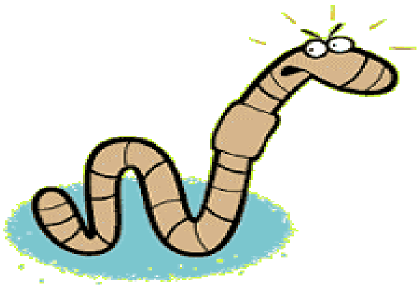

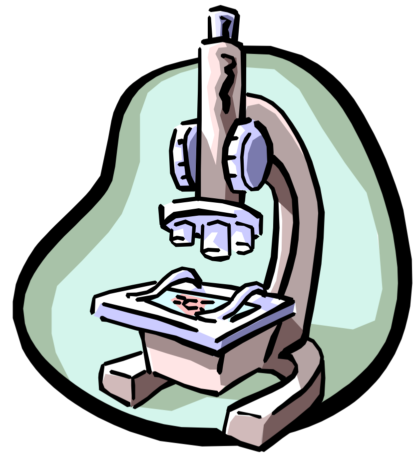

P3 Soil Indicator

Measurement and Sampling

(2002)

Credit: USDA NRCS

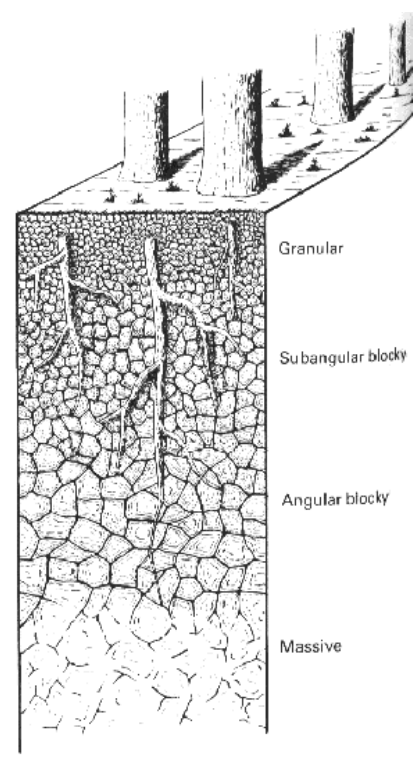

Table of Contents

Course Objectives

After participating in the Soil Measurement and Sampling Training Program, crews will be qualified to collect soil indicator data for the FIA-P3 program. This includes the ability to perform the following program objectives:

Background

a. Describe the importance of soils to forested ecosystems
b. List the major components of the soil measurement and sampling indicator

Erosion/Compaction

c. Identify the types of soil compaction
d. Estimate the area of a subplot that has been compacted
e. Demonstrate an ability to estimate % bare soil
f. Input soil erosion and compaction data into the PDR

Sample Collection

g. Correctly assemble and use soil sampling equipment
h. Describe the location of soil sampling lines and collection points on a FIA-P3 plot
i. Explain how to handle problematic sampling locations
j. Input soil sampling site data into the PDR
k. Demonstrate how to measure forest floor and litter depths
l. Show how and where to collect samples of the forest floor
m. Demonstrate how and where to collect mineral soil samples
n. Classify the texture of the mineral soil layers
o. Define an organic soil and explain how it is sampled

Sample Labeling and Shipping

p. Correctly complete soil sample labels
q. Correctly fill out soil shipping forms
r. Describe the procedure for sample shipment to the soil analytical laboratories
s. For crews working in APHIS regulated regions, explain the regulations regarding shipping of soil samples

Lesson Outline (Classroom Unit)

TOPIC	OBJECTIVES	ESTIMATED TIME
Administration		5 min.
Introduction	a, b	15 min.
Soil Compaction Measurements	c, d	10 min.
Soil Erosion Measurements	e, f	15 min.
Soil Measurements and Sampling	g-o	30 min.
Soil Texture Demonstration	n	15 min.
Sample Shipping/Regulations	p-s	15 min.
Quality Assurance		10 min.
	Total Estimated Time:	1 hr. 55 min.

Lesson Outline (Field Unit)

TOPIC	OBJECTIVES	ESTIMATED TIME
Introduction		5 min.
Demonstration Soil Compaction Measurements	c, d	20 min.
Demonstration Soil Erosion Measurements	e, f	10 min.
Practice Soil Erosion and Compaction Measurements	c-f	30 min.
Demonstration of Soil Sampling Measurements	g-o	25 min.
Practice Soil Sampling Measurements	g-o	60 min.
Field Certification Test	e-s	40-60 min.
Written Certification Test	a-s	take home
	Total Estimated Time:	3 hrs. 30 min.

