REGION ONE SOILMON TASK GROUP
Review of Soil Productivity Monitoring Methods and Trends

This report describes the conclusions of a task force of soil scientists from representative National Forest in the Northern Region. Their charge was to review soil-monitoring methods, make conclusions as to the consistency of methods and basis in scientific research, and to assess current trends in protection of soil productivity; to develop guidance for selecting benchmark soils/sites and management practices to monitor; and develop a rapid assessment technique for coarse scale monitoring. This report discusses in detail these methods in the context of Forest Service policy, applications and harvest methods for each forest, and emerging issues in maintenance of this productivity.

I. MONITORING METHODS USED IN NORTHERN REGION FORESTS

Listed below are monitoring methods being applied to four western Montana forests and one eastern Montana forest. All the methods use Howes, Hazard, and Geist (1983) as the basis for their monitoring method. Each forest applies a method that the individual soil scientist feels works for him and accomplishes what it is intended to do--to determine the effects to long-term soil productivity subsequent to a ground-disturbing activity. The basis for the elements being monitored is the Forest Service Handbook 2554 Soil Quality Monitoring (R-1 Supplement 2500-99-1, 11/12/99). The elements observed are: *compaction, erosion, displacement, rutting (surrogate for puddling), severely burned soil, soil mass movement, and organic matter [broken into fine woody debris (FWD) and coarse woody debris (CWD)].*

These methods are applied both to recent activities and past activities. It is not unusual to observe recent and past activities in the same activity area. The past activity review is used in the NEPA stage for existing cumulative effects. The results of the recent activity reviews are used in NEPA documents for projected cumulative effects. Appendix A provides background for discussion of the methods currently being used.

A. 100 Foot Transect: along every foot of the 100 feet distance an observation is made concerning erosion, puddling, displacement, burned soil, fine woody debris (FWD) and coarse woody debris (CWD). Every ten feet along the 100 feet distance a soil core is taken which is taken to the lab and measured for bulk density (a surrogate for soil compaction). Five to twelve transects are done per unit depending on the size and shape. Random points and random azimuths are selected in the office prior to seeing the unit to be monitored. The soil monitoring results are used for planning and monitoring.

B. 100 Foot Transect: along every foot of the 100 feet distance an observation is made concerning erosion, puddling, displacement, burned soil, fine woody debris (FWD) and coarse woody debris (CWD). Every ten feet along the 100 feet distance a shovel test is made regarding soil bulk density. The clod bulk density method was used to calibrate field methods. Three to twelve transects are done per unit depending on the size and shape. This method is the same as the one above except a bulk density sample is not collected and tested in the lab. Random points and random azimuths are selected in the office prior to seeing the unit to be monitored. The soil monitoring results are used for planning and monitoring.

C. <u>100 Foot Transect:</u> along every foot of the 100 feet distance an observation is made concerning erosion, puddling, displacement, burned soil, and compaction. The sand-cone bulk density method is used to calibrate field methods. Twelve to sixteen transects are done per unit depending on the size and shape. Random points and random azimuths are selected in the office prior to observing the unit to be monitored. The soil monitoring results are used for planning and monitoring.

D. <u>100 Foot Transect:</u> along every foot of the 100 feet distance an observation is made concerning erosion, puddling, displacement, burned soil, fine woody debris (FWD) and coarse woody debris (CWD), and soil compaction. A shovel test is made for soil compaction. Five to twelve transects are done per unit depending on the size and shape. Random points and random azimuths are selected in the office prior to observing the unit to be monitored. The soil monitoring results are used for planning and monitoring.

E. <u>Zig Zag Toe Count Method:</u> Random azimuths are walked through the unit until there is sufficient coverage made of the unit. At every third step an observation is made of all elements described above. The soil monitoring results are used for planning and monitoring.

F. <u>Pace Transect:</u> Transects are made from one side of the harvest unit to other. The transect is generally done along the contour of the slope, which is usually perpendicular to the activity. At every other step (pace) an observation is made concerning compaction, displacement, puddling, erosion, and burned soil. Core sampling was used to calibrate field methods. Does an infiltration test in every unit. The infiltration rate is correlated with soil structure. Two or three transects are made across the unit depending on the size and shape. The soil monitoring results are used for planning and monitoring.

