Northeast Oregon IFTNC Region
Nutrition Guidelines By Rock Type

Nutrition guidelines for use in conjunction with digital geology for the northeastern portion of the state of Oregon

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Introduction

This document was prepared as a guideline to help forest managers determine appropriate nutrient management strategies for stands on various rock types in the Intermountain Forest Tree Nutrition Cooperative's (IFTNC) northeast Oregon region (NE OR). Regional digital geology compiled by the Division of Geology and Mineral Industries (DOGAMI) personnel was utilized in the development of these guidelines. Only those map units included in the IFTNC's northeast Oregon region were categorized for this report. That portion of the IFNTC's northeast Oregon region that occurs in southeastern Washington is categorized and described in the Washington state report (Garrison-Johnston and Johnson 2007).

This report categorizes 599 lithologic units. The map units were classified into five major categories (major units), and further assigned to one of 26 subcategories (minor units). The minor units were then further subdivided into 37 lithology categories that provided the basis for discussion of expected weathering behavior and recommended nutrient management guidelines and strategies. These guidelines are based on our current state of knowledge regarding rocks and forest growth in the inland northwest. **These recommendations are conservative and should not be viewed as absolute. We fully expect these guidelines to be further refined with additional research and experience.**

IMPORTANT: Geologic maps are a useful tool for forest management as long as we recognize that geologic maps were not developed for use at the forest stand scale. We have found the DOGAMI maps to be very good for providing a general idea of the rocks likely to be found in a particular area. However, because of the variety of authors and geologic maps from which the digital data were compiled, as well as the complex geologic history of this region, there are some inconsistencies in map appearance and assigned map units, particularly in the Baker area. **Rock type should always be verified in the field as part of nutrient management planning. The information included in this report is intended only to provide general guidelines towards the formulation of silvicultural prescriptions. Managers will also need to take into account stand history and conditions, organizational objectives and other relevant information when formulating site-specific prescriptions.**

How To Use This Document

The northeast Oregon digital geology compilation may be obtained from DOGAMI at the following address:

The Nature of the Northwest Information Center
Suite 177
800 NE Oregon Street
Portland, OR 97232-2162

or by visiting their website at ***http://www.naturenw.org***. This report was compiled using **Oregon Geologic Data Compilation - Release 3.** A shapefile containing the IFTNC northeast Oregon region accompanies this report and may be used to clip the regional map, if desired. During the compilation of this report, every geologic map unit occuring within the IFTNC region was assigned a major unit, minor unit and lithology grouping, with each lithology grouping receiving a weathering susceptibility estimate and a tree value (e.g. good rock/bad rock) rating. A summary of the weathering susceptibility, tree value and ash cap effects by major and minor unit is provided in **Appendix A**. Observations regarding ash effects on stand growth rate and fertilization response, as well as nutrient management and fertilizer recommendations, are discussed in the text of this report.

This document may be used with digital geologic maps in a GIS by using the dBASE lookup table that accompanies this report (NEOR_Lith_IFTNC2010_Lookup.dbf), which assigns the IFTNC nutrition guidelines categorization scheme to each individual map unit. The join field is ***LITH_M_U_L***[1].

A description of the information included in the dBASE table is provided in **Appendix B**, along with details on how to merge the table with the digital geologic map attribute table. The information contained within the lookup table is reproduced in **Appendix C**. Once the appropriate map unit code is located and categorized according to the IFTNC heirarchy, refer to the text of this report for discussion of geology and silvicultural recommendations. A summary of inconsistencies found in the LITH_M_U_L assignments is shown in **Appendix D**.

Rationale and Recommended Reading

The Intermountain Forest Tree Nutrition Cooperative (IFTNC) has been studying forest nutrition in the Inland Northwest since 1980. Initial studies focused on nitrogen (N) nutrition, and subsequent findings suggested that potassium (K) also plays an important role in forest health (Entry et al. 1991, Mika et al. 1993, Moore et al. 1994). Nitrogen tends to promote growth by increasing foliage biomass production, thereby providing for increased stem growth via increased photosynthetic capacity. In contrast, K appears to decrease mortality by promoting production of biochemical defense compounds. The source of K and most plant nutrients other than N is the underlying rock, which in some cases may be augmented or replaced by surficially deposited parent materials. To further determine the potential role of K in decreasing tree mortality, a region-wide N and K trial known as the Forest Health and Nutrition Study was implemented by the IFTNC in the mid-1990s. The study design incorporated bedrock geology and site moisture status (as indicated by potential climax vegetation) as the principal experimental effects. While rock and vegetation series had routinely been noted as factors affecting forest growth response to fertilization in earlier studies (Shen et al. 2000), the Forest Health and Nutrition Study was the first to require that stands meeting certain rock and vegetation series criteria be included in the study. The subsequent discovery that certain stand types (drier vegetation series) could not be found on certain rock types (metasedimentary) stimulated a more in-depth look at rocks and the effect of geology on soil conditions and stand growth and health (Moore and Mika 1997, Garrison-Johnston et al. 2003, Garrison-Johnston et al. 2003, Moore et al. 2004). While these findings led to the establishment of additional studies to observe the effects of rock type on the growth and health of seedlings and young stands, they also resulted in the incorporation of rock type as a major factor influencing forest management and fertilization recommendations (Garrison and Moore 1998, Garrison-Johnston and Moore 2001, Garrison-Johnston and Johnson 2004).

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[1] Several attribute fields were considered for this join, including Map_Unit_L, Lith_M_U_L and G_MRG_U_L. All of these fields had issues with multiple (and in some cases very different) rock types being included in the same map unit. For example, within the Map_Unit_L field, the label "ls" was used for both limestone and landslide deposits. The field Lith_M_U_L also has similar issues (for example the unit srx.MIX.Lsd.Gsd.End contains ~6900 acres of sedimentary rocks and ~8500 acres of surficial deposits), but seemed to incorporate somewhat less disparity overall. A new field 'Check_Lith' indicates whether multiple rock types occur in a Lith_M_U_L category, in which case users should refer to DOGAMI's map descriptions and Appendix D of this report.

This report was developed to provide regional resource managers with the best information currently available based on the experiences and observations of IFTNC staff. Users will benefit from a *Dictionary of Geologic Terms* (American Geological Institute 1984), particularly when interpreting the terminology used on geologic maps. Another excellent book for learning about the geology of the northwest is *Northwest Exposures: A Geologic Study of the Northwest* (Alt and Hyndman 1995). Numerous textbooks on introductory geology are available through on-line book sellers. A recent review of currently available texts showed *The Practical Geologist: The Introductory Guide to the Basics of Geology and to Collecting and Identifying Rocks* (Dixon 1992) as being of potential interest to those wanting a deeper understanding of geology, and the *Smithsonian Handbooks: Rocks & Minerals* (Pellant 2002) as a good field handbook, with numerous photographs and descriptive geology basics.

Geology Overview

This document assumes a certain level of familiarity with geological classification and terminology. The recommended readings should provide useful background information. A very brief review of geologic classification is also presented below, along with a description of how the IFTNC categorizes rock types. Volcanic ash is also briefly discussed.

Basic Classification: At the broadest scale, rocks are classified into three groups: Igneous, Sedimentary and Metamorphic:

1. ***Igneous*** rocks are those derived from magma that rises from the earth's interior, cooling as it rises to the surface. There are two broad categories of igneous rock based on where and how quickly the magma crystallizes. Magma that is extruded onto the earth's surface cools rapidly, forming fine-grained crystalline rocks called extrusive or volcanic. Basalt is a good example of a volcanic rock common to the Inland Northwest. Magma that is intruded or emplaced beneath the earth's surface cools slowly, forming large-grained crystalline rocks known as intrusive or plutonic rocks. Granite is a good example of a plutonic rock.
2. ***Sedimentary*** rocks are those formed from the transported fragments of other rocks that have broken down through either chemical or physical weathering, and been transported by mechanisms such as water (alluvial/fluvial/lacustrine), wind (eolian), gravity (colluvial), or snow and ice (glacial). Sedimentary deposits may become cemented together, or lithified, such as a sandstone or conglomerate rock. Other deposits may remain unconsolidated, such as alluvial, glacial or landslide deposits.
3. ***Metamorphic*** rocks are rocks that have been altered by heat and pressure, such as that which might occur following deep burial by sediments in a marine environment, or by tectonic or volcanic activity of a mountain-building event. These intense forces often result in deformation of the rock texture and changes in the rock's mineral composition. A weakly metamorphosed rock in which the parent rock is still recognizable is considered to have undergone low-grade metamorphism. Thus, the sedimentary rocks sandstone, siltstone and claystone that underwent a low-grade metamorphism became quartzite, siltite and argillite, respectively. Granitic rocks may undergo weak to moderate levels of metamorphism and still be recognizable, such as 'granite gneiss.' In other cases the rock is so strongly metamorphosed that the parent rock is not identifiable, and textural descriptors such as 'gneiss' or 'schist' are used, perhaps with mineral modifiers such as 'mica' (mica schist) or 'biotite' (biotite gneiss). This level of alteration is the result of

high-grade metamorphism, and high-grade metamorphic rocks may be either sedimentary or igneous in origin. Metamorphic rocks are often classified as belonging to various formations that were named based on the locality in which they were first mapped.

Tree Nutrition Cooperative Classification: The IFTNC currently categorizes underlying geology into five major groups. These include Intrusive Rocks, Extrusive and Subvolcanic Rocks, Metamorphic Rocks, Sedimentary Rocks (for lithified or consolidated rocks like sandstone and conglomerate) and Unconsolidated Deposits (for loose materials such as alluvium, loess and sand). For purposes of this report, several minor units were created within each of the major units to allow additional detail within this classification system. In many instances the IFTNC does not have research sites on these rock types, and in some cases forest stands may not even occur on these rock types. Therefore, the nutrition management guidelines included in this report are based only on IFTNC experiences with forest growth and soil conditions on rocks with which we have familiarity. For the many rocks where we do not have research information, we state that the effects of that rock type on forest growth and fertilization response are 'unknown,' and offer a conservative nutrient management recommendation along with a recommendation for further research such as screening trials, if warranted. A rock type would warrant additional research if it is a common geologic parent material underlying the ownerships of our members.

Weathering Susceptibility: Field observation of soil development on various rocks suggests that deeper soils develop on some rocks than on others, even when other conditions (topographic, climatic, biotic, time) appear to be similar. This seems particularly evident amongst the Belt metasedimentary rocks, and appears related to the carbonate or calc-silicate component. In order to quantify these perceived differences in potential weathering susceptibility, an analysis of rock geochemical data from 446 samples collected throughout northern Idaho was performed by IFTNC, IGS and USGS personnel (Garrison-Johnston et al. 2003). A modification of Reiche's (1943) **weathering potential index (WPI)**[2] was selected to evaluate the potential variation in rock weathering rates due to rock geochemical composition. The WPI values were tabulated by lithology, and for most rocks ranged from a low of about 4 ('pure' quartzite, low weathering potential) to a high of about 22 (basalt, high weathering potential). It should also be noted that some rocks attained high WPI ratings based on geochemistry, but are not considered to have high weathering susceptibility because of other factors such as lack of permeability. Some examples of this would be dolomite (WPI: 72) and marble (WPI: 47). Weathering potential indices for the various lithologies are noted throughout this report, and additional commentary is included if the assigned weathering susceptibility rating varied from that suggested by the WPI analysis.

Volcanic Ash: Ash caps across much of the Inland Northwest resulted from past eruptions of Glacier Peak (WA), Mt. Mazama (Crater Lake, OR) and Mt. St. Helens (WA). Climatic conditions contribute to ash weathering. In cooler and drier areas, the ash cap is likely to have a grayish hue, but as moisture and temperature increase the ash may start to display a yellowish to reddish tint as chemical weathering commences. Ash cap soils are likely to show low bulk density, good porosity and high moisture-holding capacity. The nutritional value of ash is not particularly high, being composed primarily of silicon and aluminum. Potassium may comprise 2-3% of volcanic ash, and if plants are available on-site to take up that K then it may act as a K source. However, due to a relatively low cation exchange capacity, ash cap soil does not tend to

[2] Weathering Potential Index (WPI) is referred throughout this report as an index of weathering susceptibility.

have a strong nutrient-holding capacity, and its nutritional behavior is somewhat complicated by the development of variable-charge minerals as weathering progresses. The primary value of volcanic ash seems to be in its moisture-holding capacity, which often improves site productivity (Figure 2), and may affect fertilizer response (Figure 3). Volcanic ash will not be directly referenced as a parent material in this report, but is often referred to in the context of the improved site productivity and/or fertilization response associated with these deposits.

Site reconnaissance is usually necessary to establish the presence/influence of ash cap or other non-mapped surficial deposits, such as unmapped loess. If a shallow surficial deposit is present, that deposit may be expected to modify the effects of the underlying residual soils, but may also manifest itself in other site characteristics. For example, in northern Idaho, western red cedar or western hemlock vegetation series are often associated with deep ash deposits over various rock types. Nutrient management guidelines, in turn, rely in part on the moisture regime (as represented by vegetation series) in addition to underlying bedrock type.

Figure 1. Douglas-fir site index (ft at 50 years) by base parent material and ash cap presence. Parent materials include basalt, glacial deposit (glacial), granite, metasedimentary (metased), sedimentary (sed), modern sedimentary deposits (mod sed) and tertiary sedimentary deposits (tert sed).

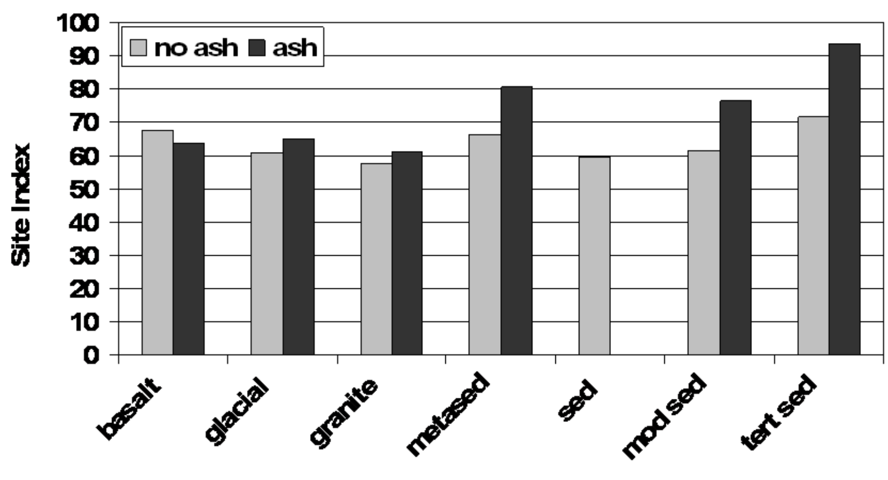
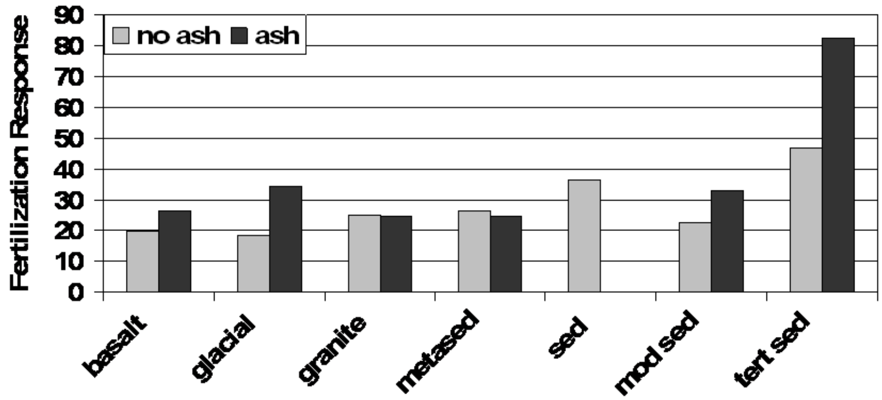


Figure 2. Six-year nitrogen fertilization response (ft³ ac⁻¹ yr⁻¹) by base parent material and ash cap presence. Parent materials include basalt, glacial deposit (glacial), granite, metasedimentary (metased), sedimentary (sed), modern sedimentary deposits (mod sed) and tertiary sedimentary deposits (tert sed).



Nutrition Overview

The term "nutrient" is used to denote any of seventeen naturally-occurring elements that are considered essential for plant growth. Three of these elements, carbon (C), hydrogen (H), and oxygen (O), are abundantly available in air, earth and water, and are not considered limiting factors to plant growth. Six elements, nitrogen (N), potassium (K), phosphorus (P), calcium (Ca), sulfur (S), and magnesium (Mg), occur in limited quantities, and because plants require these in relatively large quantities (500-14000 ppm) to grow and function adequately, they are referred to as "macronutrients." A number of other elements which occur in limited quantities are required by plants only in trace amounts (usually <100 ppm), and these are known as "micronutrients." Eight elements are currently considered micronutrients, and more will probably be added to this list over time as equipment detection levels and research techniques improve. Tables 1a and 1b respectively list the macro and micronutrients, their principal functions in higher plants, and their sources. Two non-nutritive elements that are occasionally referenced in this report are the common silicate mineral constituents, silicon (Si) and aluminum (Al).