Preparation for Training

Site Selection

Practice plots should be located in areas where field crews can learn to locate soil sampling lines, identify soil sampling sites, take soil surface measurements and collect soil samples. It is important to select training sites to provide a variety of learning opportunities for field crews. If possible, practice plots should provide opportunities to collect measurements in/on:

- Different soil conditions (e.g., rocky soils, wetland/marshy areas, dense clays)
- Areas of bare or eroding soil
- Steep slopes
- Areas with soil compaction (these may be on the same areas used for soil erosion training)

If possible, it is helpful to locate a field training site close to the classroom for quick demonstration of sampling equipment.

Equipment and Materials Required

Crews may be divided into groups of 2-3 for field training. Each group needs to have access to a complete set of soil sampling equipment. This includes: soil corer, wrenches, sampling frame (12-inch diameter bicycle tire), soil sample bags and labels, knife or trowel, tarp (or other plastic), and tile probe.

Crews will also need access to: dutch auger, shovel, and tube probe. Depending on the size of the group, 1 to 2 sets should be sufficient.

Prior to the training, collect soil samples with differing soil textures for an activity during training. Include clayey, loamy, sandy, coarse sandy and organic soils. These can be collected from near the training site or brought to the training.

Each field crew should bring their methods guide along with a highlighter pen.

Staff Meeting

Trainers and support staff involved in the classroom and field sessions will need to hold a planning meeting prior to training to discuss site logistics and training schedule.

Every effort should be made to give as much individualized attention as possible during the field training session to field crews. This is particularly important at training sites with large numbers of new field crew members.

Field Site Set-Up

- Identify practice plot area(s)
- Identify some subplot areas with bare soil
- Identify some subplot areas with soil compaction
- Select areas for training, testing and re-testing

Notes:

Overhead Notes for the P3 Soil Indicator

S-2 The P3 soil measurements were developed to address important issues related to the sustainable management of forests. Data collected on the plots will be used to answer the following questions:

What is the current status and projected trend in the area and percent of forest land with:

S-3 Soil erosion

S-4 Compaction or changes in soil physical properties resulting from human activities

S-5 Changes in the amount of moisture holding capacity, internal drainage, and rooting depth.

S-6 Diminished soil organic matter and/or other changes in soil chemical properties.

S-7 Contribution to the global carbon budget including absorption and release of carbon

S-8 The accumulation of toxic substances

For some of these questions, the P3 soil indicator data is the only source of information available in the United States.

S-9 Soil measurements can be divided into three parts: erosion, compaction, and soil chemistry. Erosion and compaction measurements consist of field observations. Soil chemistry is evaluated by collecting samples of the forest floor and mineral soil and shipping them to a laboratory for further analysis.

S-10 Soil measurements are collected on the subplots themselves (erosion, compaction) and within the annular plots (soil sampling for chemistry). The exact location for soil sampling will be described in greater detail later.

S-11 The first set of field observations that we make deal with evaluating erosion potential. Erosion is defined as the wearing away of the land surface by running water, wind, or ice. Erosion is a natural process that occurs on all non-flat areas of the landscape. However, human activity (such as timber removal or road-building) can result in accelerated rates of erosion that degrade the soil and reduce the productivity of the land

On average, the U.S. loses about 5 billion tons of soil annually to water and wind erosion. As this soil is removed from the landscape, it carries with it all of the nutrients and organic matter that took decades to centuries (or longer) to build up. On human time scales, fertile soil is not a renewable resource.

S-12 Erosion can be very difficult to measure, and even visually undetectable erosion can do serious harm to soil productivity. On FIA plots, soil erosion risk is estimated using two models. The factors that go into these models are either directly measured or estimated in the field.

S-13 The first model is the Universal Soil Loss Equation. This model is based on factors that represent how climate, soil, topography, and land use affect soil erosion and surface runoff. In the FIA program, we directly measure slope, percent cover, and forest floor thickness and we determine soil erodibility (the k factor) from soil texture. Information about vegetation density and structure are obtained from the vegetation diversity indicator.

S-14 The second model used in analyzing soil data is the Water Erosion Prediction Project, or WEPP. This model provides a more detailed approach to understanding soil erosion dynamics, but requires additional information about regional climate. This data is obtained from the weather station closest to the FIA plot.

S-15 The first erosion measurement involves estimating the % bare soil, % litter, and % ground cover on each subplot. There are numerous methods for doing this. One approach is to mentally divide the subplot into 4 quadrants, estimate the % cover in each quadrant (maximum value = 25%) and then sum them to get the total % cover.

