Landtype Associations
Of
North Central Washington

(Wenatchee, Okanogan, and Colville National Forests)

Developed by:
Carl Davis, USDA Forest Soil Scientist

Matt Karrer
Bud Kovalchik
Terry Lillybridge
Claudia Narsico

United States Department of Agriculture Forest Service – Wenatchee, Washington – 2004

Acknowledgements:
The authors would like to thank those who helped make this survey and the final report possible. Thanks go to Glen Hoffman, Staff Group Leader, Wenatchee National Forest and Forest Supervisors, Sonny O'Neal, Samuel Gehr, and Ed Schultz of the Wenatchee, Okanogan, and Colville National Forests, respectively. For without their vision, leadership and consistent support over the several years in making this product, it may not have been available for forest planning efforts. We would also like to thank those who helped with technical services during completion of the inventory and those who provided technical review. Thanks goes to Pat Murphy for providing diligent GIS leadership. Thanks goes to Ken Radik and Joni Sasich for their technical review of the draft and their suggestions for the final report. And, thanks to Joni Sasich for her writer/editor assistance in preparation of this final report.

Foreward

Landtype Associations of North Central Washington is an ecological land unit inventory for use in interpreting physical and biological processes across the landscape. Ecological land units were developed by integrating three major landscape features: a) landform patterns grouped to represent a unique set of geomorphic processes; b) geology types grouped to represent similar regolith and bedrock features and their influence on physical and biological processes; and c) potential natural vegetation to infer similar climatic environments.

The inventory comprises 5.39 million acres covering the Wenatchee, Okanogan, and Colville National Forests and was completed in 1999. A preliminary draft report issued in 2000 served as an "in-service" guide. Several years of testing and some revision have led to this final report in 2004.

Landtype Associations of North Central Washington is consistent with the National Hierarchical Framework of Ecological Units (USDA 1993). The hierarchical framework provides for ecological land units that can be aggregated for regional or national scale analysis or can be further subdivided for analysis with more narrow objectives. This survey has been conducted at the Landscape level using 1:63,360 or one inch/mile map scale. One hundred sixteen (116) unique land units have been identified. Part III of this report contains a consolidated list of Landtype Associations identified in the survey.

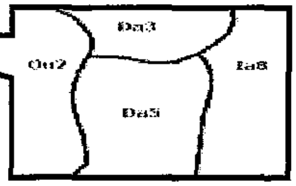
The scale of this inventory is suited for use in forest resource planning and broad scale landscape analysis. It stratifies landscape features using geomorphic characteristics that can help focus monitoring programs or more detailed project level planning and inventories. The appropriate scale for map display is 1:60,000 to 1:125,000. A few examples of where this kind of inventory can be useful are: synthesis of hydrologic processes within a basin; mapping spatial patterns of potential aquatic and wildlife habitats within a basin or several basins; developing forest-wide or district-wide strategies for road maintenance; or comparing historic fire regime patterns with inventories of present vegetation condition.

The grouping of landscape features in itself provides a useful means for interpreting ecological processes, temporally and spatially. The user is encouraged to learn and understand how the survey was developed and why certain mapping differentia or landscape features were grouped as this will enhance their understanding of each Landtype Association. A discussion of survey methods can be found in Part I. The interpretation tables in Part IV provide a comparison of general properties of landscape features and a response rating for the more common, present day management applications. These ratings are purposely broad and intended to be interpreted as a relative comparison. A detailed explanation of how general properties and ratings where derived and how they should be interpreted are included in this section. It is essential that users understand the basis for these interpretations prior to using in any analysis. Users should also know that at the landscape level, a property or response rating may not be expressed everywhere within the landtype association. The more one understands what feature is linked with the property or rating, the higher utility this tool will serve the user.

How to Use This Report and Maps

Step One: Review the introductory pages in the report and become familiar with the level and kind of interpretations that are available from the Landtype Associations (LTA) inventory. Review how the inventory was designed. As with any map resource, it is important to understand the appropriate scale to apply this information and the relative limits of the interpretations as a result of scale. This step will help in planning an effective analysis.

Step Two: Identify LTAs within your area of interest by overlaying the LTA Map on a base map. This step can be done in the GIS environment.



Step Three: Make a list of the LTAs within your area of interest. Turn to Part III, Table 3 -Landtype Association Identification Legend for a description of the landform group, geology group, and potential natural vegetation zone for the LTAs on your list.

Part III Landtype Association Identification Legend

Landtype Association *Tri-Forest* Identification Legend

Map Symbol	Landform	Bedrock Geology	Potential Natural Vegetation (PNV)	Occurrence *(National Forest)*
Ou2	Valley Bottoms	Undifferentiated	Douglas-Fir with some Ponderosa Pine/Shrub-Steppe	*Colville Okanogan Wenatchee*
Da3	Dissected Mountain Slopes	Massive and Foliated Crystalline Rocks	Douglas-Fir and Grand Fir	*Wenatchee*
Da5	Dissected Mountain Slopes	Massive and Foliated Crystalline Rocks	Grand Fir and Western Hemlock	*Wenatchee*
Ia8	Glaciated Mountain Slopes	Foliated and Massive Crystalline Rocks	Subalpine Fir with some Silver Fir/Mountain	*Colville Okanogan Wenatchee*

Step Four: For a more detailed description of each LTA component, turn to Part II for descriptions of landform groups, geology groups, and potential natural vegetation zones. Be sure to note that for some LTAs, more than one geology group or potential natural vegetation groups may be listed for a LTA.

Part II Landtype Association Map Unit Components

D Dissected Mountain Slopes

This landform occurs on moderate to very ste were the common land forming process. Rid gradients of 20 to 45% due occur. Elevation Narrow V-shaped valleys typically are in-fille of streams in a weak to well developed dendri associated with landform groups P and T.

Forest resource professionals will begin to visualize the setting of each landtype association relating to their past observations. Overlaying other data layers, such as streams and topographic contour elevations may further enhance the users' visualization of landtype association settings.

Step Five: Turn to Part IV, Landtype Association Management Applications in the Report to obtain interpretations that are of interest to your analysis. Each kind of interpretation and its relative rating or descriptor is defined in the narrative preceding the table.

Step Six: Maps displaying interpretations may be constructed at this point. For example, a map display could be constructed of all landtype associations with potential habitat for lynx or mule deer or a map could be constructed displaying areas with FLASHY hydrology or a map that displays areas requiring a higher level of monitoring for road drainage maintenance.

Under development at the time of this writing, is a GIS link to NRIS TERRA database which will allow for GIS integration of interpretations for each landtype association and their mapped location. Most interpretations contained in this Report are available in NRIS-TERRA.

Table of Contents

List of Tables

PART I:
Landtype Associations Survey Principles and Methods

Introduction

The Washington Office of the Forest Service provides national direction for ecological surveys in the National Hierarchical Framework of Ecological Units (USDA Forest Service 1993). This direction establishes a consistent approach to ecosystem mapping and analysis by providing a mapping and classification system that stratifies the earth into "progressively smaller areas of increasingly uniform ecological potential" (USDA Forest Service 1993). An overall picture of the hierarchical framework is displayed in Table 1. This approach was developed from earlier regional "landsystems" mapping approaches that stratified the landscape by integrating several terrestrial features to display multi-resource attributes of the landscape (Wertz 1972 and USDA Forest Service 1976). The concepts included in the hierarchical framework and earlier land systems approaches have been applied to this survey.

Table 1. National Hierarchical Framework of Ecological Units

Analysis Scale Ecological Unit	Map Unit Criteria	Map Scale	General Use
Ecoregions:			
Domain	• Broad climatic zones	1,000,000's to 10,000's of square miles	National and international planning, modeling, and assessments
Division	• Regional climatic types • Potential Natural Vegetation (PNV) formations • Soil Orders		
Province	• PNV formations or series • Mountains with complex vertical zonation		
Subregions: Section Subsection	• Geomorphology, stratigraphy, surficial geology, lithology • Climatic data • Soil Orders, Suborders, and Great Groups • PNV series	1,000's to 10's of square miles	Regional planning including multi-forest, statewide, and multi-agency analysis and assessments
Landscape: Landtype Association	• Geomorphic processes, geologic formation, surficial geology. • Local climate • Soil Subgroups, Families or Series • PNV series, Sub-Series, or Plant Associations	1,000's to 100's of acres	Forest or area-wide planning and watershed analysis
Land Unit: Landtype Landtype Phase	• Landform and slope position • Elevation, aspect, and slope • Soil Subgroups, Families, or Series • PNV Plant Associations or Phases	100's to less than 10 acres	Project and management area planning and analysis

The survey area had previously been stratified into Ecoregions at the broadest ecological unit in the national hierarchical framework (McNab and Avers 1994). Ecoregions are intended to be useful at regional or national scales but are inadequate to address Forest Planning, watershed issues, or other resource analysis at the Forest level. Ecoregion stratification also establishes a broad basis for further definition of the landscape at more detailed levels.

Landscape scale ecological units or Landtype Associations are the broadest scale within the hierarchical framework that meets Forest level needs. In 1997, the Forest Supervisors of the Wenatchee, Okanogan, and Colville National Forests collectively set a high priority to complete a Landscape-level, Landtype Association survey to facilitate the needs of Forest Plan revision. Planning staff from the three National Forests met to identify anticipated planning issues linked to Forest Plan Revisions. Many of the expected planning issues relate to wildlife habitat, anadromous fish and inland fish habitat, hydrologic properties, biodiversity, and soil productivity. This list of planning issues required a fairly detailed landscape survey over the tri-forest area. To be most useful, the Landtype Associations of North Central Washington survey was designed using map unit criteria that identify features that influence ecological processes and functions that would address the planning issues. Landtype Associations (LTAs) were also designed to be aggregated upward in the hierarchical framework to the Subregion-level or Subsection or to provide a basis for further resource surveys at the landscape scale or at a smaller scale in the framework.

Landtype Association Survey Design

This section discusses the four steps involved in designing the Landscape Association of North Central Washington survey. The steps are: 1) identification of survey objectives or, "what are the questions the survey needs to address", 2) identification of mapping criteria that will provide the required information identified by survey objectives, 3) identification of mappable landscape features that represent the mapping criteria and that provide consistency in stratification; and 4) development of map units based upon the array of these mappable features or mapping differentia within the survey area.

Survey objectives were defined by the Forest Plan revision and other landscape analysis needs as discussed in the Introduction Section.

Identification of mapping criteria was guided by the following discussions with respect to the hierarchical framework. Landtype Associations are normally defined by the following map unit criteria: general topography, geomorphic process, surficial geology, soil, potential natural vegetation, and local climate. Collectively, these features become diagnostic factors that control or strongly influence biotic distribution, hydrologic function, and ecological functions including natural disturbance regimes (Swanson 1979). Some diagnostic site features are more controlling of ecological process than others and therefore should be used to partition landscapes (Bailey 1996). Mapping criteria identified were geomorphic processes, bedrock or surficial geology characteristics, and potential natural vegetation. Collectively, these three criteria provide for interpretation of key ecological processes such as hydrologic regime, sedimentation regime including mass wasting and soil erosion, soil regolith properties and distribution, site productivity, wildlife habitat potential and travel corridors, and channel processes important to aquatic habitat and climatic settings.

1. Geomorphic Process

The more common geomorphic processes of interest to landscape-scale analysis are sedimentation and hydrologic processes. Specific processes are mass wasting, surface erosion, runoff, channel processes, and subsurface water movement and storage. Processes can be described and analyzed but are difficult to display on a map. A mappable surrogate of processes must be used to display this mapping criteria. *Geomorphic expression or landform* is an excellent surrogate because it is the topographic expression of the sum of geomorphic processes as they are influenced by climate, time, geology, and other landscape factors. Although historic processes may or may not be present today because of climate change or other factors, landform genesis have shaped the topography, soil regolith, and stream patterns that continue to influence present day processes. A good example is glaciated landscapes. The glaciers have long since receded but the U-shaped valleys and glacial morainal deposits continue to strongly influence sedimentation and hydrologic processes and function in contrast to unglaciated landforms.

Delineation of landforms provides a consistency in mapping. Geomorphic expression tends to be repetitive, creating landscape patterns and features easily identified on topographic maps and/or aerial photographs. This consistency can increase the level of confidence in the analysis.

Landform genesis coupled with the surveyor's understanding of the survey area can provide an in-depth understanding of many important interrelationships.

There are many examples of how understanding the relationship of geomorphic process and landforms can be useful to land managers. One example is the relationship of landform to the interpretation of channel processes and function important to aquatic habitat. Recognized early on, Strahler (1964) suggests there is conformity between landform and stream system development which can help explain some stream morphologic properties. Important site features such as channel gradient and channel confinement are diagnostic for channel classification systems such as Rosgen (1994) and Montgomery and Buffington (1993). These classification systems use channel morphology to interpret channel processes important to aquatic habitat. For watershed scale or broader, landscape level identification of geomorphic expression is a useful predictor of stream morphology diagnostic to these classification systems. Other diagnostic features such as substrate characteristics, flow dynamics, and sediment regime can be interpreted when the other mapping criteria, i.e., geology and vegetation, are integrated with geomorphic expression.

Another important link can be made between geomorphic expression and other landscape features important to hydrologic or sedimentation processes. Geomorphic expression incorporates topographic features such as: slope gradient, slope shape, surface relief, and topographic position on the landscape; and stream drainage features, such as, density, patterns, and other important morphologic features (Arnold 1993). These topographic features integrated with other mapping criteria can be used to predict soil regolith patterns and properties (Davis and others 1996). And, more specifically, an understanding of landform genesis provides insight into soil distribution and occurrence. Collectively, topographic and geomorphic features with an understanding of soil distribution can be diagnostic for runoff dynamics, flow duration and amount, subsurface flow and storage, relative turbidity, hillslope sediment delivery efficiency, mass wasting, and surface erosion. These relationships between geomorphic expression and hydrologic processes and function have been supported by numerous Wenatchee National Forest watershed assessments.

2. Geology

Geologic characteristics were identified as important mapping criteria because it influences rates of geomorphic processes over the course of landform development. Geology has a strong controlling influence on landform development, soil formation, and hydrologic response (Bailey 1996). Some diagnostic site features influenced by geology are drainage patterns, soil regolith properties, topography, and channel substrates. Rate of geomorphic processes such as mass wasting, subsurface water recharge and storage, and surface runoff are influenced directly or indirectly by weathering resistance, stability, bedrock exposure, stratigraphy, and other characteristics of different geology formations. As such, geology serves to further define diagnostic features that refine the interpretative value of the first mapping criteria, geomorphic process.

Geology formation, both bedrock and surficial deposits are the mappable feature for this mapping criteria. Formations were grouped based upon similarities in their influence on rate of geomorphic processes and on soil regolith development.

3. Potential Natural Vegetation (PNV)

Potential Natural Vegetation (PNV) is a vegetation classification system that provides a means to stratify climatic conditions and vegetation dynamics. PNV was used in the survey to infer local climate and soil climate. An additional benefit to incorporating PNV in mapping criteria is that it provides an insight into vegetation dynamics and how changes in vegetation species composition and structure may influence wildlife habitat, wildlife distribution, sedimentation, and timber productivity, temporally or spatially.

PNV at the Landtype Association scale is represented by vegetation series grouped when closely associated within a Landtype Association setting. These groups are called Vegetation Zones.

4. Soils

Soils were not identified as a mapping criteria but are an important map unit component. Numerous management interpretations in this survey are based upon soils characteristics either inferred by other mapping criteria or from existing map sources. Soil taxa were identified by overlaying National Cooperative Soil Survey maps onto the Landtype Association maps to determine the most common soil subgroups for each Landtype Association. Soil regolith characteristics were inferred using relationships between landform genesis, bedrock geology, and climate or PNV. Volcanic ash and/or coarser tephra deposits in soil surface layers occur within the tri-forest area. These surface layers can not be inferred using the mapping criteria but can be predicted using other means. Occurrence, depth and purity of tephra deposits are related to wind direction, distance from the source, and the amount of erosion subsequent to the deposition (Beget 1984 and Smith, Okazaki, and Knowles 1976). Coarser tephra occurs nearer the source. Vegetation cover and steepness of slope played a large role in re-distribution by erosion. Typically, northerly aspects and gentle slopes have wind-blown deposits of greater purity and depth whereas southerly aspects and very steep slopes on non-north aspects may have very little evidence of these deposits or deposits that are highly mixed. Coarser tephra occur near historic volcanoes such as Mt. Rainer, and Glacier Peak.

5. Identification of Mapping Differentia

The final step in survey design is to identify the array of mappable features possible for each mapping criteria. These are call mapping differentia. Table 2 displays all mapping differentia identified with in the tri-forest survey area. This differentia represents all possible map unit components available for integration to create a landtype association map unit. As will be discussed later, not all possible combinations occur within the survey area.

Table 2. Landtype Association Integration Legend - mapping differentia

	Landforms		Geology Groups		Vegetation Zones (PNV)
B	Lacustrine Benches and Deposits	a	Foliated Crystalline Rocks	1	Ponderosa Pine/Shrub Steppe
D	Dissected Mountain Slopes	b	Massive Crystalline Rocks	2	Douglas-Fir
F	Scoured Glacial Troughs	c	Tertiary Continental Sedimentary Rocks	3	Douglas-Fir & Grand Fir
G	Scoured Glaciated Slopes	d	Tertiary Volcanic Rocks	4	Douglas-Fir & Western Hemlock
H	Glacial Cirque Basins	e	Basalt Rocks - Interbedded	5	Grand Fir & Western Hemlock
I	Glaciated Mountain Slopes	f	Pyroclastic Rocks	6	Western Hemlock
J	Dissected Glaciated Slopes	g	Meta-Sedimentary Kootenay Arc Rocks	7	Silver Fir & Mountain. Hemlock
K	Glacial Troughs	h	Meta-Sedimentary Rock. Belt Series	8	Subalpine Fir
L	Glacial Moraines	i	Meta-Sedimentary Rocks	9	Parkland
M	Meltwater Canyon/Coulees	j	Meta-Sedimentary Rocks - Marine		
N	Glaciated Trough Valley Bottoms	k	Significant Inclusions		
O	Valley Bottoms/Outwash	u	Undifferentiated Includes a variety of geologic groups and surficial deposits commonly associated with the following Landform groups: landslides, valley bottoms, meltwater canyons, and lacustrine deposits		
P	Rounded Ridge Tops				
Q	Landslide & Fault & Escarpments				
S	Structural Controlled Mountain Slopes				
T	Landslides Undifferentiated				
U	Deep Ancient Landslides				
W	Moderately Gentle Volcanic Flows-Plateaus				
X	Moderately Steep Volcanic Flows				
Y	Volcanic Cone and Dome				

Mapping Procedures

A separate map was made for each mapping criteria using the map unit codes listed in Table 2. Each map was transferred into GIS. Individual maps were then overlain and integrated to form an initial Landtype Association (LTA) map. A review and edit procedure called correlation was conducted to combine units that had similar components and interpretations. Small units insignificant to landscape-scale assessments were eliminated. A final map legend and map was then produced. Below is a discussion of methods and procedures used to generate each separate map for the three mapping criteria. The next section discusses the integration of these maps and correlation procedure to produce the final LTA map.

6. Landform

In this Tri-Forest Area, landform features are very important in watershed management. For this reason, a comprehensive mapping effort was adopted to identify specific geomorphic expression or landforms. The survey area has a complex history of continental and alpine glacial epics; mass wasting; tectonics; and volcanism. Geomorphic expression or landforms were identified and incorporated in the mapping legend consistent with guidelines identified in A Geomorphic Classification System version 1.3 (Haskins and others 1996). Landforms were delineated using mirror stereoscopes and 1:63,360 (1 inch = 1 mile) aerial black and white photography. This mapping was transferred into Geographic Information Systems (GIS) by either transfer of original mapping to a 1:24,000 orthophotographic base with topographic contours and then scanned or by "heads up" digitizing using GIS orthophotographic data coverage.

Simple block diagrams were selected to illustrate landform concepts. Brief landform descriptions were developed describing central concepts and major diagnostic features; not all features across the landscape were described. The following publications were used as reference material: Panorama of Physiographic Types (Lobeck 1958), Encyclopedia of Earth Sciences (Fairbridge 1968), Landforms for Soil Surveys in the Northern Rockies (Holdorf 1990), and Soil Survey of Gallatin National Forest, Montana (Davis 1996).

The following publications among others were used to develop landform genesis concepts and to help identify geomorphic expression, particularly for glaciated landscapes: Timing and Processes of Deglaciation Along the Southern Margin of the Cordilleran Ice Sheet (Booth 1987), Glacial Geology of the Entiat and Chelan Mountains (Long undated), Glacial and Post-Glacial History of the Chelan Basin (Paul 1980), and Geomorphology and Glacial Geology of the Methow Drainage Basin (Waitt 1972).

7. Geologic Groups

Geologic groups were identified from geologic formations mapped by U.S Geological Survey or Washington State Department of Natural Resources (Tabor 1983 and 1987, Stoffel 1991) as available from Department of Natural Resources (DNR) GIS data files at 1:100:000 scale. Geologic formations were grouped according to similar bedrock features such as rock type, mineralogy, resistance to weathering; and influence on known topographic, hydrologic, and soil features. A geology group map was created by sorting the DNR geology data layer by geologic unit in the GIS environment. These maps were made available as General Geology Maps independently as a Forest information resource.

Geologic reports by Tabor (1983 and 1987) and Stoffel (1991) were used as reference material to develop these brief geologic descriptions.

8. Potential Natural Vegetation (PNV)

Classification schemes for Potential Natural Vegetation (PNV) had previously been developed for each National Forest at the plant association level (Williams and Lillybridge 1983; Williams, Kelly, Smith, and Lillybridge 1995; and Lillybridge, Kovalchik, Williams, and Smith 1995.).

A model, developed by Jan Henderson (2001), Zone Ecologist Mt. Baker Snoqualmie National Forest) was used to generate Potential Natural Vegetation (PNV) Vegetation Zone maps. Modeling criteria used to develop this initial vegetation zone map included eco-plot data, aspect, elevation, topographic moisture, precipitation zones, mean annual temperature, and regional location. Zone Ecologist, Bud Kovalchik and

Terry Lillybridge, Wenatchee Ecologist applied a variety of vegetation plots, field visits, and anecdotal information to validate the model output.

Integration and Correlation Procedure

Once the individual maps of landform, geology groups, and potential natural vegetation (PNV) were included as GIS data layers, the layers were integrated to form Landtype Associations (LTAs). A coding system was developed to represent each integrated map unit based upon the initial map codes listed in Table 2. This coding system is a modified approach described by Arnold and Ryder (1993 and 1994, respectively). Initial map codes were adjusted during a correlation process and the process is described below.

The map unit symbols for LTAs were designed initially to be representative of the mapping criteria. They consist of three (3) digits. The first digit of the symbol is an upper case alpha symbol and is representative of the landforms groups. The second digit is a lower case alpha symbol representative of the geologic groups. The third digit, a numeric symbol, is indicative of vegetation zones (PNV). Table 3 – Landtype Association Identification Legend in Part III contains a listing of the map symbols and a brief description of map unit components for the final map product.

The initial computer-assisted integration of landform groups, geologic groups, and PNV was displayed at 1:24,000 scale and contained numerous extremely small" delineations. The three digit map symbols enabled the correlation process by providing quick identification of map unit components. Map unit components were compared and the significance of small delineations was evaluated. Combinations were made to form larger more manageable units. This process is explained in greater detail in the following section.

9. Survey Correlation

The correlation criteria described below was used to eliminate the seemingly endless array of small delineations and to combine LTAs with small differences, insignificant to a landscape level generated by the GIS overlay exercise. As a result of these correlation edits, 116 LTA units were identified for the three National Forests. The Wenatchee National Forest has 80 LTAs, the Okanogan National Forest has 54 LTAs, and the Colville National Forest has 37 LTAs.

LTAs were combined and delineations assimilated to other delineations based upon the following criteria:

- Landform mapping differentia was considered primary and differing landform units were not combined or assimilated. Groupings of potential vegetation and geology mapping differentia were considered secondary and were combined to form differing LTA components within a single map unit.
- LTAs with less than 14,000 acres were combined with similar LTAs except where map unit components formed unique habitats.
- Delineations with polygon size less than 300 - 500 acres were normally combined or assimilated with adjacent LTAs.
- Exceptions to the general criteria were made for LTAs or delineations with unique features interpretatively significant to landscape analysis and Forest Plan revision

issues. For example, Glacial Cirques LTAs can be small in size but influence hydrologic processes significantly different than adjacent LTAs. A watershed without Glacial Cirques can have a different stream flow regime and consequently, different channel and aquatic processes.

- LTA's with somewhat similar components or interpretative value were also occasionally combined with more prominent or larger LTA units. For example, for the array of geology groups occurring in Scoured Glacial Trough LTAs, there is little difference in significant site features that would lead to different interpretation at the landscape scale. All units are consistently composed of very steep rocky slopes with relatively resistant bedrock with little difference in slope steepness or bedrock outcrop. Since geology group subdivision of these LTAs do not enhance interpretative value at the landscape scale they were combined. At the Land Unit scale, geology group may be more significant.

The LTA Identification Legend lists major map unit components and inclusions. Major map unit components are noted with ***and*** in the legend. Minor inclusions are represented in the Legend with the words ***with some.*** Inclusions with insignificant acreage are not included in the identification legend. These insignificant inclusions are expected to represent less than 20 percent

Using the Product

The correlation process resulted in a number of mapping edits to produce the final map of Landtype Associations. Due to the complexity and number of edits, software limitation, and the limitation of staff, a decision was made to make changes to the map unit label of the polygon but accept the final map without deleting some of the original polygons. Hence, the first draft of Landtype Association maps appeared to have adjoining polygons with the same attribute labels. Over the course of publishing maps, most of these errors have been corrected. If users have LTA maps with adjoining polygons with the same attribute labels, users should check to insure they have the latest LTA map coverage..

For map display purposes, a simple unified color coding was developed that is consistent for all three National Forests. Due to the number of LTAs and limit on color selection, LTAs were grouped to create a workable map display. Each LTA landform component was designated a specific color. Hence, LTAs that have the same geomorphic history and landform features were grouped within the same color. This allows for each LTA to be attributed with a uniform Landform color code.

The appropriate scale of map display ranges from 1:60,000 to 1:125,000. Map presentation scales less than 1:60,000 do not imply increases in accuracy or detail of mapping. The maps have utility for landscape planning or assisting other resource inventory projects. Unless properly interpreted and applied, LTA maps and interpretation tables will have less value for project level investigations and could be misleading. However, interpreted with the understanding of survey design, maps and interpretation tables can provide interpretative overviews for project studies. These overviews may be adequate for some simple project designs.

Once the user is familiar with development methods of the product, they likely will concentrate use in Part III containing the *Landtype Association Identification Legend* and Part IV containing *Management Application Interpretations.* Part II *Landtype*

Association Map Unit Components will be a useful reference for more detailed descriptions of the mapping differentia.

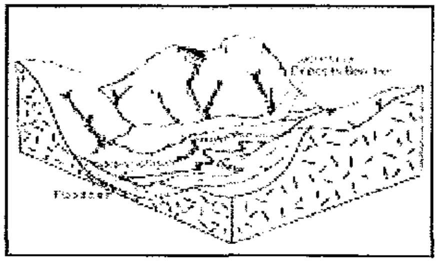
Part IV *Landtype Association Management Applications* should be used with the following understanding. Management applications include descriptions of physical properties of major site features, classifications, interpretations for major ecological processes, and natural disturbance regimes for each LTA. Descriptions are intended to reflect major concepts as they affect ecological processes and are intentionally displayed as ranges not absolutes. Classifications are listed at the lowest hierarchical level possible and reflect concepts not absolutes. Classifications have been obtained either from overlaying specific data sources and constructing a list of the dominant classes or by empirical extrapolation. Interpretations are given as potential, hazard or limitations. An in-depth treatment of channel processes increases the utility of this product for watershed analysis. Detailed descriptions of each element in the table are provided in the section. It cannot be stressed enough the importance for understanding how the interpretation or description was obtained and how to interpret a rating of low, moderate or high prior to using these resources.

PART II:
Landtype Associations Map Unit Components

This section provides the user with descriptions for the major map unit components of LTAs within the Tri-Forest survey area. Specific properties and features that help the user differentiate between map unit components and lead to an understanding of ecological processes are provided for all possible landform, geology, and potential natural vegetation components. Some geology and vegetation components have been combined during the LTA correlation process, as described in the previous section. The user is advised to refer to Part III Identification Legend for the complete list of map unit components for a Landtype Association and then read all of the map unit component descriptions that apply. Relying solely on the letter or numeric code identifier in the Landtype Association Map Unit label to identify map unit components will not provide a complete reference to all map unit components.

Landform Group Descriptions

B Lacustrine Benches and Deposits

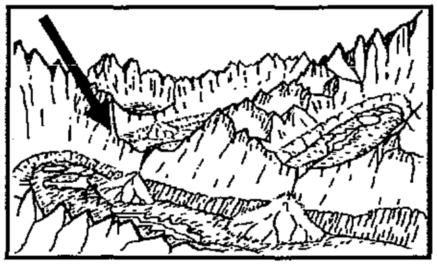


This landform occurs on flat to gently undulating surfaces underlain by very fine sediments. Lacustrine sediments were deposited in lakes temporarily impounded behind ice dams, moraines or other glacial features. Stream channels are generally weakly to moderately incised with U-shaped bottoms and over-steepened banks, but may become more deeply incised along steeper margins or escarpments. Landforms are locally underlain or dissected by coarse textured outwash or alluvial deposits and often occur in intermountain valleys and on sideslopes "perched" above the valley floor. Slope gradients are typically 0 to 20% on terrace surfaces. Significant deposits occur along the Pend Orielle River. This unit is commonly associated with landform group O.

D Dissected Mountain Slopes

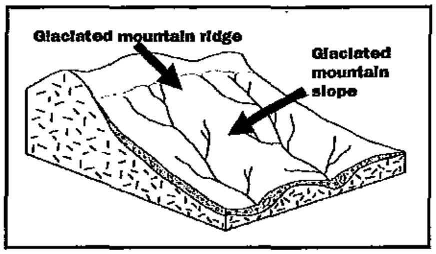
This landform occurs on moderate to very steep, dissected mountain slopes. Fluvial erosion processes and shallow rapid debris slides were the common land forming process. Ridges are narrow and slope gradients commonly exceed 45% but in some areas gentler slope gradients of 20 to 45% do occur. Elevation relief (ridgetop to valley bottom) along higher order drainages usually exceeds 1000 feet. Narrow V-shaped valleys typically are in-filled with alluvium and fan deposits. Hillslopes are dissected by a moderate to high density of streams in a weak to well developed dendritic pattern. Stream channels are moderately to deeply incised or confined. This unit is associated with landform groups P and T.

F Scoured Glacial Troughs



This landform occurs on extremely steep, rocky, irregular slopes and ridges with numerous cliffs and ledges and is on upper slopes and headwalls of U-shaped glacial valleys and cirque basins. Alpine and Continental glaciation was the common land forming processes. Ridges were scoured and over-steepened by glacial erosion. Slope gradients typically exceed 65%. Excessive bedrock outcrops are typical. Bouldery talus accumulates on ledges and along the lower margin of this landform. Avalanche and debris chutes are common. Glacial till is usually absent and residual soils are thin and poorly developed. Slopes are moderately dissected by poorly defined, high gradient, low order, streams in a parallel drainage pattern. This unit is commonly associated with landform groups H and K.

