Northern Region Soil Disturbance Monitoring Protocol

Northern Region Soil Disturbance Monitoring Protocol

Northern Region Soil Disturbance Monitoring Protocol

General Summary

This document outlines a Regional framework for soil disturbance monitoring pre- and post-timber harvesting. We define key terms, appropriate technologies, methods for data collection, and how data should be stored. By defining consistent and accepted methods with common definitions we can produce high-quality data that is accessible and useable by land managers. This technical guide can be used by practicing soil scientists, and with appropriate training timber sale administrators, and logging contractors, etc. This information can easily be conveyed to and used by the general public to describe soil condition classes before and after harvesting. Changes to this general protocol can result in observer biases and affect monitoring results. Validation of the relationships between each of the protocol variables and soil chemical, physical, and biological properties changes as well as their importance in affecting vegetative growth is a critical role for research. This integrated program between NFS and R&D will continually examine the methodology of the data collection and the propriety of the variables.

Historical Context

The concept of soil quality has been addressed to one degree or another in the Pacific Northwest, California, and Northern Regions of the Forest Service since the 1960's. Soil Hazard Ratings were used in California to help design timber harvests to protect soil quality. Most of the efforts revolved around reducing erosion, compaction, and mass wasting. The Pacific Northwest Region was probably the first to publish soil quality standards in the early 1970's and incorporate them into the Forest Service Manual and Handbook. These standards were widely copied by other western Forest Service Regions. The third iteration of the Northern Region Soil Quality Standards was written in 1999 and they became Manual Direction after wide review by soil scientists, other resource specialists, and line officers in the Northern Region.

Soil quality is a moving target and our ideas of what it is and how to measure it have evolved over the years. Soil quality standards can vary, depending on the intended use of the soil. The inherent soil characteristics that help to define soil quality vary greatly over the landscape, affecting the soils ability to support plant growth, hold and partition water, and act as an environmental buffer.

Soil quality is not an end in and of itself and maintaining pristine soil properties is not necessarily the goal of soil management. The objective of soil management is to protect the quality of the soil so that productivity, water quality, and the habitat for various organisms, including humans, is maintained. Soil characteristics are used as indicators of soil quality. Measuring and assessing those indicators is the objective of this Protocol for Soil Disturbance Monitoring.

Acknowledgments –

Thanks to the Helena National Forest for beginning the process of evaluating potential methods for monitoring. In addition, each National Forest in Region 1 committed time and resources to help locate plots and ensure field crews had maps, lodging, and access to information. Many thanks go to the numerous field crews who spent hours collecting data on potential methods and collecting validation samples. Specifically, we thank Matt Johnson, Michael Kruse, Curtis

Kvamme, and Joe Roberts for completing a great deal of the field work, Joanne Tirocke for providing laboratory support, and Tom Maffei for providing input on logging methods and needs.

Contributors

Name		**Affiliation**
Ann	Abbott	RMRS
Jeff	Bruggink	R4
Terry	Carlson	R1 Soil Scientist
Mike	Curran	BC Forest Service
Sharon	DeHart	R1, former R1 Soils Program Leader
Sue	Farley	R1
Steve	Howes	R6
Leonard	Johnson	University of Idaho
Marty	Jurgensen	Michigan Technological University
Curtis	Kvamme	RMRS
Tom	Maffei	R1
Rosa	Nygaard	R1
Dan	Neary	RMRS
John	Nesser	R1, emeritus
Deborah	Page-Dumroese	RMRS
Tom	Rice	RMRS
Henry	Shovic	R1
Joanne	Tirocke	RMRS
Carl	Trettin	SRS
Randy	Davis	WO
Jim	Keys	WO
Meredith	Webster	R1 Soils Program Leader

Chapter 1: Protocol Framework

1.1 Overview and Purpose

The Northern Region of the Forest Service, Region 1, in conjunction with R&D developed this protocol to standardize the use of visual disturbance classes for monitoring changes in soil properties. It is intended for use by field soil scientists and watershed specialists when evaluating soil physical conditions in a forested setting. However, this guide will also be useful for timber sale administrators, logging contractors, hydrologists, and the general public to understand how to assess pre- and post-harvest soil disturbance using visual classes. Determining the significance of the data should be left to a trained soil scientist. This soil quality monitoring protocol is intended for use in silviculture and fuel related projects. In addition, this protocol can be used to obtain soil condition data for forest plan monitoring.

Monitoring of management activities is a key element of land management. Monitoring allows National Forest System Regions to assess the success of management activities in meeting legal, regulatory, and policy objectives.

This Technical Guide for Soil Disturbance Monitoring is intended to serve as a consistent and efficient method for obtaining basic physical soil condition data (FSM 2554). By using a consistent monitoring approach, forests and the region can build soil resource programs to meet their specific National Forest Land and Resource Management Plans (LRMP).

The purpose of this protocol is to establish and use a standard inventory, monitoring, and assessment tool to determine soil condition class pre- and post-treatment. In addition, use of common terminology and an accessible database will allow consistent interpretation of data at local, regional, and national levels, as well as, facilitate data sharing.

This document is organized into six chapters. Chapter 1 reviews the broad protocol framework. Chapter 2 provides the strategy behind the Soil Disturbance Monitoring Protocol. Chapter 3 provides the details of data collection. Chapter 4 defines the indictors and specific protocols used. Chapters 5 and 6 discuss data management, data storage, data analysis, and reporting requirements. Finally there is a glossary, a list of references, and appendices.

1.2 Background and Business Needs

The Soil Disturbance Monitoring protocol was developed in response to a growing need for Regional guidance on soil condition monitoring in forested settings. The protocol is designed to meet a wide range of business needs: 1) LRMP or Forest Plan monitoring; 2) project level implementation and effects monitoring; 3) R1 Manual and Handbook validation monitoring; and 3) law and policy.

This protocol is the result of five years of intensive effort. It was started in the Northern Region (Region 1) to more closely tie operational soil quality monitoring to scientific principles. Scientists from the Rocky Mountain Research Station in Moscow, Idaho were pivotal in its development and testing. Definitions and methods were reviewed by a multi-disciplinary Region 1 committee and a National Soils Working Group. This working group consisted of research scientists from the Southern Research Station, the Rocky Mountain Research Station, universities, B.C. Ministry of Forests and Range, USDA Forest Service Regional Soil Scientists, and Forest Service silviculture, and database specialists.

1.3 Key Concepts

This protocol addresses the consistent and repeatable measurement of visual physical soil indicators. The Soil Disturbance Monitoring protocol is intended for use by field soil scientists and watershed specialists with broad application for other disciplines. For use in forested settings, this monitoring protocol evaluates soil surface conditions and effects where silviculture or fuel related projects are proposed. The protocol can be used to monitor pre- and post-activity area conditions.

The protocol establishes a standard inventory, monitoring, and assessment tool. In addition, it promotes common terminology. Storing data in the SoLo database will allow consistent data interpretation at local, regional, and national levels as well as facilitate data sharing.

1.4 Roles and Responsibilities

1.4.1 Regional Responsibilities (R1 FSM Supplement 2500-99-1, 2554.04.1).

The Regional Forester is responsible for

1. Developing regional soil quality standards;
2. Coordinating with research in the selection of suitable methods for monitoring soil disturbances; and
3. Ensuring technical adequacy of the soil quality monitoring plans.

The Regional Soil Scientist will

1. Keep the protocol current and updated with the best available science;
2. Provide training to forest and district soil scientists and watershed specialists relative to the use of the protocol and data interpretation; and
3. Ensure that the protocol is being applied and interpreted as intended by conducting quality assurance and quality control over monitoring projects.

1.4.2 Forest and Grassland Responsibilities (R1 FSM Supplement 2500-99-1, 2554.04.2 and 3).

Forest and District Soil Scientists and Watershed Specialists will

1. Apply the protocol in the field to silviculture or fuel projects in forested settings;
2. Apply the protocol prior to projects or post-activity as outlined in this document or the planning document for the area in question;
3. Assess the extent to which soil quality standards are being met and whether they are effective in maintaining or improving soil quality;
4. Evaluate the effectiveness of the protocol and recommend changes to the Regional Soil Scientist;
5. Enter field collected data into the SoLo database; and
6. Produce reports and summaries as requested by the Regional Soil Scientist.

1.5 Relationship to Other Federal Inventory and Monitoring Programs

The Technical Guide for Soil Disturbance Monitoring presents a protocol for field measurement of physical soil conditions related to management activity. The protocol is for site-specific analysis of soil disturbance in an activity unit, e.g. a harvest unit, in a forested setting. This program differs from other Forest Service or other Federal Agency monitoring programs in that it is designed to collect site-specific data at the project level.

1.5.1 Forest Service Programs

Other Forest Service programs also collect physical soils data. These programs include the Forest Inventory and Analysis Program (FIA) and the Terrestrial Ecological Unit Inventory (TEUI). Both of these programs are broad scale programs collecting data over large landscapes. These programs currently provide data to the field soil scientist as they determine the scope of work for a specific project. However, the data collected by these programs is often too broad to cover site-specific soil quality conditions at the activity area scale.

Management effects to soil or site productivity requires validation monitoring to ensure that land management activities are not limiting the ability of the land to produce vegetation and provide for ecosystem function. Validation monitoring is a long-term endeavor since soil or site effects may not be noticed for decades or until stands reach maturity. The North American Long-Term Soil Productivity (LTSP) program provides the framework for validation monitoring and is supported by and is supported by all USDA-FS Regions and the National USDA-FS Soil Program.

Region 1 is currently working on a regional monitoring and evaluation strategy. This strategy provides a framework for Forests during revision for their LRMP Monitoring and Evaluation Program. The Soil Disturbance Monitoring Protocol is included in this strategy under the sub-theme Soil, Water, and Air Resources – Soil Quality.

1.5.2 Programs in Other Federal Agencies

The Natural Resource Conservation Service (NRCS) leads the national soil survey program. Again, this is a broad scale soil mapping and characterization project but it provides a spring board for field soil scientists as they plan their workload related to site-specific forest management projects. In Region 1, all forests current have or are working towards having a soil survey completed for the forest, excluding wilderness areas. Older forest soil surveys are found in hardcopy publications. The surveys may not have been correlated or quality checked by NRCS and is not in the NRCS Soil Survey database NASIS. Newer surveys are available on the web through the NRCS or in hardcopy and have been quality checked by the NRCS.

1.6 Change Management

This Technical Guide for Soil Disturbance Monitoring is meant to be a dynamic document. However, changes to the protocol must be carefully considered so the overall objective of having a consistent approach to obtaining physical soil data is not lost. This section outlines conditions that may trigger a review and update of this Technical Guide for Soil Disturbance Monitoring.

Changes to Regional Soil Quality Standards will initiate a review of this protocol. Also, new science related to soil monitoring or management impacts may initiate a review and possible changes to this protocol. However, changes should not be made without a full peer-review.

Changes to the Soil Disturbance Monitoring Protocol can also be initiated from the field, but must be subject to peer and research review. A group of field and research soil scientists will convene to propose changes.

Consistent rangeland and grassland physical soil monitoring protocols are also needed. The process to establish rangeland and grassland protocols has begun and the results of this working group will be incorporated into this protocol.

Chapter 2: Protocol Strategy

2.1 Objective

This protocol defines criteria and indicators that can be measured consistently, efficiently, and economically. Recent litigation has underscored the need for this protocol. The criteria and indicators along with this methodology address national Soil Quality Standards as described in FSM 2500 as well as set the stage for us to strategically address and report watershed conditions and outcomes. This methodology addresses the Northern Region Soil Quality Standards as described in FSM 2500 – Watershed and Air Management R-1 Supplement 2500-99-1 as well as set the stage for us to strategically address and report watershed conditions and outcomes.

The protocol does not represent major changes in the existing Manual supplement. The protocol can be used in any forested setting with defined activity areas.

One of the objectives of this Soil Disturbance Monitoring Protocol is to be statistically valid with enough samples within a unit to describe the variability in soil condition and to calculate a confidence interval. It is important that the statistics and confidence levels be discussed with the decision maker, before field work, so data collection is commensurate with the needs of the line officer.

The Technical Guide for Soil Disturbance Monitoring is written for forest or district journey level soil scientist. Though the protocol can be applied in the field by other resource specialists, data interpretation requires the skills of a trained and classically educated forest soil specialist.

2.2 Soil Monitoring Conceptual Design

Visual classes have been used by a variety of public and private entities (*e.g.* Craigg and Howes 2007; Page-Dumroese et al. 2006; Curran et al. 2005; Heninger et al. 2002) for the assessment of change in soil conditions from pre- to post-harvest. Visual classes offer a method to efficiently and consistently gather information about soil conditions.

Since it is often time-consuming and costly to gather soil physical, chemical, and biological data, development of visual indicators is desirable. Regardless of which soil indicators are selected, they should be comparable to an available baseline, be timely, be applicable over a large area, and be inexpensive and easy to use (Burger and Kelting 1999). They also should provide an effective means for communicating soil conditions to clients and stakeholders.

Curran et al. (2007) reports that visual disturbance categories provide a practical method for describing soil disturbance within a forested setting. Research on using visual indicators has been done by several workers in the western USA (*e.g.,* Curran et al. 2007, Page-Dumroese et al. 2006, Howes et al. 2000) and they provide the background information on the visual indicators used in this protocol and listed in Table 1. Use of these indicators is based on two field seasons of research and testing in Region 1 (Northern Region) and collaborative work with

British Columbia Ministry of Forests and Range, Region 4 and 6 soil scientists, and published literature.

