United States Department of Agriculture
Forest Service

North Clack Integrated Resource Project
Environmental Assessment

Soil Resources Report

Prepared by:

/S/ *Gwen Collier*
Gwen Collier
District Soil Scientist

for:
Clackamas River Ranger District
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SOIL PRODUCTIVITY

Soil productivity is the inherent capacity of the soil resource to support appropriate site-specific biological resource management objectives, which includes the growth of specified plants, plant communities, or a sequence of plant communities to support multiple land uses. (Forest Service Manual 2550.5)

1.0 Introduction

The long-term sustainability of forest ecosystems depends on the productivity and hydrologic functioning of soils. Ground-disturbing management activities may adversely affect the natural capability of soils and their potential responses to use and management. Disturbances may reduce the soil's ability to supply nutrients, moisture, and air to support soil microorganisms and vegetation growth. The productivity and resilience of a soil is directly tied to the physical properties of the soil and the amount of fine organic matter and coarse woody debris retained or removed from the site. Forest soils are a non-renewable resource as measured by human lifespans, so maintenance and enhancement of soil productivity is an integral part of National Forest management. Therefore, an evaluation of the potential effects on soil productivity is essential for integrated management of forest resources.

This report summarizes the potential effects to short- and long-term soil productivity resulting from proposed and connected actions within the North Clack Integrated Resource Project Area (North Clack). Other reports cover related topics including geology, water quality, and fisheries.

Interpretations and descriptions contained in this specialist report rely heavily on local information derived from the Mt. Hood National Forest Soil Resource Inventory (Howes, 1979), historic aerial photographs, and digital spatial data in the Forest's corporate Geographic Information System (GIS). These sources were used along with topographic maps, silvicultural reports, field-based reconnaissance and sampling, various related project reports, and agency directives to characterize local conditions and analyze the likely environmental consequences of the Alternatives. Actions addressed in this report include those associated with proposed timber harvest activities, silvicultural and forest health treatments, system road usage, road closure and decommissioning, temporary road construction, and proposed resource projects. Activities for the North Clack Integrated Resource Project that are addressed in this report are summarized in Table 1. A description of the full North Clack proposed action can be found Online[1].

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[1] https://www.fs.usda.gov/nfs/11558/www/nepa/105362_FSPLT3_4630683.pdf

Table 1 - Summary of Vegetation, Road, and Recreation Management Actions

Purpose & Need	Proposed Action	Acres Miles	Notes
Improve Forest Health, Growth and Diversity while Providing Forest Products	Variable-density thinning with Skips and Gaps	4,532	• 2,080 acres in Matrix, with two acre gaps and heavy thins for forage enhancement • 191 acres in LSR • 934 acres in Riparian Reserves • 202 acres of Matrix with an emphasis of improving owl habitat in the home range • 88 acres of thinning with a huckleberry enhancement emphasis • 985 acres of young-stand thinning and brushing • 52 acres of young-stand thinning and brushin and the removal trees in diseased areas followed by planting
Provide Forest Products and Create Early-Seral Habitat	• Regeneration Harvest with Reserves • Site Preparation and Planting	255	In Matrix,
Enhance Forage	Meadow Burn	2	
Fire Hazard Reduction	• Burning • Fuel Break	541	• 150 acres of piling and burning of slash along Road 4610 and property lines • 136 acres of under burning of thinned stands • 255 acres of under burning and grapple piling in regeneration harvest units
Provide Access for Vegetation Management	Construct and Reconstruct Temporary Roads	19.5	• 14.4 miles of new road construction in locations where no road alignment previously existed. (1.5 mi of this is needed due to OHV conversion of system roads to trails) • 3.6 miles of existing road alignment reconstruction on road alignments that were once temporary roads.(0.6 mi of this is needed due to OHV conversion of system roads to trails) • 1.5 miles of existing road alignment reconstruction on road alignments that were once system roads.(1.1 mi of this was decommissioned by OHV plan)
Reduce Resource Risks and Maintenance Costs Associated with Forest Service System Roads	Convert Road to Non-Motorized Trail	41.2	• 7 miles of active and passive decommissionin of roads no longer needed. • 26.2 miles of closure and stormproofing of roads that remain on the System. • 8 miles of stormproofing of system roads not used for haul that remain on the System (4610, 4610180).
Reduce Resource Risks and Maintenance Costs Associated with Forest Service System	Convert Road to Non-Motorized Trail	1.2	4611 Remove culverts, retain a trail tread

Purpose & Need	Proposed Action	Acres Miles	Notes
Roads			
Provide Access for Vegetation Management	Return Former Forest Service System Road Back to the System	1.2	4610115
Reduce Resource Impacts Associated with Unauthorized OHV Routes	Rehabilitate Unauthorized OHV routes	7.1	

The effects analysis section assumes that the project design criteria, mitigations, best management practices, and seasonal operating restrictions specified in Chapter 2 of this Environmental Analysis are implemented. These measures were designed to minimize or mitigate potential impacts and to ensure that the project would comply with all pertinent laws, regulations, and policies.

1.1 Management Direction for Soil Resource Protection

1.1.1 Regulatory Framework

1.1.2 Mt. Hood National Forest Land and Resource Management Plan

The Mt. Hood Land and Resource Management Plan (LRMP) specifies that management activities be prescribed to protect, maintain and/or restore soil productivity throughout the Forest; stabilize and/or restore damaged or disturbed soil areas. This is accomplished by following Forest-wide Standards and Guidelines to ensure that soils are managed to provide sustained yields of managed vegetation without impairment of the productivity or ecosystem functions of the land.

1.2 Analysis Approach

1.2.1 Scope and Scale of Analysis

There are three geographic scales for the spatial scope of the soils analysis of this project. From largest to smallest, they are:

- Planning Area – The 24,830 acre North Clack Integrated Resource Project Area. General environmental and landscape characterization is presented at this scale.
- Project Area – The areas where specific activities are proposed, including actions associated with designated treatment units and other connected actions outside of those units such as system road improvements, temporary road construction, log haul, habitat enhancement, or sale area improvement projects.
- Activity Area – The 4,787 acre area of direct ground impacting activity, consisting of the smaller, forest stand-scale units delineated in the proposed action, either individually or collectively. An activity area is defined as “the total area of ground impacted by an activity, and is a feasible unit for sampling and evaluating” (FSM 2520 and Forest Plan,

page Four-49, FW-22 Note #1). Activity areas are the analysis areas for direct, indirect and cumulative effects to soil resources. These are appropriate boundaries because actions outside the unit boundaries would have little or no effect on soil productivity within the units, and actions within the unit boundaries would have little or no effect on soil productivity elsewhere.

The temporal scope of the analysis considers short-term and long-term effects. Analysis of short-term effects looks at changes to soil properties that would generally recover or revert to pre-existing conditions within five years of completing proposed activities. Long-term effects are those that would substantially remain for five years or longer in the absence of restoration treatments. This analysis considers the implementation of management requirements, Best Management Practices (BMPs), and Project Design Criteria (PDCs) that are designed to avoid, minimize, or mitigate potentially adverse soil impacts.

1.2.2 Analysis Measures

For this analysis the following measures are used to assess impacts. Forest Plan standards and guidelines that address these measures listed on pages Four-49 to Four-50 of the Mt. Hood National Forest Land and Resource Management Plan.

- Accelerated Erosion – Change in the amount of effective ground cover following proposed harvest and mitigation treatments. Erosion is measured by acres of exposed soil.
- Soil Disturbance - Change in the extent of detrimental soil conditions following proposed harvest, and mitigation treatments within individual harvest units or other activity areas. Soil Disturbance is measured by percent of unit in detrimental soil condition.
- Organic Matter - Amount and continuity of surface organic matter (duff and litter layers) and coarse woody debris (CWD) that would likely be retained to protect mineral soils from erosion and moisture loss and provide for short- and long-term nutrient cycling. Organic matter is measured by acres of soil organic layer removed.

1.2.3 Analysis Methods

Soil types within the planning area are mapped in the Mt. Hood National Forest Soil Resource Inventory (SRI) (Howes 1979). A broad-scale initial GIS-based analysis was used to identify potentially-sensitive soil types and determine the likely extent of existing detrimental soil condition. Representative units were field-verified, assessed for several potential risks, hazards, and sensitivities, and are summarized in this document. The extent of detrimental soil impacts persisting from previous management activities was characterized via general field observations. All assessments are supported through image interpretation and GIS analysis. Soil properties can vary within a mapping unit and on-site investigations are often required to refine or modify interpretations. The project Soil Scientist has adjusted the management interpretations to reflect on the existing and likely ground conditions at the time of activities considering project design criteria (PDCs), mitigation measures, best management practices (BMPs), and seasonal operating restrictions, as outlined in Chapter 2. These interpretations have also been adjusted based on the types of disturbances to the soils based on the proposed ground disturbing activities, and provide resolution to the soil map units at a site-specific scale.

Priority stands were chosen for field evaluation and validation of soil mapping units, slopes, hydrologic characteristics, and other features. Appropriate map changes were made to reflect field observations. With updated and validated soil mapping, pertinent management interpretations should be more accurate and therefore provide high confidence when determining levels of risk. Stands were also chosen based on treatment type and past harvest history for field estimates of existing soil disturbance conditions. Soil disturbance condition was assessed using visual observations on the ground, and quantitative estimates were made using historic air photos and GIS mapping.

Field reconnaissance was conducted during the summer of 2018. Investigations were primarily focused on potential harvest units and haul routes, and examined landforms, soil types, and site conditions (physical properties, existing disturbance, hydrologic conditions, topography, road conditions and proposed development, streamcourses, wet areas, and restoration opportunities). Specific harvest and road development concerns associated with the proposed action were examined, including:

- seasonal high water tables
- displacement and compaction hazard, including surface rock content
- surface organic (O horizon) and topsoil (A horizon) thicknesses
- surface erosion and delivery potential
- unique features such as rock outcrops, wet areas, wetlands, seeps and springs
- proximity to riparian areas
- potential effects to soil productivity and hydrologic conditions

Field notes regarding specific concerns and recommendations were taken. These observations, notes, and maps are available in the Project Files.

In general, the field investigations confirmed most of the SRI mapping and characterization of landforms and soils. The proposed actions for each unit (stand treatment type, road development, operating season) were considered, and used to inform site-specific recommendations, design criteria, mitigations, and best management practices that are included in this report.

1.2.4 Elements of the Proposal That Could Affect Soil Productivity

For this project, the following actions have the potential to adversely affect soil productivity: actions that disturb soil such as the skidding and yarding of logs, the use of mechanical tree harvesting equipment, the construction and reconstruction of temporary roads and landings, road decommissioning, fuel break creation, precommercial thinning, OHV rehabilitation, underburning, and the burning of a meadow and slash piles. Other aspects of the proposed action such as road repair, road closures, road decommissioning through database changes, log haul, danger tree removal, precommercial thinning, wood placement in streams, wetland enhancement with beaver, and the creation of snags would not have a meaningful or measurable effect on soil productivity because they do not alter soil conditions. Sediment that may result from these actions is addressed in other sections. Some actions are specifically designed to benefit soil productivity including the creation of down logs, road decommissioning, and decompacting temporary roads, landings, and skid trails.

The analysis also considers restorative actions and the design criteria and best management practices that are intended to minimize the extent of detrimental soil impacts. For example: existing roads, landings and skid trails would be reused where feasible, equipment would be restricted to appropriate slopes, erosion control methods such as water bars, seed and mulch or slash cover would be used.

Approximate acreage by yarding system is in the logging system specialist report and in the soils spreadsheet, which are incorporated by reference. Most units thinned with ground-based equipment would be felled mechanically, as well as some skyline and helicopter units where slopes are less than 40 percent. Approximate length of temporary roads and the treatment of temporary roads after use are addressed in the soils detrimental condition spreadsheet.

1.2.5 Assumptions for Analysis of the Proposed Action

- Existing landings, temporary roads, and skid trails would be reused.
- Where previous harvest operations created higher percent detrimental conditions, a progressively greater number of existing skid trails would be available to be reused, thereby reducing the area of new impact.
- In some cases, new landings may need to be constructed where logging system changes from the original harvest operation require alternate locations (i.e. originally tractor, now skyline), or existing landings are located too close to streams.
- New skid trail locations may be required in places where current management practices regarding stream and drainage crossing protection differ from the previous harvest operation.
- Existing temporary roads or landings not used during the project would remain in a compacted condition.
- Damage on skid trails would not exceed 12 feet in width
- New temporary road width would average 10 feet. Existing roads may have wider widths.
- The conceptual layout of logging system patterns have been designed to ensure less than 7% of the area in newly impacted (ground disturbance) within each proposed treatment that uses ground-based equipment.

- For new skid trails, this project is designed such that no ground-based yarding system would be used on slopes greater than 30 percent. Some ground-based logging would occur on steeper slopes where existing skid trails are used.
- This project is designed such that ground-based felling machines would generally be used on slopes less than 35% but could be used on slopes up to 40% in certain circumstances.
- Undisturbed soils meet the Forest Plan groundcover standards
- It is assumed ground impacts would take place during relatively dry conditions when soil damage risk is lower than for the same activities occurring under wet soil conditions. (PDC #C9)

The following table shows estimates of area used to estimate the extent of detrimental soil impacts that would be expected to occur as a result of Proposed Actions.

Table 2 – Estimated Areas Used to Estimate Detrimental Soil Impacts

Type	Landing Acres	Felling / yarding % of unit area	Fuels
Harvester		2%	
Ground-based yarding	0.08	3-7%	
Skyline, parallel setting	0.04	2-3%	
Skyline, fan setting	0.064	2-3%	
Helicopter		1%	
Broadcast burning			1.5%

After operations are completed

- Temporary roads not used for after-harvest projects would be decompacted and revegetated and/or covered with logging slash as soon as practical.
- Skyline and ground-based landings not located on system roads would be decompacted and revegetated.
- Helicopter landings not located on road prisms or within rock quarries would be decompacted and revegetated.
- After site prep, burning and planting is completed
- Mainline skidtrails in regeneration units would be decompacted and revegetated and/or covered with logging slash, avoiding adjacent leave trees.
- Temporary roads used for after-harvest projects would be decompacted and revegetated and/or covered with logging slash as soon as practical.

1.2.6 Methodology for Estimating Changes in Detrimental Soil Condition

Locations within units of proposed landings, temporary roads, units planned for harvester felling, and ground-based, skyline, and helicopter logging systems, were obtained. Aerial photos from the original clearcut harvest operation were consulted to determine what percent of the original skid trails could probably be reused (for example, if the original main skid trails crossed creeks in the unit, new skid trails would have to be constructed for the thinning operation). For ground-based yarding systems, the acres of proposed landings, skid trails, skyline corridors, and temporary roads are estimated based on professional judgment, past monitoring results, and information from the district logging system specialist. Acres of detrimental soil condition were calculated for each logging system area within the unit. Where multiple logging systems were previously used on a proposed unit, or would be used with the proposed action, a weighted average by acre was used for estimating a detrimental soil condition percentage for the entire unit. The detrimental condition spreadsheet can be found in the analysis file.

1.2.7 Cumulative Effects Analysis and Parameters

Cumulative effects to soil resources were analyzed qualitatively by evaluating the past, present, and reasonably foreseeable actions in the project area where ground-disturbing activities would overlap one another. The effects of thinning and regeneration operations, pile/burn, fuel break, and meadow burn, broadcast burn and underburn treatments were assessed at the treatment unit scale. These are appropriate boundaries because actions outside the treatment unit boundaries would have little or no affect to soil productivity within the treatment units, and the actions within the treatment unit boundaries would have little or no affect to soil productivity elsewhere. The effects of road, fuel break, and OHV treatments outside unit boundaries were assessed for the treatment locations and affected downslope influence area. In terms of the temporal effect, timber harvest and road construction that has occurred since the 1920s has created soil impacts that remain today.

This analysis focuses on soil productivity within the treatment areas. No attempt has been made to quantify soil productivity at the landscape scale.

Actions that have occurred within the soil analysis areas that may generate cumulative effects to soil involve past and proposed logging, site prep, fuel treatment, road construction/reconstruction and road restoration activities. All proposed plantation thinning and regeneration units were previously clearcut logged and broadcast burned or thinned from the 1920s to the 2000s, or are in fire-origin stands that burned prior to 1902. The following table shows a general rating of measures of magnitude, extent, and duration of impacts.

Table 3 - Cumulative Effects Parameters

Past and Proposed Actions	Past Actions - clearcuts	Proposed Actions - thinning - regeneration - other	Magnitude of Impact	Extent of unit with Detrimental Impacts	Duration of Impact
felling - harvester	NA	X	low	high	long term (>50 years)
yarding: skid trails	X	X	high	high	long term (>50 years)
cable - high lead	X		mod	low-mod	long term (>50 years)
cable - skyline	X	X	low	low	long term (>50 years)
helicopter		X	low	low	short term

Past and Proposed Actions	Past Actions - clearcuts	Proposed Actions - thinning - regeneration - other	Magnitude of Impact	Extent of unit with Detrimental Impacts	Duration of Impact
landings	X	X	high	low	short term if decompacted
temporary road construction	X	X	high	low	short term if decompacted
temporary road reconstruction	NA	X	high	low	short term if decompacted
broadcast burning	X	X	low	low	long term (>50 years)
windrowing	X	NA	high	high	long term (>50 years)
burn slash piles	X	X	high	low	long term (>50 years)
underburning	NA	X	low	low	long term (>50 years)
fuel break	NA	X	mod	low	long term (>50 years)
decompact temp roads	X	X	high	low	short term
erosion control activities	X	X	high	low	long term (>50 years)
OHV trail rehabilitation	NA	X	high	low	long term (>50 years)

These elements are included in a spread sheet in the analysis file that calculates existing, direct and cumulative impacts; it is incorporated by reference.