G. <u>Step Transect:</u> Transects are made from one side of the harvest unit to the other. The transect is generally done along the contour of the slope, which is usually perpendicular to the activity. At every step an observation is made concerning compaction, displacement, puddling, erosion, FWD and CWD, and burned soil. The clod bulk density method was used to calibrate field methods. Depending on the size and shape of the unit, one to five transects are made representing from approximately 100 to over 1500 sample points per unit. The soil monitoring results are used for planning and monitoring.

H. <u>Walk-through:</u> This represents a random walk though the unit making visual observations of all the elements on a random basis throughout the unit. This can be used to determine if further sampling is warranted.

Evaluation of Methods Across Forests

All methods are fundamentally based on the standardized, statistical methods given in 2554. In some cases, systematic sampling of representative areas is emphasized, but in all cases adequate sample size is obtained. Methods have been extended to enable more rapid sampling on Forests having large sale programs. This is because scientists with large-scale sale programs emphasized covering a larger number of projects, rather than intensively sampling fewer projects. This assures a representative sample. Extensions of methods are in all cases based on years of previous sampling and were developed by highly-experienced field-oriented specialists.

All five Forests correlate field methods with standardized procedures for compaction and infiltration. Standard methods for compaction (bulk density) are sand-cone, core, or saran-coated clod.

All definitions in 2554 are used on all Forests. In some cases, definitions of detrimental compaction may be slightly less conservative. These definitions may be collapsed to a binary system (detrimental vs. non-detrimental) to enable more rapid sampling. This collapse process is consistent across Forests.

We recommend continuation of existing methods and definitions. Methods are equivalent in concept but may vary in application. We can say with confidence, that though actual percentage values of measured units may vary somewhat, the call on whether units are above or below standards is consistent with the objectives of the monitoring procedure. All interviewed Forests with soils staff have consistent methods. Forests with no soil scientist present should re-staff with qualified personnel to assure these methods are applied consistently on all units.

Conclusions on the present status of soil productivity protection in Region One

Forests with productive soils and high-value sale programs tend to show compaction as the major impact. with soil displacement becoming a minor component of soil damage. Forests with lower volumes and less productive soils continue to show significant displacement.

There are basically three types of monitoring techniques used—the 100 foot transect; the step/pace transect; and the walk-through. The objective of each is to determine the amount of impact on the soil resource. It is the opinion of the SOILMON Group that no "standard" regional method(s) needs to be recommended. The methods currently in use are all based on the standardized methods. The methods also are accomplishing their designed purpose—that of monitoring impacts to the soil resource.

REFERENCES

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Page-Dumroese, D.; Jurgensen, M.' Elliot, W.; Rice, T.; Nesser, J.; Collins, T.; Meurisse, R. In Review. Soil quality standards and guidelines for forest sustainability: a synthesis of monitoring and research results in northwestern North America. United States Department of Agriculture, Forest Service, Rocky Mountain Research Station, Moscow, Idaho. 24 p.

II. Comments relative to the second charge for the "SOILMON", which is ***"UTILIZING ECOLOGICAL UNITS, DEDVELOP GUIDANCE FOR SELECTING BENCHMARK SOIOLS/SITES AND MANAGEMENT PRACTICES TO BE MONITORED".***

Based on the discussions of the SOILMON task group, we do not recommend detailed division of soil productivity monitoring sites based on ecological units. This is for the following reasons.

Though undoubtedly soils and site factors contribute to the effects of given management activities, as has been shown in numerous scientific studies, soil scientists in the Region feel that we do not have data to support differentiation of our soil productivity monitoring methods. The primary influence on soil productivity (at the level we measure it) is harvest method, not soil type. This has been shown in monitoring results from both west- and east-side forests.

However, there are some soil-related properties that are important even at this scale. First, the west-side forests (that have higher productivity and much higher sale volumes) all have a surface layer largely composed of weathered volcanic ash. This (at our level of monitoring) overrides other soil properties in its influence on compactibility. East-side forests have a much higher variability in terms of surface layers due to the absence of volcanic ash, with displacement becoming a significant factor. However, timber sale harvest and level of monitoring is much lower than on the west-side. Soil productivity is much lower to begin with, due to precipitation and thinner, less productive surface layers. Small soil disturbances probably make as big a relative difference to productivity as on west-side forests.