To evaluate the soil function of providing a rooting medium for vegetation, the soil indicators of organic mater, root density and penetration through the soil profile as well as burn severity and displacement are collected. Related to the hydrologic cycle, the soil indicators of soil structure, organic matter, erosion, and rutting are evaluated. For carbon balance, organic matter is the primary indicator.

Table 1. Visual indicators used in this protocol

Forest floor impacts	Forest floor material includes all organic horizons on the mineral soil surface.
Surface soil displacement	Topsoil (surface soil) primarily includes the mineral soil A horizons, but if the A horizon is shallow or undeveloped, it may include other horizons. This disturbance is probably due to machinery, but does not include "rutting" described below.
Mixed surface soil/subsoil	Surface mineral and subsoil horizons have been mixed together or inverted. Evaluation of an unharvested stand may be necessary to ascertain mixing.
Rutting	Ruts vary in depth, but are primarily the result of equipment movement. Ruts are defined as machine-generated soil displacement having smearing of the soil surface in the rut.
Burning	Burn severity includes only impacts on the forest floor and mineral soil, not on above-ground vegetation.
Compaction	Compaction by equipment results in either a compression of the soil profile or increased resistance to penetration
Platy structure/massive	Flat-lying or tabular structure in the mineral soil. "Massive" indicates no structural units are present, and soil material is a coherent mass.

In addition, the field assessment collects data related to the attributes of forest floor depth, live plants, woody residue, bare soil, and rock. These attributes are considered to be valuable additions to our monitoring database. For instance, forest floor depth must be measured to estimate forest floor nutrients (Page-Dumroese et al. 2000). In addition, information about effective ground cover may be useful in applying erosion prediction models.

2.3 Statistical Design

The goal of the data collection process is to obtain a representative estimate of the amount and types of management-caused disturbance within a particular activity area. Although there is a 'true' proportion of any area that is disturbed, the only way to determine that true proportion would be to measure every possible point within the entire activity unit. Since sampling every point is impossible given time and budget constraints, a sample must be taken. When the sample is chosen randomly (every possible sampling point within the unit has the same probability of being chosen) and 'large enough', it can be considered representative of the activity area as a whole.

A 'large enough' sample is determined by first specifying the confidence level that is acceptable for the sample estimate. As the level of confidence increases, so does the number of observations necessary to estimate the disturbance. The confidence level is determined by the line officer and then specified within either the electronic spreadsheet (see section describing use of electronic spreadsheet) for data entry or by choosing the appropriate column on the sample size table provided with the paper data sheet, and then finding the associated sample size for a given proportion of disturbance (see section describing use of paper form). At this time, available confidence levels within the electronic spreadsheet are 70%, 75%, 80%, 85%, 90% or 95%. The margin of error around each estimate is ± 5%, meaning that once the proportion of disturbance for a particular variable is estimated for the activity area, the interval calculated by taking the sample proportion ± 5% will contain the true proportion with the chosen level of confidence.

The sample size required to estimate the proportion of disturbance is first calculated individually for each indicator variable. The overall sample size is chosen to be the largest of the individual sample sizes to ensure that the margin of error is within acceptable limits for every indicator variable. Sample sizes are not dependent on the size of the activity area; they are *only* dependent on the level of confidence and the amount of variability within an activity area. The procedure outlined here is a point sample, and within any size activity area, the number of potential points to sample is infinite.

All of the variables that contribute to the overall sample size calculation are *binomial* variables, meaning that they can only take on one of two values: either the characteristic is present (1) or it is not (0). When the sample size is at least 30, the normal approximation to the binomial distribution can be used which greatly simplifies the computation. There are several advantages to using binary variables as the basis for the sample size determination (Sheaffer et al., 1996). The maximum possible variability for any site is a fixed number that is reached when 50% of the observations have the characteristic and 50% do not. Using binary variables allows variability to be estimated and sample size calculated in the field on a single sampling trip with a simple set of calculations. The method we suggest uses observations from the initial transect as the 'pilot' data for any given unit, and thus ensures that the sample size necessary for each unit is based on accurate variability estimates within that unit. Continuous variables (variables whose values can be measured in continually decreasing units) could also provide sample size estimates, but the computations are more formidable and there is no finite maximum number of observations. When the number of observations is at least 30, the binomial sampling distribution converges to an approximately normal distribution (Triola 2001), which further simplifies the computations.

The required sample size for each indicator variable is calculated according to the following formula:

$$n = \frac{(z_{\alpha/2})^2 * \hat{p} * \hat{q}}{w^2}$$

Variables within this formula are as follows:

- $z_{\alpha/2}$ is the standard normal percentile yielding the chosen confidence level for the chosen interval. The user must specify the desired confidence level within the electronic data entry spreadsheet or choose the appropriate column from the paper sample size table.
- $\hat{p}$ is the observed proportion of observations that have the condition and are marked 'present' by recording a '1'. This is computed by adding the total number of 1's and dividing by the total number of observations. The electronic spreadsheet will perform

this calculation automatically; however, those using the paper form must calculate this in the field.

- $\hat{q}$ is the observed proportion of observations that do not have the condition and are marked ‘absent’ by recording a ‘0’. This is computed by adding the total number of 0’s and dividing by the total number of observations or by subtracting $\hat{p}$ as found above from 1 since $\hat{p}$ + $\hat{q}$ = 1.
- *w* is the 1/2-width of the confidence interval. At this time, the sample sizes are calculated based on a confidence-interval width of 10%, which will result in the estimates with a plus or minus 5% margin of error.

This means that with an 80% confidence level, at the calculated sample size, the confidence interval given by the range $\hat{p}$ ± 5% will have ‘captured’ the true proportion of disturbed points in the Activity Area, 80% of the time.

The minimum number of observations is 30. This minimum number is required when using the above formula to calculate sample size. If less than 30 observations are taken, the sample sizes and confidence intervals calculated within the spreadsheet will be incorrect. The consequence of using greater than 30 samples but less than recommended by the spreadsheet is that the confidence interval will be wider, as indicated by the “Lower Bound” and “Upper Bound” values on the spreadsheet.

The confidence intervals calculated on the electronic spreadsheet are the actual confidence intervals from the sample data along the transect and may be used as summary data for reporting. For those using the paper data collection form, we suggest entering the data into the electronic spreadsheet to obtain the intervals without calculation. The formulas for the lower and upper bounds of the confidence intervals are as follows:

$$\text{Lower Bound} = \hat{p} - z_{\alpha/2}\sqrt{\frac{\hat{p} * \hat{q}}{n}}$$

$$\text{Upper Bound} = \hat{p} + z_{\alpha/2}\sqrt{\frac{\hat{p} * \hat{q}}{n}}$$

Where the variables are as defined as above for the sample size formula. The values for $z_{\alpha/2}$ are shown in Table 2.

Table 2.

Confidence Level	$z_{\alpha/2}$
70%	1.04
75%	1.15
80%	1.282
85%	1.44
90%	1.645
95%	1.96

Within the electronic spreadsheet, the estimated proportion of disturbance for the unit is shown along with the lower and upper bound of the confidence interval for each indicator variable. These values are provided for convenience in final reporting. The correct interpretation of the confidence intervals can be illustrated with the following example: if an activity area yields a $\hat{p}$ for the indicator variable "rutting? <5cm" of 0.1545 and the required sample size of 109 (from an 85% confidence level) was met by taking 110 observations, the lower bound is 0.104916 and the upper bound is 0.204175. This means that with 85% confidence, the interval (0.1, 0.2) has captured the true proportion of rutting less than 5 cm within this particular activity area. It should be noted that intervals calculated for low levels of disturbance (less than 5%) are truncated to have a lower bound of zero since negative values are impossible.

Summary levels of disturbance classes are also provided within the electronic data entry spreadsheet. Since this is an ordinal variable (meaning that levels of this variable are ordered categories), confidence intervals may not be calculated.

2.3.1 Stratification

In situations where it is known prior to sampling that the activity area can be divided into different sections with different levels of disturbance, stratification of the activity area may be efficient. When stratification is performed, completely separate sampling is conducted for each section of the activity area, and the procedures outlined for sampling should be followed for each section within the area as if it were a complete activity area. Summary statistics should be reported both for each strata (section within the area) and for the activity area as a whole. Proportions of disturbance and confidence intervals for the activity area as a whole can be calculated using the spreadsheet. To use this spreadsheet, the area of each stratum within the activity area must be known, along with the proportions of disturbance for the indicator variables and sample sizes for each stratum.

2.4 Unit Sampling Design

A randomized transect method for a point-oriented assessment has been shown to give adequate and repeatable results (Page-Dumroese et al. 2006). There are many different ways to select observation points; the key objective here is to ensure that the points are chosen in such a way that is representative of the entire unit and are unbiased. Thus randomness is critical. It is important that the chosen method of point selection is documented within the report. The confidence level for the sampling instance is determined by the journey-level soil scientist and decision maker for each project.

The “Activity Area” is a land unit that is to be evaluated for soil disturbance due to a past or planned management activity and to which soil quality standards are applied. It is often a harvest or treatment area in a vegetative management project, but could be any area of interest that is feasible to monitor. Statistical estimates of soil disturbance parameters made using this Protocol will apply to this unit if it is appropriate.

Activity Areas may be stratified for soil type or soil “sensitivity” to help reduce variability, but each sub-unit will have independent spreadsheets and statistical estimates. Activity areas can also be stratified based on disturbance level: for example, it may be prudent to separate areas within a unit if there is a distinct difference in disturbance such as landings. These can then be weighted as needed to obtain an estimate of the Activity Area as a whole. If the unit is stratified for sampling, this should occur as part of pre-work and should be map-based rather than completed in the field. This will help avoid bias.

For this protocol, the sample “point” is a six-inch diameter circular area around the sample point. The visual attribute category is chosen by selecting the one best fitting the majority of the sample point. Areas outside the “point” can be used for determining general context of the disturbance, but should not be used to decide the class of the “point”. This would bias the sample system, especially if applied differently to different visual attribute.

2.5 Soil Disturbance Classes

A four-level soil disturbance classification system has been developed for use in Region 1, but is applicable to other areas (Table 3). This system is based on work completed in the Pacific Northwest and Intermountain west (Curran et al. 2007; Craigg and Howes 2006; Page-Dumroese et al. 2006; Curran et al. 2005; Howes et al. 1983)

Disturbance classes are defined primarily by morphological attributes, not quantitative measures. The disturbance classes are correlated with soil variables that affect tree growth and hydrologic and ecological function. Finally, this classification system can facilitate communication between scientists, decision makers, and the public.

As the activity area is walked, each sample point is placed in one of these classes. It is realized that the sample point may represent soil attributes from more than one classification. The soil scientist will make an informed decision about which disturbance class best describes the sample point. It is important to collect enough data and field notes at each point to defend the unit soil disturbance call.

Local, forest level class descriptors can be added to Table 3 but core descriptors cannot be removed. The rational for this decision is so the classes remain consistent between forests. If through use of the protocols, a core classification descriptor is found to be lacking applicability across many forests, the classification descriptor will go through a regional review and the protocol update if needed.

Table 3. Soil Disturbance Classes

Soil Disturbance Class 0 – Undisturbed Soil surface: • No evidence of past equipment operation. • No depressions or wheel tracks evident. • Forest floor layers present and intact. • No soil displacement evident. • No management-generated soil erosion. • Litter and duff layers not burned. No soil char. Water repellency may be present.	**Soil Disturbance Class 1** Soil surface: • Faint wheel tracks or slight depressions evident and are <5 cm deep. • Forest floor layers present and intact. • Surface soil has not been displaced and shows minimal mixing with subsoil. • Burning light: Depth of char < 1 cm. Accessory: Litter charred, or consumed. Duff largely intact. Water repellency is similar to pre-burn conditions. Soil compaction: • Compaction in the surface soil is slightly greater than observed under natural conditions. • Concentrated from 0-10 cm in depth. Observations of soil physical conditions: • Change in soil structure from crumb or granular structure to massive or platy structure, restricted to the surface 0-10 cm. • Platy structure is non-continuous. • Fine, medium, and large roots can penetrate or grow around the platy structure. No "J" rooting is observed.
Soil Disturbance Class 2 Soil surface: • Wheel tracks or depressions are 5 to 10 cm deep. • Accessory: Forest floor layers partially intact or missing. • Surface soil partially intact and may be mixed with subsoil. • Burning moderate: Depth of char 1- 5 cm. Accessory: Duff deeply charred or consumed. Surface-soil water repellency increased compared to the pre-burn condition. Soil compaction: • Increased compaction is present from 10-30 cm in depth. Observation of soil physical condition: • Change in soil structure from crumb or granular structure to massive or platy structure, restricted to the surface 10-30 cm. • Platy structure is generally continuous • Accessory: Large roots may penetrate the platy structure, but fine and medium roots may not.	**Soil Disturbance Class 3** Soil surface: • Wheel tracks and depressions highly evident with depth >10 cm. • Accessory: Forest floor layers are missing. • Evidence of surface soil removal, gouging, and piling. • The majority of surface soil has been displaced. Surface soil may be mixed with subsoil. Subsoil partially or totally exposed. • Burning High: Depth of char > 5 cm. Accessory: Duff and litter layer completely consumed. Surface soil is water repellent. Surface reddish or orange in places. Soil compaction: • Increased compaction is deep in the soil profile (> 30 cm in depth). Observations of soil physical conditions • Change in soil structure from granular structure to massive or platy structure extends beyond 30 cm in depth. • Platy structure is continuous. • Accessory: Roots do not penetrate the platy structure.