2.0 Affected Environment

The North Clack Integrated Resource Project (North Clack) is approximately 24,830 acres in size and is located in portions of the North Fork Clackamas River (HUC# 170900110405), Roaring River (HUC# 170900110402) and Helion Creek-Clackamas River (HUC# 170900110406) 12th-field watersheds. Twenty acres of Unit 362 extends into the Upper Eagle Creek (HUC# 1709001103) 12th-field watershed. The North Clack planning area lies within the western hemlock and pacific silver fir forest vegetation zones. Elevations within the planning area range from 670 feet near the Clackamas River to 4,440 feet on the upper slopes of Plaza Creek watershed. Elevations of the proposed treatment areas range from 1,340 feet (unit 6) to 3,560 feet (Tumala Meadows beaver relocation).

The planning area is located southeast of Estacada, Oregon in the northwest portion of the Clackamas River Ranger District, and is bounded by the district boundary on the west, the district boundary and Eagle Creek drainage on the north, Roaring River on the east, and the Clackamas River on the south. The proposed treatment areas fall within the following Public Land Survey System sections:

- Township 4 South, Range 5 East, Sections 13, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 35, 36
- T4S, R6E, Sections 6, 7, 8, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 28, 29, 30, 31, 32
- T5S, R6E, Sections 5, 6

2.1 Climate

The maritime influenced climate of the area is characterized by warm, but rarely hot summers and cool winters. Persistent freezing temperatures and winter snowpack are common at higher elevations above 2,000 feet, and less so below. Estimated average annual precipitation varies from 70 to 100 inches falling in the form of rain, snow, or rain-on-snow. Most of the precipitation falls during the fall and winter. Summer rainfall is light.

2.2 Landforms and Topography

The North Clack planning area lies on the western slopes of the Cascade Range. A variety of volcanic rocks (basalts, andesites, tuffs and breccias) underlie the planning area, and nearly all of the area was glaciated or was glacially influenced. LaDee Flat, a flat upland surface in the southwest portion of the planning area was formed when pyroclastic materials were deposited over the underlying Columbia River basalt. Bedrock containing tuffs and breccias underlie the central portion of the planning area. Bedrock containing andesite underlies the moderate to steep slopes along the northeast portion of the planning area. Landforms (toeslopes, sideslopes, ridgetops, benches, and old landslide features) have formed from weathering of the basalt, pyroclastic, and andesitic materials and the effects of glaciation.

In the lower and mid elevations, ridgelines, upper hill slopes and benches are lightly dissected with generally rounded shapes. Relief is gentle with a rolling, undulating appearance. Slopes adjacent to major drainageways are steep to very steep. In the upper elevations, terrain is variable with gently sloping upland benches and moderate to steep sloping breaks between benches and sideslopes into drainages. On slopes adjacent to North Fork Clackamas, and below the breaks into the Roaring River and Clackamas River, sideslopes are generally very steep and heavily dissected.

A Geographic Information System (GIS) Hillshade map in Figure 1 of Appendix A shows the general topography and landforms in the planning area and adjacent drainages. A general lithology map shown in Figure 2 of Appendix A displays the distribution of glacial deposits and pyroclastic and andesitic bedrock within the planning area.

2.3 General Distribution and Characteristics of Soils

The Mt. Hood National Forest Soil Resource Inventory (SRI) (Howes, 1979) catalogs the descriptions and distribution of different soils mapped in the project area. In addition, updated mapping using the SRI as a base document has been done in several subwatersheds within the North Clack planning area. During updated mapping projects, soil mapping units (MU) that were comparable or sufficiently described in the SRI were used or modified to fit existing conditions or the larger scale aerial photography and contour maps. Figure 1 shows an example of the SRI and updated soil mapping in the area of Dry Creek and the Upper North Fork Clackamas River.

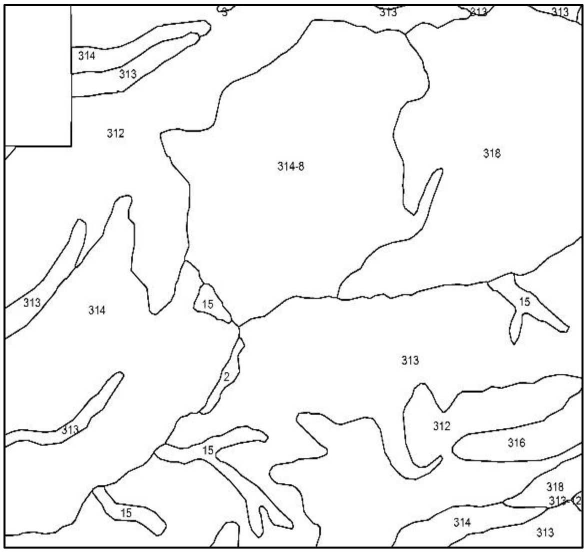

Figure 1 - Mt. Hood NF Soil Resource Inventory (SRI)

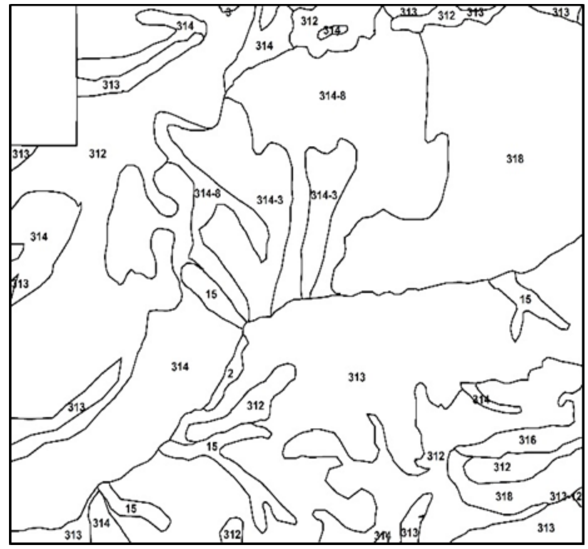

Figure 2- Updated mapping for North Clack at a project planning scale.

2.3.1 Soil Categories

The Soil Mapping Units described in the SRI and updated mapping projects can be grouped into general categories based on parent material and landform. In general, soils across the planning area have developed in residuum (formed in place) and colluvium (transported from upslope) from pyroclastic and andesitic flow materials, and the glacial material that overlays them. Table 4 below lists the landtypes and soil parent materials and associated soil mapping units within the proposed North Clack treatment areas, and their relative proportions. Figure 3 in Appendix A shows a map of the general distribution of soil types in the planning area. Table 1 of Appendix B shows SRI soil mapping unit characteristics of soils found in the proposed North Clack treatment areas.

Table 4 - North Clack soil parent materials with associated landtypes, soil types, and relative extents.

Soil Parent Material	Landtype	Description	Soil Mapping Units	Percent of Treatment Areas
Pyroclastic	flat upland surface – LaDee Flat	overlying Columbia River basalt	107	2.9%
Columbia River Basalt	very steep S & W facing slopes along the Clackamas River	shallow, very rocky	201, 201-6, 201-7	0.5 %
Deep Glacial Deposits	nearly level to sloping , smooth to slightly undulating	overlying tuff/breccia, low elevation	312, 312-4	38.8 %
Deep Glacial Deposits	nearly level to sloping , smooth to slightly undulating	overlying tuff/breccia, mid elevation	315	1.6 %%
Deep Glacial Deposits	steep to very steep mountain slopes	overlying tuff/breccia, low elevation	313, 313s, 313-12, 314, 314s, 314-8, 314-3	42.5 %
Deep Glacial Deposits	steep to very steep mountain slopes	overlying tuff/breccia, mid elevation	316, 317	3.2 %
Deep Glacial Deposits	steep to very steep mountain slopes with a high water table	overlying tuff/breccia, low & mid elevations	319, 319s	5.7 %
Deep Glacial Deposits	steep to very steep, unstable drainageways	unstable sideslopes adjacent to major drainageways	2	0.02 %
Deep Glacial Deposits	steep to very steep, unstable drainageways	resulting from active landslides and debris avalanches	15	0.7%
Shallow Glacial Deposits	steep dissected sideslopes	overlying tuff/breccia, low & mid elevations	318	4.3 %
Other	wet meadows	NA	3, 3-4	0.09 %
Other	poorly drained forested bottomlands	NA	4	0.07 %
Other	pyroclastic rock outcrop	NA	5	0.01 %
Other	unvegetated talus and rubbleland	NA	6	in complex
Other	igneous rock outcrop	NA	7	in complex
Other	dry meadows	NA	8	in complex
Other	wet talus	NA	12	in complex

2.3.2 Soil Characteristics

PYROCLASTIC PARENT MATERIAL. The soils derived from weathered pyroclastic materials (tuffs, breccias) are located in the western portion of the planning area on LaDee Flat. Pyroclastic derived soils are deep, fine textured, have high water holding capacities, are rich in nutrients, and are highly productive. Slopes are gentle. These soils are often found in association with wet and poorly drained soils. Areas of seasonally high water tables may be subject to damage. These soils have a moderate to high compaction hazard and are easily erodible. Approximately 3% of the proposed treatment acres are located on pyroclastic soils. **Soil Mapping Unit (MU) 107.**

COLUMBIA RIVER BASALT PARENT MATERIAL. The soils derived from weathered Columbia River basalt within treatment units are located on the southern edge of LaDee Flat on the breaks of the steep south facing slopes into the Clackamas River. These soils are very shallow, very rocky and are often found in complex with pyroclastic and basalt rock outcrops. Surface soil textures are cobbly and gravelly loams with 50 to 60% rock fragments. Subsoil textures are gravelly loams and silt loams with 70 to 80% rock fragments. Site Class is low on these shallow, rocky, steep, south facing slopes. Approximately 0.5% of the proposed treatment acres are located on basalt derived soils. **Soil MU 201, 201-6, 201-7, and 7-201.**

GLACIAL PARENT MATERIAL. In the majority of the planning area glacial deposits blanket the landscape. Soils formed from glacial drift and residuum from hard massive breccia formations in the low to mid elevations, and from glacial drift and residuum from andesites in the higher elevations. All treatment areas are located on the low and mid elevation glacial till soils. No treatment acres are planned for areas of the high elevation till.

Approximately 95% of the proposed treatment acres are located on glacial soils. The majority of treatment acres are on deep glacial soils, with a minor amount on shallow glacial soils. The following descriptions are of glacial soils found within the proposed treatment areas.

Low elevation deep glacial till deposits (500 – 1800 feet)

Gentle slopes (0-30%): **Soil MU 312** – these tills are uncompacted and overly hard massive breccia formations. Soil profiles characteristically have high contents of large rounded stones and boulders. The soils are located on nearly level to sloping, smooth to slightly undulating slopes. Surface textures are stoney and cobbly silt loams and light clay loams with 30% to 45% rock fragments. Subsoil textures are cobbly and very gravelly light clay loams with 30% to 40% rock. Soil depth ranges from 49 to 60 inches. This soil is found on 39% of the proposed treatment acres.

Steep slopes (30-60%): **Soil MU 313, 314 - t**hese soils are the steeper phases of Soil MU 312. Soil MU 313 is located on north and east aspects, MU **314** is located on south and west aspects. Surface textures are stoney and cobbly silt loams and light clay loams with 30% to 50% rock fragments. Subsoil textures are cobbly and gravelly clay loams and silt loams with 30% to 40%

rock. Soil depth ranges from 31 to 44 inches. This soil is found on 40% of the proposed treatment acres.

Very steep slopes (60-90%): **Soil MU 313s, 314s - t**hese soils are the steeper phases of Soil MU 313 and 314, and have similar characteristics, although soils are generally shallower and rockier. This soil is found on 2% of the proposed treatment acres.

Middle elevation deep glacial till deposits (1800 to 3000 feet)

Gentle slopes (0-30%): **Soil MU 315** - these tills are uncompacted and overly hard massive breccia formations. Soil profiles characteristically have high contents of large rounded stones and boulders. The soils are located on nearly level to sloping, smooth to slightly undulating slopes. Surface textures are gravelly loams with 30% to 40% rock fragments. Subsoil textures are gravelly and very gravelly loams with 35% rock. Soil depth ranges from 38 to 44 inches. This soil is found on 2% of the proposed treatment acres.

Steep slopes (30-60%): **Soil MU 316, 317 - t**hese soils are the steeper phases of Soil MU 315. Soil MU 316 is located on north and east aspects, MU **317** is located on south and west aspects. Surface textures are cobbly loams with 30% to 50% rock fragments. Subsoil textures are gravelly and very gravelly loams with 40% rock. Soil depth ranges from 25 to 34 inches. This soil is found on 3% of the proposed treatment acres.

Gently sloping to steep slopes (20-70%): **Soil MU 319** – these tills are uncompacted and overly hard massive breccia formations. Soil profiles characteristically have high contents of large rounded stones and boulders. The water table is high. Surface textures are cobbly and gravelly sandy loams with 30% to 40% rock fragments. Subsoil textures are cobbly and gravelly silt loams with 20% to 30% rock. Soil depth ranges from 43 to 55 inches. This soil is considered sensitive; because of the high water table, the windthrow hazard is high, and because of wetness problems, the compaction hazard is high. The soil is highly erosive. This soil is found on 5% of the proposed treatment acres.

Very steep slopes (>70%) with high water table: **Soil MU 319s** – this soil is the steeper phase of Soil MU 319 and has similar characteristics, but the soils are generally shallower and rockier. This soil is found on 0.16% of the proposed treatment acres.

Mid elevation shallow glacial till deposits

Steep slopes (20-70%): **Soil MU 318** – these soils formed on steep sideslopes. In many areas the till has been eroded exposing the massive breccia bedrock and forming deep dissections. Surface textures are cobbley and gravelly loams with 60% to 80% rock fragments. Subsoil textures are cobbley and gravelly loams with 70% rock. Soil depth ranges from 11 to 18 inches. This soil is a poor producer of timber with a low Site Class 5 Douglas-fir. This soil is considered sensitive; windthrow hazard is high, the subsoil is highly erosive, and regeneration will probably be difficult because of the shallow cobbly soils. This soil is found on 4% of the proposed treatment acres.

2.3.3 Soil Organic Material

Depth of undisturbed organic horizons (litter and duff) is variable across the planning area. All proposed treatment areas within previous plantations, burned areas or frost pockets have organic horizon depths lower than undisturbed ground due to past harvest, wildfire, and fuel treatment (broadcast burning) activities. Depths in the units visited generally ranged from ½ to 2 inches. The shallowest organic horizons observed were those in the treatment unit that had been windrowed after the initial clearcut harvest. Litter layers are important for surface soil protection (wind and water erosion, mechanical impacts), moisture storage and retention, moderation of temperature flux, nutrient cycling, and beneficial microorganism habitat. Maintenance of surface organics is important for protecting long-term soil productivity.

2.3.4 Soil Functions

The soils in the project area provide a number of important ecosystem services. They serve as productive growing media, store and cycle nutrients, provide habitat for beneficial soil macro- and microfauna (including important symbiotic fungal species), filter and store water, moderate hydrologic pulses and heat fluxes, decompose and store organic matter, and support and regenerate forest and understory cover. Sensitivity, resilience, and operational limitations vary across the project area. Some areas are unsuited for timber production or have unique values and characteristics that warrant exclusion of harvest activities. These areas are described in the *Unsuitable Soil Types* section below.

2.3.5. Soil and Site Productivity

Soil productivity in the project area is strongly correlated to soil texture, rock content, and elevation, although topographic position, aspect, soil depth and soil fertility are also key factors. Soil productivity across the planning area is considered to be low to high.

<u>Low productivity</u> areas consist of shallow glacial till deposits on steep dissected slopes. In many areas the till has been eroded and is exposing the massive breccia bedrock. The high soil rock content and shallow soil depths result in a low water holding capacity which limits site productivity. Other low site ground within the planning area includes frost pockets, talus slopes and rock outcrops, which may be present as small inclusions within some units.

<u>Moderate and low to moderate productivity</u> areas are located on the lower to middle elevation glacial soils. Soils are generally deep with moderate soil textures (loams, silt loams, silty clay loams) and low to moderate rock content. These soils have an adequate moisture holding capacity to supply growing vegetation, and soil depth is generally favorable for storing water available for uptake, although plant moisture stress can occur in the late summer period.

<u>High productivity</u> sites are located on soils which have formed from pyroclastic or basalt parent material, are deep, gentle sloped glacial tills, or are associated with wet areas or meadows. The highly productive pyroclastic and basalt derived soils are deep, fine textured, have high water holding capacities, and are rich in nutrients. The high to moderately productive low elevation, low sloped glacial tills are deep, fine textured (clay loams), and are fertile. Wet meadows are

generally associated with springs and seeps and are often perennially saturated. Soils are often Histosols or have Histic epipedons, where the upper portion of the soil is primarily made up of decomposing organic materials. Wet meadows are generally considered non-forest, though occasional conifers may be present in drier microsites within the meadows and on the fringes. Complex understory assemblages of shrubs, grasses, and forbs are present, and wet meadows and their perennial, intermittent, and ephemeral drainageways serve as important habitat for many vertebrate, invertebrate and microfaunal species.

