Soils Field Report
Fremont Winema National Forest

Pilot Timber Sale – Unit 10

When: October 8, 2018
Purpose: Post-harvest soil disturbance monitoring, Round 2

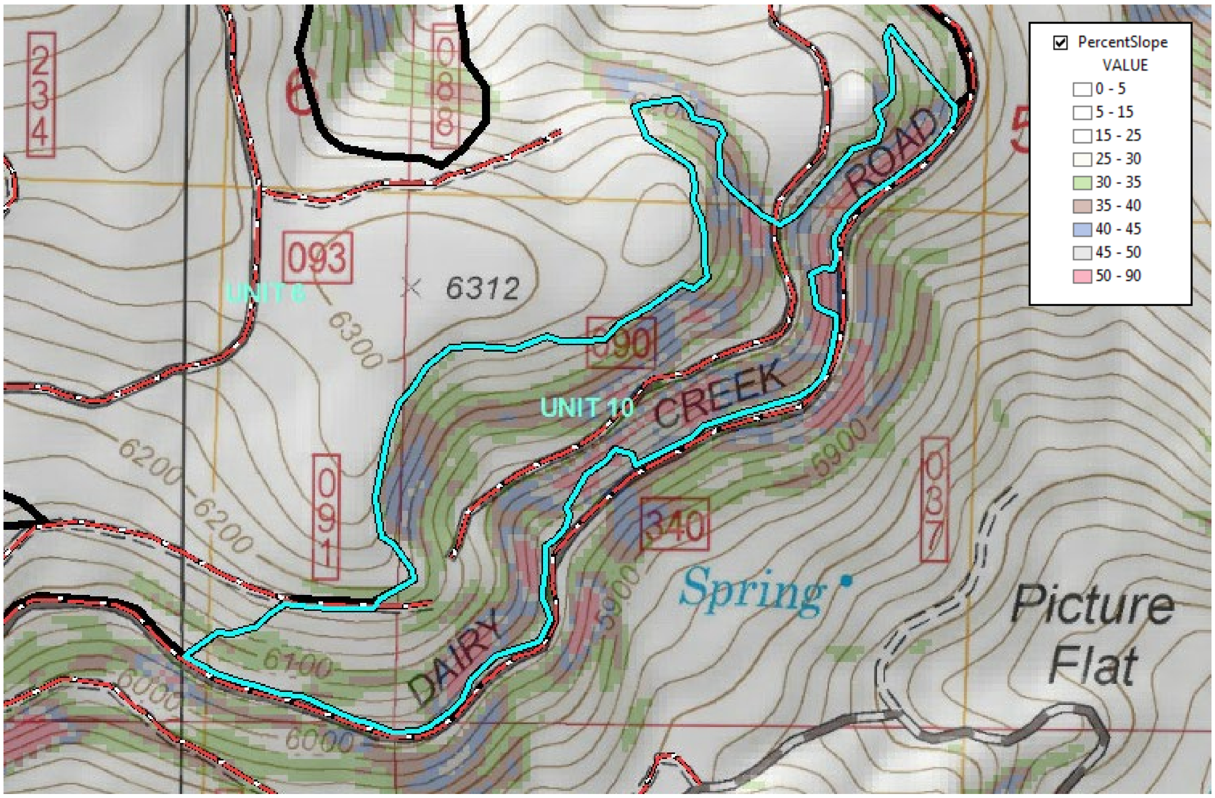

Fig. 1: Location of tethered ground-based operations associated with Unit 10 of the Pilot timber sale, Bly Ranger District. Percent slope gradients are added to provide overview of variable steepness. T36S R17E Sec. 5 & 6.

Unit #10

42° 13'08.9" -120° 21' 39.8"
Transect start

The Pilot timber sale was part of a trial project that provided an opportunity to monitor effects on soil from a cut-to-length (CTL) and forwarder operation on steep slopes >35% (Fig. 1). Thus far, two reports provide insights – initial monitoring and observations were made shortly after logging completed in 2016 (see Rone 2017); this report shares findings from follow-up monitoring in 2018 and includes a comparison of both years. Additional monitoring is planned to capture effects from prescribed fire, which will complete treatment of Unit 10.

Fig. 2: Ponsse Bear processor on site.