Chapter 3: Data Collection

3.1 Staffing Requirements

3.1.1 Qualifications

This Technical Guide for Soil Disturbance Monitoring is written for use by forest or district journey level soil scientists. While the protocols can be applied in the field by other resource specialists, data interpretation requires the skill of a trained and classically educated forest soil specialist.

A journey level soil scientist has the education, training, and experience to work at the GS-11 level or above and qualifies under the professional OPM Soil Science series, GS-470. Professional watershed specialists, geologists, hydrologists, and other physical or biological scientists may qualify as journey level soil scientists if they have proper education, training, and experience.

Data interpretation must be done by a journey level soil scientist or properly trained physical scientist. These qualifications add credence and strength to data interpretation as well as project mitigations, monitoring, or restoration plans.

3.1.2 Training

Training in the use of this protocol, data interpretation, and data storage will be the responsibility of the Regional Soils Program Leader. The Regions will provide training as needed.

3.1.3 Safety

A sample JHA has been included in Appendix1. Each Forest is encouraged to modify the JHA to suit local conditions and safety concerns.

3.2 Existing Information Sources

Prior to beginning a field evaluation of soil conditions on a site, available existing information sources should be studied and applicable information should be recorded. Generally, the following steps should be followed.

1) Consult the most current Subsection and Landtype Association maps for general site characteristics. Some of this information may be required by SoLo and can help to stratify the area for sampling. It is important to note, however, that such broad-scale maps are not appropriate for the more detailed site information needed to assess soil quality.
2) Consult available soil surveys for more detailed site information and for the description and morphology of the soils that occur in the project area. Soil surveys may have been done by the Forest Service or by the Natural Resources Conservation Service (NRCS) and may be referred to as Soil Resource Inventories, Ecological Unit Inventories, or Landtype Inventories. This information can help to establish soil reference conditions for the activity area.
3) Previous field review and soil monitoring reports should also be checked and available data utilized.
4) Review any past project records to provide an historical context for the current project.

3.3 Field Survey Method
For this protocol, the sample "point" is a six-inch diameter circular area around the sample point. The visual disturbance category is chosen by selecting the one best fitting the sample point. There is no reference in this protocol to a "hundred foot square area" or any other larger area required for decisions about the "point".

Baseline (pre-harvest) assessment

Pre-work – Fill out as much of the SoLo form as possible using existing documentation and interviews with other team members. Determine the size of the Activity Area.

Step 1: Review existing documentation and imagery to determine if there is documented past harvest or other disturbance in the Activity Area. This should also include a field walk-through. Imagery and existing documentation will help determine if the site should be stratified before going to the field (see section 2.3). If there has been no previous entry into the stand simply document that using the form in Appendix 3. If there is no evidence of any past management, rate the pre-harvest disturbance as "0".

This step may be completed by other IDT members, timber crews, fuel crews, other other field crews.

Step 2: If there is evidence (*e.g.,* stumps, skid trails, roads, differences in vegetation age or composition, or trash) of past ground-disturbing management, continue using this protocol for a quantitative estimate of the amount and extent of disturbance. If there are records of prior management that resulted in minimal soil disturbance and the activity area have similar soils, vegetation, aspect and slope throughout the unit, then a minimum of 30 sample points are to be spaced to cover the entire unit. Take note of pre-harvest forest floor depth and composition, mineral soil horizon depth(s), and depth to bedrock (if applicable).

Step 3. Monument a pre-activity starting point using GPS or other method of point location documentation. This point can be anywhere on the unit boundary. It can be picked for convenience. Start sampling 5 meters inside from this point to avoid edge effects.

Step 4: Once the starting point is located in the unit, the distance between points is calculated. This is based on unit size. Sample point distances must be pre-determined and documented before starting the transect. Points must be evenly spaced to cover the entire unit. For instance, if the unit is ~1000 m long and you need to take 30 sample points; points should be at least 35 m apart along the random transect.

Step 5: Determine, using a random number generator (or other random direction-finding method), a direction to traverse. Walk to the first point and conduct an assessment of the soil surface condition using the data form described below. When the edge of the unit is reached, select another transect at a 90 degree angle (towards the inside of the unit) from the previous transect and continue data collection on the same spreadsheet. Add columns to the worksheet as necessary. Note that as you sample, the required sample size will likely change.

Step 6: Continue assessment until the sample size is reached. On the data form, record a '1' if the indicator or statement is present and a '0' if the indicator or statement is absent, ending with a general soil disturbance class assessment (using Table 3). *Take AT LEAST 30 sample points in the Activity Area that has disturbance. Sites with no disturbance can be documented with the form in Appendix 3 (see step 1).* Temporary roads and landings within or contiguous to the

Activity Area should be measured using this protocol, but additional notes should be taken on their presence.   Estimation of disturbance on temporary roads or landings not in the Activity Area must be done separately, and manually added after completing this method.

Step 7: Use the comment field at the bottom of each row to document noteworthy existing conditions. These comments can be used to document the degree, magnitude, duration, and extent of the existing soil disturbance.

Step 7: In the last row of the spreadsheet (Appendix 4), there is a place to indicate if the sample point indicates "detrimental" disturbance. This row of information is based on the professional judgment of a qualified soil scientist and on the information found in the FSM 2500 – Watershed and Air Management R-1 Supplement 2500-99-1.

<u>Post-activity assessment</u>

Step 1: Before starting work in an activity area, examine the soil in a nearby unharvested unit for forest floor thickness and composition, soil horizon depth, and depth to bedrock (if applicable). Locate a starting point using similar methodology to the pre-harvest assessment. There is no need to replicate transect locations from the previous assessment. Since units after harvest will have more variability, there is a high likelihood that additional sampling points will be needed. It will introduce statistical problems if the original transect is used but more points are added. It is better to complete two different assessments within the unit.

Step 2: Using the procedure described above, determine the soil surface conditions. Record data points until you have taken enough samples to reach the sample size calculated from the chosen confidence level.

As in step 7 (above), indicate which points are considered detrimentally disturbed.

Post-activity assessments are based on the development of a project monitoring plan for the decision document. In this plan disclose what questions you want to answer and determine how many and which units will be monitored following the activity. Post-activity soil condition monitoring should include units from a variety of soil types and treatment methods. In addition, the project monitoring plan should include the time frame for monitoring.

Examples of questions that can be answered based on post-activity soil condition assessments include: What on the ground effects have resulted from the activity?; How do project effects compare to the effects predicted in the planning document?; Was the unit soil prescription implemented as planned?; How do the pre and post activity conditions compare to the desired condition disclosed in the Forest Plan (Does the unit following harvest and post-harvest activity meet Forest Plan Standards and Guidelines)?; What restoration activities would move soil resource conditions toward Forest Plan standards?; or Did we change the soil condition class of the unit?

Another monitoring plan consideration includes the timing of post-activity monitoring. Monitoring a project within one year of completion will provide answers related to the harvest or post-harvest activities. However, monitoring a project 3-5 years after completion will provide an indication of how resilient the soils are and the duration of the disturbance.

After the monitoring plan has been developed, use the Protocol for Soil Disturbance Monitoring Technical Guide. For statistically sampling post-activity, do not use the pre-activity transect.

The 15% limit for aerial disturbance is not defensible and should be eliminated. Restoration and rehab activities should be employed on any detrimental disturbances from past or current activities, not just those in excess of 15%.

3.3.1 Unique Sampling Design Strategies

If the unit is large, for example 300-400 ha, it may not be feasible to monitor the entire unit. Discuss the situation with the decision maker with the following options to serve as a guide.

1. Walk the entire unit and take a minimum of 30 sample points. This option is recommended if the unit has not had previous entry, is uniform relative to the soils, vegetation, slope, or aspect, and the proposed action is similar for the entire activity area.
2. If the unit has had previous entry, is not uniform ecologically, or the proposed action is not similar for the entire activity area; it is recommended you stratify your sample. Stratification will allow detailed sampling on areas that have had previous entry, have sensitive soils relative to the proposed action, or will have mechanical, ground-based equipment off system roads. As long as the point samples are collected at random and based on the established protocols the statistics of this subsample should be valid. The key is to document what was monitored and why and clearly disclose this to the decision maker and public.
3. If possible, have the planners identify where different land management prescriptions will occur within the larger unit. Complete the Protocol for Soil Disturbance Monitoring in areas of sensitive soils or where ground-disturbing activities with mechanized equipment will occur.

If the unit is small, for example 10-20 acres, it may not make sense to collect a large number of points. In this case determine a minimum spacing (~35' between points) and use this spacing to determine the number of sample points. Validation monitoring completed in Region 1 suggests that sample points spaced ~50 feet apart were close enough to determine the variability within units that were ~20 acres in size (Page-Dumroese et al. 2006).

When considering how many units to monitor, it is important to consider how the data is going to be used, the soil disturbance risk, and the variability of the individual unit and project area. Use the Protocol for Soil Disturbance Monitoring on enough units within a project area so it is possible to defend ratings for existing and detrimental condition as well as mitigations, monitoring, or restoration prescriptions. It is recommended that all units with previous entry be assessed pre-treatment.

While walking the transect line, sample points may fall on rocks, down wood, stumps, within bushes, in stream bed, etc. If this occurs, do not offset from the transect line. Record the data point as live plant, coarse wood (including stumps), and rock or under comments if it is not included in the above categories. Sample points do not have to fall on a soil surface to be counted.

Wildfire in an activity area is not counted with these protocols. These protocols are designed to describe land management activity effects to the soil resource. Wildfire creates unique soil surface conditions that need to be thoroughly described as part of a monitoring program and pre-project assessment. Wildfire severity, location, and effects will dictate unit mitigations, restoration opportunities, and post-activity monitoring during project planning.

Prescribed fire or burn piles are considered in this protocol. The R1 Manual Supplement 2500-99-1 describes severely-burned soil as: physical and biological changes to soil resulting form high-intensity burns of long duration. These types of burns may or may not be detrimental to subsequent vegetative growth, but will have to be assessed for each soil type and burn condition. The Manual Supplement further states that this standard is to be used when evaluating prescribed fire. Guidelines for assessing burn intensity are contained in the Burned-Area Emergency Rehab Handbook.

Unburned slash piles can be found on former landings, skid roads, or within the previously harvested unit. When they are on landings or skid roads, they should be assessed was part of those structures (See section 2.4) as the underlying soil will likely be similar to the surrounding impacted area. Similarly, if an old slash pile is located within the harvest unit, it is likely that the soil beneath the pile could be impacted to the same degree as the surrounding soil. It is difficult to examine the soil beneath some slash piles, so if an inference is made about the soil beneath the slash pile from the surrounding soil, a note should be made in the comments.

Landings, temporary roads, system roads:

1. **System roads** are not included in the activity area. System roads are part of the permanent transportation system and the land has been removed from the productive land base. System roads are evaluated in cumulative effects analysis and watershed scale evaluations.
2. **Landings and temporary roads that are outside the activity area** are not included. Landings and temporary roads usually limit vegetative growth by their very nature. Assign an acreage (length, width) and condition to these features and keep a tally for the existing condition, project effects, and cumulative effects discussions.
3. **Landings and temporary roads that are inside the activity area** are counted and contribute to the amount of disturbance within an activity area. Landings and temporary roads usually limit vegetative growth by their very nature. In addition to their classification rating, it is important to assign an acreage (length, width) and condition to these features. Keep a tally for the existing condition, project effects, and cumulative effects discussions.

Root or bole of a fallen tree. If a sample point lands on the root or bole of a fallen tree it is counted as coarse wood with a remark in the comment section stating “roots of fallen tree” or “tree tip”. If the reason for the tree tip can be determined it should be noted. If the tree tip can be associated to human disturbance, then the tree tip sample point is assigned a disturbance class based on what is observed immediately adjacent to the sample point. If the tree tip is not associated with human disturbance, the tree tip sample point is given a Class 0 rating.

3.4 Field Forms

3.4.1 Overview

The field form provides the minimum data collection at each point and within each unit. The form was designed so field surveys consistently looked at a standard set of physical soil quality indicators; this is the rational behind having to fill out each column completely before moving onto the next sample point. Do not modify the field form; the field form was also designed to make data entry into SoLo quick and easy. Storing the data in SoLo is part of the protocol.

3.4.2 Use of Paper Field Form

Field data can be collected on paper field forms, and then transferred into the spreadsheet provided. Do not modify this spreadsheet as it feeds directly into SoLo. All data collected, whether on paper or PDR forms, needs to be entered in the SoLo database.

When using the paper field form, the accompanying paper sample size table must also be used. Users should stop at the end of the first 30 observations and calculate the proportion of disturbed points within the first 30 by adding the number of 1's entered and then dividing by 30. This proportion is $\hat{p}$ and should be entered in the column labeled Visual Class Proportions. The visual class proportion must then be located on the paper sample size table along with the associated sample size. This must be done for each indicator variable in the form. Once the sample size is determined for each indicator variable, the largest of the list of samples should be used for the activity area sample size. An exception to this rule could occur if a single indicator variable is much more variable than all of the others, resulting in one sample size being much greater than all of the rest (where "much greater" is defined as being more than 1.5 times the sample size of the next lower sample size) AND the professional judgment of the observer is such that the indicator variable in question is not representative of the unit. In this case, the next lower sample size should be selected and a thorough explanation must be made in the comments.

