Exposed Rock. There were no observations of this class within the zone.
Conclusion: Not riparian.

Spectral Class 48
Color: Medium pink; RGB 255 158 210.
Distribution: Rare class; some near streams; more in agriculture areas or on mid-elevation slopes.
Comment: Color and distribution consistent with grass/forb riparian; also some agriculture.
Conclusion: 6201.

168	2	Grass-Forb Riparian/Wetland

Spectral Class 50
Color: Medium jade green; RGB 46 192 166.
Distribution: Sparse; some transition areas from medium to low slopes; some low areas near streams.
Comment: Color normally associated with dry rather than lush, green vegetation.
Conclusion: Not riparian.

174	1	Grass-Forb Riparian/Wetland

Spectral Class 51
Color: Dark tan; RGB 159 138 96.
Distribution: Light spackle; mid-elevation slopes and river bottom.
Comment: Color, distribution, and plot data all indicate shrub vegetation.
Conclusion: 6202.

175	2	Shrub Riparian/Wetland

Spectral Class 53
Color: Gray pink; RGB 171 126 159.
Distribution: Transition slopes from middle to lower elevations.
Comment: Appears to represent Needleleaf-Broadleaf Riparian vegetation, as well as Shrub Riparian/Wetland vegetation.
Conclusion: 6104.

181	1	Urban & Developed Land
182	1	Broadleaf Dominated Riparian

TM SCENE P42/R28

Image Analyst: Zhenkui Ma

Training Data Analysis

A total of 1828 ground-truth plots were available for labeling P42/R28 (see table below); 1234 were collected by Forest Service field crews during the1994-95 field seasons, and 487 of these were collected specifically for this TM scene. The remaining 594 plots came from pre-existing data sources such as ECODATA and TSMRS.

All the ground-truth data were converted to a point file and superimposed on the unsupervised classification to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 542) were removed from further analysis. Then the data were examined by cover type and by data source (whether or not plots were collected for this project or for other purposes, like pre-existing ECODATA or TSMRS). The latter "existing data" were only used in the training data set to supplement cover types that had insufficient plots collected during the 1994 or 1995 field seasons. Seven classes were excluded from the digital classification process: urban, agriculture, water, snow, melted snow, cloud, and cloud shadow. All ground truth data with VEG_CLASS_CODEs for urban, agriculture, or water cover types were excluded. Next, 20% of the remaining plots were randomly selected from each cover type; these plots (n = 160) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

The remaining 80% of the data (n = 630 plots) were subjected to further spectral examination. Outliers were eliminated for each cover type by visual examination of TM and elevation values for their respective regions.

Total plots in ground-truth file	1828	
Total 1994-95 field plots	1234	
Plots sampled for P42/R28		487
Plots sampled for other scenes		747
Pre-existing plots (ECODATA, TSMRS, etc.)	594	
Plots held aside or eliminated	1038	
Duplicates		542
Pre-existing plots		320
Manually labeled cover types		176
Potential training plots	790	
20% test		160
80% training		630
Supplemental plots (from pre-existing data set)	0	
Total plots available for training	630	
Total plots used for training -- cover type	428	
size class	213	
canopy	557	

Land Cover Types

Land cover types were labeled through a digital classification of the 7 TM channels plus rescaled elevation (meters divided by 25), using the Nearest Member of Group classifier. This classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2 , and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were assigned directly to the COVERTYPE field in the attribute table. Modifications were carried out using spectral class values (SPECTRAL_CLASS, or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000. Urban.	Manually identified and recoded by Steve Stegman.
2000. Agriculture.	Manually identified and recoded by Steve Stegman.
3101. Foothills Grasslands.	All grass types occurring below 1524 m (5000 ft) were relabeled as Foothills Grasslands.
3104. Montane Parklands & Subalpine Meadows.	All grass types occurring at or above 1524 m (5000 ft) were reassigned this label.
3202. Warm Mesic Shrubland.	All regions that were classified as a 3200 level shrub type were labeled as Warm Mesic Shrubland if they occurred below 1341 m (4400 ft). If they occurred between 1341 and 1646 m (5400 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
3203. Cold Mesic Shrubland.	All regions that were classified as 3200 level shrub types were labeled as Cold Mesic Shrubland if they occurred above 1646 m (5400 ft). If they occurred between 1341 (4400 ft) and 1646 m, they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
5000. Water.	All regions with spectral class (LINK = 1) and slope less than or equal to 5˚ were labeled as water; cloud shadows (see 9900 below) were recoded manually. Generally, water was more spectrally distinct than most other cover types, but in mountainous terrain, it was sometimes confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate slope and aspect values such that their slope may be greater than 5˚. This would result in the misclassification of some small ponds or lakes.

(n/a)	Melted Snow.	All regions originally classified as Melted Snow were recoded either to Exposed Rock (7301), if their slope was greater than 5˚, or to Snow (9000), if their slope was less than or equal to 5˚.
9800.	Cloud.	Manually identified and recoded by Steve Stegman.
9900.	Cloud Shadow.	Manually identified and recoded by Steve Stegman.

A total of 30 classes were labeled in the full TM scene. These included three grass types, three shrub types, fifteen forest types, one alpine type, two barren types, plus six manually labeled classes. The land cover classification was reviewed by David Hayes from the Nez Perce National Forest. Cover types are mapped in Figure F-5.

Canopy Cover Classes

Canopy cover labels (CANOPY_CODE = low, medium, or high) were assigned to tree and shrub classes based on MNDVI values. These values were plotted as frequency histograms for all coniferous forest types (Figure F-5a) as well as for two different shrub types (mesic versus xeric; Figures Fb+c). The histograms were examined visually and break points decided based on the distribution modes. Regions with MNDVI values falling below the lower break point were assigned to the low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class.

CANOPY COVER	MNDVI BREAKPOINTS		
	Tree	Shrub	
		Xeric	Mesic
Low	<180	<150	<180
Medium	≥180 and <435	≥150	≥180
High	≥435	n/a	n/a

Size Classes

Six size classes were distinguished -- four for forest cover types (seedling/sapling, pole, medium, and large/very large) and three for shrub cover types (low, medium and tall). Only the seven TM channels were used for these classifications. The Nearest Mean classifier was used for tree size classes, and the Nearest Member of Group classifier was used for shrub size classes. Tree size classes were stratified based upon the canopy cover classes described above.

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications. Note that the Forest Group accuracy was not calculated separately but was part of the overall Lifeform accuracy assessment. We feel that this Forest Group accuracy is much more reliable than the overall Lifeform accuracy because the latter includes manually labeled cover types like Urban, Agriculture, and Water. Again, no accuracy assessment was performed on the manually labeled cover types.

Classifications for P42/R28	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	21	53%	20%
Lifeform	5	n/a	65%
Forest Group	15	n/a	88%
Tree Size Class	4	83%	47%
Tree Canopy Class	3	99%	56%
Shrub Size Class	3	63%	59%
Shrub Canopy Class	2	100%	60%

Comments

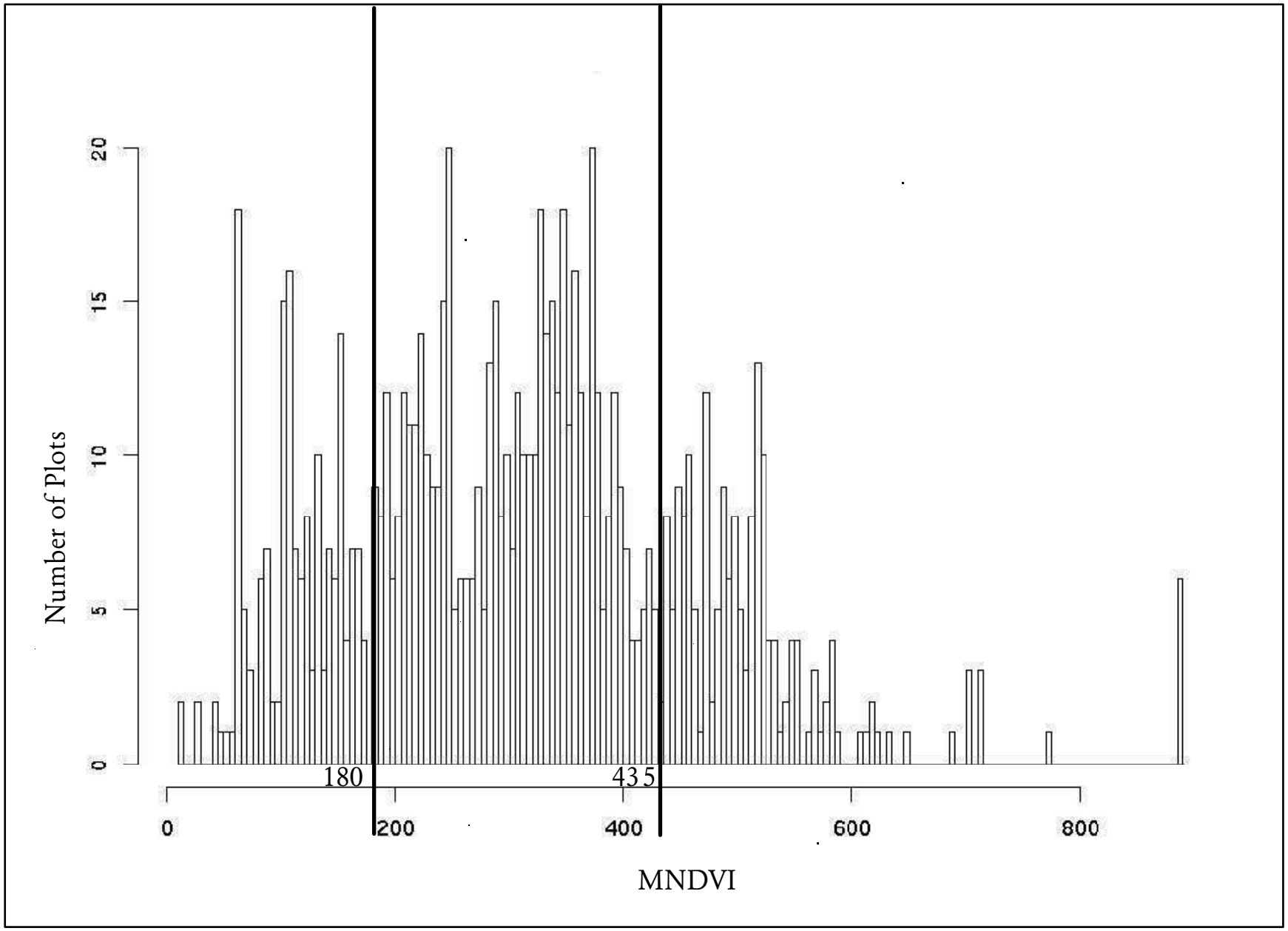
The lower accuracies for this scene were caused by several factors. First there was thin cloud cover across large areas of the scene which caused interference and shadows; the scene also was acquired early in the season (14 June 1993) and it was missing data from TM channel 6. Taken together, these reduced the overall quality of the imagery and limited the power of the classifications. Second, the majority of the training data used for this scene were actually collected for the adjacent scene (P41/R28). In other words, spectral quads and associated plots derived from a higher quality image were used for labeling a lower quality one. For most scenes, the majority of the training data available came from the scene to be labeled, rather than from overlapping ones. This was not the case here, probably because this scene was on the edge of the study area. Third, and last, all the test data were distributed in the eastern half of the scene, but the accuracy weightings occurred over the entire scene which would tend to lower the results.

Error Matrix For Cover Type Training Plots
Scene P42/R28

CLASSIFIED COVER TYPES

PLOT COVER TYPES	3101	3102	3104	3201	3202	3203	3301	4203	4206	4207	4208	4210	4212	4215	4219	4220	4221	4222	4223	4225	4226	4301	7301	7800	8101	SUM
3101	20	2	2	1	4	1	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	36
3102	2	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
3104	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	1	0	9
3201	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4
3202	7	0	1	0	13	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	2	0	26
3203	1	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	6
3301	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3
4203	0	0	0	0	0	0	0	9	1	1	1	0	2	0	0	3	9	1	0	0	0	0	0	0	0	27
4206	2	0	0	1	0	0	0	1	12	1	0	1	5	1	0	0	5	5	1	1	0	0	0	0	0	36
4207	0	0	0	0	0	0	0	1	2	11	2	0	6	0	0	0	12	3	2	1	2	0	0	0	0	42
4208	0	0	0	0	0	0	0	1	0	2	0	0	1	0	0	2	2	0	0	0	0	0	0	0	0	8
4210	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
4212	0	0	0	0	0	0	0	1	3	6	0	1	4	0	0	0	12	3	0	4	4	1	1	0	0	40
4215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0	0	4
4219	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4220	0	0	0	0	0	0	0	3	0	0	1	0	0	0	0	6	5	0	0	0	0	0	1	0	0	16
4221	0	0	0	0	1	0	0	12	6	8	0	0	12	4	0	6	23	2	3	8	2	0	0	1	0	88
4222	0	0	0	0	1	0	0	2	5	4	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	16
4223	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	4	0	0	1	0	0	0	0	0	10
4225	0	0	0	0	0	0	0	0	1	2	0	0	8	0	0	0	8	0	2	3	1	0	0	0	0	25
4226	0	0	0	0	1	0	0	0	0	1	0	0	4	1	0	0	2	0	0	1	3	1	0	0	0	14
4301	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	2
7301	1	0	1	0	1	2	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	8
7800	4	0	2	0	3	0	1	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	2	1	0	16
8101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
SUM	40	3	9	2	26	6	2	31	38	41	4	2	47	6	0	18	87	18	8	19	15	2	11	10	0	445

% AGREEMENT	24.7
TAU WITH EQUAL PROBABILITY	0.22
TOTAL DIAGONAL ELEMENTS	110
TOTAL TRAINING PLOTS IN DATA SET	445



FigureF-5a. Breaks between tree canopy cover classes inrelation to MNDVI values: TM scene P42/R28

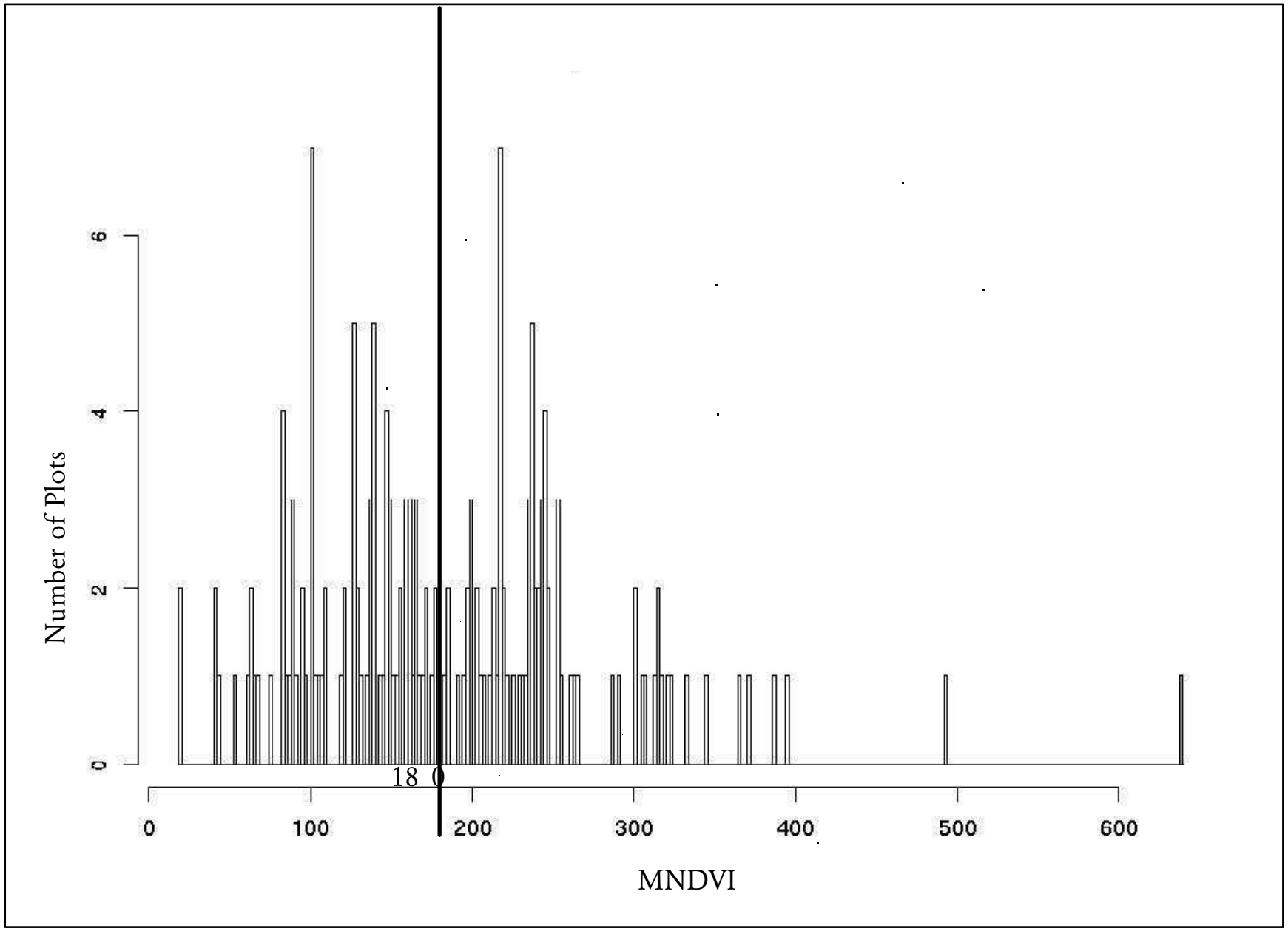


Figure F-5b. Breaks between mesic shrub canopy cover classes in relation to MNDVI values: TM scene P42/R28

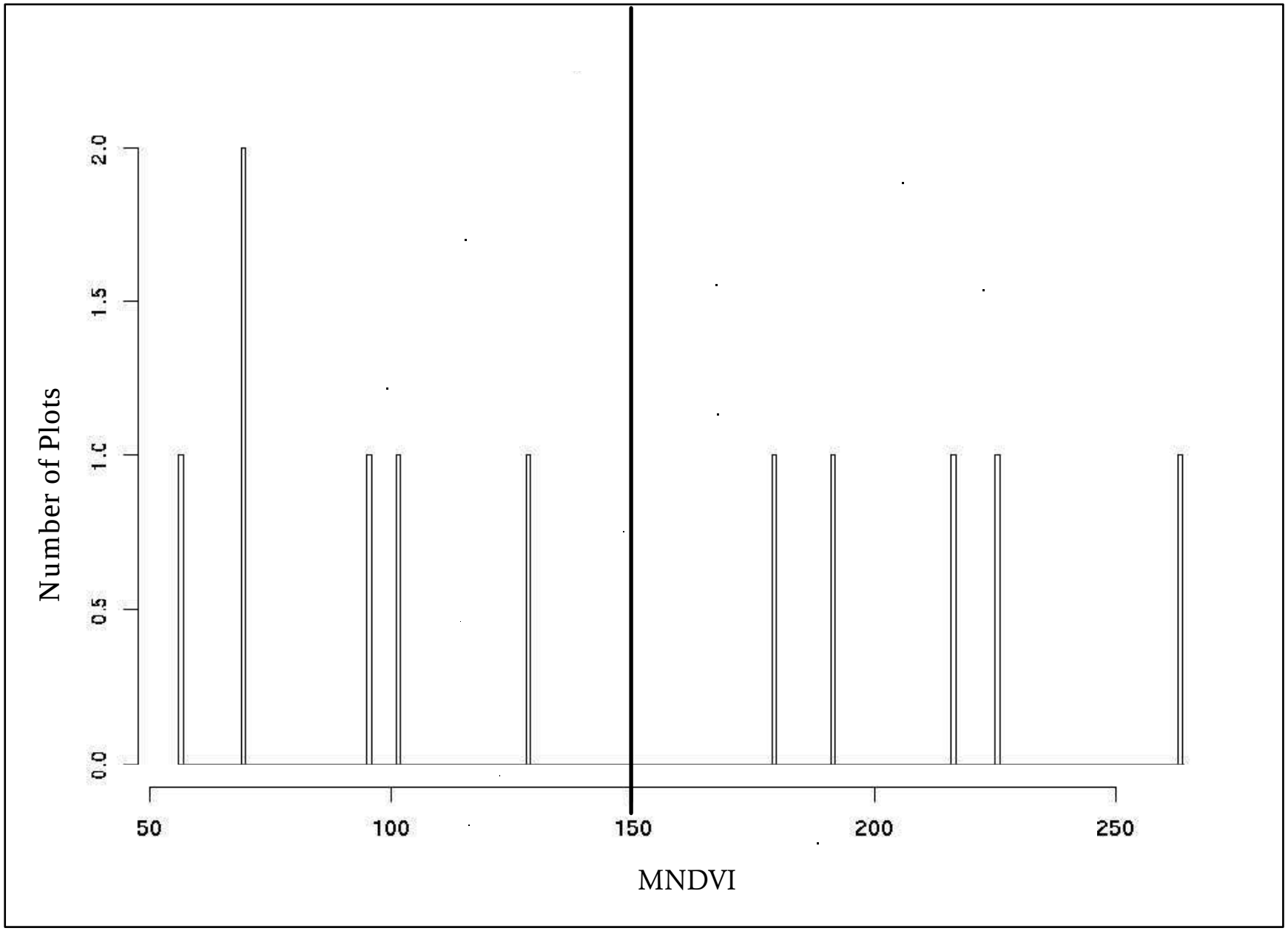


Figure F-5c. Breaks between xeric shrub canopy cover classes in relation to MNDVI values: TM scene P42/R28

Accuracy Assessment Tables for P42/R28 -- Cover Type

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3102	3104	3202	3203	3301	4203	4206	4207
3101	2(5)	0(3)	2(3)	0(1)	0(1)	0(1)	0(1)	2(1)	2(1)
3102	1(3)	1(5)	0(2)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3104	0(3)	1(3)	10(5)	3(1)	1(1)	0(1)	0(1)	0(1)	0(1)
3202	3(1)	1(1)	4(1)	12(5)	3(3)	0(2)	0(1)	5(1)	0(1)
3203	0(1)	0(1)	0(1)	0(3)	0(5)	0(2)	1(1)	0(1)	3(1)
3301	0(1)	0(1)	0(1)	0(2)	0(2)	0(5)	0(1)	0(1)	0(1)
4203	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	6(5)	0(2)	3(2)
4206	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	3(5)	1(2)
4207	1(1)	0(1)	1(1)	0(1)	0(1)	0(1)	1(2)	2(2)	9(5)
4208	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)
4210	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	1(2)	0(2)
4212	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	1(2)	4(2)	1(2)
4215	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	1(2)
4220	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	3(3)	0(2)	0(2)
4221	0(1)	0(1)	1(1)	2(1)	0(1)	0(1)	3(3)	4(2)	9(3)
4222	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)	1(2)
4223	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(3)	0(2)	0(2)
4225	1(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(2)	1(2)	3(4)
4226	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	2(2)	1(4)
4301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	1(2)	0(3)
7300	0(1)	0(1)	3(1)	0(1)	0(1)	0(1)	2(1)	0(1)	0(1)
SUM	8(0)	3(0)	21(0)	20(0)	6(0)	0(0)	17(0)	25(0)	34(0)

RF/CF	4208	4210	4212	4215	4220	4221	4222	4223	4225
3101	0(1)	1(1)	2(1)	0(1)	0(1)	2(1)	2(1)	0(1)	0(1)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)
3104	0(1)	0(1)	0(1)	0(1)	1(1)	7(1)	1(1)	0(1)	0(1)
3202	0(1)	0(1)	1(1)	0(1)	0(1)	3(1)	1(1)	0(1)	1(1)
3203	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3301	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4203	0(2)	0(2)	1(2)	1(2)	1(3)	14(3)	3(2)	1(4)	1(2)
4206	0(2)	3(2)	1(2)	0(2)	0(2)	3(3)	0(4)	0(2)	0(2)
4207	1(2)	1(2)	1(2)	0(2)	0(2)	7(3)	0(2)	1(2)	2(4)
4208	2(5)	0(2)	0(2)	0(2)	0(3)	0(3)	0(2)	0(2)	3(2)
4210	0(2)	0(5)	0(2)	0(2)	0(2)	1(3)	0(2)	0(2)	0(2)
4212	0(2)	0(2)	1(5)	0(3)	0(3)	3(3)	6(4)	1(4)	4(4)
4215	0(2)	0(2)	0(3)	0(5)	0(3)	0(3)	0(2)	0(2)	0(2)
4220	4(3)	0(2)	2(3)	0(2)	2(5)	8(2)	0(2)	0(3)	1(2)
4221	5(2)	1(3)	0(3)	2(3)	0(2)	17(5)	1(2)	0(3)	7(4)
4222	0(2)	0(2)	1(3)	0(2)	0(2)	1(2)	0(5)	1(2)	0(2)
4223	0(2)	0(2)	2(3)	0(2)	0(3)	2(3)	1(2)	0(5)	0(3)
4225	0(2)	0(2)	3(3)	0(2)	0(2)	1(4)	1(2)	1(3)	1(5)
4226	0(2)	1(3)	3(2)	0(2)	0(2)	2(4)	1(2)	0(2)	3(3)
4301	0(2)	0(3)	0(2)	0(2)	0(3)	0(3)	0(3)	0(3)	1(3)
7300	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	12(0)	8(0)	18(0)	3(0)	4(0)	71(0)	17(0)	5(0)	25(0)

Accuracy Assessment Tables for P42/R28 -- Cover Type

RF/CF	4226	4301	7300	SUM
3101	0(1)	0(1)	1(1)	18(0)
3102	0(1)	0(1)	0(1)	3(0)
3104	2(1)	0(1)	0(1)	27(0)
3202	2(1)	0(1)	1(1)	37(0)
3203	0(1)	0(1)	1(1)	5(0)
3301	0(1)	0(1)	1(1)	2(0)
4203	0(2)	0(2)	1(1)	33(0)
4206	1(2)	0(2)	0(1)	12(0)
4207	2(4)	0(2)	0(1)	29(0)
4208	0(2)	0(2)	0(1)	5(0)
4210	2(4)	0(2)	0(1)	4(0)
4212	1(2)	0(2)	0(1)	24(0)
4215	0(2)	0(2)	0(1)	1(0)
4220	0(2)	0(2)	0(1)	21(0)
4221	2(4)	0(2)	0(1)	54(0)
4222	0(2)	0(2)	0(1)	4(0)
4223	0(2)	0(2)	0(1)	6(0)
4225	0(3)	0(2)	0(1)	13(0)
4226	1(5)	0(2)	0(1)	14(0)
4301	0(3)	0(5)	0(1)	2(0)
7300	0(1)	0(1)	0(5)	6(0)
SUM	13(0)	0(0)	5(0)	320(0)

Diagonal Elements = 67; Total Test Points = 320
Percentage Agreement = 20.94; Kappa = 0.139; Tau w/equal Prob = 0.170

5 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 5 points = 1

Accuracy Assessment Tables for P42/R28 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	2	11.11	0	0.00	2	11.11	0	0.00	14	77.78
3102	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
3104	10	37.04	0	0.00	1	3.70	0	0.00	16	59.26
3202	12	32.43	0	0.00	3	8.11	0	0.00	22	59.46
3203	0	0.00	0	0.00	0	0.00	0	0.00	5	100.00
3301	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4203	6	18.18	1	3.03	15	45.45	9	27.27	2	6.06
4206	3	25.00	0	0.00	3	25.00	6	50.00	0	0.00
4207	9	31.03	4	13.79	7	24.14	7	24.14	2	6.90
4208	2	40.00	0	0.00	0	0.00	3	60.00	0	0.00
4210	0	0.00	2	50.00	1	25.00	1	25.00	0	0.00
4212	1	4.17	11	45.83	3	12.50	7	29.17	2	8.33
4215	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00
4220	2	9.52	0	0.00	9	42.86	9	42.86	1	4.76
4221	17	31.48	9	16.67	15	27.78	10	18.52	3	5.56
4222	0	0.00	0	0.00	1	25.00	3	75.00	0	0.00
4223	0	0.00	0	0.00	4	66.67	1	16.67	1	16.67
4225	1	7.69	4	30.77	4	30.77	2	15.38	2	15.38
4226	1	7.14	3	21.43	4	28.57	6	42.86	0	0.00
4301	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00
7300	0	0.00	0	0.00	0	0.00	0	0.00	6	100.00
SUM	67	20.94	34	10.63	74	23.13	66	20.62	79	24.69

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	2	11.11	2	11.11	4	22.22	4	22.22	18	100.00
3102	1	33.33	1	33.33	2	66.67	2	66.67	3	100.00
3104	10	37.04	10	37.04	11	40.74	11	40.74	27	100.00
3202	12	32.43	12	32.43	15	40.54	15	40.54	37	100.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	5	100.00
3301	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4203	6	18.18	7	21.21	22	66.67	31	93.94	33	100.00
4206	3	25.00	3	25.00	6	50.00	12	100.00	12	100.00
4207	9	31.03	13	44.83	20	68.97	27	93.10	29	100.00
4208	2	40.00	2	40.00	2	40.00	5	100.00	5	100.00
4210	0	0.00	2	50.00	3	75.00	4	100.00	4	100.00
4212	1	4.17	12	50.00	15	62.50	22	91.67	24	100.00
4215	0	0.00	0	0.00	0	0.00	1	100.00	1	100.00
4220	2	9.52	2	9.52	11	52.38	20	95.24	21	100.00
4221	17	31.48	26	48.15	41	75.93	51	94.44	54	100.00
4222	0	0.00	0	0.00	1	25.00	4	100.00	4	100.00
4223	0	0.00	0	0.00	4	66.67	5	83.33	6	100.00
4225	1	7.69	5	38.46	9	69.23	11	84.62	13	100.00
4226	1	7.14	4	28.57	8	57.14	14	100.00	14	100.00
4301	0	0.00	0	0.00	1	50.00	2	100.00	2	100.00
7300	0	0.00	0	0.00	0	0.00	0	0.00	6	100.00
SUM	67	20.94	101	31.56	175	54.69	241	75.31	320	100.00

Accuracy Assessment Tables for P42/R28 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	2	25.00	0	0.00	1	12.50	0	0.00	5	62.50
3102	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
3104	10	47.62	0	0.00	2	9.52	0	0.00	9	42.86
3202	12	60.00	0	0.00	0	0.00	0	0.00	8	40.00
3203	0	0.00	0	0.00	3	50.00	0	0.00	3	50.00
3301	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	6	35.29	0	0.00	6	35.29	2	11.76	3	17.65
4206	3	12.00	0	0.00	0	0.00	15	60.00	7	28.00
4207	9	26.47	4	11.76	9	26.47	7	20.59	5	14.71
4208	2	16.67	0	0.00	4	33.33	6	50.00	0	0.00
4210	0	0.00	0	0.00	2	25.00	4	50.00	2	25.00
4212	1	5.56	0	0.00	8	44.44	6	33.33	3	16.67
4215	0	0.00	0	0.00	2	66.67	1	33.33	0	0.00
4220	2	50.00	0	0.00	1	25.00	0	0.00	1	25.00
4221	17	23.94	3	4.23	30	42.25	9	12.68	12	16.90
4222	0	0.00	6	35.29	0	0.00	7	41.18	4	23.53
4223	0	0.00	2	40.00	1	20.00	2	40.00	0	0.00
4225	1	4.00	13	52.00	4	16.00	5	20.00	2	8.00
4226	1	7.69	6	46.15	0	0.00	2	15.38	4	30.77
4301	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7300	0	0.00	0	0.00	0	0.00	0	0.00	5	100.00
SUM	67	21.27	34	10.79	74	23.49	66	20.95	74	23.49

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	2	25.00	2	25.00	3	37.50	3	37.50	8	100.00
3102	1	33.33	1	33.33	2	66.67	2	66.67	3	100.00
3104	10	47.62	10	47.62	12	57.14	12	57.14	21	100.00
3202	12	60.00	12	60.00	12	60.00	12	60.00	20	100.00
3203	0	0.00	0	0.00	3	50.00	3	50.00	6	100.00
3301	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	6	35.29	6	35.29	12	70.59	14	82.35	17	100.00
4206	3	12.00	3	12.00	3	12.00	18	72.00	25	100.00
4207	9	26.47	13	38.24	22	64.71	29	85.29	34	100.00
4208	2	16.67	2	16.67	6	50.00	12	100.00	12	100.00
4210	0	0.00	0	0.00	2	25.00	6	75.00	8	100.00
4212	1	5.56	1	5.56	9	50.00	15	83.33	18	100.00
4215	0	0.00	0	0.00	2	66.67	3	100.00	3	100.00
4220	2	50.00	2	50.00	3	75.00	3	75.00	4	100.00
4221	17	23.94	20	28.17	50	70.42	59	83.10	71	100.00
4222	0	0.00	6	35.29	6	35.29	13	76.47	17	100.00
4223	0	0.00	2	40.00	3	60.00	5	100.00	5	100.00
4225	1	4.00	14	56.00	18	72.00	23	92.00	25	100.00
4226	1	7.69	7	53.85	7	53.85	9	69.23	13	100.00
4301	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7300	0	0.00	0	0.00	0	0.00	0	0.00	5	100.00
SUM	67	21.27	101	32.06	175	55.56	241	76.51	315	100.00

Accuracy Assessment Tables for P42/R28 -- Cover Type

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	11	11.11	0	0.00	11	11.11	0	0.00	80	77.78
3102	5	33.33	0	0.00	5	33.33	0	0.00	5	33.33
3104	13	37.04	0	0.00	1	3.70	0	0.00	20	59.26
3202	21	32.43	0	0.00	5	8.11	0	0.00	38	59.46
3203	0	0.00	0	0.00	0	0.00	0	0.00	13	100.00
3301	0	0.00	0	0.00	0	0.00	0	0.00	15	100.00
4203	10	18.18	2	3.03	26	45.45	15	27.27	3	6.06
4206	38	25.00	0	0.00	38	25.00	75	50.00	0	0.00
4207	23	31.03	10	13.79	18	24.14	18	24.14	5	6.90
4208	8	40.00	0	0.00	0	0.00	12	60.00	0	0.00
4210	0	0.00	5	50.00	3	25.00	3	25.00	0	0.00
4212	3	4.17	29	45.83	8	12.50	19	29.17	5	8.33
4215	0	0.00	0	0.00	0	0.00	5	100.00	0	0.00
4220	4	9.52	0	0.00	16	42.86	16	42.86	2	4.76
4221	54	31.48	28	16.67	47	27.78	32	18.52	9	5.56
4222	0	0.00	0	0.00	9	25.00	28	75.00	0	0.00
4223	0	0.00	0	0.00	6	66.67	1	16.67	1	16.67
4225	5	7.69	21	30.77	21	30.77	11	15.38	11	15.38
4226	4	7.14	11	21.43	14	28.57	21	42.86	0	0.00
4301	0	0.00	0	0.00	0	50.00	0	50.00	0	0.00
7300	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
SUM	199	19.98	106	10.64	228	22.89	256	25.70	207	20.78

Accuracy Assessment Tables for P42/R28 -- Cover Type

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	11	11.11	11	11.11	23	22.22	23	22.22	103	100.00
3102	5	33.33	5	33.33	11	66.67	11	66.67	16	100.00
3104	13	37.04	13	37.04	14	40.74	14	40.74	34	100.00
3202	21	32.43	21	32.43	26	40.54	26	40.54	64	100.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	13	100.00
3301	0	0.00	0	0.00	0	0.00	0	0.00	15	100.00
4203	10	18.18	12	21.21	38	66.67	53	93.94	57	100.00
4206	38	25.00	38	25.00	75	50.00	151	100.00	151	100.00
4207	23	31.03	33	44.83	51	68.97	69	93.10	74	100.00
4208	8	40.00	8	40.00	8	40.00	21	100.00	21	100.00
4210	0	0.00	5	50.00	8	75.00	10	100.00	10	100.00
4212	3	4.17	32	50.00	40	62.50	59	91.67	64	100.00
4215	0	0.00	0	0.00	0	0.00	5	100.00	5	100.00
4220	4	9.52	4	9.52	20	52.38	36	95.24	38	100.00
4221	54	31.48	82	48.15	130	75.93	161	94.44	171	100.00
4222	0	0.00	0	0.00	9	25.00	38	100.00	38	100.00
4223	0	0.00	0	0.00	6	66.67	7	83.33	9	100.00
4225	5	7.69	26	38.46	47	69.23	58	84.62	68	100.00
4226	4	7.14	14	28.57	28	57.14	50	100.00	50	100.00
4301	0	0.00	0	0.00	0	50.00	0	100.00	0	100.00
7300	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
SUM	199	19.88	304	30.37	534	53.35	792	79.12	1001	100.00

Accuracy Assessment Tables for P42/R28 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	4	SUM
1	6(5)	1(3)	0(1)	2(1)	9(0)
2	3(3)	0(5)	0(3)	1(1)	4(0)
3	4(1)	3(3)	13(5)	7(3)	27(0)
4	0(1)	0(1)	2(3)	0(5)	2(0)
SUM	13(0)	4(0)	15(0)	10(0)	42(0)

Diagonal Elements = 19; Total Test Points = 42
Percentage Agreement = 45.24; Kappa = 0.199; Tau w/equal Prob = 0.270

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	66.67	0	0.00	1	11.11	0	0.00	2	22.22
2	0	0.00	0	0.00	3	75.00	0	0.00	1	25.00
3	13	48.15	0	0.00	10	37.04	0	0.00	4	14.81
4	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00
SUM	19	45.24	0	0.00	16	38.10	0	0.00	7	16.67

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	66.67	6	66.67	7	77.78	7	77.78	9	100.00
2	0	0.00	0	0.00	3	75.00	3	75.00	4	100.00
3	13	48.15	13	48.15	23	85.19	23	85.19	27	100.00
4	0	0.00	0	0.00	2	100.00	2	100.00	2	100.00
SUM	19	45.24	19	45.24	35	83.33	35	83.33	42	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	46.15	0	0.00	3	23.08	0	0.00	4	30.77
2	0	0.00	0	0.00	4	100.00	0	0.00	0	0.00
3	13	86.67	0	0.00	2	13.33	0	0.00	0	0.00
4	0	0.00	0	0.00	7	70.00	0	0.00	3	30.00
SUM	19	45.24	0	0.00	16	38.10	0	0.00	7	16.67

Accuracy Assessment Tables for P42/R28 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	46.15	6	46.15	9	69.23	9	69.23	13	100.00
2	0	0.00	0	0.00	4	100.00	4	100.00	4	100.00
3	13	86.67	13	86.67	15	100.00	15	100.00	15	100.00
4	0	0.00	0	0.00	7	70.00	7	70.00	10	100.00
SUM	19	45.24	19	45.24	35	83.33	35	83.33	42	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	280	66.67	0	0.00	47	11.11	0	0.00	93	22.22
2	0	0.00	0	0.00	49	75.00	0	0.00	16	25.00
3	188	48.15	0	0.00	144	37.04	0	0.00	58	14.81
4	0	0.00	0	0.00	125	100.00	0	0.00	0	0.00
SUM	468	46.80	0	0.00	365	36.50	0	0.00	167	16.70

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	280	66.67	280	66.67	327	77.78	327	77.78	420	100.00
2	0	0.00	0	0.00	49	75.00	49	75.00	66	100.00
3	188	48.15	188	48.15	332	85.19	332	85.19	390	100.00
4	0	0.00	0	0.00	125	100.00	125	100.00	125	100.00
SUM	468	46.75	468	46.75	833	83.22	833	83.22	1001	100.00

Accuracy Assessment Tables for P42/R28 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	1(5)	0(3)	3(1)	4(0)
2	0(3)	1(5)	5(3)	6(0)
3	0(1)	0(3)	1(5)	1(0)
SUM	1(0)	1(0)	9(0)	11(0)

Diagonal Elements = 3; Total Test Points = 11
Percentage Agreement = 27.27; Kappa = 0.137; Tau w/equal Prob = -0.091

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	25.00	0	0.00	0	0.00	0	0.00	3	75.00
2	1	16.67	0	0.00	5	83.33	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	3	27.27	0	0.00	5	45.45	0	0.00	3	27.27

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	25.00	1	25.00	1	25.00	1	25.00	4	100.00
2	1	16.67	1	16.67	6	100.00	6	100.00	6	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	3	27.27	3	27.27	8	72.73	8	72.73	11	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3	1	11.11	0	0.00	5	55.56	0	0.00	3	33.33
SUM	3	27.27	0	0.00	5	45.45	0	0.00	3	27.27

Accuracy Assessment Tables for P42/R28 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
2	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
3	1	11.11	1	11.11	6	66.67	6	66.67	9	100.00
SUM	3	27.27	3	27.27	8	72.73	8	72.73	11	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	125	25.00	0	0.00	0	0.00	0	0.00	375	75.00
2	7	16.67	0	0.00	37	83.33	0	0.00	0	0.00
3	457	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	589	58.84	0	0.00	37	3.70	0	0.00	375	37.46

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	125	25.00	125	25.00	125	25.00	125	25.00	500	100.00
2	7	16.67	7	16.67	44	100.00	44	100.00	44	100.00
3	457	100.00	457	100.00	457	100.00	457	100.00	457	100.00
SUM	589	58.84	589	58.84	626	62.54	626	62.54	1001	100.00

Accuracy Assessment Tables for P42/R28 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	16(5)	28(3)	3(1)	47(0)
2	3(3)	32(5)	9(3)	44(0)
3	0(1)	7(3)	1(5)	8(0)
SUM	19(0)	67(0)	13(0)	99(0)

Diagonal Elements = 49; Total Test Points = 99
Percentage Agreement = 49.49; Kappa = 0.155; Tau w/equal Prob = 0.242

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	16	34.04	0	0.00	28	59.57	0	0.00	3	6.38
2	32	72.73	0	0.00	12	27.27	0	0.00	0	0.00
3	1	12.50	0	0.00	7	87.50	0	0.00	0	0.00
SUM	49	49.49	0	0.00	47	47.47	0	0.00	3	3.03

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	16	34.04	16	34.04	44	93.62	44	93.62	47	100.00
2	32	72.73	32	72.73	44	100.00	44	100.00	44	100.00
3	1	12.50	1	12.50	8	100.00	8	100.00	8	100.00
SUM	49	49.49	49	49.49	96	96.97	96	96.97	99	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	16	84.21	0	0.00	3	15.79	0	0.00	0	0.00
2	32	47.76	0	0.00	35	52.24	0	0.00	0	0.00
3	1	7.69	0	0.00	9	69.23	0	0.00	3	23.08
SUM	49	49.49	0	0.00	47	47.47	0	0.00	3	3.03

Accuracy Assessment Tables for P42/R28 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	16	84.21	16	84.21	19	100.00	19	100.00	19	100.00
2	32	47.76	32	47.76	67	100.00	67	100.00	67	100.00
3	1	7.69	1	7.69	10	76.92	10	76.92	13	100.00
SUM	49	49.49	49	49.49	96	96.97	96	96.97	99	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	74	34.04	0	0.00	129	59.57	0	0.00	14	6.38
2	466	72.73	0	0.00	175	27.27	0	0.00	0	0.00
3	18	12.50	0	0.00	125	87.50	0	0.00	0	0.00
SUM	558	55.74	0	0.00	429	42.86	0	0.00	14	1.40

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	74	34.04	74	34.04	203	93.62	203	93.62	217	100.00
2	466	72.73	466	72.73	640	100.00	640	100.00	640	100.00
3	18	12.50	18	12.50	143	100.00	143	100.00	143	100.00
SUM	558	55.80	558	55.80	986	98.60	986	98.60	1000	100.00

Accuracy Assessment Tables for P42/R28 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	4(5)	3(3)	0(1)	7(0)
2	3(3)	6(5)	0(3)	9(0)
3	1(1)	3(3)	0(5)	4(0)
SUM	8(0)	12(0)	0(0)	20(0)

Diagonal Elements = 10; Total Test Points = 20
Percentage Agreement = 50.00; Kappa = 0.153; Tau w/equal Prob = 0.250

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	57.14	0	0.00	3	42.86	0	0.00	0	0.00
2	6	66.67	0	0.00	3	33.33	0	0.00	0	0.00
3	0	0.00	0	0.00	3	75.00	0	0.00	1	25.00
SUM	10	50.00	0	0.00	9	45.00	0	0.00	1	5.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	57.14	4	57.14	7	100.00	7	100.00	7	100.00
2	6	66.67	6	66.67	9	100.00	9	100.00	9	100.00
3	0	0.00	0	0.00	3	75.00	3	75.00	4	100.00
SUM	10	50.00	10	50.00	19	95.00	19	95.00	20	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	50.00	0	0.00	3	37.50	0	0.00	1	12.50
2	6	50.00	0	0.00	6	50.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	10	50.00	0	0.00	9	45.00	0	0.00	1	5.00

Accuracy Assessment Tables for P42/R28 -- Shrub Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	50.00	4	50.00	7	87.50	7	87.50	8	100.00
2	6	50.00	6	50.00	12	100.00	12	100.00	12	100.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	10	50.00	10	50.00	19	95.00	19	95.00	20	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	413	57.14	0	0.00	310	42.86	0	0.00	0	0.00
2	185	66.67	0	0.00	92	33.33	0	0.00	0	0.00
3	0	0.00	0	0.00	0	75.00	0	0.00	0	25.00
SUM	598	59.80	0	0.00	402	40.20	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	413	57.14	413	57.14	723	100.00	723	100.00	723	100.00
2	185	66.67	185	66.67	277	100.00	277	100.00	277	100.00
3	0	0.00	0	0.00	0	75.00	0	75.00	0	100.00
SUM	598	59.80	598	59.80	1000	100.00	1000	100.00	1000	100.00

Scene P42/R28 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	48167.0	686064.1	21.7
1000	392.0	6165.8	0.2
2000	19689.0	291963.7	9.2
3101	11575.0	122881.2	3.9
3102	1748.0	17798.8	0.6
3104	8193.0	68908.9	2.2
3202	10099.0	105168.8	3.3
3203	1240.0	7417.6	0.2
3301	1327.0	15861.7	0.5
4203	10153.0	102098.3	3.2
4206	19152.0	203602.2	6.4
4207	14530.0	164070.1	5.2
4208	3491.0	52114.2	1.6
4210	2170.0	24718.4	0.8
4212	15138.0	143898.0	4.5
4215	1351.0	13066.2	0.4
4219	429.0	3580.2	0.1
4220	7137.0	91997.2	2.9
4221	33220.0	390792.1	12.4
4222	7032.0	62487.4	2.0
4223	2234.0	21036.4	0.7
4225	12815.0	155955.1	4.9
4226	8430.0	109829.4	3.5
4301	106.0	397.2	0.0
5000	8963.0	19435.5	0.6
7300	3626.0	41462.9	1.3
7800	117.0	847.2	0.0
8100	116.0	707.0	0.0
9100	2507.0	89900.8	2.8
9800	1596.0	104188.2	3.3
9900	5131.0	44570.1	1.4

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	48167.0	686064.1	21.7
Not tree/shrub	63653.0	808830.2	25.6
Shrub 1	8161.0	71866.1	2.3
Shrub 2	4505.0	56582.0	1.8
Tree 1	22425.0	198098.0	6.3
Tree 2	92318.0	1065193.6	33.7
Tree 3	22645.0	276350.9	8.7

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	48167.0	686064.1	21.7
Not tree/shrub	63653.0	808830.2	25.6
Tree 1	48949.0	531615.6	16.8
Tree 2	11355.0	123789.0	3.9
Tree 3	58339.0	698281.7	22.1
Tree 4	18745.0	185956.2	5.9
Shrub 1	3169.0	31718.6	1.0
Shrub 2	510.0	5580.9	0.2
Shrub 3	8987.0	91148.6	2.9

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	48167.0	686064.1	21.7
A	19689.0	291963.7	9.2
H	21632.0	210296.0	6.6
N	22332.0	306570.5	9.7
S	12666.0	128448.1	4.1
T	137388.0	1539642.5	48.7

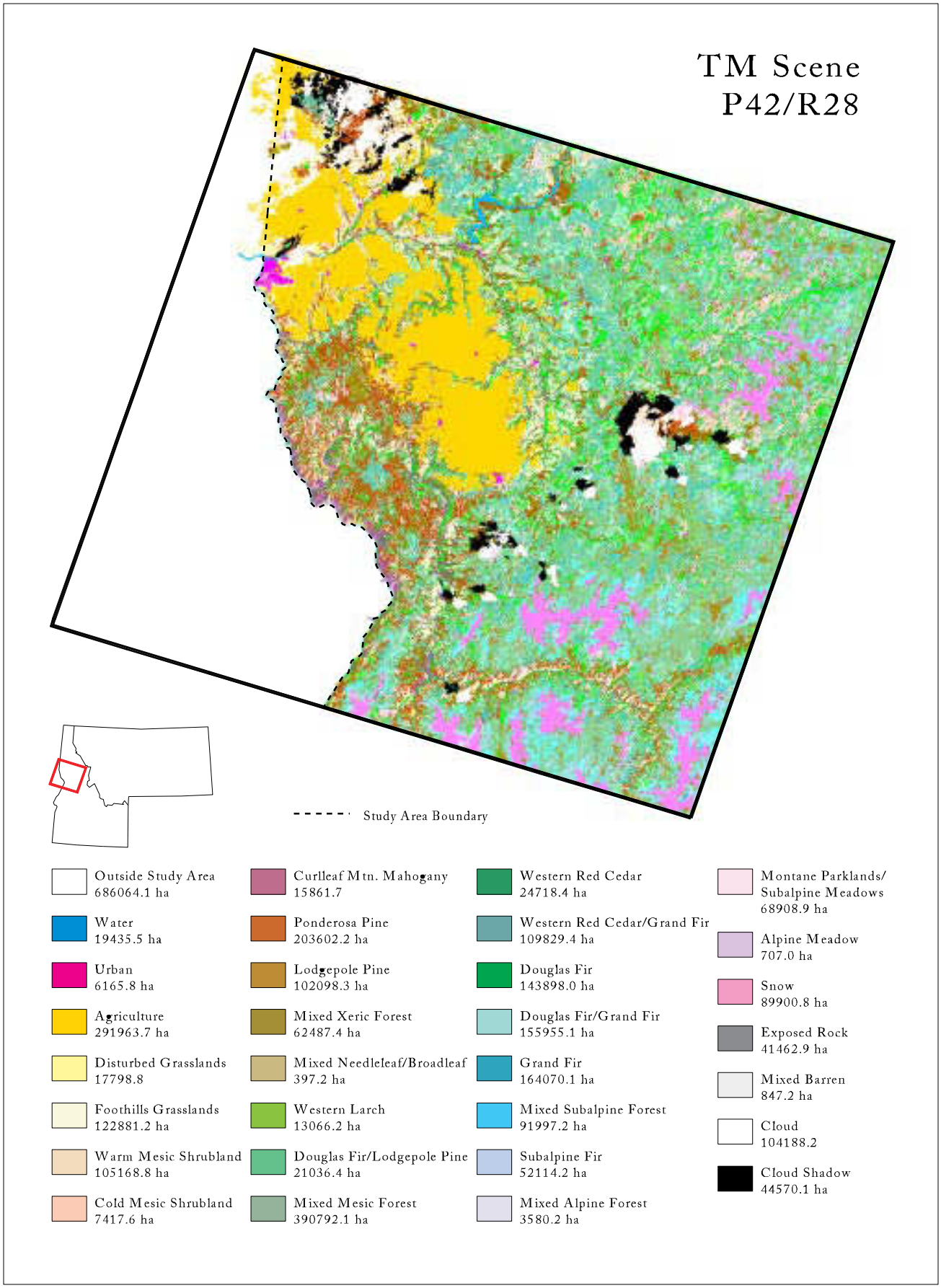


Figure F-5. Classification of land cover types for TM Scene P42/R28.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P42/R28

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4201: ENGELMANN SPRUCE FOREST

Conifer forest dominated by Engelmann spruce (Picea engelmannii) ranging from 4275 to 6240 feet in elevation. The average canopy cover is 23%, ranging from 10-30% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), subalpine fir (Abies lasiocarpa), and pacific yew (Taxus brevifolia) with average percent cover ≥1% and ≤5% and frequency of occurrence ≥40% and ≤80%.

Primary associated shrub species with ≥40% and ≤90% frequency of occurrence in Engelmann spruce stands: sitka alder (Alnus sinuata), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea), swamp current (Ribes lacustre), thimbleberry (Rubus parviflorum), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥10% and ≤80% frequency of occurrence in Engelmann spruce stands: **graminoids**: brome (Bromus spp.), Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), dropping woodreed (Cinna latifolia), woodrush (Luzula spp.), week alkaligrass (Puccinellia pauciflora), and trisetum (Trisetum spp.); **forbs**: Piper's anemone (Anemone piperi), wild ginger (Asarum caudatum), western goldthread (Coptis occidentalis), sweetscented bedstraw (Galium triflorum), arrowleaf groundsel (Senecio triangularis), western meadowrue (Thalictrum occidentale), and trefoil foamflower (Tiarella trifoliata); **ferns**: ladyfern (Athyrium filix-femina), mountain wood-fern (Dryopteris austriaca), oak-fern (Gymnocarpium dryopteris), mountain hollyfern (Polystichum lonchitis), common Christmas-fern (Polystichum munitum); **moss**: none.

2) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 3830 to 7440 feet in elevation. The average canopy cover is 30% ranging from 10-50% total cover and frequency of occurrence equal to 99%. Primary associated tree species include grand fir (Abies grandis), subalpine fir (Abies lasiocarpa), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥4% and ≤5% and frequency of occurrence ≥36% and ≤44%.

Primary associated shrub species with ≥8% and ≤62% frequency of occurrence in lodgepole pine stands: kinnikinnick (Arctostaphylos uva-ursi), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), shiny-leaf spiraea (Spiraea betulifolia), huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤91% frequency of occurrence in lodgepole pine stands: **graminoids**: Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), fescue (Festuca spp.), and smooth

woodrush (Luzula hitchcockii); **forbs**: Piper's anemone (Anemone piperi), western goldthread (Coptis occidentalis), white-flowered hawkweed (Hieracium albiflorum), mountain thermopsis (Thermopsis montana), round-leaved violet (Viola orbiculata), and beargrass (Xerophyllum tenax); **ferns**: common Christmas-fern (Polystichum munitum); **moss**: none.

3) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 1600 to 6021 feet in elevation. The average canopy cover is 27% ranging from 10-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western larch (Larix occidentalis), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤6% and frequency of occurrence ≥4% and ≤53%.

Primary associated shrub species with ≥8% and ≤25% frequency of occurrence in ponderosa pine stands: western serviceberry (Amelanchier alnifolia), ocean-spray (Holodiscus discolor), mallow ninebark (Physocarpus malvaceus), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤15% frequency of occurrence in ponderosa pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), cheatgrass (Bromus tectorum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), orchard grass (Dactylis glomerata), Idaho fescue (Festuca idahoensis), and western witchgrass (Panicum occidentale); **forbs**: common yarrow (Achillea millefolium), western hawkweed (Hieracium albertinum), common St. John's-wort (Hypericum perforatum), lupine (Lupinus spp.), American vetch (Vicia americana), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum) and selaginella (Selaginella spp.); **moss**: none.

4) 4208: SUBALPINE FIR FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 1600 to 6368 feet in elevation. The average canopy cover is 32% ranging from 10-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), and lodgepole pine (Pinus contorta) with average percent cover ≥4% and ≤5% and frequency of occurrence ≥25% and ≤50%.

Primary associated shrub species with ≥11% and ≤61% frequency of occurrence in subalpine fir stands: Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea), red mountain-heath (Phyllodoce empetriformis), subalpine spiraea (Spiraea densiflora), huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤86% frequency of occurrence in subalpine fir stands: **graminoids**: sedge (Carex spp.), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), green fescue (Festuca viridula), smooth woodrush (Luzula hitchcockii), and woodrush (Luzula spp.); **forbs**: Piper's anemone

(Anemone piperi), mountain boykinia (Boykinia major), glacier lily (Erythronium gradiflorum), bracted lousewort (Pedicularis bracteosa), sickletop lousewort (Pedicularis racemosa), groundsel (Senecio spp.), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: none.

5) 4210: WESTERN RED CEDAR FOREST

Conifer forest dominated by western red cedar (Thuja plicata) ranging from 1470 to 4600 feet in elevation. The average canopy cover is 53% ranging from 20-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western white pine (Pinus monticola), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥1% and ≤9% and frequency of occurrence ≥41% and ≤94%.

Primary associated shrub species with ≥17% and ≤57% frequency of occurrence in western red cedar stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), ocean-spray (Holodiscus discolor), twin flower (Linnaea borealis), thimbleberry (Rubus parviflorum), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤61% frequency of occurrence in western red cedar stands: **graminoids**: Columbia brome (Bromus vulgaris), reedgrass (Calamagrostis spp.), northwestern sedge (Carex concinnoides), sedge (Carex spp.), beaked sedge (Carex utriculata), and western witchgrass (Panicum occidentale); **forbs**: trail-plant (Adenocaulon bicolor), Piper's anemone (Anemone piperi), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), western rattlesnake-plantain (Goodyera oblongofolia), and starry solomon-plume (Smilacina stellata); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), brittle bladder-fern (Cystopteris fragilis), clubmoss (Lycopodium spp.), mountain hollyfern (Polystichum lonchitis), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: none.

6) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 1760 to 6369 feet in elevation. The average canopy cover is 34% ranging from 3-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), Engelmann spruce (Picea engelmannii), and ponderosa pine (Pinus ponderosa), with average percent cover ≥3% and ≤7% and frequency of occurrence ≥13% and ≤ 67%.

Primary associated shrub species with ≥19% and ≤43% frequency of occurrence in Douglas-fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), ocean-spray (Holodiscus discolor), mockorange (Philadelphus lewisii), mallow ninebark (Physocarpus malvaceus), thimbleberry (Rubus parviflorum), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤12% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), field woodrush (Luzula campestris); **forbs**: Piper's anemone (Anemone piperi), bigleaf sandwort (Arenaria macrophylla), hooker fairy-bell (Disporum hookeri), Wood's strawberry (Fragaria vesca), sweetscented bedstraw (Galium triflorum), mountain sweet-cicely (Osmorhiza chilensis), starry solomon-plume (Smilacina stellata); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), Virginia grape-fern (Botrychium virginianum), brittle bladder-fern (Cystopteris fragilis), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: none.

7) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albicaulis) and ranging from 6628 to 8880 feet in elevation. The average canopy cover is 24% ranging from 10-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥3% and ≤18% and frequency of occurrence ≥33% and ≤93%.

Primary associated shrub species with ≥7% and ≤60% frequency of occurrence in mixed whitebark pine stands: alpine wintergreen (Gaultheria humifusa), labrador-tea (Ledum glandulosum), menziesia (Menziesia ferruginea), red mountain-heath (Phyllodoce empetriformis), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤47% frequency of occurrence in mixed whitebark pine stands: **graminoids:** sedge (Carex spp.), elk sedge (Carex geyeri), red fescue (Festuca rubra), rush (Juncus spp.), and smooth woodrush (Luzula hitchcockii); **forbs**: broadleaf arnica (Arnica latifolia), showy aster (Aster conspicuus), tailcup lupine (Lupinus caudatus), globe penstemon (Penstemon globosus), skunk-leaved polemonium (Polemonium pulcherrimum), groundsel (Senecio spp.), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**; none.

8) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa), codominant species is mountain hemlock (Tsuga mertensia), and ranging from 4800 to 7640 feet in elevation. The average canopy cover of ABILAS is 17% ranging from 1-60% total cover and frequency of occurrence equal to 92%. The average canopy cover of TSUMER is 34% ranging from 1-80% total cover and frequency of occurrence equal to 22%. Primary associated tree species include Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), and lodgepole pine (Pinus contorta) with average percent cover ≥4% and ≤14% and frequency of occurrence ≥29% and ≤75%.

Primary associated shrub species with ≥4% and ≤46% frequency of occurrence in mixed subalpine stands: menziesia (Menziesia ferruginea), red mountain-heath (Phyllodoce empetriformis), scouler willow (Salix scouleriana), cascade mountain-ash (Sorbus

scopulina), globe huckleberry (Vaccinium globulare), huckleberry (Vaccinium spp.), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤82% frequency of occurrence in mixed subalpine fir stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), and smooth woodrush (Luzula hitchcockii); **forb**: Piper's anemone (Anemone piperi), broadleaf arnica (Arnica latifolia), western goldthread (Coptis occidentalis), one-sided wintergreen (Pyrola secunda), western meadowrue (Thalictrum occidentale), white trillium (Trillium ovatum), and beargrass (Xerophyllum tenax); **ferns**: stiff clubmoss (Lycopodium annotinum), clubmoss, (Lycopodium spp.), and brackenfern (Pteridium aquilinum); **moss**: none.

9) 4221: MIXED MESIC FOREST

Conifer forest dominated by grand fir (Abies grandis), codominant species are western larch (Larix occidentalis), and western red cedar (Thuja plicata), ranging from 1600 to 6800 feet in elevation. The average canopy cover for ABIGRA is 17% ranging from 1-70% total cover and frequency of occurrence equal to 95%. The average canopy cover for LAROCC is 11% ranging from 1-40% total cover and frequency of occurrence equal to 24%. The average canopy cover for THUPLI is 15% ranging from 1-50% total cover and frequency of occurrence equal to 12%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥8% and ≤13% and frequency of occurrence ≥55% and ≤75%.

Primary associated shrub species with ≥11% and ≤29% frequency of occurrence in mixed mesic stands: rocky mountain maple (Acer glabrum), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), thimbleberry (Rubus parviflorum), common snowberry (Symphoricarpos albus), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤44% frequency of occurrence in mixed mesic stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), orchard grass (Dactylis glomerata), sheep fescue (Festuca ovina), and small-flowered woodrush (Luzula parviflora)**; forbs**: Piper's anemone (Anemone piperi), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), western meadowrue (Thalictrum occidentale), white trillium (Trillium ovatum), and beargrass (Xerophyllum tenax); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), brittle bladder-fern (Cystopteris fragilis), spinulose wood-fern (Dryopteris spinulosa), mountain hollyfern (Polystichum lonchitis), common Christmas-fern (Polystichum munitum), brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

10) 4222: MIXED XERIC FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) and ranging from 1870 to 5250 feet in elevation. The average canopy cover is 16% ranging from 3-30% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir

(Abies grandis), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥12% and ≤19% and frequency of occurrence ≥9% and ≤100%.

Primary associated shrub species with ≥9% and ≤46% frequency of occurrence in mixed xeric stands: western serviceberry (Amelanchier alnifolia), redstem ceanothus (Ceanothus sanguineus), ocean-spray (Holodiscus discolor), mallow ninebark (Physocarpus malvaceus), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤28% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), purple reedgrass (Calamagrostis purpurascens), pinegrass (Calamagrostis rubescens), slender hairgrass (Deschampsia elongata), blue wildrye (Elymus glaucus), and Idaho fescue (Festuca idahoensis); **forbs**: Piper's anemone (Anemone piperi), heart-leaf arnica (Arnica cordifolia), Wood's strawberry (Fragaria vesca), sweetscented bedstraw (Galium triflorum), common St. John's-wort (Hypericum perforatum), starry solomon-plume (Smilacina stellata), and American vetch (Vicia americana); **ferns**: common Christmas-fern (Polystichum munitum), brackenfern (Pteridium aquilinum); **moss**: none.

11) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) and ranging from 2980 to 6530 feet in elevation. The average canopy cover for PINCON is 25% ranging from 10-40% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 28% ranging from 10-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), subalpine fir (Abies lasiocarpa), and Engelmann spruce (Picea engelmannii), with average percent cover ≥2% and ≤5% and frequency of occurrence ≥228% and ≤78%.

Primary associated shrub species with ≥11% and ≤39% frequency of occurrence in Douglas-fir-lodgepole pine stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), menziesia (Menziesia ferruginea), rose (Rosa spp.), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤63% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), western fescue (Festuca occidentalis), and small-flowered woodrush (Luzula parviflora); **forbs**: Piper's anemone (Anemone piperi), bigleaf sandwort (Arenaria macrophylla), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), Wood's strawberry (Fragaria vesca), and beargrass (Xerophyllum tenax); **ferns**: common Christmas-fern (Polystichum munitum), brackenfern (Pteridium aquilinum); **moss**: none.

12) 4225: DOUGLAS FIR-GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) and Douglas-fir (Pseudotsuga menziesii) and ranging from 1620 to 6160 feet in elevation. The average canopy cover for ABIGRA is 24% ranging from 3-50% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 20% ranging from 3-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), ponderosa pine (Pinus ponderosa), and western red cedar (Thuja plicata), with average percent cover ≥2% and ≤6% and frequency of occurrence ≥17% and ≤27%.

Primary associated shrub species with ≥21% and ≤54% frequency of occurrence in Douglas-fir-grand fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), ocean-spray (Holodiscus discolor), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare),

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤39% frequency of occurrence in Douglas-fir-grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), common timothy (Phleum pratense), bluegrass (Poa spp.), and trisetum (Trisetum spp.); **forb**: Piper's anemone (Anemone piperi), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), mountain sweet-cicely (Osmorhiza chilensis), starry solomon-plume (Smilacina stellata), and western meadowrue (Thalictrum occidentale); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), brittle bladder-fern (Cystopteris fragilis), spinulose wood-fern (Dryopteris spinulosa), common Christmas-fern (Polystichum munitum), brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

13) 4226: WESTERN RED CEDAR-GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) and western red cedar (Thuja plicata) and ranging from 1400 to 4690 feet in elevation. The average canopy cover for ABIGRA is 31% ranging from 10-80% total cover and frequency of occurrence equal to 100%. The average canopy cover for THUPLI is 31% ranging from 3-70% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western white pine (Pinus monticola), Douglas-fir (Pseudotsuga menziesii), and pacific yew (Taxus brevifolia) with average percent cover ≥3% and ≤6% and frequency of occurrence ≥14% and ≤64%.

Primary associated shrub species with ≥26% and ≤52% frequency of occurrence in western red cedar-grand fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), bunchberry (Cornus canadensis), twin flower (Linnaea borealis), baldhip rose (Rosa gymnocarpa), thimbleberry (Rubus parviflorum), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤52% frequency of occurrence in western red cedar-grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris), elk sedge (Carex geyeri), beaked sedge (Carex utriculata), orchard grass (Dactylis glomerata), western fescue (Festuca occidentalis), field woodrush (Luzula

campestris), and common timothy (Phleum pratense); **forbs**: trail-plant (Adenocaulon bicolor), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), sweetscented bedstraw (Galium triflorum), mountain sweet-cicely (Osmorhiza chilensis), and starry solomon-plume (Smilacina stellata); **ferns**: northern maidenhair (Adiantum pedatum), field horsetail (Equisetum arvense), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: none.

P42/R28 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	10
6102	Broadleaf Dominated Riparian	None identified for scene
6103	Needleleaf-Broadleaf Riparian	46
6104	Mixed Riparian (trees + any other)	None identified for scene
6201	Grass-Forb Riparian/Wetland	4, 16
6202	Shrub Riparian/Wetland	11, 12
6203	Mixed Grass-Forb-Shrub Riparian	None identified for scene

---

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 2
Color: White; RGB 255 255 255.
Distribution: Clouds.
Comment: Conifers and shrubs are about equally represented among training sites outside the riparian zone; one site represents Mixed Needleleaf-Broadleaf vegetation.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
1	1	Shrub Riparian/Wetland
2	2	Lakes

Spectral Class 4
Color: Moss green; 129 171 87.
Distribution: High density at lower mid-elevations, though not linear and generally distant from rivers.
Comment: Herbaceous cover types are most prevalent outside the zone, with conifers and shrubs about equally represented by training data; Mixed Needleleaf-Broadleaf and riparian (6101, 6202) vegetation are minimally included.
Conclusion: 6201.

3	1	Mesic Upland Shrubland
4	1	Lodgepole Pine
5	1	Grass-Forb Riparian/Wetland
6	1	Shrub Riparian/Wetland
7	1	Exposed Rock
8	1	Dry-land crop
9	1	Rivers & Streams

Spectral Class 7
Color: Gold tan; RGB 184 149 66.
Distribution: High density at middle to upper mid-elevations.
Comment: Coniferous and herbaceous vegetation characterize this spectral class outside the zone; riparian cover types (6201, 6202, 6101, 6103) are represented by about 15% of the training sites. Appears to represent dry shrubs and grass.
Conclusion: Not riparian.

10	1	Herbaceous Clearcut
11	1	Needleleaf Dominated Riparian
12	1	Needleleaf-Broadleaf Riparian
13	1	Grass-Forb Riparian/Wetland
14	1	Shrub Riparian/Wetland

Spectral Class 8
Color: Black; RGB 53 33 38.
Distribution: Clustered at higher elevations; some near water bodies.
Comment: Conifers dominate training data outside the zone; riparian sites (6201, 6101, 6202) comprise 18% of the sites; one site indicates Mixed Needleleaf-Broadleaf vegetation. Visual cues indicate shadows and water.
Conclusion: Not riparian.

15	1	Mixed Mesic Forest
16	1	Needleleaf Dominated Riparian

Spectral Class 9
Color: Burnt umber; RGB 154 88 56.
Distribution: High density at middle to upper mid-elevations.
Comment: Coniferous cover types are most prevalent outside the zone; several points indicate riparian vegetation (6101, 6201, 6202). Color and distribution suggest agriculture and upland grasslands.
Conclusion: Not riparian.

17	1	Ponderosa Pine & Savannah
18	2	Grass-Forb Riparian/Wetland

Spectral Class 10
Color: Brown black; RGB 86 65 49.
Distribution: High density at middle to upper elevations.
Comment: Conifers dominate training data outside the zone; riparian cover types (6201, 6202, 6101) were also noted.
Conclusion: 6101.

19	1	Grand Fir
20	1	Douglas-fir
21	4	Mixed Mesic Forest
22	3	Needleleaf Dominated Riparian
23	2	Grass-Forb Riparian/Wetland
24	3	Shrub Riparian/Wetland

Spectral Class 11
Color: Brown olive; RGB 141 133 59.
Distribution: High density at middle to upper mid-elevations.
Comment: Coniferous and shrub vegetation characterize this class outside the zone; herbaceous and riparian cover types (6201, 6202) are included.
Conclusion: 6202.

25	1	Mesic Upland Shrubland
26	1	Ponderosa Pine & Savannah
27	2	Mixed Mesic Forest
28	2	Needleleaf Dominated Riparian
29	1	Broadleaf Dominated Riparian
30	1	Needleleaf-Broadleaf Riparian
31	5	Grass-Forb Riparian/Wetland
32	4	Shrub Riparian/Wetland
33	1	Mixed Barren Land

Spectral Class 12
Color: Bright, light orange; RGB 255 149 70.
Distribution: Clusters at lower elevations, but not linear.
Comment: Herbaceous cover types, including agriculture, are most prevalent among training sites outside the zone, though some points indicate upland shrub; riparian cover types (6202, 6103, 6201) are included.
Conclusion: 6202.

34	1	Dry-land Pasture
35	1	Mesic Upland Shrubland
36	1	Grass-Forb Riparian/Wetland
37	1	Shrub Riparian/Wetland

Spectral Class 13
Color: Dark moss green; RGB 98 110 59.
Distribution: Widespread at mid elevations, light to high density.
Comment: Conifers were most recorded outside the zone; riparian cover types (6201, 6101, 6202, 6103) make up 17% of recorded sites. Locations are primarily on west and south slopes, implying drier vegetation.

Conclusion: Not riparian.

38	1	Douglas-fir
39	2	Mixed Mesic Forest
40	1	Needleleaf Dominated Riparian
41	5	Grass-Forb Riparian/Wetland
42	6	Shrub Riparian/Wetland
43	1	Shoreline & Gravel Bars
44	1	Mesic Upland Shrubland

Spectral Class 16
Color: Medium green; RGB 81 147 80.
Distribution: Light to medium density at low to middle elevations.
Comment: Needleleaf and herbaceous cover types are most prevalent in training data outside the zone; shrubs, barren land, and Needleleaf Dominated Riparian cover types are included. There appears to be some riparian grass near rivers.
Conclusion: 6201.

45	1	Grass-Forb Riparian/Wetland
46	1	Exposed Rock
47	1	Mixed Barren Land

Spectral Class 20
Color: Red orange; RGB 232 92 52.
Distribution: Clusters at some low elevation areas, but not along major streams.
Comment: Eight of nine training sites outside the zone represent agricutural lands. No training sites were recorded inside the riparian zone. Appears to represent agricultural land.
Conclusion: Not riparian.

Spectral Class 22
Color: Blue black; RGB 0 12 70.
Distribution: Water bodies.
Comment: Conifers and water features are about equally represented among training sites outside the zone; a few points indicate riparian vegetation (6101, 6202).
Conclusion: Not riparian.

48	1	Mix Needleleaf-Broadleaf
49	3	Rivers & Streams
50	3	Lakes
51	2	Reservoirs
52	2	Grass-Forb Riparian/Wetland
53	3	Shrub Riparian/Wetland
54	1	Mixed Barren Land

Spectral Class 23
Color: Gray; RGB 151 161 154.
Distribution: Cloud edges and haze.
Comment: Coniferous, shrub, herbaceous, and riparian (6202, 6101, 6201) cover types are included in training data outside the zone.
Conclusion: Not riparian.

55	1	Dry-land Pasture
56	1	Subalpine Meadow
57	1	Engelmann Spruce
58	1	Mixed Mesic Forest
59	1	Grass-Forb Riparian/Wetland
60	1	Shrub Riparian/Wetland
61	2	Mixed Barren Land

Spectral Class 24
Color: Light gray brown; RGB 139 129 122.
Distribution: Cloud edges and haze.
Comment: Cover type observations outside the zone are similar to those for class 23; some sites represent riparian vegetation (6201, 6101). Visual cues indicate urban cover.
Conclusion: Not riparian.

62	1	Mesic Upland Shrubland
63	1	Western Red Cedar
64	1	Mixed Mesic Forest
65	1	Needleleaf Dominated Riparian
66	1	Broadleaf Dominated Riparian

Spectral Class 26
Color: Light, cool orange; RGB 255 159 136.
Distribution: Thin clouds.
Comment: All seven training sites located outside the zone indicate Dry-land crop.
Conclusion: Not riparian.

70	1	Dry-land crop
71	1	Dry-land Pasture

Spectral Class 28
Color: Light rose brown; RGB 207 147 143.
Distribution: Similar to spectral class 26.
Comment: Of just nine training sites outside the zone, four represent Foothills Grassland, two

represent Dry-land crop, two represent Mesic Upland Shrubland, and one represents Douglas-fir.
Conclusion: Not riparian.

74	1	Dry-land crop
75	1	Foothills Grassland
76	1	Mesic Upland Shrubland
77	1	Grass-Forb Riparian/Wetland

Spectral Class 33
Color: Black; RGB 40 71 56.
Distribution: Mountain shadows, cloud shadows, edges of water bodies, and burned areas.
Comment: Coniferous cover types are most prevalent among training sites outside the zone; riparian cover codes include 6201, 6202, and 6101.
Conclusion: Not riparian.

80	1	Subalpine Meadow
81	3	Needleleaf Dominated Riparian
82	1	Grass-Forb Riparian/Wetland
83	2	Shrub Riparian/Wetland
84	1	Exposed Rock

Spectral Class 46
Color: Orange; RGB 222 126 91.
Distribution: Light to medium density at lower to middle elevations.
Comment: Agricultural, coniferous and grassland characterize training sites outside the zone; one site represents Shrub Riparian/Wetland.
Conclusion: 6103.

88	1	Dry-land Pasture
89	2	Foothills Grassland
90	1	Subalpine Meadow
91	1	Mesic Upland Shrubland
92	1	Grass-Forb Riparian/Wetland

Spectral Class 54
Color: Dark green; RGB 58 102 91.
Distribution: Similar to class 33.
Comment: Conifers are most prevalent in training data outside the zone; riparian cover types (6101, 6202, 6201) are included. Appears to represent clouds and water.
Conclusion: Not riparian.

97	1	Mixed Mesic Forest
98	3	Shrub Riparian/Wetland

Spectral Class 58
Color: Black; RGB 48 71 49.
Distribution: High density at upper elevations; some shadow and water locations.
Comment: Needleleaf cover types dominate training data outside the zone; riparian vegetation (6101, 6201, 6202) are also present. Color and locations suggest shadows, burned areas, and needleleaf vegetation.
Conclusion: Not riparian.

101	1	Mixed Mesic Forest
102	1	Needleleaf Dominated Riparian
103	3	Grass-Forb Riparian/Wetland
104	1	Shrub Riparian/Wetland

Spectral Class 60
Color: Brown black; RGB 56 35 38.
Distribution: Similar to Spectral Class 58.
Comment: Needleleaf cover types are most prevalent among training sites outside the riparian zone; some sites represent riparian vegetation (6101, 6202, 6201). Appears to represent primarily Douglas-fir.
Conclusion: Not riparian.

105	1	Mesic Upland Shrubland
106	1	Grand Fir
107	1	Mixed Mesic Forest
108	1	Needleleaf Dominated Riparian
109	1	Broadleaf Dominated Riparian

TM SCENE P41/R26

Image Analyst: Zhenkui Ma

Training Data Analysis

A total of 1652 ground-truth plots were available for labeling P41/R26 (see table below); 947 were collected by Forest Service field crews during the1994-95 field seasons, and 493 of these were collected specifically for this TM scene. The remaining 705 plots came from pre-existing data sources such as ECODATA and TSMRS.

All the ground-truth data were converted to a point file and superimposed on the unsupervised classification to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 317) were removed from further analysis. Then the data were examined by cover type and by data source (whether or not plots were collected for this project or for other purposes, like pre-existing ECODATA or TSMRS). The latter "existing data" were only used in the training data set to supplement cover types that had insufficient plots collected during the 1994 or 1995 field seasons. Seven classes were excluded from the digital classification process: urban, agriculture, water, snow, melted snow, cloud, and cloud shadow. All ground truth data with VEG_CLASS_CODEs for urban, agriculture, or water cover types were excluded. Next, 20% of the remaining plots were randomly selected from each cover type; these plots (n = 136) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

The remaining 80% of the data (n = 543 plots) were subjected to further spectral examination. Outliers were eliminated for each cover type by visual examination of TM and elevation values for their respective regions.

Total plots in ground-truth file	1652	
Total 1994-95 field plots	947	
Plots sampled for P41/R26		493
Plots sampled for other scenes		454
Pre-existing plots (ECODATA, TSMRS, etc.)	705	
Plots held aside or eliminated	973	
Duplicates		317
Pre-existing plots		477
Manually labeled cover types		179
Potential training plots	679	
20% test		136
80% training		543
Supplemental plots (from pre-existing data set)	0	
Total plots available for training	543	
Total plots used for training -- cover type	360	
size class	108	
canopy	403	

Land Cover Types

Land cover types were labeled through a digital classification of the 7 TM channels plus rescaled elevation (meters divided by 25), using the Nearest Member of Group classifier. This classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2 y, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were assigned directly to the COVERTYPE field in the attribute table. Modifications were carried out using spectral class values (SPECTRAL_CLASS, or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000.	Urban.	Manually identified and recoded by Zhenkui Ma.
2000.	Agriculture.	Manually identified and recoded by Zhenkui Ma.
3101.	Foothills Grasslands.	All grass types occurring below 1524 m (5000 ft) were relabeled as Foothills Grasslands.
3104.	Montane Parklands & Subalpine Meadows.	All grass types occurring at or above 1524 m (5000 ft) were reassigned this label.
3201.	Mesic Upland Shrubland.	All regions east of the Continental Divide that were classified as a 3200 level shrub type were relabeled as Mesic Upland Shrubland.
3202.	Warm Mesic Shrubland.	All regions west of the Continental Divide that were classified as a 3200 level shrub type were relabeled as Warm Mesic Shrubland if they occurred below 1463 m (4800 ft). If they occurred between 1463 and 1768 m (5800 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
3203.	Cold Mesic Shrubland.	All regions west of the Continental Divide that were classified as 3200 level shrub types were relabeled as Cold Mesic Shrubland if they occurred above 1768 m (5800 ft). If they occurred between 1463 (4800 ft) and 1768 m, they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
5000.	Water.	All regions with spectral class (LINK = 1) and slope less than or equal to 5˚ were labeled as water; cloud shadows (see 9900 below) were recoded manually. Generally, water was more spectrally distinct than most other cover types, but in mountainous terrain, it was sometimes confused with cliff shadows. A 5˚ slope threshold was

		used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate slope and aspect values such that their slope may be greater than 5˚. This would result in the misclassification of some small ponds or lakes.
(n/a)	Melted Snow.	All regions originally classified as Melted Snow were recoded either to Exposed Rock (7301), if their slope was greater than 5˚, or to Snow (9000), if their slope was less than or equal to 5˚.
9800.	Cloud.	Manually identified and recoded by Zhenkui Ma.
9900.	Cloud Shadow.	Manually identified and recoded by Zhenkui Ma.

A total of 37 classes were labeled in the full TM scene. These included three grass types, three shrub types, twenty forest types, one riparian type, one alpine type, three barren types, plus six manually labeled classes. Land cover classes were reviewed by personnel from the following National Forests: Lolo (Dave Atkins), and Flathead (Maria Mantes). Cover types are mapped in Figure F-6.

Canopy Cover Classes

Canopy cover labels (CANOPY_CODE = low, medium, or high) were assigned to tree and shrub classes based on MNDVI values. These values were plotted as frequency histograms for all coniferous forest types (Figure F-6a) and shrub types (Figure F-6b). The histograms were examined visually and break points decided based on the distribution modes. Regions with MNDVI values falling below the lower break point were assigned to the low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class.

	MNDVI BREAKPOINTS	
CANOPY COVER	Tree	Shrub
Low	<325	<310
Medium	≥325 and <560	≥310
High	≥560	n/a

Size Classes

Six size classes were distinguished -- four for forest cover types (seedling/sapling, pole, medium, and large/very large) and two for shrub cover types (low and medium). Only the seven TM channels were used for these classifications. The Nearest Mean classifier was used for tree size classes, and the Nearest Member of Group classifier was used for shrub size classes. Tree size classes were stratified based upon the canopy cover classes described above.

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications. Note that the Forest Group accuracy was not calculated separately, but was part of the overall Lifeform accuracy assessment. We feel that this Forest Group accuracy is much more reliable than the overall Lifeform accuracy, because the latter includes manually labeled cover types like Urban, Agriculture, and Water. Again, no accuracy assessment was performed on the manually labeled cover types.

Classifications for P41/R26	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	25	60%	22%
Lifeform	5	n/a	61%
Forest Group	20	n/a	91%
Tree Size Class	4	77%	23%
Tree Canopy Class	3	84%	37%
Shrub Size Class	2	97%	62%
Shrub Canopy Class	2	100%	99%

Comments

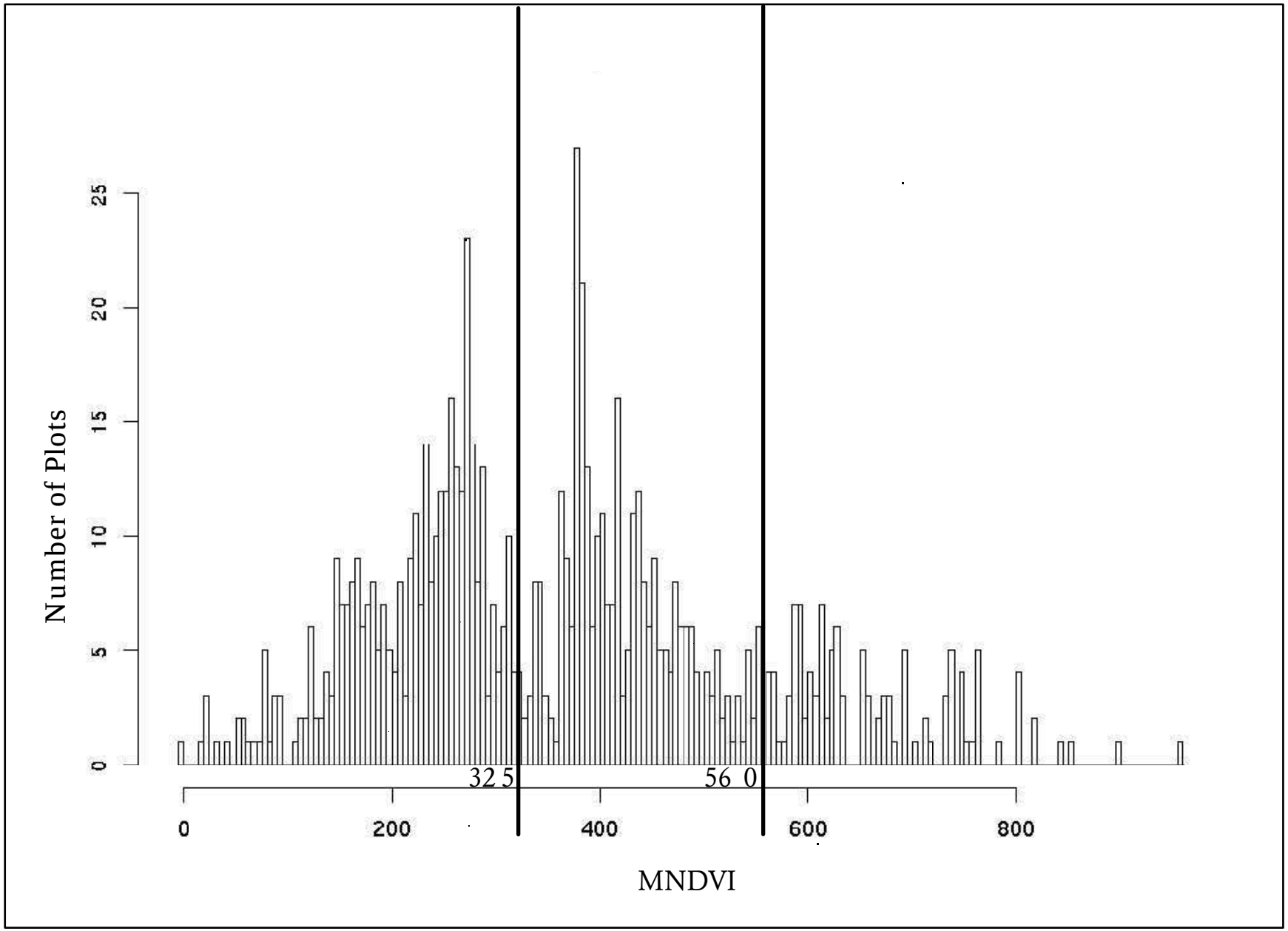
Approximately one-third of this scene extends north of the US border into Canada. No training data were available for this part of the scene; hence, the weighted accuracies for each cover type may be biased and low because the test data are not proportional to the areal representation of the cover types. This was particularly true for the grassland types that were more abundant outside than inside the study area. Thus, the classification should be more accurate inside the study area, where there were more training data and a better representation of test data, than outside the study area.

Error Matrix for Cover Type Training Plots
Scene P41/R26

F.P41/R26. 6

PLOT COVER TYPES	CLASSIFIED COVER TYPES																																
	3101	3102	3104	3201	3202	3203	4101	4102	4201	4203	4205	4207	4208	4210	4211	4212	4215	4219	4220	4221	4222	4223	4225	4226	4229	4301	7301	7800	7900	8101	SUM
3101	24	0	4	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	1	1	37
3102	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
3104	1	0	4	0	1	0	1	0	0	0	0	0	3	0	0	0	0	0	0	1	1	0	0	0	0	0	2	1	0	0	15
3201	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
3202	1	0	1	1	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
3203	0	0	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
4101	0	0	1	0	0	0	2	0	0	1	0	0	0	0	0	2	0	1	0	0	2	0	0	0	0	1	0	0	0	0	10
4102	1	0	0	0	0	0	1	14	0	0	1	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	1	0	23
4201	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	4
4203	0	0	0	0	0	0	1	0	0	6	0	0	1	0	0	1	0	1	5	7	0	0	0	0	0	1	0	0	0	0	23
4205	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6
4207	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
4208	1	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	2	3	1	0	0	0	0	0	0	0	0	0	0	11
4210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
4211	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
4212	0	0	0	0	0	0	2	1	0	1	0	0	1	0	1	1	0	0	1	2	0	0	0	0	0	0	1	0	0	0	11
4215	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	6
4219	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	9
4220	0	0	0	0	0	0	1	0	0	2	0	0	2	0	0	1	0	2	5	2	0	1	0	0	0	1	0	0	0	0	21
4221	0	0	1	0	0	0	1	2	0	4	0	1	1	0	0	3	4	0	3	22	0	1	1	0	2	3	0	0	0	0	49
4222	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	2	1	0	0	0	0	0	0	0	0	6
4223	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	2	1	0	0	0	0	1	0	0	0	0	7
4225	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3
4226	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
4229	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	4
4301	1	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	8
7301	6	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	2	0	1	0	0	0	0	0	0	48	6	0	1	67
7800	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4	0	0	0	9
7900	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	0	6
8101	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
SUM	40	0	15	5	9	3	15	21	4	18	6	1	12	1	2	10	5	10	26	56	7	5	3	0	2	7	63	8	4	2	360

% AGREEMENT	40.56
TAU WITH EQUAL PROBABILITY	0.385
TOTAL DIAGONAL ELEMENTS	146
TOTAL TRAINING PLOTS IN DATA SET	360



FigureF-6a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P41/R2 6

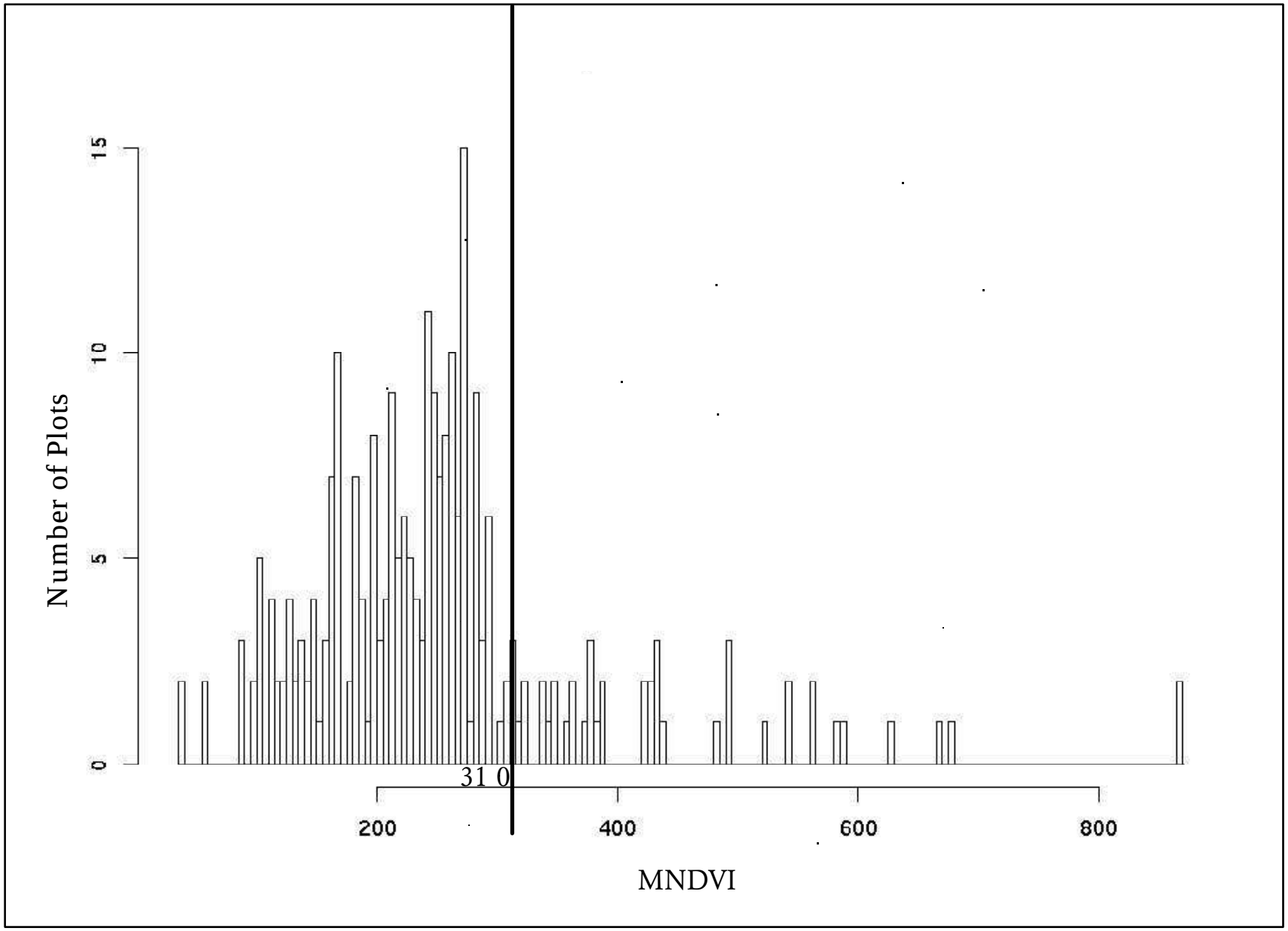


Figure F- 6b. Breaks between shrub canopy cover classes inrelation to MNDVI values: TM scene P41/R26

CONFUSION (FUZZY) MATRIX

RF/CF	3201	3202	3203	4101	4102	4201	4203	4205	4208
3201	0(5)	1(4)	0(4)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)
3202	1(4)	18(5)	7(3)	0(1)	0(1)	0(1)	3(1)	0(1)	0(1)
3203	0(4)	11(3)	5(5)	1(1)	1(1)	1(1)	2(1)	0(1)	6(1)
4101	0(1)	0(1)	0(1)	0(5)	0(4)	0(2)	0(2)	0(2)	0(2)
4102	0(1)	0(1)	0(1)	0(4)	4(5)	0(2)	0(2)	0(2)	0(2)
4201	0(1)	0(1)	1(1)	0(2)	0(2)	0(5)	2(2)	0(2)	0(3)
4203	0(1)	0(1)	0(1)	0(2)	1(2)	0(2)	14(5)	0(2)	1(2)
4205	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)	1(5)	0(2)
4208	0(1)	2(1)	0(1)	2(2)	0(2)	0(3)	11(2)	0(2)	11(5)
4212	0(1)	2(1)	0(1)	0(2)	0(2)	0(2)	1(2)	0(2)	1(2)
4215	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4219	0(1)	0(1)	0(1)	1(2)	0(2)	0(3)	7(3)	0(2)	9(3)
4220	1(1)	2(1)	0(1)	4(2)	1(2)	1(4)	15(3)	0(2)	8(3)
4221	0(1)	1(1)	0(1)	1(2)	2(2)	1(3)	5(3)	1(2)	2(2)
4222	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)	0(3)	1(2)
4223	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(3)	0(2)	0(2)
4225	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4228	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(3)	0(2)	0(2)
4229	0(1)	1(1)	0(1)	0(2)	0(2)	0(2)	1(2)	0(2)	0(2)
4301	0(1)	1(1)	0(1)	0(3)	1(3)	0(2)	1(2)	0(2)	0(2)
7300	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	1(1)
7500	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
7800	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	1(1)	0(1)	0(1)
7900	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	2(0)	39(0)	13(0)	9(0)	10(0)	4(0)	64(0)	2(0)	41(0)

Accuracy Assessment Tables for P41/R26 -- Cover Type

RF/CF	4212	4215	4219	4220	4221	4222	4223	4225	4228
3201	0(1)	1(1)	0(1)	0(1)	1(1)	0(1)	1(1)	0(1)	0(1)
3202	1(1)	11(1)	1(1)	2(1)	11(1)	3(1)	0(1)	0(1)	0(1)
3203	1(1)	2(1)	7(1)	5(1)	11(1)	0(1)	1(1)	0(1)	0(1)
4101	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4102	0(2)	0(2)	0(2)	0(2)	5(2)	0(2)	0(2)	0(2)	0(2)
4201	0(2)	1(2)	1(3)	2(4)	4(4)	0(2)	0(2)	0(2)	0(2)
4203	1(2)	0(2)	2(3)	4(3)	19(3)	1(2)	1(4)	0(2)	0(4)
4205	0(2)	0(2)	0(2)	0(2)	0(2)	0(4)	0(2)	0(2)	0(2)
4208	3(2)	0(2)	9(3)	18(3)	5(3)	0(2)	1(2)	0(2)	0(2)
4212	2(5)	1(3)	1(2)	1(3)	7(3)	0(4)	0(4)	0(4)	0(2)
4215	0(3)	4(5)	0(2)	0(3)	2(3)	0(2)	0(2)	0(2)	0(4)
4219	0(2)	0(2)	5(5)	12(3)	0(2)	0(2)	0(2)	0(2)	0(2)
4220	6(3)	1(2)	5(3)	12(5)	7(2)	1(2)	4(3)	0(2)	0(2)
4221	4(3)	3(3)	1(2)	8(2)	21(5)	0(2)	3(3)	0(4)	0(4)
4222	0(3)	0(2)	0(2)	0(2)	0(2)	0(5)	0(2)	0(2)	0(2)
4223	1(3)	0(2)	1(2)	0(3)	3(3)	0(2)	1(5)	0(3)	0(4)
4225	0(3)	0(2)	0(2)	0(2)	0(4)	0(2)	0(3)	0(5)	0(3)
4228	0(2)	0(3)	0(2)	0(3)	1(4)	0(2)	0(4)	0(3)	0(5)
4229	0(3)	1(3)	0(2)	1(3)	3(4)	0(2)	0(4)	0(3)	0(4)
4301	0(2)	3(2)	0(2)	1(3)	4(3)	0(3)	0(3)	0(3)	0(3)
7300	0(1)	0(1)	0(1)	0(1)	3(1)	0(1)	0(1)	0(1)	0(1)
7500	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
7800	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
7900	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	20(0)	28(0)	33(0)	66(0)	108(0)	5(0)	12(0)	0(0)	0(0)

Accuracy Assessment Tables for P41/R26 -- Cover Type

RF/CF	4229	4301	7300	7500	7800	7900	8101	SUM
3201	0(1)	0(1)	1(1)	0(0)	0(1)	0(1)	0(1)	6(0)
3202	0(1)	2(1)	0(1)	0(0)	0(1)	0(1)	1(1)	64(0)
3203	0(1)	0(1)	0(1)	0(0)	0(1)	0(1)	0(1)	58(0)
4101	0(2)	0(4)	0(1)	0(0)	0(1)	0(1)	0(1)	4(0)
4102	1(2)	0(4)	0(1)	0(0)	0(1)	0(1)	0(1)	10(0)
4201	0(2)	0(2)	2(1)	0(0)	0(1)	0(1)	0(1)	13(0)
4203	1(2)	0(2)	1(1)	0(0)	0(1)	0(1)	0(1)	47(0)
4205	0(2)	0(2)	0(1)	0(0)	0(1)	0(1)	0(1)	2(0)
4208	0(2)	1(2)	2(1)	0(0)	0(1)	0(1)	1(1)	67(0)
4212	1(4)	1(2)	1(1)	0(0)	0(1)	0(1)	0(1)	19(0)
4215	0(4)	1(2)	0(1)	0(0)	0(1)	0(1)	0(1)	7(0)
4219	0(2)	0(2)	2(1)	0(0)	0(1)	0(1)	1(1)	38(0)
4220	0(2)	3(2)	2(1)	0(0)	0(1)	0(1)	0(1)	74(0)
4221	1(4)	1(2)	0(1)	0(0)	0(1)	0(1)	0(1)	57(0)
4222	0(2)	0(2)	0(1)	0(0)	0(1)	0(1)	0(1)	1(0)
4223	0(4)	0(2)	0(1)	0(0)	0(1)	0(1)	0(1)	6(0)
4225	0(3)	0(2)	0(1)	0(0)	0(1)	0(1)	0(1)	1(0)
4228	0(4)	0(2)	0(1)	0(0)	0(1)	0(1)	0(1)	1(0)
4229	1(5)	0(2)	0(1)	0(0)	0(1)	0(1)	0(1)	8(0)
4301	0(3)	0(5)	0(1)	0(0)	0(1)	0(1)	0(1)	11(0)
7300	0(1)	0(1)	16(5)	0(0)	0(3)	0(2)	0(1)	24(0)
7500	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	2(0)
7800	0(1)	0(1)	3(3)	0(0)	0(5)	0(3)	0(3)	8(0)
7900	0(1)	0(1)	1(3)	0(0)	0(2)	0(5)	0(1)	2(0)
8101	0(1)	0(1)	1(1)	0(0)	0(3)	0(1)	0(5)	1(0)
SUM	5(0)	9(0)	32(0)	0(0)	0(0)	0(0)	3(0)	531(0)

Diagnol Elements = 115; Total Test Points = 531
Percentage Agreement = 21.66; Kappa = 0.147
Tau w/equal Prob = 0.184

26 points not belong to groups listed in the
test data and treated as mis-classification
Default score for these 26 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3201	0	0.00	1	16.67	0	0.00	0	0.00	5	83.33
3202	18	28.12	1	1.56	7	10.94	0	0.00	38	59.38
3203	5	8.62	0	0.00	11	18.97	0	0.00	42	72.41
4101	0	0.00	0	0.00	0	0.00	0	0.00	4	100.00
4102	4	40.00	0	0.00	0	0.00	6	60.00	0	0.00
4201	0	0.00	6	46.15	1	7.69	3	23.08	3	23.08
4203	14	29.79	1	2.13	25	53.19	5	10.64	2	4.26
4205	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4208	11	16.42	0	0.00	32	47.76	18	26.87	6	8.96
4212	2	10.53	1	5.26	9	47.37	4	21.05	3	15.79
4215	4	57.14	0	0.00	2	28.57	1	14.29	0	0.00
4219	5	13.16	0	0.00	28	73.68	1	2.63	4	10.53
4220	12	16.22	1	1.35	38	51.35	17	22.97	6	8.11
4221	21	36.84	1	1.75	16	28.07	16	28.07	3	5.26
4222	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00
4223	1	16.67	0	0.00	4	66.67	1	16.67	0	0.00
4225	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4228	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
4229	1	12.50	3	37.50	2	25.00	1	12.50	1	12.50
4301	0	0.00	0	0.00	6	54.55	4	36.36	1	9.09
7300	16	66.67	0	0.00	0	0.00	0	0.00	8	33.33
7500	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
7800	0	0.00	0	0.00	3	37.50	0	0.00	5	62.50
7900	0	0.00	0	0.00	1	50.00	0	0.00	1	50.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	115	21.66	16	3.01	185	34.84	78	14.69	137	25.80

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3201	0	0.00	1	16.67	1	16.67	1	16.67	6	100.00
3202	18	28.12	19	29.69	26	40.62	26	40.62	64	100.00
3203	5	8.62	5	8.62	16	27.59	16	27.59	58	100.00
4101	0	0.00	0	0.00	0	0.00	0	0.00	4	100.00
4102	4	40.00	4	40.00	4	40.00	10	100.00	10	100.00
4201	0	0.00	6	46.15	7	53.85	10	76.92	13	100.00
4203	14	29.79	15	31.91	40	85.11	45	95.74	47	100.00
4205	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4208	11	16.42	11	16.42	43	64.18	61	91.04	67	100.00
4212	2	10.53	3	15.79	12	63.16	16	84.21	19	100.00
4215	4	57.14	4	57.14	6	85.71	7	100.00	7	100.00
4219	5	13.16	5	13.16	33	86.84	34	89.47	38	100.00
4220	12	16.22	13	17.57	51	68.92	68	91.89	74	100.00
4221	21	36.84	22	38.60	38	66.67	54	94.74	57	100.00
4222	0	0.00	0	0.00	0	0.00	1	100.00	1	100.00
4223	1	16.67	1	16.67	5	83.33	6	100.00	6	100.00
4225	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4228	0	0.00	1	100.00	1	100.00	1	100.00	1	100.00
4229	1	12.50	4	50.00	6	75.00	7	87.50	8	100.00
4301	0	0.00	0	0.00	6	54.55	10	90.91	11	100.00
7300	16	66.67	16	66.67	16	66.67	16	66.67	24	100.00
7500	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
7800	0	0.00	0	0.00	3	37.50	3	37.50	8	100.00
7900	0	0.00	0	0.00	1	50.00	1	50.00	2	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	115	21.66	131	24.67	316	59.51	394	74.20	531	100.00

Accuracy Assessment Tables for P41/R26 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3201	0	0.00	1	50.00	0	0.00	0	0.00	1	50.00
3202	18	46.15	1	2.56	11	28.21	0	0.00	9	23.08
3203	5	38.46	0	0.00	7	53.85	0	0.00	1	7.69
4101	0	0.00	0	0.00	0	0.00	8	88.89	1	11.11
4102	4	40.00	0	0.00	1	10.00	4	40.00	1	10.00
4201	0	0.00	1	25.00	1	25.00	0	0.00	2	50.00
4203	14	21.88	0	0.00	27	42.19	16	25.00	7	10.94
4205	1	50.00	0	0.00	0	0.00	1	50.00	0	0.00
4208	11	26.83	0	0.00	17	41.46	5	12.20	8	19.51
4212	2	10.00	0	0.00	11	55.00	4	20.00	3	15.00
4215	4	14.29	0	0.00	5	17.86	5	17.86	14	50.00
4219	5	15.15	0	0.00	17	51.52	3	9.09	8	24.24
4220	12	18.18	2	3.03	37	56.06	8	12.12	7	10.61
4221	21	19.44	8	7.41	40	37.04	12	11.11	27	25.00
4222	0	0.00	0	0.00	0	0.00	2	40.00	3	60.00
4223	1	8.33	1	8.33	7	58.33	1	8.33	2	16.67
4225	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4228	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4229	1	20.00	2	40.00	0	0.00	2	40.00	0	0.00
4301	0	0.00	0	0.00	0	0.00	7	77.78	2	22.22
7300	16	50.00	0	0.00	4	12.50	0	0.00	12	37.50
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7900	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
SUM	115	22.77	16	3.17	185	36.63	78	15.45	111	21.98

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3201	0	0.00	1	50.00	1	50.00	1	50.00	2	100.00
3202	18	46.15	19	48.72	30	76.92	30	76.92	39	100.00
3203	5	38.46	5	38.46	12	92.31	12	92.31	13	100.00
4101	0	0.00	0	0.00	0	0.00	8	88.89	9	100.00
4102	4	40.00	4	40.00	5	50.00	9	90.00	10	100.00
4201	0	0.00	1	25.00	2	50.00	2	50.00	4	100.00
4203	14	21.88	14	21.88	41	64.06	57	89.06	64	100.00
4205	1	50.00	1	50.00	1	50.00	2	100.00	2	100.00
4208	11	26.83	11	26.83	28	68.29	33	80.49	41	100.00
4212	2	10.00	2	10.00	13	65.00	17	85.00	20	100.00
4215	4	14.29	4	14.29	9	32.14	14	50.00	28	100.00
4219	5	15.15	5	15.15	22	66.67	25	75.76	33	100.00
4220	12	18.18	14	21.21	51	77.27	59	89.39	66	100.00
4221	21	19.44	29	26.85	69	63.89	81	75.00	108	100.00
4222	0	0.00	0	0.00	0	0.00	2	40.00	5	100.00
4223	1	8.33	2	16.67	9	75.00	10	83.33	12	100.00
4225	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4228	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4229	1	20.00	3	60.00	3	60.00	5	100.00	5	100.00
4301	0	0.00	0	0.00	0	0.00	7	77.78	9	100.00
7300	16	50.00	16	50.00	20	62.50	20	62.50	32	100.00
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7900	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
SUM	115	22.77	131	25.94	316	62.57	394	78.02	505	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3201	0	0.00	1	16.67	0	0.00	0	0.00	3	83.33
3202	6	28.12	0	1.56	2	10.94	0	0.00	12	59.38
3203	1	8.62	0	0.00	2	18.97	0	0.00	7	72.41
4101	0	0.00	0	0.00	0	0.00	0	0.00	47	100.00
4102	14	40.00	0	0.00	0	0.00	20	60.00	0	0.00
4201	0	0.00	4	46.15	1	7.69	2	23.08	2	23.08
4203	38	29.79	3	2.13	68	53.19	14	10.64	5	4.26
4205	7	50.00	0	0.00	0	0.00	0	0.00	7	50.00
4208	12	16.42	0	0.00	35	47.76	20	26.87	7	8.96
4212	4	10.53	2	5.26	19	47.37	8	21.05	6	15.79
4215	15	57.14	0	0.00	7	28.57	4	14.29	0	0.00
4219	9	13.16	0	0.00	51	73.68	2	2.63	7	10.53
4220	23	16.22	2	1.35	74	51.35	33	22.97	12	8.11
4221	85	36.84	4	1.75	65	28.07	65	28.07	12	5.26
4222	0	0.00	0	0.00	0	0.00	72	100.00	0	0.00
4223	6	16.67	0	0.00	24	66.67	6	16.67	0	0.00
4225	0	0.00	0	0.00	0	0.00	0	0.00	6	100.00
4228	0	0.00	0	100.00	0	0.00	0	0.00	0	0.00
4229	1	12.50	2	37.50	1	25.00	1	12.50	1	12.50
4301	0	0.00	0	0.00	5	54.55	3	36.36	1	9.09
7300	0	66.67	0	0.00	0	0.00	0	0.00	0	33.33
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
7800	0	0.00	0	0.00	4	37.50	0	0.00	6	62.50
7900	0	0.00	0	0.00	8	50.00	0	0.00	8	50.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
SUM	221	21.97	18	1.79	366	36.38	250	24.85	151	15.01

ACCUMULATE MATRIX (weighted producer) (assuing 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3201	0	0.00	1	16.67	1	16.67	1	16.67	4	100.00
3202	6	28.12	6	29.69	8	40.62	8	40.62	20	100.00
3203	1	8.62	1	8.62	3	27.59	3	27.59	9	100.00
4101	0	0.00	0	0.00	0	0.00	0	0.00	47	100.00
4102	14	40.00	14	40.00	14	40.00	34	100.00	34	100.00
4201	0	0.00	4	46.15	4	53.85	6	76.92	8	100.00
4203	38	29.79	41	31.91	108	85.11	122	95.74	127	100.00
4205	7	50.00	7	50.00	7	50.00	7	50.00	13	100.00
4208	12	16.42	12	16.42	48	64.18	68	91.04	74	100.00
4212	4	10.53	6	15.79	25	63.16	33	84.21	39	100.00
4215	15	57.14	15	57.14	22	85.71	26	100.00	26	100.00
4219	9	13.16	9	13.16	60	86.84	62	89.47	70	100.00
4220	23	16.22	25	17.57	99	68.92	133	91.89	144	100.00
4221	85	36.84	89	38.60	154	66.67	218	94.74	230	100.00
4222	0	0.00	0	0.00	0	0.00	72	100.00	72	100.00
4223	6	16.67	6	16.67	30	83.33	35	100.00	35	100.00
4225	0	0.00	0	0.00	0	0.00	0	0.00	6	100.00
4228	0	0.00	0	100.00	0	100.00	0	100.00	0	100.00
4229	1	12.50	2	50.00	3	75.00	4	87.50	5	100.00
4301	0	0.00	0	0.00	5	54.55	8	90.91	8	100.00
7300	0	66.67	0	66.67	0	66.67	0	66.67	0	100.00
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
7800	0	0.00	0	0.00	4	37.50	4	37.50	10	100.00
7900	0	0.00	0	0.00	8	50.00	8	50.00	15	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
SUM	221	22.14	238	23.85	603	60.42	852	85.37	998	100.00

Accuracy Assessment Tables for P41/R26 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	4	SUM
1	9(5)	30(3)	17(1)	7(1)	71(0)
2	7(3)	17(5)	20(3)	14(1)	59(0)
3	2(1)	3(3)	6(5)	1(3)	12(0)
4	0(1)	0(1)	1(3)	0(5)	1(0)
SUM	18(0)	50(0)	44(0)	22(0)	143(0)

Diagonal Elements = 32; Total Test Points = 143
Percentage Agreement = 22.38; Kappa = -0.013; Tau w/equal Prob = -0.035

9 points not belong to groups listed in the
test data and treated as mis-classification
Default score for these 9 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	12.68	0	0.00	30	42.25	0	0.00	32	45.07
2	17	28.81	0	0.00	27	45.76	0	0.00	15	25.42
3	6	50.00	0	0.00	4	33.33	0	0.00	2	16.67
4	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
SUM	32	22.38	0	0.00	62	43.36	0	0.00	49	34.27

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	12.68	9	12.68	39	54.93	39	54.93	71	100.00
2	17	28.81	17	28.81	44	74.58	44	74.58	59	100.00
3	6	50.00	6	50.00	10	83.33	10	83.33	12	100.00
4	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
SUM	32	22.38	32	22.38	94	65.73	94	65.73	143	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	50.00	0	0.00	7	38.89	0	0.00	2	11.11
2	17	34.00	0	0.00	33	66.00	0	0.00	0	0.00
3	6	13.64	0	0.00	21	47.73	0	0.00	17	38.64
4	0	0.00	0	0.00	1	4.55	0	0.00	21	95.45
SUM	32	23.88	0	0.00	62	46.27	0	0.00	40	29.85

Accuracy Assessment Tables for P41/R26 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	50.00	9	50.00	16	88.89	16	88.89	18	100.00
2	17	34.00	17	34.00	50	100.00	50	100.00	50	100.00
3	6	13.64	6	13.64	27	61.36	27	61.36	44	100.00
4	0	0.00	0	0.00	1	4.55	1	4.55	22	100.00
SUM	32	23.88	32	23.88	94	70.15	94	70.15	134	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	35	12.68	0	0.00	116	42.25	0	0.00	124	45.07
2	79	28.81	0	0.00	126	45.76	0	0.00	70	25.42
3	115	50.00	0	0.00	77	33.33	0	0.00	38	16.67
4	0	0.00	0	0.00	220	100.00	0	0.00	0	0.00
SUM	229	22.90	0	0.00	539	53.90	0	0.00	232	23.20

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	35	12.68	35	12.68	151	54.93	151	54.93	275	100.00
2	79	28.81	79	28.81	205	74.58	205	74.58	275	100.00
3	115	50.00	115	50.00	192	83.33	192	83.33	230	100.00
4	0	0.00	0	0.00	220	100.00	220	100.00	220	100.00
SUM	229	22.90	229	22.90	768	76.80	768	76.80	1000	100.00

Accuracy Assessment Tables for P41/R26 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	4(5)	3(3)	0(1)	7(0)
2	13(3)	6(5)	19(3)	38(0)
3	1(1)	4(3)	10(5)	15(0)
SUM	18(0)	13(0)	29(0)	60(0)

Diagonal Elements = 20; Total Test Points = 60
Percentage Agreement = 33.33; Kappa = 0.057; Tau w/equal Prob = 0.000

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	57.14	0	0.00	3	42.86	0	0.00	0	0.00
2	6	15.79	0	0.00	32	84.21	0	0.00	0	0.00
3	10	66.67	0	0.00	4	26.67	0	0.00	1	6.67
SUM	20	33.33	0	0.00	39	65.00	0	0.00	1	1.67

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	57.14	4	57.14	7	100.00	7	100.00	7	100.00
2	6	15.79	6	15.79	38	100.00	38	100.00	38	100.00
3	10	66.67	10	66.67	14	93.33	14	93.33	15	100.00
SUM	20	33.33	20	33.33	59	98.33	59	98.33	60	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	22.22	0	0.00	13	72.22	0	0.00	1	5.56
2	6	46.15	0	0.00	7	53.85	0	0.00	0	0.00
3	10	34.48	0	0.00	19	65.52	0	0.00	0	0.00
SUM	20	33.33	0	0.00	39	65.00	0	0.00	1	1.67

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	22.22	4	22.22	17	94.44	17	94.44	18	100.00
2	6	46.15	6	46.15	13	100.00	13	100.00	13	100.00
3	10	34.48	10	34.48	29	100.00	29	100.00	29	100.00
SUM	20	33.33	20	33.33	59	98.33	59	98.33	60	100.00

Accuracy Assessment Tables for P41/R26 -- Shrub Size Class

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	275	57.14	0	0.00	206	42.86	0	0.00	0	0.00
2	0	15.79	0	0.00	0	84.21	0	0.00	0	0.00
3	346	66.67	0	0.00	138	26.67	0	0.00	35	6.67
SUM	621	62.10	0	0.00	344	34.40	0	0.00	35	3.50

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	275	57.14	275	57.14	481	100.00	481	100.00	481	100.00
2	0	15.79	0	15.79	0	100.00	0	100.00	0	100.00
3	346	66.67	346	66.67	485	93.33	485	93.33	519	100.00
SUM	621	62.10	621	62.10	966	96.60	966	96.60	1000	100.00

Accuracy Assessment Tables for P41/R26 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	13(5)	14(3)	3(1)	30(0)
2	10(3)	9(5)	7(3)	28(0)
3	1(1)	1(3)	2(5)	6(0)
SUM	24(0)	24(0)	12(0)	64(0)

Diagonal Elements = 24; Total Test Points = 64
Percentage Agreement = 37.50; Kappa = 0.027; Tau w/equal Prob = 0.062

4 points not belong to groups listed in the
test data and treated as mis-classification
Default score for these 4 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	13	43.33	0	0.00	14	46.67	0	0.00	3	10.00
2	9	32.14	0	0.00	17	60.71	0	0.00	2	7.14
3	2	33.33	0	0.00	1	16.67	0	0.00	3	50.00
SUM	24	37.50	0	0.00	32	50.00	0	0.00	8	12.50

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	13	43.33	13	43.33	27	90.00	27	90.00	30	100.00
2	9	32.14	9	32.14	26	92.86	26	92.86	28	100.00
3	2	33.33	2	33.33	3	50.00	3	50.00	6	100.00
SUM	24	37.50	24	37.50	56	87.50	56	87.50	64	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	13	54.17	0	0.00	10	41.67	0	0.00	1	4.17
2	9	37.50	0	0.00	15	62.50	0	0.00	0	0.00
3	2	16.67	0	0.00	7	58.33	0	0.00	3	25.00
SUM	24	40.00	0	0.00	32	53.33	0	0.00	4	6.67

Accuracy Assessment Tables for P41/R26 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	13	54.17	13	54.17	23	95.83	23	95.83	24	100.00
2	9	37.50	9	37.50	24	100.00	24	100.00	24	100.00
3	2	16.67	2	16.67	9	75.00	9	75.00	12	100.00
SUM	24	40.00	24	40.00	56	93.33	56	93.33	60	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	198	43.33	0	0.00	213	46.67	0	0.00	46	10.00
2	118	32.14	0	0.00	222	60.71	0	0.00	26	7.14
3	59	33.33	0	0.00	30	16.67	0	0.00	89	50.00
SUM	375	37.46	0	0.00	465	46.45	0	0.00	161	16.08

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	198	43.33	198	43.33	411	90.00	411	90.00	457	100.00
2	118	32.14	118	32.14	340	92.86	340	92.86	366	100.00
3	59	33.33	59	33.33	89	50.00	89	50.00	177	100.00
SUM	375	37.50	375	37.50	840	84.00	840	84.00	1000	100.00

Accuracy Assessment Tables for P41/R26 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	5(5)	0(3)	0(1)	5(0)
2	3(3)	0(5)	0(3)	3(0)
3	4(1)	1(3)	0(5)	5(0)
SUM	12(0)	1(0)	0(0)	13(0)

Diagonal Elements = 5; Total Test Points = 13
Percentage Agreement = 38.46; Kappa = 0.019; Tau w/equal Prob = 0.077

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	5	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00
3	0	0.00	0	0.00	1	20.00	0	0.00	4	80.00
SUM	5	38.46	0	0.00	4	30.77	0	0.00	4	30.77

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	5	100.00	5	100.00	5	100.00	5	100.00	5	100.00
2	0	0.00	0	0.00	3	100.00	3	100.00	3	100.00
3	0	0.00	0	0.00	1	20.00	1	20.00	5	100.00
SUM	5	38.46	5	38.46	9	69.23	9	69.23	13	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	5	41.67	0	0.00	3	25.00	0	0.00	4	33.33
2	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	5	38.46	0	0.00	4	30.77	0	0.00	4	30.77

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	5	41.67	5	41.67	8	66.67	8	66.67	12	100.00
2	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	5	38.46	5	38.46	9	69.23	9	69.23	13	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

Accuracy Assessment Tables for P41/R26 -- Shrub Canopy Closure

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	994	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	6	100.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	20.00	0	0.00	0	80.00
SUM	994	99.40	0	0.00	6	0.60	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	994	100.00	994	100.00	994	100.00	994	100.00	994	100.00
2	0	0.00	0	0.00	6	100.00	6	100.00	6	100.00
3	0	0.00	0	0.00	0	20.00	0	20.00	0	100.00
SUM	994	99.40	994	99.40	1000	100.00	1000	100.00	1000	100.00

Scene P41/R26 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	113413.0	1393778.3	41.0
1000	447.0	3565.1	0.1
2000	8515.0	112171.1	3.3
3101	16399.0	306770.2	9.0
3102	2084.0	32139.2	0.9
3104	6056.0	38398.9	1.1
3201	695.0	4390.4	0.1
3202	1986.0	19905.8	0.6
3203	1452.0	13836.5	0.4
4101	4692.0	52127.5	1.5
4102	3355.0	24898.6	0.7
4201	1233.0	10842.5	0.3
4203	14565.0	158080.1	4.7
4205	1580.0	15480.4	0.5
4207	134.0	1595.4	0.0
4208	10187.0	92506.2	2.7
4210	156.0	1014.7	0.0
4211	46.0	625.4	0.0
4212	5236.0	57471.4	1.7
4215	2926.0	36572.2	1.1
4219	12971.0	90726.7	2.7
4220	17792.0	191401.9	5.6
4221	24389.0	313970.7	9.2
4222	2684.0	26081.6	0.8
4223	4277.0	47468.6	1.4
4225	1021.0	10286.0	0.3
4226	205.0	1673.8	0.0
4229	789.0	7241.6	0.2
4301	1070.0	12010.1	0.4
5000	5320.0	33902.1	1.0
6102	375.0	3223.2	0.1
7300	24386.0	237712.0	7.0
7800	741.0	5655.6	0.2
7900	989.0	8714.5	0.3
8100	520.0	2987.6	0.1
9100	189.0	2128.5	0.1
9800	648.0	18461.2	0.5
9900	738.0	9797.5	0.3

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	113413.0	1393778.3	41.0
Not tree/shrub	67032.0	812403.4	23.9
Shrub 1	4092.0	37914.3	1.1
Shrub 2	41.0	218.3	0.0
Tree 1	46582.0	452598.0	13.3
Tree 2	42664.0	474495.9	14.0
Tree 3	20437.0	228204.6	6.7

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	113413.0	1393778.3	41.0
Not tree/shrub	67032.0	812403.4	23.9
Tree 1	18990.0	251114.6	7.4
Tree 2	31724.0	309436.9	9.1
Tree 3	29807.0	292371.4	8.6
Tree 4	29162.0	302375.7	8.9
Shrub 1	1780.0	13631.3	0.4
Shrub 3	2353.0	24501.3	0.7

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	113413.0	1393778.3	41.0
A	8515.0	112171.1	3.3
H	25059.0	380295.8	11.2
N	33458.0	319936.4	9.4
S	4133.0	38132.6	1.1
T	109683.0	1155298.6	34.0

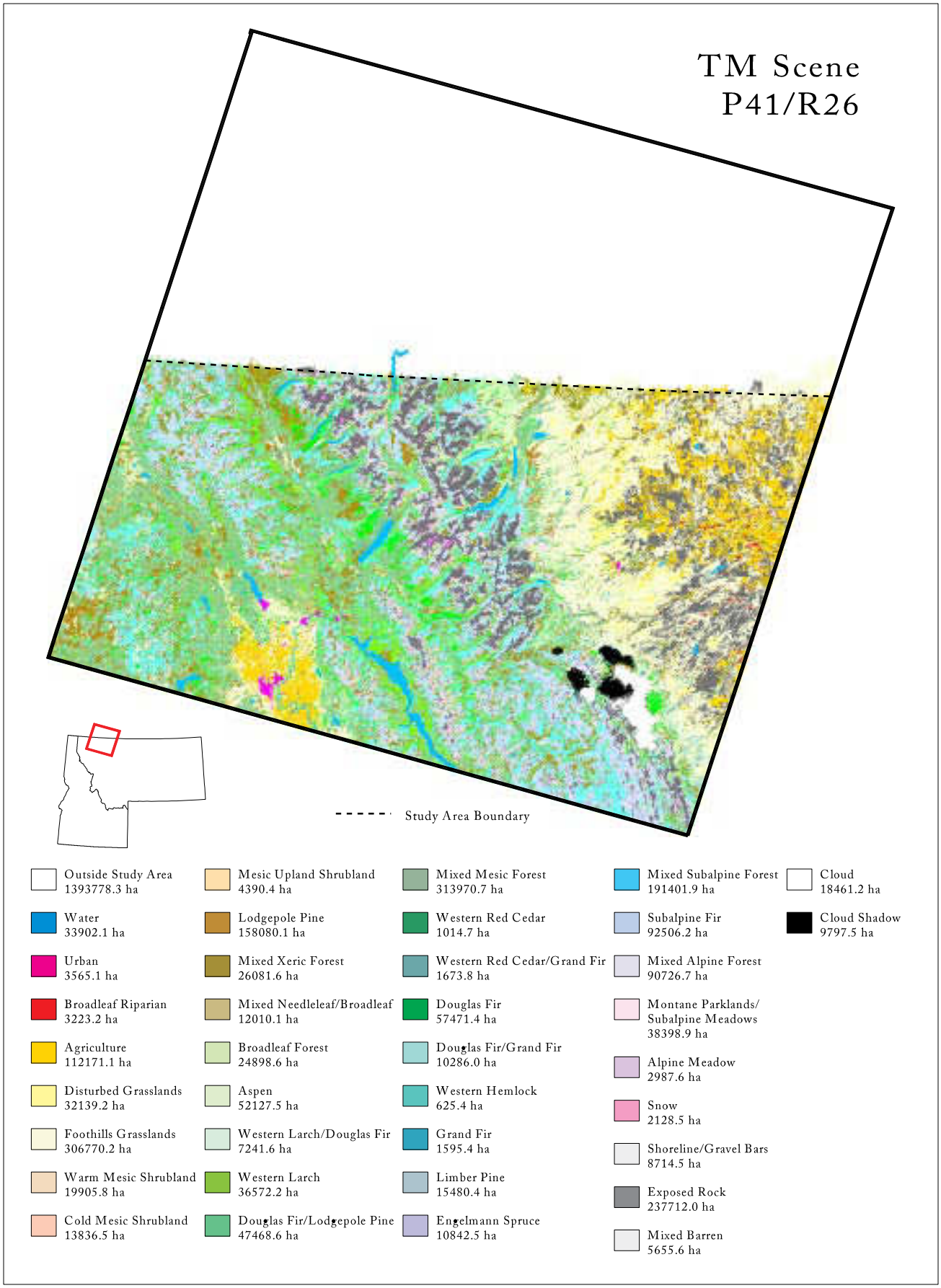


Figure F-6. Classification of land cover types for TM Scene P41/R26.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P41/R26

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4101: ASPEN FOREST

Aspen forest dominated by quaking aspen (Populus tremuloides) and ranging from 4494 to 6116 feet in elevation. The average canopy cover is 61% ranging from 40-90% total cover and frequency of occurrence equal to 94%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥3% and ≤7% and frequency of occurrence ≥17% and ≤39%.

Primary associated shrub species with ≥11% and ≤56% frequency of occurrence in aspen stands: western serviceberry (Amelanchier alnifolia), thimbleberry (Rubus parviflorum), willow (Salix spp.), scouler willow (Salix scouleriana), Canada buffaloberry (Shepherdia canadensis), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤17% frequency of occurrence in aspen stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), common timothy (Phleum pratense), and needlegrass (Stipa spp.); **forbs**: showy aster (Aster conspicuus), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), white geranium (Geranium richardsonii), cow-parsnip (Heracleum lanatum), western meadowrue (Thalictrum occidentale), and violet (Viola spp.); **ferns**: none; **moss**: none.

2) 4201: ENGELMANN SPRUCE FOREST

Conifer forest dominated by Engelmann spruce (Picea engelmannii) ranging from 3540 to 6620 feet in elevation. The average canopy cover is 34%, ranging from 10-70% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), western larch (Larix occidentalis), and lodgepole pine (Pinus contorta) with average percent cover ≥4% and ≤6% and frequency of occurrence ≥17% and ≤70%.

Primary associated shrub species with ≥17% and ≤40% frequency of occurrence in Engelmann spruce stands: sitka alder (Alnus sinuata), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), cascade mountain-ash (Sorbus scopulina), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤33% frequency of occurrence in Engelmann spruce stands: **graminoids**: Columbia brome

(Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), orchard-grass (Dactylis glomerata), smooth woodrush (Luzula hitchcockii.), marsh muhly (Muhlenbergia glomerata); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), western meadowrue (Thalictrum occidentale), trefoil foamflower (Tiarella trifoliata), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), horsetail (Equisetum spp.), oak-fern (Gymnocarpium dryopteris), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

3) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 2546 to 6550 feet in elevation. The average canopy cover is 42% ranging from 10-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤5% and frequency of occurrence ≥36% and ≤65%.

Primary associated shrub species with ≥24% and ≤56% frequency of occurrence in lodgepole pine stands: sitka alder (Alnus sinuata), western serviceberry (Amelanchier alnifolia), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤51% frequency of occurrence in lodgepole pine stands: **graminoids**: brome (Bromus spp.), Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), and blue wildrye (Elymus glaucus); **forbs**: common pearly-everlasting (Anaphalis margaritacea), heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), white-flowered hawkweed (Hieracium albiflorum), and beargrass (Xerophyllum tenax); **ferns**: field horsetail (Equisetum arvense) and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

4) 4208: SUBALPINE FIR FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 3400 to 7353 feet in elevation. The average canopy cover is 31% ranging from 1-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), and lodgepole pine (Pinus contorta) with average percent cover ≥2% and ≤5% and frequency of occurrence ≥17% and ≤61%.

Primary associated shrub species with ≥18% and ≤77% frequency of occurrence in subalpine fir stands: sitka alder (Alnus sinuata), Utah honeysuckle (Lonicera utahensis), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), cascade mountain-ash (Sorbus scopulina), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤72% frequency of occurrence in subalpine fir stands: **graminoids**: bluejoint reedgrass (Calamagrostis canadensis), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), smooth woodrush (Luzula glabrata), and smooth woodrush (Luzula hitchcockii); **forbs**: broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), arrowleaf groundsel (Senecio triangularis), western meadowrue (Thalictrum occidentale), green false hellebore (Veratrum viride), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), oak-fern (Gymnocarpium dryopteris), and brackenfern (Pteridium aquilinum); **moss**: none.

5) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 2741 to 6603 feet in elevation. The average canopy cover is 40% ranging from 10-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), western larch (Larix occidentalis), and Engelmann spruce (Picea engelmannii) with average percent cover ≥3% and ≤4% and frequency of occurrence ≥33% and ≤41%.

Primary associated shrub species with ≥35% and ≤59% frequency of occurrence in Douglas-fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤45% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), brome (Bromus spp.), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), and blue wildrye (Elymus glaucus); **forbs**: broadleaf arnica (Arnica latifolia), showy aster (Aster conspicuus), queen's cup beadlily (Clintonia uniflora), hooker fairy-bell (Disporum hookeri), white-flowered hawkweed (Hieracium albiflorum), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: oak-fern (Gymnocarpium dryopteris), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

6) 4215: WESTERN LARCH FOREST

Conifer forest dominated by western larch (Larix occidentalis) ranging from 3637 to 5260 feet in elevation. The average canopy cover is 33% ranging from 20-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii), with average percent cover ≥4% and ≤8% and frequency of occurrence ≥60% and ≤75%.

Primary associated shrub species with ≥40% and ≤75% frequency of occurrence in western larch stands: rocky mountain maple (Acer glabrum), western serviceberry

(Amelanchier alnifolia), Utah honeysuckle (Lonicera utahensis), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤55% frequency of occurrence in western larch stands: **graminoids**: Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), beaked sedge (Carex rostrata), and smooth woodrush (Luzula hitchcockii); **forbs**: common pearly-everlasting (Anaphalis margaritacea), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), ground cedar (Lycopodium complanatum), and brackenfern (Pteridium aquilinum); **moss**: none.

7) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albicaulis) and ranging from 5600 to 7220 feet in elevation. The average canopy cover is 13% ranging from 1-50% total cover and frequency of occurrence equal to 98%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥6% and ≤19% and frequency of occurrence ≥22% and ≤98%.

Primary associated shrub species with ≥6% and ≤86% frequency of occurrence in mixed whitebark pine stands: Utah honeysuckle (Lonicera utahensis), mountain-lover (Pachistima myrsinites), cascade mountain-ash (Sorbus scopulina), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), dwarf bilberry (Vaccinium myrtillus), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤48% frequency of occurrence in mixed whitebark pine stands: **graminoids:** spreading wheatgrass (Agropyron scribneri), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), Drummond's rush (Juncus drummondii), smooth woodrush (Luzula glabrata), and smooth woodrush (Luzula hitchcockii); **forbs**: arnica (Arnica spp.), broadleaf arnica (Arnica latifolia), fireweed (Epilobium angustifolium), bracted lousewort (Pedicularis bracteosa), one-sided wintergreen (Pyrola secunda), trefoil foamflower (Tiarella trifoliata), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina); **moss**: moss (moss spp.).

8) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 3220 to 7000 feet in elevation. The average canopy cover is 20% ranging from 1-60% total cover and frequency of occurrence equal to 99%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥11% and ≤13% and frequency of occurrence ≥35% and ≤90%.

Primary associated shrub species with ≥26% and ≤70% frequency of occurrence in mixed subalpine stands: sitka alder (Alnus sinuata), Utah honeysuckle (Lonicera utahensis), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), cascade mountain-ash (Sorbus scopulina), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤62% frequency of occurrence in mixed subalpine fir stands: **graminoids**: wheatgrass (Agropyron spp.), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), and smooth woodrush (Luzula hitchcockii); **forb**: broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), one-sided wintergreen (Pyrola secunda), arrowleaf groundsel (Senecio triangularis), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), oak-fern (Gymnocarpium dryopteris), clubmoss (Lycopodium spp.), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

9) 4221: MIXED MESIC FOREST

Conifer forest dominated by western larch (Larix occidentalis), codominant species is western red cedar (Thuja plicata) and ranging from 2515 to 6175 feet in elevation. The average canopy cover for LAROCC is 12% ranging from 1-98% total cover and frequency of occurrence equal to 93%. The average canopy cover for THUPLI is 10% ranging from 1-60% total cover and frequency of occurrence equal to 22%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥9% and ≤11% and frequency of occurrence ≥32% and ≤53%.

Primary associated shrub species with ≥27% and ≤41% frequency of occurrence in mixed mesic stands: rocky mountain maple (Acer glabrum), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤30% frequency of occurrence in mixed mesic stands: **graminoids**: wheatgrass (Agropyron spp.), brome (Bromus spp.), Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), and elk sedge (Carex geyeri); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), oak-fern (Gymnocarpium dryopteris), clubmoss (Lycopodium spp.), brackenfern (Pteridium aquilinum), and brackenfern (Pteridium aquilinum latiusculum); **moss**: moss (moss spp.).

10) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) and ranging from 2453 to 6080 feet in elevation. The average canopy cover for PINCON is 19% ranging from 1-40% total cover and frequency of occurrence equal to 95%. The average canopy cover for PSEMEN is 22% ranging from 10-40% total cover and frequency of occurrence equal to 95%. Primary associated tree species include subalpine fir (Abies lasiocarpa), western larch (Larix occidentalis), and Engelmann spruce (Picea engelmannii) with average percent cover ≥4% and ≤7% and frequency of occurrence ≥32% and ≤53%.

Primary associated shrub species with ≥21% and ≤47% frequency of occurrence in Douglas-fir-lodgepole pine stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), common prince's pine (Chimaphila umbellata), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤45% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pumpelly brome (Bromus inermis pumpellianus), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), tufted hairgrass (Deschampsia cespitosa), Kentucky bluegrass (Poa pratensis), and Richardson's needlegrass (Stipa richardsonii); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), showy aster (Aster conspicuus), woods strawberry (Fragaria vesca), white-flowered hawkweed (Hieracium albiflorum), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: none.

11) 4229: WESTERN LARCH-DOUGLAS FIR FOREST

Conifer forest dominated by western larch (Larix occidentalis) and Douglas-fir (Pseudotsuga menziesii) ranging from 2922 to 5000 feet in elevation. The average canopy cover for LAROCC is 21% ranging from 10-50% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 22% ranging from 10-40% total cover and frequency of occurrence equal to 94%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥4% and ≤6% and frequency of occurrence ≥33% and ≤78%.

Primary associated shrub species with ≥28% and ≤50% frequency of occurrence in western larch-Douglas-fir stands: rocky mountain maple (Acer glabrum), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥6% and ≤44% frequency of occurrence in western larch-Douglas-fir stands: **graminoids**: brome (Bromus spp.), Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), and elk sedge (Carex geyeri), and blue wildrye (Elymus glaucus); **forbs**: heart-leaf arnica (Arnica

cordifolia), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), white-flowered hawkweed (Hieracium albiflorum), one-sided wintergreen (Pyrola secunda), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

12) 4301: MIXED NEEDLELEAF/BROADLEAF FOREST

Mixed needleleaf and broadleaf forest dominated by Douglas-fir (Pseudotsuga menziesii) and ranging from 3000 to 5833 feet in elevation. The average canopy cover is 9% ranging from 1-50% total cover and frequency of occurrence equal to 69%. Primary associated tree species include paper birch (Betula papyrifera), western larch (Larix occidentalis), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥8% and ≤15% and frequency of occurrence ≥46% and ≤63%.

Primary associated shrub species with ≥23% and ≤40% frequency of occurrence in mixed needleleaf and broadleaf stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥6% and ≤26% frequency of occurrence in mixed needleleaf and broadleaf stands: **graminoids**: brome (Bromus spp.), Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), and common timothy (Phleum pratense); **forbs**: broadleaf arnica (Arnica latifolia), showy aster (Aster conspicuus), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), meadow horsetail (Equisetum pratense), oak-fern (Gymnocarpium dryopteris), brackenfern (Pteridium aquilinum), and brackenfern (Pteridium aquilinum latiusculum); **moss**: moss (moss spp.).

P41/R26 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	61
6102	Broadleaf Dominated Riparian	58
6103	Needleleaf-Broadleaf Riparian	3
6104	Mixed Riparian (trees + any other)	13
6201	Grass-Forb Riparian/Wetland	65
6202	Shrub Riparian/Wetland	10, 12, 29, 39
6203	Mixed Grass-Forb-Shrub Riparian	None identified for scene

---

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 3
Color: Dark brown; RGB 62 34 33.
Distribution: Medium to high density spackle at middle to upper elevations.
Comment: Training sites outside the riparian zone indicate primarily needleleaf cover types, with Aspen and Mixed Needleleaf-Broadleaf also reported.
Conclusion: 6103.

RECORD#	FREQUENCY	VEGETATION CLASS
3	1	Mixed Subalpine Forest
4	1	Mix Needleleaf-Broadleaf
5	1	Needleleaf-Broadleaf Riparian

Spectral Class 4
Color: Mauve; RGB 160 128 142.
Distribution: located primarily at lower elevations, especially in agricultural areas; some near streams; very light density at other elevation ranges.
Comment: Urban & Developed Land has the single highest frequency outside the zone; rock, shrub, fores, grass and riparian (6103, 6202) are about equally represented.
Conclusion: Not riparian.

6	1	Urban & Developed Land
7	1	Shrub Riparian/Wetland
8	1	Exposed Rock

Spectral Class 6
Color: Light flat green; RGB 131 181 146.
Distribution: Dominates nonagricultural areas on the plains; light to medium density north and west of Kalispell; some clustering along the North Fork of the Flathead River.
Comment: Herbaceous cover types have highest training data frequencies outside the zone;

conifers and exposed rock are next in importance. Color and distribution suggest grass and seedlings, some of which are in burned areas.
Conclusion: Not riparian.

9	1	Foothills Grassland
10	1	Subalpine Meadow
11	2	Shrub Riparian/Wetland

Spectral Class 8
Color: Gray green; RGB 109 137 134.
Distribution: Light density on foothills, low slopes and just above timberline; some clusters on the plains.
Comment: Exposed Rock has the single highest frequency outside the zone; various other cover types are minimally represented in the data. Visual cues indicate rocks.
Conclusion: Not riparian.

12	2	Urban & Developed Land
13	1	Foothills Grassland
14	1	Mixed Mesic Forest
15	1	Grass-Forb Riparian/Wetland
16	1	Sandy Areas, Blowouts

Spectral Class 10
Color: Dark tan; RGB 142 120 84.
Distribution: Medium density along streams, on foothills, and lower mid-elevation locations; light density at mid elevations and in the Kalispell valley.
Comment: Needleleaf cover types are most prevalent among training sites outside the zone; shrub, herbaceous, and riparian (6201, 6101, 6202, 6102) vegetation are included. The red component is too low to represent broadleaf forest.
Conclusion: 6202.

18	1	Subalpine Meadow
19	1	Mesic Upland Shrubland
20	1	Subalpine Fir
21	1	Mix Needleleaf-Broadleaf
22	1	Needleleaf Dominated Riparian
23	2	Broadleaf Dominated Riparian
24	2	Needleleaf-Broadleaf Riparian
25	3	Shrub Riparian/Wetland

Spectral Class 12
Color: Dark red; RGB 153 51 54.
Distribution: High density on some lower mid-elevation slopes; light density at other mountainous locations.
Comment: Needleleaf vegetation dominates training data outside the zone; Aspen and Mixed Needleleaf-Broadleaf cover types are included; two sites indicate presence of riparian vegetation (6102, 6202).
Conclusion: 6202.

29	1	Broadleaf Dominated Riparian
30	1	Needleleaf-Broadleaf Riparian

Spectral Class 13
Color: Brown; RGB 120 89 75.
Distribution: Light to high density at middle elevations; medium density along streams at lower elevations; some gully pattern.
Comment: Needleleaf cover types dominate training data outside the zone; shrub, broadleaf, Mixed Needleleaf-Broadleaf, and riparian (6201, 6102, 6103, 6202) vegetation are also present.
Conclusion: 6104.

31	1	Foothills Grassland
32	1	Douglas-fir
33	1	Mixed Mesic Forest
34	1	Rivers & Streams
35	1	Needleleaf Dominated Riparian
36	3	Broadleaf Dominated Riparian
37	2	Grass-Forb Riparian/Wetland
38	4	Shrub Riparian/Wetland

Spectral Class 14
Color: Bright orange; RGB 255126 67.
Distribution: Occurs in small clusters at lower elevations and along upper elevation slopes.
Comment: Mesic Upland Shrubland was most recorded outside the zone; conifers were next in frequency; Aspen and riparian (6202) vegetation were also noted. Appears to be upland shrub.
Conclusion: Not riparian.