Another approach is to remember that an area about the size of a card table (4.25 x 4.25 ft) is equal to 1% of the subplot. You can then sum up 1% areas to come up with an estimate for the entire subplot.

% cover estimates are made only for the forested portion of the subplot. For example, if a subplot is 50% forested and the forested portion has an 80% litter cover, than the % litter for the entire subplot is equal to half of 80%, or 40%.

S-16 Compaction can be caused by heavy equipment or by repeated passes of light equipment that compress the soil and break down soil aggregates. This compression decreases the amount of pore space in the soil, which increases the bulk density and reduces air diffusion and water infiltration. These conditions make it more difficult for plant roots to penetrate the soil and obtain necessary nutrients, oxygen, and water.

In general, compaction tends to be a greater problem on moist soils and on fine-textured soils (clays). These effects can persist for long periods of time and may result in stunted tree growth.

S-17 As you walk around the site for your percent cover measurements, or during measurements for other indicators, make a mental note of any areas that appear to have been disturbed. During the compaction measurements, re-visit these areas and look for evidence of compaction. Some examples of things to look for include:

(1) increased soil density
(2) a platy structure in the soil
(3) evidence of ruts or tire tracks
(4) loss of normal soil structure

In order to establish whether or not compaction has occurred, you may need to compare soil properties within the disturbed area to soil outside of the disturbed area (e.g. structure, density). If you need to excavate the soil to evaluate these properties, select an undisturbed area outside of the subplot to limit disturbance on the site.

S-18 Two of the forms of evidence for compaction relate to soil structure. Structure refers to the way that individual mineral particles are grouped together into aggregates (or "clods"). The shape of these aggregates is determined by the texture of the soil and the physical, chemical and biological processes occurring within the soil.

In order to evaluate soil structure, gently poke/pry at the edge of a small hole or at the soil surface with a knife. Look at the shape of the pieces that fall into your hand. A platy structure, in which the soil breaks into a series of 1-cm thick plates, may indicate compaction.

Also look for the destruction on soil structure in compacted areas, or "puddling." Puddling is caused when the individual clay particles become dispersed by water and re-settle again in parallel layers. This results in the formation of a dense soil crust that can function almost like a hardpan

S-19 One of the other types of evidence for compaction is mottling.

Soils that are well-drained and have iron in them will tend to have an orange or reddish color (point to picture A). Soils that are poorly-drained (point to picture B) have water in their pores and this reduces the oxygen content. Chemical reactions occur that cause the iron to move out of the profile, leaving behind a blue or greenish color.

Following compaction, a well-drained soil may become poorly drained. This can result in the formation of mottles, or specks of orange and green/blue color in the soil that are not evident in adjacent undisturbed soil.

Mottling does not occur in all soil types and by itself does not indicate compaction. But it may be a useful type of evidence to look for if you suspect compaction.

S-20 Once you have estimated the % area of the subplot affected by compaction, you will need to determine the type of compaction. Possible descriptions include: rutted trails, compacted trails, compacted areas, and other. Enter a code of "1" for each type of compaction you find, and a code of "0" if that type of compaction is not present.

S-21 These are some examples of the types of compaction you might see in the field. The top picture shows a rutted trail. In order to meet the criteria for "ruts", the depressions must be greater or equal than 15 cm (6 inches) measured from the soil surface or must penetrate at least 5 cm into the mineral soil.

The bottom picture represents the type of compacted trail that can result from many passes of heavy machinery. For the purposes of estimating the area affected by compaction, remember that a square 4.25 ft on a side represents 1% of the subplot.

S-22 This is a copy of the PDR screen for the erosion and compaction measurements. For both % bare soil and % compaction, data is recorded in cover classes to the nearest 5%. Trace amounts are coded as “01.”

For the types of compaction, enter a “1” for every type of compaction you find. Enter a “0” if a type is not present on the subplot.

S-23 Variables dropped from the erosion measurements:

- % litter cover and % vegetation cover
- 8-ft diameter soil erosion miniplots and associated measurements
  - Forest floor thickness
  - Height of vegetation canopy
  - Litter decomposition
- Slope length
- Evidences of compaction

S-24 The final set of soil measurements on P3 plots deal with the collection of samples for soil chemistry. Samples are collected within the annular subplot along sampling lines that run adjacent to subplots 2, 3, and 4. For most of the 2002 samples, we will be collecting samples at collection point 1. To find the location of the sampling site, start at the center of the subplot and measure 30 ft back towards the plot center. Samples collected at subsequent visits will be collected as shown in the diagram.