2.3.6 Management Interpretations

A summary of SRI mapping units and their associated management interpretations is located in Table 5 below. The soil parent material categories are subdivided based on slope steepness. Figure 4 in Appendix A shows a map of soil erosion potential across the planning area. Figure 5 in Appendix A shows a map of Compaction Hazards for the soils in the planning area, with proposed treatment areas identified.

Table 5 - Summary of the major soil types in the proposed treatment areas and associated management interpretations from the SRI.

* Indicates a minor component of a soil complex

Parent Material or miscellaneous landtype	Slope	Soil Map Unit	Natural Soil Mantle Stability	Surface Erosion Potential	Subsoil Erosion Potential	Compaction Hazard	Windthrow Hazard	Potential for Regen	Brush Reveg Potential
Pyroclastics	0 to 20%	107	Very Stable	Slight - Mod	Moderate	Mod - High	Moderate	High	Mod - High
Columbia River Basalt	60 to 90%	201	Mod Stable - Unstable	Severe – Very Severe	High	Low	Mod - High	Moderate	Low
Glacial Deposits	0 to 30%	312	Stable	Sight - Mod	Moderate	Moderate	Moderate	Moderate	Mod - High
Glacial Deposits	0 to 30%	315	Stable	Slight - Mod	Moderate	Moderate	Moderate	Moderate	Mod - High
Glacial Deposits	30 to 60%	313	Mod Stable	Moderate	High	Moderate	Moderate	Mod - High	High
Glacial Deposits	30 to 60%	314	Mod Stable	Moderate	High	Moderate	Moderate	Moderate	High
Glacial Deposits	30 to 60%	316	Stable – Mod Stable	Moderate	Mod - High	Moderate	Moderate	Moderate	Mod - High
Glacial Deposits	30 to 60%	317	Mod Stable	Moderate	Mod - High	Moderate	Moderate	Low	High
Glacial Deposits	20 to 70%	318	Stable	Moderate	Mod - High	Moderate	High	Low	Mod-High
Glacial Deposits	20 to 70%	319	Mod Stable – Unstable	Mod - Severe	High	High	Mod - High	High	High
Glacial Deposits	60 to 90%	313s, 314s	Mod Stable	Moderate	High	Moderate	Mod - High	Moderate	High
unstable drainage sideslopes	30 to 90%	2	Unstable – very Unstable	Mod Severe - Severe	High	High	High	High	High
wet meadows	0 to 5%	3	Stable	Very Slight	Low	High	NA	Low	Low-Mod
poorly drained fst bottomland	0 to 5%	4	Stable	Very Slight	Low	Mod-High	High	Moderate	Moderate
pyroclastic rock outcrop	NA	5 *	Stable	NA	NA	NA	NA	NA	NA
unvegetated talus	NA	6 *	Stable-Mod Stable	Very Slight	NA	Low	NA	NA	Low
Igneous rock outcrop	NA	7 *	Very Stable	NA	NA	NA	NA	NA	NA
dry meadows	0 to 20%	8 *	Very Stable	Slight - Mod	High	Moderate	NA	Low	Low
wet talus	NA	12 *	Stable – Mod Stable	Slight	Mod-High	Low	NA	Low	High
steep unstable drainageways	30 to 90%	15	Very Unstable	Very Severe	High	Low	High	Low - Mod	Moderate

2.3.7 Unsuitable Soil Types

The National Forest Management Act of 1976 (NFMA) requires the identification of the suitability of lands for timber management in accordance with 36 CFR Part 219. The Rules and Regulations established a process characterized by four screens through which National Forest lands must pass to identify those not suitable for timber production:

Screen 1 – Not Forest land (not stocked with 10% tree cover, and lands developed for non-Forest use).

Screen 2 – The land has been withdrawn from timber production by Congress, the Secretary of Agriculture or the Chief of the Forest Service.

Screen 3 – Technology not available to ensure timber production without irreversible resource damage.

Screen 4 – No reasonable assurance that lands can be adequately restocked within 5 years after final harvest.

The Mt. Hood National Forest 1984 process paper "Determination of Land not Suitable for Timber Production on the Mt. Hood National Forest" and a re-assessment in 1989, identified soil types on the Forest to be considered unsuitable for timber production. Within the planning area unsuitable soils for timber management include those that have seasonal or year-long high water tables, are extremely rocky, or are frost pockets. Unsuitable soil types in the North Clack project area are listed in Table 6 below and shown in a map in Figure 6 of Appendix A. Unsuitable areas identified within proposed treatment units would be included in skips or riparian buffers.

Table 6 - Unsuitable Soil Types mapped in the North Clack proposed treatment units

SRI Mapping Unit	Description	Screen	Acres in Treatment Units (% of Total Treatment Acres)
2	Unstable sideslopes adjacent to major drainageways	3	1.1 acres, (0.02%)
3, 3-4	wet meadows, and in complex with poorly drained forested bottomlands	1	3.9 acres, (0.08%)
4	poorly drained forested bottomlands	1	Not fully mapped, as some individual areas are < 5 acres
12 (313-12)	wet talus in complex with MU 313	1	minor component of soil complex, not mapped
15	steep to very steep unstable drainageways	3	32 acres, (0.7%)
various	frost pockets	4	not mapped

SRI Mapping Unit 2 consists of steep, unstable to very unstable sideslopes along some major drainageways. Soils are extremely variable but textures are usually clay loams, silty clay loams, and clays. Soil horizons are not well defined as a result of continuous soil movement.

SRI Mapping Unit 3 consists of depressional areas that are seasonally or permanently ponded. The soils are slowly permeable and imperfectly to poorly drained. Tumala Meadow is an example of a wet meadow.

SRI Mapping Unit 4 consists of depressional areas that have permanent or seasonally high water tables. The soils are slowly permeable and imperfectly to poorly drained.

SRI complex Mapping Unit 12 consists of fallen rock fragments of all sizes which occur at the foot of steep rock slopes and headwalls. Water moves through the material so supports some shrubby vegetation.

SRI Mapping Unit 15 consists of steep to very steep unstable drainageways. Soils are extremely variable as a result of active landslides and debris avalanches. In some areas, soil may be wholly lacking.

Frost pocket areas are generally depressional areas that occur in cold air drainageways at landscape positions where cold air pools. The majority of these areas grew trees at one time, but after the original harvest, re-establishment has not occurred except for minor regrowth on the fringes. Regeneration potential is very low.

3.0 Effects Analysis

3.1 Proposed Action

A brief description of projects included in this analysis follows. Planned treatment acres and miles are identified in Table 1. Other information pertaining to factors which affect soil condition are included below. Previous management activities have affected soil quality in portions of the planning area. In this report, stands are categorized and grouped into the following types for ease of discussion.

- Fire-origin stands are those that burned with no evidence of past logging regardless of the date of burn. Stands burned in the recent 36 Pit Fire are not included.
- Old plantations are stands that were highlead logged with steam donkeys to railroad lines in the 1920s and 1930s when the land was privately owned.
- Plantations are stands that were clearcut and planted after 1950.

<u>1. Mechanical overstory treatments – thinning and regeneration of fire-origin stands, old plantations, and plantations</u>. Harvest would be accomplished with ground-based, cable, and helicopter equipment. Mechanized cutting and skidding of logs would require a landing and skid trail network. Emphasis would be placed on the reuse of pre-existing skid roads and Forest Service designation of all new skid roads. Limited off-trail travel by machinery would be allowed which will minimize displacement and detrimental compaction. Placement of water bars upon completion of logging in a given area and placement of woody material on temporary road and skid trail surfaces would limit the potential for concentration of surface flow and soil erosion.

Where rock fragments are not restrictive, decompaction is planned for temporary roads and landings, and for skid trails within regeneration units, to reduce detrimental soil condition, increase infiltration, and prepare a seedbed for mulch and native forage species to be sown on exposed soil for erosion control and to enhance wildlife forage.

Twelve stands have been logged twice; eleven of the proposed thinning units on old plantations were previously thinned between 1991 and 2002, and one proposed thinning unit was previously clearcut in the 1970s.

As addressed by PDC C9, the operating season would be defined and based upon three factors; soil type, antecedent weather, and visual indicators. A soil map identifying the Group 1, 2 and 3 soil categories included in the soil type factor is included in Figure 7 of Appendix A. These soil groups identify the soils that are most susceptible, susceptible, and least susceptible to ground disturbance when moist. The memo lists associated conditions of operation for each soil group.

2. Mechanical post-harvest site-prep. Activity fuels would be grapple piled and burned within regeneration harvest units that have a ground-based logging system.

3. Fuel break construction. Fuels exceeding 7 tons/acre within 40 feet of Road 4610 east of Road 4613 would be piled, lopped and scattered, or masticated by a machine staying on the road or by hand. Fuels in excess of 7 tons/acre within 66 feet of the Forest Service boundary would be piled or lopped and scattered by machine within ground-based units, or by hand outside units and within skyline and helicopter units. No treatment would occur in riparian protection buffers.

4. Broadcast burning or underburning. Prescribed burns are planned for regeneration units that are not grapple piled and some thinning units. Fire line construction would include techniques to minimize erosion and sedimentation risks. Fire lines would not be constructed in riparian reserves.

5. Meadow burn for deer and elk forage enhancement. A prescribed, low intensity fall burn is planned for approximately 2 acres of meadow in the Boyer Creek drainage to encourage enhanced forage growth of existing species. It is anticipated that only the thatch portion of the grasses and sedges within the wet meadow areas would be burned, and that the soil organic layer would remain intact and unburned. Burning is not planned on the drier soil types surrounding the meadow that support shrub or conifer species. Conifers encroaching on the meadow may be hand cut and scattered prior to the meadow burn.

6. Road Management, Closures, and Decommissioning. A number of units lack adequate access for equipment mobilization and log haul, so there would likely be a need to construct new temporary roads, or to reuse existing road alignments as temporary roads. The exact locations and lengths of temporary roads may change, and the numbers provided in Table 1 are an estimate for describing potential temporary effects.

Some system roads are planned for closure, stormproofing, or active and passive decommissioning. Closures, stormproofing, and decommissionings would involve construction of drainage structures where needed along the length of the roads. Closures and decommissionings would also involve decompaction of road surfaces in areas, and construction of entrance barriers to prevent travel by motorized vehicles. Disturbed soils would be seeded by a native species mix and mulched with weed free materials.

7. Off-Highway Vehicle (OHV) Trail Rehabilitation. Unauthorized OHV trails would be closed, rerouted, or rehabilitated. Rehabilitation activities include decompacting soils, discouraging access by constructing berms and/or strategically placing boulders, logs, or root wads, and planting native vegetation.

3.1.1 Proposed Action Projects not assessed in this report

Some North Clack projects with negligible impacts to soil resources were not assessed.

- Non-mechanized treatments such as precommercial thinning and construction of fuel breaks outside ground-based units that are typically accomplished through a sequence of hand treatments
- Placement of wood in streams by hand felling or by helicopter
- Road maintenance activities. Small areas of soil displacement (generally under the 100-square-foot threshold required for detrimental displacement in the Regional guidelines) may result from culvert cleaning, ditch cleaning, and incidental machine traffic. Road reconstruction and maintenance is generally assumed to convey a net benefit to soils, as appropriately-shaped and drained roads prevent failures and concentrated flows that cause erosion and contribute infertile sediments to road-adjacent soil areas. Road related erosion is addressed in the Hydrology Report.
- Reforestation activities are not expected to have negative impacts to soil resources. Scalp construction (removal of surface organics to expose mineral soil) is considered necessary when planting nursery trees. The scalp prevents organic material from falling into the planting hole and causing air pockets around tree roots, which may result in tree mortality. The scalp removes surface organics, but does not disturb the topsoil (A) horizon. Successful reforestation would convey a net benefit to soils as above and below-ground organic matter cycles reestablish, roots stabilize surface soils, nutrient capture and cycling stabilizes, and symbiotic microfaunal communities recover.

3.2 Direct, Indirect and Cumulative Effects

Existing condition and direct, indirect, and cumulative effects for the three soil measures are addressed in each section below.

The current condition described in the analysis below incorporates all past actions that have occurred within the analysis areas which correspond to the proposed treatment unit boundaries. Within thinning, regeneration, underburn, broadcast burn, and fuel break treatment areas there are also no foreseeable future actions to include. While there may be future thinning or other actions, there is no proposal now for future actions that have sufficient site specificity to conduct an analysis. There are foreseeable actions related to OHV. An authorized OHV trail is planned for construction and a specified road is planned for conversion to an OHV trail.

3.3 Erosion

Natural, or geologic erosion, is erosion of the earth surface under natural or undisturbed conditions. It includes loss of soil particles from weathering processes and by forces of water, wind, and gravity. Natural erosion occurs at a relatively uniform rate except during extreme natural events when large quantities of soil can erode in short periods of time. Under natural conditions, vegetation and other effective ground cover retards erosive processes. Removal of vegetation, concentration of overland flow, or interception of subsurface flow by harvest, road building, or other ground moving activities disturbs natural conditions and the erosion rate accelerates. Accelerated erosion is the increase in soil erosion and sediment production over natural erosion.

The erosion hazard rating is based on bare surface soil properties that affect detachability, such as climate, slope gradient and length, soil texture and structure, permeability of the surface soil, and hydrologic characteristics of the soil and bedrock materials. Management ratings for erosion risk follow the variability of the soils across the landscape, with some soils mapped with a severe erosion risk, others with slight, and many in between. Although ratings are a good preliminary analysis tool, in actuality almost any soil regardless of rating can become more erosive than rated depending on site-specific circumstances. Soils with a slight erosion risk rating that are compacted and bare can become erosive even on gentle slopes. Conversely, erosive soils occurring on very steep slopes may be stable for decades because of sufficient protective groundcover (vegetation, tree needles, leaves, wood, rocks, etc.).

3.3.1 Existing Condition – Erosion

Glacial materials that overlie the majority of the North Clack planning area have formed soils with surface erosion potentials that are slight on gentle slopes and slight to moderate where slopes exceed 30%. Very steep glacial slopes range from moderate to severe. Surface erosion potential for pyroclastic derived soils varies from slight to moderate on gentle slopes. Surface erosion potential on Columbia River basalts ranges from severe to very severe on steep slopes. Subsoil erosion potentials on the glacial soils are moderate on gentle slopes and range from moderate to high on steep slopes. Subsoil erosion potentials on the pyroclastic derived soils are moderate on the gentle slopes. Subsoil erosion potential on Columbia River basalt soils are high on the steep slopes. A map of Soil Erosion Potential in the planning area, which combines surface and subsoil erosion hazard ratings, is shown in Figure 4 in Appendix A, with proposed treatment unit locations outlined in black. Refer to Table 4 above for erosion hazard risk ratings for individual soil mapping units.

Erosion rates have not accelerated to a noteworthy degree as a result of past activity. Natural re-establishment of grasses, forbs, and brush, along with stand regeneration and reforestation, has provided effective ground cover. Existing surface erosion is mainly confined to exposed soil on some unpaved road surfaces, road cutbanks, road ditches, OHV trails and dispersed recreation areas. A few isolated occurrences of overland flow were observed within proposed treatment units (primarily associated with old skid trails or OHV trails on steeper slopes), but flows generally infiltrated into the ground within a short distance. Accelerated erosion is also occurring on certain sloped road segments where runoff is concentrated and drainage features are absent or not functioning properly. Occasional small gullies have formed or cut bank ravel is observable. Segments are located on both collector and secondary roads. In nearly every circumstance there is little risk of sediment delivery to a surface water feature, and maintenance/improvement of drainage structures (water bars, drain dips, outsloping/crowning, rock surfacing) or decompaction of temporary road surfaces would correct erosion issues.

3.3.2 Direct and Indirect Effects - Erosion

Soil erosion can directly affect soil productivity by reducing soil depth and volume, resulting in a loss of nutrients and water holding capacity. An indirect effect from soil erosion is runoff from bare areas carrying soil particles to water bodies where it becomes sediment, and can decrease water quality. Other negative effects occur such as decreased air quality from dust (silt size soil particles) carried in the atmosphere.

3.3.2.1 No Action

In the absence of an extreme wildfire, erosion rates within most of the analysis area would remain as they are in the short term. Over time, as bare areas become revegetated, erosion levels would decrease. If an existing slide were to become more active, or if new landslides were to occur, an increased level of soil erosion would be expected in the exposed soil areas. OHV trails and roads that remain in use and are not maintained or rehabilitated would continue to erode and produce sediment. If the unauthorized OHV trail system is expanded over time, an increased level of soil erosion would be expected where bare soils are exposed.

3.3.2.2 Action Alternatives

Actual resource damage (accelerated erosion or sedimentation) is dependent on ground cover and weather events that provide the energy to move soil material from one location to another. Soil erosion risk would increase with the proposed action because bare soil would be exposed during implementation. In order to diminish this risk while soils are exposed, certain erosion control techniques which limit the amount of soil exposure, or which re-establish ground cover after soil is exposed, are implemented to lessen erosive energies. Effective ground cover such as down logs, slash or mulch would dissipate energy from runoff and minimize erosion. Slash and mulch are considered effective in the short term as ground cover until vegetation in the form of grass, shrubs or trees become established either from direct reseeding or through natural seeding.