39	1	Dry-land Pasture
40	1	Foothills Grassland
41	1	Shrub Riparian/Wetland

Spectral Class 15
Color: Brown orange; RGB 193 95 59.
Distribution: High density on front range foothills; light to medium density at middle elevations; some along streams at lower elevations.
Comment: Needleleaf and shrub cover types dominate training data outside the zone; broadleaf, Mixed Needleleaf-Broadleaf, and riparian (6202, 6101) cover types are included. Visual cues suggest some conifers, Aspen, and shrubs, though not riparian.
Conclusion: Not riparian.

42	5	Broadleaf Dominated Riparian

Spectral Class 17
Color: Yellow orange; RGB 255 156 71.
Distribution: Small clusters in agricultural areas and along upper elevation slopes; some along streams.
Comment: Mesic Upland Shrubland, herbaceous vegetation, and conifers characterize this spectral class outside the zone; Aspen and Mixed Needleleaf-Broadleaf are minimally present in the data. Visual indicators imply upland shrubs.
Conclusion: Not riparian.

45	1	Irrigated Crop
46	1	Shrub Riparian/Wetland

Spectral Class 21
Color: Dark blue; RGB 55 63 92.
Distribution: Most sites are in water or shadows; light density along streams, in gulleys and some mid-elevation locations.
Comment: With relatively few training sites outside the zone for reference, this spectral class is minimally characterized by conifer, rock, and riparian (6102, 6201) points.
Conclusion: Not riparian.

48	1	Mixed Mesic Forest
49	1	Mix Needleleaf-Broadleaf
50	1	Needleleaf Dominated Riparian

Spectral Class 22
Color: Dark brown; RGB 98 57 46.
Distribution: A large class. High density at most mid-elevation locations and near mountain lakes.
Comment: Needleleaf cover types dominate observations recorded outside the riparian zone; riparian vegetation (6201, 6101, 6103, 6202, 6102) is next in importance. Appears to be primarily Mixed Mesic Forest. Riparian vegetation would be overestimated if this class were selected.

Conclusion: Not riparian.

51	1	Urban & Developed Land
52	1	Foothills Grassland
53	1	Mesic Upland Shrubland
54	1	Subalpine Fir
55	1	Mixed Subalpine Forest
56	2	Needleleaf Dominated Riparian
57	2	Broadleaf Dominated Riparian
58	3	Needleleaf-Broadleaf Riparian
59	2	Shrub Riparian/Wetland

Spectral Class 26
Color: Black; RGB 0 21 54.
Distribution: High density on north slopes.
Comment: Conifers are most prevalent outside the zone; two points indicate riparian vegetation. (6101, 6201). Appears to represent shadows and Douglas-fir.
Conclusion: Not riparian.

60	1	Broadleaf Dominated Riparian
61	1	Exposed Rock

Spectral Class 29
Color: Terracotta; RGB 208 131 96.
Distribution: Medium density on front range foothills; light density at middle elevations, valley, and some portions of the plain; some along streams.
Comment: Training sites outside the zone include Mesic Upland Shrubland, conifers, and herbaceous vegetation. Two points represent riparian (6101, 6102) cover types.
Conclusion: 6202.

64	1	Urban & Developed Land
65	2	Irrigated Crop
66	1	Dry-land Pasture
67	1	Foothills Grassland
68	2	Broadleaf Dominated Riparian
69	1	Grass-Forb Riparian/Wetland
70	2	Shrub Riparian/Wetland

Spectral Class 30
Color: Yellow tan; RGB 215 190 130.
Distribution: Light to medium density at some low elevations locations; light density at high elevations.
Comment: Herbaceous, shrub, and rock cover types characterize this class outside the zone. Distribution indicates rock and developed areas.
Conclusion: Not riparian.

71	2	Irrigated Crop

Spectral Class 37
Color: Bisque pink; RGB 240 209 201.
Distribution: A rare class. Occurs at cloud edges, some high ridges, and occassional low elevation sites.
Comment: A variety of nonriparian cover types were recorded outside the zone for this class. Appears to represent agricultural lands and snow.
Conclusion: Not riparian.

75	1	Shoreline & Gravel Bars

Spectral Class 39
Color: Dark orange; RGB 244 89 59.
Distribution: Light density at some middle to upper elevation locations; very little near streams at lower elevations.
Comment: Shrub and coniferous vegetation are about equally represented among observations outside the zone; one point represents riparian vegetation (6201).
Conclusion: 6202.

76	1	Irrigated Crop

Spectral Class 51
Color: Pink orange; RGB 255 110 134.
Distribution: A rare class, occurring in some clusters on the plain.
Comment: There are no training sites located outside the riparian zone for this class. Color and locations suggest agricultural cover types.
Conclusion: Not riparian.

83	1	Urban & Developed Land
84	1	Dry-land crop

Spectral Class 58
Color: Dark red; RGB 200 67 54.
Distribution: A small class, occurring primarily on mid-elevation slopes; some near streams at lower elevations.

Comment: Conifers are most prevalent among training sites outside the zone; broadleaf forest and riparian (6102, 6103, 6202) vegetation are included. The high red component and the distribution suggest Broadleaf Dominated Riparian vegetation within the zone.
Conclusion: 6102.

86	1	Broadleaf Dominated Riparian
87	1	Shrub Riparian/Wetland

Spectral Class 60
Color: Black; RGB 58 48 42.
Distribution: Light to high density on middle elevation slopes; very little near streams.
Comment: Coniferous cover types dominate training data outside the zone; two points represent riparian vegetation (6101, 6103). Appears to represent nonriparian coniferous vegetation.
Conclusion: Not riparian.

88	1	Lodgepole Pine
89	1	Needleleaf Dominated Riparian

Spectral Class 61
Color: Black; RGB 40 29 38.
Distribution: Shadows.
Comment: Needleleaf cover types are most represented among training sites outside the zone. Several sites represent riparian vegetation (6101, 6202, 6102). Although the shadow color hinders analysis, known distributions of Needleleaf Dominated Riparian vegetation correspond to the class distribution.
Conclusion: 6101.

90	1	Mixed Mesic Forest
91	1	Needleleaf Dominated Riparian
92	2	Dry Salt Flats

Spectral Class 62
Color: Blue black; RGB 0 8 63.
Distribution: Water bodies.
Comment: Exposed Rock and coniferous vegetation are about equally represented among training sites outside the zone. Water bodies, grass, and Urban & Developed Land are included.
Conclusion: Not riparian.

93	3	Rivers & Streams
94	7	Lakes
95	1	Reservoirs
96	1	Needleleaf-Broadleaf Riparian

Spectral Class 65
Color: Olive green; RGB 84 40 42.
Distribution: Medium density on foothills and some low or mid-elevation locations; some along streams.
Comment: Coniferous and herbaceous cover types characterize training sites outside the riparian zone; two sites represent riparian vegetation (6102, 6202). Visual cues suggest Grass-Forb Riparian/Wetland vegetation.
Conclusion: 6201.

98	1	Broadleaf Dominated Riparian

TM SCENE P41/R27

Image Analyst: Zhenkui Ma

Training Data Analysis

A total of 3430 ground-truth plots were available for labeling P41/R27 (see table below); 1891 were collected by Forest Service field crews during the1994-95 field seasons, and 991 of these were collected specifically for this TM scene. The remaining 1539 plots came from pre-existing data sources such as ECODATA and TSMRS.

All the ground-truth data were converted to a point file and superimposed on the unsupervised classification to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 796) were removed from further analysis. Then the data were examined by cover type and by data source (whether or not plots were collected for this project or for other purposes, like pre-existing ECODATA or TSMRS). The latter "existing data" were only used in the training data set to supplement cover types that had insufficient plots collected during the 1994 or 1995 field seasons. Seven classes were excluded from the digital classification process: urban, agriculture, water, snow, melted snow, cloud, and cloud shadow. All ground truth data with VEG_CLASS_CODEs for urban, agriculture, or water cover types were excluded. Next, 20% of the remaining plots were randomly selected from each cover type; these plots (n = 250) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

The remaining 80% of the data (n = 1041plots) were subjected to further spectral examination. Outliers were eliminated for each cover type by visual examination of TM and elevation values for their respective regions. An insufficient number of training data were available for three forest cover types (Aspen, Broadleaf, and Engelmann Spruce). Training data for Engelmann Spruce were supplemented using ECODATA plots. In addition, some manually identified regions were added to the training data for Lodgepole Pine.

Total plots in ground-truth file	3430	
Total 1994-95 field plots	1891	
Plots sampled for P41/R27		991
Plots sampled for other scenes		900
Pre-existing plots (ECODATA, TSMRS, etc.)	1539	
Plots held aside or eliminated	2139	
Duplicates		796
Pre-existing plots		959
Manually labeled cover types		384
Potential training plots	1291	
20% test		250
80% training		1041
Supplemental plots (from pre-existing data set)	10	
Total plots available for training	1051	
Total plots used for training -- cover type	935	
size class	219	
canopy	479	

Land Cover Types

Land cover types were labeled through a digital classification of the 7 TM channels plus rescaled elevation (meters divided by 25), using the Nearest Member of Group classifier. This classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were assigned directly to the COVERTYPE field in the attribute table. Modifications were carried out using spectral class values (SPECTRAL_CLASS, or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000. Urban.	Manually identified and recoded by Zhenkui Ma.
2000. Agriculture.	Manually identified and recoded by Zhenkui Ma.
3101. Foothills Grasslands.	All grass types occurring below 1981 m (6500 ft) were relabeled as Foothills Grasslands.
3104. Montane Parklands & Subalpine Meadows.	All grass types occurring at or above 1980 m (6500 ft) were reassigned this label.
3202. Warm Mesic Shrubland.	All regions that were classified as a 3200 level shrub type were labeled as Warm Mesic Shrubland if they occurred below 1463 m (4800 ft). If they occurred between 1463 and 1768 m (5800 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
3203. Cold Mesic Shrubland.	All regions that were classified as 3200 level shrub types were labeled as Cold Mesic Shrubland if they occurred above 1768 m (5800 ft). If they occurred between 1463 (4800 ft) and 1768 m, they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
5000. Water.	All regions with spectral class (LINK = 1) and slope less than or equal to 5˚ were labeled as water; cloud shadows (see 9900 below) were recoded manually. Generally, water was more spectrally distinct than most other cover types, but in mountainous terrain, it was sometimes confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate slope and aspect values such that their slope may be greater than 5˚. This would result in the misclassification of some small ponds or lakes.
8100. Alpine Meadow.	All grass types (3100) occurring above 2500 m (8200 ft) were relabeled as Alpine Meadow. All the training plots representing Alpine Meadow occurred between 2300 and 2500 m; nonetheless, this elevational threshold was considered reasonable.
(n/a) Melted Snow.	All regions originally classified as Melted Snow were

recoded either to Exposed Rock (7301), if their slope was greater than 5˚, or to Snow (9000), if their slope was less than or equal to 5˚.

9800. Cloud. Manually identified and recoded by Zhenkui Ma.

9900. Cloud Shadow. Manually identified and recoded by Zhenkui Ma.

A total of 31 classes were labeled in the full TM scene. These included three grass types, four shrub types, fifteen forest types, two barren types, one alpine type, plus six manually labeled classes. Land cover classes were reviewed by personnel from the following National Forests: Lolo (Dave Atkins), and Flathead (Maria Mantes). Cover types are mapped in Figure F-7.

Canopy Cover Classes

Canopy cover labels (CANOPY_CODE = low, medium, or high) were assigned to tree and shrub classes based on MNDVI values. These values were plotted as frequency histograms for all coniferous forest types (Figure F-7a) as well as for two different shrub types (mesic versus xeric; Figures F-7b+c). The histograms were examined visually and break points decided based on the distribution modes. Regions with MNDVI values falling below the lower break point were assigned to the low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class.

CANOPY COVER	MNDVI BREAKPOINTS		
	Tree	Shrub	
		Xeric	Mesic
Low	<210	≤45	≤130
Medium	≥210 and < 60	>45	>130 to <220
High	≥360	n/a	≥220

Size Classes

Six size classes were distinguished -- four for forest cover types (seedling/sapling, pole, medium, and large/very large) and two for shrub cover types (low and medium). Only the seven TM channels were used for these classifications. The Nearest Mean classifier was used for tree size classes, and the Nearest Member of Group classifier was used for shrub size classes. Tree size classes were stratified based upon the canopy cover classes described above.

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications. Note that the Forest Group accuracy was not calculated separately but was part of the overall Lifeform accuracy assessment. We feel that this Forest Group accuracy is much more reliable than the overall Lifeform accuracy because the latter includes manually labeled cover types like Urban, Agriculture, and Water. Again, no accuracy assessment was performed on the manually labeled cover types.

Classifications for P41/R27	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	29	64%	25%
Lifeform	5	n/a	60%
Forest Group	15	n/a	89%
Tree Size Class	4	92%	74%
Tree Canopy Class	3	95%	51%
Shrub Size Class	2	92%	79%
Shrub Canopy Class	3	82%	44%

Comments

Both the training and test data were carefully examined and errors were corrected. The accuracies reported for the non-manually labeled cover types should be reliable for those classes for which there were adequate test plots. Some cover types were manually modified to override training information. For example, the decision rule for this cover type was that it could only occur above 2500 m, whereas we found training and test data for this type which were collected at elevations below 2500 m.

Error Matrix For Cover Type Training Plots
Scene P41/R27

		CLASSIFIED COVER TYPES														
		3101	3102	3104	3201	4203	4208	4212	4219	4220	4221	4223	4301	7301	7800	8101	SUM
PLOT COVER TYPES																	
	3101	25	6	1	10	1	1	2	0	0	3	1	0	13	6	0	69
	3102	2	7	0	1	0	0	1	0	0	2	0	0	0	0	0	13
	3104	1	0	2	2	0	0	1	0	1	0	0	0	1	0	0	8
	3201	9	2	1	22	2	1	4	1	0	20	1	0	6	4	0	73
	4203	2	0	1	0	10	2	4	0	8	24	4	0	2	1	0	58
	4208	0	0	0	1	2	4	1	4	2	2	0	0	1	0	0	17
	4212	0	2	1	7	1	0	37	0	2	58	5	3	0	2	0	118
	4219	0	0	0	0	0	3	1	6	2	0	0	0	0	2	0	14
	4220	0	0	0	0	7	3	3	2	7	10	3	0	1	1	0	37
	4221	3	2	0	15	20	3	55	0	3	121	3	5	1	2	0	233
	4223	1	0	0	2	5	0	3	0	2	8	5	0	0	0	0	26
	4301	2	0	0	0	0	0	3	0	0	7	0	0	0	0	0	12
	7301	5	1	3	9	4	3	1	2	3	4	0	0	83	5	0	123
	7800	7	0	0	5	0	0	2	1	1	3	1	0	1	0	0	21
	8101	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3
	SUM	58	20	9	74	52	20	118	16	31	262	23	8	109	23	2	825

% AGREEMENT	40.12
TAU WITH EQUAL PROBABILITY	0.385
TOTAL DIAGONAL ELEMENTS	331
TOTAL TRAINING PLOTS IN DATA SET	825

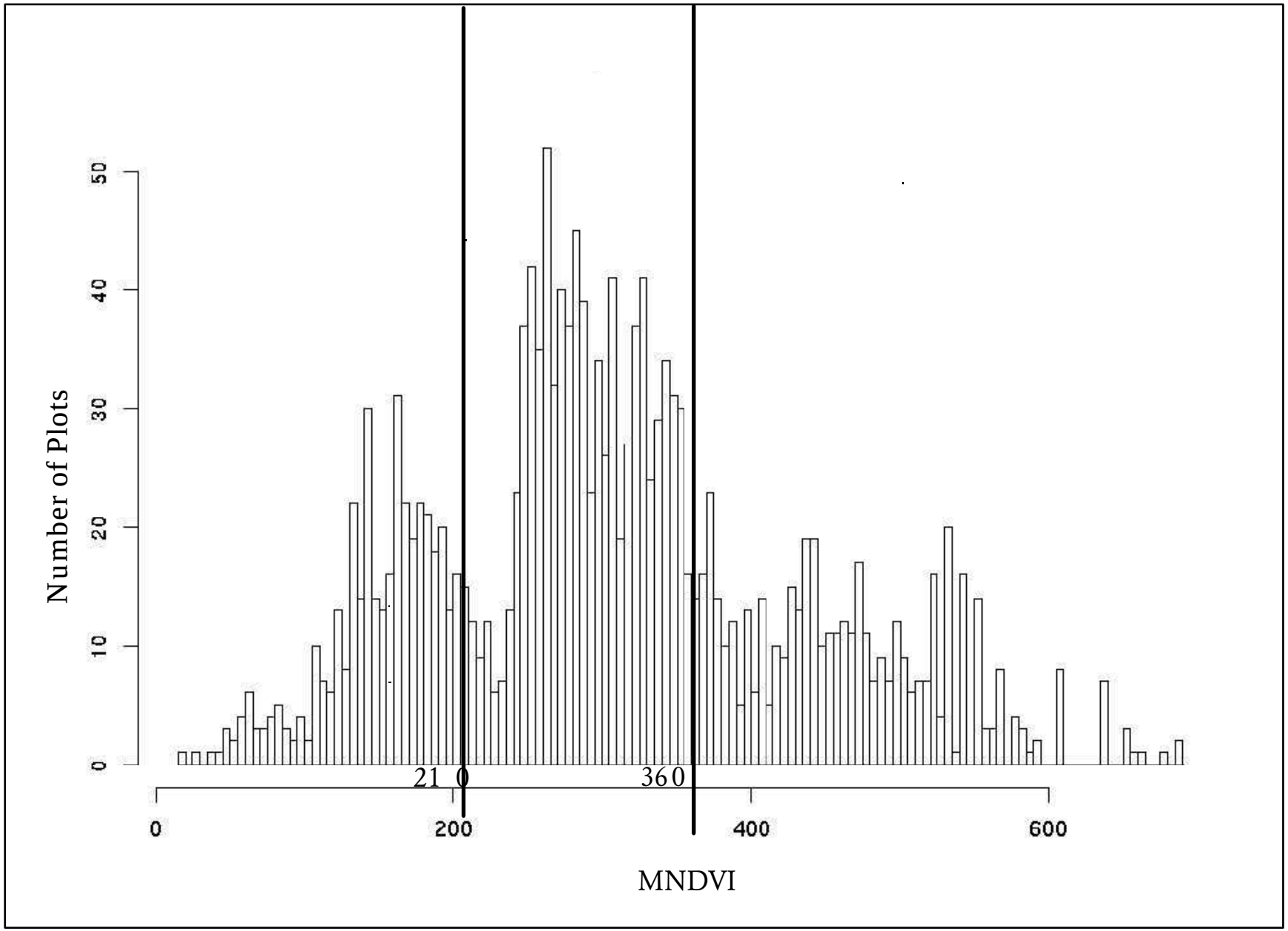


Figure F-7a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P41/R27

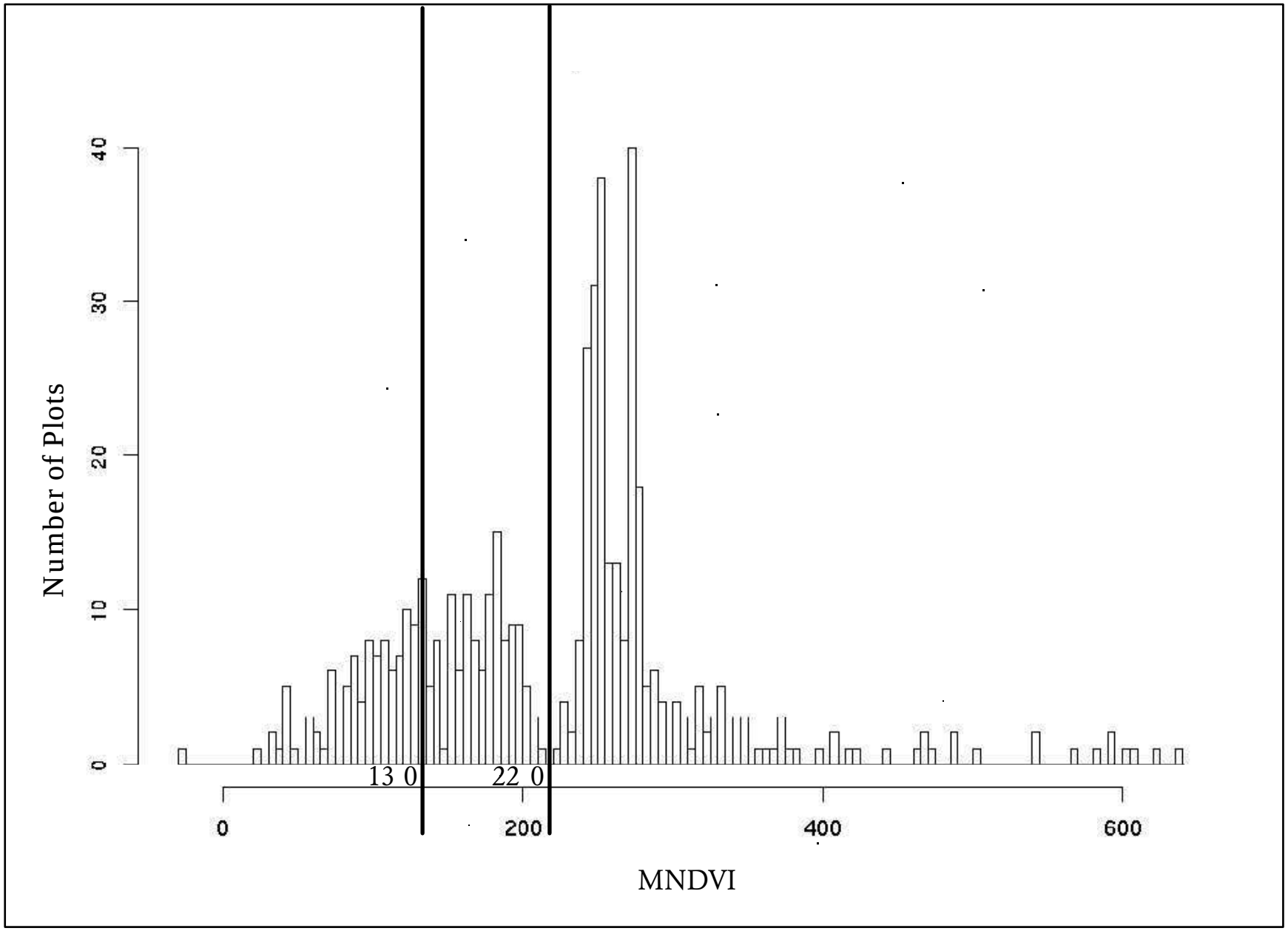


Figure F-7b. Breaks between mesic shrub canopy cover classes in relation to MNDVI values: TM scene P41/R27

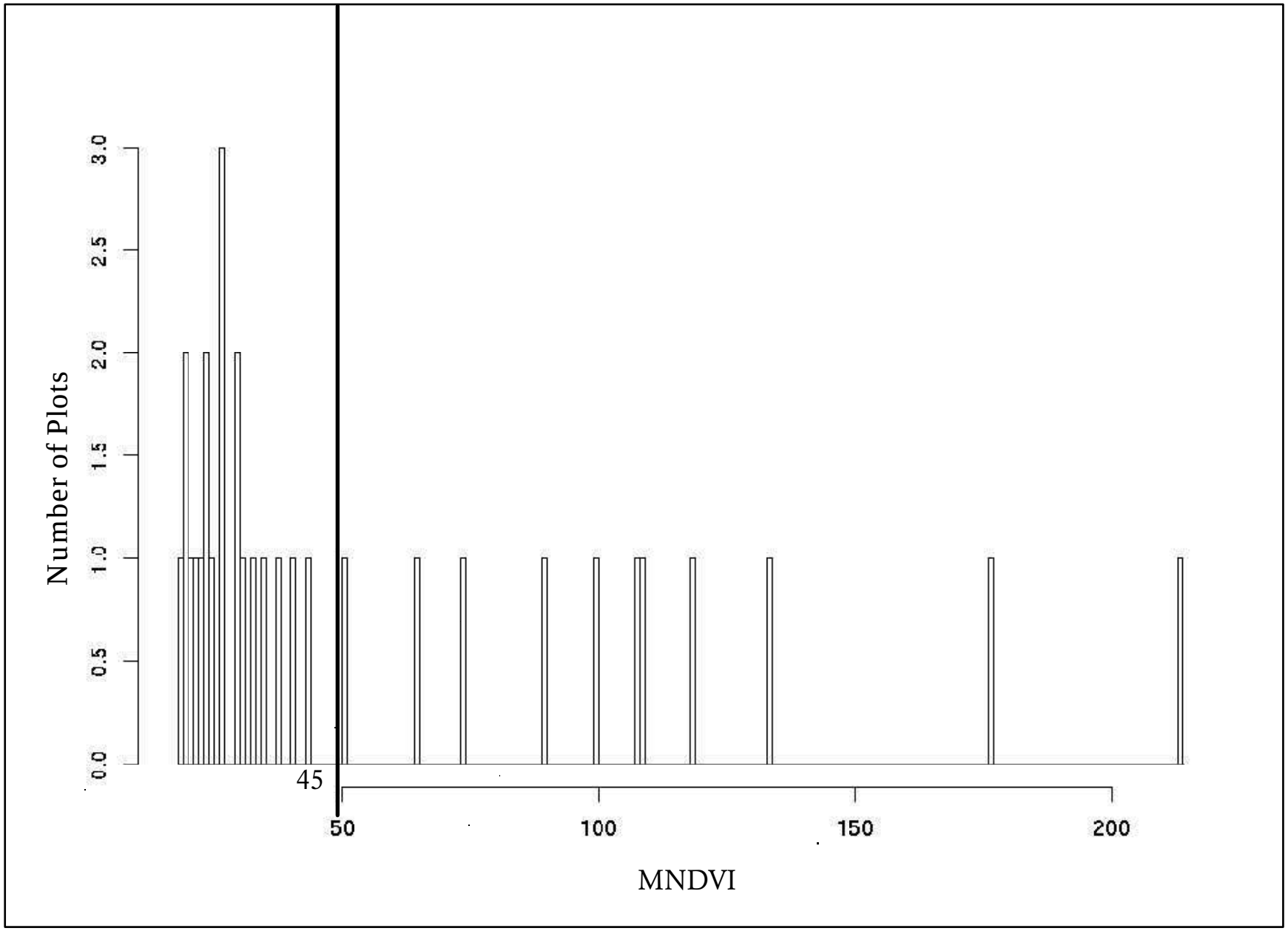


Figure F-7c. Breaks between xeric shrub canopy cover classes in relation to MNDVI values: TM scene P41/R27

CONFUSION (FUZZY) MATRIX

RF/CF	1000	2000	3101	3102	3201	3202	3203	3304	3305
1000	5(5)	0(1)	8(1)	3(1)	0(1)	0(1)	0(1)	1(1)	2(1)
2000	1(1)	103(5)	77(1)	9(1)	1(1)	4(1)	1(1)	0(1)	16(1)
3101	0(1)	0(1)	5(5)	0(3)	0(1)	3(1)	1(1)	0(1)	1(1)
3102	1(1)	0(1)	0(3)	0(5)	0(1)	0(1)	0(1)	0(1)	1(1)
3201	0(1)	0(1)	0(1)	0(1)	0(5)	2(4)	0(4)	0(2)	0(2)
3202	0(1)	0(1)	0(1)	0(1)	0(4)	1(5)	0(3)	1(2)	0(2)
3203	0(1)	1(1)	0(1)	0(1)	0(4)	0(3)	2(5)	0(2)	0(2)
3304	0(1)	0(1)	1(1)	0(1)	0(2)	0(2)	0(2)	0(5)	0(3)
3305	0(1)	0(1)	0(1)	1(1)	0(2)	0(2)	0(2)	0(3)	2(5)
4201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4203	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4206	0(1)	0(1)	1(1)	1(1)	0(1)	1(1)	1(1)	0(1)	0(1)
4207	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4208	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4210	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4212	0(1)	0(1)	0(1)	1(1)	0(1)	1(1)	1(1)	0(1)	0(1)
4215	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4219	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4220	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4221	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	1(1)	0(1)	0(1)
4222	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4223	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4225	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4228	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)
4229	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
5000	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7300	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(1)	0(1)	0(1)
7800	0(1)	0(1)	0(2)	0(1)	0(1)	2(1)	0(1)	0(1)	0(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)
SUM	7(0)	104(0)	94(0)	16(0)	1(0)	16(0)	10(0)	2(0)	22(0)

Accuracy Assessment Tables for P41/R27 -- Cover Type

RF/CF	4201	4203	4206	4207	4208	4210	4212	4215	4219
1000	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
2000	0(1)	0(1)	3(1)	0(1)	0(1)	0(1)	4(1)	0(1)	0(1)
3101	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)
3201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3202	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3203	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3304	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3305	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4201	0(5)	0(2)	0(2)	0(2)	0(3)	0(2)	0(2)	0(2)	0(3)
4203	0(2)	1(5)	0(2)	0(2)	0(2)	0(2)	1(2)	0(2)	0(3)
4206	0(2)	0(2)	2(5)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4207	0(2)	0(2)	0(2)	1(5)	0(2)	0(2)	1(2)	0(2)	0(2)
4208	0(3)	0(2)	0(2)	0(2)	0(5)	0(2)	0(2)	0(2)	1(3)
4210	0(2)	0(2)	0(2)	0(2)	0(2)	0(5)	0(2)	0(2)	0(2)
4212	0(2)	3(2)	1(2)	0(2)	0(2)	0(2)	9(5)	0(3)	0(2)
4215	0(2)	1(2)	0(2)	0(2)	0(2)	0(2)	1(3)	0(5)	0(2)
4219	0(3)	0(3)	0(2)	0(2)	0(3)	0(2)	0(2)	0(2)	1(5)
4220	0(4)	4(3)	0(2)	0(2)	1(3)	0(2)	1(3)	1(2)	1(3)
4221	0(3)	8(3)	2(2)	0(3)	0(2)	0(3)	8(3)	0(3)	0(2)
4222	0(2)	2(2)	1(3)	0(2)	0(2)	0(2)	4(3)	0(2)	0(2)
4223	0(2)	0(3)	0(2)	0(2)	0(2)	0(2)	0(3)	0(2)	0(2)
4225	0(2)	0(2)	0(2)	0(4)	0(2)	0(2)	1(3)	0(2)	0(2)
4228	0(2)	2(3)	0(2)	0(2)	0(2)	0(2)	0(2)	1(3)	0(2)
4229	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(3)	0(3)	0(2)
4301	0(2)	0(2)	0(2)	0(3)	0(2)	0(3)	0(2)	0(2)	0(2)
5000	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7300	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7800	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	0(0)	23(0)	9(0)	1(0)	1(0)	0(0)	32(0)	2(0)	3(0)

Accuracy Assessment Tables for P41/R27 -- Cover Type

RF/CF	4220	4221	4222	4223	4225	4228	4229	4301	5000
1000	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
2000	0(1)	4(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3101	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3201	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3202	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3203	1(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3304	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3305	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4201	0(4)	2(4)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)
4203	1(3)	4(3)	0(2)	1(4)	0(2)	0(4)	0(2)	0(2)	0(1)
4206	0(2)	2(3)	0(4)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)
4207	0(2)	0(3)	0(2)	0(2)	0(4)	0(2)	0(2)	0(2)	0(1)
4208	1(3)	1(3)	0(2)	1(2)	0(2)	0(2)	0(2)	0(2)	0(1)
4210	0(2)	1(3)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)
4212	0(3)	8(3)	3(4)	1(4)	0(4)	0(2)	2(4)	1(2)	0(1)
4215	0(3)	2(3)	0(2)	0(2)	0(2)	0(4)	0(4)	0(2)	0(1)
4219	1(3)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)
4220	2(5)	0(2)	1(2)	0(3)	0(2)	0(2)	0(2)	0(2)	0(1)
4221	0(2)	18(5)	2(2)	2(3)	0(4)	0(4)	0(4)	3(2)	0(1)
4222	0(2)	2(2)	0(5)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)
4223	0(3)	4(3)	1(2)	2(5)	0(3)	0(4)	0(4)	0(2)	0(1)
4225	0(2)	0(4)	0(2)	0(3)	0(5)	0(3)	0(3)	0(2)	0(1)
4228	0(3)	0(4)	0(2)	0(4)	0(3)	0(5)	2(4)	0(2)	0(1)
4229	0(3)	2(4)	0(2)	0(4)	0(3)	0(4)	0(5)	0(2)	0(1)
4301	0(3)	2(3)	0(3)	0(3)	0(3)	0(3)	0(3)	0(5)	0(1)
5000	2(1)	0(1)	0(1)	5(1)	0(1)	0(1)	1(1)	0(1)	30(5)
7300	0(1)	1(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7800	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	8(0)	57(0)	9(0)	12(0)	0(0)	0(0)	6(0)	4(0)	30(0)

Accuracy Assessment Tables for P41/R27 -- Cover Type

RF/CF	7300	7800	8101	SUM
1000	4(1)	1(1)	0(1)	24(0)
2000	5(1)	2(1)	0(1)	230(0)
3101	2(1)	0(1)	0(1)	16(0)
3102	0(1)	0(1)	0(1)	3(0)
3201	0(1)	1(1)	0(1)	4(0)
3202	0(1)	1(1)	0(1)	4(0)
3203	2(1)	2(1)	0(1)	9(0)
3304	0(1)	0(1)	0(1)	1(0)
3305	0(1)	0(1)	0(1)	3(0)
4201	0(1)	0(1)	0(1)	2(0)
4203	0(1)	0(1)	0(1)	9(0)
4206	0(1)	0(1)	0(1)	8(0)
4207	0(1)	0(1)	0(1)	2(0)
4208	0(1)	0(1)	0(1)	4(0)
4210	0(1)	0(1)	0(1)	1(0)
4212	0(1)	0(1)	0(1)	31(0)
4215	0(1)	0(1)	0(1)	4(0)
4219	0(1)	0(1)	0(1)	2(0)
4220	0(1)	0(1)	0(1)	11(0)
4221	0(1)	0(1)	0(1)	45(0)
4222	0(1)	0(1)	0(1)	10(0)
4223	0(1)	0(1)	0(1)	7(0)
4225	0(1)	0(1)	0(1)	1(0)
4228	0(1)	0(1)	0(1)	6(0)
4229	0(1)	0(1)	0(1)	3(0)
4301	0(1)	0(1)	0(1)	2(0)
5000	5(2)	1(2)	0(1)	45(0)
7300	10(5)	0(3)	0(1)	14(0)
7800	0(3)	0(5)	0(3)	3(0)
8101	0(1)	0(3)	0(5)	1(0)
SUM	28(0)	8(0)	0(0)	505(0)

Diagonal Elements = 194; Total Test Points = 505
Percentage Agreement = 38.42; Kappa = 0.297; Tau w/equal Prob = 0.363

Accuracy Assessment Tables for P41/R27 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1000	5	20.83	0	0.00	0	0.00	0	0.00	19	79.17
2000	103	44.78	0	0.00	0	0.00	0	0.00	127	55.22
3101	5	31.25	0	0.00	0	0.00	0	0.00	11	68.75
3102	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
3201	0	0.00	2	50.00	0	0.00	0	0.00	2	50.00
3202	1	25.00	0	0.00	0	0.00	1	25.00	2	50.00
3203	2	22.22	0	0.00	0	0.00	0	0.00	7	77.78
3304	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3305	2	66.67	0	0.00	0	0.00	0	0.00	1	33.33
4201	0	0.00	2	100.00	0	0.00	0	0.00	0	0.00
4203	1	11.11	1	11.11	5	55.56	1	11.11	1	11.11
4206	2	25.00	0	0.00	2	25.00	0	0.00	4	50.00
4207	1	50.00	0	0.00	0	0.00	1	50.00	0	0.00
4208	0	0.00	0	0.00	3	75.00	1	25.00	0	0.00
4210	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4212	9	29.03	6	19.35	8	25.81	5	16.13	3	9.68
4215	0	0.00	0	0.00	3	75.00	1	25.00	0	0.00
4219	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
4220	2	18.18	0	0.00	7	63.64	2	18.18	0	0.00
4221	18	40.00	0	0.00	18	40.00	7	15.56	2	4.44
4222	0	0.00	0	0.00	5	50.00	4	40.00	1	10.00
4223	2	28.57	0	0.00	4	57.14	1	14.29	0	0.00
4225	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4228	0	0.00	2	33.33	3	50.00	0	0.00	1	16.67
4229	0	0.00	2	66.67	0	0.00	0	0.00	1	33.33
4301	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00
5000	30	66.67	0	0.00	0	0.00	6	13.33	9	20.00
7300	10	71.43	0	0.00	0	0.00	0	0.00	4	28.57
7800	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	194	38.42	15	2.97	63	12.48	30	5.94	203	40.20

Accuracy Assessment Tables for P41/R27 -- Cover Type

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1000	5	20.83	5	20.83	5	20.83	5	20.83	24	100.00
2000	103	44.78	103	44.78	103	44.78	103	44.78	230	100.00
3101	5	31.25	5	31.25	5	31.25	5	31.25	16	100.00
3102	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
3201	0	0.00	2	50.00	2	50.00	2	50.00	4	100.00
3202	1	25.00	1	25.00	1	25.00	2	50.00	4	100.00
3203	2	22.22	2	22.22	2	22.22	2	22.22	9	100.00
3304	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3305	2	66.67	2	66.67	2	66.67	2	66.67	3	100.00
4201	0	0.00	2	100.00	2	100.00	2	100.00	2	100.00
4203	1	11.11	2	22.22	7	77.78	8	88.89	9	100.00
4206	2	25.00	2	25.00	4	50.00	4	50.00	8	100.00
4207	1	50.00	1	50.00	1	50.00	2	100.00	2	100.00
4208	0	0.00	0	0.00	3	75.00	4	100.00	4	100.00
4210	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4212	9	29.03	15	48.39	23	74.19	28	90.32	31	100.00
4215	0	0.00	0	0.00	3	75.00	4	100.00	4	100.00
4219	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
4220	2	18.18	2	18.18	9	81.82	11	100.00	11	100.00
4221	18	40.00	18	40.00	36	80.00	43	95.56	45	100.00
4222	0	0.00	0	0.00	5	50.00	9	90.00	10	100.00
4223	2	28.57	2	28.57	6	85.71	7	100.00	7	100.00
4225	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4228	0	0.00	2	33.33	5	83.33	5	83.33	6	100.00
4229	0	0.00	2	66.67	2	66.67	2	66.67	3	100.00
4301	0	0.00	0	0.00	2	100.00	2	100.00	2	100.00
5000	30	66.67	30	66.67	30	66.67	36	80.00	45	100.00
7300	10	71.43	10	71.43	10	71.43	10	71.43	14	100.00
7800	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	194	38.42	209	41.39	272	53.86	302	59.80	505	100.00

Accuracy Assessment Tables for P41/R27 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1000	5	71.43	0	0.00	0	0.00	0	0.00	2	28.57
2000	103	99.04	0	0.00	0	0.00	0	0.00	1	0.96
3101	5	5.32	0	0.00	0	0.00	0	0.00	89	94.68
3102	0	0.00	0	0.00	0	0.00	0	0.00	16	100.00
3201	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3202	1	6.25	2	12.50	0	0.00	0	0.00	13	81.25
3203	2	20.00	0	0.00	0	0.00	0	0.00	8	80.00
3304	0	0.00	0	0.00	0	0.00	1	50.00	1	50.00
3305	2	9.09	0	0.00	0	0.00	0	0.00	20	90.91
4201	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	1	4.35	0	0.00	14	60.87	6	26.09	2	8.70
4206	2	22.22	0	0.00	1	11.11	3	33.33	3	33.33
4207	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4208	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4210	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4212	9	28.12	0	0.00	15	46.88	2	6.25	6	18.75
4215	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00
4219	1	33.33	0	0.00	2	66.67	0	0.00	0	0.00
4220	2	25.00	0	0.00	3	37.50	0	0.00	3	37.50
4221	18	31.58	4	7.02	24	42.11	2	3.51	9	15.79
4222	0	0.00	3	33.33	0	0.00	4	44.44	2	22.22
4223	2	16.67	2	16.67	2	16.67	1	8.33	5	41.67
4225	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4228	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4229	0	0.00	4	66.67	0	0.00	0	0.00	2	33.33
4301	0	0.00	0	0.00	0	0.00	4	100.00	0	0.00
5000	30	100.00	0	0.00	0	0.00	0	0.00	0	0.00
7300	10	35.71	0	0.00	0	0.00	5	17.86	13	46.43
7800	0	0.00	0	0.00	0	0.00	1	12.50	7	87.50
8101	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	194	38.42	15	2.97	63	12.48	30	5.94	203	40.20

Accuracy Assessment Tables for P41/R27 -- Cover Type

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1000	5	71.43	5	71.43	5	71.43	5	71.43	7	100.00
2000	103	99.04	103	99.04	103	99.04	103	99.04	104	100.00
3101	5	5.32	5	5.32	5	5.32	5	5.32	94	100.00
3102	0	0.00	0	0.00	0	0.00	0	0.00	16	100.00
3201	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3202	1	6.25	3	18.75	3	18.75	3	18.75	16	100.00
3203	2	20.00	2	20.00	2	20.00	2	20.00	10	100.00
3304	0	0.00	0	0.00	0	0.00	1	50.00	2	100.00
3305	2	9.09	2	9.09	2	9.09	2	9.09	22	100.00
4201	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	1	4.35	1	4.35	15	65.22	21	91.30	23	100.00
4206	2	22.22	2	22.22	3	33.33	6	66.67	9	100.00
4207	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4208	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4210	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4212	9	28.12	9	28.12	24	75.00	26	81.25	32	100.00
4215	0	0.00	0	0.00	1	50.00	2	100.00	2	100.00
4219	1	33.33	1	33.33	3	100.00	3	100.00	3	100.00
4220	2	25.00	2	25.00	5	62.50	5	62.50	8	100.00
4221	18	31.58	22	38.60	46	80.70	48	84.21	57	100.00
4222	0	0.00	3	33.33	3	33.33	7	77.78	9	100.00
4223	2	16.67	4	33.33	6	50.00	7	58.33	12	100.00
4225	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4228	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4229	0	0.00	4	66.67	4	66.67	4	66.67	6	100.00
4301	0	0.00	0	0.00	0	0.00	4	100.00	4	100.00
5000	30	100.00	30	100.00	30	100.00	30	100.00	30	100.00
7300	10	35.71	10	35.71	10	35.71	15	53.57	28	100.00
7800	0	0.00	0	0.00	0	0.00	1	12.50	8	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	194	38.42	209	41.39	272	53.86	302	59.80	505	100.00

Accuracy Assessment Tables for P41/R27 -- Cover Type

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1000	1	20.83	0	0.00	0	0.00	0	0.00	2	79.17
2000	14	44.78	0	0.00	0	0.00	0	0.00	17	55.22
3101	20	31.25	0	0.00	0	0.00	0	0.00	44	68.75
3102	0	0.00	0	0.00	0	0.00	0	0.00	20	100.00
3201	0	0.00	1	50.00	0	0.00	0	0.00	1	50.00
3202	9	25.00	0	0.00	0	0.00	9	25.00	18	50.00
3203	3	22.22	0	0.00	0	0.00	0	0.00	12	77.78
3304	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
3305	12	66.67	0	0.00	0	0.00	0	0.00	6	33.33
4201	0	0.00	0	100.00	0	0.00	0	0.00	0	0.00
4203	11	11.11	11	11.11	54	55.56	11	11.11	11	11.11
4206	8	25.00	0	0.00	8	25.00	0	0.00	16	50.00
4207	2	50.00	0	0.00	0	0.00	2	50.00	0	0.00
4208	0	0.00	0	0.00	24	75.00	8	25.00	0	0.00
4210	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00
4212	37	29.03	24	19.35	33	25.81	20	16.13	12	9.68
4215	0	0.00	0	0.00	9	75.00	3	25.00	0	0.00
4219	7	50.00	0	0.00	7	50.00	0	0.00	0	0.00
4220	12	18.18	0	0.00	44	63.64	12	18.18	0	0.00
4221	87	40.00	0	0.00	87	40.00	34	15.56	10	4.44
4222	0	0.00	0	0.00	14	50.00	11	40.00	3	10.00
4223	10	28.57	0	0.00	20	57.14	5	14.29	0	0.00
4225	0	0.00	0	0.00	5	100.00	0	0.00	0	0.00
4228	0	0.00	0	33.33	0	50.00	0	0.00	0	16.67
4229	0	0.00	17	66.67	0	0.00	0	0.00	8	33.33
4301	0	0.00	0	0.00	8	100.00	0	0.00	0	0.00
5000	16	66.67	0	0.00	0	0.00	3	13.33	5	20.00
7300	17	71.43	0	0.00	0	0.00	0	0.00	7	28.57
7800	0	0.00	0	0.00	0	0.00	0	0.00	15	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
SUM	266	27.68	53	5.52	315	32.78	118	12.28	209	21.75

Accuracy Assessment Tables for P41/R27 -- Cover Type

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1000	1	20.83	1	20.83	1	20.83	1	20.83	3	100.00
2000	14	44.78	14	44.78	14	44.78	14	44.78	30	100.00
3101	20	31.25	20	31.25	20	31.25	20	31.25	63	100.00
3102	0	0.00	0	0.00	0	0.00	0	0.00	20	100.00
3201	0	0.00	1	50.00	1	50.00	1	50.00	1	100.00
3202	9	25.00	9	25.00	9	25.00	18	50.00	36	100.00
3203	3	22.22	3	22.22	3	22.22	3	22.22	15	100.00
3304	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
3305	12	66.67	12	66.67	12	66.67	12	66.67	18	100.00
4201	0	0.00	0	100.00	0	100.00	0	100.00	0	100.00
4203	11	11.11	22	22.22	76	77.78	87	88.89	97	100.00
4206	8	25.00	8	25.00	16	50.00	16	50.00	33	100.00
4207	2	50.00	2	50.00	2	50.00	4	100.00	4	100.00
4208	0	0.00	0	0.00	24	75.00	31	100.00	31	100.00
4210	0	0.00	0	0.00	2	100.00	2	100.00	2	100.00
4212	37	29.03	61	48.39	94	74.19	114	90.32	126	100.00
4215	0	0.00	0	0.00	9	75.00	12	100.00	12	100.00
4219	7	50.00	7	50.00	14	100.00	14	100.00	14	100.00
4220	12	18.18	12	18.18	56	81.82	69	100.00	69	100.00
4221	87	40.00	87	40.00	173	80.00	207	95.56	217	100.00
4222	0	0.00	0	0.00	14	50.00	25	90.00	27	100.00
4223	10	28.57	10	28.57	30	85.71	35	100.00	35	100.00
4225	0	0.00	0	0.00	5	100.00	5	100.00	5	100.00
4228	0	0.00	0	33.33	0	83.33	0	83.33	0	100.00
4229	0	0.00	17	66.67	17	66.67	17	66.67	25	100.00
4301	0	0.00	0	0.00	8	100.00	8	100.00	8	100.00
5000	16	66.67	16	66.67	16	66.67	19	80.00	23	100.00
7300	17	71.43	17	71.43	17	71.43	17	71.43	24	100.00
7800	0	0.00	0	0.00	0	0.00	0	0.00	15	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
SUM	266	27.85	319	33.40	633	66.28	751	78.64	955	100.00

Accuracy Assessment Tables for P41/R27 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	4	SUM
1	14(5)	2(3)	8(1)	1(1)	25(0)
2	8(3)	0(5)	24(3)	2(1)	34(0)
3	6(1)	5(3)	68(5)	2(3)	81(0)
4	0(1)	0(1)	6(3)	3(5)	9(0)
SUM	28(0)	7(0)	106(0)	8(0)	149(0)

Diagonal Elements = 85; Total Test Points = 149
Percentage Agreement = 57.05; Tau w/equal Prob = 0.427

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	14	56.00	0	0.00	2	8.00	0	0.00	9	36.00
2	0	0.00	0	0.00	32	94.12	0	0.00	2	5.88
3	68	83.95	0	0.00	7	8.64	0	0.00	6	7.41
4	3	33.33	0	0.00	6	66.67	0	0.00	0	0.00
SUM	85	57.05	0	0.00	47	31.54	0	0.00	17	11.41

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	14	56.00	14	56.00	16	64.00	16	64.00	25	100.00
2	0	0.00	0	0.00	32	94.12	32	94.12	34	100.00
3	68	83.95	68	83.95	75	92.59	75	92.59	81	100.00
4	3	33.33	3	33.33	9	100.00	9	100.00	9	100.00
SUM	85	57.05	85	57.05	132	88.59	132	88.59	149	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	14	50.00	0	0.00	8	28.57	0	0.00	6	21.43
2	0	0.00	0	0.00	7	100.00	0	0.00	0	0.00
3	68	64.15	0	0.00	30	28.30	0	0.00	8	7.55
4	3	37.50	0	0.00	2	25.00	0	0.00	3	37.50
SUM	85	57.05	0	0.00	47	31.54	0	0.00	17	11.41

Accuracy Assessment Tables for P41/R27 -- Tree Size Class

ACCUMULATE MATRIX (user)

GROUP	Score 5 N	Score 5 %	Score 4 N	Score 4 %	Score 3 N	Score 3 %	Score 2 N	Score 2 %	Score 1 N	Score 1 %
1	14	50.00	14	50.00	22	78.57	22	78.57	28	100.00
2	0	0.00	0	0.00	7	100.00	7	100.00	7	100.00
3	68	64.15	68	64.15	98	92.45	98	92.45	106	100.00
4	3	37.50	3	37.50	5	62.50	5	62.50	8	100.00
SUM	85	57.05	85	57.05	132	88.59	132	88.59	149	100.00

Accuracy Assessment Tables for P41/R27 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	SUM
1	16(5)	1(3)	18(0)
2	2(3)	3(5)	6(0)
SUM	18(0)	4(0)	24(0)

Diagonal Elements = 19; Total Test Points = 24
Percentage Agreement = 79.17; Tau w/equal Prob = 0.583

2 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 2 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	16	88.89	0	0.00	1	5.56	0	0.00	1	5.56
2	3	50.00	0	0.00	2	33.33	0	0.00	1	16.67
SUM	19	79.17	0	0.00	3	12.50	0	0.00	2	8.33

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	16	88.89	16	88.89	17	94.44	17	94.44	18	100.00
2	3	50.00	3	50.00	5	83.33	5	83.33	6	100.00
SUM	19	79.17	19	79.17	22	91.67	22	91.67	24	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	16	88.89	0	0.00	2	11.11	0	0.00	0	0.00
2	3	75.00	0	0.00	1	25.00	0	0.00	0	0.00
SUM	19	86.36	0	0.00	3	13.64	0	0.00	0	0.00

Accuracy Assessment Tables for P41/R27 -- Shrub Size Class

ACCUMULATE MATRIX (user)

GROUP	Score 5 N	Score 5 %	Score 4 N	Score 4 %	Score 3 N	Score 3 %	Score 2 N	Score 2 %	Score 1 N	Score 1 %
1	16	88.89	16	88.89	18	100.00	18	100.00	18	100.00
2	3	75.00	3	75.00	4	100.00	4	100.00	4	100.00
SUM	19	86.36	19	86.36	22	100.00	22	100.00	22	100.00

Accuracy Assessment Tables for P41/R27 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	20(5)	17(3)	4(1)	44(0)
2	21(3)	32(5)	19(3)	74(0)
3	0(1)	4(3)	9(5)	13(0)
SUM	41(0)	53(0)	32(0)	131(0)

Diagonal Elements = 61; Total Test Points = 131
Percentage Agreement = 46.56; Tau w/equal Prob = 0.198

5 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 5 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	45.45	0	0.00	17	38.64	0	0.00	7	15.91
2	32	43.24	0	0.00	40	54.05	0	0.00	2	2.70
3	9	69.23	0	0.00	4	30.77	0	0.00	0	0.00
SUM	61	46.56	0	0.00	61	46.56	0	0.00	9	6.87

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	45.45	20	45.45	37	84.09	37	84.09	44	100.00
2	32	43.24	32	43.24	72	97.30	72	97.30	74	100.00
3	9	69.23	9	69.23	13	100.00	13	100.00	13	100.00
SUM	61	46.56	61	46.56	122	93.13	122	93.13	131	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	48.78	0	0.00	21	51.22	0	0.00	0	0.00
2	32	60.38	0	0.00	21	39.62	0	0.00	0	0.00
3	9	28.12	0	0.00	19	59.38	0	0.00	4	12.50
SUM	61	48.41	0	0.00	61	48.41	0	0.00	4	3.17

Accuracy Assessment Tables for P41/R27 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

GROUP	Score 5		Score 4		Score 3		Score 2		Score 1	
	N	%	N	%	N	%	N	%	N	%
1	20	48.78	20	48.78	41	100.00	41	100.00	41	100.00
2	32	60.38	32	60.38	53	100.00	53	100.00	53	100.00
3	9	28.12	9	28.12	28	87.50	28	87.50	32	100.00
SUM	61	48.41	61	48.41	122	96.83	122	96.83	126	100.00

Accuracy Assessment Tables for P41/R27 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	6(5)	2(3)	0(1)	12(0)
2	2(3)	5(5)	1(3)	9(0)
3	0(1)	1(3)	0(5)	1(0)
SUM	8(0)	8(0)	1(0)	22(0)

Diagonal Elements = 11; Total Test Points = 22
Percentage Agreement = 50.00; Tau w/equal Prob = 0.250

5 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 5 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	50.00	0	0.00	2	16.67	0	0.00	4	33.33
2	5	55.56	0	0.00	3	33.33	0	0.00	1	11.11
3	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
SUM	11	50.00	0	0.00	6	27.27	0	0.00	5	22.73

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	50.00	6	50.00	8	66.67	8	66.67	12	100.00
2	5	55.56	5	55.56	8	88.89	8	88.89	9	100.00
3	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
SUM	11	50.00	11	50.00	17	77.27	17	77.27	22	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	75.00	0	0.00	2	25.00	0	0.00	0	0.00
2	5	62.50	0	0.00	3	37.50	0	0.00	0	0.00
3	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
SUM	11	64.71	0	0.00	6	35.29	0	0.00	0	0.00

Accuracy Assessment Tables for P41/R27 -- Shrub Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	75.00	6	75.00	8	100.00	8	100.00	8	100.00
2	5	62.50	5	62.50	8	100.00	8	100.00	8	100.00
3	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
SUM	11	64.71	11	64.71	17	100.00	17	100.00	17	100.00

Scene P41/R27 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
1000	673.0	9787.7	0.3
2000	10860.0	103372.8	3.0
3101	17963.0	221182.7	6.5
3102	5220.0	71362.0	2.1
3104	14618.0	103717.7	3.0
3202	12149.0	127004.9	3.7
3203	7333.0	54022.2	1.6
3304	293.0	2956.0	0.1
3305	2481.0	57038.8	1.7
4203	24453.0	331984.8	9.7
4206	6907.0	111833.9	3.3
4207	1238.0	13951.6	0.4
4208	9277.0	106935.6	3.1
4210	829.0	7921.8	0.2
4212	46847.0	430538.9	12.6
4215	4122.0	42118.8	1.2
4219	5886.0	49261.9	1.4
4220	17641.0	233495.5	6.9
4221	69409.0	737194.5	21.6
4222	10142.0	92783.7	2.7
4223	8664.0	117861.7	3.5
4225	2259.0	15332.0	0.5
4229	9001.0	85565.2	2.5
4301	3108.0	27302.4	0.8
5000	3560.0	80446.8	2.4
7300	16276.0	92538.6	2.7
7800	5302.0	50175.4	1.5
8100	114.0	726.6	0.0
9100	934.0	11302.4	0.3
9800	259.0	9072.4	0.3
9900	1299.0	6771.4	0.2

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not tree/shrub	77078.0	760456.3	22.3
Shrub 1	10159.0	103386.0	3.0
Shrub 2	10063.0	95111.4	2.8
Shrub 3	2034.0	42524.5	1.3
Tree 1	49619.0	507709.8	14.9
Tree 2	105681.0	1193410.8	35.0
Tree 3	64483	702961.7	20.6

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not tree/shrub	77078.0	760456.3	22.3
Tree 1	47788.0	501179.5	14.7
Tree 2	37740.0	471582.2	13.9
Tree 3	127335.0	1338734.5	39.3
Tree 4	6920.0	92586.0	2.7
Shrub 1	14140.0	169564.1	5.0
Shrub 2	6290.0	58167.5	1.7
Shrub 3	1826.0	13290.2	0.4

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
A	10860.0	103372.8	3.0
H	37915.0	396988.9	11.7
N	28303.0	260094.6	7.6
S	22256.0	241021.8	7.1
T	219783.0	2404082.2	70.6

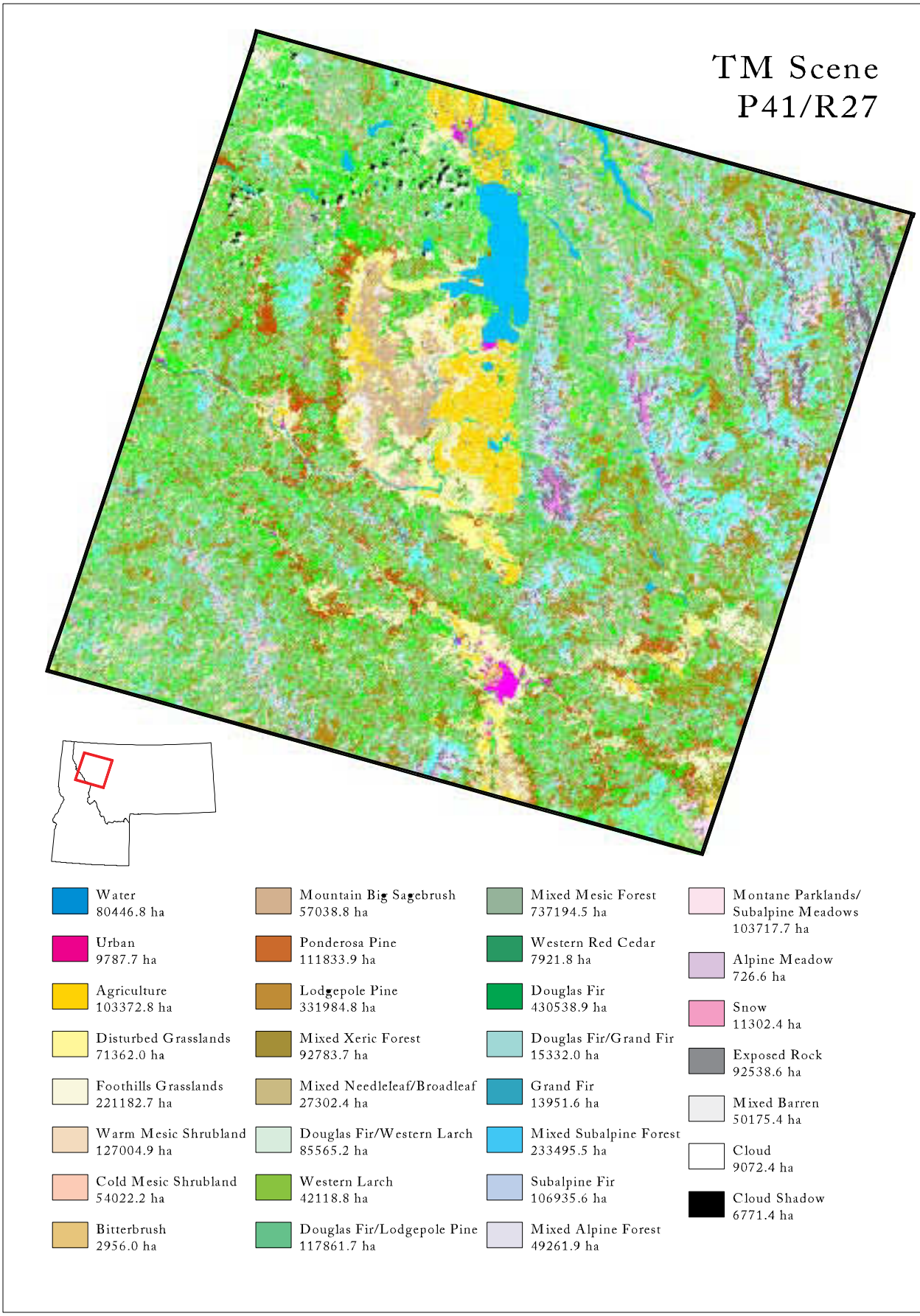


Figure F-7. Classification of land cover types for TM Scene P41/R27.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P41/R27

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 2650 to 7630 feet in elevation. The average canopy cover is 37% ranging from 10-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤4% and frequency of occurrence ≥50% and ≤56%.

Primary associated shrub species with ≥34% and ≤50% frequency of occurrence in lodgepole pine stands: western serviceberry (Amelanchier alnifolia), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤60% frequency of occurrence in lodgepole pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), sedge (Carex), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), and common timothy (Phleum pratense); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), white-flowered hawkweed (Hieracium albiflorum), and beargrass (Xerophyllum tenax); **ferns**: field horsetail (Equisetum arvense), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

2) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 3073 to 5840 feet in elevation. The average canopy cover is 32% ranging from 10-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western larch (Larix occidentalis), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤8% and frequency of occurrence ≥26% and ≤88%.

Primary associated shrub species with ≥12% and ≤41% frequency of occurrence in ponderosa pine stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), mountain balm (Ceanothus velutinus), mallow ninebark (Physocarpus malvaceus), common snowberry (Symphoricarpos albus), and dwarf huckleberry (Vaccinium cespitosum).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤43% frequency of occurrence in ponderosa pine stands: **graminoids**: pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), rough fescue (Festuca scabrella), and common timothy (Phleum pratense); **forbs**: common yarrow (Achillea millefolium), field pussy-toes (Antennaria

neglecta), arnica (Arnica spp.), spotted knapweed (Centauria maculosa), Virginia strawberry (Fragaria virginiana), northern bedstraw (Galium boreale), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: moss (moss spp.).

3) 4207: GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) ranging from 2465 to 4740 feet in elevation. The average canopy cover is 49% ranging from 10-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western larch (Larix occidentalis), Douglas-fir (Pseudotsuga menziesii), and pacific yew (Taxus brevifolia) with average percent cover ≥6% and ≤13% and frequency of occurrence ≥38% and ≤81%.

Primary associated shrub species with ≥25% and ≤56% frequency of occurrence in grand fir stands: rocky mountain maple (Acer glabrum), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤43% frequency of occurrence in grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), and roughleaf ricegrass (Oryzopsis asperifolia); **forbs**: trail-plant (Adenocaulon bicolor), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), sweetscented bedstraw (Galium triflorum), starry solomon-plume (Smilacina stellata), and trefoil foamflower (Tiarella trifoliata); **ferns**: northern maidenhair (Adiantum pedatum), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: none.

4) 4208: SUBALPINE FIR FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 4280 to 7800 feet in elevation. The average canopy cover is 32% ranging from 10-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), and lodgepole pine (Pinus contorta) with average percent cover ≥3% and ≤4% and frequency of occurrence ≥31% and ≤54%.

Primary associated shrub species with ≥17% and ≤71% frequency of occurrence in subalpine fir stands: menziesia (Menziesia ferruginea), Utah honeysuckle (Lonicera utahensis), swamp current (Ribes lacustre), cascade mountain-ash (Sorbus scopulina), subalpine spiraea (Spiraea densiflora), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤87% frequency of occurrence in subalpine fir stands: **graminoids**: Columbia brome (Bromus vulgaris), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), mountain hairgrass (Deschampsia atropurpurea), smooth woodrush (Luzula glabrata), and smooth woodrush (Luzula hitchcockii); **forbs**: broadleaf arnica (Arnica latifolia), fireweed (Epilobium angustifolium), glacier lily (Erythronium grandiflorum), arrowleaf groundsel (Senecio triangularis), western meadowrue (Thalictrum occidentale), green false hellebore (Veratrum viride), and beargrass (Xerophyllum tenax); **ferns**: ladyfern

(Athyrium filix-femina), field horsetail (Equisetum arvense), oak-fern (Gymnocarpium dryopteris), and brackenfern; **moss**: none.

5) 4210: WESTERN RED CEDAR FOREST

Conifer forest dominated by western red cedar (Thuja plicata) ranging from 2075 to 4800 feet in elevation. The average canopy cover is 57% ranging from 10-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Douglas-fir (Pseudotsuga menziesii), and pacific yew (Taxus brevifolia) with average percent cover ≥5% and ≤12% and frequency of occurrence ≥33% and ≤87%.

Primary associated shrub species with ≥27% and ≤47% frequency of occurrence in western red cedar stands: common prince's pine (Chimaphila umbellata), bunchberry (Cornus canadensis), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), thimbleberry (Rubus parviflorum), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤60% frequency of occurrence in western red cedar stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), sedge (Carex spp.), elk sedge (Carex geyeri), bearded fescue (Festuca subulata), small-flowered woodrush (Luzula parviflora), and woodrush (Luzula spp.); **forbs**: queen's cup beadlily (Clintonia uniflora), sweetscented bedstraw (Galium triflorum), western rattlesnake-plantain (Goodyera oblongofolia), starry solomon-plume (Smilacina stellata), clasping-leaved twisted-stalk (Streptopus amplexifolius), trefoil foamflower (Tiarella trifoliata), and round-leaved violet (Viola orbiculata); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), male fern (Dryopteris filix-mas), spinulose wood-fern (Dryopteris spinulosa), oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

6) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 2220 to 6603 feet in elevation. The average canopy cover is 35% ranging from 10-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western larch (Larix occidentalis), lodgepole pine (Pinus contorta), and ponderosa pine (Pinus ponderosa), with average percent cover ≥4% and ≤6% and frequency of occurrence ≥29% and ≤36%.

Primary associated shrub species with ≥18% and ≤31% frequency of occurrence in Douglas-fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), creeping Oregon grape (Berberis repens), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤61% frequency of occurrence in Douglas-fir stands: **graminoids**: bearded wheatgrass (Agropyron caninum), bluebunch wheatgrass (Agropyron spicatum), brome (Bromus spp.), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), and rough fescue (Festuca scabrella); **forbs**: heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), Virginia strawberry (Fragaria virginiana),

mountain sweet-cicely (Osmorhiza chilensis), false spikenard (Smilacina racemosa), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

7) 4215: WESTERN LARCH FOREST

Conifer forest dominated by western larch (Larix occidentalis) ranging from 3160 to 5630 feet in elevation. The average canopy cover is 30% ranging from 10-70% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii), with average percent cover ≥4% and ≤9% and frequency of occurrence ≥49% and ≤67%.

Primary associated shrub species with ≥39% and ≤61% frequency of occurrence in western larch stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥6% and ≤67% frequency of occurrence in western larch stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), western fescue (Festuca occidentalis), and Kentucky bluegrass (Poa pratensis); **forbs**: heart-leaf arnica (Arnica cordifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: oak-fern (Gymnocarpium dryopteris) and brackenfern (Pteridium aquilinum); **moss**: none.

8) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albicaulis) and ranging from 5799 to 8200 feet in elevation. The average canopy cover is 16% ranging from 1-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥7% and ≤16% and frequency of occurrence ≥18% and ≤99%.

Primary associated shrub species with ≥6% and ≤85% frequency of occurrence in mixed whitebark pine stands: menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), swamp current (Ribes lacustre), cascade mountain-ash (Sorbus scopulina), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥6% and ≤81% frequency of occurrence in mixed whitebark pine stands: **graminoids:** sedge (Carex spp.), elk sedge (Carex geyeri), mountain hairgrass (Deschampsia atropurpurea), Idaho fescue (Festuca idahoensis), smooth woodrush (Luzula glabrata), smooth woodrush (Luzula hitchcockii), bluegrass (Poa spp.), and spike trisetum (Trisetum spicatum); **forbs**: broadleaf arnica (Arnica latifolia), fireweed (Epilobium angustifolium), glacier lily (Erythronium grandiflorum), bracted lousewort (Pedicularis bracteosa), sickletop lousewort (Pedicularis racemosa), one-sided wintergreen (Pyrola secunda), and beargrass (Xerophyllum tenax);

ferns: ladyfern (Athyrium filix-femina) and brittle bladder-fern (Cystopteris fragilis); **moss**: moss (moss spp.).

9) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa), codominant species is mountain hemlock (Tsuga mertensia), and ranging from 4195 to 8290 feet in elevation. The average canopy cover is 22% ranging from 1-60% total cover and frequency of occurrence equal to 98%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥13% and ≤19% and frequency of occurrence ≥53% and ≤79%.

Primary associated shrub species with ≥18% and ≤53% frequency of occurrence in mixed subalpine stands: sitka alder (Alnus sinuata), Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤75% frequency of occurrence in mixed subalpine fir stands: **graminoids**: brome (Bromus spp.), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), and smooth woodrush (Luzula hitchcockii); **forb**: broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), arrowleaf groundsel (Senecio triangularis), green false hellebore (Veratrum viride), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), brittle bladder-fern (Cystopteris fragilis), field horsetail (Equisetum arvense), horsetail (Equisetum spp.), oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

10) 4221: MIXED MESIC FOREST

Conifer forest dominated by western larch (Larix occidentalis), codominant species are grand fir (Abies grandis), pacific yew (Taxus brevifolia), and western red cedar (Thuja plicata), ranging from 1710 to 6800 feet in elevation. The average canopy cover for LAROCC is 11% ranging from 1-40% total cover and frequency of occurrence equal to 90%. The average canopy cover for ABIGRA is 14% ranging from 1-60% total cover and frequency of occurrence equal to 41%. The average canopy cover for TAXBRE is 11% ranging from 1-50% total cover and frequency of occurrence equal to 12%. The average canopy cover for THUPLI is 25% ranging from 1-70% total cover and frequency of occurrence equal to 12%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥8% and ≤14% and frequency of occurrence ≥56% and ≤91%.

Primary associated shrub species with ≥18% and ≤37% frequency of occurrence in mixed mesic stands: rocky mountain maple (Acer glabrum), kinnikinnick (Arctostaphylos uva-ursi), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤45% frequency of occurrence in mixed mesic stands: **graminoids**: Columbia brome (Bromus

vulgaris), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: heart-leaf arnica (Arnica cordifolia), arnica (Arnica spp.), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), western rattlesnake-plantain (Goodyera oblongofolia), one-sided wintergreen (Pyrola secunda), and beargrass (Xerophyllum tenax); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), brackenfern (Pteridium aquilinum), and Oregon woodsia (Woodsia oregana); **moss**: moss (moss spp.).

11) 4222: MIXED XERIC FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) and ranging from 2600 to 7326 feet in elevation. The average canopy cover is 21% ranging from 1-50% total cover and frequency of occurrence equal to 88%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥9% and ≤22% and frequency of occurrence ≥12% and ≤94%.

Primary associated shrub species with ≥17% and ≤46% frequency of occurrence in mixed xeric stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), mountain balm (Ceanothus velutinus), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤61% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), orchard grass (Dactylis glomerata), Idaho fescue (Festuca idahoensis), rough fescue (Festuca scabrella), and common timothy (Phleum pratense); **forbs**: arnica (Arnica spp.), showy aster (Aster conspicuus), balsamroot (Balsamorhiza sagittata), spotted knapweed (Centauria maculosa), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: none.

12) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) and ranging from 2960 to 6821 feet in elevation. The average canopy cover for PINCON is 19% ranging from 3-80% total cover and frequency of occurrence equal to 99%. The average canopy cover for PSEMEN is 20% ranging from 3-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), western larch (Larix occidentalis), and Engelmann spruce (Picea engelmannii) with average percent cover ≥3% and ≤4% and frequency of occurrence ≥32% and ≤40%.

Primary associated shrub species with ≥25% and ≤45% frequency of occurrence in Douglas-fir-lodgepole pine stands: western serviceberry (Amelanchier alnifolia), creeping Oregon grape (Berberis repens), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤39%

frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), and roughleaf ricegrass (Oryzopsis asperifolia); **forbs**: common yarrow (Achillea millefolium), heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), Virginia strawberry (Fragaria virginiana), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: Oregon woodsia (Woodsia oregana); **moss**: moss (moss spp.).

13) 4225: DOUGLAS FIR-GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) and Douglas-fir (Pseudotsuga menziesii) and ranging from 2200 to 4520 feet in elevation. The average canopy cover for ABIGRA is 36% ranging from 20-60% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 27% ranging from 10-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western larch (Larix occidentalis), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥4% and ≤10% and frequency of occurrence ≥29% and ≤50%.

Primary associated shrub species with ≥25% and ≤45% frequency of occurrence in Douglas-fir-grand fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), creeping Oregon grape (Berberis repens), twin flower (Linnaea borealis), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤36% frequency of occurrence in Douglas-fir-grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), western fescue (Festuca occidentalis), and field woodrush (Luzula campestris); **forb**: trail-plant (Adenocaulon bicolor), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), mountain sweet-cicely (Osmorhiza chilensis), and beargrass (Xerophyllum tenax); **ferns**: northern maidenhair (Adiantum pedatum), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

14) 4226: WESTERN RED CEDAR-GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) and western red cedar (Thuja plicata) and ranging from 2185 to 6000 feet in elevation. The average canopy cover for ABIGRA is 31% ranging from 20-60% total cover and frequency of occurrence equal to 100%. The average canopy cover for THUPLI is 31% ranging from 10-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include red alder (Alnus rubra), western white pine (Pinus monticola), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤6% and frequency of occurrence ≥25% and ≤75%.

Primary associated shrub species with ≥50% and ≤88% frequency of occurrence in western red cedar-grand fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), bunchberry (Cornus canadensis), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), thimbleberry (Rubus parviflorum), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤36% frequency of occurrence in western red cedar-grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris), sedge (Carex spp.), beaked sedge (Carex rostrata), bearded fescue (Festuca subulata), small-flowered woodrush (Luzula parviflora), woodrush (Luzula spp.); **forbs**: trail-plant (Adenocaulon bicolor), Piper's anemone (Anemone piperi), wild ginger (Asarum caudatum), western goldthread (Coptis occidentalis), starry solomon-plume (Smilacina stellata), white trillium (Trillium ovatum), and round-leaved violet (Viola orbiculata); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), Virginia grape-fern (Botrychium virginianum), bulblet bladder-fern (Crytopteris bulbifera), oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

15) 4228: WESTERN LARCH-LODGEPOLE FOREST

Conifer forest dominated by western larch (Larix occidentalis) and lodgepole pine (Pinus contorta) ranging from 2900 to 6000 feet in elevation. The average canopy cover for LAROCC is 18% ranging from 3-40% total cover and frequency of occurrence equal to 100%. The average canopy cover for PINCON is 20% ranging from 3-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), subalpine fir (Abies lasiocarpa), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤4% and frequency of occurrence ≥35% and ≤81%.

Primary associated shrub species with ≥19% and ≤54% frequency of occurrence in western larch-lodgepole pine stands: sitka alder (Alnus sinutata), kinnikinnick (Arctostaphylos uva-ursi), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤65% frequency of occurrence in western larch-lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), western fescue (Festuca occidentalis), Kentucky bluegrass (Poa pratensis); **forbs**: heart-leaf arnica (Arnica cordifolia), arnica (Arnica spp.), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: oak-fern (Gymnocarpium dryopteris); **moss**: none.

16) 4229: WESTERN LARCH-DOUGLAS FIR FOREST

Conifer forest dominated by western larch (Larix occidentalis) and Douglas-fir (Pseudotsuga menziesii) ranging from 3200 to 6000 feet in elevation. The average canopy cover for LAROCC is 19% ranging from 3-60% total cover and frequency of occurrence equal to 98%. The average canopy cover for PSEMEN is 23% ranging from 10-70% total cover and frequency of occurrence equal to 98%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥4% and ≤6% and frequency of occurrence ≥33% and ≤47%.

Primary associated shrub species with ≥26% and ≤38% frequency of occurrence in western larch-Douglas-fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), creeping

Oregon grape (Berberis repens), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤53% frequency of occurrence in western larch-Douglas-fir stands: **graminoids**: smooth brome (Bromus inermis),
Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), Alaska oniongrass (Melica subulata); **forbs**: trail-plant (Adenocaulon bicolor), heart-leaf arnica (Arnica cordifolia), queen's cup beadlily (Clintonia uniflora), mountain sweet-cicely (Osmorhiza chilensis), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

17) 4301: MIXED NEEDLELEAF/BROADLEAF FOREST

Mixed needleleaf and broadleaf forest dominated by Douglas-fir (Pseudotsuga menziesii) and ranging from 2525 to 5607 feet in elevation. The average canopy cover is 12% ranging from 1-60% total cover and frequency of occurrence equal to 78%. Primary associated tree species include Engelmann spruce (Picea engelmannii), paper birch (Betula papyrifera), and western larch (Larix occidentalis) with average percent cover ≥9% and ≤23% and frequency of occurrence ≥56% and ≤75%.

Primary associated shrub species with ≥33% and ≤56% frequency of occurrence in mixed needleleaf and broadleaf stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), creeping Oregon grape (Berberis repens), twin flower (Linnaea borealis), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥11% and ≤47% frequency of occurrence in mixed needleleaf and broadleaf stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), western fescue (Festuca occidentalis), common timothy (Phleum pratense), fowl bluegrass (Poa palustris), and Kentucky bluegrass (Poa pratensis); **forbs**: wild sarsaparilla (Aralia nudicaulis), queen's cup beadlily (Clintonia uniflora), hooker fairy-bell (Disporum hookeri), sweetscented bedstraw (Galium triflorum), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: none.

P41/R27 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	2, 6, 44
6102	Broadleaf Dominated Riparian	16, 39
6103	Needleleaf-Broadleaf Riparian	8, 38
6104	Mixed Riparian (trees + any other)	18
6201	Grass-Forb Riparian/Wetland	14
6202	Shrub Riparian/Wetland	5, 15, 19
6203	Mixed Grass-Forb-Shrub Riparian	None identified for scene

---

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 1
Color: Cyan; RGB 119 218 243.
Distribution: Relatively rare class. Light density at highest elevations; some near streams, urban areas, and scattered across the Flathead Valley.
Comment: Training sites outside the zone are characterized by rock and herbaceous vegetation; two points indicate presence of riparian vegetation (6102, 6202) and one indicates Broadleaf Forest. Visual cues suggest dry grass vegetation.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
1	1	Urban & Developed Land
2	1	Broadleaf Dominated Riparian

Spectral Class 2
Color: Light olive: RGB 142 148 110.
Distribution: A large class. Light to medium density at middle elevations and forested valleys, especially in harvested sections.
Comment: Needleleaf vegetation, shrubs, and herbaceous vegetation are included in training data outside the zone.
Conclusion: 6101.

3	1	Foothills Grassland
4	1	Mixed Subalpine Forest
5	1	Needleleaf Dominated Riparian
6	1	Needleleaf-Broadleaf Riparian
7	1	Mixed Barren Land

Spectral Class 3
Color: Dark olive; RGB 80 90 83.
Distribution: Light to high density at middle to upper elevations; some clustering at higher elevatons.
Comment: Needleleaf cover types dominate training data outside the zone; several riparian sites (6202, 6101, 6103, 6201) were recorded. Appears to be Mixed Alpine Forest and Mixed Mesic Forest.
Conclusion: Not riparian.

8	1	Foothills Grassland
9	2	Lodgepole Pine
10	1	Mixed Subalpine Forest
11	1	Mixed Mesic Forest
12	1	Shrub Riparian/Wetland

Spectral Class 5
Color: Gold; RGB 194 179 126.
Distribution: Medium density across the image, excepting drier portions of valleys and highest elevations.
Comment: Needleleaf, shrub, and herbaceous cover types characterize training sites outside the zone. A few sites represent Mixed Needleleaf-Broadleaf vegetation and several represent riparian vegetation (6202, 6101, 6102, 6103, 6201).
Conclusion: 6202.

13	1	Disturbed Grasslands
14	1	Subalpine Meadow
15	1	Subalpine Fir
16	2	Broadleaf Dominated Riparian
17	1	Grass-Forb Riparian/Wetland
18	3	Shrub Riparian/Wetland

Spectral Class 6
Color: Tan brown; RGB 180 143 124.
Distribution: Similar to Spectral Class 5, but lighter in density.
Comment: Training data outside the zone indicate mostly needleleaf vegetation, with two points representing riparian vegetation (6101). Appears to represent dry grass.
Conclusion: 6101.

19	1	Mesic Upland Shrubland
20	1	Mixed Mesic Forest
21	1	Douglas-fir-Lodgepole
22	1	Broadleaf Dominated Riparian
23	1	Shrub Riparian/Wetland

Spectral Class 7
Color: Sage green; RGB 140 174 144.
Distribution: Similar to Spectral Class 5.
Comment: Conifers, shrubs, and herbaceous vegetation are well represented in training data outside the zone; two points indicate riparian vegetation (6201, 6202).
Conclusion: Not riparian.

24	1	Irrigated Pasture
25	1	Mixed Xeric Forest
26	1	Needleleaf Dominated Riparian
27	1	Broadleaf Dominated Riparian
28	1	Shrub Riparian/Wetland

Spectral Class 8
Color: Light warm brown; RGB 173 130 89.
Distribution: Light to medium density at middle to upper elevations; medium density in the Seeley-Swan Valley; clusters in the Blackfoot-Clearwater Wildlife Management Area.
Comment: Needleleaf cover types dominate training data outside the zone; some grass and riparian (6101, 6102) cover types are included. One point indicates Mixed Needleleaf-Broadleaf vegetation and one indicates Aspen.
Conclusion: 6103.

29	2	Subalpine Meadow
30	2	Mesic Upland Shrubland
31	1	Ponderosa Pine & Savannah
32	1	Broadleaf Dominated Riparian
33	1	Needleleaf-Broadleaf Riparian

Spectral Class 9
Color: Brown; RGG 135 82 79.
Distribution: Light to medium density at mid to upper elevations.
Comment: Recorded observations outside the zone indicate primarily needleleaf cover types; several observations represent riparian cover types (6101, 6201, 6103). Color and distribution imply Mixed Mesic Forest.
Conclusion: Not riparian.

34	2	Mixed Mesic Forest
35	1	Needleleaf Dominated Riparian
36	1	Needleleaf-Broadleaf Riparian

Spectral Class 10
Color: Cool orange; RGB 254 175 146.
Distribution: Medium density in irrigated portions of valleys.

Comment: Agricultural lands have the strongest presence in training sites for this class. Others, including Aspen, are minimally represented, with no riparian observations being reported. Appears to represent primarily agricultural lands.
Conclusion: Not riparian.
Spectral Class 12
Color: Medium light brown; RGB 147 101 93.
Distribution: Light density at middle to upper elevations and in forested valleys.
Comment: Conifers comprise all but one training site outside the riparian zone for this class. This class looks like Mixed Mesic Forest.
Conclusion: Not riparian.

41	1	Mix Needleleaf-Broadleaf
42	1	Needleleaf Dominated Riparian
43	1	Grass-Forb Riparian/Wetland

Spectral Class 13
Color: Bisque; RGB 222 168 169.
Distribution: A rare class. Primarily in urban and settled portions of valleys; some near streams.
Comment: Out of eight training sites outside the zone, five represent agricultural and one represents riparian (6102) vegetation. Appears to be a combination of agricultural and urban areas.
Conclusion: Not riparian.

Spectral Class 14
Color: Green gold; RGB 201 209 157.
Distribution: Light to medium density across the image, except drier portions of valleys and high elevations; higher density in irrigated portions of valleys.
Comment: Shrubs, conifers and herbaceous vegetation are about equally represented in training data outside the zone; one point indicates riparian vegetation (6201).
Conclusion: 6201.

44	2	Irrigated Crop
45	1	Dry-land Pasture
46	1	Grass-Forb Riparian/Wetland
47	2	Shrub Riparian/Wetland
48	1	Mixed Barren Land

Spectral Class 15
Color: Yellow orange; RGB 255 169 94.
Distribution: High density on some high elevation slopes; medium density in irrigated portions of valleys.

Comment: Outside the zone, the freqeuncy of observations for Mesic Upland Shrubland greatly exceeds the frequency of any other cover type. Needleleaf, Mixed Needleleaf-Broadleaf, herbaceous, riparian (6301, 6103), and Aspen cover types are also present.
Conclusion: 6202.

49	1	Foothills Grassland
50	2	Mesic Upland Shrubland
51	1	Shrub Riparian/Wetland

Spectral Class 16
Color: Light warm brown; RGB 194 125 95.
Distribution: Light to medium density at middle to upper elevations and in forested valleys.
Comment: Needleleaf cover types dominate training data outside the zone; some Mixed Needleleaf-Broadleaf and riparian (6102, 6101, 6103, 6201, 6202) cover types are included.
Conclusion: 6102.

52	1	Irrigated Pasture
53	1	Lodgepole Pine
54	1	Douglas-fir
55	2	Broadleaf Dominated Riparian
56	4	Grass-Forb Riparian/Wetland
57	1	Shrub Riparian/Wetland

Spectral Class 17
Color: Dark brown; RGB 129 70 69.
Distribution: Medium to high density on foothills of the Mission, Swan, and Flathead Ranges; light density at middle to upper elevations.
Comment: Outside the riparian zone, needleleaf cover types were observed most frequently; several sites represent riparian cover types (6101, 6103). Color and distribution suggest Mixed Mesic Forest.
Conclusion: Not riparian.

58	1	Western Red Cedar
59	1	Needleleaf Dominated Riparian
60	1	Broadleaf Dominated Riparian

Spectral Class 18
Color: Dark orange; RGB 231 131 85.
Distribution: Medium density at upper elevations; some also in irrigated portions of valleys.
Comment: Needleleaf vegetation is most prevalent in training data outside the zone, although Mesic Upland Shrubland is strongly represented as well. Mixed Needleleaf-Broadleaf and riparian (6102, 6201, 6103, 6202) vegetation are about equally represented, and two Aspen sites are included. Appears to be a combination of riparian shrub and broadleaf forest.
Conclusion: 6104.

61	1	Dry-land crop
62	1	Irrigated Crop
63	2	Subalpine Meadow
64	1	Mesic Upland Shrubland
65	1	Aspen
66	2	Broadleaf Dominated Riparian
67	2	Shrub Riparian/Wetland

Spectral Class 19
Color: Light orange; RGB 243 179 115.
Distribution: High density at some high elevation locations; sporadic medium to high density in wetter portions of valleys; sporadic clustering at middle elevations.
Comment: Mesic Upland Shrubland has the highest observation frequency of any cover type outside the riparian zone; needleleaf and herbaceous are nearly equally represented by observations; three sites were recorded as riparian vegetation (6202, 6103).
Conclusion: 6202.

68	4	Irrigated Crop
69	1	Irrigated Pasture
70	1	Mesic Upland Shrubland
71	1	Aspen
72	1	Lodgepole Pine
73	1	Douglas-fir
74	1	Grass-Forb Riparian/Wetland

Spectral Class 22
Color: Light cyan; RGB 182 251 254.
Distribution: Light density at highest elevations and drier portions of valleys.
Comment: Agricultural cover types, shrubs, and rock are included among observations outside the zone for this class; two points indicate riparian vegetation (6201, 6202). Appears to represent pasture and dry grass.
Conclusion: Not riparian.

78	2	Urban & Developed Land
79	1	Shrub Riparian/Wetland
80	1	Exposed Rock

Spectral Class 23
Color: Olive brown; RGB 115 94 82.
Distribution: Light to medium density in forested areas.
Comment: Needleleaf cover types dominate training data outside the zone; one Mixed

Needleleaf-Broadleaf and one riparian (6101) point are included. Visual cues indicate Mixed Subalpine Forest.
Conclusion: Not riparian.

81	1	Mixed Subalpine Forest
82	1	Needleleaf Dominated Riparian
83	1	Broadleaf Dominated Riparian
84	1	Needleleaf-Broadleaf Riparian
85	1	Shrub Riparian/Wetland

Spectral Class 26
Color: Blue black; RGB 8 40 88.
Distribution: A rare class. Light density along water features and at high elevations.
Comment: Just four training sites were recorded outside the zone: Subalpine Meadow, Engelmann Spruce, Lakes, and Exposed Rock. Color and locations indicate water features.
Conclusion: Not riparian.

87	4	Rivers & Streams
88	2	Lakes
89	1	Broadleaf Dominated Riparian

Spectral Class 27
Color: Pink; RGB 235 170 213.
Distribution: A rare class. Small clusters at high elevations and in valleys.
Comment: Agriculture, Exposed Rock, and Urban & Developed Land have highest frequencies among eleven observations taken outside the zone. Appears to be snow and agricultural cover types. There are no training sites within the riparian zone.
Conclusion: Not riparian.

Spectral Class 28
Color: Fuchia; RGB 224 78 255.
Distribution: A rare class. Occurs in large clusters at highest elevations.
Comment: Exposed Rock dominates training data outside the zone for this spectral class.
Conclusion: Not riparian.

Spectral Class 29
Color: Gray blue; RGB 151 179 202.
Distribution: Light to medium density along streams, in wetter portions of valleys, and at upper elevations; high density in Missoula.
Comment: Conifers, Exposed Rock, and herbaceous vegetation are about equally represented in training data outside the zone; some shrub and riparian (6201) vegetation are included.

Distribution and color suggest a combination of rock, Subalpine Meadow, and grass cover types.
Conclusion: Not riparian.

91	1	Urban & Developed Land
92	1	Needleleaf Dominated Riparian

Spectral Class 30
Color: Black; RGB 62 49 61.
Distribution: High density in shadows.
Comment: Conifers are most prevalent among training sites outside the zone; several represent riparian vegetation (6201, 6101, 6103); appears to be shadows, with some Douglas-fir included.
Conclusion: Not riparian.

93	1	Western Larch
94	1	Mixed Mesic Forest
95	1	Mix Needleleaf-Broadleaf
96	1	Needleleaf Dominated Riparian
97	1	Shrub Riparian/Wetland

Spectral Class 31
Color: Brown; RGB 114 73 78.
Distribution: Light to medium density in forested areas.
Comment: Conifers dominate training sites outside the zone; a few represent riparian vegetation (6101, 6201, 6202), with one indicating Mixed Needleleaf-Broadleaf vegetation. Color and locations imply Douglas-fir.
Conclusion: Not riparian.

98	1	Mixed Mesic Forest

Spectral Class 32
Color: Gray black; RGB 60 63 74.
Distribution: Shadows.
Comment: Conifers again are the most prevalent type of vegetation outside the zone; several points represent riparian vegetation (6101, 6103, 6201). This looks like Lodgepole Pine.
Conclusion: Not riparian.

99	1	Mixed Subalpine Forest
100	1	Needleleaf-Broadleaf Riparian

Spectral Class 33
Color: Dark olive; RGB 80 72 69.
Distribution: Light to medium density at mid to upper elevations.
Comment: Conifers dominate observations outside the zone. Seven points indicate riparian cover types (6102, 6202, 6102, 6103, 6201) and one indicates Mixed Needleleaf-Broadleaf. Lodgepole Pine appears to be the dominant cover type.
Conclusion: Not riparian.

101	1	Lodgepole Pine
102	1	Douglas-fir
103	1	Needleleaf Dominated Riparian
104	1	Grass-Forb Riparian/Wetland

Spectral Class 36
Color: Sea green; RGB 111 221 195.
Distribution: Large clusters in drier portions of valleys.
Comment: Exposed Rock has the highest frequency of any cover type observed outside the zone; herbaceous and shrub cover types are included as well. Color and distribution indicate dry grass cover types.
Conclusion: Not riparian.

108	1	Shrub Riparian/Wetland

Spectral Class 38
Color: Terracotta; RGB 231 131 108.
Distribution: Light density at upper elevations on the western portion of the image; medium to high density in irrigated portions of valleys.
Comment: Needleleaf and herbaceous vegetation characterize training sites outside the zone; Mixed Needleleaf-Broadleaf and riparian (6201) vegetation are minimally present.
Conclusion: 6103.

110	1	Irrigated Crop
111	1	Irrigated Pasture
112	2	Broadleaf Dominated Riparian

Spectral Class 39
Color: Light brown; RGB 155 117 91.
Distribution: Light to medium density in forested areas.
Comment: Most training sites outside the zone represent needleleaf cover types; several are riparian (6161, 6202) and one is Aspen.
Conclusion: 6102.

113	1	Lodgepole Pine
114	1	Ponderosa Pine & Savannah

115	1	Mixed Mesic Forest
116	3	Broadleaf Dominated Riparian
117	1	Shrub Riparian/Wetland

Spectral Class 40
Color: Jade green; RGB 88 162 147.
Distribution: Medium density on foothills and along river corridors; high density in one large burn; light density in valleys and at middle elevations.
Comment: Exposed Rock and herbaceous vegetation characterize training sites outside the zone; shrubs, conifers, and riparian vegetation (6101) are present. Rock and grass cover types are indicated by visual cues.
Conclusion: Not riparian.

118	1	Urban & Developed Land
119	1	Subalpine Meadow
120	1	Broadleaf Dominated Riparian
121	1	Exposed Rock
122	1	Shoreline & Gravel Bars

Spectral Class 41
Color: Very dark brown; RGB 77 46 56.
Distribution: Relatively sparse, occurring at middle to upper elevations.
Comment: Several training sites outside the zone were recorded as coniferous vegetation; one site represents riparian vegetation (6101). Color and distribution are typical of coniferous vegetation.
Conclusion: Not riparian.

Spectral Class 42
Color: Brown olive; RGB 125 112 90.
Distribution: Light to medium density in forested areas.
Comment: Training data outside the zone includes primarily needleleaf, some shrub, and one riparian (6101) observation. Appears to represent conifers.
Conclusion: Not riparian.

123	1	Douglas-fir
124	1	Needleleaf-Broadleaf Riparian
125	1	Grass-Forb Riparian/Wetland

Spectral Class 43
Color: Very dark brown; RGB 87 162 147.
Distribution: Small clusters at mid-elevation locations.

Comment: All but one training site outside the zone, a riparian site (6101), indicate needleleaf vegetation. This class also seems to be coniferous cover types.
Conclusion: Not riparian.

Spectral Class 44
Color: Gray olive; RGB 105 118 105.
Distribution: Light to medium density in forested areas.
Comment: Conifers dominate training data outside the zone; shrubs, herbaceous and riparian (6202, 6101) vegetation are included.
Conclusion: 6101.

126	1	Foothills Grassland
127	1	Mixed Mesic Forest
128	2	Needleleaf Dominated Riparian
129	1	Needleleaf-Broadleaf Riparian
130	2	Grass-Forb Riparian/Wetland
131	1	Shrub Riparian/Wetland

Spectral Class 46
Color: Light cyan; RGB 204 255 253.
Distribution: A rare class, occurring in valleys and river corridors.
Comment: Exposed Rock and agriculture were most observed outside the riparian zone. Visual cues indicate rock and barren land.
Conclusion: Not riparian.

132	1	Irrigated Crop
133	1	Shrub Riparian/Wetland
134	1	Exposed Rock

Spectral Class 47
Color: Gray; RGB 156 158 152.
Distribution: Light density at all elevations.
Comment: Conifers occur most frequently in training data outside the zone; two points indicate riparian vegetation (6101, 6201). Color and locations suggest dry agricultural lands.
Conclusion: Not riparian.

135	1	Mix Needleleaf-Broadleaf
136	1	Grass-Forb Riparian/Wetland

Spectral Class 48
Color: Flat green; RGB 114 140 124.
Distribution: Light density in most areas; somewhat more dense at middle elevations near

river corridors.
Comment: Conifers are most prevalent among training sites outside the zone; some herbaceous vegetation, including one riparian site (6201) are included.
Conclusion: Not riparian.

137	1	Ponderosa Pine & Savannah
138	1	Mixed Xeric Forest
139	2	Broadleaf Dominated Riparian
140	1	Grass-Forb Riparian/Wetland

Spectral Class 49
Color: Dark brown; RGB 97 67 70.
Distribution: Widely distributed at mid to upper elevations; medium density at mid elevations.
Comment: Needleleaf cover types characterize training sites outside the zone; several riparian sites (6101, 6201, 6102) and one Mixed Needleleaf-Broadleaf site are included.
Conclusion: Not riparian.

141	1	Mixed Mesic Forest
142	1	Douglas-fir-Lodgepole
143	1	Lakes
144	2	Needleleaf Dominated Riparian
145	1	Needleleaf-Broadleaf Riparian

Spectral Class 50
Color: Dark brown olive; RGB 100 84 75.
Distribution: Similar to Spectral Class 49.
Comment: Training sites outside the zone primarily indicate needleleaf vegetation; several riparian sites (6103, 6101, 6202) are included. Appears to represent Mixed Subalpine Forest. Color and distribution indicate a mixture on nonriparian conifers and shrubs.
Conclusion: Not riparian.

146	1	Herbaceous Clearcut
147	1	Lodgepole Pine
148	1	Mixed Mesic Forest
149	1	Mix Needleleaf-Broadleaf
150	2	Needleleaf Dominated Riparian
151	1	Needleleaf-Broadleaf Riparian

Spectral Class 51
Color: Medium light warm brown; RGB 140 95 78.
Distribution: Light density at middle to upper elevations.
Comment: Training data outside the zone indicates primarily needleleaf cover types; some shrub, riparian (6101, 6201), and Mixed Needleleaf-Broadleaf cover types are also present.
Conclusion: Not riparian.

152	1	Lodgepole Pine
153	1	Needleleaf Dominated Riparian
154	1	Needleleaf-Broadleaf Riparian

Spectral Class 52
Color: Rust; RGB 170 94 78.
Distribution: Light to medium density at middle elevations.
Comment: Coniferous, Mesic Upland Shrubland, and riparian (6101, 6103, 6102, 6201, 6202) cover types were recorded outside the zone, with the coniferous group having the highest number of observations. Visual cues imply nonriparian shrubs.
Conclusion: Not riparian.

155	1	Western Red Cedar
156	2	Mixed Subalpine Forest
157	1	Mix Needleleaf-Broadleaf
158	1	Needleleaf-Broadleaf Riparian

Spectral Class 53
Color: Black; RGB 30 36 56.
Distribution: Shadows.
Comment: Conifers dominate training data outside the zone; one point represents riparian vegetation (6101).
Conclusion: Not riparian.

159	1	Dry-land Pasture
160	1	Mixed Mesic Forest
161	1	Needleleaf Dominated Riparian

Spectral Class 54
Color: Dark flat brown; RGB 75 58 61.
Distribution: Shadows.
Comment: Needleleaf cover types are most prevalent among training sites outside the zone; ten sites represent riparian cover types (6101, 6103, 6201, 6202). Visual indicators suggest subalpine conifers.
Conclusion: Not riparian.

162	1	Mixed Subalpine Forest
163	1	Mixed Mesic Forest
164	1	Douglas-fir/Lodgepole
165	2	Shrub Riparian/Wetland

Spectral Class 55
Color: Black; RGB 8 28 46.
Distribution: Shadows and water.
Comment: All vegetation-related cover types outside the riparian zone represent conifers.
Conclusion: Not riparian.

166	1	Needleleaf Dominated Riparian
167	1	Grass-Forb Riparian/Wetland

Spectral Class 58
Color: Cyan; RGB 153 251 253.
Distribution: Occurs at highest elevations and portions of valleys.
Comment: Grasslands, agricultural land, and shrubland are about equally represented in training data outside the zone. Visual cues also indicate agricultural and dry grass cover types.
Conclusion: Not riparian.

170	1	Irrigated Crop
171	1	Shrub Riparian/Wetland

Spectral Class 60
Color: Black; RGB 0 1 40.
Distribution: Water bodies.
Comment: Of four training sites located outside the riparian zone, three indicate coniferous vegetation, and the other indicates water.
Conclusion: Not riparian.

172	8	Lakes
173	1	Needleleaf Dominated Riparian

Spectral Class 61
Color; Light grass green; RGB 169 219 172.
Distribution: Scattered, small clusters at all elevations.
Comment: Conifers, shrubs, and herbaceous vegetation are about equally represented among training sites outside the zone. The color and distribution indicate drier grasses and agricultural lands.
Conclusion: Not riparian.

174	1	Grass-Forb Riparian/Wetland

Spectral Class 62
Color: Dark jade green; RGB 54 114 128.

Distribution: A relatively rare class. High density in one large burn; light to medium density along some river corridors and middle to upper elevations; very little in valleys.
Comment: Exposed Rock has the highest frequency among cover types observed outside the riparian zone; conifers and shrubs are also present. Visual cues also indicate rock.
Conclusion: Not riparian.

175	2	Broadleaf Dominated Riparian
176	1	Grass-Forb Riparian/Wetland
177	1	Shrub Riparian/Wetland
178	1	Exposed Rock

Spectral Class 65
Color: Pale cyan; RGB 219 255 255.
Distribution: A rare class. Very light density at highest elevations; light density in wetter portions of valleys.
Comment: Seven training sites indicate Irrigated Crop, Exposed Rock, and Mines, Quarries, Gravel Pit cover types; appears to represent rock, barren land, and very dry grass.
Conclusion: Not riparian.

184	1	Grass-Forb Riparian/Wetland

TM SCENE P41/R28

Image Analyst: Zhenkui Ma

Training Data Analysis

A total of 2995 ground-truth plots were available for labeling P41/R28 (see table below); 1666 were collected by Forest Service field crews during the1994-95 field seasons, and 1240 of these were collected specifically for this TM scene. The remaining 1329 plots came from pre-existing data sources such as ECODATA and TSMRS.

All the ground-truth data were converted to a point file and superimposed on the unsupervised classification to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 591) were removed from further analysis. Then the data were examined by cover type and by data source (whether or not plots were collected for this project or for other purposes, like pre-existing ECODATA or TSMRS). The latter "existing data" were only used in the training data set to supplement cover types that had insufficient plots collected during the 1994 or 1995 field seasons. Seven classes were excluded from the digital classification process: urban, agriculture, water, snow, melted snow, cloud, and cloud shadow. All ground truth data with VEG_CLASS_CODEs for urban, agriculture, or water cover types were excluded. Next, 20% of the remaining plots were randomly selected from each cover type; these plots (n = 257) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

The remaining 80% of the data (n = 1052 plots) were subjected to further spectral examination. Outliers were eliminated for each cover type by visual examination of TM and elevation values for their respective regions. Supplemental training data (n = 121) were obtained from Vita Wright for three forest cover types (Ponderosa Pine, Douglas Fir, and Mixed Xeric Forest); these were only used for the cover type classification.

Total plots in ground-truth file	2995	
Total 1994-95 field plots	1666	
Plots sampled for P41/R28		1240
Plots sampled for other scenes		426
Pre-existing plots (ECODATA, TSMRS, etc.)	1329	
Plots held aside or eliminated	1686	
Duplicates		591
Pre-existing plots		875
Manually labeled cover types		220
Potential training plots	1309	
20% test		257
80% training		1052
Supplemental plots (from pre-existing data set)	121	
Total plots available for training	1173	
Total plots used for training -- cover type	823	
size class	276	
canopy	1045	

Land Cover Types

Land cover types were labeled through a digital classification of the 7 TM channels plus rescaled elevation (meters divided by 25), using the Nearest Member of Group classifier. This classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were assigned directly to the COVERTYPE field in the attribute table. Modifications were carried out using spectral class values (SPECTRAL_CLASS, or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000. Urban.	Manually identified and recoded by Zhenkui Ma.
2000. Agriculture.	Manually identified and recoded by Zhenkui Ma.
3101. Foothills Grasslands.	All grass types occurring below 1524 m (5000 ft) were relabeled as Foothills Grasslands.
3104. Montane Parklands & Subalpine Meadows.	All grass types occurring at or above 1524 m (5000 ft) were reassigned this label.
3202. Warm Mesic Shrubland.	All regions that were classified as a 3200 level shrub type were labeled as Warm Mesic Shrubland if they occurred below 1463 m (4800 ft). If they occurred between 1463 and 1768 m (5800 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.

3203.	Cold Mesic Shrubland.	All regions that were classified as 3200 level shrub types were labeled as Cold Mesic Shrubland if they occurred above 1768 m (5800 ft). If they occurred between 1463 (4800 ft) and 1768 m, they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
5000.	Water.	All regions with spectral class (LINK = 1) and slope less than or equal to 5˚ were labeled as water; cloud shadows (see 9900 below) were recoded manually. Generally, water was more spectrally distinct than most other cover types, but in mountainous terrain, it was sometimes confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate slope and aspect values such that their slope may be greater than 5˚. This would result in the misclassification of some small ponds or lakes.
8100.	Alpine Meadow.	All grass types (3100) occurring above 2439 m (8000 ft) were relabeled as Alpine Meadow.
(n/a)	Melted Snow.	All regions originally classified as Melted Snow were recoded either to Exposed Rock (7301), if their slope was greater than 5˚, or to Snow (9000), if their slope was less than or equal to 5˚.
9800.	Cloud.	Manually identified and recoded by Zhenkui Ma.
9900.	Cloud Shadow.	Manually identified and recoded by Zhenkui Ma.

A total of 40 classes were labeled in the full TM scene. These included three grass types, seven shrub types, twenty forest types, three barren types, one alpine type, plus six manually labeled classes. Land cover classes were reviewed by personnel from the following National Forests: Lolo (Dave Atkins), Bitterroot (Ken McBride and Linda Pietarinen), Nez Perce (Pat Green), Clearwater (Kevin Searle), and Deer Lodge (Steven Kujala). Cover types are mapped in Figure F-8.

Canopy Cover Classes

Canopy cover labels (CANOPY_CODE = low, medium, or high) were assigned to tree and shrub classes based on MNDVI values. These values were plotted as frequency histograms for all coniferous forest types (Figure F-8a) as well as for two different shrub types (mesic versus xeric; Figures F-8b+c). The histograms were examined visually and break points decided based on the distribution modes. Regions with MNDVI values falling below the lower break point were assigned to the low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class.

CANOPY COVER	MNDVI BREAKPOINTS		
	Tree	Shrub	
		Xeric	Mesic
Low	<215	<85	<180
Medium	≥215 and <425	≥85	≥180 and <280
High	≥425	n/a	≥280

Size Classes

Six size classes were distinguished -- four for forest cover types (seedling/sapling, pole, medium, and large/very large) and three for shrub cover types (low, medium and tall). Only the seven TM channels were used for these classifications. The Nearest Mean classifier was used for tree size classes, and the Nearest Member of Group classifier was used for shrub size classes. Tree size classes were stratified based upon the canopy cover classes described above.

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications. Note that the Forest Group accuracy was not calculated separately but was part of the overall Lifeform accuracy assessment. We feel that this Forest Group accuracy is much more reliable than the overall Lifeform accuracy because the latter includes manually labeled cover types like Urban, Agriculture, and Water. Again, no accuracy assessment was performed on the manually labeled cover types.

Classifications for P41/R28	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	32	58%	24%
Lifeform	5	n/a	76%
Forest Group	18	n/a	89%
Tree Size Class	4	74%	45%
Tree Canopy Class	3	95%	50%
Shrub Size Class	3	89%	67%
Shrub Canopy Class	3	83%	59%

Comments

This scene was reclassified using other supplementary ground truth data for three cover types, ponderosa pine, Douglas-fir, and mixed xeric forest. The overall cover type accuracy did not change substantially with this reclassification, but the the accuracies for ponderosa pine and mixed xeric forest both improved by nearly 10%. Apparently this came at a cost of increased commission errors for the other cover types.

Error Matrix For Cover Type Training Plots

Scene P41/R28

CLASSIFIED COVER TYPES

PLOT COVER TYPES	3101	3102	3104	3201	3202	3203	3301	3304	3305	3306	3308	4102	4201	4203	4206	4207	4208	4210	4212	4215	4219	4220	4221	4222	4223	4224	4225	4226	4228	4229	4301	7301	7500	7701	7800	7900	8101	SUM
3101	27	1	5	2	8	3	2	0	0	0	2	0	0	0	2	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	58
3102	0	0	0	1	1	1	1	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	9
3104	1	0	4	3	2	6	0	0	0	0	1	1	0	1	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	4	0	0	5	0	1	33
3201	1	2	1	1	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	11
3202	6	1	4	2	28	5	0	1	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	54
3203	1	0	10	1	3	3	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	8	0	0	0	0	0	29
3301	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
3304	1	1	0	0	0	0	0	5	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
3305	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3
3306	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3308	1	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
4102	3	1	1	0	0	0	0	0	0	0	0	6	0	0	2	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
4201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
4203	0	0	0	0	1	0	0	0	0	0	0	0	0	14	1	2	2	0	7	1	1	2	2	2	4	0	0	0	0	0	0	0	0	0	3	0	0	42
4206	1	0	0	0	2	0	0	1	2	0	0	1	0	2	41	3	0	0	9	1	0	0	4	1	0	0	0	1	0	0	0	1	0	0	0	1	0	71
4207	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	7	0	1	2	0	0	0	6	0	2	0	1	1	1	0	0	0	0	0	0	0	0	25
4208	0	0	2	0	0	1	0	0	0	0	0	0	0	2	0	0	11	0	0	0	1	4	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	23
4210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	2	0	0	1	0	0	0	1	0	0	7
4212	1	0	0	0	0	0	0	0	1	0	0	1	0	6	6	3	1	0	60	0	0	4	8	11	2	0	1	2	0	1	1	2	0	0	0	1	0	112
4215	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	3
4219	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	6
4220	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	1	4	0	4	0	2	29	4	0	0	0	1	0	1	0	0	0	0	0	1	0	0	50
4221	0	0	1	0	2	0	0	0	0	0	0	2	5	4	5	5	0	0	9	0	0	3	14	4	3	0	1	2	0	1	0	0	0	0	1	0	0	62
4222	0	0	0	0	0	0	0	0	1	0	0	0	0	3	4	0	0	0	11	0	0	0	4	4	1	0	0	0	0	0	0	0	0	0	0	0	0	28
4223	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	1	0	3	1	0	0	4	1	2	0	0	1	0	0	0	0	0	0	0	0	0	18
4224	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
4225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	1	4	1	0	0	0	2	0	0	1	0	0	0	0	0	0	12
4226	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	1	0	1	2	0	0	0	2	1	0	0	2	2	0	0	1	0	0	0	0	0	0	15
4228	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2
4229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3
7301	3	1	6	1	3	5	0	1	0	0	0	0	0	1	3	0	2	0	3	0	0	1	1	0	0	0	0	0	0	0	0	22	1	0	4	1	0	59
7500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
7701	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
7800	3	0	5	0	2	1	1	0	0	0	0	0	0	3	0	0	1	1	1	1	0	1	2	0	0	0	0	0	0	0	0	2	0	0	3	0	0	27
7900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
8101	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
SUM	50	8	42	13	56	26	8	11	5	2	6	11	7	44	75	26	26	5	119	6	4	50	66	27	15	0	7	13	3	2	4	47	1	0	24	3	1	813

% AGREEMENT	35.67
TAU WITH EQUAL PROBABILITY	0.34
TOTAL DIAGONAL ELEMENTS	290
TOTAL TRAINING PLOTS IN DATA SET	813

F. P41/R28. 6

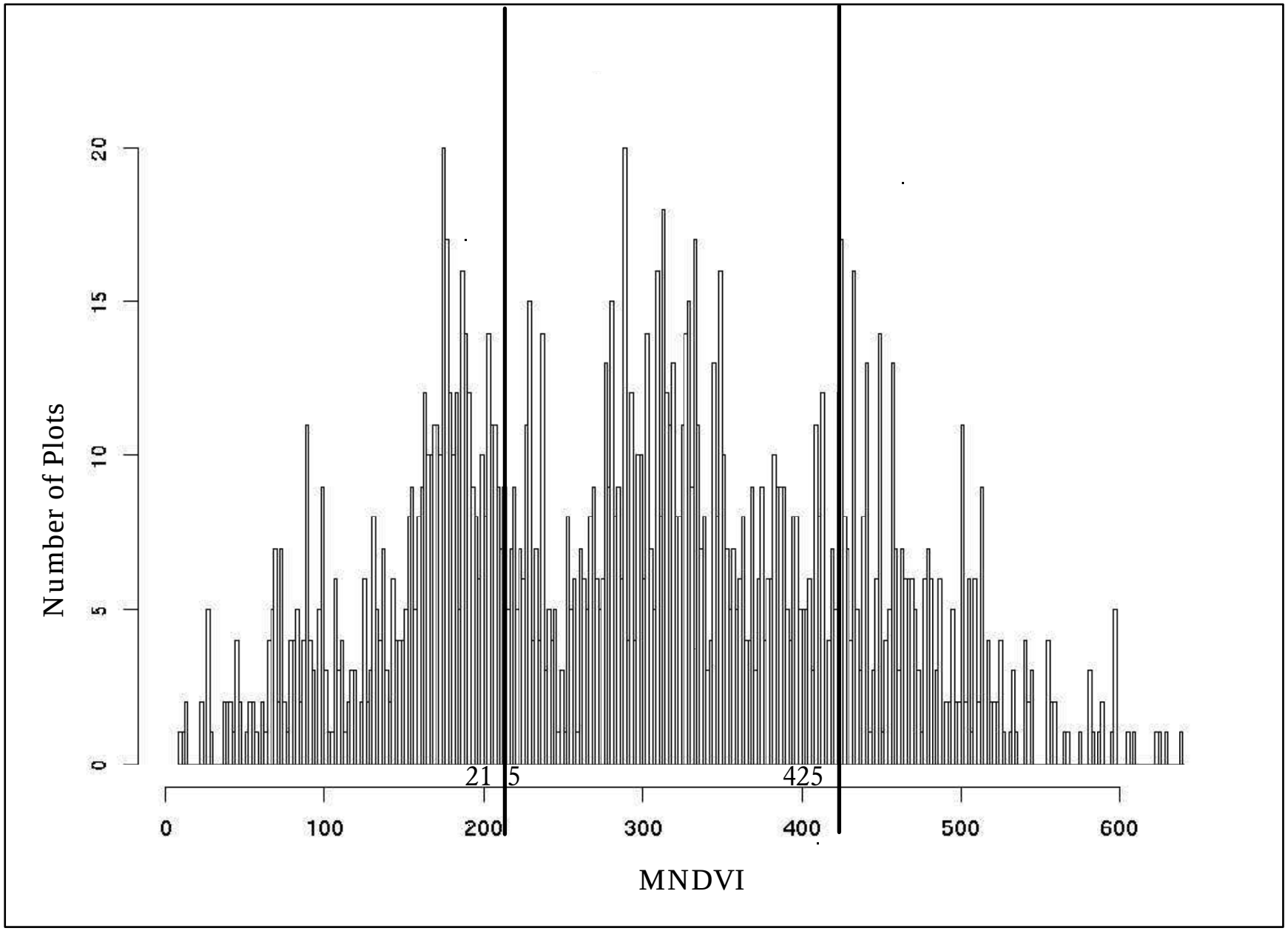


Figure F-8a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P41/R28

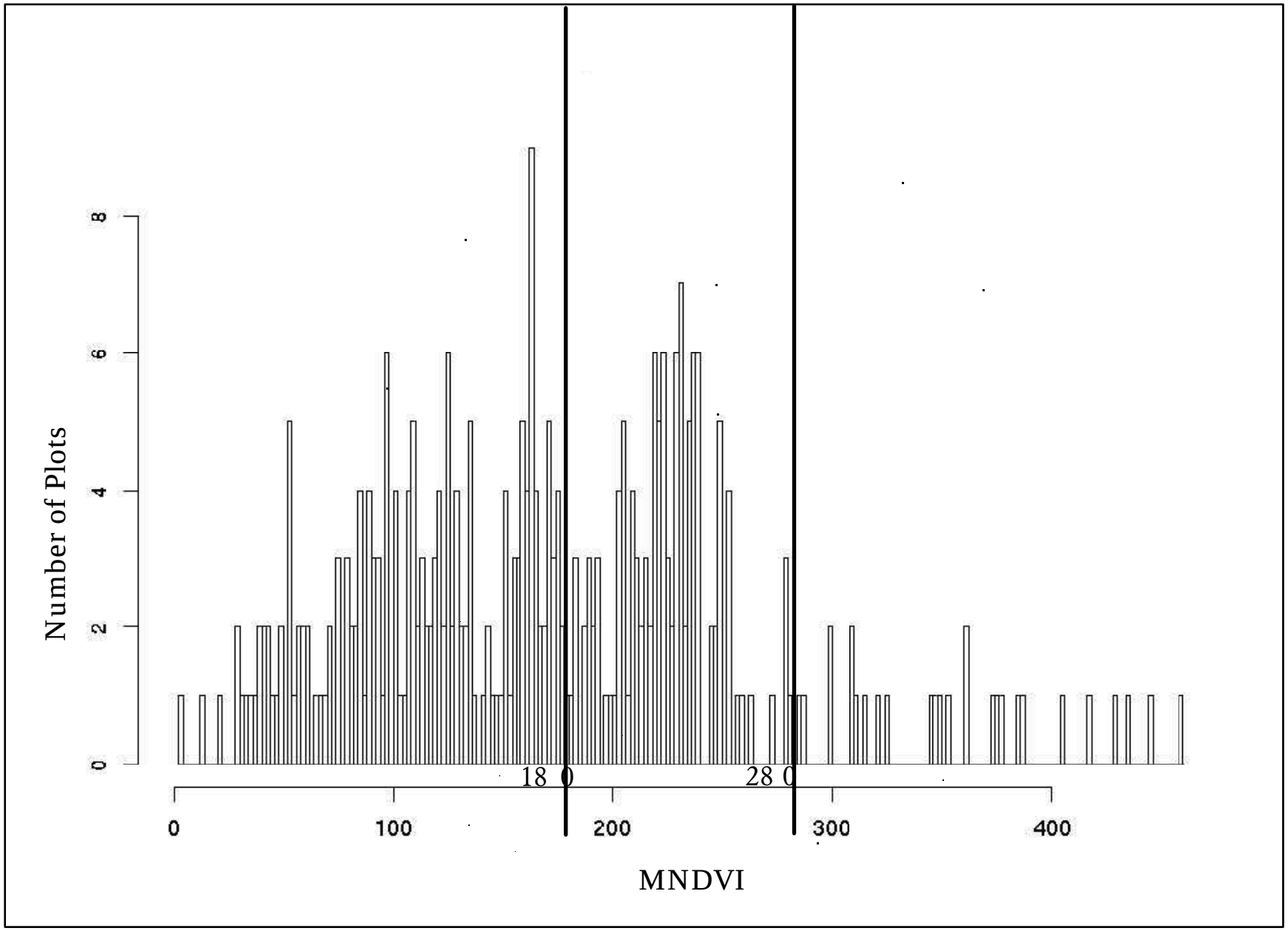


Figure F-8b. Breaks between mesic shrub canopy cover classes in relation to MNDVI values: TM scene P41/R28

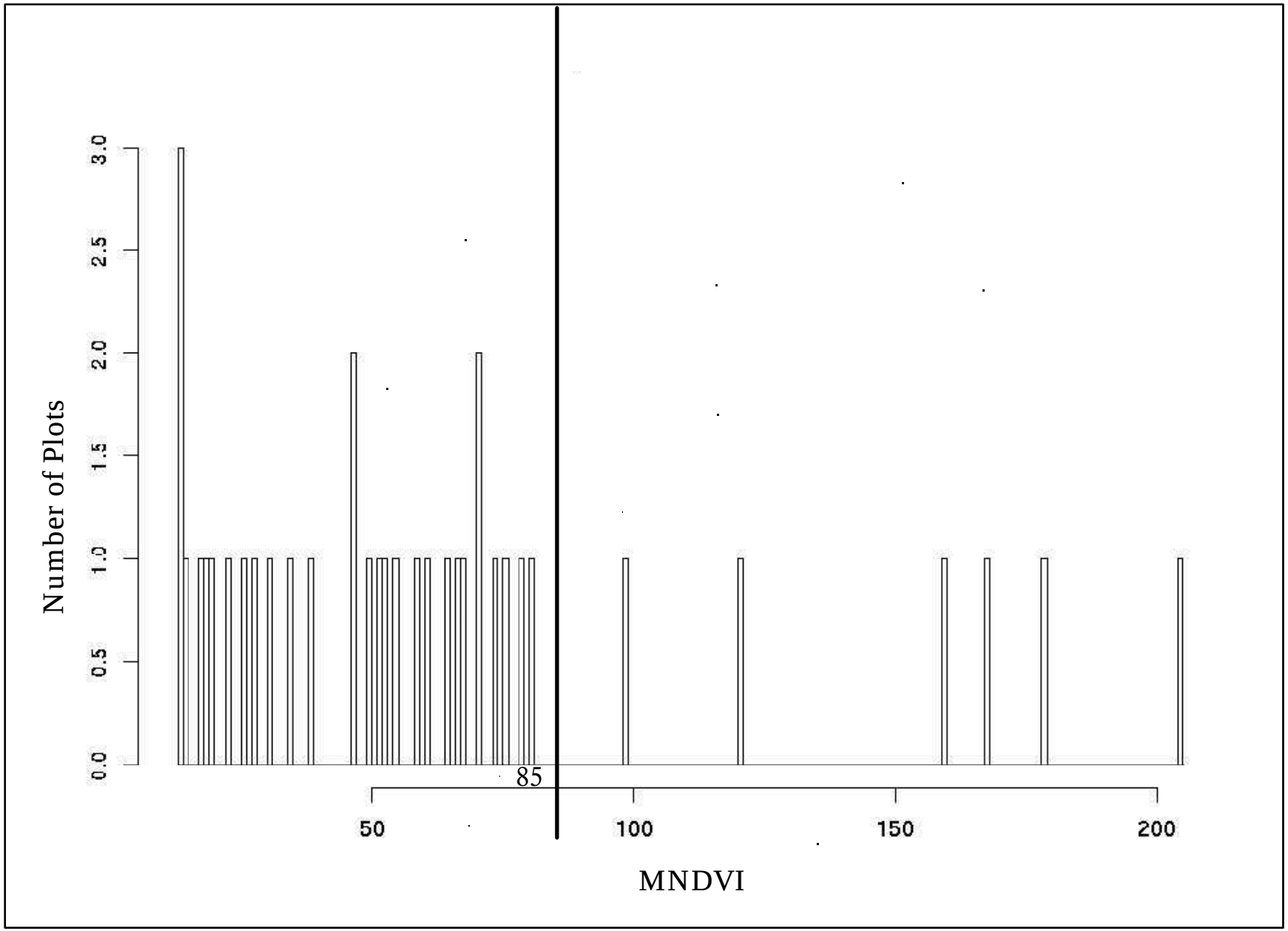


Figure F-8c. Breaks between xeric shrub canopy cover classes in relation to MNDVI values: TM scene P41/R28

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3102	3104	3201	3202	3203	3301	3304	3305
3101	5(5)	3(3)	3(3)	0(1)	3(1)	1(1)	2(1)	1(1)	0(1)
3102	1(3)	1(5)	0(2)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)
3104	10(3)	1(3)	6(5)	0(1)	11(1)	9(1)	0(1)	1(1)	0(1)
3201	0(1)	1(1)	0(1)	0(5)	1(4)	2(4)	0(2)	0(2)	0(2)
3202	5(1)	0(1)	2(1)	0(4)	40(5)	4(3)	0(2)	0(2)	0(2)
3203	0(1)	0(1)	5(1)	0(4)	3(3)	5(5)	0(2)	0(2)	0(2)
3301	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(5)	0(2)	0(2)
3304	2(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)	0(5)	0(3)
3305	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)	0(3)	0(5)
3308	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(2)	1(4)	0(4)
4201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4203	0(1)	0(1)	4(1)	0(1)	0(1)	2(1)	0(1)	0(1)	0(1)
4206	4(1)	2(1)	1(1)	0(1)	6(1)	1(1)	0(1)	0(1)	0(1)
4207	0(1)	0(1)	1(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
4208	0(1)	0(1)	3(1)	0(1)	0(1)	2(1)	0(1)	0(1)	0(1)
4210	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
4212	1(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
4215	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4219	0(1)	0(1)	1(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)
4220	0(1)	0(1)	4(1)	0(1)	2(1)	3(1)	0(1)	1(1)	0(1)
4221	0(1)	0(1)	0(1)	0(1)	6(1)	0(1)	0(1)	0(1)	0(1)
4222	2(1)	1(1)	0(1)	0(1)	4(1)	1(1)	0(1)	0(1)	1(1)
4223	0(1)	0(1)	1(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
4224	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
4225	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4226	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
4229	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7301	1(1)	0(1)	3(1)	0(1)	5(1)	0(1)	0(1)	0(1)	0(1)
7500	0(0)	0(0)	1(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
7800	2(2)	0(1)	3(1)	0(1)	0(1)	2(1)	0(1)	0(1)	0(1)
7900	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	34(0)	9(0)	38(0)	0(0)	86(0)	33(0)	2(0)	5(0)	1(0)

Accuracy Assessment Tables for P41/R28 -- Cover Type

RF/CF	3308	4201	4203	4206	4207	4208	4210	4212	4215
3101	0(1)	0(1)	0(1)	1(1)	1(1)	1(1)	0(1)	0(1)	0(1)
3102	0(1)	0(1)	0(1)	2(1)	0(1)	0(1)	0(1)	1(1)	0(1)
3104	0(1)	0(1)	2(1)	6(1)	2(1)	0(1)	0(1)	3(1)	0(1)
3201	0(2)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)
3202	0(2)	0(1)	1(1)	7(1)	2(1)	0(1)	2(1)	4(1)	1(1)
3203	0(2)	0(1)	2(1)	2(1)	1(1)	2(1)	0(1)	1(1)	0(1)
3301	0(2)	0(1)	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3304	0(4)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3305	0(3)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3308	0(5)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4201	0(1)	1(5)	0(2)	0(2)	1(2)	0(3)	0(2)	2(2)	0(2)
4203	0(1)	1(2)	31(5)	3(2)	0(2)	10(2)	0(2)	12(2)	0(2)
4206	0(1)	0(2)	1(2)	13(5)	1(2)	0(2)	1(2)	2(2)	0(2)
4207	0(1)	0(2)	1(2)	1(2)	13(5)	0(2)	1(2)	4(2)	1(2)
4208	0(1)	0(3)	8(2)	0(2)	1(2)	6(5)	0(2)	7(2)	0(2)
4210	0(1)	0(2)	1(2)	1(2)	1(2)	0(2)	4(5)	1(2)	0(2)
4212	0(1)	0(2)	7(2)	9(2)	2(2)	0(2)	1(2)	35(5)	0(3)
4215	0(1)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(3)	0(5)
4219	0(1)	0(3)	3(3)	0(2)	0(2)	7(3)	0(2)	1(2)	0(2)
4220	0(1)	0(4)	24(3)	1(2)	0(2)	14(3)	0(2)	14(3)	0(2)
4221	0(1)	3(3)	6(3)	3(2)	3(3)	2(2)	3(3)	8(3)	0(3)
4222	0(1)	0(2)	1(2)	4(3)	0(2)	1(2)	1(2)	11(3)	0(2)
4223	0(1)	0(2)	2(3)	0(2)	1(2)	2(2)	0(2)	8(3)	0(2)
4224	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
4225	0(1)	0(2)	0(2)	2(2)	2(4)	0(2)	2(2)	2(3)	0(2)
4226	0(1)	0(2)	0(2)	1(2)	0(4)	0(2)	4(3)	4(2)	0(2)
4229	0(1)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(3)	0(3)
4301	0(1)	0(2)	0(2)	0(2)	0(3)	0(2)	0(3)	1(2)	0(2)
7301	0(1)	1(1)	0(1)	3(1)	0(1)	1(1)	0(1)	4(1)	0(1)
7500	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
7800	1(1)	0(1)	0(1)	0(1)	1(1)	2(1)	0(1)	1(1)	0(1)
7900	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	1(0)	7(0)	91(0)	61(0)	32(0)	48(0)	19(0)	127(0)	2(0)

Accuracy Assessment Tables for P41/R28 -- Cover Type

RF/CF	4219	4220	4221	4222	4223	4224	4225	4226	4229
3101	0(1)	0(1)	2(1)	1(1)	0(1)	0(0)	0(1)	0(1)	0(1)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(0)	1(1)	0(1)	0(1)
3104	0(1)	2(1)	4(1)	2(1)	0(1)	0(0)	0(1)	0(1)	0(1)
3201	0(1)	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(1)	0(1)
3202	0(1)	1(1)	2(1)	5(1)	1(1)	0(0)	2(1)	0(1)	0(1)
3203	0(1)	3(1)	1(1)	0(1)	0(1)	0(0)	0(1)	0(1)	0(1)
3301	0(1)	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(1)	0(1)
3304	0(1)	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(1)	0(1)
3305	0(1)	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(1)	0(1)
3308	0(1)	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(1)	0(1)
4201	0(3)	1(4)	1(4)	0(2)	0(2)	0(0)	0(2)	0(2)	0(2)
4203	0(3)	22(3)	7(3)	1(2)	11(4)	0(0)	0(2)	0(2)	0(2)
4206	0(2)	0(2)	4(3)	4(4)	1(2)	0(0)	0(2)	0(2)	0(2)
4207	0(2)	1(2)	11(3)	1(2)	2(2)	0(0)	4(4)	3(4)	0(2)
4208	0(3)	8(3)	1(3)	0(2)	1(2)	0(0)	0(2)	0(2)	0(2)
4210	0(2)	0(2)	2(3)	0(2)	0(2)	0(0)	0(2)	1(4)	0(2)
4212	0(2)	5(3)	12(3)	6(4)	6(4)	0(0)	2(4)	4(2)	0(4)
4215	0(2)	1(3)	0(3)	0(2)	0(2)	0(0)	1(2)	0(2)	0(4)
4219	0(5)	12(3)	0(2)	0(2)	1(2)	0(0)	0(2)	0(2)	0(2)
4220	0(3)	30(5)	11(2)	0(2)	1(3)	0(0)	0(2)	0(2)	4(2)
4221	0(2)	3(2)	20(5)	1(2)	4(3)	0(0)	0(4)	5(4)	4(4)
4222	0(2)	0(2)	5(2)	2(5)	1(2)	0(0)	0(2)	0(2)	0(2)
4223	0(2)	7(3)	1(3)	0(2)	2(5)	0(0)	0(3)	1(2)	0(4)
4224	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
4225	0(2)	1(2)	1(4)	0(2)	0(3)	0(0)	2(5)	3(3)	0(3)
4226	0(2)	0(2)	2(4)	2(2)	0(2)	0(0)	2(3)	4(5)	0(3)
4229	0(2)	0(3)	0(4)	1(2)	0(4)	0(0)	0(3)	0(3)	0(5)
4301	0(2)	0(3)	0(3)	0(3)	0(3)	0(0)	0(3)	0(3)	0(3)
7301	0(1)	2(1)	0(1)	0(1)	2(1)	0(0)	0(1)	0(1)	0(1)
7500	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
7800	0(1)	0(1)	1(1)	0(1)	0(1)	0(0)	2(1)	0(1)	0(1)
7900	0(1)	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(1)	0(1)
SUM	0(0)	99(0)	88(0)	26(0)	33(0)	0(0)	16(0)	21(0)	8(0)

Accuracy Assessment Tables for P41/R28 -- Cover Type

RF/CF	4301	7301	7500	7800	7900	SUM
3101	0(1)	1(1)	0(0)	1(1)	0(1)	27(0)
3102	0(1)	0(1)	0(0)	0(1)	0(1)	7(0)
3104	1(1)	8(1)	0(0)	1(1)	0(1)	70(0)
3201	0(1)	1(1)	0(0)	0(1)	0(1)	7(0)
3202	1(1)	5(1)	0(0)	5(1)	0(1)	91(0)
3203	0(1)	3(1)	0(0)	0(1)	0(1)	29(0)
3301	0(1)	0(1)	0(0)	0(1)	0(1)	2(0)
3304	0(1)	0(1)	0(0)	0(1)	0(1)	2(0)
3305	0(1)	0(1)	0(0)	0(1)	0(1)	1(0)
3308	0(1)	0(1)	0(0)	0(1)	0(1)	1(0)
4201	0(2)	0(1)	0(0)	0(1)	0(1)	8(0)
4203	0(2)	1(1)	0(0)	1(1)	0(1)	107(0)
4206	0(2)	0(1)	0(0)	0(1)	0(1)	42(0)
4207	2(2)	0(1)	0(0)	0(1)	1(1)	51(0)
4208	0(2)	0(1)	0(0)	0(1)	0(1)	37(0)
4210	1(2)	0(1)	0(0)	0(1)	0(1)	13(0)
4212	2(2)	2(1)	0(0)	0(1)	0(1)	95(0)
4215	0(2)	0(1)	0(0)	0(1)	0(1)	2(0)
4219	0(2)	1(1)	0(0)	0(1)	0(1)	28(0)
4220	0(2)	0(1)	0(0)	0(1)	0(1)	110(0)
4221	0(2)	0(1)	0(0)	0(1)	0(1)	77(0)
4222	0(2)	2(1)	0(0)	0(1)	0(1)	38(0)
4223	0(2)	0(1)	0(0)	1(1)	0(1)	28(0)
4224	0(0)	0(0)	0(0)	1(0)	0(0)	1(0)
4225	1(2)	0(1)	0(0)	0(1)	0(1)	16(0)
4226	2(2)	0(1)	0(0)	0(1)	1(1)	23(0)
4229	0(2)	0(1)	0(0)	0(1)	0(1)	1(0)
4301	0(5)	0(1)	0(0)	0(1)	0(1)	1(0)
7301	0(1)	11(5)	0(0)	3(3)	1(2)	37(0)
7500	0(0)	0(0)	0(0)	0(0)	0(0)	1(0)
7800	0(1)	3(3)	0(0)	0(5)	2(3)	20(0)
7900	0(1)	0(3)	0(0)	0(2)	0(5)	1(0)
SUM	10(0)	38(0)	0(0)	13(0)	5(0)	974(0)

Diagonal Elements = 231; Total Test Points = 974
Percentage Agreement = 23.72; Kappa = 0.183; Tau w/equal prob = 0.213

21 points did not belong to groups listed in the test data and treated as misclassification. Default score for these 21 points = 1

Accuracy Assessment Tables for P41/R28 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	18.52	0	0.00	6	22.22	0	0.00	16	59.26
3102	1	14.29	0	0.00	1	14.29	0	0.00	5	71.43
3104	6	8.57	0	0.00	11	15.71	0	0.00	53	75.71
3201	0	0.00	3	42.86	0	0.00	0	0.00	4	57.14
3202	40	43.96	0	0.00	4	4.40	0	0.00	47	51.65
3203	5	17.24	0	0.00	3	10.34	0	0.00	21	72.41
3301	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
3304	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
3305	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3308	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
4201	1	12.50	2	25.00	0	0.00	3	37.50	2	25.00
4203	31	28.97	11	10.28	29	27.10	27	25.23	9	8.41
4206	13	30.95	4	9.52	4	9.52	6	14.29	15	35.71
4207	13	25.49	7	13.73	11	21.57	14	27.45	6	11.76
4208	6	16.22	0	0.00	9	24.32	17	45.95	5	13.51
4210	4	30.77	1	7.69	2	15.38	5	38.46	1	7.69
4212	35	36.84	14	14.74	17	17.89	25	26.32	4	4.21
4215	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00
4219	0	0.00	0	0.00	22	78.57	2	7.14	4	14.29
4220	30	27.27	0	0.00	53	48.18	16	14.55	11	10.00
4221	20	25.97	9	11.69	27	35.06	9	11.69	12	15.58
4222	2	5.26	0	0.00	15	39.47	9	23.68	12	31.58
4223	2	7.14	0	0.00	18	64.29	4	14.29	4	14.29
4224	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4225	2	12.50	3	18.75	5	31.25	6	37.50	0	0.00
4226	4	17.39	2	8.70	6	26.09	9	39.13	2	8.70
4229	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00
4301	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00
7301	11	29.73	0	0.00	3	8.11	1	2.70	22	59.46
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	5	25.00	2	10.00	13	65.00
7900	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	231	23.72	57	5.85	252	25.87	158	16.22	274	28.13

Accuracy Assessment Tables for P41/R28 -- Cover Type

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	18.52	5	18.52	11	40.74	11	40.74	27	100.00
3102	1	14.29	1	14.29	2	28.57	2	28.57	7	100.00
3104	6	8.57	6	8.57	17	24.29	17	24.29	70	100.00
3201	0	0.00	3	42.86	3	42.86	3	42.86	7	100.00
3202	40	43.96	40	43.96	44	48.35	44	48.35	91	100.00
3203	5	17.24	5	17.24	8	27.59	8	27.59	29	100.00
3301	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
3304	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
3305	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3308	0	0.00	1	100.00	1	100.00	1	100.00	1	100.00
4201	1	12.50	3	37.50	3	37.50	6	75.00	8	100.00
4203	31	28.97	42	39.25	71	66.36	98	91.59	107	100.00
4206	13	30.95	17	40.48	21	50.00	27	64.29	42	100.00
4207	13	25.49	20	39.22	31	60.78	45	88.24	51	100.00
4208	6	16.22	6	16.22	15	40.54	32	86.49	37	100.00
4210	4	30.77	5	38.46	7	53.85	12	92.31	13	100.00
4212	35	36.84	49	51.58	66	69.47	91	95.79	95	100.00
4215	0	0.00	0	0.00	1	50.00	2	100.00	2	100.00
4219	0	0.00	0	0.00	22	78.57	24	85.71	28	100.00
4220	30	27.27	30	27.27	83	75.45	99	90.00	110	100.00
4221	20	25.97	29	37.66	56	72.73	65	84.42	77	100.00
4222	2	5.26	2	5.26	17	44.74	26	68.42	38	100.00
4223	2	7.14	2	7.14	20	71.43	24	85.71	28	100.00
4224	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4225	2	12.50	5	31.25	10	62.50	16	100.00	16	100.00
4226	4	17.39	6	26.09	12	52.17	21	91.30	23	100.00
4229	0	0.00	0	0.00	0	0.00	1	100.00	1	100.00
4301	0	0.00	0	0.00	0	0.00	1	100.00	1	100.00
7301	11	29.73	11	29.73	14	37.84	15	40.54	37	100.00
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	5	25.00	7	35.00	20	100.00
7900	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	231	23.72	288	29.57	540	55.44	698	71.66	972	99.79

Accuracy Assessment Tables for P41/R28 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	14.71	0	0.00	11	32.35	2	5.88	16	47.06
3102	1	11.11	0	0.00	4	44.44	0	0.00	4	44.44
3104	6	15.79	0	0.00	3	7.89	0	0.00	28	73.68
3201	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3202	40	46.51	1	1.16	3	3.49	0	0.00	42	48.84
3203	5	15.15	2	6.06	4	12.12	0	0.00	22	66.67
3301	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
3304	0	0.00	1	20.00	0	0.00	0	0.00	4	80.00
3305	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3308	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4201	1	14.29	0	0.00	3	42.86	1	14.29	2	28.57
4203	31	34.07	0	0.00	35	38.46	19	20.88	6	6.59
4206	13	21.31	0	0.00	4	6.56	21	34.43	23	37.70
4207	13	40.62	2	6.25	3	9.38	7	21.88	7	21.88
4208	6	12.50	0	0.00	21	43.75	15	31.25	6	12.50
4210	4	21.05	0	0.00	7	36.84	6	31.58	2	10.53
4212	35	27.56	0	0.00	43	33.86	34	26.77	15	11.81
4215	0	0.00	0	0.00	0	0.00	1	50.00	1	50.00
4219	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4220	30	30.30	1	1.01	55	55.56	5	5.05	8	8.08
4221	20	22.73	4	4.55	38	43.18	16	18.18	10	11.36
4222	2	7.69	10	38.46	0	0.00	6	23.08	8	30.77
4223	2	6.06	17	51.52	5	15.15	6	18.18	3	9.09
4224	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4225	2	12.50	6	37.50	2	12.50	1	6.25	5	31.25
4226	4	19.05	9	42.86	3	14.29	5	23.81	0	0.00
4229	0	0.00	4	50.00	0	0.00	4	50.00	0	0.00
4301	0	0.00	0	0.00	0	0.00	8	80.00	2	20.00
7301	11	28.95	0	0.00	3	7.89	0	0.00	24	63.16
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	3	23.08	0	0.00	9	69.23
7900	0	0.00	0	0.00	2	40.00	1	20.00	2	40.00
SUM	231	24.24	57	5.98	252	26.44	158	16.58	253	26.55

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	14.71	5	14.71	16	47.06	18	52.94	34	100.00
3102	1	11.11	1	11.11	5	55.56	5	55.56	9	100.00
3104	6	15.79	6	15.79	9	23.68	9	23.68	37	97.37
3201	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3202	40	46.51	41	47.67	44	51.16	44	51.16	86	100.00
3203	5	15.15	7	21.21	11	33.33	11	33.33	33	100.00
3301	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
3304	0	0.00	1	20.00	1	20.00	1	20.00	5	100.00
3305	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3308	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4201	1	14.29	1	14.29	4	57.14	5	71.43	7	100.00
4203	31	34.07	31	34.07	66	72.53	85	93.41	91	100.00
4206	13	21.31	13	21.31	17	27.87	38	62.30	61	100.00
4207	13	40.62	15	46.88	18	56.25	25	78.12	32	100.00
4208	6	12.50	6	12.50	27	56.25	42	87.50	48	100.00
4210	4	21.05	4	21.05	11	57.89	17	89.47	19	100.00
4212	35	27.56	35	27.56	78	61.42	112	88.19	127	100.00
4215	0	0.00	0	0.00	0	0.00	1	50.00	2	100.00
4219	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4220	30	30.30	31	31.31	86	86.87	91	91.92	99	100.00
4221	20	22.73	24	27.27	62	70.45	78	88.64	88	100.00
4222	2	7.69	12	46.15	12	46.15	18	69.23	26	100.00
4223	2	6.06	19	57.58	24	72.73	30	90.91	33	100.00
4224	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4225	2	12.50	8	50.00	10	62.50	11	68.75	16	100.00
4226	4	19.05	13	61.90	16	76.19	21	100.00	21	100.00
4229	0	0.00	4	50.00	4	50.00	8	100.00	8	100.00
4301	0	0.00	0	0.00	0	0.00	8	80.00	10	100.00
7301	11	28.95	11	28.95	14	36.84	14	36.84	38	100.00
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	3	23.08	3	23.08	12	92.31
7900	0	0.00	0	0.00	2	40.00	3	60.00	5	100.00
SUM	231	24.24	288	30.22	540	56.66	698	73.24	951	99.79

Accuracy Assessment Tables for P41/R28 -- Cover Type

MATCH MATRIX (weighted producer) (Assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	18.52	0	0.00	6	22.22	0	0.00	16	59.26
3102	2	14.29	0	0.00	2	14.29	0	0.00	8	71.43
3104	3	8.57	0	0.00	5	15.71	0	0.00	26	75.71
3201	0	0.00	0	42.86	0	0.00	0	0.00	0	57.14
3202	23	43.96	0	0.00	2	4.40	0	0.00	28	51.65
3203	4	17.24	0	0.00	2	10.34	0	0.00	16	72.41
3301	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3304	0	0.00	0	0.00	0	0.00	0	0.00	7	100.00
3305	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
3308	0	0.00	6	100.00	0	0.00	0	0.00	0	0.00
4201	1	12.50	3	25.00	0	0.00	4	37.50	3	25.00
4203	34	28.97	12	10.28	31	27.10	29	25.23	10	8.41
4206	15	30.95	5	9.52	5	9.52	7	14.29	17	35.71
4207	11	25.49	6	13.73	9	21.57	11	27.45	5	11.76
4208	10	16.22	0	0.00	15	24.32	28	45.95	8	13.51
4210	3	30.77	1	7.69	2	15.38	4	38.46	1	7.69
4212	47	36.84	19	14.74	23	17.89	34	26.32	5	4.21
4215	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00
4219	0	0.00	0	0.00	8	78.57	1	7.14	1	14.29
4220	36	27.27	0	0.00	64	48.18	19	14.55	13	10.00
4221	28	25.97	12	11.69	37	35.06	12	11.69	17	15.58
4222	1	5.26	0	0.00	8	39.47	5	23.68	6	31.58
4223	3	7.14	0	0.00	30	64.29	7	14.29	7	14.29
4224	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4225	2	12.50	4	18.75	6	31.25	7	37.50	0	0.00
4226	4	17.39	2	8.70	6	26.09	9	39.13	2	8.70
4229	0	0.00	0	0.00	0	0.00	10	100.00	0	0.00
4301	0	0.00	0	0.00	0	0.00	3	100.00	0	0.00
7301	8	29.73	0	0.00	2	8.11	1	2.70	17	59.46
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	4	25.00	2	10.00	11	65.00
7900	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
SUM	240	24.00	70	7.00	268	26.80	194	19.40	228	22.80

Accuracy Assessment Tables for P41/R28 -- Cover Type

ACCUMULATE MATRIX (weighted producer) (Assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	18.52	5	18.52	11	40.74	11	40.74	27	100.00
3102	2	14.29	2	14.29	3	28.57	3	28.57	11	100.00
3104	3	8.57	3	8.57	8	24.29	8	24.29	34	100.00
3201	0	0.00	0	42.86	0	42.86	0	42.86	0	100.00
3202	23	43.96	23	43.96	26	48.35	26	48.35	53	100.00
3203	4	17.24	4	17.24	6	27.59	6	27.59	22	100.00
3301	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3304	0	0.00	0	0.00	0	0.00	0	0.00	7	100.00
3305	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
3308	0	0.00	6	100.00	6	100.00	6	100.00	6	100.00
4201	1	12.50	4	37.50	4	37.50	8	75.00	10	100.00
4203	34	28.97	46	39.25	77	66.36	106	91.59	116	100.00
4206	15	30.95	20	40.48	24	50.00	31	64.29	49	100.00
4207	11	25.49	16	39.22	25	60.78	37	88.24	42	100.00
4208	10	16.22	10	16.22	25	40.54	53	86.49	61	100.00
4210	3	30.77	4	38.46	5	53.85	9	92.31	10	100.00
4212	47	36.84	66	51.58	90	69.47	123	95.79	129	100.00
4215	0	0.00	0	0.00	1	50.00	2	100.00	2	100.00
4219	0	0.00	0	0.00	8	78.57	8	85.71	10	100.00
4220	36	27.27	36	27.27	100	75.45	120	90.00	133	100.00
4221	28	25.97	40	37.66	77	72.73	90	84.42	106	100.00
4222	1	5.26	1	5.26	9	44.74	14	68.42	20	100.00
4223	3	7.14	3	7.14	33	71.43	40	85.71	46	100.00
4224	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4225	2	12.50	6	31.25	12	62.50	19	100.00	19	100.00
4226	4	17.39	6	26.09	12	52.17	20	91.30	22	100.00
4229	0	0.00	0	0.00	0	0.00	10	100.00	10	100.00
4301	0	0.00	0	0.00	0	0.00	3	100.00	3	100.00
7301	8	29.73	8	29.73	11	37.84	11	40.54	28	100.00
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	4	25.00	6	35.00	17	100.00
7900	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
SUM	240	24.07	309	30.99	577	57.87	770	77.23	997	100.00

Accuracy Assessment Tables for P41/R28 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	4	SUM
1	8(5)	1(3)	6(1)	0(1)	18(0)
2	3(3)	3(5)	3(3)	0(1)	10(0)
3	7(1)	10(3)	20(5)	1(3)	39(0)
4	0(1)	1(1)	3(3)	1(5)	6(0)
SUM	18(0)	15(0)	32(0)	2(0)	73(0)

Diagonal Elements = 32; Total Test Points = 73
Percentage Agreement = 43.84; Tau w/equal prob = 0.251

6 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 6 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	8	44.44	0	0.00	1	5.56	0	0.00	9	50.00
2	3	30.00	0	0.00	6	60.00	0	0.00	1	10.00
3	20	51.28	0	0.00	11	28.21	0	0.00	8	20.51
4	1	16.67	0	0.00	3	50.00	0	0.00	2	33.33
SUM	32	43.84	0	0.00	21	28.77	0	0.00	20	27.40

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	8	44.44	8	44.44	9	50.00	9	50.00	18	100.00
2	3	30.00	3	30.00	9	90.00	9	90.00	10	100.00
3	20	51.28	20	51.28	31	79.49	31	79.49	39	100.00
4	1	16.67	1	16.67	4	66.67	4	66.67	6	100.00
SUM	32	43.84	32	43.84	53	72.60	53	72.60	73	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	8	44.44	0	0.00	3	16.67	0	0.00	7	38.89
2	3	20.00	0	0.00	11	73.33	0	0.00	1	6.67
3	20	62.50	0	0.00	6	18.75	0	0.00	6	18.75
4	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
SUM	32	47.76	0	0.00	21	31.34	0	0.00	14	20.90

Accuracy Assessment Tables for P41/R28 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	8	44.44	8	44.44	11	61.11	11	61.11	18	100.00
2	3	20.00	3	20.00	14	93.33	14	93.33	15	100.00
3	20	62.50	20	62.50	26	81.25	26	81.25	32	100.00
4	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
SUM	32	47.76	32	47.76	53	79.10	53	79.10	67	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	109	44.44	0	0.00	14	5.56	0	0.00	122	50.00
2	53	30.00	0	0.00	106	60.00	0	0.00	18	10.00
3	287	51.28	0	0.00	158	28.21	0	0.00	115	20.51
4	3	16.67	0	0.00	9	50.00	0	0.00	6	33.33
SUM	452	45.20	0	0.00	287	28.70	0	0.00	261	26.10

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	109	44.44	109	44.44	122	50.00	122	50.00	244	100.00
2	53	30.00	53	30.00	159	90.00	159	90.00	176	100.00
3	287	51.28	287	51.28	445	79.49	445	79.49	560	100.00
4	3	16.67	3	16.67	13	66.67	13	66.67	19	100.00
SUM	452	45.25	452	45.25	739	73.97	739	73.97	999	100.00

Accuracy Assessment Tables for P41/R28 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	4(5)	2(3)	1(1)	10(0)
2	0(3)	1(5)	2(3)	3(0)
3	0(1)	0(3)	2(5)	2(0)
SUM	4(0)	3(0)	5(0)	15(0)

Diagonal Elements = 7; Total Test Points = 15
Percentage Agreement = 46.67; Tau w/equal prob = 0.200

3 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 3 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	40.00	0	0.00	2	20.00	0	0.00	4	40.00
2	1	33.33	0	0.00	2	66.67	0	0.00	0	0.00
3	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	7	46.67	0	0.00	4	26.67	0	0.00	4	26.67

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	40.00	4	40.00	6	60.00	6	60.00	10	100.00
2	1	33.33	1	33.33	3	100.00	3	100.00	3	100.00
3	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
SUM	7	46.67	7	46.67	11	73.33	11	73.33	15	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	1	33.33	0	0.00	2	66.67	0	0.00	0	0.00
3	2	40.00	0	0.00	2	40.00	0	0.00	1	20.00
SUM	7	58.33	0	0.00	4	33.33	0	0.00	1	8.33

Accuracy Assessment Tables for P41/R28 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	100.00	4	100.00	4	100.00	4	100.00	4	100.00
2	1	33.33	1	33.33	3	100.00	3	100.00	3	100.00
3	2	40.00	2	40.00	4	80.00	4	80.00	5	100.00
SUM	7	58.33	7	58.33	11	91.67	11	91.67	12	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	108	40.00	0	0.00	54	20.00	0	0.00	108	40.00
2	86	33.33	0	0.00	172	66.67	0	0.00	0	0.00
3	472	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	666	66.60	0	0.00	226	22.60	0	0.00	108	10.80

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	108	40.00	108	40.00	163	60.00	163	60.00	271	100.00
2	86	33.33	86	33.33	257	100.00	257	100.00	257	100.00
3	472	100.00	472	100.00	472	100.00	472	100.00	472	100.00
SUM	666	66.60	666	66.60	892	89.20	892	89.20	1000	100.00

Accuracy Assessment Tables for P41/R28 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	35(5)	29(3)	2(1)	75(0)
2	18(3)	44(5)	10(3)	73(0)
3	0(1)	12(3)	4(5)	16(0)
SUM	53(0)	85(0)	16(0)	164(0)

Diagonal Elements = 83; Total Test Points = 164
Percentage Agreement = 50.61; Tau w/equal prob = 0.259

10 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 10 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	35	46.67	0	0.00	29	38.67	0	0.00	11	14.67
2	44	60.27	0	0.00	28	38.36	0	0.00	1	1.37
3	4	25.00	0	0.00	12	75.00	0	0.00	0	0.00
SUM	83	50.61	0	0.00	69	42.07	0	0.00	12	7.32

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	35	46.67	35	46.67	64	85.33	64	85.33	75	100.00
2	44	60.27	44	60.27	72	98.63	72	98.63	73	100.00
3	4	25.00	4	25.00	16	100.00	16	100.00	16	100.00
SUM	83	50.61	83	50.61	152	92.68	152	92.68	164	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	35	66.04	0	0.00	18	33.96	0	0.00	0	0.00
2	44	51.76	0	0.00	41	48.24	0	0.00	0	0.00
3	4	25.00	0	0.00	10	62.50	0	0.00	2	12.50
SUM	83	53.90	0	0.00	69	44.81	0	0.00	2	1.30

Accuracy Assessment Tables for P41/R28 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	35	66.04	35	66.04	53	100.00	53	100.00	53	100.00
2	44	51.76	44	51.76	85	100.00	85	100.00	85	100.00
3	4	25.00	4	25.00	14	87.50	14	87.50	16	100.00
SUM	83	53.90	83	53.90	152	98.70	152	98.70	154	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	129	46.67	0	0.00	107	38.67	0	0.00	41	14.67
2	321	60.27	0	0.00	204	38.36	0	0.00	7	1.37
3	48	25.00	0	0.00	143	75.00	0	0.00	0	0.00
SUM	498	49.80	0	0.00	454	45.40	0	0.00	48	4.80

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	129	46.67	129	46.67	236	85.33	236	85.33	277	100.00
2	321	60.27	321	60.27	526	98.63	526	98.63	533	100.00
3	48	25.00	48	25.00	190	100.00	190	100.00	190	100.00
SUM	498	49.80	498	49.80	952	95.20	952	95.20	1000	100.00

Accuracy Assessment Tables for P41/R28 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	12(5)	1(3)	1(1)	16(0)
2	6(3)	5(5)	0(3)	13(0)
3	3(1)	2(3)	0(5)	5(0)
SUM	21(0)	8(0)	1(0)	34(0)

Diagonal Elements = 17; Total Test Points = 34
Percentage Agreement = 50.00; Tau w/equal prob = 0.250

4 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 4 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	12	75.00	0	0.00	1	6.25	0	0.00	3	18.75
2	5	38.46	0	0.00	6	46.15	0	0.00	2	15.38
3	0	0.00	0	0.00	2	40.00	0	0.00	3	60.00
SUM	17	50.00	0	0.00	9	26.47	0	0.00	8	23.53

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	12	75.00	12	75.00	13	81.25	13	81.25	16	100.00
2	5	38.46	5	38.46	11	84.62	11	84.62	13	100.00
3	0	0.00	0	0.00	2	40.00	2	40.00	5	100.00
SUM	17	50.00	17	50.00	26	76.47	26	76.47	34	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	12	57.14	0	0.00	6	28.57	0	0.00	3	14.29
2	5	62.50	0	0.00	3	37.50	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	17	56.67	0	0.00	9	30.00	0	0.00	4	13.33

Accuracy Assessment Tables for P41/R28 -- Shrub Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	12	57.14	12	57.14	18	85.71	18	85.71	21	100.00
2	5	62.50	5	62.50	8	100.00	8	100.00	8	100.00
3	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	17	56.67	17	56.67	26	86.67	26	86.67	30	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	430	75.00	0	0.00	36	6.25	0	0.00	107	18.75
2	162	38.46	0	0.00	195	46.15	0	0.00	65	15.38
3	0	0.00	0	0.00	2	40.00	0	0.00	3	60.00
SUM	592	59.20	0	0.00	233	23.30	0	0.00	175	17.50

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	430	75.00	430	75.00	466	81.25	466	81.25	573	100.00
2	162	38.46	162	38.46	357	84.62	357	84.62	422	100.00
3	0	0.00	0	0.00	2	40.00	2	40.00	4	100.00
SUM	592	59.26	592	59.26	825	82.58	825	82.58	999	100.00

Scene P41/R28 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
1000	73.0	1132.1	0.0
2000	3281.0	37002.2	1.1
3101	8428.0	92896.1	2.7
3102	3562.0	38347.0	1.1
3104	15738.0	123929.2	3.6
3202	15420.0	182660.8	5.4
3203	8599.0	74268.4	2.2
3301	707.0	4853.3	0.1
3304	1385.0	25779.3	0.8
3305	1358.0	13487.1	0.4
3306	454.0	2297.3	0.1
3308	1164.0	20059.4	0.6
4102	2822.0	28246.1	0.8
4201	3524.0	34500.1	1.0
4203	30863.0	427728.1	12.6
4206	11573.0	101240.9	3.0
4207	12559.0	141165.5	4.1
4208	16912.0	207670.2	6.1
4210	3175.0	33543.1	1.0
4212	36206.0	335503.4	9.9
4215	1270.0	8042.6	0.2
4219	2714.0	32781.0	1.0
4220	37465.0	451069.4	13.3
4221	38409.0	383598.1	11.3
4222	4115.0	34334.6	1.0
4223	15192.0	190464.9	5.6
4224	322.0	2361.0	0.1
4225	6961.0	65387.7	1.9
4226	6194.0	73605.3	2.2
4228	2222.0	21821.9	0.6
4229	686.0	32268.7	0.9
4301	845.0	8790.5	0.3
5000	10227.0	6245.5	0.2
7300	14338.0	96480.4	2.8
7800	8138.0	59815.3	1.8
7900	169.0	636.0	0.0
8100	146.0	2178.2	0.1
9100	340.0	3302.4	0.1
9800	83.0	2024.2	0.1
9900	1286.0	2776.6	0.1

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not tree/shrub	65809.0	466765.3	13.7
Shrub 1	21001.0	185878.7	5.5
Shrub 2	7966.0	136258.0	4.0
Shrub 3	120.0	1269.0	0.0
Tree 1	67947.0	723171.9	21.2
Tree 2	137909.0	1393211.5	40.9
Tree 3	28173.0	497739.6	14.6

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not tree/shrub	65809.0	466765.3	13.7
Tree 1	39293.0	283490.5	8.3
Tree 2	39667.0	498157.6	14.6
Tree 3	134237.0	1553244.1	45.6
Tree 4	20832.0	279230.9	8.2
Shrub 1	10143.0	88003.7	2.6
Shrub 2	9520.0	83314.8	2.4
Shrub 3	9424.0	152087.2	4.5

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
A	3281.0	37002.2	1.1
H	27874.0	257350.5	7.6
N	34654.0	172412.6	5.1
S	29087.0	323405.7	9.5
T	234029.0	2614123.0	76.8

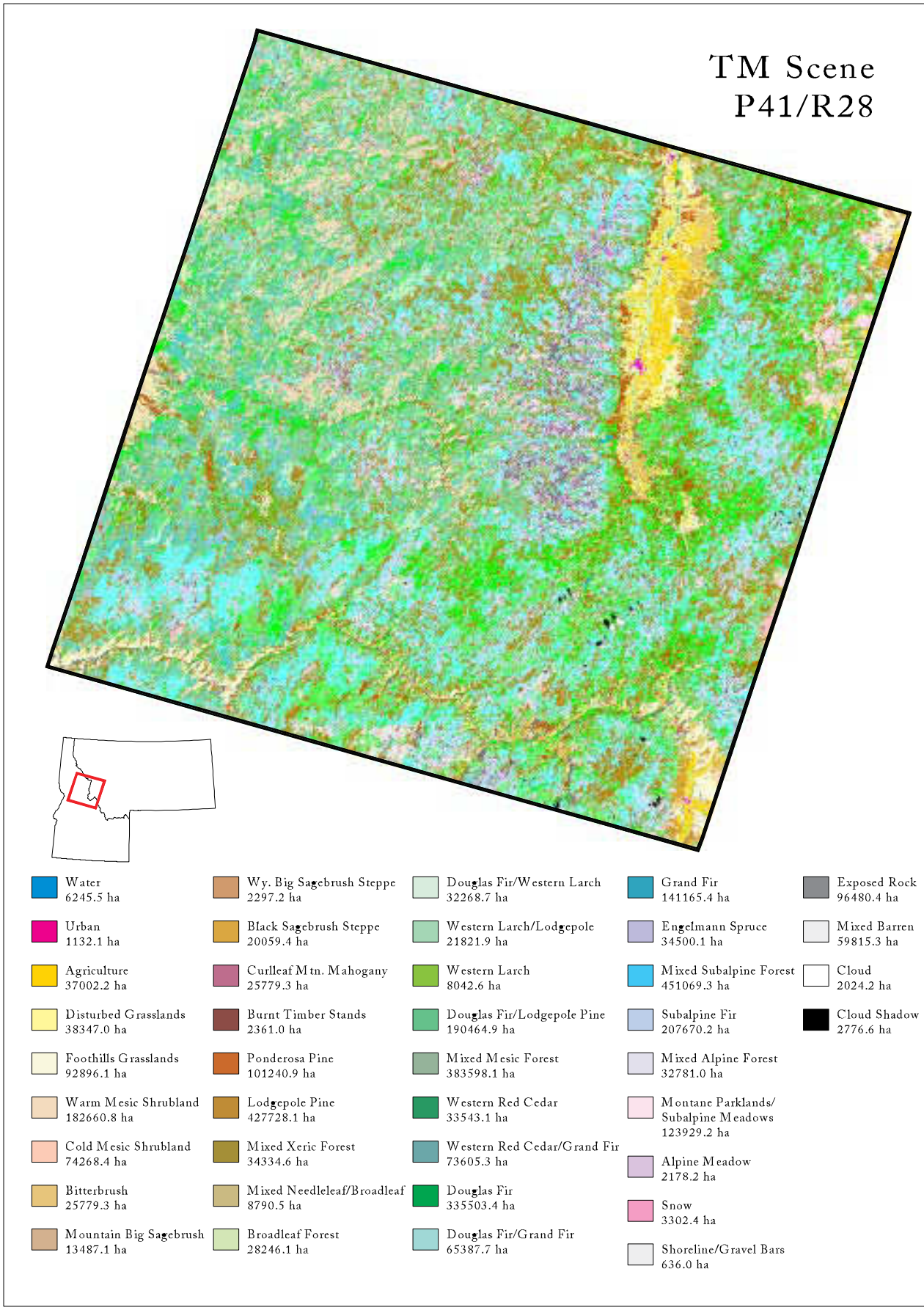


Figure F-8. Classification of land cover types for TM Scene P41/R28.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P41/R28

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 2365 to 8200 feet in elevation. The average canopy cover is 36% ranging from 10-70% total cover and frequency of occurrence equal to 97%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤8% and frequency of occurrence ≥27% and ≤52%.

