LANDTYPE ASSOCIATIONS

OF THE

NORTHERN REGION,

A FIRST APPROXIMATION

COMPILED BY

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ABSTRACT

This document describes the Landtype Associations that have been developed for National Forest land in the Northern Region. Map units were delineated at a scale of 1:100,000 and are differentiated by dominant categories of landforms and geologic materials. Descriptions of the seventy one Landtype Associations were prepared for the nineteen Sections that occur in Region 1 using the National Hierarchy of Ecological Units. A total of 40,392,207 acres were mapped. Examples of applications using landtype associations are also presented. These landtype associations were developed primarily for use in landscape and watershed characterization. A geo-referenced, electronic version of the mapping was prepared as a component of this mapping project.

Key Words: landtype associations, National Hierarchy of Ecological Units, landforms, geologic materials

PREFACE

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Chapter 1

PURPOSE, APPLICATIONS, METHODS AND LIMITATIONS

PURPOSE:

The intent of this project was to develop a set of 1:100,000 scale maps differentiating the dominant combinations of landforms and geologic materials (bedrock and surficial) that occur on Forest Service lands throughout northern Idaho, Montana, and North Dakota (Figure 1). Some areas of other ownership are included. Map unit delineations were based on a uniform legend and map unit descriptions were prepared for each of the landtype associations (LTAs) accounting for variability between Sections. The project also incorporated the use of a Geographic Information System to develop a continuous, geo-referenced electronic version of the mapping.

This report reflects our first attempt to translate on-the-ground knowledge into the landscape scale of the National Hierarchical Framework of Ecological Units (ECOMAP, 1993). (See Appendix A for a summary of this hierarchy). These maps and descriptions are a first approximation of the landtype associations of the Northern Region. Each time the landtype association maps and descriptions are refined the quality of these products will be enhanced.

Previous ecological unit mapping has been completed at the Section (Bailey and others 1994a) and Subsection levels (Nesser and others 1997) for the Northern Region. It is recommended that the reader be familiar with these documents before using this one. Landtype associations further refine the characterization of landscapes from Sections and Subsections into units that describe the composition of landscapes by similarities and repeatable patterns in landforms, their dominant formative processes, and underlying geologic materials.

The display of mapped information is not inclusive of all known geomorphic categories, nor (due to the mapping scale) is it precisely site specific. The incorporation of a conceptual ecological hierarchy into geo-referenced delineations requires many interpretive iterations; each at a more refined scale and level of resolution.

A decision was made to limit this report to the mapping and characterizations of the LTAs. Interpretations evolve and change, which can make documents such as this obsolete in a short period of time. For this reason, this report will only briefly discuss some of the general interpretations and applications which are appropriate to make using this information. For a more detailed discussion of site specific interpretations for LTAs and local soil monitoring results refer to Forest level landscape assessment documents or SOLO (Rice,et al.1997).

APPLICATIONS OF THE LANDTYPE ASSOCIATION MAPPING

This mapping is the best single source of information on the soils of the Northern Region. It can be used by itself to gain an understanding of landforms and geologic materials throughout the Northern Region, or in combination with other landscape attributes such as vegetation to support a wide range of landscape level characterizations. The inherent features of map units such as the LTAs, which depict the geomorphic environment, generally do not change with management activities so they can be used as a template for examining the existing conditions of the land (vegetation, wildlife, etc) which are subject to change by management or by natural disturbances (Bailey 1994b).

Landtype associations can be developed for a variety of interpretive purposes. These Regional LTAs were developed primarily to support landscape level characterization of watershed properties important to management. The use of landforms and geologic materials as mapping differentia for this purpose is based on the assumption that these are features which can be mapped consistently at the landscape level, and that closely predict significant differences in watershed, stream, and riparian properties. In addition to watershed characterization, the LTA's can be appropriately used to assist with a variety of landscape level analyses and interpretations.

The primary utility of this mapping is its use as a stratification tool for analyzing locations with similar geomorphic attributes and the landscape properties that these attributes control and influence. When used in conjunction with the Section and Subsection levels of the ecological mapping hierarchy, LTA information can also display the distribution and extent of landform/geologic material groups within regionally specific climatic and geographic zones.

Fundamental to the appropriate use of the LTA's is an understanding of the ecological processes controlled and influenced by geomorphic properties. These include: the physical and chemical properties of soils (ie. soil texture and nutrient status); erosional characteristics; and hydrologic basin morphometrics. As more is learned about biophysical influences on ecological processes other relationships will undoubtedly emerge.

Geologic material plays a dominant role in controlling topographic relief, the development of landforms, and their distribution across landscapes. Landforms, combined with surficial parent material and other environmental factors such as climate, greatly influence the textural classes and nutrient status of the soils that develop. Knowledge of the dominant textural class of soils is necessary for predicting erosional and depositional characteristics. The extent and distribution of various kinds of soils influences the extent and distribution of vegetation. The nutrient status of the soil plays a significant role in influencing the growth rates and vigor of vegetation.