The other factor is related to both harvest and soil properties. The cushioning effect of organic materials (duff, litter, and slash) is significant to soil protection. Ecological units having higher vegetative growth do influence harvest method effectiveness in protecting soil productivity. The methods used on those soils (where high levels of organic debris are available) are not nearly as effective on units that produce far less vegetative growth.

Ecological units could be used to differentiate effectiveness of harvest methods using productivity ranges relating to volume of slash production and presence of thick duff/litter layers. They could also provide a general cut between soils having volcanic ash (where compaction is the primary impact but there is a thick layer of remaining material) and soils in other materials (where displacement is also significant and a smaller disturbance can have a higher relative impact to productivity.)

III. Comments relative to the third charge of the "SOILMON" task group, which is ***"DEVELOP A RAPID ASSESSMENT TECHNIQUE FOR COARSE SCALE MONITORING"***.

A. Introduction

An emerging soils issue is the cumulative effects of past logging on soil quality. Pre-project monitoring of existing soil conditions in western Montana is revealing that, where ground-based skidding and/or dozer-piling have occurred on the logged units, soil compaction and displacement still are evident in the upper soil horizons several decades after logging. Transecting these units documents that the degree of compaction is high enough to be considered "detrimental compaction"; i.e. the soils now have a greater than 15% increase in bulk density compared with undisturbed soils. Associated tests of infiltration of water into the soil confirm negative soil impacts; the infiltration rates on these compacted soils are several-fold slower than rates on undisturbed soil. Further evidence of detrimental compaction is the alteration of the soil structure from friable fine granular structure in undisturbed soils to high strength, platy structure that breaks apart with difficulty and is noticeably higher in density. Understory vegetation height and cover nearly universally is lower in these damaged soil areas and plant species composition may be different from undisturbed sites. This transecting indicates that these conditions exist across much of the unit; typically 30 to 60 percent of the unit will have detrimental compaction. This amount exceeds Region 1 Soil Quality Standards (SQS), which sets upper limits for detrimental soil damage at 15 percent of an activity area (i.e. harvest unit).

These SQS are designed to maintain long-term soil productivity, soil hydrologic function, and ecosystem health in the activity areas. The soil conditions discussed above seem to be occurring in numerous units in at least some watersheds, and so the concern has been increasing of the cumulative effects on watershed health. The effects of extensive areas of compacted and/or displaced soil in conjunction with impacts from roads, negative impacts in riparian areas, fire and other impacts may be having cumulative effects on watershed health that need further evaluation. This proposal attempts to evaluate the soil conditions related to past logging on a watershed basis through a step-wise process of aerial photo interpretation, field verification of subsamples, development of a predictive model of expected soil conditions by timber stand, application of this model to each timber stand through GIS, and finally a GIS summarization of the predicted soil conditions on a watershed basis. This information can then be 1) combined with assessment of road conditions and bank erosion conditions of these watersheds to give a holistic description of watershed conditions and to help understand cause/effect relationships in watersheds; and 2) the information can be related to Region 1 SQS to determine if, on a watershed basis, soil conditions depart from these standards. Watersheds that do depart from SQS can be flagged for more accurate and intensive field study during landscape level and project level assessments. These more intensive analyses will allow the Forests to more accurately determine where these watersheds stand in relation to SQS and take appropriate actions to maintain SQS across these watersheds as a whole. This process can be viewed as applying the SQS of individual activity areas to the watershed scale with the intent of maintaining healthy watershed conditions.

B. Evaluation Factors for Development of Predictive Model

- slope from GIS
- harvest year from TSMRS

- silvicultural system groups	Group 1	clearcut	80 to 100%
canopy removal			
(from TSMRS)		seed tree	
		seed tree with reserves	
		shelterwood	
		final seed	
		final shelterwood	
	Group 2	shelterwood with reserves	60 to 80%
canopy removal			
		shelterwood prep	
	Group 3	improvement	20 to 60%
canopy removal			
		commercial thin	
		group selection	

sanitation salvage

-fuel treatment (determines if dozer-piled or not) from TSMRS

NOTE: other more direct evaluation factors such as logging system, volume removal, site preparation would have been more desirable to use, but unfortunately those fields were not mandatory fields in TSMRS, and often were not populated. The selected factors of date, silvicultural system, and fuel treatment were mandatory fields and supposedly were always populated in TSMRS.