S-25 For soil sampling measurements, you will need some special pieces of equipment. In particular, you’ll need to bring an impact-driven soil corer for collecting bulk density samples, a tile probe for measuring the depth to a restrictive layer, a sampling frame for collecting samples of the forest floor, and a small shovel for excavating the soil core.

S-26 This is a diagram of a soil profile that illustrates the layers that you are going to be sampling. You’ll collect one sample of the forest floor, which consists of a litter layer and a humus layer. You’ll then collect two cores of mineral soil, one from 0-10 cm and one from 10-20 cm.

S-27 To sample the forest floor, first place the soil sampling frame on the ground at the sampling point. Because the sampling point has a tendency to get trampled during other measurements, it’s a good idea to locate the sampling point when you first get to the subplot and place the frame down to mark the spot (to prevent others from stepping there). If the sampling point appears to be trampled or disturbed, select another point within a 5-foot diameter area.

1. Measure the thickness of the forest floor and litter layer at the four compass points (N, S, E, W) on the inner surface of the frame
2. Remove any live vegetation from within the sampling frame using your clippers. Don't try to pull out the vegetation since the roots may pull up the forest floor mat. [for crews working in northern areas where the entire forest floor may be covered by mosses, the crews should clip the green, photosynthetic portion of the moss and separate it from the rest of the sample]
3. Clip or cut along the inner edge of the sampling frame and scoop the entire forest floor into a pre-labeled gallon Ziploc bag.
4. Check to make sure that you have collected all of the organic material. Sometimes this boundary can be hard to distinguish. The next overhead will give you some tips to help you make that determination.
5. Discard any wooden debris > 0.25 in. (about the diameter of a pencil). Also discard any rocks. The lab will put these samples into a grinder and rocks will cause the blades to break.
6. Use as many bags as necessary to collect the entire sample. If you do need more than one bag, label them sequentially as "1 of 2", "2 of 2" etc. and make a note on the shipping form. Without these notes on the labels, the lab won't know what these samples are for.

NOTE: If you are collecting forest floor samples on an organic soil (> 20 cm organic material above the mineral soil surface), collect only the litter.

S-28 In some soil types, the boundary between the mineral and organic soil may be difficult to determine. In general, you are trying to find the depth at which the soil goes from being predominantly organic (> 50%) to predominantly mineral. Some things that you can look for to help you determine this boundary are:

- Evidence of plant parts (leaves, needles, twigs, etc.). If you can see them decomposing in place, you are still in the humus layer.
- Rub the soil between thumb and finger - does it crumble (humus) or feel gritty (sand), silty, or clayey?
- Shiny flecks of mica or quartz (won't help in all soils).
- Subtle change in color - humus layer is black, mineral soil is more brownish.
- Change in density – humus layer is light, mineral soil is more dense.

S-29 The final measurement that you will make is the depth to the depth to a restrictive layer. For FIA, we are defining a restrictive layer as any soil condition that limits root growth. These conditions can be caused by either physical (e.g. a rock) or chemical factors.

After each forest floor sample, push the tile probe into the center of the soil sampling site. Stop pushing when you reach a resistant layer. Repeat at the N, S, E, and W edges of the sampling site. Record the median depth (max = “50”)

Special codes for this measurement include:

Code “00” if superficial bedrock is present
Enter “99” if too many rock fragments or cobbles prevent inserting tile probe

S-30 On subplot 2, you will also be collecting cores of the mineral soil down to a depth of 20 cm. The procedure for collecting core samples is:

(1) Prepare and label two sample collection bags
(2) Assemble the bulk density sampler
(3) Drive the sampler into the soil using the slide hammer
(4) Remove the sampler, unscrew the cap, and remove the core sleeves.
(5) Trim the cores so that they are flush with the end of the sleeves
(6) Put the samples into the appropriate bag
(7) Finish filling out the labels
(8) Thoroughly clean the sampler and core sleeves (this is a federal requirement in the southeast to prevent transportation of pests)

S-31 Crews working in some regions may encounter “organic soils,” or soils that have more than 20 cm of organic matter on top of the mineral soil. Organic soils are typically associated with wetland areas such as bogs, marshes, or peatlands.

Organic soils have a high moisture content and may compact if you try to use the bulk density corer. If this happens, you can try one of three other methods outlined in the field manual.

One approach is to dig a small hole with a shovel and collect material from the sides of the hole at depths of 0-10 cm and 10-20 cm. It is important to try and collect roughly the same amount of material that would have fit in the core so that the lab has enough sample to conduct all of the analyses. If you have access to a punch tube or dutch auger, you may use these as well.

One key difference with organic soils is that only the litter is collected as part of the forest floor sample.