The distribution and extent of dominant landforms greatly determines the physiographic features of hydrologic basins. Basin morphology influences the distribution and extent of unique valley types, riparian and wetland characteristics, and stream channel properties. The extent and distribution of unique stream types within any watershed (classified by width/depth ratios, particle size distribution, cobble embeddedness, etc.) are closely correlated with the unique landform/geologic material combinations that are expressed.

Using a Geographic Information System (GIS) and the knowledge of inherent biophysical landscape relationships, a variety of models have been developed to provide additional attributes to portions of the LTA map theme. The inherent and derived attributes have been used to characterize and classify landscape level ecological units and watersheds throughout the Region. The following examples are included to illustrate some of these applications for specific projects throughout the Region:

Mass Wasting/Erosion Potential: To develop this interpretation, each LTA polygon is further attributed with a minimum, maximum, and mean slope value from 30 meter resolution Digital Elevation Models (DEMs). In addition, each LTA map unit is assigned a value for erodability based on research results for each dominant parent material/soil category. The range of slope attributes combined with dominant surface and subsurface soil texture values within unique precipitation zones are then evaluated for potential surface erosion and mass wasting.

Valley/Stream Type: Delineations of dominant valley types are inherent in the mapping. Other less prominent valleys and drainages are included as components or inclusions of many other LTA's. These can be identified using the LTA map unit descriptions and can also be displayed visually by using the streams data and DEMS for any given location. The composition of valley bottom types within each LTA is commonly within a fairly narrow range, controlled by the climatic zone and structural properties of the unit. More refined distinctions of valley and stream types within each map unit delineation can be derived by developing distinct slope categories (based on the DEMs) and assigning those to each stream segment. Stream segments, when assigned an LTA attribute to assist with the characterization of dominant width/depth ratios, particle size distribution and other parameters controlled by landform/geologic material can be more readily classified. Reasonable predictions for stream sinuosity and Rosgen stream type can also be derived for streams within each LTA map unit using calculations that combine attributes of the topography and drainage patterns.

Stream Density/Dissection: A drainage density attribute can be calculated for each LTA by dividing the sum of the length of all streams per LTA polygon by the total area per LTA to derive stream miles per square mile of map unit. This drainage density ratio can be used to evaluate landscapes for sediment delivery potential to streams in varying geographic locations.

Sediment Production and Delivery: Using the slope, dominant surface texture and stream density variable for each LTA polygon, an interpretation can be made for predicting a generalized range of values for inherent sediment production and delivery potential for each map unit or combinations of units within a watershed. To compare existing watershed sedimentation conditions with natural sedimentation, additional information representing vegetation and disturbance patterns must be included as steps in the analysis.

MAPPING METHODS:

The geo-referenced electronic data to accompany this mapping project was created using two primary techniques. In the first, each Forest Soil Scientist drafted landfom/geologic material delineations on 1:100,000 scale stable base contour maps. A professional cartographer then transferred these delineations onto a mylar base registered to the stable contour base map. Each 1:100,000 quadrangle was edge-matched with the adjacent quads during the drafting procedure. The archival mylar base maps were then electronically scanned at 400 dpi to create a geo-referenced digital file. This drawing was then transferred into the appropriate coordinate system (Albers Equal Area Projection) for the 1:100,000 scale quadrangles. A registration error of .007 was accepted as a maximum. Polygon topology was built for each coverage and a Landtype Association attribute assigned to each polygon. Individual quads were then electronically edge-matched and joined into draft coverages for larger geographic areas. This method was employed for those Forests that did not have complete landtype level mapping available. These included the Idaho Panhandle, Bitterroot, and Deerlodge Forests.

The second technique used for creating the LTA coverage was applied to those locations where existing electronic coverage of the 1:24,00 scale Landtype (Order 3 Soil Survey) mapping was available. In this situation, an LTA attribute was added to the coverage and each landtype polygon was assigned to the appropriate landform/geologic material category of the Region 1 legend. The resulting polygon coverages were then dissolved on the LTA attribute to display the broader delineations, and were ultimately joined with mapping for the adjacent Forests.

In both situations, numerous iterations of draft plots of the linework were sent to the mappers for review, corrections and additional edge matching. A final correlation of the mapping was then conducted using final draft maps, tables of acreages calculating the extent and distribution of all units, and accessory attribute information. The final resulting coverage was then associated with the electronic version of the Section and Subsection mapping to assign the appropriate upper level identifier to each LTA polygon. The electronic coverage now available represents the last corrected update of this mapping. The final Regional LTA coverage contains over 33,415 LTA polygons covering an area of 40,392,207 acres.

Hard copy versions of the mapping for each 1:100,000 scale quadrangle can be plotted using the map compositions that are included on this CD.

Throughout the Landtype Association mapping project, Geographic Information System (GIS) hardware, software, and technical expertise were provided through a cooperative agreement with the Natural Resource Information System (NRIS) of the Montana State Library. Digital data were processed using a SPARC 20 UNIX workstation running Version 7.04 of the ARC-INFO program. The LTA coverage can be retrieved from the Management Systems Group of Region 1.

