National Forest Inventory

NFI GROUND SAMPLING GUIDELINES

For use by
Fluxnet-Canada Participants

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Abstract

The Canadian Forest Service (CFS) has been cooperating with the provinces and territories to develop a new approach for the National Forest Inventory (NFI). This new approach is a response to changes in data and information needs. For instance, data for Criteria and Indicators are required, as well as data on changes in the resources and data on non-timber resources.

The basic NFI sampling design includes the selection of sample units using a 20 km x 20 km grid network; photo plot attribute estimation from air photos, "drilled" GIS-based maps, and/or satellite images; and the selection of a sub-set (1 in 10) of these photo plots for ground sampling. These guidelines describe the configuration, and major components, of the ground plot design.

Table of Contents

List of Tables

List of Figures

List of Appendices

1. Introduction

The guidelines described herein meet the basic field sampling requirements for the ground sampling component of the National Forest Inventory (NFI). The attributes to be measured, and guidelines for obtaining those measurements, are explained in detail in this document. Sample field tally cards for recording ground plot information are provided in Appendix C.

These guidelines can be referenced as they are or they may be modified to meet the objectives of a regional inventory program. Regardless, it is the responsibility of each province or territory to acquire inventory data that meet the standard described in the *National Compilation Standard for Ground Plots* (Appendix V, Version 4.0, of the NFI Design Document). Change management will be implemented, where required, primarily to the *National Compilation Standard for Ground Plots.*

Background

The NFI represents a response to support increasing demands for additional information on forest resource attributes; for policy, national and international reporting; and for reports on:

- Climate change (e.g. the Kyoto protocol);
- Criteria and indicators of sustainable forest management;
- Biodiversity and forest health; and
- Sustainability.

The design calls for a minimum of 50 forested ground plots per Ecozone, although no sampling is planned for the Arctic Ecozones. In some cases, more intensive sampling will be required in some areas to meet regional objectives. The ground samples will, in most cases, be located at the centre point of the photo plot. Approximately 10 percent of the photo plot locations will be selected at random. Whenever the randomly selected location falls on a permanently non-treed area, a substitute sample location will be chosen, again at random. The initial locations will maintain their status as NFI ground plots and although no measurements will be taken, the locations will be retained in the analysis. Measurements of ground plots will be synchronized to the best extent possible with the interpretation of photo plots.

Attributes and data collected in ground plots will complement and enhance the attributes and data from the photo plots. Additional attributes to be measured on the ground include species names of all plants in a plot (includes place of origin in the case of exotics), mortality due to stresses (fire, insects, diseases), total above ground biomass including all woody debris, and current (5-year) volume growth based on periodic re-measurements. The ground plots will also contain information that is not normally collected in forest inventories such as forest floor organics and soil carbon. Attributes related to land use, ownership, protection status, access, human influence, conversion of forest lands, and the origin of exotic trees will be collected from management records, other data sources, and mapped information.

Remote sensing data will also be used to enhance the new National Forest Inventory: to assess whether the location of plots are skewed in any fashion, to assess the extent of change and the need to revisit plots, and to provide other area-based parameters such as forest condition.

All NFI plots are permanent. Change will be estimated from repeated sampling of photo and ground plots. The intent is to completely sample the country within the next 5 years, covering 1/5 of the area each year in a statistically defensible manner. The first re-measurement will be spread over a 10-year period, covering 1/10 of the area each year in a statistically defensible manner. Each successive re-measurement will be spread over subsequent 10-year periods.

Since the CFIC meeting in 1997, considerable progress has been made on the development of the new NFI design. A number of documents were produced including a design document (Natural Resources

Canada 2000) and planning documents examining the approaches, tasks and costs associated with the implementation of the plot-based NFI. Many jurisdictions participated in pilot projects that led to a refinement of data standards and procedures. Data standards have been defined, providing the basis for the construction of data models, databases and supporting data management tools. The information management systems will be finalized over the next two years and analysis and reporting functions developed.

The inventory is being implemented through memoranda of understanding (MOU) between the federal government and the partner province or territory. The ground sampling field implementation has begun in a number of jurisdictions, and agreements are being finalized with the expectation that the remaining jurisdictions will begin implementation next year.

NFI Ground Plot Design

The NFI ground sampling design was developed to meet five criteria:

1. Plot compatibility with the inventory design.
2. Appropriate plot type, plot size and plot shape for the attributes being measured.
3. Design flexibility that is capable of expansion.
4. Design simplicity and effectiveness.
5. The generation of ground plot data that complements NFI photo plot data.

The recommended plot design includes:

1. Two, 30.0-m long, line transects for measuring woody debris and surface substrate.
2. Four micro plots, each with a radius of 0.56 m and an area of 1 m^2 (0.0001 ha), for measuring the biomass of small trees and shrubs (< 1.3 m in height, without a DBH), herbs, fine woody debris, moss and lichens and forest floor organics.
3. A soil pit.
4. A large tree plot with a radius of 11.28 m and an area of 400 m^2 (0.04 ha), for measuring large (≥ 9.0 cm DBH) trees and conducting site assessments; and
5. A small tree plot with a radius of 3.99 m and area of 50 m^2 (0.005 ha), for measuring small trees and woody shrubs that have a DBH < 9.0 cm and stumps with an top DIB ≥ 4.0 cm.

As an option, square plots may be used instead of circular ones.

The plot design is termed a core plot design because, as in the overall NFI, modifications by the provinces/territories are expected. The modifications are likely to focus on the size of the tree plots; a province/territory may find it more effective, given their individual inventory programs, to make the plots larger or smaller. As with the overall NFI design, the intent is to have results that meet a common standard, not to have identical methods of achieving those results.

This document outlines a set of procedures that provide a consistent format for installing the ground plots to a required standard. Using these guidelines will ensure a known reference for the provinces in installing NFI ground sample plots. These ground sampling guidelines have been adapted from existing provincial programs.

Plot Design Criteria

The ground plot, sampling unit was designed according to five criteria. For each criterion, a series of choices are available and the one most adaptable to a given inventory program is chosen. To assist in the decision-making process, comparisons have been made with existing inventories.

1. Plot compatibility with current inventory design.

While the NFI photo plots were designed to obtain area-based estimates, the NFI ground plots are intended to obtain point-estimate samples. Hence, there is no need to consider polygon-wide estimates. A single sample element is adequate where a cluster would be inappropriate.

2. Appropriateness of plot type, size, and shape.

A complete description of the ground plot attributes and the ground plot database structure is listed in the *National Compilation for Ground Plots* (Appendix V, Version 4.0, of the NFI Design Document). Table 1. summarizes the attributes measured by each ground plot.

Table 1. Summary of NFI ground plot attributes.

Sampling Component	Attributes Measured
Site Assessment: - Site Information	Location Measurement date Land base Land cover Landscape position Vegetation type Density class Stand structure Succession stage Plot-level, volume summaries and estimation procedures Plot-level, gross volume increment and estimation procedures Plot-level, biomass summaries and estimation procedures
- Site Disturbance	Disturbance Tree mortality
- Plot Origin	Vegetation cover origin Regeneration
- Plot Treatment	Treatment type and extent Treatment year
Woody Debris Transects	Woody debris biomass by diameter class and decay class Woody debris volume by diameter and decay class Woody debris biomass and volume estimation procedures Surface substrate
Shrub/Herb Micro plots	Shrub/herb biomass summary by layer (includes fine woody debris – pieces ≤ 1.0 cm) Forest floor organics
Soil Pit	Soil site information Soil horizon information Soil bulk density information
Small Tree Plot	Tree species by height and diameter class Small tree biomass summary by species
Large Tree Plot	Tree species and status Diameter Crown class and length Height, age and growth information

Ground plot attributes are summarized into five categories:

- **Site assessments**. These do not require a plot with specific boundaries, only an appropriately sized reference area. A circular plot shape would work well since its boundaries can easily be estimated and round plots have less edge (hence less opportunity for edge trees);
- **Woody debris measurements**. A line intersect sampling method is most commonly used in forest fuel studies to measure these attributes;
- **Soils attribute measurements**. These are best obtained from a soil pit of an appropriate size;
- **Tree, shrub and herb measurements**. These plot-based measurements include species, diameter and some heights for the trees, and species and some measurement of size for the shrubs and herbs. Many different sizes, shapes and types of plots will work satisfactorily. Again, plot size is more important than shape and type; and
- **Growth and change measurements**. An example of this is volume growth estimation. Plots are required for growth and change measurements. Plot type is the most important factor in these measurements. It is more important than plot shape or size.