Nutrient Diagnostics: Tests of foliage and soil chemistry may be performed as site-specific indicators of productivity and potential fertilization response. Most of our long-term results of fertilization research focus on N. Foliage N has been shown to be a better predictor of site productivity than soil N tests, while soil mineralizable N may be a better predictor of fertilizer response than foliage N tests (Garrison-Johnston et al. 2006). If satisfactory information on site productivity is available and the parent material/ash combination suggests that the site may be responsive to fertilization, managers should consider focusing on tests of soil mineralizable N. If mineralizable N is below 70 ppm, then the site should show a 6-year volume response of 10% or more to N-fertilization, with the potential response increasing as mineralizable N decreases. Foliage N may be tested as an indicator of overall site productivity; however the time and expense of this test make it less desirable than performing simple site height/age measurements.

Nutrient Management: “Nutrient management" refers to silvicultural activities as they affect the nutrient capital of a forest stand. Nutrient management strategies may be cultural in nature, including stand improvement, harvesting and planting, or they may be more manipulative in nature, such as by adding nutrients in the form of fertilizer.

- ***Harvesting***: Most nutrients are held in limbs and foliage (Cole et al. 1967, Pang et al. 1987, Miller et al. 1993, Moller 2000); therefore, a conservative nutrient management strategy will leave the tops and limbs on-site during harvesting operations. Because the actual amount of material removed during a harvesting operation depends on the season of the year as well as the harvesting system, some consideration as to treatment timing can have an effect on management decisions. Whole-tree operations in late fall and winter, when breakage is more likely, should be more effective at leaving nutrients on the site than those which take place in spring and summer. Bole-only extraction includes tree-length operations where trees are limbed and topped in the woods, and is considered to be a conservative nutrient management strategy year-round. The level of nutrient removal during any harvest operation also depends on the merchantability standards in effect during the harvest, and whether the sub-merchantable trees are also harvested and removed. For purposes of this report, commercial thinning and regeneration harvest operations have been designated as ‘whole-tree’ or ‘bole-only’ extraction. We recognize that there is a gradient in the amount of material that may be left on-site, ranging from removal of most materials during ‘whole-tree’ operations, to leaving most materials during ‘bole-only’ operations. By specifying particular types of harvesting systems and timing of the operation, foresters should be able to target operations to fall somewhere within this range of variability. A recommendation of ‘bole-only removal’ in these guidelines would suggest that as much material be left on-site as possible. A recommendation of ‘whole-tree acceptable’ would suggest that the site may be resilient to the removal of a greater quantity of material.
- ***Species Ecology***: Species differ in nutrient demand (Gordon 1983, Gower et al. 1993, Miller et al. 1993, Garrison and Moore 1995, Moore et al. 2004), therefore planting a nutrient-limited site with less-demanding species would be a good nutrient management strategy. In our experience, species may be ranked from high to low demand as follows:

Species	Demand
Grand fir	very high
Douglas-fir	high
White pine	moderate to high
Ponderosa pine	moderate
Lodgepole pine	low
Western larch	low
Western hemlock	low? (based on our observations)

Table 1 – (a): The macronutrients -- their function and source, and 1(b): The micronutrients -- their function and source. Most nutrient functions are from Marschner (1995). An asterisk indicates that a nutrient is available in fertilizer form.

Table 1(a): The macronutrients -- their function and source

Symbol	Element	Function	Source
N*	Nitrogen	Biomass production Photosynthesis (proteins)	Organic matter N-cycle
K*	Potassium	Disease resistance Osmotic potential, turgor Enzymatic transfer of glucose to starch Nitrate synthesis Photosynthesis and CO_2 fixation	Parent material
P*	Phosphorus	Structural constituent of DNA and RNA Basal metabolism (ATP and energy transfer) Photosynthesis (carbon partitioning)	Parent material
S*	Sulfur	Photosynthesis (proteins) Membrane structure Some defense substances	Atmosphere Parent material
Ca*	Calcium	Structural component (cell walls, membranes)	Parent material
Mg*	Magnesium	Chlorophyll Protein synthesis Enzymes and enzymatic reactions Carbohydrate partitioning	Parent material

Table 1(b): The micronutrients -- their function and source

Symbol	Element	Function	Source
Fe*	Iron	Chloroplast development, photorespiration Enzymatic reactions	Parent material
Mn*	Manganese	Enzymatic reactions Photosynthetic O_2 evolution	Parent material
Cu*	Copper	Nitrogen metabolism (NOTE: High N rates can induce Cu deficiency) Cell wall lignification Pollen formation and fertilization Carbohydrate and lipid content Enzymatic reactions	Parent material
Zn*	Zinc	Metabolic functions Complexes with N, O and S DNA replication Regulation of gene expression (NOTE: High P rates can induce Zn deficiency)	Parent material
Ni	Nickel	N metabolism	Parent material
Mo*	Molybdenum	N metabolism N_2-fixation May affect pollen formation/fruit formation Critical level increases with increasing N supply	Parent material
B*	Boron	Cell wall biosynthesis and structure Plasma membrane integrity Root elongation, apical dominance Deficient B associated with Eucosma sp. borer	Parent material
Cl*	Chlorine	Photosynthetic O_2 evolution Stomatal regulation	Parent material Atmosphere

- ***Prescribed Fire***: Prescribed burning helps to cycle and make nutrients available for tree growth. Fire suppression has increased the presence of shade-tolerant, nutrient-demanding species and has also altered the cycle by which nutrients were naturally returned to the system through fire (Little and Klock 1985, Feller 1988). Furthermore, a cool fire can effectively return much of the on-site nutrient capital to the soil. Therefore, using cool burns for slash control, site preparation or intermediate treatments would be a good nutrient management strategy.

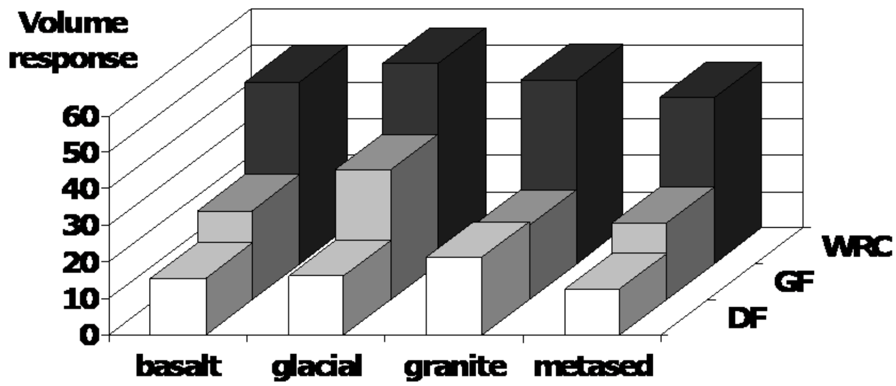
- ***Fertilization***: Fertilization is an additional nutrient management strategy which may be used to improve the health or increase the productivity of a forest stand. Based on existing IFTNC research, a broad pattern of N fertilization response based on vegetation series and rock type has been detected (Figure 4), and has been incorporated into this report. The recommendations shown in this report will be based largely on our experiences in central and northeastern Washington, northeastern Oregon and northern and central Idaho. We do not yet have adequately replicated, long-term information on fertilization response for elements other than N; however, K, S and B often provide beneficial responses in terms of growth response and decreased mortality.

- ***Fertilization Strategies*****:** *Things to consider when developing a fertilization regime:*
  → ***Moisture***: The first criteria to consider when contemplating fertilization is site moisture regime. In our experience, vegetation series is a good proxy for site moisture regime. Moist site types, characterized by western red cedar, western hemlock and western white pine, are the highest priority for fertilization, followed in descending order by sites on the grand fir vegetation series and those habitat types on the moist end of the Douglas-fir series. We have no fertilization response data for drier site types such as true ponderosa pine types, and at this time do not recommend fertilization of such sites. We strongly recommend further research in the form of short-term screening trials and long-term fertilization rate trials, particularly if drier site types comprise a significant portion of the organization's core ownership.

  → ***Parent Materials***: When selecting sites for potential fertilization or fertilization rate trials, if the vegetation series is appropriate for fertilization then rock type should next be considered along with surficial deposits. Use the guidelines in this report to determine whether a rock type is appropriate for fertilization, and what elements are recommended for application. It is assumed that the forest stand under consideration has been assessed and, based on moisture regime and organizational/financial objectives, has been deemed appropriate for fertilization. The decision of how much of each element to apply will be dictated by our current state of knowledge, as well as financial and other operational constraints. The IFTNC staff can provide guidance on application rates and expected responses.

  → ***Management History***: Recent experience suggests that young stands, particularly plantations established after high levels of biomass removal and mechanical site preparation, are often deficient in S and B. This seems to be true for all rock types, but the nutrient status is relatively worse on "bad" rock types. Thus, stand management history should also be considered when assigning fertilization priorities for any site.

Figure 3. Six-year nitrogen fertilization response (ft^3 ac^{-1} yr^{-1}) by base parent material and vegetation series. Parent materials include basalt, glacial deposit (glacial), granite and metasedimentary (metased). Vegetation series include Douglas-fir (DF), grand fir (GF) and western red cedar (WRC).



Acknowledgements

This report represents a new effort to provide geology-based nutrition guidelines for northeastern Oregon forests. We greatly appreciate the continued support and interest of all of our Cooperators in this effort. We particularly thank Mark Ferns of the Oregon Department of Geology and Mineral Industries (DOGAMI) for his instrumental technical guidance and for facilitating our access to digital geology for northeastern Oregon. In the development of this report, we relied heavily on similar geology guidelines reports recently produced for northern Idaho and western Montana and for Washington State. The technical reviewers of the Idaho/Montana document included Reed Lewis of the Idaho Geological Survey, John Mandzak of Potlatch Forest Holdings, Jeff Lonn of the Montana Bureau of Mines and Geology, and Scott McLeod (now with Washington Department of Natural Resources (DNR)) and Jeff Collins of the Montana Department of Natural Resources and Conservation. Reviewers of the Washington report included Scott McLeod (Washington DNR) and Ray Lasmanis of the Washington Department of Geology and Earth Resources. All of these reviewers provided significant improvements to the Idaho/Montana and Washington reports that are in turn reflected in this new Oregon report. We also thank the Oregon DOGAMI staff for compiling a great deal of geologic information in an accessible and user-friendly digital format that enhances our ability to incorporate geological information into these nutrition guideines and similar resource management applications.

Nutrient Management Guidelines

Northeastern Oregon Geology

Most of the rocks in the northeastern Oregon region are in the Extrusive and subvolcanic category (60%; fig. 4). Unconsolidated rocks make up the next largest portion of northeastern Oregon geology (18%), followed by the Sedimentary rocks (13%). The Metamorphic and Intrusive categories together together make up the remaining 9% of the IFTNC's northeastern Oregon region. A generalized map of northeastern Oregon shows the geographic composition of regional geology using the IFTNC Major Unit classification (Fig. 5).

Figure 4. Geologic classification of northeastern Oregon region geology by IFTNC Major Unit.

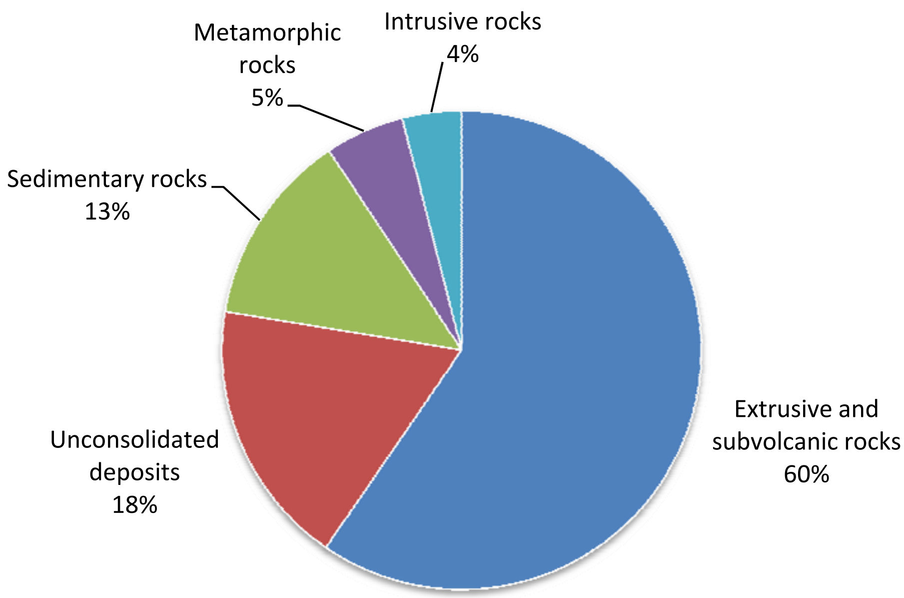
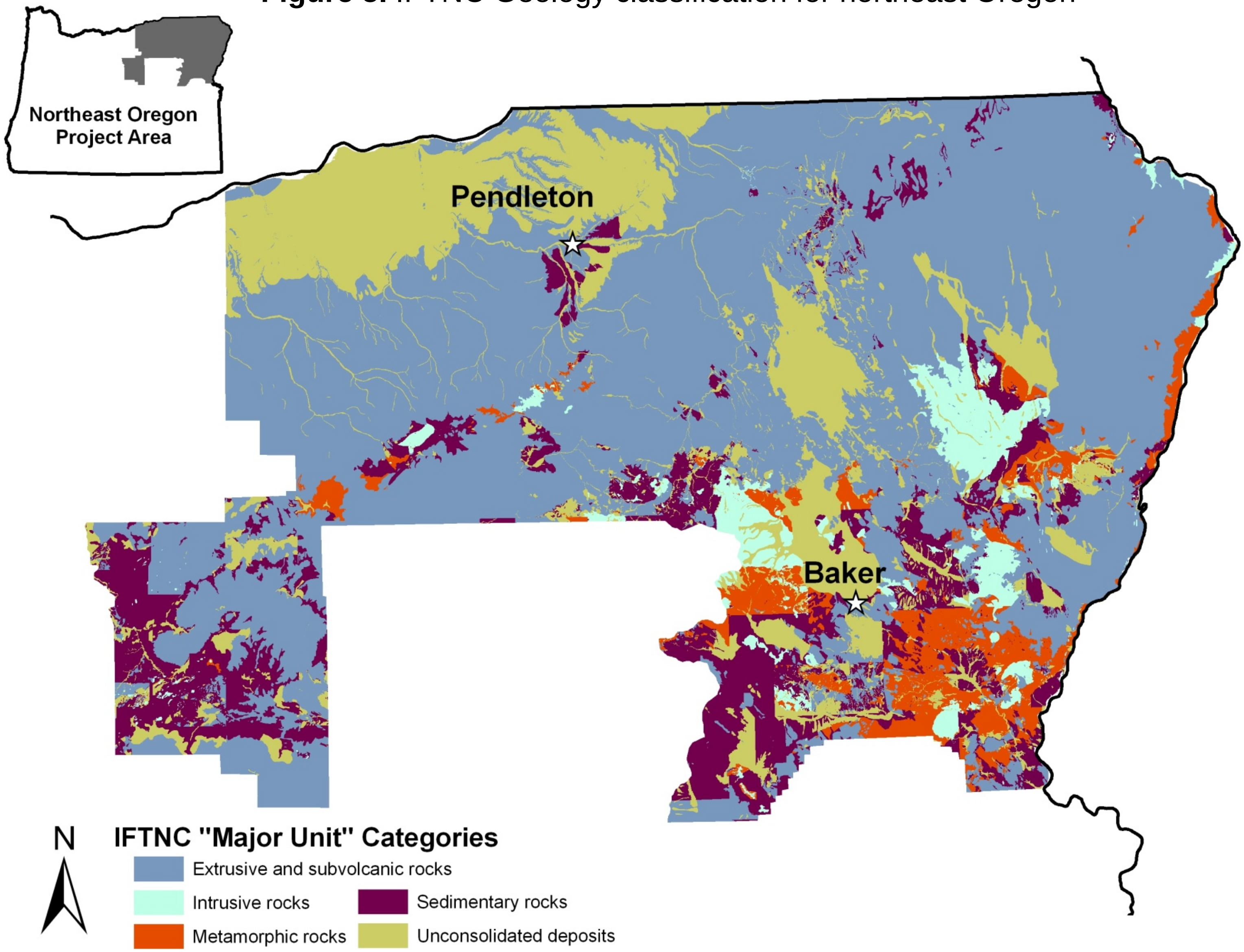
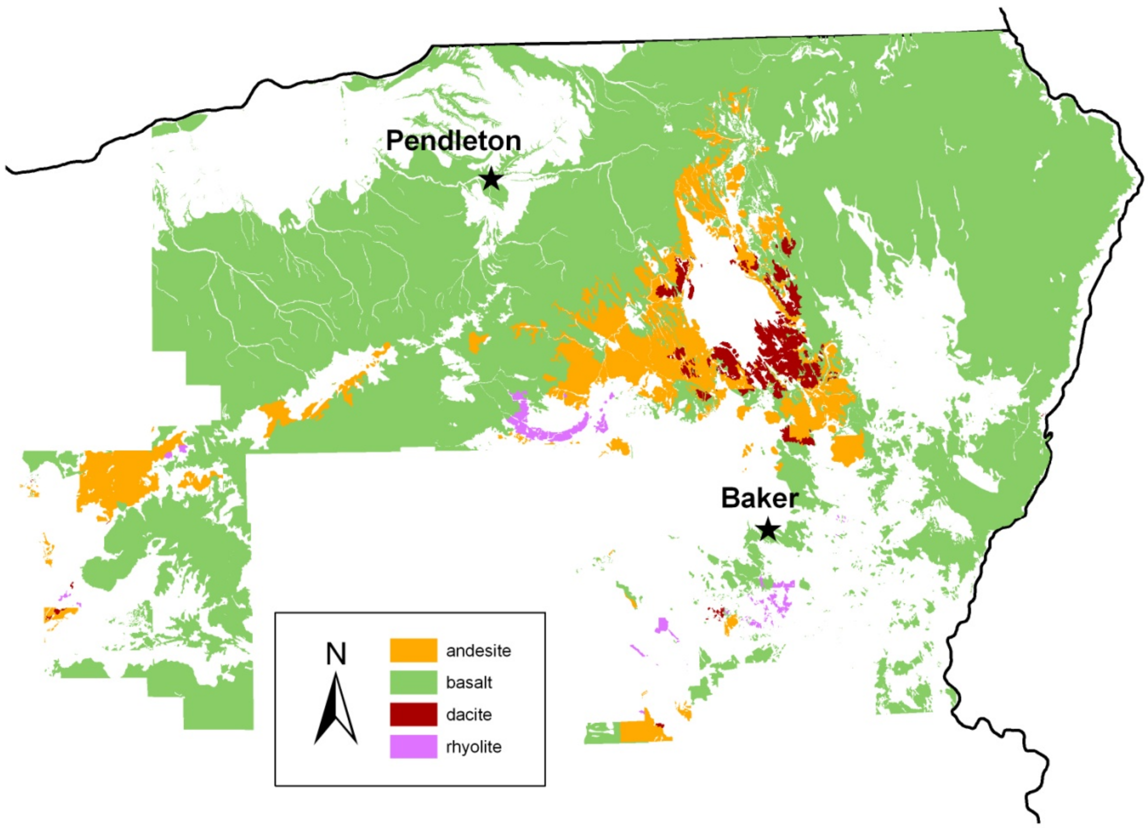


Figure 5. IFTNC Geology classification for northeast Oregon



Major Unit: Extrusive and Subvolcanic Rocks

Figure 6. Extrusive and subvolcanic rocks in the Northeastern Oregon region.