It should be noted that the sample sizes calculated from the first 30 points are likely to be larger than those calculated from a greater number. The observer is free to choose some number higher than 30 for the first set which may be more efficient if it initially appears that the activity is variable. The observer can also recalculate the sample sizes a second time if the initial sample size is quite high.

3.4.3 Use of PDR Field Form

All data needs to be entered into the SoLo database. SoLo was developed nearly 10 years ago as a place to store monitoring data across the Region. The data collected using this protocol will be stored in this database as well. The SoLo database will undergo revision to accommodate changes in terminology, data categories and measured variables. For example, "Monitoring Concerns" in the current SoLo report form (Compaction, Displacement, Rutting, Burned Soil, Surface Organics, Ground Cover, Surface Erosion and Mass Movement) will become "Visual Indicators" (Forest Floor Impacted, Displacement, Mixing, Erosion, Rutting, Burning, Compaction, Platy/Massive Structure), and the "Percent of Area" estimate will be replaced by "Proportion Positive," a calculation made and posted automatically as the survey transect is recorded.

Because this new protocol is intended to be national in scope, there is a need for it to be searchable by any ecological state, location, characteristic or activity. Therefore, the minimum requirement for data is that <u>every field, unless it is redundant or mutually exclusive, must be filled in.</u>

To use the electronic data entry form, the user must enter the confidence level determined by the line officer. Available confidence levels are 70%, 75%, 80%, 85%, 90% and 95%. All of the columns for data entry must be filled in, do not leave blanks within the form or the sample sizes and confidence intervals will be incorrect. We recommend filling out the columns for each observation point as the point is actually observed. If a point is not able to be observed, fill in the column for that point with periods (.) and carefully document the reason that it is unobservable. DO NOT FILL IN THESE POINTS WITH ZEROES!

The electronic data entry form calculates sample size and confidence intervals automatically and updates with each additional observation, however, until the first 30 observations are entered the values for sample size and confidence intervals are invalid. It is important to note that if the spreadsheet is pre-filled with zeros, the sample sizes and confidence intervals are likely to reflect an inaccurate level of variability and are likely to be incorrect.

The required sample size shown on the electronic form is the largest of the sample sizes calculated for the individual indicator variables. The individual sample sizes can be seen by changing to the "results" tab on the spreadsheet. If the required sample is more than 1.5 times larger than the next lower sample size and the professional judgment of the observer is that the indicator variable is an anomaly within the activity area, the next lower sample size can be chosen and a thorough explanation made in the comments.

3.5 Field Data Collection – Standards and Methods

This protocol represents the minimum data collection for soil disturbance conditions. The core soil disturbance indicators must be collected at each sample point. Core indicators must be collected using the protocol within this Technical Guide. Suggested changes to the core protocol must be evaluated by the Regional Soil Program Leaders and subject to peer review.

Outside of the core data, additional data can be collected using a published protocol. Provide a copy of the protocol to the Regional Soil Program Leader.

3.5.1 – Core descriptors for each activity area

A separate report must be filed for each unit (or subunit) in a project. Definitions are provided in Appendix 4? To the extent possible, each report must include:

- Project ID: Usually, a name, such as "Quarling Eagles" or "Marty Sale."
  Unit ID: Most often a number; could be alphanumeric, such as "12A"
  Project Type: For example, "Green sale," "Salvage sale," "Fuels Abatement"
- Location
  Region: Name, rather than number, to avoid cumbersome lookup
  Forest: Name, rather than number, to avoid cumbersome lookup
  District: Name, rather than number, to avoid cumbersome lookup
- Map Information
  USGS Quad(s): Name(s) of 7.5-minute quadrangle map(s) of site
  Geographic Coordinates: Either latitude & longitude (preferred) or UTM
- Topography
  Landform description/category: Such as "Glaciated hillslope" or "Alluvial terrace"
  Slope: in percent, the average or range of steepness of the unit or subunit
  Aspect: in degrees, the prevalent or range of direction the unit faces
  Elevation: in feet, the average or range of elevation of the unit or subunit
- Ecology
  Ecological Subsection: the alphanumeric subsection ID where the unit appears
  Habitat Type: the vegetative community classification of the unit
  Watershed ID: the name & the 6th-level HUC of the watershed containing the unit
  Watershed Condition Class: I, II or III, based on water clarity, etc.

- Landtype Association: the mapping unit ID, based on Landtype grouping
  Parent Material: source material of the predominant soil on the site
  Soil Classification: the taxonomic descriptor of the predominant soil
  Soil Survey: Name of the published/accepted survey of the site area
- Site History
  Fire activity: season and year of historic fire(s)
  Harvest activity: season and year of previous harvest(s)
  Grazing activity: span of years of allotted grazing
  Site prep: season and year and type of site prep work
  Planting: year of planting, species planted, stocking rate
  Thinning: year of thinning, residual stocking rate, species mix
  Reclamation: of roads, landings or other disturbance, the year(s)
  Recreational use: type and duration of recreation activities
- Current Activity
  Prescription: based on residual stocking rate, or "clearcut," "dispersed shelterwood," etc.
  Logging System: type of equipment used in current activity
  Monitoring Type: Number of months pre-activity or post-activity
  Soil Moisture: measured at time of monitoring
- Summary Statistics: These will be filled automatically as transect is assessed.
- Administrative Information {Most of this information is filled automatically.}
  Observer Name
  Observer Title
  Date Monitored
  Date of Report
  Date Approved {All reports must be approved by next-level line officer before final submission.}
  Approver Name
  Approver Title
  NEPA Document: Title of NEPA document associated with this project
  Date NEPA Completed

Chapter 4. Soil and Site Indicators and Protocols

4.1 Site Indictor Protocols

Soil Texture

Values	Database and Form #
Soil texture class – Sandy, Sandy Loam, Silty or Loamy, Clayey *Soil moisture regime – dry, moist, wet* *Coarse fragment percentage* *Size of coarse fragments in the soil profile – gravel, cobble, stone, boulder* *Location of coarse fragments in the soil profile – mixed in*	Form 1: SoLo Spreadsheet

Values	Database and Form #
profile, surface, A horizon, B horizon	

Protocol

These attribute values are core to soil disturbance monitoring allowing for pre-assessment site stratification and later stratification of data results.

Soil texture information is obtained from field examination. While published soil surveys can be valuable resources; this information is often collected over too broad of a landscape and includes too many inclusions for site-specific assessment. Soil Survey information needs to be verified within the unit. Standard techniques for identifying soil texture classes are employed. The NRCS Survey Manual provides soil texture class definitions and techniques for classification (Schoeneberger, et al., 1998). Soil texture information is recorded as Sandy, Sandy Loam, Silty, Loam, Clayey, etc.

Soil moisture is critical when interpreting soil strength as an affect of soil compaction. Record the soil moisture as dry, moist, wet. Dry soils have little to no moisture when examined in the field; in contrast wet soils are saturated or nearly saturated and you can squeeze water out of them. Soil strength generally increases as the soil dries so care must be taken when evaluating a soil for massive structure if the soils are very dry. The massive structure may be more related to soil moisture than soil compaction from equipment operations.

Information on coarse fragment percent, size, and distribution within the surface soil is important when prescribing mitigation and restoration techniques. This information can be obtained from the local soil survey and verified in the field. Coarse-fragments also determine the sensitivity of the soil to disturbance or it resiliency. The coarse-fragment percentage class is categorized as <15% coarse-fragments (no modifier, use the dominant texture), 15% - <35% (gravelly), 35% - <60% (very gravelly), 60% - <90% (extremely gravelly), >90% (no modifier, use the dominant size class – *e.g.,* gravel). The size of coarse fragments is described as gravel (2-75 mm), cobble (75-250 mm), stone (250-600 mm), or boulders (>600 mm). The location of the coarse fragments is described as being mixed throughout the surface soils, limited to the A horizon, or limited to the B horizon or deeper (as estimated during a shovel test).

This information does not need to be collected at every sample point but does need to be collected frequently enough to describe the heterogeneity or homogeneity of the unit. The information is collected as a note and recorded on Form 1 of the SoLo spreadsheet.

Protocol Reference

NRCS Field Handbook for Soil Survey (Schoeneberger, et al., 1998).

Forest or County Soil Survey. Forest and County Soil Surveys, while a valuable resource, have inclusions. Make sure that information is verified on the ground.

Site Vegetation

Values	Database and Form #
Vegetation – type of vegetation, forb, grass, shrub, tree, invasive, other *Vegetation - % cover* *Root depth/location (use the NRCS categories)* *Root abundance/density (use the NRCS categories)*	Form 1: SoLo Spreadsheet Field Notes

Protocol

These attribute values are core to the soil disturbance survey. Describing the above and below ground vegetation and root characteristics provide insight as to effective ground cover, changes in site productivity, and how well plants are utilizing the soil resource.

These values can be collected for the unit, along the transect at predetermined sample points (*e.g.* every 10 points), or when vegetation characteristics change.

Data is collected into visual categories.

Protocol Reference

NRCS Field Handbook for Soil Survey (Schoeneberger et al. 1998).

Forest or County Soil Survey

Soil Structure

Values	Database and Form #
Massive, granular, blocky, etc	Form 1: SoLo Spreadsheet

Protocol

Soil structure is the naturally occurring arrangement of soil particles into aggregates. Mechanical site treatments or prescribed fire may reduce these aggregates into smaller particles. These smaller particles may alter infiltration, water and gas exchange, and biological processes. Alternatively, mechanical treatments may cause the structure to become massive (no structural units; material is a coherent mass) or puddle (soil smeared by machine traffic during wet conditions).

Protocol Reference

NRCS Field Handbook for Soil Survey (Schoeneberger, et al. 1998).

Site History

Values	Database and Form #
Site Identification: Project, Site Name & Number, Forest, District *Location information: TRS or GPS* *Site Characteristics: Slope, Aspect, Elevation, Area, Landform, Landtype Association, Parent Material, Soil Classification, Soil Survey* *Current Activity: NEPA document, Date NEPA completed, Prescription (treatment), Monitoring timing, confidence interval selected, number of points in survey* *Administrative Information: Date Surveyed, Observer, Observer Title*	Form 1: SoLo Spreadsheet

Protocol

These attribute values are core to the visual disturbance assessment. Providing site history provides context for soil data interpretation. The values are collected once for every unit. Most of the information will be available in an office exercise prior to the field visit. See section 3.5.1 for the detailed site descriptors

Definitions of each value are provided in section 3.5.1 – Core Descriptors for each Activity Area.

4.2 Soil Indicator Protocols

Prescribed Fire and Pile Burning

Values	Database and Form #
Burn class – light, moderate, severe	Form 2: SoLo Spreadsheet

Protocol

Prescribed fire and burn piles are considered in this protocol. Wildfire is not counted. Wildfires create unique soil surface conditions that need to be thoroughly described as part of a monitoring program and pre-project assessment. Wildfire effects will factor into mitigations and restoration opportunities.

Low-severity (light) burns that create a mosaic of burned and unburned areas likely do not alter soil processes for an extensive period of time. However, as burns become hotter or have longer residence time on the soil surface, mineral soil properties are affected. Under severe burns there is usually a change in mineral soil color and oftentimes, a change in mineral soil structure. These types of burns likely affect belowground processes for a longer period of time.

This attribute is required in the current draft but is called burning light, moderate, or severe.

Protocol Reference
BAER FSH 2509.13

Compaction and Bulk Density

Values	Database and Form #
Depth of Compaction – 0-10 cm, 10-30 cm, >30 cm *Structure – platy or dense* *Extent of compaction – discontinuous or continuous*	Form 2: SoLo Spreadsheet

Protocol

Depending on soil texture, changes in soil compaction can cause a decrease, increase, or not change in vegetative growth. Local experience on specific soil textural types will determine the importance of this variable to long-term vegetative growth. A metal rod or shovel can be inserted into the ground to determine changes in a point compaction level. This surrogate for bulk density sampling can be used quite effectively if there are undisturbed soils nearby to calibrate this "push" test. This push test must also be calibrated for each observer.

Under all disturbance classes, the assessment of compaction is strictly a visual observation based on changes in soil structure or wheel ruts. Using a "push" test is another method for determining a relative change in soil compaction levels. Actual compaction changes can only be determined by physical measurements such as bulk density.

Displacement

Values	Database and Form #
Displaced? – yes, no *Forest floor impacted? yes, no* *Aerial extent of displacement, sq ft*	Form 2: SoLo Spreadsheet

Protocol

<u>Detrimental Displacement</u> – is defined in the Soil Quality Standards. Using disturbance classes is essentially a proxy method to determine whether or not observed soil disturbances are detrimental. Therefore, at some point, a call needs to be made as whether or not a site has suffered detrimental impacts to the soil resource.

Soil displacement can result in degradation of site quality by exposing unfavorable subsoil material (denser, lower in nutrients, less organic matter, calcareous, etc), altering slope hydrology, and causing excessive erosion and therefore the loss of nutrients. The impacts of displacement on long-term site productivity are governed by slope gradient, slope complexity (hills and dales), and subsoil conditions.