The use of PDCs for stream protection buffers, designated skid trails, and establishing effective ground cover by applying logging slash or seed, fertilizer, and straw mulch on the disturbed soils reduce erosion features and disturbance, and result in a low potential for soil to be moved to streams and a low potential for substantive effects to soil productivity.

Mechanical overstory treatments – thinning and regeneration. Bare soil would be exposed as logs are dragged on and machines travel over the ground surface. Of the proposed yarding systems, ground-based systems result in a greater amount of ground exposure than skyline and helicopter systems. Units that are prescribed for ground-based felling or yarding systems generally have gentle to moderate slopes, so even if the potential for erosion may be high, eroding material would not move far before redeposition occurs. On units prescribed for ground-based mechanical felling systems where slopes approach 40%, the potential for erosion increases.

Temporary roads, landings not on existing road surfaces, and felling and yarding areas would be used or reused. Most of this acreage was disturbed during past harvest operations but currently has effective ground cover. Harvest activities would result in an increase in acres of potential accelerated erosion. Ground cover on bare, disturbed areas, particularly where slopes are greater than 25%, would minimize the risk of potential chronic sources of sediment until successfully revegetated.

Mechanical understory treatments – site-prep and fuel break construction within units. Generally, units prescribed for ground-based yarding are planned for mechanical site prep involving grapple piling and mechanical fuel break construction and piling activities. Bare soil would be exposed as logs are dragged on and machines travel over the ground surface as piles are constructed. Slopes in these units are generally gentle to moderate, so eroding material would be redeposited in short distances. Site prep activities would result in an increase in acres of potential accelerated erosion. Ground cover would be reestablished on bare, disturbed areas, particularly where slopes are greater than 25%, to minimize potential chronic sources of sediment until successfully revegetated.

Low Intensity burns – meadow and underburns. Soil exposure within the meadow to be burned should be minimal. Soil exposure within the underburn areas would depend on prescriptions implemented in individual areas, but could range from no soil exposure where adequate moist vegetative species are present and thriving and encroaching brush is hand treated, to a high degree of exposure when ground disturbance and soil exposure are high. Concave landforms, low slopes, the application of mulch, and the establishment of forage species would minimize erosion and runoff from the meadow and underburn areas.

Broadcast burns on skyline and helicopter reforestation units. Soil exposure within the burn areas would depend on prescriptions implemented in individual areas, but could range from no soil exposure in areas where fire did not carry or the duff was not fully consumed, to a high degree of exposure when ground disturbance or fire severity is high. Exposed mineral soil makes soils more prone to post fire wind and water erosion. When trees and understory vegetation are killed, roots die, soil strength declines, and erosion risk increases. Proper fire line construction with adequate waterbar placement would contain sediment and minimize erosion. As ground vegetation becomes reestablished across the units, mineral soil exposure is reduced and erosion risk is diminished.

Road management. Road improvements and ongoing maintenance would continue to minimize erosion and runoff effects on primary travel routes. Segments used for log haul would receive general maintenance, have drainage features constructed or improved, and be bladed or spot surfaced as needed to ensure hydrologic stability. This project would administratively close 26.2 miles of system road. While drainage features would be constructed or improved, the road bed itself would remain intact to facilitate future administrative use. These roads would be closed to public access, and this would help minimize impacts to soils in the areas they access from dispersed recreation use and off-road vehicle travel. This project would actively and passively decommission 7 miles of system road, and would have a beneficial effect on long-term erosion rates and water quality. Decommissioning projects would increase infiltration capacity of roadbeds where decompaction occurs, resulting in a reduction in overland flow, establish effective ground cover on the road surfaces, and allow for revegetation.

OHV trail rehabilitation. OHV activities can compact soils, produce erosion, and damage vegetation. Decompaction of soil, construction of drainage structures and revegetation of disturbed areas would minimize soil erosion from the project sites. Infiltration rates would increase where decompaction occurs resulting in a reduction of overland flow. Where slopes are gentle, where erosion occurs, transport distances are minimal. Closing areas to vehicle access would minimize future impacts.

3.3.3 Cumulative Effects – Erosion

In some areas ground cover was removed where ground disturbance occurred during past fire, clearcut and thinning harvest, fuel treatment, and road construction activities. Since then the stands have regrown groundcover protecting the soil surface, and erosion has decreased. Existing surface erosion is mainly confined to exposed soil on some segments of unpaved road surfaces and OHV trails, and some road cutbanks and ditches, with a few isolated occurrences on steep skid trail segments.

Treatment activities would result in a temporary reduction in effective ground cover within underburn areas, the meadow to be burned, rehabilitated OHV trails, and the newly constructed OHV trail and OHV trail converted from a specified road, site prep areas, and on primary skid trails, landings, yarding corridors, and to a lesser extent on ground between primary skid trails. Best Management Practices and Project Design Criteria for units, OHV trails, road closure and road decommissioning projects would construct or improve drainage structures and establish effective ground cover, resulting in a reduction in erosion from those areas.

Best Management Practices and design criteria would result in little erosion from the proposed action combined with past actions and foreseeable future actions because sufficient ground cover would be applied or retained. There are no foreseeable future actions within the thinning, regeneration, underburn, site prep, and fuel break analysis areas to include. There are foreseeable OHV actions (construction of authorized OHV trail, conversion of specified road to OHV trail). The cumulative effects of the proposed actions when combined with past actions and foreseeable future OHV actions would not be substantial.

3.4 Soil Disturbance

Soil quality is the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation (USDA 2012). Many soil properties that drive soil quality are dynamic—they can change in space and time depending on how a soil is managed. Management choices can affect soil organic matter quantity, continuity and rate of decomposition, soil structure, soil depth, infiltration rates, and water and nutrient holding capacity. Soils respond differently to management depending on both the static and dynamic properties of the soil and the landscape setting.

3.4.1 Expected Soil Impacts from Treatment Activities

Machine traffic may affect soil properties in a variety of ways and generally result in some degree of soil disturbance. Detrimental soil disturbance resulting from harvest, site prep, and fuel treatment activity is commonly in the form of soil compaction, soil displacement and puddling, severe burning, accelerated erosion, excess removal of organic material, and aggravated mass wasting, and can result in an irretrievable loss of soil productivity (for definitions of listed impacts, see Forest Service Manual 2521.1, Region 6 supplement 2500-96-2, effective 6/4/96).

Compaction occurs when compressional and vibrational energy is exerted on the soil and rearranges soil particles. In compacted soils, pore space is decreased, pore size distribution changes, and bulk density and resistance to penetration increase. In general, 2,500 kPa is believed to be the soil strength threshold at which root growth is measurably affected, and above 3,000 kPa root growth largely ceases (Siegel-Issen 2005). Monitoring on the Clackamas River Ranger District, Mt. Hood National Forest for a soil of pyroclastic origin has found near-surface soil strength readings in the 2,500 to 2,800 kPa range on skid trails and landings. These levels of soil resistance are expected to produce a negative root growth response as a result of increased soil resistance (Craigg 2013). Decompaction may be an appropriate treatment to ameliorate compaction on temporary roads and landings, particularly in treatment units where the overall extent of detrimental conditions is high. In addition, decompaction of skid trails within regeneration units may be appropriate.

Puddling is a type of soil impact that occurs when compressive and vibrational energy is exerted on the soil at soil moistures greater than that which creates compaction. As soil moistures increase, the soil's shear strength and ability to compact is reduced and ability to puddle is increased. As moistures continue to increase, the soil moves from its plastic limit toward its liquid limit. Detrimental soil damage occurs when soils are at or beyond the plastic limit of moisture. Puddling results in the destruction of soil structure, a change in pore size distribution, a change in bulk density, a decrease in gas exchange, and a loss of permeability and infiltration.

Displacement is another type of soil impact that occurs when surface organics and topsoil are removed by heavy equipment pivoting, maneuvering, or sliding during sidehill travel. Displacement is important for several reasons. Glacial soils are young, poorly developed, and have thin A horizons. For most soil types, the majority of the total nitrogen in the profile is associated with the A horizon (Dyrness and Youngberg 1966). It is reasonable to assume that this is true for most other macro- and micronutrients as well. Overall nutrient capital and its distribution within forest stands are inextricably tied to organic layers and topsoil horizons. Surface organics are also crucial for water-holding capacity and water flux, and it is commonly asserted that stressed stands are more susceptible to insect attack and disease.

Windrowing is a type of fuel treatment where slash is pushed into long rows by tractors and then burned. Windrowing results in extensive soil organic horizon displacement throughout a treated unit and severe burning in concentrated areas under portions of the windrowed piles. This practice occurred on some clearcut harvest units on the district in the 1950s through 1970s, but was discontinued because of the impacts to soil.

Overstory treatments such as thinning and regeneration harvest would consist of commercial timber harvest activities where mechanized cutting and skidding of logs would require a landing and skid trail network. In certain places, temporary roads would be needed for product transport. Previously-harvested stands may still have persistent detrimental soil conditions resulting from decades-old impacts. When successive mechanized treatments are planned, mitigation measures, BMPs and action-specific design criteria are usually necessary to contain detrimental soil conditions.

A low intensity burn is planned for the wetter portions of a meadow in the Boyer Creek drainage where conditions are appropriate and an improvement in forage species is anticipated.

Rehabilitation of unauthorized OHV trails would use machinery to decompact areas to be rehabilitated, and to construct drainage structures and closure barriers. Disturbed soil would be mulched and revegetated with native species.

3.4.2 Assessment of Existing Condition – Soil Disturbance

Assessment of the extent of detrimental soil conditions resulting from historic timber harvest and other ground disturbing activities was a multi-step process. Selected pre-and post-harvest representative stands were monitored June 26-27, 2017. Field observations of a sample of proposed treatment units representing parent materials in the planning area were visited during the summer of 2018. Monitoring of Stands were chosen based on logging method, with emphasis on ground-based systems. Skyline and helicopter stands were not visited as intensively because of the relatively small soil impacts resulting from those logging methods as compared to ground-based logging.

The condition of soils was evaluated for the amount of detrimental disturbance from past activities using a combination of qualitative measures and professional judgment. Qualitative data was acquired by classifying soil disturbance using the Soil Disturbance Field Guide (USDA, 2009), a process that breaks soil disturbance into three classes based on visual evidence. The visual evidence is correlated to infiltration rates, percolation, channeling of surface water, productivity, potential restoration work, and Forest Plan standards and guidelines. Soil disturbance features observed in the field were compared to past treatment activities observed on old aerial photos, from the earliest flight flown after the stand was originally clearcut, thinned, or fire salvaged. The analysis file contains aerial photo pairs of each treatment area taken soon after the time of original harvest, and a spreadsheet showing the estimated detrimental condition for each treatment area.

Analysis concentrated on units with the highest impact to soil condition:

- Units with greater than 15% detrimental soil condition
- Units originally logged with ground-based equipment and planned for ground-based equipment during implementation of North Clack.
- Units involving a second harvest operation for thinnings, or a thinning harvest operation after a clearcut.

3.4.3 Existing Condition – Soil Disturbance

Ground disturbing activities have the potential to cause detrimental soil conditions and adversely affect the long-term productivity of a site. Previous management and dispersed recreation activities have affected soil quality in portions of the North Clack project area.

<u>Mechanical overstory treatments</u>. Many of the proposed thinning and regeneration treatment units have been logged prior to or salvaged logged after the fires of 1929 and 1939, have been clear cut harvested and broadcast burned or windrowed from 1950 to 1983, or thinned from 1991 to 2002. In addition to cable and ground-based mechanical logging, fuel treatment activities, reforestation and plantation establishment, and construction and continued use and improvement of roads, other forest-related management activities have occurred periodically for decades. Small wildfires, slash pile burning, firewood cutting, off-highway vehicle use, and dispersed recreation activities have also resulted in ground disturbance, a portion of which is considered to be detrimental.

Prior to the 1980s, soil quality standards, best management practices (BMPs), and mitigation measures were less developed and not as effective at limiting and containing detrimental soil impacts as they are today. Management practices at that time did not restrict machine movement, skid trail density, removal of woody debris or intense burning, therefore existing detrimental impacts to soil are generally higher than allowed under the current Forest Plan standards and guidelines. The aerial photo of North Clack Unit 120 to the right shows a more extensive skid trail pattern used on the original clearcut harvest operation in 1958 than would be used today.

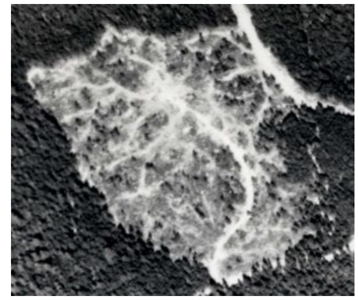

Figure 3 – Skid Trail Pattern

Natural recovery from historic impacts has occurred to varying degrees depending on the inherent productivity and resilience of the sites, but residual impacts remain and are detectable in all of the previously harvested stands. Detrimental soil conditions most commonly associated with timber harvest and plantation establishment include heavy compaction, displacement of topsoil, excessive removal of organic materials, mixing of soil horizons, and a minor degree of severely burned soils (for definitions see Forest Service Handbook, section 2520.8-1, 1998).

The percentage of area in a detrimental soil condition varies from stand to stand due to the occurrence, manner, and extent of past timber harvest and fuel treatment activities, and the soil types within the units. Heavy compaction and displacement were nearly always observed where there were old roads, landings, primary skid trails, unauthorized Off-Highway Vehicle trails, where a unit had been windrowed after the initial clearcut harvest operation, or where repeated passes of heavy equipment had occurred. Windrowing occurred on one of the proposed thinning units (unit 118).

The windrowed areas are generally visible today as long, linear mounds containing some charcoal fragments. Windrowing has substantially displaced the soil organic horizons in this unit as soil was pushed into the windrows along with the slash. The soil displacement has made the skid trail pattern from the initial clearcut difficult to discern in many areas. The aerial photo of Unit 118 in Figure 5 shows the pattern and extent of unit area that is affected by windrowing activity.

North Clack
Unit 118

1967 flight, Line 22,
photo ESF 8-191

Figure 4

Existing detrimental soil condition on proposed ground-based thinning and regeneration units was calculated based on stand origin: a. fire-origin stands b. old plantations (harvested prior to or salvaged after the 1929-1939 fires) and c. plantations clearcut or thinned after 1950. Existing detrimental soil condition was calculated to range from 1% to 21% in the proposed ground-based units or ground-based portions of units. The remaining portions of these proposed treatment areas have soils in good condition. It is estimated that all of the plantation units and units where thinning or clearcutting occurred on old plantations exceed the Forest Plan standard of 15% detrimental soil condition. Units with a fire-origin or old plantation origin do not exceed 15%. None of the areas within the proposed units that were previously logged with cable methods exceed 15%. For stands not previously harvested (fire-origin stands), the existing detrimental soil condition is very low.

Tables 6 and 7 below show a summary of existing detrimental soil condition for mechanical overstory treatments on proposed ground-based units. A spreadsheet showing all proposed ground-based treatment units with current estimated extent of detrimental soil impacts can be found in the Analysis File.

Roads and OHV. OHV use is widespread across the middle and lower elevations of the planning area. The LaDee Flat OHV Area (one of four authorized OHV use areas on the Mt. Hood National Forest) includes OHV trails of various grades accessed from segments of Roads 4610 and 4611. A road to trail conversion and trail rehabilitation are planned in the area. In addition, unauthorized OHV users are generally using closed and temporary roads and primary skid trails from past logging to extend or create new unauthorized trail networks, especially where loop connections can be developed. In the years since 2010 when OHV use was constrained to designated routes, multiple unauthorized trails in the planning area have had entrances closed to motor vehicles using boulders, debris and soil barriers. Historically OHV loop trails accessed the old Lookout Springs Campground which is located within and adjacent to planned regeneration Unit 82 and planned thinning Unit 138. The OHV loop trail from the west connected Road 4612 to 4610 through the campground, and from the east and south connected Road 4611 to the campground at Road 4610 near the Huxley Lake and Indian Ridge trailhead (Trails 521 and 507). These trails access the Roaring River Wilderness so motorized vehicles are not allowed. The access points to the trails within and adjacent to the old campground were closed to motor vehicle use in 2006 and then reworked a few years later. The current closure structures have been successful in reducing OHV access in the area.

Detrimental soil conditions exist where compaction or soil displacement occurs on roadbeds, OHV trails and access routes, and driving surfaces resulting from breached closures. Soil quality has been degraded where detrimental soil conditions persist, and long-term site productivity is diminished on those sites. The consequences may include diminished tree growth, altered organic matter turnover cycles, degraded habitat for soil macro- and microfauna, and potential impacts to hydrologic regimes. Roads that are part of the official travel network (i.e. system roads) have been converted to a non-forest status. Other sites such as trails, non-system/user-created roads, unrestored landings, and primary skid trails have remained heavily compacted and recovery would be prolonged.

3.4.4 Direct and Indirect Effects – Soil Disturbance

3.4.4.1 No Action

Soil quality would not be diminished further, but would remain compromised where roads, trails, and unrehabilitated landings and primary skid trails exist. Other than persistence of existing detrimental soil conditions, soil quality across the majority of the project area would remain in good condition. The inherent productivity and resilience of the soils would help maintain their functional capacity to serve as a growing medium, store and cycle nutrients and water, support microorganisms, produce organic biomass, and support or regenerate a contiguous forest cover.