LIMITATIONS OF THE MAPPING

As with any map product, the basic principles of scale apply to the LTA mapping. The Landtype Associations provided in this publication were compiled at a scale of 1:100,000 and should be used for stratification purposes only at larger scales such as 1:24,000.

The Sections were mapped at 1:1,000,000; the Subsections at 1:500,000. For this reason when displayed in relationship to the LTA's their boundaries are only approximately located. Section and Subsection delineations were electronically incorporated into the LTA coverage for referencing and attributing purposes only. The upper level delineations were not adjusted to the 1:100,000 map scale in the GIS processing resulting in 'slivers' that are artifacts of combining information generated at different scales. Consequently, data summaries may show some LTAs as occurring in one Section or Subsection which may actually occur in the adjacent unit. Future refinements of all levels of the ecological mapping will provide the opportunity to adjust these delineations. Time constraints prohibited that from occurring in this first approximation.

At the present time, geologic mapping is incomplete in some areas. While this LTA mapping used the best available geologic information, it will be possible to improve the landtype associations as new geologic maps become available.

This project was initiated to map Landtype Associations on National Forest land and is not intended to be the primary source of information for other ownerships. Readers desiring information on private land should consult their local Natural Resource Conservation Service office. Where Bureau of Land Management, National Park Service, or Tribal lands are of interest, contact their nearest office for information.

The authors of this document and compilers of the map series realize that there may be errors due to time or information constraints that we have failed to recognize and correct. Users of this information are encouraged to submit corrections to the Regional Soil Scientist for incorporation into the second approximation.

LANDTYPE ASSOCIATIONS OF THE NORTHERN REGION

Chapter 2

MAPPING DIFFERENTIA AND LEGEND

Map Unit Differentia:

At the Landtype Association level, ecological units delineations incorporate the intended use of the map; features used to delineate polygons are referred to as the differentiating criteria. The differentiating criteria for the LTA mapping were the dominant types of landforms and geologic materials that occur on National Forest lands in the Northern Region. The landform and geologic material groups that were used in the mapping are described in the following sections.

Other attributes (accessory characteristics) are also described for each map unit, but were not used as delineation criteria. Accessory characteristics described for the LTA's include: elevation range, slope range, average annual precipitation, surface and subsoil textures and rock fragment contents, stream pattern and density, soil taxa at the subgroup level, and potential vegetation at the series level.

The legend that was developed for the LTA mapping project was designed to cover the major types of landforms and geologic materials that occur throughout the Northern Region. Where differences in landform or geologic materials occurred, they were separated into the landform groups, rock types, or weathering classes listed in the legend.

In some areas, such as the continentally glaciated Belt rocks, the geology is relatively simple and it was possible to prepare a single map unit description for each LTA that occurred in a Section. Where the geology is more complex, it was not possible to do this. In these cases, Subsections were used as the basic template for separating differences in LTAs. If a Section had occurrences of the same general landform and geologic type but with very different accessory characteristics (soils, climate, potential vegetation). the preferred way of addressing these differences was to separate the Map Unit Descriptions (MUD’s) by Subsection.

General Discussion of the Landform Groups

The following fifteen major landform groups were used in the mapping ofLTAs. See Figure 2 for a display of their general occurrence throughout the Region. Appendix C contains the acreage figures for landform groups.

Valleys
Breaks
High Relief Mountain Slopes
Steep Glaciated Mountain Slopes
Glaciated Mountain Slopes
Mountain Slopes and Ridges
Frost Shattered Mountain Ridge Tops
Low Relief Hills
Mass Wasted and Colluvial Slopes
Glaciated Plains
Sedimentary Plains
Badlands
Glaciolacustrine Plains
Erosional Plateaus and Buttes
Hills and Plateaus

Eroded Uplands

These landform groups are described below using the following criteria:
1) Primary landforms
2) Process of development
3) Slope gradient
4) Surface shape
5) Associated landforms

VALLEYS: The primary landforms included in this unit are floodplains, terraces, and alluvial basins formed by recent streams or by glacial meltwater. A variety of water-deposited sediments occur in these valleys. The alluvial deposits vary from poorly sorted and stratified to well sorted and stratified; some dune deposits also occur. These units typically have straight or convex slopes that range in gradient from 0 to 30 percent. They may also contains narrow terrace escarpments which can be much steeper. The surface shape typically is level to very gently rolling. Associated landforms include both glaciated and unglaciated mountains slopes and gently to moderately sloping hills. Due to the scale of the mapping only major valleys are delineated. Smaller valleys and drainages are described as components of other map units.

BREAKS: In the Northern Region these are frequently referred to as breaklands. The more commonly accepted term of Breaks is used in this publication. The two main types mapped were structural breaks and stream breaks. The primary landforms included in this unit are breaks and escarpments. These generally have straight slopes in excess of 60 percent, with a slope range from 50 to greater than 100 percent. Breaks typically have abrupt changes to gentler slopes with the adjacent landforms. These landforms have developed by tectonic activity and/or rapid stream downcutting processes. In some places they have been modified by glacial action. Associated landforms include mountain slopes and ridges, and alluvial valley floors. These units occur primarily in western Montana and north Idaho.