The 54 acre unit has added significance because it was the first on the Fremont-Winema National Forests using a tethered logging system. This included a Ponsse Bear processor and a Ponsse Elephant King forwarder for extraction. Both machines used an eight-wheeled double-bogey design and were tether-equipped (Fig. 2).

Unit 10 consists of a dry mixed-conifer stand situated at an elevation of ~6,100 feet and includes generally southeast to southwest facing slopes that range between 10 to 70%. Treatment occurred between July and August of 2016 during very dry conditions. Equipment included a tether that was utilized on slopes with increasing gradient or when the very dry soils resulted in slipping tracks. Additional insight on the economic feasibility and logistical aspects of a tethered cut-to-length and forwarder system on steep slopes in this is specific unit can be found in a graduate thesis by Petitmerment (2018).

The Fremont Soil Resource Inventory identifies three soil map units associated with Unit 10. Map units 88A, 88B, and 88C are similar with the exception of slope position and range. Soils are greyish brown to yellowish brown ashy loamy skeletal sandy pumice with a very weak granular structure. Pumice gravel and rock content varies, many slopes contain shallow soils or rock outcrops. Areas of scattered localized large surface rocks are present.

The overstory in the dry mixed-conifer stand was thinned favoring ponderosa pine, leaving an assortment of age classes and scattered regeneration of trees across the unit, including white fir. The understory primarily consists of squawcarpet, manzanita, localized ceanothus, snowberry (incl. creeping), and various forbs. Numerous grasses, mostly Idaho fescue and bottlebrush squirreltail, amongst others, were also present but can be difficult to identify during the fall.

2016 Findings – Initial Monitoring

Initial monitoring occurred shortly after harvest completion in September of 2016. Findings included the following observations:

- In pumice soil, displacement accounts for most of the disturbance;
- Compaction is limited due to coarser textured soils but still present;
- Pumice soils were pulverized and churned under dry conditions;
- Equipment was sliding on lose soils along varying gradients, requiring tethering on flatter slopes and not just steep terrain;
- Side tracking and turning of equipment resulted in increased disturbance;
- Slash cover varied along trails, the required 18 inch thickness was inconsistent, slash mats deteriorated with increased use;
- Slope location, terrain, habitat type, and aspect dictated slash availability;
    - Upper slopes rockier, shallow soils, openings, less material;
    - More slash on lower end of corridors below mid-section road and on concave east-facing terrain;
- No waterbars were installed;
- Leave trees quickly shedded needle cast to provide cover on bare soils;
- Initial monitoring showed that soil disturbance remained below 20%, meeting soil quality standards.

More details can be found in an associated presentation and write-up compiled by Rone in the spring of 2017.

2018 Findings – Follow Up Monitoring

This visit followed the initial general 2016 transect route to observe what changes have occurred after the unit experienced different seasons and precipitation events. Two years past harvest treatment, the unit has changed quite a bit. Slash in the western half, almost to the unit mid-point below the FS090 road (see Fig. 1), was hand piled in 2018 to reduce debris that was left behind from CTL operations. As a result, the trails were more visible compared to those still covered within corridors.

Fig. 3: General view, SW part of unit, hand piled.

Fig. 4: General view of concave ridge, SW part of unit, hand piled.

Fig. 5: Convex slope past ridge, near terminus of FS090 road.

Fig. 6: View NE across steeper ground, increased surface rocks. Near unit center.

Fig. 7: View down near unit center upper boundary, original slash mat.

Fig. 8: View SW across upper concave side slopes above terminus of FS090.

Several corridors, especially in the southwest and southern portion of the unit, display coarser or rockier soils. Increased bearing strength resulted in reduced overall impacts but, in places, removed some of the previous thin soil or vegetation, providing a setback in cover and a harsher growing environment.

Fig. 9: View NE from trail on rocky ridge near terminus of FS091. Thistle invasion.

Fig. 10: Steep, rockier hand piled slopes below FS090 and lower boundary road FS3400.

While compaction remained on the low end for the coarser sandy loam pumice, soils within cutting corridors showed increased platyness and massive structure. They were not as easily penetrated using the shovel test compared to undisturbed soils, though many remained in Class 1. Depth and level of compaction played a large role in determining if disturbance was considered detrimental.