Primary associated shrub species with ≥7% and ≤59% frequency of occurrence in lodgepole pine stands: kinnikinnick (Arctostaphylos uva-ursi), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), scouler willow (Salix scouleriana), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤75% frequency of occurrence in lodgepole pine stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), and smooth woodrush (Luzula hitchcockii); **forbs**: Piper's anemone (Anemone piperi), arnica (Arnica spp.), western goldthread (Coptis occidentalis), fireweed (Epilobium angustifolium), bracted lousewort (Pedicularis bracteosa), round-leaved violet (Viola orbiculata), and beargrass (Xerophyllum tenax); **ferns**: clubmoss (Lycopodium); **moss**: moss (moss spp.).

2) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 1600 to 6920 feet in elevation. The average canopy cover is 26% ranging from 10-60% total cover and frequency of occurrence equal to 99%. Primary associated tree species include grand fir (Abies grandis), western white pine (Pinus monticola), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤6% and frequency of occurrence ≥4% and ≤54%.

Primary associated shrub species with ≥12% and ≤40% frequency of occurrence in ponderosa pine stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), mallow ninebark (Physocarpus malvaceus), scouler willow (Salix scouleriana), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤33% frequency of occurrence in ponderosa pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), cheatgrass (Bromus tectorum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), orchard grass (Dactylis glomerata), Idaho fescue (Festuca

idahoensis), and common timothy (Phleum pratense); **forbs**: common yarrow (Achillea millefolium), spreading dogbane (Apocynum androsaemifolium), heart-leaf arnica (Arnica cordifolia), balsamroot (Balsamorhiza sagittata), spotted knapweed (Centauria maculosa), Virginia strawberry (Fragaria virginiana), and penstemon (Penstemon spp.); **ferns**: brittle bladder-fern (Cystopteris fragilis) and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

3) 4207: GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) ranging from 1560 to 6368 feet in elevation. The average canopy cover is 45% ranging from 10-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), Douglas-fir (Pseudotsuga menziesii), and western red cedar (Thuja plicata) with average percent cover ≥4% and ≤10% and frequency of occurrence ≥24% and ≤47%.

Primary associated shrub species with ≥20% and ≤39% frequency of occurrence in grand fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), thimbleberry (Rubus parviflorum), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤43% frequency of occurrence in grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), orchard grass (Dactylis glomerata), blue wildrye (Elymus glaucus), and small-flowered woodrush (Luzula parviflora); **forbs**: Piper's anemone (Anemone piperi), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), mountain sweet-cicely (Osmorhiza chilensis), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), brittle bladder-fern (Cystopteris fragilis), oak-fern (Gymnocarpium dryopteris), clubmoss (Lycopodium), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

4) 4208: SUBALPINE FIR FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 4560 to 8600 feet in elevation. The average canopy cover is 33% ranging from 10-70% total cover and frequency of occurrence equal to 99%. Primary associated tree species include Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), and lodgepole pine (Pinus contorta) with average percent cover ≥4% and ≤7% and frequency of occurrence ≥32% and ≤59%.

Primary associated shrub species with ≥8% and ≤56% frequency of occurrence in subalpine fir stands: sitka alder (Alnus sinuata), Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea), red mountain-heath (Phyllodoce empetriformis), swamp current (Ribes lacustre), cascade mountain-ash (Sorbus scopulina), subalpine spiraea (Spiraea densiflora), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤71% frequency of occurrence in subalpine fir stands: **graminoids**: Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), sedge (Carex spp.), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), smooth woodrush (Luzula hitchcockii), and spike trisetum (Trisetum spicatum); **forbs**: broadleaf arnica (Arnica latifolia), glacier lily (Erythronium grandiflorum), sickletop lousewort (Pedicularis racemosa), one-sided wintergreen (Pyrola secunda), arrowleaf groundsel (Senecio triangularis), round-leaved violet (Viola orbiculata), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina) and selaginella (Selaginella spp.);

5) 4210: WESTERN RED CEDAR FOREST

Conifer forest dominated by western red cedar (Thuja plicata) ranging from 1470 to 5220 feet in elevation. The average canopy cover is 51% ranging from 10-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), western white pine (Pinus monticola), and Douglas-fir (Pseudotsuga menziesii), with average percent cover ≥5% and ≤7% and frequency of occurrence ≥26% and ≤97%.

Primary associated shrub species with ≥26% and ≤57% frequency of occurrence in western red cedar stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), bunchberry (Cornus canadensis), twin flower (Linnaea borealis), thimbleberry (Rubus parviflorum), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤71% frequency of occurrence in western red cedar stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), sedge (Carex spp.), elk sedge (Carex geyeri), field woodrush (Luzula campestris), woodrush (Luzula spp.), and western witchgrass (Panicum occidentale); **forbs**: trail-plant (Adenocaulon bicolor), Piper's anemone (Anemone piperi), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), western rattlesnake-plantain (Goodyera oblongofolia), starry solomon-plume (Smilacina stellata), and trefoil foamflower (Tiarella trifoliata); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), spinulose wood-fern (Dryopteris spinulosa), oak-fern (Gymnocarpium dryopteris), mountain holly-fern (Polystichum lonchitis), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

6) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 1820 to 7800 feet in elevation. The average canopy cover is 39% ranging from 3-90% total cover and frequency of occurrence equal to 98%. Primary associated tree species include grand fir (Abies grandis), lodgepole pine (Pinus contorta), and ponderosa pine (Pinus ponderosa), with average percent cover ≥5% and ≤7% and frequency of occurrence ≥19% and ≤33%.

Primary associated shrub species with ≥16% and ≤39% frequency of occurrence in Douglas-fir stands: rocky mountain maple (Acer glabrum), western serviceberry

(Amelanchier alnifolia), ocean-spray (Holodiscus discolor), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤38% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), orchard grass (Dactylis glomerata), Idaho fescue (Festuca idahoensis), and common timothy (Phleum pratense); **forbs**: common yarrow (Achillea millefolium), raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), western goldthread (Coptis occidentalis), Wood's strawberry (Fragaria vesca), starry solomon-plume (Smilacina stellata), and beargrass (Xerophyllum tenax); **ferns**: northern maidenhair (Adiantum pedatum), brittle bladder-fern (Cystopteris fragilis), common Christmas-fern (Polystichum munitum), brackenfern (Pteridium aquilinum), and Oregon woodsia (Woodsia oregana); **moss**: moss (moss spp.).

7) 4215: WESTERN LARCH FOREST

Conifer forest dominated by western larch (Larix occidentalis) ranging from 4600 to 5850 feet in elevation. The average canopy cover is 41% ranging from 20-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii), with average percent cover ≥4% and ≤10% and frequency of occurrence ≥50% and ≤70%.

Primary associated shrub species with ≥10% and ≤80% frequency of occurrence in western larch stands: mountain alder (Alnus incana), bunchberry (Cornus canadensis), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥10% and ≤50% frequency of occurrence in western larch stands: **graminoids**: pinegrass (Calamagrostis rubescens) and elk sedge (Carex geyeri); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), wild ginger (Asarum caudatum), western goldthread (Coptis occidentalis), Wood's strawberry (Fragaria vesca), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: none.

8) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albicaulis) and ranging from 6200 to 8880 feet in elevation. The average canopy cover is 19% ranging from 3-40% total cover and frequency of occurrence equal to 95%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥5% and ≤12% and frequency of occurrence ≥38% and ≤88%.

Primary associated shrub species with ≥2% and ≤71% frequency of occurrence in mixed whitebark pine stands: Utah honeysuckle (Lonicera utahensis), menziesia (Menziesia ferruginea), red mountain-heath (Phyllodoce empetriformis), mountain-heath (Phyllodoce

spp.), mountain gooseberry (Ribes montigenum), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤57% frequency of occurrence in mixed whitebark pine stands: **graminoids:** sedge (Carex spp.), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), rush (Juncus spp.), Parry's rush (Juncus parryi), smooth woodrush (Luzula hitchcockii), and spike trisetum (Trisetum spicatum); **forbs**: rosy pussy-toes (Antennaria microphylla), broadleaf arnica (Arnica latifolia), fireweed (Epilobium angustifolium), coiled-beak lousewort (Pedicularis contorta), penstemon (Penstemon spp.), spreading phlox (Phlox diffuse), and beargrass (Xerophyllum tenax); **ferns**: parsley-fern

9) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 2140 to 8168 feet in elevation. The average canopy cover is 20% ranging from 1-70% total cover and frequency of occurrence equal to 99%. Primary associated tree species include Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), and lodgepole pine (Pinus contorta) with average percent cover ≥3% and ≤16% and frequency of occurrence ≥46% and ≤77%.

Primary associated shrub species with ≥6% and ≤64% frequency of occurrence in mixed subalpine stands: sitka alder (Alnus sinuata), common prince's pine (Chimaphila umbellata), Labrador-tea (Ledum glandulosum), menziesia (Menziesia ferruginea), red mountain-heath (Phyllodoce empetriformis), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤85% frequency of occurrence in mixed subalpine fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), Parry's rush (Juncus parryi), and smooth woodrush (Luzula hitchcockii); **forb**: Piper's anemone (Anemone piperi), broadleaf arnica (Arnica latifolia), sickletop lousewort (Pedicularis racemosa), one-sided wintergreen (Pyrola secunda), trefoil foamflower (Tiarella trifoliata), round-leaved violet (Viola orbiculata), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina); **moss**: none.

10) 4221: MIXED MESIC FOREST

Conifer forest dominated by grand fir (Abies grandis), codominant species are western larch (Larix occidentalis) and western red cedar (Thuja plicata), ranging from 1600 to 7010 feet in elevation. The average canopy cover for ABIGRA is 17% ranging from 1-70% total cover and frequency of occurrence equal to 90%. The average canopy cover for LAROCC is 13% ranging from 1-50% total cover and frequency of occurrence equal to 25%. The average canopy cover for THUPLI is 14% ranging from 1-50% total cover and frequency of occurrence equal to 20%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥9% and ≤14% and frequency of occurrence ≥58% and ≤74%.

Primary associated shrub species with ≥13% and ≤42% frequency of occurrence in mixed mesic stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), thimbleberry (Rubus parviflorum), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤45% frequency of occurrence in mixed mesic stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), orchard grass (Dactylis glomerata), blue wildrye (Elymus glaucus), and smooth woodrush (Luzula hitchcockii); **forbs**: Piper's anemone (Anemone piperi), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), oak-fern (Gymnocarpium dryopteris), clubmoss (Lycopodium), mountain holly-fern (Polystichum lonchitis), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

11) 4222: MIXED XERIC FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) and ranging from 1960 to 6360 feet in elevation. The average canopy cover is 20% ranging from 3-40% total cover and frequency of occurrence equal to 97%. Primary associated tree species include grand fir (Abies grandis), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤23% and frequency of occurrence ≥16% and ≤95%.

Primary associated shrub species with ≥16% and ≤50% frequency of occurrence in mixed xeric stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), ocean-spray (Holodiscus discolor), mallow ninebark (Physocarpus malvaceus), scouler willow (Salix scoulerinana), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤60% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), and prairie junegrass (Koeleria macrantha); **forbs**: common yarrow (Achillea millefolium), spreading dogbane (Apocynum androsaemifolium), heart-leaf arnica (Arnica cordifolia), Virginia strawberry (Fragaria virginiana), Wood's strawberry (Fragaria vesca), white-flowered hawkweed (Hieracium albiflorum), and beargrass (Xerophyllum tenax); **ferns**: brittle bladder-fern (Cystopteris fragilis), spinulose wood-fern (Dryopteris spinulosa), and brackenfern (Pteridium aquilinum); **moss**: none

12) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) and ranging from 2880 to 7140 feet in elevation. The average canopy cover for PINCON is 26% ranging from 10-60% total cover and frequency of occurrence equal to 98%. The average canopy cover for PSEMEN is 29% ranging from 10-60% total cover and

frequency of occurrence equal to 98%. Primary associated tree species include grand fir (Abies grandis), subalpine fir (Abies lasiocarpa), and Engelmann spruce (Picea engelmannii) with average percent cover ≥4% and ≤5% and frequency of occurrence ≥20% and ≤36%.

Primary associated shrub species with ≥11% and ≤30% frequency of occurrence in Douglas-fir-lodgepole pine stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

.**Primary associated graminoid, forb, fern, and moss species** with ≥2% and ≤57% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), western fescue (Festuca occidentalis); **forbs**: raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), western goldthread (Coptis occidentalis), rattlesnake-plantain (Goodyera oblongofolia), one-sided wintergreen (Pyrola secunda), and beargrass (Xerophyllum tenax); **ferns**: common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: none.

13) 4225: DOUGLAS FIR-GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) and Douglas-fir (Pseudotsuga menziesii) and ranging from 1620 to 6160 feet in elevation. The average canopy cover for ABIGRA is 27% ranging from 3-60% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 25% ranging from 3-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), ponderosa pine (Pinus ponderosa), and western red cedar (Thuja plicata) with average percent cover ≥2% and ≤6% and frequency of occurrence ≥19% and ≤21%.

Primary associated shrub species with ≥17% and ≤49% frequency of occurrence in Douglas-fir-grand fir stands: rocky mountain maple (Acer glabrum), ocean-spray (Holodiscus discolor), twin flower (Linnaea borealis), baldhip rose (Rosa gymnocarpa), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤36% frequency of occurrence in Douglas-fir-grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), western fescue (Festuca occidentalis), field woodrush (Luzula campestris), common timothy (Phleum pratense), and bluegrass (Poa spp.); **forb**: trail-plant (Adenocaulon bicolor), Piper's anemone (Anemone piperi), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), sweet-scented bedstraw (Galium triflorum), and mountain sweet-cicely (Osmorhiza chilensis); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), bladder-fern (Cystopteris fragilis), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

14) 4226: WESTERN RED CEDAR-GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) and western red cedar and ranging from 1400 to 5370 feet in elevation. The average canopy cover for ABIGRA is 31% ranging from 10-60% total cover and frequency of occurrence equal to 100%. The average canopy cover for THUPLI is 33% ranging from 10-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include pacific yew (Taxus brevifolia), western white pine (Pinus monticola), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤7% and frequency of occurrence ≥25% and ≤60%.

Primary associated shrub species with ≥31% and ≤50% frequency of occurrence in western red cedar-grand fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), bunchberry (Cornus canadensis), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), thimbleberry (Rubus parviflorum), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤58% frequency of occurrence in western red cedar-grand fir stands: **graminoids**: Columbia brome (Bromus vulgaris), sedge (Carex spp.), beaked sedge (Carex rostrata), drooping woodreed (Cinna latifolia), western fescue (Festuca occidentalis), and woodrush (Luzula spp.); **forbs**: trail-plant (Adenocaulon bicolor), Piper's anemone (Anemone piperi), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), hooker fairy-bell (Disporum hookeri), mountain sweet-cicely (Osmorhiza chilensis), and starry solomon-plume (Smilacina stellata); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), male-fern (Dryopteris filix-mas), oak-fern (Gymnocarpium dryopteris), spinulose wood-fern (Dryopteris spinulosa), common Christmas-fern (Polystichum munitum), brackenfern (Pteridium aquilinum), and Oregon woodsia (Woodsia oregana); **moss**: moss (moss spp.).

15) 4301: MIXED NEEDLELEAF/BROADLEAF FOREST

Mixed needleleaf and broadleaf forest dominated by Douglas-fir (Pseudotsuga menziesii) and ranging from 1900 to 5680 feet in elevation. The average canopy cover is 12% ranging from 3-20% total cover and frequency of occurrence equal to 70%. Primary associated tree species include grand fir (Abies grandis), paper birch (Betula papyrifera), and ponderosa pine (Pinus ponderosa) with average percent cover ≥11% and ≤18% and frequency of occurrence ≥50% and ≤70%.

Primary associated shrub species with ≥33% and ≤56% frequency of occurrence in mixed needleleaf and broadleaf stands: rocky mountain maple (Acer glabrum), ocean-spray (Holodiscus discolor), mallow ninebark (Physocarpus malvaceus), thimbleberry (Rubus parviflorum), willow (Salix spp.), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥10% and ≤20% frequency of occurrence in mixed needleleaf and broadleaf stands: **graminoids**: smooth brome (Bromus inrtmis), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), and Kentucky bluegrass (Poa pratensis); **forbs**: trail-plant

(Adenocaulon bicolor), broadleaf arnica (Arnica latifolia), Wood's strawberry (Fragaria vesca), sweetscented bedstraw (Galium triflorum), starry solomon-plume (Smilacina stellata), trefoil foamflower (Tiarella trifoliata), and beargrass (Xerophyllum tenax); **ferns**: northern maidenhair (Adiantum pedatum), ladyfern (Athyrium filix-femina), spinulose wood-fern (Dryopteris spinulosa), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum), Oregon woodsia (Woodsia oregana); **moss**: moss (moss spp.).

P41/R28 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	2, 61, 65
6102	Broadleaf Dominated Riparian	20
6103	Neeleleaf-Broadleaf Riparian	None identified for scene
6104	Mixed Riparian (trees + any other)	6, 19
6201	Grass-Forb Riparian/Wetland	12, 21, 22, 23
6202	Shrub Riparian/Wetland	5, 7, 10, 71
6203	Mixed Grass-Forb-Shrub Riparian	None identified for scene

---

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 1
Color: Very dark brown; RGB 87 52 68.
Distribution: Light to medium density on mid-elevation slopes, primarily west of the Bitterroot Range; some in stream drainages on the east side of the range.
Comment: Training data outside the zone is dominated by needleleaf cover types, with several observations indicating riparian cover types (6202, 6103, 6101, 6201). Color and distribution suggest lodgepole pine is the dominant cover type represented by this class.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
1	1	Needleleaf Dominated Riparian
2	1	Broadleaf Dominated Riparian

Spectral Class 2
Color: Burgundy red; RGB 132 70 81.
Distribution: Medium density at middle elevations west of the Bitterroots; light density in stream drainages on the east side.
Comment: Outside the zone, needleleaf and riparian (6202, 6101, 6201) vegetation were recorded. Appears to be Mixed Mesic Forest, though at somewhat lower elevations than Spectral Class 1, including some riparian vegetation.
Conclusion: 6101.

3	1	Mesic Upland Shrubland
4	1	Mixed Mesic Forest
5	1	Needleleaf Dominated Riparian

Spectral Class 3
Color: Dark olive; RGB 103 90 100.
Distribution: Medium density on middle to lower elevation slopes; some in stream gullies.
Comment: Coniferous and riparian (6201, 6101, 6103, 6202, 6102) cover types were observed outside the zone. Appears to be a mixture of dry grass and shrubs.
Conclusion: Not riparian.

6	1	Engelmann Spruce
7	1	Mixed Mesic Forest
8	3	Needleleaf Dominated Riparian

Spectral Class 4
Color: Brown; RGB 158 111 112.
Distribution: Similar to class 3, but more uniformly distributed.
Comment: Outside the zone, training data includes conifers, riparian vegetation (6202, 6101, 6102, 6201), grasses, shrubs, and some agricultural vegetation. Appears to be sparse conifers on south slopes, mixed with shrub and grass.
Conclusion: Not riparian.

9	1	Engelmann Spruce
10	2	Western Red Cedar
11	1	Mixed Mesic Forest
12	1	Broadleaf Dominated Riparian
13	1	Needleleaf-Broadleaf Riparian
14	3	Grass-Forb Riparian/Wetland
15	3	Shrub Riparian/Wetland

Spectral Class 5
Color: Orange red; RGB 171 83 81.
Distribution: Medium to high density, with some clustering, at mid elevations on the western half of the image; some near streams but not linear.
Comment: Field observaions outside the zone indicate coniferous, riparian (6101, 6201, 6202, 6103), and Mixed Needleleaf-Broadleaf vegetation. Appears to be mixed mesic shrubs, riparian within the zone.
Conclusion: 6202.

16	1	Mesic Upland Shrubland
17	1	Shrub Riparian/Wetland

Spectral Class 6
Color: Gray brown; RGB 161 149 112.
Distribution: Light to medium density, not clustered, on lower slopes; some near streams or in larger valleys.

Comment: Training data for this class is quite varied, including coniferous and riparian (6201, 6101, 6102, 6103, 6202) vegetation, Mesic Upland Shrub, and some Exposed Rock and Mixed Needleleaf-Broadleaf covertypes. Appears to represent low density conifer and shrub cover types, with some riparian included.
Conclusion: 6104.

18	1	Needleleaf-Broadleaf Riparian
19	2	Grass-Forb Riparian/Wetland
20	1	Shoreline & Gravel Bars

Spectral Class 7
Color: Yellow orange; RGB 255 178 118.
Distribution: Occurs mostly on mid-elevation, southeast slopes in the northwest portion of the scene; also in agriculture areas in the larger valleys.
Comment: Here we have Mesic Upland Shrubland, conifers, riparian vegetation (6201, 6202, 6102), grasses and agriculture recorded outside the zone by field crews. Color and locations indicate substantial agricultural lands, shrubs, and riparian vegetation.
Conclusion: 6202.

21	1	Foothills Grassland
22	1	Subalpine Fir
23	2	Grass-Forb Riparian/Wetland
24	2	Shrub Riparian/Wetland

Spectral Class 8
Color: Black; RGB 71 54 75.
Distribution: Appears to be shadows.
Comment: Training data outside the zone is dominated by conifers, with some riparian (6101, 6201, 6202) and Western Larch also recorded. Appears to represent dense conifer stands.
Conclusion: Not riparian.

25	1	Grand Fir
26	1	Mixed Subalpine Forest
27	1	Needleleaf Dominated Riparian
28	1	Needleleaf-Broadleaf Riparian

Spectral Class 9
Color: Olive tan; RGB 178 156 131.
Distribution: Light to medium density on lower slopes and valleys, some near streams.
Comment: Here again, conifers dominate the class outside the zone. Observations also include shrubs, grasslands, riparian vegetation (6101, 6201, 6202), agriculture, Western Larch, and barren land. Locations are primarily on west and south slopes, representing sparse

conifers. Some sites within the riparian zone appear to be nonriparian grass.
Conclusion: Not riparian.

29	1	Douglas-fir
30	1	Mixed Mesic Forest
31	1	Broadleaf Dominated Riparian
32	1	Needleleaf-Broadleaf Riparian
33	1	Grass-Forb Riparian/Wetland
34	2	Shrub Riparian/Wetland

Spectral Class 10
Color: Dark orange; RGB 242 124 93.
Distribution: Medium density with some clustering on mid-elevation slopes; light density in valleys and some gullys.
Comment: Outside the riparian zone, observations include coniferous, Mesic Upland Shrubland, riparian (6101, 6201, 6202), Mixed Needleleaf-Broadleaf, grassland, Herbaceous Clearcut, Aspen, and Exposed Rock cover types. Appears to be Shrub Riparian/Wetland vegetation within the zone.
Conclusion: 6202.

35	1	Mix Needleleaf-Broadleaf
36	1	Needleleaf-Broadleaf Riparian
37	4	Grass-Forb Riparian/Wetland

Spectral Class 11
Color: Dark brown; RGB 107 56 75.
Distribution: Mostly in shadows, some of which are near streams.
Comment: This class has somewhat less variety in training data. Cover types include conifer, riparian (6101, 6201, 6202), and some shrub vegetation. Appears to represent nonriparian conifers.
Conclusion: Not riparian.

38	1	Grass-Forb Riparian/Wetland

Spectral Class 12
Color: Light orange; RGB 255 183 137.
Distribution: Dense on some southeast facing mid-elevation slopes; also in valley bottoms.
Comment: Mesic Upland Shrubland has the highest frequency of observations for this class outside the zone. Other cover types include coniferous, Subalpine Meadow, grassland, riparian (6101, 6201, 6202), Exposed Rock, Urban & Developed Land, agricultural, Herbaceous Clearcut, Exposed Rock, and Mixed Needleleaf-Broadleaf forest. Appears to be Grass-Forb Riparian/Wetland within the zone.

Conclusion: 6201.

39	1	Irrigated Pasture
40	1	Mixed Mesic Forest
41	3	Grass-Forb Riparian/Wetland
42	3	Shrub Riparian/Wetland

Spectral Class 13
Color: Yellow; RGB 255 230 149.
Distribution: Relatively isolated clusters on mid-elevation slopes and in valleys.
Comment: Mesic Upland Shrubland was most observed for this spectral class outside the zone. Some conifer, Exposed Rock, and meadow were noted as well. Appears to be dry grass and Exposed Rock.
Conclusion: Not riparian.

43	1	Grass-Forb Riparian/Wetland

Spectral Class 14
Color: Brown; RGB 113 99 100.
Distribution: Fairly uniformly distributed, with light to medium density at lower mid elevations; some gulley pattern; not in valleys.
Comment: Training data indicates primarily conifers outside the zone, with grass, shrub, meadow, and riparian (6101, 6201) vegetation also recorded. Appears to be mixed conifer. The uniformly scattered pattern does not suggest riparian vegetation.
Conclusion: Not riparian.

44	2	Mesic Upland Shrubland
45	1	Subalpine Fir
46	1	Needleleaf Dominated Riparian
47	2	Broadleaf Dominated Riparian
48	1	Grass-Forb Riparian/Wetland
49	3	Shrub Riparian/Wetland

Spectral Class 15
Color: Dark brown; RGB 94 81 93.
Distribution: Dense with some clustering, mostly at lower mid elevations; some gully pattern.
Comment: This class has numerous observations for needleleaf cover types outside the zone. Riparian (6101, 6201, 6202, 6103) cover types are well represented, with some shrub and "Mines, Quarries, or Gravel Pits" also observed. Appearance is similar to Spectral Class 14, except for density.
Conclusion: Not riparian.

50	1	Lodgepole Pine
51	1	Grand Fir
52	1	Douglas-fir
53	1	Mixed Subalpine Forest
54	1	Mixed Mesic Forest
55	1	Mixed Xeric Forest
56	3	Needleleaf Dominated Riparian
57	1	Grass-Forb Riparian/Wetland
58	2	Shrub Riparian/Wetland

Spectral Class 18
Color: Brown; RGB 136 95 87.
Distribution: Medium density spackle on low to mid-elevation slopes; some in stream gullies.
Comment: Needleleaf forest, riparian (6101, 6103, 6201, 6202) vegetation, Mesic Upland Shrubland, Western Larch, and Mixed Barren Land were recorded for this class outside the zone. Color and distribution indicate mixed mesic shrubs and conifers on north and east slopes. There are too few locations near water features for the class to be considered riparian.
Conclusion: Not riparian.

61	2	Mixed Subalpine Forest
62	1	Mixed Mesic Forest
63	1	Needleleaf Dominated Riparian
64	3	Grass-Forb Riparian/Wetland

Spectral Class 19
Color: Orange; RGB 252 156 131.
Distribution: Occurs in agricultural areas in valleys; also on southeast facing slopes in the western portion of the image; some linear pattern near streams.
Comment: Outside of the riparian zone, Mesic Upland Shrubland was the most observed cover type. Coniferous, riparian (6201, 6202, 6102), agricultural, grass, rock, urban, and Mixed Needleleaf-Broadleaf cover types were also observed. Appears to be a combination of shrubs and broadleaf. The high red component in the color indicates broadleaf vegetation.
Conclusion: 6104.

65	1	Mesic Upland Shrubland
66	1	Broadleaf Dominated Riparian
67	2	Grass-Forb Riparian/Wetland
68	2	Shrub Riparian/Wetland

Spectral Class 20
Color: Orange; RGB 255 158 106.
Distribution: Quite similar in distribution to Spectral Class 19, with somewhat more

clustering.
Comment: Training data for this class is also dominated by Mesic Upland Shrubland; coniferous, riparian (6201, 6202, 6103, 6101), agricultural, meadow, Aspen, and grassland cover types were recorded as well. Appears to be Broadleaf Dominated Riparian vegetation.
Conclusion: 6102.

69	1	Grass-Forb Riparian/Wetland

Spectral Class 21
Color: Orange brown; RGB 187 115 93.
Distribution: Medium density spackle on low to mid-elevation slopes in the northwest quadrant of the scene; otherwise light density on lower slopes, including those in stream canyons.
Comment: Conifers are most prevalent in training data for this class, outside the riparian zone. There are some Mesic Upland Shrubland, riparian (6101, 6102, 6201, 6202), agricultural, grass and meadow, and Exposed Rock points. Within the zone, the class appears to represent riparian grasses, with some shrubs present.
Conclusion: 6201.

70	2	Needleleaf Dominated Riparian
71	1	Broadleaf Dominated Riparian
72	2	Grass-Forb Riparian/Wetland
73	2	Shrub Riparian/Wetland

Spectral Class 22
Color: Taupe; RGB 187 176 162.
Distribution: Occurs in open areas at all elevations, but only near agriculture when in valleys; some near streams.
Comment: Several groups of cover types are well represented in training data for this spectral class: coniferous, shrub,agricultural, riparian (6201, 6101, 6202, 6102). Two points indicate Urban & Developed Land as well. Appears to be Grass-Forb Riparian/Wetland.
Conclusion: 6201.

74	2	Irrigated Pasture
75	1	Foothills Grassland
76	1	Mix Needleleaf-Broadleaf
77	1	Broadleaf Dominated Riparian
78	2	Grass-Forb Riparian/Wetland
79	1	Shrub Riparian/Wetland

Spectral Class 23
Color: Yellow; RGB 255 217 124.
Distribution: Found primarily in the northern two-thirds of the scene; medium density in agricultural areas, some connected clusters along streams and on some mountain slopes.
Comment: Mesic Upland Shrubland is most prevalent in training data for this class outside the zone. Conifers were observed somewhat more frequently than herbaceous life forms, with agricultural, riparian (6102, 6202), and Exposed Rock cover types least observed. This spectral class also seems to represent riparian grass vegetation.
Conclusion: 6201.

80	1	Grass-Forb Riparian/Wetland

Spectral Class 24
Color: Brown; RGB 155 88 81.
Distribution: Spackle on low to mid-elevation slopes.
Comment: Coniferous, riparian (6101, 6202, 6201), grass, and shrub cover types were recorded outside the zone. Appears to be scattered conifers; not sufficiently linear or clustered to be riparian vegetation.
Conclusion: Not riparian.

81	1	Western Red Cedar
82	1	Mixed Mesic Forest
83	1	Grass-Forb Riparian/Wetland

Spectral Class 26
Color: Green beige; RGB 219 219 180.
Distribution: Occurs in open areas up to ridgelines in some areas; dense in agricultural portions of valleys.
Comment: Mesic Upland Shrubland is the single most dominant cover type recorded for this class. Field data also indicates conifers, herbaceous life forms (including agriculture), and riparian (6101, 6201), Exposed Rock, and Mixed Barren Land cover types. Visually, locations indicate primarily agricultural vegetation.
Conclusion: Not riparian.

84	1	Irrigated Crop
85	1	Irrigated Pasture
86	1	Mixed Subalpine Forest
87	1	Needleleaf Dominated Riparian
88	1	Grass-Forb Riparian/Wetland
89	1	Shrub Riparian/Wetland

Spectral Class 27
Color: Brown; RGB 174 111 87.
Distribution: Relatively light density at middle elevations; some near streams but not linear in pattern.
Comment: Here, coniferous cover types dominate training sites, with some riparian (6101, 6103, 6202), Aspen, shrub, and Mixed Needleleaf-Broadleaf cover types also observed. This looks like Mixed Mesic Forest and, at higher elevations, Mixed Subalpine Forest.
Conclusion: Not riparian.

90	2	Shrub Riparian/Wetland

Spectral Class 30
Color: Mint green; RGB 178 250 218.
Distribution: Light to medium density at all elevations; some near streams but not linear.
Comment: Outside the zone, training data is dominated by shrub and herbaceous life forms. Conifers, agriculture, Exposed Rock, Mixed Barren Land, and riparian vegetation (6102, 6201, 6202) were also recorded. Visual cues indicate dry grasses.
Conclusion: Not riparian.

91	1	Foothills Grassland
92	1	Mesic Upland Shrubland
93	1	Lodgepole Pine
94	1	Grass-Forb Riparian/Wetland

Spectral Class 31
Color: Yellow; RGB 255 239 131.
Distribution: Found mostly on upper mid-elevation slopes, including some in stream canyons.
Comment: Of eight training data points outside the zone, seven are Mesic Upland Shrub, one is Aspen, and one is Foothills Grassland. Appears to be nonriparian grass and shrub vegetation. There are no training sites recorded inside the zone.
Conclusion: Not riparian.

Spectral Class 32
Color: Dark green; RGB 13 72 75.
Distribution: Some small clusters and light density spackle on low to mid-elevation slopes on the eastern and southern portions of the scene.
Comment: Training data outside the zone indicates conifers, Exposed Rock, and Mixed Barren Land. Appears to be shadows and mixed coniferous cover types.
Concluaion: Not riparian.

95	1	Lakes
96	1	Grass-Forb Riparian/Wetland
97	1	Exposed Rock

Spectral Class 33
Color: Sage green; RGB 158 203 187.
Distribution: Light to medium density at all elevations across the image, though avoiding driest open areas and densest conifer stands.
Comment: Mesic Upland Shrubland has the highest frequency of field observations outside the riparian zone, though several species of conifers add up to a higher total. Also observed were herbaceous life forms (including agriculture), Mixed Barren Land, Exposed Rock, riparian vegetation (6101, 6103, 6201, 6202), other shrubs, and Urban & Developed Land. Color and distribution indicate sparse conifers, probably Lodgepole Pine, and subalpine conifers.
Conclusion: Not riparian.

98	1	Lodgepole Pine
99	1	Douglas-fir
100	1	Grass-Forb Riparian/Wetland
101	1	Shrub Riparian/Wetland

Spectral Class 36
Color: Ice blue; RGB 236 255 255.
Distribution: This is a rare class, occurring primarily at the highest elevations; a few locations are at lower elevations, one near the Bitterroot River.
Comment: Outside the zone, training data indicates only one vegetative cover type, Foothills Grassland; five of the six points are hard surface cover types. Appears to represent high alpine areas with barren ground or rock.
Conclusion: Not riparian.

103	1	Grass-Forb Riparian/Wetland
104	1	Exposed Rock

Spectral Class 37
Color: Light turquoise; RGB 148 255 255.
Distribution: Occurs strongly along river corridors and outlying areas of wider river valleys; scattered lightly along very steep slopes and near exposed peaks.
Comment: Subalpine Meadow has the single highest frequency of observations outside the zone, with the herbaceous life form groups having the highest combined total. Conifers, shrubs, Mixed Barren Land, and Exposed Rock are also represented in the training data. Visual cues indicate dry grass.
Conclusion: Not riparian.

105	1	Shrub Riparian/Wetland

Spectral Class 38
Color: Light turquoise; RGB 155 255 255.
Distribution: Similar to Spectral Class 37, but of medium density on steep slopes.
Comment: Herbaceous cover types dominate training site data outside the zone, with several species of shrubs having the next highest combined frequency. Conifers, Mixed Barren Land, Exposed Rock, riparian (6102, 6202) vegetation, Urban & Developed Land, and Aspen were also recorded. This class also appears to represent dry grass cover types.
Conclusion: Not riparian.

106	1	Dry-land Pasture
107	1	Shrub Riparian/Wetland
108	1	Mixed Barren Land

Spectral Class 39
Color: Dark forest green; RGB 65 83 81.
Distribution: Dense spackle on mid-elevation slopes.
Comment: Appears to be Lodgepole Pine. Conifers are strongly represented in the training data outside the zone; riparian vegetation (6201, 6202, 6101, 6103), shrubs, and Herbaceous Clearcut were also recorded.
Conclusion: Not riparian.

109	1	Lodgepole Pine
110	1	Subalpine Fir
111	1	Mixed Mesic Forest
112	1	Grass-Forb Riparian/Wetland

Spectral Class 41
Color: Pale turqoise; RGB 190 255 255.
Distribution: Relatively rare; occurs at highest elevations and in agricultural areas.
Comment: There is no cover type dominating the training data for this spectral class. Mesic

Upland Shrubland, agriculture, and Mixed Barren Land have nearly equal frequencies of observations. Conifers, Herbaceous Clearcut, Foothills Grassland, and Exposed Rock are minimally included in the data. Most sites appear to be plowed agricultural fields.
Conclusion: Not riparian.

120	1	Shrub Riparian/Wetland
121	1	Exposed Rock

Spectral Class 48
Color: Navy blue; RGB 0 32 112.
Distribution: This is a rare class; nearly all locations are near streams.
Comment: The single training site observation outside the zone indicates a lake. This class appears to represent high alpine melting snow and possibly some small lakes.
Conclusion: Not riparian.

120	1	Rivers & Streams
121	2	Grass-Forb Riparian/Wetland
122	1	Shrub Riparian/Wetland
123	1	Exposed Rock
124	1	Mixed Barren Land

Spectral Class 60
Color: Blue; RGB 119 162 255.
Distribution: Relatively rare class, occuring in open areas at highest elevations, some near streams, and some openings in dense conifer stands.
Comment: Of seven observations taken outside the riparian zone, three were Exposed Rock, two were conifer, one was Urban & Developed Land, and one was Subalpine Meadow. The color of this spectral class is not indicative of vegetation. Most locations are in areas of talus and snow.
Conclusion: Not riparian.

130	1	Broadleaf Dominated Riparian
131	1	Mixed Barren Land

Spectral Class 61
Color: Gray; RGB 123 135 137.
Distribution: Medium density on slopes bordering valleys; lighter density at middle elevations across the scene.
Comment: Conifers dominate training sites outside the zone; shrubs, herbaceous and riparian (6101, 6201) vegetation, Mixed Barren Land, and Exposed Rock were also recorded. There appears to be riparian vegetation in some locations for this class; the color is more indicative of needleleaf cover types, rather than broadleaf.
Conclusion: 6101.

132	1	Needleleaf Dominated Riparian
133	1	Needleleaf-Broadleaf Riparian

Spectral Class 62
Color: Burgundy red; RGB 165 61 75.
Distribution: Scattered clusters on mid-elevation slopes in Idaho.
Comment: Coniferous and riparian (6101, 6202) cover types comprise the training data outside the calculated zone. Grand Fir is suggested by visual cues. Although dense understory pushes up the red component (especially in Grand Fir stands), riparian vegetation is not indicated. There were no observations recorded inside the riparian zone.
Conclusion: Not riparian.

Spectral Class 63
Color: Red orange; RGB 255 102 100.
Distribution: Relatively rare; some clusters in agricultural areas and near streams; mostly at mid elevation locations some distance from streams.
Comment: With just three training sites outside the zone, coniferous and agricultural cover types are indicated. Within the riparian zone, this spectral class appears to represent primarily agricultural sites.
Conclusion: Not riparian.

134	1	Grass-Forb Riparian/Wetland

Spectral Class 64
Color: Red orange; RGB 236 88 100.
Distribution: Loose clusters at middle elevations, spread over the northwest portion of the image.
Comment: Conifers, and one shrub site were observed for this class outside the zone. Appears to represent higher elevation shrubs. No training sites were recorded within the zone.
Conclusion: Not riparian.

Spectral Class 65
Color: Dark burgundy red; RGB 136 56 81.
Distribution: Light to medium density on upper mid-elevation slopes.
Comment: Only conifers were recorded for training sites outside the zone for this spectral class. This class potentially represents cedar in draws at higher elevations.
Conclusion: 6101.

135	1	Western Red Cedar

Spectral Class 68
Color: Dark emerald green; RGB 71 120 118.
Distribution: Medium density at middle elevations on the eastern and southern portions of the image; some in stream canyons.
Comment: Conifers, herbaceous cover types, Exposed Rock, riparian vegetation (6101, 6202), and Mixed Barren Land were recorded outside the zone. Lodgepole Pine and Mixed Subalpine Forest are indicated by this class.
Conclusion: Not riparian.

136	1	Broadleaf Dominated Riparian
137	1	Shrub Riparian/Wetland

Spectral Class 69
Color: Gray green; RGB 116 151 124.
Distribution: Medium density spackle at middle elevations; some near streams but not linear; some in the Bitterroot Valley.
Comment: Conifers dominate training site data outside the riparian zone. Herbaceous vegetation, shrubs, riparian vegetation (6201, 6202), Exposed Rock, Mixed Barren Land, and Urban & Developed Land were included. Appears to represent Lodgepole Pine and possibly some burns.
Conclusion: Not riparian.

138	1	Dry-land Pasture
139	1	Foothills Grassland
140	1	Lodgepole Pine
141	1	Broadleaf Dominated Riparian
142	2	Grass-Forb Riparian/Wetland

Spectral Class 71
Color: Orange; RGB 255 135 100.
Distribution: Occurs in agricultural areas at lower elevations and lightly scattered on mid-elevation slopes in the nortwestern portion of the image.
Comment: Agricultural cover types are most prevalent in training data for sites outside the

zone; Foothills Grassland and Grand Fir were also recorded. Due to the high red component and distribution, this class appears to represent Shrub Riparian/Wetland vegetation. Conclusion: 6202.

143	1	Irrigated Crop
144	1	Irrigated Pasture
145	1	Grass-Forb Riparian/Wetland

TM SCENE P41/R29

Image Analyst: Troy P. Tady

Training Data Analysis

In all, 244 ground-truth plots were available for labeling P41/R29 (see table next page). The data were initially checked over the full scene to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 26 after subtraction of unwanted cover types) were removed from further analysis. The data were then examined by cover type to determine whether or not plots were collected for this project or for other purposes (e.g., pre-existing ECODATA, TSMRS, etc.). The latter "existing data" were used as training data but not as accuracy test plots. The following classes (from item VEG_CLASS_CODE) were excluded from the digital classification process and from selection of accuracy test points: urban, agriculture, water, riparian, burns, mines/ quarries/gravel pits, clearcuts, sandy areas and shoreline/gravel bars. No other classes were excluded because they were determined to be minor components of the scene by the Forest Service. The disturbed grassland (3102) and montane parkland & subalpine meadow (3104) classes were combined with foothills grassland (3101) due to negligible spectral differences between the two classes. The 3104 class was reintroduced later using an elevational break.

Of the remaining plots, 20% were randomly selected from each cover type. These plots (n = 29) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

For the remaining 80% of this "filtered" data set, plots were subjected to further spectral examination. Outliers were eliminated for each cover type based on knowledge of general spectral patterns for various ground features. Insufficient training plots were available for the following cover types:

3304 Bitterbrush	- 2 plots
3306 Wyoming Big Sagebrush Steppe	- 1 plot
3308 Black Sagebrush Steppe	- 5 plots
4203 Lodgepole Pine	- 6 plots
4208 Subalpine Fir	- 1 plot
4215 Western Larch	- 3 plots
4219 Mixed Whitebark Pine Forest	- 1 plot
4220 Mixed Subalpine Forest	- 3 plots
4222 Mixed Xeric Forest	- 6 plots
4223 Douglas-fir - Lodgepole Pine	- 5 plots
4225 Douglas-fir - Grand Fir Forest	- 1 plot

Training data for these and most of the other cover types were supplemented from data supplied by the Boise National Forest as well as from personal knowledge of individuals familiar with areas within the scene.

Total plots in ground-truth file	244	
Total 1994-95 field plots	224	
Plots sampled for P41/R29		146
Plots sampled for other scenes		78
Pre-existing plots (ECODATA, TSMRS, etc.)	20	
Plots with codes included in the classification	182	
Plot discards	26	
Pre-existing plots		0
'Bad duplicates'		26
'Good duplicates'		0
Potential training plots	152	
20% test		29
80% training		123
Supplemental cover type plots	347	(+/-)
Supplemental size class plots	500	(+/-)
Supplemental canopy cover plots	200	(+/-)
Total plots available for training	1170	(+/-)
Total plots used for training--cover type	441	
size class	619	
canopy	107	

Land Cover Types

A digital classification of TM channels 1-7 plus rescaled elevation (raw elevation value divided by 25) produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were assigned directly to the COVERTYPE field in the database attribute table. Further modifications were carried out using spectral class values (SPECTRAL_CLASS or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000. Urban.	Manually identified and recoded by Will Gustafson.
2000. Agriculture.	Manually identified and recoded by Will Gustafson.
3101. Foothills Grassland.	All grass types occurring below 2237 m (7200 ft) were relabeled as Foothills Grassland.
3104. Montane Parkland & Subalpine Meadow.	All grass types occurring at and above 2237 m (7200 ft) were relabeled as Montane Parkland & Subalpine Meadow.
3201. Mesic Upland Shrub.	All Mesic Upland Shrub labels with an MNDVI value greater than or equal to 200 were recoded as Broadleaf Forest (see 4102).
3301. Curlleaf Mountain	Confusion with sagebrush classes will probably occur

	Mahogany.	due to the lack of training data for this class. No supplemental data were available from any agency.
3304.	Bitterbrush.	Confusion with shrub classes is likely to occur due to the lack of training data for this class. No supplemental data were available from any agency.
3306.	Wyoming Big Sagebrush Steppe.	No modification. No supplemental data.
3308.	Black Sagebrush Steppe.	Supplemental plots were acquired for this class from the Boise NF and Jeff Copeland at the University of Idaho. General distribution seems very good for this class.
4102.	Broadleaf Forest.	This class was well represented by the 7 combined 4101 and 4102 training plots. Confusion with taller shrub types may be expected, however.
4203.	Lodgepole Pine.	A significant number of supplemental plots were acquired from the Boise NF and Jeff Copeland at the University of Idaho. General distribution seems very good for this class.
4206.	Ponderosa Pine.	Ponderosa pine data were supplemented with data provided by the Boise NF and Jeff Copeland from the University of Idaho. General distribution at low elevations and in river bottoms seems to indicate likely Ponderosa Pine occurrences for this area. Some manual modifications were made for north slope grass areas that were misclassified as Ponderosa Pine. These modifications included NDVI, MNDVI and aspect rules to separate grass and Ponderosa Pine areas.
4208.	Subalpine Fir.	A significant number of supplemental data plots for Subalpine Fir were provided by the Boise NF and Jeff Copeland at the University of Idaho. Confusion with other high elevation cover types was evident in some areas of the scene.
4212.	Douglas-fir.	A significant number of supplemental data plots for Douglas-fir were provided by the Boise NF and Jeff Copeland at the University of Idaho. General distribution for this class seems reasonable although some confusion with other mesic forest types may occur at lower elevations due to high spectral variations in the Douglas-fir class.
4219.	Mixed Whitebark Pine Forest.	Supplemental data for Mixed Whitebark Pine Forest were provided by Jeff Copeland at the University of Idaho. General distribution for this class seems reasonable although sparsely vegetated areas are most likely to be classified as Rock (7300) or Montane Parkland & Subalpine Meadow (3104).

4220.	Mixed Subalpine Forest.	A significant number of supplemental data plots for Mixed Subalpine Forest were provided by the Boise NF and Jeff Copeland at the University of Idaho. Some confusion with the Mixed Mesic Forest class (4221) may be expected at lower elevations.
4221.	Mixed Mesic Forest.	No supplemental data. (See also 4220).
4222.	Mixed Xeric Forest.	Supplemental data plots for Mixed Xeric Forest were acquired from the Boise NF. The same modifications as made to Ponderosa Pine (see 4206) were applied to Mixed Mesic Forest to help alleviate confusion with grass types on shaded north facing aspects.
4223.	Douglas-fir - Lodgepole Pine.	Supplemental data plots for Douglas-fir - Lodgepole Pine were acquired from the Boise NF. Confusion with the Douglas-fir and Lodgepole Pine classes may be expected in some areas of the scene.
5000.	Water.	All regions with spectral class (LINK) = 1 and slope ≤5˚ degrees were labeled as water. Generally, water was more spectrally distinct than most other cover types, but in high mountainous terrain, it was confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate elevation and slope values such that their slope may be greater than 5˚. This would result in the misclassification of some small ponds or lakes. In the Sawtooth Recreation Area, a slope of less than or equal to 8˚ was used as a break in order to include small high elevation lakes which were missed with the 5˚ break for the rest of the scene.
7300.	Rock.	Supplemental data plots were obtained to provide a better representation of spectral variation in the 7300 class.
9100.	Snow.	Snow was classified using supplemental data. This class was very distinctive and was not confused with any other class.
9800.	Clouds.	Manually identified by Will Gustafson.
9900.	Cloud Shadows.	Manually identified by Will Gustafson.

A total of 24 classes were labeled in the full TM scene. These included two grass types, five shrub types, ten forest types, plus seven non-vegetated or manually labeled classes. Cover types are mapped in Figure F-9.

Size Classes

Seven size classes were mapped -- four for forest cover types (seedling/sapling, pole, medium, and large/very large) and three for shrub cover (low, medium, and tall). The seven TM spectral channels were used for the size classification (elevation was not included). The Nearest Member of Group (NMG) classifier was used for both tree and shrub size. Tree size classes were not stratified based on canopy cover classes (a typical processing step) because of

the lack of training data for scene P41/R29 .

Canopy Cover Classes

Canopy cover labels (CANOPYCODE = low, medium, or high) were assigned to tree and shrub classes based on Modified Normalized Distribution Vegetation Index (MNDVI) values (modified from Nemani et al. 1993). These values were plotted as frequency histograms for all coniferous forest types (Figure F-9a) as well as for one shrub type (Figure F-9b). The histograms were examined to determine break points based upon the distribution modes (see table below). Regions with MNDVI values falling below the lower break point were assigned to a low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class.

	MNDVI BREAKPOINTS	
CANOPY COVER	Tree	Shrub
Low	<135	<100
Medium	≥135 and ≤206	≥100 and ≤175
High	>206	>175

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are

listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications.

CLASSIFICATIONS FOR P41/R29	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	15	93%	93%
Tree Size Class	3	87%	87%
Tree Canopy Class	3	90%	50%
Shrub Size Class	3	100%	79%
Shrub Canopy Class	2	52%	52%

Comments

The availability of significant sources of supplementary data for a small area in the scene (where most of the US Forest Service training and test plots were located) is probably the primary reason for the high accuracy value listed for land cover type. General distributions for most cover type classes, however, seemed acceptable when viewed with Jeff Copeland from the University of Idaho. The primary sources of training data for scene P41/R29 were supplied by the Boise NF and Jeff Copeland. Only a small number of training plots were available from the Forest Service ground-truthing project. As a result, the number of accuracy test plots available for the cover type, size class, and canopy cover accuracy assessments were sufficient to provide adequate information regarding the "true" quality of the P41/R29 classification. In several cases, training plot sets for entire cover type classes were discarded due to locational or labeling errors, or were not originally present at all (i.e. broadleaf forest).

Special thanks go to Jeff Copeland for information on cover type and size classes in the Sawtooth National Recreation Area. A total of over 1000 new training data plots were obtained overall.

Error Matrix For Cover Type Training Plots
Scene P41/R29

F. P41/R29. 7

PLOT COVER TYPES	CLASSIFIED COVER TYPES																		
	3101	3104	3201	3301	3304	3306	3308	4203	4206	4208	4212	4219	4220	4221	4222	4223	7301	9100	SUM
3101	15	0	0	2	1	0	2	0	1	0	0	0	0	0	1	0	1	0	23
3104	0	8	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	9
3201	0	0	13	0	0	0	0	0	2	1	1	0	0	1	3	0	0	0	21
3301	1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	4
3304	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
3306	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
3308	1	0	0	0	0	0	5	0	0	1	0	0	0	0	3	0	0	0	10
4203	0	0	1	0	0	0	1	33	1	2	4	1	6	0	1	1	0	0	51
4206	0	0	0	0	0	0	0	0	30	0	4	0	1	1	3	0	0	0	39
4208	0	0	0	0	0	0	1	1	0	38	8	0	5	0	0	0	0	0	53
4212	0	0	0	0	0	0	0	2	3	10	70	0	0	2	1	3	0	0	91
4219	0	0	0	0	0	0	0	1	0	0	0	4	0	0	0	0	0	0	5
4220	0	0	0	0	0	0	0	4	0	3	1	0	58	0	0	2	0	0	68
4221	0	0	1	0	0	0	0	0	2	0	2	0	1	4	3	0	0	0	13
4222	0	0	2	0	0	0	2	0	1	0	2	0	0	2	2	0	0	0	11
4223	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	11	0	0	14
7301	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	11	0	13
9100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	13
SUM	18	9	17	2	2	0	11	42	41	55	95	5	72	12	17	17	13	13	441

% AGREEMENT	71.43
TAU WITH EQUAL PROBABILITY	0.698
TOTAL DIAGONAL ELEMENTS	315
TOTAL TRAINING PLOTS IN DATA SET	441

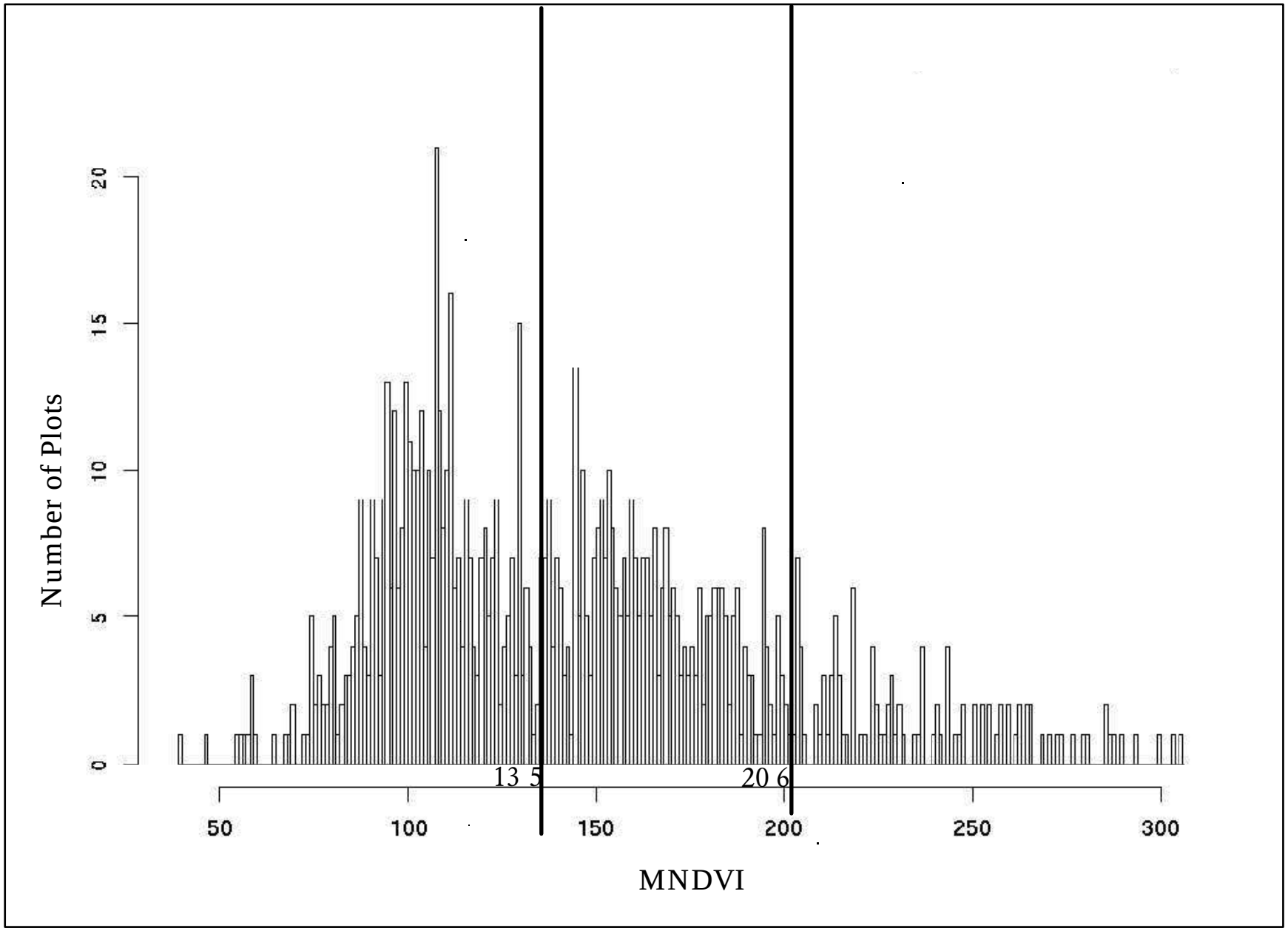


Figure F-9a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P41/R29

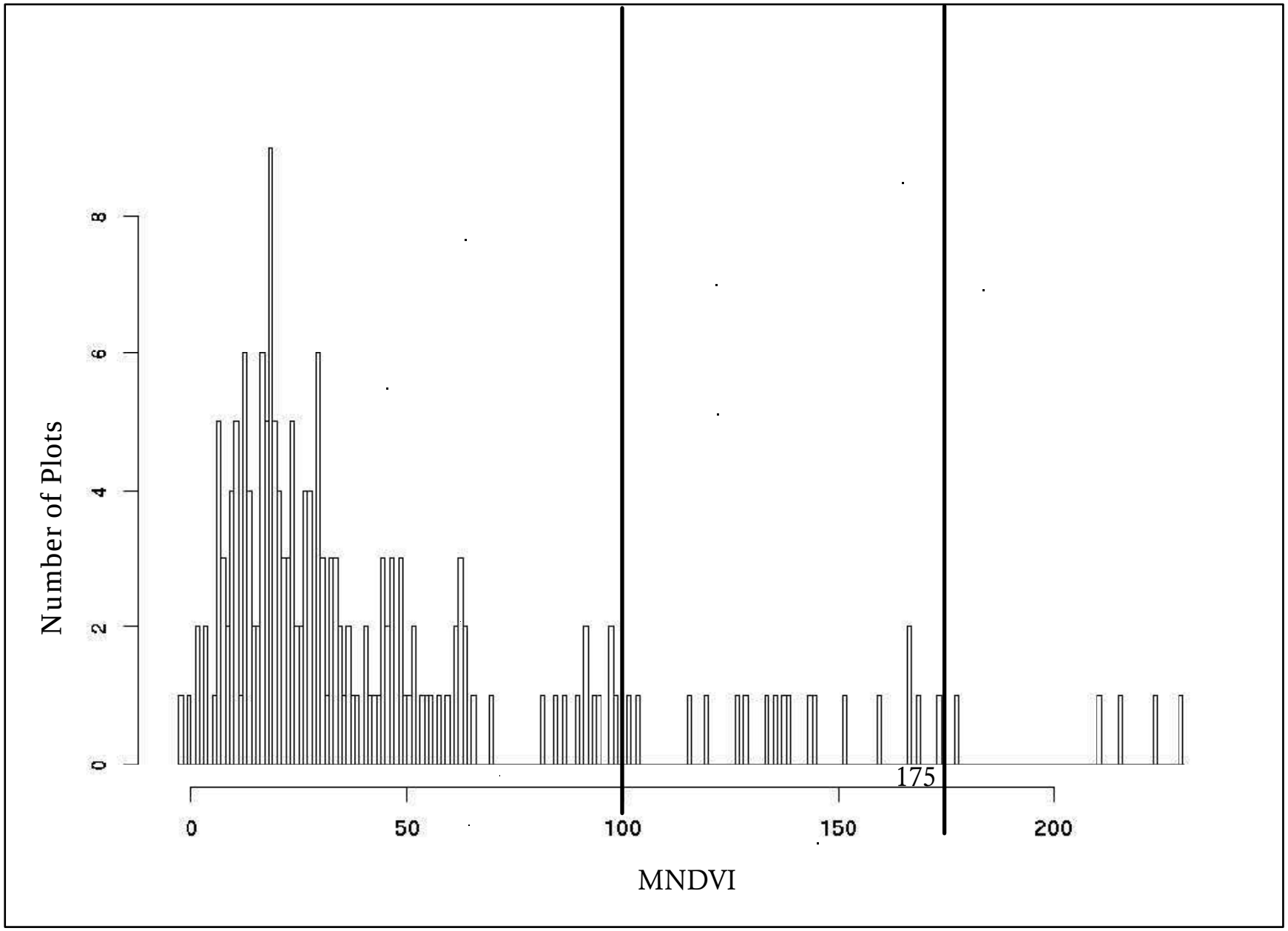


Figure F-9b. Breaks between shrub canopy cover classes in relation to MNDVI values: TM scene P41/R29

Accuracy Assessment Tables for P41/R29 -- Cover Type

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3102	3201	3202	3301	3308	4203	4206	4207
3101	5(5)	0(3)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3102	1(3)	0(5)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3201	1(1)	0(1)	1(5)	0(4)	0(2)	0(2)	0(1)	0(1)	0(1)
3202	1(1)	0(1)	0(4)	0(5)	0(2)	0(2)	0(1)	0(1)	0(1)
3301	0(1)	0(1)	0(2)	0(2)	1(5)	0(2)	0(1)	0(1)	0(1)
3308	0(1)	0(1)	0(2)	0(2)	0(2)	1(5)	0(1)	0(1)	0(1)
4203	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(5)	0(2)	0(2)
4206	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(2)	2(5)	0(2)
4207	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(5)
4212	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)
4221	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(3)	0(2)	0(3)
4222	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)	0(2)
4223	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(3)	0(2)	0(2)
4225	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(4)
7301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	8(0)	0(0)	1(0)	0(0)	2(0)	1(0)	1(0)	2(0)	0(0)

RF/CF	4212	4221	4222	4223	4225	7301	SUM
3101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	5(0)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(0)
3201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(0)
3202	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(0)
3301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(0)
3308	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(0)
4203	0(2)	0(3)	0(2)	0(4)	0(2)	0(1)	1(0)
4206	0(2)	0(3)	0(4)	0(2)	0(2)	0(1)	3(0)
4207	1(2)	0(3)	0(2)	0(2)	0(4)	0(1)	1(0)
4212	3(5)	0(3)	0(4)	0(4)	0(4)	0(1)	3(0)
4221	0(3)	3(5)	0(2)	0(3)	0(4)	0(1)	3(0)
4222	0(3)	0(2)	1(5)	0(2)	0(2)	0(1)	1(0)
4223	0(3)	0(3)	0(2)	1(5)	0(3)	0(1)	1(0)
4225	0(3)	1(4)	0(2)	0(3)	0(5)	0(1)	1(0)
7301	1(1)	0(1)	1(1)	0(1)	0(1)	0(5)	2(0)
SUM	5(0)	4(0)	2(0)	1(0)	0(0)	0(0)	27(0)

Diagonal Elements = 19; Total Test Points = 27
Percentage Agreement = 70.37; Tau w/equal prob = 0.683

Accuracy Assessment Tables for P41/R29 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3102	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
3201	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3301	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3308	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4206	2	66.67	0	0.00	0	0.00	0	0.00	1	33.33
4207	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00
4212	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4221	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4222	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4223	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4225	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
7301	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
SUM	19	70.37	1	3.70	1	3.70	1	3.70	5	18.52

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	100.00	5	100.00	5	100.00	5	100.00	5	100.00
3102	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
3201	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3301	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
3308	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4203	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4206	2	66.67	2	66.67	2	66.67	2	66.67	3	100.00
4207	0	0.00	0	0.00	0	0.00	1	100.00	1	100.00
4212	3	100.00	3	100.00	3	100.00	3	100.00	3	100.00
4221	3	100.00	3	100.00	3	100.00	3	100.00	3	100.00
4222	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4223	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4225	0	0.00	1	100.00	1	100.00	1	100.00	1	100.00
7301	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
SUM	19	70.37	20	74.07	21	77.78	22	81.48	27	100.00

Accuracy Assessment Tables for P41/R29 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	62.50	0	0.00	1	12.50	0	0.00	2	25.00
3102	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3201	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3301	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
3308	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4206	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4207	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4212	3	60.00	0	0.00	0	0.00	1	20.00	1	20.00
4221	3	75.00	1	25.00	0	0.00	0	0.00	0	0.00
4222	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4223	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4225	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7301	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	19	70.37	1	3.70	1	3.70	1	3.70	5	18.52

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	62.50	5	62.50	6	75.00	6	75.00	8	100.00
3102	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3201	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3301	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
3308	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4203	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4206	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4207	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4212	3	60.00	3	60.00	3	60.00	4	80.00	5	100.00
4221	3	75.00	4	100.00	4	100.00	4	100.00	4	100.00
4222	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4223	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4225	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7301	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	19	70.37	20	74.07	21	77.78	22	81.48	27	100.00

Accuracy Assessment Tables for P41/R29 -- Cover Type

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	162	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3102	0	0.00	0	0.00	0	100.00	0	0.00	0	0.00
3201	35	50.00	0	0.00	0	0.00	0	0.00	35	50.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
3301	19	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3308	49	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	136	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4206	38	66.67	0	0.00	0	0.00	0	0.00	19	33.33
4207	0	0.00	0	0.00	0	0.00	0	100.00	0	0.00
4212	150	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4221	109	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4222	72	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4223	163	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4225	0	0.00	0	100.00	0	0.00	0	0.00	0	0.00
7301	0	0.00	0	0.00	0	0.00	0	0.00	13	100.00
SUM	933	93.30	0	0.00	0	0.00	0	0.00	67	6.70

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	162	100.00	162	100.00	162	100.00	162	100.00	162	100.00
3102	0	0.00	0	0.00	0	100.00	0	100.00	0	100.00
3201	35	50.00	35	50.00	35	50.00	35	50.00	69	100.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
3301	19	100.00	19	100.00	19	100.00	19	100.00	19	100.00
3308	49	100.00	49	100.00	49	100.00	49	100.00	49	100.00
4203	136	100.00	136	100.00	136	100.00	136	100.00	136	100.00
4206	38	66.67	38	66.67	38	66.67	38	66.67	57	100.00
4207	0	0.00	0	0.00	0	0.00	0	100.00	0	100.00
4212	150	100.00	150	100.00	150	100.00	150	100.00	150	100.00
4221	109	100.00	109	100.00	109	100.00	109	100.00	109	100.00
4222	72	100.00	72	100.00	72	100.00	72	100.00	72	100.00
4223	163	100.00	163	100.00	163	100.00	163	100.00	163	100.00
4225	0	0.00	0	100.00	0	100.00	0	100.00	0	100.00
7301	0	0.00	0	0.00	0	0.00	0	0.00	13	100.00
SUM	933	93.39	933	93.39	933	93.39	933	93.39	999	100.00

Accuracy Assessment Tables for P41/R29 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	2(5)	0(3)	0(1)	2(0)
2	0(3)	1(5)	0(3)	1(0)
3	0(1)	0(3)	2(5)	5(0)
SUM	2(0)	1(0)	2(0)	8(0)

Diagonal Elements = 5; Total Test Points = 8
Percentage Agreement = 62.50; Tau w/equal Prob = 0.438

3 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 3 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3	2	40.00	0	0.00	0	0.00	0	0.00	3	60.00
SUM	5	62.50	0	0.00	0	0.00	0	0.00	3	37.50

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
2	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
3	2	40.00	2	40.00	2	40.00	2	40.00	5	100.00
SUM	5	62.50	5	62.50	5	62.50	5	62.50	8	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	5	100.00	0	0.00	0	0.00	0	0.00	0	0.00

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%

1	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
2	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
3	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
SUM	5	100.00	5	100.00	5	100.00	5	100.00	5	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	65	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	725	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3	84	40.00	0	0.00	0	0.00	0	0.00	126	60.00
SUM	874	87.40	0	0.00	0	0.00	0	0.00	126	12.60

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	65	100.00	65	100.00	65	100.00	65	100.00	65	100.00
2	725	100.00	725	100.00	725	100.00	725	100.00	725	100.00
3	84	40.00	84	40.00	84	40.00	84	40.00	210	100.00
SUM	874	87.40	874	87.40	874	87.40	874	87.40	1000	100.00

Accuracy Assessment Tables for P41/R29 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	1(5)	0(3)	0(1)	1(0)
2	2(3)	0(5)	0(3)	2(0)
3	0(1)	0(3)	1(5)	1(0)
SUM	3(0)	0(0)	1(0)	4(0)

Diagonal Elements = 2; Total Test Points = 4
Percentage Agreement = 50.00; Tau w/qual Prob = 0.250

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	2	50.00	0	0.00	2	50.00	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
2	0	0.00	0	0.00	2	100.00	2	100.00	2	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	2	50.00	2	50.00	4	100.00	4	100.00	4	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	33.33	0	0.00	2	66.67	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	2	50.00	0	0.00	2	50.00	0	0.00	0	0.00

Accuracy Assessment Tables for P41/R29 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	33.33	1	33.33	3	100.00	3	100.00	3	100.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	2	50.00	2	50.00	4	100.00	4	100.00	4	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	456	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	215	100.00	0	0.00	0	0.00
3	329	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	785	78.50	0	0.00	215	21.50	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	456	100.00	456	100.00	456	100.00	456	100.00	456	100.00
2	0	0.00	0	0.00	215	100.00	215	100.00	215	100.00
3	329	100.00	329	100.00	329	100.00	329	100.00	329	100.00
SUM	785	78.50	785	78.50	1000	100.00	1000	100.00	1000	100.00

Accuracy Assessment Tables for P41/R29 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	n	1	2	3	SUM
1		4(5)	2(3)	1(1)	7(0)
2		2(3)	0(5)	4(3)	6(0)
3		0(1)	0(3)	2(5)	2(0)
SUM		6(0)	2(0)	7(0)	15(0)

Diagonal Elements = 6; Total Test Points = 15
Percentage Agreement = 40.00; Tau w/equal Prob = 0.100

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	57.14	0	0.00	2	28.57	0	0.00	1	14.29
2	0	0.00	0	0.00	6	100.00	0	0.00	0	0.00
3	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	6	40.00	0	0.00	8	53.33	0	0.00	1	6.67

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	57.14	4	57.14	6	85.71	6	85.71	7	100.00
2	0	0.00	0	0.00	6	100.00	6	100.00	6	100.00
3	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
SUM	6	40.00	6	40.00	14	93.33	14	93.33	15	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	66.67	0	0.00	2	33.33	0	0.00	0	0.00
2	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00
3	2	28.57	0	0.00	4	57.14	0	0.00	1	14.29
SUM	6	40.00	0	0.00	8	53.33	0	0.00	1	6.67

Accuracy Assessment Tables for P41/R29 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	66.67	4	66.67	6	100.00	6	100.00	6	100.00
2	0	0.00	0	0.00	2	100.00	2	100.00	2	100.00
3	2	28.57	2	28.57	6	85.71	6	85.71	7	100.00
SUM	6	40.00	6	40.00	14	93.33	14	93.33	15	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	417	57.14	0	0.00	208	28.57	0	0.00	104	14.29
2	0	0.00	0	0.00	184	100.00	0	0.00	0	0.00
3	88	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	505	50.45	0	0.00	392	39.16	0	0.00	104	10.39

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	417	57.14	417	57.14	625	85.71	625	85.71	729	100.00
2	0	0.00	0	0.00	184	100.00	184	100.00	184	100.00
3	88	100.00	88	100.00	88	100.00	88	100.00	88	100.00
SUM	505	50.45	505	50.45	897	89.61	897	89.61	1001	100.00

Accuracy Assessment Tables for P41/R29 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	SUM
1	2(5)	0(3)	2(0)
2	0(3)	0(5)	2(0)
SUM	2(0)	0(0)	4(0)

Diagonal Elements = 2; Total Test Points = 4
Percentage Agreement = 50.00; Tau w/equal Prob = 0.000

2 points did not belong to groups listed in the test data and were treated as mis-classifications. Default score for these 2 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
SUM	2	50.00	0	0.00	0	0.00	0	0.00	2	50.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
2	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
SUM	2	50.00	2	50.00	2	50.00	2	50.00	4	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00

Accuracy Assessment Tables for P41/R29 -- Shrub Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
2	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	517	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	0	0.00	0	0.00	0	0.00	0	0.00	483	100.00
SUM	517	51.70	0	0.00	0	0.00	0	0.00	483	48.30

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	517	100.00	517	100.00	517	100.00	517	100.00	517	100.00
2	0	0.00	0	0.00	0	0.00	0	0.00	483	100.00
SUM	517	51.70	517	51.70	517	51.70	517	51.70	1000	100.00

Scene P41/R29 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	121990.0	1616691.1	47.5
1000	59.0	732.2	0.0
2000	242.0	6936.2	0.2
3101	9177.0	138144.2	4.1
3104	4926.0	41870.1	1.2
3201	4649.0	52195.9	1.5
3301	2899.0	31888.5	0.9
3304	194.0	1445.4	0.0
3306	639.0	13391.6	0.4
3308	4452.0	56155.7	1.7
4102	1427.0	10620.0	0.3
4203	12870.0	174804.3	5.1
4206	8676.0	83337.7	2.4
4208	10996.0	135359.7	4.0
4212	18903.0	209430.9	6.2
4219	3381.0	29758.0	0.9
4220	10566.0	167129.5	4.9
4221	5665.0	129764.3	3.8
4222	6012.0	101927.3	3.0
4223	3684.0	238016.1	7.0
5000	1556.0	14914.3	0.4
7300	984.0	6700.9	0.2
9100	1120.0	21246.5	0.6
9800	2921.0	110692.2	3.3
9900	659.0	9274.9	0.3

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	121990.0	1616691.1	47.5
Not tree/shrub	21644.0	350511.4	10.3
Shrub 1	6458.0	73665.5	2.2
Shrub 2	52987.0	580714.7	17.1
Shrub 3	5685.0	66498.7	2.0
Tree 1	16490.0	400887.2	11.8
Tree 2	690.0	14913.0	0.4
Tree 3	12703.0	298545.9	8.8

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	121990.0	1616691.1	47.5
Not tree/shrub	21644.0	350511.4	10.3
Tree 1	11547.0	104690.7	3.1
Tree 2	27254.0	303618.3	8.9
Tree 3	24268.0	371394.1	10.9
Tree 4	19111.0	500444.6	14.7
Shrub 1	3503.0	61506.4	1.8
Shrub 2	3872.0	30025.2	0.9
Shrub 3	5458.0	63545.6	1.9

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	121990.0	1616691.1	47.5
A	242.0	6936.2	0.2
H	14103.0	180014.2	5.3
N	7299.0	163561.0	4.8
S	12833.0	155077.1	4.6
T	82180.0	1280147.8	37.6

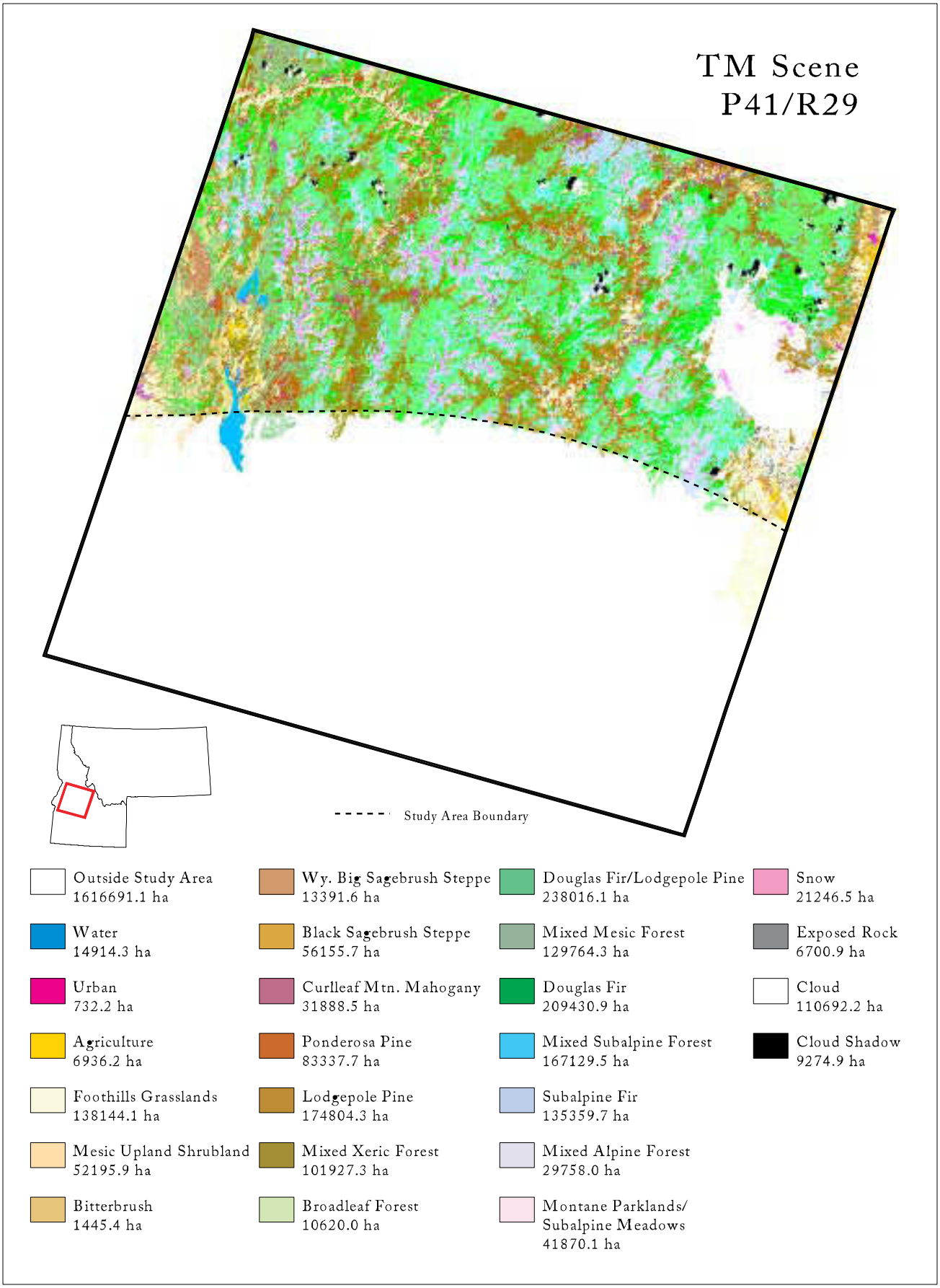


Figure F-9. Classification of land cover types for TM Scene P41/R29.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P41/R29

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 4280 to 6690 feet in elevation. The average canopy cover is 27% ranging from 10-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤11% and frequency of occurrence ≥13% and ≤47%.

Primary associated shrub species with ≥7% and ≤20% frequency of occurrence in ponderosa pine stands: mountain balm (Ceanothus velutinus), ocean-spray (Holodiscus discolor), mallow ninebark (Physocarpus malvaceus), antelope bitter-brush (Purshia tridentata), mountain snowberry (Symphoricarpos oreophilus), dwarf huckleberry (Vaccinium caespitosum), globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤33% frequency of occurrence in ponderosa pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), orchard grass (Dactylis glomerata), Idaho fescue (Festuca idahoensis), and Wheeler's bluegrass (Poa nervosa); **forbs**: heart-leaf arnica (Arnica cordifolia) and common St. John's-wort (Hypericum perforatum); **ferns**: none; **moss**: none.

2) 4207: GRAND FIR FOREST

Conifer forest dominated by grand fir (Abies grandis) ranging from 4840 to 6800 feet in elevation. The average canopy cover is 42% ranging from 20-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), ponderosa pine (Pinus ponderosa), and Douglas-fir (Pseudotsuga menziesii), with average percent cover ≥3% and ≤5% and frequency of occurrence ≥14% and ≤50%.

Primary associated shrub species with ≥7% and ≤21% frequency of occurrence in grand fir stands: rocky mountain maple (Acer glabrum), sitka alder (Alnus sinuata), Utah honeysuckle (Lonicera utahensis), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and snowberry (Symphoricarpos spp.).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤43% frequency of occurrence in grand fir stands: **graminoids**: elk sedge (Carex geyeri); **forbs**: western goldthread (Coptis occidentalis) and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: none.

3) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 2160 to 6656 feet in elevation. The average canopy cover is 29% ranging from 10-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include grand fir (Abies grandis), Engelmann spruce (Picea engelmannii), and ponderosa pine (Pinus ponderosa), with average percent cover ≥3% and ≤5% and frequency of occurrence ≥14% and ≤50%.

Primary associated shrub species with ≥7% and ≤36% frequency of occurrence in Douglas-fir stands: western serviceberry (Amelanchier alnifolia), big sagebrush (Artemisia tridentata), ocean-spray (Holodiscus discolor), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and huckleberry (Vaccinium spp.).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤29% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), and Idaho fescue (Festuca idahoensis); **forbs**: balsamroot (Balsamorhiza sagittata); **ferns**: none; **moss**: moss (moss spp.).

4) 4221: MIXED MESIC FOREST

Conifer forest dominated by grand fir (Abies grandis) ranging from 3685 to 6220 feet in elevation. The average canopy cover is 17% ranging from 1-40% total cover and frequency of occurrence equal to 95%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥10% and ≤16% and frequency of occurrence ≥55% and ≤80%.

Primary associated shrub species with ≥10% and ≤25% frequency of occurrence in mixed mesic stands: common prince's pine (Chimaphila umbellata), ocean-spray (Holodiscus discolor), twin flower (Linnaea borealis), mallow ninebark (Physocarpus malvaceus), globe huckleberry (Vaccinium globulare), big huckleberry (Vaccinium membranaceum), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤45% frequency of occurrence in mixed mesic stands: **graminoids**: pinegrass (Calamagrostis rubescens) and elk sedge (Carex geyeri); **forbs**: Piper's anemone (Anemone piperi), heart-leaf arnica (Arnica cordifolia), queen's cup beadlily (Clintonia uniflora), western goldthread (Coptis occidentalis), fireweed (Epilobium angustifolium), meadowrue (Thalictrum spp.), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: moss (moss spp.).

P41/R29 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASS
6101	Needleleaf Dominated Riparian	82
6102	Broadleaf Dominated Riparian	15
6103	Needleleaf-Broadleaf Riparian	None identified for scene
6104	Mixed Riparian (trees+ any other)	76
6201	Grass-Forb Riparian Wetland	41
6202	Shrub Riparian Wetland	10, 36, 65
6203	Mixed Grass-Forb-Shrub Riparian	4

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 2
Color: Dark Brown; RGB 73 45 71.
Distribution: Mid elevation shadows. Within the zone, light to medium density throughout the image, generally near stream origins.
Comment: Appears to be Douglas-fir. Field observations outside the zone are dominated by coniferous cover types, with some riparian vegetation (6102, 6201) observed.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
2	1	Grand Fir

Spectral Class 3
Color: Olive; RGB 138 155 106.
Distribution: Fairly dense and widely distributed across the scene, except locations at extremes in elevation or moisture. Within the zone, concentrated somewhat around Cascade Reservoir, but generally uniformly distributed at medium density. Found at various segments along streams.
Comment: Appears to be sagebrush and Mixed Xeric Forest. Outside the zone, conifers, shrubs (including sagebrush), grass, and riparian (6101, 6102) cover types were observed.
Conclusion: Not riparian.

3	1	Shrub Riparian/Wetland
4	1	Exposed Rock

Spectral Class 4
Color: Light orange; RGB 255 183 118.
Distribution: Occurs primarily in valleys, dense in some portions. Within the zone the class is mostly in the southwestern portion of the image, denser in the reservoir/lake area. Spotty at various segments of streams.
Comment: Appears to have some riparian vegetation within the zone, probably shrubs and grass. Coniferous, agricultural, shrub, riparian (6201), rock, and barren cover types were recorded outside the zone.
Conclusion: 6203.

5	1	Lodgepole Pine

Spectral Class 6
Color: Brown; RGB 146 100 90.
Distribution: Dense spackle on lower slopes. Fairly uniform across the image, medium density. Found all along streams where it exists.
Comment: Appears to be mostly dry shrub. Training data for sites outside the zone indicate primarily coniferous cover types, with riparian (6201), Foothills Grassland, and Exposed Rock cover types also present.
Conclusion: Not riparian.

6	1	Shrub Riparian/Wetland
7	1	Bare Clearcut

Spectral Class 8
Color: Orange; RGB 255 132 82.
Distribution: Appears in some low elevation agricultural areas. Relatively rare within the zone, but found in clusters in wider segments.
Comment: Appears to be agriculture. None of the recorded observation locations match unregrouped regions for this spectral class, either outside or inside the riparian zone.
Conclusion: Not riparian.

Spectral Class 10
Color: Light orange brown; RGB 210 128 90.
Distribution: Dense spackle on lower slopes. Fairly uniform across the image, medium density. Found at various segments along streams, when within the riparian zone.
Comment: Color and distribution suggest Shrub Riparian/Wetland within the zone. In descending order of frequency, conifers, Mesic Upland Shrubland, riparian vegetation (6101), and Foothills Grassland were observed outside the zone for this spectral class.
Conclusion: 6202.

9	1	Broadleaf Dominated Riparian

10	1	Grass-Forb Riparian/Wetland

Spectral Class 15
Color: Red orange; RGB 239 87 75.
Distribution: Medium density on lower mid-elevation slopes on the western portion of the image. Within the zone, the class is sparse, also found mostly on the western half of the image.
Comment: Color and distribution indicate Broadleaf Dominated Riparian vegetation within the zone. Outside the zone, conifers, Mesic Upland Shrubland, and Irrigated Pasture were observed.
Conclusion: 6102.

11	1	Broadleaf Dominated Riparian

Spectral Class 26
Color: Blue black; RGB 0 0 71.
Distribution: Water features.
Comment: There was but one training data point outside the riparian zone matching unregrouped regions for this spectral class, recorded as Grass-Forb Riparian/Wetland.
Conclusion: Not riparian.

13	1	Grass-Forb Riparian/Wetland

Spectral Class 36
Color: Cool orange; RGB 255 157 157.
Distribution: Occurs in some agricultural areas. Rare within the zone, found primarily in wider sections at lower elevations.
Comment: Color and locations indicate shrubs, riparian within the zone. A single observation, Urban & Developed Land, was recorded outside the zone.
Conclusion: 6202.

15	1	Clearcut

Spectral Class 41
Color: Yellow tan; RGB 255 219 196.
Distribution: Quite similar in distribution to spectral class 36 within the zone.
Comment: The visual impression is of riparian grass vegetation. There are no training data points zone matching unregrouped regions for this spectral class.
Conclusion: 6201.

Spectral Class 57

Color: Orange tan; RGB 255 202 180.
Distribution: Occurs sparsely in some agricultural areas. Rare within the riparian zone.
Comment: Appears to be agriculture. None of the recorded observations match locations for this spectral class, either outside or inside the zone.
Conclusion: Not riparian.

Spectral Class 65
Color: Dark orange; RGB 255 123 98.
Distribution: Medium to dense in some agricultural areas and on some lower slopes; mostly clustered in wider zone segments across the image.
Comment: There are three points for this class outside the zone, all recorded as riparian vegetation (6103, 6201, 6202).
Conclusion: 6202.

16	1	Foothills Grassland
17	1	Grass-Forb Riparian/Wetland

Spectral Class 67
Color: Dark orange; RGB 255 132 94.
Distribution: A rare class, occuring in small clusters in some agricultural areas. Within the zone, found only in clusters at wider portions of the zone on eastern and western edges of the image.
Comment: Appears to be agriculture. The single observation outside the zone was recorded as Irrigated Crop.
Conclusion: Not riparian.

Spectral Class 76
Color: Red orange; RGB 255 81 75.
Distribution: Very similar to spectral class 67.
Comment: Appears to be mostly shrubs, with some broadleaf trees. The single training data point for this spectral class was recorded as Grass-Forb Riparian/Wetland, outside the zone.
Conclusion: 6104.

Spectral Class 82
Color: Olive drab; RGB 89 117 98.
Distribution: Rather dense spackle at mid elevations, some near streams.
Comment: Appears to be Needleleaf Dominated Riparian along higher elevation stream reaches. Training sites for this class, all outside the zone, indicate conifers, Mixed Barren Land, and Curlleaf Mountain Mahogany.
Conclusion: 6101.

TM SCENE P40/R27

Image Analyst: Troy P. Tady

Training Data Analysis

In all, 2844 ground-truth plots were available for labeling P40/R27 (see table next page). The data were initially checked over the full scene to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 57) were removed from further analysis. The data were then examined by cover type to determine whether or not plots were collected for this project or for other purposes (e.g., pre-existing ECODATA, TSMRS, etc.). The latter "existing data" were to be used only as supplementary accuracy test points. The following classes were excluded from the digital classification process and from selection of accuracy test points: urban, agriculture, water, snow, riparian, mines/quarries/gravel pits, clearcuts, sandy areas and shoreline/gravel bars. Classes determined to be minor components of the scene as per USFS decisions were also excluded; this included VEG_CLASS_CODEs 3304, 3306, 3307, 3308, 3309, 3311, 4207, 4210, 4211, 4214, 4224, and 4226. The aspen (4101) cover type was combined with the general broadleaf forest class (4102) due to a lack of adequate training data for each separate class. The disturbed grassland (3102) and montane parkland & subalpine meadow (3104) classes were combined with foothills grassland (3101) due to negligible spectral differences between the two classes. The 3104 class was reintroduced using an elevational break.

Of the remaining plots, 20% were randomly selected from each cover type. These plots (n = 336) were held aside in a separate data file for use in the accuracy assessment. Existing data points were not used as training data or test plots. The same process was used to separately extract test points for size classes and for canopy cover classes. Again, existing data points were not used.

For the remaining 80% of this "filtered" data set, plots were subjected to further spectral examination. Outliers were eliminated for each cover type based on knowledge of general spectral patterns for various ground features. Insufficient training data plots were available for the following cover types:

4102 Broadleaf Forest	- 1 plot
3313 Creeping Juniper	- 4 plots
4215 Western Larch	- 5 plots
7400 Barren Alpine Tundra	- 5 plots

Training data for these and most of the other cover types were supplemented from data gathered during two Forest Service review sessions as well as from personal knowledge of individuals familiar with areas within the scene. A total of about 100 new training data plots were obtained through various review sessions.

Total plots in ground-truth file	2844	
Total 1994-95 field plots	1751	
Plots sampled for P40/R27		850
Plots sampled for other scenes		901
Pre-existing plots (ECODATA, TSMRS, etc.)	1093	
Plots with codes included in the classification	2318	
Plot discards	477	
Pre-existing plots		420
'Bad duplicates'		13
'Good duplicates'		44
Potential training plots	1684	
20% test		336
80% training		1348
Supplemental cover type plots	200	(+/-)
Total plots available for training	1584	(+/-)
Total plots used for training--cover type	1400	
size class	203	
canopy	940	

Land Cover Types

A digital classification of TM channels 1-7 plus rescaled elevation (raw elevation value divided by 25) produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were assigned directly to the COVER_TYPE field in the database attribute table. Further modifications were carried out using spectral class values (SPECTRAL_CLASS or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000. Urban.	Manually identified and recoded by Will Gustafson, Jodi Handley, and Troy Tady.
2000. Agriculture.	Manually identified and recoded by Will Gustafson and Troy Tady. MNDVI values were used to easily delineate large areas of plowed farm fields in the northeastern portion of the scene.
3101. Foothills Grassland.	All grass types occurring below 1829 m (6000 ft) were relabeled as Foothills Grassland.
3104. Montane Parkland & Subalpine Meadow.	All grass types occurring at and above 1829 m (6000 ft) were relabeled as Montane Parkland & Subalpine Meadow.

3201.	Mesic Upland Shrubland.	East of the Continental Divide only, at all elevations.
3202.	Warm Mesic Shrubland.	All regions west of the Continental Divide (half of this scene) that were classified as a 3200 level shrub type were labeled as Warm Mesic Shrubland if they occurred below 1463 m (4800 ft). If they occurred between 1463 m (4800 ft) and 1768 m (5800 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
3203.	Cold Mesic Shrubland.	All regions west of the Continental Divide (half of this scene) that were classified as a 3200 level shrub type were labeled as Cold Mesic Shrubland if they occurred above 1768 m (5800 ft). If they occurred between 1463 m (4800 ft) and 1768 m (5800 ft), they were subjected to a separate digital classification which labeled them as either Warm or Cold Mesic Shrubland.
3305.	Mountain Big Sage.	Geographically confined using Forest Service vegetation distribution limits (see also 4222).
3313.	Creeping Juniper.	This class occurred only east of the Continental Divide. The class was represented by only four training plots with no supplemental plots available. Poor mapping of this class may be expected.
4102.	Broadleaf Forest.	This class was well represented by the 19 combined 4101 and 4102 training plots. Confusion with taller shrub types may be expected, however.
4201.	Engelmann Spruce.	Although the USFS vegetation limit guidelines included 4201 as a minor cover type, representatives from the Lolo and Lewis and Clark NFs provided plots and information on the 4201 class for areas both east and west of the Continental Divide.
4203.	Lodgepole Pine.	Some confusion with 4212 on the East Front.
4205.	Limber Pine.	Isolated distribution along the East Front.
4208.	Subalpine Fir.	Confusion with 4220 both east and west of the Continental Divide.
4212.	Douglas-fir.	See 4203.
4215.	Western Larch.	During the USFS review sessions, Western Larch was found to be confused with some shrub and broadleaf classes in younger plantations. Larch data were supplemented by the Lolo NF to help correct this.

4219.	Mixed Whitebark Pine Forest.	Some confusion with 7301 was noted during the USFS the USFS review sessions. Supplemental 7301 and 4219 points helped to correct this confusion.
4220.	Mixed Subalpine Forest.	Confusion with the 4221 class commonly occurred in the western portion of the scene due to the occurrence of subalpine species at lower elevations in the Seeley-Swan. Elevation cutoffs could not be used to correct this problem. Supplemental 4221 and 4220 points were placed at relatively high densities in the Seeley-Swan area to help alleviate some of the confusion.
4221.	Mixed Mesic Forest.	See 4220.
4222.	Mixed Xeric Forest.	Supplemental 3305 plots were used to correct for Sagebrush and Xeric Forest confusion in the eastern portions of the scene. The points originally provided did not prove to be an adequate sample of the range of spectral variation for sagebrush classes. Because of this, the next most likely class, 4222, was initially overestimated in some eastern areas.
4223.	Douglas-fir - Lodgepole Pine.	No modifications.
4225.	Douglas-fir - Grand Fir.	Confined to west of the Continental Divide.
4228.	Western Larch - Lodgepole Pine.	Confined to west of the Continental Divide.
4229.	Douglas-fir - Western Larch.	Confined to west of the Continental Divide.
4301.	Broadleaf - Needleleaf Forest.	No modifications.
5000.	Water.	All regions with spectral class (LINK) = 1 and slope $\leq 5^{\circ}$ were labeled as water. Generally, water was more spectrally distinct than most other cover types, but in high mountainous terrain, it was confused with cliff shadows. A 5° slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate elevation and slope values such that their slope may be greater than 5°. This would result in the misclassification of some small ponds or lakes.
7301.	Rock.	Numerous supplemental data plots were obtained to provide a better representation of spectral variation in the 7301 class. See 4219. The following decision rule was

		used to aid in accurately mapping 7301: If 7301 and elevation ≤55, then 7800 if NDVI <20, and 3101 (or 3104) if NDVI ≥20.
7400.	Barren Alpine Tundra.	An elevation cutoff of >1829 m (6000 ft) was used to separate 7400 from 7800.
7800.	Mixed Barren.	See 7400.
8101.	Alpine Meadow.	No modifications.
9800.	Cloud.	Manually identified by Jodi Handley and Troy Tady.
9900.	Cloud Shadow.	Manually identified by Jodi Handley and Troy Tady.

A total of 32 cover types were labeled in the full TM scene. These included three grass types, five shrub types, sixteen forest types, plus eight non-vegetated or manually modified classes. Cover types are mapped in Figure F-10.

Size Classes

Seven size classes were mapped -- four for forest cover types (seedling/sapling, pole, medium, and large/very large) and three for shrub cover (low, medium, and tall). The seven TM spectral channels were used for the size classification (elevation was not included). The Nearest Member of Group (NMG) classifier was used for both tree and shrub size classes. Tree size classes were stratified based upon three canopy cover classes (see below).

Canopy Cover Classes

Three canopy cover labels (CANOPYCODE = low, medium, or high) were assigned to tree and shrub classes based on Modified Normalized Distribution Vegetation Index (MNDVI) values (modified from Nemani et al. 1993). These values were plotted as frequency histograms for all coniferous forest types (Figure F-10a) as well as for one shrub type (Figure F-10b). The histograms were examined to determine break points based upon the distribution modes (see table below). Regions with MNDVI values falling below the lower break point were assigned to a low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class. The low number of points available for the xeric (3300) shrub classes required that mesic and xeric shrub points be combined for this scene.

	MNDVI BREAKPOINTS	
CANOPY COVER	Tree	Shrub
Low	<176	<176
Medium	≥176 and ≤378	≥176 and ≤300
High	>378	>300

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\sum \frac{(\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications.

CLASSIFICATIONS FOR P40/R27	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	22	59%	34%
Tree Size Class	4	94%	41%
Tree Canopy Class	3	98%	60%
Shrub Size Class	3	95%	40%
Shrub Canopy Class	3	100%	69%

Comments

P40/R27 was classified separately in roughly two halves (west and east of the continental divide). Even using this procedure, cover type classifications were difficult because of the varied nature of vegetation types within the scene.

Error Matrix For Cover Type Training Plots
Scene P40/R27

CLASSIFIED COVER TYPES

PLOT COVER TYPES	3101	3201	3305	3313	4102	4203	4205	4206	4208	4212	4215	4219	4221	4222	4223	4301	7301	7400	7800	8101	SUM
3101	114	6	3	1	1	2	1	10	6	5	0	1	5	5	2	0	24	1	8	1	196
3201	8	7	0	0	3	3	0	3	0	3	0	0	2	0	2	0	5	0	3	0	39
3305	3	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	6
3313	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	3
4102	1	2	0	0	3	0	0	1	0	4	0	0	2	1	0	0	0	0	0	0	14
4203	2	2	0	0	3	14	0	0	1	3	0	1	2	4	3	0	1	0	0	0	36
4205	0	0	0	1	0	0	1	2	0	1	0	1	0	1	0	0	1	0	0	0	8
4206	9	3	0	0	0	0	3	6	0	3	0	0	0	0	0	0	1	0	0	0	25
4208	5	0	0	0	0	0	0	0	5	2	0	3	0	1	0	0	0	0	0	0	16
4212	8	2	0	0	5	5	1	3	2	25	1	0	9	10	2	2	7	0	0	0	82
4215	0	0	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	4
4219	0	0	0	0	0	0	0	0	2	1	0	5	0	0	0	0	0	0	0	1	9
4221	5	2	0	0	1	2	0	1	2	8	0	0	23	0	0	1	1	0	0	0	46
4222	4	2	0	0	0	1	0	1	1	11	0	0	3	4	0	0	6	0	0	0	33
4223	0	1	0	0	1	2	0	0	1	2	0	0	0	0	0	1	1	0	0	0	9
4301	0	0	0	0	0	1	0	0	0	1	0	0	1	1	1	0	0	0	0	0	5
7301	26	6	2	1	0	2	1	2	3	8	0	0	1	4	1	0	107	2	4	2	172
7400	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	5
7800	10	3	0	0	0	1	0	1	1	0	0	0	0	0	0	0	2	0	0	0	18
8101	2	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	7
SUM	199	38	7	3	18	33	8	30	24	78	1	12	49	31	13	4	161	5	15	4	733

% AGREEMENT	43.4
TAU WITH EQUAL PROBABILITY	0.41
TOTAL DIAGONAL ELEMENTS	318
TOTAL TRAINING PLOTS IN DATA SET	733

F. P40/R27. 7

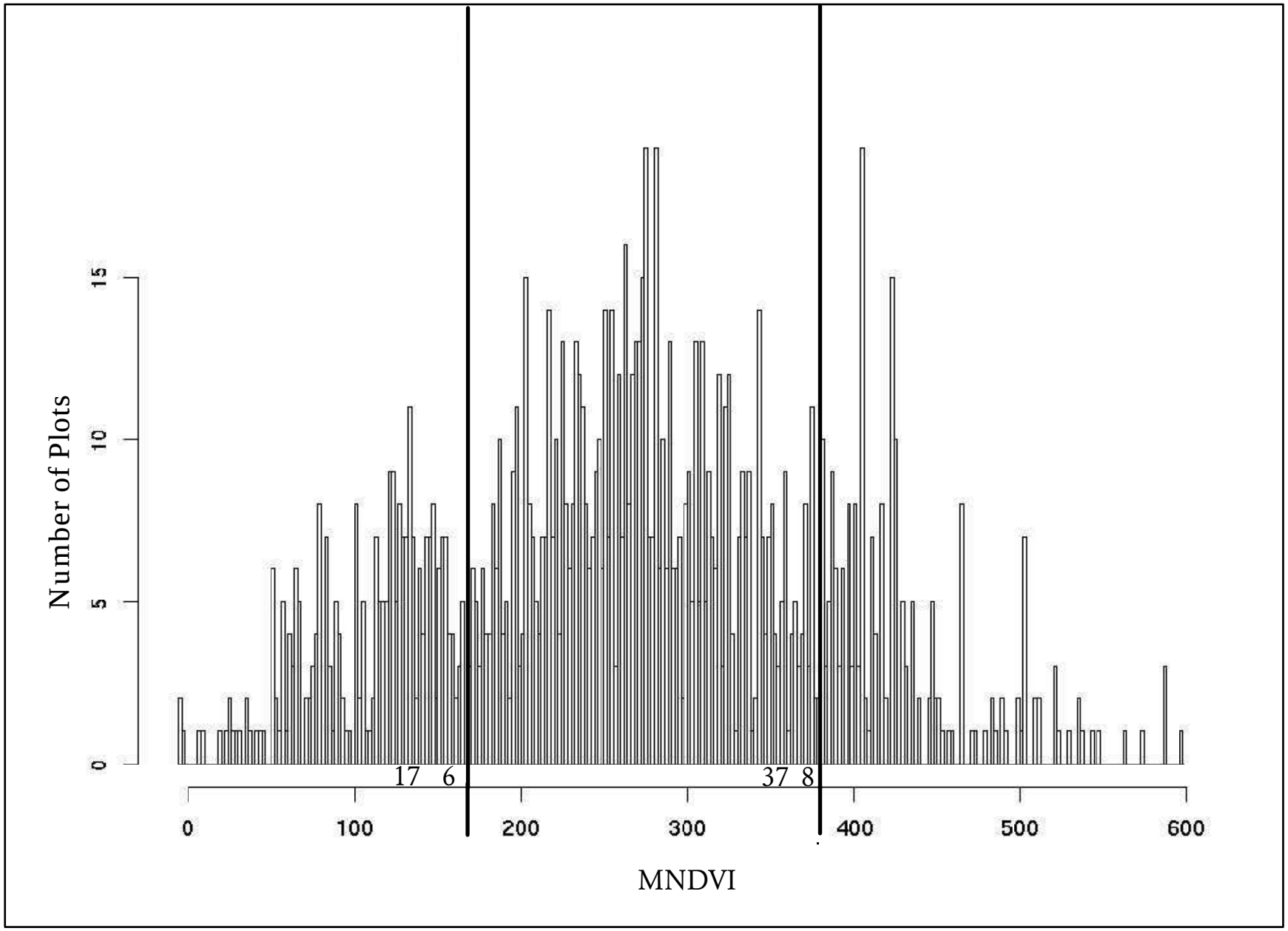


Figure F-10a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P40/R27

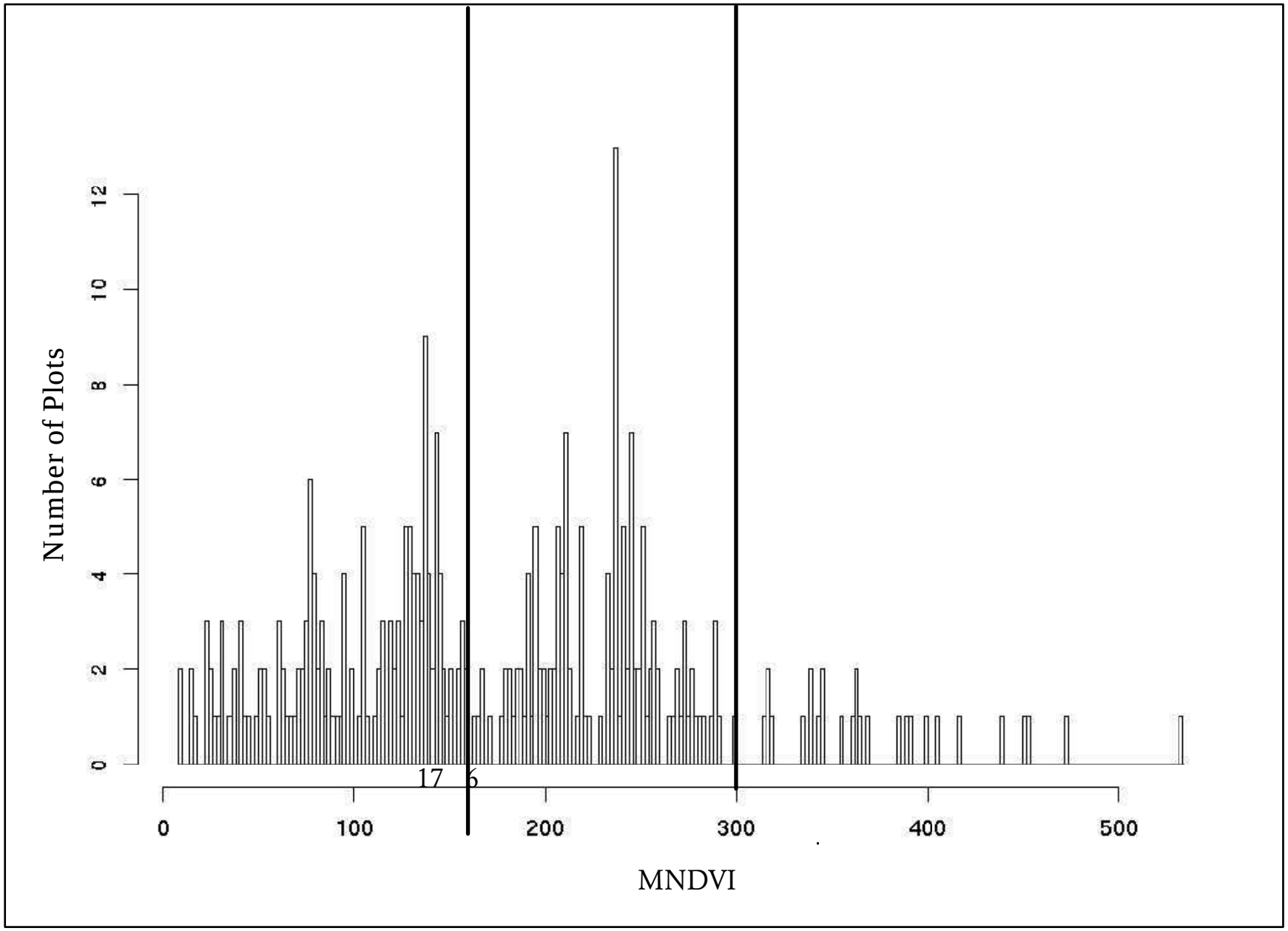


Figure F-10b. Breaks between shrub canopy cover classes in relation to MNDVI values: TM scene P40/R27

Accuracy Assessment Tables for P40/R27 -- Cover Type

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3201	3202	3203	3305	4102	4203	4205	4208
3101	60(5)	7(1)	14(1)	8(1)	3(1)	2(1)	5(1)	1(1)	2(1)
3201	1(1)	1(5)	0(4)	0(4)	0(2)	0(1)	0(1)	0(1)	0(1)
3202	0(1)	0(4)	2(5)	1(3)	0(2)	0(1)	0(1)	0(1)	0(1)
3203	0(1)	0(4)	1(3)	0(5)	0(2)	0(1)	0(1)	0(1)	0(1)
3305	0(1)	0(2)	0(2)	0(2)	2(5)	0(1)	0(1)	0(1)	0(1)
4102	0(1)	1(1)	0(1)	0(1)	0(1)	4(5)	0(2)	0(2)	0(2)
4203	1(1)	1(1)	4(1)	1(1)	0(1)	1(2)	30(5)	0(2)	1(2)
4205	0(1)	2(1)	0(1)	0(1)	0(1)	0(2)	0(2)	2(5)	0(2)
4208	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	4(5)
4212	2(1)	3(1)	5(1)	5(1)	0(1)	2(2)	22(2)	0(2)	1(2)
4215	0(1)	0(1)	0(1)	0(1)	0(1)	1(2)	0(2)	0(2)	0(2)
4219	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)	0(2)	0(3)
4220	0(1)	0(1)	0(1)	1(1)	0(1)	0(2)	4(3)	0(2)	1(3)
4221	2(1)	0(1)	3(1)	4(1)	0(1)	5(2)	5(3)	0(2)	0(2)
4222	1(1)	1(1)	0(1)	0(1)	1(1)	0(2)	1(2)	1(3)	0(2)
4223	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	1(3)	0(2)	0(2)
4228	0(1)	0(1)	1(1)	0(1)	0(1)	0(2)	1(3)	0(2)	0(2)
4229	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	2(2)	0(2)	0(2)
4301	0(1)	0(1)	0(1)	0(1)	0(1)	1(3)	0(2)	0(2)	0(2)
7301	12(1)	4(1)	0(1)	2(1)	1(1)	0(1)	0(1)	0(1)	1(1)
7800	9(2)	0(1)	1(1)	1(1)	0(1)	1(1)	0(1)	0(1)	1(1)
8101	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	89(0)	20(0)	31(0)	23(0)	7(0)	17(0)	71(0)	4(0)	11(0)

Accuracy Assessment Tables for P40/R27 -- Cover Type

RF/CF	4212	4215	4219	4220	4221	4222	4223	4228	4229
3101	1(1)	0(1)	3(1)	3(1)	2(1)	3(1)	1(1)	0(1)	0(1)
3201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3202	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3203	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3305	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4102	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4203	9(2)	3(2)	2(3)	14(3)	13(3)	2(2)	10(4)	0(4)	1(2)
4205	1(2)	0(2)	0(2)	0(2)	0(2)	0(4)	0(2)	0(2)	0(2)
4208	2(2)	0(2)	1(3)	6(3)	0(3)	2(2)	0(2)	0(2)	0(2)
4212	14(5)	10(3)	1(2)	11(3)	15(3)	6(4)	6(4)	0(2)	0(4)
4215	0(3)	2(5)	0(2)	0(3)	0(3)	0(2)	0(2)	0(4)	0(4)
4219	0(2)	0(2)	1(5)	0(3)	0(2)	1(2)	0(2)	0(2)	0(2)
4220	0(3)	0(2)	0(3)	1(5)	2(2)	0(2)	0(3)	0(2)	0(2)
4221	6(3)	7(3)	0(2)	10(2)	17(5)	1(2)	4(3)	0(4)	0(4)
4222	3(3)	1(2)	0(2)	1(2)	5(2)	2(5)	1(2)	1(2)	0(2)
4223	2(3)	0(2)	1(2)	1(3)	0(3)	0(2)	1(5)	0(4)	0(4)
4228	1(2)	0(3)	0(2)	0(3)	1(4)	0(2)	0(4)	1(5)	0(4)
4229	1(3)	1(3)	0(2)	1(3)	5(4)	1(2)	1(4)	0(4)	0(5)
4301	0(2)	0(2)	0(2)	0(3)	1(3)	0(3)	0(3)	0(3)	0(3)
7301	2(1)	0(1)	0(1)	5(1)	0(1)	1(1)	0(1)	0(1)	0(1)
7800	2(1)	0(1)	1(1)	3(1)	0(1)	1(1)	0(1)	0(1)	0(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	44(0)	24(0)	10(0)	56(0)	61(0)	20(0)	24(0)	2(0)	1(0)

Accuracy Assessment Tables for P40/R27 -- Cover Type

RF/CF	4301	7301	7800	8101	SUM
3101	1(1)	4(1)	2(1)	5(1)	131(0)
3201	0(1)	0(1)	0(1)	0(1)	2(0)
3202	0(1)	0(1)	0(1)	0(1)	4(0)
3203	0(1)	0(1)	0(1)	0(1)	1(0)
3305	0(1)	0(1)	0(1)	0(1)	2(0)
4102	0(4)	0(1)	0(1)	0(1)	5(0)
4203	1(2)	0(1)	0(1)	0(1)	94(0)
4205	0(2)	0(1)	0(1)	0(1)	5(0)
4208	0(2)	0(1)	0(1)	1(1)	16(0)
4212	2(2)	0(1)	0(1)	0(1)	105(0)
4215	0(2)	0(1)	0(1)	0(1)	3(0)
4219	0(2)	0(1)	0(1)	0(1)	2(0)
4220	0(2)	1(1)	0(1)	0(1)	10(0)
4221	7(2)	0(1)	0(1)	0(1)	71(0)
4222	0(2)	1(1)	0(1)	0(1)	20(0)
4223	0(2)	0(1)	0(1)	0(1)	6(0)
4228	1(2)	0(1)	0(1)	0(1)	6(0)
4229	1(2)	0(1)	0(1)	0(1)	13(0)
4301	0(5)	0(1)	0(1)	0(1)	2(0)
7301	0(1)	16(5)	3(3)	3(1)	51(0)
7800	0(1)	2(3)	1(5)	1(3)	24(0)
8101	0(1)	0(1)	0(3)	1(5)	2(0)
SUM	13(0)	24(0)	6(0)	11(0)	575(0)

Diagonal Elements = 162; Total Test Points = 575
Percentage Agreement = 28.17; Kappa = 0.209; Tau w/equal Prob = 0.248

6 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 6 points = 1

Accuracy Assessment Tables for P40/R27 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	60	45.80	0	0.00	0	0.00	0	0.00	71	54.20
3201	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
3202	2	50.00	0	0.00	1	25.00	0	0.00	1	25.00
3203	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
3305	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4102	4	80.00	0	0.00	0	0.00	0	0.00	1	20.00
4203	30	31.91	10	10.64	29	30.85	18	19.15	7	7.45
4205	2	40.00	0	0.00	0	0.00	1	20.00	2	40.00
4208	4	25.00	0	0.00	7	43.75	4	25.00	1	6.25
4212	14	13.33	12	11.43	36	34.29	28	26.67	15	14.29
4215	2	66.67	0	0.00	0	0.00	1	33.33	0	0.00
4219	1	50.00	0	0.00	0	0.00	1	50.00	0	0.00
4220	1	10.00	0	0.00	5	50.00	2	20.00	2	20.00
4221	17	23.94	0	0.00	22	30.99	23	32.39	9	12.68
4222	2	10.00	0	0.00	4	20.00	10	50.00	4	20.00
4223	1	16.67	0	0.00	4	66.67	1	16.67	0	0.00
4228	1	16.67	1	16.67	1	16.67	2	33.33	1	16.67
4229	0	0.00	6	46.15	3	23.08	4	30.77	0	0.00
4301	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00
7301	16	31.37	0	0.00	3	5.88	0	0.00	32	62.75
7800	1	4.17	0	0.00	3	12.50	9	37.50	11	45.83
8101	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
SUM	162	28.17	29	5.04	121	21.04	104	18.09	159	27.65

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	60	45.80	60	45.80	60	45.80	60	45.80	131	100.00
3201	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
3202	2	50.00	2	50.00	3	75.00	3	75.00	4	100.00
3203	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
3305	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4102	4	80.00	4	80.00	4	80.00	4	80.00	5	100.00
4203	30	31.91	40	42.55	69	73.40	87	92.55	94	100.00
4205	2	40.00	2	40.00	2	40.00	3	60.00	5	100.00
4208	4	25.00	4	25.00	11	68.75	15	93.75	16	100.00
4212	14	13.33	26	24.76	62	59.05	90	85.71	105	100.00
4215	2	66.67	2	66.67	2	66.67	3	100.00	3	100.00
4219	1	50.00	1	50.00	1	50.00	2	100.00	2	100.00
4220	1	10.00	1	10.00	6	60.00	8	80.00	10	100.00
4221	17	23.94	17	23.94	39	54.93	62	87.32	71	100.00
4222	2	10.00	2	10.00	6	30.00	16	80.00	20	100.00
4223	1	16.67	1	16.67	5	83.33	6	100.00	6	100.00
4228	1	16.67	2	33.33	3	50.00	5	83.33	6	100.00
4229	0	0.00	6	46.15	9	69.23	13	100.00	13	100.00
4301	0	0.00	0	0.00	2	100.00	2	100.00	2	100.00
7301	16	31.37	16	31.37	19	37.25	19	37.25	51	100.00
7800	1	4.17	1	4.17	4	16.67	13	54.17	24	100.00
8101	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
SUM	162	28.17	191	33.22	312	54.26	416	72.35	575	100.00

Accuracy Assessment Tables for P40/R27 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	60	67.42	0	0.00	0	0.00	9	10.11	20	22.47
3201	1	5.00	0	0.00	0	0.00	0	0.00	19	95.00
3202	2	6.45	0	0.00	1	3.23	0	0.00	28	90.32
3203	0	0.00	0	0.00	1	4.35	0	0.00	22	95.65
3305	2	28.57	0	0.00	0	0.00	0	0.00	5	71.43
4102	4	23.53	0	0.00	1	5.88	9	52.94	3	17.65
4203	30	42.25	0	0.00	11	15.49	25	35.21	5	7.04
4205	2	50.00	0	0.00	1	25.00	0	0.00	1	25.00
4208	4	36.36	0	0.00	1	9.09	2	18.18	4	36.36
4212	14	31.82	0	0.00	12	27.27	13	29.55	5	11.36
4215	2	8.33	0	0.00	18	75.00	4	16.67	0	0.00
4219	1	10.00	0	0.00	3	30.00	2	20.00	4	40.00
4220	1	1.79	0	0.00	33	58.93	11	19.64	11	19.64
4221	17	27.87	6	9.84	29	47.54	7	11.48	2	3.28
4222	2	10.00	6	30.00	0	0.00	7	35.00	5	25.00
4223	1	4.17	17	70.83	4	16.67	1	4.17	1	4.17
4228	1	50.00	0	0.00	0	0.00	1	50.00	0	0.00
4229	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00
4301	0	0.00	0	0.00	0	0.00	12	92.31	1	7.69
7301	16	66.67	0	0.00	2	8.33	0	0.00	6	25.00
7800	1	16.67	0	0.00	3	50.00	0	0.00	2	33.33
8101	1	9.09	0	0.00	1	9.09	0	0.00	9	81.82
SUM	162	28.47	29	5.10	121	21.27	104	18.28	153	26.89

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	60	67.42	60	67.42	60	67.42	69	77.53	89	100.00
3201	1	5.00	1	5.00	1	5.00	1	5.00	20	100.00
3202	2	6.45	2	6.45	3	9.68	3	9.68	31	100.00
3203	0	0.00	0	0.00	1	4.35	1	4.35	23	100.00
3305	2	28.57	2	28.57	2	28.57	2	28.57	7	100.00
4102	4	23.53	4	23.53	5	29.41	14	82.35	17	100.00
4203	30	42.25	30	42.25	41	57.75	66	92.96	71	100.00
4205	2	50.00	2	50.00	3	75.00	3	75.00	4	100.00
4208	4	36.36	4	36.36	5	45.45	7	63.64	11	100.00
4212	14	31.82	14	31.82	26	59.09	39	88.64	44	100.00
4215	2	8.33	2	8.33	20	83.33	24	100.00	24	100.00
4219	1	10.00	1	10.00	4	40.00	6	60.00	10	100.00
4220	1	1.79	1	1.79	34	60.71	45	80.36	56	100.00
4221	17	27.87	23	37.70	52	85.25	59	96.72	61	100.00
4222	2	10.00	8	40.00	8	40.00	15	75.00	20	100.00
4223	1	4.17	18	75.00	22	91.67	23	95.83	24	100.00
4228	1	50.00	1	50.00	1	50.00	2	100.00	2	100.00
4229	0	0.00	0	0.00	0	0.00	1	100.00	1	100.00
4301	0	0.00	0	0.00	0	0.00	12	92.31	13	100.00
7301	16	66.67	16	66.67	18	75.00	18	75.00	24	100.00
7800	1	16.67	1	16.67	4	66.67	4	66.67	6	100.00
8101	1	9.09	1	9.09	2	18.18	2	18.18	11	100.00
SUM	162	28.47	191	33.57	312	54.83	416	73.11	569	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	135	45.80	0	0.00	0	0.00	0	0.00	160	54.20
3201	23	50.00	0	0.00	0	0.00	0	0.00	23	50.00
3202	15	50.00	0	0.00	7	25.00	0	0.00	7	25.00
3203	0	0.00	0	0.00	42	100.00	0	0.00	0	0.00
3305	27	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4102	16	80.00	0	0.00	0	0.00	0	0.00	4	20.00
4203	32	31.91	11	10.64	31	30.85	19	19.15	8	7.45
4205	7	40.00	0	0.00	0	0.00	3	20.00	7	40.00
4208	5	25.00	0	0.00	8	43.75	5	25.00	1	6.25
4212	10	13.33	8	11.43	25	34.29	20	26.67	11	14.29
4215	9	66.67	0	0.00	0	0.00	4	33.33	0	0.00
4219	15	50.00	0	0.00	0	0.00	15	50.00	0	0.00
4220	8	10.00	0	0.00	42	50.00	17	20.00	17	20.00
4221	8	23.94	0	0.00	11	30.99	11	32.39	4	12.68
4222	5	10.00	0	0.00	10	20.00	24	50.00	10	20.00
4223	9	16.67	0	0.00	38	66.67	9	16.67	0	0.00
4228	0	16.67	0	16.67	0	16.67	1	33.33	0	16.67
4229	0	0.00	2	46.15	1	23.08	1	30.77	0	0.00
4301	0	0.00	0	0.00	12	100.00	0	0.00	0	0.00
7301	7	31.37	0	0.00	1	5.88	0	0.00	15	62.75
7800	1	4.17	0	0.00	2	12.50	5	37.50	7	45.83
8101	4	50.00	0	0.00	0	0.00	0	0.00	4	50.00
SUM	336	33.63	21	2.10	230	23.02	134	13.41	278	27.83

Accuracy Assessment Tables for P40/R27 -- Cover Type

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	135	45.80	135	45.80	135	45.80	135	45.80	295	100.00
3201	23	50.00	23	50.00	23	50.00	23	50.00	47	100.00
3202	15	50.00	15	50.00	22	75.00	22	75.00	29	100.00
3203	0	0.00	0	0.00	42	100.00	42	100.00	42	100.00
3305	27	100.00	27	100.00	27	100.00	27	100.00	27	100.00
4102	16	80.00	16	80.00	16	80.00	16	80.00	21	100.00
4203	32	31.91	43	42.55	74	73.40	93	92.55	101	100.00
4205	7	40.00	7	40.00	7	40.00	10	60.00	17	100.00
4208	5	25.00	5	25.00	13	68.75	17	93.75	18	100.00
4212	10	13.33	18	24.76	44	59.05	63	85.71	74	100.00
4215	9	66.67	9	66.67	9	66.67	13	100.00	13	100.00
4219	15	50.00	15	50.00	15	50.00	31	100.00	31	100.00
4220	8	10.00	8	10.00	50	60.00	67	80.00	83	100.00
4221	8	23.94	8	23.94	19	54.93	30	87.32	35	100.00
4222	5	10.00	5	10.00	15	30.00	39	80.00	49	100.00
4223	9	16.67	9	16.67	47	83.33	57	100.00	57	100.00
4228	0	16.67	1	33.33	1	50.00	2	83.33	2	100.00
4229	0	0.00	2	46.15	3	69.23	4	100.00	4	100.00
4301	0	0.00	0	0.00	12	100.00	12	100.00	12	100.00
7301	7	31.37	7	31.37	9	37.25	9	37.25	23	100.00
7800	1	4.17	1	4.17	2	16.67	8	54.17	14	100.00
8101	4	50.00	4	50.00	4	50.00	4	50.00	7	100.00
SUM	336	33.57	358	35.76	589	58.84	724	72.33	1001	100.00

Accuracy Assessment Tables for P40/R27 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	4	SUM
1	8(5)	6(3)	1(1)	0(1)	15(0)
2	3(3)	15(5)	8(3)	0(1)	26(0)
3	2(1)	12(3)	3(5)	0(3)	17(0)
4	0(1)	0(1)	0(3)	2(5)	2(0)
SUM	13(0)	33(0)	12(0)	2(0)	60(0)

Diagonal Elements = 28; Total Test Points = 60
Percentage Agreement = 46.67; Kappa = 0.179; Tau w/equal Prob = 0.289

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	8	53.33	0	0.00	6	40.00	0	0.00	1	6.67
2	15	57.69	0	0.00	11	42.31	0	0.00	0	0.00
3	3	17.65	0	0.00	12	70.59	0	0.00	2	11.76
4	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	28	46.67	0	0.00	29	48.33	0	0.00	3	5.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	8	53.33	8	53.33	14	93.33	14	93.33	15	100.00
2	15	57.69	15	57.69	26	100.00	26	100.00	26	100.00
3	3	17.65	3	17.65	15	88.24	15	88.24	17	100.00
4	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
SUM	28	46.67	28	46.67	57	95.00	57	95.00	60	100.00\

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	8	61.54	0	0.00	3	23.08	0	0.00	2	15.38
2	15	45.45	0	0.00	18	54.55	0	0.00	0	0.00
3	3	25.00	0	0.00	8	66.67	0	0.00	1	8.33
4	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	28	46.67	0	0.00	29	48.33	0	0.00	3	5.00

Accuracy Assessment Tables for P40/R27 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	8	61.54	8	61.54	11	84.62	11	84.62	13	100.00
2	15	45.45	15	45.45	33	100.00	33	100.00	33	100.00
3	3	25.00	3	25.00	11	91.67	11	91.67	12	100.00
4	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
SUM	28	46.67	28	46.67	57	95.00	57	95.00	60	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	99	53.33	0	0.00	74	40.00	0	0.00	12	6.67
2	245	57.69	0	0.00	180	42.31	0	0.00	0	0.00
3	69	17.65	0	0.00	275	70.59	0	0.00	46	11.76
4	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	414	41.36	0	0.00	529	52.85	0	0.00	58	5.79

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	99	53.33	99	53.33	173	93.33	173	93.33	185	100.00
2	245	57.69	245	57.69	424	100.00	424	100.00	424	100.00
3	69	17.65	69	17.65	344	88.24	344	88.24	390	100.00
4	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	414	41.40	414	41.40	942	94.20	942	94.20	1000	100.00

Accuracy Assessment Tables for P40/R27 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	5(5)	4(3)	1(1)	10(0)
2	3(3)	2(5)	1(3)	6(0)
3	1(1)	1(3)	1(5)	3(0)
SUM	9(0)	7(0)	3(0)	19(0)

Diagonal Elements = 8; Total Test Points = 19
Percentage Agreement = 42.11; Kappa = 0.050; Tau w/equal Prob = 0.132

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	5	50.00	0	0.00	4	40.00	0	0.00	1	10.00
2	2	33.33	0	0.00	4	66.67	0	0.00	0	0.00
3	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
SUM	8	42.11	0	0.00	9	47.37	0	0.00	2	10.53

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	5	50.00	5	50.00	9	90.00	9	90.00	10	100.00
2	2	33.33	2	33.33	6	100.00	6	100.00	6	100.00
3	1	33.33	1	33.33	2	66.67	2	66.67	3	100.00
SUM	8	42.11	8	42.11	17	89.47	17	89.47	19	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	5	55.56	0	0.00	3	33.33	0	0.00	1	11.11
2	2	28.57	0	0.00	5	71.43	0	0.00	0	0.00
3	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
SUM	8	42.11	0	0.00	9	47.37	0	0.00	2	10.53

Accuracy Assessment Tables for P40/R27 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	5	55.56	5	55.56	8	88.89	8	88.89	9	100.00
2	2	28.57	2	28.57	7	100.00	7	100.00	7	100.00
3	1	33.33	1	33.33	2	66.67	2	66.67	3	100.00
SUM	8	42.11	8	42.11	17	89.47	17	89.47	19	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	211	50.00	0	0.00	169	40.00	0	0.00	42	10.00
2	188	33.33	0	0.00	376	66.67	0	0.00	0	0.00
3	4	33.33	0	0.00	4	33.33	0	0.00	4	33.33
SUM	403	40.38	0	0.00	549	55.01	0	0.00	46	4.61

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	211	50.00	211	50.00	381	90.00	381	90.00	423	100.00
2	188	33.33	188	33.33	565	100.00	565	100.00	565	100.00
3	4	33.33	4	33.33	8	66.67	8	66.67	13	100.00
SUM	403	40.26	403	40.26	954	95.30	954	95.30	1001	100.00

Accuracy Assessment Tables for P40/R27 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	18(5)	33(3)	6(1)	57(0)
2	9(3)	35(5)	7(3)	51(0)
3	0(1)	5(3)	6(5)	11(0)
SUM	27(0)	73(0)	19(0)	119(0)

Diagonal Elements = 59; Total Test Points = 119
Percentage Agreement = 49.58; Kappa = 0.178; Tau w/equal Prob = 0.244

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	18	31.58	0	0.00	33	57.89	0	0.00	6	10.53
2	35	68.63	0	0.00	16	31.37	0	0.00	0	0.00
3	6	54.55	0	0.00	5	45.45	0	0.00	0	0.00
SUM	59	49.58	0	0.00	54	45.38	0	0.00	6	5.04

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	18	31.58	18	31.58	51	89.47	51	89.47	57	100.00
2	35	68.63	35	68.63	51	100.00	51	100.00	51	100.00
3	6	54.55	6	54.55	11	100.00	11	100.00	11	100.00
SUM	59	49.58	59	49.58	113	94.96	113	94.96	119	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	18	66.67	0	0.00	9	33.33	0	0.00	0	0.00
2	35	47.95	0	0.00	38	52.05	0	0.00	0	0.00
3	6	31.58	0	0.00	7	36.84	0	0.00	6	31.58
SUM	59	49.58	0	0.00	54	45.38	0	0.00	6	5.04

Accuracy Assessment Tables for P40/R27 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	18	66.67	18	66.67	27	100.00	27	100.00	27	100.00
2	35	47.95	35	47.95	73	100.00	73	100.00	73	100.00
3	6	31.58	6	31.58	13	68.42	13	68.42	19	100.00
SUM	59	49.58	59	49.58	113	94.96	113	94.96	119	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	55	31.58	0	0.00	101	57.89	0	0.00	18	10.53
2	444	68.63	0	0.00	203	31.37	0	0.00	0	0.00
3	98	54.55	0	0.00	81	45.45	0	0.00	0	0.00
SUM	597	59.70	0	0.00	385	38.50	0	0.00	18	1.80

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	55	31.58	55	31.58	156	89.47	156	89.47	174	100.00
2	444	68.63	444	68.63	647	100.00	647	100.00	647	100.00
3	98	54.55	98	54.55	179	100.00	179	100.00	179	100.00
SUM	597	59.70	597	59.70	982	98.20	982	98.20	1000	100.00

Accuracy Assessment Tables for P40/R27 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	8(5)	3(3)	0(1)	11(0)
2	4(3)	6(5)	0(3)	10(0)
3	0(1)	4(3)	1(5)	5(0)
SUM	12(0)	13(0)	1(0)	26(0)

Diagonal Elements = 15; Total Test Points = 26
Percentage Agreement = 57.69; Kappa = 0.301; Tau w/equal Prob = 0.365

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	8	72.73	0	0.00	3	27.27	0	0.00	0	0.00
2	6	60.00	0	0.00	4	40.00	0	0.00	0	0.00
3	1	20.00	0	0.00	4	80.00	0	0.00	0	0.00
SUM	15	57.69	0	0.00	11	42.31	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	8	72.73	8	72.73	11	100.00	11	100.00	11	100.00
2	6	60.00	6	60.00	10	100.00	10	100.00	10	100.00
3	1	20.00	1	20.00	5	100.00	5	100.00	5	100.00
SUM	15	57.69	15	57.69	26	100.00	26	100.00	26	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	8	66.67	0	0.00	4	33.33	0	0.00	0	0.00
2	6	46.15	0	0.00	7	53.85	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	15	57.69	0	0.00	11	42.31	0	0.00	0	0.00

Accuracy Assessment Tables for P40/R27 -- Shrub Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	8	66.67	8	66.67	12	100.00	12	100.00	12	100.00
2	6	46.15	6	46.15	13	100.00	13	100.00	13	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	15	57.69	15	57.69	26	100.00	26	100.00	26	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	550	72.73	0	0.00	206	27.27	0	0.00	0	0.00
2	139	60.00	0	0.00	93	40.00	0	0.00	0	0.00
3	3	20.00	0	0.00	10	80.00	0	0.00	0	0.00
SUM	692	69.20	0	0.00	309	30.90	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	550	72.73	550	72.73	756	100.00	756	100.00	756	100.00
2	139	60.00	139	60.00	231	100.00	231	100.00	231	100.00
3	3	20.00	3	20.00	13	100.00	13	100.00	13	100.00
SUM	692	69.20	692	69.20	1000	100.00	1000	100.00	1000	100.00

Scene P40/R27 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
1000	1057.0	9018.8	0.3
2000	33357.0	453876.6	13.3
3101	58777.0	800916.5	23.5
3104	12858.0	91858.0	2.7
3201	16102.0	127521.9	3.7
3202	8773.0	79019.7	2.3
3203	13452.0	112762.4	3.3
3305	4316.0	74000.3	2.2
3313	1332.0	13068.4	0.4
4102	6882.0	55941.3	1.6
4201	2944.0	36167.0	1.1
4203	19919.0	273699.8	8.0
4205	4484.0	45607.8	1.3
4208	6038.0	49485.0	1.5
4212	25299.0	201016.4	5.9
4215	2597.0	34670.2	1.0
4219	9800.0	83356.1	2.4
4220	22875.0	226669.6	6.7
4221	8380.0	94263.9	2.8
4222	17482.0	133028.7	3.9
4223	11064.0	153810.8	4.5
4225	16.0	114.6	0.0
4228	519.0	6788.0	0.2
4229	844.0	10560.0	0.3
4301	2857.0	31496.8	0.9
5000	5672.0	20701.8	0.6
7300	9208.0	63780.7	1.9
7400	1395.0	8825.3	0.3
7800	5081.0	39009.4	1.1
8100	2151.0	19263.8	0.6
9800	1610.0	30567.4	0.9
9900	2494.0	23428.7	0.7

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not tree/shrub	133660.0	1561247.0	45.9
Shrub 1	32478.0	305656.0	9.0
Shrub 2	10528.0	93547.5	2.7
Shrub 3	969.0	7169.1	0.2
Tree 1	34303.0	250245.5	7.4
Tree 2	88401.0	929139.3	27.3
Tree 3	19296.0	257291.1	7.6

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not tree/shrub	133660.0	1561247.0	45.9
Tree 1	29124.0	266037.0	7.8
Tree 2	66561.0	609667.9	17.9
Tree 3	46070.0	559650.1	16.4
Tree 4	245.0	1320.8	0.0
Shrub 1	26472.0	257435.7	7.6
Shrub 2	14770.0	124628.8	3.7
Shrub 3	2733.0	24308.2	0.7

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
A	33357.0	453876.6	13.3
H	73786.0	912038.3	26.8
N	26517.0	195332.1	5.7
S	43975.0	406372.7	11.9
T	142000.0	1436675.9	42.2

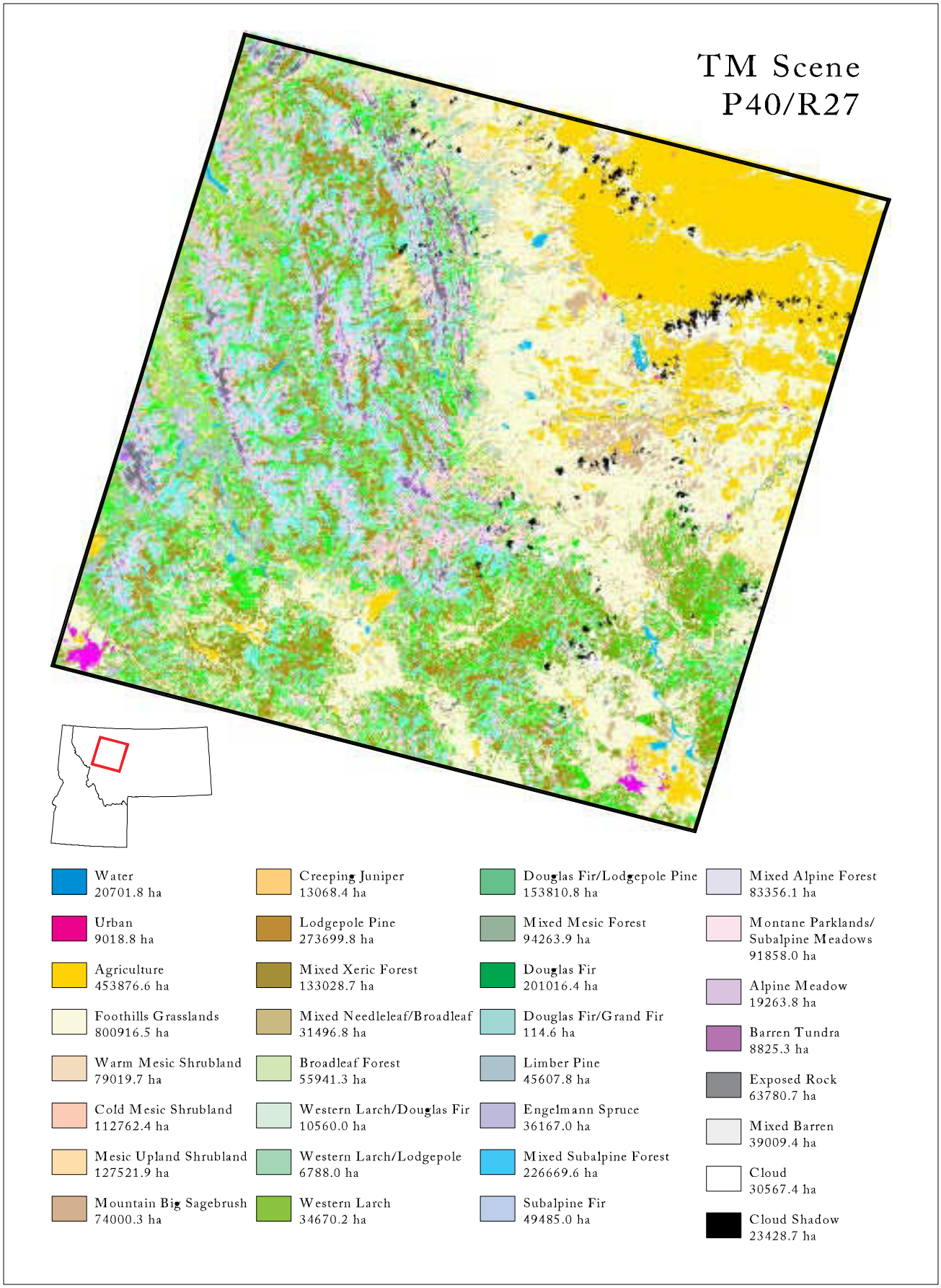


Figure F-10. Classification of land cover types for TM Scene P40/R27.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P40/R27

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4101: ASPEN FOREST

Aspen forest dominated by quaking aspen (Populus tremuloides) and ranging from 4720 to 6116 feet in elevation. The average canopy cover is 53% ranging from 20-80% total cover and frequency of occurrence equal to 96%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta), and with average percent cover ≥4% and ≤10% and frequency of occurrence ≥17% and ≤30%.