Soil quality has been degraded where detrimental soil conditions persist, and long-term site productivity is diminished on those sites. Rates of tree growth on detrimentally impacted areas are likely diminished, and the soils' ability to perform other vital ecosystem services is compromised. Thinning treatments that could indirectly increase the productivity of dense and overstocked stands by alleviating competition would not occur. Forest roads that are part of the permanent travel network have been converted to a non-forest status. Other sites such as trails, non-system roads, unrestored landings, and primary skid trails would remain heavily compacted and recovery would be prolonged. Opportunities to alleviate detrimental soil compaction as a result of proposed activities on existing landings and temporary roads designated for reuse would not be available. Funding for soil restoration projects would not be readily available through harvest-generated revenue. Existing detrimental conditions from past ground disturbance would remain in a status of lengthy natural recovery for several decades.

There would be no new temporary roads created, and no closed roads temporarily re-opened. Road maintenance and repair would continue at the current level and improvements to primary haul routes or problem sites would only be pursued on a site-by-site basis as needed. Certain segments of secondary roads with drainage control problems could remain unrepaired for years. Accelerated erosion would continue during periodic runoff events from these segments.

Off-road trailing by woodcutters and OHV users would continue to occur in the planning area. OHV users would continue using closed, decommissioned or grown-in roads and constructing unauthorized trails.

3.4.4.2 Alternative 1 – Proposed Action

<u>Mechanical overstory treatments – thinning and regeneration harvest.</u> All of the proposed units located on old plantations and plantations have been harvested previously. To minimize new disturbance, old abandoned road alignments, closed roads, old landings, and old primary skid trails would be reused whenever feasible. Some units would incur additional impact to soils where old landings and skid trail patterns would not be reused. Soils on old travel surfaces that are to be re-used would revert from a status of partial recovery back to a detrimental condition. New temporary road miles would increase the extent of detrimental soil conditions and directly convert soils to a non-productive status for the life of their use in the units they traverse. The total acreage of temporary roads would amount to much less than 1 percent of the project area. New temporary roads would be minimally constructed. Temporary roads would be obliterated and restored when no longer needed for operations. Restoration would be expected to occur within 1 year of project completion and would entail measures to hasten recovery of soil function such as decompacting the surface, dispersing slash and organic materials over the top, and hiding or barricading access.

In some units slash would be placed on skid trails during logging to help minimize increases in soil disturbance, reduce erosion, and improve future soil condition. In windrowed units where the original skid trail patterns are difficult to discern, additional impacts would be minimized by not placing new skid trails on windrowed pile areas where residual topsoil and organics remain. Skid trail rehabilitation is proposed within the regeneration harvest units and would involve deep soil tillage of skid trails with a Subsoiler, or if soils are too rocky, decompaction with an excavator and thumbed bucket, locally known as "munching". In addition, displaced soil adjacent to the skid trails would be returned to the skid trail area where feasible, slash and organic material would be spread over the surface, and access points barricaded or hidden. Leave trees in the regeneration units are widely spaced and can easily be avoided by the equipment, so that damage to tree roots would be minimal. In contrast, rehabilitation of skid trails is not proposed within thinning units because deep soil tillage on skid trails would cause adverse impacts to adjacent trees where roots have penetrated into the skid trails, leading to reduced growth, and increased root disease and tree mortality. The opportunity to mechanically rehabilitate skid trails may come in the future if and when regeneration harvest occurs.

A net increase in disturbed soil condition is predicted where more skid trails, yarding corridors, landings and roads would be constructed than already exist. On ground-based units the expected increase in detrimental soil condition is expected to stay below 8% due to spacing of designated skid trails at 150 feet apart, but on many units, where a large number of skid trails are existing from the original clearcut harvest operation and would be reused, the increase may be lower, at 3-4%. On skyline units, the increase in detrimental soil condition is estimated at 2-3%, and on helicopter units at 1%. An estimate of 2% is added for the impact of harvester machines, where allowed based on slope.

For units not previously harvested (fire-origin stands), estimated changes in detrimental soil condition are 9% on thinning units and 4 to 10% on regeneration units. These stands would remain below the Forest Plan Standard of 15% detrimental condition. On previously harvested units, changes in detrimental soil condition created by the proposed action are estimated to range from 5 to 7% on proposed thinning units and 2 to 3% on regeneration units (see Table 7 below). Regeneration units have overall lower percent effects due to the decompaction of skid trails.

<u>Mechanical understory treatments – site prep and fuel break construction.</u> Equipment used to pile slash would move throughout the regeneration units and mechanically treated fuel break areas where slash is present. They typically must travel directly to every section of ground to be treated. Detrimental impacts are estimated around 5% for site prep and 3% for fuel breaks. Skilled operators, careful sale administration oversight, and adherence to PDCs are necessary to minimize soil displacement and contain impacts.

<u>Low Intensity burns – meadow and underburns.</u> The impacts of a prescribed burn on surface soil conditions can vary depending on fuel characteristics and loading, and soil climatic conditions at the time of burning. The intent is to produce a low intensity fire that leaves much of the humus and duff layers intact to maintain soil organic material and protect the soil surface from

raindrop splash and erosion. Within the meadow, the burn would consume the thatch portion of the grass and sedges, but leave the plant crown intact and alive. Within the underburns, the burn would consume a sufficient quantity of slash and brush while protecting soil and leave trees. Soil exposure would be minor. Encroaching brush and small trees that may be cut around the outer edges of the meadow would be scattered prior to burning so that fire intensity is not concentrated in any particular area. It is anticipated that low intensity burns would result in a minor amount of detrimental soil condition.

Broadcast burns on skyline and reforestation units. During broadcast burning, soil temperatures increase as a result of heat transfer from burning of surface fuels and the smoldering combustion of organic soil horizons. Soil heating is non-uniform across the landscape due to the variability of fuel loading, fuel consumption, and soil moistures at the time of burning. The highest temperatures are generally found near burned out stumps or logs where extreme heating occurs over extended periods of time. Changes to the underlying soil can include loss of effective ground cover due to consumption of litter and duff, soil color change from oxidation, loss of structural aggregate stability due to loss of organic matter, consumption or char of fine and very fine roots in the surface soil horizon, and formation of water repellent layers that reduce infiltration (Parsons 2010). The degree of these soil changes is influenced by the soil burn severity. Detrimental soil condition occurs when soil burn severity is severe. Soil is considered severely burned when the top layer of mineral soil is significantly changed in color (usually a reddish color) and the next one-half inch is blackened from organic matter charring due to heat conducted through the top layer.

Road management. Certain segments of the existing road system that would be used for haul routes and access to activity units would be maintained or reconstructed as directed by standard contractual requirements for harvest operations. These would include segments where there are signs of accelerated surface erosion. Drainage would be improved on closed and decommissioned roads so that runoff would be routed to minimize concentration of intercepted runoff and abate accelerated erosion. Sediment that was generated would be lessened and transport off-site minimized. Restoration techniques, including road obliteration, may be implemented to improve soil conditions where the extent of detrimental soil condition post-treatment exceeds 15% of the unit’s area (FW-028).

OHV trail rehabilitation. Within the project areas, compacted soil would be decompacted and, where feasible, displaced soil would be returned to the original location. Re-establishment of native vegetation would help to maintain soil fracture over time, as would closing the areas to vehicle access. Infiltration capacity and effective rooting depth would increase, and overland flow would decrease. Unauthorized OHV trails within the planning area would be closed and rehabilitated as funds become available. A notable increase in user-created OHV trails is anticipated in Unit 82 (regeneration) and Unit 138 (thinning) where historically, unauthorized OHV use was prevalent. These units are located within and around the old Lookout Springs Campground area, and at the trailhead to wilderness trails #501 and #523, where unauthorized OHV loop trails connected the campground to Huxley Lake and the end of Road 4612. In 2006 these unauthorized OHV trails were successfully closed with large boulder/rootwad/berm structures. North Clack would open up these closure structures and remove overstory and understory vegetation in the area, creating conditions for possible increased unauthorized OHV trail expansion. Mitigation measures to prevent a reoccurrence of the unauthorized OHV loop trail traffic in this and other areas of concern would include re-constructing closure barriers to current conditions at points where access to North Clack units required removal, and placement of sufficient slash at anticipated access points and on and between skid trails to minimize unauthorized OHV travel.

Soil condition would not be affected by planned treatments within no-cut riparian buffers and small areas of wetlands excluded from treatments. Soils would remain fully functional or in a status of gradual unabated natural recovery where detrimental conditions persist from prior disturbance.

Except where there are detrimental conditions, soils across the majority of the project area would continue functioning to support and maintain long-term site productivity

3.4.4.3 Alternative 2

Mechanical overstory treatments – thinning and regeneration harvest. Effects are similar to Alternative 1 except that acreage in detrimental soil condition in the thinning category is reduced, and acreage in the regeneration harvest category is increased.

Mechanical understory treatments – site prep and fuel break construction. Effects are similar to Alternative 1 except that acreage in site prep is increased.

Low Intensity burns – meadow and underburns. Effects are similar to Alternative 1 except that acreage in underburning is reduced.

Broadcast burns on skyline and reforestation units. Effects are similar to Alternative 1 except that acreage in broadcast burning is increased.

Road management. Effects are similar to Alternative 1.

OHV trail rehabilitation. Effects are similar to Alternative 1.

3.4.5 Cumulative Effects – Soil Disturbance

3.4.5.1 Alternatives 1 and 2

Mechanical overstory treatments – thinning and regeneration. Treatments would result in all stands having undergone some form of forest management at least once since the late 1920s. Many of the proposed treatment units have been harvested previously. For this reason, the potential for cumulatively accruing detrimental soil conditions in many of the units planned for treatment is high.

Not all ground disturbances in previously managed stands is detrimental; a proportion is low-level disturbance. Light and moderate levels of disturbance are detectable where ground-based operations have occurred in the past. Entering these sites again can exacerbate lower-level disturbance and push it to a detrimental soil condition. Units where the detrimental soil conditions are currently high are especially at risk of cumulative effects, where without restoration activities, inherent soil quality and productivity could be diminished.

Existing detrimental soil condition is estimated to be above 15% on units that were previously ground-based logged and have ground-based logging proposed in North Clack. All skyline and helicopter units are estimated to remain below 15%.

Application of BMPs, PDCs, and mitigation would be necessary to contain detrimental soil conditions. Mitigation to decompact heavily disturbed surfaces on temporary roads and landings, and some skid trails within regeneration units, and application of slash or other organic materials on temporary roads, skid trails and landings would help hasten recovery of soil function.

The majority of fire-origin stands have not been previously managed. With the implementation of North Clack, detrimental soil condition on those acres is estimated to be low to moderate. Combining all mechanically treated overstory acres, whether harvested previously or not, the cumulative detrimental soil condition is estimated to be high on about 46% of the ground-based treatment acres when factoring in planned rehabilitation activities.

The tables below shows a summary of effects from past actions, the estimated effects from the proposed action, and the cumulative effects of the past plus proposed actions for ground-based thinning and regeneration units. Unit data is in a spread sheet in the analysis file and is incorporated by reference.

Table 7 - Ground-based Thinning Units - Summary of detrimental soil effects of past, proposed and cumulative effects.

Stand Origin (condition prior to North Clack)	Existing Condition	Change in DSC*	Alt. 1 Acres	Alt. 1 Cumulative DSC	Alt. 2 Acres	Alt. 2 Cumulative DSC
Fire origin	0 - 1%	8 - 12%	589	8 - 12%	482	8 - 11%
Old plantations	5 - 7%	7 - 10%	391	13 - 17%	391	13 - 17%
Old plantations, later thinned	16%	4 - 8%	447	19 - 24%	447	22 – 24%
Old plantation, later clearcut	18%	8%	7	28%	7	28%
Plantations (stands clearcut after 1950)	17 – 21%	5 - 8%	258	23 – 26%	250	23 - 26%

*DSC = Detrimental Soil Condition

Table 8 - Ground-based Regeneration Units - Summary of detrimental soil effects of past, proposed and cumulative effects.

Stand Origin (condition prior to North Clack)	Existing Condition	Change in DSC*	Alt. 1 Acres	Alt. 1 Cumulative DSC	Alt. 2 Acres	Alt. 2 Cumulative DSC
Fire origin	0 - 2 %	8 - 10%	58	10%	149	10%
Fire origin, later thinned	9%	8%	16	17%	16	17%
Old plantations	6%	9%	49	15%	49	15%
Plantations (stands clearcut after 1950)	18%	9%	38	27%	34	27%

Mechanical understory treatments – site prep and fuel break construction. Mechanical site prep would occur on most ground-based regeneration units, and mechanical fuel break construction would occur in thinning units within fuel break boundaries, resulting in impacts from a second ground-based mechanical treatment on those acres. Additional detrimental soil condition associated with site prep and fuel break activities is estimated to increase by 3% to 5% within fuel break acres. Application of BMPs and PDCs would contain detrimental soil conditions. Additional detrimental soil condition would be minimized by using existing skid trails and temporary roads as much as possible during slash piling activities, and placement of slash piles on landing, skid trail, and temporary road locations where soil condition is already detrimental.

Low intensity burns – meadow and underburns. Impacts to soils are anticipated to be low at the meadow burn because a low intensity burn is planned. Previous logging and rehabilitation work in the underburn areas, and subsequent hand treatments and/or low intensity burning is estimated to result in a low to moderate detrimental soil condition.

Broadcast burns on skyline and reforestation units. Increases in detrimental soil conditions associated with prescribed broadcast burns are anticipated to be low because projects would be implemented following planned burn prescriptions.

Road Management. The presence and use of the road system would continue, and soils have been converted to a non-forest condition. Approximately 3.6 miles of existing road alignments would be reused as temporary roads, thereby minimizing new disturbance. Approximately 14.4 miles of new temporary roads would be constructed and would result in new disturbance. The temporary roads would result in additional detrimental soil conditions that would remain in a detrimental status until restored and put on a trajectory to recovery. Approximately 26.2 miles of system roads would be closed. While drainage features would be constructed or improved, the road bed itself would remain intact to facilitate future administrative use. These roads would be closed to public access, and this would help minimize impacts to soils in the areas they access from dispersed recreation use and off-road vehicle travel. Approximately 7 miles of system roads would be actively and passively decommissioned. Drainage structures would be constructed or improved, and culverts removed. Road ditch lines would continue to function. Where the road surface remains compacted, detrimental soil conditions would continue. Approximately 8 miles of stormproofing of system roads would be implemented, involving construction of drainage features. These roads would remain open.

OHV trail rehabilitation. Decompaction, waterbar construction, and establishment of native vegetation on unauthorized OHV trails would result in increased infiltration rates, a decrease of overland flow, and enhanced riparian and upland habitat within rehabilitated OHV trail locations. An increase in unauthorized user-created OHV trails may occur where overstory and understory vegetation is removed, and closure barriers are difficult to maintain. Off-road trailing by woodcutters and OHV users would probably continue in areas not closed and rehabilitated by this project.

Despite previous vegetation management and recreation usage in the project area, soils across the vast majority of the project area would remain in a condition of acceptable productivity and function. Long-term site productivity would be protected. The extent of detrimental soil conditions would remain moderate (below 15% of the unit area) across the project area where impacts were low prior to planned treatments or mitigation measures would keep additional impacts moderate. On about 46% of ground-based treatment acres, even if the extent of detrimental soil condition is estimated to be greater than 15% of the activity area, the majority of soils in the units are not in a detrimental condition. Due to their productivity and resilience most soils would retain their capability, serving as a growing medium, storing and cycling nutrients and water, producing biomass, and supporting or regenerating a contiguous forest cover of diverse age groups. The cumulative effects of the proposed actions when combined with past actions and foreseeable future OHV actions would not be substantial.

3.5 Organic Matter

Removal and redistribution of surface organics and topsoil could affect the site quality within a stand, reduce understory species diversity, change supply and mineralization rates of nutrients (particularly nitrogen), affect below-ground continuity and distribution of microorganisms, affect soil temperature fluxes, and affect water retention and movement on a larger scale. Compaction, puddling, displacement, erosion and severe burning of soils have the potential to affect individuals and populations of soil organisms including mycorrhizal fungi, soil dwelling arthropods, nematodes and bacteria. Loss of organisms occurs through direct destruction from equipment operations and from loss of habitat or substrate. These losses are usually localized to forest floor and/or topsoil disturbance.

Course woody debris is crucial for retaining moisture and moderating soil temperature. It also provides habitat for a diverse array of fungi and macro-/micro-invertebrates that improve soil structure and quality, cycle organic carbon, and facilitate nutrient cycling.

3.5.1 Existing Condition – Organic Matter

The amount and distribution of surface organics and downed coarse woody debris (CWD) have been affected by past forest management activities. All proposed thinning and regeneration in plantation and old plantation stands have been previously clearcut harvested and broadcast burned or windrowed, or salvage logged after fires, and therefore have localized changes of soil organism communities at disturbance sites where organic matter was removed or moved. Duff layers are relatively thin and range from 0.5 to 2 inches with an average of 1 inch.