Decision Tree (assumptions: ground-based logging systems have substantially higher levels of soil damage than skyline, cable, or helicopter systems. The cable, skyline, and helicopter systems have similar levels of negative soil impacts and these levels typically are less than 5% detrimental soil damage on an areal basis. Increased levels of canopy removal are associated with increased levels of soil damage in most cases).

- if dozer-piled, assume ground-based yarding

-if not dozer-piled, could have been ground-based, skyline, cable, or helicopter; then:

-if slope < (??%) and logged pre-(year ??), assume ground-based yarding

-if slope <(??%) and logged post-(year ??); then:

if slope< 40%, assume ground-based yarding

if slope> 40%, assume skyline, cable, or helicopter

-if slope > (??%), assume skyline, cable, or helicopter

NOTE: "(slope??)" and "(year ??)" will be determined on a Forest basis. The concept is that in the earlier years of machine logging the tendency was to operate ground-based equipment on steeper slopes than currently practiced. This shift may coincide timewise with implementation of Forest Plans in the 80's or some other factor to be determined by the individual Forests. The period when this occurred can possibly be determined through a query of TSMRS in conjunction with GIS, in which GIS is used to estimate harvest unit slope, which is then correlated to logging dates. This can be done on a sufficiently large subsample to give a reliable estimate of when ground-based logging became limited to the more gentle slopes. For example, this TSMRS/GIS exercise may show that prior to 1978 ground-based skidding commonly occurred on up to 50% slopes on Forest A, but on Forest B it occurred on slopes up to 45% prior to 1987; thereafter ground-based operations were the dominant logging systems used on slopes less than 40% on both Forests.

This decision tree will be applied to the timber stand data base, stand-by-stand, for silvicultural systems groups and yarding methods in combination with slope estimates from GIS. A 3 x 3 matrix will be produced having 3 silvicultural system groups versus 3 yarding methods, for a total of 9 matrix cells, some of which may not be applicable. Estimated soil damage classes will be assigned to each matrix cell using the method below.

C. Analysis Procedure

In conjunction with the SQS assessment proposed in this proposal, there will be separate watershed assessments of road effects (using the latest version of the Water Erosion Prediction Project [WEPP] model) and streambank erosion. The concensus of a small group of watershed specialists is that all three assessments should be done in the same watersheds. These watersheds will be selected to represent the major types of broad-scale biophysical settings in the planning zone. For example, the vast majority of logging on the Bitterroot Forest has occurred on unglaciated landscapes in three biophysical settings: 1) The mylonitic Bitterroot "Face" slopes which have a fairly maritime climate; 2) the West Fork and East Fork drainages with granitic and gneissic rocks and somewhat less maritime-influenced climate; and 3) the Sapphire Belt rocks with even less maritime-influenced climate. Several watersheds per biophysical setting likely will need to be sampled.

1) using aerial photos with stereo microscope or stereoscope, sample harvest units within each biophysical setting in the watersheds selected for characterization as discussed above. These units will be photo-interpreted for estimates of soil damage. Experience has shown that skid trails even several decades old often are evident on the 9 x 9 inch color resource photos. Each unit will be associated with a cell of the 3 x 3 matrix of silvicultural system group (Groups 1,2,3) versus yarding/fuels treatment method (ground-based; ground-based plus dozer-pile; skyline/cable/helicopter) to determine estimated soil damage related to these combinations. A minimum of 5 to 10?? samples for each combination per biophysical setting should be photo-interpreted this way. Assuming that about 12 biophysical settings will cover the western Montana planning zone, this analysis could result in a maximum of: 12 biophysical settings X 9 cells X 5 (to 10) samples per cell = 540 to (1080) photo-interpreted harvest units. In reality the total should be considerably less, as all cells likely will not occur in all biophysical settings. If too few samples are obtained within the characterization watersheds, it will be necessary to also sample outside these watersheds.

2) concurrent with this photo-interpretation assessment, field sampling should also be conducted to verify and calibrate the photo-interpretations based on field transects or traverses. This field sampling needs to be done on the same units being assessed by photo-interpretation and should also cover all the biophysical settings. The number of field samples needed should be based on the degree of correlation of the photo-interpreted data and the field data. For this level of analysis the field transecting should be done using a rapid assessment method of soil conditions

3) adjust aerial photo estimates using the field data as the photo-interpretation process progresses.

