STEEP SLOPE LOGGING WITH GROUND BASED CUT TO LENGTH EQUIPMENT WITH A TETHER SYSTEM ON THE COLVILLE NATIONAL FOREST

Sarah Brame and Jason Jimenez
Soil Scientists
Colville National Forest
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Purpose

The purpose is to assess effects to soils from steep slope logging with cut to length (harvester and forwarder) tethered logging equipment. This report discusses monitoring of Ponsse cut to length equipment with a Synchrowinch that synchronizes the winch speed to the machine driving speed. Other types and systems of tethered logging is not discussed or monitored in this report.

Introduction

Tethered logging systems are recent to the Pacific Northwest and to the Forest Service. They has been used in Europe and New Zealand but recently made its way into Washington and Oregon. This logging system uses a cable to a fixed object or another piece of heavy equipment to help harvesting equipment navigate steep ground. The cable attaches a piece of equipment, usually a harvester or forwarder, to an anchor point, to assist the machine on steep slopes. This enables harvesting equipment to travel on slopes that are otherwise too steep for most ground based equipment (40% slope or greater), increasing access to areas that were previously restricted due to slope. Tethered systems are interesting to land managers for this reason and more importantly, for improvements in operator safety. Traditional steep slope cable logging relies on workers cutting trees by hand and manually setting chokers, exposing themselves to falling trees and other hazards. The tethered logging method allows workers to operate inside the cab of a machine which mitigates some of those risks. Safety, increased access, and increasing areas of restoration are potential benefits of this method.

Minimal research exists on the effects of tethered logging to soils. Since it is making its way onto the public lands, land managers and resource specialists need to better understand the soil impacts associated with tethered logging. Specifically, soil scientists and hydrologists are interested in learning how ground-based equipment associated with this new technology might affect the physical soil/hydrological conditions on steep slopes. It is well known that steep slopes are vulnerable to soil erosion and that detrimental soil effects increase with steeper slopes. On Forest Service lands, most ground-based equipment is limited to 40% slope or less, tethered equipment can operate on much steeper slopes. There are concerns for soil compaction, rutting, and soil displacement under these conditions. Deep ruts can develop while operating on steep slopes, which allow for accumulation of water runoff and subsequent soil erosion. There are additional concerns for soil mixing and topsoil displacement due to track slippage, as well as keeping within Region 6 - Soil Quality Standards.