Fig. 11: Platy compacted soils.


Fig. 12: Undisturbed soils.


Fig. 13: General appearance of vegetation difference delineating equipment travel.


Fig. 14: Differences in vegetative growth define tracks where compaction increases.

Primary soil disturbance comes from displacement and deeper ruts. Some of displacement remains difficult to discern where slash or extensive needle cast make it challenging to assess the forest floor. While compaction is not as widespread, it is present, especially where increased harvest volume and corridor length added to elevated forwarder travel.


Fig. 15: Deeply rutted and displaced soils.


Fig. 16: Side view of rutted tracks in corridor.


Fig. 17: Displacement, thistles, and more.


Fig. 18: Extreme berm from side tracking.

Fig. 19: Center mound and tracks.

Fig. 20: Deep depressions along tracks.

Fig. 21: View down onto connector trail between FS090 and 091.

Fig. 22: Visible track depressions with veg regeneration.

Fig. 23: Corridor showing no displacement.

Fig. 24: More resistance, fewer impacts towards trail bottom; rockier, less traffic.

Vegetation is re-establishing, especially pinegrass, dry sedges, and other grasses, which is typical for these pumice soils. Ponderosa pine and white fir seedlings are regenerating along with shrubs, primarily creeping snowberry, squawcarpet, and manzanita. Along the westernmost concave slopes, grasses are knee to waste high in places and horsemint (*Agastache urticifolia*), suggesting increased moisture, is present exclusively in this area.

Fig. 25: Veg in concave area above terminus of FS090 suggests soil/moisture differences.

Fig. 26: Regeneration, ponderosa above pencil.

Fig. 27: Veg breaking through slash mat.

Unfortunately, bull thistles and a lesser amount of Canada thistles are spreading across the treatment area from disturbed localities, such as trails and decks, to undisturbed areas.

Fig. 28: Bull thistles, see shovel for scale.

Fig. 29: Spread across corridors.

Fig. 30: Spread beyond corridors.

Fig. 31: General view, hand piled area in SW.

Hand piling across the western half has greatly reduced slash levels. At the time of the visit, the eastern half was not piled but slash was much less pronounced since needles have dropped and branches and smaller debris have been compressed. Some areas with thicker accumulations (>1 foot) remain.

Fig. 32: Hand piles on rocky steep slopes above southern boundary delineated by FS34.

Fig. 33: Hand piles in SW part of Unit 10.

Fig. 34: Untreated slash remains.

Fig. 35: Deeper slash remains in some places.

Fig. 36: Several inches of dropped needles from slash plus some needle cast.

Methodology

Monitoring was done using the National Forest Soil Disturbance Monitoring Protocol (Page-Dumroese et al. 2009a and 2009b). This agency-wide protocol measures physical soil disturbance using a statistically valid sampling structure and delineates site-specific analysis of management-induced soil disturbance in an activity area. A shovel is driven into the ground or a small soil pit is dug at each point and data on various attributes are collected, including but not limited to: forest floor/duff depth, topsoil displacement, compaction, and rutting. Coarse woody debris transects followed procedures outlined in Brown et al. (1974).

On the Fremont-Winema National Forest, disturbance classes 2 and 3 are considered detrimental. Soil productivity is negatively affected through a loss of hydrologic function, restriction of root growth, the removal of organic matter, displacement of soil, and changes to soil structure from wheel track rutting or mixing. All of these factors affect decomposition, nutrient turnover rates, soil biotic activity, and forest productivity. A soil disturbance class of 2 or 3 can be assigned based on one or a combination of observed attributes at a sample point.

For the "…acceptable soil quality conditions" set out in the Regional Soil Quality Standards to be met, a minimum of 80% of an activity area receives a Class 0 or 1 soil disturbance rating. Class 0 reflects undisturbed conditions. Class 1 is slightly disturbed, not considered detrimental, and expected to recover in the short term. This monitoring was conducted at an 85% confidence interval with a margin of error at ±5%.

Results & Observations

Table 1 provides a summary of results and compares findings for post-harvest soil monitoring in 2016 and 2018. System roads FS3400-090 and 091 (see Figure 1) that extend into the unit were not included during transecting but account for ~3% disturbance (periphery roads are not counted) based on GIS roads information. This allows for separation of harvest related impacts from road impacts before both are combined to reflect total detrimental disturbance for the treatment unit.