S-32 A lot of questions have been asked about why we need to use the corer to collect soil samples. The main reason is that that the core samples allow us to measure the bulk density of the soil. Although we tend to think about soil as just the solid mineral particles, it is actually a matrix of water, air, mineral, and organic particles. The ratio between the pore space and the mineral fraction is an important factor controlling water and air movement in the soil. The bulk density provides important information about the physical capacity of the soil to support vegetation.

Another way that we use the bulk density data is as a means of relating the laboratory information back to the field. To make an analogy, medicine is often prescribed in doses per pound of body weight. In order to give the correct amount of medicine, the doctor has to know how much the patient weighs. With soils, the chemical data is presented per pound of soil. In order to know whether this is good or bad for the trees, we need to know how much the soil in a given area "weighs."

S-33 For each sample collected, you will need to completely fill out the soil sampling label. Please take extra care to check your label before leaving the site. Once the sample is in the lab, it is virtually impossible to go back and figure out any mistakes. In the past, crews have occasionally written notes on the bag to indicate that something strange was going on with the sample. These kinds of field notes are great and can be a lot of use, but make sure that the information is complete. Unfortunately, if they can't figure out the label, the labs have no choice but to throw the samples out.

To fill out the sample label:

(1) You will be given labels that have the hexagon numbers pre-printed on them. First make sure that this hexagon number is correct
(2) Add the date and your crew/cruiser #
(3) Circle the correct subplot
(4) If the samples were collected in mineral soil, choose your sample I.D. from the top row of choices – forest floor, mineral 1, or mineral 2
If the samples were collected in an organic soil (> 20 cm of organic matter), select the sample type from the bottom row of choices.
(5) Finally, note how this sample was collected. Was it a bulk density sample or did you collect it some other way? The labs need to know this in order to process the sample correctly.

If you have additional information that you want the labs to know about the sample (for example, the sample was collected in a non-standard way, or you feel there may be some problem with the sample), put a note in the corner of the label that says "See shipping form" and then add more detailed information to the back of the shipping form.

S-34 Once the core samples have been collected, a small sample from the 0-10 and 10-20 cm layers are analyzed to determine soil texture. Soil texture is determined by feel. You'll be given more information about this in the field, but essentially you will collect a small sample of material from the 0-10 and 10-20 cm layers, moisten it, and then rub it between your fingers and thumb.

1. If it forms a ribbon, record the texture as "clayey"
2. If it will hold its shape as a ball, but cannot be pinched into a ribbon, record the texture as "loamy"
3. If it doesn't hold together in a ball and feels gritty between your

fingers, record texture as “sandy”

4. Coarse sandy soil looks and feels like beach sand

S-35 Data from the sample collection are entered into the PDR.

Sampled?	Enter a “1” if a soil sample was collected; if it was not sampled, you’ll need to look in the manual to determine the correct code
SampLoc	Record the number of the subplot adjacent to the soil sampling site
CondCls	Record the condition class for the soil sampling site on the PDR. If the condition class for the soil sample is different from any recorded on the 4 subplots, enter “0".
Visit#	Record the number of the soil sampling location at which the soil sample was collected.
FflThk	Record the thickness (to the nearest centimeter) of the forest floor measured from the top of the litter layer to the boundary between the forest floor and mineral soil. If the depth is exactly half way between cm readings, round the reading down if it is an even number and round up if it is an odd number. For example, a depth of 2.5 cm should be entered as 2 cm and a depth of 3.5 cm should be entered as 4 cm. Measure to a maximum depth of 50 cm. For locations where bare soil or bedrock material is exposed, enter “0" cm depth.
LitThk	Record the thickness of the litter layer (to the nearest cm) at each of the four locations within the sampling frame. At some locations, the depth of the forest floor and the litter layer may be the same. For locations where bare soil or bedrock material is exposed, enter “0" cm depth.

S-36 Once the samples have been collected, they are shipped to a soils lab for analysis. Some important things to keep in mind:

1. Soil organisms don’t know that they have been collected and will continue to function as they did in the field. However, since the oxygen and moisture conditions aren’t the same as they were in the field, these biological processes can significantly change the chemical properties of the sample.

2. To limit this as much as possible, you'll need to ship samples to the lab on a weekly basis. If you cannot do this, the samples must be stored in a refrigerator until they can be shipped

3. However, there is no need to FedEx samples. The regular mail is fine.

S-37 Crews working in certain areas will need to be aware of government regulations regarding the shipping of soil samples through the mail. Some soils contain pests such as fire ants or golden nematodes that could seriously impact agricultural production. To limit the movement of these pests in the U.S., there are government regulations regarding the shipment of samples from affected areas (red) to non-affected areas (white). All of the soil labs in the FIA program have been certified by the USDA to receive regulated soil samples. However, the responsibility for meeting shipping regulations falls on the field crews.