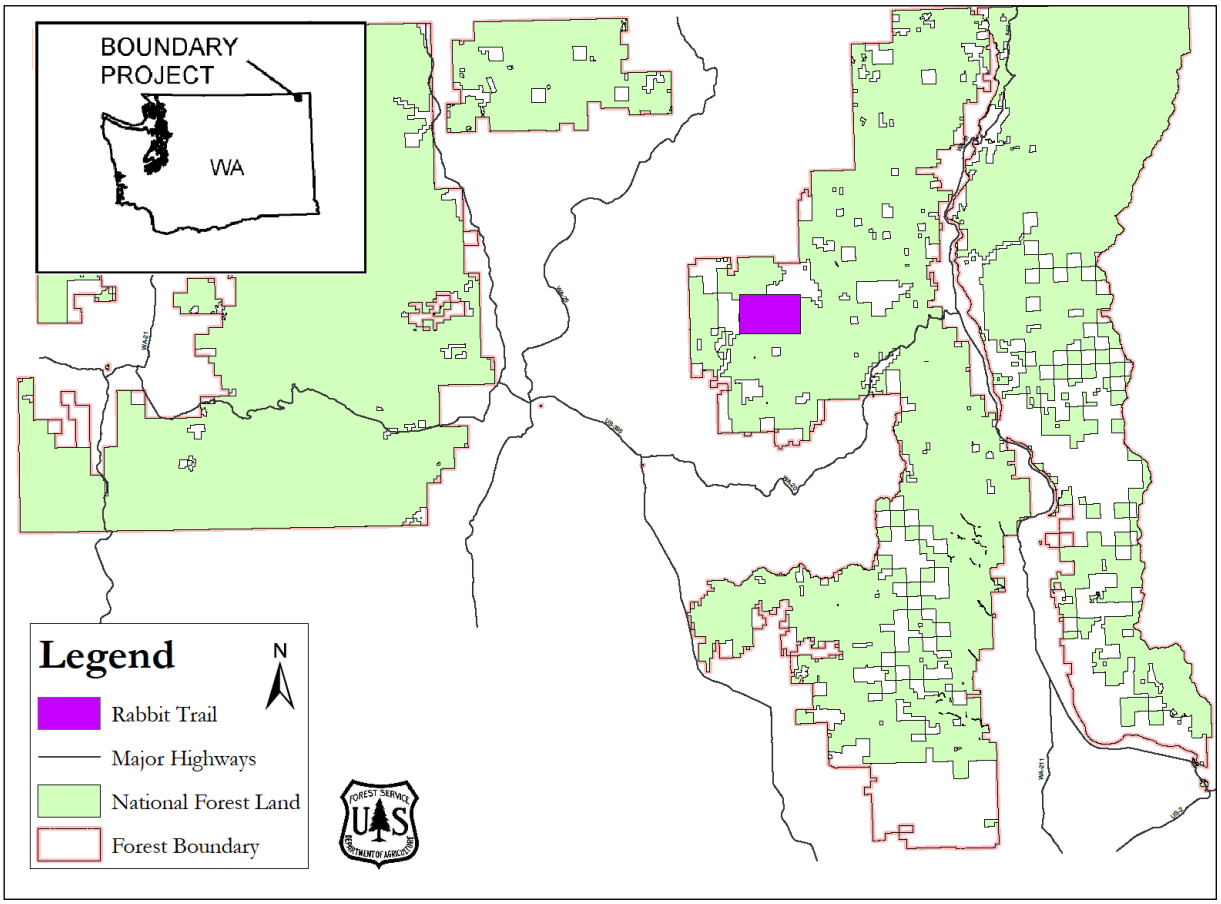
Research suggests that soil disturbance may be reduced by tethering on steep slopes. Sessions and Leshchinsky (2017) discuss tethered logging and conclude, theoretically, that under the right soil conditions, soil disturbance should be reduced. Visser and Stampfer (2015) state "that it can be assumed that a tethered assist system will reduce soil disturbance through reduced slippage of the tracks compared with that for untethered vehicles". In addition, researchers at Oregon State University (OSU) are currently studying steep slope logging; focusing on safety and assessing environmental impacts. Their initial results suggest that cable assisted equipment results in less compaction due to the decrease in ground pressure (Green, 2017). However, the research is still ongoing and additional evidence is needed to fully evaluate the effects in regard to soil productivity and hydrologic function.

Due to these concerns, a lack of soil specific data, and to provide more information to resource specialists, the Colville National Forest has taken an opportunity to study the effects to soils of steep slope tethered and non-tethered logging operations.