Primary associated shrub species with ≥4% and ≤65% frequency of occurrence in aspen stands: western serviceberry (Amelanchier alnifolia), water birch (Betula occidentalis), common chokecherry (Prunus virginiana), Wood's rose (Rosa woodsii), willow (Salix spp.), Canada buffaloberry (Shepherdia canadensis), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤17% frequency of occurrence in aspen stands: **graminoids**: bearded wheatgrass (Agropyron caninum), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), common timothy (Phleum pratense), and needlegrass (Stipa spp.); **forbs**: sharptooth angelica (Angelica arguta), showy aster (Aster conspicuus), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), white geranium (Geranium richardsonii), western meadowrue (Thalictrum occidentale), and violet (Viola spp.); **ferns**: none; **moss**: none.

2) 4201: ENGELMANN SPRUCE FOREST

Conifer forest dominated by Engelmann spruce (Picea engelmannii) ranging from 3400 to 7400 feet in elevation. The average canopy cover is 35%, ranging from 10-70% total cover and frequency of occurrence equal to 94%. Primary associated tree species include subalpine fir (Abies lasiocarpa), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥7% and ≤8% and frequency of occurrence ≥28% and ≤59%.

Primary associated shrub species with ≥19% and ≤41% frequency of occurrence in Engelmann spruce stands: common juniper (Juniperus communis), menziesia (Menziesia ferruginea), thimbleberry (Rubus parviflorum), Canada buffaloberry (Shepherdia canadensis), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤34% frequency of occurrence in Engelmann spruce stands: **graminoids**: pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Sartwell's sedge (Carex sartwellii), blue

wildrye (Elymus glaucus), smooth woodrush (Luzula hitchcockii.), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: heart-leaf arnica (Arnica cordifolia), arnica (Arnica spp.), broadleaf arnica (Arnica latifolia), fireweed (Epilobium angustifolium), sweetscented bedstraw (Galium triflorum), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), Virginia grape-fern (Botrychium virginianum), field horsetail (Equisetum arvense), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

3) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 3390 to 8100 feet in elevation. The average canopy cover is 39% ranging from 3-90% total cover and frequency of occurrence equal to 99%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤5% and frequency of occurrence ≥48% and ≤52%.

Primary associated shrub species with ≥28% and ≤55% frequency of occurrence in lodgepole pine stands: western serviceberry (Amelanchier alnifolia), creeping Oregon grape (Berberis repens), common prince's pine (Chimaphila umbellata), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤58% frequency of occurrence in lodgepole pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), and common timothy (Phleum pratense); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), showy aster (Aster conspicuus), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), white-flowered hawkweed (Hieracium albiflorum), and beargrass (Xerophyllum tenax); **ferns**: horsetail (Equisetum spp.), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: none.

4) 4205: LIMBER PINE FOREST

Conifer forest dominated by limber pine (Pinus flexilis) ranging from 4320 to 7560 feet in elevation. The average canopy cover is 30% ranging from 20-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥5% and ≤6% and frequency of occurrence ≥14% and ≤59%.

Primary associated shrub species with ≥5% and ≤46% frequency of occurrence in limber pine stands: kinnikinnick (Arctostaphylos uva-ursi), common juniper (Juniperus communis), creeping juniper (Juniperus horizontalis), shrubby cinquefoil (Potentilla fruticosa), Wood's rose (Rosa woodsii), Canada buffaloberry (Shepherdia canadensis), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤18% frequency of occurrence in limber pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), bluejoint reedgrass (Calamagrostis canadensis), purple reedgrass

(Calamagrostis purpurascens), rough fescue (Festuca scabrella), and common timothy (Phleum pratense); **forbs**: arrowleaf balsamroot (Balsamorhiza sagittata), woods strawberry (Fragaria vesca), sticky geranium (Geranium viscosissimum), western gromwell (Lithospermum ruderale), common dandelion (Taraxacom officinale), and round-leaved thermopsis (Thermopsis rhombifolia); **ferns**: none; **moss**: moss (moss spp.).

5) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 3073 to 5569 feet in elevation. The average canopy cover is 27% ranging from 10-70% total cover and frequency of occurrence equal to 100%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥5% and ≤10% and frequency of occurrence ≥13% and ≤72%.

Primary associated shrub species with ≥10% and ≤28% frequency of occurrence in ponderosa pine stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and dwarf huckleberry (Vaccinium cespitosum).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤43% frequency of occurrence in ponderosa pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), western fescue (Festuca occidentalis), rough fescue (Festuca scabrella), and Kentucky bluegrass (Poa pratensis); **forbs**: common yarrow (Achillea millefolium), arrowleaf balsamroot (Balsamorhiza sagittata), spotted knapweed (Centauria maculosa), Virginia strawberry (Fragaria virginiana), narrow-leaved cow-wheat (Melampyrum), yellow sweet-clover (Melilotus officinalis), and yellow clover (Trifolium agrarium); **ferns**: none; **moss**: moss (moss spp.).

6) 4208: SUBALPINE FIR FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 4280 to 7800 feet in elevation. The average canopy cover is 32% ranging from 10-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), and lodgepole pine (Pinus contorta) with average percent cover ≥3% and ≤4% and frequency of occurrence ≥10% and ≤63%.

Primary associated shrub species with ≥17% and ≤71% frequency of occurrence in subalpine fir stands: sitka alder (Alnus sinuata), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), Canada buffaloberry (Shepherdia canadensis), cascade mountain-ash (Sorbus scopulina), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤87% frequency of occurrence in subalpine fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), sedge (Carex spp.), elk sedge (Carex geyeri), mountain hairgrass

(Deschampsia atropurpurea), Canada wildrye (Elymus canadensis), rough fescue (Festuca campestris), and smooth woodrush (Luzula hitchcockii); **forbs**: broadleaf arnica (Arnica latifolia), fireweed (Epilobium angustifolium), Brewer's mitrewort (Mitella breweri), arrowleaf groundsel (Senecio triangularis), western meadowrue (Thalictrum occidentale), green false hellebore (Veratrum viride), and beargrass (Xerophyllum tenax); **ferns**: oak-fern (Gymnocarpium dryopteris); **moss**: none.

7) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 3460 to 7600 feet in elevation. The average canopy cover is 36% ranging from 1-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include western larch (Larix occidentalis), lodgepole pine (Pinus contorta), and ponderosa pine (Pinus ponderosa), with average percent cover ≥4% and ≤5% and frequency of occurrence ≥19% and ≤26%.

Primary associated shrub species with ≥21% and ≤35% frequency of occurrence in Douglas-fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), creeping Oregon grape (Berberis repens), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤48% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), brome (Bromus spp.), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), and rough fescue (Festuca scabrella); **forbs**: common yarrow (Achillea millefolium), raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), arrowleaf balsamroot (Balsamorhiza sagittata), Virginia strawberry (Fragaria virginiana), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: field horsetail (Equisetum arvense) and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

8) 4215: WESTERN LARCH FOREST

Conifer forest dominated by western larch (Larix occidentalis) ranging from 3860 to 5660 feet in elevation. The average canopy cover is 31% ranging from 10-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii), with average percent cover ≥3% and ≤7% and frequency of occurrence ≥54% and ≤68%.

Primary associated shrub species with ≥50% and ≤75% frequency of occurrence in western larch stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), Utah honeysuckle (Lonicera utahensis), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤79%

frequency of occurrence in western larch stands: **graminoids**: cheatgrass (Bromus tectorum), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), western fescue (Festuca occidentalis); **forbs**: queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), sweetscented bedstraw (Galium triflorum), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: oak-fern (Gymnocarpium dryopteris) and brackenfern (Pteridium aquilinum); **moss**: none.

9) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albicaulis) and ranging from 5999 to 7800 feet in elevation. The average canopy cover is 18% ranging from 3-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥7% and ≤17% and frequency of occurrence ≥23% and ≤100%.

Primary associated shrub species with ≥6% and ≤89% frequency of occurrence in mixed whitebark pine stands: common prince's pine (Chimaphila umbellata), menziesia (Menziesia ferruginea), Canada buffaloberry (Shepherdia canadensis), cascade mountain-ash (Sorbus scopulina), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤85% frequency of occurrence in mixed whitebark pine stands: **graminoids:** northwestern sedge (Carex concinnoides), sedge (Carex spp.), elk sedge (Carex geyeri), mountain hairgrass (Deschampsia atropurpurea), blue wildrye (Elymus glaucus), Idaho fescue (Festuca idahoensis), and smooth woodrush (Luzula hitchcockii); **forbs**: fireweed (Epilobium angustifolium), explorer's gentian (Gentiana calycosa), western hedysarum (Hedysarum occidentale), bracted lousewort (Pedicularis bracteosa), sickletop lousewort (Pedicularis racemosa), one-sided wintergreen (Pyrola secunda), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: none.

10) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa), codominant species is mountain hemlock (Tsuga mertensia), and ranging from 3920 to 7750 feet in elevation. The average canopy cover is 97% ranging from 1-70% total cover and frequency of occurrence equal to 97%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥13% and ≤16% and frequency of occurrence ≥49% and ≤84%.

Primary associated shrub species with ≥20% and ≤55% frequency of occurrence in mixed subalpine stands: sitka alder (Alnus sinuata), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), cascade mountain-ash (Sorbus scopulina), shiny-leaf spiraea (Spiraea betulifolia), thimbleberry (Rubus parviflorum), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤61% frequency of occurrence in mixed subalpine fir stands: **graminoids**: brome (Bromus spp.), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), and smooth woodrush (Luzula hitchcockii); **forb**: queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), western rattlesnake-plantain (Goodyera oblongofolia), one-sided wintergreen (Pyrola secunda), arrowleaf groundsel (Senecio triangularis), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), horsetail (Equisetum spp.), oak-fern (Gymnocarpium dryopteris), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: none.

11) 4221: MIXED MESIC FOREST

Conifer forest dominated by western larch (Larix occidentalis), codominant species are grand fir (Abies grandis), pacific yew (Taxus brevifolia), and western red cedar (Thuja plicata), ranging from 3300 to 6400 feet in elevation. The average canopy cover for LAROCC is 12% ranging from 1-40% total cover and frequency of occurrence equal to 93%. The average canopy cover for ABIGRA is 13% ranging from 1-50% total cover and frequency of occurrence equal to 21%. The average canopy cover for TAXBRE is 15% ranging from 1-90% total cover and frequency of occurrence equal to 19%. The average canopy cover for THUPLI is 27% ranging from 1-70% total cover and frequency of occurrence equal to 14%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥7% and ≤14% and frequency of occurrence ≥67% and ≤88%.

Primary associated shrub species with ≥26% and ≤51% frequency of occurrence in mixed mesic stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤58% frequency of occurrence in mixed mesic stands: **graminoids**: smooth brome (Bromus inermis), brome (Bromus spp.), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex spp.), and elk sedge (Carex geyeri); **forbs**: queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), western rattlesnake-plantain (Goodyera oblongofolia), one-sided wintergreen (Pyrola secunda), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), oak-fern (Gymnocarpium dryopteris), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

12) 4222: MIXED XERIC FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) and ranging from 3400 to 7326 feet in elevation. The average canopy cover is 16% ranging from 1-40% total cover and frequency of occurrence equal to 71%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), lodgepole pine (Pinus contorta), and Douglas-fir

(Pseudotsuga menziesii) with average percent cover ≥9% and ≤17% and frequency of occurrence ≥18% and ≤92%.

Primary associated shrub species with ≥16% and ≤28% frequency of occurrence in mixed xeric stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), Canada buffaloberry (Shepherdia canadensis), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤26% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), timber oat-grass (Danthonia intermedia), Idaho fescue (Festuca idahoensis), rough fescue (Festuca scabrella), and prairie junegrass (Koeleria cristata); **forbs**: showy aster (Aster conspicuus), balsamroot (Balsamorhiza sagittata), spotted knapweed (Centauria maculosa), Virginia strawberry (Fragaria virginiana), northern bedstraw (Galium boreale), sticky geranium (Geranium viscosissimum), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum) and compact selaginella (Selaginella densa); **moss**: moss (moss spp.).

13) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) and ranging from 3660 to 6720 feet in elevation. The average canopy cover for PINCON is 21% ranging from 10-80% total cover and frequency of occurrence equal to 98%. The average canopy cover for PSEMEN is 20% ranging from 3-50% total cover and frequency of occurrence equal to 98%. Primary associated tree species include subalpine fir (Abies lasiocarpa), western larch (Larix occidentalis), and Engelmann spruce (Picea engelmannii) with average percent cover ≥2% and ≤6% and frequency of occurrence ≥19% and ≤38%.

Primary associated shrub species with ≥22% and ≤46% frequency of occurrence in Douglas-fir-lodgepole pine stands: western serviceberry (Amelanchier alnifolia), creeping Oregon grape (Berberis repens), common prince's pine (Chimaphila umbellata), common juniper (Juniperus communis), mountain-lover (Pachistima myrsinites), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤52% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), Idaho fescue (Festuca idahoensis), and rough fescue (Festuca scabrella); **forbs**: harebell (Campanula rotundifolia), queen's cup beadlily (Clintonia uniflora), Virginia strawberry (Fragaria virginiana), white-flowered hawkweed (Hieracium albiflorum), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: horsetail (Equisetum spp.) and brackenfern (Pteridium aquilinum); **moss**: none.

14) 4228: WESTERN LARCH-LODGEPOLE FOREST

Conifer forest dominated by western larch (Larix occidentalis) and lodgepole pine (Pinus contorta) ranging from 3666 to 5300 feet in elevation. The average canopy cover for LAROCC is 14% ranging from 3-40% total cover and frequency of occurrence equal to 100%. The average canopy cover for PINCON is 26% ranging from 10-20% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii) and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤7% and frequency of occurrence ≥50% and ≤83%.

Primary associated shrub species with ≥42% and ≤67% frequency of occurrence in western larch-lodgepole pine stands: western serviceberry (Amelanchier alnifolia), creeping Oregon grape (Berberis repens), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤83% frequency of occurrence in western larch-lodgepole pine stands: **graminoids**: tall oatgrass (Arrhenatherum), fringed brome (Bromus ciliatus), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), and western fescue (Festuca occidentalis); **forbs**: queen's cup beadlily (Clintonia uniflora), western rattlesnake-plantain (Goodyera oblongofolia), mountain sweet-cicely (Osmorhiza chilensis), one-sided wintergreen (Pyrola secunda), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: field horsetail (Equisetum arvense), oak-fern (Gymnocarpium dryopteris), and brackenfern (Pteridium aquilinum); **moss**: none.

15) 4229: WESTERN LARCH-DOUGLAS FIR FOREST

Conifer forest dominated by western larch (Larix occidentalis) and Douglas-fir (Pseudotsuga menziesii) ranging from 3480 to 5800 feet in elevation. The average canopy cover for LAROCC is 18% ranging from 3-60% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 22% ranging from 10-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥3% and ≤7% and frequency of occurrence ≥36% and ≤42%.

Primary associated shrub species with ≥39% and ≤58% frequency of occurrence in western larch-Douglas-fir stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), creeping Oregon grape (Berberis repens), twin flower (Linnaea borealis), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤45% frequency of occurrence in western larch-Douglas-fir stands: **graminoids**: smooth brome (Bromus inermis), Columbia brome (Bromus vulgaris), pinegrass (Calamagrostis

rubescens), northwestern sedge (Carex concinnoides), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), Alaska oniongrass (Melica subulata); **forbs**: trail-plant (Adenocaulon bicolor), queen's cup beadlily (Clintonia uniflora), white-flowered hawkweed (Hieracium albiflorum), mountain sweet-cicely (Osmorhiza chilensis), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: brackenfern (Pteridium aquilinum); **moss**: none.

16) 4301: MIXED NEEDLELEAF/BROADLEAF FOREST

Mixed needleleaf and broadleaf forest dominated by Douglas-fir (Pseudotsuga menziesii) and ranging from 3590 to 5627 feet in elevation. The average canopy cover is 10% ranging from 1-30% total cover and frequency of occurrence equal to 81%. Primary associated tree species include western larch (Larix occidentalis), Engelmann spruce (Picea engelmannii), and black cottonwood (Populus trichocarpa) with average percent cover ≥9% and ≤11% and frequency of occurrence ≥38% and ≤71%.

Primary associated shrub species with ≥33% and ≤57% frequency of occurrence in mixed needleleaf and broadleaf stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), twin flower (Linnaea borealis), mountain-lover (Pachistima myrsinites), thimbleberry (Rubus parviflorum), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥10% and ≤29% frequency of occurrence in mixed needleleaf and broadleaf stands: **graminoids**: Columbia brome (Bromus vulgaris), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), blue wildrye (Elymus glaucus), western fescue (Festuca occidentalis), and common timothy (Phleum pratense); **forbs**: heart-leaf arnica (Arnica cordifolia), queen's cup beadlily (Clintonia uniflora), fireweed (Epilobium angustifolium), mountain sweet-cicely (Osmorhiza chilensis), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), Virginia grape-fern (Botrychium virginianum), brittle bladder-fern (Cystopteris fragilis), field horsetail (Equisetum arvense), common Christmas-fern (Polystichum munitum), and brackenfern (Pteridium aquilinum); **moss**: moss (moss spp.).

P40/R27 RIPARIAN CLASSIFICATION

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	7, 14, 19, 21
6102	Broadleaf Dominated Riparian	65
6103	Needleleaf-Broadleaf Riparian	64
6104	Mixed Riparian (trees + any other)	4
6201	Grass-Forb Riparian/Wetland	40
6202	Shrub Riparian/Wetland	67, 11, 12
6203	Mixed Grass-Forb-Shrub Riparian	8

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 1
Color: Olive green; RBG 143 172 138.
Distribution: Lower elevation slopes; some clearcuts; not linear in pattern.
Comment: The color and distribution suggests sage brush and dry grasses. Outside the riparian zone, Foothills Grassland and Subalpine Meadow are most frequently represented by training data. There are two Shrub Riparian, and one each of Broadleaf Dominated and Grass-Forb Riparian cover types, possibly near the zone.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
1	2	Foothills Grassland
2	1	Disturbed Grasslands
3	1	Grass-Forb Riparian/Wetland
4	1	Shrub Riparian/Wetland

Spectral Class 2
Color: Orange
Distribution: Isolated clusters in valleys and plains; also some higher slopes; not barren.
Comment: There are no field data points inside the calculated zone, and no riparian data points outside the zone, for this spectral class. The dominant cover type is Mesic Upland Shrub outside of the zone. A number of locations appear to be pivot irrigation agriculture.
Conclusion: Not riparian.

Spectral Class 3
Color: Jade green; RGB 84 154 138.
Distribution: Scattered spackle and sinuous patterns of clusters, primarily valleys and plains, some on lower slopes; not linear.
Comment: Color suggests drier vegetation, especially grass. Foothills Grassland, trailed by Disturbed Grasslands and Exposed Rock, dominate field data outside the zone. No riparian vegetation was recorded outside the zone.
Conclusion: Not riparian.

5	1	Subalpine Meadow
6	1	Broadleaf Dominated Riparian
7	1	Shrub Riparian/Wetland

Spectral Class 4
Color: Orange-red; RGB 187 81 71.
Distribution: Spackle or clusters in wetter areas in plains, valleys, and low to mid-elevation slopes; some in timber harvest sections.
Comment: Western Larch, Mixed Mesic Forest, and Aspen are nearly equally represented by training data outside the zone. Also present are other conifer and broadleaf cover types and riparian cover types (6102, 6202, 6101, 6103), in descending order of frequency values.
Conclusion: 6104.

8	1	Dry-land crop
9	1	Lodgepole Pine
10	1	Mixed Xeric Forest
11	2	Broadleaf Dominated Riparisn
12	1	Needleleaf-Broadleaf Riparian
13	4	Shrub Riparian/Wetland

Spectral Class 5
Color: Gray blue; RGB 96 130 146.
Distribution: Medium density spackle on some low elevation slopes; some clusters on the plain; some in burns.
Comment: The color is inappropriate for riparian vegetation. Visually, many locations appear to be rock and burns. Outside the riparian zone, Exposed Rock and Foothills Grassland dominate observations; there are also some other grasses and barren cover types as well as some conifer, but no riparian cover types.
Conclusion: Not riparian.

14	1	Foothills Grassland
15	1	Lakes
16	1	Broadleaf Dominated Riparisn
17	1	Grass-Forb Riparian/Wetland

18	1	Exposed Rock
19	1	Mines,Quarries,Gravel Pit
20	1	Shoreline & Gravel Bars

Spectral Class 6
Color: Gray green; RGB 143 183 159.
Distribution: Sinuous patterns of clusters on the plains; spackle on foothills and side slopes of valleys.
Comment: Color and distribution suggest grass and nonriparian shrub vegetation for this spectral class. Foothills Grassland and Subalpine Meadow are most prevalent in field data outside the zone, along with agriculture, barren cover types, shrubs, conifer and riparian (6102, 6202) vegetation, listed in descending order.
Conclusion: Not riparian.

21	2	Urban & Developed Land
22	1	Foothills Grassland
23	1	Subalpine Meadow
24	1	Greasewood
25	1	Needleleaf Dominated Riparian
26	1	Broadleaf Dominated Riparian
27	1	Mixed Barren Land
28	1	Shoreline & Gravel Bars

Spectral Class 7
Color: Very dark red; RGB 96 38 63.
Distribution: Along bases of southeast facing slopes; some gully pattern.
Comment: Color and locations indicate fairly dense conifer stands, probably mixed Mesic and mixed Xeric forests. The distribution implies a good probability of riparian vegetation within the calculated riparian zone. Outside the zone, Mixed Mesic Forest and Douglas-fir have highest training data point frequencies. There were also other conifer, shrub, and riparian (6101) cover types recorded.
Conclusion: 6101.

29	1	Needleleaf Dominated Riparian

Spectral Class 8
Color: Light orange-brown; RGB 207 146 109.
Distribution: Mid to low elevations in mountains and on the plains; along gulleys and wetter areas; some in clearcuts.
Comment: The distribution definitely includes some riparian vegetation, probably mostly grass, as well as some agriculture. Mesic Upland Shrubland dominates training data outside the zone, with Subalpine Meadow and Foothills Grassland next in frequency. Also

represented are conifer, Shrub Riparian/Wetland, barren, broadleaf, agriculture, other riparian (6101, 6102, 6103), tundra, exposed rock, and urban cover types.
Conclusion: 6203.

30	2	Foothills Grassland
31	1	Subalpine Meadow
32	1	Mesic Upland Shrubland
33	1	Lodgepole Pine
34	1	Limber Pine
35	1	Needleleaf-Broadleaf Riparian
36	1	Grass-Forb Riparian/Wetland

Spectral Class 9
Color: Gray olive green; RGB 139 154 138.
Distribution: Denser spackle along transition from the front range to the plains; lighter density on lower side slopes of valleys; some sinuous spackle-cluster pattern on the plains; very light spackle at higher elevations; some in clearcuts.
Comment: Color suggests drier vegetation, especially grass and some sage brush. Foothills Grassland was most observed in the field. Also recorded were Exposed Rock, Mesic Upland Shrub, conifer, barren, other shrub, mines, tundra, and riparian (6101, 6103, 6201) cover types.
Conclusion: Not riparian.

38	1	Irrigated Crop
39	1	Foothills Grassland
40	1	Mesic Upland Shrubland
41	1	Silver Sage
42	1	Ponderosa Pine & Savannah
43	1	Broadleaf Dominated Riparian
44	1	Grass-Forb Riparian/Wetland
45	2	Shoreline & Gravel Bars

Spectral Class 10
Color: Black; RGB 68 36 63.
Distribution: Dense spackle in shadows.
Comment: Shadow may include various cover types. Outside the zone, conifers were most recorded, with shrubs, meadow, a burn, and riparian (6101, 6102, 6201) vegetation also present.
Conclusion: Not riparian.

46	1	Western Larch
47	1	Mixed Subalpine Forest
48	2	Mixed Mesic Forest

49	2	Needleleaf Dominated Riparian
50	1	Grass-Forb Riparian/Wetland
51	1	Shrub Riparian/Wetland
52	1	Mixed Barren Land

Spectral Class 11
Color: Light brown; RGB 163 103 75.
Distribution: Medium density spackle along side slopes of valleys, along transition slopes from the front range to the plains, and within the Seeley-Swan Valley; lighter density in the mountains, on side slopes with some gully pattern.
Comment: Relatively high red component. Locations indicate mostly shrub and possibly some needleleaf vegetation. Outside the zone, Mesic Upland Shrubland has the highest frequency, with Douglas-fir, Mixed Mesic Forest, Mixed Alpine Forest, and riparian (6202) well represented.
Conclusion: 6202.

53	1	Foothills Grassland
54	1	Aspen
55	1	Lodgepole Pine
56	1	Ponderosa Pine & Savannah
57	1	Mixed Subalpine Forest
58	2	Mixed Mesic Forest
59	2	Rivers & Streams
60	3	Needleleaf Dominated Riparian
61	1	Needleleaf-Broadleaf Riparian
62	3	Grass-Forb Riparian/Wetland
63	8	Shrub Riparian/Wetland
64	1	Shoreline & Gravel Bars

Spectral Class 12
Color: Beige-tan; RGB 207 186 138.
Distribution: Scattered clusters in valleys and on the plain, mostly near wetter areas; linear pattern along ridges; some fields and clearcuts.
Comment: Color and distribution suggest primarily shrub cover types. Outside the zone, Mesic Upland Shrubland, Subalpine Meadow, and Exposed Rock have the highest frequencies, along with some agriculture, Foothills Grassland and Herbaceous Clearcut. Note that the term herbaceous in reference to clearcuts can include some types of shrubs.
Conclusion: 6202.

65	1	Urban & Developed Land
66	1	Irrigated Crop
67	1	Foothills Grassland
68	1	Rivers & Streams
69	1	Reservoirs

70	1	Shrub Riparian/Wetland

Spectral Class 13
Color: Dark brown; RGB 96 51 67.
Distribution: Mid to high elevation slopes; some in the Seeley-Swan Valley; not barren areas.
Comment: Appears to be conifer, as well as some shadows. Lodgepole Pine and Mixed Mesic Forest dominate training data outside the zone, with Douglas-fir and Mixed Subalpine Forest next in frequency. Riparian vegetation classes 6101, 6102, 6201, and 6202 are minimally represented outside the zone.
Conclusion: Not riparian.

71	1	Mixed Subalpine Forest
72	3	Mixed Mesic Forest
73	1	Mix Needleleaf-Broadleaf
74	3	Needleleaf Dominated Riparian
75	2	Broadleaf Dominated Riparian

Spectral Class 14
Color: Brown; RGB 112 58 63.
Distribution: Mid to high level elevation spackle; some in Seeley-Swan Valley; minimal gully pattern.
Comment: Color and distribution indicates conifer cover types, some around lakes and in gullys, where they are probably riparian. Conifers such as Mixed Mesic Forest, Douglas-fir, Lodgepole Pine dominate training data outside the zone. Also recorded were Mixed Needleleaf-Broadleaf, Needleleaf-Dominated Riparian, other riparian (6103, 6201, 6202), Subalpine Meadow, Foothills Grassland, and Exposed Rock.
Conclusion: 6101.

76	1	Herbaceous Clearcut
77	2	Lodgepole Pine
78	1	Mixed Subalpine Forest
79	1	Mixed Mesic Forest
80	2	Douglas-fir-Lodgepole
81	1	Grass-Forb Riparian/Wetland
82	1	Shrub Riparian/Wetland

Spectral Class 15
Color: Teal blue; RGB 68 107 138.
Distribution: Mostly in burned areas; some light density spackle on lower slopes; some near river.
Comment: The color and locations suggest rock, sage brush, and dry grass. Outside the zone Exposed Rock, Foothills Grassland, and conifer cover types have the highest training data frequencies. Also recorded were Shrub Riparian/Wetland, clearcut, and barren cover types and burns.
Conclusion: Not riparian.

83	1	Broadleaf Dominated Riparian
84	1	Needleleaf-Broadleaf Riparian
85	1	Exposed Rock
86	1	Shoreline & Gravel Bars

Spectral Class 16
Color: Orange; RGB 255 125 79.
Distribution: Spaced clusters in wetter areas on the plain.
Comment: Outside the zone, Mesic Upland Shrubland was most recorded. Irrigated Crop, Subalpine Meadow, and Urban & Developed land were also present. There are no riparian training data points either outside or inside the calculated riparian zone; the only point inside the zone indicates Dry-land Pasture.
Conclusion: Not riparian.

Spectral Class 19
Color: Dark red; RGB 155 67 67.
Distribution: Some gully pattern in the mountains, some along streams on the plain; otherwise at all elevations in the mountains and the Seeley-Swan Valley.
Comment: Color suggests needleleaf cover types. Training data outside the zone indicate that a majority of the spectral class regions represent conifer cover types, with some shrubs. Needleleaf Dominated Riparian and minimal frequencies of grass, other riparian cover types (6102, 6103, 6102), and Aspen.
Conclusion: 6101.

92	2	Lodgepole Pine
93	1	Lakes
94	1	Broadleaf Dominated Riparian
95	4	Needleleaf-Broadleaf Riparian

Spectral Class 20
Color: Blue-black; RGB 40 38 63.
Distribution: Occurs at mid- to high elevations, mostly in shadows.
Comment: The color is not associated with riparian vegetation. Outside the zone, Lodgepole Pine and other conifers are most represented by the training data, with Exposed Rock and riparian vegetation (6202, 6101, 6201) also present.
Conclusion: Not riparian.

97	1	Engelmann Spruce
98	1	Douglas-fir
99	2	Mixed Mesic Forest

Spectral Class 21
Color: Brown; RGB 112 74 71.
Distribution: Mostly found on slopes at all elevations; some along streams on the plains; some throughout the Seeley-Swan Valley; some near the Blackfoot River.
Comment: The color has a significant red component; with brown indicating needeleaf vegetation. The distribution, mostly on southeast slopes, also indicates conifers, some of with is potentially riparian. Conifers, especially Lodgepole Pine and Douglas-fir dominate training data outside the zone, with some Needleleaf Dominated Riparian, and minimal frequencies of other riparian (6102, 6201, 6202) vegetation, a burn, barren areas, and gravel bars.
Conclusion: 6101.

100	1	Foothills Grassland
101	1	Rivers & Streams
102	2	Needleleaf Dominated Riparian
103	1	Broadleaf Dominated Riparian
104	1	Needleleaf-Broadleaf Riparian
105	2	Shrub Riparian/Wetland

Spectral Class 24
Color: Black; RGB 12 20 50.
Distribution: In some mountain shadows and some cloud shadows.
Comment: The color, and the association with shadows, prohibits any valid cover type assignment to this class. Outside the zone, conifers have relatively high training data frequencies, with some Mesic Upland Shrub and Subalpine Meadow also recorded.
Conclusion: Not riparian.

108	1	Foothills Grassland
109	1	Needleleaf Dominated Riparian

Spectral Class 31
Color: Tan-brown; RGB 147 130 100.
Distribution: Mostly lower slopes; some in clearcuts; some on the plains in wetter areas; some in burns; some at mid to higher elevations; not linear.
Comment: Color and distribution are not quite sufficient to indicate the moisture required for riparian vegetation. This spectral class represents a variety of cover types, according to field data. Mesic Upland Shrubland has the highest frequency, with several conifers next in dominance. There are also Herbaceous Clearcuts, Exposed Rock, Subalpine Meadow, Mixed Barren Land, riparian (6102, 6201, 6202, 6101), and other shrub cover types.
Conclusion: Not riparian.

111	1	Urban & Developed Land
112	2	Foothills Grassland

113	1	Needleleaf Dominated Riparian
114	1	Grass-Forb Riparian/Wetland
115	6	Shrub Riparian/Wetland
116	1	Exposed Rock

Spectral Class 33
Color: Black; RGB 24 27 50.
Distribution: In mountain shadows.
Comment: Being in shadow, the cover types cannot be determined. Training data includes conifers, rock, Subalpine Meadow, and riparian vegetation (6201).
Conclusion: Not riparian.

160	1	Needleleaf Dominated Riparian

Spectral Class 35
Color: Tan-brown; RGB 155 145 113.
Distribution: Mostly low slopes; some agriculture and clearcuts; some in wetter areas on the plain; some at higher elevations; not linear in pattern; under-represented near streams.
Comment: There may possibly be some riparian shrub vegetation within the zone, but the color and distribution are not adequate to draw that conclusion. Lodgepole Pine, Douglas-fir, and other conifers dominate training data outside the zone. Grass, riparian (6101, 6102, 6201, 6202), rock, Aspen, agriculture, and urban cover types were also recorded.
Conclusion: Not riparian.

119	1	Urban & Developed Land
120	1	Disturbed Grasslands
121	1	Mesic Upland Shrubland
122	1	Rivers & Streams
123	1	Needleleaf Dominated Riparian
124	1	Broadleaf Dominated Riparian

Spectral Class 39
Color: Light lilac; RGB 203 212 255.
Distribution: Found at highest elevations in the mountains, and in some clusters in the plains and valleys close to wet areas in some cases but not near streams.
Comment: Relatively low red component; appears to be rock and barren cover types, or plowed fields. Outside the zone, Exposed Rock and Foothills Grassland were recorded most frequently. Exposed Rock was the most often observed cover types outside the calculated zone. Also observed were grass, meadow, agriculture, shrub, conifer, and Burnt Timber cover types.
Conclusion: Not riparian.

125	1	Shrub Riparian/Wetland

Spectral Class 40
Color: Pink; RGB 255 188 255.
Distribution: This is a rare class, found mostly near wet areas on the plains; some isolated high elevation and Potomac Valley locations.
Comment: The color and distribution suggest graminoid riparian vegetation. There are no training data points for this spectral class within the zone. Outside the zone there is just one Exposed Rock and one Mixed Subalpine Forest training data site.
Conclusion: Not riparian.

Spectral Class 44
Color: Black; RGB 52 54 67.
Distribution: Middle to higher elevations, some above timberline; some within proximity to the Clearwater and Blackfoot Rivers.
Comment: Relatively low red component. Conifers are most prevalent in training data outside the zone, with Exposed Rock next in occurrence. There are also some shrub, grass, meadow, riparian (6101), and Mixed Barren Land cover types.
Conclusion: Not riparian.

126	1	Lodgepole Pine
127	1	Douglas-fir
128	1	Grass-Forb Riparian/Wetland

Spectral Class 52
Color: White; RGB 255 255 255.
Distribution: Clouds.
Comment: When cloud cover obscures the vegetation, any cover type assignment would be biased. There were no cover types recorded outside the zone.
Conclusion: Not riparian.

131	1	Grass-Forb Riparian/Wetland

Spectral Class 60
Color: Black; RGB 0 0 38.
Distribution: Lakes.
Conclusion: Not riparian.

135	7	Lakes
136	1	Needleleaf Dominated Riparian

Spectral Class 64
Color: Dark red; RGB 159 47 67.
Distribution: Very light density, mostly in the mountains; some on side slopes of the Seeley-Swan Valley not linear; under-represented near streams.
Comment: Appears to be mixed Needleleaf-Broadleaf Riparian within the riparian zone. Conifers are most in evidence from field data outside the zone. Other cover types include riparian (6101, 6103), Mesic Upland Shrub, and Mixed Barren Land.
Conclusion: 6103.

137	1	Mix Needleleaf-Broadleaf
138	1	Reservoirs
139	1	Needleleaf Dominated Riparian
140	1	Grass-Forb Riparian/Wetland

Spectral Class 65
Color: Red; RGB 255 85 84.
Distribution: Relatively dense clusters in wetter areas on the plains and northeast foothills; some in the valleys; some at mid elevations.
Comment: This appears to be broadleaf and agriculture. Mesic Upland Shrubland dominates outside the zone, with some agriculture, Subalpine Meadow, and riparian (6202, 6101, 6102, 6103, 6201) cover types also reported.
Conclusion: 6102.

141	2	Mesic Upland Shrubland
142	1	Aspen

143	1	Broadleaf Forest
144	1	Needleleaf Dominated Riparian
145	1	Broadleaf Dominated Riparian

Spectral Class 66
Color: Dark green; RGB 52 85 84.
Distribution: Mostly found in burned areas; light density across the scene otherwise, some of which is in cloud shadows.
Comment: Most of the locations appear to be lodgepole pine or burns. Some sites streams are in a burned area. Conifers and Exposed Rock dominate training data outside the zone, with some grass, shrubs and riparian (6102, 6201) observed.
Conclusion: Not riparian.

146	1	Douglas-fir
147	2	Mixed Mesic Forest
148	1	Grass-Forb Riparian/Wetland

Spectral Class 67
Color: Orange; RGB 255 130 96.
Distribution: Just below timberline on higher slopes; in wetter areas on the plains and in valleys; northeast foothills of the front range.
Comment: The color and locations of this spectral class indicate riparian vegetation, probably shrub, as well as some agriculture. Mesic Upland Shrubland dominates field data outside the zone, with conifers, agriculture, grasses, Aspen, riparian (6202, 6201, 6102, 6101, 6103) vegetation, rock, and mines trailing in frequency values. The distribution pattern suggests shrubs.
Conclusion: 6202.

149	3	Mesic Upland Shrubland
150	1	Lodgepole Pine

Spectral Class 68
Color: Orange; RGB 255 130 96.
Distribution: Rare class. Found primarily in wetter areas on the plains and in valleys; some near timberline in the mountains; not linear in pattern.
Comment: There are no training data points within the zone. Outside the zone, Mesic Upland Shrub has the highest frequency of field data points, with alpine and subalpine conifers next in importance; agriculture and Subalpine Meadow were also recorded.
Conclusion: Not riparian.

Spectral Class 72
Color: Light purple; RGB 175 123 213.
Distribution: Isolated spots and within wet areas on the plains; some at highest elevations; some in Potomac Valley; under-represented along streams.

Comment: Appears to be agriculture within the zone. Outside the zone, Exposed Rock dominates the training data; there are also minimal representation of Mixed Barren Land, mines, Permanent
Snow, conifers, agriculture and urban cover types in the data.
Conclusion: Not riparian.

156	2	Urban & Developed Land
157	1	Grass-Forb Riparian/Wetland

Spectral Class 73
Color: Orange; RGB 255 110 84.
Distribution: Relatively rare class. Some at middle elevations; some in moister areas in valleys (looks like agriculture); under-represented along streams.
Comment: Appears to be agriculture within the zone. Outside of the zone, Mesic Upland Shrubland is the single most recorded cover type; several needleleaf cover types, as well as Aspen, Mixed Needleleaf-Broadleaf, agriculture, Disturbed Grasslands, and Subalpine Meadow were included in observations.
Conclusion: Not riparian.

158	1	Mesic Upland Shrubland
159	1	Mixed Subalpine Forest
160	1	Grass-Forb Riparian/Wetland

Spectral Class 75
Color: Dark teal blue; RGB 0 47 84.
Distribution: Mostly cloud shadow; some mountain shadow; some high elevation; some along the Blackfoot River.
Comment: No red component. Training data outside the zone is dominated by Exposed Rock; conifers, shrub and grass were noted.
Conclusion: Not riparian.

162	1	Rivers & Streams
163	1	Shrub Riparian/Wetland

TM SCENE P40/R28

Image Analyst: J. Chris Winne

Training Data Analysis

In all, 2026 ground-truth plots were available for labeling P40/R28 (see table below); 1393 were collected by Forest Service field crews during the 1994-95 field seasons, and 505 of these were collected specifically for this TM scene. The remaining 888 plots came from pre-existing data sources such as ECODATA and TSMRS.

All ground-truth data were converted to a point file and superimposed on the unsupervised classification to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 369) were removed from further analysis; (these plots can be identified using the following query: DUP_TYPE ne 'B', USE eq 'Y'). The data then were examined by cover type and by data source (whether or not plots were collected for this project or for other purposes, like pre-existing ECODATA or TSMRS). The latter "existing data" were only used in the training data set to supplement cover types that had insufficient plots collected during the 1994 or 1995 field seasons. Eight general classes were excluded from the digital classification process: urban, agriculture, riparian, water, snow, melted snow, cloud, and cloud shadow. All ground truth data with VEG_CLASS_CODE's for urban, agriculture, riparian or water cover types were excluded. Next, 20% of the remaining plots were randomly selected from each cover type; these plots (n = 154) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

The remaining 80% of the data (n = 623 plots) were subjected to further spectral examination. Outliers were identified for each cover type by examining plots in relation to TM and ancillary data for their respective regions (both visually and in relation to calculated standard deviations) and then eliminated.

A total of 456 points were used in the final training set, which included 46 points added from existing data and 15 from Forest Service review. Training data analysis was aided by discussions with Dan Svoboda (Beaverhead NF) and Chip Fisher.

Total plots in ground-truth file	2026	
Total 1994-95 field plots	1393	
Plots sampled for P41/R26		505
Plots sampled for other scenes		888
Pre-existing plots (ECODATA, TSMRS, etc.)	633	
Plots held aside or eliminated	1249	
Duplicates		369
Pre-existing plots		279
Manually labeled cover types		601
Potential training plots	777	
20% test		154
80% training		623
Supplemental plots (from pre-existing data set)	46	
Total plots available for training	669	
Total plots used for training -- cover type	456	
size class	92	
canopy	124	

Land Cover Types

Land cover types were labeled through a digital classification of the 7 TM channels plus rescaled elevation (elevation in meters divided by 25), using the Nearest Member of Group classifier. This classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were used and assigned directly to the COVERTYPE field in the attribute table. Modifications were carried out using spectral class values (SPECTRAL_CLASS or LINK), and/or intermediate cover code labels in conjunction with other attributes including the TM values, modified NDVI, elevation and/or slope as follows:

1000. Urban.	Manually identified and recoded by Will Gustafson.
2000. Agriculture.	Manually identified and recoded by Kristen Loken and Chris Winne.
3101. Foothills Grasslands.	All grass types (COV_CODE_1 = 3100) with a mean elevation less than or equal to 1829 m (6000 ft) were labeled as Foothills Grassland (3101).
3104. Montane Parklands & Subalpine Meadows.	All grass types occurring above 1829 m (6000 ft) and less than 2734 m (9000 ft) were reassigned this label.
3201. Mesic Upland Shrub.	This type could only occur east of the Continental Divide. All regions east of the Continental Divide that were classified as being either Warm or Cold Mesic Shrubland (3202 or 3203) were reassigned to this cover type.

3202.	Warm Mesic Shrubland.	This type could only occur west of the Continental Divide and at or below 1767 m (5800 ft). All regions west of the divide that were assigned a 3200 level code were labeled Warm Mesic Shrubland if their elevation was ≤1767 m (5800 ft).
3203.	Cold Mesic Shrubland.	This type could only occur west of the Continental Divide and above 1767 m (5800 ft). All regions west of the divide that were assigned a 3200 level code were labeled Cold Mesic Shrubland if their elevation was >1767 m (5800 ft).
3301.	Mountain Mahogany.	Based on Forest Service review, this cover type was assumed to occur primarily on south and southwest slopes. Consequently, its occurrence was eliminated from all north aspects (1, 2, 7, and 8) by reassigning COVERTYPE = COV_CODE_2.
3304.	Bitterbrush.	The geographic distribution of this cover type was limited to a specific portion of the scene by Forest Service ecologists.
3305.	Mountain Big Sage.	The geographic distribution of this cover type was limited to elevations below 2439 m (8000 ft). Six training plots for this cover type, however, were found with elevations greater than the elevational limit, suggesting that some errors could be eliminated by revising this elevational limit. Also, regions classified as Mountain Big Sage, but with MNDVI values < -10 were recoded to Exposed Rock (7301).
4000.	All Forest Types.	All forest cover types (COV_CODE_1 = 4000) were given a COVERTYPE code of Exposed Rock (7301) if the MNDVI was <0.
4206.	Ponderosa Pine.	The geographic distribution of this cover type was limited to a specific portion of the scene by Forest Service ecologists.
4221.	Mixed Mesic Forest.	The geographic distribution of this cover type was limited to a specific portion of the scene by Forest Service ecologists.
5000.	Water.	All regions with spectral class (LINK = 1) and slope ≤5˚ were labeled as water; in addition all regions with TM4 ≤40, TM5 ≤65, MNDVI ≤40, TM5 < TM4 * 1.5, and either TM7 <25 or MNDVI <10. Cloud shadows (see

		9900 below) were recoded manually. Generally, water was more spectrally distinct than most other cover types, but in mountainous terrain, it was sometimes confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate slope and aspect values such that their slope may be >5˚. This would result in the misclassification of some small ponds or lakes.
7400.	Barren Tundra.	The geographic distribution of this cover type was limited to a specific portion of the scene by Forest Service ecologists and to a minimum elevation of 2743 m (9000 ft). Regions classified as Barren Tundra but falling below this elevational limit were relabeled as Mixed Barren Land (7800). Regions recoded to this type from the Mixed Barren type (see below) were not subjected to the geographic limit.
7800.	Mixed Barren Land.	Regions classified as this type and occurring at or above 2743 m (9000 m) were relabeled as Barren Tundra (7400).
8101.	Alpine Meadow.	All grass types occurring above 2743 m (9000 ft) were labeled Alpine Meadow.
9100.	Snow.	All regions with mean ELEV >2500 m were labeled as Snow if TM3 was ≥100, TM5 ≤130, and TM6 ≤141.
(n/a)	Melted Snow.	All regions originally classified as Melted Snow were recoded either to Exposed Rock (7301), if their slope was >5˚, or to Snow (9000), if their slope was ≤5˚.
9800.	Cloud.	Manually identified and recoded by Will Gustafson.
9900.	Cloud Shadow.	Manually identified and recoded by Will Gustafson.

A total of 30 classes were labeled in the full TM scene. These included three grass types, six shrub types, ten forest types, four barren types, one alpine type, plus six manually labeled classes. Cover types are mapped in Figure F-11.

Canopy Cover Classes

Canopy cover labels (CANOPY_CODE = low(1), medium(2), or high(3)) were assigned to tree and shrub classes based on the MNDVI values. These values were plotted as frequency histograms for all forest types (Figure F-11a), as well as for two shrub types (Figures F-11b+c). The histograms were examined to determine break points based upon the distribution modes. Regions with MNDVI values falling below the lower break point were

assigned to a low canopy cover class; those greater than or equal to the lower breakpoint, but below the higher break point were assigned to the medium class; and those falling above the higher breakpoint were assigned to the high canopy cover class (see below).

Cover Type Classes	BREAKPOINTS	
	Lower	Upper
3200 shrubs	111.5	159
3300 shrubs	61.5	116.5
4000 trees	113	330

Size Classes

Seven size classes were classified -- four for forest cover types (seedling/sapling, pole, mature, and mature/overmature), and three for shrub types (low, medium, and tall). The seven TM spectral bands were used for the size classification (elevation was not included). The Nearest Member of Group (NMG) classifier was used for both tree and shrub size classes. Tree size classes were stratified based upon the three canopy cover classes described above.

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications.

Classifications for P40/R28	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	20	70%	45%
Tree Size Class	4	94%	56%
Tree Canopy Class	3	100%	78%
Shrub Size Class	3	100%	56%
Shrub Canopy Class	3	88%	42%

Comments

Considerable effort was spent trying to differentiate among forest cover types using the TM data. Nonetheless, some confusion still remains. In some cases, large regions spanned a variety of aspects, and a wide elevational range; no doubt these contained a variety of cover types and thereby contributed to the confusion. Unfortunately, these could not broken up into smaller units that better represented features on the ground. Confusion was also evident between seedling/sapling forest stands and the subalpine meadow (3104) and aspen (4101) cover types. The co-occurring species in these types made the confusion understandable. Because the subalpine meadow class was more heterogeneous than either the aspen or seedling/sapling types, it was probably over-estimated by the resulting classification.

Additional effort was made to discriminate between forest and nonforest classes. Many plots coded as being rock appeared on the basis of MNDVI values to be located in regions containing some vegetation. Similarly, many plots coded as grass or sagebrush were located in regions with MNDVI values that suggested forest cover. In the final classification, rock (7300) was weighted toward those regions with the least vegetation, and grass and sage were weighted toward those polygons with few trees.

Mountain mahogany (3301) was another problematic cover type. Although the classification tended to identify the areas where it was present, its distribution was certainly overestimated. Further complicating the classification of this cover type were clouds and haze over portions of the scene where much of the mountain mahogany was expected to occur. Overestimation was minimized by applying aspect and elevation rules; nonetheless, large regions labeled as mountain mahogany are more likely to be sagebrush or grassland types.

Error Matrix For Cover Type Training Plots
Scene P40/R28

CLASSIFIED COVER TYPES

PLOT COVER TYPES	3101	3102	3104	3202	3203	3301	3304	3305	4101	4203	4206	4208	4212	4219	4220	4221	4222	4223	7301	7400	7800	8101	SUM
3101	27	0	2	0	2	3	4	11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	50
3102	3	3	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	11
3104	5	0	3	4	0	0	1	4	0	0	1	1	0	0	0	1	0	0	0	0	0	1	21
3202	0	0	5	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	8
3203	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
3301	5	0	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	10
3304	5	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
3305	7	0	3	1	0	0	0	32	0	1	0	0	3	0	0	0	1	0	0	0	0	0	48
4101	0	0	0	2	0	0	0	0	8	0	0	0	0	0	0	0	1	0	0	0	0	0	11
4203	0	0	0	0	0	0	0	3	1	21	1	0	8	1	6	0	0	3	0	0	0	0	44
4206	0	0	1	1	0	0	0	0	0	0	12	0	2	0	2	1	2	0	0	0	0	0	21
4208	0	0	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0	2	0	0	0	0	6
4212	0	0	0	0	0	0	0	2	3	6	0	0	44	0	7	2	2	7	0	0	0	0	73
4219	0	0	0	0	0	0	0	0	0	6	0	0	0	6	0	0	0	0	0	0	0	0	12
4220	0	0	0	0	0	0	0	0	0	2	1	1	6	0	8	0	0	2	0	0	0	0	20
4221	0	0	1	0	0	0	0	0	0	0	2	0	2	0	0	5	0	1	0	0	0	0	11
4222	0	0	0	0	0	0	0	0	0	1	4	0	5	0	0	0	4	1	0	0	0	0	15
4223	0	0	0	0	0	0	0	0	0	4	0	1	5	0	1	0	0	6	1	0	0	0	18
7301	1	0	0	0	0	1	0	1	0	1	0	0	3	0	0	0	1	0	31	3	1	2	45
7400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	5
7800	3	1	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	9
8101	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	6
SUM	58	6	18	10	3	9	7	55	13	44	23	3	78	8	25	9	11	23	39	7	2	5	456

% AGREEMENT	48
TAU WITH EQUAL PROBABILITY	0.46
TOTAL DIAGONAL ELEMENTS	219
TOTAL TRAINING PLOTS IN DATA SET	456

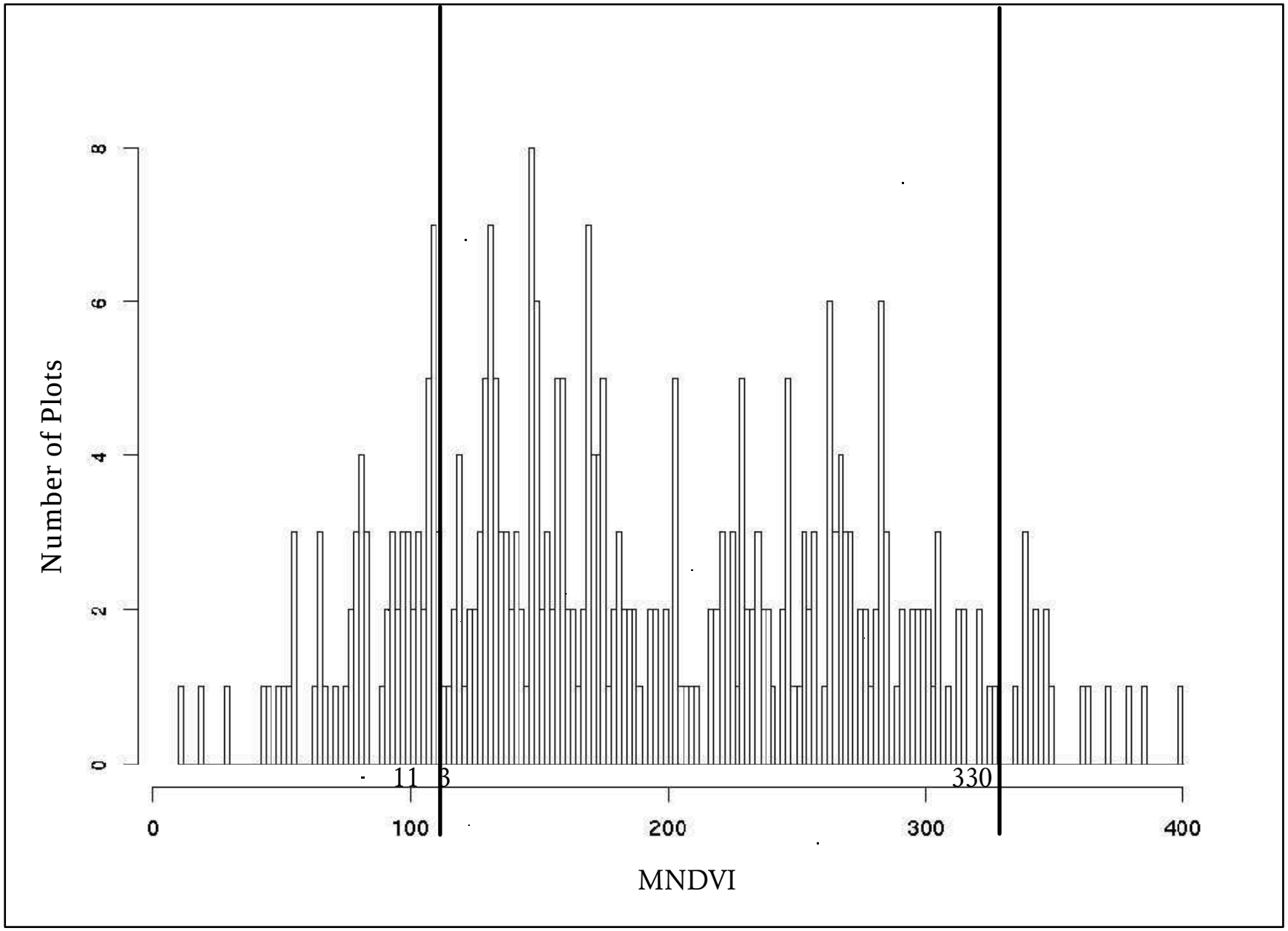


Figure F-11a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P40/R28

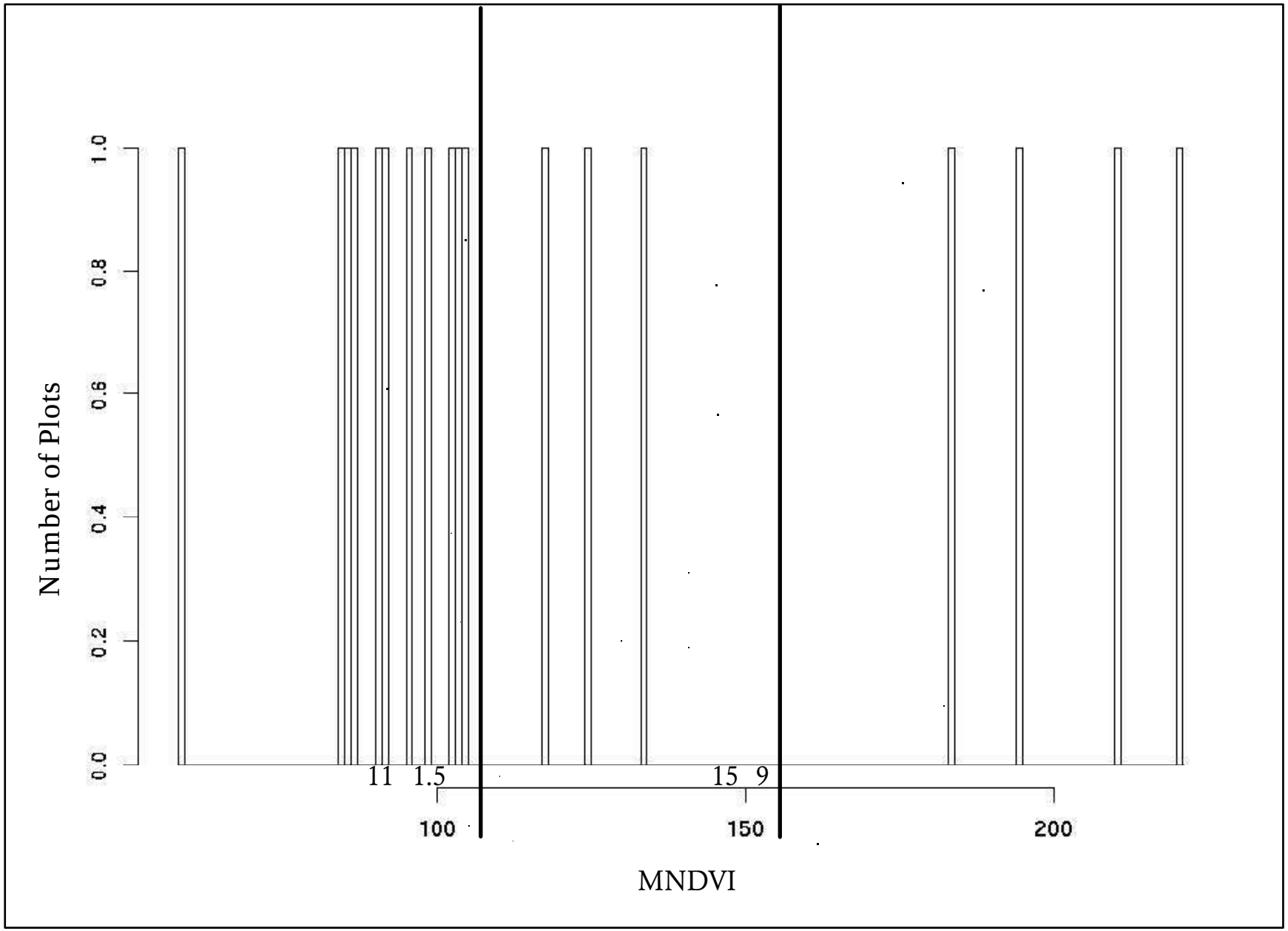


Figure F-11b. Breaks between mesic shrub canopy cover classes in relation to MNDVI values: TM scene P40/R28

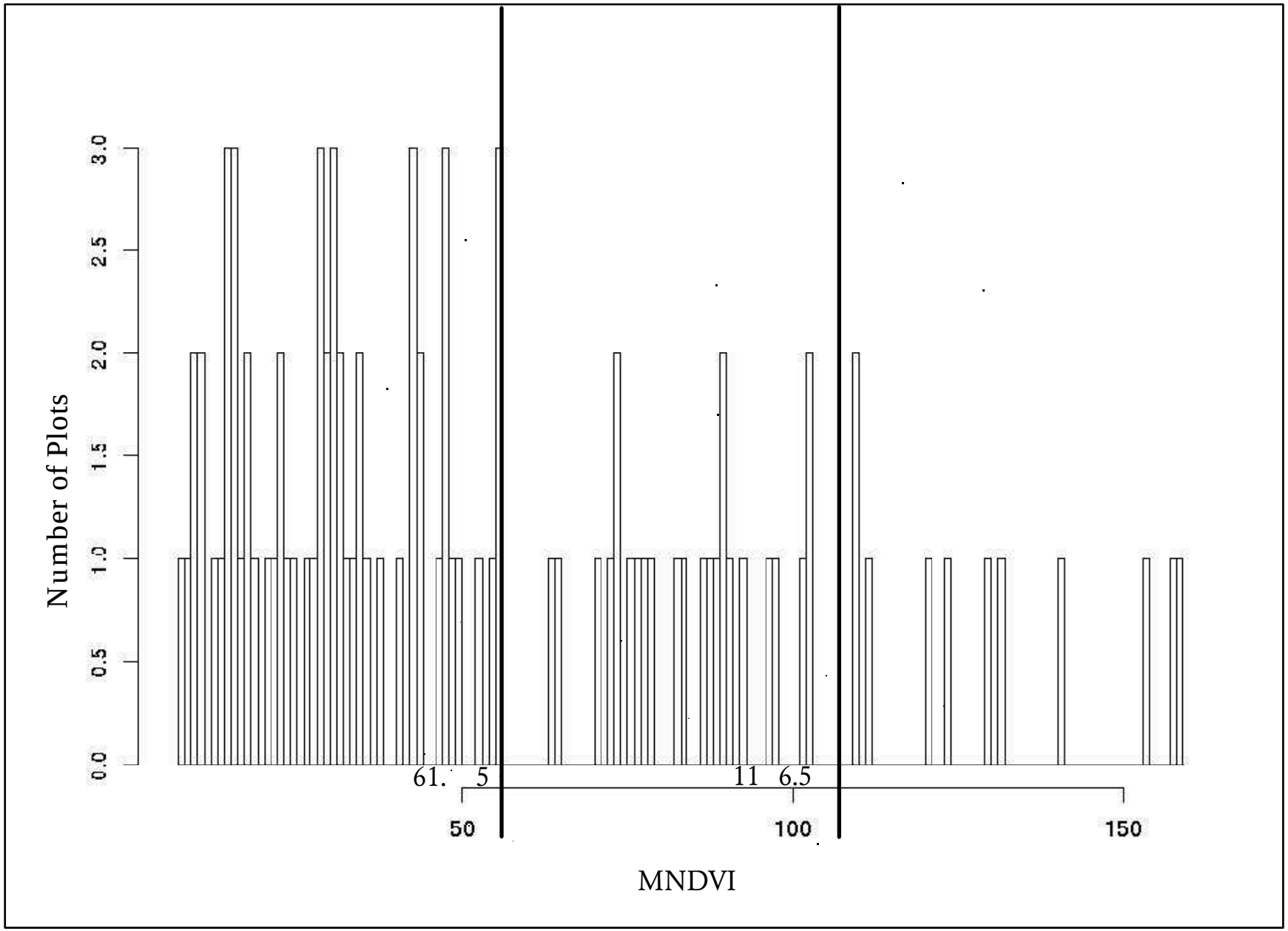


Figure F-11c. Breaks between xeric shrub canopy cover classes in relation to MNDVI values: TM scene P40/R28

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3102	3104	3201	3301	3304	3305	4101	4203
3101	5(5)	3(3)	6(3)	0(1)	0(1)	0(1)	2(1)	1(1)	0(1)
3102	1(3)	2(5)	0(2)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3104	1(3)	0(3)	1(5)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)
3201	1(1)	0(1)	0(1)	2(5)	0(2)	0(2)	0(2)	1(1)	0(1)
3301	0(1)	0(1)	0(1)	0(2)	2(5)	0(2)	0(2)	0(1)	0(1)
3304	1(1)	0(1)	0(1)	0(2)	0(2)	2(5)	0(3)	0(1)	0(1)
3305	1(1)	0(1)	2(1)	0(2)	1(2)	0(3)	11(5)	0(1)	1(1)
4101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(5)	0(2)
4203	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	1(1)	0(2)	7(5)
4206	0(1)	1(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(2)	1(2)
4208	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(2)	0(2)
4212	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	2(1)	0(2)	2(2)
4219	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	1(3)
4220	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)
4221	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(2)	0(3)
4222	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4223	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	1(3)
7301	0(1)	1(1)	2(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)
7400	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7800	0(2)	0(1)	0(1)	1(1)	0(1)	0(1)	1(1)	0(1)	0(1)
SUM	12(0)	7(0)	14(0)	5(0)	3(0)	2(0)	20(0)	4(0)	13(0)

RF/CF	4206	4208	4212	4219	4220	4221	4222	4223	7301
3101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3104	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)
3304	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3305	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4101	0(2)	0(2)	2(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)
4203	0(2)	0(2)	2(2)	1(3)	1(3)	0(3)	0(2)	2(4)	0(1)
4206	3(5)	0(2)	0(2)	0(2)	0(2)	0(3)	1(4)	0(2)	0(1)
4208	0(2)	0(5)	0(2)	0(3)	0(3)	0(3)	0(2)	0(2)	0(1)
4212	2(2)	0(2)	11(5)	0(2)	2(3)	0(3)	3(4)	3(4)	0(1)
4219	0(2)	0(3)	0(2)	3(5)	0(3)	0(2)	0(2)	0(2)	0(1)
4220	0(2)	0(3)	0(3)	0(3)	1(5)	0(2)	0(2)	0(3)	0(1)
4221	0(2)	0(2)	0(3)	0(2)	0(2)	2(5)	0(2)	0(3)	0(1)
4222	0(3)	0(2)	1(3)	0(2)	1(2)	0(2)	2(5)	0(2)	0(1)
4223	0(2)	0(2)	1(3)	0(2)	1(3)	0(3)	0(2)	2(5)	0(1)
7301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	6(5)
7400	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)
7800	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(3)
SUM	5(0)	0(0)	17(0)	4(0)	6(0)	2(0)	6(0)	7(0)	7(0)

Accuracy Assessment Tables for P40/R28 -- Cover Type

RF/CF	7400	7800	SUM
3101	0(1)	1(1)	18(0)
3102	0(1)	0(1)	3(0)
3104	0(1)	0(1)	3(0)
3201	0(1)	0(1)	4(0)
3301	0(1)	0(1)	3(0)
3304	0(1)	0(1)	3(0)
3305	0(1)	0(1)	16(0)
4101	0(1)	0(1)	4(0)
4203	0(1)	0(1)	15(0)
4206	0(1)	0(1)	7(0)
4208	0(1)	0(1)	1(0)
4212	0(1)	0(1)	26(0)
4219	0(1)	0(1)	4(0)
4220	0(1)	0(1)	2(0)
4221	0(1)	0(1)	3(0)
4222	0(1)	0(1)	6(0)
4223	0(1)	0(1)	5(0)
7301	3(3)	0(3)	13(0)
7400	1(5)	0(2)	1(0)
7800	0(3)	1(5)	3(0)
SUM	4(0)	2(0)	140(0)

Diagonal Elements = 66; Total Test Points = 140
Percentage Agreement = 47.14; Kappa = 0.427; Tau w/equal Prob = 0.444

Accuracy Assessment Tables for P40/R28 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	27.78	0	0.00	9	50.00	0	0.00	4	22.22
3102	2	66.67	0	0.00	1	33.33	0	0.00	0	0.00
3104	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
3201	2	50.00	0	0.00	0	0.00	0	0.00	2	50.00
3301	2	66.67	0	0.00	0	0.00	0	0.00	1	33.33
3304	2	66.67	0	0.00	0	0.00	0	0.00	1	33.33
3305	11	68.75	0	0.00	0	0.00	1	6.25	4	25.00
4101	2	50.00	0	0.00	0	0.00	2	50.00	0	0.00
4203	7	46.67	2	13.33	2	13.33	2	13.33	2	13.33
4206	3	42.86	1	14.29	0	0.00	1	14.29	2	28.57
4208	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4212	11	42.31	6	23.08	2	7.69	4	15.38	3	11.54
4219	3	75.00	0	0.00	1	25.00	0	0.00	0	0.00
4220	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4221	2	66.67	0	0.00	0	0.00	0	0.00	1	33.33
4222	2	33.33	0	0.00	1	16.67	1	16.67	2	33.33
4223	2	40.00	0	0.00	3	60.00	0	0.00	0	0.00
7301	6	46.15	0	0.00	3	23.08	0	0.00	4	30.77
7400	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	1	33.33	0	0.00	0	0.00	0	0.00	2	66.67
SUM	66	47.14	9	6.43	23	16.43	11	7.86	31	22.14

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	27.78	5	27.78	14	77.78	14	77.78	18	100.00
3102	2	66.67	2	66.67	3	100.00	3	100.00	3	100.00
3104	1	33.33	1	33.33	2	66.67	2	66.67	3	100.00
3201	2	50.00	2	50.00	2	50.00	2	50.00	4	100.00
3301	2	66.67	2	66.67	2	66.67	2	66.67	3	100.00
3304	2	66.67	2	66.67	2	66.67	2	66.67	3	100.00
3305	11	68.75	11	68.75	11	68.75	12	75.00	16	100.00
4101	2	50.00	2	50.00	2	50.00	4	100.00	4	100.00
4203	7	46.67	9	60.00	11	73.33	13	86.67	15	100.00
4206	3	42.86	4	57.14	4	57.14	5	71.43	7	100.00
4208	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4212	11	42.31	17	65.38	19	73.08	23	88.46	26	100.00
4219	3	75.00	3	75.00	4	100.00	4	100.00	4	100.00
4220	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4221	2	66.67	2	66.67	2	66.67	2	66.67	3	100.00
4222	2	33.33	2	33.33	3	50.00	4	66.67	6	100.00
4223	2	40.00	2	40.00	5	100.00	5	100.00	5	100.00
7301	6	46.15	6	46.15	9	69.23	9	69.23	13	100.00
7400	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
7800	1	33.33	1	33.33	1	33.33	1	33.33	3	100.00
SUM	66	47.14	75	53.57	98	70.00	109	77.86	140	100.00

Accuracy Assessment Tables for P40/R28 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	5	41.67	0	0.00	2	16.67	0	0.00	5	41.67
3102	2	28.57	0	0.00	3	42.86	0	0.00	2	28.57
3104	1	7.14	0	0.00	6	42.86	0	0.00	7	50.00
3201	2	40.00	0	0.00	0	0.00	0	0.00	3	60.00
3301	2	66.67	0	0.00	0	0.00	1	33.33	0	0.00
3304	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3305	11	55.00	0	0.00	0	0.00	0	0.00	9	45.00
4101	2	50.00	0	0.00	0	0.00	0	0.00	2	50.00
4203	7	53.85	0	0.00	2	15.38	3	23.08	1	7.69
4206	3	60.00	0	0.00	0	0.00	2	40.00	0	0.00
4208	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4212	11	64.71	0	0.00	2	11.76	4	23.53	0	0.00
4219	3	75.00	0	0.00	1	25.00	0	0.00	0	0.00
4220	1	16.67	0	0.00	4	66.67	1	16.67	0	0.00
4221	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4222	2	33.33	4	66.67	0	0.00	0	0.00	0	0.00
4223	2	28.57	5	71.43	0	0.00	0	0.00	0	0.00
7301	6	85.71	0	0.00	0	0.00	0	0.00	1	14.29
7400	1	25.00	0	0.00	3	75.00	0	0.00	0	0.00
7800	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
SUM	66	47.14	9	6.43	23	16.43	11	7.86	31	22.14

Accuracy Assessment Tables for P40/R28 -- Cover Type

ACCUMULATE MATRIX (user)

GROUP	Score 5 N	Score 5 %	Score 4 N	Score 4 %	Score 3 N	Score 3 %	Score 2 N	Score 2 %	Score 1 N	Score 1 %
3101	5	41.67	5	41.67	7	58.33	7	58.33	12	100.00
3102	2	28.57	2	28.57	5	71.43	5	71.43	7	100.00
3104	1	7.14	1	7.14	7	50.00	7	50.00	14	100.00
3201	2	40.00	2	40.00	2	40.00	2	40.00	5	100.00
3301	2	66.67	2	66.67	2	66.67	3	100.00	3	100.00
3304	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
3305	11	55.00	11	55.00	11	55.00	11	55.00	20	100.00
4101	2	50.00	2	50.00	2	50.00	2	50.00	4	100.00
4203	7	53.85	7	53.85	9	69.23	12	92.31	13	100.00
4206	3	60.00	3	60.00	3	60.00	5	100.00	5	100.00
4208	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4212	11	64.71	11	64.71	13	76.47	17	100.00	17	100.00
4219	3	75.00	3	75.00	4	100.00	4	100.00	4	100.00
4220	1	16.67	1	16.67	5	83.33	6	100.00	6	100.00
4221	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4222	2	33.33	6	100.00	6	100.00	6	100.00	6	100.00
4223	2	28.57	7	100.00	7	100.00	7	100.00	7	100.00
7301	6	85.71	6	85.71	6	85.71	6	85.71	7	100.00
7400	1	25.00	1	25.00	4	100.00	4	100.00	4	100.00
7800	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
SUM	66	47.14	75	53.57	98	70.00	109	77.86	140	100.00

Accuracy Assessment Tables for P40/R28 -- Cover Type

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	52	27.78	0	0.00	93	50.00	0	0.00	41	22.22
3102	14	66.67	0	0.00	7	33.33	0	0.00	0	0.00
3104	16	33.33	0	0.00	16	33.33	0	0.00	16	33.33
3201	18	50.00	0	0.00	0	0.00	0	0.00	18	50.00
3301	9	66.67	0	0.00	0	0.00	0	0.00	4	33.33
3304	2	66.67	0	0.00	0	0.00	0	0.00	1	33.33
3305	66	68.75	0	0.00	0	0.00	6	6.25	24	25.00
4101	6	50.00	0	0.00	0	0.00	6	50.00	0	0.00
4203	78	46.67	22	13.33	22	13.33	22	13.33	22	13.33
4206	10	42.86	3	14.29	0	0.00	3	14.29	6	28.57
4208	0	0.00	0	0.00	0	0.00	0	0.00	10	100.00
4212	48	42.31	26	23.08	9	7.69	18	15.38	13	11.54
4219	16	75.00	0	0.00	5	25.00	0	0.00	0	0.00
4220	57	50.00	0	0.00	0	0.00	0	0.00	57	50.00
4221	10	66.67	0	0.00	0	0.00	0	0.00	5	33.33
4222	9	33.33	0	0.00	4	16.67	4	16.67	9	33.33
4223	25	40.00	0	0.00	37	60.00	0	0.00	0	0.00
7301	8	46.15	0	0.00	4	23.08	0	0.00	6	30.77
7400	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	5	33.33	0	0.00	0	0.00	0	0.00	10	66.67
SUM	451	45.10	51	5.10	197	19.70	59	5.90	242	24.20

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	52	27.78	52	27.78	145	77.78	145	77.78	186	100.00
3102	14	66.67	14	66.67	21	100.00	21	100.00	21	100.00
3104	16	33.33	16	33.33	31	66.67	31	66.67	47	100.00
3201	18	50.00	18	50.00	18	50.00	18	50.00	35	100.00
3301	9	66.67	9	66.67	9	66.67	9	66.67	13	100.00
3304	2	66.67	2	66.67	2	66.67	2	66.67	2	100.00
3305	66	68.75	66	68.75	66	68.75	72	75.00	96	100.00
4101	6	50.00	6	50.00	6	50.00	13	100.00	13	100.00
4203	78	46.67	101	60.00	123	73.33	146	86.67	168	100.00
4206	10	42.86	13	57.14	13	57.14	16	71.43	22	100.00
4208	0	0.00	0	0.00	0	0.00	0	0.00	10	100.00
4212	48	42.31	74	65.38	83	73.08	101	88.46	114	100.00
4219	16	75.00	16	75.00	21	100.00	21	100.00	21	100.00
4220	57	50.00	57	50.00	57	50.00	57	50.00	114	100.00
4221	10	66.67	10	66.67	10	66.67	10	66.67	15	100.00
4222	9	33.33	9	33.33	13	50.00	18	66.67	27	100.00
4223	25	40.00	25	40.00	62	100.00	62	100.00	62	100.00
7301	8	46.15	8	46.15	12	69.23	12	69.23	18	100.00
7400	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
7800	5	33.33	5	33.33	5	33.33	5	33.33	14	100.00
SUM	451	45.10	503	50.30	699	69.90	761	76.10	1000	100.00

Accuracy Assessment Tables for P40/R28 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	4	SUM
1	20(5)	2(3)	2(1)	0(1)	24(0)
2	3(3)	7(5)	5(3)	1(1)	16(0)
3	2(1)	6(3)	18(5)	3(3)	29(0)
4	0(1)	0(1)	0(3)	3(5)	3(0)
SUM	25(0)	15(0)	25(0)	7(0)	72(0)

Diagonal Elements = 48; Total Test Points = 72
Percentage Agreement = 66.67; Kappa = 0.520; Tau w/equal Prob = 0.556

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	83.33	0	0.00	2	8.33	0	0.00	2	8.33
2	7	43.75	0	0.00	8	50.00	0	0.00	1	6.25
3	18	62.07	0	0.00	9	31.03	0	0.00	2	6.90
4	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	48	66.67	0	0.00	19	26.39	0	0.00	5	6.94

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	83.33	20	83.33	22	91.67	22	91.67	24	100.00
2	7	43.75	7	43.75	15	93.75	15	93.75	16	100.00
3	18	62.07	18	62.07	27	93.10	27	93.10	29	100.00
4	3	100.00	3	100.00	3	100.00	3	100.00	3	100.00
SUM	48	66.67	48	66.67	67	93.06	67	93.06	72	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	80.00	0	0.00	3	12.00	0	0.00	2	8.00
2	7	46.67	0	0.00	8	53.33	0	0.00	0	0.00
3	18	72.00	0	0.00	5	20.00	0	0.00	2	8.00
4	3	42.86	0	0.00	3	42.86	0	0.00	1	14.29
SUM	48	66.67	0	0.00	19	26.39	0	0.00	5	6.94

Accuracy Assessment Tables for P40/R28 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	80.00	20	80.00	23	92.00	23	92.00	25	100.00
2	7	46.67	7	46.67	15	100.00	15	100.00	15	100.00
3	18	72.00	18	72.00	23	92.00	23	92.00	25	100.00
4	3	42.86	3	42.86	6	85.71	6	85.71	7	100.00
SUM	48	66.67	48	66.67	67	93.06	67	93.06	72	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	72	83.33	0	0.00	7	8.33	0	0.00	7	8.33
2	241	43.75	0	0.00	275	50.00	0	0.00	34	6.25
3	196	62.07	0	0.00	98	31.03	0	0.00	22	6.90
4	48	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	557	55.70	0	0.00	380	38.00	0	0.00	63	6.30

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	72	83.33	72	83.33	79	91.67	79	91.67	86	100.00
2	241	43.75	241	43.75	516	93.75	516	93.75	551	100.00
3	196	62.07	196	62.07	294	93.10	294	93.10	316	100.00
4	48	100.00	48	100.00	48	100.00	48	100.00	48	100.00
SUM	557	55.64	557	55.64	937	93.61	937	93.61	1001	100.00

Accuracy Assessment Tables for P40/R28 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	9(5)	4(3)	0(1)	13(0)
2	3(3)	2(5)	0(3)	5(0)
3	0(1)	1(3)	1(5)	2(0)
SUM	12(0)	7(0)	1(0)	20(0)

Diagonal Elements = 12; Total Test Points = 20
Percentage Agreement = 60.00; Kappa = 0.227; Tau of Equal Prob = 0.400

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	69.23	0	0.00	4	30.77	0	0.00	0	0.00
2	2	40.00	0	0.00	3	60.00	0	0.00	0	0.00
3	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
SUM	12	60.00	0	0.00	8	40.00	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	69.23	9	69.23	13	100.00	13	100.00	13	100.00
2	2	40.00	2	40.00	5	100.00	5	100.00	5	100.00
3	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
SUM	12	60.00	12	60.00	20	100.00	20	100.00	20	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	75.00	0	0.00	3	25.00	0	0.00	0	0.00
2	2	28.57	0	0.00	5	71.43	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	12	60.00	0	0.00	8	40.00	0	0.00	0	0.00

Accuracy Assessment Tables for P40/R28 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	9	75.00	9	75.00	12	100.00	12	100.00	12	100.00
2	2	28.57	2	28.57	7	100.00	7	100.00	7	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	12	60.00	12	60.00	20	100.00	20	100.00	20	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	329	69.23	0	0.00	146	30.77	0	0.00	0	0.00
2	140	40.00	0	0.00	211	60.00	0	0.00	0	0.00
3	87	50.00	0	0.00	87	50.00	0	0.00	0	0.00
SUM	556	55.60	0	0.00	444	44.40	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	329	69.23	329	69.23	476	100.00	476	100.00	476	100.00
2	140	40.00	140	40.00	351	100.00	351	100.00	351	100.00
3	87	50.00	87	50.00	174	100.00	174	100.00	174	100.00
SUM	556	55.54	556	55.54	1001	100.00	1001	100.00	1001	100.00

Accuracy Assessment Tables for P40/R28 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	6(5)	23(3)	0(1)	29(0)
2	2(3)	42(5)	1(3)	45(0)
3	0(1)	6(3)	0(5)	6(0)
SUM	8(0)	71(0)	1(0)	80(0)

Diagonal Elements = 48; Total Test Points = 80
Percentage Agreement = 60.00; Kappa = 0.137; Tau w/equal Prob = 0.400

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	20.69	0	0.00	23	79.31	0	0.00	0	0.00
2	42	93.33	0	0.00	3	6.67	0	0.00	0	0.00
3	0	0.00	0	0.00	6	100.00	0	0.00	0	0.00
SUM	48	60.00	0	0.00	32	40.00	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	20.69	6	20.69	29	100.00	29	100.00	29	100.00
2	42	93.33	42	93.33	45	100.00	45	100.00	45	100.00
3	0	0.00	0	0.00	6	100.00	6	100.00	6	100.00
SUM	48	60.00	48	60.00	80	100.00	80	100.00	80	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	75.00	0	0.00	2	25.00	0	0.00	0	0.00
2	42	59.15	0	0.00	29	40.85	0	0.00	0	0.00
3	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
SUM	48	60.00	0	0.00	32	40.00	0	0.00	0	0.00

Accuracy Assessment Tables for P40/R28 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	75.00	6	75.00	8	100.00	8	100.00	8	100.00
2	42	59.15	42	59.15	71	100.00	71	100.00	71	100.00
3	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
SUM	48	60.00	48	60.00	80	100.00	80	100.00	80	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	11	20.69	0	0.00	40	79.31	0	0.00	0	0.00
2	769	93.33	0	0.00	55	6.67	0	0.00	0	0.00
3	0	0.00	0	0.00	125	100.00	0	0.00	0	0.00
SUM	780	78.00	0	0.00	220	22.00	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	11	20.69	11	20.69	51	100.00	51	100.00	51	100.00
2	769	93.33	769	93.33	824	100.00	824	100.00	824	100.00
3	0	0.00	0	0.00	125	100.00	125	100.00	125	100.00
SUM	780	78.00	780	78.00	1000	100.00	1000	100.00	1000	100.00

Accuracy Assessment Tables for P40/R28 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	17(5)	9(3)	3(1)	29(0)
2	8(3)	2(5)	2(3)	12(0)
3	2(1)	1(3)	0(5)	3(0)
SUM	27(0)	12(0)	5(0)	44(0)

Diagonal Elements = 19; Total Test Points = 44
Percentage Agreement = 43.18; Kappa = -0.107; Tau w/equal Prob = 0.148

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	17	58.62	0	0.00	9	31.03	0	0.00	3	10.34
2	2	16.67	0	0.00	10	83.33	0	0.00	0	0.00
3	0	0.00	0	0.00	1	33.33	0	0.00	2	66.67
SUM	19	43.18	0	0.00	20	45.45	0	0.00	5	11.36

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	17	58.62	17	58.62	26	89.66	26	89.66	29	100.00
2	2	16.67	2	16.67	12	100.00	12	100.00	12	100.00
3	0	0.00	0	0.00	1	33.33	1	33.33	3	100.00
SUM	19	43.18	19	43.18	39	88.64	39	88.64	44	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	17	62.96	0	0.00	8	29.63	0	0.00	2	7.41
2	2	16.67	0	0.00	10	83.33	0	0.00	0	0.00
3	0	0.00	0	0.00	2	40.00	0	0.00	3	60.00
SUM	19	43.18	0	0.00	20	45.45	0	0.00	5	11.36

Accuracy Assessment Tables for P40/R28 -- Shrub Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	17	62.96	17	62.96	25	92.59	25	92.59	27	100.00
2	2	16.67	2	16.67	12	100.00	12	100.00	12	100.00
3	0	0.00	0	0.00	2	40.00	2	40.00	5	100.00
SUM	19	43.18	19	43.18	39	88.64	39	88.64	44	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	376	58.62	0	0.00	199	31.03	0	0.00	66	10.34
2	45	16.67	0	0.00	227	83.33	0	0.00	0	0.00
3	0	0.00	0	0.00	29	33.33	0	0.00	58	66.67
SUM	421	42.10	0	0.00	455	45.50	0	0.00	124	12.40

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	376	58.62	376	58.62	575	89.66	575	89.66	641	100.00
2	45	16.67	45	16.67	272	100.00	272	100.00	272	100.00
3	0	0.00	0	0.00	29	33.33	29	33.33	87	100.00
SUM	421	42.10	421	42.10	876	87.60	876	87.60	1000	100.00

Scene P40/R28 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
1000	1022.0	10640.5	0.3
2000	1679.0	113070.9	3.3
3101	28006.0	597730.5	17.6
3102	6652.0	67824.7	2.0
3104	13265.0	156079.6	4.6
3201	2705.0	27427.7	0.8
3202	5612.0	53411.8	1.6
3203	3681.0	32930.7	1.0
3301	2968.0	42441.6	1.2
3304	648.0	7781.4	0.2
3305	17993.0	309148.2	9.1
4101	4811.0	40932.7	1.2
4203	27674.0	540481.4	15.9
4206	9455.0	72108.9	2.1
4208	6420.0	31137.4	0.9
4212	36887.0	365864.1	10.8
4219	5153.0	67538.4	2.0
4220	10400.0	366626.0	10.8
4221	1915.0	46951.4	1.4
4222	8258.0	85731.5	2.5
4223	13512.0	198957.6	5.9
5000	4993.0	11940.9	0.4
7300	7697.0	58792.2	1.7
7400	258.0	3188.8	0.1
7500	104.0	2717.7	0.1
7800	3703.0	46882.8	1.4
8100	945.0	8492.3	0.2
9100	38.0	251.5	0.0
9800	841.0	17968.2	0.5
9900	1013.0	15666.6	0.5

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not tree/shrub	70216.0	1111247.3	32.7
Shrub 1	16817.0	303415.6	8.9
Shrub 2	12137.0	128647.3	3.8
Shrub 3	4653.0	41078.5	1.2
Tree 1	8658	92739.1	2.7
Tree 2	107504.0	1496425.8	44.0
Tree 3	8323.0	227164.5	6.7

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not tree/shrub	70216.0	1111247.3	32.7
Tree 1	23787.0	155949.6	4.6
Tree 2	46647.0	1000221.5	29.4
Tree 3	45117.0	573707.7	16.9
Tree 4	8934.0	86450.7	2.5
Shrub 1	8083.0	224990.4	6.6
Shrub 2	18818.0	166048.8	4.9
Shrub 3	6706.0	82102.1	2.4

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
A	1679.0	113070.9	3.3
H	48868.0	830127.2	24.4
N	19669.0	168049.3	4.9
S	33607.0	473141.3	13.9
T	124485.0	1816329.4	53.4

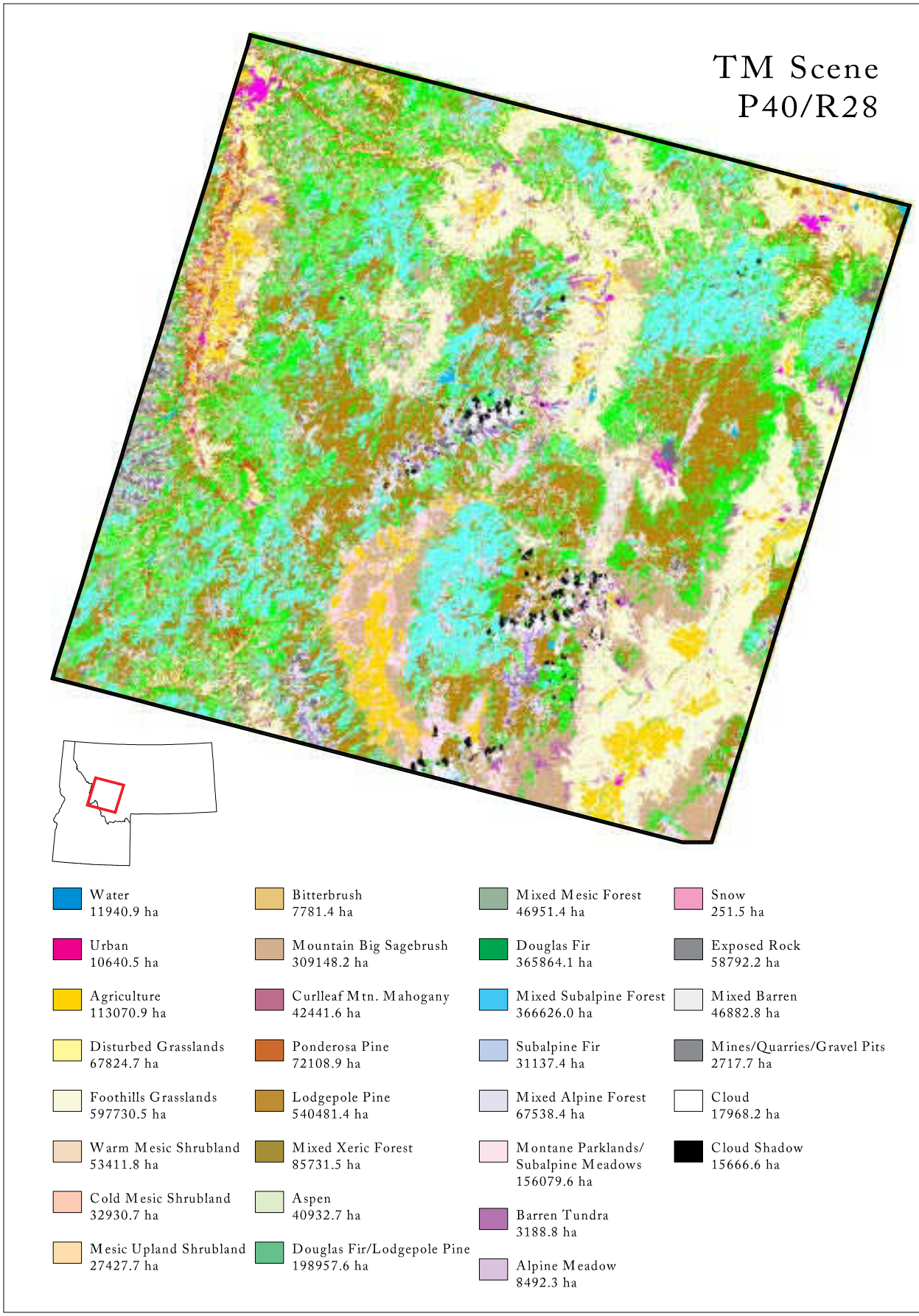


Figure F-11. Classification of land cover types for TM Scene P40/R28.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P40/R28

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4101: ASPEN FOREST

Aspen forest dominated by quaking aspen (Populus tremuloides) and ranging from 5200 to 7404 feet in elevation. The average canopy cover is 49% ranging from 10-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤4% and frequency of occurrence ≥13% and ≤35%.

Primary associated shrub species with ≥4% and ≤26% frequency of occurrence in aspen stands: rocky mountain maple (Acer glabrum), western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), Wood's rose (Rosa woodsii), Canada buffaloberry (Shepherdia canadensis), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤17% frequency of occurrence in aspen stands: **graminoids**: bearded wheatgrass (Agropyron caninum), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), common timothy (Phleum pratense), Kentucky bluegrass (Poa pratensis), and western needlegrass (Stipa occidentalis); **forbs**: common yarrow (Achillea millefolium), sharptooth angelica (Angelica arguta), heart-leaf arnica (Arnica cordifolia), roundleaf alumroot (Heuchera cylindrica), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: moss (moss spp.).

2) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 4100 to 8310 feet in elevation. The average canopy cover is 43% ranging from 10-80% total cover and frequency of occurrence equal to 98%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤9% and frequency of occurrence ≥23% and ≤42%.

Primary associated shrub species with ≥4% and ≤%42 frequency of occurrence in lodgepole pine stands: sitka alder (Alnus sinuata), kinnikinnick (Arctostaphylos uva-ursi), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤26% frequency of occurrence in lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), smooth woodrush (Luzula hitchcockii), and wheeler's bluegrass (Poa nervosa); **forbs**: candystick (Allotrope virgata), raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), arnica (Arnica spp.), fireweed (Epilobium angustifolium), lupine (Lupinus spp.), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: moss (moss spp.).

3) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 3073 to 6920 feet in elevation. The average canopy cover is 29% ranging from 10-60% total cover and frequency of occurrence equal to 98%. Primary associated tree species include aspen (Populus tremuloides), common apple (Pyrus malus), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤7% and frequency of occurrence ≥2% and ≤56%.

Primary associated shrub species with ≥8% and ≤25% frequency of occurrence in ponderosa pine stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), mallow ninebark (Physocarpus malvaceus), antelope bitter-brush (Purshia tridentata), Wood's rose (Rosa woodsii), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤39% frequency of occurrence in ponderosa pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), cheatgrass (Bromus tectorum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), rough fescue (Festuca scabrella), and prairie junegrass (Koeleria macrantha); **forbs**: common yarrow (Achillea millefolium), common pearly everlasting (Anaphalis margaritacea), spreading dogbane (Apocynum androsaemifolium), arrowleaf balsamroot (Balsamorhiza sagittata), spotted knapweed (Centauria maculosa), Virginia strawberry (Fragaria virginiana), and penstemon (Penstemon spp.); **ferns**: none; **moss**: moss (moss spp.).

4) 4208: SUBALPINE FIR FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 6100 to 8600 feet in elevation. The average canopy cover is 42% ranging from 20-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), and lodgepole pine (Pinus contorta) with average percent cover ≥4% and ≤11% and frequency of occurrence ≥31% and ≤54%.

Primary associated shrub species with ≥8% and ≤62% frequency of occurrence in subalpine fir stands: little prince's pine (Chimaphila menziesii), common prince's pine (Chimaphila umbellata), menziesia (Menziesia ferruginea), gooseberry (Ribes spp.), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥11% and ≤22% frequency of occurrence in subalpine fir stands: **graminoids**: pinegrass (Calamagrostis rubescens), sedge (Carex), elk sedge (Carex geyeri), foxtail barley (Hordeum jubatum), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: piper's anemone (Anemone piperi), heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), western rattlesnake-plantain (Goodyera oblongofolia), one-sided wintergreen (Pyrola secunda), white trillium (Trillium ovatum), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: moss (moss spp.).

5) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 3720 to 8000 feet in elevation. The average canopy cover is 39% ranging from 10-70% total cover and frequency of occurrence equal to 95%. Primary associated tree species include subalpine fir (Abies lasiocarpa), lodgepole pine (Pinus contorta), and ponderosa pine (Pinus ponderosa) with average percent cover ≥7% and ≤9% and frequency of occurrence ≥8% and ≤24%.

Primary associated shrub species with ≥13% and ≤29% frequency of occurrence in Douglas-fir stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤29% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), prairie junegrass (Koeleria cristata), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: common yarrow (Achillea millefolium), raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), Wood's strawberry (Fragaria vesca), Virginia strawberry (Fragaria virginiana), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: moss (moss spp.).

6) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albicaulis) and ranging from 7400 to 9500 feet in elevation. The average canopy cover is 18% ranging from 3-50% total cover and frequency of occurrence equal to 93%. Primary associated tree species include subalpine fir (Abies lasiocarpa), alpine larch (Larix lyallii), and lodgepole pine (Pinus contorta) with average percent cover ≥8% and ≤13% and frequency of occurrence ≥31% and ≤69%.

Primary associated shrub species with ≥3% and ≤62% frequency of occurrence in mixed whitebark pine stands: mountain big sagebrush (Artemisia tridentata), common juniper (Juniperus communis), menziesia (Menziesia ferruginea), red mountain-heath (Phyllodoce empetriformis), mountain gooseberry (Ribes montigenum), blackberry (Rubus spp.), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤31%

frequency of occurrence in mixed whitebark pine stands: **graminoids:** bluebunch wheatgrass (Agropyron spicatum), sedge (Carex spp.), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), Parry's rush (Juncus parryi), smooth woodrush (Luzula hitchcockii), and spike trisetum (Trisetum spicatum); **forbs**: rosy pussy-toes (Antennaria microphylla), thread-leaved sandwort (Arenaria capillaris), alpine buckwheat (Erigonum pyrolifolium), coiled-beak lousewort (Pedicularis contorta), penstemon (Penstemon spp.), phlox (Phlox spp.), and beargrass (Xerophyllum tenax); **ferns**: parsley-fern (Cryptogramma crispa); **moss**: moss (moss spp.).

7) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 4195 to 8290 feet in elevation. The average canopy cover is 22% ranging from 1-60% total cover and frequency of occurrence equal to 98%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥13% and ≤19% and frequency of occurrence ≥53% and ≤79%.

Primary associated shrub species with ≥10% and ≤57% frequency of occurrence in mixed subalpine stands: sitka alder (Alnus sinuata), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤59% frequency of occurrence in mixed subalpine fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), hairy brome (Bromus commutatus), mountain brome (Bromus marginatus), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Kentucky bluegrass (Poa pratensis); and spike trisetum (Trisetum spicatum); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), western rattlesnake-plantain (Goodyera oblongofolia), lupine (Lupinus spp.), one-sided wintergreen (Pyrola secunda) western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: woodsia (Woodsia spp.); **moss**: moss (moss spp.).

8) 4221: MIXED MESIC FOREST

Conifer forest dominated by western larch (Larix occidentalis), codominant species are grand fir (Abies grandis) and western red cedar (Thuja plicata), ranging from 3800 to 5900 feet in elevation. The average canopy cover for ABIGRA is 19% ranging from 1-50% total cover and frequency of occurrence equal to 43%. The average canopy cover for LAROCC is 19% ranging from 1-50% total cover and frequency of occurrence equal to 79%. The average canopy cover for THUPLI is 20% ranging from 20-20% total cover and frequency of occurrence equal to 7%. Primary associated tree species include subalpine fir (Abies lasiocarpa), ponderosa pine (Pinus ponderosa), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥9% and ≤17% and frequency of occurrence ≥57% and ≤93%.

Primary associated shrub species with ≥14% and ≤64% frequency of occurrence in mixed mesic stands: sitka alder (Alnus sinuata), western serviceberry (Amelanchier alnifolia), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), scouler willow

(Salix scouleriana), shiny-leaf spiraea (Spiraea betulifolia), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤50% frequency of occurrence in mixed mesic stands: **graminoids**: fringed brome (Bromus ciliatus), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), tall mannagrass (Glyceria elata), and nodding trisetum (Trisetum cernuum); **forbs**: heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), queen's cup beadlily (Clintonia uniflora), one-sided wintergreen (Pyrola secunda), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), and beargrass (Xerophyllum tenax); **ferns**: ladyfern (Athyrium filix-femina), field horsetail (Equisetum arvense), common scouring rush (Equisetum hyemale), and meadow horsetail (Equisetum pratense); **moss**: none.

9) 4222: MIXED XERIC FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa), codominant species is limber pine (Pinus flexilis), and ranging from 3440 to 8060 feet in elevation. The average canopy cover for PINPON is 22% ranging from 3-50% total cover and frequency of occurrence equal to 90%. The average canopy cover for PINFLE is 10% ranging from 1-20% total cover and frequency of occurrence equal to 5%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), lodgepole pine (Pinus contorta), aspen (Populus tremuloides), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥4% and ≤26% and frequency of occurrence ≥10% and ≤93%.

Primary associated shrub species with ≥14% and ≤48% frequency of occurrence in mixed xeric stands: western serviceberry (Amelanchier alnifolia), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), mallow ninebark (Physocarpus malvaceus), rose (Rosa spp.), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤61% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), rough fescue (Festuca scabrella), fescue (Festuca spp.), and prairie junegrass (Koeleria macrantha); **forbs**: common yarrow (Achillea millefolium), spreading dogbane (Apocynum androsaemifolium), heart-leaf arnica (Arnica cordifolia), arrowleaf balsamroot (Balsamorhiza sagittata), spotted knapweed (Centauria maculosa), Wood's strawberry (Fragaria vesca), and Virginia strawberry (Fragaria virginiana); **fern**: brackenfern (Pteridium aquilinum); **moss**: none.

10) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) and lodgepole pine (Pinus contorta) and ranging from 2880 to 8057 feet in elevation. The average canopy cover for PSEMEN is 29% ranging from 10-60% total cover and frequency of occurrence equal to 100%. The average canopy cover for PINCON is 27% ranging from 10-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and whitebark pine (Pinus

albicaulis) with average percent cover ≥2% and ≤8% and frequency of occurrence ≥11% and ≤38%.

Primary associated shrub species with ≥9% and ≤28% frequency of occurrence in Douglas-fir-lodgepole pine stands: kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤79% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), timber oatgrass (Danthonia intermedia), Idaho fescue (Festuca idahoensis), alpine timothy (Phleum alpinum), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: heart-leaf arnica (Arnica cordifolia), arnica (Arnica spp.), broadleaf arnica (Arnica latifolia), Virginia strawberry (Fragaria virginiana), western rattlesnake-plantain (Goodyera oblongofolia), one-sided wintergreen (Pyrola secunda), and beargrass (Xerophyllum tenax); **ferns**: meadow horsetail (Equisetum pratense); **moss**: none.

P40/R28 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	2, 18, 59
6102	Broadleaf Dominated Riparian	37
6103	Neeleleaf-Broadleaf Riparian	15
6104	Mixed Riparian (trees + any other)	14, 34, 56
6201	Grass-Forb Riparian/Wetland	5, 21
6202	Shrub Riparian/Wetland	11, 12, 25, 52
6203	Mixed Grass-Forb-Shrub Riparian	None identified for scene

---

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 1
Color: Aqua; RBG 114 178 17.
Distribution: Area pattern does not suggest riparian.
Comment: Appears to be dry grass.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
1	1	Foothills Grassland
2	1	Subalpine Meadow
3	2	Mountain Big Sagebrush
4	1	Broadleaf Dominated Riparian
5	1	Shrub Riparian/Wetland
6	1	Exposed Rock

Spectral Class 2
Color: Dark tan; RGB 162 143 135.
Distribution: Light density spackle at middle elevations; some clustering in wetter portions of valleys.
Comment: Conifers are the most prevalent vegetation types outside the riparian zone; herbaceous life forms, shrubs, and riparian vegetation (6102) were also recorded. Color and locations suggest needleleaf riparian vegetation.
Conclusion: 6101.

7	1	Foothills Grassland
8	1	Mix Needleleaf-Broadleaf
9	2	Shrub Riparian/Wetland

Spectral Class 3
Color: Light green; RGB 128 209 165.
Distribution: Area pattern does not suggest riparian.
Comment: Appears to be dry grass and sage brush.
Conclusion: Not riparian.

10	1	Irrigated Crop
11	1	Irrigated Pasture
12	1	Foothills Grassland
13	1	Shrub Riparian/Wetland

Spectral Class 4
Color: Olive brown; RGB 123 127 109.
Distribution: Widely distributed across the image, mostly on transition slopes from low to high mid- elevations; minimally present in valley bottoms.
Comment: Conifers and herbaceous life forms were most recorded in training data. Appears to be mostly higher elevation conifers.
Conclusion: Not riparian.

14	1	Shrub Riparian/Wetland

Spectral Class 5
Color: Dull orange; RGB 224 161 116.
Distribution: Clustered in wetter portions of valleys; also present in openings at middle elevations.
Comment: Herbaceous life forms and conifers are equally represented in the training data, with agriculture, riparian vegetation (6201, 6202), shrubs, and barren land also present.
Conclusion: 6201.

15	1	Irrigated Crop
16	6	Grass-Forb Riparian/Wetland
17	2	Shrub Riparian/Wetland

Spectral Class 8
Color: Olive; RGB 152 176 143.
Distribution: Spackle on lower slopes, with some reaching into valleys.
Comment: Conifers, shrubs, and herbaceous vegetation, including riparian (6201), were observed outside the zone. Appears to be Mixed Xeric Forest.
Conclusion: Not riparian.

21	1	Disturbed Grasslands
22	1	Grass-Forb Riparian/Wetland
23	1	Shrub Riparian/Wetland

Spectral Class 9
Color: Dark warm brown; RGB 108 67 67.
Distribution: Densely distributed clusters on mid-elevation side slopes; some in gullies but not linear in pattern.
Comment: Conifers dominate observations outside the zone, with shrub, Aspen, riparian (6101), Mixed Needleleaf-Broadleaf, and rock cover types also recorded. Appears to be Mixed Mesic forest.
Conclusion: Not riparian.

24	1	Engelmann Spruce
25	1	Douglas-fir
26	1	Mixed Mesic Forest
27	1	Douglas-fir-Lodgepole
28	1	Needleleaf Dominated Riparian
29	1	Grass-Forb Riparian/Wetland
30	1	Shrub Riparian/Wetland

Spectral Class 10
Color: Dark olive drab; RGB 151 127 120.
Distribution: Medium density spackle at mid elevations, some in gullies.
Comment: Conifers dominate training sites outside the zone, with riparian vegetation (6101, 6201, 6202), and shrubs also present. There are no training sites within the zone. Visual cues suggest Mixed Xeric forest.
Conclusion: Not riparian.

Spectral Class 11
Color: Gray brown; RGB 151 127 120.
Distribution: Light density on lower mid elevation slopes.
Comment: Conifers, sagebrush, riparian vegetation (6101, 6201), and herbaceous vegetation were included in training sites for this spectral class.
Conclusion: 6202.

32	2	Shrub Riparian/Wetland

Spectral Class 12
Color: Orange; RGB 207 126 98.
Distribution: Densely clustered in wetter portions of valleys; also present in open areas at mid-elevations.
Comment: Riparian vegetation (6102, 6202, 6201, 6101, 6101) had the highest training site counts outside the zone for this spectral class. Conifers, agriculture, shrubs, Aspen, and Mixed

Needleleaf-Broadleaf were also included.
Conclusion: 6202.

33	1	Mesic Upland Shrubland
34	3	Broadleaf Dominated Riparian
35	1	Grass-Forb Riparian/Wetland
36	6	Shrub Riparian/Wetland

Spectral Class 13
Color: Gray black; RGB 66 47 63.
Distribution: Medium to high density spackle with some clustering; mostly found at mid elevations.
Comment: Conifers, and some riparian (6101) and meadow vegetation were observed outside the riparian zone. Appears to be shadows and Douglas-fir.
Conclusion: Not riparian.

37	1	Douglas-fir
38	1	Douglas-fir-Lodgepole
39	2	Needleleaf Dominated Riparian

Spectral Class 14
Color: Light olive tan; RGB 183 180 143.
Distribution: Dense clusters on transition slopes, open areas at middle elevations, and along edges of, or between, wetter areas within valleys.
Comment: Conifers and herbaceous vegetation dominate training data outside the zone; shrubs and riparian vegetation (6102, 6103, 6202) had significant presences. Where the class occurs in open areas, seedlings may be present.
Conclusion: 6104.

40	2	Foothills Grassland
41	1	Aspen
42	1	Shrub Riparian/Wetland

Spectral Class 15
Color: Brownish red; RGB 172 96 80.
Distribution: Ranges from light to high density spackle and from valley bottoms to timberline; some clusters are in valley bottoms and low slopes.
Comment: Training data for sites outside the zone indicate that this class represents primarily conifers. Riparian vegetation (6101, 6102, 6201, 6202), herbaceous life forms, Aspen, and shrubs were also recorded.
Conclusion: 6103.

43	1	Douglas-fir
44	3	Broadleaf Dominated Riparian
45	1	Needleleaf-Broadleaf Riparian
46	2	Grass-Forb Riparian/Wetland
47	4	Shrub Riparian/Wetland

Spectral Class 16
Color: Brown; RGB 133 83 74.
Distribution: Light to medium density spackle at mid-elevations.
Comment: Conifers are most prevalent in training data outside the zone; riparian (6101), Aspen and meadow cover types were also recorded. Looks like low-density conifers.
Conclusion: Not riparian.

48	1	Douglas-fir
49	1	Mixed Subalpine Forest
50	1	Mixed Mesic Forest
51	1	Needleleaf Dominated Riparian
52	1	Grass-Forb Riparian/Wetland

Spectral Class 17
Color: Brown black; RGB 58 36 56.
Distribution: Lightly distributed but dense clusters at mid-elevations.
Comment: Just conifers and riparian vegetation (6101, 6102, 6202) were recorded for sites outside the zone.
Conclusion: Not riparian

53	2	Needleleaf Dominated Riparian
54	1	Shrub Riparian/Wetland

Spectral Class 18
Color: Light brown; RGB 160 121 103.
Distribution: Medium density spackle on lower mid-elevation slopes; some in valley bottoms.
Comment: Conifers, shrubs, riparian (6102, 6201, 6202), Aspen, grass, and rock comprised training data outside the zone for this class.
Conclusion: 6101.

55	1	Mixed Mesic Forest
56	3	Shrub Riparian/Wetland

Spectral Class 19
Color: Dark cool brown; RGB 89 74 72.
Distribution: Medium to dense spackle at middle elevations.
Comment: Conifers dominate training sites outside the zone; riparian (6101, 6103, 6201) and agricultural vegetation were also present.
Conclusion: Not riparian.

57	1	Needleleaf Dominated Riparian

Spectral Class 20
Color: Soft black; RGB 42 46 64.
Distribution: Medium density at middle elevations; some in gullies but not linear.
Comment: Conifers were the only recorded vegetation outside the zone. Appears to be shadows and Douglas-fir.
Conclusion: Not riparian.

58	1	Mixed Subalpine Forest
59	1	Shrub Riparian/Wetland

Spectral Class 21
Color: Medium warm brown; RGB 138 99 85.
Distribution: Light to medium density on low to mid-elevation slopes.
Comment: Conifers were most prevalent in training data outside the zone; riparian (6101, 6103) and agriculture cover types were also observed.
Conclusion: 6201.

60	1	Douglas-fir
61	1	Grass-Forb Riparian/Wetland

Spectral Class 22
Color: Medium dark warm brown; RGB 128 64 68
Distribution: Light to medium density, with sporatic distribution on mid-elevation slopes.
Comment: Conifers account for nearly all training sites outside the zone; Western Larch, riparian (6101), and shrubs were minimally represented in the data. No training sites were recorded within the zone.
Conclusion: Not riparian.

Spectral Class 23
Color: Dark sea green; RGB 123 157 139.
Distribution: Medium to dense spackle on lower to mid-elevation transition slopes; some in valleys.

Comment: Conifers, shrubs, herbaceous life forms, riparian vegetation (6102), hard surface cover types, tundra, and Aspen comprise training data outside the zone. Appears to be primarily forbs.
Conclusion: Not riparian.

62	1	Mountain Big Sagebrush
63	1	Basin Big Sage Shrubland
64	2	Needleleaf Dominated Riparian
65	1	Broadleaf Dominated Riparian
66	1	Needleleaf-Broadleaf Riparian
67	1	Shrub Riparian/Wetland

Spectral Class 24
Color: Blue black; RGB 57 59 67.
Distribution: Small clusters that are densely distributed on some mid-elevation slopes.
Comment: Conifers dominate training data outside the zone; riparian (6101, 6103), meadow, and burnt timber are minimally represented. Appears to be shadows and Douglas-fir.
Conclusion: Not riparian.

68	1	Engelmann Spruce
69	3	Mixed Subalpine Forest
70	1	Needleleaf Dominated Riparian

Spectral Class 25
Color: Bright orange; RGB 254 144 114.
Distribution: Numerous clusters in wetter portions of valleys; lightly distributer in openings at mid-elevations.
Comment: Agricultural and riparian (6102, 6103, 6201) cover types are most prevalent in training data outside the zone; urban and grass lands are also present.
Conclusion: 6202.

71	1	Dry-land crop
72	1	Irrigated Pasture
73	1	Rivers & Streams
74	3	Shrub Riparian/Wetland

Spectral Class 26
Color: Sea green; RGB 148 212 187.
Distribution: Some in valley bottoms, but mostly along valley edges.
Comment: Herbaceous vegetation dominates training data outside the zone; conifer, shrub, and riparian (6103, 6202) vegetation are also present in the data. Appears to be dry grass and possibly sage.
Conclusion: Not riparian.

75	1	Dry-land Pasture
76	1	Shrub Riparian/Wetland

Spectral Class 28
Color: Light orange; RGB 249 191 143.
Distribution: Clustered in valley bottoms and some isolated openings at middle elevations.
Comment: Agricultural cover types had highest frequencies in training data outside the zone; urban, shrub, riparian (6102, 6201, 6202), meadow, and Western Larch cover types were also recorded. Visual cues suggest agriculture cover types.
Conclusion: Not riparian.

78	1	Irrigated Crop
79	1	Irrigated Pasture
80	1	Disturbed Grasslands
81	3	Grass-Forb Riparian/Wetland
82	1	Shrub Riparian/Wetland

Spectral Class 29
Color: Dark olive; RGB 100 95 86.
Distribution: Medium to high density spackle at mid-elevations.
Comment: Conifers dominate training data outside the zone; riparian (6201, 6202), rock, and tundra cover types are also included. Appears to be Lodgepole Pine.
Conclusion: Not riparian.

83	1	Needleleaf Dominated Riparian

Spectral Class 33
Color: Very dark warm brown; RGB 100 71 81.
Distribution: Light density at middle elevations.
Comment: Training data outside the zone indicates mostly conifers, with grass and riparian (6101) minimally present.
Conclusion: Not riparian.

89	1	Subalpine Fir
90	1	Grass-Forb Riparian/Wetland

Spectral Class 34
Color: Light grass green; RGB 197 218 174.
Distribution: Clustered on lower slopes and some valley locations.
Comment: Herbaceous life forms dominate training sites outside the zone; conifer, shrub, and riparian (6101, 6102, 6201, 6202), tundra, Aspen, and rock cover types are also present. Appears to include seedlings in clearcuts.
Conclusion: 6104.

91	1	Dry-land Pasture
92	2	Shrub Riparian/Wetland

Spectral Class 35
Color: Very dark cool brown; RGB 76 57 63.
Distribution: Dense spackle at middle elevations.
Comment: Conifers were most recorded outside the zone; riparian (6101, 6201), grass, shrub, and rock were also noted.
Conclusion: Not riparian.

93	2	Needleleaf Dominated Riparian
94	1	Grass-Forb Riparian/Wetland

Spectral Class 36
Color: Very dark cool brown; RGB 86 59 65.
Distribution: Similar to spectral class 35.
Comment: Conifers dominate training data outside the zone; herbaceous and riparian (6101, 6202) are also present.
Conclusion: Not riparian.

95	1	Lodgepole Pine
96	1	Mixed Subalpine Forest
97	1	Mixed Mesic Forest
98	4	Needleleaf Dominated Riparian

Spectral Class 37
Color: Bright red orange; RGB 247 94 79.
Distribution: Small to large clusters in valley bottoms.
Comment: Agriculture, riparian (6102, 6202), Aspen, sagebrush, and meadow cover types were observed outside the zone.
Conclusion: 6102.

99	1	Aspen
100	1	Needleleaf Dominated Riparian
101	2	Broadleaf Dominated Riparian
102	3	Shrub Riparian/Wetland

Spectral Class 38
Color: Light pink; RGB 236 197 234.
Distribution: Cloud peripheries.
Comment: No cover types stand out for this spectral class outside the zone. Agriculture, urban, shrub, Aspen, riparian (6202), rock, and mines/quarries/gravel pits were recorded. No training sites were observed within the zone.
Conclusion: Not riparian.

Spectral Class 39
Color: Dark forest green; RGB 70 77 75.
Distribution: Light to high density spackle at middle elevations.
Comment: Conifers dominate training sites outside the zone; riparian (6101, 6201, 6202), grass, and agriculture cover types were also present.
Conclusion: Not riparian.

103	1	Needleleaf Dominated Riparian
104	1	Grass-Forb Riparian/Wetland

Spectral Class 43
Color: Medium green; RGB 83 123 115.
Distribution: Light to medium density on lower slopes and in some gullies.
Comment: Conifers are the predominate cover type for this class outside the zone; shrubs and rock have significant presence, herbaceous, riparian (6202, 6102), Mixed Needleleaf-Broadleaf, and Aspen cover types are present. Appears to be Lodgepole Pine.
Conclusion: Not riparian.

107	1	Grass-Forb Riparian/Wetland

Spectral Class 45
Color: Grass green; RGB 163 223 155.
Distribution: Found mostly on lower slopes bordering the the Big Hole valley; some in the valley and other open areas at lower elevations.
Comment: Foothills Grassland was most recorded outside the zone; sagebrush, conifer, and riparian (6202) cover types were noted. Appears to be too dry to be riparian vegetation.
Conclusion: Not riparian.

110	1	Grass-Forb Riparian/Wetland

Spectral Class 49
Color: Light sea green; RGB 138 241 203.
Distribution: Area pattern does not suggest riparian.
Comment: Appears to be sagebrush.
Conclusion: Not riparian.

112	1	Dry-land Pasture
113	1	Shrub Riparian/Wetland

Spectral Class 51
Color: Brown black; RGB 66 45 55.
Distribution: Dense spackle at mid-elevations.
Comment: Conifers dominate training sites outside the zone; riparian (6101), rock, and meadow cover types are minimally represented in the data. No training sites were recorded within the zone.
Conclusion: Not riparian.

Spectral Class 52
Color: Dark orange; RGB 250 123 87.
Distribution: Dense clusters in valleys; some along mountain streams,
Comment: Agriculture and riparian (6201, 6202) cover types have the highest frequencies in training data outside the zone. Color and distribution suggest shrubs, including willows.
Conclusion: 6202.

115	2	Irrigated Crop
116	1	Foothills Grassland
117	1	Mesic Upland Shrubland
118	1	Needleleaf Dominated Riparian
119	2	Broadleaf Dominated Riparian
120	4	Grass-Forb Riparian/Wetland
121	5	Shrub Riparian/Wetland

Spectral Class 55
Color: Gray; RGB 111 111 110.
Distribution: Light density spackle at middle elevations and in one valley.
Comment: Conifers dominate training data outside the zone; also present are herbaceous and shrub life forms and riparin vegetation (6101, 6201). Appears to be primarily a mix of Lodgepole Pine and Subalpine forest.
Conclusion: Not riparian.

122	1	Ponderosa Pine & Savannah
123	2	Needleleaf Dominated Riparian
124	1	Broadleaf Dominated Riparian

Spectral Class 56
Color: Olive; RGB 167 161 120.
Distribution: Medium density on lower slopes, some leading into valleys; some in clearcuts.
Comment: Herbaceous vegetation, including agriculture, is most prevalent in training data outside the zone; conifer, shrub, and riparian (6201) are also present.
Conclusion: 6104.

125	1	Dry-land Pasture
126	2	Mountain Big Sagebrush
127	1	Grass-Forb Riparian/Wetland

Spectral Class 57
Color: Forest green; RGB 84 90 85.
Distribution: Light to high density spackle at middle elevations.
Comment: Conifers are most prevalent in training data outside the zone, shrub, meadow, and

riparian (6202) vegetation, and barren land are minimally included.
Conclusion: Not riparian.

128	1	Mixed Xeric Forest
129	1	Broadleaf Dominated Riparian
130	1	Shrub Riparian/Wetland

Spectral Class 59
Color: Light brown; RGB 158 120 90.
Distribution: Light to medium density spackle at middle elevations and some valley locations.
Comment: Riparian (6201, 6103, 6102, 6202) and conifer cover types are about equally represented in training data outside the zone; Aspen, grass, Foothills Grassland, and Mixed Needleleaf-Broadleaf are minimally represented.
Conclusion: 6101.

135	1	Aspen
136	1	Needleleaf-Broadleaf Riparian

Spectral Class 63
Color: Pale pink; RGB 243 223 233.
Distribution: Clouds.
Comment: Of five training sites outside the zone, three indicate agriculture, 1 urban, and 1 rock. There are no training sites within the zone. Looks like barren cover types.
Conclusion: Not riparian.

Spectral Class 64
Color: Off white; RGB 254 255 250.
Distribution: Some clusters in valleys; very light.
Comment: There are just four training sites outside the zone: agriculture, grass, rock, and tundra. Visual cues indicate barren land.
Conclusion: Not riparian.

139	1	Grass-Forb Riparian/Wetland

Spectral Class 68
Color: Dark jade green; RGB 44 97 102.
Distribution: Very light density and burned areas at middle elevations. Exposed Rock has the single highest frequency of any cover type outside the zone; conifer, riparian (6101, 6102, 6201, 6202), urban, shrub, and herbaceous cover types are also present in the data. Appears to represent barren, rock, and tundra cover types.
Conclusion: Not riparian.

143	1	Grass-Forb Riparian/Wetland

Spectral Class 69
Color: White; 255 255 255
Distribution: Clouds.
Conclusion: Not riparian.

144	1	Shrub Riparian/Wetland

TM SCENE P40/R29

Image Analyst: Troy P. Tady

Training Data Analysis

In all, 975 ground-truth plots were available for labeling P40/R29 (see table next page). The data were initially checked over the full scene to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 137 after subtraction of unwanted cover types) were removed from further analysis. The data were then examined by cover type to determine whether or not plots were collected for this project or for other purposes (e.g., pre-existing ECODATA, TSMRS, etc.). The latter "existing data" were not used as training data or accuracy test plots. The following classes were excluded from the digital classification process and from selection of accuracy test points: urban, agriculture, water, riparian, burns, mines/quarries/ gravel pits, clearcuts, sandy areas, and shoreline/gravel bars. Classes were also excluded because they were determined to be minor scene components as per USFS decisions: 3102, 3312, 4206, 4208, and 4221. The montane parkland & subalpine meadow (3104) class was combined with foothills grassland (3101) due to negligible spectral differences between the two classes. The 3104 class was reintroduced later using an elevational break.

Of the remaining plots, 20% were randomly selected from each cover type. These plots (n = 114) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

For the remaining 80% of this "filtered" data set, plots were subjected to further spectral examination. Outliers were eliminated for each cover type based on knowledge of general spectral patterns for various ground features. Insufficient training data plots were available for the following cover types:

3201 Mesic Upland Shrub	- 5 plots
4214 Rocky Mountain Juniper	- 8 plots
4101 Aspen	- 9 plots

Training data for these and most of the other cover types were supplemented from data supplied by the Beaverhead National Forest as well as from personal knowledge from individuals familiar with areas within the scene.

Total plots in ground-truth file	975	
Total 1994-95 field plots	906	
Plots sampled for P41/R29		361
Plots sampled for other scenes		545
Pre-existing plots (ECODATA, TSMRS, etc.)	69	
Plots with codes included in the classification	761	
Plot discards	182	
Pre-existing plots		45
'Bad duplicates'		132
'Good duplicates'		5
Potential training plots	579	
20% test		114
80% training		465
Supplemental cover type plots	88	(+/-)
Total plots available for training	553	(+/-)
Total plots used for training --cover type	402	
size class	107	
canopy	302	

Land Cover Types

A digital classification of the six available TM channels (Bands 1, 2, 3, 4, 5, & 7) plus rescaled elevation (raw elevation value divided by 25) produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were used and assigned directly to the COVERTYPE field in the database attribute table. Further modifications were carried out using spectral class values (SPECTRAL_CLASS or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000. Urban.	Manually identified and recoded by Will Gustafson.
2000. Agriculture.	Manually identified and recoded by Will Gustafson.
3101. Foothills Grassland.	All grass types occurring below 2237 m (7200 ft) were relabeled as Foothills Grassland.
3104. Montane Parkland & Subalpine Meadow.	All grass types occurring at and above 2237 m (7200 ft) were relabeled as Montane Parkland & Subalpine Meadow.

3201.	Mesic Upland Shrub.	A significant number of supplemental plots were acquired for the Mesic Upland Shrub (3201) class. Confusion with Aspen (4101) may be expected and is unavoidable for stands with smaller sized trees.
3301.	Curlleaf Mountain Mahogany.	Confusion with sagebrush classes will probably occur due to the lack of training data for this class. No supplemental data were available from any agency. Manual modifications using NDVI and MNDVI were used to alleviate confusion among Curlleaf Mountain Mahogany, Mixed Mesic Shrub (3201), and Aspen (4101).
3305.	Mountain Big Sagebrush.	No modifications.
3306.	Wyoming Big Sagebrush Steppe.	No modifications.
3307.	Basin Big Sagebrush Shrubland.	No modifications.
3308.	Black Sagebrush Steppe.	No modifications.
4101.	Aspen.	A significant number of supplemental plots were acquired from Scott Miles and personnel at the Salmon Ranger Station. Confusion between Aspen and Mixed Mesic Shrub (3201) may be likely to occur in various areas of scene P40/R29.
4203.	Lodgepole Pine.	A significant number of supplemental plots were acquired from Jeff Copeland at the University of Idaho. General distribution seems very good for this class.
4212.	Douglas-fir.	A significant number of supplemental data plots for Douglas-fir were provided by Jeff Copeland at the University of Idaho. This class dominates the scene as the main conifer type.
4214.	Rocky Mountain Juniper.	No modifications.
4219.	Mixed Whitebark Pine Forest.	Supplemental data for Mixed Whitebark Pine Forest were provided by Jeff Copeland at the University of Idaho. General distribution for this class seems reasonable although sparsely vegetated areas are most likely to be

		classified as Rock (7300) or Montane Parkland & Subalpine Meadow (3104).
4220.	Mixed Subalpine Forest.	A significant number of supplemental data plots for Mixed Subalpine Forest were provided by Jeff Copeland at the University of Idaho.
4222.	Mixed Xeric Forest.	No modifications. General distribution seems reasonable for this class where it tends to occur at lower elevations or on south to south-western aspects at higher elevations.
4223.	Douglas-fir - Lodgepole Pine.	No modifications. General distribution seems good, although confusion with Douglas-fir (4212) and Lodgepole Pine (4203) is probable.
5000.	Water.	All regions with spectral class (LINK) = 1 and slope ≤5º were labeled as water. Generally, water was more spectrally distinct than most other cover types, but in high mountainous terrain, it was confused with cliff shadows. A 5º slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate elevation and slope values such that their slope may be >5º. This would result in the misclassification of some small ponds or lakes. In the Sawtooth Recreation Area, a slope of ≤8º was used as a break in order to include small high elevation lakes which were missed with the 5º break for the rest of the scene.
7300.	Rock.	No modifications.
8101.	Alpine Meadow.	All regions classified as 8101 and falling below 9000 ft (2743 m) were recoded as Montane Parkland & Subalpine Meadow (3104) (see also 3104).

A total of 23 classes were labeled in the full TM scene. These included two grass types, six shrub types, nine forest types, plus six non-vegetated or manually labeled classes. Cover types are mapped in Figure F-12.

Size Classes

Six size classes were mapped -- three for forest cover types (seedling/sapling, pole and, medium) and three for shrub cover (low, medium, and tall). The six TM spectral channels were used for the size classification (elevation was not included). The Nearest Member of

Group (NMG) classifier was used for both tree and shrub size. Tree size classes were not stratified based upon canopy cover classes because training data for scene p40/r29 were insufficient for such purposes.

Canopy Cover Classes

Canopy cover labels (CANOPYCODE = low, medium, or high) were assigned to tree and shrub classes based on Modified Normalized Distribution Vegetation Index (MNDVI) values (modified from Nemani et al. 1993). These values were plotted as frequency histograms for all coniferous forest types (Figure F-12a) as well as for one shrub type (Figure F-12b). The histograms were examined to determine break points based upon the distribution modes (see table below). Regions with MNDVI values falling below the lower break point were assigned to a low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class.

	MNDVI BREAKPOINTS	
CANOPY COVER	Tree	Shrub
Low	<85	<75
Medium	≥85 and ≤195	≥75 and ≤125
High	>195	>125

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3).

These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications.

CLASSIFICATIONS FOR P40/R29	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	19	63%	57%
Tree Size Class	3	75%	9%
Tree Canopy Class	3	100%	29%
Shrub Size Class	3	100%	79%
Shrub Canopy Class	2	95%	71%

Comments

As with P41/R29, training data for this scene were scarce. Although supplemental data were used to enhance the classification, much more data could have been used. For this reason, accuracy assessment values may not represent the "true" quality of the classification for P40/R29. In some cases, not enough plots were available to include various cover types and/or size/canopy classes in the final evaluation.

Special thanks go to Jeff Copeland for information for cover type classes in the Sawtooth National Recreation Area (also used for P41/R29), and to Scott Miles and personnel at the Salmon Ranger Station for their contributions concerning riparian and broadleaf class data.