S-38 If you are working in a regulated area, you must:

1) Double bag your samples before shipping them (place all of the individual plastic bags into a larger plastic bag – like a trash bag)

2) Place a label containing the lab permit number and the words "Regulated Soil Samples" on the outside of the box (these will be provided to you)

There are also federal regulations regarding the collection of soil samples in areas with historical or cultural artifacts (National Historic Preservation Act of 1966). If artifacts are encountered on a Phase 3 plot, do not collect any samples. Code the site as not sampled on the PDR and record a plot note explaining why the soil samples were not taken.

S-39 Once they have been collected, samples are sent to one of three regional soil laboratories. [point out the one appropriate to your crews]. You will be provided with shipping labels with the correct lab address printed on them.

S-40 Once the lab has the samples, they will analyze them for a set of physical and chemical properties. For the forest floor, these include:

Density
Water content
Total carbon
Total nitrogen

For mineral soils, analyses include:

Physical Properties	Chemical Properties
Bulk density	Organic and inorganic carbon
Water content	Total nitrogen
Coarse fragments	pH
	Exchangeable cations (sodium, potassium, magnesium, calcium)
	Extractable Aluminum
	Sulfur
	Extractable phosphorus
	Trace metals

S-41 The QA approach used for the field measurements is the same as that used for all other P3 indicators. MQO's are established for all of the methods. The MQO's are then used during training, certification, and auditing to assist with the control of data quality.

There are three kinds of checks used on P3 plots. During hot checks, auditors review methods with the field crews, identify any problems, and offer suggestions. They will also conduct independent measurements of some field variables to assess how well MQO's are being met.

In a cold check, auditors visit the site separately from the field crew and conduct spot checks of measurements.

A blind check is a complete remeasurement of the plot that is used to assess data variability. The auditors do not have access to the field crew's measurements.

All of the soils labs also have a QA procedure consisting of audits, blind checks, replicate samples, and calibration routines. In addition, the labs belong to a national proficiency testing program that requires periodic analysis of standard soil samples and submission of the results to a national database for comparison with results from outside labs.

Field Activity Lesson Plan

I. Introduction/Overview

Objectives a-c (5 min.)

Training will be divided into two parts: (1) measurements that occur on the subplots (soil erosion and soil compaction) and (2) measurements that occur in the annular plot (soil surface measurements and sampling).

Overall goal is to complete soil measurement activities within 1 to 1 ½ hours.

Suggestion: You may want to split into two groups with two trainers. One group would be trained on the soil surface measurements and sampling while the other group would train on soil erosion and compaction measurements

II. Demonstration of soil compaction measurements

Objectives c-d (20 min.)

Crews need to conduct two different types of soil compaction measurements. These consist of an estimate of the area compacted on each subplot and the type of compaction.

Demo Move to the subplot training area that you have chosen to demonstrate the soil compaction measurements. Ask the crews to identify regions that are compacted and provide an explanation of why they believe this is so. Discuss evidence of compaction and ways to identify compacted areas.

Estimate the area compacted and ask the crew members to do the same. Explain that they should use the same approaches for estimating areas as they used to estimate areas for the erosion measurements.

If any compacted area is recorded on plot, the PDR will prompt for information on the type of compaction observed. Discuss the different types of compaction and how to distinguish them in the field.

Key Concepts:

Do not include improved roads in your assessments; trails or unimproved roads are included

Measured only on forested area of the subplot; calculate as you would for % bare soil measurements

Although crews no longer have to record evidences of compaction, they do need to base their determination of compaction on something other than the present of bare soil. Not all bare soil is compacted; not all compacted soil is bare. Discuss other types of evidence for compaction.

III. Demonstration of soil erosion measurements

Objectives e-f (10 min.)

Soil erosion measurements are primarily observational. Of the measurements, the % bare soil is most important.

Demo Outline two possible approaches for estimating percent bare soil.

1 % of a plot is 4.25 ft. by 4.25 ft (about the size of a card table). Measure a square that is 4.25 ft by 4.25 ft. Put flags in at each corner. Explain that this represents an area that is 1% of the subplot. When looking for the % of bare soil, sometimes it is easier to add up 1% areas.

Another method is to divide the subplot into four quarters. Each has a possible total area of 25% of the subplot. It the area of litter cover is 10% in the first quarter, 15% in the second, 18% in the third, and 17% in the forth, the total for the plot is 10 + 15 + 18 + 17 = 60%.