Plot size is a critical factor. If the plot is too large, time is wasted measuring too many trees or other attributes. The extra time spent measuring is not offset by a comparable increase in efficiency. If the plot is too small, not enough information is gathered to reach the optimum point of cost-effectiveness. This point can only be approximated (by varying plot size) since the number of units (trees) varies from one plot to the next, and since several attributes are measured on each plot. Typically, inventory planners specify large plots for large but few units (e.g. large trees) and small plots for small but many units (e.g. small trees).

Plot type is important for growth and change measurements. Of the two primary plot types, fixed area versus variable radius plots, fixed area plots are a better design for monitoring growth and change. It is easier to assess the changes that have occurred and to identify and measure the same units (trees) in a fixed-area plot. This is particularly relevant for mortality and harvested trees. Areas converted to non-forest use can also be tracked using plot re-measurements. Many of the remaining attributes, such as the number of forest dependent species, become more significant in re-measurements of change over time than in one-time measurements.

Plot shape is critical in certain instances. For example, a long, narrow plot may be used to counter-act periodicity in the population. However, in most instances it is a question of simplicity and effectiveness.

Designating a plot for re-measurement affects plot type, size, shape, and plot establishment procedures, since the plot must be re-locatable and re-measurable.

3. Design flexibility.

The NFI Design Document describes a set of 25 key attributes designed to satisfy national reporting requirements for Criteria and Indicators of sustainable forest management (Table 2). It is very likely that attributes will be added to meet provincial or territorial management requirements. These might include provincial inventory needs, forest health indicators, ecological classification, wildlife, or new national reporting requirements (e.g. The Kyoto Protocol to limit emissions of greenhouse gases). The design must be sufficiently flexible to accommodate such expansion.

Table 2. NFI Key Attributes.

NFI Key Attributes	
1.	Total forest area
2.	Area by forest type
3.	Area of forest type by age class
4.	Area of forest types by protection status
5.	Area of other wooded land by protection status and type
6.	Area of age classes by protection status
7.	Area and percent of forest land managed primarily for protective functions
8.	Regeneration and aforestation area by type
9.	Area of surface water in forests
10.	Area of forests undisturbed by man
11.	Area of other wooded land undisturbed by man
12.	Number of forest dependent species
13.	Number of native and exotic species in forests
14.	Origin of seedlings in regenerating areas
15.	Area available for timber production
16.	Area converted to non-forest use
17.	Area and severity of insect attack
18.	Area and severity of disease infestation
19.	Area and severity of fire damage
20.	Area of forest disturbance
21.	Area and percent of forest land with significant soil erosion
22.	Total biomass by forest type, age, succession stage
23.	Total volume of all species on timber producing land
24.	Area/volume of plantations (native/exotic)
25.	Current volume growth (annual) of forest (gross, net)

4. Simplicity and effectiveness.

A simple design facilitates understanding and implementation, and helps to reduce errors. Among the fixed-area plots, the circular type is simple, easy to lay out and contains the largest area for a given perimeter. This minimizes boundary measurement problems. In dense stands however, it may be easier to lay out a square plot versus a circular one.

An effective design minimizes the cost of obtaining the data. Cost is directly affected by the time required for plot layout and measurements. A suitable target is for a crew to complete at least one plot per day. The inventory planner has only a few tools available to help meet this target: crew size can be varied, and plot type can be simplified.

5. Other data uses.

The ground plot data may be used in conjunction with the photo plot data for ground truthing purposes, to help develop interpretation keys, or to provide another estimate of the same attribute. This criterion is perhaps the least important one and any design modifications to accommodate it will be minimal.

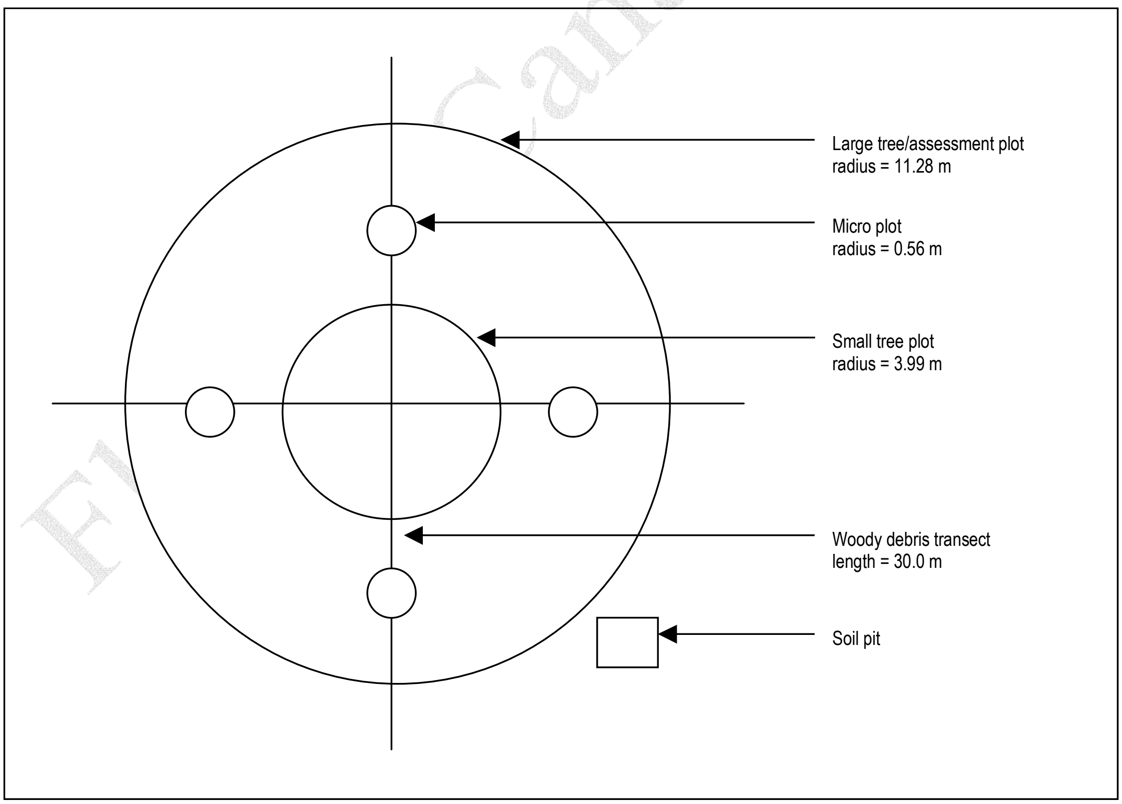
Plot Design

The preceding criteria are met using the design in Figure 1. It is comprised of a set of two concentric, circular plots with two line transects, perpendicular to each other, running through the plot center.

The plot design components include:

1. Two, 30.00-m **line transects**, perpendicular to each other, used to measure small woody debris (SWD), coarse woody debris (CWD) and surface substrate.
2. **Four micro plots**. Two micro plots located, on (or offset from) each of the line transects, each plot having a radius of 0.56 m, and an area of 1 m^2. The total area of all four plots is 4 m^2 (0.0004 ha). In order to determine gross total biomass, all vegetation will be destructively sampled. Vegetation to be clipped includes: woody shrubs and small trees without a measurable DBH, herbs, and grasses. Other materials to be collected include: fine woody debris (material ≤ 1.0 cm in diameter) and mosses and lichens. The micro plot may also be used to collect samples of forest floor organics and mineral soil samples. Alternatively, these samples may be collected in a buffer outside the large tree plot boundary (or at the end of the transects) that is representative of the plot area.
3. A **soil pit** dug either inside or outside the large tree plot for measuring soil attributes and for taking soil bulk density samples.
4. A **small tree plot** with radius, 3.99 m and area, 50 m^2 (0.005 ha). It is used to measure woody shrubs and small trees with a DBH < 9.0 cm. The small tree plot will also be used to measure stumps with an top DIB ≥ 4.0 cm.
5. A circular, **large tree plot** with radius, 11.28 m and area, 400 m^2 (0.04 ha). This size is equivalent to the 1/10 acre plot used successfully in previous inventory programs before the metric conversion of both inventory and growth plots. It is used to measure trees with DBH ≥ 9.0 cm (for volume and biomass estimates). The large tree plot is equivalent to the assessment plot used for collecting site information and for making visual assessments, e.g. site disturbance.