Error Matrix For Cover Type Training Plots
Scene P40/R29

CLASSIFIED COVER TYPES

PLOT COVER TYPES	3101	3201	3301	3305	3306	3307	3308	4101	4203	4205	4212	4214	4219	4220	4222	4223	7301	7800	8101	SUM
3101	58	0	1	9	2	3	3	0	0	0	0	1	0	0	0	0	4	6	4	91
3201	3	5	1	3	0	0	0	4	0	0	1	0	0	1	0	0	0	0	0	18
3301	2	0	0	4	0	3	0	1	0	0	0	1	0	0	0	0	0	0	0	11
3305	10	1	2	30	0	4	0	0	0	0	0	0	0	0	0	0	2	0	0	49
3306	4	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7
3307	4	0	2	1	0	7	2	0	0	0	0	0	0	0	0	0	0	0	0	16
3308	3	0	0	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	8
4101	0	3	1	1	0	0	0	19	0	0	2	0	0	0	0	0	0	0	0	26
4203	0	0	0	0	0	0	0	0	9	0	4	0	1	1	0	1	0	0	0	16
4205	0	0	0	0	0	0	0	0	1	5	2	0	2	0	0	0	0	0	0	10
4212	0	0	0	0	0	0	0	1	6	1	52	0	1	0	4	4	0	0	0	69
4214	0	0	1	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4
4219	0	0	0	1	0	0	0	0	1	2	2	0	6	0	0	0	0	0	0	12
4220	0	0	0	0	0	0	0	0	2	0	1	0	0	3	0	3	0	0	0	9
4222	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	7
4223	0	0	0	0	0	0	0	0	1	0	5	0	0	0	0	3	0	0	0	9
7301	4	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	9	5	1	22
7800	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	4	0	14
8101	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4
SUM	95	9	9	55	6	17	7	25	20	8	76	4	10	5	4	11	21	15	5	402

% AGREEMENT	53.48
TAU WITH EQUAL PROBABILITY	0.501
TOTAL DIAGONAL ELEMENTS	215
TOTAL TRAINING PLOTS IN DATA SET	402

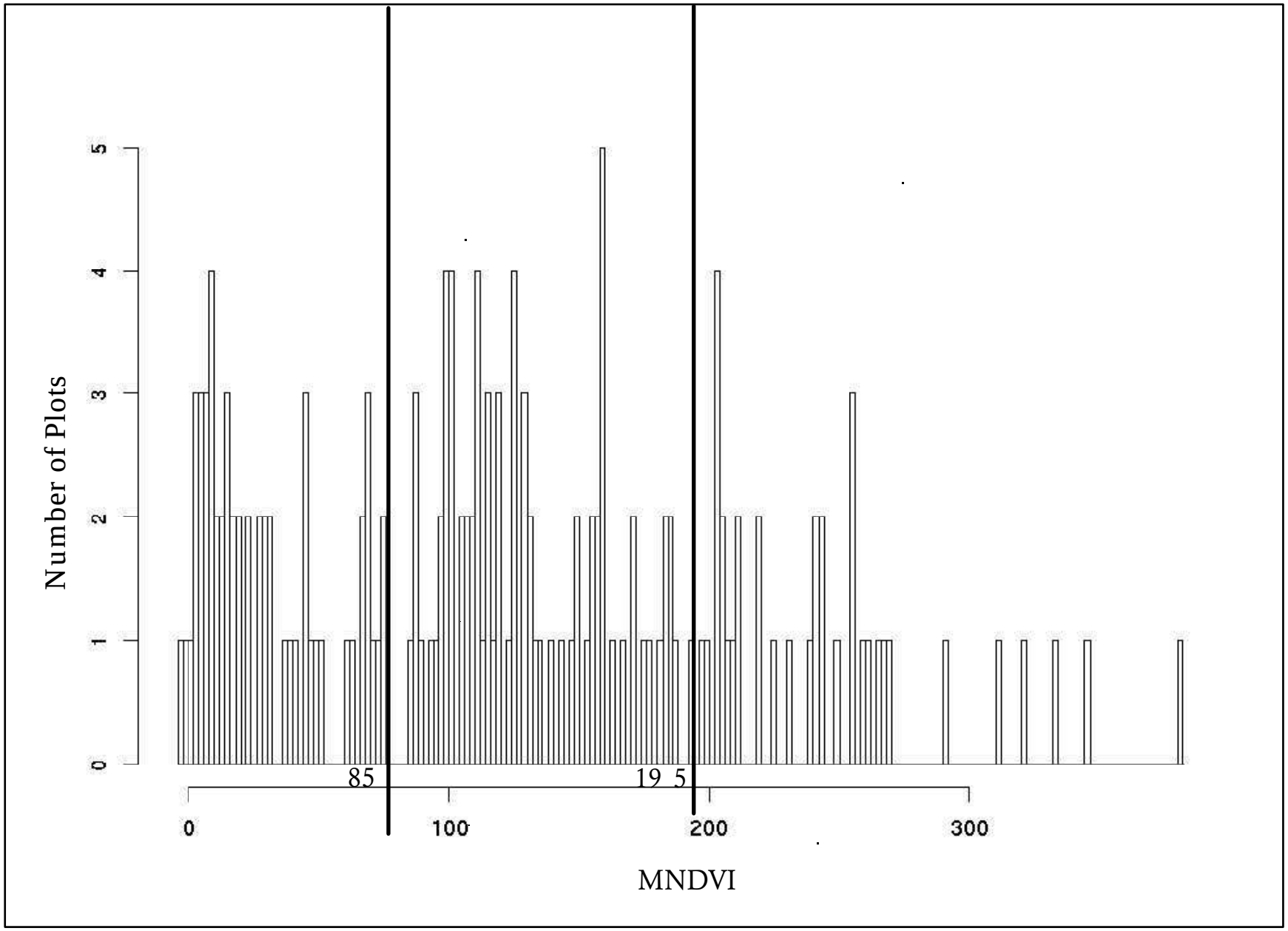


Figure F-12a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P40/R29

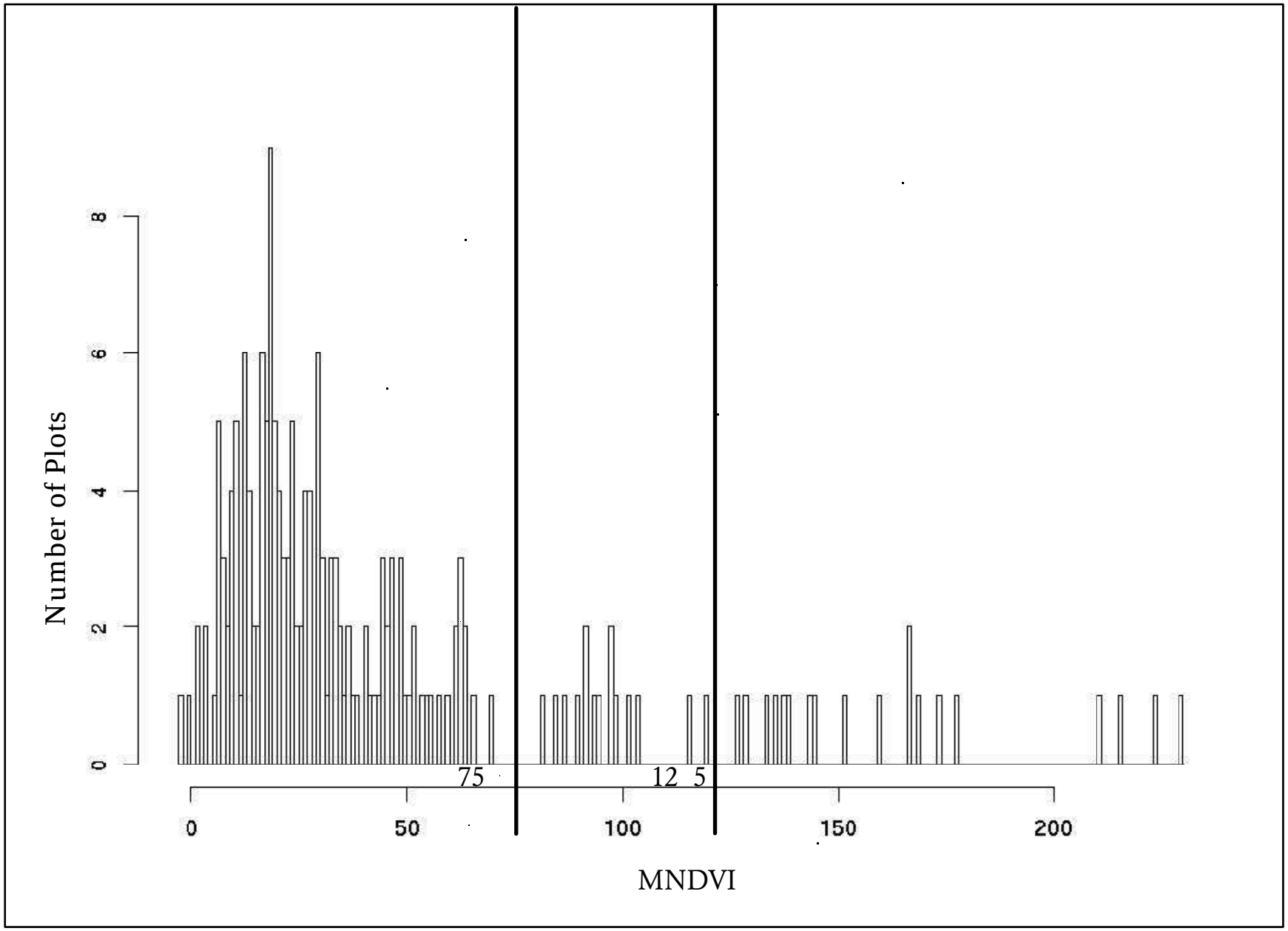


Figure F-12b. Breaks between shrub canopy cover classes in relation to MNDVI values: TM scene P40/R29

Accuracy Assessment Tables for P40/R29 -- Cover Type

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3104	3201	3301	3305	3306	3308	4101	4203
3101	9(5)	3(3)	0(1)	0(1)	2(1)	1(1)	0(1)	0(1)	0(1)
3104	0(3)	4(5)	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3201	0(1)	0(1)	1(5)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)
3301	1(1)	0(1)	0(2)	2(5)	0(2)	0(2)	0(2)	0(1)	0(1)
3305	2(1)	0(1)	0(2)	1(2)	8(5)	1(4)	2(3)	0(1)	0(1)
3306	0(1)	0(1)	0(2)	0(2)	1(4)	3(5)	0(3)	1(1)	0(1)
3308	0(1)	0(1)	0(2)	0(2)	0(4)	2(4)	2(5)	0(1)	0(1)
4101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(5)	0(2)
4203	0(1)	1(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(2)	1(5)
4205	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	1(2)
4212	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(2)	0(2)
4214	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(2)	0(2)
4219	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)
4220	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)
4222	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4223	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)
7300	0(1)	0(1)	1(1)	0(1)	1(1)	1(1)	0(1)	0(1)	0(1)
7800	1(2)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
sum	14(0)	8(0)	5(0)	3(0)	14(0)	8(0)	5(0)	3(0)	2(0)

RF/CF	4205	4212	4214	4219	4220	4222	4223	7300	7800
3101	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(1)
3104	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3305	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(1)	1(1)
3306	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3308	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4101	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)
4203	0(2)	0(2)	0(2)	0(3)	0(3)	0(2)	0(4)	0(1)	1(1)
4205	1(5)	0(2)	0(2)	0(2)	0(2)	0(4)	0(2)	0(1)	0(1)
4212	0(2)	14(5)	0(2)	0(2)	0(3)	1(4)	0(4)	1(1)	0(1)
4214	0(2)	0(2)	0(5)	0(2)	0(2)	0(4)	0(2)	0(1)	0(1)
4219	0(2)	0(2)	0(2)	2(5)	0(3)	0(2)	0(2)	0(1)	0(1)
4220	0(2)	0(3)	0(2)	0(3)	1(5)	0(2)	0(3)	0(1)	1(1)
4222	0(3)	0(3)	0(3)	0(2)	0(2)	2(5)	0(2)	0(1)	0(1)
4223	0(2)	0(3)	0(2)	0(2)	0(3)	0(2)	1(5)	0(1)	0(1)
7300	1(1)	1(1)	0(1)	3(1)	0(1)	1(1)	0(1)	2(5)	0(3)
7800	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(3)	2(5)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(3)
sum	2(0)	21(0)	0(0)	6(0)	1(0)	4(0)	1(0)	5(0)	7(0)

Accuracy Assessment Tables for P40/R29 -- Cover Type

RF/CF	8101	SUM
3101	0(1)	19(0)
3104	0(1)	7(0)
3201	0(1)	1(0)
3301	0(1)	3(0)
3305	0(1)	19(0)
3306	0(1)	5(0)
3308	0(1)	5(0)
4101	0(1)	2(0)
4203	0(1)	4(0)
4205	0(1)	2(0)
4212	0(1)	17(0)
4214	0(1)	1(0)
4219	0(1)	2(0)
4220	0(1)	2(0)
4222	0(1)	2(0)
4223	0(1)	2(0)
7300	0(1)	11(0)
7800	0(3)	5(0)
8101	1(5)	1(0)
SUM	1(0)	110(0)

Diagonal Elements = 58; Total Test Points = 110
Percentage Agreement = 52.73; Kappa = 0.477; Tau w/equal Prob = 0.501

Accuracy Assessment Tables for P40/R29 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	9	47.37	0	0.00	3	15.79	0	0.00	7	36.84
3104	4	57.14	0	0.00	0	0.00	0	0.00	3	42.86
3201	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3301	2	66.67	0	0.00	0	0.00	0	0.00	1	33.33
3305	8	42.11	1	5.26	2	10.53	1	5.26	7	36.84
3306	3	60.00	1	20.00	0	0.00	0	0.00	1	20.00
3308	2	40.00	2	40.00	0	0.00	0	0.00	1	20.00
4101	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	1	25.00	0	0.00	0	0.00	0	0.00	3	75.00
4205	1	50.00	0	0.00	0	0.00	1	50.00	0	0.00
4212	14	82.35	1	5.88	0	0.00	0	0.00	2	11.76
4214	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4219	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4220	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4222	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4223	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
7300	2	18.18	0	0.00	0	0.00	0	0.00	9	81.82
7800	2	40.00	0	0.00	0	0.00	1	20.00	2	40.00
8101	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	58	52.73	5	4.55	5	4.55	3	2.73	39	35.45

Accuracy Assessment Tables for P40/R29 -- Cover Type

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	9	47.37	9	47.37	12	63.16	12	63.16	19	100.00
3104	4	57.14	4	57.14	4	57.14	4	57.14	7	100.00
3201	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
3301	2	66.67	2	66.67	2	66.67	2	66.67	3	100.00
3305	8	42.11	9	47.37	11	57.89	12	63.16	19	100.00
3306	3	60.00	4	80.00	4	80.00	4	80.00	5	100.00
3308	2	40.00	4	80.00	4	80.00	4	80.00	5	100.00
4101	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4203	1	25.00	1	25.00	1	25.00	1	25.00	4	100.00
4205	1	50.00	1	50.00	1	50.00	2	100.00	2	100.00
4212	14	82.35	15	88.24	15	88.24	15	88.24	17	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4219	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4220	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4222	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4223	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
7300	2	18.18	2	18.18	2	18.18	2	18.18	11	100.00
7800	2	40.00	2	40.00	2	40.00	3	60.00	5	100.00
8101	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	58	52.73	63	57.27	68	61.82	71	64.55	110	100.00

Accuracy Assessment Tables for P40/R29 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	9	64.29	0	0.00	0	0.00	1	7.14	4	28.57
3104	4	50.00	0	0.00	3	37.50	0	0.00	1	12.50
3201	1	20.00	0	0.00	0	0.00	0	0.00	4	80.00
3301	2	66.67	0	0.00	0	0.00	1	33.33	0	0.00
3305	8	57.14	1	7.14	0	0.00	0	0.00	5	35.71
3306	3	37.50	3	37.50	0	0.00	0	0.00	2	25.00
3308	2	40.00	0	0.00	2	40.00	0	0.00	1	20.00
4101	2	66.67	0	0.00	0	0.00	0	0.00	1	33.33
4203	1	50.00	0	0.00	0	0.00	1	50.00	0	0.00
4205	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4212	14	66.67	0	0.00	0	0.00	0	0.00	7	33.33
4214	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4219	2	33.33	0	0.00	0	0.00	0	0.00	4	66.67
4220	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4222	2	50.00	1	25.00	0	0.00	0	0.00	1	25.00
4223	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
7300	2	40.00	0	0.00	0	0.00	0	0.00	3	60.00
7800	2	28.57	0	0.00	0	0.00	0	0.00	5	71.43
8101	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	58	52.73	5	4.55	5	4.55	3	2.73	39	35.45

Accuracy Assessment Tables for P40/R29 -- Cover Type

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	9	64.29	9	64.29	9	64.29	10	71.43	14	100.00
3104	4	50.00	4	50.00	7	87.50	7	87.50	8	100.00
3201	1	20.00	1	20.00	1	20.00	1	20.00	5	100.00
3301	2	66.67	2	66.67	2	66.67	3	100.00	3	100.00
3305	8	57.14	9	64.29	9	64.29	9	64.29	14	100.00
3306	3	37.50	6	75.00	6	75.00	6	75.00	8	100.00
3308	2	40.00	2	40.00	4	80.00	4	80.00	5	100.00
4101	2	66.67	2	66.67	2	66.67	2	66.67	3	100.00
4203	1	50.00	1	50.00	1	50.00	2	100.00	2	100.00
4205	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4212	14	66.67	14	66.67	14	66.67	14	66.67	21	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4219	2	33.33	2	33.33	2	33.33	2	33.33	6	100.00
4220	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4222	2	50.00	3	75.00	3	75.00	3	75.00	4	100.00
4223	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
7300	2	40.00	2	40.00	2	40.00	2	40.00	5	100.00
7800	2	28.57	2	28.57	2	28.57	2	28.57	7	100.00
8101	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	58	52.73	63	57.27	68	61.82	71	64.55	110	100.00

Accuracy Assessment Tables for P40/R29 -- Cover Type

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	33	47.37	0	0.00	11	15.79	0	0.00	26	36.84
3104	17	57.14	0	0.00	0	0.00	0	0.00	13	42.86
3201	22	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3301	5	66.67	0	0.00	0	0.00	0	0.00	2	33.33
3305	49	42.11	6	5.26	12	10.53	6	5.26	43	36.84
3306	11	60.00	4	20.00	0	0.00	0	0.00	4	20.00
3308	14	40.00	14	40.00	0	0.00	0	0.00	7	20.00
4101	16	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	5	25.00	0	0.00	0	0.00	0	0.00	15	75.00
4205	11	50.00	0	0.00	0	0.00	11	50.00	0	0.00
4212	107	82.35	8	5.88	0	0.00	0	0.00	15	11.76
4214	0	0.00	0	0.00	0	0.00	0	0.00	11	100.00
4219	52	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4220	201	50.00	0	0.00	0	0.00	0	0.00	201	50.00
4222	11	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4223	8	50.00	0	0.00	0	0.00	0	0.00	8	50.00
7300	0	18.18	0	0.00	0	0.00	0	0.00	0	81.82
7800	9	40.00	0	0.00	0	0.00	4	20.00	9	40.00
8101	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	574	57.17	32	3.19	23	2.29	21	2.09	354	35.26

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	33	47.37	33	47.37	44	63.16	44	63.16	69	100.00
3104	17	57.14	17	57.14	17	57.14	17	57.14	29	100.00
3201	22	100.00	22	100.00	22	100.00	22	100.00	22	100.00
3301	5	66.67	5	66.67	5	66.67	5	66.67	7	100.00
3305	49	42.11	55	47.37	67	57.89	73	63.16	115	100.00
3306	11	60.00	15	80.00	15	80.00	15	80.00	19	100.00
3308	14	40.00	27	80.00	27	80.00	27	80.00	34	100.00
4101	16	100.00	16	100.00	16	100.00	16	100.00	16	100.00
4203	5	25.00	5	25.00	5	25.00	5	25.00	20	100.00
4205	11	50.00	11	50.00	11	50.00	23	100.00	23	100.00
4212	107	82.35	115	88.24	115	88.24	115	88.24	130	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	11	100.00
4219	52	100.00	52	100.00	52	100.00	52	100.00	52	100.00
4220	201	50.00	201	50.00	201	50.00	201	50.00	402	100.00
4222	11	100.00	11	100.00	11	100.00	11	100.00	11	100.00
4223	8	50.00	8	50.00	8	50.00	8	50.00	15	100.00
7300	0	18.18	0	18.18	0	18.18	0	18.18	0	100.00
7800	9	40.00	9	40.00	9	40.00	13	60.00	21	100.00
8101	3	100.00	3	100.00	3	100.00	3	100.00	3	100.00
SUM	574	57.46	605	60.56	628	62.86	650	65.07	999	100.00

Accuracy Assessment Tables for P40/R29 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	1(5)	0(3)	2(1)	3(0)
2	1(3)	1(5)	1(3)	3(0)
3	1(1)	3(3)	0(5)	4(0)
SUM	3(0)	4(0)	3(0)	10(0)

Diagonal Elements = 2; Total Test Points = 10
Percentage Agreement = 20.00; Kappa = -0.194; Tau w/equal Prob = -0.200

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	33.33	0	0.00	0	0.00	0	0.00	2	66.67
2	1	33.33	0	0.00	2	66.67	0	0.00	0	0.00
3	0	0.00	0	0.00	3	75.00	0	0.00	1	25.00
SUM	2	20.00	0	0.00	5	50.00	0	0.00	3	30.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	33.33	1	33.33	1	33.33	1	33.33	3	100.00
2	1	33.33	1	33.33	3	100.00	3	100.00	3	100.00
3	0	0.00	0	0.00	3	75.00	3	75.00	4	100.00
SUM	2	20.00	2	20.00	7	70.00	7	70.00	10	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
2	1	25.00	0	0.00	3	75.00	0	0.00	0	0.00
3	0	0.00	0	0.00	1	33.33	0	0.00	2	66.67
SUM	2	20.00	0	0.00	5	50.00	0	0.00	3	30.00

Accuracy Assessment Tables for P40/R29 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	1	33.33	1	33.33	2	66.67	2	66.67	3	100.00
2	1	25.00	1	25.00	4	100.00	4	100.00	4	100.00
3	0	0.00	0	0.00	1	33.33	1	33.33	3	100.00
SUM	2	20.00	2	20.00	7	70.00	7	70.00	10	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	31	33.33	0	0.00	0	0.00	0	0.00	63	66.67
2	47	33.33	0	0.00	94	66.67	0	0.00	0	0.00
3	0	0.00	0	0.00	573	75.00	0	0.00	191	25.00
SUM	78	7.81	0	0.00	667	66.77	0	0.00	254	25.43

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	31	33.33	31	33.33	31	33.33	31	33.33	94	100.00
2	47	33.33	47	33.33	142	100.00	142	100.00	142	100.00
3	0	0.00	0	0.00	573	75.00	573	75.00	764	100.00
SUM	78	7.80	78	7.80	746	74.60	746	74.60	1000	100.00

Accuracy Assessment Tables for P40/R29 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	19(5)	3(3)	0(1)	22(0)
2	6(3)	0(5)	0(3)	6(0)
3	5(1)	0(3)	0(5)	5(0)
SUM	30(0)	3(0)	0(0)	33(0)

Diagonal Elements = 19; Total Test Points = 33
Percentage Agreement = 57.58; Kappa = -0.124; Tau w/equal Prob = 0.364

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	19	86.36	0	0.00	3	13.64	0	0.00	0	0.00
2	0	0.00	0	0.00	6	100.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	5	100.00
SUM	19	57.58	0	0.00	9	27.27	0	0.00	5	15.15

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	19	86.36	19	86.36	22	100.00	22	100.00	22	100.00
2	0	0.00	0	0.00	6	100.00	6	100.00	6	100.00
3	0	0.00	0	0.00	0	0.00	0	0.00	5	100.00
SUM	19	57.58	19	57.58	28	84.85	28	84.85	33	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	19	63.33	0	0.00	6	20.00	0	0.00	5	16.67
2	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	19	57.58	0	0.00	9	27.27	0	0.00	5	15.15

Accuracy Assessment Tables for P40/R29 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	19	63.33	19	63.33	25	83.33	25	83.33	30	100.00
2	0	0.00	0	0.00	3	100.00	3	100.00	3	100.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	19	57.58	19	57.58	28	84.85	28	84.85	33	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	790	86.36	0	0.00	125	13.64	0	0.00	0	0.00
2	0	0.00	0	0.00	85	100.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
SUM	790	79.00	0	0.00	210	21.00	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	790	86.36	790	86.36	915	100.00	915	100.00	915	100.00
2	0	0.00	0	0.00	85	100.00	85	100.00	85	100.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
SUM	790	79.00	790	79.00	1000	100.00	1000	100.00	1000	100.00

Accuracy Assessment Tables for P40/R29 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	2(5)	5(3)	0(1)	7(0)
2	2(3)	8(5)	6(3)	16(0)
3	0(1)	1(3)	0(5)	1(0)
SUM	4(0)	14(0)	6(0)	24(0)

Diagonal Elements = 10; Total Test Points = 24
Percentage Agreement = 41.67; Kappa = -0.057; Tau w/equal Prob = 0.125

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	28.57	0	0.00	5	71.43	0	0.00	0	0.00
2	8	50.00	0	0.00	8	50.00	0	0.00	0	0.00
3	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
SUM	10	41.67	0	0.00	14	58.33	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	28.57	2	28.57	7	100.00	7	100.00	7	100.00
2	8	50.00	8	50.00	16	100.00	16	100.00	16	100.00
3	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
SUM	10	41.67	10	41.67	24	100.00	24	100.00	24	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	50.00	0	0.00	2	50.00	0	0.00	0	0.00
2	8	57.14	0	0.00	6	42.86	0	0.00	0	0.00
3	0	0.00	0	0.00	6	100.00	0	0.00	0	0.00
SUM	10	41.67	0	0.00	14	58.33	0	0.00	0	0.00

Accuracy Assessment Tables for P40/R29 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	50.00	2	50.00	4	100.00	4	100.00	4	100.00
2	8	57.14	8	57.14	14	100.00	14	100.00	14	100.00
3	0	0.00	0	0.00	6	100.00	6	100.00	6	100.00
SUM	10	41.67	10	41.67	24	100.00	24	100.00	24	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	190	28.57	0	0.00	476	71.43	0	0.00	0	0.00
2	101	50.00	0	0.00	101	50.00	0	0.00	0	0.00
3	0	0.00	0	0.00	132	100.00	0	0.00	0	0.00
SUM	291	29.10	0	0.00	709	70.90	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	190	28.57	190	28.57	666	100.00	666	100.00	666	100.00
2	101	50.00	101	50.00	202	100.00	202	100.00	202	100.00
3	0	0.00	0	0.00	132	100.00	132	100.00	132	100.00
SUM	291	29.10	291	29.10	1000	100.00	1000	100.00	1000	100.00

Accuracy Assessment Tables for P40/R29 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	SUM
1	13(5)	3(3)	17(0)
2	9(3)	1(5)	10(0)
SUM	22(0)	4(0)	27(0)

Diagonal Elements = 14; Total Test Points = 27
Percentage Agreement = 51.85; Kappa = -0.114; Tau of Equal Prob = 0.037

1 point did not belong to groups listed in the test data and was treated as misclassification. Default score for this 1 point = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	13	76.47	0	0.00	3	17.65	0	0.00	1	5.88
2	1	10.00	0	0.00	9	90.00	0	0.00	0	0.00
SUM	14	51.85	0	0.00	12	44.44	0	0.00	1	3.70

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	13	76.47	13	76.47	16	94.12	16	94.12	17	100.00
2	1	10.00	1	10.00	10	100.00	10	100.00	10	100.00
SUM	14	51.85	14	51.85	26	96.30	26	96.30	27	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	13	59.09	0	0.00	9	40.91	0	0.00	0	0.00
2	1	25.00	0	0.00	3	75.00	0	0.00	0	0.00
SUM	14	53.85	0	0.00	12	46.15	0	0.00	0	0.00

Accuracy Assessment Tables for P40/R29 -- Shrub Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	13	59.09	13	59.09	22	100.00	22	100.00	22	100.00
2	1	25.00	1	25.00	4	100.00	4	100.00	4	100.00
SUM	14	53.85	14	53.85	26	100.00	26	100.00	26	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	707	76.47	0	0.00	163	17.65	0	0.00	54	5.88
2	7	10.00	0	0.00	67	90.00	0	0.00	0	0.00
SUM	714	71.54	0	0.00	230	23.05	0	0.00	54	5.41

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	707	76.47	707	76.47	871	94.12	871	94.12	925	100.00
2	7	10.00	7	10.00	75	100.00	75	100.00	75	100.00
SUM	714	71.40	714	71.40	946	94.60	946	94.60	1000	100.00

Scene P40/R29 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	90466.0	1141953.1	33.6
1000	97.0	1803.9	0.1
2000	3487.0	53971.3	1.6
3101	17081.0	234515.6	6.9
3104	7700.0	100250.9	3.0
3201	6943.0	67676.3	2.0
3301	2806.0	25943.9	0.8
3305	21457.0	364865.5	10.7
3306	3699.0	54296.1	1.6
3307	7668.0	172760.9	5.1
3308	4697.0	70302.1	2.1
4101	5976.0	63296.4	1.9
4203	5060.0	64482.1	1.9
4205	7464.0	55813.1	1.6
4212	32075.0	465193.1	13.7
4214	2781.0	49418.5	1.5
4219	11256.0	119211.6	3.5
4220	5481.0	59600.5	1.8
4222	5906.0	48061.3	1.4
4223	5086.0	61542.5	1.8
5000	1376.0	3034.5	0.1
7300	5074.0	49311.3	1.5
7800	3723.0	64805.6	1.9
8100	814.0	5677.6	0.2

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	90466.0	1141953.1	33.6
Not tree/shrub	39352.0	513370.8	15.1
Shrub 1	37833.0	674510.5	19.9
Shrub 2	8415.0	68481.2	2.0
Shrub 3	1022.0	12853.3	0.4
Tree 1	18845.0	187513.5	5.5
Tree 2	49536.0	437303.4	12.9
Tree 3	12704.0	361802.3	10.6

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	90466.0	1141953.1	33.6
Not tree/shrub	39352.0	513370.8	15.1
Tree 1	19811.0	187680.5	5.5
Tree 2	32877.0	302424.7	8.9
Tree 3	28397.0	496513.9	14.6
Shrub 1	40036.0	674941.1	19.9
Shrub 2	7234.0	80903.9	2.4

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	90466.0	1141953.1	33.6
A	3487.0	53971.3	1.6
H	25595.0	340444.2	10.0
N	10270.0	118955.2	3.5
S	47270.0	755844.9	22.2
T	81085.0	986619.2	29.0

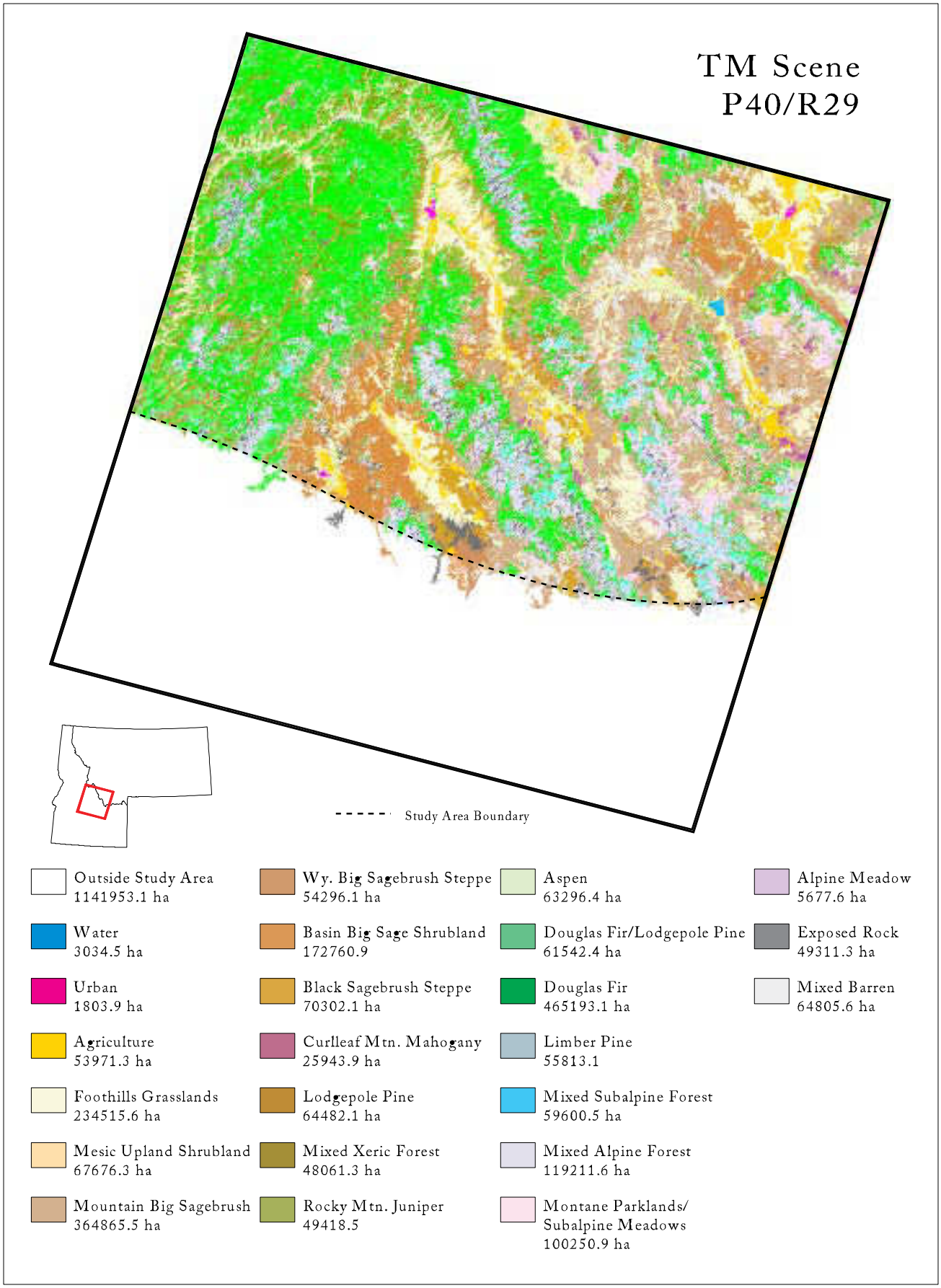


Figure F-12. Classification of land cover types for TM Scene P40/R29.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P40/R29

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 6600 to 9065 feet in elevation. The average canopy cover is 42% ranging from 20-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), whitebark pine (Pinus albicaulis), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤5% and frequency of occurrence ≥20% and ≤48%.

Primary associated shrub species all equal to 4% frequency of occurrence in lodgepole pine stands: sitka alder (Alnus sinuata), alder (Alnus spp.), creeping Oregon grape (Berberis repens), Utah honeysuckle (Lonicera utahensis), gooseberry (Ribes spp.), shiny-leaf spiraea (Spiraea betulifolia), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤26% frequency of occurrence in lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens), northwestern sedge (Carex concinnoides), sedge (Carex), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), and wheeler's bluegrass (Poa nervosa); **forbs**: raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), glacier lily (Erythronium grandiflorum), sticky geranium (Geranium viscosissimum), silvery lupine (Lupinus argenteus), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: none.

2) 4205: LIMBER PINE FOREST

Conifer forest dominated by limber pine (Pinus flexilis) ranging from 7239 to 9243 feet in elevation. The average canopy cover is 39% ranging from 20-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), rocky mountain juniper (Juniperus scopulorum), Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥1% and ≤13% and frequency of occurrence ≥10% and ≤40%.

Primary associated shrub species with ≥8% and ≤%32 frequency of occurrence in limber pine stands: big sagebrush (Artemisia tridentata) and common juniper (Juniperus communis).

Primary associated graminoid, forb, fern, and moss species with ≥10% and ≤30% frequency of occurrence in limber pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum),
pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca Idaho), and spike fescue (Hesperochloa kingii); **forbs**: milk-vetch (Astragalus spp.) and phlox (Phlox spp.); **ferns**: none; **moss**: none.

3) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 3800 to 8443 feet in elevation. The average canopy cover is 41% ranging from 20-70% total cover and frequency of occurrence equal to 100%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), lodgepole pine (Pinus contorta), and limber pine (Pinus flexilis) with average percent cover ≥2% and ≤6% and frequency of occurrence ≥6% and ≤15%.

Primary associated shrub species with ≥3% and ≤12% frequency of occurrence in Douglas-fir stands: mountain big sagebrush (Artemisia tridentata vaseyana), Wyoming big sagebrush (Artemisia tridentata wyomingensis), mallow ninebark (Physocarpus malvaceus), common snowberry (Symphoricarpos albus), snowberry (Symphoricarpos spp.), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤41% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), prairie junegrass (Koeleria cristata), Kentucky bluegrass (Poa pratensis), and western needlegrass (Stipa occidentalis); **forbs**: rosy pussy-toes (Antennaria microphylla), heart-leaf arnica (Arnica cordifolia), arnica (Arnica spp.), milk-vetch (Astragalus spp.), balsamroot (Balsamorhiza sagittata), spotted knapweed (Centauria maculosa), and silky lupine (Lupinus sericeus); **ferns**: none; **moss**: none.

4) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 7500 to 8968 feet in elevation. The average canopy cover is 27% ranging from 10-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), lodgepole pine (Pinus contorta) with average percent cover ≥3% and ≤22% and frequency of occurrence ≥46% and ≤69%.

Primary associated shrub species with ≥8% and ≤62% frequency of occurrence in mixed subalpine stands: menziesia (Menziesia ferruginea), huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤59% frequency of occurrence in mixed subalpine fir stands: **graminoids**: sedge (Carex spp.), elk sedge (Carex geyeri), and smooth woodrush (Luzula hitchcockii); **forb**: arnica (Arnica spp.), broadleaf arnica (Arnica latifolia), glacier lily (Erythronium grandiflorum), Wyeth's lupine (Lupinus wyethii), bracted lousewort (Pedicularis bracteosa), sickletop lousewort (Pedicularis racemosa), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: none.

5) 4222: MIXED XERIC FOREST

Conifer forest dominated by limber pine (Pinus flexilis), codominant species are rocky mountain juniper (Juniperus scopulorum) and ponderosa pine (Pinus ponderosa), ranging from 4100 to 8560 feet in elevation. The average canopy cover for PINFLE is 18% ranging from 3-30% total cover and frequency of occurrence equal to 64%. The average canopy

cover for PINPON is 15% ranging from 10-20% total cover and frequency of occurrence equal to 18%. The average canopy cover for JUNSCO is 11% ranging from 1-30% total cover and frequency of occurrence equal to 46%. Primary associated tree species include subalpine fir (Abies lasiocarpa), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥19% and ≤30% and frequency of occurrence ≥9% and ≤82%.

Primary associated shrub species with ≥9% and ≤27% frequency of occurrence in mixed xeric stands: mountain big sagebrush (Artemisia tridentata vaseyana), common juniper (Juniperus communis), common snowberry (Symphoricarpos albus), and dwarf bilberry (Vaccinium myrtillus).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤61% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), and Kentucky bluegrass (Poa pratensis); **forbs**: milk-vetch (Astragalus spp.), balsamroot (Balsamorhiza sagittata), spotted knapweed (Centauria maculosa) and phlox (Phlox spp.)**;** **ferns**: none; **moss**: moss (moss spp.).

6) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) and lodgepole pine (Pinus contorta) and ranging from 6360 to 8098 feet in elevation. The average canopy cover for PSEMEN is 31% ranging from 10-50% total cover and frequency of occurrence equal to 100%. The average canopy cover for PINCON is 27% ranging from 10-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa) and Engelmann spruce (Picea engelmannii), with average percent cover ≥2% and ≤17% and frequency of occurrence for each equal to 20%.

Primary associated shrub species with ≥10% and ≤30% frequency of occurrence in Douglas-fir-lodgepole pine stands: mountain gooseberry (Ribes montigenum), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤79% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri) and Idaho fescue (Festuca idahoensis); **forbs**: aster (Aster spp.), lupine (Lupinus spp.), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: none.

P40/R29 RIPARIAN CLASSIFICATION
Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	6
6102	Broadleaf Dominated Riparian	20, 58
6103	Neeleleaf-Broadleaf Riparian	None identified for scene
6104	Mixed Riparian (trees + any other)	3, 57, 59
6201	Grass-Forb Riparian/Wetland	55
6202	Shrub Riparian/Wetland	21
6203	Mixed Grass-Forb-Shrub Riparian	None identified for scene

---

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 2
Color: Light brown; RGB 27 57 91.
Distribution: Medium density at middle elevations.
Comment: Training sites outside the zone represent primarily coniferous cover types; several herbaceous and riparian (6103, 6201) sites are included. Visual cues suggest coniferous cover types.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
1	1	Broadleaf Dominated Riparian
2	1	Grass-Forb Riparian/Wetland

Spectral Class 3
Color: Light brown; RGB 214 141 99.
Distribution: Occurs primarily in clusters in wetter portions of valleys; some at mid-elevations.
Comment: Herbaceous cover types, including agricultural, are most prevalent among training sites outside the zone; about 30% of the sites were recorded as riparian vegetation (6201, 6202, 6103). Independent ground truth information indicates broadleaf and shrub riparian vegetation within the zone.
Conclusion: 6104.

3	2	Broadleaf Dominated Riparian
4	5	Grass-Forb Riparian/Wetland
5	2	Shrub Riparian/Wetland

Spectral Class 4
Color: Mauve; RGB 137 122 121.
Distribution: Light to medium density at mid-elevations; very little near streams at low elevations.
Comment: Herbaceous and coniferous cover types have nearly equal representation among training sites outside the zone. Sagebrush and riparian (6102, 6201, 6202) cover types are equally represented; one site was recorded as Aspen. Appears to represent xeric conifers.
Conclusion: Not riparian.

6	1	Shrub Riparian/Wetland

Spectral Class 5
Color: Olive; RGB 127 143 117.
Distribution: Medium to high density on foothills; light density at mid-elevations.
Comment: Herbaceous and shrub vegetation are equally represented by training sites outside the zone; Douglas-fir, rock, riparian (6202), and Aspen are included. Appearance suggests grass and sagebrush.
Conclusion: Not riparian.

7	1	Foothills Grassland
8	2	Mountain Big Sagebrush
9	3	Basin Big Sage Shrubland
10	1	Mixed Alpine Forest
11	1	Shrub Riparian/Wetland

Spectral Class 6
Color: Pinkish rust; RGB 141 71 73.
Distribution: Light density at middle elevations; very little near streams at lower elevations.
Comment: Coniferous and riparian (6201, 6202) vegetation characterize training sites outside the zone.
Conclusion: 6101.

12	1	Foothills Grassland
13	1	Subalpine Fir

Spectral Class 7
Color: Sage green; RGB 168 188 138.
Distribution: Some high density areas on foothills; otherwise light density at middle elevations.
Comment: Herbaceous and shrub vegetation, including Shrub Riparian/Wetland, account for most observations outside the zone.
Conclusion: Not riparian.

14	1	Irrigated Crop
15	1	Irrigated Pasture
16	2	Foothills Grassland
17	1	Mountain Big Sagebrush
18	1	Basin Big Sage Shrubland
19	1	Shrub Riparian/Wetland

Spectral Class 8
Color: Pale sage; RGB 187 224 225.
Distribution: Some relatively large clusters in drier portions of valleys.
Comment: Herbaceous, shrub, and barren cover types characterize training sites outside the zone.
Conclusion: Not riparian.

20	1	Foothills Grassland
21	1	Black Sagebrush Steppe
22	1	Grass-Forb Riparian/Wetland

Spectral Class 9
Color: Dark red brown; RGB 77 22 48.
Distribution: Light to high density at mid elevations.
Comment: Conifers dominate training data for sites outside the zone. One point indicates riparian vegetation (6202). Appears to be shadows and conifers.
Conclusion: Not riparian.

23	1	Needleleaf Dominated Riparian

Spectral Class 13
Color: Light olive; RGB 159 169 130.
Distribution: High density on some foothills; light density at middle elevations; some in wetter portions of valleys.
Comment: Shrubs are most prevalent outside the zone. Herbaceous, coniferous, and riparian (6102, 6201) vegetation are included. Color and locations indicate sparsely distributed upland shrubs.
Conclusion: Not riparian.

26	1	Disturbed Grasslands
27	1	Grass-Forb Riparian/Wetland

Spectral Class 17
Color: Dark rust; RGB 123 61 61.
Distribution: Light density at mid elevations.
Comment: Both training sites outside the zone represent herbaceous vegetation. Visual cues suggest Mixed Mesic Forest.
Conclusion: Not riparian.

30	1	Shrub Riparian/Wetland

Spectral Class 20
Color: Light rust; RGB 173 100 82.
Distribution: Some clustering in wetter portions of valleys; light density at mid elevations.
Comment: Conifers, agriculture, riparian vegetation (6202, 6101, 6201), Aspen, grassland, and sagebrush comprise training data for sites outside the zone. Independent ground-truth information about known sites supports the conclusion of broadleaf riparian vegetation.
Conclusion: 6102.

33	1	Mesic Upland Shrubland
34	1	Mountain Big Sagebrush
35	2	Broadleaf Dominated Riparian
36	3	Shrub Riparian/Wetland

Spectral Class 21
Color: Gray red; RGB 150 82 82.
Distribution: Light density at middle elevations; some locations are in wetter portions of valleys.
Comment: Riparian vegetation (6102, 6103, 6201, 6202) is most prevalent among the eleven training sites outside the zone.
Conclusion: 6202.

37	1	Grass-Forb Riparian/Wetland
38	2	Shrub Riparian/Wetland

Spectral Class 27
Color: Dark gray red; RGB 87 45 56.
Distribution: Medium density at middle elevations.
Comment: Conifers dominate training data for sites outside the zone. One point indicates riparian vegetation (6201). Appears to represent Lodgepole Pine and Douglas-fir.

Conclusion: Not riparian.

41	1	Douglas-fir
42	2	Needleleaf Dominated Riparian

Spectral Class 30
Color: Pale bisque; RGB 232 214 203.
Distribution: occurs in clusters in wetter portions of valleys.
Comment: Herbaceous cover types were the most recorded vegetation outside the zone. Color and locations suggest barren cover types.
Conclusion: Not riparian.

43	1	Subalpine Meadow

Spectral Class 34
Color: Light teal; RGB 132 180 177.
Distribution: Light to high density in some drier locations in valleys.
Comment: Sagebrush and herbaceous vegetation characterize training data for this class outside the zone.
Conclusion: Not riparian.

45	1	Foothills Grassland
46	1	Shrub Riparian/Wetland

Spectral Class 37
Color: Red black; RGB 32 18 43.
Distribution: Light to medium density at mid elevations.
Comment: Training data outside the zone represents primarily coniferous vegetation. One point indicates riparian vegetation (6202). Appears to be Douglas-fir and shadow.
Conclusion: Not riparian.

47	1	Needleleaf Dominated Riparian
48	1	Exposed Rock

Spectral Class 39
Color: Brown red; RGB 105 53 61.
Distribution: Light density at middle elevations.
Comment: Coniferous and shrub vegetation characterize training sites outside the zone. One site represents riparian vegetation (6202).
Conclusion: Not riparian.

49	2	Exposed Rock

Spectral Class 42
Color: Pale lavendar; RGB 237 243 255.
Distribution: Occurs in some clusters in wetter portions of valleys.
Comment: Barren cover types (Exposed Rock, Mixed Barren, Badland Breaks) and agriculture were most recorded for observations outside the riparian zone. Appears to be rocks and barren land.
Conclusion: Not riparian.

51	1	Irrigated Crop
52	1	Feedlots
53	1	Exposed Rock

Spectral Class 45
Color: Gray; RGB 82 82 95.
Distribuion pattern: Light to high density at middle elevations, some on low rises in valleys.
Comment: Coniferous cover types are most prevalent among training sites outside the zone; shrubs, rock, agriculture, barren land, and riparian vegetation (6102) are included. Visual cues indicate Lodgepole Pine.
Conclusion: Not riparian.

54	2	Curlleaf Mountain Mahogany
55	1	Shrub Riparian/Wetland

Spectral Class 55
Color: Peach; RGB 255 177 130.
Distribution: Occurs in clusters in wetter portions of valleys.
Comment: Sagebrush, agriculture, and grass/forb cover types are about equally represented by recorded observations outside the zone. One site represents riparian vegetation (6201).
Conclusion: 6201.

59	1	Irrigated Pasture
60	1	Broadleaf Dominated Riparian
61	1	Shrub Riparian/Wetland

Spectral Class 56
Color: Red orange; RGB 255 73 69.
Distribution: Also occurs in clusters in wetter portions of valleys.
Comment: Training data outside the zone indicates primarily agricultural cover types. One point indicates riparian vegetation (6202). Appears to represent agricultural land.
Conclusion: Not riparian.

62	1	Disturbed Grasslands

63	1	Broadleaf Dominated Riparian

Spectral Class 57
Color: Dark orange; RGB 255 110 82.
Distribution: Dominates wetter portions of valleys.
Comment: Riparian cover types (6201, 6202, 6102, 6103) are most prevalent among training sites outside the zone; agriculture, shrubs, and Aspen are included. Appears to be a mixture of broadleaf and shrub riparian vegetation. Independent ground-truth information also indicates a mixture of broadleaf and shrub riparian vegetation.
Conclusion: 6104.

64	1	Irrigated Pasture
65	2	Foothills Grassland
66	1	Grass-Forb Riparian/Wetland
67	6	Shrub Riparian/Wetland
68	1	Exposed Rock

Spectral Class 58
Color: Red; RGB 241 69 73.
Distribution: Occurs in clusters in wetter portions of valleys.
Comment: Agricultural, grass, riparian (6201, 6202), and Aspen cover types were observed outside the zone. Independent ground-truth information supports the conclusion of broadleaf riparian vegetation.
Conclusion: 6102.

69	2	Shrub Riparian/Wetland
70	1	Mixed Barren Land

Spectral Class 59
Color: Orange; RGB 255 114 69.
Distibution pattern: Clustered in wetter portions of valleys.
Comment: Agricultural land dominates training site observations outside the zone. Three sites represent riparian vegetation (6202, 6103).
Conclusion: 6104.

71	2	Irrigated Crop

Spectral Clss 63
Color: Light orange; RGB 255 147 99.
Distribution: Occurs in clusters in wetter portions of valleys.
Comment: Herbaceous vegetation is most prevalent outside the riparian zone. Appears to represent agricultural land.

Conclusion: Not riparian.

73	1	Irrigated Pasture

TM SCENE P39/R27

Image Analyst: J. Chris Winne

Training Data Analysis

In all, 1114 ground-truth plots were available for labeling P39/R27 (see table below); 853 were collected by Forest Service field crews during the 1994-95 field seasons, and 469 of these were collected specifically for this TM scene. The remaining 261 plots came from pre-existing data sources such as ECODATA and TSMRS.

All ground-truth data were converted to a point file and superimposed on the unsupervised classification to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 105) were removed from further analysis; (these plots can be identified using the following query: DUP_TYPE ne 'B', USE eq 'Y'). The data then were examined by cover type and by data source (whether or not plots were collected for this project or for other purposes, like pre-existing ECODATA or TSMRS). The latter "existing data" were only used in the training data set to supplement cover types that had insufficient plots collected during the 1994 or 1995 field seasons. Eight general classes were excluded from the digital classification process: urban, agriculture, riparian, water, snow, melted snow, cloud, and cloud shadow. All ground truth data with VEG_CLASS_CODE's for urban, agriculture, riparian or water cover types were excluded. Next, 20% of the remaining plots were randomly selected from each cover type; these plots (n = 134) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

The remaining 80% of the data (n = 534 plots) were subjected to further spectral examination. Outliers were identified for each cover type by examining plots in relation to TM and ancillary data for their respective regions (both visually and in relation to calculated standard deviations) and then eliminated.

A total of 342 points were used in the final training set, which included 31 points added from the Forest Service review. Training data analysis was aided by discussions with Robert Gliko (Lewis and Clark NF), Donna Hawkins (Helena NF), and David Atkins (Lolo NF).

Total plots in ground-truth file	1114	
Total 1994-95 field plots	853	
Plots sampled for P41/R26		469
Plots sampled for other scenes		384
Pre-existing plots (ECODATA, TSMRS, etc.)	261	
Plots held aside or eliminated	446	
Duplicates		105
Pre-existing plots		0
Manually labeled cover types		341
Potential training plots	668	
20% test		134
80% training		534
Supplemental plots (from pre-existing data set)	31	
Total plots available for training	565	
Total plots used for training -- cover type	342	
size class	80	
canopy	74	

Land Cover Types

Land cover types were labeled through a digital classification of the 7 TM channels plus rescaled elevation (elevation in meters divided by 25), using the Nearest Member of Group classifier. This classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were used and assigned directly to the COVERTYPE field in the attribute table. Modifications were carried out using spectral class values (SPECTRAL_CLASS or LINK), and/or intermediate cover code labels in conjunction with other attributes including the TM values, modified NDVI, elevation and/or slope as follows:

1000. Urban.	Manually identified and recoded by Polly Thornton.
2000. Agriculture.	Manually identified and recoded by Polly Thornton.
3101. Foothills Grasslands.	All grass types (COV_CODE_1 = 3100) with a mean elevation ≤1982 m (6500 ft) were labeled as Foothills Grassland (3101).
3104. Montane Parklands & Subalpine Meadows.	All grass types occurring at or above 1524 m (5000 ft) were reassigned this label.
3303. Skunkbrush Sumac.	All regions outside the southwest corner of the scene (geographical limit set by Robert Gliko, Lewis and Clark NF, and Dave Atkins, Lolo NF) with COV_CODE_1 = 3303 were assigned a COVERTYPE value equal to their COV_CODE_2 value.

4000.	All Forest Types.	All forest cover types (COV_CODE_1 = 4000) were given a COVERTYPE code of Exposed Rock (7301) if the MNDVI was <5. Conversely, regions classified as Exposed Rock (7301) but with an MNDVI >100 were assigned a COVERTYPE code equal to their COV_CODE_2 value.
4205.	Limber Pine.	This type was dropped from the classification after Forest Service review due to insufficient number of training plots and poor accuracy.
4214.	Rocky Mountain Juniper.	This type was also dropped from the classification after Forest Service review due to insufficient number of training plots and poor accuracy.
5000.	Water.	All regions with spectral class (LINK = 1) and slope ≤5˚ were labeled as water; in addition all regions with TM4 ≤40, TM5 ≤65, M_NDVI ≤40, TM5 < TM4 * 1.5, and either TM7 <25 or M_NDVI <10. Cloud shadows (see 9900 below) were recoded manually. Generally, water was more spectrally distinct than most other cover types, but in mountainous terrain, it was sometimes confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate slope and aspect values such that their slope may be >5˚. This would result in the misclassification of some small ponds or lakes.
9100.	Snow.	This cover type was identified by selecting all regions meeting the following selection criteria: TM3 >70, TM4 >65, TM5 ≤125, TM6 ≤140, MNDVI ≤5, and ELEV >2300.
(n/a)	Melted Snow.	All regions originally classified as Melted Snow were recoded either to Exposed Rock (7301), if their slope was >5˚, or to Snow (9000), if their slope was ≤5˚.
9800.	Cloud.	Manually identified and recoded by Will Gustafson.
9900.	Cloud Shadow.	Manually identified and recoded by Will Gustafson.

A total of 25 cover types were labeled in the full TM scene. These included three grass types, three shrub types, thirteen forest types, two barren types, plus four manually labeled classes.
Cover types are mapped in Figure F-13.

Canopy Cover Classes

Canopy cover labels (CANOPY_CODE = low(1), medium(2), or high(3)) were assigned to tree and shrub classes based on the MNDVI values. These values were plotted as frequency histograms for all forest types (Figure F-13a), as well as for two shrub types (Figures F-13b+c). The histograms were examined to determine break points based upon the distribution modes. Regions with MNDVI values falling below the lower break point were assigned to a low canopy cover class; those greater than or equal to the lower breakpoint, but below the higher break point were assigned to the medium class; and those falling above the higher breakpoint were assigned to the high canopy cover class (see below).

Cover Type Classes	BREAKPOINTS	
	Lower	Upper
3200 shrubs	117	198.5
3300 shrubs	75	157
4000 trees	200	342

Size Classes

Five size classes were classified -- three for forest cover types (seedling/sapling, pole, mature, and mature/overmature), and two for shrub cover (low, medium). No mature/overmature live size class plots occurred in this scene among the trees (4000 codes). Only one tall shrub size class plot occurred with the plots for this scene, and it was a plot from pre-existing data (a range allotment inventory plot). The seven TM spectral bands were used for the size classification (elevation was not included). The Nearest Member of Group (NMG) classifier was used for both tree and shrub size classes. Tree size classes were stratified based upon the three canopy cover classes described above.

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final

accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications.

Classifications for P39/R27	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	20	87%	81%
Tree Size Class	3	90%	55%
Tree Canopy Class	3	93%	63%
Shrub Size Class	2	100%	67%
Shrub Canopy Class	3	97%	36%

Comments

Cover type accuracies for this scene were remarkably high, 81% at the perfect level. Three factors appear particularly significant in reducing spectral overlap among types. First, at least within the study area boundary, the image was cloud and haze free. Second, plots for both training and testing were concentrated within the lower half of the scene, which reduced geographic differences. (Much of the northern part of the scene (outside the study area) is agriculture or grassland.) Third, the total number of regions in the scene was large, which meant that the average region size was smaller than for many other scenes. This may have provided a better match of polygon with covertype. The image acquisition date, 7 July 1991, also may have influenced the classification accuracy. This date is relatively early in the growing season, especially at higher elevations, where plant species would still have some spring green flush and be more spectrally distinct than they would have later in the season.

Error Matrix For Cover Type Training Plots
Scene P39/R27

	CLASSIFIED COVER TYPES																		
PLOT COVER TYPES	3101	3102	3104	3201	3303	3305	4101	4201	4203	4206	4208	4212	4219	4220	4222	4223	7301	7800	SUM
3101	56	1	5	0	2	1	0	0	0	1	0	0	0	0	0	0	0	1	67
3102	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
3104	7	0	13	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	22
3201	4	0	1	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	8
3303	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3
3305	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	4
4101	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	4
4201	0	0	0	0	0	0	0	1	2	0	0	0	0	2	0	1	0	0	6
4203	0	0	0	0	0	0	0	2	14	0	1	0	1	2	0	2	0	0	22
4206	0	0	0	1	1	0	0	0	0	21	0	5	0	0	9	0	0	0	37
4208	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	4
4212	0	0	0	1	0	0	1	0	2	1	0	36	0	1	3	2	0	0	47
4219	0	0	1	0	0	0	0	0	3	0	0	2	2	1	1	0	0	0	10
4220	0	0	0	0	0	0	0	2	3	0	1	1	2	10	0	6	0	0	25
4222	0	0	0	0	0	0	0	1	1	9	1	3	1	1	14	1	0	0	32
4223	0	0	0	0	0	0	0	1	3	0	0	3	0	3	0	6	0	0	16
7301	2	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	21	1	26
7800	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5
SUM	77	3	22	4	3	4	4	7	28	33	3	53	10	22	27	18	22	2	342

% AGREEMENT	59.36
TAU WITH EQUAL PROBABILITY	0.57
TOTAL DIAGONAL ELEMENTS	203
TOTAL TRAINING PLOTS IN DATA SET	342

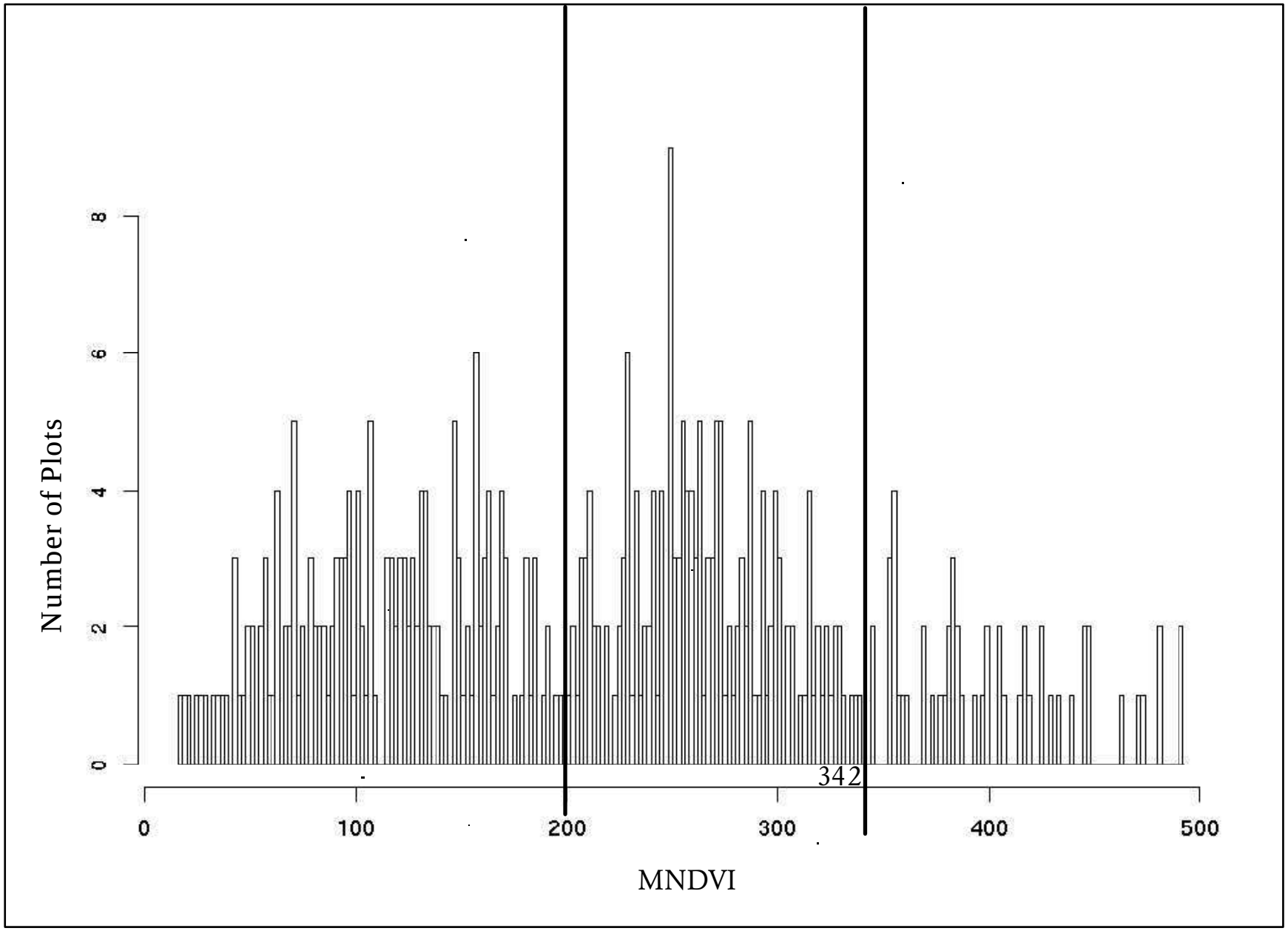


Figure F-13a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P39/R27

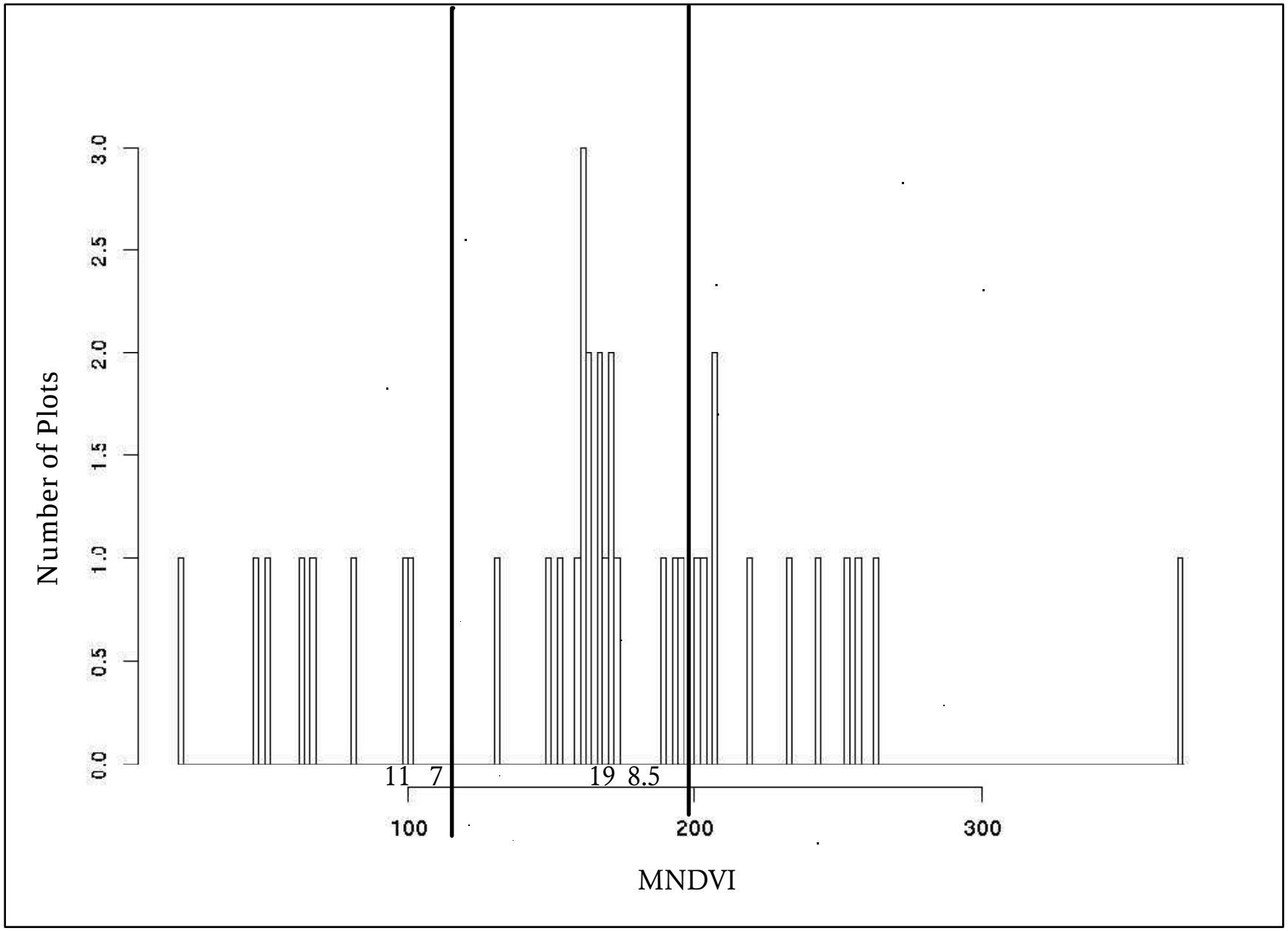


Figure F-13b. Breaks between mesic shrub canopy cover classes in relation to MNDVI values: TM scene P39/R27

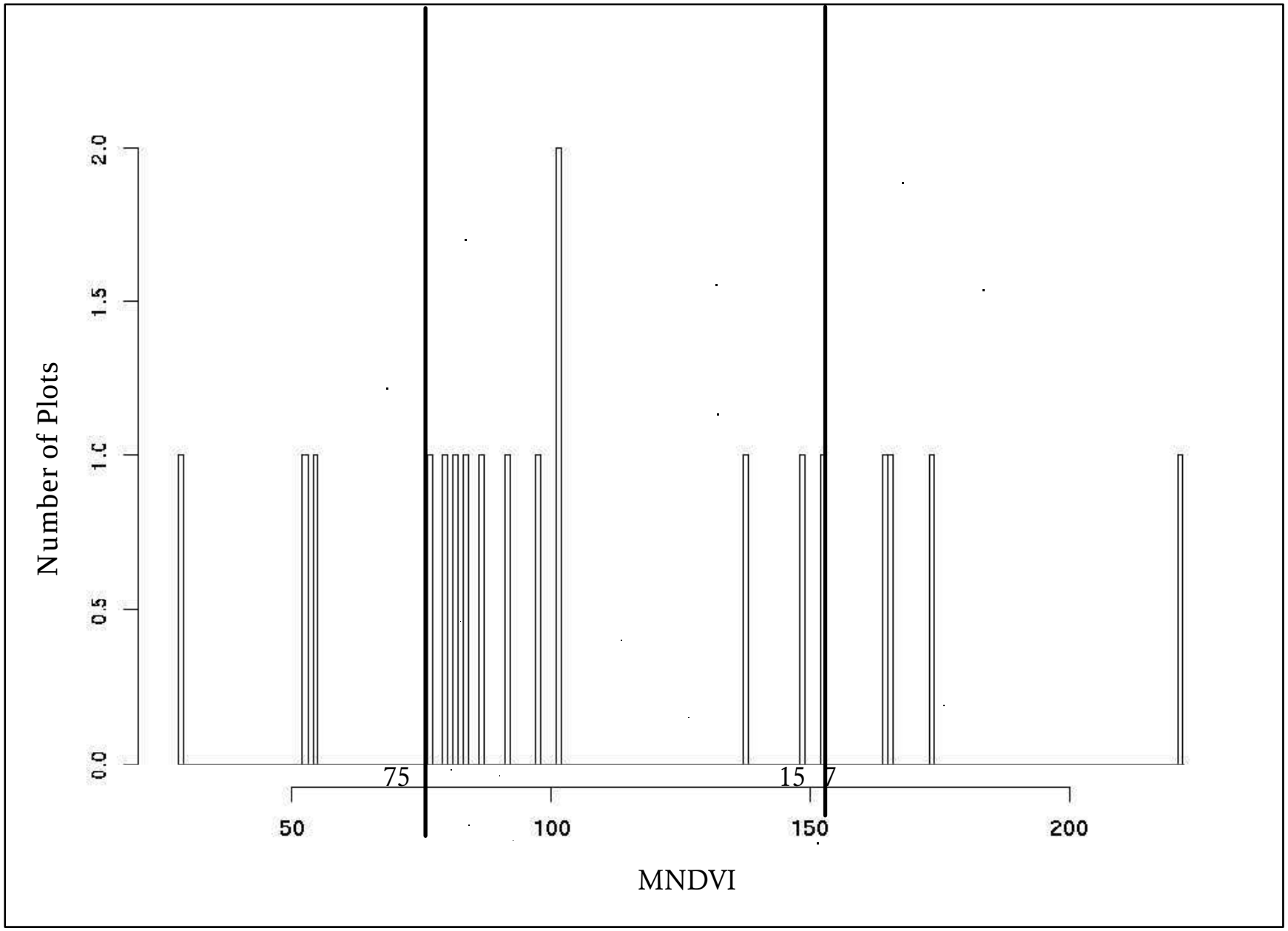


Figure F-13c. Breaks between xeric shrub canopy cover classes in relation to MNDVI values: TM scene P39/R27

Accuracy Assessment Tables for P39/R27 -- Cover Type

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3102	3104	3201	3303	3305	4101	4201	4203
3101	25(5)	0(3)	3(3)	0(1)	0(0)	0(1)	1(1)	0(1)	0(1)
3102	0(3)	1(5)	0(2)	1(1)	0(0)	0(1)	0(1)	0(1)	0(1)
3104	0(3)	0(3)	4(5)	0(1)	0(0)	0(1)	1(1)	0(1)	0(1)
3201	0(1)	0(1)	0(1)	7(5)	0(0)	0(2)	0(1)	0(1)	0(1)
3303	1(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
3305	1(1)	0(1)	0(1)	0(2)	0(0)	1(5)	0(1)	0(1)	0(1)
4101	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	2(5)	0(2)	0(2)
4201	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(2)	2(5)	0(2)
4203	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(2)	0(2)	9(5)
4205	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(2)	0(2)	0(2)
4206	2(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(2)	0(2)	0(2)
4208	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(2)	0(3)	0(2)
4212	0(1)	0(1)	0(1)	0(1)	0(0)	1(1)	0(2)	1(2)	0(2)
4214	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(2)	0(2)	0(2)
4219	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(2)	0(3)	0(3)
4220	0(1)	0(1)	0(1)	1(1)	0(0)	0(1)	0(2)	0(4)	0(3)
4222	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(2)	0(2)	0(2)
4223	0(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(2)	0(2)	0(3)
7301	4(1)	0(1)	0(1)	0(1)	0(0)	0(1)	0(1)	0(1)	0(1)
7800	0(2)	0(1)	1(1)	0(1)	0(0)	0(1)	0(1)	0(1)	0(1)
SUM	33(0)	1(0)	8(0)	9(0)	0(0)	2(0)	4(0)	3(0)	9(0)

RF/CF	4205	4206	4208	4212	4214	4219	4220	4222	4223
3101	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3104	0(1)	0(1)	1(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3303	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
3305	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4101	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4201	0(2)	0(2)	0(3)	0(2)	0(2)	0(3)	0(4)	0(2)	0(2)
4203	0(2)	1(2)	0(2)	0(2)	0(2)	0(3)	0(3)	0(2)	0(4)
4205	1(5)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(4)	0(2)
4206	0(2)	10(5)	0(2)	0(2)	0(2)	0(2)	0(2)	0(4)	0(2)
4208	0(2)	0(2)	1(5)	0(2)	0(2)	0(3)	0(3)	0(2)	0(2)
4212	0(2)	1(2)	0(2)	15(5)	0(2)	0(2)	1(3)	0(4)	1(4)
4214	0(2)	0(2)	0(2)	0(2)	1(5)	0(2)	0(2)	0(4)	0(2)
4219	0(2)	0(2)	0(3)	0(2)	0(2)	2(5)	0(3)	0(2)	0(2)
4220	0(2)	0(2)	0(3)	0(3)	0(2)	0(3)	6(5)	0(2)	0(3)
4222	0(3)	0(3)	0(2)	0(3)	0(3)	0(2)	0(2)	8(5)	0(2)
4223	0(2)	0(2)	0(2)	0(3)	0(2)	0(2)	0(3)	0(2)	2(5)
7301	0(1)	1(1)	0(1)	1(1)	0(1)	0(1)	0(1)	1(1)	0(1)
7800	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	1(0)	14(0)	2(0)	17(0)	1(0)	2(0)	7(0)	10(0)	3(0)

Accuracy Assessment Tables for P39/R27 -- Cover Type

RF/CF	7301	7800	SUM
3101	0(1)	0(1)	31(0)
3102	0(1)	0(1)	2(0)
3104	0(1)	0(1)	7(0)
3201	0(1)	0(1)	7(0)
3303	0(0)	0(0)	1(0)
3305	0(1)	0(1)	2(0)
4101	0(1)	0(1)	2(0)
4201	0(1)	0(1)	2(0)
4203	0(1)	0(1)	10(0)
4205	0(1)	0(1)	1(0)
4206	0(1)	0(1)	12(0)
4208	0(1)	0(1)	1(0)
4212	0(1)	0(1)	20(0)
4214	0(1)	0(1)	1(0)
4219	0(1)	0(1)	2(0)
4220	0(1)	0(1)	7(0)
4222	0(1)	0(1)	8(0)
4223	0(1)	0(1)	2(0)
7301	7(5)	0(3)	14(0)
7800	0(3)	1(5)	2(0)
SUM	7(0)	1(0)	134(0)

Diagonal Elements = 105; Total Test Points = 134
Percentage Agreement = 78.36; Kappa = 0.756; Tau w/equal Prob = 0.772

Accuracy Assessment Tables for P39/R27 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	25	80.65	0	0.00	3	9.68	0	0.00	3	9.68
3102	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
3104	4	57.14	0	0.00	0	0.00	0	0.00	3	42.86
3201	7	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3303	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3305	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4101	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4201	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	9	90.00	0	0.00	0	0.00	1	10.00	0	0.00
4205	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4206	10	83.33	0	0.00	0	0.00	0	0.00	2	16.67
4208	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4212	15	75.00	1	5.00	1	5.00	2	10.00	1	5.00
4214	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4219	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4220	6	85.71	0	0.00	0	0.00	0	0.00	1	14.29
4222	8	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4223	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
7301	7	50.00	0	0.00	0	0.00	0	0.00	7	50.00
7800	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
SUM	105	78.36	1	0.75	4	2.99	3	2.24	20	14.93

Accuracy Assessment Tables for P39/R27 -- Cover Type

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	25	80.65	25	80.65	28	90.32	28	90.32	31	100.00
3102	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
3104	4	57.14	4	57.14	4	57.14	4	57.14	7	100.00
3201	7	100.00	7	100.00	7	100.00	7	100.00	7	100.00
3303	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3305	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4101	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4201	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4203	9	90.00	9	90.00	9	90.00	10	100.00	10	100.00
4205	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4206	10	83.33	10	83.33	10	83.33	10	83.33	12	100.00
4208	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4212	15	75.00	16	80.00	17	85.00	19	95.00	20	100.00
4214	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4219	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4220	6	85.71	6	85.71	6	85.71	6	85.71	7	100.00
4222	8	100.00	8	100.00	8	100.00	8	100.00	8	100.00
4223	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
7301	7	50.00	7	50.00	7	50.00	7	50.00	14	100.00
7800	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
SUM	105	78.36	106	79.10	110	82.09	113	84.33	133	99.25

Accuracy Assessment Tables for P39/R27 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	25	75.76	0	0.00	0	0.00	0	0.00	7	21.21
3102	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3104	4	50.00	0	0.00	3	37.50	0	0.00	1	12.50
3201	7	77.78	0	0.00	0	0.00	0	0.00	2	22.22
3303	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3305	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4101	2	50.00	0	0.00	0	0.00	0	0.00	2	50.00
4201	2	66.67	0	0.00	0	0.00	1	33.33	0	0.00
4203	9	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4205	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4206	10	71.43	0	0.00	0	0.00	2	14.29	2	14.29
4208	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4212	15	88.24	0	0.00	0	0.00	0	0.00	2	11.76
4214	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4219	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4220	6	85.71	0	0.00	1	14.29	0	0.00	0	0.00
4222	8	80.00	0	0.00	0	0.00	0	0.00	2	20.00
4223	2	66.67	1	33.33	0	0.00	0	0.00	0	0.00
7301	7	100.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	105	78.36	1	0.75	4	2.99	3	2.24	20	14.93

Accuracy Assessment Tables for P39/R27 -- Cover Type

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	25	75.76	25	75.76	25	75.76	25	75.76	32	96.97
3102	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
3104	4	50.00	4	50.00	7	87.50	7	87.50	8	100.00
3201	7	77.78	7	77.78	7	77.78	7	77.78	9	100.00
3303	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3305	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4101	2	50.00	2	50.00	2	50.00	2	50.00	4	100.00
4201	2	66.67	2	66.67	2	66.67	3	100.00	3	100.00
4203	9	100.00	9	100.00	9	100.00	9	100.00	9	100.00
4205	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4206	10	71.43	10	71.43	10	71.43	12	85.71	14	100.00
4208	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4212	15	88.24	15	88.24	15	88.24	15	88.24	17	100.00
4214	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4219	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4220	6	85.71	6	85.71	7	100.00	7	100.00	7	100.00
4222	8	80.00	8	80.00	8	80.00	8	80.00	10	100.00
4223	2	66.67	3	100.00	3	100.00	3	100.00	3	100.00
7301	7	100.00	7	100.00	7	100.00	7	100.00	7	100.00
7800	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	105	78.36	106	79.10	110	82.09	113	84.33	133	99.25

Accuracy Assessment Tables for P39/R27 -- Cover Type

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	411	80.65	0	0.00	49	9.68	0	0.00	49	9.68
3102	16	50.00	0	0.00	0	0.00	0	0.00	16	50.00
3104	8	57.14	0	0.00	0	0.00	0	0.00	6	42.86
3201	84	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3303	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3305	9	50.00	0	0.00	0	0.00	0	0.00	9	50.00
4101	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4201	10	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	36	90.00	0	0.00	0	0.00	4	10.00	0	0.00
4205	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4206	85	83.33	0	0.00	0	0.00	0	0.00	17	16.67
4208	6	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4212	47	75.00	3	5.00	3	5.00	6	10.00	3	5.00
4214	6	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4219	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4220	25	85.71	0	0.00	0	0.00	0	0.00	4	14.29
4222	42	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4223	7	100.00	0	0.00	0	0.00	0	0.00	0	0.00
7301	6	50.00	0	0.00	0	0.00	0	0.00	6	50.00
7800	8	50.00	0	0.00	0	0.00	0	0.00	8	50.00
SUM	812	81.61	3	0.30	52	5.23	10	1.01	118	11.86

Accuracy Assessment Tables for P39/R27 -- Cover Type

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	411	80.65	411	80.65	461	90.32	461	90.32	510	100.00
3102	16	50.00	16	50.00	16	50.00	16	50.00	32	100.00
3104	8	57.14	8	57.14	8	57.14	8	57.14	15	100.00
3201	84	100.00	84	100.00	84	100.00	84	100.00	84	100.00
3303	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3305	9	50.00	9	50.00	9	50.00	9	50.00	17	100.00
4101	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4201	10	100.00	10	100.00	10	100.00	10	100.00	10	100.00
4203	36	90.00	36	90.00	36	90.00	40	100.00	40	100.00
4205	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4206	85	83.33	85	83.33	85	83.33	85	83.33	102	100.00
4208	6	100.00	6	100.00	6	100.00	6	100.00	6	100.00
4212	47	75.00	50	80.00	53	85.00	60	95.00	63	100.00
4214	6	100.00	6	100.00	6	100.00	6	100.00	6	100.00
4219	3	100.00	3	100.00	3	100.00	3	100.00	3	100.00
4220	25	85.71	25	85.71	25	85.71	25	85.71	29	100.00
4222	42	100.00	42	100.00	42	100.00	42	100.00	42	100.00
4223	7	100.00	7	100.00	7	100.00	7	100.00	7	100.00
7301	6	50.00	6	50.00	6	50.00	6	50.00	12	100.00
7800	8	50.00	8	50.00	8	50.00	8	50.00	17	100.00
SUM	812	81.36	815	81.66	868	86.97	879	88.08	998	100.00

Accuracy Assessment Tables for P39/R27 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	2(5)	2(3)	2(1)	6(0)
2	1(3)	11(5)	17(3)	29(0)
3	5(1)	7(3)	24(5)	36(0)
SUM	8(0)	20(0)	43(0)	71(0)

Diagonal Elements = 37; Total Test Points = 71
Percentage Agreement = 52.11; Kappa = 0.157; Tau w/equal Prob = 0.282

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	33.33	0	0.00	2	33.33	0	0.00	2	33.33
2	11	37.93	0	0.00	18	62.07	0	0.00	0	0.00
3	24	66.67	0	0.00	7	19.44	0	0.00	5	13.89
SUM	37	52.11	0	0.00	27	38.03	0	0.00	7	9.86

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	33.33	2	33.33	4	66.67	4	66.67	6	100.00
2	11	37.93	11	37.93	29	100.00	29	100.00	29	100.00
3	24	66.67	24	66.67	31	86.11	31	86.11	36	100.00
SUM	37	52.11	37	52.11	64	90.14	64	90.14	71	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	25.00	0	0.00	1	12.50	0	0.00	5	62.50
2	11	55.00	0	0.00	9	45.00	0	0.00	0	0.00
3	24	55.81	0	0.00	17	39.53	0	0.00	2	4.65
SUM	37	52.11	0	0.00	27	38.03	0	0.00	7	9.86

Accuracy Assessment Tables for P39/R27 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	25.00	2	25.00	3	37.50	3	37.50	8	100.00
2	11	55.00	11	55.00	20	100.00	20	100.00	20	100.00
3	24	55.81	24	55.81	41	95.35	41	95.35	43	100.00
SUM	37	52.11	37	52.11	64	90.14	64	90.14	71	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	33.33	0	0.00	20	33.33	0	0.00	20	33.33
2	126	37.93	0	0.00	205	62.07	0	0.00	0	0.00
3	406	66.67	0	0.00	118	19.44	0	0.00	85	13.89
SUM	552	55.20	0	0.00	343	34.30	0	0.00	105	10.50

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	33.33	20	33.33	40	66.67	40	66.67	60	100.00
2	126	37.93	126	37.93	331	100.00	331	100.00	331	100.00
3	406	66.67	406	66.67	524	86.11	524	86.11	609	100.00
SUM	552	55.20	552	55.20	895	89.50	895	89.50	1000	100.00

Accuracy Assessment Tables for P39/R27 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	SUM
1	4(5)	2(3)	6(0)
2	1(3)	2(5)	3(0)
SUM	5(0)	4(0)	9(0)

Diagonal Elements = 6; Total Test Points = 9
Percentage Agreement = 66.67; Kappa = 0.308; Tau w/equal Prob = 0.333

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	66.67	0	0.00	2	33.33	0	0.00	0	0.00
2	2	66.67	0	0.00	1	33.33	0	0.00	0	0.00
SUM	6	66.67	0	0.00	3	33.33	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	66.67	4	66.67	6	100.00	6	100.00	6	100.00
2	2	66.67	2	66.67	3	100.00	3	100.00	3	100.00
SUM	6	66.67	6	66.67	9	100.00	9	100.00	9	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	80.00	0	0.00	1	20.00	0	0.00	0	0.00
2	2	50.00	0	0.00	2	50.00	0	0.00	0	0.00
SUM	6	66.67	0	0.00	3	33.33	0	0.00	0	0.00

Accuracy Assessment Tables for P39/R27 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	4	80.00	4	80.00	5	100.00	5	100.00	5	100.00
2	2	50.00	2	50.00	4	100.00	4	100.00	4	100.00
SUM	6	66.67	6	66.67	9	100.00	9	100.00	9	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	412	66.67	0	0.00	206	33.33	0	0.00	0	0.00
2	254	66.67	0	0.00	127	33.33	0	0.00	0	0.00
SUM	666	66.60	0	0.00	333	33.30	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	412	66.67	412	66.67	619	100.00	619	100.00	619	100.00
2	254	66.67	254	66.67	381	100.00	381	100.00	381	100.00
SUM	666	66.60	666	66.60	1000	100.00	1000	100.00	1000	100.00

Accuracy Assessment Tables for P39/R27 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	19(5)	8(3)	3(1)	30(0)
2	4(3)	18(5)	5(3)	27(0)
3	2(1)	2(3)	2(5)	6(0)
SUM	25(0)	28(0)	10(0)	63(0)

Diagonal Elements = 39; Total Test Points = 63
Percentage Agreement = 61.90; Kappa = 0.371; Tau w/equal Prob = 0.429

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	19	63.33	0	0.00	8	26.67	0	0.00	3	10.00
2	18	66.67	0	0.00	9	33.33	0	0.00	0	0.00
3	2	33.33	0	0.00	2	33.33	0	0.00	2	33.33
SUM	39	61.90	0	0.00	19	30.16	0	0.00	5	7.94

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	19	63.33	19	63.33	27	90.00	27	90.00	30	100.00
2	18	66.67	18	66.67	27	100.00	27	100.00	27	100.00
3	2	33.33	2	33.33	4	66.67	4	66.67	6	100.00
SUM	39	61.90	39	61.90	58	92.06	58	92.06	63	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	19	76.00	0	0.00	4	16.00	0	0.00	2	8.00
2	18	64.29	0	0.00	10	35.71	0	0.00	0	0.00
3	2	20.00	0	0.00	5	50.00	0	0.00	3	30.00
SUM	39	61.90	0	0.00	19	30.16	0	0.00	5	7.94

Accuracy Assessment Tables for P39/R27 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	19	76.00	19	76.00	23	92.00	23	92.00	25	100.00
2	18	64.29	18	64.29	28	100.00	28	100.00	28	100.00
3	2	20.00	2	20.00	7	70.00	7	70.00	10	100.00
SUM	39	61.90	39	61.90	58	92.06	58	92.06	63	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	297	63.33	0	0.00	125	26.67	0	0.00	47	10.00
2	301	66.67	0	0.00	150	33.33	0	0.00	0	0.00
3	27	33.33	0	0.00	27	33.33	0	0.00	27	33.33
SUM	625	62.44	0	0.00	302	30.17	0	0.00	74	7.39

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	297	63.33	297	63.33	422	90.00	422	90.00	469	100.00
2	301	66.67	301	66.67	451	100.00	451	100.00	451	100.00
3	27	33.33	27	33.33	53	66.67	53	66.67	80	100.00
SUM	625	62.50	625	62.50	926	92.60	926	92.60	1000	100.00

Accuracy Assessment Tables for P39/R27 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	2(5)	3(3)	1(1)	6(0)
2	2(3)	2(5)	0(3)	4(0)
3	0(1)	1(3)	0(5)	1(0)
SUM	4(0)	6(0)	1(0)	11(0)

Diagonal Elements = 4; Total Test Points = 11
Percentage Agreement = 36.36; Kappa = -0.069; Tau w/equal Prob = 0.045

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	33.33	0	0.00	3	50.00	0	0.00	1	16.67
2	2	50.00	0	0.00	2	50.00	0	0.00	0	0.00
3	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
SUM	4	36.36	0	0.00	6	54.55	0	0.00	1	9.09

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	33.33	2	33.33	5	83.33	5	83.33	6	100.00
2	2	50.00	2	50.00	4	100.00	4	100.00	4	100.00
3	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
SUM	4	36.36	4	36.36	10	90.91	10	90.91	11	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	50.00	0	0.00	2	50.00	0	0.00	0	0.00
2	2	33.33	0	0.00	4	66.67	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	4	36.36	0	0.00	6	54.55	0	0.00	1	9.09

Accuracy Assessment Tables for P39/R27 -- Shrub Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	50.00	2	50.00	4	100.00	4	100.00	4	100.00
2	2	33.33	2	33.33	6	100.00	6	100.00	6	100.00
3	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	4	36.36	4	36.36	10	90.91	10	90.91	11	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	53	33.33	0	0.00	79	50.00	0	0.00	26	16.67
2	305	50.00	0	0.00	305	50.00	0	0.00	0	0.00
3	0	0.00	0	0.00	231	100.00	0	0.00	0	0.00
SUM	358	35.84	0	0.00	615	61.56	0	0.00	26	2.60

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	53	33.33	53	33.33	132	83.33	132	83.33	159	100.00
2	305	50.00	305	50.00	610	100.00	610	100.00	610	100.00
3	0	0.00	0	0.00	231	100.00	231	100.00	231	100.00
SUM	358	35.80	358	35.80	973	97.30	973	97.30	1000	100.00

Scene P39/R27 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	92199.0	1048792.1	30.8
1000	460.0	7579.6	0.2
2000	50890.0	621751.9	18.3
3101	54845.0	711025.7	20.9
3102	3259.0	68847.3	2.0
3104	4143.0	33497.5	1.0
3201	15655.0	179168.7	5.3
3303	329.0	3651.7	0.1
3305	3453.0	39296.6	1.2
4101	623.0	5022.4	0.1
4201	1564.0	21918.7	0.6
4203	6698.0	90425.8	2.7
4205	261.0	2374.6	0.1
4206	15899.0	179815.8	5.3
4208	1513.0	13797.3	0.4
4212	14105.0	139384.8	4.1
4214	814.0	7566.2	0.2
4219	991.0	7297.4	0.2
4220	3918.0	66503.2	2.0
4221	900.0	6317.6	0.2
4222	8635.0	91483.6	2.7
4223	1805.0	17010.5	0.5
5000	3958.0	15310.1	0.4
7300	2166.0	13240.0	0.4
7800	1591.0	13970.9	0.4
9100	11.0	79.6	0.0

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	92199.0	1048792.1	30.8
Not tree/shrub	121323.0	1485302.3	43.6
Shrub 1	2902.0	35465.0	1.0
Shrub 2	10967.0	137923.6	4.1
Shrub 3	5568.0	48728.4	1.4
Tree 1	31538.0	273380.1	8.0
Tree 2	19608.0	318546.6	9.4
Tree 3	6580.0	56990.9	1.7

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	92199.0	1048792.1	30.8
Not tree/shrub	121323.0	1485302.3	43.6
Tree 1	4221.0	38062.4	1.1
Tree 2	19464.0	222696.2	6.5
Tree 3	34041.0	388159.0	11.4
Shrub 1	12773.0	138444.2	4.1
Shrub 2	6664.0	83672.8	2.5

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	92199.0	1048792.1	30.8
A	50890.0	621751.9	18.3
H	62247.0	813370.4	23.9
N	8186.0	50180.1	1.5
S	19437.0	222117.0	6.5
T	57726.0	648917.6	19.1

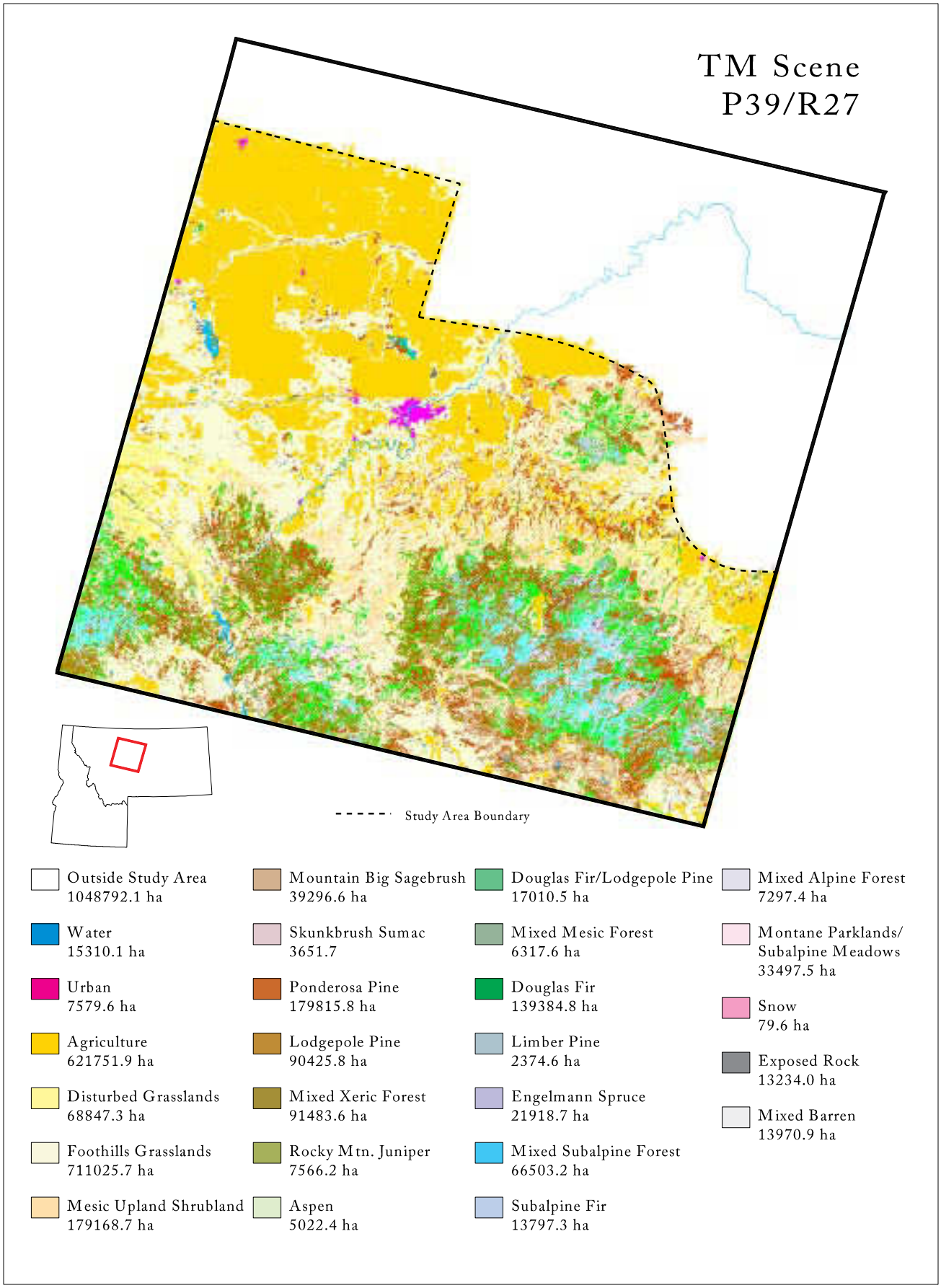


Figure F-13. Classification of land cover types for TM Scene P39/R27.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P39/R27

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4201: ENGELMANN SPRUCE FOREST

Conifer forest dominated by Engelmann spruce (Picea engelmannii) ranging from 5250 to 7700 feet in elevation. The average canopy cover is 48%, ranging from 30-70% total cover and frequency of occurrence equal to 77%. Primary associated tree species include subalpine fir (Abies lasiocarpa), lodgepole pine (Pinus contorta), and Douglas-fir (pseudotsuga menziesii) with average percent cover ≥5% and ≤9% and frequency of occurrence ≥31% and ≤46%.

Primary associated shrub species, each with frequency of occurrence ≥15% and ≤46% in Engelmann spruce stands: common juniper, (Juniperus communis), twin flower (Linnaea borealis), gooseberry (Ribes spp.), rose (Rosa spp.), booth willow (Salix boothii), common snowberry (Symphoricarpos albus), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern and moss species with ≥8% and ≤31% frequency of occurrence in Engelmann spruce stands: **graminoids**: bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), sheep sedge (Carex iliota), beaked sedge (Carex utriculata), Baltic rush (Juncus balticus), and common timothy (Phleum pratense); **forbs**: Virginia strawberry (Fragaria virginiana), northern bedstraw (Galium boreale), white geranium (Geranium richardsonii), starry Solomon-plume (Smilacina stellata), common dandelion (Taraxacum officinale), western meadowrue (Thalictrum occidentale), and Canada violet (Viola canadensis); **ferns**: field horsetail (Equisetum arvense), and horsetail (Equisetum spp.); **moss:** moss (moss spp.).

2) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 4050 to 7500 feet in elevation. The average canopy cover is 36% ranging from 20-70% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤6% and frequency of occurrence ≥16% and ≤43%.

Primary associated shrub species with ≥8% and ≤%32 frequency of occurrence in lodgepole pine stands: kinnikinnick (Arctostaphylos uva-ursi), Oregon grape (Berberis spp.), common juniper (Juniperus communis), honeysuckle (Lonicera spp.), spiraea (Spiraea spp.), huckleberry (Vaccinium spp.), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤20% frequency of occurrence in lodgepole pine stands: **graminoids**: purple reedgrass (Calamagrostis purpurascens), pinegrass (Calamagrostis rubescens), sedge (Carex), elk sedge (Carex geyeri), rough fescue (Festuca scabrella), and common timothy (Phleum pratense); **forbs**: heart-leaf arnica (Arnica cordifolia), arnica (Arnica spp.), broadleaf arnica

(Arnica latifolia), silvery lupine (Lupinus argenteus), toothleaf pyrola (Pyrola dentata), one-sided wintergreen (Pyrola secunda), and beargrass (Xerophyllum tenax); **ferns**: stiff clubmoss (Lycopodium annotinum) and clubmoss (Lycopodium spp.); **moss**: moss (moss spp.).

3) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 3920 to 6090 feet in elevation. The average canopy cover is 32% ranging from 20-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤6% and frequency of occurrence ≥8% and ≤60%.

Primary associated shrub species with ≥10% and ≤20% frequency of occurrence in ponderosa pine stands: kinnikinnick (Arctostaphylos uva-ursi), fringed sagewort (Artemisia frigida), common juniper (Juniperus communis), creeping juniper (Juniperus horizontalis), Wood's rose (Rosa woodsii), Canada buffaloberry (Shepherdia canadensis), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤28% frequency of occurrence in ponderosa pine stands: **graminoids**: bearded wheatgrass (Agropyron caninum), bluebunch wheatgrass (Agropyron spicatum), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), prairie junegrass (Koeleria cristata), Kentucky bluegrass (Poa pratensis), and needle-and-thread (Stipa comata); **forbs**: bastard toad-flax (Comandra umbellata), common hound's-tongue (Cynoglossum officinale), northern bedstraw (Galium boreale), western gromwell (Lithospermum ruderale), yellow sweet-clover (melilotus officinalis), common dandelion (Taraxacum officinale), mountain thermopsis (Thermopsis montana), and goat's beard (Tragopogon dubius); **ferns**: none; **moss**: none.

4**) 4212: DOUGLAS FIR FOREST**

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 3950 to 7600 feet in elevation. The average canopy cover is 53% ranging from 10-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), limber pine (Pinus flexilis) with average percent cover ≥4% and ≤7% and frequency of occurrence ≥15% and ≤27%.

Primary associated shrub species with ≥12% and ≤45% frequency of occurrence in Douglas-fir stands: kinnikinnick (Arctostaphylos uva-ursi), Oregon grape (Berberis spp.), common juniper (Juniperus communis), rose (Rosa spp.), shiny-leaf spiraea (Spiraea betulifolia), spiraea (Spiraea spp.), and snowberry (Symphoricarpos spp.).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤15% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), timber oatgrass (Danthonia intermedia), Idaho fescue (Festuca idahoensis), rough fescue

(Festuca scabrella), and Kentucky bluegrass (Poa pratensis); **forbs**: common yarrow (Achillea millefolium), heart-leaf arnica (Arnica cordifolia), Virginia strawberry (Fragaria virginiana), northern bedstraw (Galium boreale), sticky geranium (Geranium viscosissimum), common dandelion (Taraxacom officinale), and western meadowrue (Thalictrum occidentale); **ferns**: stiff clubmoss (Lycopodium annotinum); **moss**: moss (moss spp.)

5) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albicaulis) and ranging from 6340 to 8500 feet in elevation. The average canopy cover is 25% ranging from 10-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥5% and ≤17% and frequency of occurrence ≥36% and ≤71%.

Primary associated shrub species with ≥7% and ≤43% frequency of occurrence in mixed whitebark pine stands: kinnikinnick (Arctostaphylos uva-ursi), common juniper (Juniperus communis), shrubby cinquefoil (Potentilla fruticosa), huckleberry (Vaccinium spp.), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤14% frequency of occurrence in mixed whitebark pine stands: **graminoids:** bearded wheatgrass (Agropyron caninum), western wheatgrass (Agropyron smithii), mountain brome (Bromus carinatus), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), prairie junegrass (Koeleria cristata), western needlegrass (Stipa occidentalis); **forbs**: small-flowered anemone (Anemone parviflora), giant frasera (Frasera speciosa), northern bedstraw (Galium boreale), riparian crazyweed (Oxytropis riperia), western meadowrue (Thalictrum occidentale), pioneer violet (Viola glabella), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: none.

6) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 5560 to 7750 feet in elevation. The average canopy cover is 26% ranging from 3-60% total cover and frequency of occurrence equal to 97%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥18% and ≤20% and frequency of occurrence ≥47% and ≤78%.

Primary associated shrub species with ≥6% and ≤34% frequency of occurrence in mixed subalpine stands: Oregon grape (Berberis spp.), common juniper (Juniperus communis), twin flower (Linnaea borealis), spiraea (Spiraea spp.), snowberry (Symphoricarpos spp.), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤31% frequency of occurrence in mixed subalpine fir stands: **graminoids**: pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), common timothy (Phleum pratense), muttongrass (Poa fendleriana), pale-leaf bluegrass (Poa glaucifolia), and Kentucky bluegrass (Poa pratensis); **forbs**: heart-leaf arnica (Arnica

cordifolia), woods strawberry (Fragaria vesca), starry solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), violet (Viola spp.), western canadian violet (Viola rugulosa), and beargrass (Xerophyllum tenax); **ferns**: stiff clubmoss (Lycopodium annotinum); **moss**: moss (moss spp.).

7) 4222: MIXED XERIC FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa), codominant species are rocky mountain juniper (Juniperus scopulorum), and limber pine (Pinus flexilis), ranging from 3680 to 7320 feet in elevation. The average canopy cover for PINPON is 13% ranging from 1-30% total cover and frequency of occurrence equal to 72%. The average canopy cover for JUNSCO is 11% ranging from 1-24% total cover and frequency of occurrence equal to 56%. The average canopy cover for PINFLE is 13% ranging from 1-30% total cover and frequency of occurrence equal to 44%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥14% and ≤25% and frequency of occurrence ≥8% and ≤92%.

Primary associated shrub species with ≥8% and ≤40% frequency of occurrence in mixed xeric stands: kinnikinnick (Arctostaphylos uva-ursi), fringed sagewort (Artemisia frigida), creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), creeping juniper (Juniperus horizontalis), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤28% frequency of occurrence in mixed xeric stands: **graminoids**: thick-spiked wheatgrass (Agropyron dasystachyum), bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), Idaho fescue (Festuca idahoensis), rough fescue (Festuca scabrella), prairie junegrass (Koeleria cristata), western needlegrass (Stipa occidentalis); **forbs**: common yarrow (Achillea millefolium), rosy pussy-toes (Antennaria microphylla), field chickweed (Cerastium arvense), Virginia strawberry (Fragaria virginiana), western gromwell (Lithospermum ruderale), Missouri goldenrod (Solidago missouriensis), and common dandelion (Taraxacom officinale); **ferns**: stiff clubmoss (Lycopodium annotinum) and compact selaginella (Selaginella densa); **moss**: none.

8) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) and ranging from 5060 to 7100 feet in elevation. The average canopy cover for PINCON is 21% ranging from 10-40% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 25% ranging from 10-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and ponderosa pine (Pinus ponderosa) with average percent cover ≥3% and ≤10% and frequency of occurrence ≥7% and ≤14%.

Primary associated shrub species with ≥21% and ≤43% frequency of occurrence in Douglas-fir-lodgepole pine stands: creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), rose (Rosa spp.), shiny-leaf spiraea (Spiraea betulifolia),

spiraea (Spiraea spp.), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤36% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), and Idaho fescue (Festuca idahoensis); **forbs**: rosy pussy-toes (Antennaria microphylla), heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), lupine (Lupinus spp.), and beargrass (Xerophyllum tenax); **ferns**: none; **moss**: moss (moss spp.).

RIPARIAN CLASSIFICATION P39/R27

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	10
6102	Broadleaf Dominated Riparian	14
6103	Needleleaf-Broadleaf Riparian	None identified for scene
6104	Mixed Riparian (trees + any other)	None identified for scene
6201	Grass-Forb Riparian/Wetland	7, 15
6202	Shrub Riparian/Wetland	22, 23, 32
6203	Mixed Grass-Forb-Shrub Riparian	None identified for scene

---

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 1
Color: Olive drab; RGB 135 129 103.
Distribution: Widely distributed with high density on foothills, light density on mountains, and widely spaced clusters on level ground; some near streams but not linear.
Comment: Herbaceous cover types dominate training data outside the calculated riparian zone. Conifers, shrubs, and riparian vegetation (6201, 6102, 6202) were also recorded. Visual cues suggest dry grass.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
1	5	Urban & Developed Land
2	3	Foothills Grassland
3	1	Greasewood
4	2	Ponderosa Pine & Savannah
5	1	Grass-Forb Riparian/Wetland
6	1	Shrub Riparian/Wetland
7	1	Shoreline & Gravel Bars

Spectral Class 2
Color: Rust; RGB 145 102 86.
Distribution: Similar to Spectral Class 1.
Comment: Mesic Upland Shrubland has the highest frequency of any cover type outside the zone, but the combined frequencies of herbaceous cover types are higher than the combined frequencies of shrub covers. Riparian vegetation (6202, 6101, 6201, 6102) are more prevalent in the data than conifers. Distribution locations are generally on the outskirts of riparian areas.
Conclusion: Not riparian.

8	1	Urban & Developed Land
9	1	Irrigated Pasture
10	2	Foothills Grassland

11	1	Disturbed Grassland
12	1	Mesic Upland Shrubland
13	1	Mixed Xeric Forest
14	1	Needleleaf Dominated Riparian
15	2	Broadleaf Dominated Riparian
16	2	Grass-Forb Riparian/Wetland
17	5	Shrub Riparian/Wetland

Spectral Class 4
Color: Blue cyan; RGB 116 228 255.
Distribution: Located primarily in agricultural areas; though some occurs near streams.
Comment: Foothills Grassland has the highest frequency in training data outside the zone; appears to be plowed fields and dry pasture.
Conclusion: Not riparian.

19	1	Lakes
20	1	Grass-Forb Riparian/Wetland
21	1	Mines, Quarries, Gravel Pits

Spectral Class 6
Color: Olive; RGB 116 166 133.
Distribution: A large class, widely distributed at lower elevations occurring near streams and fringes of agricultural lands.
Comment: Herbaceous vegetation was the most observed cover type outside the zone; conifers, rock, mines or quarries, and riparian vegetation (6102) were noted as well. Distribution and color suggest sagebrush.
Conclusion: Not riparian.

22	1	Dry-land Pasture
23	1	Broadleaf Dominated Riparian

Spectral Class 7
Color: China red; RGB 245 80 82.
Distribution: Light to medium density on foothills, and dense clusters in agricultural areas; some near streams.
Comment: Herbaceous cover types account for nearly all training sites outside the zone. In descending order, riparian (6202, 6201), grassland and meadow, agricultural, and Mesic Upland Shrubland cover types were observed. Appears to be grass, riparian within the zone.
Conclusion: 6201.

24	1	Mesic Upland Shrubland
25	1	Shrub Riparian/Wetland

Spectral Class 10
Color: Cool brown; RGB 116 96 108.
Distribution: Light to medium density on mountains and below foothills; some clusters in agricultural areas, and some near streams.
Comment: Coniferous and riparian (6102, 6201, 6103, 6202, 6101) cover types dominate training data outside the zone.
Conclusion: 6101.

26	1	Foothills Grassland
27	4	Needleleaf Dominated Riparian
28	1	Grass-Forb Riparian/Wetland
29	1	Shrub Riparian/Wetland

Spectral Class 14
Color: Red; RGB 210 65 73.
Distribution: Clusters in agricultural areas with very light density elsewhere; some near streams.
Comment: Aspen and riparian (6202, 6102, 6201) cover types were most recorded outside the zone.
Conclusion: 6102.

32	1	Engelmann Spruce
33	2	Grass-Forb Riparian/Wetland
34	2	Shrub Riparian/Wetland

Spectral Class 15
Color: Terracotta; RGB 194 88 104.
Distribution: A large class, occurring with medium density on foothills and clusters in agricultural areas; some near streams. Light density on mountains.
Comment: Foothills Grassland is most prevalent in training data outside the zone; riparian (6103, 6201, 6202), agricultural, shrub, Aspen, and coniferous cover types are present.
Conclusion: 6201.

35	1	Foothills Grassland
36	1	Douglas Fir
37	1	Broadleaf Dominated Riparian
38	1	Grass-Forb Riparian/Wetland
39	3	Shrub Riparian/Wetland
40	1	Shoreline & Gravel Bars

Spectral Class 18
Color: Teal blue; RGB 61 104 121.
Distribution: Light density on mountains and some clusters in agricultural areas; medium density on some low slopes, including either side of Arrow Creek.
Comment: Conifers and grass are most prevalent in training data outside the zone; rock, barren, mines or quarries, and riparian vegetation (6202) are minimally present. Appears to be dry shrubs.
Conclusion: Not riparian.

42	1	Reservoirs
43	1	Shrub Riparian/Wetland

Spectral Class 19
Color: Dark warm brown; RGB 100 24 56.
Distribution: Medium density on lower mid-elevation slopes; isolated clusters in agricultural areas; light density along portions of some streams.
Comment: Conifers dominate training sites outside the zone; riparian (6101, 6102, 6201), grassland, shrub, and Aspen cover types are included. Appears to represent conifers, shadows, and water features.
Conclusion: Not riparian.

44	4	Needleleaf Dominated Riparian
45	1	Shrub Riparian/Wetland

Spectral Class 20
Color: Blue; RGB 60 95 172.
Distribution: Light density on mountains, along some streams, and some low slopes.
Comment: Exposed Rock has the highest frequency of any cover type outside the zone; shrubs and conifers are equally represented in the data. Visual cues suggest rock and urban areas.
Conclusion: Not riparian.

46	1	Needleleaf Dominated Riparian

Spectral Class 21
Color: Black; RGB 55 35 48.
Distribution: High density spackle on mountain slopes; some in lakes or near streams.
Comment: Conifer and riparian (6101, 6201, 6103, 6202) characterize the class outside the zone. Appears to be shadows.
Conclusion: Not riparian.

47	1	Mountain Big Sagebrush

48	3	Needleleaf Dominated Riparian
49	1	Broadleaf Dominated Riparian
50	1	Shrub Riparian/Wetland

Spectral Class 22
Color: Orange; RGB 236 133 86.
Distribution: Medium to high density coverage on foothills; some clusters in agricultural areas; some near the Missouri River.
Comment: Herbaceous life forms are most prevalent in data outside the zone; riparian (6202, 6201) and other cover types are present. Color and locations suggest Shrub Riparian/Wetland.
Conclusion: 6202.

51	2	Urban & Developed Land
52	1	Dry-land Pasture
53	1	Mesic Upland Shrubland
54	1	Grass-Forb Riparian/Wetland

Spectral Class 23
Color: Red orange; RGB 255 102 91.
Distribution: Medium density on foothills; clusters in agricultural areas; some near the Sun and Missouri rivers.
Comment: Outside the riparian zone, agriculture is the dominant type of vegetation; grass and shrubs are also present. No training sites occur within the zone.
Conclusion: 6202.

Spectral Class 28
Color: Dark orange; RGB 255 92 65.
Distribution: Occasional clusters, usually small, at lower elevations; some near rivers.
Comment: All training sites outside the zone indicate agricultural vegetation. There are no training sites within the zone for this spectral class.
Conclusion: Not riparian.

Spectral Class 32
Color: Red orange; RGB 223 78 78.
Distribution: Medium density on foothills; clusters in agricultural areas; some near rivers.
Comment: Riparian vegetation (6201, 6202, 6102) and Foothills Grassland characterize training data outside the zone.
Conclusion: 6202.

61	1	Irrigated Pasture
62	1	Needleleaf-Broadleaf Riparian
63	2	Grass-Forb Riparian/Wetland

64	3	Shrub Riparian/Wetland

Spectral Class 33
Color: Dark blue; RGB 0 0 121.
Distribution: Water.
Comment: The single training site outside the zone represents a lake.
Conclusion: Not riparian.

65	1	Reservoirs
66	1	Grass-Forb Riparian/Wetland

Spectral Class 35
Color: Very dark brown; RGB 77 33 56.
Distribution: Dense spackle at mid-elevations; some in water.
Comment: Coniferous and riparian (6101, 6202, 6201) cover types account for most observations outside the riparian zone.
Conclusion: Not riparian.

67	1	Foothills Grassland
68	3	Needleleaf Dominated Riparian
69	1	Grass-Forb Riparian/Wetland
70	3	Shrub Riparian/Wetland

Spectral Class 36
Color: Dark forest green; RGB 68 86 73.
Distribution: Medium to high density on mountains; some in agricultural areas; some in water or near streams.
Comment: Conifers were the most observed vegetation outside the riparian zone; grasslands and riparian vegetation (6101, 6202, 6201) were also observed. Appears to be Mixed Mesic Forest.
Conclusion: Not riparian.

71	1	Lodgepole Pine
72	1	Ponderosa Pine & Savannah
73	3	Needleleaf Dominated Riparian
74	1	Broadleaf Dominated Riparian
75	1	Shrub Riparian/Wetland

Spectral Class 37
Color: Black; RGB 10 20 56.
Distribution: High density at middle to upper elevations; some in water or near rivers.

Comment: Conifers and riparian vegetation (6201. 6101, 6103, 6202) characterize training sites outside the zone. Areas covered by this class are in shadow.
Conclusion: Not riparian.

76	1	Lakes
77	5	Needleleaf Dominated Riparian
78	1	Needleleaf-Broadleaf Riparian
79	1	Grass-Forb Riparian/Wetland
80	1	Shrub Riparian/Wetland

Spectral Class 38
Color: Black; RGB 0 0 35.
Distribution: Medium density at mid elevations; density increases at upper mid-elevations; very little near streams.
Comment: Coniferous and riparian (6101, 6103, 6201, 6202) cover types comprise all but one of the observations outside the zone. Appears to be shadows.
Conclusion: Not riparian.

81	1	Douglas Fir
82	1	Needleleaf Dominated Riparian

Spectral Class 41
Color: Black; RGB 23 27 52.
Distribution: Medium to high density on mountains, with density increasing as elevations increase; very little near streams.
Comment: Outside the riparian zone, conifers, then riparian vegetation (6101, 6103, 6202, 6201) were most recorded. Appears to be shadows.
Conclusion: Not riparian.

85	1	Mixed Subalpine Forest
86	3	Needleleaf Dominated Riparian
87	1	Grass-Forb Riparian/Wetland

Spectral Class 45
Color: Black; RGB 16 0 69.
Distribution: Medium density at mid-elevations; also water. Some locations near streams.
Comment: Conifers dominate training data outside the zone; riparian vegetation (6101, 6103) is included. Visual cues suggest water, conifers, and shadows.
Conclusion: Not riparian.

91	2	Needleleaf Dominated Riparian
92	1	Grass-Forb Riparian/Wetland

Spectral Class 51
Color: Black; RGB 0 0 56.
Distribution: A rare class, occurring primarily in water bodies, or possibly near them.
Comment: There are no training sites outside the zone. Appears to be water.
Conclusion: Not riparian.

94	1	Grass-Forb Riparian/Wetland

TM SCENE P39/R28

Image Analyst: J. Chris Winne

Training Data Analysis

In all, 2370 ground-truth plots were available for labeling P39/R28 (see table below); 1927 were collected by Forest Service field crews during the 1994-95 field seasons, and 791 of these were collected specifically for this TM scene. The remaining 443 plots came from pre-existing data sources such as ECODATA and TSMRS.

All ground-truth data were converted to a point file and superimposed on the unsupervised classification to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 374) were removed from further analysis; (these plots can be identified using the following query: DUP_TYPE ne 'B', USE eq 'Y'). The data then were examined by cover type and by data source (whether or not plots were collected for this project or for other purposes, like pre-existing ECODATA or TSMRS). The latter "existing data" were only used in the training data set to supplement cover types that had insufficient plots collected during the 1994 or 1995 field seasons. Eight general classes were excluded from the digital classification process: urban, agriculture, riparian, water, snow, melted snow, cloud, and cloud shadow. All ground truth data with VEG_CLASS_CODE's for urban, agriculture, riparian or water cover types were excluded. Next, 20% of the remaining plots were randomly selected from each cover type; these plots (n = 271) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

The remaining 80% of the data (n = 1088 plots) were subjected to further spectral examination. Outliers were identified for each cover type by examining plots in relation to TM and ancillary data for their respective regions (both visually and in relation to calculated standard deviations) and then eliminated.

A total of 656 points were used in the final training set, which included 25 points added from the Forest Service review. Training data analysis was aided by discussions with Robert Gliko (Lewis and Clark NF), Donna Hawkins (Helena NF), and David Atkins (Lolo NF).

Total plots in ground-truth file		2370
Total 1994-95 field plots	1927	
Plots sampled for P41/R26		791
Plots sampled for other scenes		1136
Pre-existing plots (ECODATA, TSMRS, etc.)	443	
Plots held aside or eliminated	1011	
Duplicates		374
Pre-existing plots		0
Manually labeled cover types		637
Potential training plots	1359	
20% test		271
80% training		1088
Supplemental plots (from pre-existing data set)	25	
Total plots available for training	1113	
Total plots used for training -- cover type	656	
size class	72	
canopy	160	

Land Cover Types

Land cover types were labeled through a digital classification of the 7 TM channels plus rescaled elevation (elevation in meters divided by 25), using the Nearest Member of Group classifier. This classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were used and assigned directly to the COVERTYPE field in the attribute table. Modifications were carried out using spectral class values (SPECTRAL_CLASS or LINK), and/or intermediate cover code labels in conjunction with other attributes including the TM values, modified NDVI, elevation and/or slope as follows:

1000.	Urban.	Manually identified and recoded by Polly Thornton.
2000.	Agriculture.	Manually identified and recoded by Polly Thornton.
3101.	Foothills Grasslands.	All grass types (COV_CODE_1 = 3100) with a mean elevation ≤1982 m (6500 ft) were labeled as Foothills Grassland (3101).
3104.	Montane Parklands & Subalpine Meadows.	All grass types occurring above 1982 m (6500 ft) and <2712 m (8900 ft) were reassigned this label.
3301.	Mountain Mahogany.	This cover type was limited to southern aspects and excluded from the northeast corner of the scene. It was also subject to an elevational limit of 2286 m (7500 ft).
3305.	Mountain Big Sagebrush.	All regions classified as Mountain Big Sagebrush that occurred above 2590 m (8500 ft) were recoded with COVERTYPE = COV_CODE_2.
3306.	Wyoming Big Sagebrush.	The distribution of this type was confined to geographical limits set by Forest Service ecologists and further limited to elevations below 2590 m (8500 ft). A few regions were recoded to Big Mountain Sage (3305) when neither COV_CODE_2 or COV_CODE_3 values were acceptable.
3308.	Black Sagebrush Steppe.	The distribution of this type also was confined to geographical limits set by Forest Service ecologists and further limited to elevations below 2590 m (8500 ft). A few regions were recoded to Big Mountain Sage (3305) when neither COV_CODE_2 or COV_CODE_3 values were acceptable.
4000.	All Forest Types.	All forest cover types (COV_CODE_1 = 4000) except Rocky Mountain Juniper (4214) were given a COVERTYPE code of Exposed Rock (7301) if the MNDVI was <0. If MNDVI was between 0 and 5, and COV_CODE_2 or COV_CODE_3 was a non-forest type, then COVERTYPE was assigned to the first of these alternate codes that was non-forest. Conversely,

		regions classified as Exposed Rock (COV-CODE_1 = 7301) but with MNDVI >75 were assigned a COVERTYPE code equal to their COV_CODE_2 value.
5000.	Water.	All regions with spectral class (LINK = 1) and slope ≤5˚ were labeled as water; in addition, all regions LINK = 1, SLOPE <20, and MNDVI <0 were labeled as Water. Generally, water was more spectrally distinct than most other cover types, but in mountainous terrain, it was sometimes confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate slope and aspect values such that their slope may be >5˚. This would result in the misclassification of some small ponds or lakes.
9100.	Snow.	All regions with MNDVI <0, TM3 >50, TM4 ≥75, TM5 <100 were labeled as Snow. Additional snow and ice patches were identified by selecting regions with elevation >2500 m, TM1 values >100, TM3 values ≥50, TM4 values ≥50, TM5 values <85, TM6 >115, and MNDVI <0.
(n/a)	Melted Snow.	All regions originally classified as Melted Snow were recoded either to Exposed Rock (7301), if their slope was >5˚, or to Snow (9000), if their slope was ≤5˚.
8101.	Alpine Meadow.	All grass types occurring above 2712 m (8900 ft) were labeled Alpine Meadow.
9800.	Cloud.	Manually identified and recoded by Jodi Handley.
9900.	Cloud Shadow.	Manually identified and recoded by Jodi Handley.

A total of 27 cover types were labeled in the full TM scene. These included two grass types, five shrub types, eleven forest types, two barren types, one alpine type, plus six manually labeled classes. Cover types are mapped in Figure F-14.

Size Classes

Six size classes were mapped -- three for forest cover types (seedling/sapling, pole, mature, and mature/overmature), and three for shrub cover (low, medium, and tall). The seven TM spectral bands were used for the size classification (elevation was not included). The Nearest Member of Group (NMG) classifier was used for both tree and shrub size classes. Tree size classes were stratified based upon the three canopy cover classes described above.

Canopy Cover Classes

Canopy cover labels (CANOPY_CODE = low(1), medium(2), or high(3)) were assigned to tree and shrub classes based on the MNDVI values. These values were plotted as frequency histograms for all forest types (Figure F-14a), as well as for two shrub types (Figures F-14b+c). The histograms were examined to determine break points based upon the

distribution modes. Regions with MNDVI values falling below the lower break point were assigned to a low canopy cover class; those greater than or equal to the lower breakpoint, but below the higher break point were assigned to the medium class; and those falling above the higher breakpoint were assigned to the high canopy cover class (see below).

Cover Type Classes	BREAKPOINTS	
	Lower	Upper
3200 shrubs	100	175
3300 shrubs	77	140
4000 trees	164	285

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications.

Classifications for P39/R28	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	21	71%	52%
Tree Size Class	4	94%	48%
Tree Canopy Class	3	97%	54%
Shrub Size Class	3	96%	81%
Shrub Canopy Class	3	100%	76%

Comments

The general distribution of land cover types was generally considered acceptable based on discussions with Forest Service representatives. Confusion among forest cover types was reduced somewhat by adding new plots, but the spectral overlap among some types remained substantial. This is due in part to significant geographical and elevational differences between species distributions across the scene extent. Geographical limits were added for mountain mahogany (3301), subalpine fir (3308), and mixed subalpine forest (4220) within the Lewis and Clark Forest in the northeast part of the scene. It is expected that additional, locally applied rules will further improve the classification. Confusion among non-forested types was also reduced through the identification and removal of outlier training plots. These plots often appeared to be accurately located, but were contained within a large polygon of mixed type. Finally, haze was an another factor contributing to the spectral overlap among cover types.

Much of the land cover within the extent of this scene was related to agriculture. It will be noticed that our labeling of agricultural types was conservative and conformed most closely to irrigated fields and croplands. Dry land pastures were difficult to distinguish from upland grass or rangelands based on spectral information. Hence, many of these pasture lands were undoubtedly classified as foothills grasslands. Additional work could be done to better resolve this spectral confusion for this particular TM scene.