4) based on the revised aerial photo estimates of percent soil damage, develop rule models for use with GIS/TSMRS that assign soil damage classes to the various combinations of silvicultural system group x yarding system for each biophysical setting.

5) apply these rules using the timber stand data base and GIS, based on slope, silvicultural system group, and yarding/piling method so that all timber stands are assigned the appropriate predicted soil damage value. Unmanaged watersheds can be rated as appropriate (for the most part, no detrimental soil damage).

6) summarize this data using GIS and the results of step 5 to determine weighted average estimates of soil damage for all watersheds across the planning zone.

7) relate these estimates of soil damage by watershed to the Soil Quality Standards.

APPENDIX A

SOIL MONITORING TRENDS FOR REPRESENTATIVE NATIONAL FORESTS IN THE NORTHERN REGION

The following gives detailed soil monitoring data compiled from five Region One National Forests. These are based on interviews with Forest soil scientists. *Ecological Characteristics* are general descriptions giving the landscape and management context for each Forest. *Timber Activities* are summaries of the kinds of timber management activities common on each Forest. Activities are only the most common. Others may occur. *Monitoring Methods* refers to specific methods used to monitor soil productivity after timber management activities. *Monitoring Frequency* provides a summary of the level of monitoring related to sale activity on the Forest. *Recent Results* is a summary of important results in the last few years. *Trends* indicate the perceived direction of soil productivity maintenance based on Forest data. *Emerging Issues* lists new concerns that will probably impact monitoring efforts in the future.

Forest: IDAHO PANHANDLED NATIONAL FORESTS

Ecological Characteristics: The average annual production of wood on suitable lands is 63 cubic feet. Last year sales were about 86 million board feet. Soils are developed in an average of 17 inches of volcanic ash over a variety of substrates. The volcanic ash is critical for production. All volcanic ash soils are compactible.

Timber Activities (including Harvest, Fuel Abatement, and Site Preparation): Of the available lands, about 25 percent is tractor, feller/harvester logged; 25 percent is helicopter logged, and 50 percent is logged by cable systems. Upper slope limit on tractor skidding is 35 percent. Tractor harvest operations presently utilize 100 foot trail spacing, except where roads converge at landings; feller bunchers with and without processing heads and harvesters are used primarily on small diameter timber sales, this equipment in the past has operated both on and off slash mats. The present recommendation is to operate on slash mats. These operations use 60-70 foot spaced skid trails and utilize swing skidding or forwarder operations. Some feller buncher and cable yarding operations are also used. Broadcast burning and grapple piling on slash mats are the most frequently used slash disposal methods. Primary prescriptions are seed-tree or shelterwood

Monitoring Methods: Two levels are practiced. "Intensive" monitoring uses ***100 ft., randomly placed transects (seven to ten).*** evaluating disturbance modes (displacement, organic material retention [fine and coarse woody debris], erosion, burning, and puddling.) Compaction is evaluated using core bulk densities every 10 feet. The other elements are noted and recorded every foot along the 100 foot transect. ***"Walk through"*** monitoring uses the same transect method, but using a spade to evaluate compaction. Soil monitoring results are in databases used for planning and monitoring.

Monitoring Frequency: Four sales were monitored last year. A total of 15 cutting units were monitored. A total of about 35 sales have been monitored. Efforts are made to monitor a sale per district per year and those sites where new equipment is used. All are "new" sales, meaning areas have not been disturbed by previous logging operations. The soil scientist has been formally monitoring sales since 1984. Additional monitoring may be completed if new equipment is used or on request by resource specialists or managers.

Recent Results: Compaction is the most documented problem. Problem areas include skid trails spaced too close together and where dispersed skidding is allowed (non-winter operations), or where travel is allowed on soil without slash mats. In some cases, burning when organic layers are dry has resulted in significant soil damage, particularly on south and west aspects. Less than 10 percent of the units monitored exceeded soil productivity limits

Trends: The trend is towards lower disturbance levels as Timber Sale layout becomes more efficient at prescribing methods.

Emerging Issues: Retention of organic materials is becoming an important issue. Too little downed woody debris is currently being left on site. Cumulative effects are important where harvest occurs on previously-cut sites.

