District Elk City/Red River

District Elk City/Red River

Soil Monitoring Study: Mackay Day Timber Sale

(Processor, forwarder and excavator grapple piling)
Pat Green/Nez Perce NF
October 10, 2003

Objectives:
1) To determine if feller buncher/processor, log forwarder and grapple piling activities result in soil conditions that meet forest plan or regional soil quality standards. Forest standards state: A minimum of 80 percent of an activity area shall not be detrimentally compacted, displaced, or puddle upon completion of activities. Regional soil quality guidelines state: At least 85 percent of an activity area must have soil that is in satisfactory condition. Compaction in excess of a 15 percent increase in natural bulk density is considered detrimental. An activity area is considered for these purposes as a timber harvest unit to which the activity is applied.
2) To determine if Region 6 soil assessment protocols using 6 disturbance classes can be correlated with probability of compacted or displaced conditions.

The Sites:
Two harvest areas were sampled on the Mackay Day timber sale in the South Clearwater River subbasin.

5500-5800
NW Asp.
LT-22AH6
HT Abgr

T 28N R6E
SEC 16
SE 1/4

Unit 1a was harvested Oct – December 2000. Equipment was a feller buncher/processor. Logs were forwarded uphill over a slash mat on slopes of 5-20 percent to the landing. Weather and soil moisture conditions varied from dry to moist. The unit was excavator piled in summer 2001, and piles were burned in fall 2001. The prescription was a seed tree harvest with reserves in lodgepole pine. 20 samples of the first 6.5 inches of mineral soil were taken from points well distributed throughout the unit.

5800-600
N-NW
LT 22AH6
HT Abgr

sec 26 NE 1/4

Unit 2 was harvested in October 2000. Equipment was a feller buncher/processor. Logs were forwarded downhill over slopes of 5-15 percent over a slash mat to the landing. Weather and soil moisture conditions varied from dry to moist. The unit was excavator piled in summer 2001, and piles were burned in fall 2001. The prescription was a thin in mixed conifer larch, lodgepole pine, and grand fir. Observations on November 6, 2000 by the district hydrologist stated: "Slash mats were thick and almost completely covered the forwarder trails… The only soil disturbance was observed near the road access to the unit, where trails converged." 10 samples of the first 6.5 inches of mineral soil were taken from points well distributed through the west half of the unit, which does not differ in slope or aspect from the east half.

Both sites are on convex ridges at about 5600 feet elevation. Parent materials are Batholith granodiorite and belt quartzite and schist. Soils have a surface layer 6-10 inches thick of volcanic ash influenced loess. Habitat types are grand fir/beargrass

Sampling methods:
Protocols follow Howes et al., 1983, adapted using Region 6 soil resource condition assessment protocols (Howes, no date). 10 100-foot transects were done in each unit. Transect starting points were located at 250 foot intervals along diagonal lines crossing the unit. Transect azimuth was based on a random number. Each foot along each transect was assigned to the estimated R6 condition class. Bulk density samples of mineral soil were collected at five-foot intervals and assigned to the appropriate condition class. Core volume was 270.37 cm^3. The core sampler was a drop hammer with a cylinder of fixed volume. Surface litter and duff was removed before sampling. Samples were oven dried at 105° C. Volumes and weights were corrected for large roots or wood.

Analysis:
The limiting bulk density was calculated for each unit as 1.15 of the mean of the pre-activity sample. Post-harvest samples were denoted by whether they fell below or above this limiting value, and which condition class they fell in. From this I calculated the proportion of samples in

each condition class that exceeded the limiting bulk density, and the total percent of transect length that would be considered compacted, and the total percent of transect length that would be considered damaged. Areas in Class 4 or 5 are displaced or excavated, with loss of volcanic ash topsoil, so they are considered inherently damaged. They also usually showed higher bulk densities.

The reliability of each damage estimate is computed as a confidence interval around the mean, adjusted by a t value (alpha = .1).

Results:

Unit 1a: Mean soil damage percent across 10 transects: 62.9%

Variance: 259.6

90 Percent confidence interval: 61.9-63.8%.

Mean bulk density prior to harvest (n = 20): .8882 gm/cm^3

Mean bulk density after harvest (n = 200): 1.0711 gm/cm^3

Excavated trails to accommodate the grapple piler contributed markedly to soil displacement, but compaction was widespread. This unit grossly exceeded Forest Plan and Regional soil quality standards. It appeared that, although only the excavated trails showed soil much displacement, the passage of harvester and forwarder over much of the unit contributed to widespread soil compaction.