Minor Units

- **Mafic Extrusive and Subvolcanic Rocks** (Basalt, Andesite)
- **Felsic Extrusive and Subvolcanic Rocks** (Dacite, Rhyolite)

Overview: Extrusive and subvolcanic rocks comprise the majority of the rocks underlying the IFTNC's northeastern Oregon region (Fig. 4). Extrusive and subvolcanic igneous rocks form when magma reaches the earth's surface either as a flow, explosive eruption or feeder dike or sill. Extrusive rocks cool rapidly, producing a fine grain size. Extrusive rocks may be broadly categorized based on the mineralogic composition as mafic (dark-colored) or felsic (light-colored). Extrusive and subvolcanic rocks in the IFTNC's NE OR region are predominantly mafic (>97%; Fig. 6; Table 2). Map units included in this category are predominantly flow rocks, or those that came in as magma and cooled in place. Volcanic rocks that underwent explosive or subsequent sedimentary processes (ash, tuff, pumice, breccias, etc.) were categorized as 'Mixed volcanic/volcaniclastics' in the Sedimentary rock major unit.

Table 2. Land area proportions by lithology units within IFTNC Extrusive and Subvolcanic Rocks in the northeastern Oregon region.

Mafic Extrusive and Subvolcanic Rocks	Proportion of Extrusive and Subvolcanic Rocks
Basalt	87.7%
Andesite	9.7%
Felsic Extrusive and Subvolcanic Rocks	
Dacite	1.9%
Rhyolite	0.7%

Rock Descriptions

Mafic Extrusive and Subvolcanic Rocks

Basalt is by far the most common extrusive rock that occurs in the northeastern Oregon region, occupying 87.7% of the Extrusive and subvolcanic category (Table 2). Typical basalts are composed mainly of plagioclase feldspar and clinopyroxene, and contain no quartz. Plagioclase feldspars contain Si and Al along with Ca and/or Na, but little or no K. A clinopyroxene is one of a group of minerals that contain Si, Ca, and some combination of Mg and/or Fe. Grain size and mineral composition affect the formation of clays in residual soils formed from these rocks. Basalts tend to form clay-rich soils with good moisture-holding capacity. Basaltic soils should also be fairly rich in several important nutrients, including Mg and Ca. While K content of basalt rocks is fairly low, the K-retention of basaltic soils should be quite good, again due to the clay content and resulting good cation exchange capacity (CEC). High CEC and base saturation are important qualities of basaltic soils. Expected weathering potential is high (WPI: 22.9).

Andesites are very similar in composition and appearance to basalt, but contain more silicon and are likely to have a slightly lower weathering potential (WPI 20.9). These rocks comprise another 9.7% of the Extrusives and subvolcanic category. Despite the similarity to basalt, andesitic soils do not seem to support high tree growth rates or strong fertilization response. In some cases this may be a topography issue, as discussed below.

Basalts and Topography

The ‘good rock’ reputation of basalts seems to have originated with the relatively flat topography of the Columbia River flood basalts in northeastern Oregon, southeastern Washington and portions of northern Idaho. The gentle slopes associated with those flood basalts appear to be accompanied by deeper in-place weathering than is associated with steeper topographies, as well as accumulation of overlying erosional materials resulting from blocked stream drainages during flow events, and in some cases accumulation of loess and ash caps. The soils are deep and generally have good water-holding capacity and high CEC, resulting in good tree growth and good fertilization response. However, as we approach the edges of the Columbia River flows along canyons, we find steeper topography. Associated with the steeper topography is a much lower degree of in-place weathering and less accumulation of deposited materials. Some basalts are resistant to weathering to the extent that rounded cliffs may form, and tree growth is virtually non-existent. The same is often true for dikes, sills or otherwise resistant materials, regardless of lithology. Sites which are topographically unsuitable for supporting trees are not intended for consideration in this report.

Felsic Extrusive and Subvolcanic Rocks

Dacite and rhyolite (1.9% and 0.7% of the mapping area, respectively; Table 2) are light-colored extrusive rocks that are higher in silicon content than basalt. Weatherability of dacite and rhyolite is poor compared to mafic volcanic rocks (WPI: Rhyolite 8.9, Dacite 13.7). Rhyolite has a higher silicon content than dacite, and is likely to occur as ash flows/falls, but only rarely as a lava flow. Dacite is likely to occur as both lava flows and as ash flows/falls. When the map unit descriptive information suggested that a material was deposited as ash flows/falls, the unit was categorized as a volcanic/volcaniclastic rocks within the Sedimentary rocks category. Thus, the map units categorized as Extrusive and subvolcanic rocks should be predominantly flow rocks, or perhaps flows that were contained in dikes and sills. Felsic dikes and sills are localized areas of rock at points where felsic volcanic magma intruded into small cracks and crevices in the earth's crust, or in some cases were vents for magma flows. Dikes and sills often occur as outcrops, indicating poor weatherability. In our experience, rocks comprising dikes and sills don't tend to support good tree growth, and forest stands on those rocks may be particularly susceptible to harboring forest insect populations during endemic years (Garrison-Johnston et al. 2003). We recommend field-checking map units that are labeled as dacite and/or rhyolite to verify soil conditions and site productivity.

Nutrient management recommendations

Good-to-medium: Basalt

Basalts associated with gentle topography are generally considered good rocks and good candidates for fertilization. Sites with slopes less than about 20% are likely to have some sort of accumulated deposit or deeply weathered-in-place soils. We recommend that conservative nutrient management strategies be followed. However, because of the high quality of these sites, they may be more resilient than other sites to nutrient-depleting management strategies such as intensive whole-tree removal. Research on IFTNC study sites in central Washington and northeast Oregon indicates that good response may be expected when N-only is applied, but that in some cases S may be necessary to elicit a growth response to N-fertilization.

Basalts associated with steeper topographies should be considered medium or even poor sites, and should be treated more conservatively. We would still expect moderate tree growth and moderate-to-good fertilization response.

- Expected Soil Development: Moderate to deep, fine loamy soils
- Expected Nutrient Status: Good (gentle slopes) to Medium (moderate slopes)
- Ash Effect: Ash presence does not seem to affect productivity unless associated with moister climatic conditions, in which case productivity does improve. Improved response to N-fertilization is also associated with ash cap.
- Recommended Nutrient Management Strategies:
    - Thinning: bole-only preferred, but whole-tree removal probably OK on gentle slopes

  - Regeneration Harvest: bole-only preferred, but whole-tree removal probably OK on gentle slopes
  - Species Selection: most species will do well on this rock type
- Expected Fertilization Response: Moderate to good response to N
- Fertilizer Recommendation:
  - Recommended only for moist-end Douglas-fir habitat types and grand fir or moister vegetation series
  - Recommended formulation: Research suggests N or NK will probably produce a positive response; observation suggests NKSB will produce a better response.
  - Good multi-nutrient blend candidates; consider screening trials

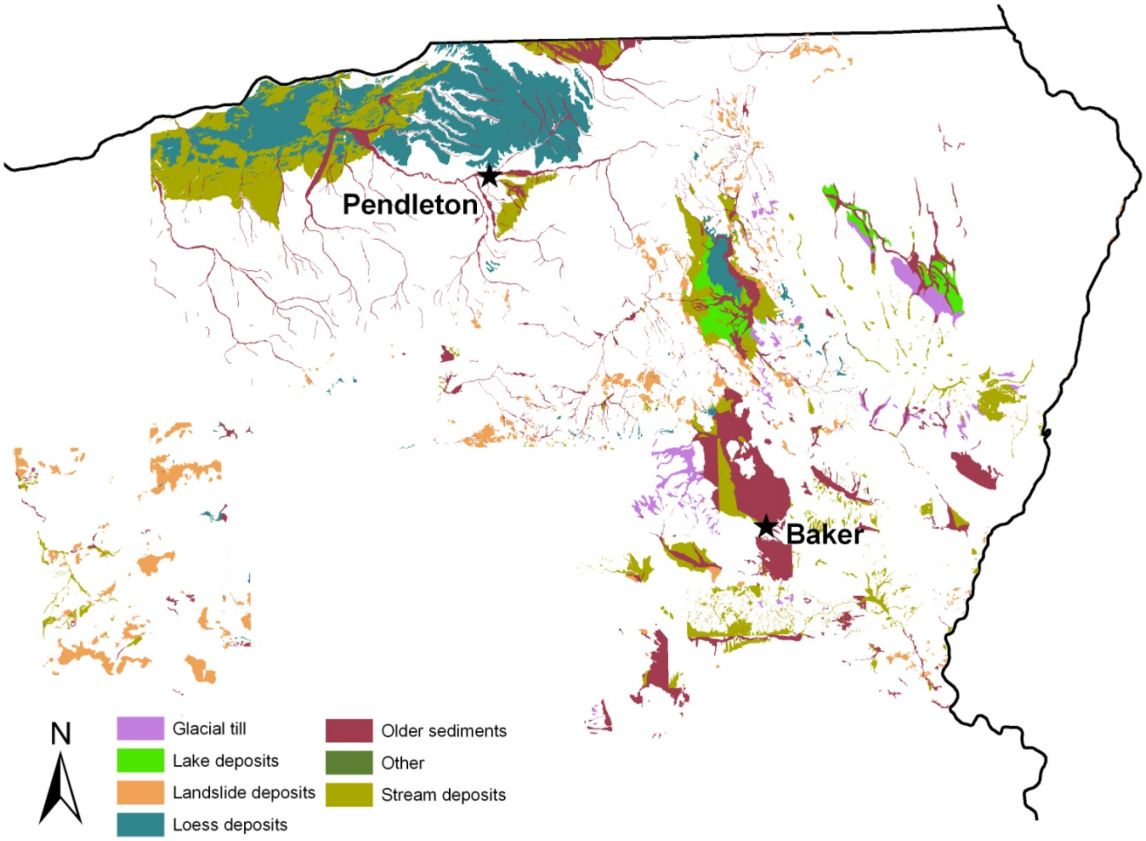
Bad: All other (non-basalt) mafic and felsic extrusive and subvolcanic rocks

These rock types are considered to have poor tree-growing value and to be poor candidates for fertilization. Conservative nutrient management practices should be followed.

- Expected Soil Development: Poor
- Expected Nutrient Status: Poor
- Ash Effect: None
- Recommended Nutrient Management Strategies:
  - Thinning: bole-only recommended, but whole-tree may be OK for thinning from below or other light thinning
  - Regeneration Harvest: bole-only
  - Species Selection: select for low nutrient-demanding species
- Expected Fertilization Response: Poor
- Fertilizer Recommendation:
  - If objectives are economic: Not recommended
  - If objectives are health- and productivity-related: Optional, grand fir or moister site types only
  - Rationale: We have not yet determined an appropriate fertilization regime to counter the "bad-rock" effect, though it will almost certainly involve various macro- and micro-nutrients besides N and K. The cost of these additional elements is not likely to justify their use, particularly if the cost must be carried over a number of years. The application of NK *may* reduce mortality in some cases; however, our understanding of when and why mortality may be affected is not yet clear. Consultation with IFTNC staff would be appropriate.

Major Unit: Unconsolidated Deposits

Figure 7. Unconsolidated deposits in the Northeastern Oregon region.



Overview: Map units assigned to the 'Unconsolidated Deposits' major unit occupy the second-greatest area of land (18%) in the IFTNC's northeastern Oregon region (Fig. 4). This unit consists of deposits of weathered rock transported from another site to the present site by wind, water, gravity, glacial activity, or some combination thereof. These deposits generally did not undergo subsequent lithification or cementation. Because of the variety in source material, site quality is likely to vary widely within this category. Recommendations for these sites are based on IFTNC research results, and research installations were highly likely to have been located on the better quality sites. Therefore, careful evaluation of sites in this category should be conducted prior to assigning management strategies.

Map units in this category are generally categorized only to the minor unit level. The exception is the stream deposits minor unit, which includes two lithology groupings (alluvial deposits and glaciofluvial deposits). Most of the Unconsolidated deposits in the northeastern Oregon region are alluvial deposits (29.8%; Table 3), followed by loess and older sedimentary deposits (26.3% and 25.7% of all Unconsolidated deposits, respectively).

Table 3. Land area by Minor and Lithology Unit within IFTNC Unconsolidated Rocks category in the northeastern Oregon region.

IFTNC Minor Unit	*IFTNC Lithology Unit*	*Proportion of Unconsolidated*
Stream deposits	alluvial deposits	27.8%
	glaciofluvial deposits	2.0%
Loess deposits	loess deposits	26.3%
Older sediments	older sediments	25.7%
Landslide deposits	landslide deposits	10.7%
Glacial till	glacial till	4.0%
Lake deposits	lake deposits	3.5%

Rock Descriptions

Stream deposits were emplaced by running water, and include both poorly-sorted debris flow and better-sorted stream flow deposits. Many of the units in this subcategory are relatively young, Quaternary era occurrences. This category includes alluvial and glaciofluvial deposits. Alluvial and glaciofluvial deposits may both be comprised of pure to mixed rock types and sizes, depending on the source and distance of transport. These deposits are generally considered 'medium' rocks, but should be evaluated for site-specific conditions.

Loess deposits are wind-deposited silts common to northeastern Oregon and southwestern Washington. For a loess deposit to be assigned as a map unit on a bedrock geology map, the deposit was likely so deep as to obscure the underlying bedrock. Mapped loess deposits comprise 24% of the unconsolidated deposits in the IFTNC's northeastern Oregon region. From a forest standpoint, loess-dominated soils are thought to have low weathering potential and moderate-to-low productivity potential. Deeper loess deposits may be associated with poor forest growth and health conditions. Depending on the depth of the deposit, an underlying parent material may have an effect on forest growth and health, as may an overlying ash deposit.

Older sediments are unconsolidated gravels or other deposits that occurred during the Tertiary (preglaciation) period. These deposits were erosional in origin and occurred when drainages were blocked by either mountain-building events or Columbia River Basalt flows (especially in northeastern Oregon). This unit can encompass a variety of materials, ranging from water-deposited volcanic ash, to clay, to fluvial gravels to debris flow deposits. Older sediments are often indeterminate in origin and can vary widely in nutrient value, therefore site visits are recommended. The 'older sediments' minor unit makes up about one-fourth of the unconsolidated deposits in IFTNC's northeastern Oregon region. However, many small, unmapped areas of these deposits are likely to occur, particularly in and around the flood basalt areas of the state. Resource managers should always be on the lookout for these deposits, and evaluate them accordingly.

Landslide deposits consist of rock fragments that have been transported downslope as either a slow gravity-driven creep or as a more rapidly occurring landslide or avalanche deposit. This category includes talus as well. These deposits are likely to be somewhat homogenous in composition though not necessarily in size, and localized in distribution depending on the source rock. They may be modern or older in age. Whereas recent scree-type deposits will obviously not provide much in the way of soil development for tree growth, older deposits may have well-developed soils and support forest stands. The recommended approach is to treat the site based on the lithology of the deposited material, taking soil development and the presence of any surficial deposits into account as well. Landslide composition should be verified and assessed in the field, though localized information will often be available in the literature that accompanies paper geology maps.