Activity Request that each person estimate the % of bare soil on the subplot and write it down. Ask how they arrived at their answer. Do not give your answer, but go back and demonstrate the procedure. As a class, work through the example and arrive at a consensus.

Key Concept % cover estimates are made only for the forested portion of the subplot. For example, if a subplot is 50% forested and the forested portion has an 80% litter cover, than the % litter for the entire subplot is equal to half of 80%, or 40%.

IV. Practice soil erosion and compaction measurements

Objectives c-f (30 min.)

Prior to the training session, identify an area (or several areas) where crews can practice erosion and compaction measurements. If possible, locate areas with a range of surface conditions (e.g., differing amounts of bare soil and litter cover, areas exhibiting compaction, etc.).

Have crews work in pairs. Have each pair of trainees go to a specified area and conduct the erosion and compaction measurements.

Observe the crews collecting the data. Review their results and answer questions.

Rotate the crews through a number of locations.

At the conclusion of this exercise, reassemble into one group. Address any questions or concerns that may have arisen.

V. Demonstration of soil sampling measurements

Objectives g-o (25 min.)

A. Soil Sampling Locations

Take crew members to a training subplot. Show them where to locate the soil sampling line and the location of soil visit sampling site #1. (Have them refer to appropriate figures in their manual).

Identify the condition class at this site and record this in the PDR.

Key Concept:

The sampling area is actually a 5-foot radius circle centered at the sampling point. We begin by looking to see if we can take a sample at the center of the circle. If there is an obstruction or other reason we cannot sample at the center, we look to find a sampling location within the 5 ft. circle. If we cannot sample, we enter the reason for not sampling as a code on the PDR.

Questions to ask:

Where would I sample if I encountered a large fallen log at this sampling point? (Move to any clear point within a 5-ft radius circle)

What would I do if there were a rock outcrop 10 ft in diameter on top of the sampling point? (You cannot collect this sample; record the reason why in the PDR)

B. Demonstration of forest floor sample collection

1. Place the sampling frame (cut 1 ft I.D. bicycle tire) at the center of the sampling site. With the aid of a compass, place four flags in the cardinal directions (N,E,S,W). Gently remove the sampling frame. Measure the depth of the forest floor at the north point and

record on the PDR. Explain that the bottom boundary of the forest floor is the beginning of the mineral soil.

2. Explain that the forest floor is composed of two layers: an organic soil layer just above the mineral soil and a litter layer. The boundary between the litter layer and the organic soil is where one can no longer distinguish plant parts. Locate this boundary and measure its depth. Repeat the procedure for measuring forest floor and then litter depths at the other 3 cardinal directions.

3. Replace the sampling frame around the 4 flags and remove the flags. With a knife, cut the forest floor in the 1 ft. diameter circle using the sampling frame. Remove any branches larger than a pencil in size. With inward scooping motions, place the litter layer in a sampling bag.

4. Points to emphasize:

   A. Explain importance of collecting all of the material within the sampling frame. This weight is used to calculate carbon storage in the forest floor.
   B. Importance of removing rocks and pebbles from the sample. This sample will be ground by the lab, and rocks will destroy the blades. At a cost of $200-$300 a set, this greatly increases the cost of the lab analyses.

5. Practice distinguishing between mineral and organic soil. Locate several areas with differing thicknesses of organic material (e.g., directly under a tree, under a fallen log, in a clearing). Have crews practice identifying the boundary.

6. Discuss how method would differ in an organic soil (> 20 cm of organic matter). In this case, crews would collect only the litter.

Key concepts:

A. Take care not to compact forest floor prior to measurement.

B. Make sure to get all of the organic material in the bag. Use as many bags as needed and label "1 of 2," "2 of 2" etc.

C. Double check your assessment of where the boundary between the mineral and organic soil is. You may need to revise your original measurements after you collect the sample.

C. Demonstration of soil corer

1. Identify all parts
2. Demonstrate how to assemble the corer. Emphasize importance of a tight connection between the slide hammer and the coring head.

3. Discussion of how to clean and maintain the corer.
4. Demonstration of how to use corer. Focus on correct way to use slide hammer and correct technique for removing core from soil (e.g., done apply leverage to the corer while the slide hammer is raised).

D. Demonstration of mineral soil sample collection

1. Explanation of what constitutes a "complete" soil core. The soil must completely fill both liner sleeves. If the core is not complete, the sample must be retaken.