Unit 2: mean soil damage percent across 10 transects: 43.2%

Variance: 654.7

90 Confidence interval: 28.4-58.06%.

Mean bulk density prior to harvest (n = 10): .84656 gm/cm3

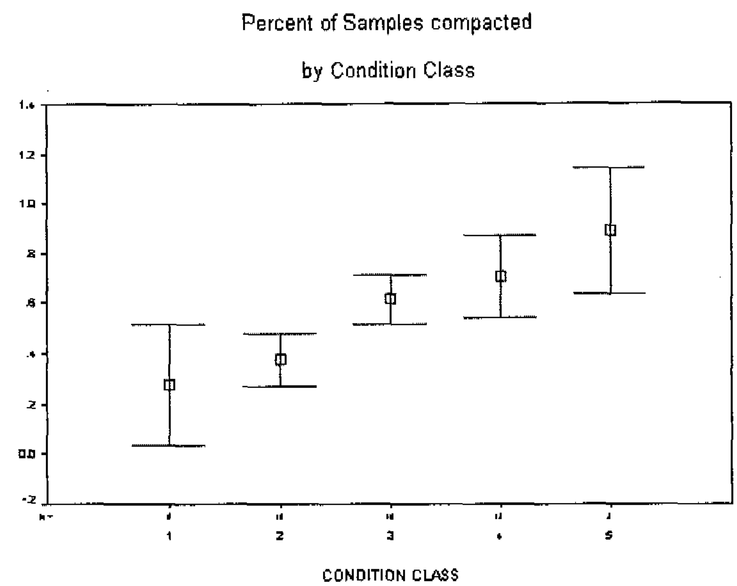
Mean bulk density after harvest (n = 195): .96176 gm/cm3

Variability was much higher, with some transects showing little compaction, and no excavated skid trails were built, but this unit still significantly exceeded Forest Plan and Regional soil quality standards.

Proportion of each condition class that was actually compacted across both units:

1: Little apparent impact:	.275
2. Slight impact:	.373
3. Moderate compaction	.613
4. Hot burn, mixed, or surface scraped	.702
5. Heavy scrape to subsoil	.887

A one-way ANOVA comparing percent of condition class actually compacted yielded a significance of .000. Post-hoc multiple comparisons indicated that classes 1 and 2 do not differ significantly from one another, nor do classes 3, 4, and 5, but that classes 1 and 2 differ from classes 3,4,5 at alpha = .05. The graph below shows means and 95 percent confidence intervals of percent of each condition class that was compacted.



Conclusions:
Both units showed less incidence of the soil mixing that is prevalent with dozers or conventional skidding. This is an improvement where retention of the integrity of the volcanic ash cap is important. However, the need to move all over the unit, to each tree, for harvest, and again with the excavator, means that compaction is widespread.

Sampling in 60-year old harvest units (Meadow Face EIS, 2002) indicated little recovery from compaction, clear impacts to plant community succession, and marked effects to stream morphology and hydrologic function.

The improved appearance of forwarder units does not appear to be supported by the data. Soils are less displaced, but more compacted. Additional data are needed to know if the compaction is less damaging than mixing. In any case, more efforts to reduce the frequency and extent of equipment passage, and reduce need for more kinds of equipment running over the site, are warranted.

The use of the Region 6 qualitative soil condition assessment procedure seems to be justified as an efficient mechanism for rapid soil condition assessment, so long as numerous well-distributed transects are done. This protocol is attached. Classes 3, 4, and 5 may not be distinguishable by degree of compaction, but they carry additional information on degree of excavation and topsoil loss so that their retention is merited. Classes 1 and 2 may not have enough difference to be retained as different classes.

References
Howes, S., Hazard, J. and Geist, J.M. 1983. Guidelines for sampling some physical conditions of surface soils. USDA Forest Service. R6-RWM-146-1983. 34 pp.

Howes, S. No date. Proposed soil resource condition assessment. Publication on file. Wallowa-Whitman National Forest.9 pp.

USDA Forest Service. 2002. Meadow Face Stewardship Pilot project. Specialist soils report. On file at Nez Perce Forest Headquarters.