G Scoured Glaciated Mountain Slopes

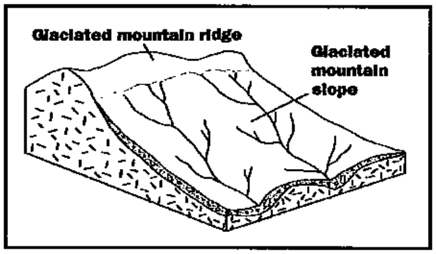


This landform occurs on moderate relief mountain slopes and smooth convex ridges. Continental and alpine glaciation was the common landforming processes. Slopes were scoured leaving bedrock close to the surface which tends to control topographic expression and vegetative patterns. Slope gradients range from 20-45% with steeper gradients along breaklands bordering higher order streams. Residual soils are shallow and poorly developed but pockets of glacial till may occur along lower slopes and draws. Veneers of loess and ash are not uncommon. Landforms are dissected by moderate gradient, lower order, intermittent streams. Bedrock and geologic structure strongly influence stream pattern and density. Drainage pattern varies from weak rectangular to dendritic, and sub-parallel along steeper side slopes. This unit is commonly associated with landform groups I, J, K, M, O and P.

H Glacial Cirque Basins

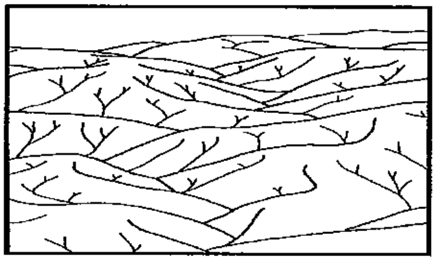
This landform occurs as semi-circular to elongated basins carved into headwalls of glacial valleys. Alpine glaciation was the primary land forming process. Very steep rocky slopes with talus form a headwall around the basins. Smaller delineations may include headwalls that range from 65% to 100% slopes. Basins are characterized by gentle slope gradients of 0-20% with undulating relief, smooth rocky knobs, and some swales containing wet meadows. Cirque outlets are typically defined by a steep rocky lip. Numerous, poorly defined intermittent or perennial streams form a centripetal or sub-dendritic drainage pattern. Cirque lakes are common. Seeps often occur below talus. This unit is commonly associated with landform groups F and K.

I **Glaciated Mountain Slopes**



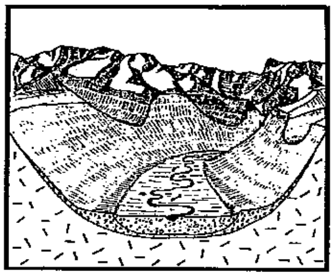
This landform occurs on moderate relief mountain slopes and smooth, moderately broad convex ridges mantled with glacial till. Landforms were shaped by continental or alpine glacial ice sheets. Glacial till deposits occur typically in deeper draws and north facing slopes and are shallow or absent along ridges. Slopes are commonly less than 45%. Bedrock and geologic structure often control topographic expression but vegetation patterns are influenced by depth of glacial deposits and elevation. Valleys are mildly V-shaped to U-shaped. Slopes are dissected by well defined, moderate to high gradient, intermittent and perennial streams in a sub-parallel to dendritic pattern. Streams are moderately to deeply incised. Seeps and springs are common along concave lower slopes and occur on upper slopes near the boundary with landform group G. This unit is commonly associated with landform groups G, I, J, L, O and P.

J **Dissected Glaciated Mountain Slopes**



This landform occurs on relatively steep, high relief mountain slopes with moderately narrow ridgetops and steep sideslopes. Slopes form relatively V-shaped valleys. Landforms were shaped by fluvial erosion and locally with some continental glaciation. Slope gradients range from 35-65%. Glacial till deposits if present, occur on north-facing slopes. Differential surface erosion influences topographic expression with south-facing slopes being steeper and more highly dissected. Slopes are dissected by a relatively high density of confined, moderate to high gradient streams in a sub-parallel to weak dendritic pattern. This unit is commonly associated with landform groups G, I, and L.

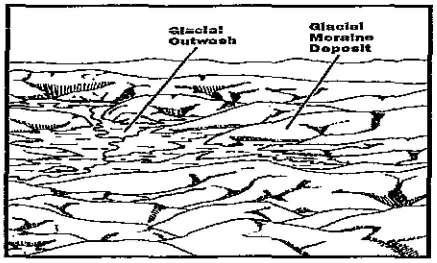
K **Glacial Troughs**



This landform occurs on till mantled slopes of glacially eroded U-shaped valleys. Some narrower glacial trough delineations include the valley bottoms of glacially eroded U-shaped valleys. Alluvial fans, glacial moraine deposits are common along the lower slopes associated with the valley bottoms. Lower sideslopes are commonly concave, upper slopes are normally straight. Slope gradients range from 35 to 90%. Troughwalls are dissected by a high density of perennial to intermittent low order streams in a trellis drainage pattern. Tributary channels are often weakly defined with moderate to high gradients.

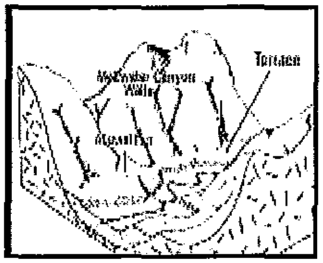
Avalanche chutes and debris tracks are common and associated with low order channels. Seeps are common along lower slopes. This unit is commonly associated with landform groups F, G, I, L, N and O.

L Glacial Moraines



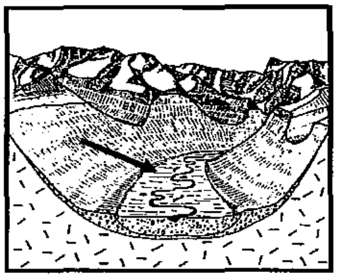
This landform occurs on low to moderate relief, undulating or hummocky surfaces underlain by very deep glacial deposits. Glacial deposition was the most common land forming process and the landform commonly is underlain with ice-marginal and pro-glacial deposits such as eskers and outwash. Glacial till deposits are typically much greater than 20 feet deep but some rocky knobs or erratics may protrude on the surface. Slope gradients range from 0-20%. Local relief (ridge top to valley bottom) rarely exceeds 1,000 feet. Glacial moraine landforms occur mostly in wide upland valleys but occasionally occur as a mantle along ridges and mountain passes. Slopes are dissected by well defined, low to moderate gradient streams in a weak dendritic to deranged drainage pattern. Streams are usually deeply incised. Seeps, springs and ponding in depressions are common. Included within the landform are glacial-flood or lacustrine deposits. Pothole lakes are common. These glacial moraine landforms typically occur away from the proximity of the glacial trough landforms and are not confined in a glacial trough. This unit is commonly associated with landform groups I, K, and O.

M Meltwater Canyons and Coulees



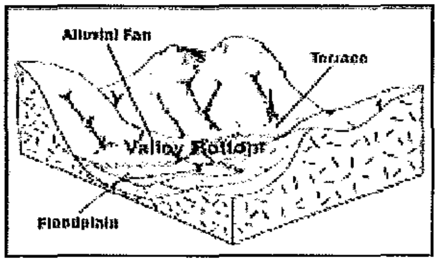
This landform occurs on extremely steep, rocky sideslopes bordering relatively flat valley bottoms. Landforms were shaped by glacial/fluvial flooding induced by the melting of glaciers. Slope gradients on sideslopes typically exceed 60% and valley floor slope gradients are generally less than 20%. Valley floors are typically underlain with glacial outwash and morainal deposits. Glacial till deposits are generally absent from sideslopes but may occur along toeslope positions or at mouths of tributary drainages. Canyonwalls are dissected by weakly defined, low order, intermittent streams in a parallel drainage pattern. Mainstem streams, if present, can be higher energy, low gradient and perennial. Channels are commonly meandering and substrate is moderately to well sorted sand to boulder size. Ponds, marshes, overflow channels, and morainal lakes are not uncommon. This unit is commonly associated with landform groups G or O.

N Glaciated Trough Valley Bottoms



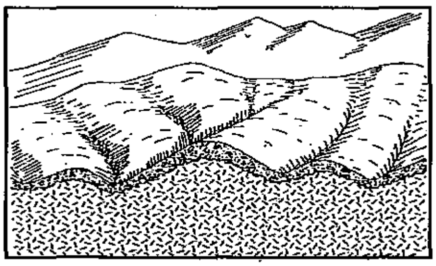
This landform occurs in the valley bottoms of glacially eroded U-shaped glacial troughs. These glaciated trough valley bottoms occur in wider valley bottoms in which scale allows separation from K landform units. Slope gradients are gentle (<30%) and planar to undulating where debris and alluvial fan deposits occur. This landform was shaped by glaciers advancing and receding in glacial valleys intermittently eroding and depositing material and subsequent glacial-fluvial processes and finally, fluvial processes. Glacial till deposits, debris fan deposits, outwash deposits, and overridden bedrock all occur. Channel types range from meandering above gradient "niche" points forming wetlands to moderate gradient and confined by bedrock or glacial deposits. This unit is commonly associated with landform groups K and in lower elevations, landform group O.

O Valley Bottoms/Outwash



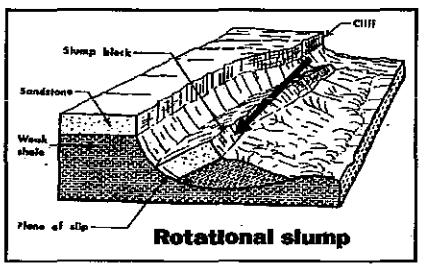
This landform occurs on nearly level terraces and floodplains in broad valley bottoms. Glacial/fluvial outwash deposition was the primary land forming process. Slopes gradients range from 0 to 20% and are generally less than 10% and are dissected by high energy, low gradient, perennial streams. Stream channels most commonly meander but may be braided in some reaches. Substrate is usually comprised of stratified sand to cobble size material but very large boulders are not uncommon. Ponds, marshes and overflow channels may occur. Valley bottoms are subject to frequent flooding. Subsurface and in-stream flow may be in continuity. Included within this landform are alluvial fans and colluvial deposits located along the valley sides. This unit is commonly associated with landform groups B, G, I, L, K, M and S.

P Rounded Ridge Tops



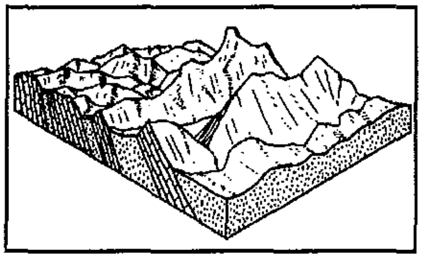
This landform occurs on smooth, broad, gently rolling convex ridges and upper side slopes. Landforms are considered to be shaped by frost action associated with peri-glacial processes. Deeply weathered bedrock and a mantle of moderately deep residual soil are characteristic of this landform. Inclusions of bedrock close to the surface do occur. Slope gradients generally range from 20 to 45%. This landform is dissected by poorly defined, low order intermittent and perennial streams with a weak, dendritic pattern. These units most often occur on upper ridges within areas association with continental and alpine glacial ice fields and are commonly associated with landform groups G, I and D.

Q Fault and Slide Escarpment



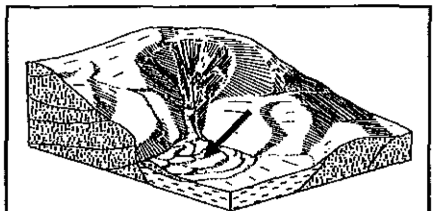
This landform occurs on steep to extremely steep, rocky slopes that border ridges and drainage divides. Landforms are fault or landslide escarpments representing tectonic and mass wasting processes.. Slope gradients range from 35% to greater than 90%. Bedrock outcrops are typical and soils are shallow and poorly developed. Streams form a sub-parallel drainage pattern but convergent drainages may occur on slide escarpments. High gradient channels are weakly to moderately incised. Colluvial and alluvial material collects where drainages are convergent, triggering recurring debris flows and torrents. This unit is commonly associated with landform groups T, U, V, W, and X.

S <u>Structurally Controlled Mountain Slopes</u>



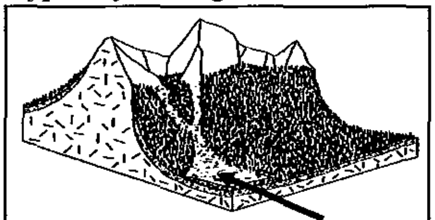
This landform occurs on steep, high relief mountain slopes underlain by inclined or folded sedimentary bedrock. Differential erosion and mass wasting was, and remains, the primary land forming processes. Slope shape is controlled by the orientation of sedimentary bedrock characterized by dip or scarp slopes or complexes. Ridges are very narrow and valleys typically are V-shaped. Slope gradients commonly greater than 35% with scarp slopes exceeding 60%. Slopes are dissected by a moderately high density of intermittent streams in a weak trellis to sub-dendritic drainage pattern. Channels are typically confined and moderately to deeply incised. Larger streams often follow dominant geologic structural trends. Soils are generally shallow with variable textures depending upon the type of bedrock. This unit is commonly associated with landform group O.

T <u>Landslide Undifferentiated</u>



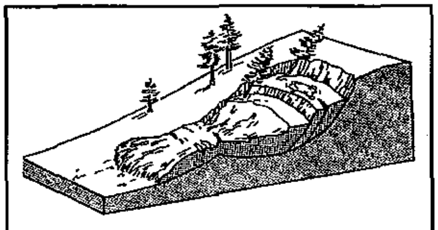
Mud flow

This landform occurs on lower gradient slopes consisting of benches and/or an irregular pattern of mounds and depressions. Landforms are the depositional areas of shallow rapid and sporadic semi-shallow mass wasting. Landslides originate in relatively cohesive soil, weathered bedrock, or glacial till deposits. Slope gradients range from 20 to 45%. Drainage patterns are typically deranged or contorted in the area of landslide deposition. Channels are generally poorly defined but can be entrenched where well developed. Subsurface and surface drainage divert water to depressions. Seeps and springs are common. Surface runoff and sediment commonly contained within the unit except where streams are entrenched. Mainstem streams occasionally undercut toe slopes triggering slope movement. This unit is most commonly associated with landform groups D, K, S, W, and X.



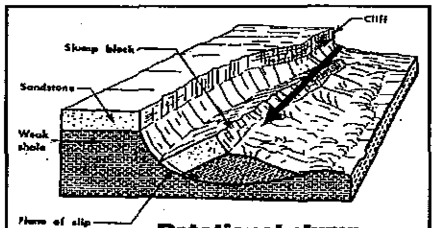
Debris flow

U Deep Ancient Landslides



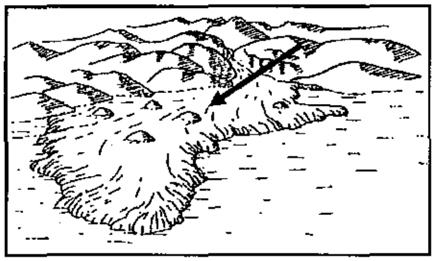
Rotational slide

This landform occurs on deep large-scale landslide deposits. It consists of a series of benches intermixed with hummocky irregular mounds and depressions. The landform is shaped by mass movement of deep, semi-consolidated material. Landslides are commonly triggered by earthquakes, prolong periods of saturation, changes in toe slope ballast, accelerated weathering processes and/or flooding associated with glacial recession. Slope gradients range from 10-40%. Channels are low gradient and poorly defined and are weakly to moderately incised. They have a deranged or contorted to weakly dendritic pattern. Subsurface and surface drainage diverts water to depressions creating seeps, springs and ponds. Streams along landslide margins can destabilize the mass locally reactivating a portion of the landslide mass. This unit is commonly associated with landform groups T, X, and W.



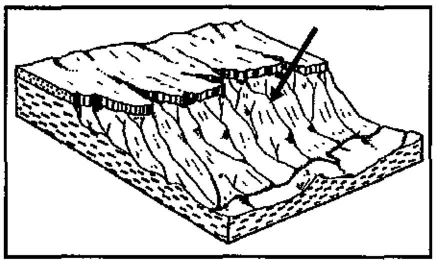
Rotational slump

W Moderately Gentle Volcanic Flows – Plateaus



This landform occurs on low to moderate relief, rolling terrain with smooth, broad, convex ridges and narrow flat bottomed valleys. These landforms were shaped from fluvial erosion on the gently sloping surface of volcanic and volcaniclastic flows (locally referred to as basalt flows). Slope gradients are generally 0 to 20%. Slopes are dissected by a low density of weakly to moderately incised intermittent streams in a dendritic pattern. Stream channels have low to moderate gradients. Aquifers contained by impervious rock may become exposure sideslopes producing springs. This unit is commonly associated with landform group Q, T, U, X and Y.

X Moderately Steep Volcanic Flows



This landform occurs on moderate to steep hillslopes with smooth convex ridges and flat bottomed valleys. These landforms have been shaped by fluvial erosion on volcanic and pyroclastic flows. Slope gradients ranges from greater than 20 percent to over-steepened escarpments exceeding 45 percent. Slopes are dissected by a low density of moderately to highly incised intermittent streams in a parallel to dendritic drainage pattern. Channels have moderate to high gradients. This unit is commonly associated with landform group Q, T, U, W and Y.

Y **Volcanic Cones and Domes**

This landform occurs on a cone-shaped mound. The land forming process primarily was repeated volcanic eruptions. Slope gradients typically range from 35 to 90%. Slopes are dissected by a low to moderate density of incised streams in a radial drainage pattern. This unit is commonly associated with landform groups W and X.

Geology Group Descriptions

a **Foliated Crystalline Rocks** Bedrock is comprised of highly foliated metamorphic rock which displays gneissic or schistic fabric created by alignment of mineral grains into sheets or layers by intense heat or pressure. Typically these rocks are physically tough and chemically resistant. Rock composition ranges from felsic to mafic, with mafic lithology often seen as amphibolites. A rectangular joint pattern is common. Rocks weather to coarse and moderately coarse textured soils. Typical formations include pre-Tertiary banded gneiss (pTbg) and as the Tonasket and Swakane biotite gneiss (Ksg).

b **Massive Crystalline Rocks** Bedrock is comprised of igneous plutonic rock of Cretaceous and Tertiary age. Bedrock structure is massive, but earlier plutons may display gneissic or migmatic fabric due to regional metamorphism or partial re-melting during intrusion of younger magmas. These rocks are resistant to weathering and commonly form ridges in areas of past alpine glaciation. Rhyolitic and/or granitic dikes are locally present. Rocks weather to coarse and moderately coarse textured soils. Typical formations include Mount Stuart and Entiat Plutons, and mixed metamorphic and igneous rocks (KJmi) of Tiffany Mountain.

c **Continental Sedimentary Rocks** Bedrock is comprised of structurally folded sedimentary bedrock of early Tertiary age. Rocks are derived from consolidation of continental sediments that were rapidly deposited into large fault-controlled basins. Lithology is primarily medium to coarse grained mica and feldspar-rich sandstones commonly interbedded with siltstone and shale with minor conglomerate and volanic units. Bedding ranges from thin interbeds to massive cross beds. Bedrock structure and weathering resistance influences land shape; hillslope and hydrologic processes. Resistant and/or vertical beds form ridges. Less resistant rock readily weathers to shallow, sandy to fine sandy loam soils. Typical units include the Swauk and Chumstick Formations.

d **Tertiary Volcanic Rocks** Bedrock is comprised of volcanic rocks, primarily of middle to late Tertiary age. Rock was formed from lava flows and extrusions of andesite, dacite, basalt and/or rhyolite composition and include minor interbeds of volcanic ash and clastic sediment. Mineral composition is fine grained and chemistry is similar to the intrusive crystalline geology groups. The fine grain size, absence of mica, and a glassy matrix make these rocks resistant to weathering. Soils are relatively shallow and weakly developed with coarse, angular rock fragments. Typical bedrock units include andesites and dacite of Carter Mountain and the Sanpoil Volcanics, and the flows and domes which occur in the South Cascade Mountains.

e **Basalt Rocks - Interbedded** Bedrock is formed from multi-layers of basaltic lava flows extruded in the early to mid Miocene. Accumulating to over 1,000 feet, this rock unit is structurally segmented by columnar jointing and interbeds of weakly cemented sedimentary and pyroclastic deposits of the Ellensburg formation. Bedrock is relatively resistant and weathers to clay loam soil textures. Plateaus and broad structurally folded ridges are common landforms. Typical formations are Grande Rhonde and other related units of the Columbia River Basalt Group.

f **Pyroclastic Rocks** Bedrock is comprised of a complex mix of, often interstratified, rocks from mid to late Tertiary volcanic flows, interbedded with pyroclastic flows, ash fall deposits, tuffs, breccias, volcaniclastics, and volcanic rich sandstones. Lahar and debris flow deposits are common. Commonly, strata are deeply weathered with areas of more resistant facies or beds. This group also includes local metamorphic rock units with similar weathering characteristics and other management concerns. Typically these rocks weather to moderately fine and fine textures. Typical formations include the Fifes Peak and Naches Formations.

g **Meta-Sedimentary Rocks - Kootenay Arc** Bedrock is comprised of a sequence of broadly to tightly folded, faulted, partially metamorphosed strata consisting of interbedded metacarbonates, metaargillites, metasiltites, and quartzites. Bedrock structure is alternating layers of massive and thin bedded rock 1,000 meters and more thick and is derived from marine and near shore sediments deposited from 630 to 420 million years ago. Typical formations are Meta-argillite (Oar), the Ledbetter Slate and Meta-quartzite (C-Zq) and the Gypsy-Addy Quartzite.

h **Meta-Sedimentary Rocks - Old Belt Series** Bedrock is comprised of Pre-Cambrian rocks of the Belt Super Group. In Northeast Washington strata is a 7,500M thick sequence of thinly bedded, quartz and mica argillite, and quartzite. The beds are moderately dipping and broken typically segmented into orthogonal blocks by multiple large-scale joint sets. The dominant outcrop trend of this widespread unit follows a regional northeast orientation. Ravalli Group (Yms_2) is the most typical formation.

i **Meta-SedimentaryRocks** Bedrock is comprised of meta sedimentary and volcanic bedrock of pre to late Cretaceous age. Strata consists of interbedded to massive continental sedimentary, volcaniclastic and/or volcanic rock, most likely derived from sediments deposited in a volcanic or "fore arc" basin and metamorphosed under low temperatures and pressures. Composition is predominantly aluminous siliceous. Rocks weather to soils of variable texture, ranging from silt to sandy loams. Typical formations include the Buck Mountain Formation and the Newby Group.

j **Meta-Sedimentary Rocks - Marine** Bedrock is comprised of marine meta-sedimentary rock of early Cretaceous age. Lithology consists of interbedded to finely laminated gray feldspathic sandstone, black shale and minor conglomerate. These are derived mainly from sediments deposited in shallow to deep water along the continental margin and then, metamorphosed under low temperature and pressure. Rock composition is variable ranging from basic to calcareous and aluminous siliceous with minor ultra-basic. Rocks weather to fine-textured soils and non-expandable clays. Typical units include Marine Meta-sedimentary Rocks of the Hart Pass; Goat Creek and Panther Creek formations.

k **Significant Inclusions** This geology group consists of varied bedrock formations of limited extent which contain unique characteristics important to ecological processes. At the scale (1:100,000) mapped, it consists mainly of the Ingalls complex, an assemblage of lower grade and thermally metamorphosed rock of mafic and ultra mafic composition. Primary rock composition includes foliated and massive serpentinite and serpentinized meta-peridotites, with local inclusions of meta-sedimentary rocks and hornblende.

u **Undifferentiated** This geology group consists primarily of surficial deposits such as glacial till, alluvium, landslide deposits, and glacial outwash. These deposits are generally of Pleistocene age or relatively young. Surficial deposits have non-rock matrix which varies in grain size mixed with rock fragments transported from a diversity of origins. Transport mechanisms determine whether material is poorly sorted or well sorted in terms of grain size distribution. Rock types are varied. Soil textures usually reflect the non-rock matrix texture and can vary from coarse to moderately fine.

Potential Natural Vegetation Group (PNV) Descriptions

1 **Dry Woodland/Shrub-Steppe Group** This group is extensive in continental climate zones on hot, dry sites, often in a narrow ecological band at the lower limits of the treeline transition to mountain grass/shrub lands. It can also extend to moderate elevations on hot, dry southerly exposures. It is relatively uncommon in maritime and inland maritime climatic regimes. Mature stands are dominated by ponderosa pine and/or Douglas-fir woodlands, often in mosaic with shrub-steppe. Characteristic plant associations include PSME/AGSP, PIPO-PSME/AGSP, PIPO/PUTR/AGSP, and PSME/PUTR/AGSP. Seral stands have similar tree composition. Inclusions of more or less closed forests of Douglas-fir (PNV Group 2) may occur on more mesic sites and subalpine fir and/or Engelmann spruce (PNV Group 8) on cooler sites at high elevations or at low to moderate elevations in stream bottoms. Oregon white oak woodlands are considered part of PNV Group 1 but are limited to the extreme southeast corner of Wenatchee National Forest.

2 **Douglas-fir Group** This group is extensive in continental climate zones on warm, dry sites and does not exist within maritime and inland maritime climate zones. Mature stands in this group are dominated by Douglas-fir. Characteristic plant associations include PSME/CARU, PSME/ARUV/CARU, PSME/SPBEL/CARU, PSME/SYAL, PSME/PHMA and PSME/PHMA-LIBOL. Seral stands on warmer, drier sites tend to be dominated by Douglas fir and/or ponderosa pine while cooler, mesic Douglas-fir sites are dominated by lodgepole pine and/or western larch. Inclusions of subalpine fir (PNV Group 8) occur along the cooler fringes of this group, at the upper, colder elevations, and along valley bottoms or in cold air depressions. Ponderosa pine and Douglas-fir woodlands/shrub-steppe (PNV Group 1) may be found as inclusions on hotter, drier aspects.

3 **Douglas-fir/Grand Fir Group** This group is found in the interzonal maritime and inland maritime climate zones. Sites are relatively warm and dry for these climatic zones and occur largely on more southerly aspects or at lower elevations on northerly aspects. This PNV group is found on the west side of the Cascade Crest on the Mt. Baker/Snoqualmie NF portion administered by the Okanogan N.F., the eastern portion of the Colville N.F., and the Naches, Cle Elum, Leavenworth, and Lake Wenatchee Ranger Districts of the Wenatchee N.F. Mature stands in this group are predominately Douglas-fir Series and Grand Fir Series and occur in a complex mix on the landscape.. Characteristic plant associations include PSME/PAMY, PSME/PHMA-LIBOL, PSME/CARU, PSME/CAGE, ABGR/ARCO, ABGR/CARU and ABGR/PHMA. Seral stands may be dominated by Douglas-fir, lodgepole pine, or western larch. Inclusions of western hemlock/western red cedar (PNV Group 6) occur on more moist sites. Inclusions of subalpine fir (PNV Group 8) occur on higher, colder sites on the Colville N.F.

4 **Douglas-fir (Grand Fir)/Western Hemlock Group** This group is found within the inland maritime climate zones. Sites are relatively warm and dry on southerly aspects

and warm and moist on northern exposures or in drainageways. This PNV group is found east of the Kettle Crest on the Colville N.F. Mature stands in this group are predominately Douglas-fir and western red cedar/western hemlock and occur in complex patterns across landscapes. Characteristic plant associations include PSME/CARU, PSME/PHMA, PSME/PHMA-LIBOL and PSME/SYAL on drier sites; higher moisture sites support TSHE/MEFE and TSHE/VAME. Wetter sites are characterized by TSHE/ARNU3 and THPL/OPHO. Seral species include lodgepole pine, grand fir, Douglas-fir, western white pine, grand fir, western larch, and Engelmann spruce. Inclusions of moist to wet sites support a continuous stand of western hemlock /western red cedar (PNV Group 6) characterized by TSHE/ARNU3 and THPL/OPHO plant associations. Inclusions of subalpine fir (PNV Group 8) may occur on cooler sites on the western third of this survey area where the climate becomes transitional to continental climates in the vicinity of the Kettle Crest.

5 **Grand Fir/Western Hemlock Group** This group is found in a broad transition from continental to maritime climate on the Naches, Cle Elum, Leavenworth, and Lake Wenatchee Ranger Districts of the Wenatchee N.F. Sites are relatively warm and moist. Mature stands in this group are predominately by grand fir on dry sites and western hemlock on more moist sites. This group occurs in a complex mix across landscapes. Characteristic plant associations include ABGR/SPBEL/PTAQ, variations of ABGR/ACCI, ABGR/BENE, and ABGR/ACTR on drier sites and western hemlock associations on more moist upland sites, e.g., TSHE/BENE and TSHE/ACTR. Wetter sites are characterized by TSHE/ASCA3 and TSHE/OPHO. Seral species include lodgepole pine, grand fir, Douglas-fir, western white pine, grand fir, western larch, and Engelmann spruce. Inclusion of moist to wet sites support a continuous stands of western hemlock/western red cedar (PNV Group 6) characterized by TSHE/ARNU3 and THPL/OPHO plant associations. Inclusions of subalpine fir (PNV Group 8) may occur on colder sites.

6 **Western Hemlock/Western Red Cedar Group** These warm, moist sites are prominent in the inland maritime climate found on the east two-thirds of the Colville National Forest, the maritime climate on the extreme west side of the Algonkian near Ross Lake, and where continental climates blend with maritime climates on the Wenatchee National Forest. Mature stands are dominated by western hemlock and/or western red cedar. Characteristic plant associations include TSHE/ACTR, TSHE/BENE, variations of TSHE/ACCI, TSHE/MEFE and TSHE.VAME. Seral stands may be dominated by a wide variety of species including lodgepole pine and western larch following stand replacement fires to Douglas-fir or grand fir where stands have been maintained by frequent low intensity fires. Inclusions of Douglas-fir/grand fir (PNV Group 3 and PNV Group 5) may occur on warmer, drier sites on Wenatchee N.F. and Douglas-fir/western hemlock (PNV Group 4) on the Colville N.F. Subalpine fir (PNV Group 8) inclusions occur at higher elevations on the Colville N.F. whereas Silver fir (PNV Group 7) may occupy higher, cool, moist inclusions on the Algonkian and Wenatchee National Forests.

7 **Silver Fir/Mountain Hemlock Group** This group is abundant within the cool, moist maritime climate along the Cascade Crest. Mature stands are dominated by silver fir and/or mountain hemlock. Mountain hemlock generally occurs at higher elevations characterized by longer winters and deeper snowpack. Characteristic plant

associations include ABAM/ACTR, ABAM/VAME-PYSE, TSME/RHAL-VAME and TSME/VASC/LUHI. Seral stands may be dominated by wide variety of trees, including subalpine fir, western hemlock, western red cedar, Engelmann spruce, lodgepole pine, western white pine, noble fir, Alaska yellow cedar, and western white pine. Inclusions of subalpine fir (PNV Group 8) or parkland/alpine (PNV Group 9) occur at higher elevations and western hemlock/western red cedar (PNV Group 6) at lower elevations. There are also inclusions of mountain meadows.