Error Matrix For Cover Type Training Plots
Scene P39/R28

CLASSIFIED COVER TYPES

PLOT COVER TYPES	3101	3104	3201	3301	3305	3306	3308	4101	4203	4205	4206	4208	4212	4214	4219	4220	4222	4223	7301	7800	8101	SUM
3101	163	9	9	0	8	2	1	0	0	0	1	0	0	0	0	0	2	0	0	2	2	199
3104	11	10	0	0	1	0	0	0	0	1	0	0	0	0	2	0	1	0	0	1	1	28
3201	7	0	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	12
3301	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
3305	11	1	1	2	14	1	2	0	0	1	0	0	0	2	0	0	0	0	0	0	1	36
3306	2	0	0	0	1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
3308	4	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	10
4101	0	0	0	0	0	0	0	10	0	0	0	0	2	0	0	0	0	0	0	0	0	12
4203	0	0	0	0	0	0	0	0	11	0	0	1	7	0	0	5	0	4	0	0	0	28
4205	0	1	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4
4206	1	0	0	0	0	0	0	0	0	0	6	0	1	0	0	0	6	0	0	0	0	14
4208	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0	1	0	0	0	0	0	6
4212	0	0	0	0	0	0	0	1	8	0	2	2	70	0	2	5	9	7	0	0	0	106
4214	4	0	0	0	0	1	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	16
4219	0	2	0	0	0	0	0	0	0	0	0	0	0	0	13	1	0	0	0	0	0	16
4220	0	0	0	0	0	0	0	0	6	0	0	4	8	0	2	3	1	3	0	0	0	27
4222	1	1	0	0	0	0	0	1	0	0	5	0	14	0	0	0	10	2	0	0	0	34
4223	0	0	0	0	0	0	0	0	3	0	0	0	4	0	0	3	3	5	0	0	0	18
7301	4	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47	1	0	54
7800	5	0	0	1	0	1	3	0	0	0	0	0	0	0	0	0	0	0	1	1	0	12
8101	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	7	10
SUM	215	25	14	9	29	11	8	12	28	3	15	9	109	13	20	18	32	21	48	6	11	656

% AGREEMENT	60.1
TAU WITH EQUAL PROBABILITY	0.58
TOTAL DIAGONAL ELEMENTS	394
TOTAL TRAINING PLOTS IN DATA SET	656

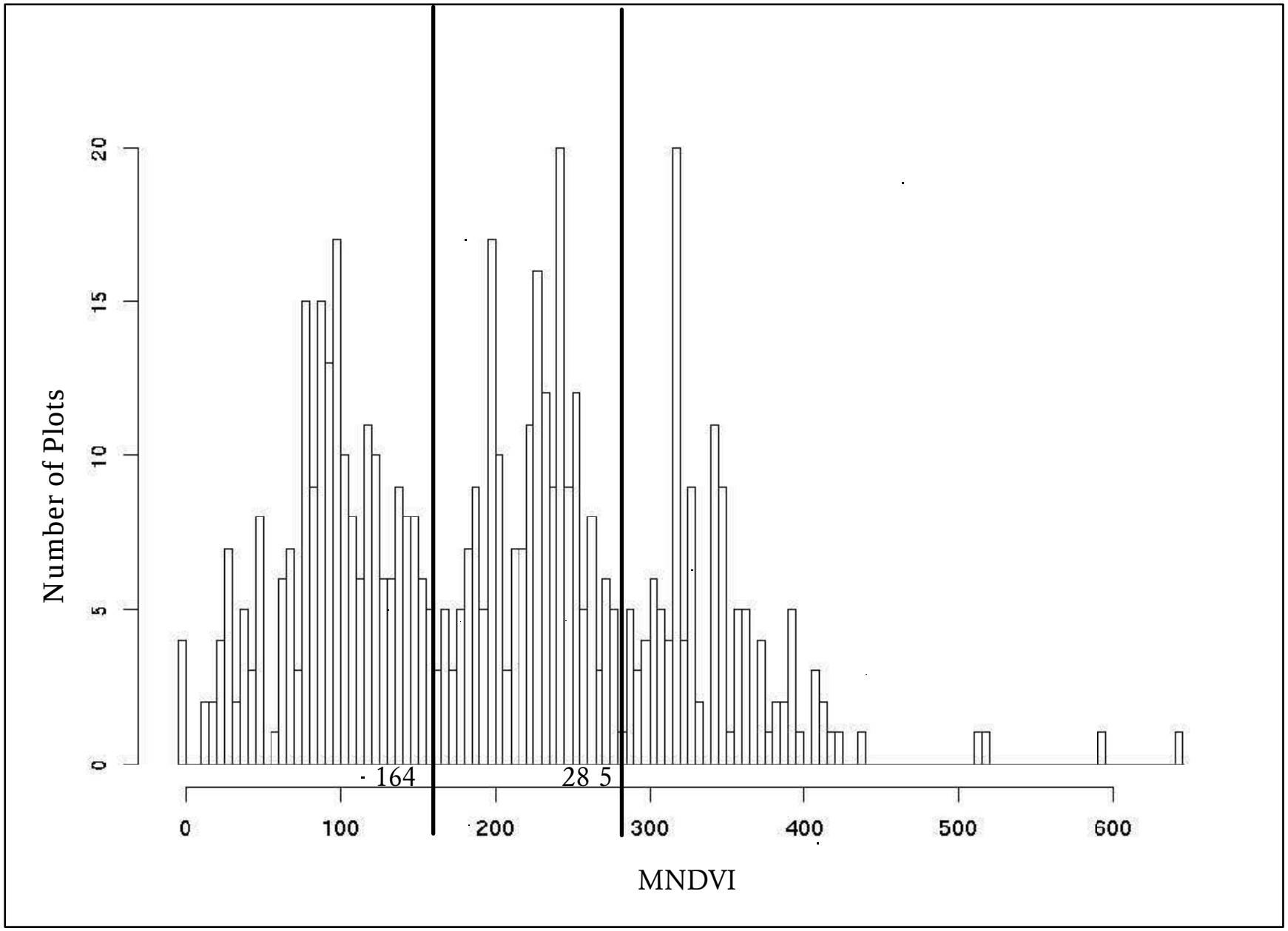


Figure F-14a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P39/R28

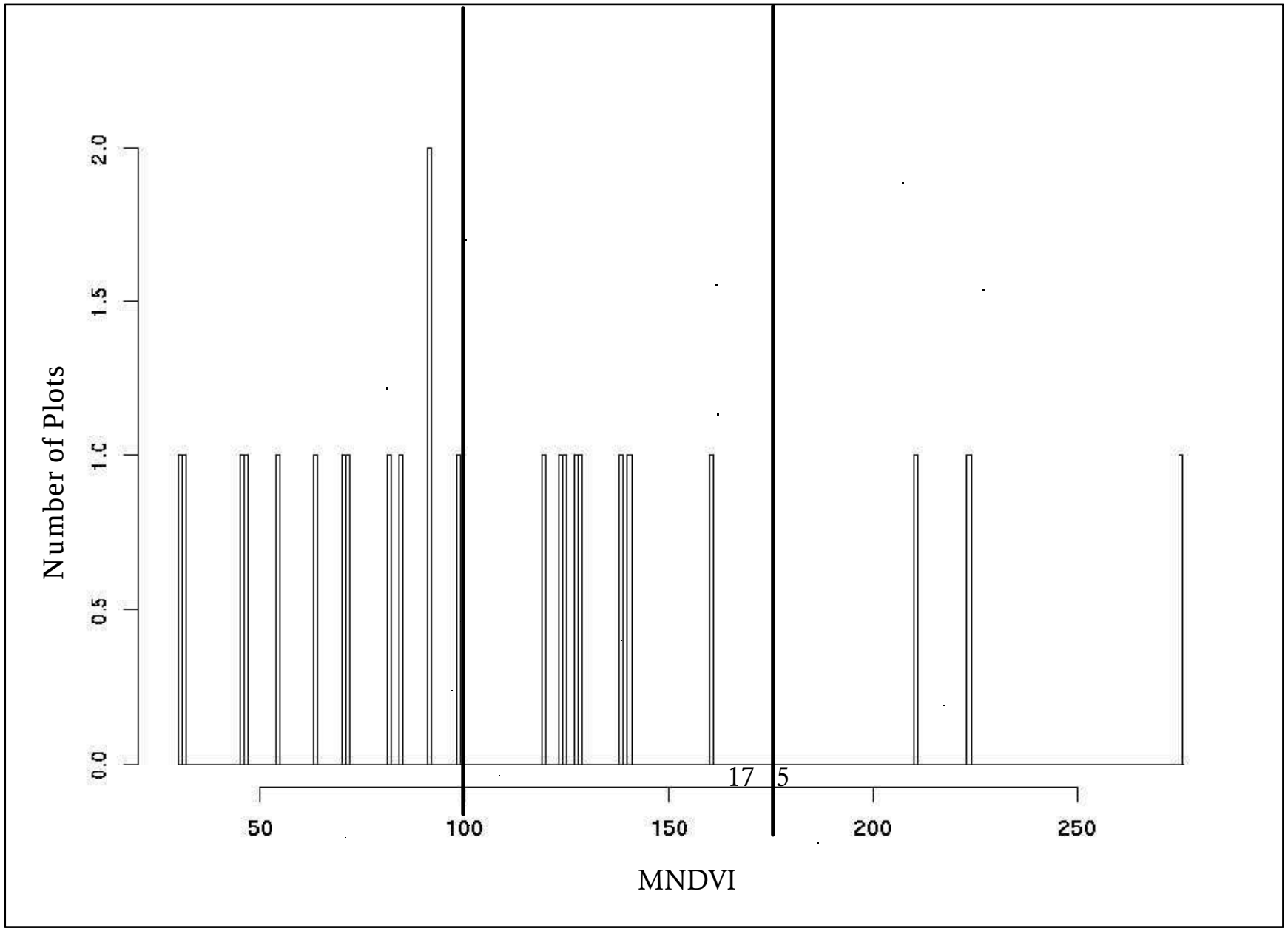


Figure F-14b. Breaks between mesic shrub canopy cover classes in relation to MNDVI values: TM scene P39/R28

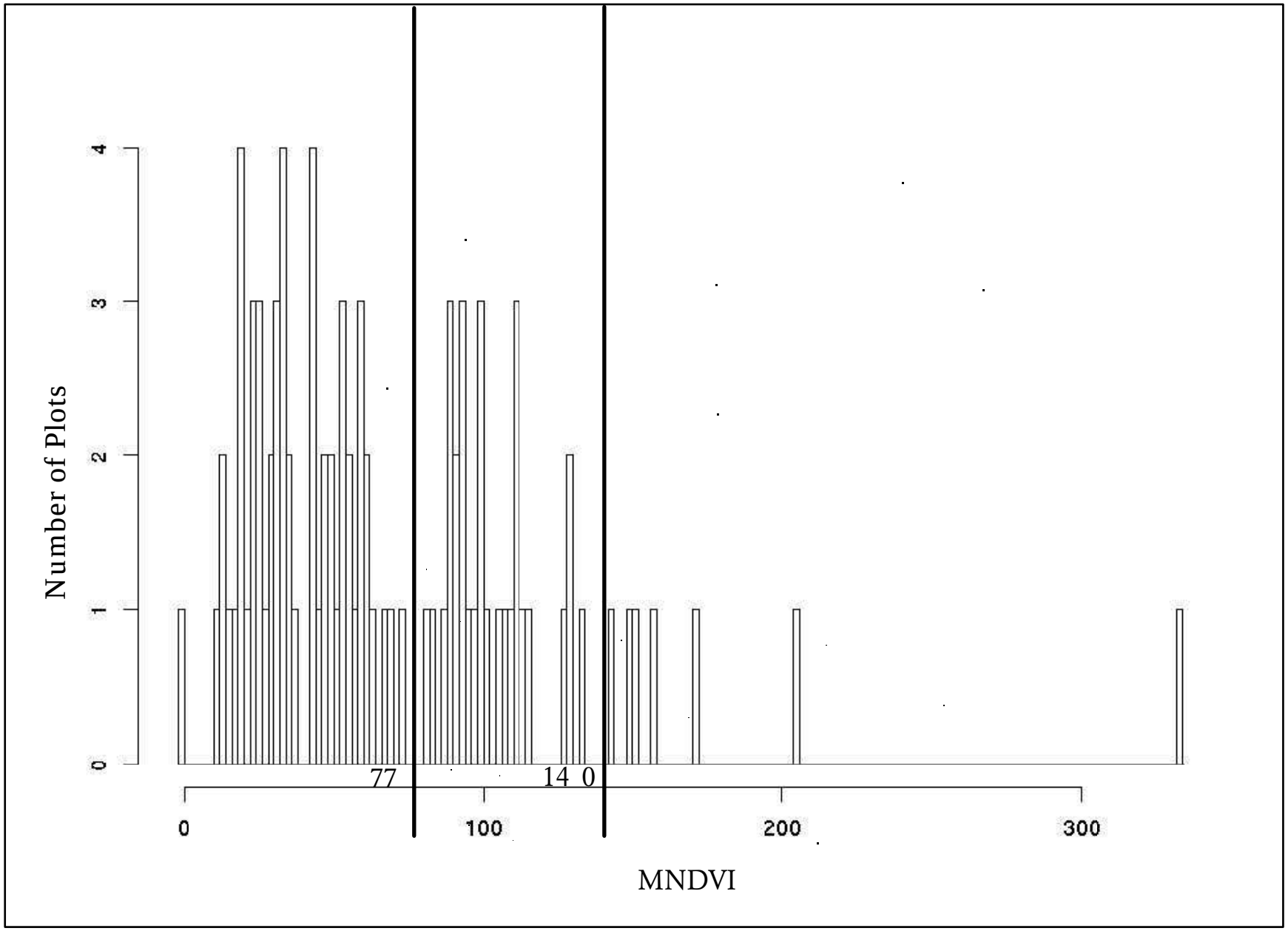


Figure F-14c. Breaks between xeric shrub canopy cover classes in relation to MNDVI values: TM scene P39/R2877 140

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3104	3201	3301	3305	3306	3308	4101	4203
3101	47(5)	8(3)	1(1)	1(1)	7(1)	1(1)	0(1)	0(1)	0(1)
3104	1(3)	5(5)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3201	1(1)	4(1)	1(5)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)
3301	0(1)	0(1)	0(2)	1(5)	2(2)	0(2)	0(2)	0(1)	0(1)
3305	4(1)	6(1)	0(2)	0(2)	7(5)	0(4)	0(3)	0(1)	0(1)
3306	1(1)	0(1)	0(2)	0(2)	0(4)	1(5)	1(3)	0(1)	0(1)
3308	1(1)	0(1)	0(2)	0(2)	0(4)	2(4)	0(5)	0(1)	0(1)
4101	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(5)	0(2)
4203	0(1)	3(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	3(5)
4205	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4206	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4208	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4212	1(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	5(2)
4214	3(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(2)	0(2)
4219	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	1(3)
4220	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)
4222	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4223	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	1(3)
7301	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
7800	1(2)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	62(0)	30(0)	4(0)	2(0)	18(0)	5(0)	1(0)	2(0)	10(0)

Accuracy Assessment Tables for P39/R28 -- Cover Type

RF/CF	4205	4206	4208	4212	4214	4219	4220	4222	4223
3101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)
3104	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)
3201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3305	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)
3306	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3308	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4101	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4203	0(2)	0(2)	0(2)	3(2)	0(2)	0(3)	2(3)	3(2)	1(4)
4205	0(5)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	1(4)	0(2)
4206	0(2)	2(5)	0(2)	0(2)	0(2)	0(2)	0(2)	3(4)	0(2)
4208	0(2)	0(2)	1(5)	0(2)	0(2)	0(3)	0(3)	0(2)	0(2)
4212	0(2)	1(2)	0(2)	22(5)	0(2)	0(2)	2(3)	8(4)	2(4)
4214	0(2)	0(2)	0(2)	0(2)	0(5)	0(2)	0(2)	1(4)	0(2)
4219	0(2)	0(2)	0(3)	0(2)	0(2)	1(5)	0(3)	0(2)	0(2)
4220	0(2)	0(2)	1(3)	1(3)	0(2)	0(3)	4(5)	0(2)	1(3)
4222	0(3)	0(3)	0(2)	2(3)	0(3)	0(2)	0(2)	6(5)	0(2)
4223	0(2)	0(2)	0(2)	1(3)	0(2)	0(2)	2(3)	0(2)	1(5)
7301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7800	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	0(0)	3(0)	2(0)	29(0)	0(0)	2(0)	10(0)	25(0)	5(0)

Accuracy Assessment Tables for P39/R28 -- Cover Type

RF/CF	7301	7800	8101	SUM
3101	1(1)	1(1)	0(1)	68(0)
3104	0(1)	0(1)	0(1)	8(0)
3201	0(1)	0(1)	1(1)	7(0)
3301	0(1)	0(1)	0(1)	3(0)
3305	0(1)	0(1)	0(1)	18(0)
3306	0(1)	0(1)	0(1)	3(0)
3308	0(1)	0(1)	0(1)	3(0)
4101	0(1)	0(1)	0(1)	4(0)
4203	0(1)	0(1)	0(1)	15(0)
4205	0(1)	0(1)	0(1)	1(0)
4206	0(1)	0(1)	0(1)	5(0)
4208	0(1)	0(1)	0(1)	3(0)
4212	0(1)	0(1)	0(1)	42(0)
4214	0(1)	0(1)	0(1)	5(0)
4219	2(1)	0(1)	1(1)	5(0)
4220	0(1)	0(1)	0(1)	8(0)
4222	0(1)	0(1)	0(1)	9(0)
4223	0(1)	0(1)	0(1)	5(0)
7301	15(5)	1(3)	0(1)	17(0)
7800	1(3)	0(5)	0(3)	4(0)
8101	2(1)	0(3)	1(5)	3(0)
SUM	21(0)	2(0)	3(0)	236(0)

Diagonal Elements = 120; Total Test Points = 236
Percentage Agreement = 50.85; Kappa = 0.438; Tau w/equal Prob = 0.484

Accuracy Assessment Tables for P39/R28 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	47	69.12	0	0.00	8	11.76	0	0.00	13	19.12
3104	5	62.50	0	0.00	1	12.50	0	0.00	2	25.00
3201	1	14.29	0	0.00	0	0.00	0	0.00	6	85.71
3301	1	33.33	0	0.00	0	0.00	2	66.67	0	0.00
3305	7	38.89	0	0.00	0	0.00	0	0.00	11	61.11
3306	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
3308	0	0.00	2	66.67	0	0.00	0	0.00	1	33.33
4101	2	50.00	0	0.00	0	0.00	0	0.00	2	50.00
4203	3	20.00	1	6.67	2	13.33	6	40.00	3	20.00
4205	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
4206	2	40.00	3	60.00	0	0.00	0	0.00	0	0.00
4208	1	33.33	0	0.00	0	0.00	0	0.00	2	66.67
4212	22	52.38	10	23.81	2	4.76	6	14.29	2	4.76
4214	0	0.00	1	20.00	0	0.00	0	0.00	4	80.00
4219	1	20.00	0	0.00	1	20.00	0	0.00	3	60.00
4220	4	50.00	0	0.00	3	37.50	0	0.00	1	12.50
4222	6	66.67	0	0.00	2	22.22	0	0.00	1	11.11
4223	1	20.00	0	0.00	4	80.00	0	0.00	0	0.00
7301	15	88.24	0	0.00	1	5.88	0	0.00	1	5.88
7800	0	0.00	0	0.00	1	25.00	1	25.00	2	50.00
8101	1	33.33	0	0.00	0	0.00	0	0.00	2	66.67
SUM	120	50.85	18	7.63	26	11.02	15	6.36	57	24.15

Accuracy Assessment Tables for P39/R28 -- Cover Type

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	47	69.12	47	69.12	55	80.88	55	80.88	68	100.00
3104	5	62.50	5	62.50	6	75.00	6	75.00	8	100.00
3201	1	14.29	1	14.29	1	14.29	1	14.29	7	100.00
3301	1	33.33	1	33.33	1	33.33	3	100.00	3	100.00
3305	7	38.89	7	38.89	7	38.89	7	38.89	18	100.00
3306	1	33.33	1	33.33	2	66.67	2	66.67	3	100.00
3308	0	0.00	2	66.67	2	66.67	2	66.67	3	100.00
4101	2	50.00	2	50.00	2	50.00	2	50.00	4	100.00
4203	3	20.00	4	26.67	6	40.00	12	80.00	15	100.00
4205	0	0.00	1	100.00	1	100.00	1	100.00	1	100.00
4206	2	40.00	5	100.00	5	100.00	5	100.00	5	100.00
4208	1	33.33	1	33.33	1	33.33	1	33.33	3	100.00
4212	22	52.38	32	76.19	34	80.95	40	95.24	42	100.00
4214	0	0.00	1	20.00	1	20.00	1	20.00	5	100.00
4219	1	20.00	1	20.00	2	40.00	2	40.00	5	100.00
4220	4	50.00	4	50.00	7	87.50	7	87.50	8	100.00
4222	6	66.67	6	66.67	8	88.89	8	88.89	9	100.00
4223	1	20.00	1	20.00	5	100.00	5	100.00	5	100.00
7301	15	88.24	15	88.24	16	94.12	16	94.12	17	100.00
7800	0	0.00	0	0.00	1	25.00	2	50.00	4	100.00
8101	1	33.33	1	33.33	1	33.33	1	33.33	3	100.00
SUM	120	50.85	138	58.47	164	69.49	179	75.85	236	100.00

Accuracy Assessment Tables for P39/R28 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	47	75.81	0	0.00	1	1.61	1	1.61	13	20.97
3104	5	16.67	0	0.00	8	26.67	0	0.00	17	56.67
3201	1	25.00	0	0.00	0	0.00	0	0.00	3	75.00
3301	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
3305	7	38.89	0	0.00	0	0.00	2	11.11	9	50.00
3306	1	20.00	2	40.00	0	0.00	0	0.00	2	40.00
3308	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4101	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4203	3	30.00	0	0.00	2	20.00	5	50.00	0	0.00
4205	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4206	2	66.67	0	0.00	0	0.00	1	33.33	0	0.00
4208	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
4212	22	75.86	0	0.00	4	13.79	3	10.34	0	0.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4219	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4220	4	40.00	0	0.00	6	60.00	0	0.00	0	0.00
4222	6	24.00	13	52.00	0	0.00	3	12.00	3	12.00
4223	1	20.00	3	60.00	1	20.00	0	0.00	0	0.00
7301	15	71.43	0	0.00	1	4.76	0	0.00	5	23.81
7800	0	0.00	0	0.00	1	50.00	0	0.00	1	50.00
8101	1	33.33	0	0.00	0	0.00	0	0.00	2	66.67
SUM	120	50.85	18	7.63	26	11.02	15	6.36	57	24.15

Accuracy Assessment Tables for P39/R28 -- Cover Type

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	47	75.81	47	75.81	48	77.42	49	79.03	62	100.00
3104	5	16.67	5	16.67	13	43.33	13	43.33	30	100.00
3201	1	25.00	1	25.00	1	25.00	1	25.00	4	100.00
3301	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
3305	7	38.89	7	38.89	7	38.89	9	50.00	18	100.00
3306	1	20.00	3	60.00	3	60.00	3	60.00	5	100.00
3308	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4101	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
4203	3	30.00	3	30.00	5	50.00	10	100.00	10	100.00
4205	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4206	2	66.67	2	66.67	2	66.67	3	100.00	3	100.00
4208	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
4212	22	75.86	22	75.86	26	89.66	29	100.00	29	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4219	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4220	4	40.00	4	40.00	10	100.00	10	100.00	10	100.00
4222	6	24.00	19	76.00	19	76.00	22	88.00	25	100.00
4223	1	20.00	4	80.00	5	100.00	5	100.00	5	100.00
7301	15	71.43	15	71.43	16	76.19	16	76.19	21	100.00
7800	0	0.00	0	0.00	1	50.00	1	50.00	2	100.00
8101	1	33.33	1	33.33	1	33.33	1	33.33	3	100.00
SUM	120	50.85	138	58.47	164	69.49	179	75.85	236	100.00

Accuracy Assessment Tables for P39/R28 -- Cover Type

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	245	69.12	0	0.00	42	11.76	0	0.00	68	19.12
3104	34	62.50	0	0.00	7	12.50	0	0.00	13	25.00
3201	1	14.29	0	0.00	0	0.00	0	0.00	7	85.71
3301	1	33.33	0	0.00	0	0.00	2	66.67	0	0.00
3305	35	38.89	0	0.00	0	0.00	0	0.00	54	61.11
3306	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
3308	0	0.00	1	66.67	0	0.00	0	0.00	1	33.33
4101	6	50.00	0	0.00	0	0.00	0	0.00	6	50.00
4203	13	20.00	4	6.67	9	13.33	26	40.00	13	20.00
4205	0	0.00	6	100.00	0	0.00	0	0.00	0	0.00
4206	7	40.00	11	60.00	0	0.00	0	0.00	0	0.00
4208	1	33.33	0	0.00	0	0.00	0	0.00	3	66.67
4212	65	52.38	30	23.81	6	4.76	18	14.29	6	4.76
4214	0	0.00	1	20.00	0	0.00	0	0.00	4	80.00
4219	4	20.00	0	0.00	4	20.00	0	0.00	13	60.00
4220	24	50.00	0	0.00	18	37.50	0	0.00	6	12.50
4222	54	66.67	0	0.00	18	22.22	0	0.00	9	11.11
4223	5	20.00	0	0.00	22	80.00	0	0.00	0	0.00
7301	25	88.24	0	0.00	2	5.88	0	0.00	2	5.88
7800	0	0.00	0	0.00	11	25.00	11	25.00	22	50.00
8101	1	33.33	0	0.00	0	0.00	0	0.00	2	66.67
SUM	522	52.10	53	5.29	140	13.97	57	5.69	230	22.95

Accuracy Assessment Tables for P39/R28 -- Cover Type

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	245	69.12	245	69.12	287	80.88	287	80.88	354	100.00
3104	34	62.50	34	62.50	40	75.00	40	75.00	54	100.00
3201	1	14.29	1	14.29	1	14.29	1	14.29	8	100.00
3301	1	33.33	1	33.33	1	33.33	3	100.00	3	100.00
3305	35	38.89	35	38.89	35	38.89	35	38.89	89	100.00
3306	1	33.33	1	33.33	1	66.67	1	66.67	2	100.00
3308	0	0.00	1	66.67	1	66.67	1	66.67	2	100.00
4101	6	50.00	6	50.00	6	50.00	6	50.00	12	100.00
4203	13	20.00	17	26.67	26	40.00	51	80.00	64	100.00
4205	0	0.00	6	100.00	6	100.00	6	100.00	6	100.00
4206	7	40.00	18	100.00	18	100.00	18	100.00	18	100.00
4208	1	33.33	1	33.33	1	33.33	1	33.33	4	100.00
4212	65	52.38	95	76.19	101	80.95	119	95.24	125	100.00
4214	0	0.00	1	20.00	1	20.00	1	20.00	5	100.00
4219	4	20.00	4	20.00	8	40.00	8	40.00	21	100.00
4220	24	50.00	24	50.00	42	87.50	42	87.50	47	100.00
4222	54	66.67	54	66.67	71	88.89	71	88.89	80	100.00
4223	5	20.00	5	20.00	27	100.00	27	100.00	27	100.00
7301	25	88.24	25	88.24	27	94.12	27	94.12	29	100.00
7800	0	0.00	0	0.00	11	25.00	22	50.00	45	100.00
8101	1	33.33	1	33.33	1	33.33	1	33.33	4	100.00
SUM	522	52.25	575	57.56	712	71.27	768	76.88	999	100.00

Accuracy Assessment Tables for P39/R28 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	4	SUM
1	7(5)	6(3)	2(1)	0(1)	15(0)
2	1(3)	8(5)	6(3)	0(1)	15(0)
3	1(1)	5(3)	5(5)	0(3)	11(0)
4	0(1)	1(1)	1(3)	0(5)	2(0)
SUM	9(0)	20(0)	14(0)	0(0)	43(0)

Diagonal Elements = 20; Total Test Points = 43
Percentage Agreement = 46.51; Kappa = 0.215; Tau w/equal Prob = 0.287

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	7	46.67	0	0.00	6	40.00	0	0.00	2	13.33
2	8	53.33	0	0.00	7	46.67	0	0.00	0	0.00
3	5	45.45	0	0.00	5	45.45	0	0.00	1	9.09
4	0	0.00	0	0.00	1	50.00	0	0.00	1	50.00
SUM	20	46.51	0	0.00	19	44.19	0	0.00	4	9.30

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	7	46.67	7	46.67	13	86.67	13	86.67	15	100.00
2	8	53.33	8	53.33	15	100.00	15	100.00	15	100.00
3	5	45.45	5	45.45	10	90.91	10	90.91	11	100.00
4	0	0.00	0	0.00	1	50.00	1	50.00	2	100.00
SUM	20	46.51	20	46.51	39	90.70	39	90.70	43	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	7	77.78	0	0.00	1	11.11	0	0.00	1	11.11
2	8	40.00	0	0.00	11	55.00	0	0.00	1	5.00
3	5	35.71	0	0.00	7	50.00	0	0.00	2	14.29
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	20	46.51	0	0.00	19	44.19	0	0.00	4	9.30

Accuracy Assessment Tables for P39/R28 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	7	77.78	7	77.78	8	88.89	8	88.89	9	100.00
2	8	40.00	8	40.00	19	95.00	19	95.00	20	100.00
3	5	35.71	5	35.71	12	85.71	12	85.71	14	100.00
4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	20	46.51	20	46.51	39	90.70	39	90.70	43	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	47	46.67	0	0.00	40	40.00	0	0.00	13	13.33
2	217	53.33	0	0.00	190	46.67	0	0.00	0	0.00
3	220	45.45	0	0.00	220	45.45	0	0.00	44	9.09
4	0	0.00	0	0.00	5	50.00	0	0.00	5	50.00
SUM	484	48.35	0	0.00	455	45.45	0	0.00	62	6.19

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	47	46.67	47	46.67	87	86.67	87	86.67	100	100.00
2	217	53.33	217	53.33	406	100.00	406	100.00	406	100.00
3	220	45.45	220	45.45	440	90.91	440	90.91	484	100.00
4	0	0.00	0	0.00	5	50.00	5	50.00	10	100.00
SUM	484	48.40	484	48.40	938	93.80	938	93.80	1000	100.00

Accuracy Assessment Tables for P39/R28 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	20(5)	1(3)	1(1)	22(0)
2	3(3)	2(5)	1(3)	6(0)
3	0(1)	0(3)	1(5)	1(0)
SUM	23(0)	3(0)	3(0)	29(0)

Diagonal Elements = 23; Total Test Points = 29
Percentage Agreement = 79.31; Kappa = 0.446; Tau w/equal Prob = 0.690

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	90.91	0	0.00	1	4.55	0	0.00	1	4.55
2	2	33.33	0	0.00	4	66.67	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	23	79.31	0	0.00	5	17.24	0	0.00	1	3.45

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	90.91	20	90.91	21	95.45	21	95.45	22	100.00
2	2	33.33	2	33.33	6	100.00	6	100.00	6	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	23	79.31	23	79.31	28	96.55	28	96.55	29	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	86.96	0	0.00	3	13.04	0	0.00	0	0.00
2	2	66.67	0	0.00	1	33.33	0	0.00	0	0.00
3	1	33.33	0	0.00	1	33.33	0	0.00	1	33.33
SUM	23	79.31	0	0.00	5	17.24	0	0.00	1	3.45

Accuracy Assessment Tables for P39/R28 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	20	86.96	20	86.96	23	100.00	23	100.00	23	100.00
2	2	66.67	2	66.67	3	100.00	3	100.00	3	100.00
3	1	33.33	1	33.33	2	66.67	2	66.67	3	100.00
SUM	23	79.31	23	79.31	28	96.55	28	96.55	29	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	728	90.91	0	0.00	36	4.55	0	0.00	36	4.55
2	58	33.33	0	0.00	115	66.67	0	0.00	0	0.00
3	26	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	812	81.28	0	0.00	151	15.12	0	0.00	36	3.60

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	728	90.91	728	90.91	765	95.45	765	95.45	801	100.00
2	58	33.33	58	33.33	173	100.00	173	100.00	173	100.00
3	26	100.00	26	100.00	26	100.00	26	100.00	26	100.00
SUM	812	81.20	812	81.20	964	96.40	964	96.40	1000	100.00

Accuracy Assessment Tables for P39/R28 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	28(5)	26(3)	3(1)	57(0)
2	9(3)	29(5)	13(3)	51(0)
3	2(1)	8(3)	12(5)	22(0)
SUM	39(0)	63(0)	28(0)	130(0)

Diagonal Elements = 69; Total Test Points = 130
Percentage Agreement = 53.08; Kappa = 0.269; Tau w/equal Prob = 0.296

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	28	49.12	0	0.00	26	45.61	0	0.00	3	5.26
2	29	56.86	0	0.00	22	43.14	0	0.00	0	0.00
3	12	54.55	0	0.00	8	36.36	0	0.00	2	9.09
SUM	69	53.08	0	0.00	56	43.08	0	0.00	5	3.85

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	28	49.12	28	49.12	54	94.74	54	94.74	57	100.00
2	29	56.86	29	56.86	51	100.00	51	100.00	51	100.00
3	12	54.55	12	54.55	20	90.91	20	90.91	22	100.00
SUM	69	53.08	69	53.08	125	96.15	125	96.15	130	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	28	71.79	0	0.00	9	23.08	0	0.00	2	5.13
2	29	46.03	0	0.00	34	53.97	0	0.00	0	0.00
3	12	42.86	0	0.00	13	46.43	0	0.00	3	10.71
SUM	69	53.08	0	0.00	56	43.08	0	0.00	5	3.85

Accuracy Assessment Tables for P39/R28 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	28	71.79	28	71.79	37	94.87	37	94.87	39	100.00
2	29	46.03	29	46.03	63	100.00	63	100.00	63	100.00
3	12	42.86	12	42.86	25	89.29	25	89.29	28	100.00
SUM	69	53.08	69	53.08	125	96.15	125	96.15	130	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	127	49.12	0	0.00	118	45.61	0	0.00	14	5.26
2	304	56.86	0	0.00	231	43.14	0	0.00	0	0.00
3	113	54.55	0	0.00	75	36.36	0	0.00	19	9.09
SUM	544	54.35	0	0.00	424	42.36	0	0.00	33	3.30

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	127	49.12	127	49.12	245	94.74	245	94.74	258	100.00
2	304	56.86	304	56.86	535	100.00	535	100.00	535	100.00
3	113	54.55	113	54.55	188	90.91	188	90.91	206	100.00
SUM	544	54.45	544	54.45	968	96.90	968	96.90	999	100.00

Accuracy Assessment Tables for P39/R28 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	14(5)	2(3)	0(1)	16(0)
2	8(3)	3(5)	2(3)	13(0)
3	0(1)	0(3)	1(5)	1(0)
SUM	22(0)	5(0)	3(0)	30(0)

Diagonal Elements = 18; Total Test Points = 30
Percentage Agreement = 60.00; Kappa = 0.250; Tau w/equal Prob = 0.400

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	14	87.50	0	0.00	2	12.50	0	0.00	0	0.00
2	3	23.08	0	0.00	10	76.92	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	18	60.00	0	0.00	12	40.00	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	14	87.50	14	87.50	16	100.00	16	100.00	16	100.00
2	3	23.08	3	23.08	13	100.00	13	100.00	13	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	18	60.00	18	60.00	30	100.00	30	100.00	30	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	14	63.64	0	0.00	8	36.36	0	0.00	0	0.00
2	3	60.00	0	0.00	2	40.00	0	0.00	0	0.00
3	1	33.33	0	0.00	2	66.67	0	0.00	0	0.00
SUM	18	60.00	0	0.00	12	40.00	0	0.00	0	0.00

Accuracy Assessment Tables for P39/R28 -- Shrub Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	14	63.64	14	63.64	22	100.00	22	100.00	22	100.00
2	3	60.00	3	60.00	5	100.00	5	100.00	5	100.00
3	1	33.33	1	33.33	3	100.00	3	100.00	3	100.00
SUM	18	60.00	18	60.00	30	100.00	30	100.00	30	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	713	87.50	0	0.00	102	12.50	0	0.00	0	0.00
2	41	23.08	0	0.00	138	76.92	0	0.00	0	0.00
3	6	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	760	76.00	0	0.00	240	24.00	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	713	87.50	713	87.50	815	100.00	815	100.00	815	100.00
2	41	23.08	41	23.08	179	100.00	179	100.00	179	100.00
3	6	100.00	6	100.00	6	100.00	6	100.00	6	100.00
SUM	760	76.00	760	76.00	1000	100.00	1000	100.00	1000	100.00

Scene P39/R28 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
1000	680.0	10526.6	0.3
2000	19169.0	261453.4	7.7
3101	98124.0	1085233.1	31.9
3104	16781.0	165170.0	4.9
3201	3857.0	25678.9	0.8
3301	975.0	8476.5	0.3
3305	28011.0	273105.9	8.0
3306	582.0	6845.8	0.2
3308	543.0	6164.6	0.2
4101	4653.0	37772.0	1.1
4203	3431.0	197389.2	5.8
4205	1651.0	17851.8	0.5
4206	2954.0	56038.4	1.6
4208	6485.0	11523.9	0.3
4212	25698.0	383863.1	11.3
4214	1602.0	14224.4	0.4
4219	4614.0	64232.1	1.9
4220	6742.0	145745.3	4.3
4222	16658.0	246629.0	7.2
4223	2791.0	83990.4	2.5
5000	3970.0	27136.6	0.8
7300	9700.0	88661.7	2.6
7800	10207.0	136779.7	4.0
8100	1270.0	11073.5	0.3
9100	44.0	327.0	0.0
9800	1724.0	20999.5	0.6
9900	1892.0	16543.0	0.5

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not tree/shrub	163561.0	1823904.1	53.6
Shrub 1	25411.0	260727.6	7.7
Shrub 2	8161.0	57684.1	1.7
Shrub 3	396.0	1859.9	0.1
Tree 1	28166.0	325117.5	9.6
Tree 2	33722.0	674206.9	19.8
Tree 3	15391.0	259935.0	7.6

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not tree/shrub	163561.0	1823904.1	53.6
Tree 1	8814.0	125702.7	3.7
Tree 2	33863.0	511859.1	15.0
Tree 3	32540.0	609709.5	17.9
Tree 4	2062.0	11988.2	0.4
Shrub 1	27948.0	256954.1	7.5
Shrub 2	4588.0	54209.5	1.6
Shrub 3	1432.0	9108.0	0.3

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
A	19169.0	261453.4	7.7
H	116175.0	1261476.6	37.1
N	28217.0	300974.0	8.8
S	33968.0	320271.7	9.4
T	77279.0	1259259.5	37.0

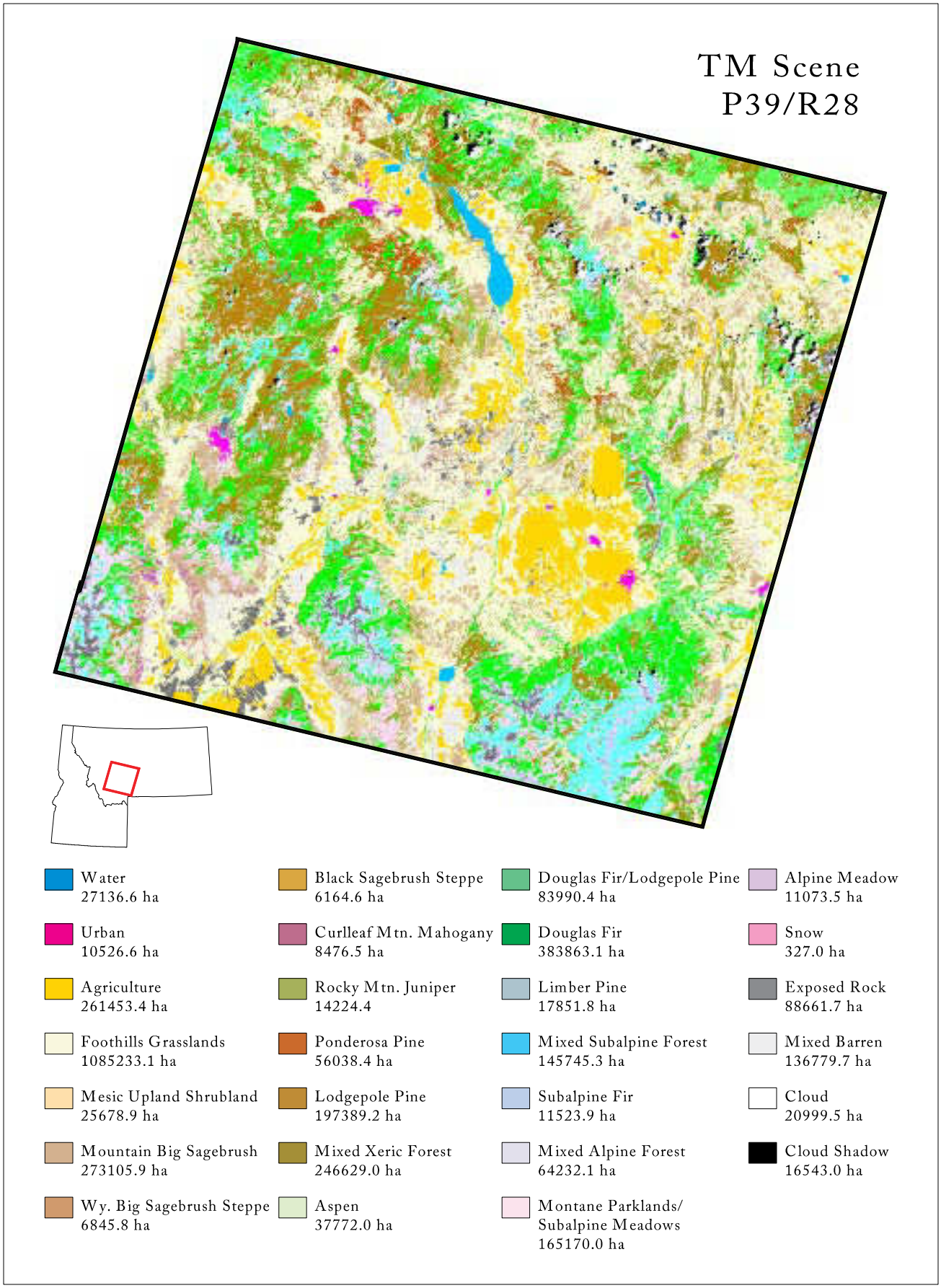


Figure F-14. Classification of land cover types for TM Scene P39/R28.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P39/R28

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4201: ENGELMANN SPRUCE FOREST

Conifer forest dominated by Engelmann spruce (Picea engelmannii) ranging from 5600 to 7672 feet in elevation. The average canopy cover is 44%, ranging from 20-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), lodgepole pine (Pinus contorta), and Douglas-fir (pseudotsuga menziesii) with average percent cover ≥4% and ≤14% and frequency of occurrence ≥33% and ≤73%.

Primary associated shrub species, each with frequency of occurrence ≥7% and ≤33% in Engelmann spruce stands: sitka alder (Alnus sinuata), twin flower (Linnaea borealis), sticky current (Ribes viscosissimum), willow (Salix spp.), common snowberry (Symphoricarpos albus), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern and moss species with ≥7% and ≤47% frequency of occurrence in Engelmann spruce stands: **graminoids**: pinegrass (Calamagrostis rubescens), and sedge (Carex spp.); **forbs**: heart-leaf arnica (Arnica cordifolia), glacier lily (Erythronium grandiflorum), clasping-leaved twisted-stalk (Streptopus amplexifolius), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss:** none.

2) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 4960 to 8310 feet in elevation. The average canopy cover is 42% ranging from 20-90% total cover and frequency of occurrence equal to 97%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤6% and frequency of occurrence ≥22% and ≤40%.

Primary associated shrub species with ≥8% and ≤%32 frequency of occurrence in lodgepole pine stands: common juniper (Juniperus communis), shiny-leaf spiraea (Spiraea betulifolia), spiraea (Spiraea spp.), common snowberry (Symphoricarpos albus), huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare) and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤20% frequency of occurrence in lodgepole pine stands: **graminoids**: mountain brome (Bromus carinatus), pinegrass (Calamagrostis rubescens), sedge (Carex), elk sedge (Carex geyeri), common timothy (Phleum pratense), Kentucky bluegrass (Poa pratensis), and spike trisetum (Trisetum spicatum); **forbs**: raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), showy aster (Aster conspicuus), fireweed (Epilobium angustifolium), small-leaved alumroot (Heuchera parvifolia), mountain

sweet-cicely (Osmorhiza chilensis), and beargrass (Xerophyllum tenax); **ferns**: stiff clubmoss (Lycopodium annotinum); **moss**: none.

3) 4205: LIMBER PINE FOREST

Conifer forest dominated by limber pine (Pinus flexilis) ranging from 5120 to 9150 feet in elevation. The average canopy cover is 24% ranging from 20-30% total cover and frequency of occurrence equal to 89%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum) and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥7% and ≤9% and frequency of occurrence ≥56% and ≤67%.

Primary associated shrub species with ≥11% and ≤56% frequency of occurrence in limber pine stands: rocky mountain maple (Acer glabrum), kinnikinnick (Arctostaphylos uva-ursi), common juniper (Juniperus communis), and shiny-leaf spiraea (Spiraea betulifolia).

Primary associated graminoid, forb, fern, and moss species with ≥11% and ≤22% frequency of occurrence in limber pine stands: **graminoids**: Idaho bentgrass (Agrostis idahoensis), quackgrass (Agropyron repens), pinegrass (Calamagrostis rubescens), narrow-leaved sedge (Carex stenophylla), timber oatgrass (Danthonia intermedia), Idaho fescue (Festuca idahoensis), and common timothy (Phleum pratense); **forbs**: rosy pussy-toes (Antennaria microphylla), arrowleaf balsamroot (Balsamorhiza sagittata), tapertip hawksbeard (Crepis acuminata), wyeth buckwheat (Erigonum heracleoides), small-leaved alumroot (Heuchera parvifolia), moss phlox (Phlox muscoides), and rosecrown stonecrop (Sedum rhodanthum); **ferns**: none; **moss**: none.

4) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 3920 to 5200 feet in elevation. The average canopy cover is 27% ranging from 20-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum) and Douglas-fir (Pseudotsuga menziesii) with average percent cover equal to 5% and frequency of occurrence ≥47% and ≤53%.

Primary associated shrub species with ≥5% and ≤11% frequency of occurrence in ponderosa pine stands: western serviceberry (Amelanchier alnifolia), common chokecherry (Prunus virginiana), antelope bitter-brush (Purshia tridentata), Wood's rose (Rosa woodsii), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤47% frequency of occurrence in ponderosa pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), smooth brome (Bromus inermis), rough fescue (Festuca scabrella), and Kentucky bluegrass (Poa pratensis); **forbs**: rosy pussy-toes (Antennaria microphylla), spreading dogbane (Apocynum androsaemifolium), arrowleaf balsamroot (Balsamorhiza sagittata), and yellow sweet-clover (Melilotus officinalis); **ferns**: none; **moss**: none.

5) 4208: SUBALPINE FIR FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 5960 to 8500 feet in elevation. The average canopy cover is 40% ranging from 3-70% total cover and

frequency of occurrence equal to 94%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥4% and ≤9% and frequency of occurrence ≥33% and ≤56%.

Primary associated shrub species with ≥6% and ≤33% frequency of occurrence in subalpine fir stands: sitka alder (Alnus sinuata), twin flower (Linnaea borealis), menziesia (Menziesia ferruginea), Utah honeysuckle (Lonicera utahensis), swamp current (Ribes lacustre), huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare) and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥6% and ≤28% frequency of occurrence in subalpine fir stands: **graminoids**: mountain brome (Bromus carinatus), pinegrass (Calamagrostis rubescens), sedge (Carex), elk sedge (Carex geyeri), foxtail barley (Hordeum jubatum), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), collomia (Collomia spp.), glacier lily (Erythronium grandiflorum), white geranium (Geranium richardsonii), mountain sweet-cicely (Osmorhiza chilensis), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: moss (moss spp.).

6) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) and ranging from 3950 to 8000 feet in elevation. The average canopy cover is 41% ranging from 3-90% total cover and frequency of occurrence equal to 95%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), lodgepole pine (Pinus contorta), and limber pine (Pinus flexilis) with average percent cover ≥4% and ≤6% and frequency of occurrence ≥15% and ≤26%.

Primary associated shrub species with ≥8% and ≤31% frequency of occurrence in Douglas-fir stands: rocky mountain maple (Acer glabrum), kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥1% and ≤34% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), mountain brome (Bromus carinatus), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: common yarrow (Achillea millefolium), heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), northern bedstraw (Galium boreale), false spikenard (Smilacina racemosa), common dandelion (Taraxacom officinale), and western meadowrue (Thalictrum occidentale); **ferns**: stiff clubmoss (Lycopodium annotinum) and compact selaginella (Selaginella densa); **moss**: moss (moss spp.).

7) 4214: ROCKY MOUNTAIN JUNIPER FOREST

Conifer forest dominated by rocky mountain juniper (Juniperus scopulorum) and ranging

from 3800 to 6000 feet in elevation. The average canopy cover is 31% ranging from 20-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include limber pine (Pinus flexilis) and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥4% and ≤6% and frequency of occurrence ≥42% and ≤58%.

Primary associated shrub species with ≥8% and ≤17% frequency of occurrence in rocky mountain juniper stands: fringed sagewort (Artemisia frigida), black sagebrush (Artemisia nova), green rabbitbrush (Chrysothamnus viscidiflorus), skunk-brush sumac (Rhus trilobata), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤83% frequency of occurrence in rocky mountain juniper stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Idaho fescue (Festuca idahoensis), rough fescue (Festuca scabrella), and Kentucky bluegrass (Poa pratensis); **forbs**: common yarrow (Achillea millefolium), rosy pussy-toes (Antennaria microphylla), arrowleaf balsamroot (Balsamorhiza sagittata), and clover (Trifolium spp.); **ferns**: selaginella (Selaginella spp.); **moss**: none.

8) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albicaulis) and ranging from 7240 to 9500 feet in elevation. The average canopy cover is 27% ranging from 10-50% total cover and frequency of occurrence equal to 91%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥9% and ≤18% and frequency of occurrence ≥31% and ≤74%.

Primary associated shrub species with ≥6% and ≤51% frequency of occurrence in mixed whitebark pine stands: mountain big sagebrush (Artemisia tridentata), common juniper (Juniperus communis), creeping juniper (Juniperus horizontalis), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), globe huckleberry (Vaccinium globulare) and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤29% frequency of occurrence in mixed whitebark pine stands: **graminoids:** pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), oniongrass (Melica bulbosa), muttongrass (Poa fendleriana), and nodding bluegrass (Poa reflexa); **forbs**: raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), glacier lily (Erythronium grandiflorum), baldhead waterleaf (Hydrophyllum capitatum), silky lupine (Lupinus sericeus), and slender cinquefoil (Potentilla gracilia); **ferns**: none; **moss**: none.

9) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 5630 to 8800 feet in elevation. The average canopy cover is 20% ranging from 1-50% total cover and frequency of occurrence equal to 93%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga

menziesii) with average percent cover ≥16% and ≤19% and frequency of occurrence ≥61% and ≤80%.

Primary associated shrub species with ≥4% and ≤27% frequency of occurrence in mixed subalpine stands: sitka alder (Alnus sinuata), common prince's pine (Chimaphila umbellata), twin flower (Linnaea borealis), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥6% and ≤26% frequency of occurrence in mixed subalpine fir stands: **graminoids**: pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), orchard-grass (Dactylis glomerata), blue wildrye (Elymus glaucus), common timothy (Phleum pratense), and bluegrass (Poa spp.); **forbs**: heart-leaf arnica (Arnica cordifolia), arnica (Arnica spp.), showy aster (Aster conspicuus), glacier lily (Erythronium grandiflorum), Virginia strawberry (Fragaria virginiana), sticky geranium (Geranium viscosissimum), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: moss (moss spp.).

10) 4222: MIXED XERIC FOREST

Conifer forest dominated by rocky mountain juniper (Juniperus scopulorum), codominant species are limber pine (Pinus flexilis) and ponderosa pine (Pinus ponderosa), ranging from 3834 to 7880 feet in elevation. The average canopy cover for JUNSCO is 15% ranging from 1-60% total cover and frequency of occurrence equal to 67%. The average canopy cover for PINFLE is 11% ranging from 1-30% total cover and frequency of occurrence equal to 42%. The average canopy cover for PINPON is 16% ranging from 1-30% total cover and frequency of occurrence equal to 51%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥15% and ≤20% and frequency of occurrence ≥7% and ≤95%.

Primary associated shrub species with ≥4% and ≤24% frequency of occurrence in mixed xeric stands: kinnikinnick (Arctostaphylos uva-ursi), common juniper (Juniperus communis), creeping juniper (Juniperus horizontalis), mallow ninebark (Physocarpus malvaceus), Canada buffaloberry (Shepherdia canadensis), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥6% and ≤26% frequency of occurrence in mixed xeric stands: **graminoids**: bearded wheatgrass (Agropyron caninum), bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), rough fescue (Festuca scabrella), and western needlegrass (Stipa occidentalis); **forbs**: common yarrow (Achillea millefolium), rosy pussy-toes (Antennaria microphylla), harebell (Campanula rotundifolia), blanket-flower (Gaillardia aristata), northern bedstraw (Galium boreale), western gromwell (Lithospermum ruderale), and Missouri goldenrod (Solidago missouriensis); **fern**: stiff clubmoss (Lycopodium annotinum) and compact selaginella (Selaginella densa); **moss**: moss (moss spp.).

11) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii) and ranging from 5260 to 7680 feet in elevation. The average canopy cover for PINCON is 23% ranging from 3-50% total cover and frequency of occurrence equal to 100%. The average canopy cover for PSEMEN is 25% ranging from 10-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and whitebark pine (Pinus albicaulis) with average percent cover $\geq$2% and $\leq$7% and frequency of occurrence $\geq$10% and $\leq$36%.

Primary associated shrub species with $\geq$10% and $\leq$36% frequency of occurrence in Douglas-fir-lodgepole pine stands: creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), shiny-leaf spiraea (Spiraea betulifolia), spiraea (Spiraea spp.), common snowberry (Symphoricarpos albus), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with $\geq$2% and $\leq$48% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), mountain brome (Bromus carinatus), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), Kentucky bluegrass (Poa pratensis), and western needlegrass (Stipa occidentalis); **forbs**: raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), woods strawberry (Fragaria vesca), roundleaf alumroot (Heuchera cylindrica), Fendler's meadowrue (Thalictrum Fendleri), and western meadowrue (Thalictrum occidentale); **fern**: stiff clubmoss (Lycopodium annotinum); **moss**: moss (moss spp.).

P39/R28 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASS
6101	Needleleaf Dominated Riparian	6, 21
6102	Broadleaf Dominated Riparian	51
6103	Needleleaf-Broadleaf Riparian	25
6104	Mixed Riparian (trees+ any other)	23
6201	Grass-Forb Riparian Wetland	None identified for scene
6202	Shrub Riparian Wetland	52, 53
6203	Mixed Grass-Forb-Shrub Riparian	None identified for scene

---

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 2
Color: Tan; RGB 192 176 145.
Distribution: Found primarily near wetter portions of valleys and some lower mid-elevation slopes; lighter density at middle to upper elevations.
Comment: Outside the calculated riparian zone, herbaceous cover types dominate recorded observations; coniferous and riparian (6102, 6101, 6201, 6202) vegetation were also observed. Visual cues suggest drier shrub vegetation.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION
2	3	Urban & Developed Land
3	1	Irrigated Crop
4	2	Dry-land Pasture
5	1	Irrigated Pasture
6	3	Foothills Grassland
7	1	Broadleaf Dominated Riparian
8	1	Grass-Forb Riparian/Wetland
9	3	Shrub Riparian/Wetland

Spectral Class 3
Color: Dark moss green; RGB 87 100 98.
Distribution: Light to medium density on lower slopes; light density at mid to high elevations.
Comment: Conifers are most prevalent in training data outside the zone; grass and meadow, shrub, and riparian (6101, 6201, 6202) cover types are also present. Appears to be conifers.
Conclusion: Not riparian.

10	1	Limber Pine
11	2	Needleleaf Dominated Riparian
12	1	Grass-Forb Riparian/Wetland
13	1	Shrub Riparian/Wetland

Spectral Class 4
Color: Very dark red; RGB 108 35 59.
Distribution: Light to medium density on lower mid-elevation slopes.
Comment: The majority of training sites outside the zone were recorded as coniferous vegetation; a few sites were recorded as riparian vegetation (6201, 6202). Locations and color suggest shadows and coniferous vegetation.
Conclusion: Not riparian.

14	1	Shrub Riparian/Wetland

Spectral Class 5
Color: Sea green; RGB 108 170 157.
Distribution: Widely distributed at lower elevations, with smoe large clusters; generally some distance from water features.
Comment: Herbaceous and shrub life forms are most prevalent among training sites outside the zone; two riparian sites (6101, 6102) are included. Color and distribution indicate dry shrubs.
Conclusion: Not riparian.

15	1	Foothills Grassland
16	1	Disturbed Grasslands
17	1	Grass-Forb Riparian/Wetland

Spectral Class 6
Color: Tan brown; RGB 150 126 110.
Distribution: Light density at mid-elevations; light to medium density on lower slopes and near wetter portions of valleys.
Comment: Conifers, grasslands, and shrubs characterize training sites outside the zone; several sites represent riparian vegetation (6201, 6202, 6102, 6101). Appears to be junipers.
Conclusion: 6101.

18	1	Dry-land Pasture
19	1	Mesic Upland Shrubland
20	1	Rocky Mountain Juniper
21	3	Broadleaf Dominated Riparian
22	1	Needleleaf-Broadleaf Riparian
23	2	Shrub Riparian/Wetland

Spectral Class 7
Color: Black; RGB 49 31 55.
Distribution: Light to dense spackle in the mountains.
Comment: Primarily conifers were observed outside the zone; several riparian sites (6202, 6201, 6101, 6103) were noted. Color and locations indicate shadows, conifers, and water.
Conclusion: Not riparian.

24	1	Foothills Grassland
25	1	Douglas-fir
26	1	Mixed Subalpine Forest
27	2	Needleleaf Dominated Riparian

Spectral Class 10
Color: Flat green; RGB 101 139 129.
Distribution: Medium density with some clustering, on foothills; very light density at mid-elevations.
Comment: Grasslands, conifers, and shrubs were most observed outside the zone; one site represents riparian (6201) vegetation. Visual cues suggest drier shrubs.
Conclusion: Not riparian.

28	1	Foothills Grassland
29	1	Mixed Xeric Forest
30	1	Shrub Riparian/Wetland

Spectral Class 11
Color: Light green; RGB 147 203 188.
Distribution: Generally occurs on foothill slopes; some near wetter portions of valleys.
Comment: Herbaceous vegetation, including agriculture, dominate training data outside the zone, with shrubs also present. Two points indicate riparian vegetation (6202). Appears to represent dry grasses.
Conclusion: Not riparian.

31	1	Irrigated Crop
32	2	Foothills Grassland
33	1	Mountain Big Sagebrush
34	1	Broadleaf Dominated Riparian

Spectral Class 13
Color: Gray; RGB 136 174 184.
Distribution: Occurs primarily on lower slopes and along valley edges, densely in some locations; some near wetter portions of valleys.
Comment: Shrub and herbaceous life forms were most recorded outside the zone; some conifer and one riparian (6101) observation were also noted. The class appears to represent

dry shrubs, perhaps black sage.
Conclusion: Not riparian.

36	1	Foothills Grassland
37	1	Wyoming Big Sagebrush Steppe
38	1	Shrub Riparian/Wetland

Spectral Class 14
Color: Black; RGB 59 50 67.
Distribution: Medium to very high density at middle to upper elevations.
Comment: Conifers dominate observations outside the zone; several riparian sites (6201, 6101, 6103) were noted as well. Visual cues indicate conifers.
Conclusion: Not riparian.

39	1	Mountain Big Sagebrush
40	1	Engelmann Spruce
41	2	Mixed Subalpine Forest
42	1	Rivers & Streams
43	3	Needleleaf Dominated Riparian
44	1	Broadleaf Dominated Riparian
45	3	Shrub Riparian/Wetland

Spectral Class 15
Color: Dark warm brown; RGB 91 54 67.
Distribution: Medium to high density at mid-elevations.
Comment: Training sites outside the zone indicate primarily coniferous cover types; several sites indicate riparian (6101, 6201, 6202, 6103) cover types. Appears to represent Mixed Mesic Forest.
Conclusion: Not riparian.

46	1	Mountain Big Sagebrush
47	1	Lodgepole Pine
48	1	Douglas-fir
49	1	Mixed Mesic Forest
50	6	Needleleaf Dominated Riparian
51	1	Needleleaf-Broadleaf Riparian
52	3	Shrub Riparian/Wetland

Spectral Class 17

Color: Cool brown; RGB 98 76 75.
Distribution: Similar to Spectral Class 15.
Comment: Coniferous and riparian (6102, 6202, 6101, 6103, 6201) cover types characterize training sites outside the hypothetical riparian zone. Visual cues similar to Spectral Class 15.
Conclusion: Not riparian.

53	1	Urban & Developed Land
54	1	Irrigated Crop
55	1	Lodgepole Pine
56	1	Douglas-fir
57	2	Mixed Subalpine Forest
58	1	Mixed Mesic Forest
59	1	Needleleaf Dominated Riparian
60	1	Grass-Forb Riparian/Wetland
61	3	Shrub Riparian/Wetland

Spectral Class 18
Color: Brown black; RGB 42 17 51.
Distribution: Light to high density at mid-elevations.
Comment: Conifers dominate training data outside the zone; a few sites represent riparian vegetation (6101, 6103). Appears to represent conifers, especially Douglas Fir.
Conclusion: Not riparian.

62	1	Mixed Subalpine Forest
63	1	Mixed Mesic Forest
64	1	Needleleaf Dominated Riparian

Spectral Class 19
Color: Black; RGB 21 17 47.
Distribution: Similar to Spectral Class 19.
Comment: Conifers were most recorded outside the riparian zone; two points indicate riparian vegetation (6101, 6201). Distribution and color indicate shadows.
Conclusion: Not riparian.

65	1	Needleleaf Dominated Riparian

Spectral Class 21
Color: Brown; RGB 108 87 90.
Distribution: Light to medium denity on slopes, generally more dense at lower mid-elevations; some near streams at lower elevations.
Comment: Coniferous cover types were most recorded outside the zone; several observations indicate riparian cover types (6202, 6101, 6201). Appears to represent conifers, riparian within

the zone.
Conclusion: 6101.

66	1	Ponderosa Pine & Savannah
67	1	Broadleaf Dominated Riparian
68	1	Grass-Forb Riparian/Wetland
69	1	Shrub Riparian/Wetland

Spectral Class 23
Color: Warm tan; RGB 182 140 114.
Distribution: A large class. Occurs most densely on lower slopes; medium to high density in some wetter portions of valleys; lighter density at mid-elevations.
Comment: Foothills Grassland has the highest frequency of any cover type recorded outside the zone; agricultural, coniferous, and riparian (6201, 6202, 6102, 6102, 6103) cover types are about equally represented. Visual indicators imply a mixture of conifers, shrubs, and grass.
Conclusion: 6104.

75	1	Urban & Developed Land
76	1	Dry-land Pasture
77	4	Foothills Grassland
78	1	Disturbed Grasslands
79	1	Mesic Upland Shrubland
80	1	Ponderosa Pine & Savannah
81	1	Mixed Mesic Forest
82	1	Mixed Xeric Forest
83	1	Mix Needleleaf-Broadleaf
84	1	Broadleaf Dominated Riparian
85	4	Grass-Forb Riparian/Wetland
86	3	Shrub Riparian/Wetland

Spectral Class 24
Color: Olive drab; RGB 129 113 102.
Distribution: Medium density on mid-elevation and lower slopes; lighter density on some foothills and near wetter portions of valleys.
Comment: Conifers dominate training data outside the zone, with herbaceous and shrub lifeforms included; several observations represent riparian vegetation (6202, 6101, 6102, 6201). Visual cues suggest dry shrubs, with perhaps some juniper.
Conclusion: Not riparian.

87	1	Dry-land crop
88	1	Mixed Subalpine Forest
89	1	Mixed Xeric Forest
90	1	Needleleaf Dominated Riparian

91	3	Shrub Riparian/Wetland

Spectral Class 25
Color: Rust brown; RGB 126 63 71.
Distribution: Relatively high density at lower mid-elevations; lighter density at upper mid-elevations; lighter density near lower elevation streams.
Comment: Coniferous vegetation was most recorded outside the riparian zone; riparian cover types include 6101, 6201, 6102, 6103, 6202.
Conclusion: 6103.

92	1	Foothills Grassland
93	1	Mesic Upland Shrubland
94	1	Needleleaf Dominated Riparian
95	1	Broadleaf Dominated Riparian
96	1	Needleleaf-Broadleaf Riparian
97	1	Shrub Riparian/Wetland

Spectral Class 31
Color: Light lilac; RGB 217 203 235.
Distribution: Some clusters in low elevations, genearally away from water features.
Comment: Exposed Rock has the highest frequency of any cover type outside the zone; agriculture, shrubs, grassland, and tundra are also present. Appears to represent pastures and grasslands.
Conclusion: Not riparian.

105	1	Irrigated Crop
106	2	Grass-Forb Riparian/Wetland

Spectral Class 38
Color: Brown black; RGB 73 30 55.
Distribution: Medium density on lower to mid-elevation slopes; light density at upper mid-elevations; very little near streams at lower elevations.
Comment: Coniferous vegetation is most prevalent among cover types outside the zone; several sites represent riparian vegetation (6101, 6201, 6102, 6202). Visual cues indicate conifers and shadows.
Conclusion: Not riparian.

108	1	Engelmann Spruce
109	1	Needleleaf Dominated Riparian

Spectral Class 44
Color: Blue black; RGB 0 9 63.

Distribution: A rare class. Some in cloud shadows and water bodies; very light density at high elevations.
Comment: Exposed Rock dominates training data outside the zone.
Conclusion: Not riparian.

110	3	Rivers & Streams
111	1	Grass-Forb Riparian/Wetland
112	1	Shoreline & Gravel Bars

Spectral Class 47
Color: White; RGB 255 255 255.
Distribution: A rare class. Occurs in clouds over mountains and at a few locations at low elevations, a couple of which are near a confluence of streams.
Comment: Vegetation accounts for less than 50% of the training sites outside the zone. Most locations are in clouds.
Conclusion: Not riparian.

113	1	Shrub Riparian/Wetland

Spectral Class 50
Color: Orange; RGB 255 113 75.
Distribution: Occurs primarily in wetter portions of valleys.
Comment: Agricultural cover types, especially Irrigated Crop, dominate training sites outside the zone.
Conclusion: Not riparian.

114	1	Foothills Grassland

Spectral Class 51
Color: Red orange; RGB 255 83 75.
Distribution: Medium to high density in wetter portions of most valleys.
Comment: Agricultural cover types are most prevalent outside the zone; fourteen points indcate riparian cover types (6202, 6201, 6102, 6101).
Conclusion: 6102.

115	1	Dry-land crop
116	2	Irrigated Crop
117	1	Foothills Grassland
118	4	Grass-Forb Riparian/Wetland
119	6	Shrub Riparian/Wetland

Spectral Class 52
Color: Brownish orange; RGB 203 89 75.
Distribution: Light density at mid-elevations; clustered in weter portions of valleys; light to medium density on lower slopes.
Comment: Outside the zone, riparian cover types (6202, 6201, 6102, 6101, 6103) are most prevalent in the training data; agriculture and Aspen are next in importance, with grass and meadow vegetation, conifers, and shrubs also present.
Conclusion: 6202.

120	2	Irrigated Crop
121	2	Aspen
122	1	Douglas-fir
123	1	Mixed Mesic Forest
124	9	Broadleaf Dominated Riparian
125	4	Grass-Forb Riparian/Wetland
126	9	Shrub Riparian/Wetland

Spectral Class 53
Color: Orange; RGB 255 128 102.
Distribution: Medium to high density in wetter portions of valleys; some linear pattern on foothills.
Comment: Herbaceous cover types, including agriculture, dominate training data outside the zone; eight sites indicate presence of riparian vegetation (6202, 6201).
Conclusion: 6202.

127	1	Irrigated Pasture
128	1	Foothills Grassland
129	2	Mesic Upland Shrubland
130	1	Rivers & Streams
131	1	Broadleaf Dominated Riparian
132	1	Grass-Forb Riparian/Wetland
133	3	Shrub Riparian/Wetland

Spectral Class 55
Color: Gray blue; RGB 122 124 180.
Distribution: Clusters at lower elevations, but some distance from streams; very light density at high elevations.
Comment: Foothills Grassland and Exposed Rock have the highest frequencies among cover types outside the zone; agriculture, shrubs, and conifers are about equally represented. Appears to represent urban sites.
Conclusion: Not riparian.

134	1	Shrub Riparian/Wetland

Spectral Class 56
Color: Dark green; RGB 42 72 114.
Distribution: Light density at highest elevations and some low areas; clustering in one burn; some in water or near streams.
Comment: Exposed Rock dominates training data outside the zone.
Conclusion: Not riparian.

135	1	Needleleaf Dominated Riparian
136	1	Shrub Riparian/Wetland
137	1	Shoreline & Gravel Bars

TM SCENE P39/R29

Image Analyst: J. Chris Winne

Training Data Analysis

In all, 1780 ground-truth plots were available for labeling P39/R29 (see table below); 1512 were collected by Forest Service field crews during the 1994-95 field seasons, and 787 of these were collected specifically for this TM scene. The remaining 268 plots came from pre-existing data sources such as ECODATA and TSMRS.

All ground-truth data were converted to a point file and superimposed on the unsupervised classification to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 214) were removed from further analysis; (these plots can be identified using the following query: DUP_TYPE ne 'B', USE eq 'Y'). The data then were examined by cover type and by data source (whether or not plots were collected for this project or for other purposes, like pre-existing ECODATA or TSMRS). The latter "existing data" were only used in the training data set to supplement cover types that had insufficient plots collected during the 1994 or 1995 field seasons. Eight general classes were excluded from the digital classification process: urban, agriculture, riparian, water, snow, melted snow, cloud, and cloud shadow. All ground truth data with VEG_CLASS_CODE's for urban, agriculture, riparian or water cover types were excluded. Next, 20% of the remaining plots were randomly selected from each cover type; these plots (n = 188) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

The remaining 80% of the data (n = 781 plots) were subjected to further spectral examination. Outliers were identified for each cover type by examining plots in relation to TM and ancillary data for their respective regions (both visually and in relation to calculated standard deviations) and then eliminated.

A total of 415 points were used in the final training set, which included 7 points added (1 from the Forest Service review and 6 from existing data). Training data analysis was aided by discussions Dan Svoboda (Beaverhead NF) and Chip Fisher.

Total plots in ground-truth file	1780	
Total 1994-95 field plots	1512	
Plots sampled for P41/R26		787
Plots sampled for other scenes		725
Pre-existing plots (ECODATA, TSMRS, etc.)	268	
Plots held aside or eliminated	811	
Duplicates		214
Pre-existing plots		141
Manually labeled cover types		456
Potential training plots	969	
20% test		188
80% training		781
Supplemental plots (from pre-existing data set)	7	
Total plots available for training	788	
Total plots used for training -- cover type	415	
size class	176	
canopy	86	

Land Cover Types

Land cover types were labeled through a digital classification of the 7 TM channels plus rescaled elevation (elevation in meters divided by 25), using the Nearest Member of Group classifier. This classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were used and assigned directly to the COVERTYPE field in the attribute table. Modifications were carried out using spectral class values (SPECTRAL_CLASS or LINK), and/or intermediate cover code labels in conjunction with other attributes including the TM values, modified NDVI, elevation and/or slope as follows:

1000. Urban.	Manually identified and recoded by Will Gustafson.
2000. Agriculture.	Manually identified and recoded by Will Gustafson.
3101. Foothills Grasslands.	This cover type was highly confused with sagebrush types (3305, 3306, 3307, and 3308) because in many places they are interspersed. Furthermore, many large regions, likely to contain mosaics of these types, were delineated. Dan Svoboda suggested that for this scene, a mixed grassland/sagebrush cover type would be appropriate. For this reason, the relationship between grass and sagebrush was changed in the fuzzy set matrix to acceptable (score 3) for this scene's accuracy assessment.
3201. Mesic Upland Shrub.	This type was not classified in the scene because it was

		such a minor component.
3301.	Mountain Mahogany.	Based on Forest Service review, the occurrence of this cover type was limited to southern aspects. If COV_CODE_1 = 3301 and ASP was not southerly, then COVERTYPE = COV_CODE_2. Some of the larger regions labeled as 3301 are more likely to be grassland or sagebrush types.
3305.	Mountain Big Sagebrush.	See comments for 3101.
3306.	Wyoming Big Sagebrush.	The distribution of this type was confined to geographical limits set by Forest Service ecologists.
3307.	Basin Big Sagebrush.	The distribution of this type was confined to geographical limits set by Forest Service ecologists. For accuracy assessment, it was combined with the Mountain Big Sagebrush class. Commission errors could be reduced by further restricting its occurrence to terraces and bottomlands associated with riparian areas.
3308.	Black Sagebrush Steppe.	This cover type appeared to be confused with other sagebrush types. As with Basin Big Sagebrush, commission errors could be reduced by restricting occurrence to terraces and bottomlands.
4101.	Aspen.	This type was often confused with meadows containing scattered clumps of conifers. Also, because aspen stands are typically linear, many appeared to be lost as a result of merging 30 m pixels to the 2 ha MMU.
4203.	Lodgepole Pine.	Forest Service review revealed frequent confusion between the Lodgepole Pine and Douglas-Fir (4212) cover types. Some of this confusion could not be resolved.
4205.	Limber Pine.	This cover type appeared to be confused with other low density forest stands, in particular the Mixed Whitebark Pine Forest type (4219).
4208.	Subalpine Fir.	Very few plots were available for this type, so even though it was mapped, its accuracy cannot be fairly assessed.
4214.	Rocky Mountain Juniper.	Forest Service review indicated that most regions labeled 4214 were in areas that actually contained juniper, although some confusion with the Foothills Grassland

type was also evident.

5000.	Water.	All regions with spectral class (LINK = 1) and slope ≤5˚ were labeled as water; in addition all regions with LINK = 1, MNDVI ≤20, SLOPE ≤20, and TM4 ≤40 were recoded as being water. Cloud shadows (see 9900 below) were recoded manually. Generally, water was more spectrally distinct than most other cover types, but in mountainous terrain, it was sometimes confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate slope and aspect values such that their slope may be >5˚. This would result in the misclassification of some small ponds or lakes.
7301.	Exposed Rock.	Forest types (COV_CODE_1 = 4000) with MNDVI values <30 (or <10 for 4214) were recoded as being Exposed Rock. Conversely, regions classified as Exposed Rock (COV_CODE_1 = 7301) were recoded to their COV_CODE_2 value if MNDVI was >75 (suggesting a vegetated cover type).
7400.	Barren Tundra.	The distribution of this type was confined to geographical limits set by Forest Service ecologists.
(n/a)	Melted Snow.	All regions originally classified as Melted Snow were recoded either to Exposed Rock (7301), if their slope was >5˚, or to Snow (9000), if their slope was ≤5˚.
8101.	Alpine Meadow.	
9100.	Snow.	Regions were labeled as Snow if LINK = 20, TM2 ≥49, TM3 ≥58, TM5 ≤89, MNDVI ≤ -14, and ELEVATION >2750 m.
9800.	Cloud.	Manually identified and recoded by Will Gustafson.
9900.	Cloud Shadow.	Manually identified and recoded by Will Gustafson.

A total of 27 cover types were labeled in the full TM scene. These included two grass types, five shrub types, ten forest types, three barren types, one alpine type, plus six manually labeled classes. Cover types are mapped in Figure F-15.

Canopy Cover Classes

Canopy cover labels (CANOPY_CODE = low(1), medium(2), or high(3)) were

assigned to tree and shrub classes based on the MNDVI values. These values were plotted as frequency histograms for all forest types (Figure F-15a), as well as for one shrub type (Figure F-15b). The histograms were examined to determine break points based upon the distribution modes. Regions with MNDVI values falling below the lower break point were assigned to a low canopy cover class; those greater than or equal to the lower breakpoint, but below the higher break point were assigned to the medium class; and those falling above the higher breakpoint were assigned to the high canopy cover class (see below).

Cover Type Classes	BREAKPOINTS	
	Lower	Upper
3300 shrubs	39	104
4000 trees	112.5	193.5

Size Classes

Seven size classes were classified -- four forest cover types (seedling/sapling, pole, mature, and mature/overmature), and three shrubs (low, medium, and tall). The seven TM spectral bands were used for the size classification (elevation was not included). The Nearest Member of Group (NMG) classifier was used for both tree and shrub size classes. Tree size classes were stratified based upon the three canopy cover classes described above.

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications.

Classifications for P39/R29	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	20	80%	45%
Tree Size Class	4	94%	65%
Tree Canopy Class	3	90%	58%
Shrub Size Class	3	95%	76%
Shrub Canopy Class	3	94%	63%

Comments

General distributions of the land cover types appeared to be reasonable when reviewed by Dan Svoboda (Beaverhead National Forest) and Chip Fisher. Based on this review, outlier training plots were identified and eliminated. As a result, better differentiation was achieved between specific, problematic cover types such as aspen. The small size and linear nature of many aspen stands, however, complicated the classification of this type, but commission error was reduced by eliminating all plots except those most uniformly and distinctly aspen. Significant confusion still exists between lodgepole pine and Douglas-fir, and between foothills grassland and mountain big sage. The classification of these types was complicated by the presence of large regions that contained a wide range of aspects and elevations.

Error Matrix For Cover Type Training Plots
Scene P39/R29

CLASSIFIED COVER TYPES

PLOT COVER TYPES	3101	3104	3301	3305	3306	3307	3308	4101	4203	4205	4208	4212	4214	4219	4220	4222	4223	7301	7400	7800	8101	SUM
3101	38	3	4	12	4	0	1	0	0	0	0	0	1	0	0	0	0	0	0	2	0	65
3104	4	33	0	10	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	50
3301	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
3305	9	4	2	43	9	1	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	73
3306	2	0	0	6	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
3307	0	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	4
3308	1	0	0	7	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
4101	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	8
4203	0	0	0	0	0	0	0	0	8	1	1	4	0	0	0	0	2	0	0	0	0	16
4205	2	2	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	7
4208	0	0	0	1	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	4
4212	0	0	0	0	0	0	0	0	3	0	0	62	0	0	2	0	3	0	0	0	0	70
4214	1	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	4
4219	0	0	0	0	0	0	0	0	0	2	2	0	0	4	0	0	0	0	0	0	0	8
4220	0	0	0	0	0	0	0	0	1	0	0	2	0	0	5	0	1	0	0	0	0	9
4222	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	4
4223	0	0	0	0	0	0	0	0	2	0	0	1	0	0	1	0	0	0	0	0	0	4
7301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	1	0	0	34
7400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	1	6
7800	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	9	0	11
8101	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	6
SUM	60	43	6	84	23	2	9	9	17	7	3	70	5	6	8	0	6	33	8	11	5	415

% AGREEMENT	64.1
TAU WITH EQUAL PROBABILITY	0.62
TOTAL DIAGONAL ELEMENTS	266
TOTAL TRAINING PLOTS IN DATA SET	415

f. p39/r29. 8

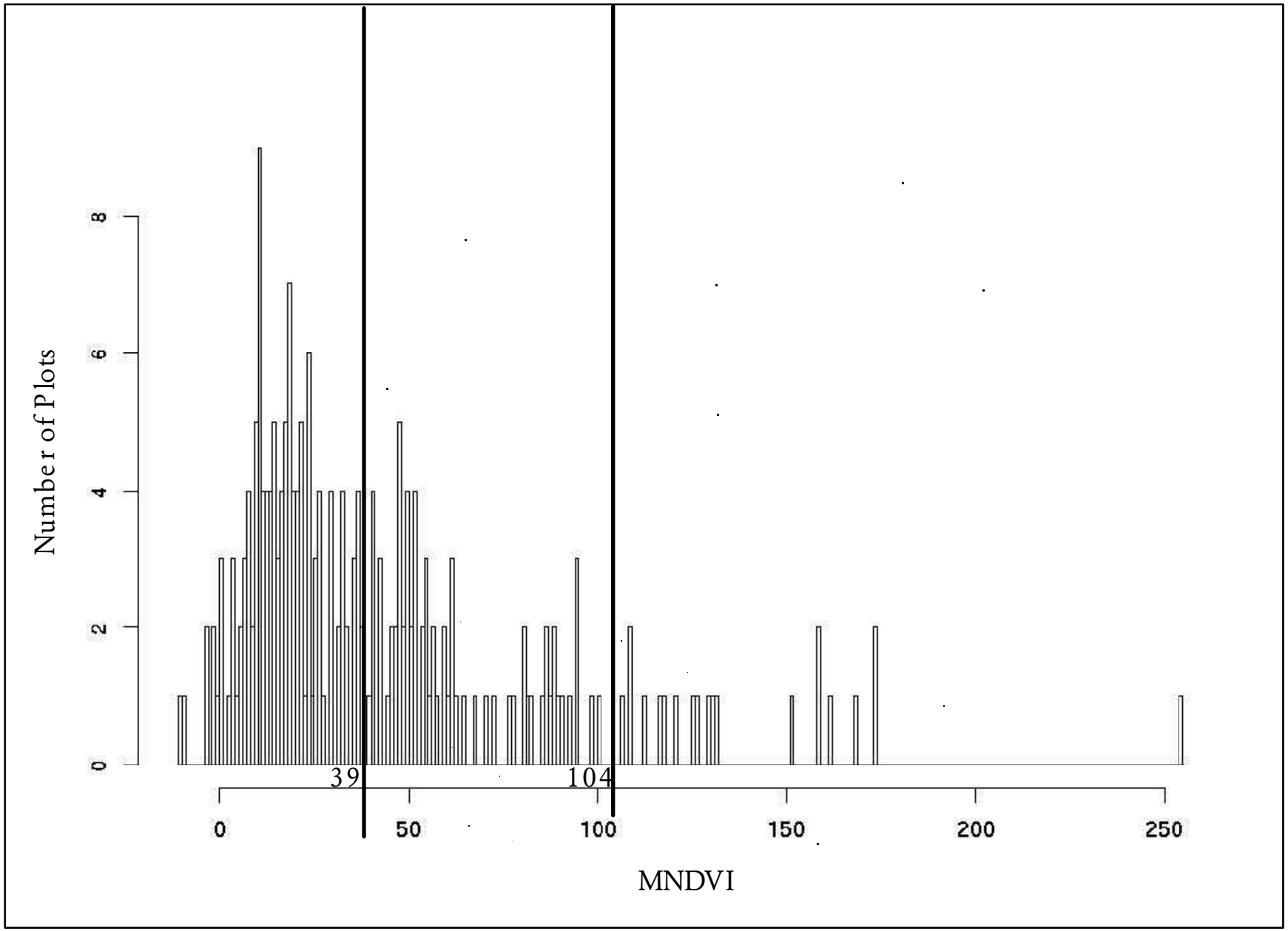
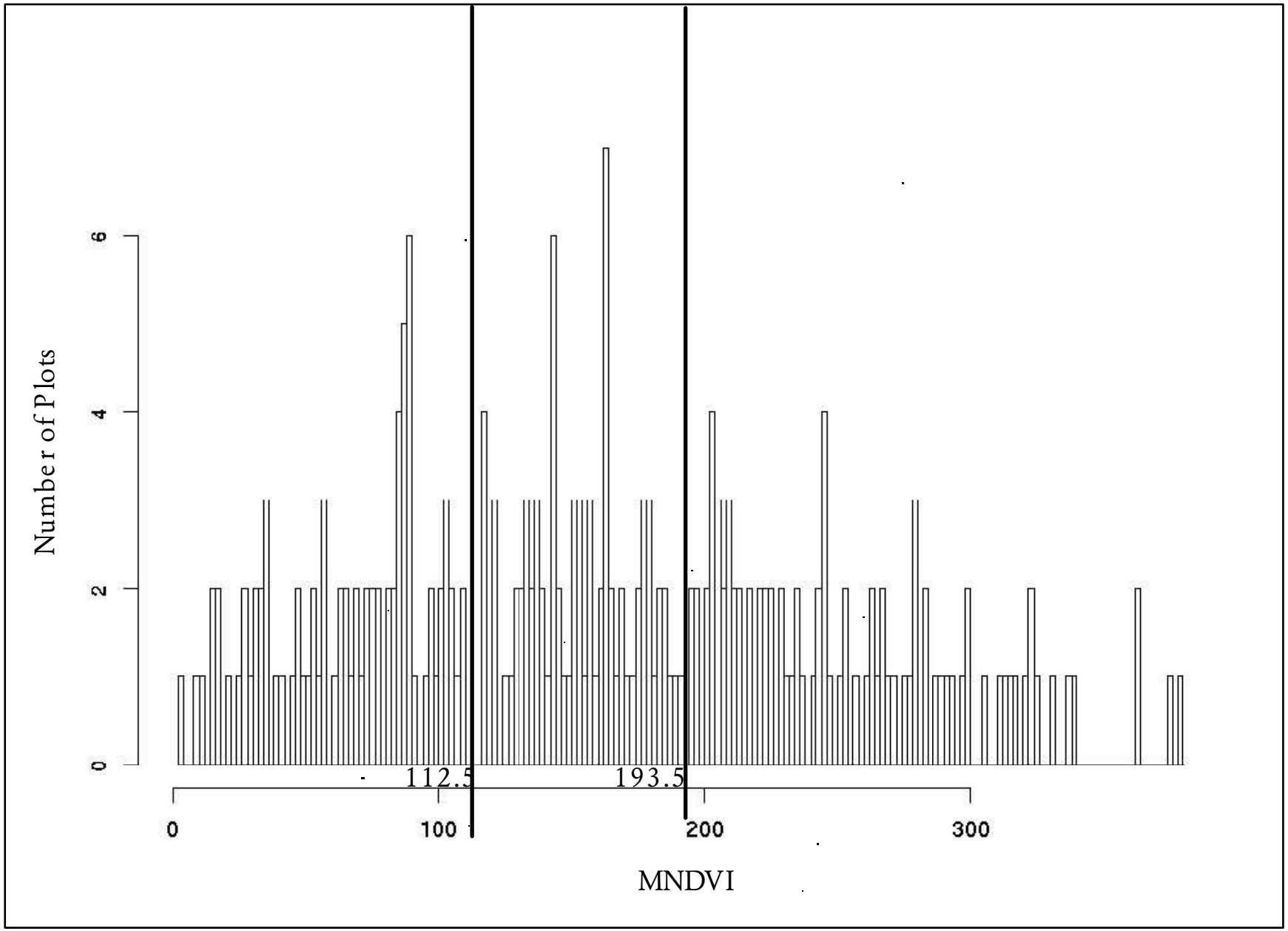


Figure F-15b. Breaks between shrub canopy cover classes in relation to MNDVI values: TM scene P39/R29



f. p39/r29. 9

Figure F-15a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P39/R29

Accuracy Assessment Tables for P39/R29 -- Cover Type

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3104	3301	3305	3306	3308	4101	4203	4205
3101	12(5)	6(3)	0(1)	6(3)	0(3)	1(3)	0(1)	0(1)	3(1)
3104	2(3)	14(5)	0(1)	0(3)	0(3)	0(3)	0(1)	0(1)	2(1)
3301	0(1)	0(1)	0(5)	0(2)	0(2)	1(2)	0(1)	0(1)	0(1)
3305	6(3)	5(3)	1(2)	22(5)	2(4)	2(3)	0(1)	0(1)	2(1)
3306	1(3)	0(3)	0(2)	1(4)	3(5)	0(3)	0(1)	0(1)	1(1)
3308	0(3)	0(3)	0(2)	1(4)	2(4)	1(5)	0(1)	0(1)	0(1)
4101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	3(5)	0(2)	0(2)
4203	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	2(5)	1(2)
4205	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(2)	1(2)	1(5)
4208	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)
4212	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	1(2)	3(2)	1(2)
4214	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)
4219	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(3)	0(2)
4220	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	2(3)	0(2)
4222	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	1(2)	0(3)
4223	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	1(3)	0(2)
7301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7400	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7800	0(2)	0(1)	0(1)	1(1)	0(1)	2(1)	0(1)	0(1)	0(1)
8101	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	23(0)	30(0)	1(0)	32(0)	7(0)	7(0)	4(0)	10(0)	11(0)

RF/CF	4208	4212	4214	4219	4220	4222	4223	7301	7400
3101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3104	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)
3301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3305	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3306	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3308	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4101	0(2)	0(2)	0(2)	0(2)	0(2)	1(2)	0(2)	0(1)	0(1)
4203	0(2)	1(2)	0(2)	0(3)	1(3)	1(2)	0(4)	0(1)	0(1)
4205	0(2)	0(2)	0(2)	1(2)	0(2)	0(4)	0(2)	0(1)	0(1)
4208	0(5)	0(2)	0(2)	0(3)	1(3)	0(2)	0(2)	0(1)	0(1)
4212	0(2)	15(5)	0(2)	0(2)	5(3)	5(4)	0(4)	0(1)	0(1)
4214	0(2)	0(2)	0(5)	0(2)	0(2)	0(4)	0(2)	0(1)	0(1)
4219	0(3)	2(2)	0(2)	1(5)	1(3)	0(2)	0(2)	0(1)	0(1)
4220	1(3)	1(3)	0(2)	0(3)	2(5)	0(2)	0(3)	0(1)	0(1)
4222	0(2)	2(3)	0(3)	0(2)	0(2)	0(5)	0(2)	0(1)	0(1)
4223	0(2)	0(3)	0(2)	0(2)	0(3)	0(2)	0(5)	0(1)	0(1)
7301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	11(5)	1(3)
7400	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(2)	1(5)
7800	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(3)	0(3)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(3)
SUM	1(0)	21(0)	1(0)	2(0)	10(0)	7(0)	0(0)	14(0)	2(0)

Accuracy Assessment Tables for P39/R29 -- Cover Type

RF/CF	7800	8101	SUM
3101	3(1)	0(1)	31(0)
3104	1(1)	0(1)	20(0)
3301	0(1)	0(1)	1(0)
3305	0(1)	0(1)	40(0)
3306	0(1)	0(1)	6(0)
3308	0(1)	0(1)	4(0)
4101	0(1)	0(1)	4(0)
4203	0(1)	0(1)	6(0)
4205	0(1)	0(1)	4(0)
4208	0(1)	0(1)	1(0)
4212	0(1)	0(1)	31(0)
4214	0(1)	0(1)	2(0)
4219	0(1)	0(1)	5(0)
4220	0(1)	0(1)	6(0)
4222	0(1)	0(1)	3(0)
4223	0(1)	0(1)	1(0)
7301	2(3)	1(1)	15(0)
7400	0(2)	0(3)	3(0)
7800	3(5)	0(3)	7(0)
8101	0(3)	0(5)	3(0)
SUM	9(0)	1(0)	193(0)

Diagonal Elements = 91; Total Test Points = 193
Percentage Agreement = 47.15; Kappa = 0.411; Tau w/equal Prob = 0.444

Accuracy Assessment Tables for P39/R29 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	12	38.71	0	0.00	13	41.94	0	0.00	6	19.35
3104	14	70.00	0	0.00	2	10.00	0	0.00	4	20.00
3301	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00
3305	22	55.00	2	5.00	13	32.50	1	2.50	2	5.00
3306	3	50.00	1	16.67	1	16.67	0	0.00	1	16.67
3308	1	25.00	3	75.00	0	0.00	0	0.00	0	0.00
4101	3	75.00	0	0.00	0	0.00	1	25.00	0	0.00
4203	2	33.33	0	0.00	1	16.67	3	50.00	0	0.00
4205	1	25.00	0	0.00	0	0.00	2	50.00	1	25.00
4208	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4212	15	48.39	5	16.13	5	16.13	5	16.13	1	3.23
4214	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4219	1	20.00	0	0.00	1	20.00	2	40.00	1	20.00
4220	2	33.33	0	0.00	4	66.67	0	0.00	0	0.00
4222	0	0.00	0	0.00	2	66.67	1	33.33	0	0.00
4223	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
7301	11	73.33	0	0.00	3	20.00	0	0.00	1	6.67
7400	1	33.33	0	0.00	0	0.00	1	33.33	1	33.33
7800	3	42.86	0	0.00	0	0.00	0	0.00	4	57.14
8101	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
SUM	91	47.15	11	5.70	47	24.35	17	8.81	27	13.99

Accuracy Assessment Tables for P39/R29 -- Cover Type

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	12	38.71	12	38.71	25	80.65	25	80.65	31	100.00
3104	14	70.00	14	70.00	16	80.00	16	80.00	20	100.00
3301	0	0.00	0	0.00	0	0.00	1	100.00	1	100.00
3305	22	55.00	24	60.00	37	92.50	38	95.00	40	100.00
3306	3	50.00	4	66.67	5	83.33	5	83.33	6	100.00
3308	1	25.00	4	100.00	4	100.00	4	100.00	4	100.00
4101	3	75.00	3	75.00	3	75.00	4	100.00	4	100.00
4203	2	33.33	2	33.33	3	50.00	6	100.00	6	100.00
4205	1	25.00	1	25.00	1	25.00	3	75.00	4	100.00
4208	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4212	15	48.39	20	64.52	25	80.65	30	96.77	31	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4219	1	20.00	1	20.00	2	40.00	4	80.00	5	100.00
4220	2	33.33	2	33.33	6	100.00	6	100.00	6	100.00
4222	0	0.00	0	0.00	2	66.67	3	100.00	3	100.00
4223	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
7301	11	73.33	11	73.33	14	93.33	14	93.33	15	100.00
7400	1	33.33	1	33.33	1	33.33	2	66.67	3	100.00
7800	3	42.86	3	42.86	3	42.86	3	42.86	7	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
SUM	91	47.15	102	52.85	149	77.20	166	86.01	193	100.00

Accuracy Assessment Tables for P39/R29 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	12	52.17	0	0.00	9	39.13	0	0.00	2	8.70
3104	14	46.67	0	0.00	11	36.67	0	0.00	5	16.67
3301	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00
3305	22	68.75	2	6.25	6	18.75	0	0.00	2	6.25
3306	3	42.86	4	57.14	0	0.00	0	0.00	0	0.00
3308	1	14.29	0	0.00	3	42.86	1	14.29	2	28.57
4101	3	75.00	0	0.00	0	0.00	1	25.00	0	0.00
4203	2	20.00	0	0.00	3	30.00	5	50.00	0	0.00
4205	1	9.09	0	0.00	0	0.00	2	18.18	8	72.73
4208	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4212	15	71.43	0	0.00	3	14.29	3	14.29	0	0.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4219	1	50.00	0	0.00	0	0.00	1	50.00	0	0.00
4220	2	20.00	0	0.00	8	80.00	0	0.00	0	0.00
4222	0	0.00	5	71.43	0	0.00	2	28.57	0	0.00
4223	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7301	11	78.57	0	0.00	0	0.00	1	7.14	2	14.29
7400	1	50.00	0	0.00	1	50.00	0	0.00	0	0.00
7800	3	33.33	0	0.00	2	22.22	0	0.00	4	44.44
8101	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	91	47.15	11	5.70	47	24.35	17	8.81	27	13.99

Accuracy Assessment Tables for P39/R29 -- Cover Type

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	12	52.17	12	52.17	21	91.30	21	91.30	23	100.00
3104	14	46.67	14	46.67	25	83.33	25	83.33	30	100.00
3301	0	0.00	0	0.00	0	0.00	1	100.00	1	100.00
3305	22	68.75	24	75.00	30	93.75	30	93.75	32	100.00
3306	3	42.86	7	100.00	7	100.00	7	100.00	7	100.00
3308	1	14.29	1	14.29	4	57.14	5	71.43	7	100.00
4101	3	75.00	3	75.00	3	75.00	4	100.00	4	100.00
4203	2	20.00	2	20.00	5	50.00	10	100.00	10	100.00
4205	1	9.09	1	9.09	1	9.09	3	27.27	11	100.00
4208	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4212	15	71.43	15	71.43	18	85.71	21	100.00	21	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4219	1	50.00	1	50.00	1	50.00	2	100.00	2	100.00
4220	2	20.00	2	20.00	10	100.00	10	100.00	10	100.00
4222	0	0.00	5	71.43	5	71.43	7	100.00	7	100.00
4223	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7301	11	78.57	11	78.57	11	78.57	12	85.71	14	100.00
7400	1	50.00	1	50.00	2	100.00	2	100.00	2	100.00
7800	3	33.33	3	33.33	5	55.56	5	55.56	9	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
SUM	91	47.15	102	52.85	149	77.20	166	86.01	193	100.00

Accuracy Assessment Tables for P39/R29 -- Cover Type

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	97	38.71	0	0.00	105	41.94	0	0.00	49	19.35
3104	51	70.00	0	0.00	7	10.00	0	0.00	15	20.00
3301	0	0.00	0	0.00	0	0.00	8	100.00	0	0.00
3305	112	55.00	10	5.00	66	32.50	5	2.50	10	5.00
3306	36	50.00	12	16.67	12	16.67	0	0.00	12	16.67
3308	5	25.00	16	75.00	0	0.00	0	0.00	0	0.00
4101	37	75.00	0	0.00	0	0.00	12	25.00	0	0.00
4203	15	33.33	0	0.00	8	16.67	23	50.00	0	0.00
4205	8	25.00	0	0.00	0	0.00	15	50.00	8	25.00
4208	0	0.00	0	0.00	9	100.00	0	0.00	0	0.00
4212	33	48.39	11	16.13	11	16.13	11	16.13	2	3.23
4214	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4219	3	20.00	0	0.00	3	20.00	7	40.00	3	20.00
4220	27	33.33	0	0.00	55	66.67	0	0.00	0	0.00
4222	0	0.00	0	0.00	7	66.67	4	33.33	0	0.00
4223	0	0.00	0	0.00	9	100.00	0	0.00	0	0.00
7301	18	73.33	0	0.00	5	20.00	0	0.00	2	6.67
7400	1	33.33	0	0.00	0	0.00	1	33.33	1	33.33
7800	6	42.86	0	0.00	0	0.00	0	0.00	8	57.14
8101	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
SUM	449	45.08	49	4.92	297	29.82	86	8.63	115	11.55

Accuracy Assessment Tables for P39/R29 -- Cover Type

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	97	38.71	97	38.71	203	80.65	203	80.65	251	100.00
3104	51	70.00	51	70.00	59	80.00	59	80.00	73	100.00
3301	0	0.00	0	0.00	0	0.00	8	100.00	8	100.00
3305	112	55.00	123	60.00	189	92.50	194	95.00	204	100.00
3306	36	50.00	48	66.67	60	83.33	60	83.33	72	100.00
3308	5	25.00	21	100.00	21	100.00	21	100.00	21	100.00
4101	37	75.00	37	75.00	37	75.00	49	100.00	49	100.00
4203	15	33.33	15	33.33	23	50.00	46	100.00	46	100.00
4205	8	25.00	8	25.00	8	25.00	23	75.00	30	100.00
4208	0	0.00	0	0.00	9	100.00	9	100.00	9	100.00
4212	33	48.39	44	64.52	55	80.65	66	96.77	68	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4219	3	20.00	3	20.00	7	40.00	14	80.00	17	100.00
4220	27	33.33	27	33.33	82	100.00	82	100.00	82	100.00
4222	0	0.00	0	0.00	7	66.67	11	100.00	11	100.00
4223	0	0.00	0	0.00	9	100.00	9	100.00	9	100.00
7301	18	73.33	18	73.33	23	93.33	23	93.33	24	100.00
7400	1	33.33	1	33.33	1	33.33	3	66.67	4	100.00
7800	6	42.86	6	42.86	6	42.86	6	42.86	15	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
SUM	449	44.99	499	50.00	799	80.06	886	88.78	998	100.00

Accuracy Assessment Tables for P39/R29 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	4	SUM
1	6(5)	1(3)	7(1)	0(1)	14(0)
2	5(3)	18(5)	16(3)	1(1)	40(0)
3	3(1)	17(3)	73(5)	3(3)	96(0)
4	0(1)	1(1)	0(3)	1(5)	2(0)
SUM	14(0)	37(0)	96(0)	5(0)	152(0)

Diagonal Elements = 98; Total Test Points = 152
Percentage Agreement = 64.47; Kappa = 0.327; Tau w/equal Prob = 0.526

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	42.86	0	0.00	1	7.14	0	0.00	7	50.00
2	18	45.00	0	0.00	21	52.50	0	0.00	1	2.50
3	73	76.04	0	0.00	20	20.83	0	0.00	3	3.12
4	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
SUM	98	64.47	0	0.00	42	27.63	0	0.00	12	7.89

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	42.86	6	42.86	7	50.00	7	50.00	14	100.00
2	18	45.00	18	45.00	39	97.50	39	97.50	40	100.00
3	73	76.04	73	76.04	93	96.88	93	96.88	96	100.00
4	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
SUM	98	64.47	98	64.47	140	92.11	140	92.11	152	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	42.86	0	0.00	5	35.71	0	0.00	3	21.43
2	18	48.65	0	0.00	18	48.65	0	0.00	1	2.70
3	73	76.04	0	0.00	16	16.67	0	0.00	7	7.29
4	1	20.00	0	0.00	3	60.00	0	0.00	1	20.00
SUM	98	64.47	0	0.00	42	27.63	0	0.00	12	7.89

Accuracy Assessment Tables for P39/R29 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	42.86	6	42.86	11	78.57	11	78.57	14	100.00
2	18	48.65	18	48.65	36	97.30	36	97.30	37	100.00
3	73	76.04	73	76.04	89	92.71	89	92.71	96	100.00
4	1	20.00	1	20.00	4	80.00	4	80.00	5	100.00
SUM	98	64.47	98	64.47	140	92.11	140	92.11	152	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	22	42.86	0	0.00	4	7.14	0	0.00	26	50.00
2	134	45.00	0	0.00	157	52.50	0	0.00	7	2.50
3	487	76.04	0	0.00	134	20.83	0	0.00	20	3.12
4	4	50.00	0	0.00	0	0.00	0	0.00	4	50.00
SUM	647	64.76	0	0.00	295	29.53	0	0.00	57	5.71

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	22	42.86	22	42.86	26	50.00	26	50.00	52	100.00
2	134	45.00	134	45.00	291	97.50	291	97.50	298	100.00
3	487	76.04	487	76.04	621	96.88	621	96.88	641	100.00
4	4	50.00	4	50.00	4	50.00	4	50.00	9	100.00
SUM	647	64.70	647	64.70	942	94.20	942	94.20	1000	100.00

Accuracy Assessment Tables for P39/R29 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	11(5)	1(3)	0(1)	12(0)
2	4(3)	5(5)	0(3)	9(0)
3	2(1)	0(3)	1(5)	3(0)
SUM	17(0)	6(0)	1(0)	24(0)

Diagonal Elements = 17; Total Test Points = 24
Percentage Agreement = 70.83; Kappa = 0.467; Tau w/equal Prob = 0.562

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	11	91.67	0	0.00	1	8.33	0	0.00	0	0.00
2	5	55.56	0	0.00	4	44.44	0	0.00	0	0.00
3	1	33.33	0	0.00	0	0.00	0	0.00	2	66.67
SUM	17	70.83	0	0.00	5	20.83	0	0.00	2	8.33

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	11	91.67	11	91.67	12	100.00	12	100.00	12	100.00
2	5	55.56	5	55.56	9	100.00	9	100.00	9	100.00
3	1	33.33	1	33.33	1	33.33	1	33.33	3	100.00
SUM	17	70.83	17	70.83	22	91.67	22	91.67	24	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	11	64.71	0	0.00	4	23.53	0	0.00	2	11.76
2	5	83.33	0	0.00	1	16.67	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	17	70.83	0	0.00	5	20.83	0	0.00	2	8.33

Accuracy Assessment Tables for P39/R29 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	11	64.71	11	64.71	15	88.24	15	88.24	17	100.00
2	5	83.33	5	83.33	6	100.00	6	100.00	6	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	17	70.83	17	70.83	22	91.67	22	91.67	24	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	552	91.67	0	0.00	50	8.33	0	0.00	0	0.00
2	181	55.56	0	0.00	145	44.44	0	0.00	0	0.00
3	24	33.33	0	0.00	0	0.00	0	0.00	47	66.67
SUM	757	75.78	0	0.00	195	19.52	0	0.00	47	4.70

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	552	91.67	552	91.67	603	100.00	603	100.00	603	100.00
2	181	55.56	181	55.56	326	100.00	326	100.00	326	100.00
3	24	33.33	24	33.33	24	33.33	24	33.33	71	100.00
SUM	757	75.70	757	75.70	953	95.30	953	95.30	1000	100.00

Accuracy Assessment Tables for P39/R29 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	6(5)	8(3)	0(1)	14(0)
2	4(3)	9(5)	17(3)	30(0)
3	1(1)	0(3)	4(5)	5(0)
SUM	11(0)	17(0)	21(0)	49(0)

Diagonal Elements = 19; Total Test Points = 49
Percentage Agreement = 38.78; Kappa = 0.099; Tau w/equal Prob = 0.082

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	42.86	0	0.00	8	57.14	0	0.00	0	0.00
2	9	30.00	0	0.00	21	70.00	0	0.00	0	0.00
3	4	80.00	0	0.00	0	0.00	0	0.00	1	20.00
SUM	19	38.78	0	0.00	29	59.18	0	0.00	1	2.04

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	42.86	6	42.86	14	100.00	14	100.00	14	100.00
2	9	30.00	9	30.00	30	100.00	30	100.00	30	100.00
3	4	80.00	4	80.00	4	80.00	4	80.00	5	100.00
SUM	19	38.78	19	38.78	48	97.96	48	97.96	49	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	54.55	0	0.00	4	36.36	0	0.00	1	9.09
2	9	52.94	0	0.00	8	47.06	0	0.00	0	0.00
3	4	19.05	0	0.00	17	80.95	0	0.00	0	0.00
SUM	19	38.78	0	0.00	29	59.18	0	0.00	1	2.04

Accuracy Assessment Tables for P39/R29 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	54.55	6	54.55	10	90.91	10	90.91	11	100.00
2	9	52.94	9	52.94	17	100.00	17	100.00	17	100.00
3	4	19.05	4	19.05	21	100.00	21	100.00	21	100.00
SUM	19	38.78	19	38.78	48	97.96	48	97.96	49	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	100	42.86	0	0.00	134	57.14	0	0.00	0	0.00
2	82	30.00	0	0.00	191	70.00	0	0.00	0	0.00
3	394	80.00	0	0.00	0	0.00	0	0.00	99	20.00
SUM	576	57.60	0	0.00	325	32.50	0	0.00	99	9.90

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	100	42.86	100	42.86	234	100.00	234	100.00	234	100.00
2	82	30.00	82	30.00	273	100.00	273	100.00	273	100.00
3	394	80.00	394	80.00	394	80.00	394	80.00	493	100.00
SUM	576	57.60	576	57.60	901	90.10	901	90.10	1000	100.00

Accuracy Assessment Tables for P39/R29 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	17(5)	5(3)	2(1)	24(0)
2	6(3)	5(5)	1(3)	12(0)
3	0(1)	1(3)	0(5)	1(0)
SUM	23(0)	11(0)	3(0)	37(0)

Diagonal Elements = 22; Total Test Points = 37
Percentage Agreement = 59.46; Kappa = 0.186; Tau w/equal Prob = 0.392

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	17	70.83	0	0.00	5	20.83	0	0.00	2	8.33
2	5	41.67	0	0.00	7	58.33	0	0.00	0	0.00
3	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
SUM	22	59.46	0	0.00	13	35.14	0	0.00	2	5.41

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	17	70.83	17	70.83	22	91.67	22	91.67	24	100.00
2	5	41.67	5	41.67	12	100.00	12	100.00	12	100.00
3	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
SUM	22	59.46	22	59.46	35	94.59	35	94.59	37	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	17	73.91	0	0.00	6	26.09	0	0.00	0	0.00
2	5	45.45	0	0.00	6	54.55	0	0.00	0	0.00
3	0	0.00	0	0.00	1	33.33	0	0.00	2	66.67
SUM	22	59.46	0	0.00	13	35.14	0	0.00	2	5.41

Accuracy Assessment Tables for P39/R29 -- Shrub Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	17	73.91	17	73.91	23	100.00	23	100.00	23	100.00
2	5	45.45	5	45.45	11	100.00	11	100.00	11	100.00
3	0	0.00	0	0.00	1	33.33	1	33.33	3	100.00
SUM	22	59.46	22	59.46	35	94.59	35	94.59	37	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	510	70.83	0	0.00	150	20.83	0	0.00	60	8.33
2	115	41.67	0	0.00	161	58.33	0	0.00	0	0.00
3	0	0.00	0	0.00	4	100.00	0	0.00	0	0.00
SUM	625	62.50	0	0.00	315	31.50	0	0.00	60	6.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	510	70.83	510	70.83	660	91.67	660	91.67	720	100.00
2	115	41.67	115	41.67	276	100.00	276	100.00	276	100.00
3	0	0.00	0	0.00	4	100.00	4	100.00	4	100.00
SUM	625	62.50	625	62.50	940	94.00	940	94.00	1000	100.00

Scene P39/R29 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	49815.0	819833.5	24.2
1000	84.0	926.3	0.0
2000	2495.0	56070.5	1.7
3101	35488.0	520390.9	15.3
3104	28466.0	255391.6	7.5
3301	706.0	9054.7	0.3
3305	31318.0	498712.0	14.7
3306	4345.0	131821.6	3.9
3307	573.0	7380.9	0.2
3308	4437.0	60407.1	1.8
4101	3481.0	56465.4	1.7
4203	6326.0	145705.0	4.3
4205	7334.0	62372.0	1.8
4208	2492.0	30119.6	0.9
4212	17973.0	206779.8	6.1
4214	939.0	22633.5	0.7
4219	6002.0	57993.8	1.7
4220	7826.0	268791.2	7.9
4222	3911.0	33198.8	1.0
4223	1161.0	27550.1	0.8
5000	3551.0	15006.5	0.4
7300	6164.0	63578.8	1.9
7400	1370.0	10855.5	0.3
7800	2357.0	21783.5	0.6
8100	1346.0	9213.5	0.3
9100	19.0	125.2	0.0
9800	90.0	932.0	0.0
9900	107.0	679.9	0.0

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	49815.0	819833.5	24.2
Not tree/shrub	81537.0	954954.2	28.1
Shrub 1	26402.0	496784.1	14.6
Shrub 2	14840.0	208454.3	6.1
Shrub 3	137.0	2138.0	0.1
Tree 1	18423.0	205863.8	6.1
Tree 2	20065.0	253056.3	7.5
Tree 3	18957.0	452688.8	13.3

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	49815.0	819833.5	24.2
Not tree/shrub	81537.0	954954.2	28.1
Tree 1	3413.0	41789.0	1.2
Tree 2	14009.0	280559.2	8.3
Tree 3	39229.0	580311.0	17.1
Tree 4	794.0	8949.8	0.3
Shrub 1	21471.0	427847.1	12.6
Shrub 2	16597.0	244913.8	7.2
Shrub 3	3311.0	34615.4	1.0

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	49815.0	819833.5	24.2
A	2495.0	56070.5	1.7
H	65300.0	784996.0	23.1
N	13742.0	113887.7	3.4
S	41379.0	707376.4	20.8
T	57445.0	911608.9	26.9

f. p39/r29. 26

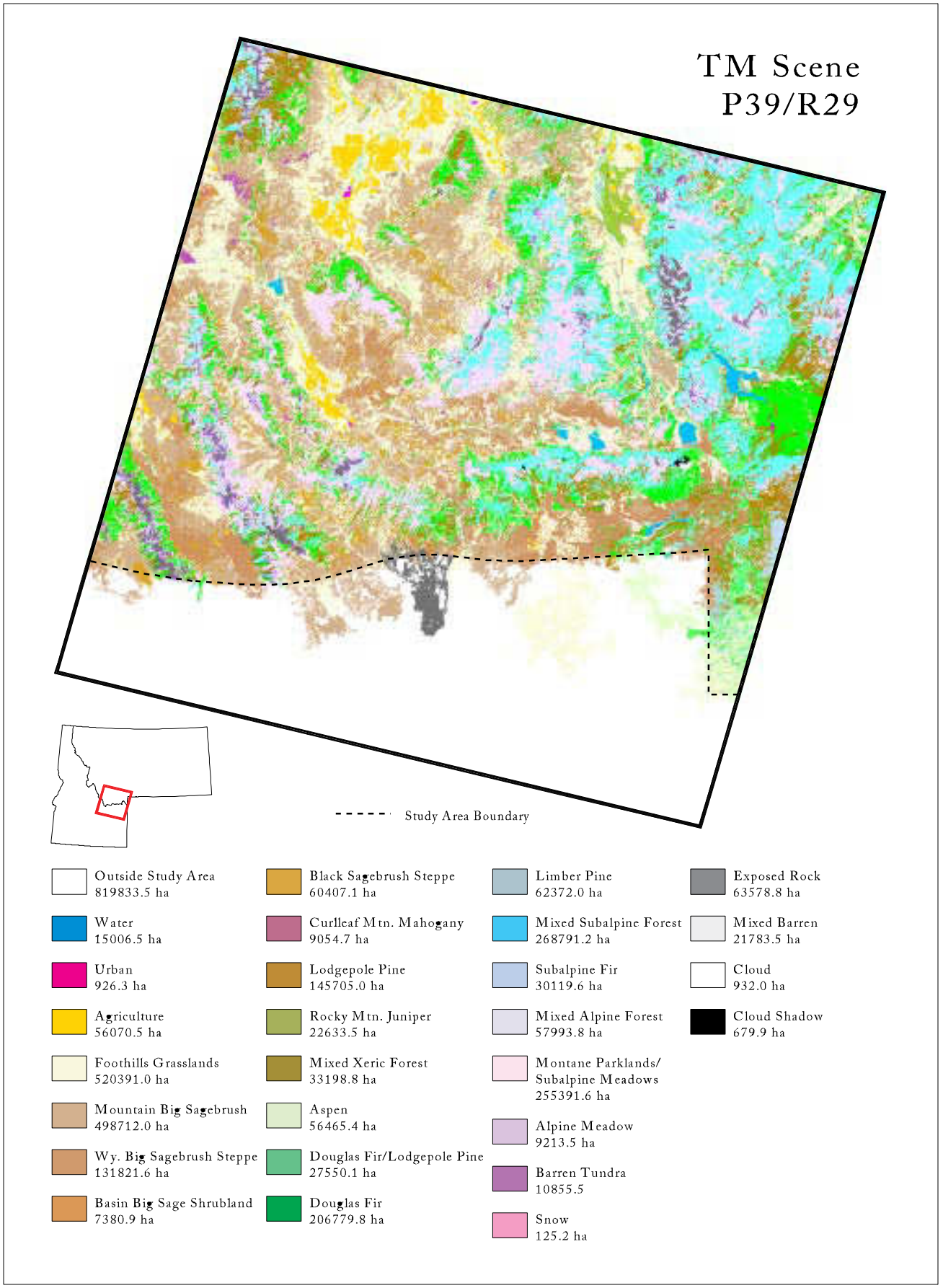


Figure F-15. Classification of land cover types for TM Scene P39/R29.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P39/R29

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4101: ASPEN FOREST

Aspen forest dominated by quaking aspen (Populus tremuloides) and ranging from 6913 to 8600 feet in elevation. The average canopy cover is 39% ranging from 20-70% total cover and frequency of occurrence equal to 100%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤4% and frequency of occurrence ≥9% and ≤27%.

Primary associated shrub species with ≥5% and ≤27% frequency of occurrence in aspen stands: kinnikinnick (Arctostaphylos uva-ursi), common juniper (Juniperus communis), prickly rose (Rosa acicularis), Wood's rose (Rosa woodsii), Canada buffaloberry (Shepherdia canadensis), common snowberry (Symphoricarpos albus), and mountain snowberry (Symphoricarpos oreophilus).

Primary associated graminoid, forb, fern, and moss species with ≥14% and ≤36% frequency of occurrence in aspen stands: **graminoids**: smooth brome (Bromus inermis), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), common timothy (Phleum pratense), Kentucky bluegrass (Poa pratensis), and needlegrass (Stipa spp.); **forbs**: weedy milk-vetch (Astragalus microcystis), Virginia strawberry (Fragaria virginiana), sticky geranium (Geranium viscosissimum), slender cinquefoil (Potentilla gracilis), starry solomon-plume (Smilacina stellata), common dandelion (Taraxacom officinale), and western meadowrue (Thalictrum occidentale); **ferns**: field horsetail (Equisetum arvense) and western polypody (Polypodium hesperium); **moss**: none.

2) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 6000 to 9065 feet in elevation. The average canopy cover is 43% ranging from 20-80% total cover and frequency of occurrence equal to 95%. Primary associated tree species include subalpine fir (Abies lasiocarpa), whitebark pine (Pinus albicaulis), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤7% and frequency of occurrence ≥25% and ≤44%.

Primary associated shrub species with ≥5% and ≤30% frequency of occurrence in lodgepole pine stands: sitka alder (Alnus sinuata), common juniper (Juniperus communis), Canada buffaloberry (Shepherdia canadensis), shiny-leaf spiraea (Spiraea betulifolia), dwarf huckleberry (Vaccinium caespitosum), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤25% frequency of occurrence in lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens), sedge (Carex), elk sedge (Carex geyeri), danthonia (Danthonia spp.), Idaho fescue (Festuca idahoensis), Kentucky bluegrass (Poa pratensis), and spike trisetum

(Trisetum spicatum); **forbs**: raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), milk-vetch (Astragalus spp.), Virginia strawberry (Fragaria virginiana), lupine (Lupinus spp.), mountain sweet-cicely (Osmorhiza chilensis), and western meadowrue (Thalictrum occidentale); **ferns**: selaginella (Selaginella spp.); **moss**: none.

3) 4205: LIMBER PINE FOREST

Conifer forest dominated by limber pine (Pinus flexilis) ranging from 5920 to 9243 feet in elevation. The average canopy cover is 38% ranging from 20-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥1% and ≤13% and frequency of occurrence ≥8% and ≤31%.

Primary associated shrub species with ≥8% and ≤15% frequency of occurrence in limber pine stands: big sagebrush (Artemisia tridentata), common juniper (Juniperus communis), and mountain gooseberry (Ribes montigenum).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤31% frequency of occurrence in limber pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), and spike-fescue (Hesperochloa kingii); **forbs**: raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), milk-vetch (Astragalus spp.), phlox (Phlox spp.), sticky polemonium (Polemonium viscosum), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: none.

4) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 3827 to 8443 feet in elevation. The average canopy cover is 43% ranging from 20-70% total cover and frequency of occurrence equal to 91%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and with average percent cover ≥4% and ≤9% and frequency of occurrence ≥11% and ≤20%.

Primary associated shrub species with ≥6% and ≤16% frequency of occurrence in Douglas-fir stands: mountain big sagebrush (Artemisia tridentata), creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), Wood's rose (Rosa woodsii), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and mountain snowberry (Symphoricarpos oreophilus).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤26% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), prairie junegrass (Koeleria cristata), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), milk-vetch (Astragalus spp.), Wood's strawberry (Fragaria vesca), Virginia strawberry (Fragaria virginiana), mountain sweet-cicely (Osmorhiza chilensis), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: moss (moss spp.).

5) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albicaulis) and ranging from 8000 to 9500 feet in elevation. The average canopy cover is 28% ranging from 10-80% total cover and frequency of occurrence equal to 96%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥12% and ≤24% and frequency of occurrence ≥36% and ≤68%.

Primary associated shrub species with ≥4% and ≤16% frequency of occurrence in mixed whitebark pine stands: mountain big sagebrush (Artemisia tridentata), common juniper (Juniperus communis), mountain gooseberry (Ribes montigenum), huckleberry (Vaccinium spp.), dwarf bilberry (Vaccinium myrtillus), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤24% frequency of occurrence in mixed whitebark pine stands: **graminoids:** redtop (Agrostis alba), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), and pale-leaf bluegrass (Poa glaucifolia); **forbs**: raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), aster (Aster spp.), glacier lily (Erythronium grandiflorum), mountain sweet-cicely (Osmorhiza chilensis), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: none.

6) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 6100 to 8968 feet in elevation. The average canopy cover is 22% ranging from 3-50% total cover and frequency of occurrence equal to 92%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥15% and ≤24% and frequency of occurrence ≥37% and ≤71%.

Primary associated shrub species with ≥5% and ≤45% frequency of occurrence in mixed subalpine stands: common juniper (Juniperus communis), twin flower (Linnaea borealis), mountain gooseberry (Ribes montigenum), Canada buffaloberry (Shepherdia canadensis), shiny-leaf spiraea (Spiraea betulifolia), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤34% frequency of occurrence in mixed subalpine fir stands: **graminoids**: pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), blue wildrye (Elymus glaucus), common timothy (Phleum pratense), bluegrass (Poa spp.), and spike trisetum (Trisetum spicatum); **forbs**: raceme pussy-toes (Antennaria racemosa), yellow columbine (Aquilegia flavescens), heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), aster (Aster spp.), mountain sweet-cicely (Osmorhiza chilensis), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: moss (moss spp.).

7) 4222: MIXED XERIC FOREST

Conifer forest dominated by limber pine (Pinus flexilis), codominant species is rocky mountain juniper (Juniperus scopulorum) and ranging from 5510 to 8680 feet in elevation.

The average canopy cover for PINFLE is 15% ranging from 1-30% total cover and frequency of occurrence equal to 71%. The average canopy cover for JUNSCO is 15% ranging from 1-40% total cover and frequency of occurrence equal to 59%. Primary associated tree species include subalpine fir (Abies lasiocarpa) and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥17% and ≤20% and frequency of occurrence ≥18% and ≤77%.

Primary associated shrub species with ≥6% and ≤29% frequency of occurrence in mixed xeric stands: creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), creeping juniper (Juniperus horizontalis), rose (Rosa spp.), mountain snowberry (Symphoricarpos oreophilus), and dwarf bilberry (Vaccinium myrtillus).

Primary associated graminoid, forb, fern, and moss species with ≥6% and ≤18% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), mountain brome (Bromus carinatus), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), common timothy (Phleum pratense), Kentucky bluegrass (Poa pratensis), and Sandberg's bluegrass (Poa secunda); **forbs**: pale agoseris (Agoseris glauca), heart-leaf arnica (Arnica cordifolia), milk-vetch (Astragalus spp.), willow-herb (Epilobium spp.), phlox (Phlox spp.), slender cinquefoil (Potentilla gracilis), and western meadowrue (Thalictrum occidentale); **fern**: none; **moss**: moss (moss spp.).

8) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) and lodgepole pine (Pinus contorta) and ranging from 6620 to 8400 feet in elevation. The average canopy cover for PSEMEN is 23% ranging from 10-50% total cover and frequency of occurrence equal to 93%. The average canopy cover for PINCON is 25% ranging from 3-40% total cover and frequency of occurrence equal to 93%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and limber pine (Pinus flexilis), with average percent cover ≥2% and ≤14% and frequency of occurrence ≥20% and ≤33%.

Primary associated shrub species with ≥13% and ≤33% frequency of occurrence in Douglas-fir-lodgepole pine stands: creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), Canada buffaloberry (Shepherdia canadensis), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), snowberry (Symphoricarpos spp.), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥7% and ≤40% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), common timothy (Phleum pratense), pale-leaf bluegrass (Poa glaucifolia), inland bluegrass (Poa interior), and Trinius' bluegrass (Poa stenantha); **forbs**: raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), milk-vetch (Astragalus spp.), harebell (Campanula rotundifolia), Wood's strawberry (Fragaria vesca), Virginia strawberry (Fragaria virginiana), western rattlesnake-plantain (Goodyera oblongofolia), one-sided wintergreen (Pyrola secunda), and beargrass (Xerophyllum tenax); **ferns**: selaginella (Selaginella spp.); **moss**: none.

P39/R29 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASS
6101	Needleleaf Dominated Riparian	14
6102	Broadleaf Dominated Riparian	55
6103	Needleleaf-Broadleaf Riparian	None identified for scene
6104	Mixed Riparian (trees+ any other)	21
6201	Grass-Forb Riparian Wetland	7, 46
6202	Shrub Riparian Wetland	3, 45, 58, 59
6203	Mixed Grass-Forb-Shrub Riparian	None identified for scene

---

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 2
Color: Black; RGB 67 30 50.
Distribution: Medium to high density at mid-elevations.
Comment: Coniferous cover types characterize training sites outside the riparian zone; two sites represent riparian vegetation (6101, 6201). Appears to represent shadows and coniferous vegetation.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
4	1	Douglas-fir
5	1	Mixed Subalpine Forest
6	1	Shrub Riparian/Wetland

Spectral Class 3
Color: Ochre; RGB 185 110 84.
Distribution: Light to medium density on foothills and at mid-elevation locations; clusters in agricultural areas.
Comment: Riparian (6202, 6201, 6103, 6102) and herbaceous cover types (including agricultural) are the most prevalent vegetation outside the zone; sagebrush and Aspen are included.
Conclusion: 6202.

7	1	Dry-land Pasture
8	1	Mountain Big Sagebrush
9	2	Needleleaf Dominated Riparian
10	3	Broadleaf Dominated Riparian
11	6	Grass-Forb Riparian/Wetland
12	13	Shrub Riparian/Wetland

Spectral Class 4
Color: Dark brown; RGB 100 26 46.
Distribution: Light to high density at middle elevations; some also near streams.
Comment: Coniferous cover types dominate training data outside the zone; about 10% of observations outside the zone represent riparian vegetation (6101, 6103, 6102). Visual cues indicate Mixed Mesic Forest.
Conclusion: Not riparian.

13	1	Mixed Xeric Forest
14	1	Needleleaf-Broadleaf Riparian
15	1	Grass-Forb Riparian/Wetland
16	1	Shrub Riparian/Wetland

Spectral Class 6
Color: Aqua; RGB 115 169 176.
Distribution: Light to high density in drier portions of valleys, including some large clusters; some small clusters in agricultural areas.
Comment: Shrubs are the most prevalent group of cover types outside the zone. Color and locations indicate sagebrush cover types.
Conclusion: Not riparian.

18	1	Dry-land Pasture
19	1	Foothills Grassland
20	1	Mountain Big Sagebrush
21	1	Rabbitbrush
22	1	Lodgepole Pine
23	1	Shrub Riparian/Wetland

Spectral Class 7
Color: Terracotta; RGB 200 135 130.
Distribution: Occurs in clusters in agricultural areas; also with light to medium density on foothills and near timberline.
Comment: Outside the zone, herbaceous cover types (including agriculture) were recorded most frequently, coniferous and riparian (6202, 6201) vegetation were also observed. Appearance suggests a mixture of agricultural and grass riparian vegetation.
Conclusion: 6201.

24	2	Irrigated Crop
25	1	Irrigated Pasture
26	1	Foothills Grassland
27	2	Shrub Riparian/Wetland

Spectral Class 10
Color: Moss green; RGB 137 177 134.
Distribution: Medium density on foothills; some light density patches in agricultural areas.
Comment: Sagebrush and herbaceous cover types characterize training sites outside the riparian zone.
Conclusion: Not riparian.

29	1	Foothills Grassland
30	1	Wyoming Big Sagebrush Steppe
31	1	Basin Big Sage Shrubland
32	1	Broadleaf Dominated Riparian
33	1	Grass-Forb Riparian/Wetland
34	1	Shrub Riparian/Wetland

Spectral Class 14
Color: Warm brown; RGB 140 72 71.
Distribution: Light to high density at middle elevations; some near streams.
Comment: Training sites outside the zone represent primarily coniferous cover types; riparian cover types (6201, 6102, 6202, 6101) are included. Color and some locations suggest Needleleaf Dominated Riparian vegetation within the zone.
Conclusion: 6101.

35	1	Aspen
36	1	Douglas-fir
37	1	Mixed Mesic Forest
38	1	Douglas-fir-Lodgepole
39	2	Needleleaf Dominated Riparian
40	1	Broadleaf Dominated Riparian
41	1	Grass-Forb Riparian/Wetland
42	8	Shrub Riparian/Wetland

Spectral Class 15
Color: Olive drab; RGB 129 106 92.
Distribution: Light to medium density on foothills; some near streams.
Comment: Conifers, shrubs, and herbaceous vegetation are about equally represented by training sites outside the zone; one site represents Needleleaf-Broadleaf Riparian vegetation. Visual cues indicate mixed vegetation that is too dry to be riparian.
Conclusion: Not riparian.

43	2	Shrub Riparian/Wetland

Spectral Class 17
Color: Olive; RGB 140 139 113.

Distribution: Light to medium density on foothills and some lower mid-elevation slopes; some near streams or agricultural areas.
Comment: Herbaceous, shrub, and coniferous vegetation make up training data outside the zone; several sites represent riparian vegetation (6202, 6201). Appears to represent dry grass and shrub vegetation.
Conclusion: Not riparian.

46	1	Foothills Grassland
47	1	Needleleaf-Broadleaf Riparian
48	1	Grass-Forb Riparian/Wetland
49	5	Shrub Riparian/Wetland

Spectral Class 19
Color: Light cyan; 181 239 238.
Distribution: Occurs in medium-sized clusters in areas adjacent to agriculture, in some valleys.
Comment: Herbaceous and shrub cover types have nearly equal frequencies in training data for sites outside the zone; barren land is also present. Probably represents dry pasture and grassland.
Conclusion: Not riparian.

52	1	Foothills Grassland
53	1	Grass-Forb Riparian/Wetland
54	1	Mixed Barren Land

Spectral Class 21
Color: Cool brown; RGB 148 118 105.
Distribution: Light to medium density on foothills; some in agricultural areas and near streams.
Comment: Outside the zone, riparian cover types (6202, 6102, 6103, 6201) were most recorded; herbaceous, shrub, and coniferous vegetation are included.
Conclusion: 6104.

56	1	Dry-land Pasture
57	1	Grass-Forb Riparian/Wetland
58	2	Shrub Riparian/Wetland

Spectral Class 23
Color: Gray brown; RGB 107 102 96.
Distribution: Light to medium density on lower mid-elevation slopes and some foothills; light density at mid elevations; some near streams.
Comment: Coniferous cover types were the most observed vegetation outside the zone; herbaceous and shrub cover types are included; two sites represent riparian vegetation (6103,

6201). Color and distribution suggest Mixed Xeric Forest vegetation.
Conclusion: Not riparian.

59	1	Needleleaf Dominated Riparian
60	1	Shrub Riparian/Wetland

Spectral Class 25
Color: Black; RGB 41 26 50.
Distribution: Light density at mid elevations, with a few dense patches on the northestern portion of the image; some near streams.
Comment: Training sites outside the zone were recorded primarily as coniferous vegetation. Visual cues indicate that the class represents burned areas, shadows and water features.
Conclusion: Not riparian.

61	1	Rivers & Streams
62	1	Shrub Riparian/Wetland

Spectral Class 36
Color: Blue black; RGB 0 0 75.
Distribution: A rare class. Very light density along streams and at highest elevations.
Comment: Training sites outside the zone are comprised of water features and rock.
Conclusion: Not riparian.

72	1	Foothills Grassland
73	1	Rivers & Streams
74	1	Shrub Riparian/Wetland

Spectral Class 40
Color: Brown; RGB 103 50 59.
Distribution: Medium to high density at middle elevations. Some near streams in agricultural areas.
Comment: Outside the zone, coniferous cover types are most prevalent among training sites; riparian (6102, 6201, 6101, 6202), Aspen, and shrub cover types are included. Visual indicators suggest xeric conifers.
Conclusion: Not riparian.

75	1	Mountain Big Sagebrush
76	1	Wyoming Big Sagebrush Steppe
77	2	Mixed Subalpine Forest
78	1	Broadleaf Dominated Riparian
79	1	Needleleaf-Broadleaf Riparian
80	1	Grass-Forb Riparian/Wetland

81	1	Shrub Riparian/Wetland

Spectral Class 45
Color: Light warm brown; RGB 155 98 84.
Distribution: Generally light density at middle elevations, with occasional medium density patches; some near streams.
Comment: Conifers and riparian vegetation (6102, 6201, 6202) are about equally represented by training sites outside the zone; Aspen, sagebrush, meadow, and Mixed Needleleaf-Broadleaf are included.
Conclusion: 6202.

84	1	Dry-land Pasture
85	1	Foothills Grassland
86	1	Broadleaf Dominated Riparian
87	1	Needleleaf-Broadleaf Riparian
88	2	Shrub Riparian/Wetland

Spectral Class 46
Color: Tan; 185 159 121.
Distribution: Medium density on some foothills and lower mid-elevation slopes; light density at other mid-elevation locations; some in agricultural areas relatively close to streams.
Comment: Herbaceous cover types account for most observations outside the riparian zone; riparian (6201, 6202, 6101), agriculture, sagebrush, conifers, and barren land are included.
Conclusion: 6201.

89	1	Urban & Developed Land
90	1	Irrigated Crop
91	1	Foothills Grassland
92	2	Subalpine Meadow
93	1	Broadleaf Dominated Riparian
94	1	Grass-Forb Riparian/Wetland
95	1	Shrub Riparian/Wetland

Spectral Class 54
Color: Red orange; 255 98 75.
Distribution: Occurs in clusters in agricultural areas; some near streams.
Comment: Training sites outside the zone indicate primarily agricultural land. One site represents riparian vegetation (6202).
Conclusion: Not riparian.

98	1	Irrigated Crop
99	1	Irrigated Pasture

Spectral Class 55
Color: Red orange; RGB 251 80 88.
Distribution: Occurs primarily in agricultural areas; light density at some mid-elevation locations.
Comment: Riparian (6201, 6202, 6101) and agricultural lands are about equally represented by training sites outside the zone; other herbaceous vegetation, Aspen, and Douglas-fir are included.
Conclusion: 6102.

100	1	Dry-land Pasture
101	2	Foothills Grassland
102	1	Disturbed Grasslands
103	1	Subalpine Meadow
104	1	Aspen
105	1	Rocky Mountain Juniper
106	2	Broadleaf Dominated Riparian
107	4	Shrub Riparian/Wetland

Spectral Class 56
Color: Gray green; 107 151 130.
Distribution: Light to high density on foothills, reaching into valleys. Some near streams.
Comment: Herbaceous and shrub vegetation are most prevalent among recorded sites outside the zone; coniferous, riparian (6201, 6202), and Aspen cover types are included. Appears to represent dry grass and sagebrush.
Conclusion: Not riparian.

108	1	Mountain Big Sagebrush
109	2	Basin Big Sage Shrubland
110	1	Grass-Forb Riparian/Wetland
111	2	Shrub Riparian/Wetland

Spectral Class 58
Color: Light orange; RGB 244 169 130.
Distribution: A small class. Some locations are in agricultural areas; others are at middle or high elevations.
Comment. Most training sites outside the zone represent agricultural lands; herbaceous and shrub vegetation are included.
Conclusion: 6202.

112	1	Irrigated Pasture

Spectral Class 59
Color: Orange; 255 122 105.
Distribution: Occurs primarily at lower elevations, usually in agricultural areas; some at middle elevations.
Comment: Herbaceous vegetation, including agricultural, dominate observations for sites outside the zone; riparian (6201, 6202) and Aspen cover types are included.
Conclusion: 6202.

113	1	Irrigated Crop
114	1	Dry-land Pasture
115	2	Irrigated Pasture
116	1	Grass-Forb Riparian/Wetland
117	1	Shrub Riparian/Wetland

Spectral Class 60
Color: Irish green; 100 173 134.
Distribution: Most locations are in drier portions of valleys; very little is near agricultural land or streams.
Comment: Outside the riparian zone, sagebrush was the most recorded cover; herbaceous and barren cover types are included in the data. Visual cues suggest that dry grassland is represented by this spectral class.
Conclusion: Not riparian.

118	1	Shrub Riparian/Wetland

TM SCENE P38/R27

Image Analyst: Zhenkui Ma

Training Data Analysis

A total of 465 ground-truth plots were available for labeling P38/R27 (see table below); 272 were collected by Forest Service field crews during the1994-95 field seasons, and 204 of these were collected specifically for this TM scene. The remaining 193 plots came from pre-existing data sources such as ECODATA and TSMRS.

All the ground-truth data were converted to a point file and superimposed on the unsupervised classification to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 149) were removed from further analysis. Then the data were examined by cover type and by data source (whether or not plots were collected for this project or for other purposes, like pre-existing ECODATA or TSMRS). The latter "existing data" were only used in the training data set to supplement cover types that had insufficient plots collected during the 1994 or 1995 field seasons. Seven classes were excluded from the digital classification process: urban, agriculture, water, snow, melted snow, cloud, and cloud shadow. All ground truth data with VEG_CLASS_CODEs for urban, agriculture, or water cover types were excluded. Next, 20% of the remaining plots were randomly selected from each cover type; these plots (n = 9) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

The remaining 80% of the data (n = 114 plots) were subjected to further spectral examination. Outliers were eliminated for each cover type by visual examination of TM and elevation values for their respective regions.

Total plots in ground-truth file	465	
Total 1994-95 field plots	272	
Plots sampled for P38/R27		204
Plots sampled for other scenes		68
Pre-existing plots (ECODATA, TSMRS, etc.)	193	
Plots held aside or eliminated	342	
Duplicates		149
Pre-existing plots		100
Manually labeled cover types		93
Potential training plots	123	
20% test		9
80% training		114
Supplemental plots (from pre-existing data set)	0	
Total plots available for training	114	
Total plots used for training -- cover type	113	
size class	74	
canopy	101	

Land Cover Types

Land cover types were labeled through a digital classification of the 7 TM channels plus rescaled elevation (m elevation divided by 25), using the Nearest Member of Group classifier. This classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were assigned directly to the COVERTYPE field in the attribute table. Modifications were carried out using spectral class values (SPECTRAL_CLASS, or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000.	Urban.	Manually identified and recoded by Willard Gustafson.
2000.	Agriculture.	Manually identified and recoded by Willard Gustafson.
3101.	Foothills Grasslands.	All grass types occurring below 1981 m (6500 ft) were relabeled as Foothills Grasslands.
3104.	Montane Parklands & Subalpine Meadows.	All grass types occurring at or above 1980 m (6500 ft) were relabeled as Montane Parklands and Subalpine Meadows.
5000.	Water.	All regions with spectral class (LINK = 1) and slope less than or equal to 5˚ were labeled as water; cloud shadows (see 9900 below) were recoded manually. Generally, water was more spectrally distinct than most other cover types, but in mountainous terrain, it was sometimes confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate slope and aspect values such that their slope may be greater than 5˚. This would result in the misclassification of some small ponds or lakes.
(n/a)	Melted Snow.	All regions originally classified as Melted Snow were recoded either to Exposed Rock (7301), if their slope was greater than 5˚, or to Snow (9000), if their slope was less than or equal to 5˚.
9800.	Cloud.	Manually identified and recoded by Willard Gustafson.
9900.	Cloud Shadow.	Manually identified and recoded by Willard Gustafson.

A total of 20 classes were labeled in the full TM scene. These included three grass types, two shrub types, nine forest types, three barren types, plus three manually labeled classes. Land cover classes were reviewed by Dave Atkins of the Lolo National Forest. Personnel from the Judith and Musselshell Ranger Districts of the Lewis & Clark National

Forest provided aerial photos and TSMRS data for use in the review. Cover types are mapped in Figure F-16.

Canopy Cover Classes

Canopy cover labels (CANOPY_CODE = low, medium, or high) were assigned to tree and shrub classes based on MNDVI values. These values were plotted as frequency histograms for all coniferous forest types (Figure F-16a) and shrub types (Figure F-16b). The histograms were examined visually and break points decided based on the distribution modes. Regions with MNDVI values falling below the lower break point were assigned to the low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class.

	MNDVI BREAKPOINTS	
CANOPY COVER	Tree	Shrub
Low	<175	<100
Medium	≥175 and <24	≥100
High	≥ 324	n/a

Size Classes

Six size classes were distinguished: four for forest cover types (seedling/sapling, pole, large, and large/very large) and two for shrub cover types (low and medium). Only the seven TM channels were used for these classifications. The Nearest Mean classifier was used for tree size classes, and the Nearest Member of Group classifier was used for shrub size classes. Tree size classes were stratified based upon the canopy cover classes described above.

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number

of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match amd accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications. Note that the Forest Group accuracy was not calculated separately but was part of the overall Lifeform accuracy assessment. We feel that this Forest Group accuracy is much more reliable than the overall Lifeform accuracy because the latter includes manually labeled cover types like Urban, Agriculture, and Water. Again, no accuracy assessment was performed on these manually labeled cover types. No weighted producer accuracies were calculated for the size or canopy classes because of limited training data from only a small portion of the scene.

Classifications for P38/R27	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	11	51%	27%
Lifeform	5	n/a	51%
Forest Group	4	n/a	91%

Comments

Ground-truth data were collected only within the southern portion of the image that was within the study area. The aspen forest cover type (4101) was modified after Dave Atkins examined the first classification. The mixed mesic forest class (4221) was eliminated from this area and renamed as either mixed subalpine forest (4220) or mixed xeric forest (4222).

Error Matrix For Cover Type Training Plots
Scene P38/R27

CLASSIFIED COVER TYPES

PLOT COVER TYPES	3102	3104	3201	3305	4101	4203	4205	4206	4208	4212	4219	4220	4222	7301	7500	7800	SUM
3102	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
3104	1	12	0	1	1	0	1	0	0	0	0	0	0	1	0	0	17
3201	0	0	2	0	1	0	0	0	0	0	0	1	0	1	0	0	5
3305	0	1	0	2	0	0	0	0	0	0	0	0	0	1	0	0	4
4101	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	9
4203	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	3
4205	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
4206	0	0	0	0	0	0	0	15	0	2	1	0	0	0	0	0	18
4208	0	0	0	0	0	0	0	0	4	0	0	2	0	0	0	0	6
4212	0	0	0	0	0	0	0	1	1	3	0	0	1	0	0	0	6
4219	0	1	0	0	0	0	0	1	0	0	2	1	0	0	0	0	5
4220	0	0	0	0	0	1	0	1	1	0	1	6	0	0	0	0	10
4222	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	3
7301	0	1	0	1	0	0	0	0	0	0	0	0	0	14	0	1	17
7500	0	0	0	0	0	0	0	1	0	0	0	0	0	1	6	0	8
7800	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2
SUM	3	17	2	4	11	2	3	21	6	6	4	11	1	19	6	2	118

% AGREEMENT	68.84
TAU WITH EQUAL PROBABILITY	0.667
TOTAL DIAGONAL ELEMENTS	81
TOTAL TRAINING PLOTS IN DATA SET	118

f, p38/r27.5

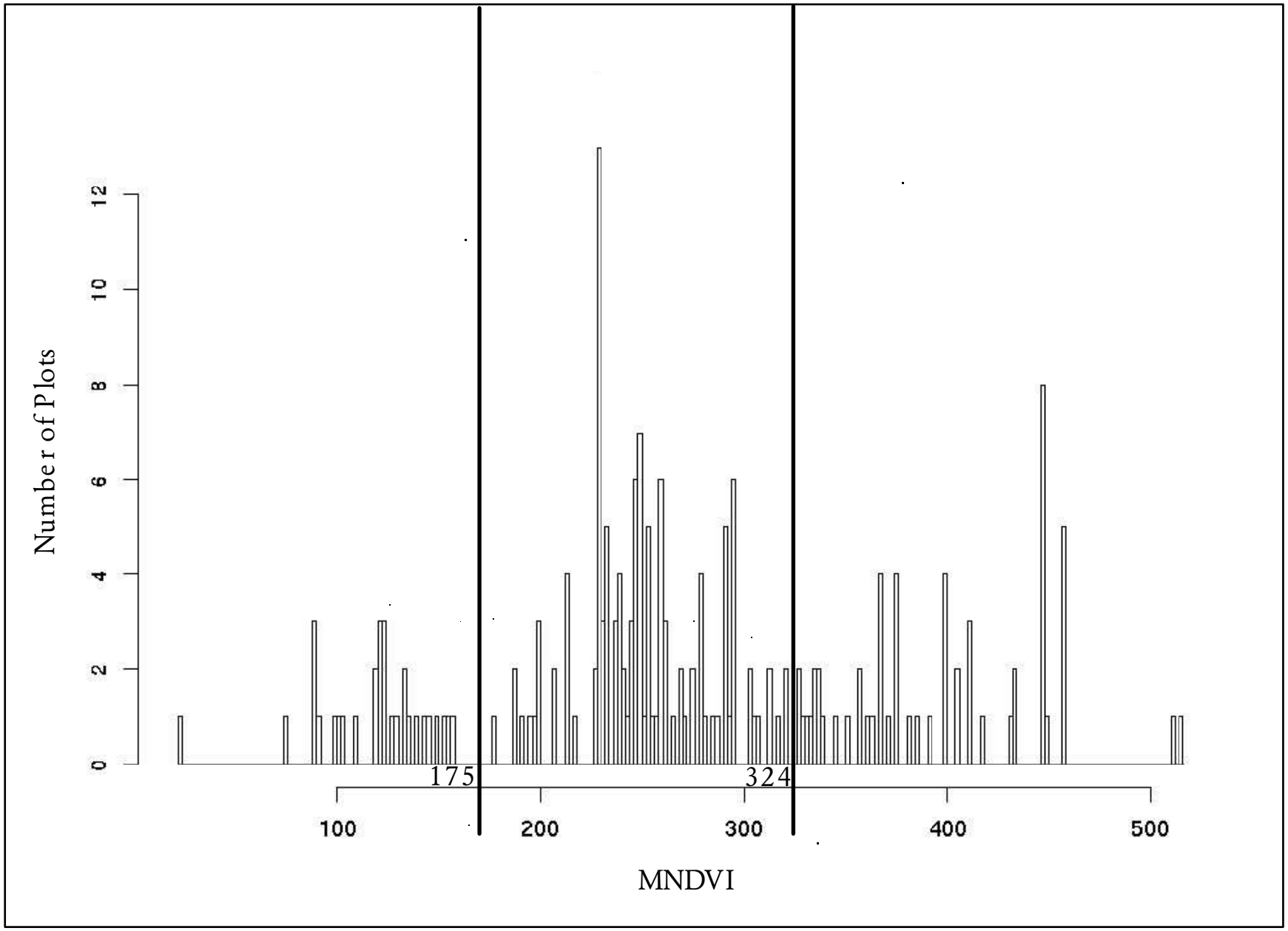


Figure F-16a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P38/R27

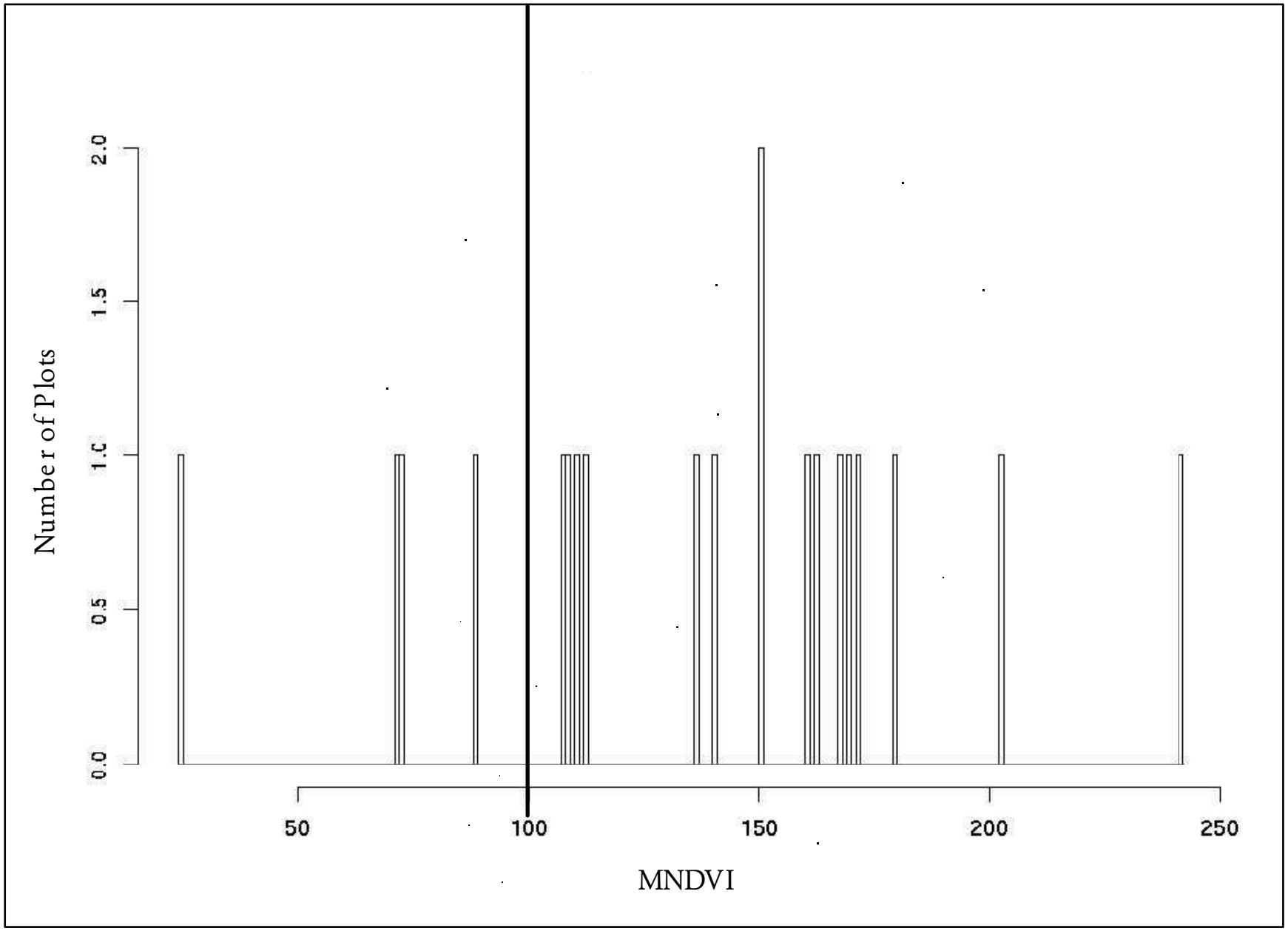


Figure F-16b. Breaks between shrub canopy cover classes in relation to MNDVI values: TM scene P38/R27

f.p38/r27.7

Accuracy Assessment Tables for P38/R27 -- Cover Type

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3104	3201	4101	4203	4205	4206	4212	4219
3101	6(5)	0(3)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	2(1)
3104	1(3)	2(5)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3201	0(1)	0(1)	1(5)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4101	0(1)	0(1)	0(1)	2(5)	0(2)	0(2)	0(2)	0(2)	0(2)
4203	0(1)	0(1)	0(1)	0(2)	1(5)	0(2)	1(2)	7(2)	0(3)
4205	0(1)	0(1)	0(1)	0(2)	0(2)	1(5)	0(2)	0(2)	0(2)
4206	0(1)	0(1)	0(1)	0(2)	0(2)	0(2)	5(5)	1(2)	0(2)
4212	0(1)	0(1)	2(1)	2(2)	0(2)	0(2)	4(2)	3(5)	1(2)
4219	0(1)	0(1)	0(1)	0(2)	0(3)	0(2)	0(2)	1(2)	0(5)
4220	0(1)	0(1)	0(1)	0(2)	0(3)	0(2)	0(2)	1(3)	0(3)
4222	0(1)	0(1)	0(1)	0(2)	0(2)	0(3)	0(3)	1(3)	0(2)
SUM	7(0)	2(0)	3(0)	6(0)	1(0)	1(0)	10(0)	14(0)	3(0)

RF/CF	4220	4222	SUM
3101	0(1)	0(1)	16(0)
3104	0(1)	0(1)	4(0)
3201	0(1)	0(1)	2(0)
4101	0(2)	1(2)	3(0)
4203	8(3)	0(2)	17(0)
4205	0(2)	0(4)	2(0)
4206	0(2)	1(4)	8(0)
4212	4(3)	1(4)	19(0)
4219	2(3)	0(2)	3(0)
4220	0(5)	0(2)	1(0)
4222	1(2)	0(5)	3(0)
SUM	15(0)	3(0)	78(0)

Diagonal Elements = 21; Total Test Points = 78
Percentage Agreement = 26.92; Kappa = 0.198; Tau w/equal Prob = 0.196

13 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 13 points = 1

Accuracy Assessment Tables for P38/R27 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	6	37.50	0	0.00	0	0.00	0	0.00	10	62.50
3104	2	50.00	0	0.00	1	25.00	0	0.00	1	25.00
3201	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4101	2	66.67	0	0.00	0	0.00	1	33.33	0	0.00
4203	1	5.88	0	0.00	8	47.06	8	47.06	0	0.00
4205	1	50.00	0	0.00	0	0.00	0	0.00	1	50.00
4206	5	62.50	1	12.50	0	0.00	1	12.50	1	12.50
4212	3	15.79	1	5.26	4	21.05	7	36.84	4	21.05
4219	0	0.00	0	0.00	2	66.67	1	33.33	0	0.00
4220	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
4222	0	0.00	0	0.00	1	33.33	1	33.33	1	33.33
SUM	21	26.92	2	2.56	17	21.79	19	24.36	19	24.36

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	6	37.50	6	37.50	6	37.50	6	37.50	16	100.00
3104	2	50.00	2	50.00	3	75.00	3	75.00	4	100.00
3201	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4101	2	66.67	2	66.67	2	66.67	3	100.00	3	100.00
4203	1	5.88	1	5.88	9	52.94	17	100.00	17	100.00
4205	1	50.00	1	50.00	1	50.00	1	50.00	2	100.00
4206	5	62.50	6	75.00	6	75.00	7	87.50	8	100.00
4212	3	15.79	4	21.05	8	42.11	15	78.95	19	100.00
4219	0	0.00	0	0.00	2	66.67	3	100.00	3	100.00
4220	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
4222	0	0.00	0	0.00	1	33.33	2	66.67	3	100.00
SUM	21	26.92	23	29.49	40	51.28	59	75.64	78	100.00

Accuracy Assessment Tables for P38/R27 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	6	85.71	0	0.00	1	14.29	0	0.00	0	0.00
3104	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3201	1	33.33	0	0.00	0	0.00	0	0.00	2	66.67
4101	2	33.33	0	0.00	0	0.00	2	33.33	2	33.33
4203	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4205	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4206	5	50.00	0	0.00	0	0.00	5	50.00	0	0.00
4212	3	21.43	0	0.00	2	14.29	9	64.29	0	0.00
4219	0	0.00	0	0.00	0	0.00	1	33.33	2	66.67
4220	0	0.00	0	0.00	14	93.33	1	6.67	0	0.00
4222	0	0.00	2	66.67	0	0.00	1	33.33	0	0.00
SUM	21	32.31	2	3.08	17	26.15	19	29.23	6	9.23

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	6	85.71	6	85.71	7	100.00	7	100.00	7	100.00
3104	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
3201	1	33.33	1	33.33	1	33.33	1	33.33	3	100.00
4101	2	33.33	2	33.33	2	33.33	4	66.67	6	100.00
4203	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4205	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4206	5	50.00	5	50.00	5	50.00	10	100.00	10	100.00
4212	3	21.43	3	21.43	5	35.71	14	100.00	14	100.00
4219	0	0.00	0	0.00	0	0.00	1	33.33	3	100.00
4220	0	0.00	0	0.00	14	93.33	15	100.00	15	100.00
4222	0	0.00	2	66.67	2	66.67	3	100.00	3	100.00
SUM	21	32.31	23	35.38	40	61.54	59	90.77	65	100.00

Scene P38/R27 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	231974.0	2464917.3	72.3
1000	90.0	655.6	0.0
2000	14741.0	184661.8	5.4
3101	6324.0	69758.6	2.0
3102	14775.0	209035.0	6.1
3104	1200.0	8467.1	0.2
3201	5423.0	37068.8	1.1
3305	7560.0	73133.9	2.1
4101	4752.0	36364.1	1.1
4203	876.0	8345.3	0.2
4205	943.0	6297.4	0.2
4206	6377.0	82686.4	2.4
4208	923.0	17389.0	0.5
4212	3738.0	72196.4	2.1
4219	2572.0	18482.0	0.5
4220	1471.0	79404.6	2.3
4222	1397.0	11689.5	0.3
5000	1823.0	885.6	0.0
7300	1955.0	12764.6	0.4
7500	1368.0	12656.2	0.4
7800	43.0	552.8	0.0

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	231974.0	2464917.3	72.3
Not tree/shrub	42319.0	499437.3	14.7
Shrub 1	9968.0	83617.3	2.5
Shrub 2	2945.0	26183.1	0.8
Shrub 3	70.0	402.4	0.0
Tree 1	9546.0	63374.9	1.9
Tree 2	10927.0	206572.5	6.1
Tree 3	2576.0	62907.2	1.8

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	231974.0	2464917.3	72.3
Not tree/shrub	42319.0	499437.3	14.7
Tree 1	7135.0	51022.2	1.5
Tree 2	10335.0	142556.9	4.2
Tree 3	5579.0	139275.5	4.1
Shrub 1	8384.0	79509.5	2.3
Shrub 2	4599.0	30693.2	0.9

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	231974.0	2464917.3	72.3
A	14741.0	184661.8	5.4
H	22299.0	287260.6	8.4
N	5279.0	27514.8	0.8
S	12983.0	110202.7	3.2
T	23049.0	332854.6	9.8

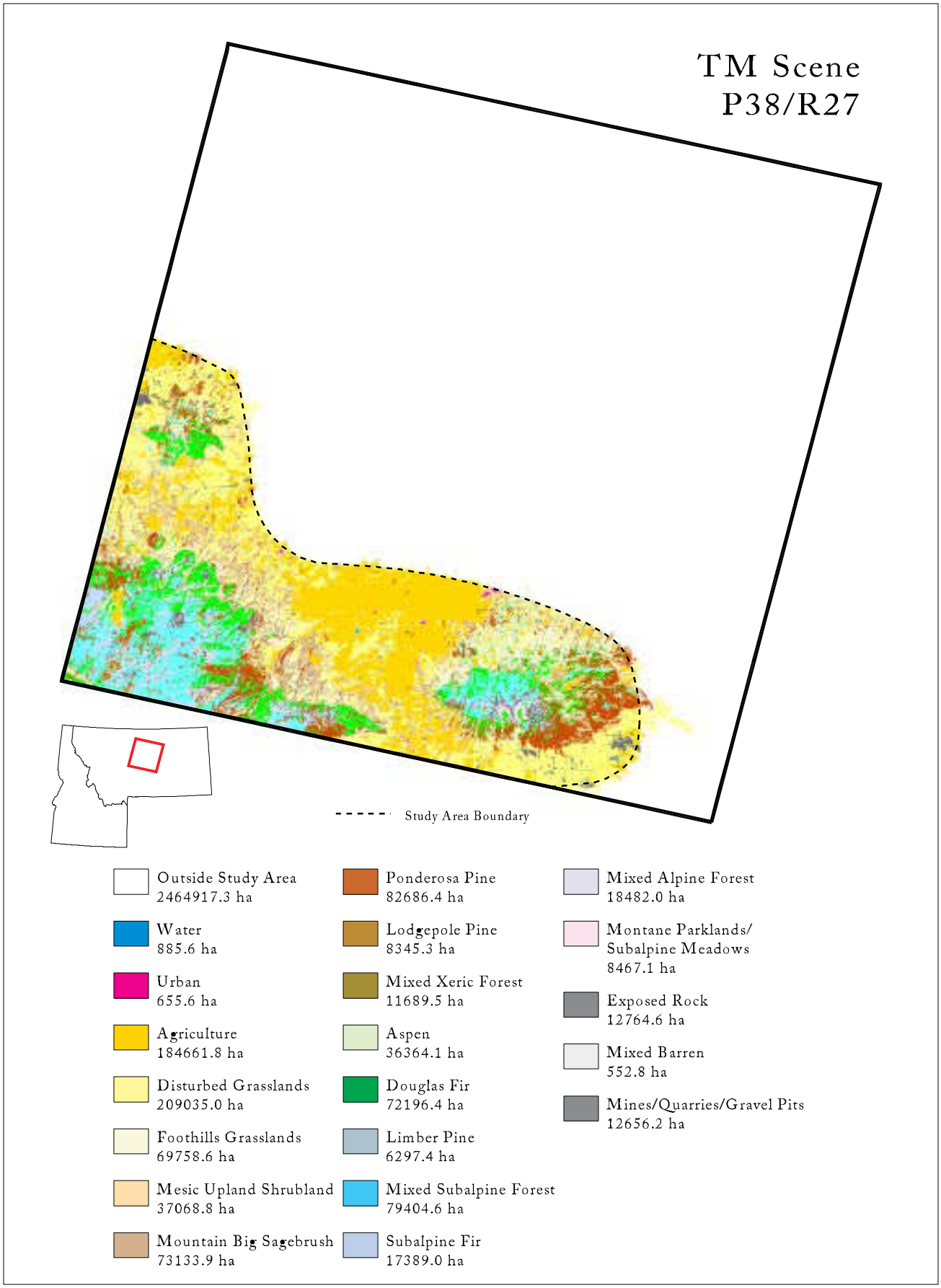


Figure F-16. Classification of land cover types for TM Scene P38/R27.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P38/R27

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4201: ENGELMANN SPRUCE FOREST

Conifer forest dominated by Engelmann spruce (Picea engelmannii) ranging from 5280 to 7700 feet in elevation. The average canopy cover is 51%, ranging from 20-80% total cover and frequency of occurrence equal to 86%. Primary associated tree species include subalpine fir (Abies lasiocarpa), lodgepole pine (Pinus contorta), and Douglas-fir (pseudotsuga menziesii) with average percent cover ≥5% and ≤9% and frequency of occurrence ≥21% and ≤43%.