HIGH RELIEF MOUNTAIN SLOPES: Unglaciated mountain slopes of high relief. In general, an elevational change of greater than 244 meters (800 feet) is common to these units. Slope gradients are greater than 40 percent. These units were primarily mapped east of the Continental Divide.

STEEP GLACIATED MOUNTAIN SLOPES: The primary landforms included in this unit include cirque headwalls, glacial troughwalls, alpine ridges and cirque basins. These landforms are predominantly formed by alpine glacial erosion processes but include areas of glacial deposition. Due to the scale of the mapping and the close physical association of these landforms, they were combined into a single map unit. Cirque headwalls and glacial troughs typically have straight or concave slopes that range in gradient from 50 to greater than 100 percent. Alpine ridges have convex slopes ranging from 10 to 40 percent. Cirque basins are typically bowl-shaped landforms with gradients from 0 to 30 percent.

Associated landforms include gentle to moderately sloping glaciated lands, mountain ridge tops, and valley floors. This steep glaciated map unit has characteristics similar to the gentle to moderately sloping glaciated land produced by continental glaciation; however that unit typically has more subdued topography and occurs at lower elevations. This unit also includes broad, ice-cap ridges having less than 40 percent slopes and equal amounts of subdued glacial erosion and deposition. These units were mapped throughout the mountainous areas of the Region.

GLACIATED MOUNTAIN SLOPES: The dominant landforms include glacial moraines, glaciated mountain slopes, and glaciated mountain ridetops. These landforms represent depositional and erosional surfaces formed primarily by continental glaciation with some areas modifed by alpine glaciers. These surfaces have subdued relief with rolling topography. They are a combination of eroded, convex ridges, glacial deposits on slightly concave valley sideslopes, and deep glacial deposits on valley floors. Slope gradients range from 15 to 50 percent. Associated landforms include gentle to moderately sloping frost shattered ridges and sideslopes, steep glaciated lands, and glacial outwash and glaciolacustrine landforms. These were mapped primarily in northwest Montana and north Idaho.

MOUNTAIN SLOPES AND RIDGES: The primary landforms are ridges and sideslopes that have formed by fluvial and colluvial processes. The ridges are generally convex and the sideslopes are straight. Slope gradients generally range from 20 to 65 percent with 35 to 60 percent being dominant. A variety of weathering classes are expressed. Infrequent small nivational basins are included. Associated landforms are valley floors, and steep glaciated lands where alpine glaciers have been active at higher elevations. Some broader ridges may also occur where frost action has occurred. These were mapped throughout the Region south of the continentally glaciated areas.

FROST SHATTERED MOUNTAIN RIDGETOPS: The mountain ridge top is a broad convex landform that commonly occurs above mountain slopes and adjacent to steep glaciated lands. They have formed mainly by physical weathering and periglacial frost shattering. They are usually undissected. Slope gradients range from 5 to 40 percent. As mapped, these landforms can include small areas of weak glacial erosion and deposition. The geologic materials commonly have a high rock fragment content which has been loosened and mixed by frost action and other weathering processes. Rock outcrops are infrequent. Frost shattered mountain ridge tops were mapped primarily at higher elevations in western Montana and north Idaho.

LOW RELIEF HILLS: This group consists primarily of low relief hills (less than 100 meters) with lesser amounts of alluvial fans, terrace remnants and colluvial slopes. These landforms are the result of shallow stream dissection of deeply weathered surfaces. They are frequently protected from deep dissection by nick points. Slope gradients are generally less than 45 percent with a typical range of 20 to 40 percent. Surface shape consists of simple to complex slopes of all shapes. Associated landforms are recent terraces and fans, hills and mountain slopes, deep frost shattered ridges, and slopes.

MASS WASTED AND COLLUVIAL DEPOSITS: The dominant landforms are rotational and translational failures. Included are a variety of types of failures, such as debris avalanches, slumps, and deep mantle failures. Slope gradients for the translational failures are generally greater than 50 percent and commonly occur on the steep mountain sideslope units, either glaciated or unglaciated. Rotational failures generally occur on lower slope gradients on the gently to moderately sloping mountain sideslope units, either glaciated or unglaciated. Associated landforms, in addition to the mountain sideslope units, are ridge tops at higher elevations and valley floors at lower elevations. Generally small in size (less than 50 acres), these units may also occur as inclusions in other landform groups.

GLACIATED PLAINS: The primary landforms in this unit include glaciated rolling plains and glaciated dissected plains. These landforms resulted from the deposition of glacial till from continental glaciation, and also by lacustrine and deltaic sediments from glacial lakes. Glaciated rolling plains consist of hills and swales or slightly dissected, slightly entrenched drainageways. Slopes are usually less than 15 percent and relief is less than 200 feet. Glaciated dissected plains consist of hills and moderately to strongly dissected and entrenched drainageways. Slopes are usually 15 to greater than 40 percent and relief is usually greater than 60 meters

(200 feet). Associated landforms include sedimentary rolling and dissected plains, breaks, and valleys. Glaciated plains were mapped on the Custer National Forest.