8 **Subalpine Fir Group** This group is a major dominant in continental climatic zones on cool, moist, high elevation sites and extends to lower elevations along river bottoms. Mature stands are dominated by more or less closed forests of subalpine fir and/or Engelmann spruce. Many seral stands are dominated by lodgepole pine due to large stand replacement fires. Characteristic Plant Associations include ABLA2/VAME, ABLA2/COCA, ABLA2/VASC, and ABLA2/PAMY. This PNV group is more limited in moist climatic regimes; mountain hemlock or western hemlock occupies sites that would otherwise be occupied by subalpine fir. Inclusions of the group (PNV Group 2) occur at lower elevations on unusually warmer sites. Mountain hemlock parkland (PNV Group 9) may occur as inclusions on cold, harsh, high elevation sites in maritime zones while parklands of whitebark pine or alpine larch (PNV Group 9) are common inclusions on similar but drier sites.

9 **Parkland/Alpine Group** This very cold, moist group occurs in a narrow ecological band at the upper limits of treeline. Depending on elevation and climate, these "parklands" are variously dominated by alpine larch, whitebark pine, subalpine fir or mountain hemlock. Mountain hemlock parklands dominate within strong maritime areas while whitebark pine is prominent in inland maritime climate. Subalpine fir, whitebark pine or alpine larch parklands are widespread in continental climates. Stand structures are variable and generally characterized as parkland, woodland or krumholtz. Characteristic plant associations include LALY/CAME-LUPE, PIAL/VASV/LUHI, ABLA/2VASC/LUHI and TSME/PHEM-VADE. Extensive areas of true alpine communities are included within this group. Inclusions of closed forests of mountain hemlock (PNV Group 7) and subalpine fir (PNV Group 8) occur along the lower elevations of this group.

PART III:
Landtype Associations Identification Legend

Table 3. Tri-Forest Landtype Association Identification Legend

Landtype Association *Tri-Forest* Identification Legend				
Map Symbol	**Landform**	**Bedrock Geology**	**Vegetation Zones** (PNV)	**Occurrence** *(National Forest)*
Bu6	Lacustrine Benches	Undifferentiated	Western Hemlock and Supalpine Fir with some Douglas-Fir	*Colville*
Da3	Dissected Mountain Slopes	Massive and Foliated Crystalline Rocks	Douglas-Fir and Grand Fir	*Wenatchee*
Da5	Dissected Mountain Slopes	Massive and Foliated Crystalline Rocks	Grand Fir and Western Hemlock	*Wenatchee*
Da8	Dissected Mountain Slopes	Massive and Foliated Crystalline Rocks	Subalpine Fir	*Wenatchee*
Db1	Dissected Mountain Slopes	Massive and Foliated Crystalline Rocks	Ponderosa Pine and Shrub-Steppe	*Wenatchee*
Db2	Dissected Mountain Slope	Massive and Foliated Crystalline Rocks	Douglas-Fir with some Ponderosa Pine/Shrub-Steppe	*Okanogan Wenatchee*
Db4	Dissected Mountain Slopes	Massive and Foliated Crystalline Rocks	Douglas-Fir and Western Hemlock	*Colville*
Fa2	Scoured Glacial Troughs	Massive and Foliated Crystalline Rocks	Douglas-Fir and Ponderosa Pine/Shrub-Steppe with some Grand Fir	*Wenatchee*
Fb7	Scoured Glacial Troughs	Massive and Foliated Crystalline and Pyroclastic, with some Tertiary Continental Sedimentary Rocks	Silver Fir and Mountain Hemlock with some Western Hemlock	*Okanogan Wenatchee*
Fb8	Scoured Glacial Troughs	Massive and Foliated Crystalline with some Tertiary Continental Sedimentary Rocks	Subalpine Fir	*Okanogan Wenatchee*
Fb9	Scoured Glacial Trough	Massive and Foliated Crystalline with some Tertiary Continental Sedimentary Rocks	Parkland with some Subalpine Fir	*Okanogan Wenatchee*
Ff9	Scoured Glacial Troughs	Pyroclastic, Tertiary Volcanic and Kootenay Arc, Old-Belt, and Marine Metasedimentary Rocks	Parkland with some Subalpine Fir	*Colville Okanogan Wenatchee*
Fj2	Scoured Glacial Trough	Marine Meta-Sediments	Douglas-Fir with some Ponderosa Pine/Shrub-Steppe	*Okanogan*

Table 3. Tri-Forest Landtype Association Identification Legend (continued)

Landtype Association *Tri-Forest* Identification Legend				
Map Symbol	**Landform**	**Bedrock Geology**	**Vegetation Zones** (PNV)	**Occurrence** ***(National Forest)***
Ga2	Scoured Glaciated Mountain Slopes	Foliated and Massive Crystalline with some Meta-Sedimentary Rocks	Douglas-Fir with some Ponderosa Pine/Shrub-Steppe	*Colville Okanogan Wenatchee*
Gb4	Scoured Glaciated Mountain Slopes	Massive and Foliated Crystalline Rocks	Douglas-Fir and Western Hemlock	*Colville*
Gb7	Scoured Glaciated Mountain Slopes	Massive and Foliated Crystalline Rocks	Silver Fir and Mountain Hemlock	*Wenatchee*
Gb8	Scoured Glaciated Mountain Slopes	Massive and Foliated Crystalline Rocks	Subalpine Fir and Parkland with some Silver Fir/Mountain Hemlock	*Colville Okanogan Wenatchee*
Gb9	Scoured Glaciated Mountain Slopes	Massive and Foliated Crystalline Rocks	Parkland	*Okanogan Wenatchee*
Gd2	Scoured Glaciated Mountain Slopes	Tertiary Volcanic Rocks	Douglas-Fir with some Ponderosa Pine/Shrub-Steppe	*Colville Okanogan*
Gd5	Scoured Glaciated Mountain Slopes	Tertiary Volcanic, Pryoclastic, Tertiary Continental Sedimentary Rocks	Grand Fir and Western Hemlock	*Wenatchee*
Gd7	Scoured Glaciated Mountain Slopes	Tertiary Volcanic, Pryoclastic, Tertiary Continental Sedimentary Rocks	Silver Fir and Mountain Hemlock	*Wenatchee*
Gd8	Scoured Glaciated Mountain Slopes	Tertiary Volcanic, Pryoclastic, Tertiary Continental Sedimentary Rocks	Subalpine Fir and Parkland with some Silver Fir/Mountain Hemlock	*Wenatchee*
Gg3	Scoured Glaciated Mountain Slopes	Meta-Sedimentary: Kootenay Arc and Old Belts Series Rocks	Douglas-Fir and Grand Fir	*Colville*
Gg8	Scoured Glaciated Mountain Slopes	Meta-Sedimentary: Kootenay Arc and Old Belts Series Rocks	Subalpine Fir with some Parkland	*Colville*
Gi8	Scoured Glaciated Mountain Slopes	Meta-Sediments excluding Kootenay Arc and Old-Belt Series with some Tertiary Volcanic Rocks	Subalpine Fir	*Okanogan*

Table 3. Tri-Forest Landtype Association Identification Legend (continued)

Landtype Association *Tri-Forest* Identification Legend				
Map Symbol	**Landform**	**Bedrock Geology**	**Vegetation Zones** (PNV)	**Occurrence** *(National Forest)*
Ha7	Glacial Cirque Basins	Massive and Foliated Crystalline with some Pyroclastic Rocks	Silver Fir and Mountain Hemlock	*Okanogan Wenatchee*
Ha8	Glacial Cirque Basins	Foliated and Massive Crystalline Rocks	Subalpine Fir	*Colville Okanogan Wenatchee*
Hb9	Glacial Cirque Basins	Massive and Foliated Crystalline Rocks	Parkland	*Okanogan Wenatchee*
Hi9	Glacial Cirque Basins	Pyroclastic and Tertiary Volcanic, Meta-Sediments excluding Kootenay Arc and Old-Belt Series Rocks	Parkland	*Colville Okanogan Wenatchee*
Ia2	Glaciated Mountain Slopes	Foliated and Massive Crystalline Rocks with some Tertiary Continental Sedimentary Rocks	Douglas-Fir with some Ponderosa Pine/Shrub-Steppe	*Colville Okanogan Wenatchee*
Ia3	Glaciated Mountain Slopes	Foliated and Massive Crystalline Rocks	Douglas Fir and Grand Fir	*Wenatchee*
Ia7	Glaciated Mountain Slopes	Foliated and Massive Crystalline Rocks	Silver Fir and Mountain Hemlock	*Wenatchee*
Ia8	Glaciated Mountain Slopes	Foliated and Massive Crystalline Rocks	Subalpine Fir with some Silver Fir/Mountain Hemlock	*Colville Okanogan Wenatchee*
Ib6	Glaciated Mountain Slopes	Massive and Foliated Crystalline Rocks	Douglas-Fir and Western Hemlock	*Colville*
Ic5	Glaciated Mountain Slopes	Tertiary Continental Sedimentary and Foliated Crystalline Rocks with some Tertiary Volcanic Rocks	Grand Fir and Western Hemlock	*Wenatchee*
Id2	Glaciated Mountain Slopes	Tertiary Volcanic Rocks	Douglas-Fir and Ponderosa Pine/Shrub-Steppe	*Colville Okanogan Wenatchee*
Id7	Glaciated Mountain Slopes	Tertiary Volcanic and Pyroclastic Rocks with some Tertiary Continental Sedimentary Rocks	Silver Fir and Mountain Hemlock	*Wenatchee*
Ig4	Glaciated Mountain Slopes	Meta-Sedimentary: Kootenay Arc with some Old-Belts Series Rocks	Douglas-Fir and Western Hemlock	*Colville*
Ig6	Glaciated Mountain Slopes	Meta-Sedimentary: Kootenay Arc Rocks	Western Hemlock with some Subalpine Fir	*Colville*

Table 3. Tri-Forest Landtype Association Identification Legend (continued)

Landtype Association *Tri-Forest* Identification Legend				
Map Symbol	**Landform**	**Bedrock Geology**	**Vegetation Zones** (PNV)	**Occurrence** ***(National Forest)***
Ih6	Glaciated Mountain Slopes	Meta-Sedimentary: Old-Belt Rocks	Western Hemlock	*Colville*
Ih8	Glaciated Mountain Slopes	Meta-Sedimentary: Old-Belts Series Rocks	Subalpine Fir	*Colville*
Ja8	Dissected Glaciated Mountain Slopes	Foliated and Massive Crystalline Rocks	Subalpine Fir	*Okanogan*
Jb1	Dissected Glaciated Mountain Slopes	Massive and Foliated Crystalline Rocks	Ponderosa Pine and Shrub-Steppe	*Okanogan*
Jb2	Dissected Glaciated Mountain Slopes	Massive and Foliated Crystalline Rocks	Douglas-Fir with some Ponderosa Pine/Shrub-Steppe	*Okanogan*
Ji8	Dissected Glaciated Mountain Slopes	Meta-Sedimentary excluding Kootenay Arc and Old-Belt Series with some Tertiary Volcanic Rocks	Subalpine Fir	*Okanogan*
Jj1	Dissected Glaciated Mountain Slopes	Meta-Sedimentary excluding Kootenay Arc and Old-Belt Series with some Tertiary Volcanic Rocks	Ponderosa Pine and Shrub-Steppe	*Okanogan*
Jj2	Dissected Glaciated Mountain Slopes	Meta-Sedimentary excluding Kootenay Arc and Old-Belt Series with some Tertiary Volcanic Rocks	Douglas-Fir with some Ponderosa Pine/Shrub-Steppe	*Okanogan*
Ka2	Glacial Troughs	Massive and Foliated Crystalline Rocks	Douglas-Fir with some Ponderosa Pine/Shrub-Steppe	*Wenatchee*
Ka5	Glacial Troughs	Foliated and Massive Crystalline Rocks with some Tertiary Continental Sedimentary Rocks	Grand Fir and Western Hemlock	*Okanogan Wenatchee*
Ka6	Glacial Troughs	Foliated and Massive Crystalline and Pryoclastic with some Tertiary Continental Sedimentary Rocks	Western Hemlock	*Wenatchee*
Ka7	Glacial Troughs	Foliated and Massive Crystalline and Pryoclastic with some Tertiary Continental Sedimentary Rocks	Silver Fir and Mountain Hemlock with some Western Hemlock	*Okanogan Wenatchee*

Table 3. Tri-Forest Landtype Association Identification Legend (continued)

Landtype Association *Tri-Forest* Identification Legend

Map Symbol	Landform	Bedrock Geology	Vegetation Zones (PNV)	Occurrence *(National Forest)*
Kb8	Glacial Troughs	Massive and Foliated Crystalline with some Tertiary Continental Sedimentary Rocks	Subalpine Fir with some Douglas-Fir	*Okanogan Wenatchee*
Kb9	Glacial Troughs	Massive and Foliated Crystalline with some Tertiary Continental Sedimentary Rocks	Parkland	*Okanogan Wenatchee*
Kc6	Glacial Troughs	Tertiary Continental Sedimentary Rocks	Grand Fir and Western Hemlock	*Okanogan Wenatchee*
Kf5	Glacial Troughs	Pyroclastic Rocks	Grand Fir and Western Hemlock	*Wenatchee*
Kf7	Glacial Troughs	Pyroclastic with some Tertiary Volcanic Rocks	Silver Fir and Mountain Hemlock	*Okanogan Wenatchee*
Kf8	Glacial Troughs	Pyroclastic with some Tertiary Volcanic Rocks	Subalpine Fir	*Wenatchee*
Kj2	Glacial Troughs	Meta-Sedimentary excluding Kootenay Arc and Old-Belt Series Rocks	Douglas-Fir	*Okanogan*
Kj3	Glacial Troughs	Meta-Sedimentary excluding Kootenay Arc and Old-Belt Series Rocks	Douglas-Fir and Grand Fir	*Okanogan*
Kj8	Glacial Troughs	Meta-Sedimentary including Kootenay Arc and Old-Belt Series Rocks	Subalpine Fir with some Western Hemlock	*Okanogan Colville*
Kk7	Glacial Troughs	Significant Inclusions: Serpentine with some Tertiary Continental Sedimentary Rocks	Silver Fir and Mountain Hemlock with some Subalpine Fir	*Wenatchee*
La1	Glacial Moraines	Foliated and Massive Crystalline Rocks	Ponderosa Pine and Shrub-Steppe	*Okanogan*
La2	Glacial Moraines	Foliated and Massive Crystalline Rocks	Douglas-Fir with some Ponderosa Pine/Shrub-Steppe	*Colville Okanogan Wenatchee*
Lb4	Glacial Moraines	Massive and Foliated Crystalline Rocks	Douglas Fir and Western Hemlock	*Colville*
Lb6	Glacial Moraines	Massive and Foliated Crystalline Rocks	Western Hemlock with some Douglas-Fir and Subalpine Fir	*Colville*
Lb8	Glacial Moraines	Massive and Foliated Crystalline Rocks	Subalpine Fir	*Colville Okanogan Wenatchee*
Ld2	Glacial Moraines	Tertiary Volcanic Rocks	Douglas-Fir and Ponderosa Pine/Shrub-Steppe	*Colville Okanogan*
Lg4	Glacial Moraines	Meta Sedimentary including Kootenay Arc with some Tertiary Volcanic Rocks	Douglas Fir, Grand fir and Western Hemlock	*Colville*

Table 3. Tri-Forest Landtype Association Identification Legend (continued)

Landtype Association *Tri-Forest* Identification Legend				
Map Symbol	**Landform**	**Bedrock Geology**	**Vegetation Zones** (PNV)	**Occurrence** *(National Forest)*
Lg6	Glacial Moraines	Meta Sedimentary including Kootenay Arc with some Tertiary Volcanic Rocks	Western Hemlock with some Douglas-Fir and Subalpine Fir	*Colville*
Lh6	Glacial Moraines	Meta Sedimentary including Old-Belts Series Rocks	Western Hemlock with some Douglas-Fir and Subalpine Fir	*Colville*
Lj1	Glacial Moraines	Meta-Sedimentary excluding Kootenay Arc and Old-Belts Series Rocks	Ponderosa Pine and Shrub-Steppe	*Okanogan*
Lj2	Glacial Moraines	Meta-Sedimentary including Kootenay Arc and Old-Belt Series Rocks	Douglas-Fir with some Ponderosa Pine/Shrub-Steppe	*Colville* *Okanogan*
Lj8	Glacial Moraines	Meta-Sedimentary excluding Kootenay Arc and Old-Belt Series Rocks	Subalpine Fir	*Okanogan*
Mu2	Meltwater Canyon and Coulees	Undifferentiated	Douglas-Fir with some Ponderosa Pine and Subalpine Fir	*Colville* *Okanogan*
Mu6	Meltwater Canyon and Coulees	Undifferentiated	Douglas Fir, Western Hemlock, and Subalpine Fir	*Colville* *Wenatchee*
Na5	Glaciated Trough Valley Bottoms	Foliated and Massive Crystalline Rocks	Grand Fir and Western Hemlock	*Okanogan* *Wenatchee*
Na6	Glaciated Trough Valley Bottoms	Foliated and Massive Crystalline Rocks	Western Hemlock with some Douglas-Fir and Subalpine Fir	*Wenatchee*
Na7	Glaciated Trough Valley Bottoms	Foliated and Massive Crystalline Rocks	Silver Fir and Mountain Hemlock with some Subalpine Fir	*Okanogan* *Wenatchee*
Nb8	Glaciated Trough Valley Bottoms	Massive and Foliated Crystalline with some Tertiary Continental Sedimentary Rocks	Subalpine Fir	*Okanogan* *Wenatchee*
Nf5	Glaciated Trough Valley Bottoms	Pyroclastic with some Tertiary Volcanic Rocks	Grand Fir and Western Hemlock	*Okanogan* *Wenatchee*
Nj2	Glaciated Trough Valley Bottoms	Meta-Sedimentary including Kootenay Arc and Old-Belt Series Rocks	Douglas-Fir with some Ponderosa Pine and Subalpine Fir	*Okanogan*
Nj8	Glaciated Trough Valley Bottoms	Meta-Sedimentary including Kootenay Arc and Old-Belt Series Rocks	Subalpine Fir	*Okanogan*
Nk7	Glaciated Trough Valley Bottoms	Significant Inclusions: Serpentine with some Tertiary Continental Sedimentary Rocks	Silver Fir and Mountain Hemlock with some Subalpine Fir	*Wenatchee*

Table 3. Tri-Forest Landtype Association Identification Legend (continued)

Landtype Association *Tri-Forest* Identification Legend				
Map Symbol	**Landform**	**Bedrock Geology**	**Vegetation Zones** (PNV)	**Occurrence** ***(National Forest)***
Nu2	Glaciated Trough Valley Bottoms	Undifferentiated	Douglas-Fir with some Ponderosa Pine and Subalpine Fir	*Okanogan Wenatchee*
Nu6	Glaciated Trough Valley Bottoms	Undifferentiated	Douglas Fir, Western Hemlock, and Subalpine Fir	*Okanogan Wenatchee*
Ou2	Valley Bottoms	Undifferentiated	Douglas-Fir with some Ponderosa Pine/Shrub-Steppe	*Colville Okanogan Wenatchee*
Ou6	Valley Bottoms	Undifferentiated	Douglas-Fir, Western Hemlock, Spruce, and Subalpine Fir	*Colville Okanogan Wenatchee*
Pa9	Rounded Ridge Tops	Foliated and Massive Crystalline Rocks	Parkland with some Subalpine Fir	*Colville Okanogan Wenatchee*
Pb8	Rounded Ridge Top	Massive and Foliated Crystalline Rocks	Subalpine Fir	*Colville Okanogan Wenatchee*
Pi9	Rounded Ridge Top	Volcanics, Meta-Sedimentary including Kootenay Arc and Old-Belt Series Rocks	Parkland and Subalpine Fir	*Colville Okanogan Wenatchee*
Qu2	Landslide and Fault Escarpments	Undifferentiated	Douglas-Fir with some Grand Fir	*Wenatchee*
Qu8	Landslide and Fault Escarpments	Undifferentiated	Subalpine Fir with some Silver Fir	*Wenatchee*
Sc1	Structurally Controlled Mountain Slopes	Tertiary Continental Sedimentary Rocks	Ponderosa Pine and Shrub/Steppe	*Wenatchee*
Sc2	Structurally Controlled Mountain Slopes	Tertiary Continental Sedimentary Rocks	Douglas-Fir	*Wenatchee*
Sc3	Structurally Controlled Mountain Slopes	Tertiary Continental Sedimentary with some Basalt Rocks	Douglas-Fir and Grand Fir	*Wenatchee*
Sc5	Structurally Controlled Mountain Slopes	Tertiary Continental Sedimentary with some Basalt Rocks	Subalpine Fir with some Silver Fir/Mountain Hemlock	*Wenatchee*
Sc8	Structurally Controlled Mountain Slopes	Tertiary Continental Sedimentary with some Basalt Rocks	Subalpine Fir with some Silver Fir/Mountain Hemlock	*Wenatchee*
Sh4	Dissected Mountain Slopes	Meta-Sedimentary: Old Belts Series Rocks	Douglas-Fir and Western Hemlock	*Colville*

Table 3. Tri-Forest Landtype Association Identification Legend (continued)

Landtype Association *Tri-Forest* Identification Legend				
Map Symbol	**Landform**	**Bedrock Geology**	**Vegetation Zones** (PNV)	**Occurrence** *(National Forest)*
Tu3	Landslides Undifferentiated	Undifferentiated	Douglas-Fir and Grand Fir with some Ponderosa Pine/Shrub-Steppe	*Wenatchee*
Tu5	Landslides Undifferentiated	Undifferentiated	Grand Fir and Western Hemlock	*Wenatchee*
Tu7	Landslides Undifferentiated	Undifferentiated	Silver Fir and Mountain Hemlock	*Wenatchee*
Tu8	Landslides Undifferentiated	Undifferentiated	Subalpine Fir	*Wenatchee*
Uu3	Deep Ancient Landslides	Undifferentiated	Douglas-Fir and Grand Fir with some Ponderosa Pine/Shrub-Steppe	*Wenatchee*
Uu5	Deep Ancient Landslides	Undifferentiated	Grand Fir and Western Hemlock	*Wenatchee*
Uu7	Deep Ancient Landslides	Undifferentiated	Silver Fir and Mountain Hemlock	*Wenatchee*
Uu8	Deep Ancient Landslides	Undifferentiated	Subalpine Fir	*Okanogan Wenatchee*
We1	Moderately Gentle Volcanic Flows- Plateaus	Basalt with some Tertiary Volcanic/Pyroclastic Rocks	Ponderosa Pine and Shrub-Steppe with some Ponderosa Pine/Shrub-Steppe	*Wenatchee*
We3	Moderately Gentle Volcanic Flows- Plateaus	Basalt with some Tertiary Volcanic/Pyroclastic Rocks	Ponderosa Pine, Shrub-Steppe, Douglas-Fir and Grand Fir	*Wenatchee*
We5	Moderately Gentle Volcanic Flows- Plateaus	Basalt with some Tertiary Volcanic/Pyroclastic Rocks	Grand Fir and Western Hemlock	*Wenatchee*
We7	Moderately Gentle Volcanic Flows- Plateaus	Basalt with some Tertiary Volcanic/Pyroclastic Rocks	Silver Fir and Mountain Hemlock	*Wenatchee*
We8	Moderately Gentle Volcanic Flows- Plateaus	Basalt with some Tertiary Volcanic/Pyroclastic Rocks	Subalpine Fir with some Silver Fir/Mountain Hemlock	*Wenatchee*
Xe3	Moderately Steep Volcanic Flows	Basalt with some Tertiary Volcanic/Pyroclastic Rocks	Douglas-Fir and Grand Fir with some Ponderosa Pine/Shrub-Steppe	*Wenatchee*
Xe5	Moderately Steep Volcanic Flows	Basalt with some Tertiary Volcanic/Pyroclastic Rocks	Grand Fir and Western Hemlock	*Wenatchee*
Xf7	Moderately Steep Volcanic Flows	Pyroclastic with some Tertiary Volcanic Rocks	Silver Fir and Mountain Hemlock with some Subalpine Fir	*Wenatchee*

Table 3. Tri-Forest Landtype Association Identification Legend (continued)

Landtype Association *Tri-Forest* Identification Legend				
Map Symbol	**Landform**	**Bedrock Geology**	**Vegetation Zones** (PNV)	**Occurrence** *(National Forest)*
Xf8	Moderately Steep Volcanic Flows	Pyroclastic and Basalt Rocks	Subalpine Fir with some Parkland	*Wenatchee*
Yd5	Volcanic Cones and Domes	Tertiary Volcanic Rocks	Grand Fir and Western Hemlock	*Wenatchee*

Below, is Table 4 listing acreage occurrence by Forest for all Landtype Association in the Tri-Forest survey area. This acreage summary was generated by GIS.

Table 4. Acreage Summary for Landtype Association - acres

Map Symbol	Colville National Forest	Okanogan National Forest	Wenatchee National Forest	TOTAL ACREAGE
Bu6	60003			60003
Da3			10059	10059
Da5			29152	29152
Da8			24693	24693
Db1			56131	56131
Db2		1459	94589	96048
Db4	21961			21961
Fa2			49336	49336
Fb7		4207	74233	78440
Fb8		3026	113096	116122
Fb9		114568	146878	261446
Ff9	10272	112435	74115	196822
Fj2		18324		18324
Ga2	97453	63807	25843	187103
Gb4	81210			81210
Gb7			4456	4456
Gb8	69718	52243	35474	157435
Gb9		32336	11448	43783
Gd2	59778	47000		106778
Gd5			8240	8240
Gd7			31280	31280
Gd8			2905	2905
Gg3	81920			81920
Gg8	28808			28808
Gi8		20788		20788
Ha7		6284	8806	15090
Ha8	272	20340	10381	30993
Hb9		23157	54558	77715
Hi9	847	24677	719	26244
Ia2	60825	67075	32448	160348
Ia3			11098	11098
Ia7			14615	14615
Ia8	47842	63140	32959	143941
Ib6	55047			55047

Table 4. Acreage Summary for Landtype Association – acres (continued)

Map Symbol	Colville National Forest	Okanogan National Forest	Wenatchee National Forest	TOTAL ACREAGE
Ic5			38068	38068
Id2	16839	16391	220	33450
Id7			25100	25100
Ig4	27506			27506
Ig6	48985			48985
Ih6	28012			28012
Ih8	20071			20071
Ja8		52515		52515
Jb1		27512		27512
Jb2		81179		81179
Ji8		55272		55272
Jj1		33820		33820
Jj2		50135		50135
Ka2			16827	16827
Ka5		4971	23120	28091
Ka6			16238	16238
Ka7		29099	194075	223174
Kb8		50269	53912	104180
Kb9		3679	27216	30894
Kc6		2824	6717	9541
Kf5			17289	17289
Kf7		28172	71703	99875
Kf8			9498	9498
Kj2		9759		9759
Kj3		13961		13961
Kj8	4995	84347		89342
Kk7			14882	14882
La1		18719		18719
La2	31946	97177	2211	131334
Lb4	38778			38778
Lb6	141947			141947
Lb8	43288	77481	10329	131098
Ld2	18681	10946		29627
Lg4	30591			30591
Lg6	44631			44631
Lh6	50776			50776
Lj1		12398		12398
Lj2	711	13132		13843
Lj8		23971		23971
Mu2	7505	62079		69584
Mu6	11486		1245	12731
Na5		66	11664	11730
Na6			17081	17081
Na7		11939	33008	44947
Nb8		16698	11577	28276
Nf5		599	32399	32998
Nj2		5330		5330
Nj8		24638		24638
Nk7			8200	8200

Table 4. Acreage Summary for Landtype Association – acres (continued)

Map Symbol	Colville National Forest	Okanogan National Forest	Wenatchee National Forest	TOTAL ACREAGE
Nu2		7857	14820	22676
Nu6		6894	45451	52344
Ou2	12075	22425	18123	52624
Ou6	61008	10573	6850	78431
Pa9	4524	48280	3816	56620
Pb8	14743	30219	14297	59259
Pi9	17948	9215	478	27641
Qu2			8363	8363
Qu8			11963	11963
Sc1			33612	33612
Sc2			47148	47148
Sc3			108005	108005
Sc5			27277	27277
Sc8			6688	6688
Sh4	61189			61189
Tu3			36675	36675
Tu5			44717	44717
Tu7			32060	32060
Tu8			21842	21842
Uu3			24832	24832
Uu5			26269	26269
Uu7			9564	9564
Uu8		141	9007	9148
water			15672	15672
We1			6242	6242
We3			22554	22554
We5			21480	21480
We7			10253	10253
We8			28725	28725
Xe3			63572	63572
Xe5			78711	78711
Xf7			40381	40381
Xf8			18898	18898
Yd5			6672	6672
Grand Total	1414191	1729546	2465109	5608846

PART IV: Landtype Associations Management Applications

This section contains lists of properties; hazard ratings, limitations or suitability for management consideration, and potential response to natural disturbance. Ratings are relative to each other and are derived mostly from empirical interpretation of dominant processes identified with each Landtype Association or from field observation. Limitations or suitability are developed from field observations. Lists of key properties are developed from field or aerial photo observation and from published sources. Properties are listed based upon their dominance or importance to major ecological processes in a Landtype Association. Potential responses to natural disturbances are based upon regionally or nationally recognized classification systems and research literature. Narrative sections prior to interpretation tables contain definitions, sources, and clarifications important to understanding the qualification of the interpretation. It is important to read these sections prior to using the interpretation tables.

There are many uses for this information. For example, road managers may find Table 5 and portions of Table 6 and Table 7 useful in road maintenance planning and travel planning; wildlife managers may find Table 9 useful for assessing a watershed or larger area for the potential of special habitats or potential travel corridors; Tables 5, Table 6, and Table 7 will help with rating relative risk of flooding, runoff events, and slope stability after wildfire or storm events to aid in prioritizing field review; vegetation managers, ecologists, and silviculturists may find soil regolith properties, soil fertility, and Potential Natural Vegetation lists in Tables 5 and 8 helpful in broadly rating landscapes for potential site productivity or to assess vegetation dynamics; fisheries managers may find channel processes information in Table 6 and 7 useful in absence of field inventories or in correlating sedimentation and hydrological processes with channel processes; and those interested in assessing natural disturbance regimes and hydrologic or vegetation response may find Table 10 useful.

Physical Properties and Responses

Table 5 contains the physical properties and responses for each Landtype Association. Listed below is a brief description of the information contained in each column.

Soil Classification Subgroups: This column contains the predominant soil taxa found in each Landtype Association. The taxa list was developed from National Cooperative Soil Surveys (NCSS) of Cashmere Mountain, Naches Area, Okanogan-Methow Highlands, Ferry County, and Stephens County, and Pend Oreille County. Taxa determinations were classified according to *Keys To Soil Taxonomy* (USDA Soil Survey Staff 1998) at the subgroup level.

The presence, depth and purity of tephra from historic volcanic eruptions are usually indicated by the taxa classification by some form of the word "andic". Occurrence of these deposits is common but not consistent throughout the map unit. Distribution, depth, and purity are generally correlated with steepness of slope and slope aspect. The greater purity and depths occur on north aspects and mid to higher elevation gentle slopes. Coarser tephra occurs near the volcanic source while finer tephra, such as volcanic ash can occur far from the source.

Regolith Texture: Regolith is the unconsolidated material from the ground surface to the top of bedrock and includes soils and their parent materials. This column contains the predominant texture for the regolith in terms of soil textural groups (USDA Soil Survey 1993). Typically relatively shallow surface layers containing volcanic ash were not recognized when considering the entire depth of the regolith. Exceptions do occur where volcanic ash layers are deep and occur on gentle slopes. Textural groups combine textural classes in similar groupings for broad interpretation. The textural classes within each group are as follows: *coarse texture* includes sands and loamy sands; *moderately coarse* includes sandy loams; *medium* includes very fine sands, loams, silt loams, and silt; *moderately fine* includes clay loams, sandy clay loams, and silty clay loams; and *fine* includes sandy clay, silty clay, and clay.