Primary associated shrub species, each with 14% frequency of occurrence in Engelmann spruce stands: kinnikinnick (Arctostaphylos uva-ursi), common juniper, (Juniperus communis), twin flower (Linnaea borealis), honeysuckle (Lonicera spp.), gooseberry (Ribes spp.), common snowberry (Symphoricarpos albus), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern and moss species with ≥7% and ≤29% frequency of occurrence in Engelmann spruce stands: **graminoids**: nodding brome (Bromus anomalus), pinegrass (Calamagrostis rubescens), sheep sedge (Carex iliota), tufted hairgrass (Deschampsia caespitosa), common timothy (Phleum pratense), Kentucky bluegrass (Poa pratense), western needlegrass (Stipa occidentalis); **forbs**: Virginia strawberry (Fragaria virginiana), northern bedstraw (Galium boreale), white geranium (Geranium richardsonii), starry Solomon-plume (Smilacina stellata), common dandelion (Taraxacum officinale), western meadowrue (Thalictrum occidentale), and Canada violet (Viola canadensis); **ferns**: field horsetail (Equisetum arvense), and horsetail (Equisetum spp.); **moss:** moss (moss spp.)**.**

2) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 5000 to 7500 feet in elevation. The average canopy cover is 33% ranging from 20-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤5% and frequency of occurrence ≥20% and ≤34%.

Primary associated shrub species with ≥17% and ≤46% frequency of occurrence in lodgepole pine stands: kinnikinnick (Arctostaphylos uva-ursi), oregongrape (Berberis spp.), common juniper (Juniperus communis), rose (Rosa spp.), spiraea (Spiraea spp.), huckleberry (Vaccinium spp.), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤43% frequency of occurrence in lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens) and sedge (Carex spp.); **forbs**: fireweed (Epilobium angustifolium); **ferns**:

clubmoss (Lycopodium spp.); **moss**: none.

3) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 4680 to 6090 feet in elevation. The average canopy cover is 36% ranging from 20-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤8% and frequency of occurrence ≥13% and ≤63%.

Primary associated shrub species with ≥8% and ≤25% frequency of occurrence in ponderosa pine stands: kinnikinnick (Arctostaphylos uva-ursi), fringed sagewort (Artemisia frigida), common juniper (Juniperus communis), creeping juniper (Juniperus horizontalis), Canada buffaloberry (Shepherdia canadensis), spiraea (Spiraea spp.), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤8% frequency of occurrence in ponderosa pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), Idaho fescue (Festuca idahoensis), rough fescue (Festuca scabrella), prairie junegrass (Koeleria cristata), muhly (Mulenbergia spp.), Kentucky bluegrass (Poa pratensis), and green needlegrass (Stipa viridula); **forbs**: small-flowered anemone (Anemone parviflora), bastard toad-flax (Comendra umbellata), northern bedstraw (Galium boreale), western gromwell (Lithospermum ruderale), Hood's phlox (Phlox hoodii), common dandelion (Taraxacom officinale), and remarkable goatsbeard (Tragopogon dubius); **ferns**: none; **moss**: none.

4) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 5400 to 7100 feet in elevation. The average canopy cover is 61% ranging from 10-90% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), limber pine (Pinus flexilis) with average percent cover ≥5% and ≤9% and frequency of occurrence ≥24% and ≤34%.

Primary associated shrub species with ≥18% and ≤61% frequency of occurrence in Douglas-fir stands: kinnikinnick (Arctostaphylos uva-ursi), oregongrape (Berberis spp.), common juniper (Juniperus communis), rose (Rosa spp.), buffaloberry (Shepherdia spp.), spiraea (Spiraea spp.), and snowberry (Symphoricarpos spp.).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤8% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), narrow-leaved sedge (Carex stenophylla), Idaho fescue (Festuca idahoensis), rough fescue (Festuca scabrella), Kentucky bluegrass (Poa pratensis), western needlegrass (Stipa occidentalis); **forbs**: small-flowered anemone (Anemone parviflora), ballhead sandwort (Arenaria congesta), Wood's strawberry (Fragaria vesca), Virginia strawberry (Fragaria virginiana), northern bedstraw (Galium boreale), prairie smoke (Geum triflorum), and Missouri goldenrod (Solidago

missouriensis); **ferns**: none; **moss**: none.

5) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albus) and ranging from 6340 to 8500 feet in elevation. The average canopy cover is 24% ranging from 10-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥5% and ≤11% and frequency of occurrence ≥39% and ≤69%.

Primary associated shrub species with ≥8% and ≤39% frequency of occurrence in mixed whitebark pine stands: kinnikinnick (Arctostaphylos uva-ursi), common juniper (Juniperus communis), shrubby cinquefoil (Potentilla fruticosa), huckleberry (Vaccinium spp.), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤15% frequency of occurrence in mixed whitebark pine stands: **graminoids:** western wheatgrass (Agropyron smithii), mountain brome (Bromus carinatus), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), prairie junegrass (Koeleria cristata), Kentucky bluegrass (Poa pratensis), western needlegrass (Stipa occidentalis); **forbs**: small-flowered anemone (Anemone parviflora), ballhead sandwort (Arenaria congesta), giant frasera (Frasera speciosa), northern bedstraw (Galium boreale), prairie smoke (Geum triflorum), riparian crazyweed (Oxytropis riperia), western meadowrue (Thalictrum occidentale), and pioneer violet (Viola glabella); **ferns**: none; **moss**: none.

6) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 5800 to 7480 feet in elevation. The average canopy cover is 29% ranging from 3-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥15% and ≤22% and frequency of occurrence ≥27% and ≤91%.

Primary associated shrub species with ≥5% and ≤46% frequency of occurrence in mixed subalpine stands: oregongrape (Berberis spp.), creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), twin flower (Linnaea borealis), honeysuckle (Lonicera spp.), spiraea (Spiraea spp.), huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare, and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤36% frequency of occurrence in mixed subalpine stands: **graminoids**: pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), common timothy (Phleum pratense), pale-leaf bluegrass (Poa glaucifolia), Wheeler's bluegrass (Poa nervosa), and Kentucky bluegrass (Poa pratense); **forbs**: heart-leaf arnica (Arnica cordifolia), elkslip marshmarigold (Caltha leptosepala), white geranium (Geranium richardsonii), starry Solomon-plume (Smilacina stellata), western meadowrue (Thalictrum occidentale), violet (Viola spp.), and western Canadian violet (Viola rugulosa); **ferns**: stiff clubmoss (Lycopodium annotinum); **moss**:

moss (moss spp.).

7) 4222: MIXED XERIC FOREST

Conifer forest dominated by limber pine (Pinus flexilis), codominant species is ponderosa pine (Pinus ponderosa), and ranging from 5400 to 7100 feet in elevation. The average canopy cover for PINFLE is 16% ranging from 1-30% total cover and frequency of occurrence equal to 70%. The average canopy cover for PINPON is 18% ranging from 10-20% total cover and frequency of occurrence equal to 60%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥8% and ≤18% and frequency of occurrence ≥30% and ≤90%.

Primary associated shrub species with ≥10% and ≤70% frequency of occurrence in mixed xeric stands: kinnikinnick (Arctostaphylos uva-ursi), creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), honeysuckle (Lonicera spp.), shrubby cinquefoil (Potentilla fruticosa), Canada buffaloberry (Shepherdia canadensis), and spiraea (Spiraea spp.).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤36% frequency of occurrence in mixed xeric stands: **graminoids**: spike bentgrass (Agrostis exarata), western wheatgrass (Agropyron smithii), bluebunch wheatgrass (Agropyron spicatum), Idaho fescue (Festuca idahoensis), rough fescue (Festuca scabrella), prairie junegrass (Koeleria cristata), and common timothy (Phleum pratense); **forbs**: common yarrow (Achillea millefolium), rosy pussy-toes (Antennaria microphylla), arrowleaf balsamroot (Balsamorhiza sagittata), Wyoming kittentail (Besseya wyomingensis), field chickweed (Cerastium arvense), blanket-flower (Gaillardia aristata), and blue flax (Linum perenne); **ferns**: compact selaginella (Selaginella dense); **moss**; none.

P38/R27 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASS
6101	Needleleaf Dominated Riparian	None identified for scene
6102	Broadleaf Dominated Riparian	19, 25, 38, 40, 47, 48
6103	Needleleaf-Broadleaf Riparian	36
6104	Mixed Riparian (trees+ any other)	24, 26, 45, 62
6201	Grass-Forb Riparian Wetland	None identified for scene
6202	Shrub Riparian Wetland	14, 15
6203	Mixed Grass-Forb-Shrub Riparian	27

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 9
Color: Dark pink; RGB 230 109 170.
Distribution: A small class. Some clusters occur in agricultural areas; very little near streams.
Comment: There are no training sites for this spectral class. Visual indicators suggest agricultural land.
Conclusion: Not riparian.

Spectral Class 14
Color: Orange tan; RGB 225 153 128.
Distribution: Light density at low elevation, some of which is near streams; light to medium density on foothills, some at middle to upper elevations.
Comment: Of nine training sites, three represent riparian vegetation (6101, 6102, 6202); others represent urban, meadow, and pine cover types.
Conclusion: 6202.

Spectral Class 15
Color: Bright orange; RGB 255 109 55.
Distribution: Medium to high density on foothills, often following water channels; light density at lower and higher elevations.
Comment: Shrub, herbaceous, and riparian (6202, 6201) vegetation characterize training sites; one site represents Mixed Needleleaf-Broadleaf vegetation. All training sites are outside the riparian zone.
Conclusion: 6202.

Spectral Class 16
Color: Light grape; RGB 166 124 165.
Distribution: Light density scattering of small clusters at lower elevations, some in agricultural areas and some along water channels.

Comment: The single training site represents Foothills Grassland. Appears to represent agricultural land.
Conclusion: Not riparian.
Spectral Class 19

Color: Maroon; RGB 136 63 90.
Distribution: Light density at mid-elevations, along some streams, and at some other low elevation locations.
Comment: Outside the zone, training sites were recorded primarily as coniferous forest; one site represents Needleleaf-Broadleaf Riparian vegetation.
Conclusion: 6102.

RECORD #	FREQUENCY	VEGETATION CLASS
3	3	Needleleaf Dominated Riparian

Spectral Class 24
Color: Dark orange; RGB 221 85 47.
Distribution: Medium density on foothills, some in water channels; light density at lower and higher elevations; some along streams.
Comment: Broadleaf cover types, including Shrub Riparian/Wetland, Aspen, Mesic Upland Shrubland, and Broadleaf Forest, are most prevalent among training sites for this class.
Conclusion: 6104.

6	1	Needleleaf Dominated Riparian
7	1	Broadleaf Dominated Riparian
8	1	Needleleaf-Broadleaf Riparian
9	3	Shrub Riparian/Wetland

Spectral Class 25
Color: Red; RGB 196 29 28.
Distribution: Light density at mid-elevations and some lower elevation locations; medium density on some foothills; some along streams.
Comment: Training sites outside the zone include Aspen, riparian (6102, 6201, 6202), and coniferous vegetation.
Conclusion: 6102.

10	1	Broadleaf Dominated Riparian
11	3	Shrub Riparian/Wetland

Spectral Class 26
Color: Dark red; RGB 136 22 28.
Distribution: Medium density at mid-elevations and along some sections of the Missouri River.
Comment: Coniferous vegetation is the most prevalent group of cover types outside the zone; Mixed Needleleaf-Broadleaf, Broadleaf Forest, and riparian (6101, 6201) cover types were also observed.
Conclusion: 6104.

12	6	Needleleaf Dominated Riparian
13	1	Broadleaf Dominated Riparian
14	2	Shrub Riparian/Wetland

Spectral Class 27
Color: Light brown; RGB 183 126 90.
Distribution: Medium density on foothills; light density between the Little Belt Mountains and the Big Snowy Mountains.
Comment: Training sites outside the zone were recorded as shrub, coniferous, rock, and riparian (6102, 6103) cover types. Visual cues suggest a mix of grass and shrub riparian vegetation.
Conclusion: 6203.

15	1	Foothills Grassland

Spectral Class 28
Color: Pink; RGB 255 153 184.
Distribution: A small class. Some clusters are located on the west sides of both the Bears Paw Mountains and the Highwood Mountains; occasional clusters occur at lower elevations.
Comment: There are no training sites for this spectral class. Appears to represent agricultural and grass lands.
Conclusion: Not riparian.

Spectral Class 31
Color: Black; RGB 77 0 33.
Distribution: Medium density at mid-elevations; light density on bluffs along coulees either side of the Missouri River.
Comment: Coniferous cover types dominate training sites outside the zone; riparian cover types (6101, 6201) are included.
Conclusion: Not riparian.

16	3	Needleleaf Dominated Riparian
17	1	Shrub Riparian/Wetland

Spectral Class 35
Color: Black; RGB 81 36 47.
Distribution: Light to medium density at middle to upper elevations; light density on bluffs at lower elevations; very little along streams.
Comment: Most training sites outside the zone were recorded as coniferous vegetation; several sites represent riparian vegeatation (6101, 6103, 6201, 6202). May include junipers, but not riparian vegetation.
Conclusion: Not riparian.

18	3	Needleleaf Dominated Riparian

Spectral Class 36
Color: Medium brown; RGB 136 100 90.
Distribution: Light density at low to mid-elevations; some near streams.
Comment: All training sites outside the zone indicate needleleaf vegetation, including cedar and Ponderosa Pine.
Conclusion: 6103.

19	1	Needleleaf Dominated Riparian
20	1	Broadleaf Dominated Riparian

Spectral Class 38
Color: Bright red orange; RGB 255 53 24.
Distribution: Medium density on foothills; some along streams.
Comment: Riparian (6201, 6202), grass, Aspen, shrub and coniferous cover types were observed outside the zone. Color and locations indicate Aspen.
Conclusion: 6102.

21	1	Grass-Forb Riparian/Wetland

Spectral Class 40
Color: Orange; RGB 255 141 80.
Distribution: Medium density on foothills; some at lower elevations or along streams.
Comment: Foothills Grassland, Supalpine Meadow, and riparian (6201, 6202) cover types comprise training data for sites outside the zone.
Conclusion: 6102.

22	1	Foothills Grassland
23	1	Grass-Forb Riparian/Wetland

Spectral Class 42
Color: Eggplant; RGB 119 0 85.
Distribution: A rare class. Very light density along streams and at high elevations.
Comment: There are no training sites for this class. Appears to represent conifers and shadows.
Conclusion: Not riparian.

Spectral Class 43
Color: Dull yellow; RGB 230 206 151.
Distribution: A rare class. Occurs occasionally at low elevations and on foothills.
Comment: All four training sites for this class were recorded as Dry-land Pasture.
Conclusion: Not riparian.

Spectral Class 45
Color: Warm brown; RGB 166 78 38.
Distribution: Light density at mid-elevations, on foothills, and at some lower elevation sites; very little near streams.
Comment: Broadleaf cover types outside the zone include Aspen, Mixed Needleleaf-Broadleaf, Broadleaf Dominated Riparian, Shrub Riparian/Wetland, and Mesic Upland Shrubland; Subalpine Meadow and Needleleaf Dominated Riparian are minimally included.
Conclusion: 6104.

25	1	Needleleaf Dominated Riparian

Spectral Class 47
Color: Cool red; RGB 221 53 90.
Distribution: Light density at lower elevations; somealong streams; some at mid-elevations.
Comment: There are no training sites for this spectral class. Visual cues suggest a combination of broadleaf and agricultural cover types.
Conclusion: 6102.

Spectral Class 48
Color: Warm red; RGB 255 7 47.
Distribution: A rare class. Very light density at middle and lower elevations; some near streams.
Comment: There are no training sites for this class.
Conclusion: 6102.

Spectral Class 51
Color: Yellow orange; RGB 255 182 109.
Distribution: A rare class. Light density on foothills; some at low elevations.
Comment: There is one observation for this spectral class, Dry-land Pasture. Appears to represent agricultural land.
Conclusion: Not riparian.

Spectral Class 57
Color: Light yellow; RGB 238 243 165.
Distribution: A rare class. Occurs very sparsely at all but the lowest elevations; very little near streams.
Comment: There are no training sites for this class. May represent barren land and rocks.
Conclusion: Not riparian.

Spectral Class 58
Color: Light pink; RGB 251 214 255.
Distribution: A small class, occurring in some clusters at low elevations.
Comment: Just two observations were recorded outside the zone for this class, one as Exposed Rock and one as Urban & Developed Land. Appears to represent agriculture and barren land.
Conclusion: Not riparian.

26	2	Lakes

Spectral Class 62
Color: Warm brown; RGB 174 97 61.
Distribution: Light density on foothills and some lower elevation sites; some along water channels and near rivers.
Comment: Aspen, coniferous, and riparian (6101, 6202) vegetation are equally represented by training data for this class. No sites fall within the riparian zone. Visual cues suggest Mixed Riparian vegetation within the zone.
Conclusion: 6104.

27	1	Mixed Xeric Forest
28	1	Needleleaf Dominated Riparian

Spectral Class 66
Color: Black; RGB 60 0 0
Distribution: Medium to high density at mid-elevations.
Comment: Conifers are the most prevalent cover types outside the zone; two sites represent riparian vegetation (6101, 6103). Appears to represent Douglas-fir.

Conclusion: Not riparian.

29	2	Lakes
30	1	Needleleaf Dominated Riparian
31	1	Needleleaf-Broadleaf Riparian

Spectral Class 67
Color: Black; RGB 68 0 14.
Distribution: Medium denisty at mid-elevations; very little at low elevations or near streams.
Comment: Outside the zone, coniferous cover types have the highest frequency of observation; riparian (6101, 6201, 6202), Aspen, and Broadleaf Forest are included. Visual indicators suggest coniferous cover types, especially Douglas-fir.
Conclusion: Not riparian.

32	1	Mixed Subalpine Forest
33	3	Needleleaf Dominated Riparian

Spectral Class 68
Color: Black; RGB 47 0 24.
Distribution: Medium to high density at mid-elevations; light density on bluffs along coulees.
Comment: Coniferous and riparian (6201, 6101, 6202, 6103) cover types comprise characterize training sites outside the zone. Appears to represent Douglas-fir.
Conclusion: Not riparian.

34	1	Engelmann Spruce
35	1	Lakes
36	2	Needleleaf Dominated Riparian
37	1	Grass-Forb Riparian/Wetland
38	1	Shrub Riparian/Wetland

TM SCENE P38/R28

Image Analyst: Zhenkui Ma

Training Data Analysis

A total of 1750 ground-truth plots were available for labeling P38/R28 (see table below); 1418 were collected by Forest Service field crews during the1994-95 field seasons, and 829 of these were collected specifically for this TM scene. The remaining 332 plots came from pre-existing data sources such as ECODATA and TSMRS.

All the ground-truth data were converted to a point file and superimposed on the unsupervised classification to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 281) were removed from further analysis. Then the data were examined by cover type and by data source (whether or not plots were collected for this project or for other purposes, like pre-existing ECODATA or TSMRS). The latter "existing data" were only used in the training data set to supplement cover types that had insufficient plots collected during the 1994 or 1995 field seasons. Seven classes were excluded from the digital classification process: urban, agriculture, water, snow, melted snow, cloud, and cloud shadow. All ground truth data with VEG_CLASS_CODEs for urban, agriculture, or water cover types were excluded. Next, 20% of the remaining plots were randomly selected from each cover type; these plots (n = 176) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

The remaining 80% of the data (n = 864 plots) were subjected to further spectral examination. Outliers were eliminated for each cover type by visual examination of TM and elevation values for their respective regions.

Total plots in ground-truth file	1750	
Total 1994-95 field plots	1418	
Plots sampled for P38/R28		829
Plots sampled for other scenes		589
Pre-existing plots (ECODATA, TSMRS, etc.)	332	
Plots held aside or eliminated	710	
Duplicates		281
Pre-existing plots		233
Manually labeled cover types		196
Potential training plots	1040	
20% test		176
80% training		864
Supplemental plots (from pre-existing data set)	0	
Total plots available for training	864	
Total plots used for training -- cover type	570	
size class	40	
canopy	12	

Land Cover Types

Land cover types were labeled through a digital classification of the 7 TM channels plus rescaled elevation (m elevation divided by 25), using the Nearest Member of Group classifier. This classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were assigned directly to the COVERTYPE field in the attribute table. Modifications were carried out using spectral class values (SPECTRAL_CLASS or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000.	Urban.	Manually identified and recoded by Anne VanderMeer.
2000.	Agriculture.	Manually identified and recoded by Willard Gustafson.
3101.	Foothills Grasslands.	All grass types occurring below 1981 m (6500 ft) were relabeled as Foothills Grasslands.
3104.	Montane Parklands & Subalpine Meadows.	All grass types occurring at or above 1980 m (6500 ft) were reassigned this label.
5000.	Water.	All regions with spectral class (LINK = 1) and slope less than or equal to 5˚ were labeled as water; cloud shadows (see 9900 below) were recoded manually. Generally, water was more spectrally distinct than most other cover types, but in mountainous terrain, it was sometimes confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate slope and aspect values such that their slope may be greater than 5˚. This would result in the misclassification of some small ponds or lakes.
(n/a)	Melted Snow.	All regions originally classified as Melted Snow were recoded either to Exposed Rock (7301), if their slope was greater than 5˚, or to Snow (9000), if their slope was less than or equal to 5˚.
9800.	Cloud.	Manually identified and recoded by Zhenkui Ma.
9900.	Cloud Shadow.	Manually identified and recoded by Zhenkui Ma.

A total of 29 classes were labeled in the full TM scene. These included three grass types, two shrub types, fourteen forest types, three barren types, one alpine type, plus six manually labeled classes. Land cover classes were reviewed by personnel from the following National Forests: Gallatin (Stephen Brigham), Lewis & Clark (Tim Horn), and Custer (Chuck Mark). Cover types are mapped in Figure F-17.

Canopy Cover Classes

Canopy cover labels (CANOPY_CODE = low, medium, or high) were assigned to tree and shrub classes based on MNDVI values. These values were plotted as frequency histograms for all coniferous forest types (Figure F-17a), as well as for two different shrub types (mesic versus xeric; Figures F-17b+c). The histograms were examined visually and break points decided based on the distribution modes. Regions with MNDVI values falling below the lower break point were assigned to the low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class.

CANOPY COVER	MNDVI BREAKPOINTS		
	Tree	Shrub	
		Xeric	Mesic
Low	<225	≤74	≤149
Medium	≥225 and <400	>74	>149
High	≥400	n/a	n/a

Size Classes

Five size classes were distinguished -- three for forest cover types (seedling/sapling, pole, and medium) and two for shrub cover types (low and medium). Only the seven TM channels were used for these classifications. The Nearest Mean classifier was used for tree size classes, and the Nearest Member of Group classifier was used for shrub size classes. Tree size classes were stratified based upon the canopy cover classes described above.

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a

hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications. Note that the Forest Group accuracy was not calculated separately but was part of the overall Lifeform accuracy assessment. We feel that this Forest Group accuracy is much more reliable than the overall Lifeform accuracy because the latter includes manually labeled cover types like Urban, Agriculture, and Water. Again, no accuracy assessment was performed on these manually labeled cover types.

Classifications for P38/R28	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	28	55%	35%
Lifeform	5	n/a	42%
Forest Group	14	n/a	84%
Tree Size Class	3	91%	61%
Tree Canopy Class	3	88%	65%
Shrub Size Class	2	100%	25%
Shrub Canopy Class	2	100%	92%

Comments

Note that a weight was not applied to the foothills grassland cover type (3101) in the accuracy assessment; a majority of this TM scene was classified as 3101, yet this type was poorly sampled because more than 50% of the scene covers privately-owned lands. Also, the weighted accuracies for grass and shrub classes may not be appropriate because there were so few ground truth data collected from private land. Although the accuracies for lodgepole pine (4203) and mixed alpine forest (4219) were high at the acceptable level (score 3), we feel that the mixed alpine forest class contains some lodgepole pine that could be better classified if more training data can be acquired for lodgepole, especially at high elevations.

Error Matrix For Cover Type Training Plots
Scene P38/R28

	CLASSIFIED COVER TYPES																
PLOT COVER TYPES	3102	3104	3201	3305	4101	4203	4205	4206	4208	4212	4219	4220	4222	7301	7500	7800	SUM
3102	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
3104	1	12	0	1	1	0	1	0	0	0	0	0	0	1	0	0	17
3201	0	0	2	0	1	0	0	0	0	0	0	1	0	1	0	0	5
3305	0	1	0	2	0	0	0	0	0	0	0	0	0	1	0	0	4
4101	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	9
4203	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	3
4205	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
4206	0	0	0	0	0	0	0	15	0	2	1	0	0	0	0	0	18
4208	0	0	0	0	0	0	0	0	4	0	0	2	0	0	0	0	6
4212	0	0	0	0	0	0	0	1	1	3	0	0	1	0	0	0	6
4219	0	1	0	0	0	0	0	1	0	0	2	1	0	0	0	0	5
4220	0	0	0	0	0	1	0	1	1	0	1	6	0	0	0	0	10
4222	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	3
7301	0	1	0	1	0	0	0	0	0	0	0	0	0	14	0	1	17
7500	0	0	0	0	0	0	0	1	0	0	0	0	0	1	6	0	8
7800	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2
SUM	3	17	2	4	11	2	3	21	6	6	4	11	1	19	6	2	118

% AGREEMENT	68.64
TAU WITH EQUAL PROBABILITY	0.667
TOTAL DIAGONAL ELEMENTS	81
TOTAL TRAINING PLOTS IN DATA SET	118

f. p38/r28.5

f.p38/r28.6

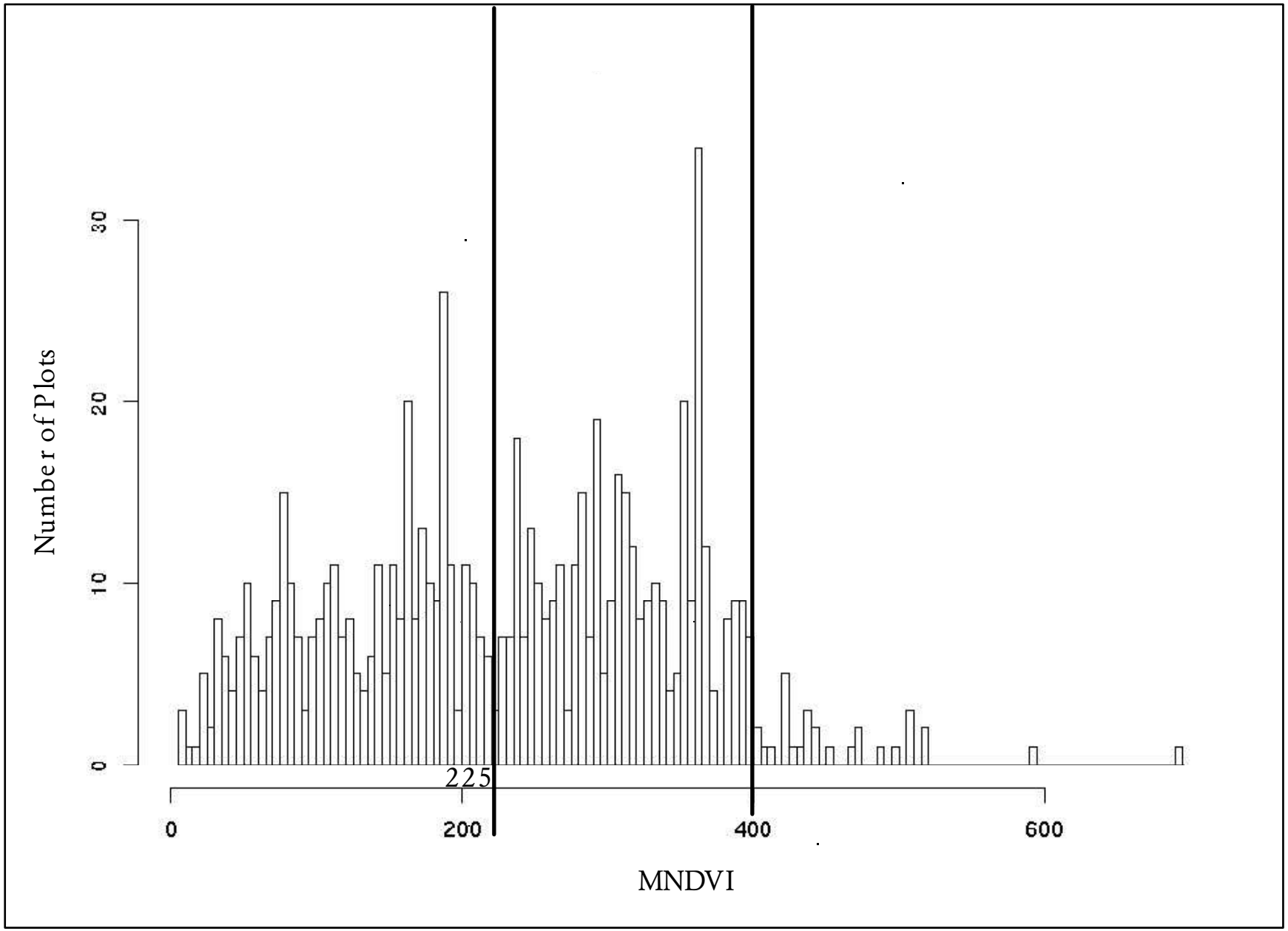


Figure F-17a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P38/R28

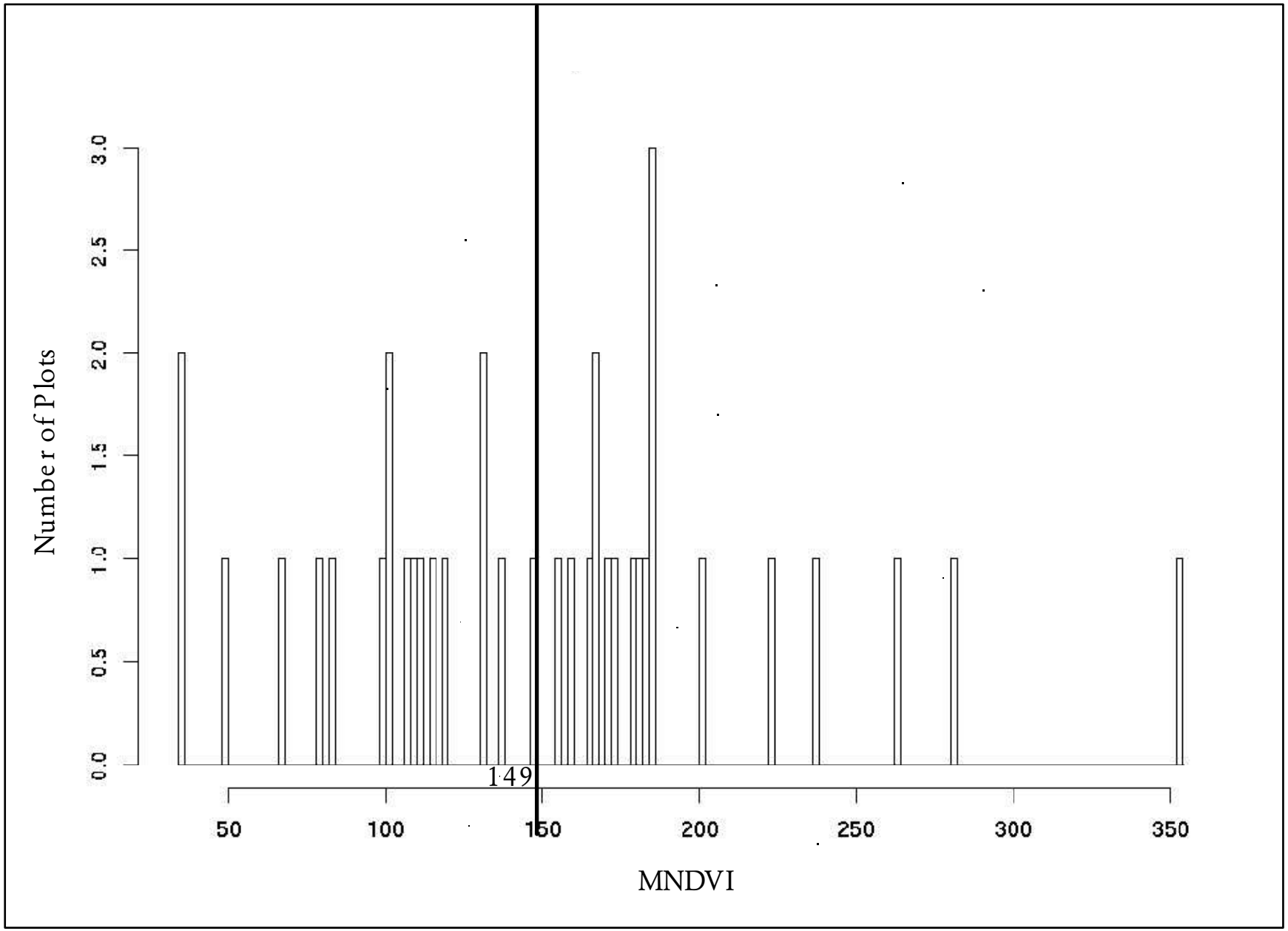


Figure F-17b. Breaks between mesic shrub canopy cover classes in relation to MNDVI values: TM scene P38/R28

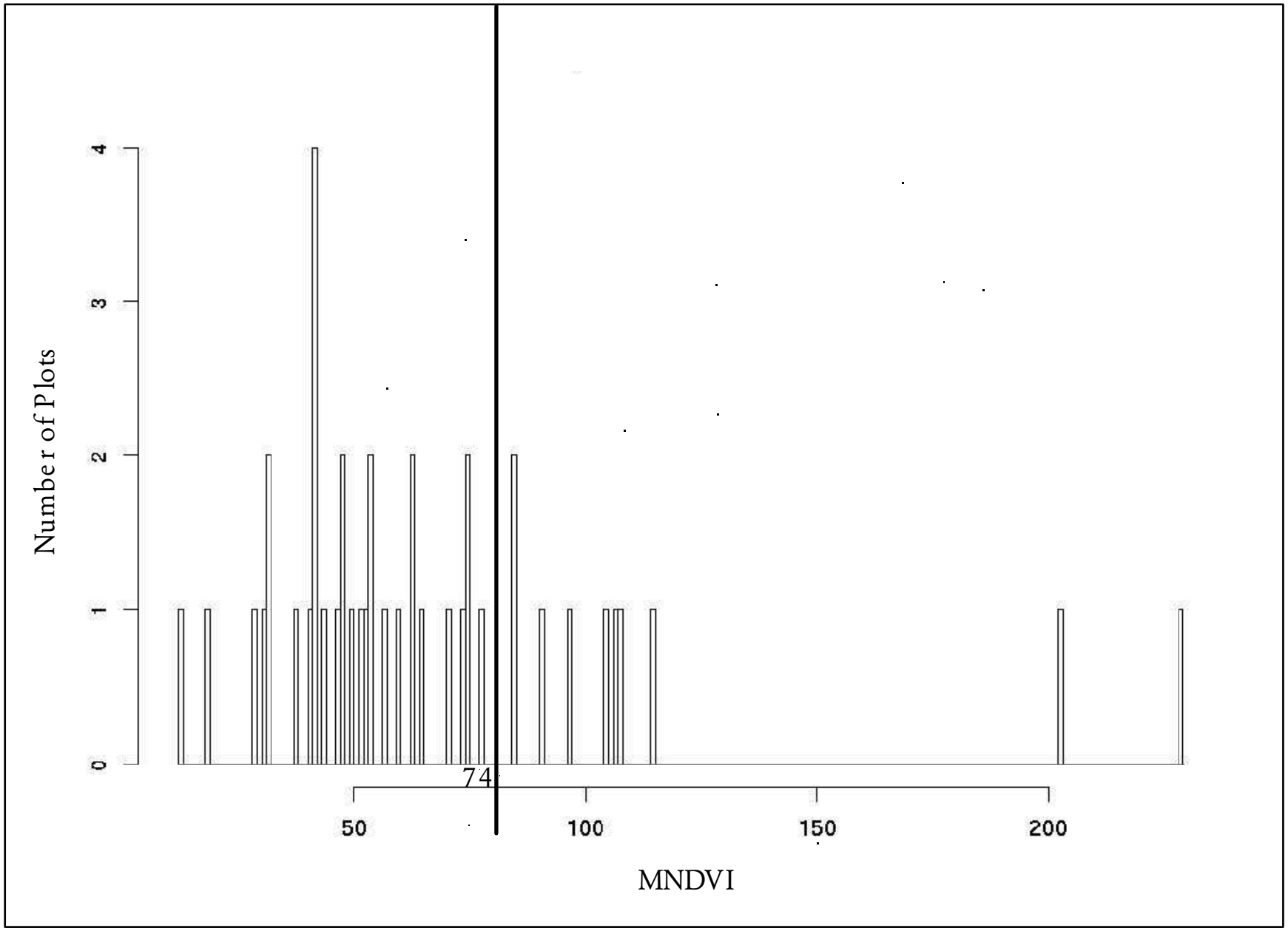


Figure F-17c. Breaks between xeric shrub canopy cover classes in relation to MNDVI values: TM scene P38/R28

f. p38/r28. 8

Accuracy Assessment Tables for P38/R28 -- Cover Type

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3102	3104	3201	3202	3203	3304	3305	4101
3101	34(5)	0(3)	10(3)	9(1)	0(1)	0(1)	0(1)	16(1)	0(1)
3102	1(3)	0(5)	0(2)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3104	1(3)	1(3)	4(5)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3201	1(1)	1(1)	1(1)	0(5)	0(4)	0(4)	0(2)	0(2)	1(1)
3202	1(1)	0(1)	1(1)	1(4)	0(5)	0(3)	0(2)	0(2)	0(1)
3203	0(1)	0(1)	0(1)	0(4)	0(3)	0(5)	0(2)	0(2)	0(1)
3304	1(1)	0(1)	0(1)	0(2)	0(2)	0(2)	0(5)	0(3)	0(1)
3305	3(1)	0(1)	1(1)	0(2)	0(2)	0(2)	0(3)	2(5)	0(1)
4101	0(1)	0(1)	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)	6(5)
4102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(4)
4201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)
4203	0(1)	0(1)	2(1)	1(1)	0(1)	0(1)	0(1)	2(1)	0(2)
4205	1(1)	0(1)	1(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(2)
4206	1(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	2(1)	0(2)
4208	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)
4212	1(1)	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)
4214	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(2)
4219	0(1)	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)
4220	0(1)	0(1)	2(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(2)
4221	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(2)
4222	1(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)
4223	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)
4301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(3)
7300	3(1)	0(1)	3(1)	0(1)	0(1)	0(1)	0(1)	2(1)	0(1)
7800	0(2)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
8101	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
9101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
9200	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	50(0)	2(0)	31(0)	17(0)	0(0)	0(0)	0(0)	25(0)	10(0)

RF/CF	4102	4201	4203	4205	4206	4208	4212	4214	4219
3101	1(1)	0(1)	0(1)	0(1)	1(1)	2(1)	1(1)	0(1)	0(1)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3104	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3202	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3203	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)
3304	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3305	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4101	0(4)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4102	0(5)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4201	0(2)	0(5)	1(2)	0(2)	0(2)	1(3)	0(2)	0(2)	1(3)
4203	0(2)	1(2)	9(5)	0(2)	0(2)	2(2)	3(2)	0(2)	2(3)
4205	0(2)	0(2)	0(2)	0(5)	0(2)	0(2)	0(2)	0(2)	1(2)
4206	0(2)	0(2)	0(2)	0(2)	0(5)	0(2)	3(2)	0(2)	0(2)
4208	0(2)	0(3)	0(2)	0(2)	0(2)	0(5)	1(2)	0(2)	2(3)
4212	1(2)	2(2)	5(2)	1(2)	0(2)	1(2)	38(5)	0(2)	2(2)
4214	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(5)	0(2)
4219	0(2)	0(3)	0(3)	0(2)	0(2)	1(3)	1(2)	0(2)	3(5)

Accuracy Assessment Tables for P38/R28 -- Cover Type

4220	0(2)	1(4)	0(3)	0(2)	0(2)	1(3)	2(3)	0(2)	0(3)
4221	0(2)	0(3)	1(3)	0(2)	0(2)	0(2)	0(3)	0(2)	0(2)
4222	0(2)	0(2)	1(2)	0(3)	0(3)	0(2)	9(3)	0(3)	0(2)
4223	0(2)	0(2)	1(3)	0(2)	1(2)	0(2)	1(3)	0(2)	1(2)
4301	0(3)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
7300	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7800	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	1(1)	0(1)	1(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
9101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
9200	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	3(0)	4(0)	19(0)	1(0)	2(0)	8(0)	60(0)	0(0)	14(0)

RF/CF	4220	4221	4222	4223	4301	7300	7800	8101	9101
3101	0(1)	0(1)	1(1)	0(1)	0(1)	4(1)	0(1)	0(1)	0(1)
3102	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3104	2(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)
3201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3202	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3203	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3304	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)
3305	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)
4101	0(2)	0(2)	0(2)	1(2)	0(4)	0(1)	0(1)	0(1)	0(1)
4102	0(2)	0(2)	0(2)	0(2)	0(4)	0(1)	0(1)	0(1)	0(1)
4201	2(4)	0(4)	0(2)	0(2)	0(2)	0(1)	0(1)	0(1)	0(1)
4203	16(3)	0(3)	2(2)	4(4)	0(2)	0(1)	0(1)	0(1)	0(1)
4205	0(2)	0(2)	0(4)	0(2)	0(2)	1(1)	0(1)	0(1)	0(1)
4206	0(2)	0(3)	1(4)	0(2)	0(2)	2(1)	0(1)	0(1)	0(1)
4208	1(3)	0(3)	0(2)	0(2)	0(2)	0(1)	0(1)	0(1)	0(1)
4212	15(3)	0(3)	5(4)	7(4)	0(2)	1(1)	0(1)	0(1)	0(1)
4214	0(2)	0(2)	0(4)	0(2)	0(2)	1(1)	0(1)	0(1)	0(1)
4219	2(3)	0(2)	0(2)	0(2)	0(2)	0(1)	0(1)	0(1)	0(1)
4220	3(5)	0(2)	0(2)	1(3)	0(2)	1(1)	0(1)	0(1)	0(1)
4221	0(2)	0(5)	0(2)	0(3)	0(2)	0(1)	0(1)	0(1)	0(1)
4222	1(2)	0(2)	1(5)	0(2)	0(2)	2(1)	0(1)	0(1)	0(1)
4223	4(3)	0(3)	0(2)	1(5)	0(2)	0(1)	0(1)	0(1)	0(1)
4301	0(3)	0(3)	0(3)	0(3)	0(5)	0(1)	0(1)	0(1)	0(1)
7300	2(1)	0(1)	0(1)	0(1)	0(1)	13(5)	1(3)	0(1)	0(1)
7800	0(1)	0(1)	0(1)	5(1)	0(1)	1(3)	0(5)	0(3)	0(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	1(1)	0(3)	0(5)	0(1)
9101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	5(5)
9200	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	4(1)
SUM	48(0)	0(0)	10(0)	19(0)	0(0)	30(0)	1(0)	0(0)	9(0)

RF/CF	9200	SUM
3101	0(1)	79(0)
3102	0(1)	1(0)
3104	0(1)	10(0)
3201	0(1)	4(0)
3202	0(1)	4(0)
3203	0(1)	1(0)
3304	0(1)	2(0)

3305	0(1)	7(0)
4101	0(1)	9(0)
4102	0(1)	1(0)
4201	0(1)	5(0)
4203	0(1)	44(0)
4205	0(1)	5(0)
4206	0(1)	10(0)
4208	0(1)	5(0)
4212	0(1)	81(0)
4214	0(1)	2(0)
4219	0(1)	9(0)
4220	0(1)	12(0)
4221	0(1)	2(0)
4222	0(1)	16(0)
4223	0(1)	9(0)
4301	0(1)	1(0)
7300	0(1)	24(0)
7800	0(1)	9(0)
8101	0(1)	2(0)
9101	0(1)	5(0)
9200	0(5)	4(0)
SUM	0(0)	363(0)

Diagonal Elements = 119; Total Test Points = 363
Percentage Agreement = 32.78; Kappa = 0.259; Tau w/equal Prob = 0.303

Accuracy Assessment Tables for P38/R28 -- Cover Type

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	34	43.04	0	0.00	10	12.66	0	0.00	35	44.30
3102	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
3104	4	40.00	0	0.00	2	20.00	0	0.00	4	40.00
3201	0	0.00	0	0.00	0	0.00	0	0.00	4	100.00
3202	0	0.00	1	25.00	0	0.00	0	0.00	3	75.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3304	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
3305	2	28.57	0	0.00	0	0.00	0	0.00	5	71.43
4101	6	66.67	0	0.00	0	0.00	1	11.11	2	22.22
4102	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
4201	0	0.00	2	40.00	2	40.00	1	20.00	0	0.00
4203	9	20.45	4	9.09	18	40.91	8	18.18	5	11.36
4205	0	0.00	0	0.00	0	0.00	1	20.00	4	80.00
4206	0	0.00	1	10.00	0	0.00	3	30.00	6	60.00
4208	0	0.00	0	0.00	3	60.00	1	20.00	1	20.00
4212	38	46.91	12	14.81	15	18.52	12	14.81	4	4.94
4214	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4219	3	33.33	0	0.00	3	33.33	1	11.11	2	22.22
4220	3	25.00	1	8.33	4	33.33	0	0.00	4	33.33
4221	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00
4222	1	6.25	0	0.00	9	56.25	2	12.50	4	25.00
4223	1	11.11	0	0.00	6	66.67	2	22.22	0	0.00
4301	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
7300	13	54.17	0	0.00	1	4.17	0	0.00	10	41.67
7800	0	0.00	0	0.00	1	11.11	0	0.00	8	88.89
8101	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
9101	5	100.00	0	0.00	0	0.00	0	0.00	0	0.00
9200	0	0.00	0	0.00	0	0.00	0	0.00	4	100.00
SUM	119	32.78	22	6.06	77	21.21	33	9.09	112	30.85

Accuracy Assessment Tables for P38/R28 -- Cover Type

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	34	43.04	34	43.04	44	55.70	44	55.70	79	100.00
3102	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
3104	4	40.00	4	40.00	6	60.00	6	60.00	10	100.00
3201	0	0.00	0	0.00	0	0.00	0	0.00	4	100.00
3202	0	0.00	1	25.00	1	25.00	1	25.00	4	100.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3304	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
3305	2	28.57	2	28.57	2	28.57	2	28.57	7	100.00
4101	6	66.67	6	66.67	6	66.67	7	77.78	9	100.00
4102	0	0.00	1	100.00	1	100.00	1	100.00	1	100.00
4201	0	0.00	2	40.00	4	80.00	5	100.00	5	100.00
4203	9	20.45	13	29.55	31	70.45	39	88.64	44	100.00
4205	0	0.00	0	0.00	0	0.00	1	20.00	5	100.00
4206	0	0.00	1	10.00	1	10.00	4	40.00	10	100.00
4208	0	0.00	0	0.00	3	60.00	4	80.00	5	100.00
4212	38	46.91	50	61.73	65	80.25	77	95.06	81	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
4219	3	33.33	3	33.33	6	66.67	7	77.78	9	100.00
4220	3	25.00	4	33.33	8	66.67	8	66.67	12	100.00
4221	0	0.00	0	0.00	1	50.00	2	100.00	2	100.00
4222	1	6.25	1	6.25	10	62.50	12	75.00	16	100.00
4223	1	11.11	1	11.11	7	77.78	9	100.00	9	100.00
4301	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
7300	13	54.17	13	54.17	14	58.33	14	58.33	24	100.00
7800	0	0.00	0	0.00	1	11.11	1	11.11	9	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
9101	5	100.00	5	100.00	5	100.00	5	100.00	5	100.00
9200	0	0.00	0	0.00	0	0.00	0	0.00	4	100.00
SUM	119	32.78	141	38.84	218	60.06	251	69.15	363	100.00

Accuracy Assessment Tables for P38/R28 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	34	68.00	0	0.00	2	4.00	0	0.00	14	28.00
3102	0	0.00	0	0.00	1	50.00	0	0.00	1	50.00
3104	4	12.90	0	0.00	10	32.26	0	0.00	17	54.84
3201	0	0.00	1	5.88	0	0.00	0	0.00	16	94.12
3202	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3304	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3305	2	8.00	0	0.00	0	0.00	0	0.00	23	92.00
4101	6	60.00	1	10.00	1	10.00	1	10.00	1	10.00
4102	0	0.00	0	0.00	0	0.00	1	33.33	2	66.67
4201	0	0.00	1	25.00	0	0.00	3	75.00	0	0.00
4203	9	47.37	0	0.00	2	10.53	7	36.84	1	5.26
4205	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00
4206	0	0.00	0	0.00	0	0.00	1	50.00	1	50.00
4208	0	0.00	0	0.00	3	37.50	3	37.50	2	25.00
4212	38	63.33	0	0.00	12	20.00	8	13.33	2	3.33
4214	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4219	3	21.43	0	0.00	5	35.71	4	28.57	2	14.29
4220	3	6.25	2	4.17	38	79.17	1	2.08	4	8.33
4221	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4222	1	10.00	6	60.00	0	0.00	2	20.00	1	10.00
4223	1	5.26	11	57.89	1	5.26	1	5.26	5	26.32
4301	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7300	13	43.33	0	0.00	1	3.33	0	0.00	16	53.33
7800	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
9101	5	55.56	0	0.00	0	0.00	0	0.00	4	44.44
9200	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	119	32.78	22	6.06	77	21.21	33	9.09	112	30.85

Accuracy Assessment Tables for P38/R28 -- Cover Type

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	34	68.00	34	68.00	36	72.00	36	72.00	50	100.00
3102	0	0.00	0	0.00	1	50.00	1	50.00	2	100.00
3104	4	12.90	4	12.90	14	45.16	14	45.16	31	100.00
3201	0	0.00	1	5.88	1	5.88	1	5.88	17	100.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3304	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3305	2	8.00	2	8.00	2	8.00	2	8.00	25	100.00
4101	6	60.00	7	70.00	8	80.00	9	90.00	10	100.00
4102	0	0.00	0	0.00	0	0.00	1	33.33	3	100.00
4201	0	0.00	1	25.00	1	25.00	4	100.00	4	100.00
4203	9	47.37	9	47.37	11	57.89	18	94.74	19	100.00
4205	0	0.00	0	0.00	0	0.00	1	100.00	1	100.00
4206	0	0.00	0	0.00	0	0.00	1	50.00	2	100.00
4208	0	0.00	0	0.00	3	37.50	6	75.00	8	100.00
4212	38	63.33	38	63.33	50	83.33	58	96.67	60	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4219	3	21.43	3	21.43	8	57.14	12	85.71	14	100.00
4220	3	6.25	5	10.42	43	89.58	44	91.67	48	100.00
4221	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4222	1	10.00	7	70.00	7	70.00	9	90.00	10	100.00
4223	1	5.26	12	63.16	13	68.42	14	73.68	19	100.00
4301	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7300	13	43.33	13	43.33	14	46.67	14	46.67	30	100.00
7800	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
9101	5	55.56	5	55.56	5	55.56	5	55.56	9	100.00
9200	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	119	32.78	141	38.84	218	60.06	251	69.15	363	100.00

Accuracy Assessment Tables for P38/R28 -- Cover Type

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	226	43.04	0	0.00	66	12.66	0	0.00	232	44.30
3102	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
3104	11	40.00	0	0.00	5	20.00	0	0.00	11	40.00
3201	0	0.00	0	0.00	0	0.00	0	0.00	37	100.00
3202	0	0.00	0	25.00	0	0.00	0	0.00	0	75.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
3304	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
3305	35	28.57	0	0.00	0	0.00	0	0.00	87	71.43
4101	17	66.67	0	0.00	0	0.00	3	11.11	6	22.22
4102	0	0.00	10	100.00	0	0.00	0	0.00	0	0.00
4201	0	0.00	3	40.00	3	40.00	1	20.00	0	0.00
4203	9	20.45	4	9.09	19	40.91	8	18.18	5	11.36
4205	0	0.00	0	0.00	0	0.00	1	20.00	3	80.00
4206	0	0.00	1	10.00	0	0.00	2	30.00	3	60.00
4208	0	0.00	0	0.00	6	60.00	2	20.00	2	20.00
4212	30	46.91	10	14.81	12	18.52	10	14.81	3	4.94
4214	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
4219	11	33.33	0	0.00	11	33.33	4	11.11	8	22.22
4220	12	25.00	4	8.33	16	33.33	0	0.00	16	33.33
4221	0	0.00	0	0.00	0	50.00	0	50.00	0	0.00
4222	1	6.25	0	0.00	12	56.25	3	12.50	6	25.00
4223	1	11.11	0	0.00	9	66.67	3	22.22	0	0.00
4301	0	0.00	0	0.00	0	100.00	0	0.00	0	0.00
7300	0	54.17	0	0.00	0	4.17	0	0.00	0	41.67
7800	0	0.00	0	0.00	0	11.11	0	0.00	0	88.89
8101	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
9101	0	100.00	0	0.00	0	0.00	0	0.00	0	0.00
9200	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
SUM	353	35.26	32	3.20	160	15.98	37	3.70	419	41.86

Accuracy Assessment Tables for P38/R28 -- Cover Type

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	226	43.04	226	43.04	292	55.70	292	55.70	525	100.00
3102	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
3104	11	40.00	11	40.00	16	60.00	16	60.00	26	100.00
3201	0	0.00	0	0.00	0	0.00	0	0.00	37	100.00
3202	0	0.00	0	25.00	0	25.00	0	25.00	0	100.00
3203	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
3304	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
3305	35	28.57	35	28.57	35	28.57	35	28.57	121	100.00
4101	17	66.67	17	66.67	17	66.67	20	77.78	26	100.00
4102	0	0.00	10	100.00	10	100.00	10	100.00	10	100.00
4201	0	0.00	3	40.00	6	80.00	7	100.00	7	100.00
4203	9	20.45	14	29.55	32	70.45	41	88.64	46	100.00
4205	0	0.00	0	0.00	0	0.00	1	20.00	3	100.00
4206	0	0.00	1	10.00	1	10.00	2	40.00	5	100.00
4208	0	0.00	0	0.00	6	60.00	8	80.00	9	100.00
4212	30	46.91	40	61.73	52	80.25	61	95.06	64	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
4219	11	33.33	11	33.33	23	66.67	27	77.78	34	100.00
4220	12	25.00	16	33.33	32	66.67	32	66.67	48	100.00
4221	0	0.00	0	0.00	0	50.00	0	100.00	0	100.00
4222	1	6.25	1	6.25	14	62.50	17	75.00	22	100.00
4223	1	11.11	1	11.11	10	77.78	13	100.00	13	100.00
4301	0	0.00	0	0.00	0	100.00	0	100.00	0	100.00
7300	0	54.17	0	54.17	0	58.33	0	58.33	0	100.00
7800	0	0.00	0	0.00	0	11.11	0	11.11	0	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
9101	0	100.00	0	100.00	0	100.00	0	100.00	0	100.00
9200	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
SUM	353	35.41	386	38.72	547	54.86	583	58.48	997	100.00

Accuracy Assessment Tables for P38/R28 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	3(5)	1(3)	4(1)	8(0)
2	0(3)	3(5)	4(3)	7(0)
3	1(1)	2(3)	8(5)	11(0)
SUM	4(0)	6(0)	16(0)	26(0)

Diagonal Elements = 14; Total Test Points = 26
Percentage Agreement = 53.85; Kappa = 0.268; Tau w/equal Prob = 0.308

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	37.50	0	0.00	1	12.50	0	0.00	4	50.00
2	3	42.86	0	0.00	4	57.14	0	0.00	0	0.00
3	8	72.73	0	0.00	2	18.18	0	0.00	1	9.09
SUM	14	53.85	0	0.00	7	26.92	0	0.00	5	19.23

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	37.50	3	37.50	4	50.00	4	50.00	8	100.00
2	3	42.86	3	42.86	7	100.00	7	100.00	7	100.00
3	8	72.73	8	72.73	10	90.91	10	90.91	11	100.00
SUM	14	53.85	14	53.85	21	80.77	21	80.77	26	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	75.00	0	0.00	0	0.00	0	0.00	1	25.00
2	3	50.00	0	0.00	3	50.00	0	0.00	0	0.00
3	8	50.00	0	0.00	4	25.00	0	0.00	4	25.00
SUM	14	53.85	0	0.00	7	26.92	0	0.00	5	19.23

Accuracy Assessment Tables for P38/R28 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	75.00	3	75.00	3	75.00	3	75.00	4	100.00
2	3	50.00	3	50.00	6	100.00	6	100.00	6	100.00
3	8	50.00	8	50.00	12	75.00	12	75.00	16	100.00
SUM	14	53.85	14	53.85	21	80.77	21	80.77	26	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	27	37.50	0	0.00	9	12.50	0	0.00	36	50.00
2	130	42.86	0	0.00	174	57.14	0	0.00	0	0.00
3	453	72.73	0	0.00	113	18.18	0	0.00	57	9.09
SUM	610	61.06	0	0.00	296	29.63	0	0.00	93	9.31

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	27	37.50	27	37.50	36	50.00	36	50.00	73	100.00
2	130	42.86	130	42.86	304	100.00	304	100.00	304	100.00
3	453	72.73	453	72.73	567	90.91	567	90.91	623	100.00
SUM	610	61.00	610	61.00	907	90.70	907	90.70	1000	100.00

Accuracy Assessment Tables for P38/R28 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	SUM
1	3(5)	4(3)	7(0)
2	2(3)	0(5)	2(0)
SUM	5(0)	4(0)	9(0)

Diagonal Elements = 3; Total Test Points = 9
Percentage Agreement = 33.33; Kappa = -0.421; Tau w/equal Prob = -0.333

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	42.86	0	0.00	4	57.14	0	0.00	0	0.00
2	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00
SUM	3	33.33	0	0.00	6	66.67	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	42.86	3	42.86	7	100.00	7	100.00	7	100.00
2	0	0.00	0	0.00	2	100.00	2	100.00	2	100.00
SUM	3	33.33	3	33.33	9	100.00	9	100.00	9	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	60.00	0	0.00	2	40.00	0	0.00	0	0.00
2	0	0.00	0	0.00	4	100.00	0	0.00	0	0.00
SUM	3	33.33	0	0.00	6	66.67	0	0.00	0	0.00

Accuracy Assessment Tables for P38/R28 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	3	60.00	3	60.00	5	100.00	5	100.00	5	100.00
2	0	0.00	0	0.00	4	100.00	4	100.00	4	100.00
SUM	3	33.33	3	33.33	9	100.00	9	100.00	9	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	250	42.86	0	0.00	334	57.14	0	0.00	0	0.00
2	0	0.00	0	0.00	416	100.00	0	0.00	0	0.00
SUM	250	25.00	0	0.00	750	75.00	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	250	42.86	250	42.86	584	100.00	584	100.00	584	100.00
2	0	0.00	0	0.00	416	100.00	416	100.00	416	100.00
SUM	250	25.00	250	25.00	1000	100.00	1000	100.00	1000	100.00

Accuracy Assessment Tables for P38/R28 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	14(5)	2(3)	0(1)	16(0)
2	14(3)	19(5)	0(3)	43(0)
3	6(1)	11(3)	1(5)	20(0)
SUM	34(0)	32(0)	1(0)	79(0)

Diagonal Elements = 34; Total Test Points = 79
Percentage Agreement = 43.04; Kappa = 0.173; Tau of Equal Prob = 0.146

12 points did not belong to groups listed in the test data and were treated as misclassifications. Default score for these 12 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	14	87.50	0	0.00	2	12.50	0	0.00	0	0.00
2	19	44.19	0	0.00	14	32.56	0	0.00	10	23.26
3	1	5.00	0	0.00	11	55.00	0	0.00	8	40.00
SUM	34	43.04	0	0.00	27	34.18	0	0.00	18	22.78

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	14	87.50	14	87.50	16	100.00	16	100.00	16	100.00
2	19	44.19	19	44.19	33	76.74	33	76.74	43	100.00
3	1	5.00	1	5.00	12	60.00	12	60.00	20	100.00
SUM	34	43.04	34	43.04	61	77.22	61	77.22	79	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	14	41.18	0	0.00	14	41.18	0	0.00	6	17.65
2	19	59.38	0	0.00	13	40.62	0	0.00	0	0.00
3	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	34	50.75	0	0.00	27	40.30	0	0.00	6	8.96

Accuracy Assessment Tables for P38/R28 -- Tree Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	14	41.18	14	41.18	28	82.35	28	82.35	34	100.00
2	19	59.38	19	59.38	32	100.00	32	100.00	32	100.00
3	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	34	50.75	34	50.75	61	91.04	61	91.04	67	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	466	87.50	0	0.00	67	12.50	0	0.00	0	0.00
2	186	44.19	0	0.00	137	32.56	0	0.00	98	23.26
3	2	5.00	0	0.00	26	55.00	0	0.00	19	40.00
SUM	654	65.33	0	0.00	230	22.98	0	0.00	117	11.69

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	466	87.50	466	87.50	532	100.00	532	100.00	532	100.00
2	186	44.19	186	44.19	322	76.74	322	76.74	420	100.00
3	2	5.00	2	5.00	29	60.00	29	60.00	48	100.00
SUM	654	65.40	654	65.40	883	88.30	883	88.30	1000	100.00

Accuracy Assessment Tables for P38/R28 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	SUM
1	6(5)	1(3)	7(0)
2	0(3)	2(5)	2(0)
SUM	6(0)	3(0)	9(0)

Diagonal Elements = 8; Total Test Points = 9
Percentage Agreement = 88.89; Kappa = 0.727; Tau w/equal Prob = 0.778

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	85.71	0	0.00	1	14.29	0	0.00	0	0.00
2	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	8	88.89	0	0.00	1	11.11	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	85.71	6	85.71	7	100.00	7	100.00	7	100.00
2	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
SUM	8	88.89	8	88.89	9	100.00	9	100.00	9	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	2	66.67	0	0.00	1	33.33	0	0.00	0	0.00
SUM	8	88.89	0	0.00	1	11.11	0	0.00	0	0.00

Accuracy Assessment Tables for P38/R28 -- Shrub Canopy Closure

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	6	100.00	6	100.00	6	100.00	6	100.00	6	100.00
2	2	66.67	2	66.67	3	100.00	3	100.00	3	100.00
SUM	8	88.89	8	88.89	9	100.00	9	100.00	9	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	454	85.71	0	0.00	76	14.29	0	0.00	0	0.00
2	470	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	924	92.40	0	0.00	76	7.60	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	454	85.71	454	85.71	530	100.00	530	100.00	530	100.00
2	470	100.00	470	100.00	470	100.00	470	100.00	470	100.00
SUM	924	92.40	924	92.40	1000	100.00	1000	100.00	1000	100.00

Scene P38/R28 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	80750.0	967261.1	28.4
1000	280.0	2515.0	0.1
2000	5536.0	118304.0	3.5
3101	67248.0	842466.3	24.8
3102	525.0	2686.8	0.1
3104	9412.0	80794.8	2.4
3201	8886.0	99062.7	2.9
3305	18570.0	308745.1	9.1
4101	3919.0	67584.1	2.0
4102	2970.0	19999.2	0.6
4201	1962.0	21682.6	0.6
4203	11487.0	141185.7	4.1
4205	1180.0	10689.4	0.3
4206	1946.0	15891.1	0.5
4208	3561.0	29197.6	0.9
4212	17466.0	184648.7	5.4
4219	9275.0	106056.5	3.1
4220	15896.0	147260.6	4.3
4222	5310.0	54341.2	1.6
4223	2002.0	41443.6	1.2
4224	1315.0	4630.2	0.1
4301	99.0	466.1	0.0
5000	1060.0	2521.3	0.1
7300	19126.0	129554.5	3.8
7800	79.0	954.0	0.0
8100	35.0	228.8	0.0
9100	507.0	3248.5	0.1
9800	8.0	194.0	0.0
9900	3.0	136.0	0.0

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	80750.0	967261.1	28.4
Not tree/shrub	103819.0	1183604.0	34.8
Shrub 1	16819.0	193571.6	5.7
Shrub 2	10637.0	214236.3	6.3
Tree 1	43146.0	430004.9	12.6
Tree 2	24250.0	372303.7	10.9
Tree 3	10992.0	42768.0	1.3

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	80750.0	967261.1	28.4
Not tree/shrub	103819.0	1183604.0	34.8
Tree 1	4560.0	59960.5	1.8
Tree 2	25424.0	262054.3	7.7
Tree 3	48404.0	523061.7	15.4
Shrub 1	19043.0	214073.4	6.3
Shrub 2	8413.0	193734.5	5.7

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	80750.0	967261.1	28.4
A	5536.0	118304.0	3.5
H	77220.0	926176.7	27.2
N	21063.0	139123.3	4.1
S	27456.0	407807.8	12.0
T	78388.0	845076.6	24.8

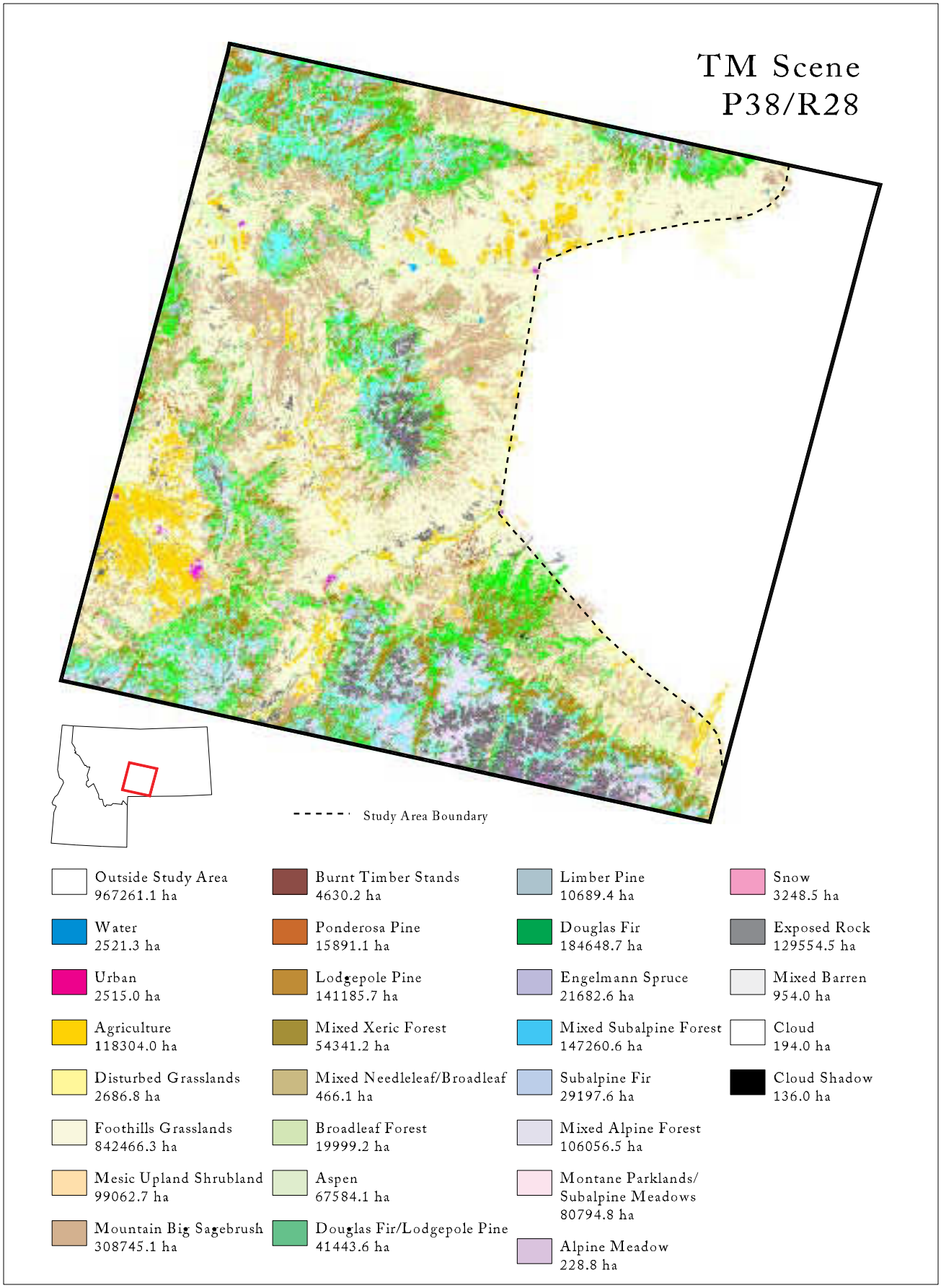


Figure F-17. Classification of land cover types for TM Scene P38/R28.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P38/R28

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4101: ASPEN FOREST

Aspen forest dominated by quaking aspen (Populus tremuloides) and ranging from 5160 to 7000 feet in elevation. The average canopy cover is 48% ranging from 10-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤3% and frequency of occurrence ≥15% and ≤31%.

Primary associated shrub species with ≥12% and ≤54% frequency of occurrence in aspen stands: western serviceberry (Amelanchier alnifolia), common juniper (Juniperus communis), mallow ninebark (Physocarpus malvaceus), prickly rose (Rosa sayi), Wood's rose (Rosa woodsii), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤35% frequency of occurrence in aspen stands: **graminoids**: bearded wheatgrass (Agropyron caninum), mountain brome (Bromus carinatus), pinegrass (Calamagrostis rubescens), blue wildrye (Elymus glacus), alpine timothy (Phleum alpinum), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: Virginia strawberry (Fragaria virginiana), sticky geranium (Geranium viscosissimum), lupine (Lupinus spp.), sweet-cicely (Osmorhiza spp.), buttercup (Ranunculus spp), common dandelion (Taraxacom officinale), and long-stalked clover (Trifolium longipes); **ferns**: none; **moss**; none.

2) 4201: ENGELMANN SPRUCE FOREST

Conifer forest dominated by Engelmann spruce (Picea engelmannii) ranging from 5280 to 9240 feet in elevation. The average canopy cover is 46%, ranging from 20-70% total cover and frequency of occurrence equal to 89%. Primary associated tree species include subalpine fir (Abies lasiocarpa), lodgepole pine (Pinus contorta), and Douglas-fir (pseudotsuga menziesii) with average percent cover ≥4% and ≤11% and frequency of occurrence ≥19% and ≤54%.

Primary associated shrub species with ≥8% and ≤23% frequency of occurrence in Engelmann spruce stands: kinnikinnick (Arctostaphylos uva-ursi), red-osier dogwood (Cornus stolonifera), twin flower (Linnaea borealis), shrubby cinquefoil (Potentilla fruticosa), common snowberry (Symphoricarpos albus), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤23% frequency of occurrence in Engelmann spruce stands: **graminoids**: pinegrass (Calamagrostis rubescens), sheep sedge (Carex iliota), beaked sedge (Carex utriculata), tufted hairgrass (Deschampsia caespitosa), Baltic rush (Juncus balticus), common timothy (Phleum pratense), and western needlegrass (Stipa occidentalis); **forbs**: heart-leaf arnica

(Arnica cordifolia), milk-vetch (Astragalus), glacier lily (Erythronium grandiflorum), Virginia strawberry (Fragaria virginiana), bigseed desert-parsley (Lomatium macrocarpum), dandelion (Taraxacum spp.), common dandelion (Taraxacum officinale), western meadowrue (Thalictrum occidentale), and violet (Viola spp.); **ferns**: field horsetail (Equisetum arvense), common scouring-rush (Equisetum hyemale), horsetail (Equisetum spp.), and sedgelike horsetail (Equisetum scirpoides); **moss**: moss (moss spp.).

3) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 4820 to 9280 feet in elevation. The average canopy cover is 45% ranging from 20-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥4% and ≤6% and frequency of occurrence ≥20% and ≤38%.

Primary associated shrub species with ≥8% and ≤32% frequency of occurrence in lodgepole pine stands: kinnikinnick (Arctostaphylos uva-ursi), common juniper (Juniperus communis), shiny-leaf spiraea (Spiraea betulifolia), spiraea (Spiraea spp.), huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare, and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤29% frequency of occurrence in lodgepole pine stands: **graminoids**: tickle grass (Agrostis scabra), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), blue wildrye (Elymus glacus), common timothy (Phleum pratense), Kentucky bluegrass (Poa pratensis), and spike trisetum (Trisetum spicatum); **forbs**: rosy pussy-toes (Antennaria microphylla), raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), Wood's strawberry (Fragaria vesca), Virginia strawberry (Fragaria virginiana), mountain sweet-cicely (Osmorhiza chilensis), toothleaf pyrola (Pyrola dentata), and western meadowrue (Thalictrum occidentale); **ferns**: stiff clubmoss (Lycopodium annotinum); **moss**: moss (moss spp.).

4) 4205: LIMBER PINE FOREST

Conifer forest dominated by limber pine (Pinus flexilis) ranging from 4800 to 7400 feet in elevation. The average canopy cover is 29% ranging from 20-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥4% and ≤5% and frequency of occurrence ≥54% and ≤69%.

Primary associated shrub species with ≥8% and ≤32% frequency of occurrence in limber pine stands: rocky mountain maple (Acer glabrum), mountain big sagebrush (Artemisia tridentata), common juniper (Juniperus communis), creeping juniper (Juniperus horizontalis), skunk-bush sumac (Rhus trilobata), and shiny-leaf spiraea (Spiraea betulifolia).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤39% frequency of occurrence in limber pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), cheatgrass (Bromus tectorum), Idaho fescue (Festuca idahoensis),

spike oat (Helictotrichon hookeri), spike-fence (Hesperochloa kingii), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: desert alyssum (Alyssum desertorum), umber pussy-toes (Antennaria umbrinella), spreading dogbane (Apocynum androsaemifolium), arrowleaf balsamroot (Balsamorhiza sagittata), spotted knapweed (centaurea maculosa), northern bedstraw (Galium boreale), and cup clover (Trifolium cyathiferum); **ferns**: none; **moss**: none.

5) 4206: PONDEROSA PINE FOREST

Conifer forest dominated by ponderosa pine (Pinus ponderosa) ranging from 4600 to 6300 feet in elevation. The average canopy cover is 40% ranging from 20-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include rocky mountain juniper (Juniperus scopulorum), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤8% and frequency of occurrence ≥13% and ≤63%.

Primary associated shrub species with ≥8% and ≤25% frequency of occurrence in ponderosa pine stands: kinnikinnick (Arctostaphylos uva-ursi), fringed sagewort (Artemisia frigida), common juniper (Juniperus communis), creeping juniper (Juniperus horizontalis), gooseberry (Ribes spp.), Wood's rose (Rosa woodsii), common snowberry (Symphoricarpos albus), and snowberry (Symphoricarpos spp.).

Primary associated graminoid, forb, fern, and moss species with ≥8% and ≤39% frequency of occurrence in ponderosa pine stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), elk sedge (Carex geyeri), narrow-leaved sedge (Carex stenophyla), Idaho fescue (Festuca idahoensis), prairie junegrass (Koeleria cristata), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: common yarrow (Achillea millefolium), nodding onion (Allium cernuum), rosy pussy-toes (Antennaria microphylla), hairy golden-aster (Chrysopsis villosa), wyeth buckwheat (Erigonum heracleoides), western gromwell (Lithospermum ruderale), and American vetch (Vicia americana); **ferns**: stiff clubmoss (Lycopodium annotinum); **moss**: none.

6) 4208: SUBALPINE FIR FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 5960 to 8800 feet in elevation. The average canopy cover is 46% ranging from 20-70% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥4% and ≤11% and frequency of occurrence ≥33% and ≤57%.

Primary associated shrub species with ≥5% and ≤48% frequency of occurrence in subalpine fir stands: sitka alder (Alnus sinuata), twin flower (Linnaea borealis), Utah honeysuckle (Lonicera utahensis), swamp current (Ribes lacustre), thimbleberry (Rubus parviflorus), globe huckleberry (Vaccinium globulare, and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤29% frequency of occurrence in subalpine fir stands: **graminoids**: mountain brome (Bromus

carinatus), bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), soft-leaved sedge (Carex disperma), elk sedge (Carex geyeri), sheep sedge (Carex iliota), and Wahlenberg's woodrush (Luzula wahlenbergii); **forbs**: heart-leaf arnica (Arnica cordifolia), hairy arnica (Arnica mollis), showy aster (Aster conspicuus), brook saxifrage (Saxifraga odotoloma), arrowleaf groundsel (Senecio triangularis), clasping-leaved twisted-stalk (Streptopus amplexifolius), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: moss (moss spp.).

7) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 5100 to 7800 feet in elevation. The average canopy cover is 57% ranging from 1-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), limber pine (Pinus flexilis) with average percent cover ≥4% and ≤8% and frequency of occurrence ≥9% and ≤23%.

Primary associated shrub species with ≥4% and ≤43% frequency of occurrence in Douglas-fir stands: oregongrape (Berberis spp.), common juniper (Juniperus communis), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and snowberry (Symphoricarpos spp.).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤10% frequency of occurrence in Douglas-fir stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), and common timothy (Phleum pratense); **forbs**: common yarrow (Achillea millefolium), nodding onion (Allium cernuum), raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), balsamroot (Balsamorhiza sagittata), harebell (Campanula rotundifolia), common dandelion (Taraxacum officinale); **ferns**: stiff clubmoss (Lycopodium annotinum); **moss**: moss (moss spp.).

8) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albus) and ranging from 6340 to 10060 feet in elevation. The average canopy cover is 27% ranging from 10-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥10% and ≤27% and frequency of occurrence ≥38% and ≤75%.

Primary associated shrub species with ≥3% and ≤59% frequency of occurrence in mixed whitebark pine stands: kinnikinnick (Arctostaphylos uva-ursi), common juniper (Juniperus communis), creeping juniper (Juniperus horizontalis), shrubby cinquefoil (Potentilla fruticosa), shiny-leaf spiraea (Spiraea betulifolia), huckleberry (Vaccinium spp.), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥3% and ≤25% frequency of occurrence in mixed whitebark pine stands: **graminoids:** elk sedge (Carex geyeri), narrow-leaved sedge (Carex stenophyla), timber oatgrass (Danthonia intermedia), tufted hairgrass (Deschampsia caespitosa), Idaho fescue (Festuca idahoensis), muttongrass

(Poa fendleriana), and spike trisetum (Trisetum spicatum); **forbs**: rosy pussy-toes (Antennaria microphylla), heart-leaf arnica (Arnica cordifolia), broadleaf arnica (Arnica latifolia), harebell (Campanula rotundifolia), glacier lily (Erythronium grandiflorum), hawkweed (Hieracium spp.), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: none.

9) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 5680 to 9600 feet in elevation. The average canopy cover is 24% ranging from 1-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥18% and ≤21% and frequency of occurrence ≥40% and ≤83%.

Primary associated shrub species with ≥4% and ≤47% frequency of occurrence in mixed subalpine stands: sitka alder (Alnus sinuata), kinnikinnick (Arctostaphylos uva-ursi), common prince's pine (Chimaphila umbellata), common juniper (Juniperus communis), huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤26% frequency of occurrence in mixed subalpine fir stands: **graminoids**: mountain brome (Bromus carinatus), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), showy sedge (Carex spectabilis), and orchard grass (Dactylis glomerata); **forb**: heart-leaf arnica (Arnica cordifolia), silky lupine (Lupine sericeus), green wintergreen (Pyrola chlorantha), toothleaf pyrola (Pyrola dentata), western meadowrue (Thalictrum occidentale), violet (Viola spp.), and western Canadian violet (Viola rugulosa); **ferns**: none; **moss**: moss (moss spp.).

10) 4222: MIXED XERIC FOREST

Conifer forest dominated by limber pine (Pinus flexilis), codominant species are ponderosa pine (Pinus ponderosa), and rocky mountain juniper (Juniperus scopulorum), ranging from 5280 to 7880 feet in elevation. The average canopy cover for PINFLE is 13% ranging from 1-30% total cover and frequency of occurrence equal to 73%. The average canopy cover for PINPON is 20% ranging from 3-30% total cover and frequency of occurrence equal to 43%. The average canopy cover for JUNSCO is 10% ranging from 1-20% total cover and frequency of occurrence equal to 32%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥16% and ≤20% and frequency of occurrence ≥27% and ≤95%.

Primary associated shrub species with ≥11% and ≤32% frequency of occurrence in mixed xeric stands: fringed sagewort (Artemisia frigida), common juniper (Juniperus communis), mallow ninebark (Physocarpus malvaceus), Wood's rose (Rosa woodsii), Canada buffaloberry (Shepherdia canadensis), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤22% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), prairie junegrass (Koeleria cristata), common timothy (Phleum pratense), and western needlegrass (Stipa occidentalis); **forbs**: common yarrow (Achillea millefolium), small-flowered anemone (Anemone parviflora), rosy pussy-toes (Antennaria microphylla), arrowleaf balsamroot (Balsamorhiza sagittata), harebell (Campanula rotundifolia), northern bedstraw (Galium boreale), and western gromwell (Lithospermum ruderale); **ferns**: none; **moss**: none.

11) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) and lodgepole pine (Pinus contorta) and ranging from 5520 to 8000 feet in elevation. The average canopy cover for PSEMEN is 27% ranging from 11-50% total cover and frequency of occurrence equal to 100%. The average canopy cover for PINCON is 26% ranging from 10-50% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and limber pine (Pinus flexilis) with average percent cover ≥2% and ≤6% and frequency of occurrence ≥23% and ≤52%.

Primary associated shrub species with ≥16% and ≤39% frequency of occurrence in Douglas-fir-lodgepole pine stands: creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤22% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: mountain brome (Bromus carinatus), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), and blue wildrye (Elymus glacus); **forbs**: raceme pussy-toes (Antennaria racemosa), heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), spurred lupine (Lupinus laxiflorus), mountain sweet-cicely (Osmorhiza chilensis), toothleaf pyrola (Pyrola dentata), and western meadowrue (Thalictrum occidentale); **ferns**: stiff clubmoss (Lycopodium annotinum); **moss**: moss (moss spp.).

P38/R28 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASSES
6101	Needleleaf Dominated Riparian	28
6102	Broadleaf Dominated Riparian	71
6103	Neeleleaf-Broadleaf Riparian	None identified for scene
6104	Mixed Riparian (trees + any other)	None identified for scene
6201	Grass-Forb Riparian/Wetland	31, 33
6202	Shrub Riparian/Wetland	5, 6
6203	Mixed Grass-Forb-Shrub Riparian	12

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 1
Color: Light brown; RGB 170 135 111.
Distribution: Light to medium density at mid elevations with some linearity; medium density on foothills, along with some sizeable clusters; smaller clusters in wetter areas and near streams on the plains.
Comment: Outside the calculated riparian zone, Foothills Grassland is the dominant cover type; conifers and shrubs are next in importance with riparian vegetation (6102, 6103, 6202) also recorded. Appears to be grass and shrubs, but not riparian.
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
1	1	Subalpine Meadow
2	1	Lodgepole Pine
3	1	Shrub Riparian/Wetland
4	1	Exposed Rock

Spectral Class 2
Color: Brown black; RGB 57 46 51.
Distribution: Medium to high density on mid-elevation slopes and sides of buttes.
Comment: Conifers dominate training data outside the zone; riparian vegetation (6101, 6202, 6103, 6201) and rock are the only other cover types present. Appears to be shadows and Douglas-fir.
Conclusion: Not riparian.

5	1	Engelmann Spruce
6	1	Mixed Alpine Forest
7	1	Shrub Riparian/Wetland

Spectral Class 3

Color: Very dark warm brown; RGB 77 28 42.
Distribution: High density on mid-elevation slopes.
Comment: Training data outside the zone is characterized primarily by conifers, with some riparian vegetation (6101, 6103, 6201, 6202). Appears to be mixed conifers.
Conclusion: Not riparian.

8	2	Mixed Subalpine Forest
9	4	Needleleaf Dominated Riparian
10	2	Needleleaf-Broadleaf Riparian
11	1	Shrub Riparian/Wetland

Spectral Class 4
Color: Black; RGB 53 8 37.
Distribution: Dense spackle on mid-elevation slopes; some on side slopes of buttes.
Comment: Conifers account for the majority of training data points outside the zone; riparian vegetation (6201, 6101, 6202) is next in importance. Appears to be shadows.
Conclusion: Not riparian.

12	2	Engelmann Spruce
13	6	Needleleaf Dominated Riparian
14	1	Grass-Forb Riparian/Wetland

Spectral Class 5
Color: Dark tan; RGB 178 141 107.
Distribution: Medium density on foothills, with some large clusters also on foothills.
Comment: Herbaceous life forms, including agriculture, were most recorded outside the riparian zone; other cover types were minimally noted. Appears to be riparian shrub vegetation within the calculated zone.
Conclusion: 6202.

15	1	Broadleaf Dominated Riparian

Spectral Class 6
Color: Bright orange; RGB 235 94 70.
Distribution: Numerous small clusters along streams and washes; also in wetter portions of the Madison River Valley.
Comment: Aspen has the single highest frequency of cover types recorded outside the zone; riparian (6201, 6101, 6102, 6202) and agriculture are next in frequency values.
Conclusion: 6202.

16	1	Dry-land Pasture
17	1	Mesic Upland Shrubland

18	1	Needleleaf Dominated Riparian
19	1	Broadleaf Dominated Riparian
20	1	Grass-Forb Riparian/Wetland
21	3	Shrub Riparian/Wetland

Spectral Class 8
Color: Black; RGB 49 0 19.
Distribution: Light to medium density spackle at mid elevations and side slopes of buttes.
Comment: Conifers dominate observations outside the zone; some riparian (6101, 6201) training sites were included in the observations. Appears to be shadows.
Conclusion: Not riparian.

23	1	Mixed Mesic Forest
24	1	Needleleaf-Broadleaf Riparian

Spectral Class 9
Color: Dark warm brown; RGB 97 42 65.
Distribution: Light to medium density at mid elevations and on butte sideslopes; some near streams on the plains.
Comment: Conifers were recorded most frequently outside the zone; riparian cover types (6101, 6202) were also recorded. Appears to be water within the zone.
Conclusion: Not riparian.

25	2	Shrub Riparian/Wetland

Spectral Class 10
Color: Dark cool brown; RGB 97 60 83.
Distribution: Similar to Spectral Class 9.
Comment: Again, conifers stand out in the training data, with riparian vegetation (6102, 6201) minimally present. Appears to be mesic forest.
Conclusion: Not riparian.

26	1	Rivers & Streams
27	3	Needleleaf Dominated Riparian
28	1	Broadleaf Dominated Riparian

Spectral Class 11
Color: Black; RGB 45 30 51.
Distribution: Medium to high density at mid elevations; medium density on side slopes of buttes.
Comment: Conifers dominate training data outside the zone; riparian cover types (6103, 6201,

6101, 6202) are included. Appears to be shadows.
Conclusion: Not riparian.

29	1	Urban & Developed Land
30	1	Rivers & Streams
31	1	Needleleaf Dominated Riparian
32	1	Grass-Forb Riparian/Wetland
33	1	Shrub Riparian/Wetland

Spectral Class 12
Color: Tan; RGB 178 167 130.
Distribution: Light to medium density at mid elevations with some linearity; medium density on foothills, along with some sizeable clusters; smaller clusters in wetter areas and near streams on the plains.
Comment: Herbaceous cover types, especially Foothills Grassland, dominate training data outside the zone; riparian (6201) vegetation is minimal. Visual cues suggest grass and shrubs within the riparian zone.
Conclusion: 6203.

34	1	Foothills Grassland
35	1	Shrub Riparian/Wetland

Spectral Class 14
Color: Dark red brown; RGB 125 42 46.
Distribution: High density spackle at mid elevations; some along streams in the Madison valley and on the plains.
Comment: Outside the zone, this class is characterized by conifers, riparian vegetation (6202, 6101, 6102, 6103, 6201), and Aspen. Color and distribution indicate mixed conifers.
Conclusion: Not riparian.

36	1	Mesic Upland Shrubland
37	7	Needleleaf Dominated Riparian
38	4	Broadleaf Dominated Riparian
39	1	Grass-Forb Riparian/Wetland
40	2	Shrub Riparian/Wetland

Spectral Class 16
Color: Light warm brown; RGB 154 88 65.
Distribution: Medium density at mid elevations; some along streams.
Comment: Three cover type groups dominate training data outside the zone: conifer, riparian vegetation (6102, 6201, 6101, 6103), and herbaceous life forms, Aspen and rock are also notable by their frequencies. Visual cues indicate mixed conifers.
Conclusion: Not riparian.

41	1	Needleleaf Dominated Riparian
42	2	Broadleaf Dominated Riparian
43	3	Grass-Forb Riparian/Wetland
44	3	Shrub Riparian/Wetland

Spectral Class 19
Color: Dark gray; RGB 81 76 97.
Distribution: Light density at mid elevations; medium to high density on side slopes of buttes.
Comment: Conifer cover types are most frequent in observations outside the zone; riparian vegetation (6101, 6202) is minimal. Color and locations suggest rock and high alpine forest.
Conclusion: Not riparian.

46	1	Urban & Developed Land
47	1	Mixed Subalpine Forest
48	1	Needleleaf Dominated Riparian
49	1	Grass-Forb Riparian/Wetland

Spectral Class 20
Color: Orange; RGB 247 122 83.
Distribution: Clustering along streams and wetter areas of the valley and foothills.
Comment: Herbaceous life forms, including agriculture, grass and meadow, and riparian vegetation (6201, 6102, 6202) are most notable for this class. Agricultural lands appear to dominate this class.
Conclusion: Not riparian.

50	1	Irrigated Crop
51	2	Broadleaf Dominated Riparian
52	3	Grass-Forb Riparian/Wetland

Spectral Class 21
Color: Black; RGB 12 0 23.
Distribution: Medium to dense spackle at mid elevations.
Comment: Conifers were recorded most frequently in training data outside the zone; riparian vegetation (6101, 6201) was recorded for two sites. Locations and color indicate shadows.
Conclusion: Not riparian.

53	2	Needleleaf Dominated Riparian

Spectral Class 26
Color: Light orange; RGB 255 159 97.

Distribution: Medium density spackle on foothills, some clustering; some near streams.
Comment: Agriculture and grasslands account for nearly all training sites outside the zone. Appears to be agricultural cover types.
Conclusion: Not riparian.

55	1	Rivers & Streams
56	1	Broadleaf Dominated Riparian

Spectral Class 28
Color: Dark gray; RGB 89 84 102.
Distribution: Medium density on mid-elevation slopes; high density on sides of buttes.
Comment: Conifers dominate training data outside the zone; two points indicate riparian vegetation (6101, 6202).
Conclusion: 6101.

57	1	Lodgepole Pine
58	1	Broadleaf Dominated Riparian

Spectral Class 29
Color: Black; RGB 28 0 28.
Distribution: High density spackle at mid-elevations.
Comment: Conifers, with some riparian vegetation (6101, 6103, 6202) characterize training data outside the zone.
Conclusion: Not riparian.

59	1	Mixed Subalpine Forest
60	3	Needleleaf Dominated Riparian
61	1	Broadleaf Dominated Riparian

Spectral Class 31
Color: Dull red; RGB 202 98 93.
Distribution: Medium density on lower slopes and foothills; strong presence along streams and in wetter portions of the valley; sporadic clusters on the plain.
Comment: Foothills Grassland, riparian vegetation (6101, 6102, 6201, 6202), followed by Aspen and conifers, were most recorded outside the zone.
Conclusion: 6201.

62	1	Broadleaf Forest
63	1	Broadleaf Dominated Riparian
64	1	Shrub Riparian/Wetland

Spectral Class 33

Color: Pale gray beige; RGB 206 205 185.
Distribution: Sporadic clusters on the plain, some on foothills or at higher elevations; medium density in the valley.
Comment: Foothills Grassland has the highest frequency among cover types recorded outside the riparian zone; sites indicating agricultural lands are present but there are none indicating riparian vegetation.
Conclusion: 6201.

65	1	Urban & Developed Land
66	2	Irrigated Crop
67	1	Grass-Forb Riparian/Wetland

Spectral Class 36
Color: Dark gray pink; RGB 166 88 121.
Distribution: A rare class. Some clusters and blocks at low elevations; light density at some foothill and higher elevation locations; some in urban areas.
Comment: Training sites outside the zone include herbaceous vegetation, some conifer, no riparian, and several minimally represented cover types. Color and locations indicate urban cover types.
Conclusion: Not riparian.

68	1	Shrub Riparian/Wetland

Spectral Class 37
Color: Black; RGB 53 20 32.
Distribution: Dense spackle at mid-elevations.
Comment: Conifer, and some riparian (6201, 6101, 6102, 6202) cover types characterize the class outside the zone. Appears to be shadows.
Conclusion: Not riparian.

69	3	Needleleaf Dominated Riparian
70	1	Grass-Forb Riparian/Wetland
71	2	Shrub Riparian/Wetland

Spectral Class 54
Color: Blue black; RGB 0 0 65.
Distribution: Some near streams or lakes; light density at high elevations.
Comment: Mixed Mesic Forest, Exposed Rock, and Burnt Timber Stands comprise training data outside the zone. Locations are in shadow.
Conclusion: Not riparian.

76	1	Shrub Riparian/Wetland

Spectral Class 55
Color: Royal blue; RGB 69 76 172.
Distribution: A rare class. Some urban areas; some at highest elevations; some on lower slopes.
Comment: Exposed Rock, Foothills Grassland, and Urban & Developed Land were observed outside the zone. Visual cues indicate water,urban, and snow.
Conclusion. Not riparian.

77	1	Broadleaf Dominated Riparian
78	1	Shoreline & Gravel Bars

Spectral Class 56
Color: Gray; RGB 105 120 130.
Distribution: Medium density on foothills and bluff slopes; light density at mid elevations.
Comment: Coniferous and agricultural cover types are most prevalent in training sites outside the riparian zone; two points indicate riparian vegetation (6102, 6202). Appears to be sagebrush.
Conclusion: Not riparian.

79	1	Needleleaf Dominated Riparian

Spectral Class 67
Color: Gray green; RGB 77 139 130.
Distribution: Some near streams; mostly clustered at some distance from streams and on side slopes of buttes; light density at higher elevations.
Comment: Foothills Grassland is slightly dominant outside the riparian zone; with shrubs, agriculture, conifers, and riparian vegetation (6103) also present. Relatively dry grass is indicated by visual cues.
Conclusion: Not riparian.

86	1	Needleleaf-Broadleaf Riparian

Spectral Class 68
Color: Gray aqua; RGB 88 180 171.
Distribution: Strong presence at lower elevations, some large areas; some near streams but not linear.
Comment: Foothills Grassland dominates training data outside the zone; agricultural lands and shrubland are also indicated. Appears to represent grass and sagebrush.
Conclusion: Not riparian.

87	1	Dry-land Pasture
88	1	Ponderosa Pine & Savannah
89	1	Broadleaf Dominated Riparian
90	1	Grass-Forb Riparian/Wetland

Spectral Class 69
Color: Light gray brown; RGB 154 153 144.
Distribution: Some at highest elevations; medium density on foothills; sporadic on the plains.
Comment: Herbaceous vegetation, including agriculture, have the highest frequencies in training data outside the zone; conifers, shrubs, and riparian vegetation (6101, 6201) are also included in the data. Visually indicates rather dry grass and shrub cover types.
Conclusion: Not riparian.

91	1	Grass-Forb Riparian/Wetland

Spectral Class 71
Color: Red orange; RGB 243 52 46.
Distribution: Small clusters along streams, wetter portions of Madison Valley.
Comment: Aspen has the highest frequency of any cover type recorded outside the zone; riparian (6102, 6202) cover types are next in importance.
Conclusion: 6102.

92	1	Irrigated Crop
93	1	Aspen
94	1	Needleleaf Dominated Riparian
95	1	Needleleaf-Broadleaf Riparian
96	1	Grass-Forb Riparian/Wetland
97	5	Shrub Riparian/Wetland

Spectral Class 73
Color: Gold; RGB 206 159 88.
Distribution: Light density on foothills; some near streams and at higher elevations.
Comment: This class is characterized by herbaceous vegetation, including agriculture, grassland and meadow, and riparian (6201) vegetation. Appears to represent non-riparian grasses.
Conclusion: Not riparian.

98	1	Grass-Forb Riparian/Wetland

TM SCENE P38/R29

Image Analyst: Zhenkui Ma

Training Data Analysis

A total of 932 ground-truth plots were available for labeling P38/R29 (see table below); 838 were collected by Forest Service field crews during the1994-95 field seasons, and 711 of these were collected specifically for this TM scene. The remaining 94 plots came from pre-existing data sources such as ECODATA and TSMRS.

All the ground-truth data were converted to a point file and superimposed on the unsupervised classification to identify duplicates (one or more plots falling in the same region but with different cover type labels). All unresolved duplicate plots (n = 101) were removed from further analysis. Then the data were examined by cover type and by data source (whether or not plots were collected for this project or for other purposes, like pre-existing ECODATA or TSMRS). The latter "existing data" were only used in the training data set to supplement cover types that had insufficient plots collected during the 1994 or 1995 field seasons. Seven classes were excluded from the digital classification process: urban, agriculture, water, snow, melted snow, cloud, and cloud shadow. All ground truth data with VEG_CLASS_CODEs for urban, agriculture, or water cover types were excluded. Next, 20% of the remaining plots were randomly selected from each cover type; these plots (n = 119) were held aside in a separate data file for use in the accuracy assessment. The same process was used to separately extract test points for size classes and for canopy cover classes.

The remaining 80% of the data (n = 502 plots) were subjected to further spectral examination. Outliers were eliminated for each cover type by visual examination of TM and elevation values for their respective regions. To supplement this training data set, an additional 164 training plots were obtained for the Targhee National Forest (Region 4) and Yellowstone National Park from Dr. Andrew Hansen at Montana State University.

Total plots in ground-truth file	932	
Total 1994-95 field plots	838	
Plots sampled for P38/R29		711
Plots sampled for other scenes		127
Pre-existing plots (ECODATA, TSMRS, etc.)	94	
Plots held aside or eliminated	311	
Duplicates		101
Pre-existing plots		71
Manually labeled cover types		139
Potential training plots	621	
20% test		119
80% training		502
Supplemental plots (from pre-existing data set)	164	
Total plots available for training	666	
Total plots used for training -- cover type	565	
size class	173	
canopy	488	

Land Cover Types

Land cover types were labeled through a digital classification of the 7 TM channels plus rescaled elevation (m elevation divided by 25), using the Nearest Member of Group classifier. This classification produced three intermediate cover type labels in descending order of likelihood: COV_CODE_1, COV_CODE_2, and COV_CODE_3. For cover types not subjected to additional modification (see below), COV_CODE_1 values were assigned directly to the COVERTYPE field in the attribute table. Modifications were carried out using spectral class values (SPECTRAL_CLASS, or LINK) and/or intermediate cover code labels in conjunction with other attributes like elevation and slope as follows:

1000.	Urban.	Manually identified and recoded by Anne VanderMeer.
2000.	Agriculture.	Manually identified and recoded by Willard Gustafson.
3101.	Foothills Grasslands.	All grass types occurring below 2195 m (7200 ft) were relabeled as Foothills Grasslands.
3104.	Montane Parklands & Subalpine Meadows.	All grass types occurring at or above 2195 m (7200 ft) were reassigned this label.
5000.	Water.	All regions with spectral class (LINK = 1) and slope less than or equal to 5˚ were labeled as water; cloud shadows (see 9900 below) were recoded manually. Generally, water was more spectrally distinct than most other cover types, but in mountainous terrain, it was sometimes confused with cliff shadows. A 5˚ slope threshold was used to resolve this confusion. Given the accuracy limits of the DEM data, small water bodies may have inaccurate slope and aspect values such that their slope may be greater than 5˚. This would result in the misclassification of some small ponds or lakes.
(n/a)	Melted Snow.	All regions originally classified as Melted Snow were recoded either to Exposed Rock (7301), if their slope was greater than 5˚, or to Snow (9000), if their slope was less than or equal to 5˚.
9800.	Cloud.	Manually identified and recoded by Zhenkui Ma.
9900.	Cloud Shadow.	Manually identified and recoded by Zhenkui Ma.

A total of 30 classes were labeled in the full TM scene. These included three grass types, three shrub types, fourteen forest types, one alpine type, and three barren types, plus six manually labeled classes. Land cover classes were reviewed by personnel from the following National Forests: Gallatin (Stephen Brigham and Mark Novak) and Custer (Jeff DiBenedetto). Cover types are mapped in Figure F-18.

Canopy Cover Classes

Canopy cover labels (CANOPY_CODE = low, medium, or high) were assigned to tree and shrub classes based on MNDVI values. These values were plotted as frequency histograms for all coniferous forest types (Figure F-18a), as well as for two different shrub types (mesic versus xeric; Figures F-18b+c). The histograms were examined visually and break points decided based on the distribution modes. Regions with MNDVI values falling below the lower break point were assigned to the low canopy cover class; those falling above the higher break point were assigned to the high canopy cover class; and those in between were assigned to the medium class.

CANOPY COVER	MNDVI BREAKPOINTS		
	Tree	Shrub	
		Xeric	Mesic
Low	<150	<120	<180
Medium	≥150 and <350	≥120	≥180
High	≥350	n/a	n/a

Size Classes

Six size classes were distinguished -- four for forest cover types (seedling/sapling, pole, medium, and large/very large) and two for shrub cover types (low and medium). Only the seven TM channels were used for these classifications. The Nearest Mean classifier was used for tree size classes, and the Nearest Member of Group classifier was used for shrub size classes. Tree size classes were stratified based upon the canopy cover classes described above.

Accuracy Analysis

As described in the methods section of this report, our accuracy assessment was based on a fuzzy set analysis that ranked classification results from being absolutely right (score 5) to acceptable (score 3) to absolutely wrong (score 1). Note that accuracy was not assessed for all the classes that were mapped. Specifically, classes like urban, agriculture, and water were omitted from the accuracy assessment, in part because the available test data were not representative of common occurrences of these classes. Nevertheless, because urban, agriculture, and water classes can be readily identified through visual interpretation, their actual accuracy should exceed 80%. Riparian classes also were omitted because they were mapped separately, and at such a fine resolution (30 m pixels) that the correspondence between test plot and individual pixel could not be guaranteed.

For the remaining cover types, producer and user accuracies were assessed both individually (for scores 5, 4, 3, 2, and 1) and cumulatively (for scores 5+4+3+2+1). Final accuracy figures were weighted for each cover type using the proportion of the scene mapped as that cover type (as a surrogate for its population size), and results were scaled to a hypothetical population of 1000 units (to make numbers easier to interpret). Thus, the number of these units correctly classified for each cover type can be estimated by multiplying the percentage of the scene mapped as that cover type, times the hypothetical population size of 1000, times the cumulative percentage of test plots correctly classified (using scores 5+4+3). These estimates are summed for each cover type, and the results are divided by 1000 to yield the overall area-weighted producer's accuracy:

$$\frac{\sum (\%\ \text{cover type in scene}) * 1000 * (\%\ \text{correct plots})}{1000}$$

$$= \sum (\%\ \text{cover type in scene}) * (\%\ \text{correct plots})$$

Results showing producer and user accuracies, by cover type and averaged over all types, are listed in the following match and accumulate matrices. Overall area-weighted producer's accuracies are tabulated below for different classifications. Note that the Forest Group accuracy was not calculated separately but was part of the overall Lifeform accuracy assessment. We feel that this Forest Group accuracy is much more reliable than the overall Lifeform accuracy because the latter includes manually labeled cover types like Urban, Agriculture, and Water. Again, no accuracy assessment was performed on these manually labeled cover types.

Classifications for P38/R29	N Classes	Score 3 (Acceptable)	Score 5 (Perfect)
Cover Type	26	66%	44%
Lifeform	5	n/a	70%
Forest Group	15	n/a	85%
Tree Size Class	3	74%	24%
Tree Canopy Class	3	87%	55%
Shrub Size Class	2	100%	42%
Shrub Canopy Class	2	100%	65%

Comments

This scene was initially classified using only the training data available from the Forest Service; these plots covered approximately one third of the TM scene. By supplementing these with ground-truth data collected from Yellowstone National Park and Targhee National Forest, the cover type accuracy was improved by 10%. Even further improvements could be realized if additional training data were obtained, especially for lodgepole pine at high elevations.

Error Matrix For Cover Type Training Plots
Scene P38/R29

CLASSIFIED COVER TYPES

PLOT COVER TYPES	3101	3102	3104	3201	3202	3305	3306	3308	3309	3312	4101	4102	4201	4203	4205	4208	4212	4214	4219	4220	4221	4222	4223	4301	7301	7400	7500	7800	8101	8200	SUM
3101	30	0	0	2	2	10	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	48
3102	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
3104	0	0	6	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	9
3201	1	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	6
3202	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
3305	14	0	0	0	1	5	7	1	1	0	0	0	0	1	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	33
3306	1	0	0	0	0	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	10
3308	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3309	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2
3312	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4101	0	0	0	0	0	0	0	0	0	0	21	5	0	1	0	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0	31
4102	2	0	0	0	0	0	0	0	0	0	7	5	0	2	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	19
4201	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	0	0	0	2	0	2	0	0	0	0	0	0	0	9
4203	0	0	0	0	0	0	0	0	0	0	1	1	1	59	0	3	9	0	5	9	0	2	6	1	0	0	0	0	0	0	97
4205	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
4208	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	6
4212	1	0	0	0	0	1	0	0	0	0	1	4	7	11	1	1	25	2	1	10	3	1	4	0	0	0	0	0	0	0	73
4214	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2
4219	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	37	14	0	0	0	0	0	0	0	0	0	0	60
4220	0	0	0	0	0	2	0	0	0	0	1	0	0	14	0	3	9	0	12	12	3	0	3	0	0	0	0	0	0	0	59
4221	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	6	1	1	0	1	0	0	0	0	0	12
4222	1	0	0	0	0	2	0	0	0	0	0	0	0	2	1	0	1	2	0	1	1	0	1	0	0	0	0	0	0	0	12
4223	0	0	0	0	0	0	0	0	0	0	0	1	4	7	0	0	4	1	0	2	0	0	3	0	0	0	0	0	0	0	22
4301	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3
7301	2	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	12	1	1	0	1	0	21
7400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
7500	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	5
7800	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3
8101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	2	6
8200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	3
SUM	56	2	7	4	5	25	15	4	2	0	33	17	14	113	4	7	61	6	56	52	17	8	23	3	19	1	3	2	4	2	565

% AGREEMENT	41.42
TAU WITH EQUAL PROBABILITY	0.395
TOTAL DIAGONAL ELEMENTS	234
TOTAL TRAINING PLOTS IN DATA SET	565

F. P38/R29.5

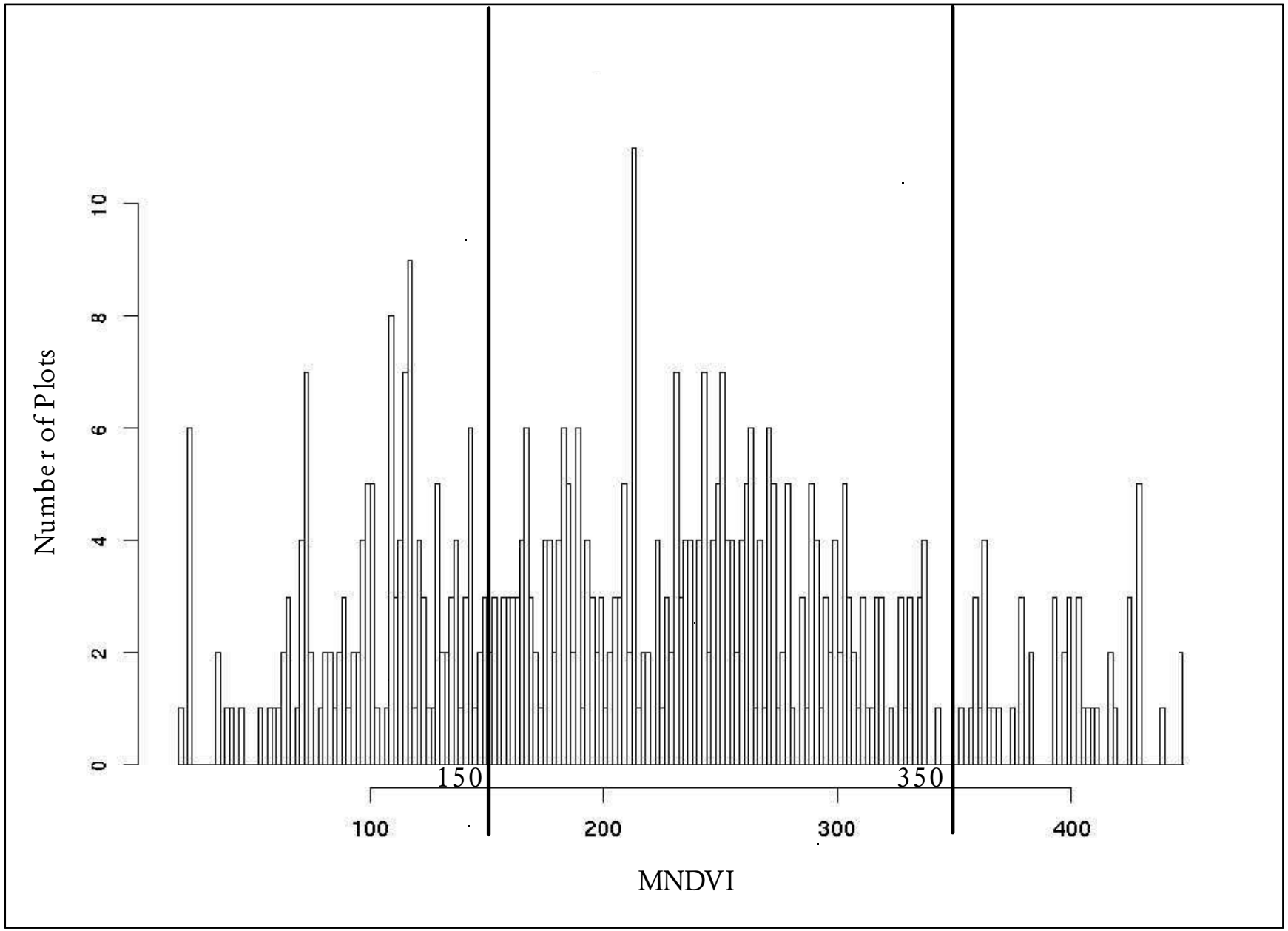


Figure F-18a. Breaks between tree canopy cover classes in relation to MNDVI values: TM scene P38/R29

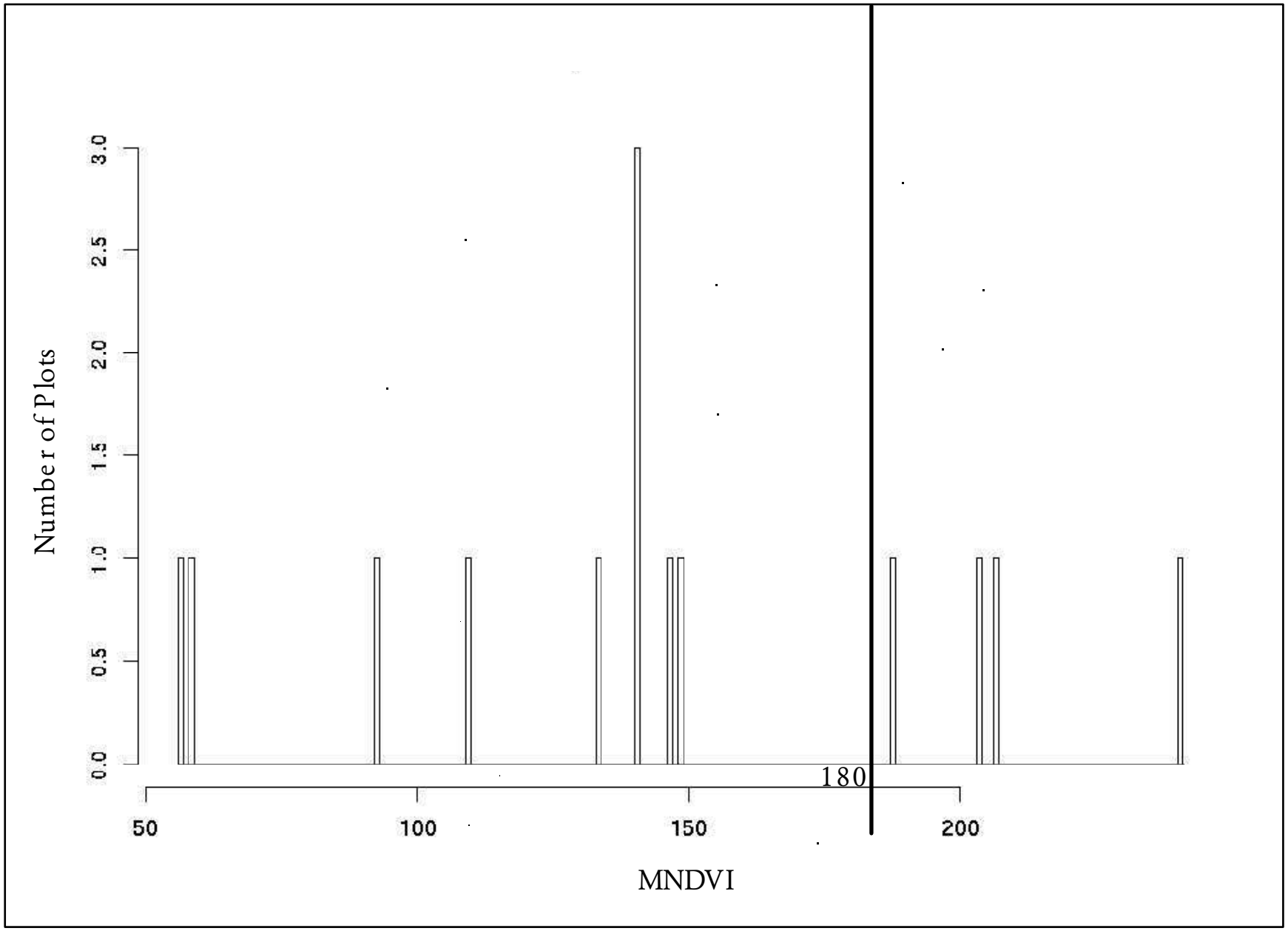


Figure F-18b. Breaks between mesic shrub canopy cover classes in relation to MNDVI values: TM scene P38/R29

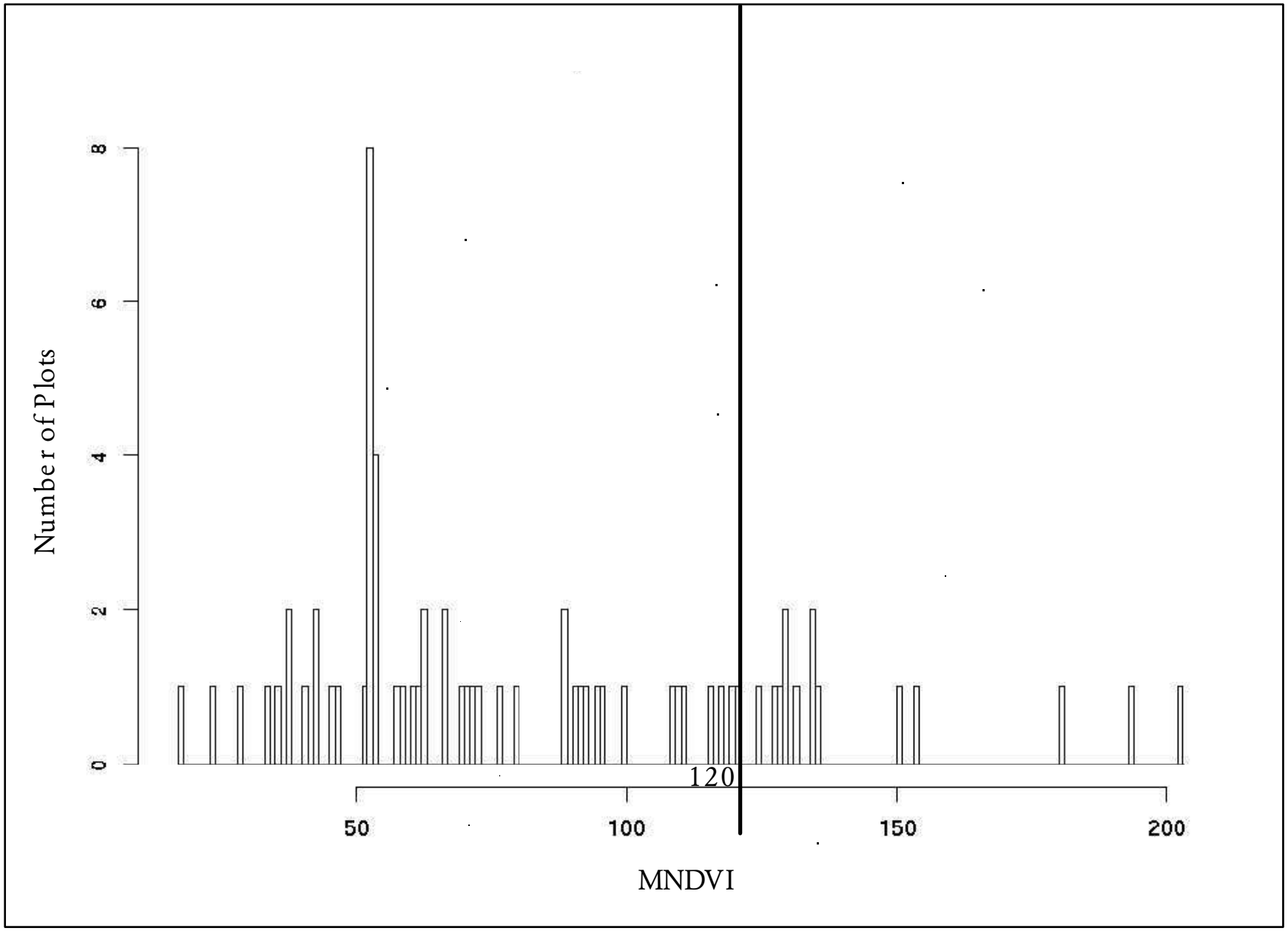


Figure F-18c. Breaks between xeric shrub canopy cover classes in relation to MNDVI values: TM scene P38/R29

Accuracy Assessment Tables for P38/R29 -- Cover Type

CONFUSION (FUZZY) MATRIX

RF/CF	3101	3104	3201	3202	3305	3306	3308	4101	4102
3101	6(5)	3(3)	0(1)	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)
3104	0(3)	0(5)	0(1)	0(1)	1(1)	0(1)	0(1)	1(1)	0(1)
3201	0(1)	1(1)	0(5)	0(4)	0(2)	0(2)	0(2)	0(1)	0(1)
3202	0(1)	0(1)	0(4)	0(5)	0(2)	0(2)	0(2)	0(1)	0(1)
3305	1(1)	1(1)	0(2)	0(2)	4(5)	0(4)	0(3)	0(1)	0(1)
3306	0(1)	0(1)	0(2)	0(2)	0(4)	2(5)	0(3)	0(1)	0(1)
3308	0(1)	0(1)	0(2)	0(2)	1(4)	0(4)	0(5)	0(1)	0(1)
4101	1(1)	1(1)	2(1)	0(1)	0(1)	0(1)	0(1)	2(5)	0(4)
4102	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	1(4)	0(5)
4201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4203	0(1)	1(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(2)	0(2)
4205	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4208	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4212	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	1(2)	0(2)
4214	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4219	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4220	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(2)	0(2)
4221	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4222	0(1)	0(1)	0(1)	0(1)	2(1)	0(1)	0(1)	0(2)	0(2)
4223	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(2)	0(2)
4224	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
4301	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(3)	0(3)
7301	0(1)	2(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
7500	1(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
7800	0(2)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	11(0)	9(0)	3(0)	0(0)	14(0)	2(0)	0(0)	5(0)	0(0)

RF/CF	4201	4203	4205	4208	4212	4214	4219	4220	4221
3101	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
3104	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3201	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3202	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3305	0(1)	0(1)	0(1)	0(1)	1(1)	0(1)	0(1)	0(1)	0(1)
3306	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
3308	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
4101	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4102	0(2)	0(2)	0(2)	0(2)	1(2)	0(2)	0(2)	1(2)	0(2)
4201	2(5)	0(2)	0(2)	0(3)	0(2)	0(2)	0(3)	0(4)	0(4)
4203	0(2)	8(5)	0(2)	0(2)	2(2)	0(2)	0(3)	3(3)	0(3)
4205	0(2)	0(2)	1(5)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)
4208	0(3)	1(2)	0(2)	0(5)	0(2)	0(2)	1(3)	0(3)	0(3)
4212	1(2)	3(2)	0(2)	0(2)	3(5)	0(2)	0(2)	3(3)	0(3)
4214	0(2)	0(2)	0(2)	0(2)	0(2)	0(5)	0(2)	0(2)	0(2)
4219	1(3)	0(3)	0(2)	0(3)	0(2)	0(2)	4(5)	0(3)	0(2)
4220	0(4)	2(3)	0(2)	0(3)	2(3)	0(2)	0(3)	3(5)	0(2)
4221	0(3)	0(3)	0(2)	0(2)	0(3)	0(2)	0(2)	1(2)	0(5)
4222	0(2)	0(2)	0(3)	0(2)	1(3)	0(3)	0(2)	0(2)	0(2)
4223	1(2)	2(3)	0(2)	0(2)	1(3)	0(2)	0(2)	0(3)	0(3)

Accuracy Assessment Tables for P38/R29 -- Cover Type

4224	0(0)	1(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
4301	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(2)	0(3)	0(3)
7301	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	2(1)	0(1)	0(1)
7500	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
7800	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
8101	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)
SUM	5(0)	18(0)	1(0)	0(0)	12(0)	0(0)	7(0)	11(0)	0(0)

RF/CF	4222	4223	4224	4301	7301	7500	7800	8101	SUM
3101	1(1)	0(1)	0(0)	0(1)	0(1)	0(0)	0(1)	0(1)	14(0)
3104	0(1)	0(1)	0(0)	0(1)	0(1)	0(0)	0(1)	0(1)	2(0)
3201	0(1)	0(1)	0(0)	0(1)	0(1)	0(0)	0(1)	0(1)	1(0)
3202	0(1)	0(1)	0(0)	0(1)	0(1)	0(0)	0(1)	0(1)	1(0)
3305	1(1)	0(1)	0(0)	0(1)	0(1)	0(0)	0(1)	0(1)	8(0)
3306	0(1)	0(1)	0(0)	0(1)	0(1)	0(0)	0(1)	0(1)	2(0)
3308	0(1)	0(1)	0(0)	0(1)	0(1)	0(0)	0(1)	0(1)	1(0)
4101	0(2)	0(2)	0(0)	0(4)	0(1)	0(0)	0(1)	0(1)	6(0)
4102	1(2)	0(2)	0(0)	0(4)	0(1)	0(0)	0(1)	0(1)	5(0)
4201	1(2)	0(2)	0(0)	0(2)	0(1)	0(0)	0(1)	0(1)	3(0)
4203	0(2)	0(4)	0(0)	0(2)	0(1)	0(0)	0(1)	0(1)	15(0)
4205	0(4)	0(2)	0(0)	0(2)	0(1)	0(0)	0(1)	0(1)	1(0)
4208	0(2)	0(2)	0(0)	0(2)	0(1)	0(0)	0(1)	0(1)	3(0)
4212	2(4)	1(4)	0(0)	0(2)	0(1)	0(0)	0(1)	0(1)	14(0)
4214	0(4)	0(2)	0(0)	0(2)	0(1)	0(0)	0(1)	0(1)	1(0)
4219	0(2)	0(2)	0(0)	0(2)	1(1)	0(0)	0(1)	0(1)	6(0)
4220	0(2)	0(3)	0(0)	0(2)	0(1)	0(0)	0(1)	0(1)	8(0)
4221	0(2)	0(3)	3(0)	0(2)	0(1)	0(0)	0(1)	0(1)	4(0)
4222	1(5)	0(2)	0(0)	0(2)	0(1)	0(0)	0(1)	0(1)	4(0)
4223	0(2)	0(5)	0(0)	0(2)	0(1)	0(0)	0(1)	0(1)	4(0)
4224	0(0)	0(0)	1(0)	0(0)	0(0)	0(0)	0(0)	0(0)	2(0)
4301	0(3)	0(3)	0(0)	0(5)	0(1)	0(0)	0(1)	0(1)	1(0)
7301	0(1)	0(1)	1(0)	0(1)	0(5)	0(0)	0(3)	2(1)	7(0)
7500	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1(0)
7800	0(1)	0(1)	0(0)	0(1)	0(3)	0(0)	0(5)	0(3)	1(0)
8101	0(1)	0(1)	0(0)	0(1)	1(1)	0(0)	1(3)	0(5)	2(0)
SUM	7(0)	1(0)	5(0)	0(0)	2(0)	0(0)	1(0)	2(0)	117(0)

Diagonal Elements = 37; Total Test Points = 117
Percentage Agreement = 31.62; Kappa = 0.264; Tau w/equal Prob = 0.289

1 point did not belong to groups listed in the test data and was treated as misclassification. Default score for these 1 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	6	42.86	0	0.00	3	21.43	0	0.00	5	35.71
3104	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
3201	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00

3305	4	50.00	0	0.00	0	0.00	0	0.00	4	50.00
3306	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3308	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
4101	2	33.33	0	0.00	0	0.00	0	0.00	4	66.67
4102	0	0.00	1	20.00	0	0.00	3	60.00	1	20.00
4201	2	66.67	0	0.00	0	0.00	1	33.33	0	0.00
4203	8	53.33	0	0.00	3	20.00	2	13.33	2	13.33
4205	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4208	0	0.00	0	0.00	1	33.33	1	33.33	1	33.33
4212	3	21.43	3	21.43	3	21.43	5	35.71	0	0.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4219	4	66.67	0	0.00	1	16.67	0	0.00	1	16.67
4220	3	37.50	0	0.00	4	50.00	0	0.00	1	12.50
4221	0	0.00	0	0.00	0	0.00	1	25.00	0	0.00
4222	1	25.00	0	0.00	1	25.00	0	0.00	2	50.00
4223	0	0.00	0	0.00	3	75.00	1	25.00	0	0.00
4224	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4301	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
7301	0	0.00	0	0.00	0	0.00	0	0.00	6	85.71
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
8101	0	0.00	0	0.00	1	50.00	0	0.00	1	50.00
SUM	36	30.77	5	4.27	20	17.09	14	11.97	35	29.91

Accuracy Assessment Tables for P38/R29 -- Cover Type

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	6	42.86	6	42.86	9	64.29	9	64.29	14	100.00
3104	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
3201	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
3305	4	50.00	4	50.00	4	50.00	4	50.00	8	100.00
3306	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
3308	0	0.00	1	100.00	1	100.00	1	100.00	1	100.00
4101	2	33.33	2	33.33	2	33.33	2	33.33	6	100.00
4102	0	0.00	1	20.00	1	20.00	4	80.00	5	100.00
4201	2	66.67	2	66.67	2	66.67	3	100.00	3	100.00
4203	8	53.33	8	53.33	11	73.33	13	86.67	15	100.00
4205	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4208	0	0.00	0	0.00	1	33.33	2	66.67	3	100.00
4212	3	21.43	6	42.86	9	64.29	14	100.00	14	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4219	4	66.67	4	66.67	5	83.33	5	83.33	6	100.00
4220	3	37.50	3	37.50	7	87.50	7	87.50	8	100.00
4221	0	0.00	0	0.00	0	0.00	1	25.00	1	25.00
4222	1	25.00	1	25.00	2	50.00	2	50.00	4	100.00
4223	0	0.00	0	0.00	3	75.00	4	100.00	4	100.00
4224	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4301	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
7301	0	0.00	0	0.00	0	0.00	0	0.00	6	85.71
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
8101	0	0.00	0	0.00	1	50.00	1	50.00	2	100.00
SUM	36	30.77	41	35.04	61	52.14	75	64.10	110	94.02

Accuracy Assessment Tables for P38/R29 -- Cover Type

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	6	54.55	0	0.00	0	0.00	0	0.00	4	36.36
3104	0	0.00	0	0.00	3	33.33	0	0.00	6	66.67
3201	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3305	4	28.57	1	7.14	0	0.00	0	0.00	9	64.29
3306	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3308	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4101	2	40.00	1	20.00	0	0.00	1	20.00	1	20.00
4102	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4201	2	40.00	0	0.00	1	20.00	2	40.00	0	0.00
4203	8	44.44	0	0.00	4	22.22	4	22.22	1	5.56
4205	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4208	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4212	3	25.00	0	0.00	4	33.33	3	25.00	2	16.67
4214	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4219	4	57.14	0	0.00	1	14.29	0	0.00	2	28.57
4220	3	27.27	0	0.00	6	54.55	2	18.18	0	0.00
4221	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4222	1	14.29	2	28.57	0	0.00	2	28.57	2	28.57
4223	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
4224	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4301	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7301	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
SUM	36	31.03	5	4.31	20	17.24	14	12.07	34	29.31

Accuracy Assessment Tables for P38/R29 -- Cover Type

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	6	54.55	6	54.55	6	54.55	6	54.55	10	90.91
3104	0	0.00	0	0.00	3	33.33	3	33.33	9	100.00
3201	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3305	4	28.57	5	35.71	5	35.71	5	35.71	14	100.00
3306	2	100.00	2	100.00	2	100.00	2	100.00	2	100.00
3308	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4101	2	40.00	3	60.00	3	60.00	4	80.00	5	100.00
4102	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4201	2	40.00	2	40.00	3	60.00	5	100.00	5	100.00
4203	8	44.44	8	44.44	12	66.67	16	88.89	17	94.44
4205	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
4208	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4212	3	25.00	3	25.00	7	58.33	10	83.33	12	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4219	4	57.14	4	57.14	5	71.43	5	71.43	7	100.00
4220	3	27.27	3	27.27	9	81.82	11	100.00	11	100.00
4221	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4222	1	14.29	3	42.86	3	42.86	5	71.43	7	100.00
4223	0	0.00	1	100.00	1	100.00	1	100.00	1	100.00
4224	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4301	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7301	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
8101	0	0.00	0	0.00	0	0.00	0	0.00	2	100.00
SUM	36	31.03	41	35.34	61	52.59	75	64.66	109	93.97

Accuracy Assessment Tables for P38/R29 -- Cover Type

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	27	42.86	0	0.00	13	21.43	0	0.00	22	35.71
3104	0	0.00	0	0.00	0	0.00	0	0.00	37	100.00
3201	0	0.00	0	0.00	0	0.00	0	0.00	11	100.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
3305	30	50.00	0	0.00	0	0.00	0	0.00	30	50.00
3306	41	100.00	0	0.00	0	0.00	0	0.00	0	0.00
3308	0	0.00	0	100.00	0	0.00	0	0.00	0	0.00
4101	8	33.33	0	0.00	0	0.00	0	0.00	17	66.67
4102	0	0.00	0	20.00	0	0.00	0	60.00	0	20.00
4201	5	66.67	0	0.00	0	0.00	2	33.33	0	0.00
4203	99	53.33	0	0.00	37	20.00	25	13.33	25	13.33
4205	7	100.00	0	0.00	0	0.00	0	0.00	0	0.00
4208	0	0.00	0	0.00	4	33.33	4	33.33	4	33.33
4212	16	21.43	16	21.43	16	21.43	27	35.71	0	0.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4219	132	66.67	0	0.00	33	16.67	0	0.00	33	16.67
4220	52	37.50	0	0.00	70	50.00	0	0.00	17	12.50
4221	0	0.00	0	0.00	0	0.00	0	25.00	0	0.00
4222	3	25.00	0	0.00	3	25.00	0	0.00	7	50.00
4223	0	0.00	0	0.00	11	75.00	4	25.00	0	0.00
4224	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4301	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
7301	0	0.00	0	0.00	0	0.00	0	0.00	36	85.71
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	0	0.00	0	0.00	11	100.00
8101	0	0.00	0	0.00	12	50.00	0	0.00	12	50.00
SUM	420	43.61	16	1.66	199	20.66	62	6.44	266	27.62

Accuracy Assessment Tables for P38/R29 -- Cover Type

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
3101	27	42.86	27	42.86	40	64.29	40	64.29	63	100.00
3104	0	0.00	0	0.00	0	0.00	0	0.00	37	100.00
3201	0	0.00	0	0.00	0	0.00	0	0.00	11	100.00
3202	0	0.00	0	0.00	0	0.00	0	0.00	0	100.00
3305	30	50.00	30	50.00	30	50.00	30	50.00	59	100.00
3306	41	100.00	41	100.00	41	100.00	41	100.00	41	100.00
3308	0	0.00	0	100.00	0	100.00	0	100.00	0	100.00
4101	8	33.33	8	33.33	8	33.33	8	33.33	25	100.00
4102	0	0.00	0	20.00	0	20.00	0	80.00	0	100.00
4201	5	66.67	5	66.67	5	66.67	7	100.00	7	100.00
4203	99	53.33	99	53.33	135	73.33	160	86.67	185	100.00
4205	7	100.00	7	100.00	7	100.00	7	100.00	7	100.00
4208	0	0.00	0	0.00	4	33.33	8	66.67	12	100.00
4212	16	21.43	32	42.86	48	64.29	75	100.00	75	100.00
4214	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
4219	132	66.67	132	66.67	165	83.33	165	83.33	198	100.00
4220	52	37.50	52	37.50	122	87.50	122	87.50	139	100.00
4221	0	0.00	0	0.00	0	0.00	0	25.00	0	25.00
4222	3	25.00	3	25.00	7	50.00	7	50.00	13	100.00
4223	0	0.00	0	0.00	11	75.00	15	100.00	15	100.00
4224	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
4301	0	0.00	0	0.00	0	0.00	0	0.00	3	100.00
7301	0	0.00	0	0.00	0	0.00	0	0.00	36	85.71
7500	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
7800	0	0.00	0	0.00	0	0.00	0	0.00	11	100.00
8101	0	0.00	0	0.00	12	50.00	12	50.00	24	100.00
SUM	420	43.66	436	45.32	635	66.01	697	72.45	962	100.00

Accuracy Assessment Tables for P38/R29 -- Tree Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	0(5)	4(3)	4(1)	8(0)
2	3(3)	2(5)	2(3)	7(0)
3	2(1)	2(3)	2(5)	6(0)
SUM	5(0)	8(0)	8(0)	21(0)

Diagonal Elements = 4; Total Test Points = 21
Percentage Agreement = 19.05; Kappa = -0.202; Tau w/equal Prob = -0.214

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	0	0.00	0	0.00	4	50.00	0	0.00	4	50.00
2	2	28.57	0	0.00	5	71.43	0	0.00	0	0.00
3	2	33.33	0	0.00	2	33.33	0	0.00	2	33.33
SUM	4	19.05	0	0.00	11	52.38	0	0.00	6	28.57

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	0	0.00	0	0.00	4	50.00	4	50.00	8	100.00
2	2	28.57	2	28.57	7	100.00	7	100.00	7	100.00
3	2	33.33	2	33.33	4	66.67	4	66.67	6	100.00
SUM	4	19.05	4	19.05	15	71.43	15	71.43	21	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	0	0.00	0	0.00	3	60.00	0	0.00	2	40.00
2	2	25.00	0	0.00	6	75.00	0	0.00	0	0.00
3	2	25.00	0	0.00	2	25.00	0	0.00	4	50.00
SUM	4	19.05	0	0.00	11	52.38	0	0.00	6	28.57

Accuracy Assessment Tables for P38/R29 -- Tree Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	0	0.00	0	0.00	3	60.00	3	60.00	5	100.00
2	2	25.00	2	25.00	8	100.00	8	100.00	8	100.00
3	2	25.00	2	25.00	4	50.00	4	50.00	8	100.00
SUM	4	19.05	4	19.05	15	71.43	15	71.43	21	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	0	0.00	0	0.00	120	50.00	0	0.00	120	50.00
2	100	28.57	0	0.00	249	71.43	0	0.00	0	0.00
3	137	33.33	0	0.00	137	33.33	0	0.00	137	33.33
SUM	237	23.70	0	0.00	506	50.60	0	0.00	257	25.70

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	0	0.00	0	0.00	120	50.00	120	50.00	240	100.00
2	100	28.57	100	28.57	349	100.00	349	100.00	349	100.00
3	137	33.33	137	33.33	274	66.67	274	66.67	411	100.00
SUM	237	23.70	237	23.70	743	74.30	743	74.30	1000	100.00

Accuracy Assessment Tables for P38/R29 -- Shrub Size Class

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	SUM
1	5(5)	3(3)	8(0)
2	4(3)	0(5)	4(0)
SUM	9(0)	3(0)	12(0)

Diagonal Elements = 5; Total Test Points = 12
Percentage Agreement = 41.67; Kappa = -0.400; Tau w/equal Prob = -0.167

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	5	62.50	0	0.00	3	37.50	0	0.00	0	0.00
2	0	0.00	0	0.00	4	100.00	0	0.00	0	0.00
SUM	5	41.67	0	0.00	7	58.33	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	5	62.50	5	62.50	8	100.00	8	100.00	8	100.00
2	0	0.00	0	0.00	4	100.00	4	100.00	4	100.00
SUM	5	41.67	5	41.67	12	100.00	12	100.00	12	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	5	55.56	0	0.00	4	44.44	0	0.00	0	0.00
2	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00
SUM	5	41.67	0	0.00	7	58.33	0	0.00	0	0.00

Accuracy Assessment Tables for P38/R29 -- Shrub Size Class

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	5	55.56	5	55.56	9	100.00	9	100.00	9	100.00
2	0	0.00	0	0.00	3	100.00	3	100.00	3	100.00
SUM	5	41.67	5	41.67	12	100.00	12	100.00	12	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	424	62.50	0	0.00	254	37.50	0	0.00	0	0.00
2	0	0.00	0	0.00	321	100.00	0	0.00	0	0.00
SUM	424	42.44	0	0.00	575	57.56	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	424	62.50	424	62.50	679	100.00	679	100.00	679	100.00
2	0	0.00	0	0.00	321	100.00	321	100.00	321	100.00
SUM	424	42.40	424	42.40	1000	100.00	1000	100.00	1000	100.00

Accuracy Assessment Tables for P38/R29 -- Tree Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	SUM
1	11(5)	8(3)	0(1)	21(0)
2	5(3)	20(5)	2(3)	32(0)
3	4(1)	13(3)	2(5)	19(0)
SUM	20(0)	41(0)	4(0)	72(0)

Diagonal Elements = 33; Total Test Points = 72
Percentage Agreement = 45.83 ; Kappa = 0.168; Tau w/equal Prob = 0.188

7 points did not belong to groups listed in the test data and were treated as mis-classification. Default score for these 7 points = 1

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	11	52.38	0	0.00	8	38.10	0	0.00	2	9.52
2	20	62.50	0	0.00	7	21.88	0	0.00	5	15.62
3	2	10.53	0	0.00	13	68.42	0	0.00	4	21.05
SUM	33	45.83	0	0.00	28	38.89	0	0.00	11	15.28

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	11	52.38	11	52.38	19	90.48	19	90.48	21	100.00
2	20	62.50	20	62.50	27	84.38	27	84.38	32	100.00
3	2	10.53	2	10.53	15	78.95	15	78.95	19	100.00
SUM	33	45.83	33	45.83	61	84.72	61	84.72	72	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	11	55.00	0	0.00	5	25.00	0	0.00	4	20.00
2	20	48.78	0	0.00	21	51.22	0	0.00	0	0.00
3	2	50.00	0	0.00	2	50.00	0	0.00	0	0.00
SUM	33	50.77	0	0.00	28	43.08	0	0.00	4	6.15

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%

1	11	55.00	11	55.00	16	80.00	16	80.00	20	100.00
2	20	48.78	20	48.78	41	100.00	41	100.00	41	100.00
3	2	50.00	2	50.00	4	100.00	4	100.00	4	100.00
SUM	33	50.77	33	50.77	61	93.85	61	93.85	65	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	237	52.38	0	0.00	172	38.10	0	0.00	43	9.52
2	306	62.50	0	0.00	107	21.88	0	0.00	77	15.62
3	6	10.53	0	0.00	40	68.42	0	0.00	12	21.05
SUM	549	54.90	0	0.00	319	31.90	0	0.00	132	13.20

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	237	52.38	237	52.38	409	90.48	409	90.48	452	100.00
2	306	62.50	306	62.50	413	84.38	413	84.38	490	100.00
3	6	10.53	6	10.53	46	78.95	46	78.95	58	100.00
SUM	549	54.90	549	54.90	868	86.80	868	86.80	1000	100.00

Accuracy Assessment Tables for P38/R29 -- Shrub Canopy Closure

CONFUSION (FUZZY) MATRIX

RF/CF	0	1	2	3	SUM
0	0(0)	2(0)	1(0)	0(0)	3(0)
1	0(0)	7(5)	2(3)	0(1)	9(0)
2	1(0)	1(3)	0(5)	0(3)	2(0)
3	0(0)	0(1)	1(3)	0(5)	1(0)
SUM	1(0)	10(0)	4(0)	0(0)	15(0)

Diagonal Elements = 7; Total Test Points = 15
Percentage Agreement = 46.67; Kappa = 0.032; Tau w/equal Prob = 0.289

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	7	77.78	0	0.00	2	22.22	0	0.00	0	0.00
2	0	0.00	0	0.00	1	50.00	0	0.00	0	0.00
3	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00
SUM	7	46.67	0	0.00	4	26.67	0	0.00	0	0.00

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	7	77.78	7	77.78	9	100.00	9	100.00	9	100.00
2	0	0.00	0	0.00	1	50.00	1	50.00	1	50.00
3	0	0.00	0	0.00	1	100.00	1	100.00	1	100.00
SUM	7	46.67	7	46.67	11	73.33	11	73.33	11	73.33

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	7	70.00	0	0.00	1	10.00	0	0.00	0	0.00
2	0	0.00	0	0.00	3	75.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	7	46.67	0	0.00	4	26.67	0	0.00	0	0.00

ACCUMULATE MATRIX (user)

Score 5	Score 4	Score 3	Score 2	Score 1

Accuracy Assessment Tables for P38/R29 -- Shrub Canopy Closure

GROUP	N	%	N	%	N	%	N	%	N	%
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	7	70.00	7	70.00	8	80.00	8	80.00	8	80.00
2	0	0.00	0	0.00	3	75.00	3	75.00	3	75.00
3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	7	46.67	7	46.67	11	73.33	11	73.33	11	73.33

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	562	77.78	0	0.00	160	22.22	0	0.00	0	0.00
2	0	0.00	0	0.00	139	50.00	0	0.00	0	0.00
3	0	0.00	0	0.00	0	100.00	0	0.00	0	0.00
SUM	562	65.27	0	0.00	299	34.73	0	0.00	0	0.00

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	562	77.78	562	77.78	722	100.00	722	100.00	722	100.00
2	0	0.00	0	0.00	139	50.00	139	50.00	139	50.00
3	0	0.00	0	0.00	0	100.00	0	100.00	0	100.00
SUM	562	65.27	562	65.27	861	100.00	861	100.00	861	100.00

Scene P38/R29 Frequency Tables

COVER TYPE	# REGIONS	HECTARES	% OF SCENE
Not project area	64790.0	653307.8	19.2
1000	73.0	614.9	0.0
2000	1088.0	24113.4	0.7
3101	10245.0	144378.0	4.2
3102	422.0	6256.1	0.2
3104	10813.0	101598.8	3.0
3201	3361.0	27198.1	0.8
3305	13314.0	146377.8	4.3
3306	2399.0	112375.8	3.3
4101	5951.0	53915.9	1.6
4201	1970.0	20003.2	0.6
4203	35680.0	532178.6	15.7
4205	537.0	13906.2	0.4
4208	1781.0	35387.6	1.0
4212	18451.0	182006.9	5.4
4214	159.0	1701.1	0.1
4219	43907.0	498056.2	14.7
4220	29711.0	361234.2	10.6
4221	8.0	37.1	0.0
4222	2956.0	33195.4	1.0
4223	3530.0	41595.2	1.2
4224	2797.0	96479.7	2.8
4301	797.0	6740.4	0.2
5000	3765.0	69458.7	2.0
7300	14070.0	107634.8	3.2
7400	155.0	1319.1	0.0
7800	3085.0	29681.5	0.9
8100	7033.0	57159.9	1.7
9100	1500.0	11883.8	0.3
9800	1029.0	11306.0	0.3
9900	8168.0	18394.5	0.5

CANOPY CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	64790.0	653307.8	19.2
Not tree/shrub	61446.0	583799.4	17.2
Shrub 1	13692.0	233695.8	6.9
Shrub 2	5382.0	52255.9	1.5
Tree 1	69638.0	865941.7	25.5
Tree 2	73666.0	916578.1	27.0
Tree 3	4931.0	93918.0	2.8

SIZE CLASS	# REGIONS	HECTARES	% OF SCENE
Not project area	64790.0	653307.8	19.2
Not tree/shrub	61446.0	583799.4	17.2
Tree 1	25672.0	203297.8	6.0
Tree 2	60468.0	792449.5	23.3
Tree 3	59480.0	862097.0	25.4
Tree 4	2615.0	18593.5	0.5
Shrub 1	11373.0	180243.1	5.3
Shrub 2	7701.0	105708.6	3.1

LIFE FORM	# REGIONS	HECTARES	% OF SCENE
Not project area	64790.0	653307.8	19.2
A	1088.0	24113.4	0.7
H	28513.0	309392.7	9.1
N	31845.0	250293.2	7.4
S	19074.0	285951.7	8.4
T	148235.0	1876437.7	55.2

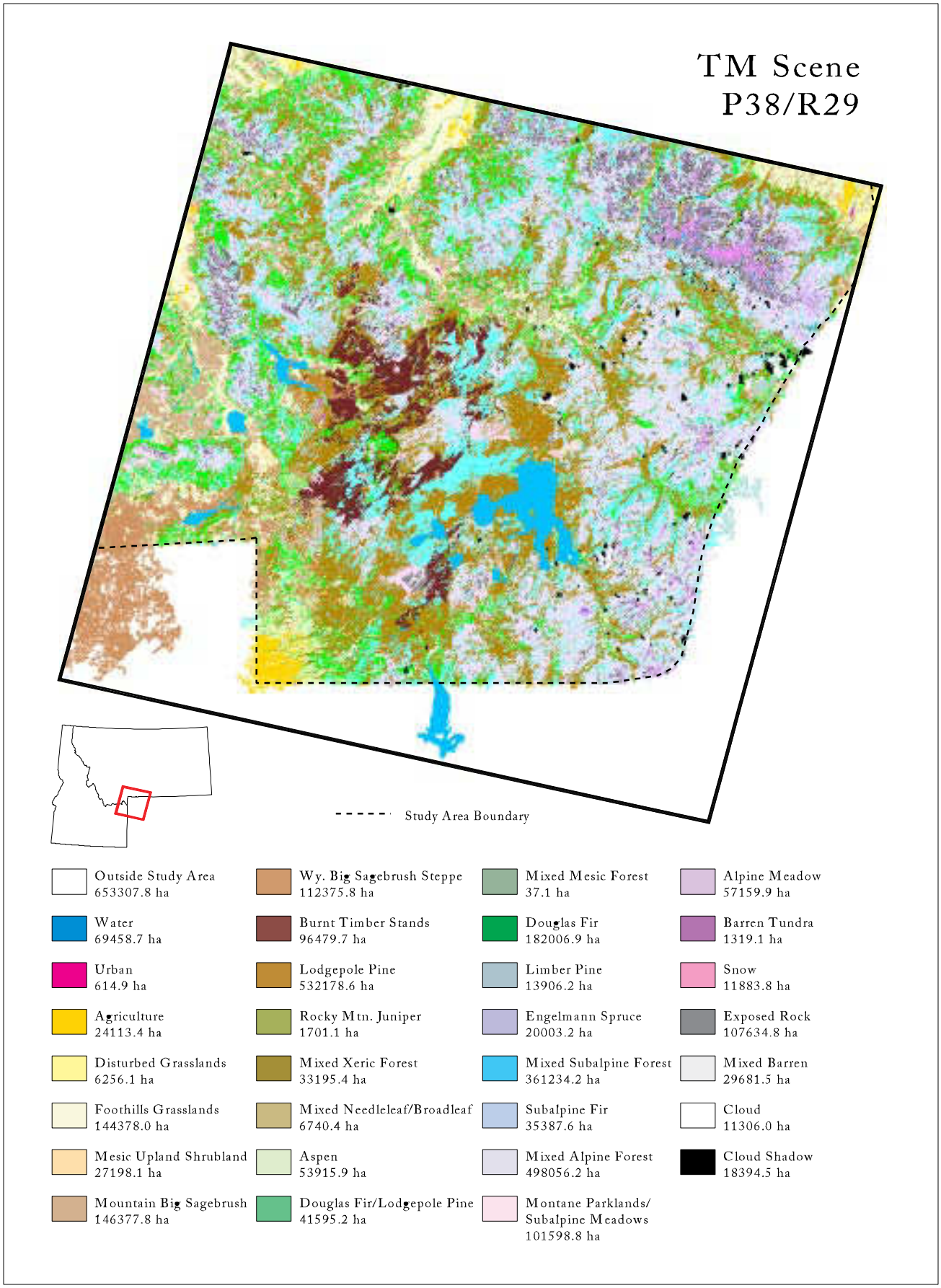


Figure F-18. Classification of land cover types for TM Scene P38/R29.