Forest: KOOTENAI NATIONAL FOREST

Ecological Characteristics: The average annual production of wood fiber on suitable lands is 58 cubic feet. The average volume for the last five years is 85 million board feet. The soils are developing in glacial till or residual soils. Four to 14 inches of volcanic ash overlies the parent materials. There are some areas where ash is mixed with the substrate material. Volcanic ash is absent on 20-25 percent of the area. Almost all of the underlying bedrock is Precambrian Belt metasediments. The volcanic ash is critical for production. All volcanic ash soils are compactible.

Timber Activities (including Harvest, Fuel Abatement, and Site Preparation): About 50 percent of managed lands are tractor ground. Out of available lands, 50 percent is tractor-logged, 45 percent forwarder systems, and five percent cable. Upper slope limit on tractor skidding is 40 percent. Feller-bunchers are used, with processing heads to distribute slash. Feller-bunchers operate on a "slash mat" of material stripped from trees. Tractor or rubber-tired skidder (RTS) skidding uses 60 to 70 ft. spaced skid trails with little activity allowed off trails. Timber is accessed by directional felling and cable pulling methods. Broadcast burn is often used for hazard abatement and site preparation. Grapple piling is allowed if on a slash mat. Primary prescriptions are seed-tree, intermediate, shelterwood, or sanitation salvage. Soil moisture level must be less than 18 percent for harvest to proceed using ground-disturbing methods. Higher soil moistures have been allowed in some cases with forwarders operating on slash mats.

Monitoring Methods: Two levels are practiced. "Intensive" monitoring uses ***step transects (one to four per cutting unit)*** depending on size and shape of the harvest unit. Each step represents a monitoring point. Transects are placed in a systematic manner, on the contour, to most efficiently monitor the direction of activity in the cutting unit. All disturbance modes (compaction, displacement, erosion, burning, and puddling.) are evaluated. A general observation is also made of the organics. Soil clods for bulk density were used to calibrate field methods. ***"Walk through"*** monitoring uses the same transect method, but uses a random walk through the unit to evaluate disturbance levels while using a spade system (calibrated to compaction tests). This method is also used to determine if a more detailed look is needed for the unit. Soil monitoring results are in databases used for planning and monitoring. These are linked to spatial data. The soil scientist has been formally monitoring sales since 1985 and informally since 1977.

Monitoring Frequency: There were 15 sales monitored last year for a total of 30 cutting units. A total of 75 sales have been monitored, with a total of 150 cutting units. A total of 355 transects have been completed with over 80,000 transect points. The total area involved in the monitoring units is about seven percent of the total harvest area. Additional monitoring may be completed if new equipment is used or on request by resource specialists or managers.

Recent Results: All sales last year were within standards. In the last five years no units have been over fifteen percent and of 88 monitored units and only one has been over ten percent. The main disturbance mode has been soil compaction. Ninety-five percent of sales were in areas not previously harvested.

Trends: The trend is definitely downward. With more operations involving forwarders and excavators, being more cognitive of operating on an organic mat, doing winter operations, etc., the soil resource is definitely benefiting. Winter logging is increasingly used. Soil disturbance is also gradually lessening as operators and administrators become familiar with these methods.

Emerging Issues: Retention of organic materials is becoming an important issue. Too little downed woody debris is currently being left on some sites. Cumulative effects are important, especially as harvest begins to occur on previously cut sites.

Forest: FLATHEAD NATIONAL FOREST

Ecological Characteristics: Production of wood is 60 to 100 cft. per year. Last year sales were about 20 million board feet. Soils are developed in five to seven inches of volcanic ash over a variety of substrates. There are many areas where ash is mixed with substrate material. The volcanic ash is critical for production. All soils are compactible.

Timber Activities (including Harvest, Fuel Abatement, and Site Preparation): About 50 percent of lands are tractor ground. Upper slope limit on ground-based systems is 45 percent. Feller-bunchers or forwarders are used, but only some machines have the processers to trim slash. Feller-bunchers seldom operate on a "slash mat." Tractor or rubber-tired skidder (RTS) skidding uses 60 to 75 ft. spaced skid trails with minimal activity allowed off trails. Piles are generally next to skid roads. Excavators are used for piling and site preparation. These systems have been shown to cause little soil disturbance. Timber is accessed by directional fell methods. Broadcast burn is often used for site preparation. Primary prescriptions are seed-tree or shelterwood. Soil moisture level must be less than 18 percent for harvest to proceed using ground-disturbing methods. Allowed soil moisture may be higher using excavators.