SEDIMENTARY PLAINS: The primary landforms in this unit include rolling plains and dissected plains. These units have formed in sandstone and shale sediments as a result of chemical and physical weathering, fluvial and colluvial processes. Rolling plains consist of hills and swales or slightly dissected, slightly entrenched drainageways. Slopes are usually less than 15 percent and relief is less than 60 meters (200 feet). Dissected plains consist of hills and moderately to strongly dissected and entrenched drainageways. Slopes are usually 15 to greater than 40 percent and relief is usually greater than 200 feet. The surfaces are level to steep with slopes usually less than 45 percent. Associated landforms include glaciated rolling plains, glaciated dissected plains, badlands, breaks and valleys. Sedimentary plains were mapped on the Custer National Forest.

BADLANDS: The primary landforms in this unit include hills, knobs, alluvial fans, ridges and drainageways. These landforms have developed from erosion caused by infrequent heavy showers on sparsely vegetated landscapes. This has resulted in rough, narrowly and steeply gullied topography where soft bedrock of shale and sandstone are widely exposed. Runoff is very rapid and permeability is very slow. Little true soil development has taken place and erosion is active. Vegetation is limited to bottoms of draws, smooth benchlike areas, or gentle slopes where soil can form or has not been eroded. The surfaces are sloping to steep. Slope gradients range from 5 to greater than 45 percent. Associated landforms include rolling plains, dissected plains, and valleys. Badlands were mapped on the Custer National Forest.

GLACIOLACUSTRINE PLAINS (Deltaic Plains/Eolian Deposits): The primary landforms include glacial lake deltaic deposits, sandhills and dunes. These landforms developed from the deposition of sediments at the mouth of the Sheyenne River as it discharged into glacial Lake Agassiz which filled the Red River Valley of North Dakota and Minnesota. The deltaic deposits consist of very fine to fine grained sand, a transition zone of interbedded silt and sand and silt and clay. The sands were then redistributed and moved by the wind into the dunelike topography presently in the area. Glacial lake deltaic deposits consist of nearly level hills and swales. Slopes are usually less than 5 percent and relief is less than 3 meters (10 feet). Sandhills and dunes consist of hills, dunes and hummocks that are slightly dissected, and slightly entrenched. Slopes are usually 5 to 20 percent and relief is usually less than 25 feet. Associated landforms include valleys. Glaciolacustrine deltaic plains and eolian deposits were mapped on the Custer National Forest.

EROSIONAL PLATEAUS AND BUTTES: The primary landforms in this unit include nearly level to flat topped summits and relatively steep slopes or cliffs. These landforms were formed as a result of erosion by water. The landforms are a remnant of a higher surface and are typically capped with erosion resistant rocks. The summits are nearly level to flat with slopes from 0 to 12 percent. The steep slopes often contain rubble and talus and slope gradients are 25to greater than 90 percent. Associated landforms are rolling and dissected plains, badlands, and valleys.

HILLS AND PLATEAUS: The plateaus are associated with flows of Columbia River basalt. The hills are usually associated with deposits of wind blown loess. Hills and plateaus were mapped on the Clearwater National Forest.

ERODED UPLANDS: These areas are transitional between higher elevation plateaus and lower elevation plains. They are not as gullied, can have more relief, and have more vegetation than the badlands. The primary landforms in this unit include ridges, plateau remnants, hills, and drainages. These landforms were formed by stream erosion. Plateau remnants are nearly level to flat. Ridges and hills have straight to concave steep slopes. Slopes generally range from 15 to 60 percent. Associated landforms are plateaus, dissected plains, and valleys. Eroded uplands were mapped on the Custer National Forest.

General Discussion of Geologic Material Groups

Twelve geologic material groups were used for the Landtype Association mapping and are listed below:

- Schists and Gneisses (usually weakly or moderately weathered)
- Metasedimentary (Belt) (vary with degree of metamorphism)
- Quartzites (frequently mapped with schists and gneisses)
- Sandstones and Shales
- Carbonates
- Granitics (weakly, moderately and highly weathered classes)
- Volcanics
- Calc-silicates
- Loose Sediments
    - Fine Sediments: lacustrine, ash and loess
    - Coarse Sediments: till, wind deposited sand, talus

These groups are briefly summarized below. See Figure 3 for asmall scale map showing their distribution throughout the Region. Appendix D contains the acreage figures for the geologic material groups.

SCHIST AND GNEISS: This includes all schists and gneisses in the Region regardless of age or origin. Included are the Archean basement rocks (about 2.8 billion years old) exposed in the Beartooths, the metamorphosed Belt rocks of Zone 3 (described in the Belt section which follows) and the rocks which occur in the Western Idaho Suture Zone (WISZ). This is a zone of intensely metamorphosed rocks that started as Belt or granitics and are now gneisses and schists. During this process the rocks were mechanically abused as well, resulting in a weak broken material subject to deep chemical weathering, shot through with planes of failure and resulting in erosive weathering products such as grus or fine micaceous sand. The old term for this area was `Border Zone’, when it was thought to be the result of intrusion of the Idaho Batholith. The change to WISZ reflects a newer understanding that in addition to the effects of the batholith, this is the collision zone where Washington and Oregon docked when they were added to the Idaho coast. Throughout this area schists, gneisses and quartzites are mapped together.