Protocol Reference

B.C. Ministry of Forests. 2001. Soil Conservaton Surveys Guidebook 2nd edition. For. Prac, Br., B.C. Min. For., Victoria, B.C. Forest Practice Code of British Columbia Guidbook. 63 p.

B.C. Ministry of Forests. 1999. Hazard assessment keys for evaluating site sensitivity to soil degrading processes guidebook. 2nd edition, version 2.1. For. Prac. Br., B.C. Min. For., Victoria, B.C. Forest Practice Code of British Columbia Guidebook 18 p.

Rutting

Values	**Database and Form #**
Depth of Rut - <5 cm, 5-10 cm, > 10 cm *Length of the rut*	Form 2: SoLo Spreadsheet

Protocol

These attribute values are core to the physical soil quality survey. Wheel tracks or ruts are impressions in the soil caused by heavy equipment. These vary in depth and width. On sites that have a high compaction hazard (fine textured, steep slopes, etc.), a shallow rut may cause a degradation in site quality by altering the flow of water and gasses in the soil. On sites with a low compaction hazard (coarse-textured, flatter areas), deeper ruts may not cause a detrimental change to water and gas flow. However, regardless of texture, wheel tracks and ruts can cause water to be routed off a site and unavailable for plant growth. Within a rut or wheel track there could also be altered soil structure, increased soil density, puddling, and compacted deposits of forest floor, fine slash and woody debris (not readily excavated with a shovel). Work in British Columbia indicates that ruts 2 m long can cause changes in the hydrologic function of a site.

Protocol Reference

B.C. Ministry of Forests. 2001. Soil Conservaton Surveys Guidebook 2nd edition. For. Prac, Br., B.C. Min. For., Victoria, B.C. Forest Practice Code of British Columbia Guidbook. 63 p.

Curran, M.P., D.G. Maynard, R.L. Heninger, T.A. Terry, S.W. Howes,, D. Stone, T. Niemann, and R.E. Miller. 2007. Elements and rationale for a common approach to assessment and reporting of soil disturbance. For. Chronicle. 83: 852-866

Platy/Puddled structure

Values	**Database and Form #**
Platy/Puddled? – yes, no	Form 2: SoLo Spreadsheet

Protocol

Both puddling and platy structure are a proxy for changes in soil structure and a reduction in pore sizes and a change in pore size distribution. Although platy structure can imply naturally occurring, flat, or tabular-like units in the profile, it can also be caused by harvesting equipment. Soil puddling is the destruction of soil structure and the associated loss of macro porosity that results from working on a soil that is wet. The degree of puddling and its' impact on site productivity is governed by the load bearing capacity of the soil and is affected by soil texture, coarse fragment content, moisture regime, and forest floor depth.

Protocol Reference

B.C. Ministry of Forests. 1999. Hazard assessment keys for evaluating site sensitivity to soil degrading processes guidebook. 2nd edition, version 2.1. For. Prac. Br., B.C. Min. For., Victoria, B.C. Forest Practice Code of British Columbia Guidebook 18 p.

Erosion

Values	Database and Form #
Active erosion – yes, historic *Erosion – no, sheet, rill, gully, other* *Erosion result – pedestaling, exposed roots, rock pavement, bare soil, surface crust, change in vegetation*	Form 2: SoLo Spreadsheet

Protocol

These attribute values are core to the physical soil quality survey. Soil erosion is the movement of soil by water and wind. Accelerated erosion is usually caused by human activities that are more than the historic erosion rates. It causes both on-site (soil loss, nutrient loss, lower productivity, shallower mineral soil) and off-site (reduced water quality increased sedimentation, loss of habitat) impacts. Erosion noted in these protocols is for surface soils within a harvest unit. It is not designed for roads, ditches or where the subsoil is exposed. The extent of erosion should be listed in the comment section of Form #2.

Protocol Reference

B.C. Ministry of Forests. 1999. Hazard assessment keys for evaluating site sensitivity to soil degrading processes guidebook. 2nd edition, version 2.1. For. Prac. Br., B.C. Min. For., Victoria, B.C. Forest Practice Code of British Columbia Guidebook 18 p.

Coarse Woody Debris

Values	Data-base and Form #
Optional	Additional field form

Protocol

This attribute value is optional. Coarse wood on and within the soil surface serves several functions. On the soil surface it helps stop erosion and is the location for numerous fungal, insect, and plant species. As it decays it can become a moisture source during the summer. Within the soil surface it functions as organic matter, helps retain moisture, and can be a refugia for ectomycorrhizae after harvest activities. Common methods for collection of woody residue data are listed below. In addition the photo guide described by Keane et al. (2007) can be a useful measure of coarse wood remaining on a site.

Protocol Reference

Brown, J. K. 1974. Handbook for inventorying downed woody material. Gen. Tech. Rep. INT-GTR-16. Ogden, UT. USDA For. Serv. Intermountain Res. Stn. 24 p.

Lutes, D.C. 2002. Assessment of the line transect method: an examination of the spatial patterns of down and standing dead wood. *In*: Proceedings of the symposium on the ecology and management of dead wood in western forests. Gen. Tech Rep. PSW-GTR-181. USDA For Sev. Pac. Southwest Stn. p. 665-677.

Keane, R.E. and Dickinson, L.J. 2007. The photoload smapling technique: estimating surface fuel loadings from downward-looking photographs of synthetic fuelbeds. Gen. Tech. Rep. RMRS-GTR-190. USDA For. Serv. Rocky Mtn. Res. Stn.

Soil Organic Matter

Values	Data-base and Form #
Forest floor depth (cm)	SoLo Form #2

Protocol

This attribute value is optional. Forest floor (all layers combined) depth can be used to determine loss of nutrients from the organic layers. If the organic layers are piled and burned, those nutrients are also lost from the site. Page-Dumroese et al.(2000) describes how to use the NRCS soil data to determine approximate nutrient amounts and losses. This value can be collected for the unit or along the transect at predetermined sample points (*e.g.* every 10 points). Measured forest floor depth with a pocket ruler

Chapter 5: Data Management and Storage

4.1 QA/QC

Quality assurance and quality control will be provided by both the Regional Office and Forest Soil Scientist. Prior to recording data in SoLo, the data is to be checked to ensure it was collected per the protocol, it is complete, and the results are reasonable, e.g. There are no data entry errors.

4.2 SoLo

SoLo has been selected as the Region 1 database to house physical soil quality monitoring data until a corporate database becomes available. Monitoring conducted per this protocol is required to be entered into SoLo. Required SoLo fields are discussed above under the individual attributes and values. Required SoLo fields are identified on the data forms with shaded heading blocks. In future versions of the SoLo database, reports (*.pdf), maps, and photos can be uploaded.

The soil disturbance assessment data is to be entered into SoLo at the end of each field season, but no later than the end of January each year. It is suggested that all monitoring for a specific project be entered at one time.

Chapter 6: Data Analysis and Reporting

5.1 Synthesis and Interpretation

5.1.1 Proxies and Professional Judgment

Proxies: Indirect methods of measuring soil properties, called “indices” or “proxies” can be used in taking observations of visual soil attributes at sample points. Collecting data will be done by a journey-level soil scientist or a person trained by a journey-level soil scientist. It is the responsibility of the journey-level soil scientist to interpret the data to account for variability in soils and management systems and to ascertain that the proxies have a satisfactory relationship to local soil properties.

5.1.2 Links to the Region 1 Soil Quality Standards

The purpose of these protocols is to help make a determination that the requirements of the National Forest Management Act of 1979 are being met. While judgment is certainly involved in assessing detrimental soil conditions, “detrimental” soil conditions are defined in the SQS. Those definitions should be adhered to and individual interpretation of what the standards are should be minimized since consistent and reliable soil quality monitoring is the objective.

It is the responsibility of the journey-level soil scientist to determine how the results from the visual attributes and soil disturbance classes relate to “detrimental” disturbance as defined in the soil quality standards given in FSM 2500. To make these decisions, field data is compared to Forest or Regional Soil Quality Standards which includes an analysis of the distribution, extent, duration, and degree of the individual point samples. From this analysis, an overall unit condition class rating and detrimental rating can be given.

Detrimental soil quality conditions are those factors that are limiting, over time, to vegetation growth or hydrologic functions. It is important to consider how the conditions or disturbance will change over time. Detrimental soil quality conditions are generally very site-specific. Determination of the overall condition class or detrimental rating for an activity unit may not match 1:1 for all soil properties. The value of a given soil disturbance class may be “detrimental” using one visual attribute and not “detrimental” for another. Curran et al. (2007) suggest that the effects of soil disturbance on tree growth may be the net effect of a number of limiting factors. This requires a judgment call by a soil scientist. In addition, detrimental conditions may or may not be ameliorated by natural processes such as a freeze-thaw cycle or root growth. These processes can be considered when assessing whether or not a point or site has detrimental disturbance.

R1 Soil Quality Standards are guidelines or benchmark values "... that indicate when changes in soil properties and soil conditions would result in significant change or impairment of soil quality based on available research and Regional experience. Proper application of these standards requires professional knowledge and judgment" (pg 3 of the Supplement: Monitoring statement 2554.1). It is the responsibility of the Decision Maker to weight the risks and make decisions based on field and scientific evidence. With this being said, it is recommended that the Forest or Region 1 Soil Quality Standards be followed unless there is clear evidence for altering the guidelines.

When evaluating detrimental soil quality conditions, the collected data will have a confidence interval. This confidence interval must be pre-determined and displayed in any reports.

The following matrix has been included in this Technical Guide to aid soil scientists in making a detrimental soil condition call based on R1 Soil Quality Standards. This matrix must be site-specific and based on standards and guidelines in the forest plan and local soil characteristics, sensitivity, and resilience.

<u>5.1.3. Matrix for determining detrimental disturbance in an activity area</u>

This matrix must be modified by the Forest Soil Scientist to adequately explain the interaction of Forest Plans, local soil types, and local research findings. *The R1 Manual Supplement direction is provided as a basis for the matrix, exchange this direction with Forest Plan Standards and Guidelines as appropriate.* The detrimental disturbance call and discussion will be completed by the Forest or a journey-level soil scientist based on data collected with this protocol and his/her education and experience.

Compaction

Manual Direction – 15% increase in natural bulk density.

Proxy – these values are in the current protocol (Table 3). Platy structure extends deeper than 10 cm. and shows preferential tendency to separate along horizontal planes. Change in soil structure from granular structure to massive, puddled, or platy structure that extends from 10 cm to beyond 30 cm in depth. Compaction is continuous. There is evidence of hydrologic changes (infiltration), vegetation conversion to shallow rooted species, or rooting impacts – fine and medium roots do not penetrate the platy or massive structure.

- *Where platy structure and horizontal planes are observable but a soil sample readily fractures both horizontally and vertically; Compaction is NOT detrimental.*
- *If fine or medium roots are observed passing through a soil sample with platy structure; Compaction is NOT detrimental.*

Displacement

Manual Direction – Removal of 1 or more inches (depth) of any surface soil horizon, usually the A horizon, from a continuous area greater than 100 square feet.

Proxy – these values are in the current protocol. There is no proxy for displacement. Displacement is an ocular estimate as defined in manual direction. Visual keys - The subsoil is partially or totally exposed, the surface soil is mixed with the subsoil.

Rutting

Manual Direction - Wheel ruts at least 5 cm (2 in) deep in wet soils are detrimental.

Proxy – There is no proxy for rutting. Rutting is an ocular estimate as defined in manual direction. Rutting can also be a proxy for compaction because water can be channeled down ruts and cause erosion even if the ruts are not detrimentally compacted. It can also a proxy for a change in hydrologic function – water will follow the rut and flow off-site instead of infiltrating.

Severely-burned Soils

Manual Direction – Physical and biological changes to soil resulting from high-intensity burns of long duration are detrimental. This standard is used when evaluating prescribed fire. Guidelines for assessing burn intensity are contained in the Burned-Area Emergency Rehabilitation Manual (BAER FSH 2509.13).

Proxy – these values are in the current protocol. Depth of char is greater than 5 cm with the duff and litter layer completely consumed. Surface soil is water repellent or a crust has developed (where soil texture allows). The water repellency or crust is continuous. Surface soil color is reddish or orange (where soil texture allows).

Surface Erosion

Manual Direction – Rills, gullies, pedestals, and soil deposition are all indicators of detrimental surface erosion. Minimum amounts of ground cover necessary to keep soil loss to within tolerable limits (generally less than 1-2 tons per acre per year) should be established locally depending on site characteristics.

Proxy - There is no proxy for surface erosion. Surface erosion is an ocular estimate as defined in manual direction and modified by the Forest Soil Scientist for local conditions. Visual keys – The presence of continuous sheet erosion, rills, gullies, pedestals, missing forest floor layer, exposed roots, rock pavement, bare soil, rain drop impact, surface crust. Effective ground cover should be within the range expected for the habitat type.

Loss of Surface Organic Matter

Manual Direction – Objectives for fine organic matter layer thickness and distribution should be determined locally based on similar soil and ecologic types. Research guidelines such as those contained in Graham et al. 1994, should be used if more specific local guidelines are not available. Management guidelines for coarse woody material are based on local objectives.