Monitoring Methods: Three levels are practiced. "Intensive" monitoring uses ***100 ft., randomly-placed transects (seven to ten)***, to represent the cutting unit, evaluating all disturbance modes (compaction, displacement, erosion, burning, and puddling.) ***"Zig-zag-toe count"*** monitoring uses the same transect method, but using a randomly oriented, continuous transect through the unit and using a spade system (calibrated to compaction tests.) A binary system of classification is used for this method. ***"Walk through"*** is a random look at the unit to determine if further transecting is warranted. Soil monitoring results are in databases used for planning and monitoring. The soil scientist has been formally monitoring sales since 1983 and informally since 1977.

Monitoring Frequency: There were two sales last year, and both were monitored with a total of 15 cutting units. A total of 30 sales have been monitored. Candidate units are selected using "sensitive" landtypes during the planning process. Additional monitoring may be completed if new equipment is used or on request by resource specialists or managers.

Recent Results: Compaction is the primary disturbance mode. Sales using feller-bunchers without processers (on no slash mat) sometimes exceed soil protection standards. Other sales fall within standards.

Trends: Trends are towards lower levels of soil disturbance. Use of forwarders and excavators, winter logging, and designated skid trail is partially responsible for this trend. Harvest levels are decreasing to the point where monitoring can occur on nearly all sales.

Emerging Issues: Retention of organic materials (fine organic material and large woody debris) is becoming an important issue, especially in broadcast burned areas. Use of excavators has increased residual organic material left. Cumulative effects will soon become important as harvest begins to occur on previously cut sites.

Forest: BITTERROOT NATIONAL FOREST

Ecological Characteristics: Production of wood 20 to 80 cft. per year. Last year sales were about 5 million board feet. Roughly fifty percent of the soils have 5 to 7 inches of volcanic ash surface, in some areas this ash layer is mixed with the substrate. The volcanic ash is critical for production. All soils are compactible. Most present projects are in dry ponderosa pine or Douglas-fir community types.

Timber Activities (including Harvest, Fuel Abatement, and Site Preparation): About 15 percent of lands are appropriate for tractor-based systems. Slope limits on ground-based systems are 35 percent. Feller-bunchers are used, with few machines having the processors to trim slash. Feller-bunchers seldom operate on a "slash mat." Tractor or rubber-tired skidder (RTS) skidding uses 100 ft. spacing of skid trails with minimal activity allowed off trails. Timber is accessed by directional fell methods. Underburning is often used for site preparation. Whole tree yarding is common. Primary prescriptions are partial cuts or improvement cuts.

Monitoring Methods: "Intensive" monitoring uses systematic ***"pace transects" (two to three per unit)*** along contours. Monitored disturbance modes are compaction, displacement, erosion, burning, and puddling. Coring for bulk density was used for calibration of field methods, and infiltration tests are completed on most units. About 80 percent of monitoring is in previously-cut units. Soil monitoring results are in documents used for planning and monitoring. The soil scientist has been formally monitoring sales since 1991.

Monitoring Frequency: Including pre-project monitoring, and an average of three sales a year for the past three years, 30 cutting units have been monitored each year. All proposed units are monitored for pre-project activities. For post-project activities, monitoring is primarily initiated by District resource specialists or managers.

Recent Results: For pre- and post- activities, over 50 percent substantially exceed standards. Compaction is the primary disturbance mode for pre-project monitoring. Displacement is a problem for post-project units on slopes greater than 30 percent. Sales using feller-bunchers without processers (on no slash mat) sometimes exceed soil protection standards. Other sales fall within standards.

Trends: Trends are towards lower levels of soil disturbance. The Forest has recently made large changes in planning and implementation of projects to attempt to remedy the situation.

Emerging Issues: Retention of organic materials (fine organic material and large woody debris) is becoming an important issue. Watershed-level cumulative effects from previous logging activities are now being considered in forest planning. Monitoring indicates winter logging on this forest does not always protect soils, and future monitoring will emphasize this method.

Forest: GALLATIN NATIONAL FOREST

Ecological Characteristics: Production of wood is 20 to 65 cft. per year. Last year sales were less than 2 million board feet. Soils are developed a variety of substrates with no volcanic ash. All soils are compactible with the exception of extremely gravelly soils developed in glacial till derived from coarse-crystalline rocks.