Figure 1. NFI ground plot design.



*Note: because of the destructive nature of the micro plots, they may be off set from the transect line or located at the end of the transects in a representative 'buffer' outside of the large tree plot boundary.

As an option, square plots may be used instead of the circular plots. However, it is important that the two plot types be the same area. This design satisfies the five aforementioned components:

1. A single sample element satisfies the first criterion- the plot is compatible with the inventory design.
2. Variable plot sizes accommodate the measurement of a few large units and many small units, and a fixed-area plot design allows for the monitoring of growth and change. This satisfies the second criterion- the plot design is appropriate for the attributes being measured.
3. The design is flexible and allows for expansion.
4. Circular or square plots, centered on the network grid point, are simple and effective.
5. The design permits the ground plot data to be used in conjunction with the photo plot data.

The NFI ground plot design is likely to be modified by the provinces or territories. The modifications are likely to focus on the size of the tree plots. A province or territory may find it more effective, given their objectives or sampling conditions, to modify the plot size to suit their own management needs. As with the overall design of the NFI, the intent is to have results that meet a common standard. It is not imperative to have identical methods of achieving those results.

Statistical measures can be useful aids in determining optimum plot size. The measurement time per tree (or unit) must be balanced by the precision of the resulting estimate. By varying the number of units sampled and the precision of the resulting estimate, an optimum can be achieved. However, different unit types, e.g. trees versus shrubs and herbs, are measured in the same plot therefore the optimum will only apply to one of them. Also, forest stands vary in age and density therefore optimum levels for one attribute or forest type may not be applicable to another. The Canadian Forest Service, Forest Health Assessment Network suggests 40 trees per plot as an appropriate target. A suggested "efficient number of trees for analysis" is 4 to 8 trees for each of the five sub-plots in a cluster (B.C. Ministry of Forests 1999), meaning a whole cluster would contain 20 to 40 trees.

Timing and Order of Measurements

The measured attributes include annual plants. They are included in estimates of biomass and biodiversity; therefore it is important to take measurements when the plants are fully developed. At the same time, it is also important to take measurements at the end of the normal, tree-growing season. These two constraints create a very small window of opportunity for field work- late summer or early fall. If it is impossible to do fieldwork during that period, efforts must be made to be consistent in the timing of successive measurements. For example, if plot measurements are made in July at the time of plot establishment, they should also be made in July in year 10, at the time of re-measurement.

To avoid trampling of the shrubs and herbs during fieldwork, measurements should be made as soon as possible after plot establishment. Generally, this means starting with the transects and the associated micro plots, establishing the soil pit, then the small tree plot, followed by the large tree plot. If the soil pit is to be located outside of the large tree plot, it can be completed at any time.

Field Equipment List

A field equipment list is provided in Appendix B of these guidelines. This list identifies each ground plot sampling component and the necessary sampling equipment required to complete the field measurements.

Tally Cards

Example tally cards are provided in Appendix C. The tally cards provided in these guidelines serve as examples of forms that could be used for collecting the field information required for NFI reporting. Electronic copies can be obtained by contacting:

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Several NFI ground plot attributes listed in the *National Compilation Standard for Ground Plots* (Appendix V, Version 4.0, of the NFI Design Document) will need to be compiled in the office or measured in the lab following the field measurements. This document does not attempt to describe any procedures for compiling or measuring these attributes.

Standards of Accuracy

It is assumed that each province or territory will collect ground sampling data that meet the standards described in the *National Compilation Standard for Ground Plots* (Appendix V, Version 4.0, of the NFI Design Document). Each province or territory is responsible for its own quality assurance and field checking program to ensure that quality and consistent data are generated.

Change Management

This document may undergo periodic updates to reflect changes to the *National Compilation Standard for Ground Plots* (Appendix V, Version 4.0, of the NFI Design Document). These guidelines provide a basis for NFI ground sampling and are not intended for use as an absolute reference. Accordingly, each province or territory may choose to change or alter the suggested guidelines to meet their program's inventory requirements as long as the data generated meets the terms outlined by the compilation standards document.

2. Field Orientation and Navigation

Introduction

This section outlines the steps for traversing from a geographically located feature (tie point) to the sample plot center. The field crew is responsible for selecting suitable tie points, navigating to the reference point and sample plot center, and for recording the information. The route must be suitably marked to locate the sample plot center, and to aid in short-term and long-term sample relocation for check plots and re-measurements.

Objectives

1. To locate the sample plot center (in the position indicated on the photo).
2. To mark and document the location and navigation points to allow for short-term and long-term sample relocation.

General Procedures

Office Preparation

1. Prepare and become familiar with forest characteristics, sample plot center, and access prior to field visitation.
2. Identify the location of the sample plot center on the photo.
3. Identify the location of the sample plot center on the map.

4. Determine the relative accuracy of the map to photo relationship.
5. Locate a potential tie point and alternatives on the map and photograph.

Field Location

1. Locate and confirm a tie point in the field and mark the tie point reference.
2. Navigate to the reference point.
3. Ensure the correct ground position as indicated by the UTM co-ordinates of the sample point.
4. Drive the reference pin in the ground.
5. Mark the reference tree and measure the bearing and distance to the reference pin.
6. Measure the final 15.00 m to the sample plot center.
7. Drive a pin in the ground. This is the sample plot center.

Attributes for NFI Reporting

No attributes are required for NFI reporting in this section.

Detailed Procedures

Locating and Marking the Tie Point

A tie point is selected and marked to ensure it can be found again with reasonable effort using the field crew's documentation.

Office Preparation

1. Locate the tie point:

The field crew is responsible for the selection of a suitable tie point. A tie point should have the following characteristics:

- It is locatable on the ground;
- It is locatable on the appropriate mid-scale aerial photo;
- It is locatable on the appropriate inventory map; and
- It permits efficient access to the sample for short-term and long-term sample relocation.

Some possible locations are:

- Major road junctions (use the intersection of the road centerlines);
- Pre-located, corrected GPS coordinates;
- Bridge on a stream crossing (on small creeks use the centerline of the bridge at the middle of the creek; on larger streams specify which edge of the stream was used);
- Definite timber boundary features on the photo (cut block edges should be used with caution as there may have been additional harvesting, or the map placement may be inaccurate);
- Major creek junctions;
- Well-defined swamps, ponds, or lake edges.

2. Locate the sample:

- The sample location is marked on the field aerial photo by the project manager(s) prior to sampling.
- Observe the sample location and potential tie point locations on the photo in stereo. Select primary and secondary tie point locations.

Field Location

1. Describe the access point:

Access notes should include a narration of the route traveled from a known location (for example, the junction of a highway and a secondary road) to the tie point, in enough detail to aid future relocation.

In some instances, the tie point will not be directly accessible. For example, the crew may need to land at a helispot in a swamp and navigate to the tie point using rough bearings and distances, or the crew may walk to the corner of a cutblock and then traverse from this point. At this point record the following:

- A description of the location;
- The bearing(s) and distance(s) from the access point to the tie point;
- GPS locator data.

2. Establish the tie point in the field:

- Confirm the tie point location or select an alternative.
- Select a tie point tree of suitable size so that the stem will be present for a number of years (not beside a road where it may be removed during road maintenance).
- Where no suitable trees are available, use another feature, such as a rock cut, boulder, and so on. A small rock cairn can aid relocation.

3. Mark the tie point tree for relocation of the samples in the short term (5 to 10 years):

Make the tie point visible to a field crew conducting surveys, but not overly visible to the general public. For example:

- If possible, the tree should be greater than 20 cm in diameter;
- Choose conifers over deciduous;
- Limb the complete stem to shoulder height;
- Remove understory vegetation around the tree, if practical;
- If appropriate, blaze the tree above breast height taking care not to girdle the tree;
- Spray paint the blazed surfaces;
- Ribbon the tree bole; and
- Record the species, diameter, azimuth and distance from the tie point tree to the tie point.
- Measure the bearing and horizontal distance from the face of the Tie Point reference to the tie point. Where the tie point is a singular tree, this tree may be blazed and marked.
- Securely nail an aluminum identification tag with aluminum nails to the tie point tree. If practical, the tag should face the tie point location and be at the base of the tree below potential felling height.
- *Note: if establishing a ground plot in a Park, other designated protected land or private land, do not tag or mark the trees in any way.

4. Mark the field photo and field map:

- Locate the selected tie point and pinprick the location on the field photo.
- Record the following information on the back of the photo: project identity, ground plot number; azimuth directions and distances from tie point to plot center.
- Locate and mark the tie point and the ground sample point on the field map.
- Record the same information as above on the map.