Proxy - There is no proxy for loss of surface organic matter. Surface organic matter is a measured value modified by the Forest Soil Scientist for local conditions. Visual keys –effective ground cover and organic matter depth should be within the range expected for the habitat type. If the forest floor are totally removed and there is a well developed platy or massive structure matrix item #1 must be detrimental), mixing of the surface soil with the subsoil, or displacement (matrix item #2 must be detrimental); the Point IS considered detrimental.

Proxy - There is no proxy for Coarse Woody Material. Coarse Woody Material is a measured value modified by the Forest Soil Scientist for local conditions.

Soil Mass Movement

Manual Direction – Any soil mass movement caused by management activities is detrimental.

Proxy - There is no proxy for soil mass movement. Soil mass movement is an ocular estimate as defined in manual direction and modified by the Forest Soil Scientist for local conditions. Visual keys – Evidence of slumps, scarps, pistol butted trees, sag ponds, springs, seeps.

Detrimental Soil Disturbance Distribution, Duration, Extent, and Degree

The distribution (one isolated area vs. scattered through the unit), duration (length of time since the disturbance), extent (area occupied by the change), and degree (amount of change) must be considered when making a unit call as to the percent detrimental soil disturbance and effects of the detrimental soil disturbance on soil or site productivity.

5.1.3 Professional Judgment

Ultimately the soil condition class for a unit and how much of an area could be in a condition that is detrimental to vegetative growth needs to be a professional judgment based on site-specific measurements and peer reviewed research. Professional judgment must weight the extent, location, degree, sensitivity of the soil to the proposed action against the measurements.

5.2 Reporting

5.2.1 Format and Content

Accomplishment Reporting - Accomplishment reporting will consist of the number of units monitored with this protocol and reported in SoLo, the number of units monitored and in SoLo pre-activity and post-activity using this protocol, as well as any recommended changes or additions for the next field season.

Pre-Activity Monitoring - Since pre-activity monitoring data is intended for use in project work, the soil specialist report will suffice for any additional pre-activity reporting.

Post-Activity Monitoring - For units monitored post-activity, a soil specialist monitoring report will be prepared and shared with the regional office and other forest units to increase the knowledge and database related to post-activity effects. The post-activity monitoring report will follow “Classical” reporting formats, including but not limited to a discussion of the project, questions to be answered, the monitoring method, results, discussion, and conclusions. The post-activity monitoring report does not have to be lengthy, but should tell the story of what was done, why, and what we learned.

5.2.2 Accomplishment Reporting and Scheduling

Accomplishment Reporting - The forests will provide the Regional Office with accomplishment reporting annually, by January 31 of each year.

Pre-Activity Monitoring – No reporting schedule is given since this report is a function of the planning process.

Post-Activity Monitoring - The forests will provide the regional office with a post-activity monitoring report annually, by project, by January 31 of the following year.

Summary

This technical document outlines the theory and practice of statistically-defensible soil quality monitoring in a standardized protocol. As such, it did not, nor was it intended to answer all the questions. It does outline a way to improve our answers. Although this comprises a minimum dataset in a standardized format, it does not obviate the need for competent judgment as to its application. Scientists on National Forests will have to systematically interpret it for use in their conditions and for their management practices.

That said; use of this protocol *will* make a large step towards more defensible decisions, and ultimately, better protection and use of soils. Quoting Mark Twain, "Buy land, they're not making it any more." Indeed it is true. They are *not* making it any more. With the reality of global warming, increasing demands on our resources, population growth, and shrinking budgets, we need to protect the soil we have. Using this protocol is a step in doing so.

Glossary

Areal extent: the area impacted by any activity.

Activity area: a harvest unit, excluding system roads as well as landings and temporary roads outside of the harvest unit boundary.

Analysis area: Analysis Areas are not Activity Areas. They tend to be larger, more conceptual units, and have greater variability than Activity Areas. They may not have specified harvest methods, or may have multiple harvest methods. They generally do not have enough specificity to trigger a soil "monitoring" event, but can trigger an "assessment".

Assessment: A review to determine best harvest methods, soil limitations, and evidence of previous disturbance.

Biological indicators of Soil quality: Measures of living organisms or their activity used as indicators of soil quality. Measuring soil organisms can be done in three general ways:
1) counting soil organisms or measuring microbial biomass,
2) measuring their activity (e.g. soil basal respiration, cotton strip assay, or potentially mineralizable nitrogen), or
3) measuring diversity, such as diversity of functions (e.g., biolog plates) or diversity of chemical structure (e.g. cell components, fatty acids, or DNA).

Burn severity levels

1) Burning light: depth of char <1 cm
2) Burning moderate: depth of char is 1-5 cm. The forest floor layer is deeply charred or consumed. The surface soil is more water repellent that pre-burn levels.
3) Burning high: depth of char is >5 cm. The forest floor layers are completely consumed. The surface soil is water repellent. Mineral soil has turned red or orange in places.

Chemical indicators of soil quality: These include tests of organic matter, pH, electrical conductivity, heavy metals, cation exchange capacity, and other parameters.

Compaction: See soil compaction

Displacement: See soil displacement

Disturbance: See soil disturbance

Long-term – impacts that last more than a few years (and oftentimes as long as a rotation ?)

Short-term – impacts that are of a temporary nature (1 to 5 years ?)

Dynamic soil quality: That aspect of soil quality relating to soil properties that change as a result of soil use and management or over the human time scale.

Erosion: The detachment and movement of soil or rock by water, wind, ice, or gravity. (SSSA)

Forest Floor: All organic soil horizons and both living and dead plant material on the surface of the mineral soil surface.

Inherent soil quality: That aspect of soil quality relating to a soil's natural composition and properties as influenced by the factors and processes of soil formation, in the absence of human impacts.

Irreversible soil damage: Soil damage that cannot be ameliorated using practical and available means. This type of damage may result in a permanent loss of soil productivity.

Land productivity: The capacity of a site to produce specific products, such as timber or wildlife, over time. Net primary productivity (NPP) provides the fundamental measure of land productivity.

Massive soil: A coherent mass of soil without structural units. It is not necessarily cemented or compacted.

Monitoring: Using the Soil Disturbance Protocol for formal statistical evaluation of levels of soil disturbance.

Physical indicators of soil disturbance: Physical characteristics that vary with management include bulk density, aggregate stability, infiltration, hydraulic conductivity, and penetration resistance.

Platy soil structure: The arrangement of soil particles into aggregates that are flat horizontally. Platy structure can be natural or it can be caused by soil compaction.

Significant change: Changes in soil properties that are expected to result in statistically significant changes in productive capacity over Forest planning timeframes. Based on available research and current technology, threshold values for measurable or observable significant changes in soil properties or conditions are those that can be validated. (FSH Modified)

Significant impairment: Changes in soil properties which would result in significant negative changes in the inherent productive capacity that last beyond the planning horizon. (FSH Modified)

Soil compaction: A physical change in soil properties from compression, vibration, or shearing that increases soil bulk density and decreases porosity, air exchange, root penetration, infiltration, and permeability (R1 FSM)

Soil displacement: The lateral movement of the forest floor (litter, duff and humus layers) and surface soil from one place to another by mechanical forces such as equipment blades used in piling or windrowing, vehicle traffic, or logs being yarded. Mixing of surface soil layers by disking, chopping, or bedding operation, are not considered displacement. (FSH and R6 FSM)

Soil disturbance: Any activity or natural phenomenon that alters the existing physical, chemical, and/or biological properties of the soil. (R8 FSH)

Soil function: Any service, role, or task that soil performs, especially:

1) sustaining biological activity, diversity, and productivity;

2) regulating and partitioning water and solute flow (hydrologic function);

3) filtering, buffering, degrading, and detoxifying potential pollutants;

4) storing and cycling nutrients; and

5) providing support for buildings and other structures (trees) and to protect archaeological treasures (cultural features). (NRCS Modified)

Soil productivity: The inherent capacity of a soil to support the growth of specified plants, plant communities, or a sequence of plant communities. Soil productivity may be expressed in terms of volume or weight/unit area/year, percent plant cover, or other measures of biomass accumulation. (FSH)

Soil quality : The capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation and ecosystem health. In short, the capacity of the soil to function. There are two aspects of the definition: inherent soil quality and dynamic soil quality. (NRCS Modified)

Soil quality indicator: A quantitative or qualitative measure used to estimate soil functional capacity. Indicators should be adequately sensitive to change, accurately reflect the processes or biophysical mechanisms relevant to the function of interest, and be cost effective and relatively easy and practical to measure. Soil quality indicators are often categorized into biological, chemical, and physical indicators. (NRCS)

Soil quality monitoring: Tracking trends in quantitative indicators or the functional capacity of the soil in order to determine the success of, or changes associated with, management practices (land uses or disturbances) or the need for additional management changes. Monitoring involves the orderly collection, analysis, and interpretation of data from the same locations over time. (NRCS)

Soil quality standards: Stated quantitative or qualitative guidelines for soil properties or conditions established to maintain or improve the suitability or productive potential of a soil. These threshold values, along with disturbed aerial extent limits, are indicators of significant reduction in soil productivity. (R8 FSH)

Soil restoration: "Restoration" is a planned measure to improve soil productivity on a previously disturbed site.

Soil rutting: Deformation of the soil under saturated conditions by vehicle traffic resulting in detrimental changes to soil structure and reduced porosity. (R1 FSM Modified) Note: Remove "under saturated conditions". Rutting can occur in

both dry and wet soils.

Soil structure: The naturally occurring arrangement of particles into aggregates that results from pedogenic processes.

Granular – small polyhedrals, with curved or very irregular faces
Platy – flat and tabular-like units
Massive – no structural units; material is a coherent mass

Subsoil: The B horizons or soil immediately below the surface soil layer. Roots normally grow in the subsoil.

Surface Soil: The upper portion of the mineral soil profile.

Top Soil: Usually the A horizon or that portion of the mineral soil profile that is considered the most productive

References – not complete in this draft.

Burger, J.A. and D.L. Kelting. 1999. Using soil quality indicators to assess forest stand management. For. Ecol. and Manage. 122: 155-166.

Craigg, T.L. and S.W. Howes. 2006. Assessing quality in volcanic ash soils**.** *In*: Page-Dumroese D., R. Miller, J. Mital, P. McDaniel, D. Miller, (Tech. Eds). Volcanic ash-derived forest soils of the inland northwest: properties and implications for management and restoration. 9-10 Nov. 2005; Coeur d'Alene, ID. Proceedings RMRS-P-44; Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. P. 47-66.

Curran, M.P., R.E. Miller, S.W. Howes, D.G. Maynard, T.A. Terry, R.L. Heninger, T. Niemann, K. van Rees, R.F. Powers, S.H. Shoenholtz. 2005. Progress toward more uniform assessment and reporting of soil disturbance for operations, research, and sustainability protocols. J. For. Ecol. and Manage. 220: 7-30.

Debano, L.F., D.G. Neary, and P.F. Folliott. 1998. Fire: its effect on soil and other ecosystem resources. J. Wiley and Sons.

Heninger, R., W. Scott, A. Dobkowski, R. Miller, H. Anderson, S. Duke. 2002. Soil disturbance and 10-year growth response of coast Douglas-fir on nontilled and tilled skid trails in the Oregon Cascades. Can. J. For. Res. 32: 233-246.

Page-Dumroese, D., M. Jurgensen, W. Elliot, T. Rice, J. Nesser, T. Collins, and R. Meurisse. 2000. Soil quality standards and guidelines for forest sustainability in northwestern North America. For. Ecol. and Manage. 138: 445-462.

Page-Dumroese, D., Jurgensen, M., Abbott, A., Rice, T., Tirocke, J. Farley, S., DeHart, S. 2006. Monitoring changes in soil quality from post-fire logging in the Inland Northwest. In: Andrews, P.L, Butler, B.W. (comps). Fuels management-How to measure success: Conference Proceedings. 2006 28-30 March; Portland, OR. Proceedings RM-P-41. Ft. Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 605-614.