Regolith Rock Fragments (Size and Percent Volume): This column contains the predominant shape and size of rock fragments in terms of NCSS soil description methods (USDA Soil Survey Staff 1993). *Gravelly* represents angular and spherical rock 2-75 mm diameter. *Cobbly* represents angular and spherical rock 75-250 mm. *Bouldery* represents angular and spherical rock greater than 250mm diameter. *Channery* represents flat, thin rocks less than 150mm long. The percent of rock fragments in regolith will be expressed either as greater than 25 percent or less than 25 percent. The degree of rock fragments is quite variable and these figures should not be absolute but considered as a general trend.

Bedrock Exposure: This column contains an average range of bedrock exposed. This interpretation was based upon field observations and NCSS soil survey map unit descriptions.

Bedrock Durability: This column contains an empirical interpretation of the relative compressive strength of the rock or in other words, an estimate of the force or combination of forces which the material can support. When combined with other geologic and geotechnical information it is an indication of the rock's performance for applications such as: the ease or difficulty of excavation, suitability for aggregate, rip rap, pit run or embankments, as well as general weathering and stability characteristics of the bedrock.

The properties of the bedrock which affect durability include: porosity and density; grain size, shape, and orientation; hardness or degree of induration, cementation or bonding of grains; mineralogy; and moisture content. Factors such as degree of weathering, or the presence of joints, fractures, or other random or aligned planes of breakage can add considerable variability to the inherent strength or durability of a given rock unit.

LOW (L) - These bedrock units are weak to very weak. Compressive strength is generally less than 100 N/mm^2. They are easily compressed leaving craters under the impact of hammer blows, can be scratched with a pocket knife, and those of lower strength may crumble or be broken with hand pressure. Planes of breakage are common. These usually can be easily excavated or ripped. Rock suitable for engineering application is infrequent. Typical bedrock units include serpentine and basic and diabasic rock; low grade metamorphic including graphite, talc and some schists; most siltstones and shales; many pyroclastics and sandstones, and some limestones and volcanics.

MODERATE (M) - These bedrock units are moderate to moderately strong. Compressive strength generally ranges from 100 to 200 No/mm. They usually dent or pit under the impact of a hammer blow and may leave a powder trace when scratched with a knife. Preferred planes of breakage are typical. These generally can be excavated or ripped due to foliated structure, jointing and/or fracturing. This rock may be suitable for a range of engineering applications including pit run and decorative stone. Typical bedrock units include gneiss, most schists occurring in the North Cascade and Okanogan Highland Provinces, many limestones and volcanics, and some granitic rocks.

HIGH (H) - These bedrock units are generally strong to very strong. Compressive strength generally exceeds 200 /mm^2. Hammer blows typically rebound from the surface upon impact. Structure is generally massive with large scale joints common. These generally can not be excavated and must be blasted. They are often suitable for crushed aggregate, rip rap, and/or building stone. Typical bedrock units include massive diorites, amphibolites and mafic igneous units, quartzites, most granitic-type rocks, and some basalt.

Depth of Bedrock: This column contains the empirical interpretation of the depth of unconsolidated soil or surficial deposits to consolidated bedrock. This interpretation was based upon field observations of road cutslopes and from the NCSS soil surveys.

Slope Gradient: This column contains an average range or predominant slope gradient range of each map unit. This interpretation was based upon field observations and the NCSS soil survey map unit descriptions.

Slope Stability Hazard: This column contains a rating for the relative probability of down slope movement of masses of soil and rock material under natural or non-managed conditions. Two major kinds of slope stability hazards are recognized; deep-seated and shallow-rapid landslides. The deep-seated landslides are commonly recognized as rotational slumps or translational movement that is either sporadic or slow involving thick masses of material over a relatively large area. Shallow rapid landslides are debris slides such as debris avalanche, debris flows or debris torrents involving relatively shallow masses over a relatively small area. The ratings are based upon observations of existing landslides; empirical observations of geomorphic processes associated with each Landtype Associations, and research relating site indicators of slope stability hazards. Evaluation by a qualified specialist is critical at the project level where hazard ratings are moderate or high.

A number of complex factors influence *deep-seated landslides* (Dragovich and Brunengo 1995, Swanson and Swanston 1977, and Sidle 1985). Many of these site factors were used in this survey for developing deep seated landslide hazards and follow:

1. easily weathered bedrock high in minerals weathering to clay
2. geologic structural features such as folding, faulting, and/or interbedded strata
3. geomorphic shape features (escarpments and converging concave topography)
4. fine textured surficial deposits
5. slope gradients greater than 20 percent
6. indications of concentrated ground water
7. indications of surface and subsurface water

A number of complex factors influence *shallow-rapid landslides* (Dragovich and Brunengo 1995, Sidle 1985, Swanston 1970 and 1974, Wu & Swanston 1980). Many of these site factors were used in this survey to develop shallow-rapid landslides and follow:

1. slope gradients greater than 40%
2. convergent drainages and/or catchment basins
3. unconsolidated coarse textured soils
4. interface of materials with discontinuous hydrologic properties
5. sparse vegetation patterns
6. geomorphic features (debris chutes associated with debris cones or alluvial fans)
7. high low order drainage density especially with parallel patterns

The first rating represents deep-seated landslides while the second indicates shallow-rapid landslides. For example, a H/L rating is a Landtype Association with a high hazard for deep-seated failures and a low hazard for shallow-rapid landslides. The hazard ratings are as follows:

LOW (L) - Landtype Association has very few of the properties associated with landside probability. Little evidence of landslides have been observed. The degree of limitation is minor and can be overcome easily.

MODERATE (M) - Landtype Association has properties commonly associated with landslide probability. These properties occur over a small extent of the area. Evidence of landslides has been observed but is not common. The degree of limitation can usually be overcome by special planning, design, or maintenance.

HIGH (H) - Landtype Association has most of the properties associated with landslide probability. Evidence of landslides has been observed over most of the area. The degree of limitation generally requires major reclamation, special design, or intensive maintenance.

<u>Soil Erosion</u>: This column contains the relative interpretation for surface or hillslope erosion hazard. The rating represents the susceptibility of the bare, unvegetated surface to erosion by water and wind. The site factors used to develop this interpretation were: soil texture, surface rock fragments, slope relief, rate of vegetation establishment after disturbance, and climatic conditions (precipitation timing, intensity, and duration).

LOW (L) - Landtype Associations generally contain site features that limit the probability of sheet erosion. Generally the site conditions include sufficient rock fragments to armor surfaces, irregular and complex slope shapes with less than 20% gradients, cohesive soils with moderately fine and fine textures, rapid vegetation recovery, and/or surface water runoff is seldom concentrated.

MODERATE (M) - Landtype Associations generally contain site features that limit sheet erosion to rilling. Erosion control treatments and design is normally required on bare surfaces and is usually adequate in controlling surface erosion. Generally the site conditions include some rock fragments but insufficient to fully armor the surface, long straight slopes with 20-45% gradients, medium and moderately coarse textured soils, moderately rapid vegetation recovery (2-5yrs), and/or some probability of concentrated surface runoff.

HIGH (H) - Landtype Associations generally contain site features that develop extensive rilling which can enlarge into gullies. Special erosion control treatments and design should be a standard practice and may not be totally successful. Generally the site conditions include long straight slopes with gradients exceeding 45%, coarse to moderately coarse textured soils, vegetation recovery is slow (greater than 5 years), and/or a high probability of concentrated surface runoff.

<u>Native Road Surface</u>: This column represents the relative interpretation of the quality of the soil regolith for native road surfacing. The ratings indicate whether native surfacing will be durable, and will resist compression (rutting). The factors evaluated to develop this interpretation were: geology, soil regolith texture; soil regolith depth; percent of rock fragments; shape of rock fragments. The amount of road traffic was not considered in the assessment.

The interpretation has two parts, suitability and limiting site features. The first rating is the suitability or quality of soil regoliths for native road surfacing. Limiting site features are noted if they require special planning or treatment. Listed below is the explanation for ratings and limiting features.

LOW (L) - Landtype Associations generally contain site features that severely limit the quality of soil regoliths for native road surface. Some features produce conditions that adversely limit road prism maintenance.

MODERATE (M) - Landtype Associations generally contain site features that produce a range of qualities of soil regoliths for native road surface.

HIGH (H) - Landtype Associations generally contain site features that produce high quality soil regoliths for native road surface. These features do not produce conditions that adversely limit road prism maintenance

Lack of cohesion – Regolith materials are coarse or moderately coarse textured with a low clay content and low internal friction. Sand particles are relatively fine and can be transported during high intensity storms and rapid snowmelt. Sheet and rill erosion can degrade road surfaces and fill road drainage structures.

Fines – Regolith materials contain a high amount of fine particles and may have high contents of silt and clay. Native road materials have low bearing strength, rut easily, and are slippery when wet and can be a source of high amounts of air particulates when dry.

Excess rock fragments (rounded) – Round and subrounded rock fragments in native road surfaces create a uneven road surface; potholes are a common problem. Blading to a smooth running surface is difficult. Soil matrices with high sand content also lack a binder for a stable running surface base and can become washboard under heavy traffic.

Excess rock fragments (angular) – angular and subangular rock fragments in native road surfaces are in excess over fines. Native road surfaces lack cohesion and running surfaces lack a good binder for a stable running base and can become washboard under heavy traffic.

Shallow soils –Bedrock exposures in the road surface cause an uneven running surface. Roads are difficult to grade and to maintain adequate road drainage function. This limitation is a function of slope gradient and regolith depth; the lower the slope gradient the shallower the regolith must be for the road to intersect bedrock.

<u>Road Maintenance (Cutslope stability)</u>: This column contains the interpretation for the relative frequency and effort to maintain functioning drainage and trafficability due to road cutslope instability. Road cutslope instability includes rock fall, dry ravel, and slumping that can fill in road drainage structures and road prisms. The site features used for this interpretation are slope gradient, soil regolith texture; percent

and shape of regolith rock fragments; and the possibility of roads intersecting subsurface drainage. This interpretation assumes a normal precipitation regime. Significant hydrologic events such as high intensity convective storms and rain-on-snow may accelerate erosion processes.

LOW (L) - Landtype Associations generally contain site features that support roads that require a lower frequency or effort of road maintenance. Cutslope instability is relatively low. Maintenance of road drainage structures such as ditches and cross drains and road prisms for trafficability can possibly be extended. .

MODERATE (M) - Landtype Associations generally contain site features that support roads that require fairly frequent road maintenance. There is varying degrees and extent of road cutslope raveling or shallow slumping. Road drainage inspections should be conducted fairly frequently. Routine maintenance may be limited to local areas of cutslope instability.

HIGH (H) - Landtype Associations generally contain roads that require frequent road maintenance and inspection. Cutslope instability from dry ravel or slumping is chronic usually due to very steep cutslope angles on very steep slope gradients, deep-seated mass movement, seep areas, and/or highly erosive soils.

Table 5. Physical Properties and Management Considerations

LTA	Soil Classification (Subgroups)	Regolith		Bedrock			Slope Gradient (%)	Slope Stability (Deep-seated/ shallow rapid landslide hazard)	Soil Erosion	Native Road Surface (Suitability – Limits)	Road Maintenance
		Texture	Rock Fragments (size/%volume)	Exposure (%)	Durability	Depth (feet)					
Bu6	Vitrandic and Typic Eutrudepts Aquic Hapludalfs Psammentic Hapludalfs	medium to fine	none	0	L	>10	0-20	H/L	M	L *Fines*	H
Da3	Vitrandic and Typic Haploxerepts Typic Vitrixerands	moderately coarse	cobbly >25%	20-40	M-H	5-10	>45	L/M	M-H	H	M
Da5	Andic Eutrochrepts Typic Vitrixerands	moderately coarse	cobbly >25%	20-40	M-H	5-10	>45	L/M	M-H	H	M
Da8	Typic Vitricryands Vitrandic Eutrocryepts	moderately coarse	bouldery >25%	20-40	M-H	5-10	>45	L/M	H	H	M
Db1	Lithic Ultic Haploxerolls Vitrandic Haploxerolls Vitrandic Haploxerepts	moderately coarse	sandy to cobbly variable	10-20	M-H	5-10	20-45+	L/M	M-H	M *Lack of cohesion*	M
Db2	Vitrandic and Typic Haploxerepts Typic Vitrixerands	moderately coarse	sandy to cobbly variable	10-20	M-H	5-10	20-45+	L/M	H	M *Lack of cohesion*	M
Db4	Vitrandic Haploxerepts Typic Vitrixerands	moderately coarse	sandy to cobbly variable	20-40	H	5-10	35-65	L/M	M-H	M *Lack of cohesion*	M
Fa2	Lithic Ultic Haploxerolls Vitrandic Haploxerolls Vitrandic Dystroxerepts	coarse	stony to bouldery >25%	40-50	H	<2	65-100	L/H	M-H	L *Shallow soils, excess angular rocks*	H
Fb7	Humic Vitricryands Andic and Humic Dystrocrepts Andic Humicryods	coarse to moderately coarse	cobbly to bouldery > 25%	40-50	H	<2	65 -100	L/H	H	L *Shallow soils, excess angular rocks*	H
Fb8	Andic Humicryods Humic Vitricryands Andic Dystrocrepts	coarse	bouldery >25%	>50	H	<2	65-100	L/H	H	L *Shallow soils, excess angular rocks*	H
Fb9	Andic Humicryods Humic Vitricryands Andic Dystrocryepts	coarse	bouldery >25%	>50	H	<2	65-100	L/H	H	L *Shallow soils, excess angular rocks*	H
Ff9	Andic Humicryods Vitrandic, Humic and Typic Eutrocryepts	medium	cobbly >25%	>50	L	<2	65-100	M/H	H	L *Shallow soils*	H

Table 5. Physical Properties and Management Considerations (continued)

LTA	Soil Classification Subgroups	Regolith		Bedrock			Slope Gradient (%)	Slope Stability (Deep-seated/ shallow rapid landslide hazard)	Soil Erosion	Native Road Surface (Suitability – Limits)	Road Maintenance
		Texture	Rock Fragments (size/%volume)	Exposure (%)	Durability	Depth (feet)					
Fj2	Vitrandic Haploxerepts Lithic Haploxerepts	coarse to moderately	cobbly to channery >25%	40-50	L	2-5	65-100	M/M	M-H	L *Shallow soils*	H
Ga2	Lithic, Humic and Typic Vitrixerands Vitrandic Dystroxerepts	moderately coarse	cobbly >25%	20-40	M-H	2-5	20-45	L/M	L	M *Shallow soils; excessive round rocks*	M
Gb4	Vitrandic Dystroxerepts Lithic and Typic Vitrixerands	coarse to moderately coarse	sandy to cobbly variable	20-40	H	2-5	20-45	L/M	M	M *Lack of cohesion; excessive angular or round rock;*	M
Gb7	Humic Vitricryands Aquic Vitricryands	coarse to moderately coarse	sandy to bouldery variable	20-40	H	2-5	20-45	L/M	M	M *Shallow soils, lack of cohesion, excessive angular and round rocks –*	M
Gb8	Xeric Vitrcryands Vitrandic Dystrocrepts Lithic and Humic Vitricryands	moderately coarse	sandy to bouldery variable	40-50	H	2-5	20-45	L/M	M	M *Lack of cohesion, excessive angular and round rocks*	H
Gb9	Xeric Vitricryands Lithic Vitricryands Humic Vitricryands	coarse to moderately coarse	sandy to bouldery variable	20-40	H	2-5	20-45	L/M	M-H	M *Lack of cohesion, excessive angular and round rocks*	H
Gd2	Lithic Haploxerepts Typic Vitrixerands	medium	cobbly >25%	20-40	M	2-5	20-45	L/M	L-M	M *Shallow soils*	M
Gd5	Andic Dystrochrepts Vitrandic Haploxeralfs	medium	cobbly >25%	20-40	M	2-5	20-45	L/M	L-M	M *Shallow soils, fines*	M
Gd7	Humic Vitricryands Aquic Vitricryands Aquic Haplocryods	medium to moderately fine	cobbly >25%	20-40	L	2-5	20-45	L/M	L-M	L *Shallow soils, fines*	H

Table 5. Physical Properties and Management Considerations (continued)

LTA	Soil Classification Subgroups	Regolith		Bedrock			Slope Gradient (%)	Slope Stability (Deep-seated/ shallow rapid landslide hazard)	Soil Erosion	Native Road Surface (Suitability – Limits)	Road Maintenance
		Texture	Rock Fragments (size/%volume)	Exposure (%)	Durability	Depth (feet)					
Gd8	Humic Vitricryands Aquic Vitricryands	medium	cobbly >25%	20-40	L	2-5	20-45	L/M	L-M	L *Shallow soils, fines*	H
Gg3	Vitrandic Haploxerepts Typic Udivitrands	moderately coarse	cobbly >25%	20-40	M	2-5	20-45	L /M	L-M	M *Shallow soils*	M
Gg8	Typic Vitricryands Vitrandic and Typic Eutrocryepts	medium to moderately coarse	cobbly >25%	20-40	M	2-5	20-45	L /M	M	M *Shallow soils*	M
Gi8	Typic Eutrocryepts Vitrandic Eutrocryepts	medium to moderately coarse	cobbly >25%	20-40	L	2-5	20-45	L/M	M	L *Shallow soils*	H
Ha7	Andic Humicryods Humic and Spodic Dystrocryepts	moderately coarse	cobbly to bouldery >25%	20-30	M-H	2-5	0-20	L/L	M-H	M *Shallow soils, excessive round rocks*	H
Ha8	Andic Humicryods Humic and Spodic Dystrocryepts	moderately coarse	bouldery >25%	20-30	M-H	2-5	0-20	L/L	H	M *Shallow soils, excessive round rocks*	H
Hb9	Humic Dystrocryepts Vitrandic Dystrocryepts	moderately coarse	sandy to bouldery variable	20-30	H	2-5	0-20	L/L	H	M *Shallow soils, excessive round rocks*	H
Hi9	Vitrandic and Humic Eutrocryepts	moderately coarse to fine	cobbly variable	10-20	M	2-5	0-20	L/L	H	L *Shallow soils*	H
Ia2	Typic Vitrixerands Lithic Ultic Haploxerolls Vitrandic Dystroxerepts	coarse to moderately coarse	bouldery 10-20%	10-20	M-H	10-20	20-45	L/M	L-M	M *Excessive round rocks*	M-H
Ia3	Typic Vitrixerands Andic Dystroxerepts	coarse to moderately coarse	bouldery 10-20%	10-20	M-H	10-20	20-45	L/M	L-M	M *Excessive round rocks*	M-H
Ia7	Xeric Vitricryands Typic Vitricryands	coarse to moderately coarse	bouldery >25%	20-40	M-H	10-20	20-45	L/M	H	M *Excessive round rocks*	M-H
Ia8	Vitrandic Dystrocryepts Xeric Vitricryands Andic Humicryods	coarse to moderately coarse	bouldery >25%	20-40	M-H	10-20	20-45	L/M	H	M *Excessive round rocks*	M-H

Table 5. Physical Properties and Management Considerations (continued)

LTA	Soil Classification Subgroups	Regolith		Bedrock			Slope Gradient (%)	Slope Stability (Deep-seated/ shallow rapid landslide hazard)	Soil Erosion	Native Road Surface (Suitability – Limits)	Road Maintenance
		Texture	Rock Fragments (size/%volume)	Exposure (%)	Durability	Depth (feet)					
Ib6	Vitrandic Dystrudepts Typic Udivitrands	coarse to moderately coarse	sandy to gravelly variable	10-20	H	10-20	20-45	L/M	M-H	M *Excessive round rocks, lack of cohesion*	M-H
Ic5	Typic Udivitrands Vitrandic Hapludalfs Vitrandic Haploxeralfs	moderately coarse to medium	cobbly >25%	10-20	L	10-20	20-45	M/M	M	L *Fines, excessive round rocks*	M
Id2	Typic and Humic Vitrixerands Vitrandic Haploxerepts	fine to medium	cobbly >25%	10-20	M	10-20	20-45	L/M	L-M	M *Fines*	L-M
Id7	Typic and Aquic Vitricryands	medium to fine	cobbly. >25%	10-20	M	10-20	20-45	L/M	M	L *Fines*	H
Ig4	Typic Vitrixerands Tpic Udivitrands	moderately coarse to fine	cobbly >25%	10-20	M	10-20	20-45	M/M	M	M *Fines*	M
Ig6	Vitrandic Eutrudepts Typic Udivitrands	moderately coarse to fine	cobbly >25%	10-20	M	10-20	20-45	M/M	H	M *Fines*	M-H
Ih6	Vitrandic Eutrudepts Typic Udivitrands	moderately coarse to medium	cobbly >25%	10-20	M	10-20	20-45	L/M	M-H	M *Fines*	M
Ih8	Typic Vitricryands Vitrandic Eutrocryepts	moderately coarse to medium	cobbly >25%	10-20	M	10-20	20-45	L/M	M-H	M *Fines*	M
Ja8	Andic Eutrocryepts Xeric Vitricryands	moderately coarse	cobbly >25%	10-20	H	5-10	35-65	L/M	H	M *Shallow soils, excessive angular rocks*	M
Jb1	Vitrandic Haploxerepts Vitrandic Haploxerolls Typic Vitrixerands	moderately coarse	cobbly >25%	10-20	M	5-10	35-65	L/M	M-H	M *Shallow soils, excessive angular rocks*	L
Jb2	Vitrandic Haploxerepts Typic Vitrixerands	moderately coarse	cobbly >25%	10-20	M	5-10	35-65	L/M	M	M *Shallow soils, excessive angular rocks*	L
Ji8	Andic Eutrocryepts Lithic Eutrocryepts	moderately coarse	cobbly >25%	10-20	L	5-10	35-65	M/M	H	L *Shallow soils*	M

Table 5. Physical Properties and Management Considerations (continued)

LTA	Soil Classification Subgroups	Regolith		Bedrock			Slope Gradient (%)	Slope Stability (Deep-seated/ shallow rapid landslide hazard)	Soil Erosion	Native Road Surface (Suitability – Limits)	Road Maintenance
		Texture	Rock Fragments (size/%volume)	Exposure (%)	Durability	Depth (feet)					
Jj1	Lithic Ultic Haploxerolls Vitrandic Haploxerolls Vitrandic Haploxerepts	moderately coarse	cobbly <25%	10-20	M	5-10	35-65	M/L	M-H	L *Shallow soils*	L
Jj2	Vitrandic Haploxerepts Vitrandic Haploxerolls Lithic Ultic Haploxerolls	moderately coarse	cobbly <25%	10-20	M	5-10	35-65	M/L	H	L *Shallow soils*	L
Ka2	Humic Vitrixerands Humic Dystroxerepts Vitrandic Dystroxerepts	moderately coarse	bouldery >25%	10-20	M	variable	35-90	L/H	M-H	M *Excessive round rocks*	M
Ka5	Vitrandic Dystrudepts Humic Dystroxerepts Vitric Hapludands	moderately coarse	bouldery >25%	10-20	M	variable	35-90	L/H	M-H	M *Excessive round rocks*	M-H
Ka6	Typic Vitrixerands Xeric Vitricryands	moderately coarse	bouldery >25%	10-20	H	variable	35-90	L/H	M-H	M *Excessive round rocks*	H
Ka7	Andic Haplocryods Typic Vitricryands	moderately coarse	bouldery >25%	10-20	H	variable	35-90	L/H	M-H	M *Excessive round rocks*	H
Kb8	Typic Vitricryands Andic Haplocryods	moderately coarse	bouldery >25%	10-20	H	variable	35-90	L/H	H	M *Excessive round rocks*	H
Kb9	Typic Vitricryands Vitrandic Dystrocryepts	coarse to moderately coarse	bouldery >25%	20-40	H	variable	35-90	L/H	H	M *Excessive round rocks*	H
Kc6	Typic Udivitrands Vitrandic Eutrudepts	moderately coarse	cobbly to bouldery >25%	10-20	L	variable	35-90	M/H	M-H	L *Fines*	H
Kf5	Vitrandic Haploxeralfs Alfic Vitrixerands Typic Udivitrands	moderately coarse to medium	cobbly variable	10-20	L-M	variable	35-90	M/H	M-H	L *Fines*	H
Kf7	Typic Vitricryands Andic Haplocryods	medium to fine	cobbly variable	20-40	M	variable	35-90	M/H	M-H	L *Fines*	H
Kf8	Typic Vitricryands Andic Haplocryods	medium to fine	cobbly variable	20-40	M	variable	35-90	M/H	M-H	L *Fines*	H
Kj2	Vitrandic Haploxerolls Vitrandic Haploxerepts Lithic Haploxerepts	moderately coarse to medium	cobbly >25%	10-20	M	variable	35-90	M/H	H	M *Fines*	M
Kj3	Andic Dystrocrepts Typic Udivitrands	moderately coarse to medium	cobbly >25%	10-20	M	variable	35-90	M/H	H	M *Fines*	M

Table 5. Physical Properties and Management Considerations (continued)

LTA	Soil Classification Subgroups	Regolith		Bedrock			Slope Gradient (%)	Slope Stability (Deep-seated/ shallow rapid landslide hazard)	Soil Erosion	Native Road Surface (Suitability – Limits)	Road Maintenance
		Texture	Rock Fragments (size/%volume)	Exposure (%)	Durability	Depth (feet)					
Kj8	Andic Haplocryods Vitrandic Eutrocryepts	coarse to moderately coarse	cobbly to bouldery >25%	20-40	M	variable	35-90	M/H	H	M	H
Kk7	Typic Vitricryands Vitrandic and Typic Eutrocryepts	medium	cobbly to bouldery >25%	10-20	L-M	variable	35-90	M/H	M-H	M *Fines*	H
La1	Typic and Humic Vitrixerands Vitrandic Dystroxerepts Vitrandic Haploxeralfs	moderately coarse	cobbly to bouldery >25%	0-10	M	>20	0-20	M/L	L-M	M *Excessive round rocks*	L
La2	Typic and Humic Vitrixerands Vitrandic Dystroxerepts Vitrandic Haploxeralfs	moderately coarse	cobbly to bouldery >25%	0-10	M	>20	0-20	M/L	L	M *Excessive round rocks*	L-M
Lb4	Vitrandic Dystroxerepts Typic Vitrixerands Typic Udivitrands	coarse to moderately coarse	sandy to bouldery variable	0-10	L-M	>20	0-20	M/L	M	M *Excessive round rocks, lack of cohesion*	M-H
Lb6	Typic Udivitrands Vitrandic and Typic Dystrudepts	moderately coarse	sandy to bouldery variable	0-10	L-M	>20	0-20	M/L	M-H	M *Excessive round rocks, lack of cohesion*	H
Lb8	Xeric and Typic Vitricryands Andic Haplocryods Aquandic Cryoquepts	moderately coarse	sandy to bouldery variable	10-20	M	>20	0-20	M/L	H	M *Excessive round rocks, lack of cohesion*	M
Ld2	Typic Vitrixerands Vitrandic Haploxerepts	moderately coarse to medium	cobbly to bouldery >25%	0-10	M	>20	0-20	M/L	L	M *Fines*	L -M
Lg4	Vitrandic Haploxerepts Typic Haploxerolls	moderately coarse to medium	gravelly to cobbly >25%	0-10	L	>20	0-20	L/L	M	L *Fines*	M-H
Lg6	Vitrandic Eutrudepts Typic Udivitrands Vitrandic Hapludalfs	moderately coarse to medium	gravelly to cobbly >25%	0-10	L	>20	0-20	M/L	M-H	L *Fines*	H
Lh6	Vitrandic Eutrudepts Typic Udivitrands Vitrandic Hapludalfs	moderately coarse to medium	gravelly to cobbly >25%	0-10	M	>20	0-20	M/L	M	L *Fines*	M

Table 5. Physical Properties and Management Considerations (continued)

LTA	Soil Classification Subgroups	Regolith		Bedrock			Slope Gradient (%)	Slope Stability (Deep-seated/ shallow rapid landslide hazard)	Soil Erosion	Native Road Surface (Suitability – Limits)	Road Maintenance
		Texture	Rock Fragments (size/%volume)	Exposure (%)	Durability	Depth (feet)					
Lj1	Vitrandic Haploxerolls Vitrandic Haploxerepts	coarse to moderately coarse	sandy to cobbly variable	0-10	L	>20	0-20	M/L	L	L *Lack of cohesion*	L
Lj2	Vitrandic Haploxerepts Vitrandic Haploxerolls	coarse to moderately coarse	sandy to cobbly variable	0-10	L	>20	0-20	M/L	M	L *Lack of cohesion*	M
Lj8	Andic Eutrocryepts Xeric Vitricryands	coarse to moderately coarse	sandy to cobbly variable	0-10	L	>20	0-20	M/L	H	L *Lack of cohesion*	M
Mu2	Vitrandic Haploxerepts Typic Vitrixerands Andic Haploxerepts	variable	variable	>50	M	variable	variable	L/M	L-H	M *Shallow soils*	L-H
Mu6	Typic Udivitrands Vitrandic Haploxerepts Vitrandic Dystroxerepts	variable	variable	>50	M	variable	variable	M/M	L-H	M *Shallow soils*	L-H
Na5	Typic Vitrixerands Typic Cryorthents Xerofluvents	moderately coarse	cobbly to bouldery >25%	0-10	M	>10	0-30	L/L	L	M *Excessive round rocks*	L
Na6	Xeric Vitricryands Typic Vitrixerands Xerofluvents	moderately coarse	cobbly to bouldery >25%	0-10	M	>10	0-30	L/L	L	M *Excessive round rocks, fines*	L
Na7	Andic Haplocryods Typic Vitricryands Cryofluvents	moderately coarse	cobbly to bouldery >25%	0-10	M	>10	0-30	L/L	L	M *Excessive round rocks, fines*	L
Nb8	Typic Vitricryands Andic Eutrocryepts Cryofluvents	moderately coarse	cobbly to bouldery >25%	<20	M	>10	0-30	L/L	L	M *Excessive round rocks*	L
Nf5	Typic Cryaqands Xeric Vitricryands Typic Vitrixerands Cryosaprists	moderately coarse to medium	cobbly variable	0-10	L-M	>10	0-30	L/L	L	L *Excessive round rocks, fines*	L
Nj2	Typic Vitrixerands Vitrandic Dystroxerepts Xerofluvents	moderately coarse to medium	cobbly >25%	0-10	M	>10	0-30	L/L	L	M *Excessive round rocks, fines*	L
Nj8	Andic Haplocryods Typic Vitricryands Cryofluvents	moderately coarse to medium	cobbly >25%	0-10	M	>10	0-30	L/L	L	M *Excessive round rocks, fines*	L

Table 5. Physical Properties and Management Considerations (continued)