- *Note: the tie point must be placed in its relative position on the map. It is not enough to specify a road junction on both the photo and map without making sure that the map is accurate in its relative placement of that road junction.

5. Collect GPS data at the tie point location and record the file identification:

- When GPS data cannot be collected, move to an area where data can be collected (such as an opening).
- Measure the distance and bearing from the point where GPS data was gathered, back to the tie point, and record.

6. Navigating to the reference point:

From the tie point, navigate to the reference point location.

Procedures

1. Locate the reference point using appropriate methods (e.g. nylon survey chain).
2. Use offsets to traverse around unsafe or difficult situations.
3. Correct all measured distances to the horizontal.
4. Flag the tie line well enough to be easily followed. Flagging is to aid in short-term relocation of the sample plot center (within one field season).
5. Evaluate the location. When you find that the air photo and ground location agree, proceed with establishing the reference point and reference tree. When you arrive at the reference point and find that the air photo and ground location do not agree, evaluate the problems and find the correct sample location.
6. *Note: the objective is to **find the correct location on the ground as per the given UTM co-ordinates** of the sample point. You will not be "moving" the plot location if there is a conflict, you will be "finding" it. The map, GPS, and other tools are aids in finding the correct location.
7. There are a number of possible source of error:
    - The wrong starting point;
    - An incorrect bearing;
    - The wrong compass declination;
    - A significant local magnetic attraction;
    - Error in base map.
8. Possible solutions could include:
    - Return to the tie point and re-run the tie line;
    - Select another tie point and traverse from this point to the sample;
    - If the original calculations are in error, you may be able to establish the location relative to known features near you and calculate the distance and bearing to the correct location.

Establishing the Reference Point and Reference Tree

The purpose of establishing a reference point is to eliminate potential small-scale bias for the sample plot center location. The reference point will also help in relocating the sample plot center. In standard forest conditions, the reference point marking and reference tree will be marked as follows. If the sample occurs in a Park, other designated protected area or private land, the project manager will designate that hidden plot procedures are employed (Appendix E).

Procedures

1. Measure from the tie point along the pre-determined azimuth direction, towards the location of the sample plot center, using appropriate field methods.

2. Stop 15.00 m short of the full distance. Establish the reference pin at this point. For example, if the sample plot center location is 380 m from the tie point, establish the reference pin at 365 m from the tie point. If the reference point falls in an unmapped local feature, such as a swamp, offset the reference point to avoid the feature. Make note of the offset direction and distance.
3. Drive the pin firmly into the ground until it is level with the ground surface. If appropriate, establish a small rock cairn at the pin location.
4. Choose a suitable reference tree (greater than 20 cm in diameter, if possible). The reference tree should be reasonably close to the reference point, in relatively good health, with a high probability of survival, and with particular distinguishing features when possible (such as a forked tree, aspen in a spruce stand, veteran in an immature stand). The reference tree should not be a tree in the sample plot.
5. Measure the bearing and distance from the tag on the reference tree to the reference pin.
6. Record the reference tree details.
7. Mark the tree with flagging tape and blaze above DBH. The blazing should be visible but not severe enough to kill the tree. Paint the blazes to enhance visibility and to protect the tree from insects and pathogens.
8. Nail a pre-numbered metal tag to the base of the tree below where the tree would be cut if it were harvested, and facing the reference pin. If site conditions make this impossible, the tag location is at the discretion of the crew. Scribe the tag and record the tag number as part of the plot information.

Establishing the Plot Center

From the reference point, measure to the plot center.

Procedures

1. Accurately measure the remaining 15.00 m, along the correct bearing, to the sample plot center to eliminate any possible small-scale bias in placing the center. If you have offset for a local feature, reverse the offset to get back to the correct sample location. This point becomes the sample plot center regardless of the site or conditions. The plot center may be in an open forest, a rocky area, a creek, or inside a standing tree.
2. *Note: if the site location is unsafe or poses an undue hazard, the plot may be dropped. The project supervisor will review other means of completing all or some of these hazardous plots.
3. Drive a pin or stake firmly into the ground at the sample plot center. If site conditions make it impossible or inappropriate to imbed the stake at the sample plot center, place it as close as possible to the plot center, and record the offset distance and bearing from the pin to the plot center.
4. Collect GPS data at the sample plot center. When GPS data cannot be collected at the plot center, move to an area where data can be collected, such as an opening. Measure the distance and bearing from the point where data was collected back to the sample plot center. Record these measurements.

Inaccessible Plots

In some instances, a plot (or some part of it) may be inaccessible because of factors such as denied access or physical safety concerns. A field crew is not expected to sample beyond what is considered reasonable and safe. **The safety of the field crew is the first priority.**

Local procedures, regarding inaccessible plots, should be followed and as much information as possible should be completed on the field records to the point where fieldwork was terminated. When all or part of a plot is dropped, advise the project manager. Specify detailed comments as to why the plot was not established, for example:

- "Access to the plot was too dangerous."
- "Plot was located in an unsafe or inaccessible area (e.g. river or lake)."
- "Permission denied accessing private land."

Partially Forested Plots

All plots must be established in forested and treed conditions. In the event that a plot or transect falls partially out of the forested, treed polygon, the entire plot is still measured (unless it is unsafe to do so) and mapped. It is important to be especially diligent in noting in the comments what portions of the plot fall in or out of the forested polygon area.

Procedure:

1. Perform all of the ground plot measurements as per the normal protocol.
2. Indicate on the plot location tallycard, through descriptions and diagrams, which part of the plot falls in the forested polygon and which part of the plot falls in the non-forested polygon.
3. Indicate on each of the sampling component tallycards, e.g. woody debris, large tree plot, small tree plot, etc. which part of the plot was measured in the forested area and which plot of the plot was measured in the non-forested conditions.
4. On the large tree plot tallycard, it should be obvious which part of the plot was measured in the non-forested conditions, however, in the shrub and herb vegetation species list, this might not be so obvious so it is important to note it well in the comments section.
5. You may wish to fill out separate tally cards for each of the forested and non-forested portions.
6. For each sampling component, record on the tallycard, the area or length of transect that was completely sampled. In the comments section of the tallycard, note why the rest of the plot was not sampled. For example, if only the first 10.0 m of the woody debris transect was sampled because the other 20.0 m of the transect was submerged under water, under the attribute 'transect length' you would record: '10.0 m' and then in the comments section you would record, "Only the first 10.0 m of transect 1 was sampled due to deep, ephemeral pond of water.
7. Completely map the entire plot, indicating the location of the plot that falls in the non-forested area. If possible, plot an approximate bearing and distance of a line that divides the forested from the non-forested part of the plot. You may wish to log a few points, using a GPS, so that the boundary between the forested and non-forested parts of the plot can be effectively mapped.
8. Ensure an adequate range of plot photographs are taken in order to describe and illustrate the plot conditions. This may mean taking more than the recommended eight plot photographs.

3. Plot Establishment

Introduction

An NFI ground plot consists of the components previously illustrated by Figure 2. This section presents guidelines for the establishment of each sampling component.