Sheaffer, Richard L., William Mendenhall and Lyman Ott. 1996. Elementary Survey Sampling—5th Edition. Wadsworth Publishing Company, Belmont, CA

Appendices

Appendix 1: JHA

U.S. Department of Agriculture **Forest Service**	1. WORK PROJECT/ACTIVITY **Soil Quality Monitoring**	2. LOCATION	3. UNIT
JOB HAZARD ANALYSIS (JHA)	4. NAME OF ANALYST	5. JOB TITLE	6. DATE PREPARED

7. TASKS/PROCEDURES	8. HAZARDS	9. ABATEMENT ACTIONS Engineering Controls * Substitution * Administrative Controls * PPE
COMMUNICATION	**Communication breakdown**	Never travel or work alone in isolated areas without preparing and discussing a detailed JHA that includes emergency evacuation procedures and a communication plan. Talk to each other. Let other crew members know when you see a hazard. Avoid working near known hazard trees. Yell "ROCK!" if you see one start to roll down the hill. Always know the whereabouts of fellow crew members. Review Emergency Evacuation Procedures (see below). Carry a radio and spare batteries. Ensure that local frequencies and repeaters are programmed in radios. Contact local districts or resource areas prior to field work to determine appropriate communication protocols. If going to a remote area alone, let someone know specifically where you will be; be sure someone knows you have returned.
TRAVEL	**Overdue, no contact**	File itinerary of planned routes of travel, destination, ETD/ETA, employee names, emergency phone numbers/communication system and contact points, and check in/check out system.
WALKING AND WORKING IN THE FIELD	**Falling down, twisted ankles and knees, poor footing, and general slips, trips, and falls** **Crossing creeks, seeps, bogs, wet Logs, wet rock, wet vegetation slopes, and**	Always watch your footing. Slow down and use extra caution around logs, rocks, and animal holes. Steep slopes (>20%) can be hazardous under wet or dry conditions. Wear laced boots with non-skid Vibram-type soles for ankle support and traction. Stretch before hiking. Watch where you walk in streams, expect rocks to be slippery, and don't cross if you feel unsafe. Cross facing upstream so knees don't buckle, use a stick for extra balance. Expect mud and vegetation covered water to be deeper than it

Formatted: Width: 11", Height: 8.5"

	wet ash slopes	appears. Expect logs to be slippery, especially when the bark is worn off. Expect trails in wet areas to give way to pressure near toe slopes. Keep limber and alert at all times. Be aware in areas of wet ash, loose rocks, and unstable slopes. Slopes with wet vegetation are frequently slick and hazardous.
	Stobs, sharp limbs, and other puncturing objects	Long pants, good boots, and cautious attention will mitigate the danger of possible punctures and tears associated from stobs. Puncture wounds are particularly difficult to clean completely in the field, monitor closely for swelling and throbbing. Obtain medical treatment if these conditions persist. Always expect hidden stobs in dense vegetation. Learn to roll, do not use arms to break fall. As an option, staging pant legs may reduce falls associated with stobs.
	Falling objects	When applicable, wear your hardhat for protection from falling limbs and pine cones, and from tools and equipment carried by other crew members. Always wear your hardhat in burned areas, high snag density areas, falling rock areas, high wind situations. Try to stay out of the woods during extremely high winds.
	Damage to eyes	Watch where you walk, especially around trees and brush with limbs sticking out. Exercise caution when clearing limbs from tree trunks. Advise wearing eye protection.
	Bee and wasp stings	Watch for respiratory problems. Notify dispatcher/other crew members/supervisor and get person to a doctor immediately if there is trouble breathing. Always know where the first aid kit is. Gently scrape stinger off if one is present. Apply analgesic swab and a cold pack if possible, and watch for infection. Flag the location of any known nests and inform other crew members. Carry anti-histamine and asthma-inhaler for bee stings. If known allergic, carry proper medication and instruct coworkers in administration.
	Ticks and infected Mosquitoes	Wear long sleeve shirts. Tuck pants into socks/boots. Visually check each other for ticks while in the field. Check yourself carefully at home at day's end. Use repellent at your discretion. If a tick is imbedded in you: • Gently pull the tick out with tweezers or fingernails using a quick tug • Ensure tick head is removed • Wash the infected area and monitor for a red rash • Monitor the tick bite for inflammation, color alteration, or swelling See a doctor is problems present themselves

Environmental Health Considerations	**Heat stress**	Remain constantly aware of the four basic factors that determine the degree of heat stress (air temperature, humidity, air movement, and heat radiation) relative to the surrounding work environmental heat load. Drink enough water to keep hydrated and prevent heat exhaustion or heat stroke (at least 2 quarts in summer). Consumption of caffeine and alcohol greatly increase susceptibility to dehydration. Limit these intakes before and during exposure to heat stress. Know the signs and symptoms of heat exhaustion, heat cramps, and heat stroke. Heat stroke is a true medical emergency requiring immediate emergency response action. NOTE: The severity of the effects of a given environmental heat stress is decreased by reducing the work load, increasing the frequency and/or duration of rest periods, and by introducing measures which will protect employees from hot environments.
	Cold extremes	Cover all exposed skin and be aware of frostbite. While cold air will not freeze the tissues of the lungs, slow down and use a mask or scarf to minimize the effect of cold air on air passages. Additional measures to avoid cold weather problems are: **a.** Dress in layers with wicking garments (those that carry moisture away from the body) and a weatherproof slicker. A wool or breathable synthetic outer garment is recommended. **b.** Take layers off as you heat up; put them on as you cool down. **c.** Wear head protection that provides adequate insulation and protects the ears. **d.** Maintain your energy level. Avoid exhaustion and over-exertion which causes sweating, dampens clothing, and accelerates loss of body heat and increases the potential for hypothermia. **e.** Acclimate to the cold climate to minimize discomfort. **f.** Maintain adequate water/fluid intake to avoid dehydration.
	Wind	Wind chill greatly affects heat lose. Avoid working in old, decomposed timber, especially hardwoods, during periods of high winds due to snag hazards. Wind also exacerbates the likelihood of hypothermia. Always carry appropriate rain gear (both jacket and pants), as rain gear greatly mitigates the effects of wind-

		chill.
	Rain	Always, carry appropriate rain gear (both jacket and pants). Hypothermia is much more likely, i.e. the lowering of the body's core temperature, when moisture is directly on or near the skin.
	Sun rays	Ultraviolet light from the sun can be damaging to the eyes; look for sunglasses that specify significant protection from UV-A and UV-B radiation. Ultraviolet light from the sun can be damaging to the skin and lead to sunburn or skin cancer; on bright sunny days and over-cast days, always carry and apply to exposed skin, spf 15 rated sun block lotion, a wide brimmed hat, long-sleeve shirt, and pants to mitigate harmful light rays on the skin.
	Lightning	Check weather report, stay off ridge tops and open slopes during lightning storms. If stuck in open keep radio and metallic objects away from you, squat down with only feet on ground using insulating pad if possible, keep as much of your body off the ground as possible. Never use radios or cell phones in lightning. Stay away from large trees that may act as lighting rods. Look for cover in even-aged tree stands. Above all else, stay out of streams during lighting activity, and do not carry stadia rods or other survey tools – graphite, fiberglass, aluminum, and wood can all attract lighting, especially when wet. Never use any electronic devices during lightning activity.
Camping	**Environmental hazards**	Choose campsites that are free of snags, leaning green trees, danger of rolling rocks, slides, and flash floods.
	Animal problems	Don't camp in areas with known animal problems. Hang food and follow food and cooking guidelines when in bear country. Keep a clean camp, don't leave food out, and clean up spills.
	Ecological impacts	Follow Leave No Trace guidelines to minimize impacts from camping.
Water Acquisition	**Giardia cryptosporidium**	Drink filtered or tap water at all times. Boil water if you do not have a filter or access to clear potable tap water. Iodine tablets can also be used.

	and other parasites	
Work/Sleep Schedule	**Fatigue, carelessness**	Get plenty of sleep at night. Be careful and do the job right the first time, safely.
Health and Hygiene	**Wounds, scraps, bruises, sprains, rashes, burns, infections, and general ailments**	Carefully clean all cuts, punctures, scrapes, and such with antiseptic. Dress with clean bandages, replacing as necessary. Closely monitor all wounds, taking caution not to worsen them by continued physical activity. If ill, do not continue exertion and worsen the ailment. Take special care not to pass contagious ailments to fellow workers. Notify other crewmembers and immediate supervisor of all accidents, illness, and wounds, including those obtained before going on a tour. If applicable this notification should take place before departing into the backcountry.
	Toilet paper and feminine hygiene waste materials	These items, when used or unused, and if scented, must be considered attractants for animals, but carry the added weight of being considered biohazardous waste when used. Disposal of these items will be handled in one of two ways: 1. Pack it in, pack it out – dedicate two plastic ziploc bags for this method or 2. Dig a 4"- 6" cathole to bury items along with waste.
	Blisters and other foot injuries	These wounds are quite common in the back country and should be planned for. Plenty of clean dry socks should be on hand (two for each day if you are prone to blisters). Regular changing of sock prevents blisters and reduces infection of existing ones. Additionally, thick moisture wicking socks with thin nylon liners are quite useful for preventing blisters. Boots should be broken in before the start of the field season as well. Proper fitting boots are essential. Always carry moleskin, rubbing alcohol, and duct tape for mitigating these problems.
Trash and Garbage	**Trash**	All trash is to be packed out by the survey crew. All food- oriented trash will be treated the same as food in terms of wildlife attraction.
	Other trash, left by other people	It is encouraged to pick up other trash, found during surveys, but exercise extreme caution when doing so. Broken glass and the edges of tin cans can be

		hazardous. There are reports of bottles fermenting in the sun, and building pressure, only to shatter and send glass fragments flying when disturbed by trash collection. Thus, gloves, eye protection, and long sleeve shirt and pants are good ideas when handling trash.
Illegal Drugs	**Meth-amphetamine remains**	It has come to the attention of Law Enforcement that many illegal drug producers are using National Forests as ground upon which to make illegal drugs. Specifically, meth-amphetamine, also known as crystal-meth, remains or trash have been found on a much more frequent basis. Thus, any trash that may appear suspicious, or emit toxic odors should be avoided, and located on the map. A report to the local LEO is in order for such suspicious trash. There is an FS course on recognizing and dealing with meth-amphetamine hazards. This course is recommended.
	Marijuana	Forest Service employees are advised, when encountering marijuana growing on National Forest property, to leave the vicinity carefully, cautiously, and immediately. In some cases, these areas have been known to be guarded and/or booby-trapped. Notify local LEO immediately.
Evacuation Plan	**Communication**	In a case where evacuation is needed, communication procedures are essential. Know how to use the radio and who to contact in an emergency.
	Medical evacuation	In cases where injury, illness, or accident initiates the need to evacuate a person, the first priority is to contact other crews in the drainage for assistance, and then emergency crews from the District Office or Supervisor's Office. If the wounded person is mobile, the crew should calmly and steadily proceed via the most direct and easy route to the vehicles in an effort to get to professional medical care. If the hurt crew member is not mobile, preparations must be made for back country extraction via a search and rescue team. In either case, if there is no radio contact, a crew member should be dedicated to hiking to the ridge for getting a radio signal out. If search and rescue must intervene, be prepared with GPS coordinates and legal description of the location. Also plan to send a healthy crew member to the vehicles to assist search and rescue in locating the wounded crew member. Always remember your back country safety training during these times, and remember to think cool, calm, and collected. Shock is often instilled by the atmosphere of the accident, so mitigate shock by providing a relaxed, attentive, and well-thought-out atmosphere.

	Danger evacuation **Once to the vehicle**	In a case of evacuation needed because of weather, wildlife, human, or otherwise generated dangers, the group should stay together, collectively, and proceed to safe quarters. Utilize your safety briefings regarding shelter areas and communications in case of these events, as you will be trained for such occasion. Look at additional evacuation measures regarding vehicle safety, but always remember, that driving should be cautious, even in the face of an accident or dangerous situation.

10. LINE OFFICER SIGNATURE	11. TITLE	12. DATE

Appendix 2: Technical Specifications of PDR's

Portable data recorders (PDR's) come in many varieties. It is possible, and not uncommon, to see scientists in the field carrying laptop computers, some with instruments attached which transmit data directly into a spreadsheet or database form. Many smaller devices provide almost the same capabilities, with the exception that data transfer occurs only when the device is connected to a computer once the user returns to the office. Which variety a user carries into the field depends partly on personal preference, partly on the capability of the device but mostly on the task at hand. If the user is going to be constantly in motion or changing locations at regular or relatively short intervals, the device should be comparatively small, lightweight and conveniently accessible. The device must be capable of running whatever software is used for the data recording and processing needs, and have sufficient storage capacity. An optional capability is wireless connectivity for immediate data transfer.

For our purposes, the requirements are:

- Microsoft operating system (Pocket PC; Windows CE; etc.) or other operating system that can run a compatible spreadsheet software
- Pocket Excel (or Excel Mobile) or other compatible spreadsheet software
- Screen visible in direct sunlight and under a thick forest canopy
- Touchscreen or keypad data input
- Connectivity for data download and upload

Some highly-recommended specifications:

- Small; i.e., handheld
- Lightweight, to allow several hours of carriage at a time
- Rugged and weatherproof, or with a padded and weatherproof case
- Battery life of at least 8 hours
- Serial and/or USB connectors
- Minimum of 32MB of memory

Recommended Accessories

- Additional storage capacity (e.g., compact flash cards)
- Rechargeable or spare batteries
- In-Car charger
- Bring laptop along (keep in car or at lodging) for nightly data transfer to insure against data loss
- Optional network or wireless connectivity
- GPS card
- GIS display software
- Carrying case

One choice is the Trimble or TDS Recon Pocket PC handheld field data collector ($1799 and up.). Immersible and shock resistant, it runs Microsoft Windows Mobile 2003 software, which includes Pocket Excel and Pocket Word. It has an illuminated color touchscreen (2 ¼ ”x3 7/8 ”) with software keyboard, and, with 64MB of active memory, the Recon can in most cases store an entire day's data collection. The Recon also provides 64MB of flash memory for backups. If more storage is needed, there are two covered CF adapters for expanded memory. These can also accommodate add-ons such as GPS or modem. It runs GIS software called “SOLO” or “ARCPAD” that can help locate you in the field, including background images, shapefile-format activity area polygons, and GPS location.

The Recon uses a “PowerBoot Module” instead of standard rechargeable batteries. The PowerBoot Module, when fully charged, typically provides approximately 15 hours of battery life. An AC adapter/charger is included in the base price.