2. Begin the demonstration of the bulk density sampling by first determining whether or not a soil sample can be taken at the center of the circle just sampled. With a center pin, probe the soil to a depth of 8 inches. If an obstacle is encountered, move to the side and try again. Explain that if they still encounter an obstacle such as bedrock, they can probe within the 5 ft. radius circle to find a place for a soil sample. The goal is to obtain a representative sample of soil to represent the soil on the adjacent subplots, not to force a measurement at the assigned location.

3. Assemble the bulk density sampler. Demonstrate that the lid must be tight (hand tight is okay) in the sampling core to prevent damage to the threads. With the use of the slide hammer, push the bulk density corer into the soil to the depth marked on the side of the sampler with paint to represent the inside level of the sampler lid. With the slide hammer in the closed (down) position, rock the sampler core from side to side to make it easier to remove and to break the soil off at the bottom. Pull the sampler out of the soil.

4. Remove the lid from the sampler and then push the brass (or plastic) rings with associated soil from the sampler. With your knife, cut the sample between the top and bottom rings (at the 10 cm depth) and cut the excess soil from the bottom of the lower ring (at the 20 cm depth). Place the samples into the sample bags and label the bags.

5. Clean the brass rings and sampler with the brush and cleaning cloths.

Key Concepts:

When collecting bulk density cores, it is better to slightly overfill the core than to underfill.

Note that the lab data will often reveal whether or not the core has been correctly taken (so there is an "MQO" for this measurement, but it can not be assessed until after the sample has been sent to the lab).

E. Demonstration/Discussion of how to sample organic soils or other difficult sampling situations

1. Organic soils

If possible, identify an area of organic rich soil for demonstration purposes (e.g., wetland, marshy area). Alternately, prepare a bucket filled with peat. Demonstrate why the soil corer will compact the sample. Suggest alternatives.

2. Rocky soils

   If possible, identify an area of rocky soil for demonstration. Alternately, discuss how you would sample in rocky soils if you could not use the corer.

3. Sandy soils

   If possible, identify an area of sandy soil for demonstration. Alternately, discuss how you would sample in sandy soils if you could not use the corer.

4. Steep slopes.

   Demonstrate that when sampling on slopes, the corer should be oriented at a 90^{o} angle to the slope.

F. Sample labels and Shipping Form

Ask the class to write down how they would label the samples that were collected in the demonstration. Discuss as a group.

Emphasize the importance of filling out the labels completely and accurately. In some cases, an incorrect label means that the sample has to be discarded (since the lab personnel will be unable to determine how to handle the sample). In all cases, the lab personnel will contact the regional supervisor to alert them to problems.

Key Concepts:

1. In past years, there has been some confusion between “organic soil” and “organic horizon.” An organic soil is defined as having > 20 cm of organic material above the mineral soil. These are typically associated with peatlands. The term “organic horizon” has been replaced by the terms “humus” or “duff” and refers to the layer of organic matter directly above the mineral soil and below the litter.

2. The shipping form needs to be filled out in its entirety. The lab uses these forms to develop a sample inventory. If the shipment becomes lost, there is no way to determine which samples are missing. Alternately, samples may become misplaced due to a lab error. In addition to preventing problems in the lab, a complete shipment form protects the field crews from having responsibility for errors attributed to them.

3. Multiple bags containing the same sample need to be labeled as “1 of 2,” “2 of 2,” etc. These bags can become separated during shipping and logging samples in. If this is not clear, lab personnel may then process these as separate samples. It then becomes very

difficult to determine whether these are multiple samples or a labeling error and often requires contacting the regional coordinators to straighten out.

VI. Practice soil sampling measurements

Objectives g-o (60 min.)

1. Have crews break up into groups of 2-3 (depending on amount of equipment available). Maximum group size for this exercise is 4 people. Practice collecting cores and placing samples in bag.

Each crew member must collect a total of 5 practice cores. Ask the groups to rotate locations so that they experience a range of conditions.

VII. Field Certification

Objectives e-s (40-60 min.)

Before receiving certification, trainer must ensure that each crew member can:

Erosion and Compaction

1. Estimate % bare soil on a subplot within MQO's
2. Estimate compacted area within MQO's

Soil Sampling

1. Correctly locate soil sampling site
2. Assemble and operate the soil corer.
3. Consistently identify the boundary between organic and mineral soil (must observe crews making assessment in more than 1 location).
4. Correctly sample an organic and mineral soil sample.
5. Correctly fill out the sample label.

Depending on the ratio of students to trainers, these assessments can be done as a separate test or by observing crews and asking questions as they collect practice samples. In either case, each crew member must be observed correctly collecting a sample prior to certification.

Provide crews with a copy of the audit form. The items on this sheet indicate how their performance will be assessed.