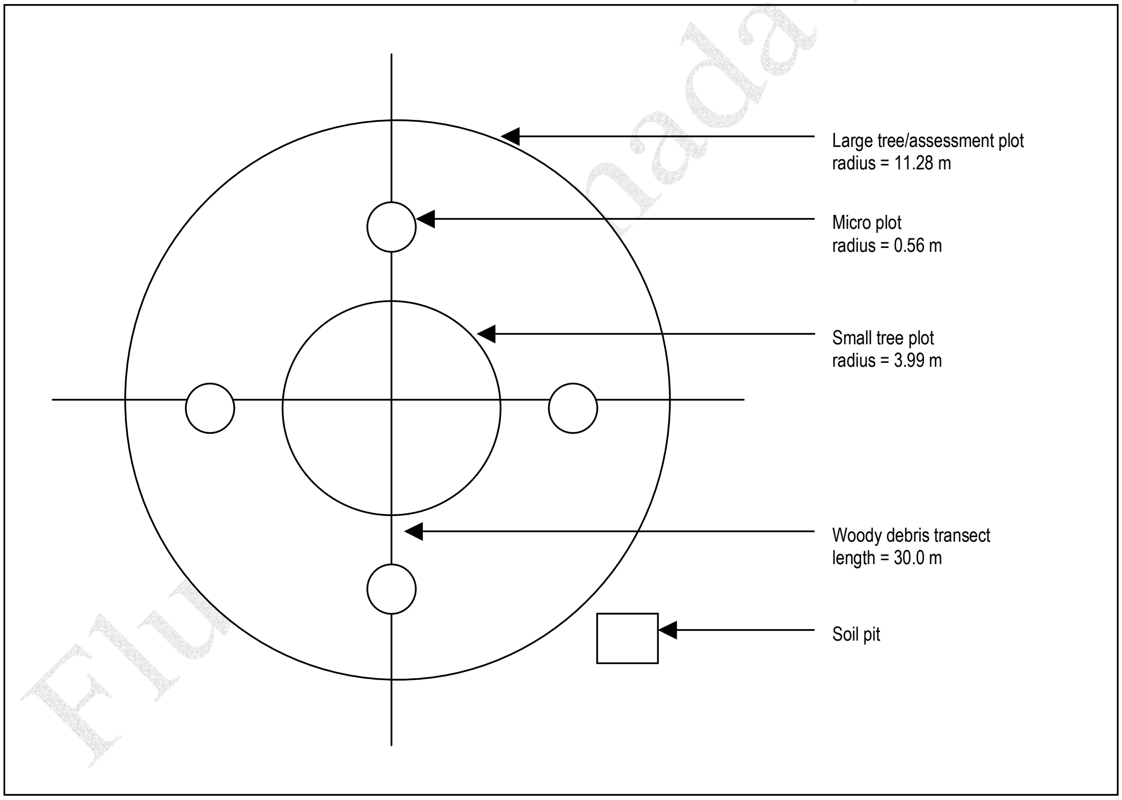
Objectives

1. To establish ground plot sampling components, including: two woody debris line transects, four micro plots, a soil pit, a small tree plot and a large tree plot.
2. To record site, disturbance, origin and treatment information for the plot.

General Procedures

1. Confirm that the plot center is the correct location.
2. Assess safety considerations.
3. Determine and carry out the sequence of activities. Assess the site vegetation and determine the most efficient sequence of measurements to ensure that specific values are not degraded by other activities. For example, shrub and herb cover and species information will need to be recorded before destructive sampling for biomass. Shrubs and herbs may be trampled if tree heights are measured first.
4. Establish the ground plot components in the following order: woody debris line transects, micro plots, soil pit, small tree plot and large tree plot. The soil pit may be established outside the ground plot, simultaneously with the other components.
5. Record site information attributes.
6. Record disturbance, origin, and treatment attributes for the plot.

Figure 2. Layout of NFI ground plot components.



*Note: because of the destructive nature of the micro plots, they may be off set from the transect line or located at the end of the transects in a representative ‘buffer’ outside of the large tree plot boundary.

Table 3. Summary of detailed data collected by each ground plot component.

Component	Summary of data collected
30.00 m transects	-small woody debris (>1.0 cm diameter ≤7.5 cm) -coarse woody debris (>7.5 cm diameter) -surface substrate
0.56 fixed-radius micro plots 4 micro plots x 1 m^2 (0.0001 ha)	-shrub and herb clipping for biomass -fine woody debris (≤1.0 cm in diameter) -surface substrate -forest floor organic sample (may also be collected at the soil pit) -bulk density soil samples (may also be collected at the soil pit)
Soil pit	-CSSC soil classification -measurement of coarse fragments -forest floor organic and bulk density soils samples for lab analysis
3.99 m fixed-radius small tree plot 50 m^2 (0.005 ha)	-small tree and woody shrub species data (<9.0 cm DBH) -stump detail
11.28 m fixed-radius large tree plot 400 m^2 (0.04 ha)	-large tree and woody shrub species data (≥9.0 cm DBH) -site tree details (measured within quadrants) -succession interpretations -plot disturbance -plot origin -plot treatment -defect and pathological indicators

Detailed Procedures

Depending on the sequence of measurements chosen, perform the procedures described in the following sections.

Woody debris line transects (30.00 m)

1. Establish two, 30.00 m horizontal line transects that intersect the plot center. They must be established along a previously selected, random bearing.
2. Starting at the plot center, measure and record woody debris information for all coarse woody debris pieces >30.0 cm in diameter for 5-m of the line.
3. For the next 5-m of line, measure and record woody debris information for all coarse woody debris ≥7.5 cm in diameter.
4. For the next 5-m of line, measure and record woody debris information for all woody debris >1.0 cm in diameter (use the go-no-go tool to tally the smaller classes).
5. Include detailed measurements at the transect crossing point on diameter, tilt angle, and decay class for the small and coarse woody debris pieces. Also record species and piece description.
6. Measure surface substrate, every second meter, from one end of the transect to the other.
7. Repeat the woody debris tally from the other end of the transect, back to the plot center.
8. Establish a second 30.00 m horizontal transect that intersects the plot center at +90° from the first line and repeat entire measurement process.

Micro plots (0.56 m fixed-radius)

1. Establish four plot of 0.56 m radius, offset 1-m from the woody debris transect lines at 7.0 m (horizontally corrected distance) from the plot center.
2. Clip and collect shrubs, herbs and grasses, mosses and lichens from the micro plot. Collect each layer in a separate bag (bags from all four micro plots may be combined for each layer).
3. Measure and collect the fine woody debris.
4. Sample the forest floor organic and bulk density soil samples (if they are not being collected at the soil pit).

Small tree, woody shrub and stump plot (3.99 m fixed-radius)

1. Establish a 3.99 m fixed-radius plot, centered on the plot center.
2. Count live and dead small trees with >0.0 cm DBH <9.0cm. Record status code (live or dead), DBH class and height class.
3. Count all main stems of woody shrubs with >0.0 cm DBH <9.0 cm. Record status code (live or dead), DBH class and height class.
4. Collect stump data (>4.0 cm top DIB) in this plot.
5. Collect herb, grass, and bryoid species and cover information.

Large tree plot (11.28 m fixed-radius)

1. Establish a 11.28 m fixed-radius plot for trees 9.0 cm DBH and larger.
2. Number (tag) the trees (if appropriate) sequentially clockwise in quadrants, from the north.
3. Make detailed measurements on the selected 'in' tree for diameter, height (or length and offset distance), defects and pathological indicators, species, etc.
4. Record site tree details.
5. Record succession interpretations.
6. Record, disturbance, origin and treatment information.

Taking Ground Photographs

At each ground plot, eight photographs are taken using a 35 mm camera (with a flash) or a digital camera. The photographic images will be digitally stored and are useful for:

- Initial assessments by potential users who may want to sub-sample on these locations for other values;
- Capturing information that is not measured directly (e.g. assessing vegetation competition);
- Serving as a basis for comparison when the time comes for re-measurement;
- Reference or clarification purposes of future users of NFI ground plot data.
-

All photographs are to be submitted to the NFI in digital format, complete with the network label, the photo number, and a description of the photo.

Procedures

1. Take eight photos at each NFI ground plot site (more photos may be required if anomalous conditions are encountered). Do not cut trees or vegetation to provide an unobstructed view. Take the photo before taking measurements if the site may be damaged during sampling. In each photo, include a written tag or label with lettering that is not less than 7 cm in height, and that includes: 1) photo number, 2) network label and/or plot number and 3) photo description, e.g. "north transect", "forest canopy", "soil profile", "plot center", etc.

2. Photo 1: Photograph the plot center pin at a steep angle (about 60°) above the pin showing the pin and the ground for approximately one meter or more around the pin so the vegetation can be seen. Include a written tag or label in this photo, which records the plot number.
3. Photos 2-5: Take four, horizontal photographs of each of the transect lines from a position behind the plot center pin. Include the plot center pin in the foreground if possible. Include something for relative scale determination. Try to include the various crown levels with a “portrait” (vertical) format, if required.
4. Photo 6: Photograph the vegetation in the plot at 1.3 m, in a cardinal direction, at the plot center pin. For a representative photo, photograph a portion of the plot that the crew considers representative of the sample vegetation and structure. Include an item for scale in the photo.
5. Photo 7: Photograph the forest canopy directly overhead, at the plot center pin.
6. Photo 8: Photograph the soil profile that has been described, at the pit. Make sure a tape measure or meter stick has been placed along the profile with the 0 cm mark at the ground surface. Photograph the profile face from outside the pit, preferably with the sun behind the photographer shining on the exposed profile.
7. Photograph any other unusual features that you think would be of interest to users of this data. You may wish to illustrate issues about the sampling process, such as when rules do not seem clear or appropriate. Make notes about these photos so the points can be addressed later.
8. Try to include people in each photo for scale. Use a scale in any close-up photos.
9. Record the photos taken (roll and photo number) and any comments on plot tally cards.