Glacial till often contains a wide array of rocks that vary in lithology, size and nutrient value. These deposits comprise only a small portion (4.0%) of unconsolidated deposits in northeastern Oregon. Generally speaking, tills may be continental or alpine in origin. Continental glaciers carried rocks across a wide geographic region, and deposits are characterized by hummocky topography. Alpine glaciers, in contrast to continental glaciers, occur in small localized areas in mountainous regions, and the associated tills may be characterized by somewhat homogenous rock composition. Most of the glacial materials in northeastern Oregon are likely alpine in origin. Because of this, they should be treated as a local landslide deposit, based on the lithologic composition of the till.

Lake deposits are associated with old or modern lakebeds. Likely components of lacustrine deposits are sand, silt and clay-sized particles of the stable minerals quartz, potassium feldspar and mica as well as clay minerals. Deposits associated with Glacial Lake Missoula are often dominated by silt-sized particles. Organic-rich rocks can also form in lacustrine environments. Research in the Missoula region of Montana suggests that moderate growth rates and fertilization response to N and NK can occur in forest stands on lake deposits, and strong responses have occurred following NKSB fertilization.

Geologic units that were mapped as ***Other*** in this report include one lithology unit identified as <u>saprolite</u>. Saprolite is a deeply weathered-in-place material that is no longer identifiable as rock, and may be somewhat clay-like in texture.This unit was not included in Figure 7 or Table 3 because of its limited occurrence, and was not assigned a management recommendation.

<u>Nutrient management recommendations</u>

Medium: Lake deposits, stream (alluvial) deposits, perhaps loess (verify stand condition prior to treatment)

Sites on these deposits should be checked for soil depth and development as well as productivity. Poor-performing sites or those with shallow soils should be treated as for sandstones, conglomerates, etc. (Sedimentary Rocks major unit). Good fertilization response has been obtained on some lake deposits.

- <u>Expected Soil Development</u>: Moderately deep to deep, sand to sandy loam, cobbly
- <u>Expected Nutrient Status</u>: Moderate to Good
- <u>Ash Effect</u>: Expect better productivity and fertilization response with ash presence.
- <u>Recommended Nutrient Management Strategies:</u>
    - Thinning: bole-only recommended, but whole-tree may be OK for thinning from below or other light thinning
    - Regeneration Harvest: bole-only recommended
    - Species Selection: Select for moderate to low nutrient-demanding species. Areas that tend to be frost-influenced may be favorable for lodgepole pine.

- Expected Fertilization Response: Variable
- Fertilizer Recommendation:
  - Recommended only for grand fir or moister site types
  - Research suggests that N-only is probably OK, but NKSB and perhaps P would be preferable.
  - Multi-nutrient (including P and micronutrient) blend screening trials recommended.
  - Extensive agricultural use prior to forest stand establishment may dictate a need for P and B in the fertilization blend

Variable: All other unconsolidated deposits

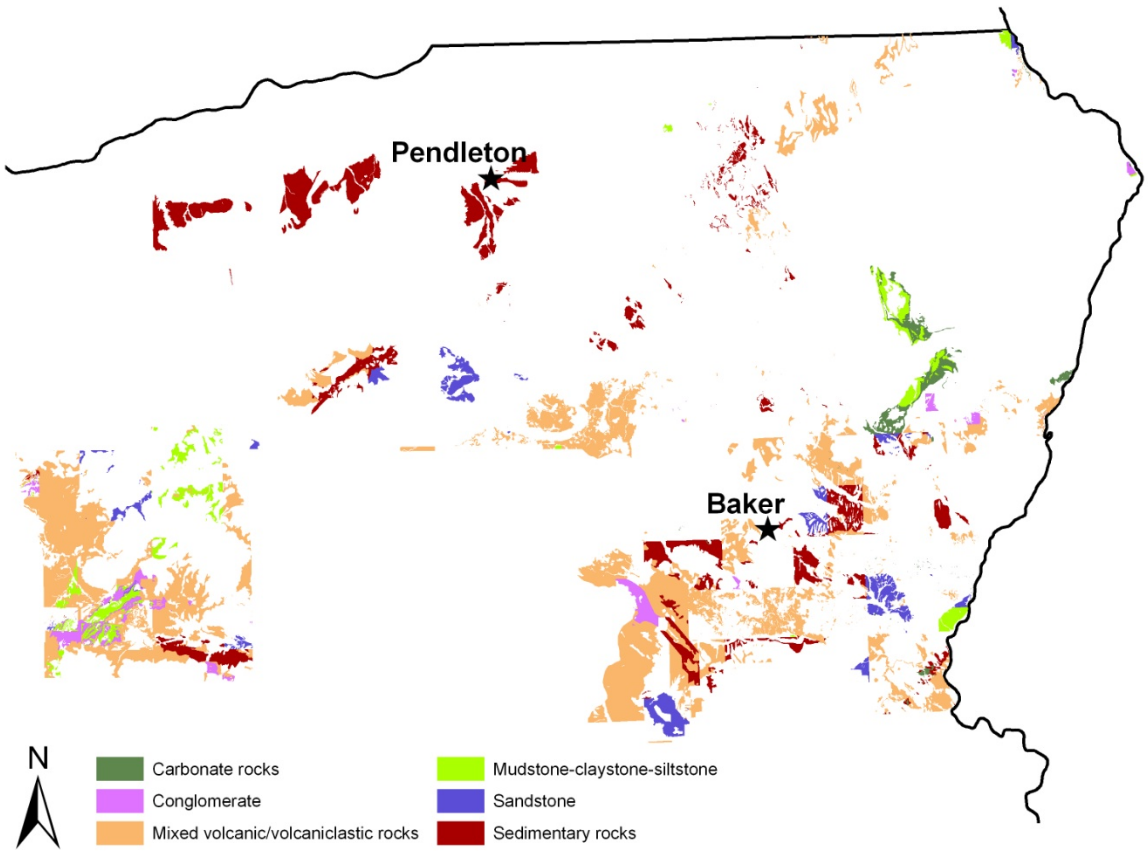
Many unconsolidated deposits are not predictable from a forest nutrition standpoint. Weathering potential ranges from high (older deposits) to low (gravels). Nutritional value depends on the composition and size of the deposited materials. Sites with a greater variety of size classes and rock compositions will likely support more productive forest stands than those with a homogenous mix of materials. We have detected very good growth and fertilization response on some sites underlain by unconsolidated deposits, but have seen others that are unable to be successfully regenerated. Because of the large degree of variability encompassed by unconsolidated deposits, site visits are highly recommended to evaluate soil depth and productivity potential prior to selecting nutrient management strategies.

Recommended Nutrient Management Strategies:

- Poor quality site (poor soil development, poor tree growth): Treat as for non-basalt extrusive and sub-volcanic rocks (Extrusives and subvolcanics major unit).
- Better quality site: Treat as for lake & alluvial deposits (above)

Major Unit: Sedimentary Rocks

Figure 8. Sedimentary rocks in the Northeastern Oregon region.



Overview: Sedimentary rocks generally consist of weathered and transported remnants of other rocks. Because the geologic history of northeastern Oregon is so complex, sedimentary materials that are volcanic in origin (related to Columbia River Basalt flows and related volcanic/tectonic activities) are fairly common, and were included here as well. Therefore, to be included in the Sedimentary rocks category,the transported materials must have been either (a) lithified (cemented together) to form a consolidated rock, or (b) resulting from explosive volcanic activity and subsequent mixing (volcaniclastic), with or without lithification. Sedimentary rocks overall comprise about 13% of IFTNC's northeastern Oregon region (Fig. 4), of which over half (57.9%) are volcanic/volcaniclastic (Table 4). Differences in field identification and nomenclature across various geology maps have lead to boundary inconsistencies for some map units. In these cases, verification against the original geology map documentation and/or a field visit is recommended. The IFTNC herirarchical classification for the Sedimentary rocks category in Northeastern Oregon extends only to the minor unit level, with one lithology unit occuring in each minor unit.

Table 4. Land area by Minor and Lithology Unit within IFTNC Sedimentary Rocks category in the northeastern Oregon region.

IFTNC Minor Unit	*IFTNC Lithology Unit*	*Proportion of Sedimentary*
Mixed volcanic/volcaniclastic rocks	mixed volcanic/volcaniclastic rocks	57.9%
Sedimentary rocks	undifferentiated sedimentary rocks	22.0%
Sandstone	sandstone	6.6%
Mudstone-claystone-siltstone	mudstone-claystone-siltstone	6.5%
Conglomerate	conglomerate	4.1%
Carbonate rocks	limestone	2.9%

Rock Descriptions

Mixed volcanic/volcaniclastic rocks dominate the sedimentary rocks in the NE OR region (Table 4), and generally consist of airfall ash and debris, lava flows and reworked volcanic deposits such as breccia and tuffs. The materials comprising these deposits may be of felsic or mafic volcanic origin, and may or may not be lithified (cemented together). Landscapes underlain by volcanic and volcaniclastic rocks often display a bouldery, rubbly topography with occasional outcrops of resistant materials. Because of the highly variable nature of these materials, field checks are highly recommended prior to considering any silvicultural or nutrient management recommendations. We are conservatively classifying these as 'bad' rocks, though future field investigations may lead to refinements in our recommendations**.**

Sedimentary rocks includes those map units that were clearly sedimentary, but that could not be further refined. Because of the variable and often mixed nature of these rocks, identification to a particular map unit is often difficult, and in some cases not practical or reasonable. A good deal of heterogeneity also exists in how map units were assigned, based on map author and the complex geologic history of this area. A field visit to assess soil quality and forest tree growth in these areas is recommended prior to undertaking any nutrient management activities.

About 17% of the rocks included in the Sedimentary rocks category were classified as either ***Conglomerate***, ***Sandstone***, or ***Mudstone-claystone-siltstone*** (Table 4). These rocks consist of mineral grains or rock fragments that originated from the weathering of igneous, metamorphic or other sedimentary rocks, and were transported to another location and cemented together (lithified). ***Conglomerates*** consist of rounded pebbles, cobbles and boulders of various rock types and sizes in a fine-grained and lithified matrix, while ***sandstones*** consist of cemented sand-sized grains. ***Mudstones***, ***claystones*** and ***siltstones*** consist of mud- or clay-sized and silt-sized grains (respectively) in a cement matrix. Potassium is often a component of the cement which holds the mineral grains and rock fragments together in a sedimentary rock. The mineral grains most commonly found in sedimentary rocks are quartz, feldspar and mica, all of which are common rock-forming minerals resistant to weathering. Weathering susceptibility of these rocks is generally low. Sandstones and conglomerates together comprise almost two-thirds of the sedimentary rocks in the NE OR region.

Carbonate rocks are comprised primarily of carbonate minerals, and range in composition from calcium carbonate (limestone) to calcium-magnesium carbonate (dolomite). These rocks formed primarily in marine environments. Extensive mixing of the carbonate component with non-carbonate materials such as the silts, sands and clays found in these environments also occurred. The carbonate rocks minor unit in northeast Oregon appears to be restricted to limestones. Though they have a high weathering potential index (WPI: Dolomite 72.1), carbonate rocks have been observed to display low weatherability and form massive outcrops, particularly in dry environments. Their nutrient value to softwood forest stands is also considered fairly poor. In a dry forest environment, the carbonate rock units can be slow-weathering and form soils high in pH, which in turn can result in micronutrient deficiencies such as Fe and Mn. In southwestern Montana, carbonate rocks tend to support stands of poorly-performing Douglas-fir and ponderosa pine.

Nutrient management recommendations

Medium: Mudstone-claystone-siltstone

Rocks in this category are expected to form fine sandy or loamy soils, and often contain colluvial and residual cobbles. Moisture and nutrient-holding capacity are thought to be moderate to low. Site productivity is also likely to be moderate to low, though an overlying ash cap may boost productivity if present. Field examination should be performed to assess soil depth, ash presence and stand performance. Well-performing stands may be treated as for basalts (*ie* good rocks). Poor-performing stands and those with poor soil development should be treated as for sandstone and conglomerate rocks. Whole-tree removals are discouraged, as they may run the risk of depleting some of the limited nutrient availability on these sites.

Expected Soil Development: Moderate to deep sandy to loamy soils, cobbles may be present
Expected Nutrient Status: Low to Moderate; may be better if ash present
Recommended Nutrient Management Strategies:

- Thinning: bole-only recommended
- Regeneration Harvest: bole-only recommended
- Species Selection: select for moderate to low nutrient-demanding species

Expected Fertilization Response: Moderate; may be better if ash present.
Fertilizer Recommendation:

- Recommended only for Douglas-fir or moister site types
- Recommended formulation: N may be sufficient for feldspathic sandstone, particularly on deeper soils and in the presence of ash cap. Use N+K on mudstones. Consider S and B as well for both rock types.
- Recommended for multinutrient (w/micronutrient) screening trials.

Bad: Sandstone, conglomerate, carbonate rocks

We do not have a great deal of experience with stands on carbonate rocks, sandstones or conglomerates. Limestones in southwestern Montana tend to support stands of poorly-performing Douglas-fir, and even worse-performing stands of ponderosa pine. We generally consider the carbonate rocks, conglomerates and sandstones as poor rocks, slow-weathering and forming high pH soils. We recommend conservative nutrient management strategies. We do not currently recommend fertilization on any of these rock types, especially if they have shallow soils. Further research is warranted, particularly on the conglomerate rocks.

- Expected Soil Development: Poor
- Expected Nutrient Status: Poor
- Ash Effect: None noted.
- Recommended Nutrient Management Strategies:
  - Thinning: bole-only recommended
  - Regeneration Harvest: bole-only recommended
  - Species Selection: select for low nutrient-demanding species
- Expected Fertilization Response: Unknown
- Fertilizer Recommendation:
  - If objectives are economic: Not recommended
  - If objectives are health- and productivity-related: Optional, NKSB recommended. Only fertilize grand fir or moister site types.
  - Rationale: We have not yet determined an appropriate fertilization regime to counter the "bad-rock" effect, though it will almost certainly involve various macro- and micro-nutrients besides N and K. The cost of these additional elements is not likely to justify their use, particularly if the cost must be carried over a number of years. The application of NK *may* reduce mortality in some cases; however, our understanding of when and why mortality may be affected is not yet clear. Consultation with IFTNC staff would be appropriate.

Variable: Sedimentary and Mixed volcanic/volcaniclastic rocks

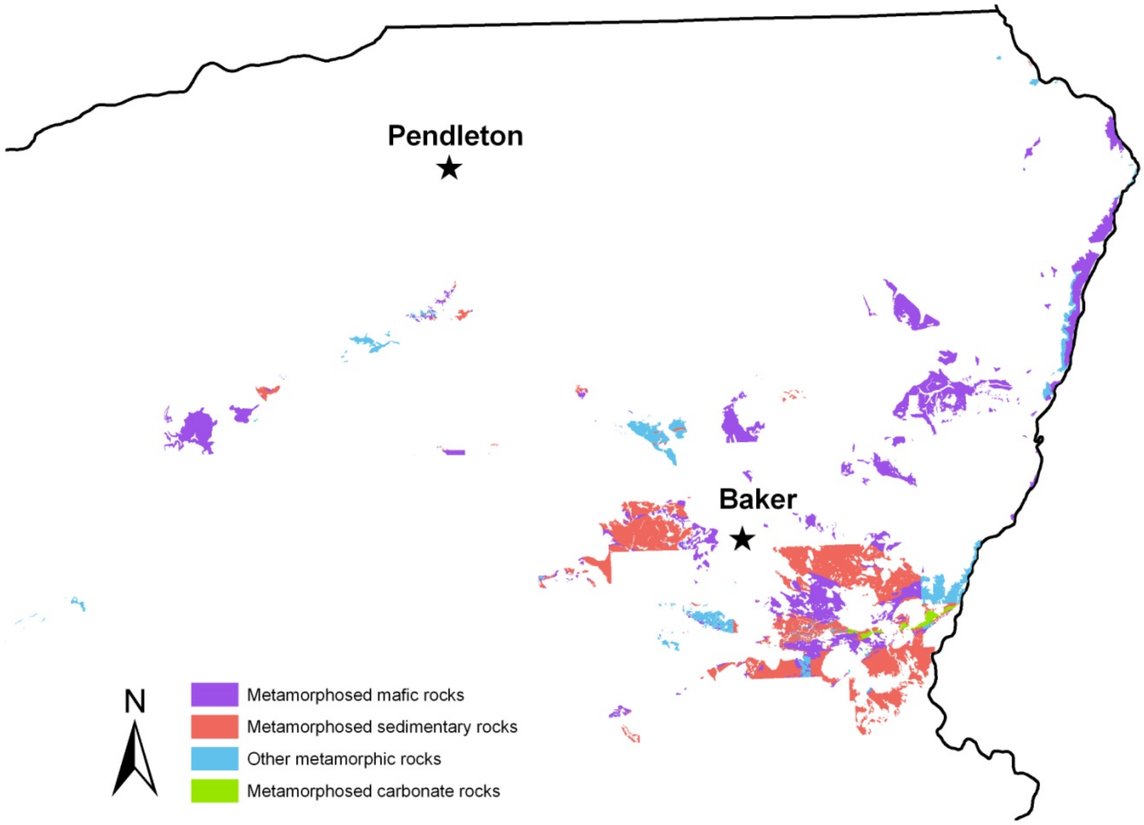
These sedimentary rocks not only encompass variability in how they were mapped, but are also not predictable from a forest nutrition standpoint. Weathering potential ranges from high (basaltic volcaniclastics) to low (rhyolitic tuffs). Nutritional value depends on the composition, size and degree of lithification of the sedimentary materials. Sites with a greater variety of size classes and rock compositions will likely support more productive forest stands than those with a homogenous mix of materials. Because of the large degree of variability encompassed by undifferentiated sedimentary deposits and volcaniclastic materials, site visits are highly recommended to evaluate soil depth and productivity potential prior to selecting nutrient management strategies.