METASEDIMENTARY (Belt): The Belt Supergroup is the bedrock of about 65 percent of the Northern Region. Because of its complex history these rocks assume a wide variety of lithologies and appearances. Many of these are described here under other categories, such as calc-silicates, WISZ, schists and gneisses depending on their metamorphic grade. For this document, Belt is defined as that portion of the Belt lithology that is dominated by alternating thin beds of argillite, siltite, and quartzite. It includes thick carbonate units at the bottom and in the middle. It also includes large dark colored intrusives shot in along bedding planes. This occurs most commonly in the lower, older rocks. The Region is divided into three zones based on metamorphic grade (see Figure 4).

In the extreme east is Zone One, extending from the Little Belts east and northward. This is the least metamorphosed area of the Belt basin with the rocks being only slightly altered and much more like sedimentary rocks.

Zone Two makes up the bulk of the Region extending to the Idaho line near Missoula to Coeur d'Alene and northward. In this zone the rocks are harder.

Slaty cleavage shows but they are still recognizable as sediments.

Zone Three extends to near Orofino, Idaho where it merges into the Western Idaho Suture Zone (WISZ) explained below. These rocks are where sediments begin to turn into schist and gneiss and become increasingly hard to recognize as sediments. Belt time spans the period of 2.2 billion to about 850 million years ago.

QUARTZITES: Refers to the Flathead Formation where it is a quartzite, and the Quadrant Formation. The Flathead lies atop the Belt rocks on a regional scale unconformity. It is early Cambrian in age spanning the time 570 to 550 million years. The Quadrant is Pennsylvanian (about 4000 feet above the Flathead) spanning 320 to 290 million years. Both formations have blocky outcrops, low fertility, and excessively drained sites. They both tend to be resistant ridge formers and nickpoints in the landscape.

SANDSTONES AND SHALES: Refers to all sedimentary strata above the Cambrian not dominated by carbonates, or large quartzite units. This does not include the unindurated Tertiary Sediments. These are the less resistant clastics that underlie rounded hills or are swales in the landscape. Some of the larger sandstones are ridge formers and moderately resistant. These span from 600 million to 1.7 million years. Sandstones and shales occur mostly in central and eastern Montana and in North Dakota.

CARBONATES: Refers to all carbonates, including dolomites, above the Cambrian. The most prominent formations are paleozoic in age including Cambrian Meagher and Pilgrim Formations, and the Devonian aged Three Forks Formation. The largest is the Mississippian Madison Group. These units tend to be resistant ridgeformers. This position in the landscape allows the chemically reactive erosion products to move downslope with gravity, mixing with and adding lime to all the soils below them. Structurally controlled drainages and stable drainageways are features of landscapes in these units. Water chemistry is dominated by carbonate influence. Karst and dramatic water loss from perennial streams is common as are large volume springs. Many thermal springs originate from these formations.

GRANITICS: Refers to all light colored intrusive rocks of any age. Most of these masses date from late Cretaceous to early Tertiary (70 to 55 million). Important properties stem from the fact that they occur as large homogenous masses of equagranular rock made up of minerals with different properties. In moist regimes exposed to soil acids they are very reactive to chemical weathering, while in dry or nonacid regimes are very resistant. This leads to landforms at the ends of the spectrum being made of the same material. Where covered with soil and vegetation, it makes weak, gentle, rounded landforms and is erosive, while where bare it is resistant, fresh, and rugged. This also affects the nature of sediments produced. The weathering product-grus is equagranular, noncohesive, and very erodible and is primarily in the medium to coarse sand range. Fresh material makes cobbles and boulders that persist and are resistant in running water. The granitics occur in north Idaho and western Montana as a number of igneous bodies such as the Idaho, Boulder and Kaniksu Batholiths along with related intrusives.

To maintain uniformity between forests in mapping granitic weathering classes, the system developed by Clayton and Arnold (1972) was used and should be consulted for more information. In the LTA map unit descriptions if granite is listed without a weathering class it is described as unweathered or weakly weathered. Moderate and highly weathered modifiers are used where these classes occur. A brief summary of weathering classes defined in this publication is given below. These definitions were used to classify the degree of weathering of the granitic materials.

Unweathered: This corresponds to class 1 being fresh unweathered material. It is most common in glacially scoured landscapes where it has been protected from vegetation by slope, altitude, or running water. Cracks are fresh and sharp, it rings when hit with a hammer, and crystals are sharp and fresh including the black mica.

Weakly weathered: This corresponds to Classes 2 and 3. It represents the first stages of weathering including features like weak iron stains emanating from the black mica, and the feldspars turning from fresh white or transparent to a cloudy white condition. It gives a duller sound when struck with a hammer.

Moderately weathered: This corresponds to classes 4 and 5 including material that spalls (crumbles) and gives a dull thud when hammered. This material requires a hammer to break and does not generally go directly to grus.