ATTACHMENT 1

FINAL DRAFT

PROPOSED
SOIL RESOURCE CONDITION ASSESSMENT

S. W. Howes

Wallowa-Whitman National Forest

Background:

The soil productivity protection standards currently in effect on the Forest define soil compaction in quantitative terms (15 or 20 percent increase in soil bulk density, 50 percent decrease in macroporosity) while defining other forms of soil damage such as displacement, puddling, and severe burning in either quantitative or qualitative terms or both.
Assessment of soil compaction using quantitative measurements of density, porosity, or strength makes sampling complex, time consuming, and expensive. Categories of soil damage are not always mutually exclusive. Soil compaction often occurs in combination with other forms of soil damage, particularly soil displacement, making sampling and reporting even more complex.

Some of the theory behind quantitative soil condition assessment surveys is contained in Hazard and Geist (1984). A method of conducting quantitative soil condition assessment surveys can be found in Howes, Hazard, and Geist (1983). This method has been used as a model by the Forest Service for soil assessment surveys throughout the Western US.

Impacts of soil disturbance are not absolute. They vary along a continuum from slight to severe damage. They are also affected by soil type as well as other compensation factors such as local climatic and vegetation conditions. The probability of implementing adequate or successful soil restoration measures also varies along the continuum.

The inherent difficulty and expense associated with making quantitative assessments of soil resource conditions has limited soil-monitoring efforts on the Forest and in the Blue Mountains. We need more information on the impacts of management activities on soils. Hopefully use of monitoring systems that rely on qualitative rather than quantitative assessments will allow us to collect and analyze more information.

Proposal:

In order to facilitate soil resource monitoring on the Forest, the following system is proposed. It is a modification of a system originally proposed by Scott et al. (1979) for use on Weyerhaeuser Company timberlands. It was further described by Miller et al. (1988). The system has been found to be relatively easy to use and has provided land managers, operators, and others with useful information on the status of soil resources within relatively short timeframes.

This system defines soil disturbance categories or classes that are based on observable characteristics and relates them to soil damage defining criteria and Regional/Forest Plan standards for soil productivity protection. Each of the classes can be assessed and measured using a variety of sampling systems and at varying sampling intensities.

Separate definitions are proposed for old and new soil disturbances classes. Most forested areas of the Blue Mountains have been affected by previous timber management activities. In many instances, information on existing soil resource conditions is needed prior to planning new entries so that adequate treatment and restoration prescriptions can be developed. Older soil disturbance is not always easy to observe. New plant communities and/or litter and duff layers may be developing. Some natural recovery of compacted soils may have taken place. Organic matter may be accumulating in surface soils.

When monitoring cumulative impacts of past and present treatment activities, both existing and recent soil disturbance must be accounted for.

SOIL DISTURBANCE CLASS DEFINITIONS

Old (Existing) Soil Disturbance:

Class 0	Undisturbed	No evidence of past equipment operation. Soils are undisturbed or considered to be in a natural state.
Class 1	Slight Disturbance	Site is virtually undisturbed. Old litter and duff layers intact. Vegetation present or redeveloping with well established root systems. Some faint impressions of heel tracks or slight depressions evident. Surface soils (A horizons) intact. Surface soil structure unaffected by past equipment operation. No evidence of platiness developing in surface soils.
Class 2	Some Disturbance	Old litter and duff layers intact. Vegetation present or redeveloping with well established root systems. Some visible indications of past equipment operation. Surface soils (A horizons) intact but may show some signs of compaction (i.e. minor amounts or discontinuous platiness at soil surface). No evidence of surface soil removal.
Class 3	Moderate Disturbance	Old litter and duff layer partially intact or missing. New litter layer developing. Vegetation present or redeveloping. Surface soils (A horizons) intact but show evidence of compaction and puddling (surface platiness or lack of structure). Depressions or old wheel tracks evident. Small amounts of surface soil removal.
Class 4	High Disturbance	Old litter and duff layer removed. New litter layer may be redeveloping. Surface soils (A horizons) partially or totally removed of mixed with subsoil material. Evidence of surface soil removal. Some pedestalling at base of trees.
Class 5	Severe Disturbance	Old litter and duff layer removed. New litter layer redeveloping or absent. Evidence of excessive or extreme surface soil removal. Surface soils (A horizon) absent. Subsoils exposed, compacted, or removed.
Class 6	Altered Drainage	Alteration of internal soil drainage characteristics. Results in permanently saturated soils of standing water.