Recommended Nutrient Management Strategies:

- Poor quality site (poor soil development, poor tree growth): Treat as sandstones and carbonate rocks (above)
- Better quality site: Treat as for mudstone-claystone-siltstone (above)

Major Unit: Metamorphic Rocks

Figure 9. Metamorphic rocks in the northeastern Oregon region.



Overview: Metamorphic rocks occupy about 5% of the IFTNC's NE OR region (Fig. 4). These rocks are challenging to classify from a geology-forest nutrition standpoint because they are so diverse in origin. Metamorphic map units often contain mixed lithologies resulting from variation in original composition, reflecting sedimentary and/or igneous origins. Further to this, different geologists working in a particular area may categorize these rocks somewhat differently, leading to some discontinuity in map units. An even further degree of complexity is introduced in northeast Oregon because of the volcanic activity associated with the Columbia River Basalt flows, which provided the heat and pressure to metamorphose surrounding regional rocks. Broadly speaking, metamorphic rocks are classified by their texture, which in turn is related to the degree of pressure and temperature changes (e.g. metamorphism) that they have undergone, or by composition. Some are weakly metamorphosed (low-grade metamorphic) rocks such as argillite and siltite. Strongly metamorphosed (high-grade metamorphic) rocks include schist, gneiss and serpentinite. If the original (or parent) rock is known, that may be referred to in the lithology description. Metamorphic rocks are sometimes further described by color, with 'mafic' referring to dark-colored rocks. Metamorphic rocks in northestern Oregon were divided into four minor units based on color and/or composition of the parent rock (Table 5). At the moment, we do not have strong fertilization recommendations for many metamorphic rocks largely because we don't have a significant number of trials on these rock types. This is particularly true for the suspected 'bad' rocks, as we were unlikely to establish research plots in the associated poor-quality stands. We do, however, have some theories based on observation of weathering characteristics of these rocks that helped guide our selection of nutrient management guidelines.

Table 5. Land area by Minor and Lithology Unit within IFTNC Metamorphic Rocks category in the northeastern Oregon region.

IFTNC Minor Unit	*IFTNC Lithology Unit*	*Proportion of Metamorphic Rocks*
Metamorphosed mafic rocks	greenstone	32.3%
	other mafic/ultramafic rocks	11.2%
	serpentinite	0.7%
Metamorphosed sedimentary rocks	siltite-argillite	29.5%
	metasedimentary rocks	12.9%
	quartzite	0.0%
Other metamorphosed rocks	metamorphosed mixed rocks	11.9%
	schist-gneiss	0.3%
Metamorphosed carbonate rocks	marble	1.2%

Rock Descriptions

Metamorphosed mafic rocks

Metamorphosed mafic rocks and those containing green minerals such as chlorite and epidote were assigned the '***metamorphosed mafic rock***' minor unit, and together comprise over 40% of the Metamorphic rocks in the northeastern Oregon region (Table 5). This group is dominated by greenstone, but also includes the more highly metamorphosed serpentenite, and a variety of map units consisting of other mafic/ultramafic rocks, often containing some combination of greenstone, serpentine, and metamorphosed plutonic rocks such as amphibolites, gabbro and/or diorite. Some of the map units that were categorized as greenstone may be mixed with other lithologies as well. Greenstones were conservatively treated as 'bad' rocks in this report, though they are thought to be good nutrient sources in the moist, acidic climate of the northeastern United States. While serpentenites did not comprise a large part of the area, they were recognized separately because of concerns that they develop into soils that are low in plant nutrients and potentially high in toxic metals. Ultramafic rocks are dark-colored rocks consisting principally of high amounts of pyroxene or olivine and little or no quartz. Despite a somewhat high weathering potential (WPI: Ultramafics 48.7), the mono-mineralic nature of these rocks results in poor weatherability in the field, where they appear as massive and relatively slow-weathering rocks, often in outcrops which don't weather as easily as surrounding rocks. Ultramafic rocks are localized in occurrence in northeastern Oregon. In our experience, ultramafic rocks and others comprising dikes and sills don't tend to support good tree growth, and forest stands on those rocks may be particularly susceptible to harboring forest insect populations during endemic years (Garrison-Johnston et al. 2003).

Metamorphosed sedimentary rocks

Argillite and siltite were jointly assigned to a siltite-argillite lithology unit, and comprise 29.5% of the metamorphic rocks in the IFTNC's northeastern Oregon region (Table 5). Most of these are argillites. Siltites and argillites are low-grade metasedimentary rocks, meaning that the original 'parent' rock is usually still distinguishable. Argillites originated from claystones, are somewhat 'silky' in appearance and texture, have indistinguishable grains, and can be scratched sometimes with a fingernail and more easily with a knife. Argillites have a somewhat low weathering susceptibility (WPI: Argillite 8.0), and are likely to weather to flat, sharp-edged plates and form very shallow soils, particularly on steeper slopes. Siltites originated from siltstones, and are slightly coarser-grained than argillites, and can also be scratched with a knife, but with more difficulty than argillite (WPI: Siltite 9.0). In our experience, some argillites have a high K content, but little else in the way of nutrients. Site visits to validate soil depth and forest stand conditions are recommended.

Quartzites originate from sandstone and contain sand-sized grains mostly of quartz, and cannot be scratched with a knife. Our current categorization for northeastern Oregon rocks indicates that there are very few quartzites in this region, so this category is not as of much concern here as elsewhere. Quartzites in particular are very low in nutrients, containing mostly quartz sand (WPI: Quartzite 4.2). These rocks are conservatively rated as very low weathering potential and very bad rocks for tree growth. Pending further research data, we recommend a field check to verify the productivity potential of stands on sites mapped as quartzite.

Undifferentiated metasedimentary rocks may include any of the above, but sufficient information to further categorize them was not available. Because of this uncertainty, rocks in this map unit should be field-verified and stand conditions evaluated.

Other metamorphosed rocks

This lithology unit is dominated by metamorphosed mixed rocks on the Oregon digital geology layer, and includes a variety of rocks subjected to some subsequent metamorphic event, such as heat and pressure associated with the Columbia River basalt flows. These rocks can be difficult to classify because of the mixed igneous, sedimentary and/or metamorphic nature of the parent rocks and the processes that have acted on them over time. Because of the mixed and altered nature of many of the map units in this category, we consider them too variable to assign a weathering characteristic. Stands on these rocks should be field-verified and evaluated on a site by site basis.

This lithology unit also includes schists and gneisses, both considered high-grade metamorphic rocks. High-grade metamorphic rocks underwent strong pressure and/or temperature changes. Because of this high degree of metamorphism, the parent rock is often very difficult to distinguish. Schists usually contain aligned layers of mica, leading to a fine-layered appearance and platy breakage patterns, and are most often felsic in coloration. Gneisses are coarser and less friable rocks, with grain sizes of several millimeters, and usually contain alternating light and dark bands of felsic and mafic minerals. Some breccia units were grouped with gneisses and schists because a high degree of metamorphism was associated with these otherwise normally volcanic rocks. The rocks in the 'schist-gneiss' minor unit may refer to either sedimentary- or igneous-origin, mafic or felsic rocks. Schists and gneisses usually contain quartz, potassium feldspar and plagioclase feldspar, along with mica and/or hornblende (WPI: Schist 8.3, Gneiss 9.1).

Metamorphosed carbonate rocks

The carbonate rocks include limestone (calcium carbonate) and dolomite (calcium-magnesium carbonate), and in unaltered (non-metamorphosed) state are considered to be sedimentary rocks. For a carbonate rock to be included in the metamorphic category of this report, some heating and/or apparent alteration must have occurred. In northeastern Oregon, marble (metamorphosed limestone or dolomite) dominates the metarmorphosed carbonate rock category. Based on our experience with fertilization research trials, metamorphosed carbonate rocks are considered poor candidates for tree growth and fertilization, likely because of the mono-mineralic nature of the rock (and therefore limited nutrient diversity), despite having a high theoretical weathering rate (WPI: marble=46.8). In practice, rock weathering does not appear to be particularly high for marbles in the interior northwest, probably because of the relatively dry environment and generally neutral acidity of regional precipitation. While ash cap presence may lead to improved productivity on carbonate-bearing metasedimentary rocks, ash cap does not seem to have a marked effect on N fertilization response.

Nutrient management recommendations

Medium: Siltite-argillite, schist-gneiss, metasedimentary rocks

Rocks in this category are expected to form fine sandy or loamy soils, and often contain colluvial and residual cobbles. Soil particles will be largely composed of quartz, muscovite and feldspars. Moisture and nutrient-holding capacity are thought to be low. Site productivity is likely to be low to moderate, though an overlying ash cap may boost productivity if present. Field examination should be performed to assess soil depth, ash presence and stand performance. Extensive whole-tree removals are discouraged, as they may run the risk of depleting some of the limited nutrients available on these sites.

- Expected Soil Development: Moderate to deep sandy to loamy soils, cobbles may be present
- Expected Nutrient Status: Low to Moderate; better if ash present
- Ash Effect: Slight improvement in productivity with ash presence, but ash has no apparent effect on fertilization response.
- Recommended Nutrient Management Strategies:
    - Thinning: bole-only recommended
    - Regeneration Harvest: bole-only recommended
    - Species Selection: select for moderate to low nutrient-demanding species
- Expected Fertilization Response: Moderate. On poor sites, response may be relatively good when compared to the poor growth rates of unfertilized trees. Consider economic feasibility of return if objectives are financially-based.
- Fertilizer Recommendation:
    - Recommended only for grand fir or moister vegetation series

    - Recommended minimum formulation is NK, but consider S and B as well
    - Recommended for multinutrient (w/micronutrient) screening trials.

Bad: Metamorphosed mafic rocks, metamorphosed carbonate rocks (marble), quartzite

These rocks are not expected to support productive softwood stands. If a site shows deep soils and supports a healthy and productive forest stand, refer to prior recommendations for 'medium' metamorphic rocks. Otherwise, consider these as bad rocks, and follow conservative nutrient management strategies.

- Expected Soil Development: Poor
- Expected Nutrient Status: Poor
- Ash Effect: None noted. We have few research sites on these rock types, except for some feldspathic quartzites (not commonly noted in northeastern Oregon), which may behave similarly to siltite and argillite in terms of ash effect.
- Recommended Nutrient Management Strategies:
    - Thinning: bole-only recommended
    - Regeneration Harvest: bole-only recommended
    - Species Selection: select for low nutrient-demanding species
- Expected Fertilization Response: May be significant in comparison to the low, unfertilized growth rates on these rock types; may not be economically desirable
- Fertilizer Recommendation:
    - If objectives are economic: Not recommended
    - If objectives are health- and productivity-related: Optional, NKSB recommended on grand fir or moister vegetation series only.
    - Rationale: We have not yet determined an appropriate fertilization regime to counter the "bad-rock" effect, though it will almost certainly involve various macro- and micro-nutrients besides N and K. The cost of these additional elements is not likely to justify their use, particularly if the cost must be carried over a number of years. The application of NK *may* reduce mortality in some cases; however, our understanding of when and why mortality may be affected is not yet clear. Consultation with IFTNC staff would be appropriate.

Variable: Metamorphosed mixed rocks

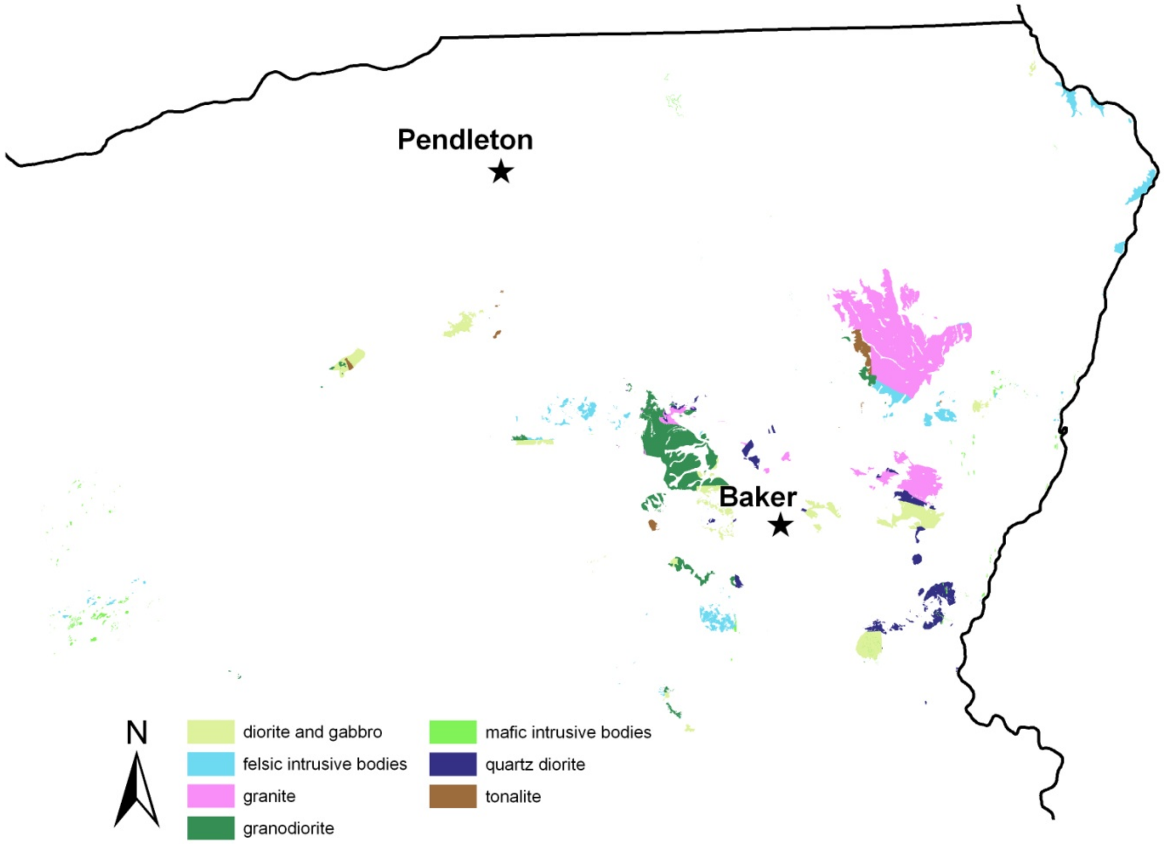
Because of the high degree of variability encompassed by rocks classified as 'metamorphosed mixed rocks,' site visits are highly recommended to evaluate soil depth and productivity potential prior to selecting nutrient management strategies.

Recommended Nutrient Management Strategies:

- Poor quality site (poor soil development, poor tree growth): Treat as for metamorphosed/mafic rocks (above)
- Better quality site: Treat as for siltite-argillite and other metasedimentary rocks (above)

Major Unit: Intrusive Rocks

Figure 10. Intrusive rocks in the Northeastern Oregon region.



Minor Units

- **Felsic Intrusive Rocks**
- **Mafic Intrusive Rocks**

Overview: Intrusive rocks are relatively uncommon in northeastern Oregon, underlying only about 4% of the IFTNC's work region (Fig. 4). Intrusive rocks form when magma cools inside the earth's crust. Because of the associated slow cooling process, intrusive rocks form large grains which are usually visible in a hand sample. Granites are the most common example of intrusive rocks. Felsic intrusive rocks are dominated by silicate minerals and tend to occur in relatively large bodies. Mafic rocks tend to be dark, heavy, silicon-poor rocks that occur in dikes, sills and other smaller, localized bodies. Within the IFTNC's NE OR region, intrusive rocks occur mostly in two large, felsic bodies: The Bald Mountain Batholith, located to the northwest of Baker, and the Wallowa Batholith, near LaGrande. Several mafic bodies occur in the vicinity of Baker, and a few other small intrusive bodies are scattered throughout the region.

Table 6. Land area proportions by lithology units within IFTNC Intrusive Rocks category in the northeastern Oregon region.

Felsic intrusive rocks	Proportion of Intrusive rocks
granite	41.4%
granodiorite	19.0%
felsic intrusive bodies	10.9%
tonalite	2.4%
Mafic intrusive rocks	
diorite and gabbro	15.8%
quartz diorite	8.1%
mafic intrusive bodies	2.4%

Rock Descriptions

Felsic Intrusive Rocks

About three-quarters of the rocks mapped in the IFTNC's northeastern Oregon region are felsic (Table 6). Granite contains mostly quartz and potassium feldspar, with some plagioclase feldspar, and very few dark minerals. Those granites that are dominated by potassium feldspars may be pinkish in appearance. Weathering susceptibility of these rocks is rather low (WPI: 'Pink' granite 8.6). Granodiorite and tonalite contain primarily quartz and plagioclase (non-potassium) feldspar, with some potassium feldspar and an abundance of dark minerals. They will probably be grayish in color or have a salt-and-pepper appearance. Tonalite will have more plagioclase feldspar than granodiorite, but otherwise will be difficult to distinguish from granodiorite in the field. Weathering susceptibility of these rocks is somewhat higher than the potassium feldspar-dominated 'pink' granites (WPI: Granite 10.3, Granodiorite 11.4, Tonalite 14.6). In general, granitic rocks weather to coarse, well-drained soils with low water-holding and low nutrient-holding capacity. Soil particles will be largely composed of quartz, feldspars and mica. Clay content and cation exchange capacity (CEC) of granitic soils are expected to be low. One of the black minerals often contained in granites is biotite, a K-bearing mica. Biotite expands when it weathers, which contributes to a faster breakdown of the granite. Another dark mineral commonly found in granites is hornblende. Hornblende does not have the same weathering properties as biotite, and is not a major K source. In a hand sample, biotite appears very shiny and breaks easily into sheets. Hornblende is blocky, not as sparkly in the sun, and does not break into sheets.