LTA	Soil Classification Subgroups	Regolith		Bedrock			Slope Gradient (%)	Slope Stability (Deep-seated/ shallow rapid landslide hazard)	Soil Erosion	Native Road Surface (Suitability – Limits)	Road Maintenance
		Texture	Rock Fragments (size/%volume)	Exposure (%)	Durability	Depth (feet)					
Nk7	Andic Haplocryods Typic Cryorthents Cryofluvents	medium	cobbly to bouldery >25%	0-10	L-M	>10	0-30	L/L	L	M *Excessive round rocks, fines*	L
Nu2	Typic Vitrixerands Fluventic Haploxerolls Xerofluvents	variable	variable	0-10	variable	>10	0-30	L/L	L	M *Excessive round rocks*	M-H
Nu6	Vitrandic Eutrudepts Typic Udorthents Udifluvents	variable	variable	0-10	variable	>10	0-30	L/L	L	M *Excessive round rocks*	M-H
Ou2	Typic Vitrixerands Fluventic Haploxerolls Entic Ultic Haploxerolls Aeric Fluvaquents Mollic Xerofluvents	variable	variable	0-10	variable	>20	0-20	L/L	L	M – *Excessive round rocks*	M-H
Ou6	Aquic Udifluvents Typic Udorthents Vitrandic Eutrudepts Vertic Palexeralfs	variable	variable	0-10	variable	>20	0-20	L/L	L	M *Excessive round rocks*	M-H
Pa9	Vitrandic Dystrocryepts Humic Dystrocryepts Typic Haplocryolls	coarse to moderately coarse	gravelly to cobbly variable	0-10	M-H	5-10	20-45	L/L	H	H	M
Pb8	Xeric Vitricryands Typic Udivitrands Vitrandic Dystrocryepts	coarse to moderately coarse	sandy to cobbly variable	0-10	H	5-10	20-45	L/L	M	H	L-M
Pi9	Xeric Vitricryands Vitrandic Eutrocryepts Typic Vitricryands	medium	gravelly to cobbly >25%	0-10	M	5-10	20-45	L/M	H	M *Fines*	M
Qu2	Andic Haploxeralfs Typic Palexeralfs Typic Argixerolls	moderately coarse to moderately fine	gravelly to cobbly >25%	20->40	M	<2	35-90	M/H	H	L *Fines*	H
Qu8	Xeric Vitricryands Pachic Haplocryolls Ultic Vitricryands	moderately coarse to moderately fine	gravelly to cobbly >25%	20->40	M	<2	35-90	M/H	H	L *Fines*	H
Sc1	Lithic Haploxerepts Ultic Haploxeralfs	medium to fine	channery <25	10-20	L	5-10	35-65	M/M	L-M	L *Fines*	H
Sc2	Ultic Haploxeralfs Lithic Haploxerepts	medium to fine	channery <25	10-20	L	5-10	35-65	M/M	M	L *Fines*	H

Table 5. Physical Properties and Management Considerations (continued)

LTA	Soil Classification Subgroups	Regolith		Bedrock			Slope Gradient (%)	Slope Stability (Deep-seated/ shallow rapid landslide hazard)	Soil Erosion	Native Road Surface (Suitability – Limits)	Road Maintenance
		Texture	Rock Fragments (size/%volume)	Exposure (%)	Durability	Depth (feet)					
Sc3	Ultic Haploxeralfs Vitrandic Haploxerepts	medium to fine	channery variable	10-20	L	5-10	35-65	M/M	H	L *Fines*	H
Sc5	Andic Dystrochrepts Lithic Ultic Haploxerolls	medium to fine	channery variable	10-20	L	5-10	35-65	M/M	H	L *Fines*	H
Sc8	Vitrandic Eutrocryepts	medium to fine	channery >25	20-40	L	5-10	35-65	M/M	H	L *Fines*	H
Sh4	Vitrandic Haploxerepts Entic Ultic Haploxerolls Typic Vitrixerands	moderately coarse to medium	cobbly to channery >25%	20-40	M-H	5-10	35-65	L/L	M	M *Fines*	M
Tu3	Vitrandic Palexeralfs Vitrandic Haploxeralfs Vitrandic Haploxerepts	variable	variable	0-10	L	>20	20-45	H/L	L-M	L *Fines*	M
Tu5	Typic Udivitrands Typic Vitrixerands Vitrandic Haploxeralfs Vitrandic Hapludalfs	variable	variable	0-10	L	>20	20-45	H/L	L-M	L *Fines*	M
Tu7	Typic Vitricryands Andic Haplocryods	variable	variable	0-10	L	>20	20-45	H/M	L	L *Fines*	M-H
Tu8	Xeric Vitricryands Pachic Haplocryolls	variable	variable	0-10	L	>20	20-45	H/M	M	L *Fines*	M-H
Uu3	Vitrandic Palexeralfs Vitrandic Haploxeralfs	variable	variable	0-10	L	>20	10-40	M/L	L-M	L *Fines*	L-M
Uu5	Vitrandic Palexeralfs Andic Haploxeralfs Andic Haplocryalfs	variable	variable	0-10	L	>20	10-40	M/L	L-M	L *Fines*	L-M
Uu7	Typic Vitricryands	variable	variable	0-10	L	>20	10-40	M/L	L	L *Fines*	M-H
Uu8	Humic Xeric Vitricryands Alfic Vitricryands Vitrandic Haplocryalfs	variable	variable	0-10	L	>20	10-40	M/L	M	L *Fines*	L-M
We1	Typic Argixerolls Vitrandic Haploxerolls Lithic Haploxerolls	medium to moderately fine	cobbly variable	0-20	M	5-10	0-20	L/L	M	M *Fines*	L
We3	Vitrandic Haploxeralfs Vitrandic Haploxerepts	medium to moderately fine	cobbly variable	0-20	M	5-10	0-20	L/L	M	M *Fines*	L

Table 5. Physical Properties and Management Considerations (continued)

LTA	Soil Classification Subgroups	Regolith		Bedrock			Slope Gradient (%)	Slope Stability (Deep-seated/ shallow rapid landslide hazard)	Soil Erosion	Native Road Surface (Suitability – Limits)	Road Maintenance
		Texture	Rock Fragments (size/%volume)	Exposure (%)	Durability	Depth (feet)					
We5	Andic Haploxeralfs Andic Dystroxerepts Ultic Haploxeralfs Lithic Haploxerolls	medium to moderately fine	cobbly variable	0-20	M	5-10	0-20	M/L	H	M *Fines*	M
We7	Xeric Vitricryands Vitrandic Haploxeralfs	medium to moderately fine	cobbly variable	0-20	M	5-10	0-20	M/L	H	M *Fines*	M
We8	Typic Vitricryands Humic Xeric Vitricryands Lithic Argicryolls Vitrandic Haplocryalfs	medium to moderately fine	cobbly variable	0-20	M	5-10	0-20	M/L	H	M *Fines*	M
Xe3	Humic and Alfic Vitrixerands Vitrandic Haploxeralfs Ultic Palexeralfs Vitrandic Palexeralfs	medium to moderately fine	cobbly >25%	0-20	M	2-5	20-45	M/L	H	M *Shallow soils*	M
Xe5	Humic Vitrixerands Typic Udivitrands Vitrandic Haploxeralfs	moderately coarse to moderately fine	cobbly >25%	20-50	M	2-5	20-45	M/M	H	M *Shallow soils*	M
Xf7	Andic Haplocryalfs Andic Haplocryods Alfic Vitricryands	medium to moderately fine	cobbly >25%	10-40	M	2-5	20-45	M/M	H	M *Shallow soils*	M
Xf8	Alfic Vitricryands Pachic Haplocryolls Andic Haplocryalfs	medium to moderately fine	cobbly >25%	20-50	M	2-5	20-45	M/M	H	M *Shallow soils*	M
Yd5	Typic Vitricryands	coarse to moderately coarse	bouldery >25%	>50	M	<2	35-90	L/M	H	M *Shallow soils*	L

Hydrologic Properties and Responses

Table 6 and Table 7 contain hydrologic classifications, properties, features, and responses for each Landtype Association. Listed below is a brief description of the information contained in each column of the table.

Stream Reach Types: This column contains the dominant channel types based upon a classification system documented in Montgomery and Buffington (1993). This classification system describes stream bed morphology, sediment transport processes, and sediment flux characteristics as controlled by hydraulic discharge and sediment supply. Channel response is also described based on stream confinement, debris flow impacts, and large woody debris loading and is useful for interpretation of channel response to changes in sediment, wood, and discharge within a stream network. Channel types for each Landtype Association were identified based upon field experience and aerial photo interpretation and extrapolated using general geomorphic characteristics associated with landtype associations. The identification of channel types provides a first step for assessing potential channel responses to increases or decreases in discharge and in-channel sediment (Montgomery and Buffington 1993). According to Montgomery and Buffington: *"The spatial distribution of source, transport, and response reaches governs the distribution of potential impacts and watershed recovery time. General response for source, transport, and response reaches define patters of sensitivity to altered discharge, sediment supply, or debris flow scour within a watershed".*

SOURCE - Source reaches are transport-limited channels that allow for sediment storage. The most common channel type is *colluvial* channels. These channels fill with colluvial deposition from hillslopes, upslope hollows or catchment basins. Increased sediment storage may result in large downslope deliveries of sediment during major channel scouring events. High discharge may mobilize streambeds, scour streambeds or cause debris flows which transports sediment downstream. In time, these scoured channels begin to refill with sediment. This action is intermittent or episodic with various frequencies depending on hydrologic regimes. In steep, upper elevations, colluvial channels are very active and are not stable enough to store sediment for extended periods of time.

TRANSPORT - Transport reaches are resilient, high gradient channels that are capable of rapidly conveying increased sediment inputs. The most common channel types are bedrock, cascade, and step pool.

Bedrock channels are confined by exposed bedrock, channel width and channel depth will increase to handle increased discharge. Moderate changes in discharge or sediment load are rapidly transmitted downstream without significant morphological changes within these reaches.

Cascade channels generally have well armored immobile boulders and are laterally confined by valley walls. Channel bank cutting or down-cutting are unlikely responses to changes in sediment supply or discharge. These types of confined channels can also respond to increased discharge by simple flow expansion. Because of their position within the network, cascade channels typically are subject to debris flow impacts. However, in-channel sediment loading from debris slides is often short lived and easily flushed downstream. Significant morphological changes within these reaches are not expected with normal sediment input from debris slides.

Step pool channels are confined channels with series of cascades and small pools. High transport capacities enable increased discharges or sediment loads to be transmitted downstream. As with other confined channels, increased discharge may result in flow width and height expansion without bank cutting or channel down-cutting. However, changes in pool depth, and thus channel storage are significant morphological changes. Usually these changes in pool depth are temporary and associated with a decline in the frequency and duration of pool scouring flows or large increases in sediment. Channel morphology is generally re-established after flood events.

RESPONSE - Response reaches are low gradient, channels in which significant morphologic adjustments occurs in response to increased sediment supply. Typically, these types of channels are the depositional reaches of stream networks. Sediment is collected and accumulated in these segments.

Plane Bed channels tend to have planar channel beds with occasional channel spanning rapids. They are distinguished from step-pool and pool-riffle channels in that they lack rhythmic bedforms. These channels may lack sufficient flow dynamics to cause pool development except where obstructions such as large wood debris create local pool or bar formation. These channels occur in confined and unconfined valleys and hence, have a variety of responses to changes in sediment and discharge. Potential responses include channel widening, incision, bed aggradation, and changes in size of streambed materials.

Pool-riffle channels have a sequence of bars, pools, and riffles and tend to have the widest variety of potential responses. These channels are generally unconfined, which allows widening in response to either increased discharge or sediment supply. Increased discharge may also cause bank cutting and meander. Sediment deposition can occur with higher sediment loads or decreased discharge. High peak flows can potentially increase the depth of scour and decrease sediment storage. Less frequent high flows favor pool filling and increased sediment storage.

Regime channels are low gradient, sand-bedded channels exhibiting a succession of bedforms with increasing flow velocity. Some reaches in gravel and boulder bedded channels also exhibit regime channel characteristics. With increasing flow velocity bedforms are created in a sequential pattern of planar bed, ripples, sand waves, dunes, high-energy planar bed, and finally antidunes. In coarser stream beds, bedload migrates in sheets and bedforms are less distinguishable. Regime channels have the lowest relative transport capacities may widen in response to either increased discharge or sediment deposition. Increased discharge can also result in meandering or channel migration.

Braided channels have a condition of high sediment supply relative to transport capacity. A significant increase in discharge or decrease in sediment supply may result in conversion to a single thread channel. Conversely, an increase in sediment deposition may result in further widening of the active channel and development of multiple channels. Plane bed and regime channels may convert to braided channels with increases in sediment or decrease in discharge.

<u>Stream Types</u>: This column contains the dominant stream types based upon a classification system documented in Rosgen (1994). Rosgen's classification provides a morphological description of the channel using stream gradient, width:depth ratio, substrate size, channel confinement, and near channel landform stability. This classification is useful in broad assessments, monitoring condition, and in setting

stream restoration objectives. Each Landtype Association was evaluated to determine the predominant morphologic type based upon field observations.

Aa *Stream Types*- Streams that have extremely steep gradients and are deeply entrenched. They are most often associated with stream segments in the upper elevation zones of high relief landforms formed from glacial erosion and over-steepening. Most common channel morphology is debris chutes, vertical steps, with shallow scour pools, and waterfalls. Most common stream reach types are bedrock and colluvial.

A Stream Types - Streams that have steep gradients and are normally entrenched. Most often associated with stream segments in the mid to upper elevation zones of high relief landforms formed from glacial or fluvial erosional processes. Most common stream reach type is cascade and step pool.

B Stream Types - Streams that have moderate gradients and entrenchment. Most often associated with stream segments in the mid elevation zones of high relief landforms formed from glacial or fluvial erosional processes. Most common stream reach type is step pool and forced step pool.

C Stream Types - Streams that have low gradients and are unconfined from valley walls. Width depth ratios are high. These are alluvial channels with broad well defined flood plains. Most often associated with stream segments in the lower elevation zones of low relief landforms formed from glacial or fluvial depositional processes. Most common stream reach type is pool riffle channels.

D Stream Types - Streams that have braided channels associated with high bedload deposition. Most often associated with stream segments in lower elevation zones of low relief landforms formed from glacial or fluvial deposition (outwash). Most common stream reach type is braided channels.

E Stream Types - Streams that have low gradients and are unconfined from valley walls. Streams are highly sinuous with finer textured banks and little channel roughness. Width depth ratios are low. Most often associated with stream segments in the lower elevation zones of low relief landforms formed from glacial or fluvial depositional processes. Most common stream reach type is plane bed channels.

F Stream Types - Streams that have low gradients and are entrenched. Width depth ratios are high. These are streams that have entrenched meandering channels which are in the process of reestablishing a functional floodplain. Most often associated with dynamic change of discharge power. Most common stream reach type is plane bed and pool riffle channels.

G Stream Types - Streams that have moderate to steep gradients and are entrenched. These streams are usually associated with gullies from erosional events. Width depth ratios are very low. Most common stream reach type is plane bed and step pool channels.

<u>Drainage Features</u>: This column contains the most representative drainage patterns and stream orders occurring in each Landtype Association. Drainage patterns refer to the spatial arrangement or form of a stream and its tributaries (Fairbridge 1968). Stream order is a classification based upon the degree of tributary branching (Strahler 1964). All unbranched tributaries are first order. With each successive stream branching, streams are given a higher number, that is, second order, then third order

and so on. In Table 6, stream orders have been grouped into either low or high orders. Listed below are stream order groups identified for each Landtype Association.

Low order streams are headwater streams in upper watersheds. They include first, second and occasionally third order streams.

High order streams are major channels downstream of headwater streams in mid and lower watershed position. They include fourth order streams and higher and occasionally include third order streams in watershed with smaller basin area.

Listed below are the stream patterns identified for each Landtype Association. Often Landtype Associations can have more than one stream pattern. Stream patterns can vary with changes in bedrock stratigraphy, depth of surficial deposits, or highly contrasting slope shape.

Dendritic or Subdendritic - Stream patterns resemble the branching of a tree. Stream pattern and subsequent valley arrangement is characterized by irregular branching in many directions. This pattern is typically developed on geology of uniform resistance, such as horizontal sedimentary units and massive igneous and metamorphic rocks.

Parallel or Subparallel - Streams are regularly spaced in parallel or subparallel forms. Normally these patterns occur on very steep slopes of glacial origin or mass wasting escarpments.

Rectangular and Trellis - Stream patterns are characterized by orthogonal bends in both the tributaries and the mainstem. Rectangular patterns are often associated right angle faults and joints. Trellis patterns are shaped like a garden trellis with primary or secondary tributaries joining the mainstem at nearly right angles. Trellis patterns are often associated with folded and tilted bedrock, usually resistant to weathering.

Centripetal - Streams patterns characterized by all branching converging to a central point. These patterns are usually associated with mass wasting escarpments.

Radial - Stream patterns characterized by radiating out from a central point. These patterns are commonly associated with volcanic cones and domes.

Deranged or Contorted - Stream patterns characterized by drainages not being connected. Often streams empty into local basins, sag ponds, or lakes. These patterns are commonly associated with mass wasting and glacial moraine landforms which have local "hummock" topographic expression.

<u>Unique Features</u>: This column describes some of the hydrologic processes and functions common to stream segments unique to the Landtype Association. This interpretation is based on field observation.
<u>Stream Flow</u>: This column describes stream flow duration and amount for mainstem streams. Duration is noted as either perennial or intermittent and amount is the degree of flow expected during the summer months. This interpretation was based upon field observations.
<u>Aquifer Recharge</u>: This column describes the degree of near surface ground water storage within each Landtype Association. This interpretation is an indication of the ability of Landtype Associations to regulate stream flows especially late into the season. It can also help indicate the Landtype Associations that have shallow aquifers that contribute to stream flow recharge and temperature moderation. Factors used to develop this interpretation include: soil regolith depth and texture; landform shape,

slope exposures and gradient; geologic fracturing and structure; annual precipitation; and surface drainage configuration.

LOW (L) - Landtype Associations have little storage capacity for near surface ground water. Shallow aquifers are limited and recharge to stream flow is very low. Summer stream flows are often intermittent or flows are unusually low in comparison to watershed size. Low aquifer recharge of summer stream flows may be a factor in elevated stream temperatures. Surface water is concentrated and routed quickly to stream systems causing elevated spring peaks. Few seeps and springs are present. Usually Landtype Associations have a set of the following site features: very shallow regolith over bedrock; landform shape, slope gradient and drainage systems that route surface and subsurface water rapidly to larger order streams; geologic features (faults, fractures, and folds) route subsurface water into deep aquifers or the lack of these features cause subsurface water to be routed quickly to drainage systems; or areas without potential for water table retention that receive low annual precipitation much of which is in the form of rain.

MODERATE (M) - Landtype Associations have storage capacity for near surface ground water but recharge of the aquifer is highly variable which influences recharge to stream flow. Summer stream flows are usually perennial but stream flows are variable. Aquifer recharge of stream flows may not be enough to modify summer or winter stream temperatures in all stream systems. Surface water has the ability to be absorbed and stored for recharge of stream flows but normally not enough to fully charge these shallow aquifers annually. Seeps and springs are present. Usually Landtype Associations have a set of the following site features: soil regolith depth is variable but often moderately deep; landform shape, slope gradient, and drainage systems route surface and subsurface water slowly to larger order streams; geologic features restrict downward movement of groundwater; receive little drainage water from upslope landforms; and areas receive moderate amounts of annual precipitation of which there is an equal amount in the form of rain and snow.

HIGH (H) - Landtype Associations have a tremendous storage capacity for near surface ground water. Shallow aquifers are immense and recharge to stream flow is very high. Summer stream flows are perennial and stream flows are high in comparison to other drainage systems. High aquifer recharge of stream flows may help moderate summer and winter stream temperatures. Surface water has the ability to be absorbed and stored for recharge of summer stream flows. Seeps and springs are a common feature. Usually Landtype Associations have a set of the following site features: very deep coarse textured regoliths; landform shape, slope gradient, and drainage systems that route surface and subsurface water slowly to larger order streams; geologic features restrict the downward movement of groundwater; receive a tremendous amount of drainage water from upslope landforms; and areas receive high amount of annual precipitation much of which is in the form of snow.

<u>Surface Runoff</u>: This column contains the interpretation for relative response time for runoff from snowpack melt or high intensity rainstorms to become concentrated flow in first order streams. This interpretation is an indication of the ability or inability of Landtype Association to absorb and route surface water and potential for shallow rapid landslides such as debris slides and debris torrents given additional contributing factors. The site factors used to develop this interpretation include: slope gradient; vegetation cover, soil regolith texture and rock fragment content; amount of exposed bedrock; density of first order drainages; amount, form and timing of precipitation, and stream patterns.

SLOW - Landtype Associations can absorb a great deal of surface water and runoff normally is well regulated and does not become concentrated in first order streams.

Landtype Association features limit surface water from being routed quickly to first order stream systems. First order stream channels do not have evidence of scour or non-vegetated deposition. Normally these Landtype Associations have not had a history of shallow rapid landslides. Usually Landtype Associations have a set of the following site features: low slope gradients <25%), more than 80 percent vegetation cover; deep, coarse textured regolith; very little exposed bedrock; low drainage density of confined or entrenched first order streams; area not normally exposed to rain on snow events or high intensity thunder storms.

MODERATE - Landtype Associations absorb some surface water and runoff is somewhat well regulated but some concentrated flows are routed into first order drainages. Landtype Association features are somewhat efficient in routing surface water into first order stream systems. First order stream channels have some evidence of scour. Normally these Landtype Associations have had an infrequent history of shallow rapid landslides. Usually Landtype Associations have a set of the following site features: slope gradients between 25 and 45 percent; vegetation cover is 30 to 80 percent; regolith depths that vary from shallow to moderately deep; exposed bedrock is less than 25 percent of the area; moderate drainage density of confined or entrenched first order stream systems; area exposed to infrequent rain on snow events or high intensity summer storms.

FLASHY - Landtype Associations do not absorb a great deal of surface water, runoff is poorly regulated and concentrated flows are routed rapidly into first order drainages. Landtype Association features are extremely efficient in routing surface water into first order stream systems. First order stream channels have evidence of scour or non-vegetated deposition. Normally these Landtype Associations have had a relatively frequent history of shallow rapid landslides. Usually Landtype Associations have a set of the following site features: steep slope gradients (45%+); less than 30 percent vegetation cover; shallow regolith; exposed bedrock exceeds 25 percent of the area; high drainage density of confined or entrenched first order streams; area is exposed to frequent rain on snow events or high intensity summer storms.

<u>Sediment Delivery Routing Efficiency</u>: This column contains the interpretation of the relative efficiency of hillslope landforms in Landtype Associations to route eroded debris into first order stream channels and deliver sediment into mainstem streams. The most efficient routing mechanism is from scoured first order stream channels and catchment basins from high intensity storms or concentrated road drainage or from accelerated road erosion delivered directly to perennial channels. The factors used to rate Landtype Associations are: surface runoff response, slope gradient and shape, low order stream density, stream patterns where channels that regulate sediment transport are absent between source channels and the mainstem (e.g., first order channels flowing directly to third order channels or higher), and potential for shallow rapid landslides. This interpretation excludes the sediment delivery processes associated with streambanks and toeslopes along mainstems as it is a site-scale interpretation not landscape level interpretation.

LOW (L) - Landtype Associations can absorb a great deal of surface water before individual soil particles are detached. Surface runoff normally is well dispersed and does not become concentrated in first order streams. Landtype Association features limit surface water and sediment from being routed quickly to first order stream systems. First order stream catchment basins do not have evidence of rilling and channels do not have a history of scour or non-vegetated deposition. Normally these Landtype Associations have not had a history of shallow rapid landslides being delivered into mainstem streams. Usually Landtype Associations have a set of the following site features: low slope gradients <25%, more than 80 percent vegetation cover; deep, coarse textured regoliths; very little exposed bedrock; low drainage density first order streams; area not normally exposed to rain-on-snow events or high intensity rainstorms.

MODERATE (M) - Landtype Associations absorb some surface water before individual soil particles are detached. Surface runoff is somewhat well dispersed but some concentrated flows are routed into first order drainages. Landtype Association features are somewhat efficient in routing surface water and sediment into first order stream systems. First order stream catchment basins have some evidence of past rilling and stream channels have some evidence of scour. Normally these Landtype Associations have had an infrequent history of shallow rapid landslides that are delivered into mainstem streams. Usually Landtype Associations have a set of the following site features: slope gradients between 25 and 45 percent; vegetation cover is 30 to 80 percent; regolith depths that vary from shallow to moderately deep; exposed bedrock is less than 25 percent of the area; moderate drainage density of confined or entrenched first order stream systems; area exposed to infrequent rain-on-snow events or high intensity rainstorms.

HIGH (H) - Landtype Associations do not absorb a great deal of surface water before individual soil particles detach. Surface runoff is poorly regulated and concentrated flows are routed rapidly into first order drainages. Landtype Association features are extremely efficient in routing surface water and sediment into first order stream systems. First order catchment basins have evidence of past rilling and stream channels have evidence of scour or non-vegetated deposition. Normally these Landtype Associations have had a relatively frequent history of shallow rapid landslides that are delivered into mainstem streams. Usually Landtype Associations have a set of the following site features: steep slope gradients (45%+); less than 30 percent vegetation cover; shallow regoliths; exposed bedrock exceeds 25 percent of the area; high drainage density of confined or entrenched first order streams; area is exposed to frequent rain-on-snow events or high intensity rainstorms.

Table 6. Hydrological Classifications and Properties

LTA	Stream Segment	Stream Reach Types (*Montgomery and Buffington 1993*)	Stream Types (*Rosgen 1994*)	Drainage Properties (Common stream patterns/stream order)	Unique Properties
Bu6	Tributaries:	Source and Transport (Colluvial, Plane bed)	C,E	Dendritic Low Order	Fine sediment
	Mainstems:	Transport and Response (Plane bed, pool riffle)	C,E	Dendritic High Order	Fine sediment
Da3 Da5 Da8 Db1 Db2 Db4	Tributaries:	Source (Cascade; Colluvial)	A	Dendritic Low Order	Tributaries often Intermittent
	Mainstems:	Transport and Response (Step pool; Pool riffle)	B,C	Dendritic High Order	Historic sediment deposition caused valley widening
Fa2 Fb7 Fb8 Fb9 Ff9 Fj2	Tributaries Only:	Source (Bedrock, Colluvial)	Aa, A	Parallel Low Order	High amount of precipitation on very shallow soils or bedrock. Snow/Debris Avalanche
Ga2 Gb4 Gb7 Gb8 Gb9 Gd2 Gd5 Gd7 Gd8 Gg3 Gg8 Gi8	Tributaries:	Source (Bedrock, Cascade)	A	Dendritic Low Order	Tributaries often intermittent, follow bedrock joints and are debris avalanche chutes
	Mainstems:	Transport and Response (Step pool, Pool riffle)	B,C	Dendritic Low Order	Stream alignment often controlled by bedrock
Ha7 Ha8 Hb9 Hi9	Tributaries:	Transport (Step pool)	B	Centripetal Low Order	Cirque lakes common; seeps below talus and scree slopes
	Mainstems:	Transport and Response (Step pool, Pool riffle)	B, E	Sub-dendritic Low Order	
Ia2 Ia3 Ia7 Ia8 Ib6 Ic5 Id2 Id7 Ig4 Ig6 Ih6 Ih8	Tributaries:	Transport (Step pool)	B	Sub-parallel Dendritic Low Order	Upper basins have some seeps along drainageways
	Mainstems:	Response (Pool riffle)	C	Sub-parallel Dendritic Low Order	Some seeps in lower valleys

Table 6. Hydrological Classifications and Properties (continued)

LTA	Stream Segment	Stream Reach Types (*Montgomery and Buffington 1993*)	Stream Types (*Rosgen 1994*)	Drainage Properties (Common stream patterns/stream order)	Unique Properties
Ja8 Jb1 Jb2 Ji8 Jj1 Jj2	Tributaries:	Source and Transport (Bedrock, Step pool	A, B	Sub-parallel Low Order	Debris slides source; often intermittent
	Mainstems:	Response (Pool riffle)	C, G	Sub-parallel High Order	Small or lacking floodplains in narrow, confined valleys
Ka2 Ka5 Ka6 Ka7 Kb8 Kb9 Kc6 Kf5 Kf7 Kf8 Kj2 Kj3 Kj8 Kk7	Tributaries:	Source and Transport (Bedrock, Cascade, Colluvial)	Aa, A	Parallel Low Order	Source of snow/debris avalanche. Alluvial fans at tributary mouths, common.
	Mainstems:	Transport and Response (Step pool, Pool riffle)	B, C	Trellis High Order	Channels can be bounded by alluvial fan deposits. Stream migration in C channels, common. Seeps along valley toeslopes.
La1 La2 Lb4 Lb6 Lb8 Ld2 Lg4 Lg6 Lh6 Lj1 Lj2 Lj8	Tributaries:	Source and Transport (Bedrock, Cascade, Colluvial)	B	Sub-dendritic, Deranged Low Order	Upper basins can have seeps along drainageways.
	Mainstems:	Transport (Step pool)	B, C	Sub-dendritic High Order	Some seeps in upper valley sideslopes
Mu2 Mu6	Tributaries:	Source (Bedrock)	A	Parallel Low Order	Source for debris slides
	Mainstems:	Response (Pool riffle, Braided, Plane bed)	B, C, D, E	Dendritic High Order	Hyporheic flows; May have interrupted flow or lakes and marshes. B channels common.
Na5 Na6 Na7 Nb8 Nf5 Nj2 Nj8 Nk7 Nu2 Nu6	Tributaries:	Source and Transport (Step pool)	B, C, E	Trellis Low Order	Base level at tributary confluence can be elevated above mainstem and subject to avulsion.
	Mainstems:	Transport and Response (Pool riffle, Braided, Plane bed, Plane bed)	B, C, E	Trellis High Order	Hyporheic flows; Most are confined by terraces. Bedrock and fan niche points create changes in gradient.