4. Large Tree Plot

Introduction

The large tree plot will be used in the identification and collection of detailed tree information from which total volume and gross total biomass can be estimated, site quality can be assessed, and site potential can be determined. Trees may be sampled using variable-radius plots or fixed-radius plots. The procedures described here assume fixed-radius plots.

Objectives

1. To collect attributes for the calculation of tree volumes and biomass.
2. To collect information for the calculation of site index.
3. To assess and collect tree attributes for:
    - future growth and yield assessment,
    - wildlife,
    - decay research, and
    - forest health information.

General Procedures

Field crews should conduct tree measurements in the most efficient sequence. A general suggestion for tree measurements is the following steps:

1. Establish plot layout, select appropriate plot size and shape and identify trees to measure.
2. Identify and record tree attributes.
3. Record damage agents and severity codes.
4. Measure and record stump data.
5. Identify trees for top height and site tree measurements.
6. Select and record top height tree data.
7. Determine leading species composition (by basal area) for the plot.

Detailed Procedures

Plot Establishment

Fixed area plots are the suggested plot types for the purposes of the NFI. The center of the large tree plot is the center of the main plot and the perimeter is a circle with a radius of 11.28 m (for square plots, the side length is 20.00 m). Using only one plot size eliminates a potential source of bias, which could be introduced if crews change the plots sizes in the field to obtain some desired tree count. Figure 1 illustrates the plot layout for the large tree plot.

An optional, 5-m buffer can installed at the end of the woody debris transects, outside the large tree plot. This could serve as the sampling area for the destructive sampling portion, e.g. micro plot of the ground plot.

Measuring Borderline Trees

1. Correct all measurements to horizontal distance.

2. Use the central point of the tree stem at "point of germination" to determine if the tree is "in" or "out" of the sample. The central point is generally equated with the tree pith.

Large Tree Plot, Header and Summary Information Attributes for NFI Reporting

Attribute	Instructions for reporting
Network label	-NFI label that identifies the point on the network associated with the ground plot. -Enter a value between 1 and 1,600,000. -The ground plots, for the most part, should be located at the center point of the photo plot boxes on the 20 km x 20 km grid network.
Measurement date	-Enter the date of information capture in the field. -The format of entry must be (YYYY-MON-DD) and must be more recent than Jan1, 1995.
Measurement number	-Enter a measurement number between 0 to 999. -A newly established plot will have measurement number = 0. The first re-measurement would be 1, etc. -Measurement numbers must be consecutive.
Plot type	-Enter a three-character plot type: LTC = circular large tree plot LTS = square large tree plot
Plot size	-Describes the area of the large tree plot in ha. -Enter the plot size, correct to the nearest 0.001 ha.

Office-compiled Attributes - Large Tree Plot, Header and Summary Information Attributes for NFI Reporting

The following attributes will be compiled by the CFS based on reported NFI field-measured attributes.

- Site index (m)
- Site index genus
- Site index species
- Average height (m)
- Average age (years)
- Basal area (m^2/ha)
- Stem density (stems/ha)

Identifying and Recording Tree List Attributes for NFI Reporting

Record the following measurements in the appropriate fields on the field card. The fields to be recorded are listed and described in the sections following.

For the purposes of this inventory, a tree is defined as:

- A woody plant, usually with a single stem and a definite crown, that is capable of reaching a mature height of 5 m somewhere within its natural range. Refer to the NFI Design Document, Tree Species Code List Appendix;
- Longer than 1.3 m, having roots attached to the bole or an identifiable root collar; and
- With a DBH ≥ 9.0 cm.

Tree Number

All trees will be numbered to identify them in the field and on the field cards. The plots will be re-measured in the future and are subject to audit cruising, and numbering the trees in a consistent sequence will enhance the chances of a successful re-measurement program. Trees will be marked (usually with log marking paint) in a way similar to an operational cruise plot so other visitors to the site will not treat the plot in a "special" manner.

Marking the Plot Boundary

1. Using a plot tape, measure the 11.28 m plot radius from the plot center stake.
   - On sloping plots apply a slope correction to the radius. See Appendix F – Calculating slope allowances.
2. Measure the plot radius to accurately determine the plot circumference, mark this circumference with plot string as required.
3. Check trees close to the circumference with the plot tape. These trees are called line trees. Include line trees in the plot when at least half their base at the "point of germination" is inside the plot.

Dividing the Plot into Sectors

Divide the plot into 8 pie-shaped, 0.005 ha (45°) sectors. These are the tagging sectors. Tagging sectors are later combined into pairs in order to have 0.01 ha quadrants (site sectors) for the selection of site trees.

Sector 1, is always the first sector clockwise from due north. The additional sectors are numbered clockwise from sector 1.

Tagging Trees

Tag all living (standing and fallen) and dead (standing only) trees that have a DBH of 9.0 cm and greater within the 11.28 m fixed-radius large tree plot. Use pre-numbered aluminum tags. Do not duplicate tag numbers in a plot.

Tagging by Sectors

1. Start with sector 1. In this sector, affix the tags so that they face the **plot center**. If the tag will be highly visible in this location move the tag around the tree at a height equivalent to high side until the tag is less visible.
2. Tag the trees nears the plot center first; then continue tagging outward by moving side-to-side across the pie-shaped sector.
3. As you reach the circumference of sector 1, make the last sideways pass in the direction of sector 2 so that the last tree tagged in sector 1 is, as near as possible to the first tree you will tag in sector 2.
4. Begin tagging sector 2. In this sector, affix the tags so that they face the circumference, not the plot center (as in sector 1).
5. Tag the trees near the circumference, first, and then continue tagging inward by moving side-to-side across the pie-shaped sector.
6. Make sure the last tree you tag in this sector is the one closest to the plot center.
7. Repeat the procedures used in sectors1 and 2 for the remaining sectors. Remember that tags in odd-numbered sectors face the plot center while those in even-numbered sectors face the circumference.

Attaching Tags to Trees

1. Affix tags at the base of the tree (at the high side or highest point of the ground on the uphill side) and mark the breast height location, which is 1.3 m above the base of the tree on the uphill side. Use a 1.3 m long DBH stick to measure the correct height.
2. Nail the tag to the base of the tree:
   - Use 6 cm aluminum nails;
   - Drive the nail slightly upward so the tag hangs away from the tree;
   - Drive the nail into the trunk just enough to hold the tag securely and yet allow for radial growth.

Tagging Forked Trees

Here are special rules for tagging forked trees:

1. Tag the stem as a single tree if:
   - the fork occurs above 1.3 m, and;
   - the stem has a measurable DBH < 9.0 cm within the 3.99 m fixed-radius plot or has a DBH of at least 9.0 cm or greater within the 11.28 m fixed-radius large tree plot.
2. Tag each stem separately if:
   - the fork occurs below 1.3 m, and
   - two or more of the fork's stems have a measurable DBH < 9.0 cm within the 3.99 m fixed-radius small tree plot or has a DBH of 9.0 cm or greater if the stems are within the 11.28 m fixed-radius large tree plot. Use consecutive numbers when you tag (tag the stem farthest to the left first and finish with the stem farthest to the right) these stems.
   - Locate the tag at high side ground level directly below the fork so it is evident which tag belongs to each stem.
3. Tag the stem as a single tree if:
   - the fork occurs below 1.3 m, and
   - only one of the fork's stems has a measurable DBH of < 9.0 cm within the 3.99 m fixed-radius sub-plot or has a DBH of 9.0 cm or greater if the stems within the 11.28 m large tree plot.

Recording Tree Sector Numbers (Optional)

If tree sector numbers are used, all trees will have the sector number recorded to assist relocation at the time of re-measurement.

Plots With No Trees

All newly established ground plot must be forested and treed. If, upon re-measurement, there are not trees in the plot, no trees are present, put a line across the data area and record "NO TREES".

Tree Genus, Species and Variety

1. Record the genus, species and variety information for all tree species within the large tree plot with a DBH greater than or equal to 9.0 cm.
2. For the purposes of this inventory, a tree is defined as a woody plant, usually with a single stem and a definite crown that is capable of reaching a mature height of 5 m somewhere within its natural range.