Study Area Description

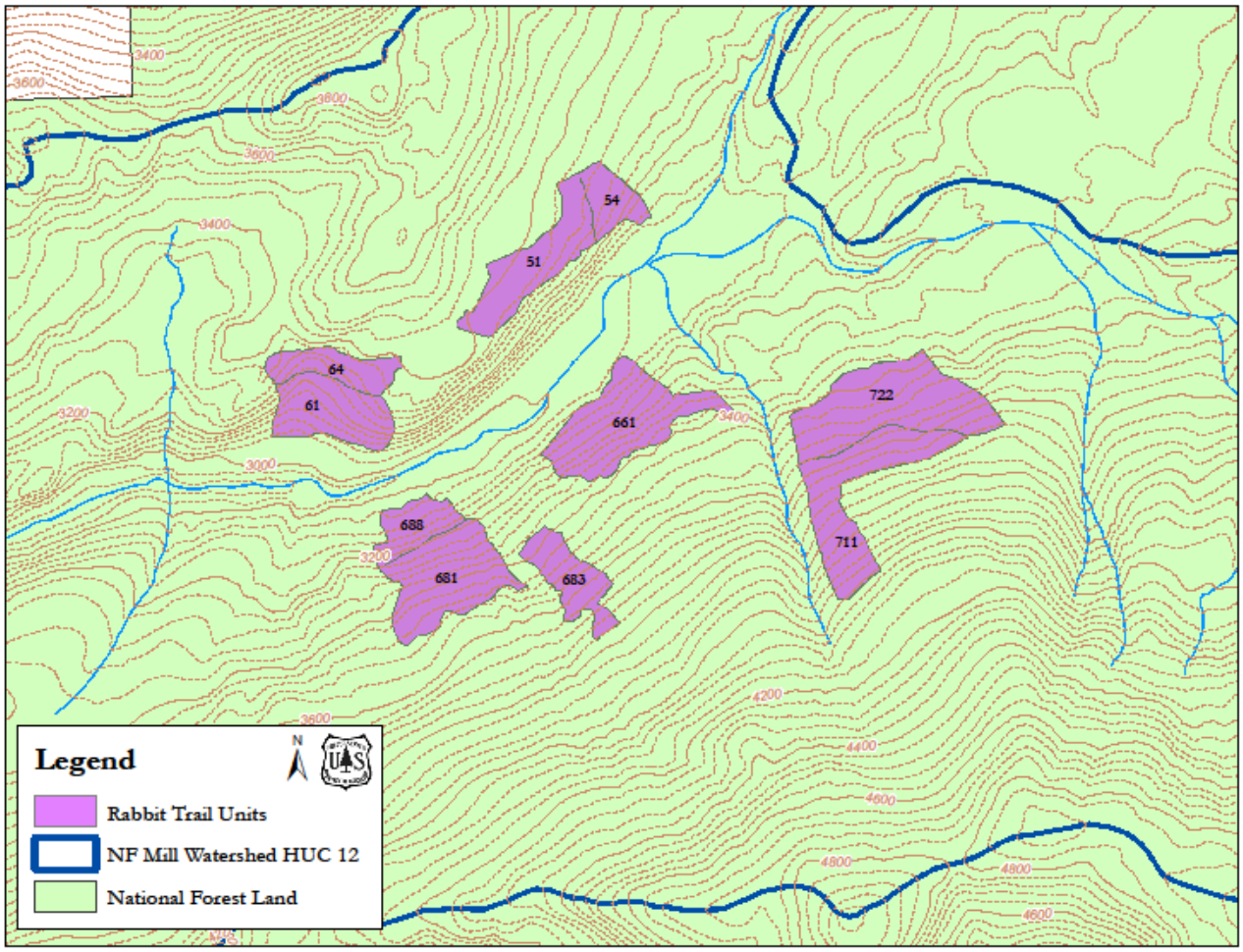
The study area is located in the Colville National Forest in Washington State within the Rabbit Trail Timber Sale. The sale is part of a large vegetation management project with in the Three Rivers Ranger District (map 1).

Map 1- Colville National Forest Study Area



The study area lays within the North Fork Mill Creek Watershed (map 2). Glaciated mountain slopes dominate the area with an annual precipitation of 58-64 cm (23-25 inches). The lithology is a mix of glacial deposits and metasedimentary rocks of mostly phyllite and quartzite. Western cedar and Douglas-fir are the major tree species, along with smaller amounts grand fir and western hemlock. Soils in the area formed mainly form glacial till and colluvium, with a mantle of volcanic ash, and have a forest floor depth of 4-7 cm of litter and duff.

Map 2 - North Fork Mill Creek Watershed- Rabbit Trail



The dominant soil series inside the study area are Waits loams, Aits loams, and Hartill silt loams. Aits and Wait loams formed in glacial till and are mantled with volcanic ash and loess, while the Hartill series formed in colluvium and residuum derived from shaley rock. These soils range from ashy silt loams to ashy sandy loams with good drainage and low to moderate compaction resistance. The majority of these soils are highly productive due to the volcanic ash component and forest floor depth. These features contribute to high holding water capacity and nutrient exchange.

Methods

A total of 10 harvest units were surveyed within the study area. Soil characteristics of each unit were analyzed using SSURGO Data and verified in the field by the soil scientists (Table 1).