Table 6. Hydrological Classifications and Properties (continued)

LTA	Stream Segment	Stream Reach Types (*Montgomery and Buffington 1993*)	Stream Types (*Rosgen 1994*)	Drainage Properties (Common stream patterns/stream order)	Unique Properties
Ou2 Ou6	Mainstems Only:	Response (Pool riffle, Plane bed, Braided)	B, C, D	Dendritic High Order	B Channels are in upper elevation valleys
Pa9 Pb8 Pi9	Tributaries Only:	Transport (Step pool)	B	Dendritic Low Order	Low stream density
Qu2 Qu8	Tributaries Only:	Source and Transport (Colluvial, Cascade, Step pool)	A	Sub-parallel, Centripetal Low Order	Tributaries source of debris slides
Sc1 Sc2 Sc3 Sc5 Sc8	Tributaries:	Source and Transport (Bedrock, Colluvial, Cascade)	A, B	Sub-dendritic Low Order	Channels subject to debris slides; often intermittent
	Mainstems:	Response (Pool riffle, Braided, Plane bed)	B, C, D, E	Sub-dendritic High Order	Silt fills low gradient pools
Sh4	Tributaries Only:	Source and Transport (Colluvial, Cascade, Step pool)	A, B	Sub-dendritic Low Order	
Tu3 Tu6 Tu7 Tu8 Uu3 Uu5 Uu7 Uu8	Tributaries:	Source and Transport (Plane bed, Step pool)	B	Contorted Low Order	Tributaries can undermine landslide mass
	Mainstems:	Response (Pool riffle)	C	Sub-dendritic High Order	Landslides can alter stream alignment and confine channels
We1 We3 We5 We7 We8	Tributaries:	Source and Transport (Bedrock, Step pool)	B	Dendritic Low Order	Tributaries well armored and often intermittent; may have interrupted flows
	Mainstems:	Response (Pool riffle)	C	Dendritic High Order	Old terraces can have hyporheic flow in C channels
Xe3 Xe5 Xf7 Xf8	Tributaries:	Source (Colluvial, Cascade)	A	Parallel, Dendritic Low Order	Tributaries often intermittent and can be source of debris slides
	Mainstems:	Response (Pool riffle)	C	Dendritic High Order	Old terraces can have hyporheic flow in C channels.
Yd7	Tributaries Only:	Source (Cascade, Bedrock)	Aa	Radial Low Order	Channels confined by bedrock

Table 7. Hydrologic Properties and Responses

LTA	Stream Flow In Largest Streams (Duration, amount)	Aquifer Recharge	Surface Runoff (Snowpack melt/summer storms)	Sediment Delivery Efficiency
Bu6	Perennial High Flow	High	Moderate/ Moderate	Low-High
Da3	Perennial or Intermittent Low Flow	Low	Moderate/ Flashy	High
Da5	Perennial or Intermittent Low Flow	Low	Moderate/ Flashy	High
Da8	Perennial Moderate Flow	Low	Moderate/ Flashy	High
Db1	Perennial or Intermittent Low Flow	Low	Moderate/ Flashy	High
Db2	Perennial or Intermittent Low Flow	Low	Moderate/ Flashy	High
Db4	Perennial Low Flow	Low	Moderate/ Flashy	High
Fa2	Intermittent Low Flow	Low	Flashy/ Flashy	High
Fb7	Intermittent Low Flow	Low	Flashy/ Flashy	High
Fb8	Intermittent Low Flow	Low	Flashy/ Flashy	High
Fb9	Intermittent Low Flow	Low	Flashy/ Flashy	High
Ff9	Intermittent Low Flow	Low	Flashy/ Flashy	High
Fj2	Intermittent Low Flow	Low	Flashy/ Flashy	High
Ga2	Perennial or Intermittent Low Flow	Low	Moderate/ Flashy	Moderate
Gb4	Perennial or Intermittent Low Flow	Low	Moderate/ Flashy	Moderate
Gb7	Perennial Low Flow	Low	Moderate/ Flashy	High
Gb8	Perennial Low Flow	Low	Moderate/ Flashy	High
Gb9	Perennial Low Flow	Low	Moderate/ Flashy	High
Gd2	Perennial or Intermittent Low Flow	Low	Moderate/ Flashy	Moderate

Table 7. Hydrologic Properties and Responses (continued)

LTA	Stream Flow In Largest Streams (Duration, amount)	Aquifer Recharge	Surface Runoff (Snowpack melt/summer storms)	Sediment Delivery Efficiency
Gd5	Perennial Low Flow	Low	Moderate/ Flashy	Moderate
Gd7	Perennial Low Flow	Low	Moderate/ Flashy	Moderate
Gd8	Perennial Low Flow	Low	Moderate/ Flashy	Moderate
Gg3	Perennial or Intermittent Low Flow	Low	Moderate/ Flashy	Moderate
Gg8	Perennial Low Flow	Low	Moderate/ Flashy	Moderate
Gi8	Perennial Low Flow	Low	Moderate/ Flashy	Moderate
Ha7	Perennial Low Flow	High	Low/Low	Low
Ha8	Perennial Low Flow	High	Low/Low	Low
Hb9	Perennial Low Flow	High	Low/Low	Low
Hi9	Perennial Low Flow	High	Low/Low	Low
Ia2	Perennial or Intermittent Low Flow	Low-Moderate	Moderate/ Moderate	Low
Ia3	Perennial or Intermittent Low Flow	Low-Moderate	Moderate/ Moderate	Low
Ia7	Perennial or Intermittent Low Flow	Low-Moderate	Moderate/ Moderate	Low
Ia8	Perennial or Intermittent Low Flow	Low-Moderate	Moderate/ Moderate	Low
Ib6	Perennial or Intermittent Low Flow	Moderate	Moderate/ Moderate	Low
Ic5	Perennial or Intermittent Low Flow	Low-Moderate	Moderate/ Moderate	Low
Id2	Perennial or Intermittent Low Flow	Low-Moderate	Moderate/ Moderate	Low
Id7	Perennial or Intermittent Low Flow	Low-Moderate	Moderate/ Moderate	Low
Ig4	Perennial or Intermittent Low Flow	Low-Moderate	Moderate/ Moderate	Low

Table 7. Hydrologic Properties and Responses (continued)

LTA	Stream Flow In Largest Streams (Duration, amount)	Aquifer Recharge	Surface Runoff (Snowpack melt/summer storms)	Sediment Delivery Efficiency
Ig6	Perennial or Intermittent Low Flow	Moderate	Moderate/ Moderate	Low
Ih6	Perennial or Intermittent Low Flow	Moderate	Moderate/ Moderate	Low
Ih8	Perennial or Intermittent Low Flow	Low-Moderate	Moderate/ Moderate	Low
Ja8	Perennial Low Flow	Low	Moderate /Flashy	High
Jb1	Perennial Low Flow	Low	Moderate /Flashy	High
Jb2	Perennial Low Flow	Low	Moderate /Flashy	High
Ji8	Perennial Low Flow	Low	Moderate /Flashy	High
Jj1	Perennial Low Flow	Low	Moderate /Flashy	High
Jj2	Perennial Low Flow	Low	Moderate /Flashy	High
Ka2	Perennial High Flow	High	Moderate/ Flashy	High
Ka5	Perennial High Flow	High	Moderate/ Flashy	High
Ka6	Perennial High Flow	High	Moderate/ Flashy	High
Ka7	Perennial High Flow	High	Flashy/ Flashy	High
Kb8	Perennial High Flow	High	Moderate// Flashy	High
Kb9	Perennial High Flow	Moderate	Flashy/ Flashy	High
Kc6	Perennial High Flow	High	Moderate/ Flashy	High
Kf5	Perennial High Flow	High	Moderate/ Flashy	High
Kf7	Perennial High Flow	Moderate	Flashy/ Flashy	High
Kf8	Perennial High Flow	High	Flashy/ Flashy	High
Kj2	Perennial High Flow	High	Moderate/ Flashy	High

Table 7. Hydrologic Properties and Responses (continued)

LTA	Stream Flow In Largest Streams (Duration, amount)	Aquifer Recharge	Surface Runoff (Snowpack melt/summer storms)	Sediment Delivery Efficiency
Kj3	Perennial High Flow	High	Moderate/ Flashy	High
Kj8	Perennial High Flow	High	Flashy/ Flashy	High
Kk7	Perennial High Flow	High	Flashy/ Flashy	High
La1	Perennial or Intermittent Low Flow	Low-Moderate	Slow/Slow	Low
La2	Perennial or Intermittent Low Flow	Low-Moderate	Slow/Slow	Low
Lb4	Perennial Low Flow	Low-Moderate	Slow/Slow	Low
Lb6	Perennial Moderate Flow	Moderate	Slow/Slow	Low
Lb8	Perennial Moderate Flow	Moderate	Slow/Slow	Low
Ld2	Perennial or Intermittent Low Flow	Low-Moderate	Slow/Slow	Low
Lg4	Perennial Low Flow	Low-Moderate	Slow/Slow	Low
Lg6	Perennial Moderate Flow	Low-Moderate	Slow/Slow	Low
Lh6	Perennial Moderate Flow	Low-Moderate	Slow/Slow	Low
Lj1	Perennial or Intermittent Low Flow	Low-Moderate	Slow/Slow	Low
Lj2	Perennial or Intermittent Low Flow	Low-Moderate	Slow/Slow	Low
Lj8	Perennial Moderate Flow	Low-Moderate	Slow/Slow	Low
Mu2	Intermittent Flow varies	Low-High	Slow-Moderate/ Slow-Moderate	Low
Mu6	Perennial Flow varies	Low-High	Slow/Slow	Low
Na5	Perennial High Flow	High	Slow/Moderate	Low
Na6	Perennial High Flow	High	Slow/Moderate	Low
Na7	Perennial High Flow	High	Slow/Moderate	Low

Table 7. Hydrologic Properties and Responses (continued)

LTA	Stream Flow In Largest Streams (Duration, amount)	Aquifer Recharge	Surface Runoff (Snowpack melt/summer storms)	Sediment Delivery Efficiency
Nb8	Perennial High Flow	High	Slow/Moderate	Low
Nf5	Perennial High Flow	High	Slow/Moderate	Low
Nj2	Perennial High Flow	High	Slow/Moderate	Low
Nj8	Perennial High Flow	High	Slow/Moderate	Low
Nk7	Perennial High Flow	High	Slow/Moderate	Low
Nu2	Perennial High Flow	High	Slow/Moderate	Low
Nu6	Perennial High Flow	High	Slow/Moderate	Low
Ou2	Perennial Flow varies	High	Slow/Slow	Low
Ou6	Perennial Flow varies	High	Slow/Slow	Low
Pa9	Intermittent Low Flow	Low-Moderate	Slow/Slow	Low
Pb8	Intermittent Low Flow	Low-Moderate	Slow/Slow	Low
Pi9	Intermittent Low Flow	Low-Moderate	Slow/Slow	Low
Qu2	Intermittent Low Flow	Low	Flashy/ Flashy	High
Qu8	Intermittent Low Flows	Low	Flashy/ Flashy	High
Sc1	Perennial Low Flow	Low	Moderate/ Flashy	High
Sc2	Perennial Low Flow	Low	Moderate/ Flashy	High
Sc3	Perennial Low Flow	Low	Moderate/ Flashy	High
Sc5	Perennial Low Flow	Low	Moderate/ Flashy	High
Sc8	Perennial Low Flow	Low	Moderate/ Flashy	High
Sh4	Perennial Low Flow	Low	Moderate/ Moderate	Moderate

Table 7. Hydrologic Properties and Responses (continued)

LTA	Stream Flow In Largest Streams (Duration, amount)	Aquifer Recharge	Surface Runoff (Snowpack melt/summer storms)	Sediment Delivery Efficiency
Tu3	Perennial Moderate Flow	Moderate	Slow/Slow	Moderate-High
Tu5	Perennial Moderate Flow	Moderate	Slow/Slow	Moderate-High
Tu7	Perennial Moderate Flow	Moderate	Slow/Slow	Moderate-High
Tu8	Perennial Moderate Flow	Moderate	Slow/Slow	Moderate-High
Uu3	Perennial Moderate Flow	Moderate	Slow/Slow	Moderate-High
Uu5	Perennial Moderate Flow	Moderate	Slow/Slow	Moderate-High
Uu7	Perennial Moderate Flow	Moderate	Slow/Slow	Moderate-High
Uu8	Perennial Moderate Flow	Moderate	Slow/Slow	Moderate-High
We1	Perennial Low Flow	Low	Moderate/ Moderate	Low
We3	Perennial Low Flow	Low	Moderate/ Moderate	Low
We5	Perennial Low Flow	Low	Moderate/ Moderate	Low
We7	Perennial Low Flow	Low	Moderate/ Moderate	Low
We8	Perennial Low Flow	Low	Moderate/ Moderate	Low
Xe3	Perennial Low Flow	Low	Moderate/ Flashy	Moderate
Xe5	Perennial Low Flow	Low	Moderate/ Flashy	Moderate
Xf7	Perennial Low Flow	Low-Moderate	Moderate/ Flashy	High
Xf8	Perennial Low Flow	Low-Moderate	Moderate/ Flashy	Moderate
Yd7	Intermittent Low Flow	Low	Flashy/ Flashy	High

Vegetation Properties and Responses

Table 8 contains the vegetation properties and responses for each Landtype Association. Listed below is a brief description of the information contained in each column.

Potential Natural Vegetation (PNV) Representative Plant Association Group (PAG): This column contains the most prominent Plant Association Groups (PAG) occurring in each Landtype Association. PAGS were developed for eastern Washington National Forests for the PNV mapping project, Area II Ecology Program, March 3 1999 by Jan Henderson, Bud Kolvachik, and Terry Lillybridge. Representative PAGS for each LTA were determined by overlaying GIS data layers with LTA coverages and identifying the most dominant PAGS. From this list the most representative was selected and listed in Table 8.

Plant Association Group (PAG) Number: This column contains the number assigned for each Plant Association Group for identification purposes.

Percent Non-Forest: This column contains the amount of each Landtype Association that occurs as non-forest (meadows or grasslands). The amount of non-forest will be expressed in percent land cover. This interpretation was based upon aerial photo and field observations.

Inferred Climatic Regime: This column represents the generalized climatic setting occurring in each Landtype Association. This interpretation was based upon potential natural vegetation and field observations.

Inherent Soil Fertility: This column contains an interpretation of inherent soil fertility. Soil fertility comprises many soil characteristics along with two key characteristics, water holding capacity and nutrient availability. Often inherent soil fertility is reflected in the kind and diversity of vegetative species and in the ease of re-establishment after disturbance.

The purpose of this interpretation is to provide a rating that can be used in association with potential natural vegetation or plant associations to reflect an overall concept of productivity for each Landtype Association. This relative rating is provided in absence of actual site productivity data associated directly to each Landtype Association. The interpretation suggests whether the particular LTA is on the "low, mid, or high end" of the general ranges given for potential site productivity as indicated by plant association groups.

The rating is based upon the inherent water holding capacity and nutrient availability of the soil regolith. This is empirically derived using soil texture, mineralogy of soil parent material or regolith, and soil climate factors that limit availability of nutrients due to low temperature or moisture stress. The mapping differentia and map unit features associated with this differentia used to develop the interpretation are: geology group, regolith textural group, plant associations in LTAs reflecting extreme moisture stress within PNV Group 1 or extreme cold soil temperatures which limits biological processes reflected by plant associations within PNV Group 8 and all of PNV Group 9, and soil subgroup classification (classification indicating a wind blown deposit of volcanic ash).

VERY LOW (VL) – Site productivity is likely at the lowest end of the range of potential productivity for a given plant association group. The soil regolith has relatively very low water holding capacity and nutrient availability due to coarse to moderately coarse

textures with a high amount of coarse sands in the soil matrix, and/or severe moisture stress or cold temperatures limiting biological processes; and/or shallow soil depth and a high amount of bedrock exposure severely influences water or nutrient capacity.
LOW (L) - Site productivity is likely at the low end of the range of potential productivity for a given plant association group. The soil regolith has relatively low water holding capacity and nutrient availability due to moderately coarse textures or somewhat finer textures that have limited biological processes due to cold temperatures or moisture stress or limited capacity due to shallow soil depths and a high amount of bedrock exposure.
MODERATE (M) - Site productivity is likely in the middle of the range of potential productivity for a given plant association group. The soil regolith has relatively moderate water holding capacity and nutrient availability due to moderately coarse to medium textures from geology parent materials that produce fine sands and silts in the matrix. Coarser, sandier soil textures are included when soils have a surface layer of wind blown volcanic ash which substantially enhances productivity. Somewhat finer textures are included when it is expected that biological processes are limited due to cold temperatures or capacity is limited due to shallow soil depths and a high amount of bedrock exposure.
HIGH (H) - Site productivity is likely at the high or very high end of the range of potential productivity for a given plant association group. The soil regolith has a relatively high water holding capacity and nutrient availability due to moderately fine to fine textures. Most soils have a surface layer of wind blown volcanic ash that enhances productivity. Biological processes are not typically limited by cold temperatures.
Variable - Landtype association has a wide range of geologic parent materials and other site features. Inherent soil fertility was not rated as soil fertility varies with these factors.

<u>Inherent Site Productivity</u>: These columns contain three interpretations. They are potential wood fiber productivity, potential productivity of the herbaceous component of a forested stand, and potential productivity of the herbaceous component of non-forest areas.

<u>Potential Wood Fiber Productivity (cuft/ac/yr.)</u>: This interpretation is based upon the ranges of relative annual average basal area growth per acre by plant association as summarized in the respective plant association field guides for each Forest. The productivity information was purposefully broad recognizing a limited sample size, use of various sources and use of various sampling methods. The ranges are to be used as a relative interpretation. Ranges have been converted to qualitative terms as referenced below and should be used as a relative comparison between Landtype Associations, not as an absolute potential production.

VERY LOW (VL) – Wood fiber production is less than 50 cubic feet per acre per year. Landtype Association generally contains site features that infer very low productive conditions for wood fiber. A very low potential production typically reflects one or more of the following: low available soil moisture, low soil fertility, a high amount of bedrock, shallow soils, or climatic conditions that limit plant growth. These areas typically support only sparse forests.
LOW (L) – Wood fiber production ranges from 50 to 80 cubic feet per acre per year. Landtype Association generally contains site features that infer low productive conditions for wood fiber. A low potential production typically reflects one or more of the following: low available soil moisture, low soil fertility, a high amount of bedrock, shallow soil or climatic conditions that limit plant growth. These areas are less likely to

support dense vigorous forests and when dense forests occur, stands tend to stagnate prior to maturity.

MODERATE (M) – Wood fiber production ranges from 80 to 120 cubic feet per acre per year. Landtype Association generally contains site features that infer intermediate productive conditions for wood fiber. A moderate potential production typically reflects one or more of the following: moderate available soil moisture and relatively good soil fertility, and moderately deep soils. Soil water holding capacity may compensate for periods of no precipitation and soil fertility may compensate for other periodic climatic limitations on plant growth. Landtype Associations typically have a closed canopy forest at the upper end of the range but trees actively compete for moisture and nutrients with each other and with the forest understory plants.

HIGH (H) – Wood fiber production ranges from 120 to 160 cubic feet per acre per year. Landtype Associations generally contain site features that infer highly productive conditions for wood fiber. A high potential production typically reflects one or more of the following: freely available soil moisture and relatively good soil fertility, and relatively deep soils. Precipitation and soil water holding capacity work in consort to maintain plant growth throughout the growing season. Landtype Associations typically have closed canopy forests supporting multiple layers of trees and understory plants.

<u>Understory Herbage Potential (lbs air-dry/acre/yr)</u>: This column contains the relative interpretation for herbaceous production in the forest understory. Herbaceous production is based upon the total production of grasses, forbs, and sedges and excludes plants with woody stems. Herbage production should not be confused with forage production. Forage is that portion of the herbage production that is edible or desirable for grazing animals. This interpretation is based upon the pounds of herbage produced annually from representative plant associations groups. Project clipping studies along with Eco-plot studies helped to support these estimates. The interpretation is expressed in pounds of air dry weight. This interpretation should be used to help compare Landtype Association herbage production and not as an absolute level of production.

VERY LOW (L) - Herbage production is less than 500 pounds of air dry weight per year. Landtype associations generally contain site features that infer very low productive conditions for herbage. Generally the area contains one or more of the following conditions: maritime climatic conditions; dense multi structured forest canopies; and forest understories dominated by low and mid-level woody shrubs. Normally natural openings are a result of disturbance and are often dominated by mid to tall woody shrubs.

LOW (L) - Herbage production ranges from 500 to 1000 pounds of air dry weight per year. Landtype associations generally contain site features that infer low productive conditions for herbage. Generally the area contains one or more of the following conditions: upper elevation continental climatic conditions; relatively dense forest canopies; and forest understories dominated by low growing woody shrubs with some grasses.

MODERATE (M) - Herbage production ranges from 1000 to 1500 pounds of air dry weight per year. Landtype associations generally contain site features that infer moderate or intermediate productive conditions for herbage. Generally the area contains one or more of the following conditions: continental climatic conditions; open to partially closed, single-storied forest canopies; and forest understories dominated by a mixture of grasses, forbs, and low growing woody shrubs.

HIGH (H) - Herbage production normally exceeds 1500 pounds of air dry weight per year. Landtype Associations generally contain site features that infer highly productive conditions for herbage. Generally the area contains one or more of the following site conditions: continental climatic conditions; scattered coniferous trees; ground cover is dominated by a mixture of grasses, forbs, and sedges associated with warm low level shrubs (bitterbrush and sagebrush); moderately fine textured soil regoliths; depth of bedrock is greater than two feet; intermediate or subirrigated areas creating wet meadows or moist grasslands.

Vegetation Recovery: This column contains the relative interpretation for sites to regenerate and support ground cover (herbaceous and woody shrubs) after disturbance. Two disturbance levels are rated. The rating for the column labeled "less disturbed" is when the ground cover is disturbed but the surface soil layer has not been altered. The rating for the column labeled "disturbed" is when both ground cover and the surface soil has been significantly altered.

Site factors used to develop this interpretation include: harsh climatic conditions, moisture stress, and unique soil regoliths such as from serpentine geology. Harsh climatic conditions are associated with elevations generally exceeding 5000 feet elevation and support the following potential natural vegetation zones: Silver Fir/Mountain Hemlock; Subalpine fir; and Parkland. These high elevations have short growing seasons or are exposed to desiccation by winds that limit plant growth. Moisture stress conditions are generally associated with a set of the following conditions: shallow surface horizons over coarse textured, bouldery regoliths; southern exposures; and low elevations were moisture and heat stress can affect seedling establishment. Moisture stress can occur in upper elevations associated with wind desiccation. Geologic features such as serpentine soils may produce soil chemical and physical properties that that hinder regeneration (Walker 1954).

VERY LOW (VL) - Site features generally cause extreme limitations for herbaceous vegetation and shrubs to regenerate and occupy sites. Very harsh climatic conditions or soil/site features create extreme moisture stress or geologic features inhibit regeneration of herbaceous vegetation and shrubs. These site features are predominant in the area.

LOW (L) - Landtype Association contain site features that generally create severe limitations for herbaceous vegetation and shrubs to regenerate and occupy sites. Harsh climatic conditions or soil/site features that create severe moisture stress, or geologic features severely limit regeneration of herbaceous vegetation and shrubs. These site features predominate throughout the area.

MODERATE (M) - Landtype Association generally contains soil or site features that create some limitations for herbaceous vegetation and shrubs to regenerate and occupy sites. These site features are common but do not occur throughout the area.

HIGH (H) - Landtype Association generally contain site and soil features that do not limit herbaceous vegetation and shrubs from regenerating and occupying sites.

Table 8. Vegetation Properties and Responses

LTA	Potential Natural Vegetation Representative Plant Association Groups (PAG)	PAG (#)	Non-Forest (%)	Inferred Climatic Regime	Inherent Soil Fertility	Inherent Site Productivity			Vegetation Recovery	
						Forested		Non-Forested	Undisturbed	Disturbed
						Wood fiber	Herbaceous	Herbaceous		
Bu6	TSHE/VAME/CLUN PSME/PHMA-SYAL	1901 1404	0-10	Inland Maritime warm/dry	H	H	L	H-VH	H	M
Da3	PSME/CARU-CAGE ABGR/ACCI-BENE/ACTR	1403 1603	20-30	Continental warm/dry	L-M	M	L-M	M	H	M-H
Da5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1602 1905	20-30	Maritime warm/moist	M	M	L-M	M	H	M-H
Da8	ABLA2/VAME-LIBOL	2503	20-30	Continental cool/moist	L-M	L	L	M-H	M	L
Db1	PIPO/AGSP	1001	>60	Continental hot/dry	VL-L	VL	M-H	M-H	M-H	L
Db2	PSME/CARU-CAGE PSME/PUTR/AGSP	1403 1401	30-40	Continental warm/dry	L	L	L-M	M	H	M
Db4	PSME/PHMA-SYAL TSHE/VAME/CLUN	1404 1901	20-30	Inland Maritime warm/moist	L-M	M	L	M	H	M
Fa2	PSME/CARU-CAGE PSME/PUTR/AGSP PIPO/AGSP	1403 1401 1001	>60	Continental warm/dry	VL	L	L-M	M	H	L-M
Fb7	TSME/RHAL-VAME ABAM/MEFE-PHAL-VAME	2302 2205	>60	Maritime cool/moist	L	M-H	L	L	H	H
Fb8	ABLA2/VASC ABLA2/VAME-LIBOL ABLA2/RHAL-XETE	2502 2503 2504	>60	Continental cool/moist	L	M	L	L	M-H	M
Fb9	PARKLAND	3301	>60	Continental very cold/moist	L	VL	L	M	L	VL
Ff9	PARKLAND	3301	>60	Continental very cold/moist	L	VL	L	L-M	L	VL
Fj2	PSME/CARU-CAGE	1403	>60	Continental warm/dry	VL-L	L	L-M	M	H	L-M
Ga2	PSME/PHMA-SYAL PSME/CARU-CAGE PSME/VAME-VAMY-VACA	1404 1403 1405	40-60	Continental warm/dry	L	L	L-M	M	H	M

Table 8. Vegetation Properties and Responses (continued)

LTA	Potential Natural Vegetation Representative Plant Association Groups (PAG)	PAG (#)	Non-Forest (%)	Inferred Climatic Regime	Inherent Soil Fertility	Inherent Site Productivity			Vegetation Recovery	
						Forested		Non-Forested	Undisturbed	Disturbed
						Wood fiber	Herbaceous	Herbaceous		
Gb4	PSME/PHMA-SYAL TSHE/VAME/CLUN	1404 1901	40-60	Inland Maritime warm/moist	VL-L	L-M	L	M	H	M
Gb7	ABAM/ACCI/TITRU TSME/RHAL-VAME	2207 2302	40-60	Maritime cool/moist	M	M-H	L	L	H	H
Gb8	ABLA2/VASC ABLA2/VAME-LIBOL	2502 2503	>60	Continental cool/moist	L	M	L	M	M	L
Gb9	PARKLAND	3201	>60	Continental very cold/moist	VL	VL	L-M	M	L	VL
Gd2	PSME/PHMA-SYAL	1404	40-60	Continental warm/dry	M	L	L-M	M	H	M
Gd5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1603 1905	30-40	Maritime warm/moist	H	H	M	M	H	M-H
Gd7	ABAM/ACCI/TITRU TSME/RHAL-VAME	2206 2302	30-40	Maritime cool/moist	H	H	L	L-H	H	H
Gd8	ABLA2/VASC ABLA2/VAME-LIBOL	2502 2503	30-40	Continental cool/moist	M-H	M	L	M	M	L
Gg3	PSME/CARU-CAGE ABGR/ACCI-BENE/ACTR	1403 1602	40-60	Continental warm/dry	M	M	M	L-M	H	M-H
Gg8	ABLA2/VAME-LIBOL	2503	40-60	Continental cool/moist	H	H	L	M	L-M	VL
Gi8	ABLA2/VAME-LIBOL ABLE2/VASC	2503 2502	40-60	Continental cool/moist	M-H	M	L	M	L-M	VL
Ha7	ABAM/ACCI/TITRU TSME/RHAL-VAME	2206 2302	30-40	Maritime cool/moist	M	M-H	L	M-VH	H	M-H
Ha8	ABLA2/COCA/EQUIS	2507	40-60	Continental cool/moist	M	M	L	H-VH	L-M	VL
Hb9	PARKLAND	3201	>60	Continental very cold/moist	L	VL	L-M	H-VH	L	VL
Hi9	PARKLAND	3201	>60	Continental very cold/moist	M	VL	L-M	H-VH	L	VL
Ia2	PSME/PHMA-SYAL PSME/CARU-CAGE	1404 1403	30-40	Continental warm/dry	VL-M	L	L-M	M	H	M

Table 8. Vegetation Properties and Responses (continued)

LTA	Potential Natural Vegetation Representative Plant Association Groups (PAG)	PAG (#)	Non-Forest (%)	Inferred Climatic Regime	Inherent Soil Fertility	Inherent Site Productivity			Vegetation Recovery	
						Forested		Non-Forested	Undisturbed	Disturbed
						Wood fiber	Herbaceous	Herbaceous		
Ia3	PSME/CARU-CAGE ABGR/ACCI-BENE/ACTR	1403 1603	30-40	Continental warm/dry	L-M	M	M	M	H	M-H
Ia7	ABAM/ACCI/TITRU TSME/RHAL-VAME	2207 2302	30-40	Maritime cool/moist	M-H	M-H	L	L	H	H
Ia8	ABLA2/VAME-LIBOL ABLA2/COCA/EQUIS	2503 2507	30-40	Continental cool/moist	L-M	M	L	H-VH	L	VL
Ib6	TSHE/VAME/CLUN PSME/PHMA-SYAL	1901 1404	20-30	Inland Maritime warm/moist	L-M	M-H	L	H-VH	M-H	M
Ic5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1603 1905	20-30	Maritime warm/moist	H	M-H	L	L-M	H	M-H
Id2	PSME/PHMA-SYAL	1404	30-40	Continental warm/dry	M	M-H	L-M	M	H	M
Id7	ABMA/ACCI/TITRU TSME/RHAL-VAME	2207 2302	20-30	Maritime cool/moist	M-H	H	L	L-H	H	H
Ig4	PSME/PHMA-SYAL TSHE/VAME/CLUN	1404 1901	20-30	Inland Maritime warm/moist	M-H	M	L	M-H	M-H	M
Ig6	TSHE/VAME/CLUN	1901	20-30	Inland Maritime warm/moist	H	H	L	H-VH	M-H	M
Ih6	TSHE/VAME/CLUN TSHE/MEFE-XETE	1901 1912	20-30	Inland Maritime warm/moist	H	H	L	H-VH	H	M-H
Ih8	ABLA2/RHAL-XETE	2504	30-40	Continental cool/moist	M-H	M-H	L	H-VH	H	M-H
Jb1	PIPO/AGSP PSME/PUTR/AGSP	1001 1401	>60	Continental hot/dry	L	VL	M-H	M-H	M-H	L
Jb2	PSME/CARU-CAGE PSME/PUTR/AGSP	1403 1401	30-40	Continental warm/dry	M	L	L-M	M	H	M
Ja8	ABLA2/VASC	2502	30-40	Continental cool/moist	M	M	L	M-H	L-M	L
Ji8	ABLA2/VAME-LIBOL ABLA2/VASC	2503 2502	30-40	Continental cool/moist	M	M	L	M-H	L-M	L
Jj1	PIPO/AGSP PSME/PUTR/AGSP	1001 1401	>60	Continental hot/dry	M	VL	M-H	M-H	M-H	L

Table 8. Vegetation Properties and Responses (continued)

LTA	Potential Natural Vegetation Representative Plant Association Groups (PAG)	PAG (#)	Non-Forest (%)	Inferred Climatic Regime	Inherent Soil Fertility	Inherent Site Productivity			Vegetation Recovery	
						Forested		Non-Forested	Undisturbed	Disturbed
						Wood fiber	Herbaceous	Herbaceous		
Jj2	PSME/CARU-CAGE	1403	30-40	Continental warm/dry	M	L	L-M	M	H	M
Ka2	PSME/CARU-CAGE PSME/PHMA-SYAL	1403 1404	30-40	Continental warm/dry	L-M	L	L-M	M	H	M
Ka5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1603 1905	20-30	Maritime warm/moist	L-M	M	L	L-M	H	H
Ka6	TSHE/ACCI-BENE-PAMY	1905	20-30	Maritime warm/moist	M	M-H	L	L-H	H	H
Ka7	ABAM/VAME-RULA ABAM/MEFE-RHAL-VAME TSME/RHAL-VAME	2204 4405 2303	20-30	Maritime cool/moist	M	M-H	L	L-H	H	H
Kb8	ABLA2/COCA/EQUIS ABLA2/VAME-LIBOL ABLA2/VASC	2507 2503 2502	30-40	Continental cool/moist	L-M	M	L	M	M	L-M
Kb9	PARKLAND TSME/MEFE-VAAL	3201 2303	>60	Continental very cold/moist	L	VL	L	H	L-M	VL-M
Kc6	TSHE/ACCI-BENE-PAMY	1905	20-30	Maritime warm/moist	H	M-H	L	L-H	H	H
Kf5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1603 1905	20-30	Maritime warm/moist	H	M-H	L	L-M	H	H
Kf7	ABAM/VAME-RULA ABAM/MEFE-RHAL-VAME TSME/RHAL-VAME	2204 2205 2302	30-40	Maritime cool/moist	H	H	L	L-H	H	M-H
Kf8	ABLA2/COCA/EQUIS ABLA2/VAME-LIBOL ABLA2/VASC	2507 2503 2502	30-40	Continental cool/moist	M-H	M	L	M	M	L-M
Kj2	PSME/CARU-CAGE	1403	30-40	Continental warm/dry	M	L	L-M	M	H	L-M
Kj3	PSME/CARU-CAGE ABGR/ACCI-BENE/ACTR	1403 1602	30-40	Continental warm/dry	M-H	M	L-M	M	H	M-H
Kj8	ABLA2/VAME-LIBOL ABLA2/VASC ABLA2/RHAL-XETE	2503 2502 2504	30-40	Continental cool/moist	L-H	M	L	M	M	L-M