3. Trees are listed with the genus, species and variety being described using the codes listed in the Tree Species Code List (NFI Design Document, Appendix X).
4. Enter a four-character genus code using the first four letters of the scientific genus name. For unknown conifers, use the code "GENC". For unknown hardwoods, use the code, "GENH".
5. Enter a three-letter species code using the first three letters of the scientific species name. For unknown species, use the code, "SPP".
6. Enter a three-letter variety code using the first three letters of the scientific variety name. For unknown variety, leave the field blank.

Tree Status

Assigning tree status codes allows for reporting trees in categories and reflects some potential for future growth. Note that dead fallen trees are **not** tallied in this section. They are counted as woody debris. Dead fallen trees (woody debris) include downed and dead, sound and rotting logs and uprooted stumps that are non-self-supporting. They may be in various stages of decomposition and >50% of their surface area must be lying above the soil.

7. Record for each tree whether it is live standing, live fallen, dead standing, cut (on re-measurement), or ingrowth (recruitment).
8. Use the codes described in Table 4.

Table 4. Tree status codes.

Code		Description
Live standing	**LS**	Live trees have enough foliage to keep them alive (live cambium is present), are intact and rooted into the ground. Lack of foliage for some species, of course, is no indication of death during some seasons. Standing trees are self-supporting (that is, the tree would remain standing if all supporting materials were removed).
Live fallen	**LF**	See previous definition of "live". Fallen live trees are not self-supporting and would not remain standing if all supporting materials were removed.
Dead standing	**DS**	Dead trees are obviously (physiologically) dead. They are still self-supporting (rooted into the ground) and would remain standing if all supporting materials were removed, e.g. snags.
Cut	**C**	E.g. tree was selectively harvested and only a stump remains upon re-measurement.
Ingrowth	**I**	Refers to trees that have grown from being small trees (< 9.0 cm DBH) to being large trees (9.0 cm DBH or greater) during the course of successive re-measurement periods.

Diameter at Breast Height (DBH), Measured or Estimated

Measure and record the diameter of all live/dead, standing/fallen trees equal to or greater than 9.0 cm DBH.

1. Determine high side ground level at the base of the tree.
2. High side is defined as the highest point of mineral soil or a humus layer around the base of the tree, no lower than the point of germination. Breast height is 1.3 m above high side measured parallel to the tree bole.
3. Measure the DBH to the nearest 0.1 cm from the ground on the high side.
4. Use a stake marked at 1.3 m to accurately locate DBH on straight stems. On curved stems measure along the curve parallel to the centre of the tree.
5. Paint a line on the tree where DBH was measured, preferably facing the plot centre.

6. Record the DBH with a tight diameter tape, outside the bark, making no allowance for missing bark.
7. Record whether the DBH was measured (M) or estimated (E).

Tree Height

Measure the height of each tree within the large tree plot, including broken and fallen trees. Measure all trees except where the measurement is physically obstructed, where it is unsafe to make the measurement, or when an accurate measurement is impossible. In such cases, estimate the tree height. For trees with broken tops, see discussion of broken tops below. For leaning trees, calculate the tree's height using the length and an offset distance.

1. Estimate the tree height before measuring as a check on your calculations.
2. Measure the height of the tree from the ground level on the high side along the stem to the top of the stem. Record height to the nearest 0.1 m.
3. For broken stems, measure the height that allows the most appropriate application of volume functions for calculating the volume of the tree.
4. For fallen broken trees, record the length of the stem to the break. Measure the portion of the tree from the root collar to the top of the last connected portion (the pieces must be physically attached so that if one part is moved the next part will move).
5. Record whether the length was measured (M) or estimated (E).

Crown Class

Crown class is a ranking by crown position of a tree in relation to other trees in the immediate area surrounding the tree being measured. The crown class will be useful in future growth models.

1. Assign a crown class code to all standing live trees using the descriptions in Table 5.
2. Dead trees and fallen live trees will not have a crown class assigned.
3. On trees with broken or dead tops, assess the remaining live portion of the crown, relative to its present interception of light in the immediate area around the measured tree. For example, a tree was formerly in a dominant crown position but the top of the crown has died back and only the lower limbs are alive. This crown would most likely be ranked in the intermediate or suppressed position based on the current light interception of the remaining crown.

Table 5. Crown class codes.

Code	Description
D	**Dominant** Trees with crowns that extend above the general level of the trees immediately around the measured trees. They are somewhat taller than the codominant trees, and have well-developed crowns, which may be somewhat crowded on the sides, receiving full light from above and partly from the side.
C	**Codominant** Trees with crowns forming the general level of the trees immediately around the measured trees. The crown is generally smaller than those of the dominant trees and is usually more crowded on the sides, receiving full light from above and little from the sides.
I	**Intermediate** Trees with crowns below, but extending into, the general level of the trees immediately around the measured trees. The crowns are usually small and quite crowded on the sides, receiving little direct light from above but none from the sides.
S	**Suppressed** Trees with crowns entirely below the general level of the trees around the measured trees, receiving no direct light either from above or from the sides.
V	**Veteran**

Code	Description
	Mature trees that are considerably older than the rest of the stand. Usually, veterans are trees remaining from a previous forest that have survived while a new forest has been growing up around them. Different jurisdictions will have different age thresholds for the age at which a tree becomes a veteran (Dunster, 1996).

Live Crown Length

Live crown length is the vertical distance from the tip of the leader to base of the crown, measured to the lowest live whorl (Helms, 1998). Crown length is recorded to the nearest 0.1 m. Crown length can be calculated using total tree height and height to live crown.

Height to Live Crown

Measure the height to the live crown. Height to live crown is the distance along the bole from the high side ground level to the crown base. The primary objective is to estimate the "effective" extent of live crown for growth projections.

4. Determine the crown base. The crown base is normally the location on the stem where live branches occupy about three-quarters of the stem circumference. If this is obviously not an effective definition, then use your judgment as to the effective crown length.
5. Record the height to live crown for all live trees to the nearest metre.
6. Record trees that are dead or have no effective crown (those having only a few green branches) as dashes (– –).

Azimuth and Distance (Stem Mapping)

All tree stems in the large tree plot should ideally be stem mapped to aid re-measurement and for research in stand structure stem distribution.

1. Measure and record the azimuth from the plot center pin to the face of the tree (to the nearest degree).
2. Measure and record the horizontal distance from the plot center pin to the face of the tree (to 0.01 m).

Office-compiled Attributes - Large Tree List

The following attributes will be compiled by the CFS based on reported NFI field-measured attributes.

- Total tree volume (to the nearest 0.0001 m^3).
- Total tree biomass (to the nearest 0.01 kg).

Large Tree Plot, Defects and Pathological Indicator Attributes for NFI Reporting

1. Defects and pathological indicators can be an indicator of forest health as they are frequently signs of decay or rot in the wood. They may include abiotic, disease, insects, treatments, vegetation and wildlife.
2. Assess damage agent(s) or conditions, and location or severity (ies) on all numbered trees, dead or alive within the large tree plot. Refer to Table 6 for a comprehensive list of codes and descriptions of damage and pathological indicators.
3. Record the damage agents for each tree.
4. When the tree has more than two damage agents, list the most important two damage agents.
5. Record "0" if no damage agent is observed.

6. In many instances damage may be evident, such as forks and scars and the damage agent is not known. In these instances record a "-" in the damage agent field.

Defect(s) and/or Pathological Indicator(s)

Table 6. Damage agent attributes and descriptions.

Damage Agent Code	Code
Non-biological (abiotic) injuries	NB: Fire ND: Drought NF: Flooding NG: Frost NH: Hail NK: Fumekill NL: Lightening NN: Road salt NR: Redbelt NS: Slide NW: Windthrow NY: Snow or ice NX: Scarring and rubbing NZ: Sunscald
Diseases	DB: Broom rusts DD: Stem rot DF: Foliage disease DL: Disease-caused dieback of leader DM: Dwarf mistletoe DR: Root disease DS: Stem disease
Insects	IA: Aphids IB: Bark beetles ID: Defoliators IS: Shoot insects IW: Root and terminal weevil
Mite damage	M: mites
Treatment injuries	TC: Chemical TL: Logging TH: Harvested TP: Planting (incorrectly planted) TM: Other mechanical damage (non-logging) TR: Pruning wound TT: Thinning or spacing wound
Animal	AB: Bear AC: Cattle AD: Deer AE: Elk AH: Hare or rabbit AM: Moose AP: Porcupine AS: Squirrel AV: Vole AX: Birds AZ: Beaver
Vegetation problems	VH: Herbaceous competition VP: Vegetation press VS: Shrub competition VT: Tree competition
No detectable abiotic or biotic damage	O: No detectable abiotic or biotic damage
Damage evident but causal agent unknown	U: Damage evident but causal agent unknown

Defect Location Code

1. This field indicates the location of the defect on the individual tree.
2. Enter a one-digit code indicating the portion of the tree that is affected:
   - **1** = Lower third only
   - **2** = Middle third only
   - **3** = Upper third only
   - **4** = Lower and middle third
   - **5** = Middle and upper third
   - **6** = Lower and upper third
   - **7** = Entire tree

Severity

This field indicates the severity of the effect on the tree. It is assessed subjectively using a percent value or can be left blank (severity is difficult to assess without training). Enter a subjectively assessed percent value as to the portion of it that has been affected (to the nearest percent).