If you choose this option, we recommend the 400Mhz version, with 64MB of RAM and 128MB of flash memory, to eliminate the need for additional cards. We also bought the optional in-car charger and extra data transfer cables (We lost one almost immediately.). Our crews were able to remain in the field for extended periods unconcerned about power loss or data storage limitations.

Another, less expensive choice is a Compaq (now HP) Ipaq 3600, which also runs the Pocket PC software. It has 32MB of memory, which is divided between “storage” memory and “program” memory. Capacity can be expanded if you also purchase a hard sleeve which incorporates a compact flash card slot. However, this product is neither weather proof nor shock resistant. Prices are upward from $499.99. Accessories such as in-car adapters are available.

Other handheld computers may be comparable. Any unit that meets the requirements listed above can be used. There may be compatible equipment that has fallen out of use in your local organization and can be borrowed or bartered. Husky Brand field data recorders were in vogue not long ago for use in cruising timber, etc. They are suited for the work presented in this guide, as they satisfy the operating system and software requirements, although they must be protected from the weather and handled with care. Check with local timber management personnel and others for availability.

Portable data recorders (PDR's) come in many varieties. It is possible, and not uncommon, to see scientists in the field carrying laptop computers, some with instruments attached which transmit data directly into a spreadsheet or database form. Many smaller devices provide almost the same capabilities, with the exception that data transfer occurs only when the device is connected to a computer once the user returns to the office. Which variety a user carries into the field depends partly on personal preference, partly on the capability of the device and partly on what is available for purchase. FS users are generally limited to what is listed on the corporate contract. Contracts change as new technology becomes available, so rushing to purchase one type of PDR may preclude acquiring a type better suited to the task.

In general, if the user is going to be constantly in motion or changing locations at regular or relatively short intervals, the device should be comparatively small, lightweight and conveniently accessible. The device must be capable of running whatever software is used for the data recording and processing needs, and have sufficient storage capacity. An optional capability is wireless connectivity for immediate data transfer.

For our purposes, the requirements are:

- Microsoft operating system (Pocket PC; Windows CE; etc.) or other operating system that can run compatible spreadsheet software
- Pocket Excel (or Excel Mobile) or other compatible spreadsheet software
- Screen visible in direct sunlight and under a thick forest canopy
- Touchscreen or keypad data input
- Connectivity for data download and upload

Some highly-recommended specifications:

- Small; i.e., handheld or tablet
- Lightweight, to allow several hours of carriage at a time
- Rugged and weatherproof, or with a padded and weatherproof case
- Battery life of at least 8 hours
- Serial and/or USB connectors
- Minimum of 32MB of memory

Recommended Accessories

- Additional storage capacity (e.g., compact flash cards)
- Rechargeable or spare batteries
- In-Car charger
- Bring laptop along (keep in car or at lodging) for nightly data transfer to insure against data loss
- If your PDR is not rugged or weather proof, bring Zip-lock style bags and a lanyard to tie the recorder to your person.

Optional

- network or wireless connectivity
- GPS card
- GIS display software
- Carrying case

We chose the Trimble or TDS Recon Pocket PC handheld field data collector ($1799 and up.). Immersible and shock resistant, it runs Microsoft Windows Mobile 2003 software, which includes Pocket Excel and Pocket Word. It has an illuminated color touchscreen (2 ¼ ”x3 7/8 ”) with software keyboard, and, with 64MB of active memory, the Recon can in most cases store an entire day’s data collection. The Recon also provides 64MB of flash memory for backups. If more storage is needed, there are two covered CF adapters for expanded memory. These can also accommodate add-ons such as GPS or modem. It runs GIS software called “SOLO” or “ARCPAD” that can help locate you in the field, including background images, shapefile-format activity area polygons, and GPS location.

The Recon uses a “PowerBoot Module” instead of standard rechargeable batteries. The PowerBoot Module, when fully charged, typically provides approximately 15 hours of battery life. An AC adapter/charger is included in the base price.

If you choose this option, we recommend the 400Mhz version, with 64MB of RAM and 128MB of flash memory, to eliminate the need for additional cards. We also bought the optional in-car charger and extra data transfer cables (We lost one almost immediately.). Our crews were able to remain in the field for extended periods unconcerned about power loss or data storage limitations.

Another, less expensive choice is a Compaq (now HP) Ipaq 3600, which also runs the Pocket PC software. It has 32MB of memory, which is divided between “storage” memory and “program” memory. Capacity can be expanded if you also purchase a hard sleeve which incorporates a compact flash card slot. However, this product is neither weather proof nor shock resistant. Prices are upward from $499.99. Accessories such as in-car adapters are available.

Drawbacks of these handheld recorders include a small viewing area – an important limitation due to the size of the input form used with the Visual Indicators. Also, input speed (response time of the mobile software to stylus-taps) and the dexterity required for precise stylus-tapping are factors which affect the efficiency and enjoyment of the exercise. A ruggedized upgrade of the Husky FeX21 is available; it runs Microsoft’s Handheld PC 2000 operating system, and claims improved response time – and still sports the built-in keyboard, for $1999.

Tablet-style recorders, with the ability to display an 8.5”x 11” page, are, perhaps, a better choice, providing a view of more of the data input spreadsheet. Prices range from ~$850.00 to more than $2,000.00, depending on brand name and configuration. If you are able to purchase this option (it wasn’t on the contract as of November, 2007 – Dell doesn’t make one) through Technical Approval, remember that the response time is dependent upon processor speed and RAM. Look for outdoor visibility, battery life and ruggedness as well.

Other handheld computers may be comparable. Any unit that meets the requirements listed above can be used. There may be compatible equipment that has fallen out of use in your local organization and can be borrowed or bartered. Husky Brand field data recorders were in vogue not long ago for use in cruising timber, etc. They are suited for the work presented in this guide, as they satisfy the operating system and software requirements, although they must be protected from the weather and handled with care. Check with local timber management personnel and others for availability.

A non-technical alternative is to use paper forms in the field and transfer the data to the electronic spreadsheet upon return to the office or temporary duty station. One advantage to this method is that the drop-down lists useful on the PC version of the spreadsheet do not function after transfer to handheld, field-going PDRs – a consequence of the limited instruction set available in the mobile operating system.

Appendix 3: Soil Disturbance Documentation Form

Documentation of Soil Disturbance

Date: ______________________

Project Name: ____

Stand or Unit ID: ____

Observer(s): ____

Name of Old Timber Sale (if known):
____

Lat/Long and datum: ____

☐ **No past disturbance visible**

Check all that apply

Type	Past Disturbance	Approximate Age/Timber Sale Name
Stumps*		
- with disturbance nearby		
- w/o obvious disturbance		
Skid Trails		
Excavated Skid Trails		
Old Roads		
- decommissioned		
- storage		
Skyline Corridors		
Landings		
Slash Piles		
Horse Logging		
Homestead / Pasture		
Other		

*stumps could be from ground-based, skyline, helicopter logging, or firewood cutting.

Comments:

Appendix 4. Example spreadsheet for collecting soil disturbance monitoring results. NOTE: this spreadsheet example only contains 17 data points.

Activity Area and Transect:								Forest/Unit:									
Date:								Treatment:									
Sample point	1	2	**3**	4	5	**6**	7	8	**9**	10	11	**12**	13	14	**15**	16	17
f. floor depth (cm):																	
Forest floor impacted?																	
Topsoil displacement?																	
Erosion?, comment!																	
Rutting? <5cm																	
Rutting? 5-10cm																	
Rutting? >10cm																	
Burning light																	
Burning moderate																	
Burning severe																	
Compaction? 0-10 cm																	
Compaction? 10-30 cm																	
Compaction? >30cm																	
Puddled//Massive/Platy structure 0-10 cm																	
Puddled//Massive/Platy structure 10-30 cm																	
Puddled//Massive/Platy structure >30 cm																	
Live Plant?																	
Fine Woody? <7 cm																	
Coarse Woody? >7cm																	
Bare Soil?																	
Rock?																	
Estimated Soil Disturbance Class	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Comments (Right Click and Use Insert Comment)																	

Appendix 5: FAQ's: Forest Comments and Questions

General

Q - Make sure tech guide has a version number
A – Will be included on the title page and all forms. The guide will be a spiral bound version for 2008 with the published version in 2009. Both versions will include a cd in the back that will include forms, additional protocol material, references, and appendices.

Q - Are these protocols mandatory and does the information have to be entered in SoLo?
A – Yes.

Q – If I want to modify one of these protocols or use my own, can I?
A – The protocols are intended to provide a consistent regional approach to collecting a core set of physical soil indicators. The process to modify one of these protocols or to use one of your own has been included in the guide under Section 3.5 Field Data Collection.

Q – A realization of the amount of time it takes to use the protocols
A – It is realized that these protocols may take more time, however the tradeoff is that you have a consistent, repeatable, statistical, peer reviewed method of collecting core physical soil quality data. At the project level, it is important to discuss time considerations with the decision maker at the start of the project so that data is collected commiserate with the line officers level of risk, project budget, and expectations. This document will provide you with the sideboards of how the collected data can be used and interpreted based on different sample sizes.
As the acting regional soil scientist who has recent field experience, I have expressed this concern to the researchers involved in the project. The level of detail and data collection in the protocol reflects the desire for statistical validation. Statistical validation is a legacy of soil litigation.
One caution is to not drop the handwritten notes and comments to save a little time. This information proves invaluable as you write existing condition and effects analysis or defend your detrimental determination, mitigations, monitoring, or restoration plans. Numbers do not tell the story of the landscape.

Statistics

Q – Application of Statistics
A – Section 2.3 is greatly expanded to include more information about statistical applications in the collected soil quality data. It is important to discuss the confidence intervals and statistics with the decision maker, before you go to the field, so everyone is clear as to the level of data collection or what the data can and cannot be used to describe.
A – A method to calculate sample size when using paper forms will be included in Section 2.3

A – The interpretation section, Section 5.1 will include a discussion on how to use the confidence interval and statistical data, e.g. what you can say if you collect the statistically valid number of sample points, what you can say if you collect less than the statistically valid number of sample points, and what you can't not say by collecting data using this protocol.

Spreadsheet

Q – Improvements to the Spreadsheet
A – The spreadsheet and data collection form has been and will continue to be updated. A version number will be affixed to the form. It will be up to the field soil scientist or watershed specialist to insure that the latest version of the form is being used. Contact the Regional Soil Scientist or check the SoLo website for the latest version if in question.
A – The new spreadsheet will provide summary information for duff, percent of area with rock, bare soil, and wood. However, this information is not used to calculate the number of sample points needed, it is summarized to make reporting easier.

When and How to Use the Survey

Q – How do I figure out how many and which units need to be surveyed?
A – Court opinions to data have not provided a definitive number on how many units need to be surveyed. What the judges have consistently said is that the discussion of existing condition, effects, detrimental condition, mitigation, restoration, etc need to be site-specific and based on field review. The recommendation is that the resource specialist walks enough units to describe the conditions and the variability within the units and project area. How many and which units to survey should be discussed with the decision maker so they realize the risks associated data collection.
A – A 3 tier matrix is provided in Section 2.4 for pre-harvest (existing condition surveys) and post-activity monitoring.

Q - How do I handle large units, some fuel units are approaching 300-400 acres with only a small corner in mechanical treatment or mechanical treatment scattered through the large acreage?
A – This question is clarified in the Tech Guide, Section 2.4.

Q - How to deal with small units, e.g. 10-20 acres?
A – This question is clarified in the Tech Guide, Section 2.4.

Q – What happens if rocks, down wood, or stumps fall on the transect line?
A – This question is clarified in the Tech Guide, Section 2.4.

Q - How do I handle a unit survey if there has been wildfire?
A – This question is clarified in the Tech Guide, Section 2.4.

Q - How do I factor in landings, temp roads, and system roads?
A – This question is clarified in the Tech Guide, Section 2.4

Q - How do I handle tree tips?
A – This question is clarified in the Tech Guide, Section 2.4

Protocols

Q – A large number of questions and comments related to the protocols were received:

- *The soil classes do not work well for old slash piles*.
- *Use a 6" x 6" plot size or 5' diameter or something else? 6"x6" might be too small to really look at what is going on along the transect.*
- *Time of year to survey?*
- *Eliminate recording Platy/Massive structures.*
- *Adding the selection of the presence of Duff/Litter to this section is important as it is a common ground cover.*
- *Soil texture and soil moisture need to be a core attribute.*
- *Information on rock %, size, and location need to be core attribute.*
- *Include substitute methods to use on the east side or where soils are too rocky for a shovel test*

4. *Are we duplicating by having three levels of compaction and rutting?*
5. *Defining massive structure is soil moisture and soil texture dependent.*
6. *Platy structure may not develop in all soil types.*

A – These topics have been addressed in section 3.5 of the Technical Guide and on the updated datasheet.

Discussion on Detrimental Soil Condition

Q – There was interest from the field to include a detrimental soil discussion in the Tech Guide.

A – The Tech Guide now contains a Section 5.1.2 which discusses detrimental soil conditions. However this protocol and spreadsheet will NOT determine detrimental condition within a unit. This determination needs to be made by a qualified soil scientist.

- *The concept of detrimental relates to national and regional SQS and in itself does not define the soil condition. It is an interpretation of the soil condition. This protocol collects the data which can then be interpreted.*
- *"Detrimental" is a judgment, not data. Soil disturbance classes may change, but the basic data won't. Detrimental determinations should be based on soil sensitivity and risk factors.*