Table 1 – Soil Characteristics for Survey Units

Unit	Acres (Approx.)	Slope (%)	Aspect	Soil Series	Texture	Rock Fragment Content* (%)	Average Forest Floor Depth (cm)	Ash Depth (Approx.) (cm)
51	17	10-45	SE	Waits loam, Waits-Rock rock outcrops	Ashy Silt loam	5-10	4.4	30
54	7	25-50	SE	Waits loam	Ashy Silt loam	5-10	4.3	30
61	16	20-65	SE	Waits-Rock outcrop Belzar-Rock outcrop	Ashy Silt loam	25-50	3.8	25
64	9	25-65	SW	Waits-Rock outcrop Belzar-Rock outcrop	Ashy Silt loam	5-10	4.1	30
661	24	35-50	NW	Hartill Silt loam, Aits loam	Ashy silt loam	0-5	4.6	15
681	22	30-50	NW	Hartill ashy silt loam Aits loam	Ashy loam	10-15	5.6	30
683	11	30-65	NW	Aits loam	Ashy loam	5-10	6.1	25
688	8	45-65	N	Hartill ashy silt loam	Ashy silt loam	10-20	7.2	20
711	22	30-50	NW	Aits loam	Ashy loam	5-10	5.9	30
722	29	20-50	NW	Aits loam	Ashy sandy loam	15-20	5.5	20

* taken at a depth of 15 cm from the mineral layer

All units were monitored in May/June of 2019. **Pre-harvest assessments were not conducted.** Post-harvest conditions were assessed using the Forest Service Disturbance Monitoring Protocol (FSDMP) (Page-Dumroese et al, 2009a and 2009b) using a 90% confidence interval. Random transects were conducted across the unit with points taken at a regular interval. FSDMP assesses forest floor depth, presence of live plants, presence of fine woody material, presence of course woody material, soil erosion, soil compaction, soil mixing, rutting, and changes to soil surface structure. Data includes a visual soil disturbance class is assigned to each point using the Soil Disturbance Field Guide (Napper et al. 2009), ranging from D0 – Undisturbed to D3 – Severely Disturbed. On the Colville National Forest, Disturbance Classes D2 and D3 are considered detrimental disturbance that negatively affects soil productivity due to loss of hydrologic function and restriction of root growth by compaction, the removal of organic matter, and soil cover from the loss of the forest floor, and/or the displacement of soil and changes to soil structure from wheel track rutting.

Ash depths and gravel content were collected at two separate soil pits in each unit. Slash depths were recorded on forwarder trails at several points and averaged. Due to restricted access from a wildfire as well as the consumption of slash during that fire not all slash depth measurements were taken.

Unit 688 was bisected by an established forest road and was monitored as two separate units: 688N and 688S. Unit 681 was harvested with a feller buncher and rubber tired skidders in the southern half, therefore only the northern half of the unit was surveyed for this monitoring.

Treatments

All units were harvested during the winter of 2018 using the same harvesting equipment. Each were treated using a cut to length system with a Ponsse harvester and forwarder with the Synchrowinch system. Some units were tethered or non-tethered depending on slope and accessibility determined by the operator.

Fully tethered units: **54, 64, 661, 681N, 688**
Partially tethered units: **61, 683, 711, 722**
Not tethered: **51**

Results

Overall, detrimental soil conditions were within Region 6 - Soil Quality Standards but varied, ranging from 0-13% (table 2). Little erosion was observed, despite monitoring being conducted several seasons post-harvest. Small areas of bare soil and mixing were seen at all units. Most of the disturbance was from compaction and rutting from the equipment. The majority of the ruts were shallow with light compaction, which was likely due to the treatment and timing of the operation. The distribution of disturbance classes, the associated treatments, and the correlation to slope steepness are discussed further.

Table 2 – Summary of FSDMP Post-harvest Data– Rabbit Trail

Unit	Acres (Approx.)	Slope (%)	Detrimental Soil Condition (%)	Forest Floor Depth (cm)	Bare Ground (%)	Live Plant Present (%)	Soil Compaction Present* (%)	Soil Rutting Present* (%)	Soil Erosion Present (%)
51	17	10-45	13	4.4	2	25	20	5	0
54	7	25-50	12	4.3	6	31	28	8	1
61	16	20-65	10	3.8	5	51	15	8	1
64	9	25-65	9	4.1	10	40	17	8	1
661	24	35-50	5	4.6	5	85	15	7	4
681n	11	30-50	6	6.3	3	2	12	5	0
683	11	30-65	8	6.1	2	0	11	8	0
688n	4	50-65	0	6.9	0	3	7	3	0
688s	4	45-65	0	7.4	3	0	7	13	3
711	22	30-50	4	5.9	2	16	8	6	0
722	29	20-50	3	5.5	0	0	16	3	0