Highly weathered: This corresponds to classes 6 and 7. This covers materials that extend from that which goes directly togrus and can be broken by hand, up to material where feldspars have gone to clay and material that is plastic when wet.

VOLCANICS: Refers to all extrusive rocks regardless of age or composition. The region is bimodal having a lot of lava with minimal silica in it (basalt), containing little ash, scoria or welded material in far ranging flows, or having a lot of ashy welded rocks with abundant silica with short trashy flows intermixed. This leads to the two class definitions:

Basalt dominated: These are the great flood basalts of the Columbia River Plateau. They typically have the flat upper surface of a fluid lava flow. They are deeply dissected by the main trunk streams forming the characteristic stepped breaks controlled by resistant flows. These units also include paleosols and gravel interbeds that are locally important in controlling stability and groundwater. The resistant beds are nickpoints in many drainages. These rocks are alkaline and the groundwater and surface water reflect this. They are Miocene (17 million to 8 million years) in age. The basalts are most abundant in Idaho.

Intermediate composition (andesite-rhyolite) dominated: These rocks are piles of siliceous volcanic rocks that fell out of the air or slid down the sides and were welded into rock by their remaining heat, mixed with lava flows, mudflows, mass failures, and ash falls. They tend toward rounded gentle landforms until flow or solidly welded material approaches 50 percentof the pile; these act as resistant units. The ash typically weathers rapidly to clays. These layers greatly affect stability and act as aquatards for perched aquifers and determine seep horizons. Slumps and landslides are common, even pervasive in many landscapes dominated by these rocks. The andesites and rhyolites are most abundant in Montana.

CALC-SILICATES: These are the mid-Belt carbonates where they have been subjected to metamorphism such that little carbonate remains (Middle Wallace Formation of the Belt Supergroup). Where referred to as dirty carbonates, the carbonate has reacted with soil to become calcium aluminum, or calcium magnesium silicates. There are often zones of schist or gneissic rocks included. The calc-silicates were mapped mostly on the Bitterroot National Forest.

LOOSE SEDIMENTS: This refers to all unindurated material. This is Quaternary to Recent material spanning the last 1.7 million years. This material tends to be bimodal, either predominantly coarse or fine.

Fine grained: (<.25 mm or <60 mesh) This is predominantly sediment deposited in ponded water (lacustrine sediments) or wind deposited ash and loess. The largest expanses are from lakes ponded by ice during the ice ages, or mass failure dams in smaller drainages. This includes fine colluvial material or mass failures in any of this fine grained material. The loess occurs mostly in Idaho, while the volcanic ash occurs in both north Idaho and western Montana. Glacial lake deposits occur in north Idaho and western Montana.

Coarse grained: (>.25 mm or >60 mesh) This includes coarse material deposited by modern streams, glacial meltwater, glacial till and wind deposited sand. Also included are gravity deposits, such as talus or mass failure in coarse materials. An unusual occurrence is that of coarse delta deposits into Lake Missoula in western Montana. The continental till occurs in north Idaho and northwest Montana. Alpine till occurs many high elevation mountainous areas throughout the Region. Areas which were occupied by ice caps or piedmont glaciers occur in western Montana. The sandhills and sand dunes are most abundant on the Custer National Forest.

THE MAP LEGEND

Listed below is the legend used for the mapping. It is organized with the first subdivision being landform and the second being geologic material. The number given is the LTA identifier. For the convenience of the user, Appendix H contains a second version of the legend which is arranged by geologic material first and landform second. Figures 83 and 84 display the legend categories with the colors used on all maps showing the LTAs.

Plains

1	Shales, Siltstones and Sandstones

Glaciated Plains

2	Shales, Siltstones and Sandstones

Dissected Plains

3	Shales, Siltstones and Sandstones

Glaciated Dissected Plains

4	Shales, Siltstones and Sandstones

Badlands

5	Shales, Siltstones and Sandstones

Eroded Uplands

6	Volcanic Tuffs, Shales, Siltstones, and Sandstones

Erosional Plateaus and Buttes

7	Shales, Siltstones and Sandstones

Glaciolacustrine Plains

8	Glacial Lake Deltaic Sediments
9	Sandhills and Sand Dunes

Valleys

10	Recent Coarse Alluvium
11	Lacustrine Sediments
12	Outwash and Other Older Coarse Alluvial Deposits
13	Fine Glacial Sediments
14	Recent Fine Alluvium

Hills and Plateaus

17	Loess

Breaks

20	Metasedimentary (Belts)
21	Granitics, Highly Weathered
22	Granitics, Weakly Weathered
23	Schists and Gneisses
24	Volcanics
25	Sandstones and Shales
26	Gneisses, Quartzites, SchistS, Moderately Weathered
27	Carbonates
28	Metasedimentary (Dissected Belt Breaks)
29	Quartzites and Calc-silicates