Timber Activities (including Harvest, Fuel Abatement, and Site Preparation): About 30 percent of available lands are tractor ground. The upper slope limit on tractor skidding is 35 percent. Sawyers are still used for harvest, but the trend is towards feller-bunchers. Tractor or rubber-tired skidder (RTS) skidding use 75 ft. spaced skid trails with NO activity allowed off trails. Timber is accessed by directional fell and cable pull methods. Site preparation is by tractor. Primary prescriptions are clear-cuts.

Monitoring Methods: "Intensive" monitoring uses ***100 ft., randomly placed transects (five to ten)*** to represent the cutting unit, evaluating all disturbance modes (compaction, displacement, erosion, burning, and puddling.) Sand-cone bulk density methods are used to calibrate field methods. Soil monitoring results are placed in documents used for planning and monitoring. ***"Walk through"*** monitoring is a random walk through the cutting unit, measuring soil disturbance to determine if further sampling is warranted. The soil scientist has been formally monitoring sales since 1994.

Monitoring Frequency: There were two sales last year, and each was monitored with a total of four cutting units. A total of seven sales have been monitored, with a total of 18 cutting units.

Recent Results: In 1994 and 1995 soil disturbance monitoring showed excessive disturbance, well over soil protection guidelines. The Forest made changes in tractor harvest methods to meet guidelines. There was not enough sale activity to warrant monitoring until 1999 when two sales were monitored. The first sale monitored in 1999 met standards. It was winter-logged and soil guidelines were followed. The latter sale did follow soil protection guidelines. Slope and skid trail guidelines were not followed in the sale planning process. The Timber Sale Administrator initiated mitigative measures.

Trends: The Forest has made changes in the planning process to reduce soil disturbance. However, not enough sales have occurred to evaluate effectiveness of these methods.

Emerging Issues: Future sales should be planned and executed to meet soil protection guidelines. Retention of organic materials will become an important issue. Cumulative effects will eventually become important as harvest begins to occur on previously cut sites, particularly in shelterwood prescriptions.

GENERAL COMMENTS

Forests with lower volumes and less productive soils continue to show high levels of soil damage, though those Forests have recently made steps in improvement.

Protection of the soil appears to be dependent on two factors. The first is physical protection by operating only on 4 to 8 inch slash mats, made up of branches, tops, and small logs, or over snow (with some exceptions.) Even high-impact equipment may do little soil damage.

The second factor is the equipment type and its use. The use of forwarders and harvesters (having slash production capabilities), excavators for site preparation, and cable skidding result in improvement in productivity protection. Methods using tractors often increase soil damage. Dozer piling methods contribute to this damage. Dispersed skidding methods generally cause unacceptable soil damage. Designating skid trails with no or minimal activity allowed off trail reduces impacts. The trend towards less intensive site preparation also contributes to this.

Control of operations is an important part of all harvest activities, and is a secondary objective in all soil monitoring projects.

SOIL QUALITY MONITORING TASK GROUP

Task Group Members: Lou Kuennen, Kootenai NF (Group Leader)
Henry Shovic, Gallatin NF
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Coordination and Technical Oversight: John Nesser, RO

Advisory Board (to be confirmed): Charles Sells, RO
Edward Maffei, Helena NF
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Objective: Develop consistent and cost-effective methods for soil quality monitoring in the Northern Region using established soil quality standards and SOLO.

Charges: 1) Develop consistent site level techniques for both qualitative and quantitative soil quality monitoring including recommendations for use.

2) Utilizing ecological units, develop guidance for selecting benchmark soils / sites and management practices to be monitored.

3) Develop a rapid assessment technique for coarse scale monitoring.

Timelines: March 1, 2000 -- Task Group to submit draft report to Advisory Board.

March 31, 2000 -- Advisory Board to complete review of draft report and submit comments to Task Group.

April 15, 2000 -- Final report completed and implementation begins.

Working Relationships: The Task Group should plan on working independently, scheduling meetings and phone conferences as necessary. Notification of meetings and conferences should be sent to the Advisory Board and Coordinator.

It is anticipated that a meeting between the Task Group and Advisory Board will need to occur in late March or early April.