Monitoring shows that harvest activities in Unit 10 detrimentally impacted ~15% in 2016 and 13% in 2018 (Table 1). With the added ~3% system road disturbance, this results in a total disturbance of ~18% and 16%, respectively. Regional and Forest soil quality standards of not exceeding 20 percent are therefore met for both years.

Table 1: *Summary of 2016 and 2018 soil disturbance monitoring for Unit 10 of the Pilot timber sale..*

Unit 10	Detrimental Soil Disturbance %	Total Points Collected	Disturbance Class %*				System Road Disturbance %
			0	1	2	3	
2016	**18**	150	67	18	9	6	3
2018	**16**	117	60	27	7	6	3

*Class 0 = undisturbed; Class 1 = disturbed, not detrimental; Classes 2 & 3 = exceeding to severe disturbance, detrimental; system roads count towards 20% disturbance limits.

Several factors are thought to contribute to a reduction in disturbance between 2016 and 2018. First, monitoring right after harvest completion generally presents a sobering view where physical impacts are at its rawest, fresh, and clearly visible due to recent activities. After several seasons, precipitation events, freeze-thaw, snow pack, wetting, and re-establishment of vegetation and associated biota provide opportunities for recovery and soil settling. The positive trend observed for Unit 10 thus far also reflects on good slope and soil stability under post-harvest conditions since no evidence of erosion was found that could contribute to negative ratings.

Displacement was the primary disturbance type from tether-assist ground-based operations in pumice soils for this test unit. It is important to understand that tethering only occurs on an as needed basis, meaning that only parts of Unit 10 were treated with such assistance (Fig. 37). Where wheel tracks pushed soils aside, ruts of various depths and extent remain. These were usually most detrimental where equipment entered the haul road and were passes from the forwarder may have increased in number due to slope length, stand density, and material cut. Where tracks turned, center mounds and berms along the sides are present. Added bearing strength reduced negative impacts in areas where soil fragment content was elevated or surface rocks were in place.

Equipment use during the driest time of the summer turned the generally coarse sandy loams into dust. Both operators commented that the “weak” soils on this site drove the decision to tether at flatter slopes than they were accustomed to in western Oregon (Petitmerment 2018). Concerns were expressed over getting bogged down and/or causing undue damage to the soil, which drove the operator’s judgement to use the tether on a corridor-by-corridor basis (Fig. 37). The cautious decisions to implement tether-assist when needed, along with the protection of the slash mat, may just be some of the key reasons why disturbance levels were kept within acceptable limits. Since tethering can cut into production time (Petitmerment 2018), these decisions have economic consequences that may negatively affect resources.

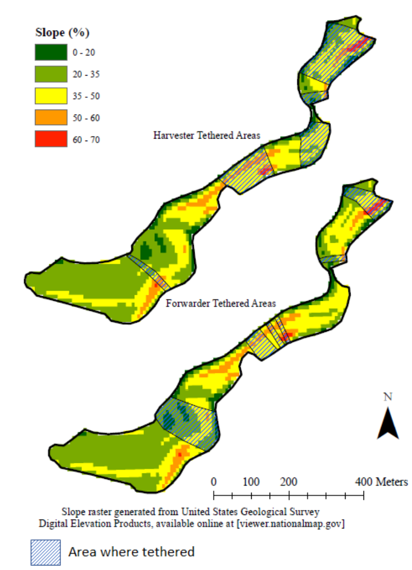

Fig. 37: Areas of tethered and untethered operation by machine type for the lower section of Unit 10 (Petitmerment 2018).

The most valuable portion of a soil resides in its upper inches. Organic matter in the form of duff or incorporated in the below-lying horizon provides, among other benefits, increased water holding capacity and stability. Topsoil displacement, mixing with less productive subsoils, and reduction of cover influences soil productivity and hydrologic function on these droughty south-facing aspects. This can affect regeneration and vegetation type.