Retention of CWD in managed stands has been a standard Best Management Practice (BMP) implemented to varying degrees over the last several decades but was not a standard practice when the proposed thinning and regeneration units were initially logged. Therefore most plantation or old plantation units have levels of CWD on the forest floor below the historic range that naturally occurred prior to harvest and fuel treatment. CWD levels vary between units primarily due to differences in past treatments, the degree of decay in the mature trees, and whether cull logs were removed or left in place during the original harvest. Recruitment from standing residual trees would recur and serve as a future source.

3.5.2 Direct and Indirect Effects – Organic Matter

3.5.2.1 No Action

Forest organic litter input, organic decomposition rates, duff layer development and soil fauna and microbe activity would be unchanged. Organic matter decomposition and nutrient cycling is influenced substantially by temperature and moisture which would be subject to climate change. Organic materials would be subject to disturbances such as windthrow, fire and climatic change. As unthinned stands age, trees would die and fall (see snag and down wood analysis in Wildlife Report). These stands would eventually produce substantial quantities of small woody debris and some large trees, which would be a source of future large and small decaying logs on the ground.

3.5.2.2 Alternative 1 – Proposed Action

Mechanical overstory treatments – thinning and regeneration harvest. Logs existing on the forest floor would be retained. The harvesting operations would add small woody debris the size class of the cut trees. This would include the retention of cull logs, tree tops, branches, broken logs and any snags that would be felled for safety reasons. Snags or green trees that fall down after the harvest operation would contribute to the down wood component of the future stand. Within plantations, an estimated two to seven trees per acre would be felled or girdled to create coarse woody debris. Partially rotted down logs left from the previous fires, thinnings, or clearcut may be degraded if moved or run over by ground-based equipment. Most fire-origin stands currently have sufficient quantities of coarse woody debris logs.

Duff disturbance would be minimized where full suspension yarding occurs in skyline and helicopter operations, where designated and existing skid trails are used in ground-based yarding operations, and where harvesters travel over slash mats when traveling away from designated skid trails. Soil microbial populations would likely be reduced initially in areas of exposed soils. Leaving branches and needles throughout the units where trees are felled should help maintain carbon and nutrient levels. Organic material would be displaced where soil is exposed during mechanical felling, yarding and temporary road construction and reconstruction operations.

Mechanical understory treatments – site prep and fuel break construction. Coarse woody debris meeting piling specifications would be reduced across the units and fuel break areas where piling occurs. Some litter and duff would be displaced and soil exposed where equipment disturbs the organic ground cover.

Low intensity burns – meadow and underburns. The intent is to produce a low intensity fire that leaves much of the humus or duff layer intact to maintain soil organic material and protect the soil surface from raindrop splash and erosion.

Broadcast burns on skyline and reforestation units. Extent of effective organic ground cover (litter, unburned duff, charred duff, woody debris) remaining after a broadcast burn would depend on fuel characteristics, fuel loading, burn characteristics and vegetative moisture at the time of burning. Effective ground cover prevents erosion and runoff. Organic materials in the surface soil horizon act as an adhesive that bind soil particles into stable aggregates that resist detachment. When burned this soil structure can be changed. Depending on the soil type and degree of heating, exposed soils may become more susceptible erosion.

Road management and OHV trail rehabilitation. Road decommissioning and OHV trail rehabilitation projects would increase soil organic matter within roadbeds and OHV trails where the surfaces are decompacted and revegetated, and course woody debris is placed within the road and trail prisms.

3.5.2.3 Alternative 2

Mechanical overstory treatments – thinning and regeneration harvest. Effects are similar to Alternative 1 except that acres of site-prep and burning would increase proportional to the increase in regeneration harvest acres.

Low Intensity burns – meadow and underburns. Effects are similar to Alternative 1 except that underburn acreage would be reduced, proportional to the reduction of thinning acres planned for underburns.

Road management. Effects are similar to Alternative 1.

OHV trail rehabilitation. Effects are similar to Alternative 1.

3.5.3 Cumulative Effects – Organic Matter

3.5.3.1 Alternatives 1 and 2

In the analysis area, previous timber harvest, fuel treatment, and road construction activities have resulted in reduced duff and large woody debris levels, and a probable change in soil organism communities in disturbed areas. Decomposition of large wood recycles nutrients, is a substantial contributor to biological carbon sequestration, contributes to soil structure, slows evaporation of soil moisture during dry periods, and maintains a moist environment and food source for a large variety of soil and other organisms. Cumulatively the reduction of large wood removed by clearcutting and road building has had long term impacts to these ecological processes.

A sufficient tonnage of branches and down logs left after harvest is completed is expected to remain on site to provide for organic matter input to the ecosystem once all activities are complete. Based on previous experience with similar stands, approximately 27 tons per acre of debris would be retained in the plantation units, and a greater amount in fire-origin stands, which are sufficient levels in west side forests to maintain long-term productivity.

The cumulative effect of additional disturbance from the proposed action added to the existing condition would slightly increase displacement of organic material on exposed soils, increase numbers of coarse woody debris logs the size of thinned material, and reduce the decay cycle timeframe of rotting down logs that are moved or run over by equipment.

The cumulative effects of the proposed actions when combined with past actions and foreseeable future OHV actions would not be substantial and trees and other vegetation are expected to continue growing and developing at appropriate rates.

Forest Plan Standards and Guidelines

Mt. Hood Forest Plan References
Forestwide Soil Productivity Standards and Guidelines - FW-22 to FW-38, page Four-49
Forestwide Geology Standards and Guidelines – FW-1 to FW-16, page Four-46
See Mt. Hood FEIS pages IV-11, and IV-155 to IV-167
Northwest Forest Plan - Coarse Woody Debris Standards and Guidelines - page C-40
Soil Disturbance Standards and Guidelines - page C-44
Modify Fire and Pesticide Use, Minimize Soil Disturbance Standards and Guidelines - page C44

Table 9 – Summary of Standards and Guidelines

Standard	Notes
FW-1 to 16	Slope stability concern areas have been identified by the Forest Geologist, and have been deleted from the proposed units.
FW-22 to 23	Most units that were logged with ground-based equipment in the original harvest are not consistent with the FW-022 standard. See discussion below for exception.
FW-24	Minimization of rutting would be achieved through the BT6.6 and CT6.6 or similar provisions in the contract.
FW-25	Ground cover would be maintained at the prescribed levels.
FW-28 to 30	Rehabilitation would be accomplished only on skid trails in regeneration harvest units, and only on roads and landings used by the operator. Rehabilitative techniques may not restore the soil resource to a level of less than 15% impaired. See discussion below for exception.
FW-31 to 34	Sufficient woody debris (>25 tons/acre) would be left on site including existing down logs, tops and branches and trees felled to create coarse woody debris.
FW-37	Many aspects of the project include design features that limit disturbance to the soil's organic horizon: skyline and helicopter systems are used where appropriate, existing temporary roads, landings and skid trails would be reused where appropriate and mechanical fellers would operate on top of branches and tops.

Exceptions

Exceptions to Forest Plan standards and guidelines FW-022, FW-028, and FW-030 are proposed. These relate to soil productivity which is defined in the Forest Plan as the capacity of a soil to produce a specified crop such as fiber or forage under defined levels of management. Productivity is generally dependent on available soil moisture and nutrients, and length of growing season (Glossary p. 30).

FW-022

The combined cumulated detrimental impacts, occurring from both past and planned activities, of detrimental soil compaction, puddling, displacement, erosion or severely burned soil should not exceed 15% of the activity area.

Thinning units on plantations and old plantations with one additional harvest operation, and regeneration units located on plantations already exceed 15%. The proposed action would increase it somewhat in some units while reducing it in other areas depending on site-specific factors (s. 3.4.5.1). The potential to reduce impact even further as suggested by FW-028 was considered and is discussed below.

There was no standard and guideline for limiting the extent of detrimental soil impacts when the original clearcuts were logged prior to the Forest Plan. Back then, ground-based logging was less restricted and operators were not required to limit their skid-trail system, landings, and temporary roads to a specified extent. Post-harvest activity such as site preparation for reforestation often added to the extent of detrimental ground disturbance after the initial harvest. In more recent years, unauthorized user created OHV trails have also added to the extent of detrimental disturbance.

Some system roads have been decommissioned and while these were previously not included in the calculation, they are included now because the decommissioning has not fully restored soils.

The Forest would continue to manage soil resources with the goal of maintaining or enhancing its productivity. The proposed action has been designed to minimize additional detrimental soil impacts. The following project design criteria and contractual specifications would be employed that aim to contain the extent of detrimental soil conditions.

- All or portions of a few thinning units that were originally logged with ground-based equipment would be thinned using skyline machines or helicopters which have lower soil impact.
- Old roads and landings would be reused where appropriate.
- Existing skid trails would be reused where they are not hydrologically connected.
- Where the existing skid trail pattern has far more trails than are needed with today’s equipment and logging techniques, only the skid trails that are needed to efficiently operate would be reused and the unused skid trails would be allowed to continue to recover.
- Where new skid trails are needed due to changes in logging system or landing location, they would be spaced 150 feet apart and on appropriate slopes.
- Mechanical harvesters would walk on layers of slash.
- Ground-based operations would occur during dry conditions when soil moisture conditions are sufficiently dry to prevent excessive compaction, rutting or erosion.

- Some trees would be felled to create down woody debris.
- Appropriate erosion control techniques would be used including constructing waterbars on skid trails and placing slash on certain skid trails and OHV routes.
- After operations are completed, temporary roads and landings that were used would be decompacted.
- Some system roads would be decommissioned.
- Unauthorized OHV trails would be blocked and restored.
- Some system roads would be stormproofed and closed which would reduce unauthorized OHV use.
- In areas not disturbed again, natural recovery would continue to occur, as roots and burrowing animals penetrate and break up compacted soils, as organic matter accumulates, and as soil wetting/drying and freezing/thawing cycles occur.

In dense stands, site and soil resources are used by all the trees to stay alive with little left over for root expansion and stem strength. When high tree density is coupled with the existing extent of detrimental soil conditions, productivity could be considered lower than the sites potential. Conversely, thinning to maintain tree spacing and therefore stand health, results in a reallocation of site and soil resources to the remaining trees, therefore offsetting to some degree, the negative effects of detrimental soil condition. The availability of site and soil resources for growth would increase substantially after thinning.

The objective of maintaining long-term site productivity would still be met. Section 3.4.5.1 describes that site productivity has not been impaired and that the cumulative effects of the proposed actions would not be substantial and trees and other vegetation are expected to continue growing and developing at appropriate rates.

FW-028

Following completion of project activities, if more than 15% of the activity area remains in an impaired (e.g. compacted, puddled, displaced or eroded) soil condition, rehabilitative techniques should be used to restore the soil resource to a level of less than 15% impaired.

Even though many units already exceed this level it is not possible or practical to rehabilitate all of the impacts at this time. At the time of the original clearcut harvest, ground-based logging was less restricted and operators were not required to limit their skid-trail system, landings, and temporary roads to a specified extent. Temporary roads and landings were also created to access the stands. Some of the detrimental condition has been caused by site preparation techniques prior to planting that used tractors or involved intense burning. In more recent years, unauthorized user created OHV trails have added to displacement and compaction.

Temporary roads, landings and skid trails are a key part of the stand management transportation system and where appropriately located, would likely be reused when stand management is proposed. Stand management techniques have evolved over time changing the portion of land used for the stand management transportation system and the portion kept productive and resilient to grow trees and other vegetation at appropriate rates.

Even though there have been advances in the past 50 years in understanding the critical role soil conditions play in forest productivity, it is not always possible to reverse all past impacts so that soils can be returned to the same level of functionality that they once had. For example where severe burning resulted in scorched soils or where duff and the top soil horizon have been moved a great distance, it is not feasible to restore these impacts quickly. Some actions are proposed to restore or minimize impacts to soils including those listed above for FW-022; they would provide some benefit but they are not likely to fully restore soils.

One technique used in the past to partially restore soils is to use deep soil tillage equipment on skid trails. This has been done before in regeneration harvests where a winged subsoiler pulled by a tractor was used to decompact soils on skid trails. This technique is recommended by another guideline (FW-030) which suggests that all logging skid trails should be considered for rehabilitation through deep soil tillage techniques as a means to achieve the goals of FW-028. This technique is appropriate in some circumstances such as directly after a regeneration harvest or shelterwood harvest, but is not appropriate in other circumstances. This guideline was not a requirement at the time of the initial clearcutting.

While the existing skid trails are still considered to have detrimental soil conditions, there are tree roots that have penetrated into the skid trails. Reusing the skid trails again may add some additional compaction around these roots but they would likely remain intact. Deep soil tillage of skid trails in a thinning unit would break the roots that have penetrated into the trails and lead to reduced growth, increased root disease and tree mortality. Using this technique on skid trails that are not reused at this time, (e.g. where there are more skid trails than needed or where units are changed to skyline or helicopter) would require that trees growing in the trails be cut prior to treatment. This would set back the partial recovery that has occurred on these skid trails.

Deep soil tillage was considered for all skid trails, and the technique was selected for the regeneration harvest units but not selected for the thinning units. The project is consistent with FW-030 because serious consideration was given to this technique even though it was not selected for all units. The opportunity to mechanically rehabilitate skid trails in thinning units by deep soil tillage may come in the future if and when regeneration harvest occurs in these stands. Most proposed units that were logged with ground-based equipment in the original clearcut or thinning harvest would remain above 15% detrimental soil condition.

5.0 References

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Appendix A

Figure 1a. Hillshade map showing landforms—North Clack Integrated Resource Planning Area

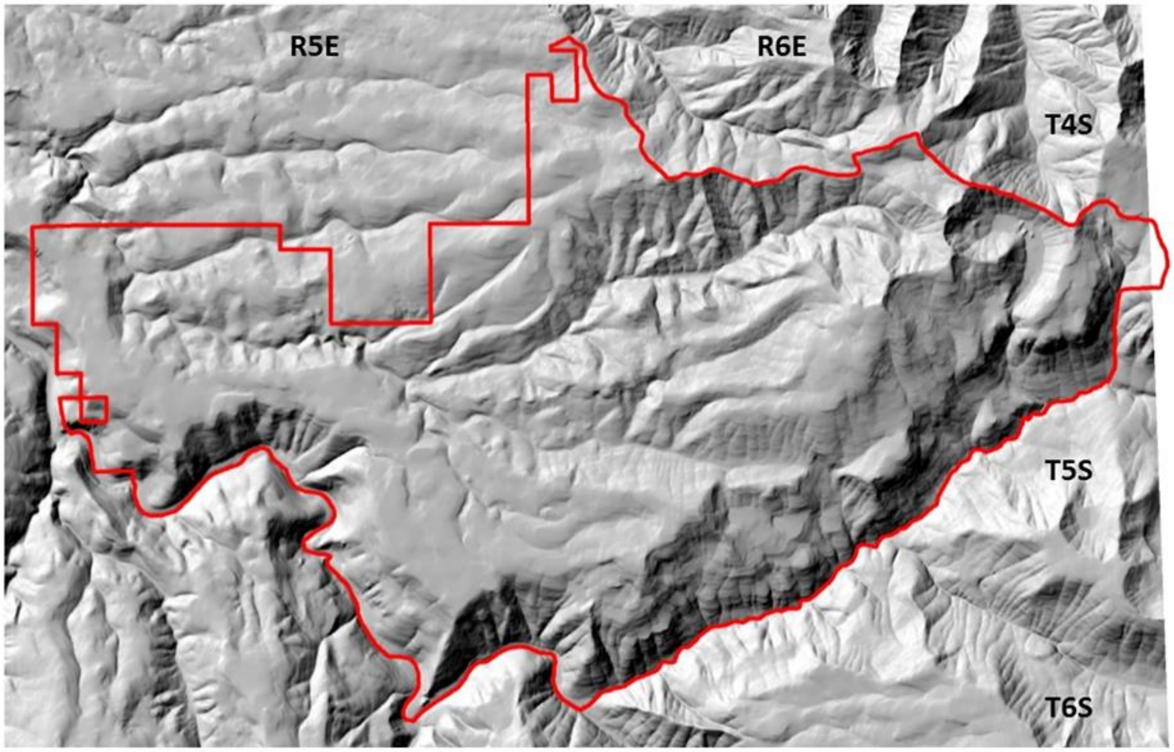
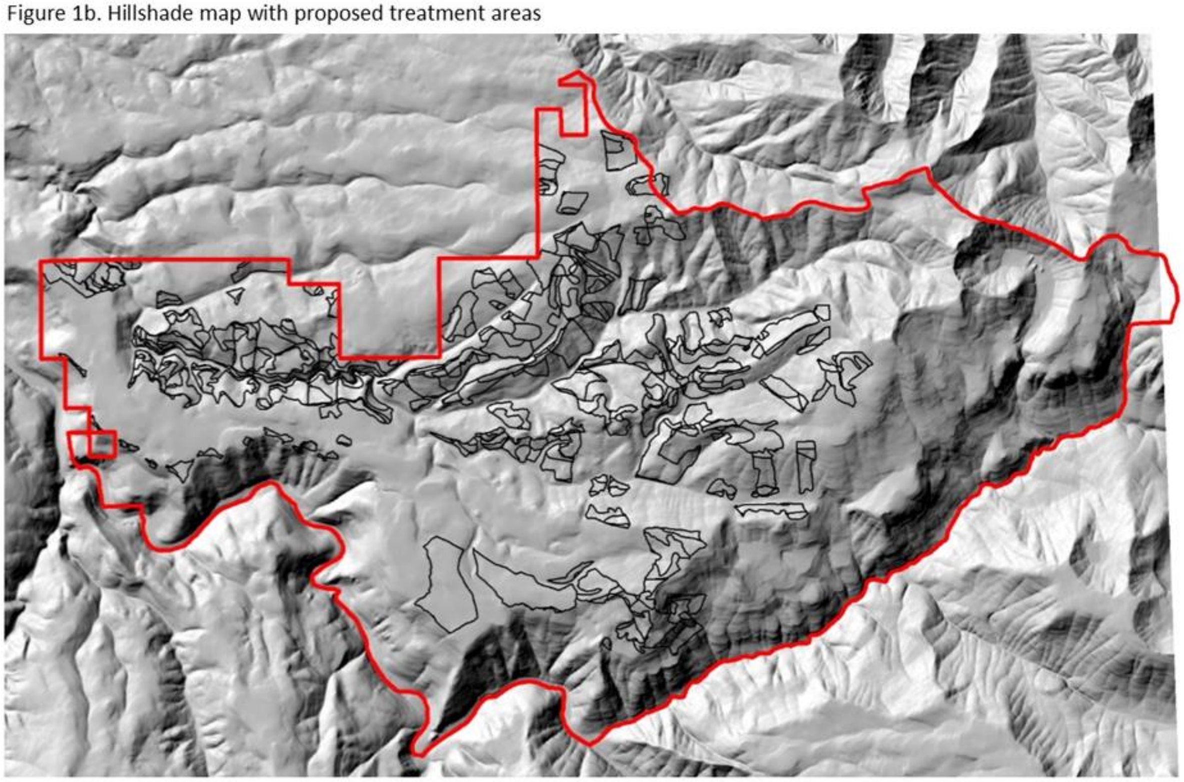