A few of the felsic intrusive rocks mapped in the northeastern Oregon region are classified as felsic intrusive bodies. This category includes any dikes or sills mapped as intrusive, as well as stocks, plutons and other similar intrusions. While dikes and sills are usually narrow bodies occupying crevices in the earth's crust, stocks tend to be somewhat more irregular in shape, and are likely to be larger than dikes or sills. The term pluton can be applied to a variety of intrusive bodies, including dikes, sills and stocks, and may also refer to groupings of intrusive bodies. We have conservatively classified felsic intrusive bodies as 'bad' rocks because of the slow weathering rates and potential health issues that are associated with dikes and sills. However, *site visits and individual stand assessment are highly recommended for stands on* *rocks in this category*. Many are noted as being of granitic, granodioritic, quartz monzonitic or other felsic intrusive composition. If the soils are well-formed and the forest stand is healthy and relatively productive, then the underlying rock should be upgraded to 'medium.'

Mafic Intrusive Rocks

Mafic, or dark-colored, intrusive rocks comprise about one-fourth of the intrusive rocks in the IFTNC's northeastern Oregon region. Quartz diorite is the intrusive equivalent of andesite, while diorite and gabbro are the intrusive equivalents of basalt. Very few mafic intrusive bodies occur in the mapping area, but should be treated the same as felsic intrusive bodies (see prior section). Because of the similarity in chemical composition, weathering potential of these rocks is also similar to their extrusive equivalents (WPI: Quartz diorite 17.9, Diorite 22.4). Field checks are recommended prior to assigning any nutrient management prescriptive measures.

Nutrient management recommendations

Medium: All intrusive rocks except intrusive bodies, diorite, and gabbro

Granitic rocks are generally considered 'medium' for tree growth, and conservative nutrient management strategies are recommended. Whole-tree removals on these rock types may run the risk of depleting some of the limited nutrients available on these sites. Generally, moderate to poor results have been obtained through fertilization with N-only on intrusive rock types. The addition of K to the blend is expected to give a better response than N alone, especially on the felsic intrusives. Multinutrient fertilization is an option; however, fertilization screening trials would be recommended to evaluate the potential response and cost-effectiveness of such an operation, in conjunction with growth response studies. Field evaluation of sites mapped as syenite is recommended before proceeding with nutrient management planning.

- Expected Soil Development: Moderate to deep coarse soils
- Expected Nutrient Status: Moderate (slightly better for mafic)
- Ash Effect: Slight improvement in productivity with ash presence, but no observed effect on fertilization response
- Recommended Nutrient Management Strategies:
  - Thinning: bole-only recommended, but whole-tree may be OK for thinning from below, especially on mafics
  - Regeneration Harvest: bole-only recommended
  - Species Selection: select for moderate to low nutrient-demanding species
- Expected Fertilization Response: Moderate . Ash presence does not seem to affect response. On lower-productivity sites, even a low response may be of some value relative to the poor growth rates of unfertilized trees. Balance economic feasibility of return with management objectives.
- Fertilizer Recommendation:
  - All: Recommend grand fir or moister vegetation series.
  - Felsic intrusive rocks: Do not fertilize with N-only. A minimum formulation of NK is recommended. Observation suggests that NKSB may be preferred.

    - Mafic intrusive rocks: N-only or NSB might be acceptable if rock contains biotite. Otherwise NK or NKSB is recommended.
    - Syenite and anorthosite: Unknown response, no recommendation at this time
    - Possible multi-nutrient blend candidates -- recommend screening trials.

Bad: Intrusive bodies, diorite, and gabbro

These rocks are considered to be poor candidates for fertilization. Conservative nutrient management practices should be followed.

- Expected Soil Development: Poor
- Expected Nutrient Status: Poor
- Ash Effect: None noted.
- Recommended Nutrient Management Strategies:
    - Thinning: bole-only
    - Regeneration Harvest: bole-only
    - Species Selection: select for low nutrient-demanding species
- Expected Fertilization Response: Unknown
- Fertilizer Recommendation:
    - If objectives are economic: Not recommended
    - If objectives are health- and productivity-related: Optional, grand fir or moister site types only.
    - Rationale: We have not yet determined an appropriate fertilization regime to counter the “bad-rock” effect, though it will almost certainly involve various macro- and micro-nutrients besides N and K. The cost of these additional elements is not likely to justify their use, particularly if the cost must be carried over a number of years. The application of NK *may* reduce mortality in some cases; however, our understanding of when and why mortality may be affected is not yet clear. Consultation with IFTNC staff would be appropriate.

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Appendices

Appendix A: Quick Reference

Major Unit	***Minor Unit***	***Weathering susceptibility***	***Tree value***	***Ash effect on growth rate***	***Ash effect on fertilization response***
Extrusive and subvolcanic rocks	Felsic extrusive/subvolcanic rocks	medium	bad	no change	no difference
	Mafic extrusive/subvolcanic rocks	high	good (basalt, gentle slope) to bad (andesite, mafic dikes & sills)	better (moist) to no change (dry)	better
Intrusive rocks	Felsic intrusive rocks	medium	medium (most) to bad (pegmatite, felsic intrusive bodies, syenite)	slightly better	no change
	Mafic intrusive rocks	high	medium (quartz diorite) to bad (everything else)	slightly better (most) to no information (mafic int. bodies)	no change
Metamorphic rocks	Metamorphosed mafic rocks	medium (greenstone) to bad (ultramafic)	bad	better	no change
	Metamorphosed carbonate rocks	medium	bad	no information	no information
	Metamorphosed mixed rocks	variable	variable	better	no change
	Metamorphosed sedimentary rocks	medium (most) to very low (quartzite)	medium (most) to bad (quartzite)	no information	no information

Appendix A Quick Reference Continued:

Major Unit	Minor Unit	Weathering susceptibility	Tree value	Ash effect on growth rate	Ash effect on fertilization response
Sedimentary rocks	Carbonate rocks	medium	bad	no information	no information
	Conglomerate	low	bad	no information	no information
	Mixed volcanic/volcaniclastic rocks	medium	variable	no information	no information
	Mudstone-claystone-siltstone	medium	medium	no information	no information
	Sedimentary rocks	variable	variable	no information	no information
	Sandstone	low	bad	no information	no information
Unconsolidated deposits	Glacial till (alpine)	medium	variable	slightly better	better
	Lake deposits	medium	medium	slightly better	better
	Landslide deposits	medium	variable	slightly better	better
	Loess deposits	low	medium to bad	slightly better	better
	Older sediments	high	variable	better	better
	Other deposits (saprolite)	not evaluated	not evaluated	no information	no information
	Stream deposits	low	medium (alluvial) to bad (glaciofluvial)	slightly better	better

Appendix B: Description of dBase Lookup Table

Introduction: The dBASE file entitled *NEOR_Lith_IFTNC2010_Lookup.dbf* is intended to supplement the report "*Northeast Oregon IFTNC Nutrition Guidelines By Rock Type: Nutrition guidelines for use in conjunction with digital geology for Oregon*" produced by the Intermountain Forest Tree Nutrition Cooperative at the University of Idaho in March of 2010.

Digitial geology for northeastern Oregon: Digitial geology for the northeastern Oregon region was obtained directly from the Oregon Department of Geology and Mining Industries (DOGAMI). Our contact person is Mark Ferns with DOGAMI, currently based out of the Baker County courthouse (mark.ferns@dogami.state.or.us).

Northeastern Oregon Region: This report was produced for the IFTNC's northeastern Oregon region. The accompanying shapefile (**IFTNC_NEOR_Region.shp**; projected coordinate system *NAD 1983 State Plane Oregon North FIPS 3601 Feet*) may be used to clip this region from the larger digital geology region provided by DOGAMI.

Electronic Table Description: The dBASE file entitled *NEOR_Lith_IFTNC2010_Lookup.dbf* was derived using the attribute table that accompanied the digital geology obtained from DOGAMI. The dBASE file may be merged directly with this attribute table by joining on the 'LITH_M_U_L' column. The file contains a lookup table that includes six new fields: '*IFTNC_Check*', '*Major_Unit,*' '*Minor_Unit*', '*IFTNC_Lithology,*' '*Weathering_Susceptibility*' and '*Tree_Value*'.

Because of disparities in the assignment of digital geologic map units to the LITH_M_U_L category, the '*IFTNC_Check*' field was created for use with the DOGAMI digital geology. If this column reads 'no' for a particular unit, then we are comfortable that the IFTNC categorization scheme can be applied to this unit. If the column reads 'yes,' then the LITH_M_U_L assignment included very different rock types. In this case, the IFTNC categorization was applied based on the lithology with the greatest acreage, and Appendix D may be referred to for further guidance on how to treat rocks in this unit.

Hard-copy Lookup Table Description: An abbreviated hard-copy version of the lookup table (Appendix C) is arranged alphabetically by LITH_M_U_L. This table includes the map unit code, followed by the IFTNC-assigned classifications of '*IFTNC_Check*', '*Major_Unit,*' '*Minor_Unit*', '*IFTNC_Lithology,*' '*Weathering_Susceptibility*' and '*Tree_Value*' ratings, respectively. For discussion of nutrient management recommendations, refer to the relevant section in the main text of this report.

Appendix C: Lookup Table

LITH_M_U_L	IFTNC _CHCK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHERING	TREE_ VALUE
flw.AND.Lnd.Cc.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND.Lnd.Cf.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND.Lnd.Cf.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND.Lnd.Cmix.Ebrcjnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND.Lnd.Cmix.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND.Lnd.Cmix.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND.Lnd.Cnd.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND.Lnd.Cnd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND.Lnd.Cvf_f.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND.Lnd.Cvfc.Efrcjnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND.Ltc.Cnd.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND_BAS.Lma.Csd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND_BND.Lnd.Cmix.Esd	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND_BND.Lnd.Csd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND_BND.Lnd.Cvf.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND_DAC.Lma.Cmix.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND_DAC.Lnd.Csd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND_DAC.Lnd.Cvf.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.AND_TAT.Lflb.Cvff.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.BAS.Lflb.Cvf.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lma.Cf.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lma.Cnd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cc.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cf.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cf_m.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cf_m.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cm_c.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cmix.Efrc	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cmix.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cmix.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cnd.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cnd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good

LITH_M_U_L	IFTNC _CHCK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHERING	TREE_ VALUE
flw.BAS.Lnd.Cnd.End.	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Csd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cvf.Efrc	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cvf.Efrcjnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cvf.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cvf.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cvff.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lnd.Cvff.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lsd.Cnd.Ebrc	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lsd.Cnd.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lsd.Cnd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lsd.Csd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lsd.Cvff.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Ltc.Cvff.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lth.Cf_m.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lth.Cm.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lth.Cmix.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lth.Cnd.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lth.Cnd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lth.Cvf.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS.Lth_me.Cf_m.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS_BND.Lma.Cmix.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS_BND.Lnd.Cf.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS_BND.Lnd.Cm_c.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS_BND.Lnd.Cmix.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS_BND.Lnd.Cvf.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS_BND.Lth.Cnd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS_BTA.Lnd.Cnd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BAS_RHY.Lma.Cmix.End	no	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
flw.BND.Lnd.Cf.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BND.Lnd.Cf_m.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BND.Lnd.Cmix.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BND.Lnd.Cnd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BND.Lnd.Csd.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BND.Lnd.Cvf.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
flw.BND_TBT.Lds.Cvf.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BST_TBT.Lnd.Cnd.Efrc	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BTA.Lflb.Cmix.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.BTA_TAN.Lnd.Cnd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.DAC.Lnd.Cnd.Efrcjnt	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	dacite	medium	bad
flw.DAC.Lnd.Cnd.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	dacite	medium	bad
flw.DAC.Lnd.Cvf.Efrc	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	dacite	medium	bad
flw.DAC.Lnd.Cvf.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	dacite	medium	bad
flw.DAC.Lnd.Cvfc.Ejnt	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	dacite	medium	bad
flw.DAC.Lsd.Cvf.Ejnt	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	dacite	medium	bad
flw.DAC_RHY.Lnd.Cnd.Ejnt	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	dacite	medium	bad
flw.DAC_RYD.Lnd.Cmix.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	dacite	medium	bad
flw.FAN.Lnd.Cvf.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.FAN.Lsd.Cvf.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
flw.FEL.Lnd.Cnd.Ebrc	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.KER.Lma.Cmix.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
flw.MIX.Lnd.Cf.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.MIX.Lnd.Cf_m.Ejnt	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.MIX.Lnd.Cnd.Ejnt	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.MIX.Lnd.Cnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.MIX.Lnd.Csd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.MIX.Lnd.Cvf.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.MIX.Lnd.Cvf_f.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.MIX.Lplt.Cmix.Efrcjnt	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.MIX.Lsd.Cnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.MIX.Lsd.Csd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.MIX.Lsd.Csd.Esd	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.RHY.Lflb.Cmix.Ejnt	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
flw.RHY.Lflb.Csd.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
flw.RHY.Lma.Cnd.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
flw.RHY.Lma.Cvf.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
flw.RHY.Lnd.Cmix.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
flw.RHY.Lnd.Cnd.Ebrc	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
flw.RHY.Lnd.Cnd.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
flw.RHY_RYD.Lflb.Cnd.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
flw.RYD.Lflb.Cnd.Ebrcfrc	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
flw.RYD.Lnd.Cnd.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
flw.RYD.Lnd.Cvf_f.Ejnt	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
flw.TBT.Lnd.Cvf.Esd	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
flw.VIT.Lflb.Cnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
flw.VIT.Lnd.Cnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
intr.AND.Lnd.Cmix.Efrcjnt	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.AND.Lnd.Cmix.Ejnt	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.AND.Lnd.Cnd.Ejnt	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.AND.Lnd.Cnd.End	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.AND.Lnd.Cvf.End	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.AND_BAS.Lnd.Cmix.End	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.AND_BND.Lnd.Cmix.End	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.AND_BND.Lnd.Cvf.End	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.AND_DAC.Lnd.Cc.Esd	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.AND_DAC.Lnd.Cmix.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.AND_DAC.Lnd.Cnd.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.APL_GRT.Lnd.Cfm.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.BAS.Lnd.Cc.End	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.BAS.Lnd.Cf_m.Ejnt	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.BAS.Lnd.Cmix.Ejnt	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.BAS.Lnd.Cmix.End	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.BAS.Lnd.Cnd.Ejnt	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.BAS.Lnd.Cnd.End	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.BAS_BND.Lnd.Cnd.Ejnt	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.BAS_BND.Lnd.Cvf.End	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.BND.Lnd.Cnd.End	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.BND.Lnd.Cvf.Efrcjnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
intr.BND.Lnd.Cvf.Ejnt	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.BXA.Lnd.Cvf.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
intr.DAC.Lnd.Cm_c.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.DAC_RHY.Lnd.Cmix.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	dacite	medium	bad
intr.DAC_RHY.Lnd.Cnd.Esd	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.FAN.Lnd.Cvf.Ejnt	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
intr.GDT.Lnd.Cf_m.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.GDT.Lnd.Cmix.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.GDT.Lnd.Cnd.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.GDT.Lpo.Cmix.Ejnt	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.LMP.Lnd.Cmix.End	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
intr.MIX.Lma.Csd.Ejnt	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.MIX.Lnd.Cmix.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.MIX.Lnd.Cnd.Ejnt	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.MIX.Lnd.Cnd.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.RHY.Lla.Cnd.Ejnt	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.RHY.Lla.Cvf.Ejnt	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.RHY.Lla_ma.Cnd.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
intr.RHY.Lnd.Cmix.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
intr.RHY.Lnd.Cnd.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.RHY.Lnd.Cvf.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intr.RYD.Lnd.Cnd.Ejnt	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
intrm.SYN.Lnd.Cf.Eshd	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
ip.MIX.Lnd.Csd.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
ipm.MIX.Lnd.Cnd.End	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
isv.MIX.Lnd.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
isv.MIX.Lnd.CGsd.End	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
iv.AND_DAC.Lsd.CGmix.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
iv.BAS.Lnd.CGnd.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
iv.DAC_RHY.Lla.CGnd.Ejnt	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	dacite	medium	bad
iv.DAC_RHY.Lsd.CGsd.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	dacite	medium	bad
iv.MIX.Lnd.CGmix.Ejnt	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
iv.MIX.Lnd.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
iv.MIX.Lnd.CGsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
iv.RHY.Lnd.CGnd.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
met.AMP.Lgn.Cf.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
met.AMP.Lgn.Cnd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
met.AMP.Lsd.Cf_c.Edfm	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
met.AMP.Lsd.Cnd.Efrc	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
met.ARG_SLA.Lnd.Cnd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
met.GRN_GSC.Lma.Cnd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
met.GRN_GSC.Lsch.Cnd.Eclv	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
met.GRN_GSC.Lsch.Cnd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
met.GSC.Lsch.Cf.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
met.HRN.Lnd.Cnd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	metasedimentary rocks	medium	medium
met.MIX.Ldsth.Cnd.Emyl	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
met.MIX.Ldsth.Csd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	metasedimentary rocks	medium	medium
met.MIX.Lgnsch.Cnd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	metasedimentary rocks	medium	medium
met.MIX.Lnd.Cnd.End	yes	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
met.MIX.Lsd.Cnd.Emix	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
met.MIX.Lsd.Csd.End	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
met.MIX.Lthma.Cnd.End	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
met.MRB.Lma.Cnd.Eclv	no	Metamorphic rocks	Metamorphosed carbonate rocks	marble	medium	bad
met.MRB.Lmix.Cf.Eclv	no	Metamorphic rocks	Metamorphosed carbonate rocks	marble	medium	bad
met.MRB.Lnd.Cc.Ejnt	no	Metamorphic rocks	Metamorphosed carbonate rocks	marble	medium	bad
met.MRB.Lnd.Cc.Eshd	no	Metamorphic rocks	Metamorphosed carbonate rocks	marble	medium	bad
met.MRB.Lnd.Cnd.Efrc	no	Metamorphic rocks	Metamorphosed carbonate rocks	marble	medium	bad
met.MRB.Lnd.Cnd.Emix	no	Metamorphic rocks	Metamorphosed carbonate rocks	marble	medium	bad
met.MRB_PHY.Lth_ma.Cf.End	no	Metamorphic rocks	Metamorphosed carbonate rocks	marble	medium	bad
met.PHY.Lnd.Cnd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
met.PHY.Lsd.Csd.Esd	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
met.PHY_QZT.Lnd.Cnd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
met.PHY_QZT.Lnd.Cnd.Esd	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
met.PHY_QZT.Lsch.Cnd.Edfm	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
met.PHY_SCH.Lma.Cf.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
met.QZT.Lnd.Cf.Esd	no	Metamorphic rocks	Metamorphosed sedimentary rocks	quartzite	very low	very bad
met.QZT.Lnd.Cnd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	quartzite	very low	very bad
met.QZT_SCH.Lsd.Cf_c.Eclv	no	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
met.QZT_TLC.Lnd.Cc.Eshd	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
met.SCH.Lma.Cm_c.End	no	Metamorphic rocks	Other metamorphic rocks	schist-gneiss	medium	medium
met.SCH.Lsch.Cc.Eshd	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
met.SCH.Lsch.Cf.End	no	Metamorphic rocks	Other metamorphic rocks	schist-gneiss	medium	medium
met.SCH.Lsch.Cnd.End	no	Metamorphic rocks	Other metamorphic rocks	schist-gneiss	medium	medium
met.SCH.Lsch.Cnd.Eshd	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
met.SCH.Lsd.Cf_m.Eclv	no	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
mp.MIX.Lsd.Cnd.End	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
mps.MIX.Lsd.CGnd.End	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
msv.MIX.Lnd.CGnd.End	yes	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
plu.DRT.Lnd.Cf_m.Eclv	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plu.DRT.Lnd.Cm.End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plu.DRT.Lnd.Cm_c.End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plu.DRT.Lnd.Cmix.End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plu.DRT_QDT.Lnd.Cnd.End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plu.DRT_TNT.Lnd.Cm.End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plu.GBR.Lma.Cmix.End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plu.GBR.Lma.Cnd.End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plu.GBR.Lnd.Cm.End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plu.GBR.Lnd.Csd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plu.GBR_NRT.Lban.Cnd..End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plu.GBR_QDT.Lnd.Csd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plu.GDT.Lma.Cm.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.GDT.Lnd.Cc.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.GDT.Lnd.Cf_m.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.GDT.Lnd.Cm.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.GDT.Lnd.Cmix.Esd	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.GDT.Lnd.Cnd.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.GDT.Lnd.Cvf.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.GDT_QDT.Lnd.Cc.End	no	Intrusive rocks	Mafic intrusive rocks	quartz diorite	high	medium
plu.GDT_QDT.Lnd.Cf.End	no	Intrusive rocks	Mafic intrusive rocks	quartz diorite	high	medium
plu.GDT_QDT.Lnd.Cm.End	no	Intrusive rocks	Mafic intrusive rocks	quartz diorite	high	medium
plu.GDT_QDT.Lnd.Cm_c.End	no	Intrusive rocks	Mafic intrusive rocks	quartz diorite	high	medium
plu.GDT_QMZ.Lnd.Cc.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.GDT_TDJ.Lnd.Cf.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.GDT_TNT.Lnd.Cf_m.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.GDT_TNT.Lnd.Cm_c.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.GDT_TNT.Lnd.Cnd.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.GRT.Lnd.Cm.End	no	Intrusive rocks	Felsic intrusive rocks	granite	medium	medium
plu.GRT.Lnd.Cm_c.End	no	Intrusive rocks	Felsic intrusive rocks	granite	medium	medium
plu.GRT.Lnd.Cmix.End	no	Intrusive rocks	Felsic intrusive rocks	granite	medium	medium
plu.GRT.Lnd.Cnd.Ejnt	no	Intrusive rocks	Felsic intrusive rocks	granite	medium	medium
plu.GRT.Lnd.Cnd.End	no	Intrusive rocks	Felsic intrusive rocks	granite	medium	medium