High Relief Mountain Slopes

34	Volcanics
36	Sandstones and Shales
37	Carbonates

Steep Glaciated Mountain Slopes

39	Gneisses, Schists and Associated Metamorphics
40	Metasedimentary (Belt)
41	Granitics and Other Coarse Grained Intrusive Rocks
42	Volcanics
43	Carbonates
44	Sandstones and Shales
46	Alpine Troughs and Troughwalls, Granitics
47	Alpine Troughs and Troughwalls, Belts

Glaciated Mountain Slopes

35	Weakly Glaciated Mountain Slopes and Ridges, Calci-silicates and Quartzites
45	Weakly Glaciated Mountain Slopes and Ridges, Granitics
50	Metasedimentary (Belts)
51	Granitics
53	Sandstones and Shales
54	Volcanics
57	Gneisses, Schists and Associated Metamorphic Rocks
58	Highly Weathered Belt Till

Mountain Slopes and Ridges

59	Gneisses, Quartzites, Schists, Moderately Weathered
60	Metasedimentary (Belt)
61	Granitics, Highly Weathered
62	Granitics, Weakly Weathered
63	Schists, Gneisses and Associated Metamorphics
64	Volcanics
65	Soft Sedimentary Rocks
66	Carbonates
67	Quartzites and Calci-silicates
68	Sandstones and Shales
69	Pediment, Mixed Geology

Frost Shattered Mountain Ridge Tops

70	Metasedimentary (Belt)
71	Granitics, Highly Weathered
72	Granitics, Weakly Weathered
73	Volcanics
74	Sandstones and Shales
75	Calc-silicates and Quartzites
77	Gneisses, Quartzites, Schists, Moderately Weathered

Low Relief Hills

80	Metasedimentary (Belt)
81	Granitics, Highly Weathered
82	Volcanics
83	Fine Tertiary Sediments
84	Schists, Highly Weathered
85	Gneisses, Quartzites, Schists, Moderately Weathered
88	Coarse Tertiary Sediments

Mass Wasted Slopes

90	Mixed Geology

Colluvial Slopes

92	Mixed Geology

Water

99	Lakes and Reservoirs

OVERVIEW OF THE LANDTYPE ASSOCIATION DESCRIPTIONS

The seventeen landform groups and twelve geologic materials groups were combined to produce seventy one Landtype Associations for the Northern Region. Some of these LTAs occur across very large areas and therefore have many differences in accessory characteristics (soils, climate, potential vegetation) which are addressed by identifying and describing each LTA based on the Section in which it occurs.

When an LTA occurred in more than one Section, a separate MUD was prepared for each Section. The exception to this was if an LTA occurred in adjacent Sections and the two occurrences were considered to have similar enough characteristics that one MUD could be prepared to address both Sections. In this case a single MUD was prepared for multiple sections-each identified at the beginning of the MUD. One of the reasons it was possible to write a single MUD to cover the occurrence of an LTA in several Sections is that the higher levels of soil taxonomy (subgroup) and PNV classification (series) were used for the landtype association characterization.

Some Sections have a few landtype associations which occupy large acreages and are clearly the major units; other LTAs in each Section are of lesser acreage and can be considered minor units. LTAs which have very limited acreage may be considered incidental. An LTA can be a major unit in some Sections, a minor unit in others, and incidental or not present in other Sections. The geomorphic complexity of some Sections in the Northern Region is evident when evaluating the composition by LTA. For example, the Yellowstone Highlands (Section M331A) has occurrences of thirty different LTAs. As an interpretation aid, bar charts summarizing the LTA information into landform and geologic material groups by Section are included in each chapter.

In cases where the same LTA occurred in different Subsections of the same Section and had very different accessory characteristics in each location, MUDs were prepared for these LTAs distinguished and characterized by Subsection. In the map unit descriptions which follow, the MUDs that were prepared for single subsections are listed first, and are followed by the MUDs for the rest of that LTA in the Section.

The map unit descriptions for the landtype associations are presented in the following chapters. Preceding the map unit descriptions for each Section is a map showing the location of that Section within the Region, a landscape photograph from that Section, a map showing the distribution of LTAs within that Section and bar charts showing the distribution of major landform groups and geologic material groups. The map unit descriptions have the following format.

LTA symbol: The LTA identifier is hyphenated to include the Section label. Landform name; type of geologic material. If the LTA description is for a single Section, the identifier at the top of the description would follow the format of LTA number then Section Symbol, such as LTA 20-M331A. If one MUD covers two Sections, the identifiers are written as LTA10-M332A, LTA10-M332B.

Location: River drainage, Mountain Ranges, National Forest

Acreage by Section: number of acres of this LTA which occur in each Section (or subsections in some cases) covered by this map unit description.

LTA Setting and General Characteristics

Differentiating Characteristics: Geologic materials and landforms used to differentiate this unit from the others.

Accessory Characteristics: General soil characteristics, general type of vegetation, mean annual precipitation range, elevation range, dominant slope gradient, stream pattern and density

LTA Components: Identification of major landscape components described in the following paragraphs.

Description of landforms, geologic materials, soil characteristics, slope gradients, soil classification at subgroup level, potential natural vegetation at series level, and percent of the LTA that is occupied by this landscape component.

Compiled by: The name of person who prepared this map unit description and their home unit.