Compaction, though not as widespread as displacement, was found frequently but was not deemed detrimental in many cases, especially when limited to the uppermost inches of surface soil. One main forwarder trail connected the 091 and 090 roads over a rocky ridge (Fig. 21). Its evolution was tracked during several visits while operations were ongoing. Initial extensive impacts were attempted to be remedied at this location by smoothing over the deep ruts and berms that established on this east-facing slope. While some mitigation occurred, the area was impacted and provides added opportunities to observe and track potential recovery.

Corridor/trail spacing was ~25 to 40 feet and driven by boom reach limitations of the equipment. Corridors primarily paralleled each other perpendicular to the contour but also converged and overlapped based on topography, steepness, and/or location of roadside decks. Side tracking was observed in some parts above the mid-slope road FS090. Similarly, several old non-system roads from a previous treatment were discovered during pre-harvest reconnaissance, were in part re-utilized, and remain on the landscape.

The slash mats were identified as the main reason why no waterbars were installed. This, however, does not account for post-harvest conditions once slash is treated by pile- or prescribed burning. With the removal of cover, sediment movement or gully formation, especially on steep slopes, could take place. Fortunately, no signs of rilling, gullying, or flow have been encountered thus far after two post-harvest years. Soils remain stable, likely aided by plentiful needlecast, remaining slash, and understory vegetation that is re-establishing. Increased light availability from overstory removal and recovering vegetation, especially when forming a mat (for example squawcarpet, *Ceanothus prostratus*), steadily increases protective cover. Additional monitoring is planned once final slash and fuel treatments are completed.

Coarse woody debris is adequate for the habitat type and consists primarily of older rotten material aside from newer branches, small twigs, debris, and a lesser amount of solid down trees (Table 2). The reduction from 34 tons/acre in 2016 to 21 tons/acre in 2018 is due to hand piling that occurred in much of the western half of the unit. Organic matter was monitored in 2016 but recordings were inadequate so that only 2018 data is available (Table 2). Findings reveal that duff, in various decomposition stages, is satisfactory with a variable but adequate depth spread across the unit. No increases in wind throw were apparent in the thinned stand post-harvest.

Table 2: *Summary of organic matter and coarse woody debris findings for Unit 10.*

Unit 10	Organic Matter (%)		
	<¾ inch - low	¾ to 1¾ - optimum	>1¾ - increased
2018*	26	52	22
	Coarse Woody Debris tons/acre		
2016	34.2		
2018	21.2		

*OM was observed in 2016 but recording was inadequate.

Much of the initial slash mat has now disintegrated, needles have dropped, and slash depths were compacted by snow pack during the past two winter seasons. Initial observations in 2016 showed that slash availability varied due general slope position on this landscape. Upper elevation slopes within Unit 10 had shallower soils, larger rocky or shrubby openings, and less trees compared to mid-or lower section slopes. There, thicker stands, differing age classes, and a more shaded environment provided added biomass compared to the more exposed drier upper slopes. Overall, where slash mats were not continuous, effectiveness was reduced and resulted in a greater display of disturbances within several corridors.

Summary

Monitoring effects on pumice soils from a cut-to-length and forwarder operation on steep slopes >35% resulted in detrimental disturbance levels below 20%, meeting regional and forest soil quality standards (Table 1). As a whole, Unit 10 has a pleasant appearance after thinning treatment of the dry mixed-conifer stand was completed. While disturbances linger across the landscape, soils are showing a slight trend of recovery and continue to foster the re-establishment of vegetation. Hand piling of slash in the western half aids in the management of fuels and preparation for a future prescribed burn.

Dry summer conditions resulted in soils turning to dust. As a result, equipment was tethered even in flatter terrain to reduce adverse impacts. The slash mat produced by the harvester further protected soils where adequate material remained in place to absorb added impacts from forwarder travel within cutting corridors. While an 18 inch slash depth requirement was in place, certain stand and topographic characteristics resulted in areas were little or no slash was available.

The state-of-the-art equipment, slash mat, two well-seasoned skilled operators, and the fact that logging treatments were also part of a graduate research study by Oregon State University likely contributed to the favorable outcome for soils in Unit 10 up to this point. Additional monitoring is planned to capture final fuel treatments and may also include additional measures to observe vegetation and cover trends over time.

/s/ *Gina G. Rone*

Forest Soil Scientist

References

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