New Soil Disturbance:

Class 0	Undisturbed	No evidence of equipment operation. Soils are undisturbed or are considered to be in a natural state.
Class 1	Slight Disturbance	Site is virtually undisturbed. Litter and diff layers intact. Surface soil (A horizons) intact. Impressions of wheel tracks or slight depressions in surface soils may be present. No exposed surface soils (unless natural). No exposed subsoils.
Class 2	Some Disturbance	Litter and duff layers generally intact. Surface soil (A horizon) intact but may show some evidence of platiness. No evidence of surface soil removal or deposition.
Class 3	Moderate Disturbance	Litter and duff layers only partially intact or missing. Surface soil (A horizons) intact but show evidence of paltiness or lack of structure. Equipment tire tracks or cleat marks evident.
Class 4	High Disturbance	Litter and duff layers totally removed. Surface soils (A horizons) partially removed or may be mixed with subsoil material. Surface soil structure destroyed (large, thick plates instead of granular or crumb structure). Some shiny or slick appearing soil surfaces may be present.
Class 5	Severe Disturbance	Litter and duff layers totally removed. Surface soils (A horizons) nearly all or completely removed. Evidence of topsoil removal and/or gouging. Subsoils partially or totally exposed.
Class 6	Altered Drainage	Alteration of internal soil drainage characteristics by equipment operation. Results in permanently saturated soils or standing water.

Relationship of Disturbance Classes to Regional and Forest Plan Standards:

The above classes are based on observable features and are intended to represent the range of soil disturbances that one might expect to result from common treatment activities in the Blue Mountains. It is hoped that by making observations (no quantitative measurements) of surface features. One can make inferences regarding subsurface conditions and relative impacts on productive potential and hydrologic function. Observations may include limited use of tile spades or other devices to assess surface soil compaction.

In conducting land management activities in the Blue Mountains, prudent managers will strive to limit the amount of ground surface impacted by equipment, to conserve litter and duff layers, and to not allow removal of surface soil horizons. Describing soil resource status in terms of the classes defined above should provide managers with the necessary information at a suitable level of accuracy to properly prescribe treatment and restoration measures.

Class 0 soil disturbance is undisturbed and therefore represents the condition against which the other categories are compared. This category represents maximum potential productivity.

In areas of Class 1 soil disturbance, subsoils are intact and are uncompacted. Infiltration and percolation rates are generally unimpeded except for only small, localized areas. Productivity is unaffected. Restoration activities are not warranted in areas of Class 1 disturbance. Soil damage defining criteria not met.

In areas of Class 2 soil disturbance, subsoils are intact and may be slightly compacted. Some localized reduction in infiltration rates may occur. Generally no impact on percolation rates. No measurable reduction in growth rates. Restoration work usually not required. Affect areas recover well naturally. Soil damage defining criteria are not met.

Class 3 soil disturbance meets Regional and Forest Plan standards for defining soil damage. Subsoils are intact but may be compacted. Infiltration and percolation rates are reduced. Productivity reductions are below acceptable levels. Restoration work is warranted and effective in restoring productive potential.

Class 4 soil disturbance meets Regional and Forest Plan standards for defining soil damage. Subsoils are exposed and compacted. Drainage characteristics of soils are affected. Channeling of surface water may occur and cause erosion. Significant productivity reductions are likely. Normal restoration activities are effective in restoring productive potential. Class 4 soil disturbance should be avoided while carrying out management activities.
Class 5 soil disturbance also meets Regional and Forest Plan standards for defining soil damage. Subsoils are exposed or may be removed or compacted. Drainage characteristics of soils affected. Channeling of surface water may occur and cause erosion and gully formation. Significant productivity reductions are highly likely. Restoration measures are difficult yet should be carried out. Class 5 soil disturbance should be avoided while carrying out management activities.

Class 6 soil disturbance should be avoided if at all possible. Permanent standing water is the result of altered internal drainage characteristics. Restoration to natural conditions impossible or nearly so.

Areal Extent of Soil Disturbance:

Areal extent refers to the ground surface area occupied by a particular class or classes of soil disturbance. It is commonly expressed as a percentage of the total treatment area' or it can be expressed in actual acres.

Regional and Forest Plan standards require that no more than 20 percent of an activity area be left in soil conditions determined to be detrimental or that significantly reduce site productivity. This generally includes Class 3 soil disturbance and above as well as permanent features of the transportation system (approximately 5 percent of an activity area). In areas that may already have more than 20 percent detrimental soil conditions as a result of past activities, new entries may not add to this amount and plans must be in place to bring the site into compliance with the standards.

Sampling Protocols for Measuring Areal Extent of Soil Disturbance:

Soil assessment surveys can be done at varying levels of intensity. They can be done by simply walking through a treatment area, making a quick visual assessment of soil conditions, and documenting results. They can be made by establishing a number of transects within a treatment area and measuring and recording amounts of soil disturbance along each transect. Finally, they can be made through use of transects and sophisticated measuring devices.