Figure 1b. Hillshade map with proposed treatment areas



Appendix A

Figure 2a. General Lithology map—North Clack Integrated Resource Planning Area

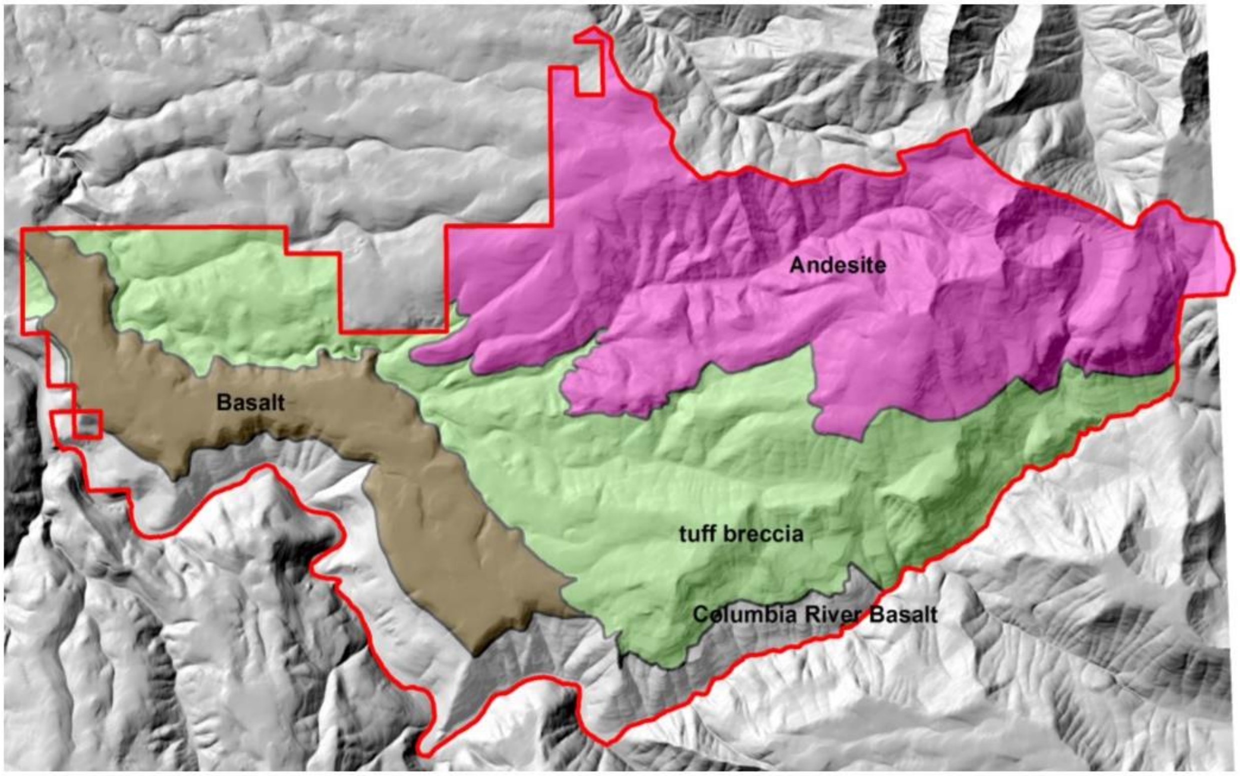
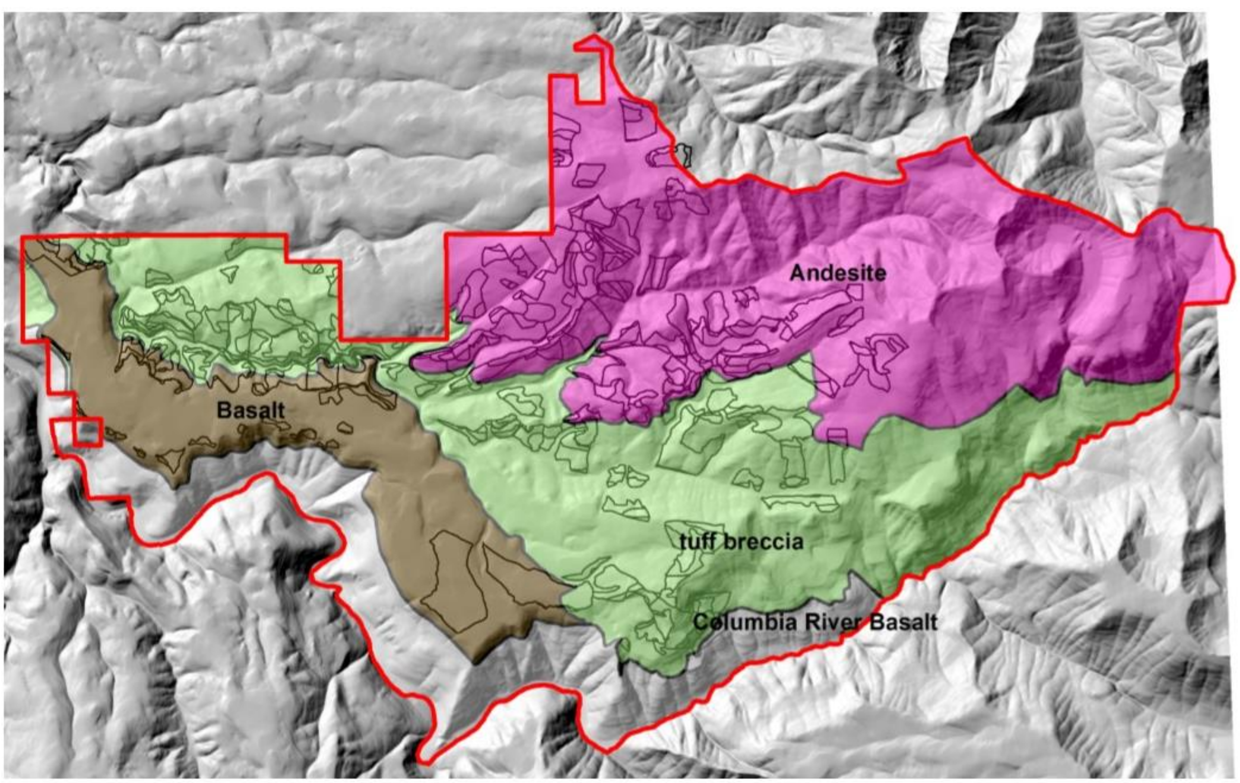
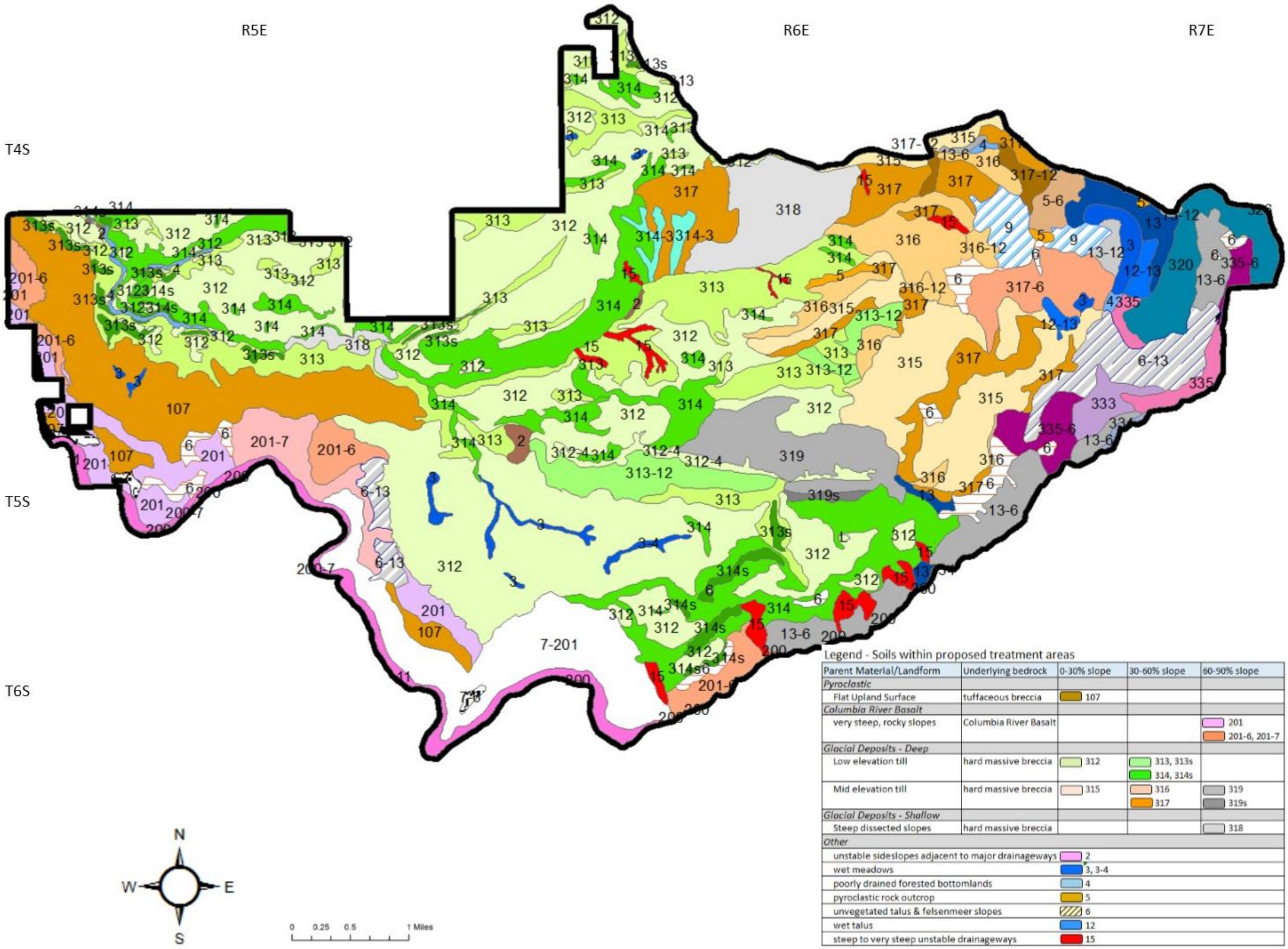


Figure 2b. Lithology map with proposed treatment areas.



Appendix A

Figure 3. General Soil Map of North Clack Integrated Resource Planning Area

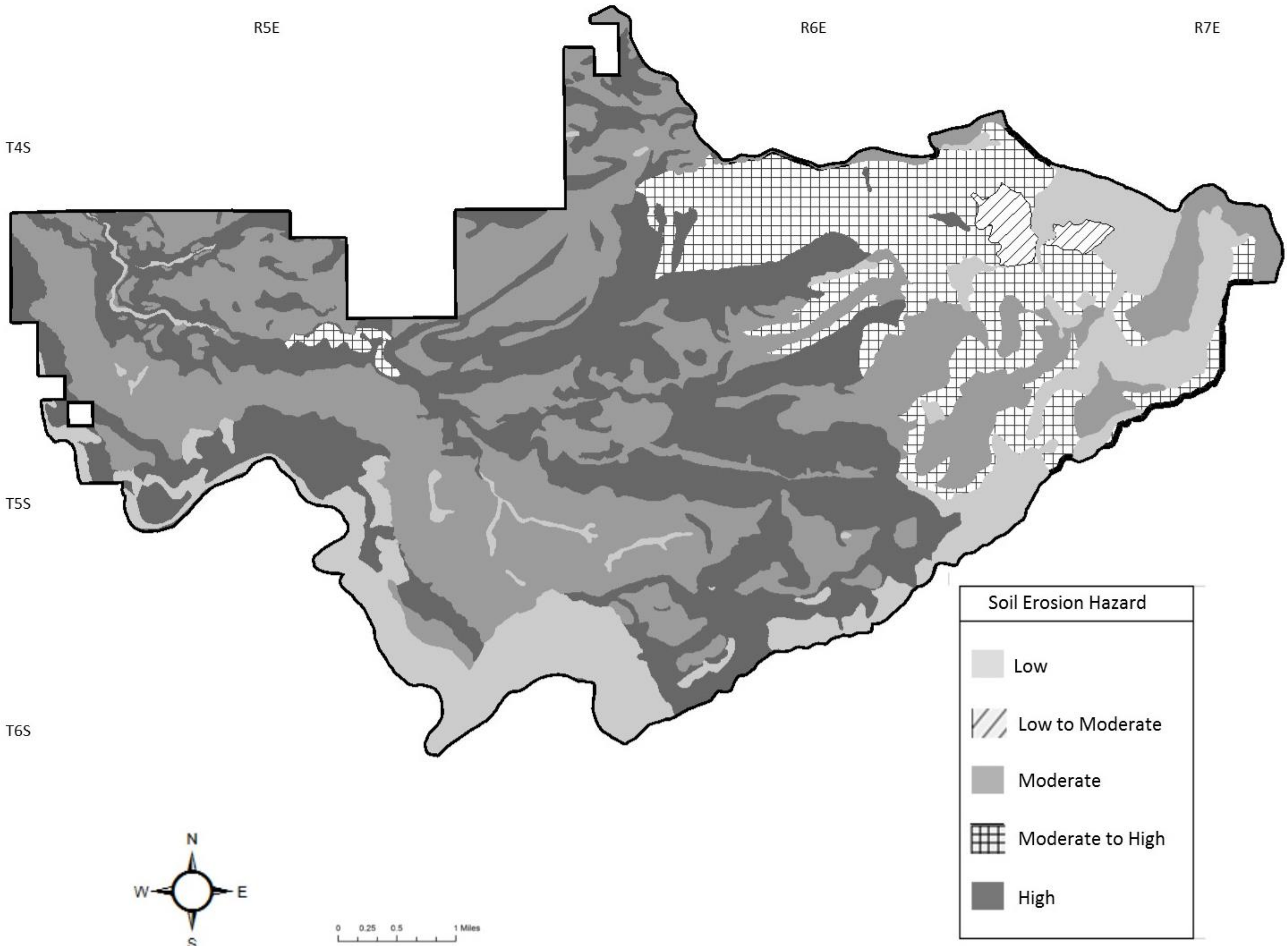


Legend - Soils within proposed treatment areas

Parent Material/Landform	Underlying bedrock	0-30% slope	30-60% slope	60-90% slope
Pyroclastic				
Flat Upland Surface	tuffaceous breccia	107		
Columbia River Basalt				
very steep, rocky slopes	Columbia River Basalt			201 201-6, 201-7
Glacial Deposits - Deep				
Low elevation till	hard massive breccia	312	313, 313s 314, 314s	
Mid elevation till	hard massive breccia	315	316 317	319 319s
Glacial Deposits - Shallow				
Steep dissected slopes	hard massive breccia			318
Other				
unstable sideslopes adjacent to major drainageways		2		
wet meadows		3, 3-4		
poorly drained forested bottomlands		4		
pyroclastic rock outcrop		5		
unvegetated talus & felsenmeer slopes		6		
wet talus		12		
steep to very steep unstable drainageways		15		