Table 8. Vegetation Properties and Responses (continued)

LTA	Potential Natural Vegetation Representative Plant Association Groups (PAG)	PAG (#)	Non-Forest (%)	Inferred Climatic Regime	Inherent Soil Fertility	Inherent Site Productivity			Vegetation Recovery	
						Forested		Non-Forested	Undisturbed	Disturbed
						Wood fiber	Herbaceous	Herbaceous		
Kk7	ABAM/VAME-RULA TSME/RHAL-VAME TSME/MEFE-VAAL	2204 2302 2303	20-30	Maritime cool/moist	L	M-H	L	L-H	H	M-H
La1	PIPO/AGSP PSME/PUTR-AGSP	1001 1401	>60	Continental hot/dry	L-M	VL	M-H	M-H	M-H	VL-L
La2	PSME/PHMA-SYAL	1404	20-30	Continental warm/dry	L-M	L	L-M	M	H	M
Lb4	PSME/PHMA-SYAL TSHE/VAME/CLUN	1404 1901	10-20	Inland Maritime warm/moist	VL-M	L-M	L	M-H	M-H	M
Lb6	TSHE/VAME/CLUN	1901	10-20	Inland Maritime warm/moist	M	M-H	L	M-H	M-H	L-M
Lb8	ABLA2/VAME-LIBOL	2503	20-40	Continental cool/moist	L-M	M	L	H-VH	M	L-M
Ld2	PSME/PHMA-SYAL	1404	20-30	Continental warm/dry	M-H	M	L-M	M	H	M
Lg4	PSME/PHMA-SYAL TSHE/VAME/CLUN	1404 1901	10-20	Inland Maritime warm/moist	M-H	M	L	M-H	M-H	M
Lg6	TSHE/VAME/CLUN	1901	0-10	Inland Maritime warm/moist	H	M-H	L	H-VH	M	M
Lh6	TSHE/VAME/CLUN	1901	0-10	Inland Maritime warm/moist	H	M	L	H	M	M
Lj1	PIPO/AGSP PSME/PUTR-AGSP	1001 1401	>60	Continental hot/dry	L	VL	M-H	M-H	M-H	VL-L
Lj2	PSME/CARU-CAGE PSME/PHMA-SYAL	1403 1404	20-30	Continental warm/dry	L-M	L	L-M	M	H	M
Lj8	ABLA2/VAME-LIBOL	2503	20-30	Continental cool/moist	M	M	L	M	M	L-M
Mu2	PSME/PHMA-SYAL PIPO/AGSP	1404 1001	40-60	Continental warm/dry	variable	L	L-M	L-VH	M-H	M
Mu6	TSHE/VAME/CLUN ABLA2/VAME-LIBOL	1901 2503	40-60	Maritime warm/moist	variable	M-H	L	L-VH	M	M

Table 8. Vegetation Properties and Responses (continued)

LTA	Potential Natural Vegetation Representative Plant Association Groups (PAG)	PAG (#)	Non-Forest (%)	Inferred Climatic Regime	Inherent Soil Fertility	Inherent Site Productivity			Vegetation Recovery	
						Forested		Non-Forested	Undisturbed	Disturbed
						Wood fiber	Herbaceous	Herbaceous		
Na5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1603 1905	10-20	Maritime warm/moist	L-M	M	L	L-M	H	H
Na6	TSHE/ACCI-BENE-PAMY	1905	10-20	Maritime warm/moist	M	M-H	L	L-H	H	H
Na7	ABAM/VAME-RULA ABAM/MEFE-RHAL-VAME TSME/RHAL-VAME	2204 4405 2302	10-20	Maritime cool/moist	L-M	M-H	L	L-H	H	H
Nb8	ABLA2/COCA/EQUIS ABLA2/VAME-LIBOL ABLA2/VASC	2507 2503 2502	10-20	Continental cool/moist	L-M	M	L	M	M	L-M
Nf5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1603 1905	10-20	Maritime warm/moist	H	M-H	L	L-M	H	H
Nj2	PSME/CARU-CAGE	1403	10-20	Continental warm/dry	M	L	M	M	H	M
Nj8	ABLA2/COCA/EQUIS ABLA2/VAME-LIBOL ABLA2/VASC	2507 2503 2502	10-20	Continental cool/moist	L-M	M	L	M	M	L-M
Nk7	ABAM/VAME-RULA TSME/RHAL-VAME TSME/MEFE-VAAL	2204 2302 2303	10-20	Maritime cool/moist	L-M?	M-H	L	L-H	H	M-H
Nu2	PSME/CARU-CAGE	1403	10-20	Continental warm/dry	variable	L	M	M	H	M
Nu6	TSHE/ACCI-BENE-PAMY	1905	10-20	Maritime warm/moist	variable	M-H	L	L-H	H	H
Ou2	PSME/PUTR/AGSP PSME/PHMA-SYAL	1401 1404	20-30	Continental warm/dry	L-M	M	L-M	L-VH	H	M
Ou6	TSHE/ACCI-BENE-PAMY TSHE/VAME/CLUN ABLA2/VAME-LIBOL	1905 1901 2503	0-10	Maritime warm/moist	M-H	H	L-M	L-VH	H	M-H
Pa9	PARKLAND	3301	>60	Continental very cold/moist	VL-L	VL	L	M-H	L	VL
Pb8	ABLA2/VASC ABLA2/VAME-LIBOL	2502 2503	20-30	Continental cool/moist	L	L-M	L	L-M	L-M	VL-L

Table 8. Vegetation Properties and Responses (continued)

LTA	Potential Natural Vegetation Representative Plant Association Groups (PAG)	PAG (#)	Non-Forest (%)	Inferred Climatic Regime	Inherent Soil Fertility	Inherent Site Productivity			Vegetation Recovery	
						Forested		Non-Forested	Undisturbed	Disturbed
						Wood fiber	Herbaceous	Herbaceous		
Pi9	PARKLAND	3301	>60	Continental very cold/moist	M	VL	L	M-H	L	VL
Qu2	PSME/CARU-CAGE	1403	40-60	Continental warm/dry	M-H	L	M	M-H	H	L-M
Qu8	ABLA2/VAME-LIBOL	2503	40-60	Continental cool/moist	M-H	M	L	M	M	L
Sc1	PIPO/AGSP	1001	>60	Continental hot/dry	L	VL	M-H	M-H	M-H	L-M
Sc2	PSME/CARU-CAGE PSME/PHMA-SYAL	1403 1404	30-40	Continental warm/dry	L-M	L	L-M	M	H	M
Sc3	PSME/CARU-CAGE ABGR/ACCI-BENE/ACTR	1403 1603	20-30	Maritime warm/dry	M-H	M	L-M	M	H	M-H
Sc5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1603 1905	20-30	Maritime warm/moist	M-H	M-H	L	M-H	H	M-H
Sc8	ABLA2/VAME-LIBOL ABLA2/COCA/EQUIS ABLA2/VASC	2503 2507 2502	40-60	Continental cool/moist	M-H	M-H	L	M-H	L-M	L
Sh4	PSME/PHMA-SYAL TSHE/VAME/CLUN	1404 1901	20-30	Inland Maritime warm/moist	M-H	L-M	L-M	M	M-H	M
Tu3	PSME/CARU-CAGE ABGR/VAME-VACA	1403 1605	10-20	Maritime warm/dry	variable	M	L-M	H-VH	H	M-H
Tu5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1603 1905	10-20	Maritime warm/moist	variable	M-H	L	H-VH	H	M-H
Tu7	ABAM/MEFE-VAAL ABAM/VAME-RULA TSHE/RHAL-VAME	2203 2204 2302	10-20	Maritime cool/moist	variable	H	L	H-VH	H	M-H
Tu8	ABLA2/VAME-LIBOL ABLA2/VASC	2503 2502	20-30	Continental cool/moist	variable	H	L	H-VH	M	L
Uu3	PSME/CARU-CAGE ABGR/ACCI-BENE/ACTR	1403 1602	10-20	Maritime warm/dry	variable	M-H	L-M	M-VH	H	M-H
Uu5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1603 1905	10-20	Maritime warm/moist	variable	H	L	M-VH	H	M-H

Table 8. Vegetation Properties and Responses (continued)

LTA	Potential Natural Vegetation Representative Plant Association Groups (PAG)	PAG (#)	Non-Forest (%)	Inferred Climatic Regime	Inherent Soil Fertility	Inherent Site Productivity			Vegetation Recovery	
						Forested		Non-Forested	Undisturbed	Disturbed
						Wood fiber	Herbaceous	Herbaceous		
Uu7	ABAM/VAME-RULA TSHE/RHAL-VAME	2204 2302	10-20	Maritime cool/moist	variable	H	L	H-VH	H	M-H
Uu8	ABLA2/VAME-LIBOL ABLA2/VASC	2503 2502	20-30	Continental cool/moist	variable	H	L	H-VH	M	L
We1	PIPO/AGSP	1001	40-60	Continental hot/dry	L-M	VL	M-H	M-H	M-H	M
We3	PSME/CARU-CAGE ABGR/ACCI-BENE/ACTR	1403 1602	10-30	Maritime warm/dry	M-H	L-M	L-M	M-H	H	M
We5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1603 1905	10-30	Maritime warm/moist	H	M-H	L	H-VH	H	M-H
We7	ABAM/MEFE-VAAL ABAM/VAME-RULA TSHE/RHAL-VAME	2203 2204 2302	10-30	Maritime cool/moist	H	H	L	H-VH	H	M-H
We8	ABLA2/VASC ABLA2/VAME-LIBOL	2502 2503	20-40	Continental cool/moist	M-H	M	L	H	M	L
Xe3	PSME/CARU-CAGE ABGR/ACCI-BENE/ACTR	1403 1602	10-30	Maritime warm/dry	H	L-M	L-M	M	H	M-H
Xe5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1603 1905	30-40	Maritime warm/moist	H	M	L	M	H	H
Xf7	ABAM/VAME-RULA TSHE/RHAL-VAME	2204 2302	20-40	Maritime cool/moist	H	H	L	M	H	M-H
Xf8	ABLA2/VAME-LIBOL	2503	40-60	Continental cool/moist	M-H	H	L	M	M	L
Yd5	ABGR/ACCI-BENE/ACTR TSHE/ACCI-BENE-PAMY	1603 1905	>60	Maritime warm/moist	H	M	L	M	H	H

Fish and Wildlife Habitat Properties and Responses

Table 9 contains the Wildlife and Fish Potential Habitat and Responses for each Landtype Association. Listed below is a brief description of the information contained in each column of the table.

Unique Habitat Features: This column contains some of the site properties that provide important habitat components for some wildlife species. The presence or absence of these properties is normally linked to geomorphic expression. They were identified on aerial photographs at 1 inch equals one mile scale (1:63,360) and observations were supported by field experience of the mapping team. In some cases, site features, not easily seen on aerial photographs were inferred through processes or site-scale landforms that are associated with geomorphic expression. For example, larger seeps are identifiable by vegetation type and pattern. Exact locations of smaller seeps may not be seen on aerial photography but can be inferred through extrapolation of known slope configuration and groundwater movement controlled by a landform, its typical position and geomorphic history in a watershed, and/or geology group. Some glacial landforms are highly predictable in this regard, in that, glacial deposits often occur along or at the toe of steep sideslopes where groundwater is intercepted.

Potential Lynx Habitat: This column contains an interpretation of the quality of habitat for potential Lynx habitat in each Landtype Association. The interpretation is for potential and not existing habitat quality. Potential habitat is important because the natural role of fire disturbance will likely alter present and future habitat quality. The highest quality habitat is associated with forests with a structure that includes branches low to the ground; has persistent winter snow with depths exceeding 2 feet; and slope gradients less than about 30 percent. Lodgepole pine seral forests within the subalpine fir series offer the greatest potential for the largest contiguous area having the first two listed habitat features. Although, other series have lodgepole pine seral forests and other associated factors such as snow depth and forest structure, they usually lack consistent presence over large land area and hence, have less potential to provide contiguous quality habitat. Potential Natural Vegetation (PNV) was used to predict potential for forest type and structure components and geomorphic expression or landform was used to interpret slope gradient.

Travel corridors are an important component of Lynx habitat. Again, interpretation ratings are in terms of potential not existing. The criteria used in this interpretation are: continuous slope gradients less than 30 percent on landforms with persistent winter snow.

VERY HIGH (VH) - Landtype Associations contain a preponderance of subalpine fir series and landforms with slope gradients less than 30 percent.

VERY HIGH (VHT) - Landtype Associations contain very high quality habitat as well as possible major travel corridors. Units contain a preponderance of subalpine fir series and consist of broad gently rolling ridge tops with slopes generally less than 30 percent.

HIGH (H) - Landtype Associations contain subalpine fir series and landforms with slope gradients generally less than 30 percent; however some slopes exceed 30 percent.

MODERATE (M) - Landtype Associations contain subalpine fir series and landforms with slope gradients that generally exceed 30 percent; however inclusions of slope gradients less than 30% may occur.

LOW (L) - Landtype Associations contain moist Douglas-fir, grand fir, and western redcedar/hemlock series and have landforms with slope gradients generally less than 30 percent; however, some slopes exceed 30 percent.

VERY LOW (VL) - Landtype Associations contain moist Douglas-fir, grand fir, and western redcedar/hemlock series and have landforms with slope gradients that generally exceeding 30 percent; however, some slopes are less than 30 percent.

Potential Wolverine Denning Habitat: This column contains an interpretation of the quality for wolverine denning habitat in each Landtype Association. The criteria or factors used to help develop denning habitat are as follows: aspect; relief; elevation, presence of boulder talus, and snow depth and persistence during denning season (Copeland 1996). Only HIGH and MODERATE quality ratings are displayed. Those Landtype Associations without a rating should be considered to have low quality denning habitat.

HIGH (H) - All site features for high quality denning habitat exist in the Landtype Association. Landtype Associations are on north or northeast aspects; have boulder talus slopes; are above 5500 feet elevation and have at least moderate depths of winter snow; and have concave to flat slope configuration. Cirque basins contain all of these site features.

MODERATE (M) – Some but not all of the site qualities associated with denning habitat is present in the Landtype Association. Typically, these LTAs include some boulder talus but may not include all of the other important site properties such as aspect, relief, and elevation features.

Mule Deer Winter Range: This column contains the relative interpretation of the quality for mule deer winter range in each Landtype Association. The criteria or factors used to help identify mule deer winter range habitat are as follows: southern exposures; slope; elevation zone linked to low snow-fall areas, vegetation zones, and adjoining security areas. Only HIGH and MODERATE ratings are displayed. All other Landtype Associations would be considered to have low quality Mule Deer Winter Range.

HIGH (H) – Landtype Associations consist of the following: south-facing aspects with ponderosa pine and shrub-steppe potential natural vegetation; slopes are generally below 3500 feet in elevation; and slope gradients are greater than 30 percent. These south facing slopes are adjacent to north-facing slopes that support dense canopied forests within the Douglas-fir series that provide thermal cover.

MODERATE (M) - Landtype Associations that generally lack the ponderosa pine vegetation zone component but include all the other winter range factors or criteria.

Security Cover (S) – Landtype Associations have a high potential to provide security cover in close association with mule deer winter range. Landtype Association features used to indicate potential security cover are: potential natural vegetation series which support multi-layered dense forests that provide vegetative screening; and landforms associated with narrow canyons or with a high complexity of dissection or change in slope shape that reduces distance of line of sight.

Mountain Goat Habitat: This column contains the relative interpretation of the quality for mountain goat habitat in each Landtype Association. The criteria or factors used to help identify mountain goat habitat are as follows: avalanche chutes; scree or talus slopes, slope gradients exceeding 75 percent; abundant bedrock exposures; alpine meadows, and timber-line vegetation zones. Only HIGH and MODERATE quality ratings are displayed. All the other Landtype Associations would be considered to have low quality mountain goat habitat.

HIGH (H) - Landtype Associations that contain all of the habitat features associated with high quality habitat such as; avalanche chutes, scree and talus slopes, slopes greater than 75 percent, abundant bedrock exposures, alpine meadows, and timber line forest zones (subalpine and mountain hemlock vegetation zones).

MODERATE (M) - Landtype Associations that contain many but not all of the habitat features associated with high quality habitat. The missing features significantly reduce the quality of habitat.

WINTER RANGE (W) - Landtype Associations that contain all of the habitat features association with high quality winter range, such as; slopes greater than 75 percent, abundant bedrock exposures, winter snow depths less than two feet, security cover vegetation; southern exposures or vegetation zones that represent warm dry conditions; and foraging habitat associated with Douglas-fir/ponderosa pine potential natural vegetation zones.

Bull Trout Spawning/Rearing: This column rates the potential for spring upwelling areas along stream channels within each Landtype Association. Spring upwelling tends to help maintain adequate stream flow and moderates water temperatures (Baxer and Hauer 2000). Site factors used to identify potential upwelling areas include: thick, unconsolidated glacial drift deposits occurring below prominent "rocky" ridges; concave slope relief normally characteristic of U-shaped glacial valleys; stream segments bounded by alluvial fans in valley bottom positions; mainstem channel morphology interrupted by bedrock nick-points; and known spring upwelling areas identified by field observations. Only HIGH and MODERATE ratings are displayed. All the other Landtype Associations would be considered to have low probability for spring upwelling.

HIGH (H) - Landtype Associations contain all features associated with spring upwelling that may produce high quality bull trout spawning/rearing habitat. The site features include: thick, unconsolidated glacial drift deposits; glacial drift deposits occur below prominent "rocky" ridges; concave slope relief characteristic of U-shaped glacial valleys; stream segments that are bounded by coalescing alluvial fans; and occasional bedrock nick-points in the valley floor.

MODERATE (M) - Landtype Associations that contain many but not all of the features associated with spring upwelling that may produce quality of bull trout spawning/rearing. Site features include: glacial drift deposits but are not found in glacial U shape valleys and are not associated with upper "rocky" ridges.

Table 9. Fish and Wildlife Habitat and Responses

LTA	Unique Habitat Features								Potential Lynx Habitat	Potential Wolverine Denning	Mule Deer Winter Range	Goat Habitat	Moose Habitat	Bull Trout Spawning
	Seeps	Pond/ Lakes	Streams	Cliffs	Talus	Avalanche Chutes	Grassland/ Meadows	Caves						
Bu6	M	M	M						L					
Da3							M		L		M			
Da5									L					
Da8						M			M					
Db1							H				H			
Db2							M		L		M-HS			
Db4									L				M	
Fa2				M	M	M	H				H	HW		
Fb7				H	H	H						H		
Fb8				H	H	H				M		H		
Fb9				H	H	H	M			M		H		
Ff9				H	H	H	M	M				H		
Fj2				M	M	M	H	M			H	HW		
Ga2							M		L		M			
Gb4									L		MS		M	
Gb7			M						L					
Gb8			M						H	M		M		
Gb9			M				H			M		M		
Gd2							M		L		MS			
Gd5			M						L					
Gd7	L	L	M				M		L					
Gd8			M						H	M		M		
Gg3			M					H	L		MS		M	
Gg8			M					H	H	M			M	
Gi8			M						H	M				
Ha7	H	H	H	M					L	H		M		
Ha8	H	H	H	M			M		VH	H		M		
Hb9	H	H	H	M			H		VH	H		M		
Hi9	H	H	H	M			H		VH	H		M		
Ia2							M		L		M-HS			
Ia3											MS			
Ia7	M		M						L					M
Ia8	M		M				M		VH					M
Ib6	M		M						L				H	M
Ic5	M		M						L					

Table 9. Fish and Wildlife Habitat and Responses

LTA	Unique Habitat Features								Potential Lynx Habitat	Potential Wolverine Denning	Mule Deer Winter Range	Goat Habitat	Moose Habitat	Bull Trout Spawning
	Seeps	Pond/ Lakes	Streams	Cliffs	Talus	Avalanche Chutes	Grassland/ Meadows	Caves						
Id2							M		L		M-HS			
Id7	H	H	H				M		L					M
Ig4	M		M						L		MS		M	
Ig6	M		M						L				H	M
Ih6	M		M						L				H	M
Ih8	M		M						VH				M	M
Ja8			M		M				M					
Jb1							H				H			
Jb2							M		L		M-HS			
Ji8			M		M				M					
Jj1							H	M			H			
Jj2							H	M	L		M-HS			
Ka2				M	M	M	M		L		M-HS	HW		
Ka5	M		H	M	M	H			L			M-MW	M	M
Ka6	H		H	M	M	H			L			M	M	H
Ka7	H		H	M	M	H			L			M		H
Kb8	H		H	M	M	H			M	M		M	M	H
Kb9	H		H	M	H	H	M		M	M		H		H
Kc6	H		H		M	H			L			M		H
Kf5	M		H		M	H			L			M-MW		M
Kf7	H		H		M	H			L			M		H
Kf8	H		H	M	M	H			M	M		M	M	H
Kj2					M	M	H	M	L		M-HS	HW		
Kj3					M	M	H	M	L		MS	H		
Kj8	H		H		M	H		M	M	M		M	H	H
Kk7	H		H		M	H			L			M		H
La1							H				H			
La2			M				M		L		M-HS			
Lb4	M								L		MT		M	
Lb6	M		M						L					M
Lb8	M		M						VH					H
Ld2	M						M		L		M-HS			
Lg4									L		MST		M	
Lg6	M		M						L				H	M
Lh6	M		M						L				H	M
Lj1							H				H			
Lj2	M						M		L		M-HS			
Lj8	M		M						L					M
Mu2		M	M	H	H	M	M		L		M-HST			
Mu6		M	M	H	H	M			L				H	M
Na5	M		H						L				M	H

Table 9. Fish and Wildlife Habitat and Responses

LTA	Unique Habitat Features								Potential Lynx Habitat	Potential Wolverine Denning	Mule Deer Winter Range	Goat Habitat	Moose Habitat	Bull Trout Spawning
	Seeps	Pond/ Lakes	Streams	Cliffs	Talus	Avalanche Chutes	Grassland/ Meadows	Caves						
Na6	H		H						L				H	H
Na7	H		H						M				H	H
Nb8	H		H						H	M			H	H
Nf5	M		H						L				M	H
Nj2	M		H											M
Nj8	H		H						H	M			H	H
Nk7	H		H						M				H	H
Nu2	M		H											M
Nu6	H		H						L				H	H
Ou2	M		H				H		L		M-HS			
Ou6	M		H						L				H	M
Pa9							H		VHT					
Pb8									VHT					
Pi9							H		VHT					
Qu2				M	M	H	H		L		MS	MW		
Qu8				H	H	H	H		M			M		
Sc1				H	H		H				H			
Sc2				M			H	M	L		M-HST			
Sc3							M		L		MS			
Sc5									L					
Sc8				M	M	M			M					
Sh4				M	M				L		MS		M	
Tu3	H	M	M				M		L		MS			
Tu5	H	M	M						L					
Tu7	H	M	M						L					
Tu8	H	H	H						VH					
Uu3	H	H	H				M		L		MS			
Uu5	H	H	H				M		L					
Uu7	H	H	H						L					
Uu8	H	H	H				M		VH					
We1							H	H			H			
We3							M	H	L		M-MS			
We5	M						M	H	L					
We7	M							M	M					
We8								M	VH					
Xe3				M	M		M	H	L		M-MS			
Xe5				M	M	M		H	L					
Xf7				H	M	H		H	L					
Xf8				H	M	H		H	M					
Yd5				H	M				L					

Natural Disturbance Regimes

Table 10 contains the Natural Disturbance Regimes for each Landtype Association. Listed below is a brief description of the information contained in each column of Table10.

Hydrologic Regime Disturbance

Each Landtype has been rated for response to significant hydrologic events that are known to occur in the area. A significant event is defined as being one that causes change in channel morphology or flooding from increased stream flow and/or sediment deposition.

Stream Segment: Within each Landtype association, channel characteristics differ between *tributary* and *mainstem* streams. Within these two categories, common stream types were identified.

A *tributary* segment is typically applied to small streams on hillslopes that are commonly 1st -3rd Order channels. Small streams flowing to large 4th Order and larger on large floodplains were also included as tributary streams on large floodplain stream systems. A *mainstem* segment is typically a channel that is at the base of a hillslope, in a valley, or within an obvious floodplain and is commonly 4th Order or larger. Included are 3rd Order streams that have a significantly different morphology than their upstream components. Not all Landtype associations have both types of stream segments and some Landtype Associations effect mainstem streams that flow along the bounds of the Landtype.

Hydrologic Event: Three *types* are identified as most likely to cause a channel response or flood. They are late fall/winter rain-on-snow; high intensity convective storms; and rapid spring snowmelt. These events do not occur in all Landtype Associations, they occur in some regions and not in others within the same Landtype Association, and the event can vary with elevation. Rain-on-snow is very uncommon on the Colville National Forest, less common on the Okanogan National Forest, and most common on the Wenatchee National Forest. It usually occurs between 2500 - 4000 feet elevation. High intensity convective storms occur during late spring and early summer and are very difficult to predict. They are local in extent covering one to several subwatersheds per event and are often generated by local or regional orographic effects. This table does not capture every circumstance where convective storms may occur but highlights where they have occurred in recent history at a higher incidence. A significant event can occur with rapid spring snowmelt, particularly when the ground is still frozen or when combined with spring rains.

Frequency of event is based upon local observation of forest hydrologists. It is the measure of how often a significant event has been known or is expected to occur. The more often the frequency of significant events, the more dynamic the channel processes. Frequencies with a wide range may be an indication of less certainty of the frequency, or may be an indication of a less dynamic channel system. If the Landtype occurs in all three Forests, the wide range may be a result of summarizing the drier inland climate of the Colville National Forest with the wetter maritime climates of the Wenatchee and Okanogan National Forests.

Hydrologic Response: The table lists dominant geomorphic and hydrologic processes that are affected by the hydrologic event that can lead to a predicted channel response. Road drainage failures and cut/fill failures have been noted for those Landtype

Associations where significant hydrologic events have chronically caused road failures that create or increase effects to channel processes.

Channel Response: This column rates tributary and mainstem streams response to hydrologic events. Stream processes and response to hydrologic events can be empirically predicted using inherent stream characteristics such as, streambed morphology, stream confinement, and relative transport capacity somewhat controlled by overall geomorphic expression associated with the Landtype Association landform and geology groupings. Montgomery and Buffington (1993) have defined stream classifications using these basic stream characteristics. These classifications have been used to summarize predicted response from a significant hydrologic event. Factors used in characterizing response include stream type; valley confinement, size and persistence of sediment which comprise the channel bed and bank, hillslope erosion processes including mass movement, sediment and runoff delivery mechanisms, recruitment and role of large woody debris, and the size, type, and frequency of significant hydrologic events.

Category I – Highly confined, very high gradient colluvial, bedrock and cascade channels are characteristic. Colluvial channels fill over time with sediment and may flush during high flow events producing channel scour or debris flows. Bedrock and cascade channels are maintained by consistent stream flows that keep finer colluvium from collecting in the channel. They also may be channel forms subsequent to a debris flow event. Inherent stream processes for these channels are relatively resilient to increases in flow or sediment. Channels have very low sediment storage capacity and respond by flow expansion. Therefore, they transport both sediment and runoff rapidly downstream.

Category II – Highly confined, high gradient step-pool channels are characteristic stream types. Transport capacity is high with a small capacity to regulate sediment flow during lower discharge. Structure provided by large wood debris and larger substrate is important in maintain channel stability. Periodic reduction in discharge and/or increase in sediment may result in pool infilling that is flushed during peak flow events. These channels can accommodate a moderate increase in discharge through flow expansion. Channel bed and bank material can readily mobilize under extreme high flows. Significant hydrologic events may cause channel incision causing downcutting or bank erosion. Shallow rapid landslides delivered to these channels either from Category I streams or hillslope instability can result in debris torrents, debris flows, and episodic dam-break flood events.

Category III – Stream categories can be highly variable in these moderate gradient channels and are generally confined in narrow valleys with low stream terraces or alluvial fan deposits. Channel morphologies can include step-pool, plane-bed, and pool-riffle. Channels are characterized by great diversity of stream morphology longitudinally. Processes are cyclic and often act to regulate transport of flow and sediment. Debris flow deposits and bedrock structural features can create knickpoints that restrict flow and create valley infilling upstream. Valley infilling reduces channel gradient and generally increasing channel meandering in moderately confined valleys. Where confinement limits meandering, extended step-pool or plane-bed morphology occurs above knickpoints. Extreme flows can cause downcutting, meander abandonment or migration above knickpoints and scouring pools at and below the knickpoints. Large woody debris is generally critical in maintaining channel function and stability.

Category IV – Channel gradient and size of sediment in substrate is generally lower than for Category III. Channel morphologies are typically plane-bed or pool riffle. These channels are sensitive to downcutting due to finer substrates. Channels can become rapidly entrenched which limits access to their floodplain and reduces ability to dissipate energy during flood events. Lower stream base levels as a result of entrenchment effects access to water tables by riparian vegetation. Large woody debris and beaver dams may be an important component in maintaining stability in these channels.

Category V – Stream types are unconfined, low gradient, pool riffle channels with well developed meanders with floodplains. Channel bank stability is maintained by riparian vegetation. Due to relatively low transport capacities, pool riffle channels respond readily to changes in sediment supply and discharge. Prediction of specific response is complicated by a large number of possible adjustments both spatially and temporally during and after a significant hydrologic event. Channel avulsions and rapid channel migration, bank undercutting, and channel bed scour are the most common responses. Side channels and access to floodplain are important to dissipation of flood energy. Large wood can protect banks from local scour during less extreme flow events in smaller systems.

Category VI – Unconfined, low gradient channels flowing through glacial fluvial valley bottoms. Stream types are typically braided, plane bed or pool riffle and rarely, regime. These streams are redistributing material previously transported by a much different flow and sediment flux than today. Streams have a relatively low transport capability. Unconfined plane bed streams respond to extreme flow events by widening. In glacial fluvial Landtypes, sediment supply from bedload and streambanks is high relative to discharge and these types tend to widen in unconfined valleys. Where channels are confined by terraces, channels may downcut. Unconfined channels may form braided segments. Streams may flow subsurface during low flow. Where large wood or other structural components exist, pool riffle segments may exist. Conversely, lack of large wood can transform pool riffle morphology back to plane bed morphology. Extreme flow events may transport wood downstream removing structure in one segment and creating structure in another. Braided channels are formed where sediment supply is higher than the relative transport capacity. This situation can also occur where the flow regime has been significantly reduced, either geologically or man-related. Although braided channels are relatively insensitive to hydrologic disturbance, it is possible for extreme flow events to create a single channel (Montgomery and Buffington 1993).