Obtaining a representative sample during soil assessment surveys is also important. This means that all portions of a treatment area have an equal chance of being included in the sample. If subsamples are taken, they must be representative of the entire area or results will be skewed.

Knowing the level of intensity at which soil assessment surveys have been made, and whether or not they are representative of the entire treatment area, is useful information. For example, more detailed information may be required for developing restoration contracts when only estimates based on walk throughs are available. This information could prove useful in prioritizing areas that may require resampling.

The following are some suggested protocols for methodologies for measuring areal extent of soil disturbance:

1. Ocular Estimates:

   Ocular estimates are based on a simple walk through of a proposed or new treatment area. This type of sampling is subject to criticism in that segments of treatment areas may be missed. It is also subject to the biases of the observer. Ocular estimates should only be used if the observer has had experience in soil disturbance measurement using some of the methods described below.

2. Paced Transects with Quadrant Observations:

   Establish some randomly oriented transects throughout an activity area (Figure 1). At pre-determined intervals along the transect, observe a 5x5 foot area and classify it into one of the seven soil disturbance categories. Record information on a form similar to Form 1. Calculate percent area in each category (# of observations in each category/total # observations). Attempt to take at least two observations per acre' however the larger the sample size, the more precise the information will be. Make sure all segments of the activity area are sampled.

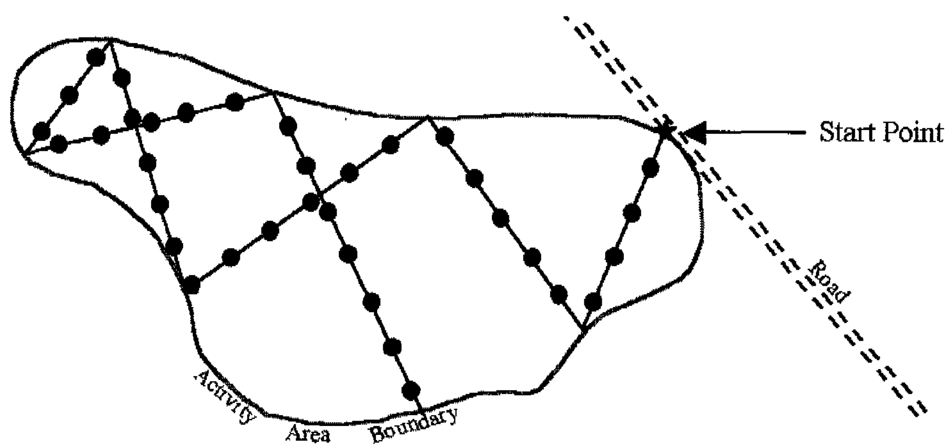


Figure 1. Paced Transects. Quadrant observations made at pre-determined intervals along randomly oriented Transects (point observations of disturbance classes).

3. Paced Transects with Measured Distances:

   Establish some randomly oriented transects throughout an activity area (Figure 2). Along the transects, measure, pace, or estimate the lineal distances of each soil disturbance category and record on a data form. Calculate the percent area occupied by each of the categories by dividing the total lineal distance in each category by the total distance of the transects.

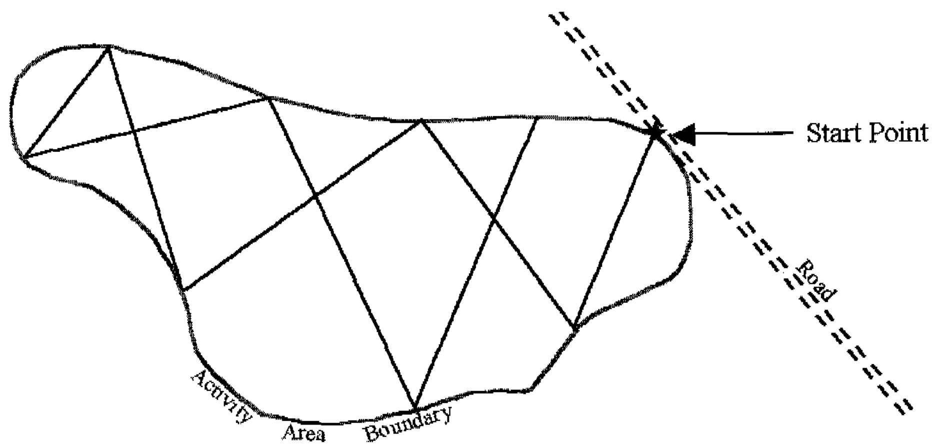


Figure 2. Paced or Measured Transects. Pace or measure distances of soil disturbance classes along randomized transects (need total length of transects).