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
plu.GRT_QDT.Lgn.Cnd.Emyl	no	Intrusive rocks	Felsic intrusive rocks	granite	medium	medium
plu.LMP.Lnd.Cmix.End	no	Intrusive rocks	Mafic intrusive rocks	mafic intrusive bodies	high	bad
plu.MIX.Lnd.Cf_m.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
plu.MIX.Lnd.Cmix.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.MIX.Lnd.Cnd.End	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
plu.MIX.Lnd.Cvf_c.Ejnt	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
plu.MZD.Lnd.Cc.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plu.NRT_TNT.Lnd.Cnd.End	no	Intrusive rocks	Felsic intrusive rocks	tonalite	medium	medium
plu.QDT.Lnd.Cf_m.End	no	Intrusive rocks	Mafic intrusive rocks	quartz diorite	high	medium
plu.QDT.Lnd.Cm.End	no	Intrusive rocks	Mafic intrusive rocks	quartz diorite	high	medium
plu.QDT.Lnd.Cm_c.End	no	Intrusive rocks	Mafic intrusive rocks	quartz diorite	high	medium
plu.QDT.Lnd.Cnd.End	no	Intrusive rocks	Mafic intrusive rocks	quartz diorite	high	medium
plu.QDT.Lsd.Cnd.End	no	Intrusive rocks	Mafic intrusive rocks	quartz diorite	high	medium
plu.TDJ.Lnd.Cm.End	no	Intrusive rocks	Felsic intrusive rocks	tonalite	medium	medium
plu.TDJ.Lnd.Cm_c.End	no	Intrusive rocks	Felsic intrusive rocks	tonalite	medium	medium
plu.TDJ.Lnd.Cnd.End	no	Intrusive rocks	Felsic intrusive rocks	tonalite	medium	medium
plu.TNT.Lnd.Cm_c.End	no	Intrusive rocks	Felsic intrusive rocks	tonalite	medium	medium
plu.TNT.Lnd.Cnd.End	no	Intrusive rocks	Felsic intrusive rocks	tonalite	medium	medium
plum.DRT.Lma.Cnd.Eshd	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plum.DRT.Lnd.Cm_c.End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plum.DRT.Lnd.Cnd.Ebrc	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plum.DRT.Lnd.Cnd.End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plum.DRT.Lsch.Cc.Ecat	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plum.DRT_GBR.Lnd.Cc.Edfm	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plum.DRT_GBR.Lsch.Cnd.Ecat	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plum.DRT_GBR.Lsd.Cc.End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plum.DRT_QDT.Lsch.Cm.Ecat	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plum.GBR.Lban.Cfc.Eshd	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plum.GBR.Lnd.Cc.Eshd	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plum.GBR.Lnd.Cf_m.End	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plum.GBR.Lnd.Cm.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plum.GBR.Lnd.Cnd.Edfm	no	Intrusive rocks	Mafic intrusive rocks	diorite and gabbro	high	bad
plum.GBR.Lnd.Cnd.Emylshd	no	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
plum.GBR.Lnd.Cnd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plum.GBR.Lnd.Cnd.Eshd	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
plum.GBR_SRP.Lsd.Cnd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
plum.GDT_TNT.Lnd.Cm.End	no	Intrusive rocks	Felsic intrusive rocks	granodiorite	medium	medium
plum.GRT.Lnd.Cc.Emylshd	no	Intrusive rocks	Felsic intrusive rocks	granite	medium	medium
plum.GRT.Lnd.Cf_c.Eshd	no	Intrusive rocks	Felsic intrusive rocks	granite	medium	medium
plum.GRT.Lnd.Cm.End	no	Intrusive rocks	Felsic intrusive rocks	granite	medium	medium
plum.MIX.Lnd.Cf_c.Edfm	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
plum.MIX.Lnd.Cnd.Eclvshd	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plum.MIX.Lnd.Cnd.Emylshd	no	Intrusive rocks	Felsic intrusive rocks	felsic intrusive bodies	medium	bad
plum.MIX.Lnd.Cnd.End	yes	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
plum.MIX.Lnd.Cvf.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plum.MIX.Lsch.Cmc.Ecat	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plum.QDT.Lgn.Cc.End	no	Intrusive rocks	Mafic intrusive rocks	quartz diorite	high	medium
plum.QDT.Lnd.Cm.End	no	Intrusive rocks	Mafic intrusive rocks	quartz diorite	high	medium
plum.QDT.Lnd.Cm_c.Ejnt	no	Intrusive rocks	Mafic intrusive rocks	quartz diorite	high	medium
plum.TDJ.Lnd.Cm.Edfm	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
plum.TNT.Lgn.Cm_c.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
psvm.GBR.GRN.Lnd.CGnd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
psvm.MIX.Lgn.CGnd.End	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
psvm.MIX.Lnd.CGnd.End	yes	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
pvm.BAS_GBR.Lnd.Csd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
sed.GVL.Lla.Gpeb_bou.Esd	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
sed.GVL.Lnd.Gnd.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
sed.MIX.Lla.Gnd.End	no	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
sed.MIX.Lnd.Gbou.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
sed.MIX.Lnd.Gcly_gvl.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
sed.MIX.Lnd.Ggvl.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
sed.MIX.Lnd.Gnd.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
sed.MIX.Lnd.Gslt_gvl.End	no	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
sed.MIX.Lsd.Gnd.End	no	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
sed.SHL.Lnd.Gcly.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.ARG.Lsd.Gsd.Emix	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
srx.ARG_CHT.Lla_th.Gnd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
srx.ARG_CHT.Lma.Gnd.Edfmshd	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
srx.ARG_CHT.Lnd.Gnd.Edfm	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
srx.ARG_CHT.Lnd.Gnd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
srx.ARG_CHT.Lsd.Gnd.Edfm	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
srx.ARG_CHT.Lsd.Gnd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
srx.ARG_CHT.Lsd.Gsd.Emix	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
srx.ARG_SDS.Lnd.Gnd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
srx.ARG_SDS.Lth_me.Gsd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
srx.ARG_STS.Lth.Gnd.Eclvfrc	no	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
srx.CGL.Lm_tc.Gsnd_gvl.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL.Lma.Gnd.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL.Lma.Gpeb.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL.Lnd.Gbou.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL.Lnd.Ggvl.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL.Lnd.Ggvl_bou.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL.Lnd.Gnd.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL.Lnd.Gsnd_gvl.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL.Lsd.Gnd.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL.Lsd.Gpeb_bou.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL.Ltc.Gslt_peb.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL_SDS.Lds.Gmix.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL_SDS.Lds.Gnd.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL_SDS.Lnd.Gnd.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL_SDS.Lnd.Gsltpeb.Efrcshd	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
srx.CGL_SDS.Lnd.Gsnd.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL_SDS.Lsd.Gmix.Esd	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL_SDS.Lsd.Gnd.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL_SDS.Lsd.Gsd.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL_SDS.Lth.Gsltpeb.Edfm	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL_SHL.Lnd.Gnd.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CGL_STS.Lnd.Gsd.End	no	Sedimentary rocks	Conglomerate	conglomerate	low	bad
srx.CHT.Lnd.Gnd.Ebrcfrc	no	Metamorphic rocks	Metamorphosed sedimentary rocks	metasedimentary rocks	medium	medium
srx.CLS.Lla_ma.Gnd.Efrc	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.CLS.Lnd.Gcly.Efrc	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.CLS.Lsd.Gnd.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.CLS.Lth_tc.Gnd.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.CLS_MDS.Lnd.Gnd.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
srx.LST.Ldstc.Gnd.Eshd	no	Sedimentary rocks	Carbonate rocks	limestone	medium	bad
srx.LST.Lla_ma.Gnd.Edfm	no	Sedimentary rocks	Carbonate rocks	limestone	medium	bad
srx.LST.Lnd.Gnd.End	no	Sedimentary rocks	Carbonate rocks	limestone	medium	bad
srx.LST.Lnd.Gslt_snd.End	no	Sedimentary rocks	Carbonate rocks	limestone	medium	bad
srx.LST.Lpo_ma.Gslt.End	no	Sedimentary rocks	Carbonate rocks	limestone	medium	bad
srx.LST.Lth_ma.Gnd.End	no	Sedimentary rocks	Carbonate rocks	limestone	medium	bad
srx.LST.Lth_ma.Gpeb.End	no	Sedimentary rocks	Carbonate rocks	limestone	medium	bad
srx.LST.Lth_tc.Gslt.End	no	Sedimentary rocks	Carbonate rocks	limestone	medium	bad
srx.LST_MDS.Lth_ma.Gnd.End	no	Sedimentary rocks	Carbonate rocks	limestone	medium	bad
srx.LST_SHL.Lnd.Gnd.Edfm	no	Sedimentary rocks	Carbonate rocks	limestone	medium	bad
srx.MDS.Lma.Gnd.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.MDS.Lmix.Gmix.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.MDS.Lnd.Gnd.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.MDS.Lth.Gnd.Efrc	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.MDS_SDS.Lnd.Gnd.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.MDS_STS.Lth.Gsd.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.MFB.Lnd.Gnd.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.MIX.Lds.Gmix.End	no	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
srx.MIX.Lla_ma.Gnd.End	no	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
srx.MIX.Lmix.Gmix.Esd	no	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
srx.MIX.Lnd.Gnd.Efrc	no	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
srx.MIX.Lnd.Gnd.End	yes	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
srx.MIX.Lnd.Gpeb.End	no	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
srx.MIX.Lnd.Gsd.End	no	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
srx.MIX.Lnd.Gsd.Eshd	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
srx.MIX.Lnd.Gslt_snd.End	no	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
srx.MIX.Lsd.Gmix.End	no	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
srx.MIX.Lsd.Gnd.End	yes	Sedimentary rocks	Carbonate rocks	limestone	medium	bad
srx.MIX.Lsd.Gsd.End	yes	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
srx.MIX.Ltc.Gcly.End	no	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
srx.SDS.Lla.Gslt_peb.End	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srx.SDS.Lnd.Gpeb.End	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srx.SDS.Lstr.Gnd.End	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srx.SDS.Ltc.Gslt_peb.End	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srx.SDS.Lth.Gnd.End	no	Sedimentary rocks	Sandstone	sandstone	low	bad