*Includes all levels D0-D3 *Disturbance Class Distribution*

Disturbance classes varied in the units from D0-undisturbed to D3-severely disturbed (table 3). The D0 undisturbed class had the highest percentage of the classes and was largely observed outside the equipment tracks (photo 1). The D1 was the most commonly observed class within the equipment tracks under a slash

mat (photo 2). These points typically exhibited shallow rutting, little or no compaction, no erosion, no mixing, and no bare soil. The D2 class was also seen in the equipment tracks but to a lesser degree (photo 3). These points displayed deeper rutting and stronger compaction, usually seen with no or a thinner slash mat. The D3 class was rarely observed in the units. These points exhibited deep rutting and strong compaction, with either bare soil or erosion.

Table 3- FSMP Disturbance Class Ratings

Unit	Detrimental Soil Conditions (%)	Treatment	D0%	D1 %	D2 %	D3%	Slash Depth Average (cm)	Total Points Collected
51	13	Not tethered	68	20	11	1	NA*	120
54	12	Fully tethered	62	26	12	0	NA	90
61	10	Partially tethered	79	11	10	0	7	98
64	9	Fully tethered	77	14	9	0	NA	90
661	5	Fully tethered	82	13	5	0	4	55
681n	6	Fully tethered	82	12	6	0	17	65
683	11	Partially tethered	78	14	6	2	NA	90
688n	0	Fully tethered	83	17	0	0	19	30
688s	0	Fully tethered	77	23	0	0	19	30
711	4	Partially tethered	78	18	4	0	NA	49
722	3	Partially tethered	56	41	3	0	38	32

*not taken due to fire


Photo 1- D0 Soil Profile


Photo 2- D1 Soil Profile


Photo 3- D2 Soil Profile

Treatments Comparison

Data collected in the three different treatments (fully tethered, partially tethered, and non-tethered) resulted in different detrimental percentages. The fully tethered units averaged a soil detrimental percentage of 5.3 %, the partially tethered units 7 %, and the non-tethered unit 13%. This data suggests the tethered equipment resulted in less detrimental conditions.

Steep Slope and Detrimental Classes

Since the slope was so varied within the units, it is difficult to determine whether or not there was a correlation between slope and detrimental soil condition percentages. On the Colville National Forest, similar percentages are seen on lower slope percentages with the same treatment in post-harvest units.

Conclusions

These results are similar than what is typically seen in winter logged, cut to length harvest treatments. Typically these systems range in detrimental soil conditions of 0-13% (Rona, 2011) (Craig, 2005). The results from this study fall under the same range of 0-13% detrimental soil conditions. These results were expected due to the treatment as well as the timing of the operations. The soils were better protected under winter logging conditions and the slash mat buffered the full impact of the equipment. Likely the slash mat, the timing of the operation, and the skill level of the operator all helped to protect the ground from exceeding Forest Plan and Regional Soil Quality Standard detrimental soil conditions.

The data demonstrates soil effects from steep slope logging using a cut to length with tether winter harvest system and does not result in detrimental soil conditions exceeding Colville National Forest Plan or Region 6 - Soil Quality Standards.

Summary and Recommendations

These are initial findings and a greater sample size is needed develop a better understanding of logging steep slopes with tethered assisted ground based equipment. Additional monitoring of these activities is needed to assess ground impacts outside of winter logging conditions and to compare the extent of detrimental soil conditions between different soil types.

There is also concerns related to fuel loading due to the cut to length equipment processing slash into the trails and not on a landing. Due to the stand type, slash depths on forwarder trails exceeded 2 feet in areas with a high volume of small bole wood. A majority of vegetation treatments on the Colville National Forest is an effort to restore historic forest structure and reduce historically high levels of fuel accumulations. Due to the steep slopes involved with these operations, it is difficult and expensive to treat the slash.

The Colville National Forest is currently involved in ongoing monitoring with tethered logging systems with the goal to protect the soil resource while supporting the need for landscape scale forest restoration at increased pace and scale.

Acknowledgements

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