4. Randomly Oriented Transects Originating from Grid Points:

Measure the lineal distance occupied by each disturbance category along randomly oriented transects of pre-determined distance (usually 100 feet)(Figure 3). Attempt to measure at least 10 transects per activity area. Calculate area mean percentages for each disturbance category. Record data on for similar to Form 2.

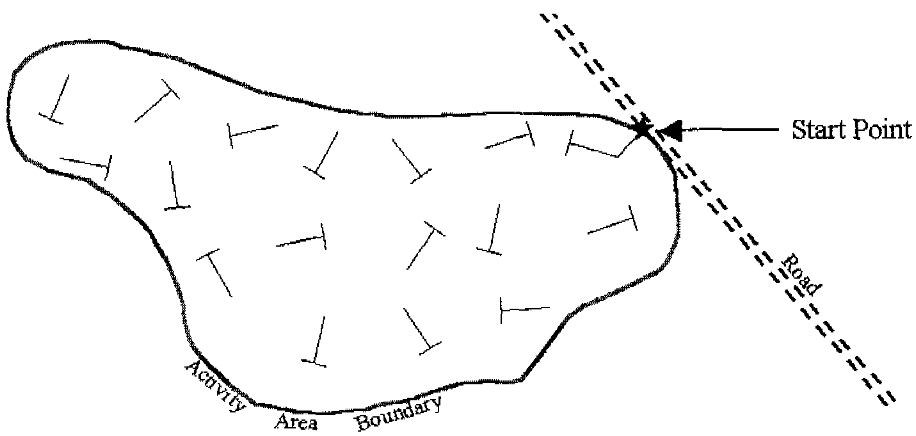


Figure 3. Established Transects. Pre-established grid (randomly oriented) with transects oriented along random azimuths. Transects are of standard length, usually 100 feet.

Distribution of Soil Damage:

Simply knowing the amount or extent of soil disturbance occurring in a treatment area does not give a complete picture of potential impacts on productivity. The pattern or distribution of disturbance is also important. Fore example, 20 percent soil damage may have different impacts if it is concentrated in one area rather than being well distributed throughout a treatment area. Need for restoration may also be affected.

Make provisions on the data for to include information regarding distribution patterns of each of the soil disturbance categories, especially Class 3 and above.

DRAFT

Soil Disturbance Assessment Form
Form No. 1 – Paced/Measured Transects

Project: ______________________________ Unit:

____

Observer(s): ______________________________ Date:

____

Observatio No.	Old or New Disturbance (O or N)	Soil Disturbance Class						
		Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6

Form_soil-disturb_paced-measured_transects.doc

DRAFT

Soil Disturbance Assessment Form
Form No. 2 – Random Transects

Project: ______________________________ Unit:

____

Observer(s): ______________________________ Date:

____

Transect No.	Soil Disturbance Class						
	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
1							
Sub-Total							
2							
Sub-Total							
3							
Sub-Total							
4							
Sub-Total							
5							
Sub-Total							
6							
Sub-Total							
MEAN							
EXTENT							
Distribution:							

Form_soil-disturb_random-transects.doc

REFERENCES

Hazard, J.W., and J.M. Geist. 1984. Sampling forest soil conditions to assess impacts of management activities. Forest soils and treatment impacts. Proceedings of the Sixth North American Forest Soils Conference. University of Tennessee, Knoxville. June 1983.

Howes, S.W., J.W. Hazard, and J.M. Geist. 1983. Guidelines for sampling some physical conditions of surface soils. USDA Forest Service. Pacific Northwest Region. ^6-RWM-146-1983. July 1983.

Miller, R.E., W.I. Stein, R.L. Henniger, W. Scott, S.N. Little and D.J. Goheen. 1989. Chapter 7. Maintaining and improving site productivity in the Douglas-fir region. In D.A. Perry and others (Eds). Maintaining the Long-term Productivity of Pacific Northwest forest Ecosystems. Proceedings of March 31-April 2, 1987 symposium. Oregon State University, Corvallis. P.98-136

Scott, W., G.C. Gillis, and D. Thronson. 1979. Ground skidding soil management guidelines. Weyerhaeuser Co. Internal Report. WTC. Federal Way, WA.