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
srx.SDS.Lth.Gpeb.End	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srx.SDS.Lth_ma.Gpeb.End	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srx.SDS.Lth_tc.Gnd.End	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srx.SDS_STS.Lmix.Gsd.End	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srx.SDS_STS.Lnd.Gnd.Efrc	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srx.SDS_STS.Lnd.Gnd.End	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srx.SDS_STS.Lnd.Gsd.End	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srx.SDS_STS.Lsd.Gsd.End	yes	Sedimentary rocks	Sandstone	sandstone	low	bad
srx.SHL_STS.Lnd.Gnd.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.STS.Lla.Gcly_slt.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srx.STS.Lnd.Gnd.End	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
srxm.LST.Lth_ma.CGnd.End	no	Metamorphic rocks	Metamorphosed carbonate rocks	marble	medium	bad
srxm.LST_MRB.Lnd.CGc.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	metasedimentary rocks	medium	medium
srxm.MIX.Lnd.CGnd.Eclv	no	Metamorphic rocks	Metamorphosed sedimentary rocks	metasedimentary rocks	medium	medium
srxm.MIX.Lnd.CGnd.Eclvshd	no	Metamorphic rocks	Metamorphosed sedimentary rocks	metasedimentary rocks	medium	medium
srxm.MIX.Lnd.CGnd.Edfm	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
srxm.MIX.Lnd.CGnd.End	no	Metamorphic rocks	Metamorphosed sedimentary rocks	metasedimentary rocks	medium	medium
srxm.MIX.Lnd.CGnd.Esd	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
srxm.MIX.Lnd.CGnd.Eshd	yes	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
srxm.MIX.Lnd.CGvf.Eshd	no	Metamorphic rocks	Metamorphosed sedimentary rocks	metasedimentary rocks	medium	medium
srxm.SDS.Lla_tc.CGslt_gvl.Eclvfrc	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srxm.SDS_STS.Lnd.CGnd.Eclvshd	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srxm.SDS_STS.Lnd.CGnd.End	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srxm.SDS_STS.Lpo.CGnd.Eclvshd	no	Sedimentary rocks	Sandstone	sandstone	low	bad
srxm.STS.Lds.CGnd.Eclvshd	no	Sedimentary rocks	Mudstone-claystone-siltstone	mudstone-claystone-siltstone	medium	medium
sv.BAS.Lnd.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.BXA_SDS.Lnd.CGsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.BXA_SDS.Lsd.Gpeb_bou.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.CLS_TFF.Lnd.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.LST_TFF.Lsd.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.MIX.Lds.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.MIX.Lgrd.CGsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.MIX.Lmix.CGmix.Emix	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
sv.MIX.Lmix.CGmix.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
sv.MIX.Lnd.CGmix.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
sv.MIX.Lnd.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.MIX.Lnd.CGsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.MIX.Lnd.CGsd.Esd	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.MIX.Lsd.CfGsnd_gvl.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.MIX.Lsd.CGmix.Esd	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.MIX.Lsd.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.MIX.Lsd.CGsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.MIX.Lsd.CGsd.Esd	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
sv.MIX.Lth.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.MIX.Lth_ma.CGsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.MIX.Lth_me.CGsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
sv.SDS_TFF.Lnd.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
svm.MIX.Lnd.CGsd.Efrc	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
svm.MIX.Lsd.CGmix.Ejnt	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
svm.MIX.Lsd.CGnd.Eclvdfm	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
svm.MIX.Lsd.CGnd.End	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
svm.MIX.Lsd.CGsd.End	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
umf.AMP_SRP.Lnd.Cnd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
umf.DUN_PRX.Lnd.Cc.End	no	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
umf.MIX.Lnd.Cm_c.End	no	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
umf.MIX.Lnd.Cnd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
umf.MIX.Lnd.Cnd.Eshd	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
umf.MIX.Lsd.Cnd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
umf.PDT.Lban.Cc.End	no	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
umf.PDT.Lnd.Csd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
umf.PDT_PRX.Lnd.Cc.Eshd	no	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
umf.SRP.Lma.Csd.Eshd	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
umf.SRP.Lnd.Cnd.Ebrc	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
umf.SRP.Lnd.Cnd.Edfmshd	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
umf.SRP.Lnd.Cnd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
umf.SRP.Lnd.Cnd.Eshd	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
umf.SRP.Lnd.Cvf.End	no	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
unc.ELN.Lnd.Gnd.End	no	Unconsolidated deposits	Loess deposits	loess deposits	low	medium
unc.ELN.Lnd.Gslt.End	no	Unconsolidated deposits	Loess deposits	loess deposits	low	medium
unc.ELN_FLV.Lnd.Gnd.End	no	Unconsolidated deposits	Loess deposits	loess deposits	low	medium

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
unc.ELN_FLV.Lnd.Gslt_gvl.End	no	Unconsolidated deposits	Loess deposits	loess deposits	low	medium
unc.ELN_GCL.Lpo.Gslt_gvl.End	no	Unconsolidated deposits	Loess deposits	loess deposits	low	medium
unc.ELN_LKE.Lnd.Gcly_slt.End	no	Unconsolidated deposits	Loess deposits	loess deposits	low	medium
unc.FLV.Lma_tc.Gcly_peb.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gbou.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gcly_bou.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gcly_gvl.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
unc.FLV.Lnd.Ggvl.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gmix.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gnd.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gpeb.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gsd.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gslt.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gslt_bou.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gslt_gvl.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
unc.FLV.Lnd.Gslt_peb.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gsnd_bou.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gsnd_gvl.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lnd.Gsndgvl.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lsd.Gcly_gvl.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lsd.Gnd.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV.Lsd.Gpeb_bou.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
unc.FLV.Lsd.Gsd.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
unc.FLV.Lsd.Gsltbou.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV_GCL.Lnd.Gmix.End	no	Unconsolidated deposits	Stream deposits	glaciofluvial deposits	low	bad
unc.FLV_GCL.Lnd.Gnd.End	no	Unconsolidated deposits	Stream deposits	glaciofluvial deposits	low	bad
unc.FLV_GCL.Lnd.Gsd.End	no	Unconsolidated deposits	Stream deposits	glaciofluvial deposits	low	bad
unc.FLV_GCL.Lnd.Gslt_gvl.End	no	Unconsolidated deposits	Stream deposits	glaciofluvial deposits	low	bad
unc.FLV_GRV.Lnd.Gnd.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.FLV_LKE.Lnd.Gcly_gvl.End	no	Unconsolidated deposits	Lake deposits	lake deposits	medium	medium
unc.FLV_LKE.Lnd.Gcly_snd.End	no	Unconsolidated deposits	Lake deposits	lake deposits	medium	medium
unc.FLV_LKE.Lnd.Gnd.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
unc.FLV_LKE.Lnd.Gslt_bou.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
unc.FLV_LKE.Lnd.Gslt_gvl.End	no	Unconsolidated deposits	Lake deposits	lake deposits	medium	medium
unc.FLV_LKE.Lnd.Gsnd_gvl.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
unc.FLV_LKE.Lth_tc.Gsnd_gvl.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
unc.FLV_LSD.Lnd.Gnd.End	no	Unconsolidated deposits	Landslide deposits	landslide deposits	medium	variable
unc.FLV_LSD.Lnd.Gslt_gvl.End	no	Unconsolidated deposits	Landslide deposits	landslide deposits	medium	variable
unc.GCL.Lnd.Gbou.End	no	Unconsolidated deposits	Glacial till	alpine glacial till	medium	variable
unc.GCL.Lnd.Gnd.End	no	Unconsolidated deposits	Glacial till	alpine glacial till	medium	variable
unc.GCL.Lnd.Gslt_bou.End	no	Unconsolidated deposits	Glacial till	alpine glacial till	medium	variable
unc.GCL_GRV.Lnd.Ggvl_bou.End	no	Unconsolidated deposits	Glacial till	alpine glacial till	medium	variable
unc.GRV.Lnd.Gcly_bou.End	no	Unconsolidated deposits	Glacial till	alpine glacial till	medium	variable
unc.GRV.Lnd.Ggvl_bou.End	no	Unconsolidated deposits	Glacial till	alpine glacial till	medium	variable
unc.GRV.Lnd.Gnd.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
unc.GRV.Lnd.Gpeb_bou.End	no	Unconsolidated deposits	Glacial till	alpine glacial till	medium	variable
unc.LKE.Lla.Gnd.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
unc.LKE.Lnd.Gslt.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
unc.LSD.Lnd.Gbou.End	no	Unconsolidated deposits	Landslide deposits	landslide deposits	medium	variable
unc.LSD.Lnd.Gnd.Edfmshd	no	Unconsolidated deposits	Landslide deposits	landslide deposits	medium	variable
unc.LSD.Lnd.Gnd.End	no	Unconsolidated deposits	Landslide deposits	landslide deposits	medium	variable
unc.MIX.Lnd.Gnd.End	no	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
unc.MIX.Lnd.Gslt_bou.End	no	Unconsolidated deposits	Older sediments	older sediments	high	variable
unc.SAP.Lnd.Gnd.End	no	Unconsolidated deposits	Other	saprolite	low	variable
vlc.AND.Lnd.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.AND.Lpo.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.AND.Ltc.Gpeb_gvl.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.AND_BND.Lpo_me.Gpeb_bou. End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.ASH_TFF.Lme.Gslt.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.ASH_TFF.Lnd.Gsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.BAS.Lma.Gsd.Esd	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.BND.Lnd.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.BXA.Lflb.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.BXA.Lla.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.BXA.Lma.Gsd.Ejnt	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.BXA.Lnd.Gmix.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.BXA.Lnd.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.BXA.Lsd.Gsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.BXA_TFF.Lla.Gsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
vlc.BXA_TFF.Lpo_ma.Gsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.BXA_TFW.Lnd.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.BXA_TFW.Lsd.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.MAF.Lnd.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.MFB.Lnd.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.MFB.Lnd.Gsnd_bou.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.MIX.Lnd.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.MIX.Lnd.Gsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.MIX.Lnd.Gsd.Esd	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.MIX.Lsd.Gnd.Efrc	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.MIX.Lsd.Gsnd_bou.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.PLG.Lsd.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.RHY.Lma.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lflb.Gmix.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lflb.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lla.Gnd.Ejnt	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lma.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lnd.Gcly.Efrc	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lnd.Gcly.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lnd.Gmix.Efrcjnt	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lnd.Gnd.Efrc	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lnd.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lnd.Gsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lnd.Gslt.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lpo.Gcly_slt.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lpo.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Ltc.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF.Lth.Gcly.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF_TFW.Lnd.Gnd.Esd	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFF_TFW.Lnd.Gsd.Esd	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFW.Lflb.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFW.Lla.Gnd.Ejnt	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFW.Lla.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFW.Lla_ma.Gcly.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFW.Lla_ma.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
vlc.TFW.Lla_th.Gpeb.Ejnt	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFW.Llath.Gcly.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFW.Lnd.Gnd.Ejnt	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFW.Lnd.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFW.Lsd.Gnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vlc.TFW.Lth.Gnd.Ejnt	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.AND.Lnd.CGsd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
vol.AND_BAS.Lnd.CGmix.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
vol.AND_BXA.Lnd.CGnd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
vol.AND_DAC.Lflb.CGsd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	andesite	high	bad
vol.BAS.Lnd.CfGslt.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
vol.BAS.Lnd.CGmix.Ejnt	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
vol.BAS.Lnd.CGmix.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
vol.BAS.Lnd.CGnd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
vol.BAS_BND.Lma_tc.CGnd.End	no	Extrusive and subvolcanic rocks	Mafic volcanic/subvolcanic rocks	basalt	high	good
vol.BXA_MAF.Lnd.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.BXA_RHY.Lsd.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.FAN.Lsd.CGvf.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.MIX.Lflb.CGvf.Ejnt	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.MIX.Lnd.CGmix.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.MIX.Lnd.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.MIX.Lnd.CGnd.Esd	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.MIX.Lnd.CGsd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
vol.MIX.Lsd.CGmix.Esd	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.MIX.Lsd.CGnd.Esd	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.MIX.Lsd.CGsd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.MIX.Lsd.CGsd.Esd	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.MIX.Ltc.CGmix.Esd	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.RHY.Lmix.CGvf.Ejnt	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
vol.RHY.Lnd.CGnd.End	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
vol.RHY.Lsd.CGsd.Ejnt	no	Extrusive and subvolcanic rocks	Felsic volcanic/subvolcanic rocks	rhyolite	medium	bad
vol.RHY_TFF.Lnd.CGnd.Ejnt	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.TFF_VIT.Lnd.CGnd.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable
vol.TFW_VIT.Lnd.CGvf.End	no	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	Mixed volcanic/volcaniclastic rocks	medium	variable

LITH_M_U_L	IFTNC _CHK	IFTNC_MAJO	IFTNC_MINO	IFTNC_LITH	WEATHER-ING	TREE_ VALUE
volm.AND.Lma.CGf.Eclv	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
volm.AND.Lnd.CGnd.Eshd	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
volm.AND_BAS.Lnd.CGnd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
volm.MIX.Lmix.CGmix.End	no	Metamorphic rocks	Other metamorphic rocks	metamorphosed mixed rocks	medium	variable
volm.MIX.Lnd.CGnd.Eclv	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
volm.MIX.Lnd.CGnd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
volm.MIX.Lnd.CGnd.Eshd	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
volm.MIX.Lnd.CGsd.End	no	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
volm.TFF.Lnd.CGf.Eclv	no	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad

Appendix D: IFTNC_Check

Map units assigned the LITH_M_U_L field on the left may include any of the IFTNC Major Unit and/or Minor Unit categories on the right. For each map unit, the IFTNC assignment selected for inclusion in the Lookup Table is shown in bold-face type (selected based on the acreage distribution). Oher possible assignments that could occur within each LITH_M_U_L unit are shown below:

LITH_M_U_L	GN_LITH_TY	Acres	G_Rock_TY or Map_Unit_N or Formation	IFTNC_MAJOR	IFTNC_MINOR	IFTNC_LITH	WEATHERING	TREE_VALUE
met.MIX.Lnd.Cnd.End	Metamorphic	12289	Amphibolite, metagabbro, and metadiorite	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
	Metamorphic	**21862**	**Sedimentary, volcanic and intrusive rocks**	**Metamorphic rocks**	**Metamorphosed mixed rocks**	**metamorphosed mixed rocks**	**medium**	**variable**
plum.MIX.Lnd.Cnd.End	**Metmorphic**	**11552**	**Greenstone**	**Metamorphic rocks**	**Metamorphosed mafic rocks**	**greenstone**	**medium**	**bad**
	Plutonic	835	Metamorphosed mafic plutonics	Metamorphic rocks	Metamorphosed mafic rocks	other mafic/ultramafic rocks	low	bad
psvm.MIX.Lnd.CGnd.End	Metavolcanic	390	Greenstone	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
	Sedimentary	1041	Limestone (metamorphosed)	Metamorphic rocks	Metamorphosed carbonate rocks	marble	medium	bad
	Metavolcanic	**1329**	**Mixed lithology**	**Metamorphic rocks**	**Metamorphosed mafic rocks**	**other mafic/ultramafic rocks**	**low**	**bad**
	Metavolcanic	1249	Serpentinite	Metamorphic rocks	Metamorphosed mafic rocks	serpentinite	medium	bad
srx.MIX.Lsd.Gsd.End	Sedimentary	6887	mixed lithologies	Sedimentary rocks	Sedimentary rocks	undifferentiated sedimentary rocks	medium	variable
	Surficial Sediments	**8485**	**Quaternary surficial deposits**	**Unconsolidated deposits**	**Stream deposits**	**alluvial deposits**	**low**	**medium**
	Volcanic	303	volcaniclastics	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	mixed volcanic/volcaniclastic rocks	medium	variable
srx.SDS_STS.Lsd.Gsd.End	**Sedimentary**	**34302**	**sandstone-siltstone**	**Sedimentary rocks**	**Sandstone**	**sandstone**	**low**	**bad**
	Volcanic	2360	volcaniclastics	Sedimentary rocks	Mixed volcanic/volcaniclastic rocks	mixed volcanic/volcaniclastic rocks	medium	variable

LITH_M_U_L	GN_LITH_TY	Acres	G_Rock_TY or Map_Unit_N or Formation	IFTNC_MAJOR	IFTNC_MINOR	IFTNC_LITH	WEATHE RING	TREE_ VALUE
srx.MIX.Lnd.Gnd.End	Metamorphic	2597	metasedimentary	Metamorphic rocks	Metamorphosed sedimentary rocks	siltite-argillite	medium	medium
	Sedimentary	**76452**	**mixed lithology sedimentary rocks**	**Sedimentary rocks**	**Sedimentary rocks**	**undifferentiated sedimentary rocks**	**medium**	**variable**
	Surficial Sediments	293	Quaternary surficial deposits	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
srx.MIX.Lnd.Gsd.Eshd	**Metamorphic**	**2725**	**Foliated sedimentary and volcanic rocks and marble**	**Metamorphic rocks**	**Metamorphosed mixed rocks**	**metamorphosed mixed rocks**	**medium**	**variable**
	Sedimentary	203	Varicolored lacustrine and fluvial tuffs	Sedimentary rocks	Mixed volcanic/ volcaniclastic rocks	mixed volcanic/ volcaniclastic rocks	medium	variable
srx.MIX.Lsd.Gnd.End	**Sedimentary**	**2539**	**limestone**	**Sedimentary rocks**	**Carbonate rocks**	**limestone**	**medium**	**bad**
	Volcanic	78	mixed volcaniclastics	Sedimentary rocks	Mixed volcanic/ volcaniclastic rocks	mixed volcanic/ volcaniclastic rocks	medium	variable
sv.MIX.Lnd.CGsd.End	**Sedimentary**	**131**	**Gravel, tuff, and tuffaceous sediments**	**Sedimentary rocks**	**Mixed volcanic /volcaniclastic rocks**	**Mixed volcanic/ volcaniclastic rocks**	**medium**	**variable**
	Surficial Deposits	952	alluvial fan deposits	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
	Volcanic	**4552**	**mixed lithologies**	**Sedimentary rocks**	**Mixed volcanic/ volcaniclastic rocks**	**mixed volcanic/ volcaniclastic rocks**	**medium**	**variable**
	Volcanic	4583	greenstone	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
	Volcanic	**41815**	**felsic lithologies (volcaniclastic)**	**Sedimentary rocks**	**Mixed volcanic/ volcaniclastic rocks**	**Mixed volcanic/ volcaniclastic rocks**	**medium**	**variable**
vlc.MIX.Lnd.Gnd.End	**Sedimentary**	**28710**	**sedimentary/volcan iclastic**	**Sedimentary rocks**	**Mixed volcanic/ volcaniclastic rocks**	**mixed volcanic/ volcaniclastic rocks**	**medium**	**variable**
	Volcanic	16182	greenstone (sedimentary & volcanic)	Metamorphic rocks	Metamorphosed mafic rocks	greenstone	medium	bad
vlc.TFF.Lnd.Gnd.End	Sedimentary	23888	Alluvial deposits	Unconsolidated deposits	Stream deposits	alluvial deposits	low	medium
	Volcanic	**14036**	**Volcaniclastic sediments -tuffs**	**Sedimentary rocks**	**Mixed volcanic/ volcaniclastic rocks**	**mixed volcanic/ volcaniclastic rocks**	**medium**	**variable**