A DESCRIPTION OF COVER TYPES MAPPED IN TM SCENE P38/R29

-- Kristen Loken

FOREST TYPE (≥ 15% TREE COVER)

1) 4101: ASPEN FOREST

Aspen forest dominated by quaking aspen (Populus tremuloides) and ranging from 5560 to 8130 feet in elevation. The average canopy cover is 41% ranging from 10-70% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), limber pine (Pinus flexilis), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥2% and ≤4% and frequency of occurrence ≥20% and ≤30%.

Primary associated shrub species with ≥5% and ≤40% frequency of occurrence in aspen stands: western serviceberry (Amelanchier alnifolia), common juniper (Juniperus communis), mallow ninebark (Physocarpus malvaceus), thimbleberry (Rubus parviflorus), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), snowberry (Symphoricarpos spp.).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤35% frequency of occurrence in aspen stands: **graminoids**: bluejoint reedgrass (Calamagrostis canadensis), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), blue wildrye (Elymus glacus), Idaho fescue (Festuca idahoensis), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), geranium (Geranium spp.), sticky geranium (Geranium viscosissimum), cow-parsnip (Heracleum lanatum), groundsel (Senecio spp.), and western meadowrue (Thalictrum occidentale); **ferns**: field horsetail (Equisetum arvense); **moss**: none.

2) 4201: ENGELMANN SPRUCE FOREST

Conifer forest dominated by Engelmann spruce (Picea engelmannii) ranging from 5600 to 9240 feet in elevation. The average canopy cover is 48%, ranging from 30-80% total cover and frequency of occurrence equal to 94%. Primary associated tree species include subalpine fir (Abies lasiocarpa), lodgepole pine (Pinus contorta), and Douglas-fir (pseudotsuga menziesii) with average percent cover ≥4% and ≤11% and frequency of occurrence ≥56% and ≤63%.

Primary associated shrub species with ≥6% and ≤%31 frequency of occurrence in Engelmann spruce stands: rocky mountain maple (Acer glabrum), sitka alder (Alnus sinuata), red-osier dogwood (Cornus stolonifera), twin flower (Linnaea borealis), Canadian buffaloberry (Shepherdia canadensis), common snowberry (Symphoricarpos albus), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥13% and ≤44% frequency of occurrence in Engelmann spruce stands: **graminoids**: pinegrass

(Calamagrostis rubescens); **forbs**: heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), fireweed (Epilobium angustifolium), and western meadowrue (Thalictrum occidentale); **ferns**: field horsetail (Equisetum arvense); **moss**: moss (moss spp.).

3) 4203: LODGEPOLE PINE FOREST

Conifer forest dominated by lodgepole pine (Pinus contorta) ranging from 4820 to 8800 feet in elevation. The average canopy cover is 47% ranging from 20-80% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤5% and frequency of occurrence ≥26% and ≤42%.

Primary associated shrub species with ≥8% and ≤32% frequency of occurrence in lodgepole pine stands: sitka alder (Alnus sinuata), common juniper (Juniperus communis), twin flower (Linnaea borealis), shiny-leaf spiraea (Spiraea betulifolia), huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤20% frequency of occurrence in lodgepole pine stands: **graminoids**: tickle grass (Agrostis scabra), northern reedgrass (Calamagrostis inexpense), pinegrass (Calamagrostis rubescens), sedge (Carex), elk sedge (Carex geyeri), danthonia (Danthonia spp.), and Kentucky bluegrass (Poa pratensis); **forbs**: showy aster (Aster conspicuus), Canada thistle (Cirsium arvense), fireweed (Epilobium angustifolium), Virginia strawberry (Fragaria virginiana), lupine (Lupinus spp.), pink wintergreen (Pyrola asarifolia), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: none.

4) 4208: SUBALPINE FIR FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 6600 to 8800 feet in elevation. The average canopy cover is 39% ranging from 20-60% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), whitebark pine (Pinus albicaulis), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥3% and ≤11% and frequency of occurrence ≥44% and ≤67%.

Primary associated shrub species with ≥11% and ≤67% frequency of occurrence in subalpine fir stands: sitka alder (Alnus sinuata), labrador tea (Ledum glandulosum), twin flower (Linnaea borealis), swamp current (Ribes lacustre), huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥11% and ≤22% frequency of occurrence in subalpine fir stands: **graminoids**: bluejoint reedgrass (Calamagrostis canadensis), soft-leaved sedge (Carex disperma), sheep sedge (Carex iliota), Drummond rush (Juncus drummondii), and Wahlenberg's woodrush (Luzula wahlenbergii); **forbs**: heart-leaf arnica (Arnica cordifolia), hairy arnica (Arnica mollis), five-stamened mitrewort (Mitella pentandra), brook saxifrage (Saxifraga odontoloma), arrowleaf groundsel (Senecio triangularis), clasping-leaved twisted-stalk (Streptopus amplexifolius), and western

meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: moss (moss spp.).

5) 4212: DOUGLAS FIR FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) ranging from 5830 to 8000 feet in elevation. The average canopy cover is 48% ranging from 20-98% total cover and frequency of occurrence equal to 100%. Primary associated tree species include Engelmann spruce (Picea engelmannii), lodgepole pine (Pinus contorta), limber pine (Pinus flexilis) with average percent cover ≥5% and ≤9% and frequency of occurrence ≥15% and ≤29%.

Primary associated shrub species with ≥5% and ≤29% frequency of occurrence in Douglas-fir stands: oregongrape (Berberis spp.), creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), twin flower (Linnaea borealis), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), common snowberry (Symphoricarpos albus), and snowberry (Symphoricarpos spp.).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤29% frequency of occurrence in Douglas-fir stands: **graminoids**: Japanese brome (Bromus japonicus), pinegrass (Calamagrostis rubescens), sedge (Carex spp.), elk sedge (Carex geyeri), Idaho fescue (Festuca idahoensis), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: showy aster (Aster conspicuus), milk-vetch (Astragalus), Virginia strawberry (Fragaria virginiana), sticky geranium (Geranium viscosissimum), lupine (Lupinus spp.), common dandelion (Taraxacom officinale), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: moss (moss spp.).

6) 4219: MIXED WHITEBARK PINE FOREST

Conifer forest dominated by whitebark pine (Pinus albicaulis) and ranging from 7240 to 9520 feet in elevation. The average canopy cover is 22% ranging from 10-30% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and lodgepole pine (Pinus contorta) with average percent cover ≥10% and ≤19% and frequency of occurrence ≥39% and ≤96%.

Primary associated shrub species with ≥4% and ≤57% frequency of occurrence in mixed whitebark pine stands: rocky mountain maple (Acer glabrum), common juniper (Juniperus communis), huckleberry (Vaccinium spp.), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥4% and ≤9% frequency of occurrence in mixed whitebark pine stands: **graminoids:** pinegrass (Calamagrostis rubescens) and elk sedge (Carex geyeri); **forbs**: heart-leaf arnica (Arnica cordifolia) and glacier lily (Erythronium grandiflorum); **ferns**: none; **moss**: none.

7) 4220: MIXED SUBALPINE FOREST

Conifer forest dominated by subalpine fir (Abies lasiocarpa) and ranging from 5680 to 9000 feet in elevation. The average canopy cover is 19% ranging from 1-50% total cover and frequency of occurrence equal to 91%. Primary associated tree species include Engelmann

spruce (Picea engelmannii), lodgepole pine (Pinus contorta), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥15% and ≤26% and frequency of occurrence ≥56% and ≤76%.

Primary associated shrub species with ≥7% and ≤44% frequency of occurrence in mixed subalpine stands: sitka alder (Alnus sinuata), twin flower (Linnaea borealis), shiny-leaf spiraea (Spiraea betulifolia), spiraea (Spiraea spp.), huckleberry (Vaccinium spp.), globe huckleberry (Vaccinium globulare), and whortleberry (Vaccinium scoparium).

Primary associated graminoid, forb, fern, and moss species with ≥2% and ≤26% frequency of occurrence in mixed subalpine fir stands: **graminoids**: pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), blue wildrye (Elymus glacus), alpine timothy (Phleum alpinum), common timothy (Phleum pratense), bluegrass (Poa spp.), and spike trisetum (Trisetum spicatum); **forbs**: heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), fireweed (Epilobium angustifolium), glacier lily (Erythronium grandiflorum), Virginia strawberry (Fragaria virginiana), one-sided wintergreen (Pyrola secunda), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: moss (moss spp.).

8) 4222: MIXED XERIC FOREST

Conifer forest dominated by rocky mountain juniper (Juniperus scopulorum), codominant species is ponderosa pine (Pinus ponderosa), and ranging from 5360 to 7100 feet in elevation. The average canopy cover for JUNSCO is 23% ranging from 1-60% total cover and frequency of occurrence equal to 63%. The average canopy cover for PINPON is 18% ranging from 3-30% total cover and frequency of occurrence equal to 21%. Primary associated tree species include lodgepole pine (Pinus contorta), limber pine (Pinus flexilis), and Douglas-fir (Pseudotsuga menziesii) with average percent cover ≥9% and ≤15% and frequency of occurrence ≥21% and ≤95%.

Primary associated shrub species with ≥5% and ≤16% frequency of occurrence in mixed xeric stands: common juniper (Juniperus communis), creeping juniper (Juniperus horizontalis), mallow ninebark (Physocarpus malvaceus), rose (Rosa spp.), Wood's rose (Rosa woodsii), shiny-leaf spiraea (Spiraea betulifolia), and common snowberry (Symphoricarpos albus).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤26% frequency of occurrence in mixed xeric stands: **graminoids**: bluebunch wheatgrass (Agropyron spicatum), pinegrass (Calamagrostis rubescens), elk sedge (Carex geyeri), basin wildrye (Elymus cinereus), Idaho fescue (Festuca idahoensis), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis); **forbs**: showy aster (Aster conspicuus), balsamroot (Balsamorhiza sagittata), and hairy golden-aster (Chrysopsis villosa); **ferns**: none; **moss**: moss (moss spp.).

9) 4223: DOUGLAS FIR-LODGEPOLE FOREST

Conifer forest dominated by Douglas-fir (Pseudotsuga menziesii) and lodgepole pine (Pinus contorta) and ranging from 5520 to 8000 feet in elevation. The average canopy cover for PSEMEN is 24% ranging from 10-40% total cover and frequency of occurrence equal to

100%. The average canopy cover for PINCON is 24% ranging from 3-40% total cover and frequency of occurrence equal to 100%. Primary associated tree species include subalpine fir (Abies lasiocarpa), Engelmann spruce (Picea engelmannii), and limber pine (Pinus flexilis) with average percent cover ≥2% and ≤7% and frequency of occurrence ≥36% and ≤50%.

Primary associated shrub species with ≥9% and ≤32% frequency of occurrence in Douglas-fir-lodgepole pine stands: creeping Oregon grape (Berberis repens), common juniper (Juniperus communis), mallow ninebark (Physocarpus malvaceus), shiny-leaf spiraea (Spiraea betulifolia), Canada buffaloberry (Shepherdia canadensis), common snowberry (Symphoricarpos albus), and globe huckleberry (Vaccinium globulare).

Primary associated graminoid, forb, fern, and moss species with ≥5% and ≤41% frequency of occurrence in Douglas-fir-lodgepole pine stands: **graminoids**: pinegrass (Calamagrostis rubescens), sedge (Carex spp.), and elk sedge (Carex geyeri); **forbs**: heart-leaf arnica (Arnica cordifolia), showy aster (Aster conspicuus), lupine (Lupinus spp.), and western meadowrue (Thalictrum occidentale); **ferns**: none; **moss**: moss (moss spp.).

P38/R29 RIPARIAN CLASSIFICATION

Representative spectral classes for riparian cover types:

CODE	COVER TYPE	SPECTRAL CLASS
6101	Needleleaf Dominated Riparian	12
6102	Broadleaf Dominated Riparian	73
6103	Needleleaf-Broadleaf Riparian	31
6104	Mixed Riparian (trees+ any other)	72
6201	Grass-Forb Riparian Wetland	18
6202	Shrub Riparian Wetland	25, 69
6203	Mixed Grass-Forb-Shrub Riparian	None identified for scene

---

For each spectral class below, plots falling within the riparian zone are listed.

Spectral Class 1
Color: Brownish yellow; RGB 226 194 103.
Distribution: Some in open meadows near wetter areas or agriculture fields; most on low slopes bordering valleys.
Comment: Appears to be dry grass, due to spectral class color and homogeneous texture. Training data outside the calculated riparian zone is quite varied, from Mountain Big Sagebrush, Foothills Grassland, and Subalpine Meadow to Aspen, conifers, agriculture, and riparian vegetation (6201).
Conclusion: Not riparian.

RECORD #	FREQUENCY	VEGETATION CLASS
1	1	Foothills Grassland
2	1	Needleleaf-Broadleaf Riparian

Spectral Class 3
Color: Dark brown; RGB 78 67 61.
Distribution: Primarily found within Yellowstone National Park, occurring in dense clusters northwest of Yellowstone Lake.
Comment: Appears to be conifers. Field observations are all outside the riparian zone, consisting of conifers and one instance of Exposed Rock. The spectral class occurs primarily near stream origins, probably in steep terrain where there is little riparian vegetation. There are no training data locations within the zone.
Conclusion: Not riparian.

Spectral Class 5
Color: Mint green; RGB 137 226 160.
Distribution: Some near timberline, but most occurs in low-lying areas; not linear.
Comment: The color and pattern indicate dry grass vegetation. Outside the calculated riparian

zone, field observations indicate sagebrush, rock and barren, grass, agriculture, juniper, and tundra.
Conclusion: Not riparian.

6	1	Mountain Big Sagebrush
7	1	Broadleaf Dominated Riparian

Spectral Class 6
Color: Dark brown; RGB 73 52 65.
Distribution pattern. Mostly shadow; some near streams but not linear.
Comment: Appears to be conifers on north facing slopes. Portions of the riparian zone where this spectral class occurs are of minimum width, indicating the actual zone may be narrower than 30m. Outside the riparian zone, conifers dominate training site data, with some riparian vegetation (6101, 6201, 6202), barren areas and rock.
Conclusion: Not riparian.

8	1	Mixed Mesic Forest
9	3	Needleleaf Dominated Riparian
10	1	Grass-Forb Riparian/Wetland
11	3	Shrub Riparian/Wetland

Spectral Class 9
Color: Dusty blue; RGB 99 133 181.
Distribution: Widely distributed linear pattern; also some light density spackle at higher and lower elevations.
Comment: Appears to be dry shrubs and grass. There is no strongly reported cover type for this class either inside or outside the calculated zone. Sagebrush was most frequently recorded outside the zone, with grass, conifers, and Broadleaf Dominated Riparian vegetation minimally represented.
Conclusion: Not riparian.

13	1	Urban & Developed Land
14	1	Foothills Grassland
15	1	Broadleaf Dominated Riparian

Spectral Class 10
Color: Light olive green; RGB 174 180 114.
Distribution: Mostly lower side slopes, some mid elevations, not linear.
Comment: Appears to be upland shrub, perhaps with some sparse trees as well; too dry to be riparian. Foothills Grassland has the single highest frequency of training data points outside the zone, with conifers having a larger combined total. There were also some agricultural, Subalpine Meadow, Rocky Mountain Juniper, Alpine tundra, and riparian (6201, 6202) cover types observed.

Conclusion: Not riparian.

16	1	Dry-land Pasture
17	2	Foothills Grassland
18	1	Mesic Upland Shrubland
19	1	Wyoming Big Sagebrush Steppe
20	1	Aspen
21	2	Broadleaf Dominated Riparian
22	1	Grass-Forb Riparian/Wetland
23	1	Shrub Riparian/Wetland

Spectral Class 11
Color: Moss green; RGB 123 159 95.
Distribution: Low to mid elevations; loosely connected denser areas around and inside the perimeter of Yellowstone National Park, not linear in pattern.
Comment: The color and distribution are similar to Spectral Class 10. Field observations for this spectral class include conifers, Aspen, sagebrush, and rock.
Conclusion: Not riparian.

24	1	Broadleaf Dominated Riparian

Spectral Class 12
Color: Dark red; 135 69 61.
Distribution: Low to mid elevations, mostly outside the park with some gully pattern.
Comment: Appears to be Mixed Mesic Conifers, possibly with some riparian vegetation along higher elevation streams. Conifers, especially Douglas-fir, dominate the field data outside the zone. There are also riparian (6101, 6102, 6201, 6202), Aspen, Mixed Barren Land, and Subalpine Meadow cover types
Conclusion: 6101.

25	1	Engelmann Spruce
26	1	Mixed Subalpine Forest
27	5	Needleleaf Dominated Riparian
28	1	Broadleaf Dominated Riparian
29	1	Needleleaf-Broadleaf Riparian
30	2	Shrub Riparian/Wetland

Spectral Class 13
Color: Brown olive green; RGB 105 102 68.
Distribution: Mostly mid elevation with occasional gully pattern.
Comment: Appears to be Lodgepole Pine vegetation. Conifers dominate outside the riparian zone; some Rocky Mountain Juniper and riparian (6101, 6103) cover types were also

observed.
Conclusion: Not riparian.

31	1	Engelmann Spruce
32	1	Lodgepole Pine
33	1	Mixed Mesic Forest
34	1	Mixed Xeric Forest
35	1	Broadleaf Dominated Riparian
36	1	Shrub Riparian/Wetland

Spectral Class 16
Color: Brown; RGB 90 71 69.
Distribution: Mid elevations; some gully pattern.
Comment: *Field observations are dominated by coniferous cover types, with some Mixed Barren Land and Exposed Rock outside the zone.
Conclusion: Not riparian.

40	1	Engelmann Spruce
41	1	Mixed Subalpine Forest
42	1	Needleleaf Dominated Riparian

Spectral Class 18
Color: Olive green; RGB 165 161 91.
Distribution: Mostly mid elevations outside the park.
Comment: This spectral class shows more linearity and proximity to water. A variety of life forms and cover types were reported, including conifers, Foothills Grassland, riparian (6102, 6103, 6202), shrubs, Aspen, Mixed Barren Land, and Exposed Rock.
Conclusion: 6201.

45	1	Douglas-fir-Lodgepole
46	1	Shrub Riparian/Wetland

Spectral Class 19
Color: Black; RGB 31 31 61.
Distribution: Sparse, in shadows.
Comment: The three training data points located outside the zone all indicate coniferous or burnt forest cover types.
Conclusion: Not riparian.

47	1	Grass-Forb Riparian/Wetland
48	1	Shrub Riparian/Wetland

Spectral Class 20
Color: Spring green; RGB 112 190 126.
Distribution: Lower elevations.
Comment: Found in burns, as evidenced by reflectances typical of exposed grass. There appear to be some sparse conifers on north slopes. Outside the zone, sagebrush is the most recorded cover type, with the conifer group next; there are also some agriculture and Exposed Rock cover types in the training data.
Conclusion: Not riparian.

49	1	Needleleaf-Broadleaf Riparian

Spectral Class 25
Color: Orange; RGB 254 130 68.
Distribution: Clusters in some lower elevations outside the park, some at mid elevations.
Comment: The color is light enough to suggest shrubs rather than trees. Training data indicates primarily Foothills Grassland, then Subalpine Meadow, agriculture and sagebrush outside the zone. In a portion of the scene, the spectral class is concentrated in what appear to be riparian locations.
Conclusion: 6202.

52	1	Dry-land Pasture
53	1	Rivers & Streams

Spectral Class 27
Color: Light spring green; RGB 174 222 160.
Distribution: Mostly found on lower slopes along valley edges.
Comment: Color and distribution suggest dry grass. Field observations report a variety of cover types: conifer, sagebrush, grassland, Mesic Upland Shrub, Urban & Developed Land, Herbaceous Clearcut, Mixed Barren Land, agriculture, and Alpine Tundra.
Conclusion: Not riparian.

55	1	Foothills Grassland
56	1	Wyoming Big Sagebrush Steppe
57	1	Broadleaf Dominated Riparian

Spectral Class 28
Color: Dark brown; RGB 78 27 49.
Distribution: Shadows.
Comment: Appears to be conifer in shadowed areas.
Conclusion: Not riparian.

Spectral Class 31
Color: Light orange; RGB 254 156 88.
Distribution: Occurs primarily on lower slopes; some near streams but not linear in pattern.
Comment: Appears to be Mixed Needleleaf-Broadleaf vegetation in color and distribution. Most of the field observations report conifers, with agriculture and grasses about equal; riparian (6101, 6102, 6201), Aspen, Mixed Needleleaf-Broadleaf, Mesic Upland Shrubland, and Alpine Tundra were also recorded. This is a large class, occurring throughout the calculated riparian zone.
Conclusion: 6103.

60	1	Douglas-fir
61	1	Mixed Mesic Forest
62	2	Broadleaf Dominated Riparian
63	2	Shrub Riparian/Wetland

Spectral Class 35
Color: Dark Brown; RGB 62 33 49.
Distribution: Shadows.
Comment: Appears to be conifers, primarily on steep slopes. With the exception of two Mixed Barren Land observations, training data reports conifer cover types.
Conclusion: Not riparian.

66	1	Shrub Riparian/Wetland

Spectral Class 39
Color: Dark olive; RGB 73 100 72.
Distribution: There is some gully pattern, but most of the class occurs in large, dense patches in relatively flat terrain within the park.
Comment: Appears to be Lodgepole Pine. Except for one riparian (6202) point, the training data indicates conifer cover types.
Conclusion: Not riparian.

68	1	Needleleaf Dominated Riparian

Spectral Class 69
Color: Orange; RGB 255 117 69
Distribution: Clusters in lower elevations, some near streams and lakes.
Comment: Appears to be broadleaf vegetation. Aspen is the dominant cover type recorded outside the zone; riparian (6102, 6201, 6202), agricultural, coniferous, grass, Urban & Developed Land, and Mixed Needleleaf-Broadleaf cover types also occur. Distribution and color suggest shrub vegetation.

Conclusion: 6202.

73	1	Douglas-fir
74	1	Broadleaf Dominated Riparian

Spectral Class 72
Color: Orange; RGB 199 113 65.
Distribution: Found primarily on lower slopes.
Comment: There appears to be some needleleaf and broadleaf, though not mixed. Douglas-fir, Shrub Riparian/Wetland, and Aspen were about equally observed outside the zone; other riparian (6102, 6101, 6103, 6201), other conifers, Broadleaf Forest, Dry-land Pasture, Mesic Upland Shrubland, and Mixed Barren Land cover types were also recorded.
Conclusion: 6104.

75	1	Foothills Grassland
76	1	Mixed Mesic Forest
77	1	Mixed Xeric Forest
78	1	Needleleaf Dominated Riparian
79	2	Shrub Riparian/Wetland

Spectral Class 73
Color: Bright red-orange; RGB 238 96 61.
Distribution: Appears primarily in agriculure areas and low slopes near those areas; some relatively isolated clusters near streams.
Comment: Color and locations within the riparian zone, suggest cottonwoods. Field observations indicate Aspen and Mixed Needleleaf-Broadleaf cover types outside the zone.
Conclusion: 6102.

80	1	Aspen

APPENDIX G. Draft manuscript, to be submitted to *Photogrammetric Engineering and Remote Sensing*. In large part, text and figures coincide with information presented in the body of this report.

USING A COLOR PALETTE TO DRIVE UNSUPERVISED CLASSIFICATIONS OF REMOTELY SENSED IMAGES: WHAT YOU SEE IS WHAT YOU GET

A process is described for simulating manually digitized boundaries of land cover patterns from a color composite of a remotely sensed image; an illustration is provided for a landscape in northwestern Montana.

10 April 1996

Zhenkui Ma, Melissa M. Hart, and Roland L. Redmond

Montana Cooperative Wildlife Research Unit

The University of Montana

Missoula, MT 59812

ABSTRACT

VIMAP, a two-pass algorithm for digital classification of remotely sensed images, effectively simulates manual delineation of land cover patterns. The first pass involves randomly selecting a number of pixels, then saving into a color palette file those pixel values that exceed a specified Euclidean distance cutoff. The second pass uses the color palette as training data for an unsupervised classification of all other pixels, again based on Euclidean distance calculations. This classified image is automatically color-matched with the color composite. After classification, output is generalized through a rule- and object-based process; only raster polygons larger than the specified minimum mapping unit are maintained. The merging process completes the delineation of raster polygons which can then serve as units in a GIS database for further manipulation and analysis. Because the entire process is digital, it is faster, more consistent, and more easily repeated than traditional methods.

INTRODUCTION

As federal and state agencies increasingly turn to ecosystem management concepts to manage public lands (Salwasser, 1994), and landscape and regional analyses are more frequently undertaken, development of broad-scale vegetation maps becomes especially important. For example, in the USA, a project called Gap Analysis is being conducted in many states as a proactive effort to map indicators of biodiversity and to identify areas where management efforts might be adjusted to better conserve natural resources (Scott *et al.*, 1993). To conduct a gap analysis, a digital map of statewide land cover patterns is a necessary input. Such a map, in turn, can become part of a database in a geographic information system (GIS) that is used for ecological analysis, assessment, and modeling. Although conventional supervised and unsupervised classifications of remotely sensed satellite images can be used to produce such land cover maps (Hixson, 1980; Justice and Townshend, 1982; Tom and Miller, 1984; Lillesand and Kiefer, 1987), the outputs often do not agree with manual interpretations of the same images (Scott *et al*., 1993). Moreover, conventional pixel classifications of large geographic areas can involve more pixels than can be handled individually in a GIS database.

Because of problems inherent to digital classification methods, some broad-scale mapping efforts have relied on manual interpretation of cover types from color composites of Landsat TM imagery (e.g., several state-level Gap Analysis projects; Scott *et al*., 1993, Davis *et al*., 1994, 1995). Cover type boundaries are manually digitized based on an operator's interpretation of the patterns visible in the color composite, and the resulting polygons are labeled manually using aerial photos, existing maps, and field data (Davis *et*

al., 1994, 1995). When large minimum mapping units (MMUs) are selected, this method can successfully produce generalized boundaries of land cover patterns, provided that interpreters have sufficient expertise and patience to work consistently and carefully. When small MMUs are preferred, however, manual interpretation becomes too labor-intensive and is not feasible. To combine the advantages of both digital and manual methods of mapping vegetation and land cover types, we have developed a new procedure of digital classification which closely resembles the process of manually digitizing and labeling polygons. In this paper, we describe the first part of the procedure, delineating raster polygons of a user-specified MMU based on an unsupervised classification. The second step, labeling these raster polygons, is described in a companion paper (Ma *et al*., ms.).

Premises Behind the Process

Our process of delineating raster polygons hinges upon mimicking the patterns observed in a color composite; literally, what you see on-screen is what you get in the classified output file. If the colors of a classified image appear similar to the color composite from which it is drawn, important patterns presumably have been retained through the classification process. If too many spectral classes result, ones with similar color patterns may be regrouped into a single class in the same manner as an interpreter recognizes a single type based on its color pattern in a color composite.

The classification method used to emulate patterns in the color composite has its roots in the field of graphic display. A color palette is a data file used by the computer to map an image file to a set of available colors. The color palette is composed of three

separate arrays (256 bytes), each representing one of the three color components -- red, green, and blue. Color palettes were initially developed to enable the display of 24-bit data by storing 8-bit data in a frame buffer. Conceptually, when remotely sensed images are displayed using an 8-bit frame buffer, an unsupervised classification is required, however rudimentary and temporary. One example that incorporates color palette theory in image classification is RGB clustering (ERDAS, 1991). RGB clustering can produce a classified image with an appearance similar to the color composite, but it is designed more for display than for interpretation, unless a large number of classes are specified (see ERDAS, 1991).

CLASSIFICATION ALGORITHM

The VIMAP (visualization/mapping) algorithm involves two passes; in the first, a color palette is created from the input image, and in the second, an unsupervised classification is conducted, driven by the color palette. The entire process focuses on the relationship between each pixel's digital numbers and RGB color space. With a three-channel color composite, various combinations of digital numbers in the three dimensional space are reflected by different color schemes. Each color pattern in a color composite is comprised of a group of pixels with similar digital numbers, and hence with a similar proportion of that color component in an RGB color cube (Fig. 1). After one reference pixel in a group has been identified, other pixels with similar proportions of color components will also be assigned to that group. In three-dimensional RGB color space, each color group is represented by a line from the origin (0,0,0) to the outer boundary of

the cube. The same color group is defined by the measure of similarity between a pixel on the line and all other pixels. Pixels occupying various positions along the line have different brightness values. The brightness of pixels on this line depends on the distance between their position and the origin. Greater distances from the origin indicate brighter colors, and smaller distances indicate darker colors. To demonstrate the relationship between pixel values and colors, several pairs of RGB values are listed in Table 1. Subgroups, called *spectral groups* in this paper, are indicated by brightness differences between RGB values along a line. Spectral groups become entries in a color palette file, from which the actual pixel values representing each spectral group are used as training data for an unsupervised classification.

The relationship and measurement of color groups and spectral groups in Table 1 are visually interpreted in Figure 1. The line representing the gray color group in the RGB cube (solid line) gradually shifts from black to white when a point with equal proportions of RGB color components is moved from the origin (0,0,0) to an outer boundary of the cube. The line projected in the cube representing the pink color group, with an unequal proportion of color components, also changes brightness when a point is moved from the origin toward the outer boundary. Once a point in the RGB cube is identified, a line for a color group can be defined by connecting the origin to the identified point and extending the line to the outer boundary. An interval on the line bounded by a user-defined criterion determines the spectral group. To identify a spectral group in three dimensional color space, pixels from the same spectral group must be similar in color and in brightness to the color composite. If either condition is not satisfied, a new spectral group is identified. In

this manner, the color palette is built.

Euclidean distance is used not only to identify spectral groups, and thereby to create a color palette, but also to measure similarities of individual pixels with spectral groups already identified, thus converting data from 24-bit to 8-bit format. In the first pass of this unsupervised classification process, a new spectral group is identified if the Euclidean distance (Equation 1) between a pixel and a previously identified spectral group is larger than the user-specified criterion value. In the second pass, all pixels are assigned to the spectral group to which they are closest in terms of Euclidean distance:

$$D_{xy} = \sum_{i=1}^{M} (X_i - Y_i)^2 \qquad (1)$$

where X is a previously identified spectral group, Y is an input pixel, and M is the number of TM channels (here, M = 3). The unsupervised classification procedure using a color palette is described according to the following steps (Fig. 2):

1. ***Create Color Palette:***
    a. Set the criterion value for Euclidean distance (D_c); new spectral groups will be defined based on this cutoff value. Determine the skip factor, or percentage of pixels to be sampled from the input image.
    b. Randomly select a pixel from the input image and save values for each channel in a color palette file. X_{ij} is a pixel in the color palette, *i* is the channel number from 1 to M (often corresponding to TM channels 4, 5, and 3 for classifications of growing vegetation), and *j* is the pixel number in the color palette (here, *j* = 1). The first selected pixel seeds the color palette; its values automatically

define the first spectral group.

c. Randomly sample pixels from the image data, and calculate the Euclidean distance (D_{xy}) between the pixel from the input image and pixel(s) from the color palette. Pixels from the image data are randomly sampled so that selected pixels are likely to be drawn from the majority distribution of each spectral group. The number of input pixels sampled is determined by the operator; generally, 50-80 pixels in a color palette offer a representative sample.

d. If the smallest value of D_{xy} (e.g., the smallest distance between that pixel and any other pixel already in the color palette) exceeds the cutoff value (D_c), define a new spectral group by adding the input pixel to the color palette. ≠

e. Repeat Steps 3 and 4 until all randomly sampled pixels have been examined. Pixels in the color palette will be used as representative spectral groups for an unsupervised classification.

2. ***Classify input image using the newly-created color palette:***

a. Classify input image data using Euclidean distance with the decision rule described as:

an unknown pixel Y belongs to group *i* if

$D[Y,X_i] < D[Y,X_j]$ for all $j \neq i$,

where *i* and *j* are individual pixels in the color palette.

b. To enhance contrast and optimize display, stretch pixel values in the original color palette with the same parameters used for displaying the color composite,

and thereby generate a new color palette, or color map file, for displaying the classified image.

c. Visually compare the classified image (8-bit data) to the color composite (24-bit data displayed with a 24-bit graphics card).

d. If there is a color difference between the classified image and the color composite, add a pixel randomly selected from the missing spectral group to the color palette. Repeat Steps 2a-2c until a satisfactory result is obtained.

Two advantages are conferred by random selection of input pixels when identifying spectral groups: 1) there is no geographical bias in classification of image data, as compared with methods biased toward pixels at the beginning or end of the input file (e.g., K-MEANS, ERDAS, 1991); and 2) the probability of a spectral group's selection is proportional to its population size; thus, large groups are unlikely to be missing from the color palette.

If a spectral group with a small population is not selected in the first pass because of its correspondingly small probability, and the group is known or suspected to be important for accurate land cover mapping, a pixel from this group can be manually identified and added to the color palette. When the above steps are followed, a classified image similar in appearance to the color composite is ensured.

REGROUPING

When unsupervised classifications are conducted, the original classification

typically is regrouped -- often manually -- to reduce the data to a more manageable, yet still meaningful, number of spectral classes. To make sound decisions when combining classes, the operator must invest a considerable amount of time in examining the raw and classified imagery. This proves difficult when working with data from a full TM scene, because so many data cannot be displayed on a terminal in adequate detail. Although an operator can only examine a small part of the scene at one time, any regrouping decision based on a small area will influence results over the whole scene. Regrouping in this manner is an especially cumbersome process; the time an operator will invest in regrouping is much greater than the actual computing time for image classification.

We offer a digital alternative for regrouping spectral classes which greatly reduces the amount of time required for an operator to examine each section of an entire scene, although results must still be manually evaluated. This step is optional depending on individual project needs; regrouping may be more critical when larger MMUs are selected. Regardless of MMU, users may wish to selectively regroup classes so that known types (e.g., water and cloud) are represented by a single spectral class. To regroup classes, pixels are clustered in the color palette (the stretched version created in Step 2b). In an extension of the method described earlier, Euclidean distance is used to group pixels in the color palette based on their positions in the RGB color cube. The grouped pixels are then used to determine the colors for displaying the original classified image. After visually comparing the original classified image to the color composite (with a 24-bit graphics card), pixel groupings in the color palette can be manually adjusted as desired. If the grouped color palette produces a satisfactory display of the original classified image, spectral groups in

the classified image are recombined to correspond with the revised color palette.

MERGING

After regrouping the image, each contiguous area of pixels assigned to the same spectral class is referred to as a raster polygon, or *region*; regions less than the selected MMU are eliminated in a rule- and object-based merging process (Ford et. al., 1993; Guo, 1993; Ma, 1995). The merging process centers around construction of a similarity matrix used to control the incorporation of small regions into larger neighbors. This matrix is built based on the attribute values of the input spectral groups. Normally, these would be spectral values, but if other attributes are available (e.g., slope or aspect) these could be used as well. The merging process first identifies regions smaller than the MMU, lists neighboring regions, then examines similarities between small regions and their neighbors. Small regions are then merged with larger neighbors having the most similar attribute values. In our example using Landsat TM data, a 2 ha MMU was selected, which corresponds to a 22 pixel threshold (30 m * 30 m * 22 = 19,800 m^2 = 1.98 ha). Once the merging process has been completed, the remaining regions can serve as base units in a GIS database; various attributes may be collected for and attached to these regions, such as mean values for the seven TM channels.

EXAMPLE FROM A MONTANA LANDSCAPE

Plate 1 shows the color composite of TM Channels 4, 5, and 3 and the results from an unsupervised classification of these three channels for the central Swan Valley in

northwestern Montana. The illustrated area occupies 14,664 ha, or approximately 0.43% of the full Landsat TM scene (path 41, row 27) from which it was taken. The color composite in Plate 1(a) was made by displaying a linear stretch of TM channels 4 (R), 5 (G), and 3 (B) with a 24-bit graphics card. In this image, elevation decreases from left to right. High-elevation lakes and patches of snow are evident in the lower left, and the Swan River is visible in the upper right. Here, timber harvest activities have been taken place in a naturally diverse and complex landscape where original patterns were created in large part by fire and glaciation. Creating a useful and accurate map of existing vegetation and land cover for this highly heterogeneous area thus presents a fair challenge.

The original classification in Plate 1(b) results from 71 representative pixels in the color palette. These 71 pixels were used to emulate the appearance of the color composite of TM channels 4, 5, and 3. The high degree of similarity between images in Plates 1(a) and 1(b) indicates the quality of the unsupervised classification: All spectral information shown in the color composite has been summarized in a classified image with only 71 spectral classes. This original classification has a high proportion of "salt and pepper" regions which are not practical to maintain, or even necessarily meaningful, for purposes of natural resources management. The total number of regions shown in Plate 1(b), before "salt and pepper" regions are removed, is 66,682. Extrapolated to the full TM scene, the number of regions almost certainly exceeds the database handling capabilities of any commercially available GIS software package, thus necessitating a means of data reduction. Regrouping spectral classes and merging small regions are two options presented below.

In this complex landscape, some cover types vary greatly in distribution of digital

numbers such that two or more spectral classes are associated with a single cover type. Spectral classes representing similar color groups were digitally regrouped, and the results were carefully compared with the color composite and checked against available field information. Plate 1(c) shows the classified image after regrouping spectral classes and merging small regions. Through regrouping, the number of spectral groups in the color palette was reduced from 71 to 26, but the colors and patterns still appear close to those in the color composite (Plate 1(a)). Some color changes, for example, those for water, are caused by combining spectral groups representing deep lakes, ponds, and rivers into one group; here, the color is represented by the mean value of digital numbers from these subgroups of the overall water class. The same is true for snow; several groups, including those representing thick snow cover, thin snow cover, and wet, melting snow were combined into a single group. After regrouping and merging the classified image in Plate 1(b), only 1526 regions remain (Plate 1(c)). Thus, the number of regions post-merge is nearly 44 times less than that of the original classification (66,682 / 1526 = 43.70). This represents a significant reduction in the amount of data which must be stored and processed. Further, those regions maintained or generated through the rule- and object-based merging process exhibit boundaries of land cover patterns similar to those resulting from manual interpretation. However, this digital process is much faster than a manual technique, and it is likely to produce more consistent and detailed boundaries, especially when small MMUs are required. Plate 1(d) shows polygon boundaries derived from regions in Plate 1(c) overlaid on the color composite of TM Channels 4, 5, and 3. This overlay indicates that regions obtained from this classification satisfactorily represent

patterns seen in the color composite, and presumably, those on the ground as well.

CONCLUSIONS

This two-pass unsupervised classification algorithm, VIMAP, is more objective than both conventional clustering processes and manual techniques for delineating land cover patterns. VIMAP produces detailed and consistent output, the quality of which can be easily examined through comparison with a color composite for the raw image data. Minimal processing time offers another advantage. When regrouping of spectral classes is necessary, operator time is reduced as well. Further, the rule- and object-based merging process greatly reduces data storage and processing time, and also produces meaningful output for resource management, because both spatial relationships and attribute values among neighboring regions are incorporated. This simple modification of existing methods thus offers a vast improvement in classification outputs.

ACKNOWLEDGEMENTS

This research was funded in part by the U.S. Department of Interior, Fish and Wildlife Service and National Biological Service for the Montana Gap Analysis project, the U.S. Department of Agriculture, Forest Service Northern Region (contracts 53-0343-3-00027 and 53-0343-4-00012), and the National Aeronautics and Space Administration, Montana EPSCoR Program. IBM Corporation and the National Fish and Wildlife Foundation also contributed to this effort. We also thank Steven R. Holloway and Jim Schumacher for help with figure construction.

REFERENCES

Davis, F.W., P.A. Stine, and D.M. Stoms, 1994. Distribution and conservation status of coastal sage scrub in southwestern California. *Journal of Vegetation Science* 5(5):743-756.

Davis, F.W., P.A. Stine, D.M Stoms, M.I. Borchert, and A.D. Hollander, 1995. Gap analysis of the actual vegetation of California 1. The southwestern region. *Madroño* 42(1): 40-78.

ERDAS, 1991. **Field Guide**, Second Edition, Version 7.5, Printed in the United Statesof America, 394 p.

Ford, R., Z. Ma, R. L. Redmond, 1993. Aggregation of image classification units for mapping large areas. The 1993 Northwest ARC/INFO Users Conference, Whitefish, Mont.

Guo, J., 1993. An object-oriented model with efficient algorithms for identifying and merging raster polygons. M.S. Thesis, Department of Computer Science, University of Montana, Missoula, Mont.

Heckert, P, 1982. Color Image Quantization for Frame Buffer Display. *SIGGRAPH 1982 Proceedings*, pp. 297.

Hixson, M., D. Scholz, N. Fuhs, and T. Akiyama, 1980. Evaluation of Several Schemes for Classification of Remotely Sensed Data. *Photogrammetric Engineering and Remote Sensing*, 46(12):1547-1553.

Justice, C., and J. Townshend, 1982. A Comparison of Supervised and Unsupervised Classification Procedures on LANDSAT MSS Data for An Area of Complex Surface Conditions in Basilicata, Southern Italy. *Remote Sensing of Environment*, Vol. 12:407-420.

Lillesand, T. M. and R. W. Kieffer, 1987. **Remote Sensing and Image Interpretation**, 2nd ed., John Wiley & Sons, New York, New York, 721 p.

Ma, Z., 1995. Using an rule-based merging algorithm to eliminate 'salt-pepper' and small regions of classified image. *Proceedings of the Ninth Annual Symposium on Geographic Information Systems*, Vol. II, pp. 834-837.

Ma, Z., M. M. Hart, and R. L. Redmond, in prep. Mapping vegetation across large geographic areas: integration of remote sensing and GIS to classify multisource data.

Salwasser, H., 1994. Ecosystem Management: Can it Sustain Diversity and Productivity? *Journal of Forestry*, 92(8): 6-10.

Scott, J. M., F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'erchia, T. C. Edwards, Jr., J. Ulliman, and R. G. Wright, 1993. Gap Analysis: A Geographic Approach to Protection of Biological Diversity. *Wildlife Monographs*, A Publication of The Wildlife Society, 41 p.

Tom, C. H., and L. D. Miller, 1984. An Automated Land-use Mapping Comparison of the Bayesian MAXIMUM LIKELIHOOD and Linear Discriminant Analysis Algorithms. *Photogrammetric Engineering and Remote Sensing*, 50(2):193-207.

Table 1. Pixel values, or digital numbers, for hypothetical spectral groups. Such values are contained in the color palette that is used to drive unsupervised classifications of satellite image data.

RED	GREEN	BLUE	COLOR GROUP	SPECTRAL GROUP
255	0	0	red	bright red
100	0	0	red	darker red
255	255	0	yellow	bright yellow
50	50	0	yellow	darker yellow
255	255	255	gray	bright/white
10	10	10	gray	darker/black
255	160	140	pink	bright pink
205	110	90	pink	darker pink

Figure 1. RGB color cube. The unsupervised algorithm relies on Euclidean distances calculated between pixel values within this color space.

Figure 2. Two-pass unsupervised classification procedure. Output files can be regrouped and merged to the desired minimum mapping unit, then used as base units in a GIS database.

Plate 1. (a) Color composite of TM channels 4, 5, 3 (R G B). (b) Unsupervised classification of TM channels 3, 4, 5. (c) Classification regrouped and merged to 2 ha minimum mapping unit. (d) Polygons, derived through regrouping and merging, overlaid with color composite.

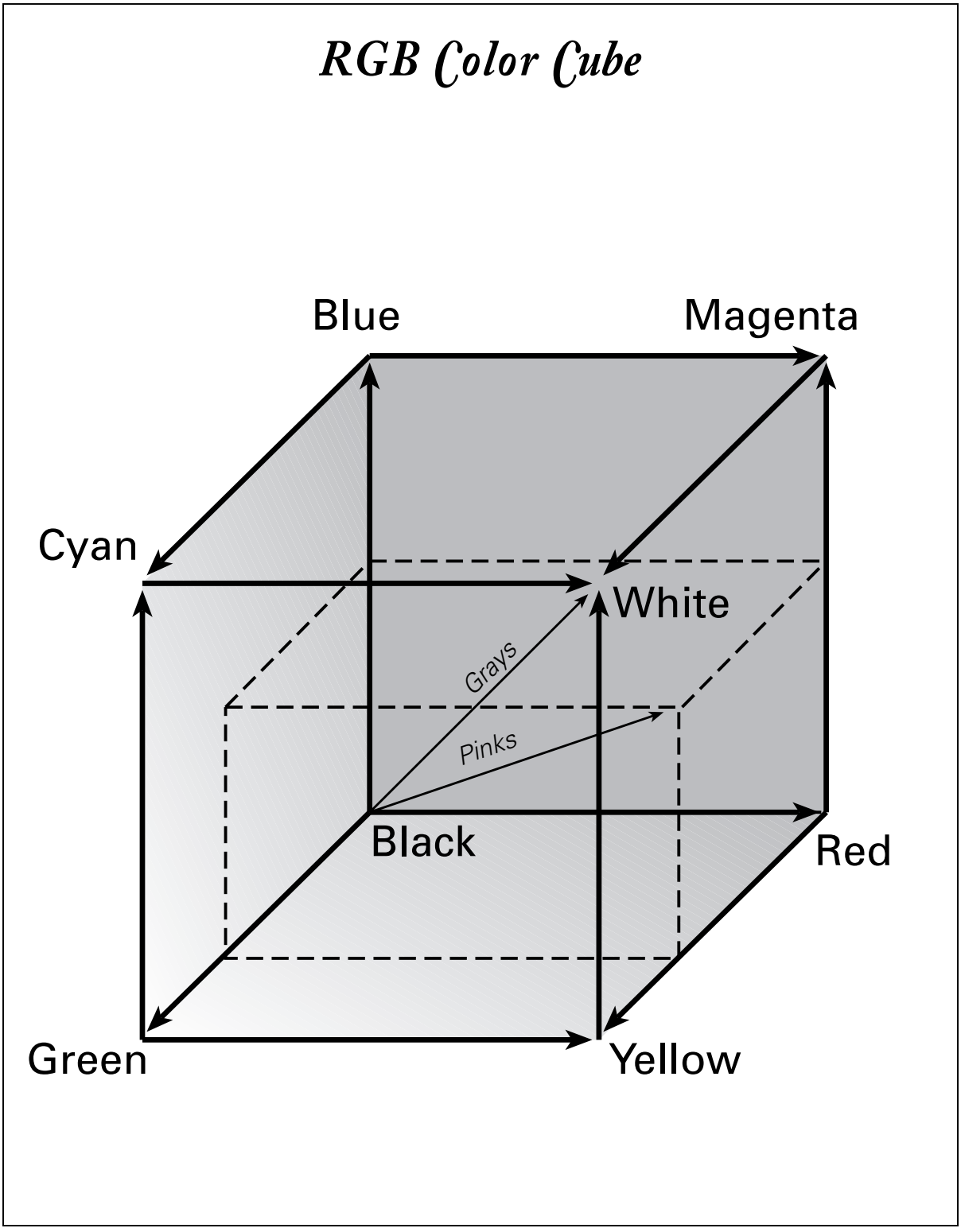


Figure 1. RGB Color Cube.

The unsupervised algorithm relies on Euclidean distances calculated between pixel values within this color space.

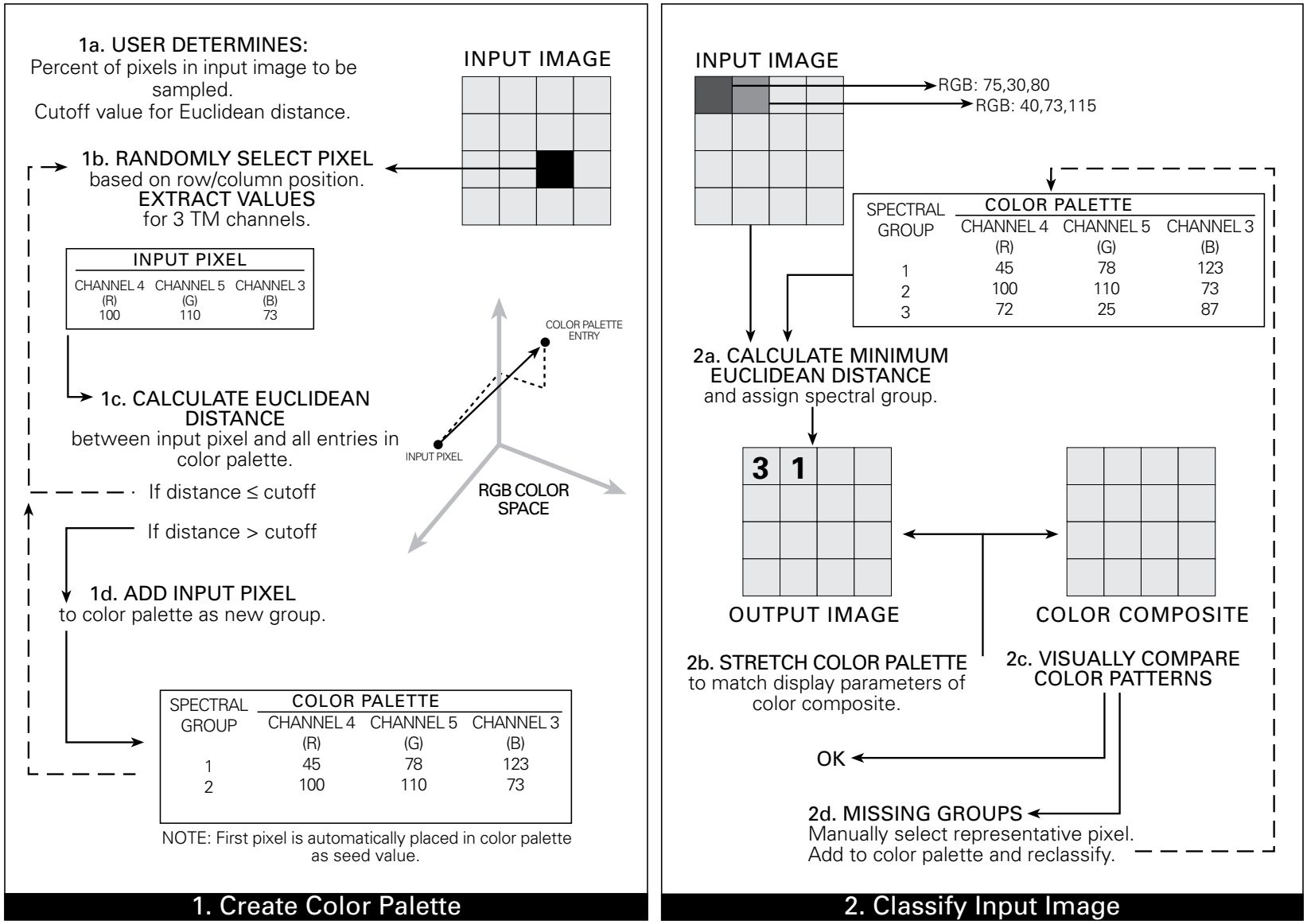
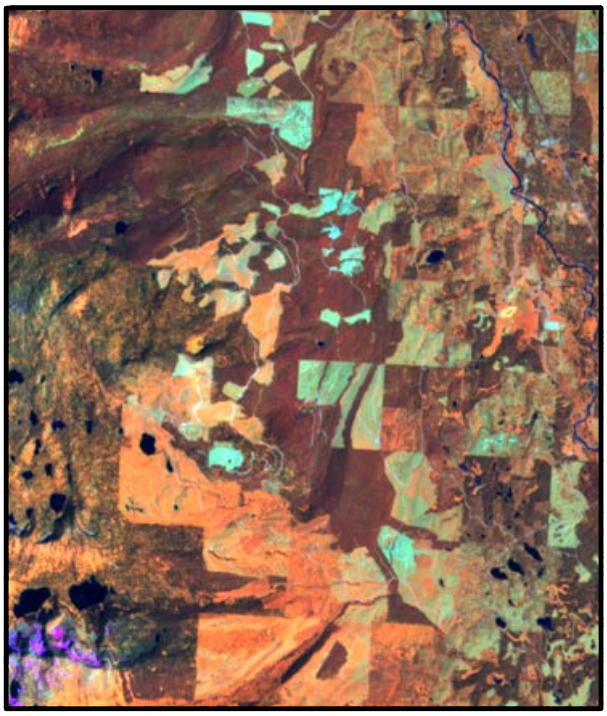
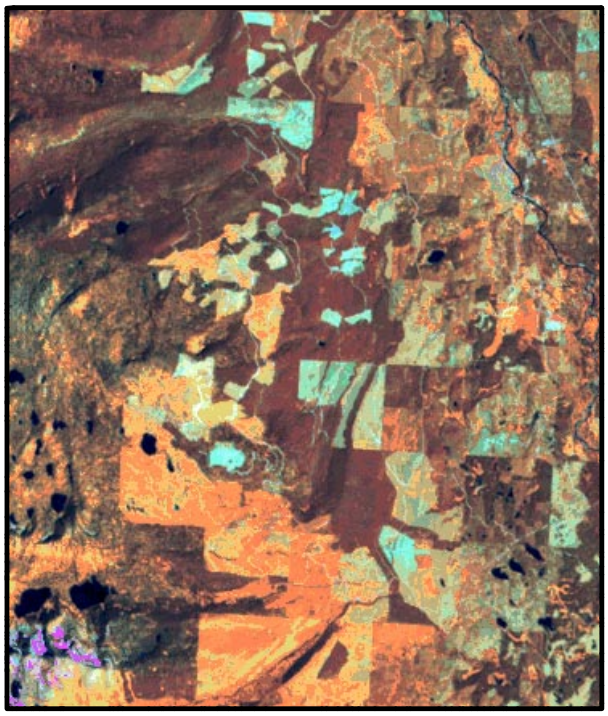


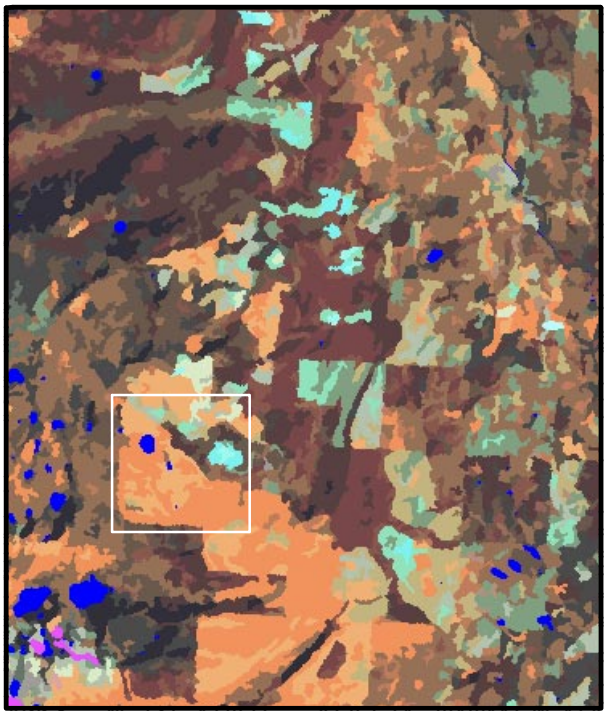
Figure 2. Two-pass unsupervised classification procedure. Output files can be regrouped and merged to the desired minimum mapping unit, then used as base units in a GIS database.



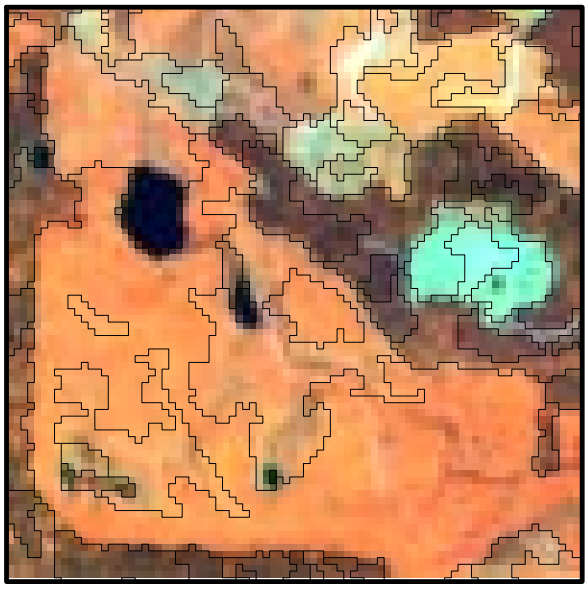
(a) Color composite of TM channels 4,5,3 (R G B).



(b) Unsupervised classification of TM channels 3,4,5.



(c) Classification regrouped and merged to 2 ha minimum mapping unit, with area of enlargement *(d)* outlined.



(d) Enlargement showing polygons derived from *(c)*, overlaid on *(a)*.



Figure 8. Steps in the unsupervised classification process, illustrated for the central Swan Valley, Montana.

APPENDIX H. Draft manuscript, to be submitted to *Photogrammetric Engineering and Remote Sensing*. In large part, text and figures coincide with information presented in the body of this report.

MAPPING VEGETATION ACROSS LARGE GEOGRAPHIC AREAS: INTEGRATION OF REMOTE SENSING AND GIS TO CLASSIFY MULTISOURCE DATA

Large areas can be mapped using a two-stage classification procedure, the second of which is described here: Once base regions, or raster polygons have been delineated in the first stage, an unsupervised classification and merging process, attributes can be collected for each region in a GIS. A supervised procedure can then be used to classify regions according to land cover type.

(Draft 4/12/96)

Zhenkui Ma, Melissa M. Hart, and Roland L. Redmond

Montana Cooperative Wildlife Research Unit

The University of Montana

Missoula, MT 59812

ABSTRACT

We describe the second half of a process for digitally mapping existing vegetation and land cover across large geographic areas by integrating Landsat TM data with ancillary biophysical data in a GIS. Classified images, created using the VIMAP algorithm and generalized to a 2 ha minimum mapping unit, are converted into raster databases: Individual regions, or raster polygons, are identified and assigned values for various spectral and biophysical variables. These variables, along with ground-truth data, are incorporated in supervised classifications of regions according to cover type and size class. Canopy cover is labeled using decision rules based on modified NDVI. Accuracy levels are assessed using fuzzy sets. Databases per TM scene are virtually edge-matched to create seamless outputs across large areas. By consolidating and maintaining each scene's data in a single raster database, many traditional limitations are avoided, and large areas can be processed quickly and efficiently.

INTRODUCTION

Several major issues come into play when mapping land cover across large geographic areas (Table 1). First, multisource data are necessary, either during the classification, or for post-classification refinement (Brown *et al.*, 1993). Multisource data include raw TM data and derived information (e.g., measures of texture), digital elevation model (DEM) data and derived information (e.g., slope and aspect), and other biophysical data (e.g., soils and climate). Using multisource data increases the power of distinguishing land cover types, but it also increases computing time and disk storage, which in turn necessitate an efficient means of data handling.

Compounding the problem of multiple data layers for a given TM scene is the requirement of multiple scenes to provide coverage of broad geographic areas. Although adjacent TM scenes overlap by roughly 40%, common ground points within the overlapping area do not coincide unless each scene has been geometrically corrected. For areas of high relief, two-dimensional, geometrically corrected TM data may not meet standards of accuracy for registering common ground features to other biophysical data. Thus, correction of terrain displacement is especially critical in mountainous areas, and a specific process of terrain correction, with reference to digital elevation data, is required.

Once source data are acquired and properly georeferenced, a classification algorithm must be carefully selected to achieve the best classification results (Justice and Townshend, 1982; Tom and Miller, 1984). The most commonly used classification algorithms are MAXIMUM LIKELIHOOD and K-MEANS clustering. Although many classification procedures have been developed, most of them are modifications of the above algorithms (Skidmore and Turner, 1988). Various classification algorithms should

be evaluated based on their respective capabilities of translating spectral variations into land cover/use patterns. In a previous paper (Ma et al., ms.), we presented the VIMAP algorithm, which effectively preserves patterns observed in the color composite of image data.

Another issue for mapping large areas is the selection of the archiving file format within the GIS. Most GIS software packages are able to handle both raster and vector formats. Raster format presents an advantage for setting up and maintaining large files in GIS databases, whereas vector format offers the advantage of being better supported by many software packages. Raster files store image and attribute information more efficiently than vector files; in ARC/INFO, the same file can be nearly seven times as large in vector as in raster format. Thus, the GIS software is able to handle much more information in raster than in vector format, permitting broader areas to be analyzed for the same image and attribute information (Ma and Redmond, 1992). Furthermore, it is easier to collect attribute information for raster files than it is for vector files (ESRI, 1991). Finally, because more GIS modeling techniques are available in the raster environment, working with raster data is more convenient, and hence more productive.

Next, the minimum mapping unit (MMU) for the archiving file must be properly selected and generated. A single pixel will seldom be a desirable mapping unit over large areas; consequently, once image data have been classified, "salt and pepper" pixels must be filtered, and small *regions* (continuous areas, analogous to vector polygons) merged with their neighbors. Smaller MMUs result in larger archiving files, but larger MMUs are unlikely to contain homogeneous information. Commercial software currently available for aggregating regions to a selected mapping unit is not entirely appropriate for natural

resources management, because small areas are merged with larger neighbors without consideration of the similarity of their attributes.

Once archiving files have been constructed, adjacent files need to be correctly edge-matched to each other if they are generated from different TM scenes. The edge-matching process is influenced by at least two factors: quality of the geometric correction of the scenes, and land cover types occurring within the area of overlap between two (or more) adjacent scenes. When edge-matching is done properly, the boundary between adjacent TM scenes should not be apparent.

Each archiving file requires an attribute table containing all information related to the map layer itself. These attributes offer a versatile database, simplifying future applications. With this attribute table, the archiving file can be readily expanded, updated, and modified through digital or manual processes. Furthermore, many new GIS layers can be rapidly created from the items stored in this attribute table.

Finally, accuracy assessment and quality control are especially important aspects of the mapping process. Because errors can accumulate at each step of the mapping process (Heuvelink *et al.*, 1989), all processes and products must be examined carefully and systematically. Note that the commonly used point/pixel method of accuracy assessment is not entirely appropriate for a final map product across a large area. Once a MMU has been applied, the majority area of a mapping unit determines its cover type, and points sampled within minority cover types do not represent the overall nature of the mapping unit. Hence, modified techniques for accuracy assessment become necessary. One option could be collection of a cluster of points within each sampled mapping unit; clusters could then be summarized to determine mapping unit characteristics. A second option, which

may be simpler and less costly to apply across large areas, is the incorporation of fuzzy logic into accuracy assessment (Gopal and Woodcock, 1994).

All of the above issues are critical considerations in mapping large areas; below, we propose solutions for these and related problems, and describe a digital classification procedure developed for mapping existing vegetation and land cover across the state of Montana using Landsat TM imagery. Our objective, to construct a statewide GIS layer that maintains a high level of detail and resolution, presents a challenging prospect: Montana covers roughly 380,850 km^2 and is covered by portions of 31 Landsat TM scenes. Hence, our methodology has been tailored toward construction of a detailed land-cover database across such large areas.

MAPPING INPUTS

Digital Data

Landsat TM imagery and digital elevation models (DEMs) are the primary data layers incorporated in the mapping process. Ideally, the most recent, cloud-free imagery available within the growing season should be obtained. Three data types are available for purchase: system-corrected, precision-corrected, and terrain-corrected data. For areas with high relief, we suggest purchasing terrain-corrected TM scenes with mosaic quality; we found them to provide the most accurate geographic locations for land features in western Montana (J. Troutwine, unpubl. data). Elevation, slope, and aspect information can be derived from digital elevation data. To most accurately represent topographic features, U.S. Geological Survey (USGS) 7.5' DEMs should be used wherever they are available.

Ground-truth Data

Compilation of a training dataset is a critical step in classifying existing vegetation, because the resultant map can only be as good as the training data used to develop it. In order to collect sufficient ground-truth data for classifying existing vegetation and land cover, we suggest a sampling method like that developed by the U.S. Forest Service Northern Region in conjunction with our mapping efforts. A stratified sampling scheme, similar to that described by Warren *et al.* (1990), can be adopted: For each TM scene, spectral classes can be examined according to landtype group or a similar means of stratifying the landscape. USGS 7.5' quadrangles are selected for field sampling based on factors like high spectral diversity, presence of rare spectral classes, and/or presence of poorly represented classes. After such criteria are applied, additional quadrangles can be selected to improve the overall geographic distribution of samples. If multiple field seasons are scheduled, after the first field season, the number of plots collected for each cover type in the classification scheme should be tallied. Quadrangle selection for the second field season then can be targeted toward sampling cover types for which insufficient plots have been previously collected.

Once quadrangles have been selected for sampling, field maps are prepared for each quadrangle, displaying spectral classes at 30 m resolution along with boundaries for raster polygons at 2 ha MMU. Hydrography and roads should be overlaid for reference. Although sampling is targeted toward the 2 ha MMU polygons, this display convention allows field crews to locate their plots in homogeneous areas within polygons as indicated by the 30 m data. After receiving the maps, field crews then sample the 2 ha MMU

polygons using ECODATA methodology (Keane et al. 1990) or similar standardized techniques. To maximize positional accuracy, plot coordinates should be determined based on differentially-corrected GPS locations whenever possible.

After field plots are entered in digital format, they must be subjected to a series of logical and positional checks to ensure their validity. ARC/INFO point coverages with all plot attributes can then be created and manipulated by analysts to obtain training datasets for each TM scene to be classified (see below).

CREATING A LAND COVER DATABASE

We employ a two-stage classification process which integrates remote sensing and GIS technology (Fig. 1). In the first stage, land cover patterns are derived from a color composite of TM data using an unsupervised classification algorithm, and pixels are grouped into regions (Ma *et al*., ms.). The second stage incorporates a supervised classification algorithm within a GIS to label unknown regions according to existing vegetation and land cover type. The first stage is analogous to the process of manually digitizing polygon boundaries based on spectral patterns. Similarly, the second-stage, supervised classification is analogous to the process of manually labeling polygons, but uses digital attribute values for each region to determine labels. In manual labeling techniques, non-digital attributes are typically assimilated from analysts' knowledge, aerial photo interpretation, and/or field validation (Scott *et al*., 1993).

Euclidean distance (Equation 1) is central to our entire mapping process. This measure is used to assess the similarities between input pixels and spectral classes in the first stage, and the similarities between unknown regions and cover types in the second

stage.

$$D_{xy} = \sum_{i=1}^{M} (X_i - Y_i)^2 \qquad (1)$$

For stage one, X is a known spectral group and Y is an unknown pixel (see Ma *et al*., ms.). For stage two, X is a known cover type in the training data set and Y is an unknown region to be classified.

Setting up the Raster Database

The supervised classification, where regions are assigned labels based on ground-truth data, requires a raster database containing multiple TM and ancillary attributes. Logically, then, classifications cannot take place until such databases (or scene grids) have been constructed for each TM scene. Once a classified and merged image has been created through the unsupervised classification process, the resultant file is converted from ERDAS GIS to ARC/INFO GRID format, thus maintaining its raster file structure. Each scene grid contains roughly 300,000 regions. Next, for each scene grid, a value attribute table (VAT) is built to contain statistics by region for spectral and biophysical (TM and DEM) data (Ma and Redmond, 1992).

Archiving data within a raster database in this manner presents distinct advantages. For example, TM data archived as a *region spectrum* (for each region, composed of mean values for each of the seven TM channels) occupies much less storage space than the raw imagery. This region spectrum can be retrieved as a multispectral image with a smoother appearance than raw TM data. In addition, each region functions as a smoothing window, reducing noise within individual TM channels and thus producing more useful data for

classification. In principle, this smoothing technique is similar to a Fourier transformation (Russ, 1992), but it employs a variable window size. It is especially suitable for spatial data because it stops at region boundaries and does not smooth the edges between types.

In addition to deriving the mean values for TM channels 1-7, mean elevation and slope values for each region are calculated and stored within the attribute table. Because mean values are unlikely to offer representative measures for aspect (e.g., when averaged, northeast and northwest slopes would be recorded as south), we classify aspect into eight groups and store majority values for each region. We also calculate a version of modified NDVI (normalized difference vegetation index) adapted from Nemani *et al.* (1993):

MNDVI = (TM4 - TM3) / (TM4 + TM3 + 1) * (256 / (TM5 + 1)) * 100

Once derived, these attributes can be used to drive subsequent supervised classifications.

Training Data Analysis

As mentioned above, the supervised classifications cannot occur until raster databases have been constructed. Even more importantly, they would not be possible without the input of high-quality training data. Thus, the analysts must carefully examine the ground-truth plot collected for each TM scene, and identify any plots that may cause problems during the supervised classification process. When problems cannot be resolved, plots must be eliminated from the training set. Examples include multiple plots with different vegetation types in a single region, and plots with low or unknown locational accuracy. Plots are also set aside if they have cover type codes that will be manually rather than digitally labeled; these include urban, agricultural, and water cover types.

From the remaining set, 20% of the plots for each cover type are held aside for

assessing classification accuracy. The other 80% comprise the potential training set for cover type classification. These plots are subjected to further spectral examination. Outliers are identified for each cover type by examining plots in relation to TM and ancillary data for the regions in which they fell. Plots are inspected both visually and in relation to statistical measures like Euclidean distance and standard deviation. Outlier or otherwise questionable plots are eliminated from the training set. Separate test and training sets for tree and shrub size classes are created using this process as well.

Training data analysis does not truly end until all supervised classifications are complete. To assess the quality of training data at various stages throughout the process, we use a bootstrap method. This approach involves removing each training plot from the data set in turn, and using the remaining plots to classify that single plot. An error matrix then is generated from the classified output files to evaluate potential confusion among training plots. Misclassified plots (omission and commission errors) are further evaluated and in some cases dropped altogether from subsequent analyses. The bootstrap program provides the three most likely codes for each plot to aid in evaluations. Even if plots are correctly classified by others, they still may be deleted; clusters of problem plots can be fairly common.

Supervised Classification of Regions

Once the raster database and training data sets are in place for a given TM scene, supervised classifications are conducted to assign cover type and size class labels to each region. This proves to be an iterative process. Multiple classifications may be conducted for a single attribute, with intermediate modifications to training data, until satisfactory

results are obtained. Furthermore, 'classifications within classifications' may be conducted. For example, within areas initially classified as mixed mesic coniferous forest, further classifications may be attempted to sort out various combinations of dominant tree species. TM scenes spanning distinct ecoregions may also require stratified classifications.

The supervised classification algorithm that we use to label regions differs from conventional classifications using Euclidean distance because each region is composed of a group of pixels, and thus each attribute value for a region represents a summary statistic for that group. The TM digital number and ancillary data for some cover types have multi-modal distributions; one simple mean value may not provide the best characterization of such cover types. When measuring similarities between unsampled regions and those with known cover types, this potential weakness is circumvented by treating the mean vector of TM and ancillary data for each region in the training set independently. Thus, each training region can make a unique contribution to the classification; taken in concert, training regions for a given cover type are likely to better represent the type's entire distribution.

The algorithm used to classify regions is a supervised, nonparametric classification called the NEAREST MEMBER of GROUP (NMG). The mathematical description of NMG is:

An unknown region Y belongs to group i if

$ED(Y,X_i) < ED(Y,X_j)$ for j <> i

where ED is Euclidean distance, X_i and X_j are supervised training data, and X_i is any one of the known training regions for group i. With NMG, Euclidean distances are calculated between each unknown (i.e., unsampled) region and every training region in the data set.

Thus, all training regions are treated independently, and have an equal chance of affecting the assignment of labels. Each region is assigned a label corresponding to the group that contains the training region closest to the unknown region in terms of Euclidean distance.

NMG differs from the conventional NEAREST NEIGHBOR algorithm (also called MINIMUM-DISTANCE-TO-MEAN by Lillesand and Kiefer, 1987) in two respects: 1) it is a nonparametric method, and 2) it assigns an unknown region to a cover type group based on the smallest Euclidean distance to any one member of that group within the training data set. The conventional, supervised nonparametric method uses information for the whole group (I.e., all training plots for a cover type) to identify an unknown data case (Skidmore and Turner, 1988). Assigning an unknown region based on the smallest Euclidean distance to any one member of the group mirrors the process of manually labeling regions. When manually labeling regions, an analyst will compare the attributes of a region with the attributes of members of each reference group. If any data record in one group most closely matches the attributes of the unknown region, the unknown region will be assigned to this group.

The supervised classification in the second stage of our mapping process presents distinct advantages over traditional methods of labeling spectral classes derived from an unsupervised classification. With traditional methods, only one cover type can be assigned to a spectral class, because the spectral class is the only attribute that can be used for labeling. When remotely sensed data are integrated in a GIS, however, individual spectral classes can be assigned to multiple cover types during the labeling process through the use of any appropriate and available attributes in the database.

The first step in each supervised classification is to overlay training plots with

regions in the raster database, and extract the necessary attributes from each region for use in the classification. For each training plot, an attribute is added to identify the exact region in which it falls. Attribute tables are then related for the training plot and raster files, and the values for attributes used in each classification are exported into a training data file (ASCII format), sorted by group (cover type or size class). To classify cover types (Fig. 2), we use mean values for TM channels 1-7 and elevation. Because TM values range from 0-255, well below typical values for elevation (m), elevation is rescaled by dividing the raw value by 25 so that it is not accorded extra weight in the classification. In separate classifications of forest and shrub size classes, only TM data are incorporated; presumably, elevation should not influence size class as it could cover type. In addition to creating ASCII files for training data, similar files are created by exporting a matching set of attributes for every region in the raster database. Using VIMAP software (written by Z. Ma), the file of training data is compared with the file of regions to be classified, and every region is classified using the NMG algorithm. The NMG algorithm uses Euclidean distances derived as follows:

$$(TM1_{train} - TM1_{unknown})^2 + (TM2_{train} - TM2_{unknown})^2 + \ldots (TM7_{train} - TM7_{unknown})^2 + (ELE_{train} - ELE_{unknown})^2$$

Distances between attribute values are squared to : 1) avoid mixing positive and negative values, and 2) magnify the amplitude of distances, thus helping to distinguish differences among groups. Attribute values thus play the primary role in determining which labels should be assigned to each region; these are the values between which Euclidean distances are calculated. Three cover type labels are assigned to each region, in decreasing order of likelihood (or rather, increasing Euclidean distance). Labels are maintained without any

modifications in the raster database. Along with these cover type labels, the actual Euclidean distance values (rescaled by dividing ED by 1000) are recorded as well. Smaller values indicate a higher likelihood of correct classification: even if a cover type assignment proves to be incorrect for a given region, a very small ED value indicates that, based on the training data available, the assigned label offers the best possible fit. These ED values can be used in evaluating classification results by looking at the relative differences between all three values for individual regions, and various combinations of values across regions. ED values are also instrumental in making some modifications to cover type labels. After the cover type classification is complete, a new attribute is added and populated with values for the most likely cover type identified through the classification; this attribute is later manipulated through manual modifications.

Often, for size classifications, the NEAREST MEAN classifier may offer better results, and can be used rather than NMG. NEAREST MEAN is a special case of NMG, where only one set of attribute values is used to represent each group (e.g., size class). Typically, NEAREST MEAN is best in situations where groups are quite distinct; when groups have a high degree of overlap, this classifier can be problematic, because means are not likely to adequately represent such variation. Attribute values are extracted for the training data as described above; mean values are derived and used in another set of Euclidean distance calculations. Separate attributes are created for tree and shrub size classes; all regions in the database, regardless of their assigned cover types, are assigned both tree and shrub size classes. By so doing, we ensure that if cover types are modified, such that lifeforms change, size classes are still available. Later, once cover type labels have been finalized, we create a new attribute which contains unique values for each tree

and shrub class, and is only populated for regions carrying tree and shrub cover types.

Manual Modifications

Once supervised classifications have been conducted, manual modifications prove simple within the raster database structure. Many rule sets based on if/then logic can be developed, tested, and if the desired results are not obtained, discarded within a few minutes. We use three basic types of manual modifications: attribute recoding based on decision rules, application geographic limits, or visual interpretation of Landsat TM imagery.

As an example of a rule-based modification, we use MNDVI in conjunction with training data to classify canopy cover for forest and shrub types. We use this method rather than a supervised classification because of considerable variation observed in the training data for canopy cover. MNDVI offers an objective alternative because it provides a proven measure of the amount of vegetation on the ground (Nemani *et al*., 1993). Separate histograms showing frequency distributions for MNDVI are plotted and examined for forest, mesic shrub, and xeric shrub training regions. Breakpoints for low, medium, and high canopy cover are determined based on the distribution modes. A decision rule is then used to assign canopy classes to regions with tree and shrub cover types based on those breakpoints. Other decision rules are used to subdivide or recode cover types based on elevation or other attributes; cover types like water, snow, and rock are readily manipulated in this manner.

By simply integrating more GIS layers, or by working with region centroids, geographic limits also can be applied to cover type distributions. For example, the

distribution of limber pine (*Pinus flexilis*) may be restricted to areas east of the North American Continental Divide.

Finally, when attempting to distinguish between land use and land cover -- a task not typically feasible within a totally digital environment -- visual interpretations may be the only option.. In this case, raster polygons can be displayed according to spectral group, compared to the original TM imagery, and recoded by the analyst. We use this method to classify urban and agricultural lands, as well as clouds and cloud shadows.

Edge-matching

We employ a simple solution for seamlessly edge-matching classified data from adjacent scenes once the raster database has been constructed. This ‘cookie cutter’ method was designed to preserve the integrity of individual scene classifications, and to minimize the perception of an "edge" between adjacent overlapping scenes. It allows each image to be processed independently using all available spectral information, then edge-matched to its neighbors based on natural boundaries observed from land cover patterns. Through this method, adjacent scenes are "virtually" edge-matched. Rather than physically deleting regions, they are simply flagged to indicate whether or not they should be used in subsequent analyses. As a result, the original data can always be retrieved, and new edge-matching schemes can be devised and implemented at any time.

Edge-matching occurs only within overlapping areas for adjacent scenes (Fig. 3); before edge-matching begins, each scene within the mapping area must be evaluated and a dominance matrix established to consider relationships among all adjacent scene pairs. Factors like the distribution of cloud cover, the image acquisition date, and classification

accuracy levels for each scene should be carefully weighed in determining which scenes should take precedence over others. Once this scheme has been established, the following sequence of steps is implemented for each pair of adjacent scenes, starting with scenes that are dominant on the most sides as defined in the matrix:

1. Based on the dominance matrix, one scene is identified as dominant, the other subordinate.
2. A selection area is drawn on the dominant scene on-screen; at least one of its sides must fall within the overlap area. All regions on the dominant scene that fall at least partially within the boundaries of the selection area are identified. Shapes of selection areas may vary; boundaries can be drawn to avoid clouds or include other specific features. Two files are used as reference in drawing selection areas: the image produced through the unsupervised classification process (classified and merged to 2 ha MMU), and vector files showing the scene boundaries (so that the area of overlap is evident). Selection areas are drawn for all sides on which the scene is dominant (north, east, south, or west) at one time.

3. A new, intermediate attribute called EDGE is added to the raster database. All regions on the dominant image that fall at least partially within the selection area are assigned EDGE = 1. Regions completely outside of the area are assigned EDGE = 0 to indicate that these regions will be dropped in any physical edge-matching processes. When the two scenes are combined, the dominant scene acts as a cookie cutter; its regions replace underlying areas in the subordinate scene.

Natural boundaries between TM scenes can be generated through the above processes (Fig. 4), laying the groundwork for seamless output across large areas. After 'virtual' edge-matching has been completed, data can be cut and archived into more manageable tile units, such as 1:100,000 scale quadrangles (1˚ latitude by 2˚ longitude), or into specific units that can be either ecological or administrative in nature (e.g., a watershed versus a National Forest).

Accuracy Assessment

Because the land cover classification scheme employed for Montana is complex (more than 90 cover types), and many types overlap to varying degrees, we evaluate map accuracy using fuzzy sets (Gopal and Woodcock, 1994). A fuzzy matrix, derived from two-way tabulation of cover types, can be constructed to evaluate the acceptability of various misclassification possibilities (Table 2). Acceptability is ranked through scores assigned to each cell in this matrix. For example, confusion between Douglas-fir (*Pseudotsuga menziesii*) and Douglas-fir/lodgepole pine (*Pinus contorta*) may be considered less troublesome than confusion between Douglas-fir and foothills grassland.

Acceptability is rated on a scale from 1 to 5, as outlined by Gopal and Woodcock (1994): 1) absolutely wrong; 2) understandable, but wrong; 3) acceptable; 4) good; 5) perfect match. By rating acceptability in this manner, accuracy assessments can be conducted at both the acceptable and ideal levels, thus offering more information than traditional approaches.

We conduct separate assessments of accuracy for cover type, size class, and canopy cover. Plots from the test data sets are overlayed with the regions in the raster database; plot attributes are compared with classification results, and scores of 1-5 are drawn from the fuzzy matrix. Match and accumulate matrices for producer's and user's accuracies are constructed based on score distributions for each cover type, size class, or canopy class. Match matrices show the percentage of test plots for each score by cover type, etc.; accumulate matrices show the percentage of test plots for each score cumulatively, starting with score 5. The final accuracy figure for the TM scene is then weighted by the population size for each classified cover type: the accuracy obtained for each cover type (based on the test plots) is multiplied by the relative frequency of the cover type within the TM scene, with the assumption that the test data set contains 1000 plots.

In essence, the fuzzy matrix simply collapses a complex classification scheme to a more manageable number of classes. It does not compensate for spatial errors that may result from mapping generalizations. In the process of mapping large areas, error is introduced as a by-product when regions smaller than the selected MMU are eliminated. Likely, these small regions contain cover types dissimilar to the larger neighbors with which they are aggregated. Thus, if a sampling point does not fall in the majority value for an aggregated region, a point-based approach will be prone to bias. A modified systematic

cluster sampling for accuracy analysis (Ma and Olson, 1990) is a good approach for sampling test regions, where the cluster of points from each region is summarized as a representation of the region. In future efforts to assess thematic accuracy, we will consider incorporating this approach in addition to the fuzzy matrix.

Quality Control

As a last step, the raster databases for each scene must be examined for consistency and completeness, because each analyst may incorporate slightly different methods when analyzing training data and conducting supervised classifications. Thus, we used an AML to standardize final products. For example, attribute names are made more intuitive, attribute order is logically reorganized, and extraneous attributes are deleted. Key attributes are queried to confirm that their values match a list of acceptable possibilities. This final step helps to ensure data quality, and also yields a database that is efficiently and conveniently structured.

CONCLUSIONS

Mapping large areas using our two-stage process offers an approach that effectively balances the volume of data to be handled and the time frame allotted for a project. When TM and ancillary data are integrated in a GIS database, users can process information contained in many layers in a cost-efficient manner and at a controlled level of accuracy. The nonparametric, supervised classification algorithm, NEAREST MEMBER of GROUP, is flexible regarding the number of points in the training set, and it efficiently handles clustering of multisource data. Attribute information stored in a raster archiving

file offers distinct advantages for data retrieval and GIS modeling. Even databases covering large geographic areas can be archived and retrieved quickly and efficiently, minimizing computation time and storage space for a great volume of data. Further, these multisource attributes are well integrated in the GIS, and are efficiently stored for display, query, update, and spatial analysis in future applications. Many problems arising in conventional classifications of Landsat images across large areas have thus been suitably resolved, including computing time, file size, information storage, and edge-matching issues.

ACKNOWLEDGEMENTS

This research was funded in part by the U.S. Department of Interior, Fish and Wildlife Service and National Biological Service for the Montana Gap Analysis project, the U.S. Department of Agriculture, Forest Service Northern Region (Contract Nos. 53-0343-3-00027 and 53-0343-4-000012), and the National Aeronautics and Space Administration, Montana EPSCoR Program. IBM Corporation and the National Fish and Wildlife Foundation also contributed to this effort. L. Guy McWethy, Ronald L. Righter, Troy P. Tady, Judy M. Troutwine, and J. Christopher Winne made significant contributions to the development of various stages in this process. Steven R. Holloway, Ashley D. Jones, and Jim Schumacher helped with figure construction.

REFERENCES

Brown, J. F., T. R. Loveland, J. W. Merchant, B. C. Reed, and D. O. Ohlen, 1993. Using Multisource Data in Global Land Cover Characterization: Concepts, Requirements, and Methods. *Photogrammetric Engineering and Remote Sensing*, 59(6): 977-987.

Congalton, R. G., 1988. A Comparison of Sampling Schemes Used in Generating Error Matrices for Accessing the Accuracy of Map Generated from Remote Sensing Data. *Photogrammetric Engineering and Remote Sensing*, 54(5): 593-600.

Crist, E. P., and R. C. Cicone, 1983. Investigation of Thematic Mapper Data Dimensionality and Features Using Field Spectrometer Data. *Proceedings of the Seventeenth International Symposium on Remote Sensing of Environment*, Vol. III, pp. 1313-1322.

ERDAS, 1991. **Field Guide**, Second Edition, Version 7.5, Printed in the United States of America, 394 p.

ESRI, 1991. **Cell-based Modeling with Grid**. Version 6.0, Printed in the United States of America.

Gopal, S., and C. Woodcock, 1994. Theory and methods for accuracy assessment of thematic maps using fuzzy sets. *Photogrammetric Engineering and Remote Sensing*, 60(2): 181-188.

Heckbert, P., 1982. Color image quantization for frame buffer display. *Computer Graphics*, 16(3): 297-307.

Heuvelink, G. B. M., P. A. Burroughs, and A. Stein, 1989. Propagation of Errors in Spatial Modelling with GIS. *International Journal of Geographical Information Systems,* 3(4): 303-322.

Hixson, M., D. Scholz, N. Fuhs, and T. Akiyama, 1980. Evaluation of Several Schemes for Classification of Remotely Sensed Data. *Photogrammetric Engineering and Remote Sensing,* 46(12): 1547-1553.

Justice, C., and J. Townshend, 1982. A Comparison of Supervised and Unsupervised Classification Procedures on LANDSAT MSS Data for An Area of Complex Surface Conditions in Basilicata, Southern Italy. *Remote Sensing of Environment,* Vol. 12:407-420.

Keane, R. E., M. E. Jensen, and W. J. Hann. 1990. ECODATA and ECOPAC: analytical tools for integrated resource management. *The Compiler* 8(3):24-29, 31, 33-37.

Lillesand, T. M. and R. W. Kiefer, 1987. **Remote Sensing and Image Interpretation**, 2nd ed., John Wiley & Sons, New York, New York, 721 p.

Ma, Z., 1995. Merging "salt pepper" / small regions with large neighboring regions based on similarity of attributes. *GIS'95 Symposium on Natural Resources, Environment and Land Information Management,* Vancouver, British Columbia, Canada, pp. 834-837.

Ma, Z., M. M. Hart, and R.L. Redmond, in prep. What you see is what you get: using a color palette to drive unsupervised classifications of remotely sensed images. To be submitted to *Photogrammetric Engineering and Remote Sensing.*

Ma, Z. and R. L. Redmond, 1992. Building Attribute Tables for Raster GIS Files with ARC/INFO. Gap Analysis Technical Bulletin, The University of Idaho, Moscow, Idaho.

Ma, Z. and C. E. Olson, 1989. Spectral Matching in Supervised Classification of Terrain Features. *IGARSS '89*, Vol. II, pp. 638-640.

Ma, Z. and C. E. Olson, 1989. A Measurement of Spectral Overlap among Cover Type. *Photogrammetric Engineering and Remote Sensing*, 55(10): 1441-1444.

Ma, Z. and C. E. Olson, 1990. Accuracy Evaluation of Computed Classified Thematic Map with a Systematic Cluster Sampling Scheme. *IGARSS '90*, Vol. III, pp. 2379-2382.

Nemani, R., L. Pierce, S. Running, and S. Band, 1993. Forest Ecosystem Processes at the Watershed Scale: Sensitivity to Remotely-sensed Leaf Area Index Estimates. *Int. J. Remote Sensing*, 14(13): 2519-2534.

Russ, J. C., 1992. **The Image Processing Handbook**, CRC Press, Boca Raton, Florida, 445 p.

Scott, J. M., F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'erchia, T. C. Edwards, Jr., J. Ulliman, and R. G. Wright, 1993. Gap Analysis: A Geographic Approach to Protection of Biological Diversity. *Wildlife Monographs*, A Publication of The Wildlife Society, 41 p.

Skidmore, A. K., and B. J. Turner, 1988. Forest Mapping Accuracies Are Improved Using a Supervised Nonparametric Classifier with SPOT Data. *Photogrammetric Engineering and Remote Sensing*, 54(10): 1415-1421.

Tom, C. H., and L. D. Miller, 1984. An Automated Land-use Mapping Comparison of the Bayesian MAXIMUM LIKELIHOOD and Linear Discriminant Analysis Algorithms. *Photogrammetric Engineering and Remote Sensing*, 50(2): 193-207.

Warren, S. D., M. O. Johnson, W. D. Goran, and V. E. Diersing, 1990. An automated, objective procedure for selecting representative field sample sites. *Photogrammetric Engineering and Remote Sensing*, 56(3): 333-335.

Table 1. Issues related to mapping land cover across large geographic areas.

• *Integration of multisource data within a GIS database*
• *Multi-scene processing necessitates precise registration*
• *Choice of classification algorithm -- unsupervised versus supervised techniques*
• *Relative efficiency of raster and vector database formats*
• *Choice of minimum mapping unit for processing, mapping, and archiving data -- grain versus extent*
• *Methods for edge-matching results*
• *Accuracy control and assessment*

Table 2. Example of the user-defined fuzzy matrix incorporated in accuracy assessment, showing shades of acceptability between cover types (1 = absolutely wrong; 2 = wrong, but understandable; 3 = acceptable; 4 = good; 5 = perfect match).

	3101[a]	3104	3201	3305	4206	4212	4223	7300
3101	5	3	1	1	1	1	1	1
3104		5	1	1	1	1	1	1
3201			5	2	1	1	1	1
3305				5	1	1	1	1
4206					5	2	2	1
4212						5	4	1
4223							5	1
7300								5

[a] 3101 = foothills grassland; 3104 = montane parkland/subalpine meadow; 3201 = mesic upland shrub; 3305 = mountain big sage (*Artemisia tridentata*); 4206 = ponderosa pine (*Pinus ponderosa*); 4212 = Douglas-fir (*Pseudotsuga menziesii*); 4223 = Douglas-fir/lodgepole pine (*Pseudotsuga menziesii/Pinus contorta*); 7300 = exposed rock.

Figure 1. Major steps in the two-stage process developed for mapping existing vegetation and land cover across large areas. Both the first stage, an unsupervised classification of pixels, and the second stage, a supervised classification of regions, are driven by Euclidean distance calculations.

Figure 2. Land cover types. Polygons, mapped at 2 ha MMU, are labeled using a nonparametric, supervised classification algorithm.

Figure 3. Area of overlap between neighboring Landsat TM scenes.

Figure 4. The “cookie cutter” edge-matching process, whereby raster polygons from the dominant TM scene replace underlying areas in the subordinate TM scene to create a seamless output map.

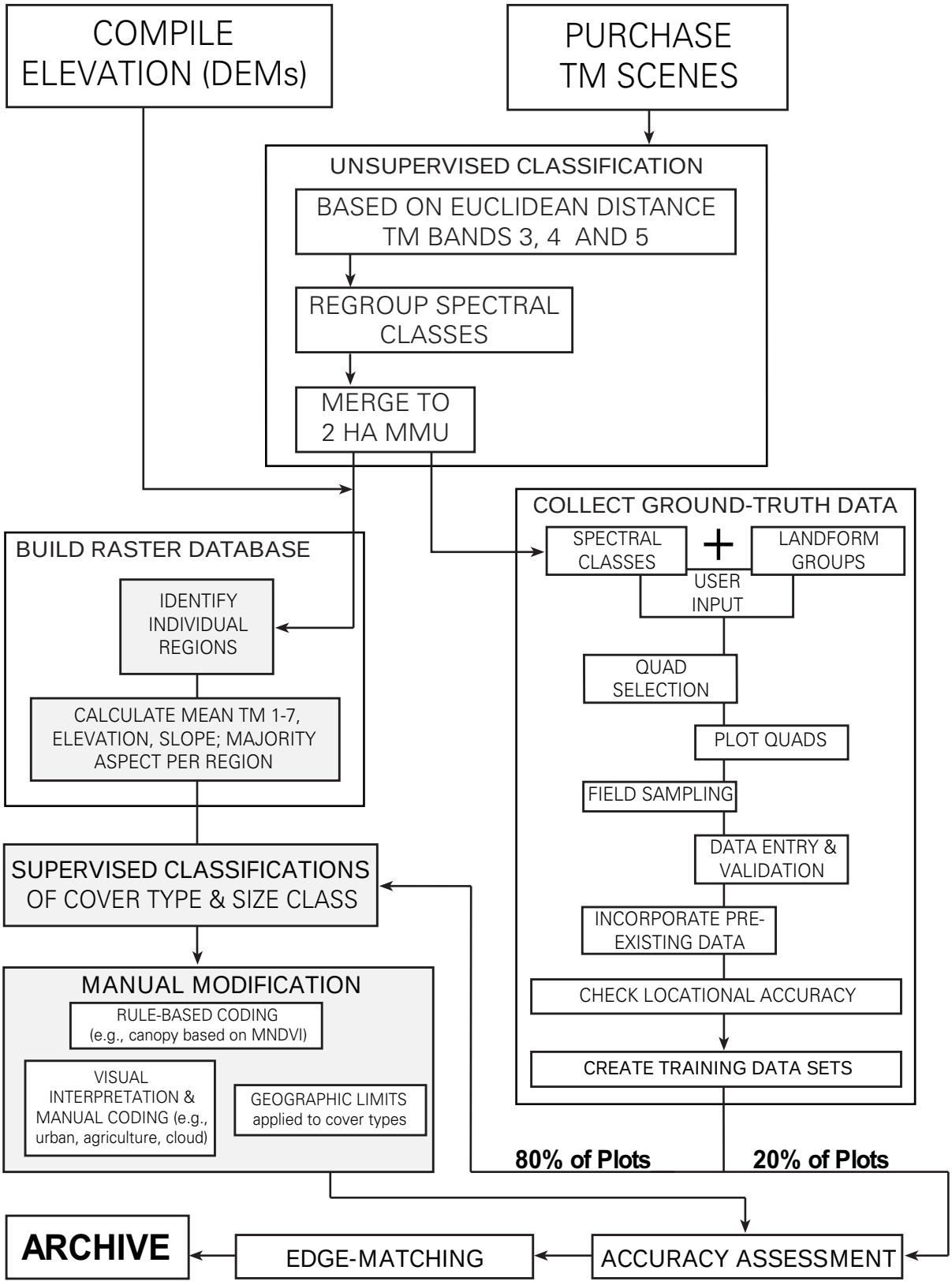


Figure 1. Major steps in the two-stage process developed for mapping existing vegetation and land cover across large areas. Both the first stage, an unsupervised classification of pixels, and the second stage, a supervised classification of regions, are driven by Euclidean distance calculations.

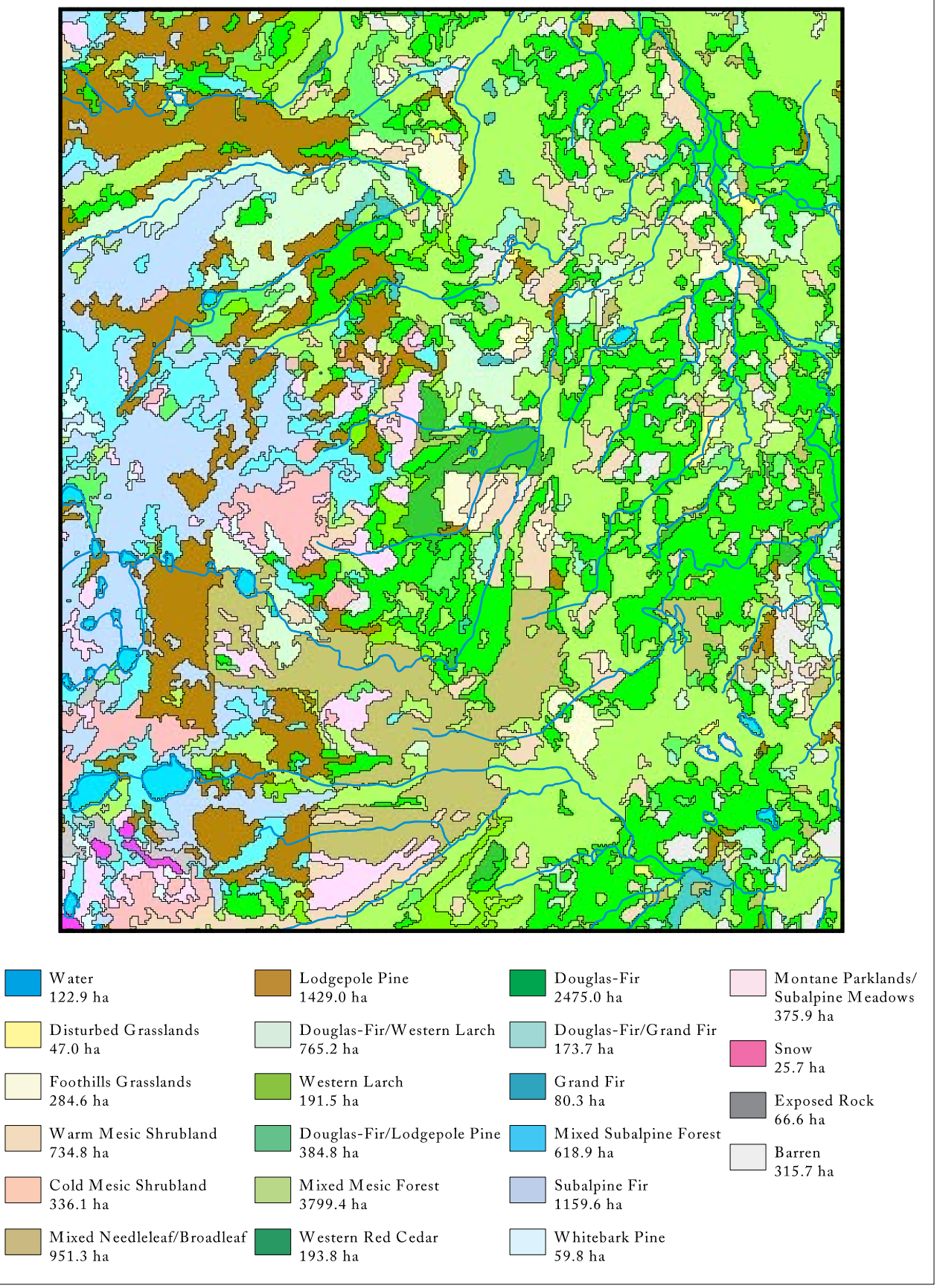
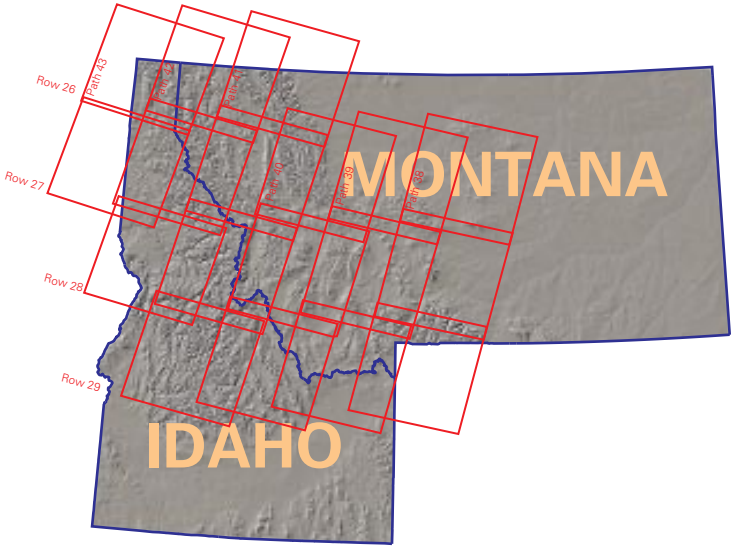
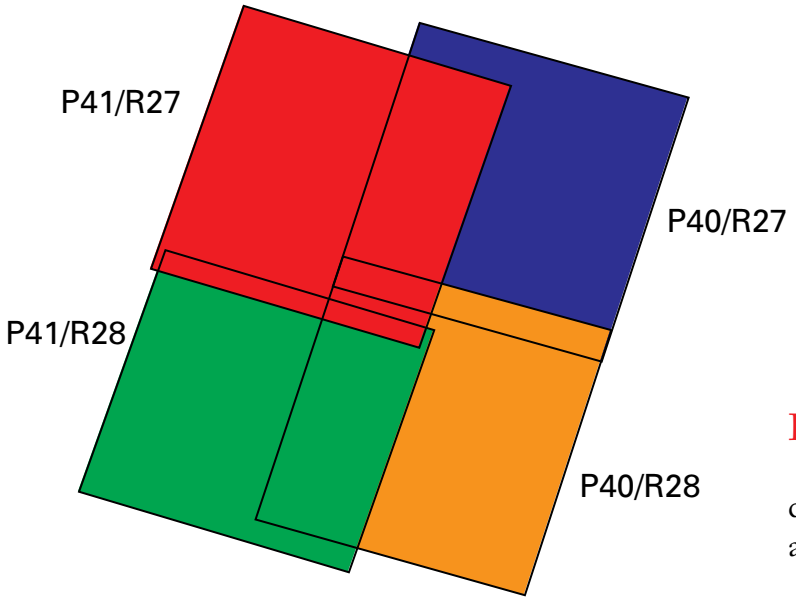


Figure 13. Classification of land cover types for the central Swan Valley, Montana.

Overlap:

Landsat TM scenes within the study area overlap roughly 40% by row and 20% by path.





Dominance:

Areas within the overlap are ordered by dominance. Four scenes from the 18 in the study area are shown at left, layered by their order of dominance.

Figure 3. Landsat TM Scenes: Overlap & Dominance

Edge-Matching Method

When an area to be classified and mapped extends beyond the boundaries of a single digital image, one must contend with how to edge-match adjacent images. Seamless edge-matching is desireable when any planning or assessment units, such as National Forests, counties, watersheds, or individual states, extend across multiple images. The cookie-cutter method is designed to preserve the integrity of individual image classifications and to minimize the perception of an "edge" between adjacent overlapping data sets. When adjacent images must be fitted together (as for the Montana land-cover map), multiple edge-matching operations must be performed.

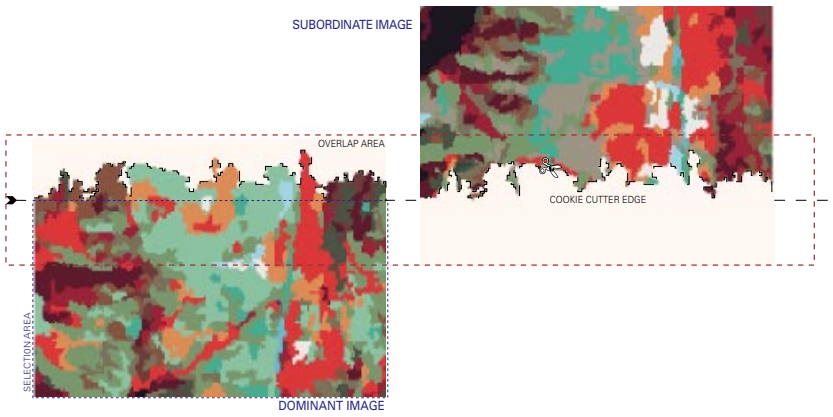
Cookie Cutter Method

The cookie cutter involves several GIS operations to perform the edge-matching. The result is an invisible boundary which follows natural patterns delineated in at least one of the images.

1. Select one image as dominant based on user specifications.

2. Draw a selection area on the dominant image; at least one of its sides must fall within the overlap area. This area is used to identify all polygons on the dominant image that lie at least partially within its boundaries. The MMU of the polygons must be small enough such that when selected they will not exceed the overlap area. The selection area can be any shape, and its boundaries can be drawn to avoid or include clouds or other features. Starting with scenes that are most dominant, selection areas are drawn for all necessary sides at the same time.

3. Create a new item in the GIS database called EDGE. All polygons on the dominant image at least partially within the selection area are assigned EDGE=1. Polygons outside the area are assigned EDGE=0 and will be dropped in the edge-matching process. The selected polygons (EDGE=1) are shown on the dominant image below.



4. Merge the dominant image with the subordinate one. In the process, the dominant image acts as a "cookie cutter", replacing the underlying portion of the subordinate image as shown to the right.



Figure 4. Edge-Matching Method

APPENDIX I: Land Cover Attributes for Northern Idaho and Western Montana

May 1996

The following items are contained in the raster databases (ARC/INFO grids) of existing vegetation and land cover created for each of the 18 Landsat TM scenes. Item definitions apply to the corresponding riparian grids as well; however, not all items are included in the riparian grids. Each of the 18 land-cover grids is roughly 50 megabytes in size (range ~40 -55 Mb), and has an average of 290,000 *regions*, or raster polygons (range ~228,000 -359,000). File sizes for riparian grids tend to be smaller because they have fewer attributes; however, because riparian data are maintained at 30 m MMU, these grids may contain nearly as many regions. Land-cover grids are named according to the following convention: p*r*zp (e.g., p41r27zp); riparian grids are p*r*ripzp. Actual item definitions, units, and valid ranges are included in Tables I-1 (for land cover) and I-2 (for riparian grids) at the end of this appendix.

Note that after edge-matching, some attribute values (especially mean and majority values) may be rendered inaccurate for subordinate regions in one scene that are partially obliterated or subdivided by dominant regions from the adjacent scene. Regions that are subdivided will be non-contiguous; without a second regiongrouping to reassign values, such regions cannot be identified. By repeating the operations used to derive those values (such as ZONALSTATS), attributes may be updated as needed. Original values were maintained because these are the values on which the classifications of cover type, size class, and canopy cover were based.

VALUE: Unique region identification number created by ARC/INFO; value should never be changed because it plays a critical part in maintaining raster topology, or the link between spatial and attribute data.

COUNT: Number of 30 m^2 pixels in the region; value calculated by ARC/INFO and should not be changed.

LIFEFORM: Dominant lifeform of the region; assigned by AML that queries COVERTYPE and CANOPYCODE values. If null, the region falls outside of the study area boundary.

N = non-vegetation
T = tree
S = shrub
H = grass/forb
A = agriculture

COVERTYPE: Land cover type assigned to the region (Appendix A), e.g. 4206 = ponderosa pine forest, 3201 = mesic upland shrub, 9100 = snow, 7300 = rock, etc. If this value does not equal the value in COV_CODE_1, then it has been manually modified. If zero, the region falls outside of the study area boundary. (Called **RIPARIAN** in the riparian grids.)

CANOPYCODE: Canopy closure class assigned to tree or shrub region based on

sliced MNDVI histogram. If zero, the region falls outside of the study area boundary.

1 = Low (15-39%)
2 = Medium (40-69%)
3 = High (70-100%)

SIZECLASS: Size class for tree and shrub cover types combined; equals zero for other lifeforms. If zero, the region falls outside of the study area boundary.

1 = Seedling/Sapling tree (< 5.0" DBH)
2 = Pole tree (5.0 - 8.9" DBH)
3 = Medium tree (9.0 - 20.9" DBH)
4 = Large/very large tree (> 21.0" DBH)
5 = Low shrub (< 2.5' tall)
6 = Medium shrub (2.5 - 6.5' tall)
7 = Tall shrub (> 6.5' tall)

ELE: Mean elevation (in meters) of region; value calculated in ARC/INFO (ZONALSTATS) using 7.5 min DEM data when available; otherwise, 3 arc second data resampled to 30 m^2 by Hughes/STX.

SLP: Mean slope value of region (in degrees); value calculated in ARC/INFO (ZONALSTATS) using 7.5 min DEM data when available; otherwise, 3 arc second data resampled to 30 m^2 by Hughes/STX.

ASP: Majority aspect value of region; value calculated in ARC/INFO (ZONALSTATS) using 7.5 min DEM data when available; otherwise, 3 arc second data resampled to 30 m^2 by Hughes/STX. Manually recoded to the following nine classes:

0 = flat
1 = north
2 = northeast
3 = east
4 = southeast
5 = south
6 = southwest
7 = west
8 = northwest

SPECTRAL_CLASS: Alternate name LINK. Spectral class code from unsupervised classification; value input directly into ARC/INFO and should not be changed.

COV_CODE_1: Most likely cover type assigned to region by supervised classification (Nearest Member of Group classifier; VIMAP).

COV_PROB_1: Euclidean distance that led to the cover type assigned by the supervised classification (COV_CODE_1); this is the smallest Euclidean distance that was calculated between attributes for this region and those for any region in the training data set. Assigned through supervised classification based on Nearest Member of Group classifier. Value has been rescaled by dividing by 1000:

$((TM1_{train} - TM1_{unk})^2 + (TM2_{train} - TM2_{unk})^2 + ...(TM7_{train} - TM7_{unk})^2 + (ELE_{train} - ELE_{unk})^2) / 1000$

COV_CODE_2: Second most likely cover type assigned to region by supervised classification (Nearest Member of Group classifier; VIMAP).

COV_CODE_3: Third most likely cover type assigned to region by supervised classification (Nearest Member of Group classifier; VIMAP).

TREE_SIZE: Live size class assigned to tree region; populated for all regions regardless of lifeform. Created through supervised classification based on either Nearest Member of Group, or in some cases Nearest Mean classifier; VIMAP.

1 = Seedling/Sapling (< 5.0" DBH)
2 = Pole Tree (5.0 - 8.9" DBH)
3 = Medium Tree (9.0 - 20.9" DBH)
4 = Large/Very Large Tree (> 21.0" DBH)

TREE_SIZE_P: Euclidean distance as described for COV_PROB_1. Value has been rescaled by dividing by 1000; formula is like that for COV_PROB_1, but ELE is not included.

SHRUB_SIZE: Live size class assigned to shrub region; populated for all regions regardless of lifeform. Created through supervised classification based on either Nearest Member of Group, or in some cases Nearest Mean classifier; VIMAP.

.

1 = Low (< 2.5' tall)
2 = Medium (2.5 - 6.5' tall)
3 = Tall (> 6.5' tall)

SHRUB_SIZE_P: Euclidean distance as described for COV_PROB_1. Value has been rescaled by dividing by 1000; formula is like that for COV_PROB_1, but ELE is not included.

MNDVI: Modified normalized difference vegetation index; calculated in ARC/INFO according to the following equation modified from Nemani et al. (1993):
(TM4 - TM3) / (TM4 + TM3 + 1) * (256 / (TM5 + 1)) * 100

TM1: Mean spectral value of region (TM channel 1); value calculated through overlay of region boundaries and 30 m pixels for TM channel 1 (ZONALSTATS).

TM2: Mean spectral value of region (TM channel 2); calculated as for TM1.

TM3: Mean spectral value of region (TM channel 3); calculated as for TM1.

TM4: Mean spectral value of region (TM channel 4); calculated as for TM1.

TM5: Mean spectral value of region (TM channel 5); calculated as for TM1.

TM6: Mean spectral value of region (TM channel 6); calculated as for TM1. If null for all regions, data for TM channel 6 were not available for this scene.

TM7: Mean spectral value of region (TM channel 7); calculated as for TM1.

HECTARES: Area for the region in hectares (COUNT * 0.09).

PERIMETER: Perimeter of region (meters); value automatically calculated by ARC/INFO when a temporary conversion from raster to vector format was performed.

X_COORD: X coordinate of region center (in meters defined by Albers Equal Area projection); corresponds to polygon label point automatically assigned by ARC/INFO when a temporary conversion from raster to vector format was performed.

Y_COORD: Y coordinate of region center (in meters defined by Albers Equal Area projection); corresponds to polygon label point automatically assigned by ARC/INFO when a temporary conversion from raster to vector format was performed.

SCENEPOLY_ID: Unique region identifier for entire project area. Generated by multiplying the scene number (1-18 below) by 1 million and adding the VALUE item. Required for clipping, and should not be modified.

1	P38/R27
2	P38/R28
3	P38/R29
4	P39/R27
5	P39/R28
6	P39/R29
7	P40/R27
8	P40/R28
9	P40/R29
10	P41/R26
11	P41/R27
12	P41/R28
13	P41/R29
14	P42/R26
15	P42/R27
16	P42/R28
17	P43/R26
18	P43/R27

DOM: 4-character value indicating specific dominance relationships between the scene in which this region falls, and the surrounding four scenes. The four characters correspond to N, E, S, and W (in that order); see items below. Values of 1 indicate that, after the edge-matching process, this region will be kept when certain combinations of scene grids are merged and clipped in subsequent processes; the position(s) of 1 values indicate scene combinations for which this holds true. In all, there are sixteen possible combinations: 1000 means that the region will be kept when merging with the grid to the north; 1010 means that the region would be kept in merging with the grid to the north and/or the south, but not to the east and west. Required for clipping, and should not be modified. Similar to KEEP (see below), but stores information on more complex relationships. Populated for all regions, regardless of whether or not they fall within the project area boundary.

DOM_N: Single-character value for this region indicating dominance relationship between the scene in which this region is located and the scene to the north. A value of 1 indicates that this scene is dominant; 0 indicates that the scene is subordinate to the one to the north.

DOM_W: Single-character value for this region indicating dominance relationship between the scene in which this region is located and the scene to the west. A value of 1 indicates that this scene is dominant; 0 indicates that the scene is subordinate to the one to the west.

DOM_S: Single-character value for this region indicating dominance relationship between the scene in which this region is located and the scene to the south. A value of 1 indicates that this scene is dominant; 0 indicates that the scene is subordinate to the one to the south.

DOM_E: Single-character value for this region indicating dominance relationship between the scene in which this region is located and the scene to the east. A value of 1 indicates that this scene is dominant; 0 indicates that the scene is subordinate to the one to the east.

KEEP: Single-character value for this region indicating whether or not the region will be kept when adjacent files are merged according to the currently defined edgematching scheme for the project area. A value of 1 indicates that the region will be kept, at least in part (regions along edges may be subdivided when files are merged); 0 indicates that the region will be entirely dropped. As with COVERTYPE and similar attributes, the KEEP item has only been populated for regions that fall at least partly within the project area boundary. If working with areas outside the project area boundary, DOM must be used.

Note that if a new grid is created based solely on the KEEP item (i.e., OUTPUT = P43R27ZP.KEEP), there may appear to be holes (areas where KEEP = 0 entirely surrounded by KEEP = 1) well within the edge-matched boundary on edges where the scene is subordinate (Fig. I-1). These holes are an artifact of the manner in which KEEP was created; if even a part of a region will be kept in the edge-matching process, the entire region will be coded KEEP = 1.

Where large polygons from the dominant scene extend into the subordinate scene, some configurations of subordinate polygons will be such that a subordinate polygon (S1) closer to the edge spans some portion of a dominant polygon (D). S1 will be coded KEEP = 1; when displayed, S1 will essentially cut off any subordinate polygon farther from the edge (S2) where KEEP = 0 because it is entirely within D. If completely surrounded by regions like S1, S2 will appear to be a hole. When the two scenes are merged into one, S2 will be entirely overwritten by D, as will the extra portion of S1. Thus, KEEP offers an appropriate shortcut for the entire edge-matching

process (clipper.aml), as long as the dominance order of scenes is maintained when merging scenes together (see below). It will, however, provide some extra information along scene borders (e.g., the part of S1 that will later be overwritten) and, when mapped out, will not present an exact geographic match with the specific area to be kept per scene. Furthermore, KEEP is not intended for single-scene operations.

SCENE DOMINANCE ORDER: To be used when merging adjacent scenes together based on KEEP in conjunction with other attributes.

(i.e., OUTPUT = MERGE(CON(P41R27ZP.KEEP == 1, P41R27ZP.COVERTYPE), CON(P41R26ZP.KEEP == 1, P41R26ZP.COVERTYPE).

1	P41/R27
2	P39/R27
3	P39/R28
4	P38/R29
5	P38/R28
6	P38/R27
7	P41/R28
8	P40/R28
9	P40/R29
10	P39/R29
11	P40/R27
12	P43/R27
13	P42/R27
14	P42/R26
15	P41/R26
16	P43/R26
17	P42/R28
18	P41/R29

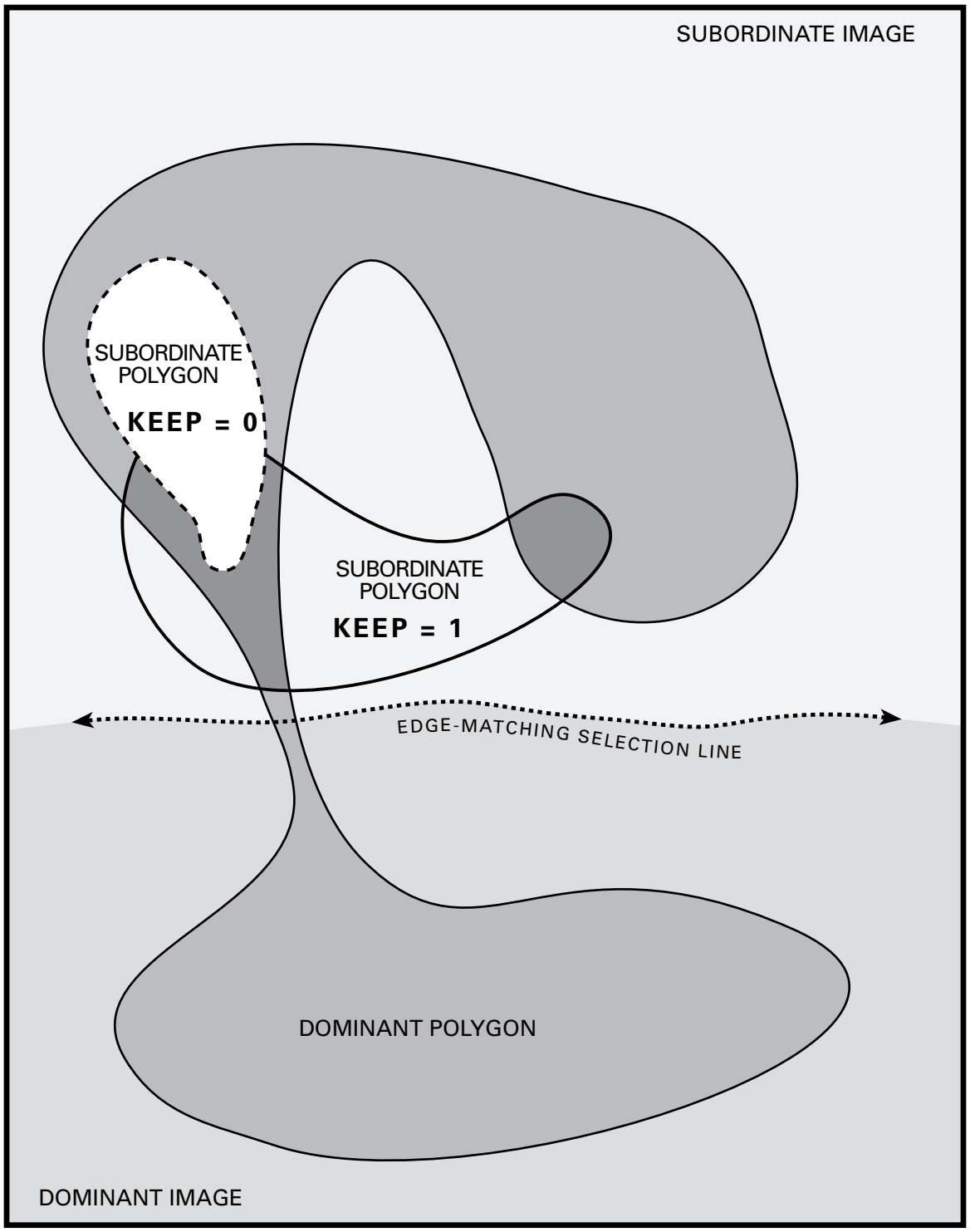


Figure I-1. Creation of new grids based on the KEEP item may suggest the presence of holes in the edge-matched raster databases. These "holes" occur where large, complex polygons in the dominant image stretch far into the subordinate image. "Holes" appear if small subordinate polygons are completely contained within large dominant ones (KEEP = 0), and yet are surrounded by subordinate polygons partly outside the dominant ones (KEEP = 1).

Table I-1. Items as defined in the value attribute tables (VATs) for the land-cover databases (ARC/INFO grid format) created for 18 Landsat TM scenes across northern Idaho and western Montana.

ITEM NAME	WIDTH	OUTPUT	TYPE	N.DEC	Units	Valid Range
VALUE	4	10	B	-		
COUNT	4	10	B	-		
LIFEFORM	1	2	C	-		A,H,S,T,N,<null>
COVERTYPE	2	5	B	-		0,(≥1000, <10,000), List
CANOPYCODE	2	4	B	-		0,1,2,3
SIZECLASS	2	4	B	-		0,1 - 7
ELE	2	4	B	-	m	0 - 5000
SLP	4	4	F	0	degs	0 - 90.0
ASP	2	2	B	-		0 - 8
SPECTRAL_CLASS	4	4	B	-		(Alternate Name = LINK)
COV_CODE_1	2	5	B	-		(≥1000, <10,000)
COV_PROB_1	4	8	F	5		
COV_CODE_2	2	5	B	-		(≥1000, <10,000)
COV_CODE_3	2	5	B	-		(≥1000, <10,000)
TREE_SIZE	2	2	B	-		1,2,3,4
TREE_SIZE_P	4	8	F	5		
SHRUB_SIZE	2	2	B	-		1,2,3
SHRUB_SIZE_P	4	8	F	5		
MNDVI	2	6	B	-		
TM1	2	4	B	-		0 - 255
TM2	2	4	B	-		0 - 255
TM3	2	4	B	-		0 - 255
TM4	2	4	B	-		0 - 255
TM5	2	4	B	-		0 - 255
TM6	2	4	B	-		0 - 255
TM7	2	4	B	-		0 - 255
HECTARES	4	12	F	2	ha	>0
PERIMETER	4	10	B	-	m	>120
X-COORD	4	8	F	0		
Y-COORD	4	8	F	0		
SCENEPOLY_ID	4	10	B	-		<sceneid><VALUE>
DOM	2	5	B	-		0,1111
DOM_N	2	2	B	-		0,1
DOM_W	2	2	B	-		0,1
DOM_S	2	2	B	-		0,1
DOM_E	2	2	B	-		0,1
KEEP	2	2	B	-		0,1

Table I-2. Items as defined in the value attribute tables (VATs) for the riparian databases (ARC/INFO grid format) created for 18 Landsat TM scenes across northern Idaho and western Montana.

ITEM NAME	WIDTH	OUTPUT	TYPE	N.DEC	Units	Valid Range
VALUE	4	10	B	-		
COUNT	4	10	B	-		
RIPARIAN	2	5	B	-		0,(≥6000, <7000), List
ELE	2	4	B	-	m	0 - 5000
SLP	4	4	F	0	degs	0 - 90.0
ASP	2	2	B	-		0 - 8
MNDVI	2	6	B	-		
TM1	2	4	B	-		0 - 255
TM2	2	4	B	-		0 - 255
TM3	2	4	B	-		0 - 255
TM4	2	4	B	-		0 - 255
TM5	2	4	B	-		0 - 255
TM6	2	4	B	-		0 - 255
TM7	2	4	B	-		0 - 255
HECTARES	4	12	F	2	ha	>0
PERIMETER	4	12	F	2	m	>120
X-COORD	4	8	F	0		
Y-COORD	4	8	F	0		
SCENEPOLY_ID	4	10	B	-		<sceneid><VALUE>
DOM	2	5	B	-		0,1111
DOM_N	2	2	B	-		0,1
DOM_W	2	2	B	-		0,1
DOM_S	2	2	B	-		0,1
DOM_E	2	2	B	-		0,1
KEEP	2	2	B	-		0,1

APPENDIX J. Interpreting Error Matrices

Error matrices, also referred to as "confusion matrices" or "difference matrices," are tables used as a method for assessing accuracy or agreement between a set of reference data ("true" data) and a set of data from a classified map. We have used this method of agreement analysis in two ways. First, error matrices were generated from USFS plot data to assess the ability of plots to correctly classify themselves, and thereby to evaluate spectral distinguishability among cover type classes. Error matrices were also used to assess the final accuracy of mapped cover types in relation to test plots. An understanding of error matrices and how they specifically apply to the land cover database is important in order to make the best use of this product; basic information on interpreting error matrices is provided toward this end. For additional information, see Congalton (1991) and Lachowski, et. al. (1995).

Assessing Confusion

To determine the spectrally representative nature of ground-truth plots, or how well a set of data correspond to consistent patterns of spectral reflectance, an assessment of the training plots may be made using an error matrix. The error matrix shows confusion between plots, and also cover type misrepresentation by certain plots in a ground-truth data set. It further provides a sense of the general variation in spectral patterns represented by the ground-truth set overall. To assess confusion, we used a technique called "bootstrapping." A single plot was extracted from the full data set (the population), and then classified as a cover type (size class, canopy cover class, etc.) using the spectral information provided by the remaining plots in the data set. The Nearest Member of Group classifier was used to identify the plot in the remaining set that had the smallest Euclidean distance from the extracted plot (based on the seven TM channels, as well as elevation for cover type). The extracted plot then received a cover type label corresponding to the label for the plot identified as the best match. This process was repeated for all of the points in the ground-truth set. The output of the bootstrapper program, the error matrix, provides an abundance of useful information if interpreted correctly. As an example, we will interpret an error matrix generated for cover type codes from the ground-truth data set for scene P43/R27 (Table J-1).

Table J-1. Error (confusion) matrix calculated for cover type classes from test data for P43/R27.

RF/CF	3101	3201	4102	4203	4206	4207	4208	4210	4212	4215	4220	4221	4222	4223	4301	7301	7800	0	
3101	61	12	1	1	4	0	0	0	0	0	0	1	1	0	1	2	3	|	87
3201	18	28	1	1	2	0	0	0	1	0	0	2	0	0	0	0	0	|	53
4102	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|	1
4203	1	0	0	2	0	0	0	1	2	2	1	7	0	2	0	0	0	|	18
4206	5	4	1	0	7	0	0	0	3	1	0	2	2	0	0	0	0	|	25
4207	0	0	0	0	0	0	1	2	0	0	0	8	2	0	0	0	0	|	13
4208	0	0	0	0	0	1	3	0	0	2	1	4	0	0	0	0	0	|	11
4210	0	0	0	1	0	2	0	7	0	0	0	1	0	1	1	0	0	|	13
4212	0	1	0	3	2	4	1	0	12	1	1	3	3	2	2	0	0	|	35
4215	0	0	0	1	1	0	1	1	1	2	1	2	1	1	0	0	0	|	12
4220	0	0	0	0	0	0	1	0	1	0	10	1	0	0	0	0	0	|	13
4221	0	2	0	7	2	7	3	1	9	2	1	64	3	5	4	0	1	|	111
4222	0	2	0	0	7	2	0	0	2	1	0	2	5	0	0	0	0	|	21
4223	0	0	0	2	0	0	0	1	1	2	0	6	0	0	1	1	0	|	14
4301	1	0	0	0	1	1	0	1	1	0	0	5	1	1	1	0	0	|	13
7301	3	1	0	0	0	0	0	0	0	0	0	0	0	1	0	4	1	|	10
7800	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	7	|	12
0	92	51	3	18	26	17	10	14	33	13	15	109	18	13	10	8	12		

PERCENTAGE AGREEMENT: 46.10%
TAU WITH EQUAL PROBABILITY: 0.4276
TOTAL DIAGONAL ELEMENTS : 213
TOTAL DATA POINTS: 462

The matrix provides information for all of the cover type codes represented by the ground-truth plot set. Starting in the upper left corner, "RF/CF" refers to the "Reference File" (RF), and the "Classified File" (CF). These may also be labeled "Plot Cover Types" (RF), and "Classified Cover Types" (CF). The cover type codes are listed across the top and down the left column of the matrix. The codes along the top of the matrix represent the output classified data set generated from the bootstrapper program (CF), and those along the left column represent the input ground-truth data set (assumed to be 100% accurate) or reference data set (RF). Note that often error matrices are constructed with columns representing the reference data set and rows as the classified data set, but the principles of interpretation remain the same. The rows and columns of an error matrix should always be labeled to allow correct

interpretation of the matrix.

The major diagonal shows how many points classified by the ground-truth training set were actually given the same code as their original designation. These "correct hits" are referred to as "diagonal elements." For example, if a ground-truth plot labeled as 3101 was extracted from the ground-truth training set and then classified as 3101 in the bootstrapping process, the plot would be counted on the diagonal as an exact match or as having no error. Table J-1 shows that 61 out of 87 plots coded as 3101 were actually classified as 3101 (61 diagonal elements).

The matrix is read across each row to assess commission error, or errors of inclusion, located off of the major diagonal. For example, Table J-1 shows that 12 out of 87 plots coded as 3101 (Foothills Grassland) were incorrectly classified as 3201 (Disturbed Grassland). The matrix is read down the columns to assess omission error, or mistakes due to exclusion. In the case mentioned above, 12 plots that should have been classified as 3201 were omitted from that class and instead classified as 3101. Errors of commission and omission are simply inverse concepts that have different implications toward a map's utility for various purposes, or in the case of Table J-1, what kind of problems are likely to be associated with the training plots. Each of the above examples can be measured using one of the following accuracy assessments:

User's Accuracy: This measurement relates to commission error and represents the probability that a classified plot (or any other sort of unit) actually represents that class on the ground or in the ground-truth set in the case of Table J-1. User's accuracy is calculated by dividing the total number of correct classifications for a class (diagonal elements) by the total number of classified data plots for that class, found in the bottom row of each column.

User's Accuracy for 3101 = 61/92 = 66%

Producer's Accuracy: This measurement relates to omission error and represents the probability of a plot (or any other sort of unit) being correctly classified. Producer's accuracy is calculated by dividing the total number of correct classifications for a class (diagonal elements) by the total number of reference plots for that class, found in the far right column for each row.

Producer's Accuracy for 3101 = 61/87 = 70%

Overall Accuracy: This measurement is calculated by dividing the total number of correct classifications (diagonal elements) by the total number of ground-truth data plots. It is equal to percentage agreement (Table J-1).

Overall Accuracy = 213/462 = 46%

Tau with Equal Probability: Because percentage agreement does not take into account agreement between data sets due to chance alone, it tends to overestimate classification accuracy. The Tau coefficient is one way to adjust for chance agreement (see Ma and Redmond, 1995); it is calculated as:

$$T = \frac{\%\ \text{Agree} - P_r}{1 - P_r} = \frac{0.43 - \frac{1}{17}}{1 - \frac{1}{17}} = 0.43$$

where

$P_r = \frac{1}{\text{n groups}}$, with equal probability

The bootstrapper error matrix is used to help image analysts decide which ground-truth plots are inadequate for use as training data for the supervised classification process. The overall accuracy figure for the error matrix also gives a fairly reliable prediction of the actual supervised classification accuracy. Ground-truth plots that do not represent their assigned cover type cause major problems during cover type labeling processes, and must be set aside at the earliest possible step. Examples include plots that fall in the wrong geographic location, and plots that are atypical of the assigned cover type (e.g., a forested plot that just meets the 15% cover breakpoint for assignment to a forest type, where spectral reflectance is dominated by shrub species). The influence of one incorrect training plot can potentially spread throughout an entire map. The use of an error matrix to assess potential training plot confusion is a simple and effective method that, when employed at an early stage, may increase the accuracy of a land-cover classification based on satellite imagery. We point out, however, that an exact match between plots does not necessarily mean that the plot is a good representative of a cover type, but only that it is similar to other plots with the same cover type in the ground-truth set.

Interpreting Outputs of Accuracy Assessment Using Fuzzy Sets

The following tables are accuracy assessment outputs for a classification of tree size for P43/R27. The first is a standard confusion, or error, matrix; however, it also includes the fuzzy scores in parentheses rating each classification possibility. Again, this table can be used as an indication of which types tend to be confused with each other. The match matrices for producer's and user's accuracies show the number (N) and percentage of plots in each group that received each score, from 5 (perfect match) to 1 (absolutely wrong), with an average over all groups reported as well (SUM). The accumulate matrices, again for producer's and user's accuracies, show cumulative totals (scores 5+4+3+2+1). For example, for group 1 (seedling/ sapling), 2 out of 5 plots were absolutely correct (score 5; 40%); no additional plots received a score of good (4), so the percentage remained the same; 2 additional plots were acceptable (3), making the cumulative total 80%; no additional plots were understandable but wrong (2); and the final plot was absolutely wrong (1), bringing the cumulative total to 100% of the plots. The final tables are match and accumulate matrices for area-weighted producer's accuracies. Notice that all percentages within the table are the same as for the unweighted producer's accuracy -- only the the overall percentage (SUM) has changed. Unlike the percentages, plot numbers have changed, because the formula for calculating weighted producer's accuracy operates on the assumption of 1000 test plots (see Methods). Accuracy figures reported in the Results and Discussion were drawn from the producer's accumulate matrices (unweighted and weighted). All of the tables below were maintained, however, because each offers slightly different information to the user in deriving conclusions about the validity and utility of various classifications.

CONFUSION (FUZZY) MATRIX

RF/CF	1	2	3	4	SUM
1	2(5)	2(3)	1(1)	0(1)	5(0)
2	1(3)	1(5)	2(3)	0(1)	4(0)
3	2(1)	9(3)	15(5)	3(3)	29(0)
4	0(1)	0(1)	0(3)	1(5)	1(0)
SUM	5(0)	12(0)	18(0)	4(0)	39(0)

Diagonal Elements = 19; Total Test Points = 39

Percentage Agreement = 48.72; Tau w/equal Prob = 0.316

MATCH MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	40.00	0	0.00	2	40.00	0	0.00	1	20.00
2	1	25.00	0	0.00	3	75.00	0	0.00	0	0.00
3	15	51.72	0	0.00	12	41.38	0	0.00	2	6.90
4	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	19	48.72	0	0.00	17	43.59	0	0.00	3	7.69

ACCUMULATE MATRIX (producer)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	40.00	2	40.00	4	80.00	4	80.00	5	100.00
2	1	25.00	1	25.00	4	100.00	4	100.00	4	100.00
3	15	51.72	15	51.72	27	93.10	27	93.10	29	100.00
4	1	100.00	1	100.00	1	100.00	1	100.00	1	100.00
SUM	19	48.72	19	48.72	36	92.31	36	92.31	39	100.00

MATCH MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	40.00	0	0.00	1	20.00	0	0.00	2	40.00
2	1	8.33	0	0.00	11	91.67	0	0.00	0	0.00
3	15	83.33	0	0.00	2	11.11	0	0.00	1	5.56
4	1	25.00	0	0.00	3	75.00	0	0.00	0	0.00
SUM	19	48.72	0	0.00	17	43.59	0	0.00	3	7.69

ACCUMULATE MATRIX (user)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	2	40.00	2	40.00	3	60.00	3	60.00	5	100.00
2	1	8.33	1	8.33	12	100.00	12	100.00	12	100.00
3	15	83.33	15	83.33	17	94.44	17	94.44	18	100.00
4	1	25.00	1	25.00	4	100.00	4	100.00	4	100.00
SUM	19	48.72	19	48.72	36	92.31	36	92.31	39	100.00

MATCH MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	43	40.00	0	0.00	43	40.00	0	0.00	22	20.00
2	78	25.00	0	0.00	235	75.00	0	0.00	0	0.00
3	258	51.72	0	0.00	207	41.38	0	0.00	34	6.90
4	79	100.00	0	0.00	0	0.00	0	0.00	0	0.00
SUM	458	45.85	0	0.00	485	48.55	0	0.00	56	5.61

ACCUMULATE MATRIX (weighted producer) (assuming 1000 points)

	Score 5		Score 4		Score 3		Score 2		Score 1	
GROUP	N	%	N	%	N	%	N	%	N	%
1	43	40.00	43	40.00	86	80.00	86	80.00	108	100.00
2	78	25.00	78	25.00	314	100.00	314	100.00	314	100.00
3	258	51.72	258	51.72	465	93.10	465	93.10	499	100.00
4	79	100.00	79	100.00	79	100.00	79	100.00	79	100.00
SUM	458	45.80	458	45.80	944	94.40	944	94.40	1000	100.00