Large Woody Debris Response (LWD): Large wood debris plays an important role in structure and function of some stream types. The source and transport of LWD is an important feature in stream process and aquatic habitat function. This column identifies the most dominant source of LWD for streams for each Landtype association. The sources are: stream adjacent, debris slides, and in-stream re-distribution.

Stream adjacent: LWD is delivered by tree fall directly into the channel from streambank collapse, wind, or tree mortality.

Debris slides: Debris slides and flows transport LWD far from the source. Typically LWD is delivered mixed with sediment. Sources are from upslope landslides depositing in the channel and from channel scour from debris flows in the channel.

In-stream redistribution: LWD source is generally from in-channel transport downstream or from channel avulsion within the floodplain.

Channel Sensitivity: This rating predicts the relative response to extreme increases in flow or sediment supply as a result of a significant hydrologic event. The factors used to develop this rating are: stream transport and storage capacity, valley confinement, size and cohesiveness of the bed and bank material, potential for sediment supply, role of riparian vegetation and large wood debris.

LOW (L) – These channels are relatively insensitive to hydrologic disturbance. Channels are confined and have a high degree of armoring of the streambed and streambanks by boulder size material or bedrock. Sediment supply is low relative to the stream's capacity to transport sediment; storage is limited and temporary. Role of riparian vegetation in stabilizing channels is negligible or transient.

MODERATE (M) – These channels are somewhat sensitive to hydrologic disturbance either due to valley confinement and/or stability of channel bed and banks. Extreme flows move through the system with minimal disturbance to channel bed, bank or migration pattern. Flood waters are accommodated through flow expansion but some h downcutting, migration, or widening of the channel can occur. Sediment supply is usually in balance with transport capacity. Structure contributed by rejuvenation of riparian vegetation and large woody debris recruitment are important to channel processes.

HIGH (H) – These channels are sensitive to hydrologic disturbance due to high potential for streambank instability or channel erosion from uncohesive materials (silts or sands); and potential for sediment supply exceeding transport capacity.

Fire Regime Disturbance (Historical)

This column lists the numeric or alphanumeric code associated with historic fire regimes in north central Washington as defined by Lueschen (2000). This interpretation is limited to historical fire disturbance in an unmanaged setting. Fire regimes were applied to each LTA based upon the most dominant potential natural vegetation (PNV) or vegetation zone for the LTA. In some cases, PNV was combined with landform groups when terrain features uniquely influences distribution patterns of potential natural vegetation or frequency of fire. A table is provided below that describes fire frequency and severity and outlines the criteria for each fire regime code used in Lueschen (2000). In addition, this table includes a relative rating for each fire regime as it may affect vegetation communities either directly or indirectly.

It is widely accepted that most forest communities in the Interior Columbia Basin evolved and were maintained under various fire regimes. This interpretation is useful in comparing historical patterns of fire disturbance with today's existing or potential fire regimes given the additional information on existing vegetation structure and fuel loading. According to research conducted from the Wenatchee Sciences Lab, historic fire regimes began to change approximately 100 years ago with the onset of forest management. Past management activities including grazing, vegetation manipulation, fire suppression have altered vegetation structure which can alter natural fire regimes (Everett, Schellhaas, Keenum, Spurbeck, and Ohlson [undated draft]). The effect of altered natural fire regimes is of concern to management and is currently being studied.

Fire Regimes of Oregon and Washington (Lueschen 2000) and Relative Disturbance and Response in LTAs

Code	Frequency and Severity	Plant Communities and Fire Regime Description	Relative disturbance and response in LTAs
I	0-35 years, Low Severity	Typical potential plant communities include ponderosa pine, eastside/dry Douglas fir, pine-oak woodlands, Jeffery pine on serpentine soils, oak woodlands, and very dry white fir. Large stand-replacing fire can occur under certain weather conditions, but are rare events (i.e. every 200+ years).	VERY LOW – Low severity fire was likely a major contributor to nutrient cycling; converting forest floor to available nutrients. Frequent historic fire intervals kept fuels from accumulating that would have caused higher severity. Natural wood debris would have ranged from 5-15 tons/acre (Graham 1994). Forest floor duff layers ranged from non-existent to no more than one inch depth.
II	0-35 years, Stand-replacing, non-forest	Typical potential plant communities includes true grasslands and savannahs with typical fire return intervals of less than 10 years; mesic sagebrush communities with typical fire return intervals of 25-35 years up to 50 years, and mountain shrub communities (e.g., bitterbrush, snowberry, ninebark, ceanothus, Oregon chaparral) with fire return intervals of 10-25 years. Fire severity is generally high to moderate; grasses and fire-tolerant shrubs are not completely killed and usually resprout.	LOW – Effects from natural fires were probably low as most fires occurred in late summer when vegetation was semi-dormant from drought. Downed woody debris was localized and less than 5 tons/acre. Forest floor duff layers ranged from non-existent to over two inches in depth depending on fire frequency.
III	35-100+ years, Mixed Severity	This regime results in heterogeneous plant communities and includes several communities as described in subcategories "a-c" below. Large, stand-replacing fires may occur but are usually rare events. Such stand-replacing fires may "reset" large areas but subsequent mixed intensity fires are important for creating heterogeneity. Within this regime, stand structure and composition is not dominated by one or two age classes.	MODERATE – Effects from a range of non-lethal to lethal fire causes a diversity of disturbances. Downed woody debris would have been somewhat common and accumulations ranged from 10-15 tons/acre. Mixed severity fires causing some tree mortality would have contributed to cycling of down woody debris. Forest floor duff layers ranged from 0.5 to 1.0 inch depending on fire intervals. Thicker duff layers would have been maintained with lower frequency fire returns.
IIIa	<50 years, Mixed Severity	Typical potential plant communities include mixed conifer, very dry westside Douglas-fir, and dry grand fir. Lower severity fire tends to predominate in many events.	
IIIb	50-100 years, Mixed Severity	Typical potential plant communities include well drained western hemlock; warm, mesic grand fir, particularly east of the Cascade crest; and eastside western redcedar. The relative amount of lower and higher severity patches within a given event is intermediate between IIIa and IIIc.	
IIIc	100-200 years, Mixed Severity	Typical potential plant communities include western hemlock, Pacific silver fir, and whitebark pine at or below 45 degrees latitude and cool, mesic grad fir and Douglas-fir. Higher severity fire tends to dominate in many events.	
IV	35-100+ years, Stand-replacing	Typical potential plant communities are those where seral communities are maintained by stand replacing fires. Seral communities are comprised of Lodgepole pine, aspen, western larch, and western white pine. Dry sagebrush communities also fall within this fire regime. (Natural ignitions within this regime resulting in large fires may be relatively rare). This category is separated into subcategories having different potential climax	HIGH – High severity fire is common with a variety of short term and long term effects to soils and forest structure. Highly variable patterns of age class and density is somewhat controlled by fire extent and regeneration response on different slope gradients and aspects. Downed woody debris would have been common and may have been extensive

Fire Regimes of Oregon and Washington (Lueschen 2000) and Relative Disturbance and Response in LTAs

Code	Frequency and Severity	Plant Communities and Fire Regime Description	Relative disturbance and response in LTAs
		plant communities.	
IVa	**35-100+ years, Stand-replacing, Juxtaposed**	Typical potential plant communities are located upslope from a plant community with a shorter fire regime interval. The community experiences a shorter fire interval that would be expected due to association with a plant community with a more frequent fire interval downslope. Examples include Lodgepole pine immediately above ponderosa pine in the eastside Washington Cascades and aspen imbedded within dry grand fir in the Blue Mountains. This regime is often found in lower elevations or drier sites than is considered typical for regime IV.	as a result of tree mortality. "Reburns' in areas of high debris accumulation would have reduced fuel levels and caused severe heating of soils and removal of duff layers. Down woody debris average range may have been 15-25 tons/acre (Graham 1994) or higher and forest floor duff layers ranged from 0.5 to 1.5 inches depending on severity and frequency.
IVb	**100+ years, Stand-replacing, Patchy arrangement**	Typical potential communities include subalpine fir and mountain hemlock parkland and whitebark pine north of 45 degrees latitude.	
IVc	**100-200 years, Stand-replacing**	Typical forest communities include subalpine mixed conifer (e.g., spruce-fir), western larch, and western white pine. Important potential plant communities include mountain hemlock in the Cascades and Pacific silver fir north of 45 degrees latitude.	
V	**>200 years, Stand-replacing**	This fire regime occurs at the environmental extremes where natural ignitions are very rare or virtually non-existent or environmental conditions rarely result in large fires. Sites tend to be very cold, very hot, very wet, very dry or some combination of these conditions.	VERY HIGH – High severity fire in plant communities less adapted to fire disturbance. Downed woody debris would have been abundant and often exceeded 30 tons/acre (Graham 1994). Coarse woody debris would have substantially contributed to biomass of forest floor duff layers. Duff layers often exceeded 2 inches and were composed of approximately 50 percent decaying wood. After fire, these characteristics would be reset.
Va	**200-400 years, Stand-replacing**	Plant communities are somewhat fire adapted. Typical communities include Douglas-fir, noble fir, and mountain hemlock on drier sites in western Washington.	
Vb	**400_ years, Stand-replacing**	Plant communities are less fire adapted. Typical plant communities include Douglas-fir, Pacific silver fir, western hemlock western redcedar, and mountain hemlock on moister sites in western Washington.	
Vc	**No Fire**	Plant communities have no evidence of fire for 500+ years. Typical plant communities include Sitka spruce, Pacific silver fir and very wet western redcedar sites.	NONE – Natural fire of any extent is uncommon.
Vd	**Non-forest**	Typical plant communities include black sagebrush, salt desert scrub, alpine communities, and subalpine heath. Most species tend to be small and low growing. Bare ground is common.	

Insect and Disease Disturbance (Outbreak Category):

This column lists the major insect and disease species with the highest potential for natural disturbance for a given Landtype Association. To qualify as a natural disturbance, the outbreak must progress to epidemic proportion causing forest composition to be significantly altered by tree mortality or to become vulnerable to other natural disturbance agents, such as, fire. The entries in this column are based upon the likelihood that some time in the forest stand history the factors leading to an epidemic outbreak may be present, not that they are present currently. This rating could be used in landscape level planning to anticipate management actions in response to this potential. There is evidence to suggest that tree mortality from insect and disease may accelerate return intervals of natural fire as well as played an important role of setting the stage for fire in vegetation zones that experience naturally long return intervals.

The following is a discussion of the rationale and references used to support this interpretation. It is important to understand that there is much that is not understood about the interrelationships of factors leading to insect and disease occurrence. Hence, these interpretations are the best state-of-knowledge, to date. Occurrence can be measured by individual tree mortality or stand mortality both having consequences to stand composition. Since the survey is at the landscape-scale, ratings concentrate primarily on landscape-scale disturbance or patch mortality. Since insects and disease need a host, forest composition and structure have the strongest association with specific disturbance species. Other factors have been associated with insect and disease incidence but are less clear in our understanding. These factors are topographic setting, soils, logging history, landscape scale change in forest compositions, and site productivity (Hessburg, Smith, Miller, Kreiter, and Salter 1999, Smith 1972, McDonald 1990, Byler, Marsden, and Hagle 1990, and Hagle, Byler, et al 1994.)

The entries in this column are based primarily on Modeling Change in Potential Landscape Vulnerability to Forest Insect and Pathogen Disturbances: Methods for Forested Subwatersheds sampled in the Midscale Interior Columbia River Basin Assessment by Hessburg, Smith, Miller, Kreiter, and Salter (1999). Potential natural vegetation and natural fire regimes identified with each Landtype Association were used to indicate potential host species, stand composition, and stand structure. For example, dwarf mistletoe species persists in a multi-layer stand structure with overstory trees infecting seedling/saplings in the understory. Fire regimes with mixed severity fire and patch mortality are more likely to produce outbreak conditions for dwarf mistletoe than stand replacing fire regimes.

Pine beetle epidemics coincide with drought cycles and are exacerbated by other stressors such as competition for high stand density, age, or damage from fire. Tree diameter favors some beetles and not others. Landtypes are rated based upon whether the tree species has the potential to occur at the size and/or density that favors pine beetle attack.

Landform and topographic setting, relative site productivity, and relative soil moisture/fertility factors associated with Landtype Associations were used for *Armillaria* root disease, Douglas-fir dwarf mistletoe, and spruce beetle as supported by the following research literature. Spruce beetle is associated with continuous spruce forests which typically are associated with valley bottoms (Hessburg, Smith, Miller, Kreiter, and Salter 1999) and more specifically in this survey area, narrow glaciated valleys. Douglas-fir dwarf mistletoe has a much faster rate of spread in edaphically dry sites where Douglas-fir dominates the overstory and understory. On moister sites where shade tolerant species such as western hemlock dominate the understory, the lack of understory host reduces the occurrence of dwarf mistletoe (Smith, R. 1972). In western Montana, northern Idaho, and eastern most Washington, individual tree mortality from *Armillaria* appears to be highest in grand fir and moister Douglas fir series, western redcedar and western hemlock series (Byler, Marsden. Hagle 1990, MacDonald 1990, Hagle, Byler, et al 1994). Mortality from *Armillaria* is strongly associated with site productivity between 65-100 feet/year which excludes ponderosa pine series, coastal Douglas fir series, and the driest, cold subalpine fir series (MacDonald 1990). One of the few research projects to look at specific soil type/habitat type occurrences, Byler, Marsden, and Hagle (1990) found the highest occurrences in western Montana of patch mortality from *Armillaria* were associated with moderately sloping, mid-elevation, southerly aspects that supported moister Douglas fir series and/or grand fir series. Soils on these sites were classified as Andic Dystrochrepts indicating an udic moisture regime.

Some insects and pathogens were not considered for the following reasons: they are somewhat ubiquitous in nature and are more prone to individual tree mortality (several root, butt or stem diseases), abundance of host species in stands are less likely than in the past (e.g., western white pine blister rust on white pine); pathogen abundance, distribution, or mortality is not well documented (lodgepole pine dwarf mistletoe). Western larch dwarf mistletoe was noted for only Landtype Associations occurring on the Colville National Forest based upon consultation with Jim Hadfield, Plant Pathologist, U.S. Forest Service Region 6 Forest Pest Management.

Table 10. Natural Disturbance Regimes and Responses

LTA	Hydrologic Regime Disturbance: Stream Segment	Hydrologic Event: Category	Hydrologic Event: Frequency (Years)	Hydrologic Response	Channel Response	Large Woody Debris (LWD)	Channel Sensitivity Rating	Fire Regime Disturbance	Insect/Disease Disturbance
	LTAs with similar hydrologic regimes are grouped by tributary and mainstem characteristics.							*Disturbance Regimes are for each LTA.*	
Bu6	Tributaries	Rapid spring snowmelt	10-25	Streambank erosion; saturation of lacustrine soils	Category III	Stream adjacent	High	IVc	DFDM DFB WSB WLDM
	Mainstems:		25-50		Category IV	Stream adjacent; in-stream transport	High		
Da3	Tributaries:	Convective storm	5-10	Rapid, convergent runoff; debris slides; road drainage failures; channel scour.	Category I, II	Upslope and in-channel debris slides	Low	I	WPB, DFDM WPB/MPB/IPS
Da5								IIIb	DFB,FE DFDM
Da8								IVa	MPB
Db1	Mainstems:	Convective storm	5-10	Flow exceeds bankfull; debris slides; debris torrents; debris jams	Category III	Debris torrents; stream adjacent	High	II	NONE
Db2								I	WPB WPB/MPB/IPS
Db4								IIIb	DFDM/WLDM DFB, DFTM AROS
Fa2	Tributaries:	Rapid spring snowmelt	10-25	Rapid runoff from shallow soils; snow avalanche; debris slides	Category I	LWD rarely available	Low	II	DFDM, DFB WPB
Fb7		Convective storm	5-10					Va	WSB DFB, DFTM
Fb8								IVc	MPB LPDM
Fb9	Mainstems: not applicable							IVb	WPBR type 2
Ff9								IVb	WPBR type 2
Fj2								I	DFDM DFB, WPB

Table 10. Natural Disturbance Regimes and Responses

LTA	Hydrologic Regime Disturbance: Stream Segment	Hydrologic Event: Category	Hydrologic Event: Frequency (Years)	Hydrologic Response	Channel Response	Large Woody Debris (LWD)	Channel Sensitivity Rating	Fire Regime Disturbance	Insect/Disease Disturbance
	LTAs with similar hydrologic regimes are grouped by tributary and mainstem characteristics.							*Disturbance Regimes are for each LTA.*	
Ga2	Tributaries:	Convective storm	5-15	Rapid runoff from shallow soils	Category I, III	Stream adjacent	Low	I	DFDM, DFB WPB
Gb4		Rapid spring snowmelt	10-25					IIIb	DFDM/WLDM DFB, DFTM,AROS
Gb7		Rain-on-snow (Wenatchee only)	2-25					Vb	WSB DFTM
Gb8								IVc	MPB, LPDM FE
Gb9								IVb	WPBR type 2
Gd2								I	DFDM,DFB WPB
Gd5								IIIb	DFDM, DFB, WPB AROS
Gd7	Mainstems: Not applicable							Va	WSB DFB,DFTM
Gd8								IVc	MPB, LPDM FE
Gg3								IIIb	AROS, DFDM/WLDM DFB,WSB
Gg8								IVc	FE MPB
Gi8								IVc	FE, WPBR type 2 MPB
Ha7	Tributaries:	Rapid spring snowmelt	25-50	Lakes exceed bank; overland flow	Category III	Lake and stream adjacent	Low	Va	FE SB
Ha8								IVc	MPB, FE SB
Hb9	Mainstems: not applicable							IVb	NONE
Hi9								IVb	NONE

Table 10. Natural Disturbance Regimes and Responses (continued)

LTA	Hydrologic Regime Disturbance							Fire Regime Disturbance	Insect/Disease Disturbance
	Stream Segment	Hydrologic Event: Category	Frequency (Years)	Hydrologic Response	Channel Response	Large Woody Debris (LWD)	Channel Sensitivity Rating		
	LTAs with similar hydrologic regimes are grouped by tributary and mainstem characteristics.							*Disturbance Regimes are for each LTA.*	
Ia2	Tributaries:	Rain-on-snow (Wenatchee only); Rapid spring snowmelt	2-25 15-35	Road drainage failures; seep areas	Category II,III	Stream adjacent (*High stream flows in Ic5 may destablize mass failures causing channel realignment)	Moderate (*LTA Ic5 – High)	I	DFDM, DFB WPB
Ia3								IIIb	AROS, DFDM DFB, WSB
Ia7								Vb	WSB,DFB, DFTM FE
Ia8								IVa	FE MPB
Ib6								IIIb	AROS, DFDM/WLDM DFB, DFTM, WSB
Ic5								IIIb	AROS, DFDM DFB, WSB
Id2								I	DFDM, DFB WPB
Id7	Mainstems:	Rain-on-snow (Wenatchee only); Rapid spring snowmelt	10-15 25-50	Road drainage failures; road cut/fill failures; high flows	Category III	Stream adjacent (*High stream flows in Ic5 may destablize mass failures causing channel realignment)	Moderate (*LTA Ic5 – High)	Vb	WSB, DFTM FE
Ig4								IIIb	DFDM/WLDM DFB, DFTM, AROS
Ig6								IVc	DFDM/WLDM DFB, FE
Ih6								IVc	DFDM/WLDM DFB, DFTM, FE
Ih8								IVc	FE MPB
Ja8	Tributaries:	Convective storms Rapid spring snowmelt	10-20 15-35	Rapid convergent runoff from high stream density; road drainage failures; road cut/fill failures; seep areas	Category II	Stream adjacent; upslope and in-stream debris flows	Moderate	IVa	MPB
Jb1								II	WPB
Jb2								I	DFDM DFB, WPB
Ji8								IVa	MBP

Table 10. Natural Disturbance Regimes and Responses (continued)

LTA	Hydrologic Regime Disturbance							Fire Regime Disturbance	Insect/Disease Disturbance
	Stream Segment	Hydrologic Event		Hydrologic Response	Channel Response	Large Woody Debris (LWD)	Channel Sensitivity Rating		
		Category	Frequency (Years)						
	LTAs with similar hydrologic regimes are grouped by tributary and mainstem characteristics.							*Disturbance Regimes are for each LTA.*	
Jj1	Mainstems:	Rapid spring snowmelt	25-50	Rapid convergent runoff from high stream density; high flows	Category III	Stream adjacent; tributary debris flows	Moderate	II	WPB
Jj2								I	DFDM, DFB WPB
Ka2	Tributaries:	Convective storms	20-30	Rapid runoff from shallow soils; seep areas; debris slides; snow avalanche	Category I	Upslope and in-stream debris slides	Low	I	DFDM, DFB AROS
Ka5		Rapid spring snowmelt;	15-35					IIIc	AROS, DFB, DFTM DFDM
Ka6		Rain-on-snow (Wenatchee only)	10-15					Vb	DFB WSB
Ka7								Vc	WSB, DFB,DFTM FE
Kb8								IVc	FE MPB
Kb9								IVb	WPBR type 2
Kc6								IVc	DFDM, DFB FE
Kf5	Mainstems:	Rapid spring snowmelt	25-50	High flows; tributary sediment deposition; debris jams	Category III	Stream adjacent; tributary debris slide deposition	Low	IIIc	AROS, DFB, DFTM DFDM
Kf7		Rain-on-snow (W only	5-10					Vc	MPB
Kf8								IVc	MPB FE
Kj2								I	DFDM, DFB AROS
Kj3								IIIb	DFDM, DFB, DFTM AROS
Kj8								IVc	FE MPB
Kk7								Vc	*

Table 10. Natural Disturbance Regimes and Responses (continued)

LTA	Hydrologic Regime Disturbance								Fire Regime Disturbance	Insect/Disease Disturbance
	Stream Segment	Hydrologic Event: Category	Hydrologic Event: Frequency (Years)	Hydrologic Response	Channel Response	Large Woody Debris (LWD)	Channel Sensitivity Rating			
	LTAs with similar hydrologic regimes are grouped by tributary and mainstem characteristics.								*Disturbance Regimes are for each LTA.*	
La1	Tributaries	Rapid spring snowmelt;	25-50	High flows; road drainage failures	Category III		Low		II	NONE
La2		Rain-on-snow (Wenatchee only)	10-25						I	WPB WPB/MPB/IPS
Lb4									IIIb	DFDM/WLDM DFB, DFTM, AROS
Lb6									IVc	DFDM/WLDM DFB/MPB, DFTM, AROS
Lb8									IVa	MPB FE
Ld2									I	WPB WPB/MPB/IPS
Lg4	Mainstems:	Rapid spring snowmelt;	25-50	High flows	Category IV, V		Moderate		IIIb	DFDM/WLDM DFB/MPB, DFTM, AROS
Lg6		Rain-on-snow (Wenatchee only)	10-25						IVc	DFDM/WLDM DFB/MPB, DFTM, AROS
Lh6									IVc	DFDM/WLDM DFB/MPB, AROS
Lj1									II	NONE
Lj2									I	WPB WPB/MPB/IPS
Lj8									IVa	MPB
Mu2	Tributaries:	Rapid spring snowmelt	5-35	Rapid runoff from shallow soils; debris slides;	Category I		Low		IIIa	AROS, DFB FE
Mu6	Mainstems:	Rapid spring snowmelt		High flows; floodwaters occupy floodplain.	Category IV	Stream adjacent	High		IVc	DFB, DFTM FE, SB

Table 10. Natural Disturbance Regimes and Responses (continued)

LTA	Hydrologic Regime Disturbance: Stream Segment	Hydrologic Event: Category	Hydrologic Event: Frequency (Years)	Hydrologic Response	Channel Response	Large Woody Debris (LWD)	Channel Sensitivity Rating	Fire Regime Disturbance	Insect/Disease Disturbance
	LTAs with similar hydrologic regimes are grouped by tributary and mainstem characteristics.							*Disturbance Regimes are for each LTA.*	
Na5	Tributaries:	Rapid spring snowmelt	5-35	High flows; channel avulsion; debris slides realign or raise base levels	Category II,V	Debris slides and channel migration at mouth	High at mouth, Low upslope	IIIc	AROS, DFB FE
Na6								Va	DFB, DFTM FE,SB
Na7								Vc	SB FE
Nb8								IVc	SB
Nf5								Va	AROS DFB, DFTM
Nj2	Mainstems:	Rapid spring snowmelt	25-50	High flows; debris jams, and channel migration	Category III, IV	Tributaries, stream adjacent, in-stream redistribution	Moderate	IIIc	WPB WPB/MPB/IPS
Nj8								IVc	SB
Nk7								Vc	*
Nu2								IIIc	WPB WPB/MPB/IPS
Nu6								Vb	DFB, DFTM FE, SB
Ou2	Mainstems:	Rapid spring snowmelt	25-50	High flows; floodwaters occupy floodplain and overflow channels; debris jams	Category IV,V	Stream adjacent; in-stream redistribution	High	IIIa	WPB DFDM
Ou6		Rain-on-snow (Wenatchee only)	10-25					Va	DFDM, SB FE, AROS

Table 10. Natural Disturbance Regimes and Responses (continued)

LTA	Hydrologic Regime Disturbance: Stream Segment	Hydrologic Event: Category	Hydrologic Event: Frequency (Years)	Hydrologic Response	Channel Response	Large Woody Debris (LWD)	Channel Sensitivity Rating	Fire Regime Disturbance	Insect/Disease Disturbance
	LTAs with similar hydrologic regimes are grouped by tributary and mainstem characteristics.							*Disturbance Regimes are for each LTA.*	
Pa9	Tributaries:	Rapid spring snowmelt; Convective storms; Rain-on-snow (Wenatchee only)	20-25 5-25 5-10	Rapid runoff on frozen or saturated soils; roads concentrate and divert overland flow to underfit streams	Category III	Rare	Moderate	IVb	WPBR type2 FE
Pb8	Mainstems: not applicable							IVa	FE MPB
Pi9								IVb	FE MPB
Qu2	Tributaries:	Rapid spring snowmelt	15-30	Debris slides; Increase water tables in deep seated landslides	Category II, III	Debris slides	High	I	AROS DFDM/WLDM
Qu8		Rain-on-snow	15-20					IVc	FE
Sc1	Tributaries:	Rapid spring snomelt	5-10	Rapid runoff; hillslope erosion delivers to channel; debris slides; channel erosion	Category II	Sc1, Sc2 rare Others – stream adjacent	High	II	WPB
Sc2		Convective storms	20-25					I	DFDM, AROS WPB/MPB/IPS
Sc3								I	AROS, WSB DFB
Sc5	Mainstems:	Rapid spring snowmelt	5-15	High flows; channel erosion	Category III	Stream adjacent	High	IIIb	DFB, DFTM WSB, AROS
Sc8								IVc	MPB, FE WSB
Sh4	Tributaries:	Rapid spring snowmelt	5-15-	High flows	Category I, III	Stream adjacent	Low	IIIa	AROS, WSB DFB, DFTM
	Mainstems:	Rapid spring snowmelt	5-15	High flows	Category III	Stream adjacent	Low		

Table 10. Natural Disturbance Regimes and Responses (continued)

LTA	Hydrologic Regime Disturbance: Stream Segment	Hydrologic Event: Category	Hydrologic Event: Frequency (Years)	Hydrologic Response	Channel Response	Large Woody Debris (LWD)	Channel Sensitivity Rating	Fire Regime Disturbance	Insect/Disease Disturbance
	LTAs with similar hydrologic regimes are grouped by tributary and mainstem characteristics.							*Disturbance Regimes are for each LTA.*	
Tu3	Tributaries:	Rapid spring snowmelt	25-50	High flows; Ponded water in depressions; Increases water tables	Category III, IV	Stream adjacent	Moderate	I	AROS, WSB DFB
Tu5		Rain-on-snow (Wenatchee only)	5-10					IIIa	DFB, AROS FE
Tu7	Mainstems: (usually borders LTA)	Rapid spring snowmelt	25-50	High flows; Debris slides; Deep seated mass movement	Category III, IV	Stream adjacent	High	Vc	WSB, DFTM
Tu8		Rain-on-snow (Wenatchee only)	5-15					IVc	MPB FE
Uu3	Tributaries:	Rapid spring snowmelt	25-50	High flows; Streams along slide margin may undercut toeslope of slide; Stream realignment	Category III	Stream adjacent; bank failures	Moderate	I	AROS, DFB WSB, DFDM
Uu5		Rain-on-snow (Wenatchee only)	5-15					IIIb	DFB, DFTM AROS, FE
Uu7	Mainstems:	Rapid spring snowmelt	25-50	High flows; Streams along slide margin may undercut toeslope of slide; Stream realignment	Category III	Stream adjacent; bank failures	High	Vb	WSB DFTM
		Rain-on-snow (Wenatchee only)	5-15						
Uu8								IVc	MPB FE
We1	Tributaries:	Rapid spring snowmelt	25-50	Runoff on frozen or saturated soils	Category III, V	Rare	Low	II	NONE
We3		Rain-on-snow (Wenatchee only)	15-20					I	AROS, WPB,WSB DFB
We5								IIIa	DFB, DFTM AROS, FE

Table 10. Natural Disturbance Regimes and Responses (continued)

LTA	Hydrologic Regime Disturbance							Fire Regime Disturbance	Insect/Disease Disturbance
	Stream Segment	Hydrologic Event: Category	Frequency (Years)	Hydrologic Response	Channel Response	Large Woody Debris (LWD)	Channel Sensitivity Rating		
	LTAs with similar hydrologic regimes are grouped by tributary and mainstem characteristics.							*Disturbance Regimes are for each LTA.*	
We7	Mainstems:	Rapid spring snowmelt	25-50	High flows	Category IV, V	Stream adjacent	Moderate	Vb	WSB DFTM
We8		Rain-on-snow	15-20					IVc	MPB FE
Xe3	Tributaries:	Rapid spring snowmelt	5-15	Rapid, convergent runoff; Road drainage failures	Category I, II	Debris slides	Low - Moderate	I	AROS, WPB,WSB DFB
Xe5		Rain-on-snow	5-15					IIIa	DFB, DFTM AROS, FE
Xf7	Mainstems:	Rapid spring snowmelt Rain-on-snow	5-15 5-15	High flows	Category III, V	Stream adjacent; Tributary debris flows	Moderate - High	Vb	WSB DFTM
Xf8								IVc	MPB FE
Yd5	Tributaries Only:	Rapid spring snowmelt	5-15	Rapid convergent runoff	Category I	Debris slides	Low	IIIb	WSB, DFTM FE
		Rain-on-snow	5-15						

Abbreviations:

* – No specific information on insect and disease on soils influenced with serpentine bedrock

NONE – Disturbance occurrence will not alter plant community composition significantly

AROS – Armillaria root disease

DFB – Douglas-fir beetle

DFDM – Douglas-fir dwarf mistletoe

DFTM – Douglas-fir tussock moth

FE – Fir engraver beetle

IPS – Pine engraver beetle

LPDM – Lodgepole pine dwarf mistletoe

MPB – Mountain pine beetle

WLDM – Western larch dwarf mistletoe

WPBR type2 – White pine blister rust on whitebark pine

WPB – Western pine beetle

WPB/MPB/IPS – Western pine beetle/mountain pine beetle/pine engraver

WSB – Western spruce beetle

110