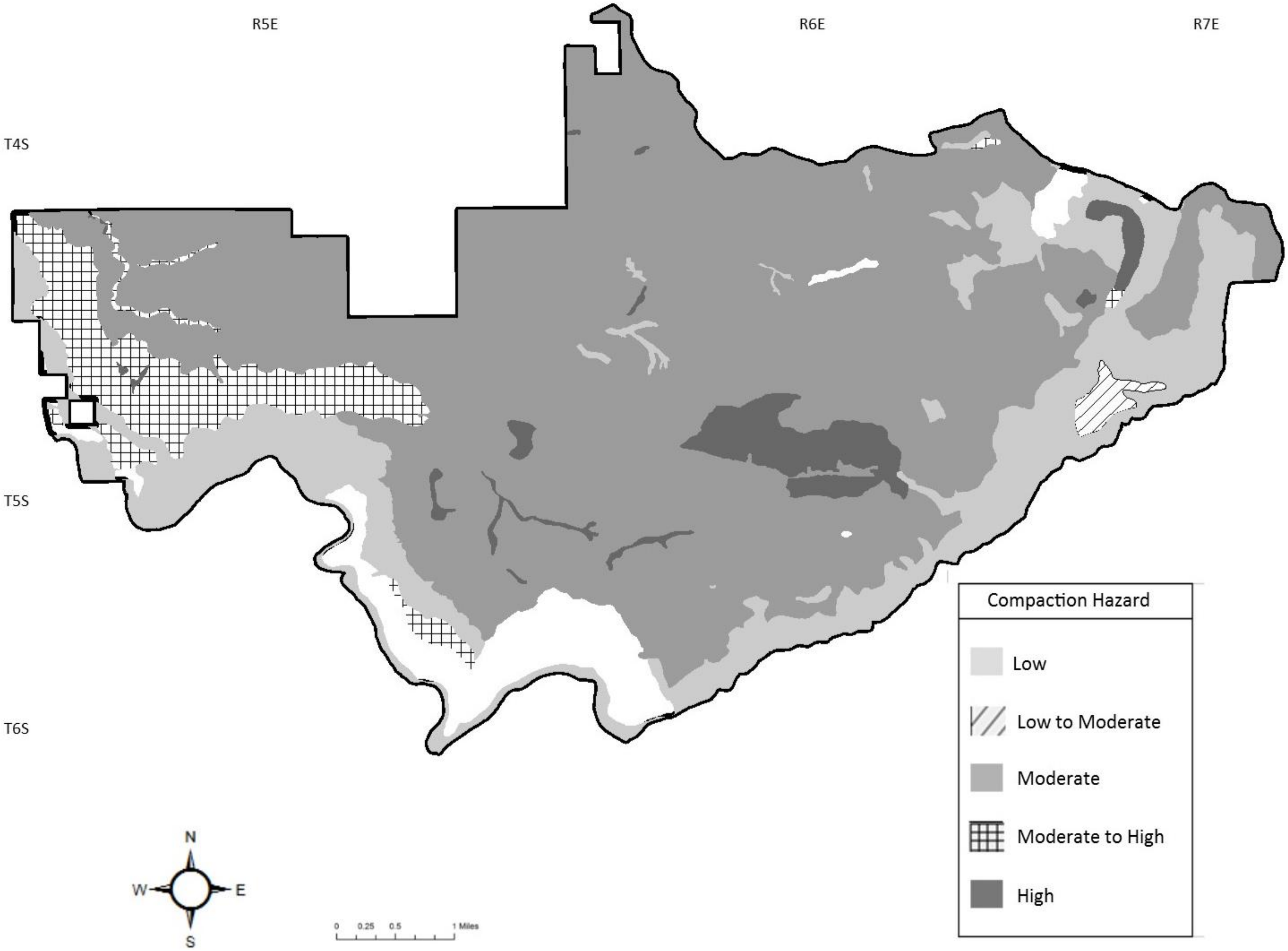
Appendix A

Figure 4. Soil Erosion Hazard Map - North Clack Integrated Resource Area



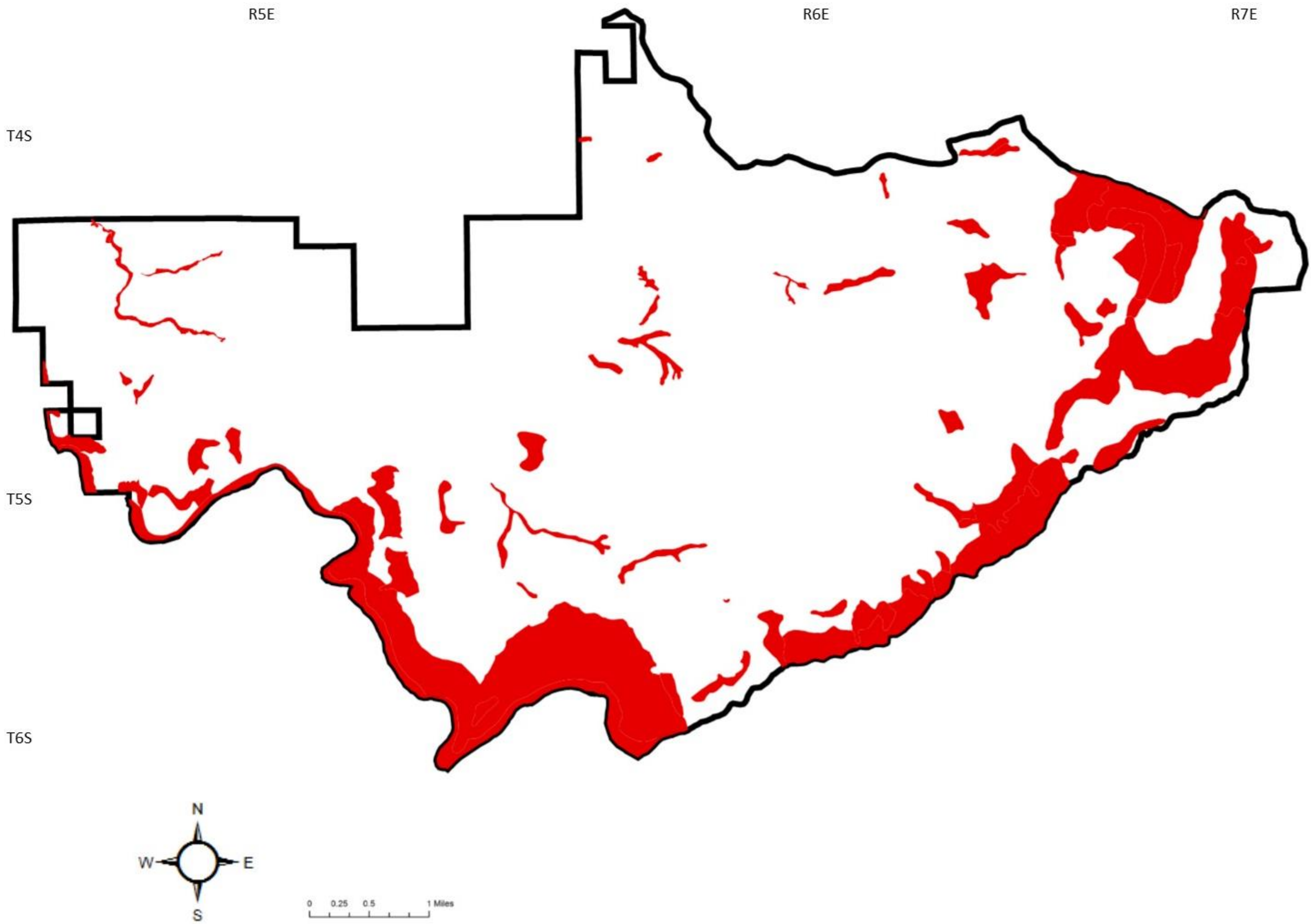
Appendix A

Figure 5. Compaction Hazard Map - North Clack Integrated Resource Area



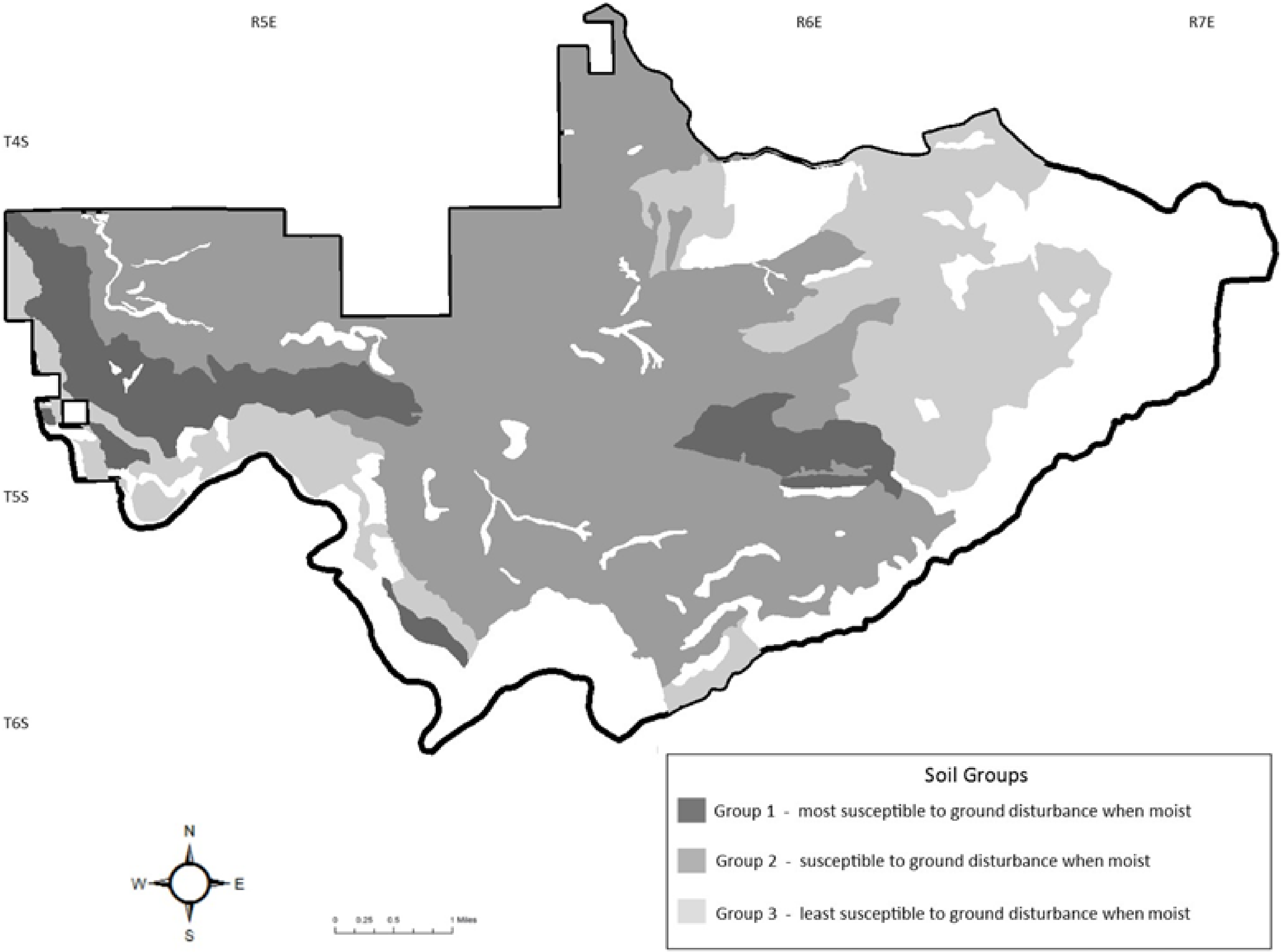
Appendix A

Figure 6. Unsuitable soil types identified in the Mt. Hood SRI General Soil Map within North Clack Integrated Resource Area.



Appendix A

Figure 7 . Soil Groups 1, 2, and 3 as addressed in PDC C9



Appendix B

Table 1 - SRI Mapping Unit Soil Characteristics — **North Clack Planning Area**

Soil								Litter	Surface				Subsoil				Total
MU	Geology	Landform	slope	Aspect	Elev	Veg	Mgmt		color	texture	rock	depth	color	texture	rock	depth	depth
2	Unstable sideslopes adjacent to major drainageways	Steep unstable to very unstable sideslopes along major drainageways. Soils are extremely variable but textures are usually clay loams, silty clay loams, and clays. Soil horizons are not well defined as a result of continuous soil movement. Produces high quality timber.															
3	Wet Meadows	Depressional areas that are seasonally or permanently ponded.	0-3%				Soils slowly permeable and imperfectly to poorly drained. No machinery.										
4	Poorly drained forested bottomlands	Depressional areas that have permanent or seasonally high water tables. Soils are slowly permeable and imperfectly to poorly drained.					Veg = willows, sedges, rushes. Drop areas from logging units and buffer.										
5	Pyroclastic rock outcrop	Rock outcrops of tuffs and breccias. Rock is generally soft and incompetent. May include areas of shallow soils.															
6	Unvegetated talus and rubbleland	Fallen rock fragments of all sizes which occur at the foot of steep rock slopes and headwalls. Devoid of vegetation except for mosses and lichens.															
7	Igneous rock outcrop	Rock outcrops of basalt and andesite, rock generally hard and competent. May contain areas of shallow soils.															
8	Dry Meadows	shallow loamy soils on convex slopes which are devoid of trees	5-60%														
15	Steep to very steep, unstable drainageways	Active landslides and debris avalanches that produce extremely variable soils. In some areas soil is wholly lacking.					Avoid unstable areas										
107	**PYROCLASTIC FORMATIONS** Massive deposits of tuffaceous breccia. Weathers rapidly to fine-textured material, with high water holding capacities. High compaction and erosion hazards. The pyroclasic rocks are underlain by hard Columbia River Basalt.	Nearly level slopes of LaDee Flat.	0-20%	All	1000-2000'	WH ↓	Good producer of timber. Topography suitable for tractor logging but has a high compaction hazard. Some areas with seasonally high water tables may also be subject to damage.	1/2 to 1-1/2"	dark grayish brown to dark yellowish brown	loams and silt loams	10-15%	13-17"	dark yellowish brown to yellowish brown	loams and silt loams	15-20%	25-32"	45-60" depth to bedrock 4-5'

Appendix B

Table 1 - SRI Mapping Unit Soil Characteristics - continued

North Clack Planning Area

Soil MU	Geology	Landform	slope	Aspect	Elev	Veg	Mgmt	Litter	Surface color	Surface texture	Surface rock	Surface depth	Subsoil color	Subsoil texture	Subsoil rock	Subsoil depth	Total depth
201	**COLUMBIA RIVER BASALT** very shallow soils, south aspect, and very steep slopes	steep south and west facing slopes	60-90%	S,W	500-2000'	WH	Timber mgmt very difficult due to very shallow soild, a south aspect, and very steep slopes. When harvested, erosion hazard ans soil mantle failure potential are high. Road building difficult.	1/2"	very dark brown to dark brown	cobbly and gravelly loams	50-60%	3-5"	dark brown to dark yellowish brown	gravelly loams and silt loams	70-80%	10-12"	13-17"
312	**GLACIAL DEPOSITS** Deep glacial till deposits, uncompacted and overly hard massive breccia formations. Have high contents of large rounded stones and boulders.	nearly level to sloping, smooth to slightly undulating, glaciated slopes near Fanton.	0-30%	All	500-1800'		Good producer of timber. Generally Site Class 2 & 3. Topography suitable for tractor logging but has a moderate compaction hazard. Potential for subsoil erosion high.	3-4"	very dark grayish brown to brown	stony and cobbly silt loams and light clay loams	30-45%	11-15"	dark yellowish brown to light yellowish brown	cobbly and very gravelly light clay loams	30-40%	38-45"	49-60"
313		steep north and east facing slopes alond drainageways near Fanton	30-60%	N & E			Good producer of timber. Generally Site Class 3. Terrain not suitable for tractor logging and surface and subsoil erosion hazard is high.	1-2"			40-50%	8-10"		cobbly and gravelly clay loams and silt loams	40%	20-34"	37-44"
314		steep south and west facing slopes alond drainageways near Fanton		S & W			Average producer of timber. Site Class 4 Df. Terrain is not suitable for tractor yarding and surface and subsoil erosion potential is high.	1-2"			30-40%	6-9"			30-40%	25-30"	31-43"
315		nearly level to sloping, smooth to slightly undulating slopes in the Wildcat Area.	0-30%	All	1800-3000'		Site Class 4 DF. Terrain is suitable for tractor but soils have a moderate compaction hazard.Surface erosion is slight to moderate, and subsoil erosion is moderate.	1-2"	dark brown to yellowish brown	gravelly loams	30-40%	11-14"	yellowish brown to yellow	gravelly and very gravelly loams	35%	27-30"	38-44"
316		steep, smooth to slightly undulating slopes in the Wildcat Area and near High Rock.	30-60%	N & E			Good producer of timber. Generally Site Class 3 & 4. Fully suspend cable yarding. Surface erosion is moderate, and exposed subsoils erode rapidly.	1/2 - 1-1/2"		cobbly loams	40-50%	8-10"			40%	20-24"	28-34"
317				S & W			Generally Site Class 4. Fully suspend cable yarding. Surface erosion is moderate, and exposed subsoils are moderate to high (erode rapidly).	1/2 - 3/4"			30-40%	7-9"			40%	18-20"	25-29"
319		gently sloping to steep slopes near High Rock	20-70%	All	2000-4000'		Produces Site Class 3 & 4 D-f. Because of wetness problems, the compaction hazard is high. Because the water table is within 2 ft. of the soil surface, windthrow hazard is also high. Regen not a problem.	2-3"	very dark grayish brown to dark gray	cobbly and gravelly sandy loams	30-40%	8-10"	brown to light yellowish brown	cobbly and gravelly silt loams	20-30%	35-45"	43-55"