5. Age, Height and Growth Information

Introduction

Core samples will be taken from each of the NFI ground plots in order to determine the age of trees that are representative of the plot. The age data from these samples can be used for a variety of purposes such as: stand age calculations, growth relationships and the site index calculations. From further analysis of the core samples, information related to insect, disease or other environmental stresses might also be interpreted.

Core samples will be counted in the field to obtain age and radial increment data in the event that cores are subsequently lost in transit. The field age count will also be useful in determining succession interpretations. The cores will be recounted under magnification, by CFS lab technicians, to determine the actual age and annual growth increment.

Objectives

1. To determine the age of trees representative of the plot.
2. To determine incremental growth.
3. To determine site quality (when combined with tree height).
4. To determine the age class structure of the trees within the plot.

General Procedures

1. Determine which trees will be cored.
2. Core the selected trees and perform a field age count and radial increment measurement(s).
3. Record age, height and growth information on tally card or using data logger.
4. Label straws and store in cool (refrigerated conditions).
5. Ship samples to CFS lab for analysis.

Detailed Procedures

Site Tree Selection

1. Establish and boundary of the large tree plot and the four 0.01 ha quadrants.
2. Select age and height trees used the descriptions outlined below.
3. The following types of trees are measured for age and height:
   - **Top height**: the largest DBH tree in the large tree plot, regardless of the species. It must be alive and dominant or co-dominant in status.
   - **Leading species**: the largest DBH tree in each quadrant of the large tree plot, of leading species by basal area. It must be alive and dominant or co-dominant in status. Must not be a residual of a former stand.
   - **Second species**: the largest DBH tree in each quadrant of the large tree plot, having more than 20% of the basal area in the plot. It must be alive and dominant or co-dominant in status. Must not be a residual of a former stand.
   - **Other major species**: the largest DBH tree in each quadrant of the large tree plot, of all species, other than the leading or second leading species, having more than 20% of the basal

area in the plot. It must be alive and dominant or co-dominant in status. Must not be a residual of a former stand.

- **Non-standard selection type**: an additional tree that is selected in a non-standard manner (at the discretion of the field crew). This flexibility is provided for special cases where the field crew feels that adequate information cannot be provided following the standard procedure alone. For example, a tree might be unsafe to measure or it might be located in a patch of recently killed trees. Comments must be supplied on the tally card to explain why the tree was selected.

4. *Note: on fixed radius plots collected on electronic field data recorders the basal area calculations are performed within the program. When paper tally cards are used an excel spreadsheet and paper worksheet can be used to calculate the basal area of all species in the field or at the field office (see Appendix G - Calculating basal areas in the field).
5. Measure and record tree height for each selected tree. If the tree is leaning, use the tree length and an offset distance to calculate the height of the tree.
6. Measure and record the length of the tree along the stem from the high side ground. If the tree is broken off, measure and record the length to the break.
7. Determine suitability for height (see criteria in following section) and record the appropriate codes. If the height is not "suitable" make sure that comments are recorded on the tally card as to why the tree is not suitable and if possible, estimate a projected height.
8. Measure the age and radial increment for each selected tree.
9. Determine suitability for age (see criteria in following section) and enter appropriate code.

Site Tree Suitability for Age and Height

A tree may meet the above selection criteria and still not provide a suitable age and/or height for site determination. The age and height are still recorded in these instances with an "N" placed in the appropriate column. An explanation must be recorded in the comments section of the tally card as to why the age and/or height are not suitable.

The S/H (suitable for height) and S/A (suitable for age) columns are to be filled out for all site trees that are selected. These columns indicate whether the age or height is suitable to be used in compiling age, height and site index for the sample. In these columns, a "Y" means the item is suitable and an "N" means it is not suitable.

The age and height data may be used for purposes such as ecological correlation studies. These studies may require additional screening for tree suitability. The screening will rely on the physiological age values, age prorate information and additional crew comments to screen trees with rot, suppression or other damage.

Examples of trees that would not be suitable for height include:

- Significant broken top (projected height is recorded in the comments for broken top trees).
- Significant dead top.
- Fork or crook that significantly affect height growth.
- Abnormally high amount of scarring or other damage that may have affected height growth (e.g. significant mistletoe infection).
- *Note: significant refers to a reduction in the length of the tree compared to what it would be if undamaged. The reduction is great enough that a reliable site index estimate could not be obtained from the tree measurements.

Examples of tree that would not be suitable for age include:

- The tree is a residual: a residual tree is defined as a living remnant of a former stand; in even-aged stands, the occasional (< 25 per ha) large stem of an older age class than the stand as a whole. Typically these trees may have larger diameters, a higher incidence or indications of decay, thicker bark, larger branching and “ragged” or flat tops. These trees must be clearly residual. Uneven-aged stands do not generally have residual trees.

Core Sample Extraction, Transport and Storage

As the core samples are going to be lab analyzed by the CFS for a number of different purposes, it is very important that the cores be protected from damage and rot. The following procedures outline how to ensure this.

1. Use a 5.5 mm borer to collect the core, as thinner cores are too fragile to survive the handling, transport and processing required.
2. Maintain sharp borers to prevent the inevitable twisting, damage and breakup caused by dull borers.
3. Bore the tree at DBH facing plot center, if possible. If DBH cannot be bored conveniently, record the height of boring; corrections will be made later.
4. Determine the age by a ring count and enter the data in the field count section of the tally card. The count will be the number of full rings. It is up to the field crew to determine when diameter growth has essentially stopped for the season.
5. If you need to “mark” periodic rings to help establish age, please use a pencil, not a pen. Pen marks tend to soak into the core, making later analysis difficult.
6. The pith should be included in sample tree cores as often as possible to ensure accuracy. If you can get within a few years of the pith (relative to the tree age) and can confidently estimate the remainder, there is no need to rebore the tree or use a “physiological” age calculation. Even if the pith was missed, the age can be determined in the lab as long as the measurement of the bark thickness is present. Record the actual age counted on the increment borer core at the level where the tree was bored. Adjustments for years to reach that point will be done in the lab and office analysis.
7. On large trees, or trees that have rotten centers, record the code for rot, age of the sound portion, and the length of the sound core. During the lab and office analysis, the age can be calculated.
8. *Note: age relationships can also be derived from actual stump counts if working near felled road rights-of-way or logged areas.
9. Collect all tree cores in labeled, clear “straws” and return the to the field office. It is important that the straws with the cores in them are stapled (**not taped nor folded**) so that moisture can freely exit the straw. Taped cores will cause the sample to rot, impairing an accurate lab analysis.
10. Clearly record at least the following on the straw in waterproof marker or on self-adhesive, waterproof labels:
    - Date (yy/mon/dd)
    - NFI plot number or local plot number
    - Tree number
    - Species
    - Field age count
11. The samples should be dried as soon as possible in a 70° oven for at least 24 hours. This reduces the moisture content to below 10% and arrests any deterioration by fungi. The cores may be left inside the straws while they are drying in the oven as the straws can tolerate 70° temperatures without melting.

12. If the cores cannot be dried right away, they should be maintained chilled until the end of the field shift, and then dried in a proper drying oven. Note that refrigeration is preferable to freezing the cores as it can cause cell-rupturing due to the build up of ice needles on the sample.
13. Bundle the cores from each sample into groups prior to shipment. The cores should be shipped, if practical, at the end of each field shift after they have been dried.
14. With each bundle, a typed spreadsheet should be included with the following minimum information for each core:
    - Date of collection (yy/mon/dd)
    - NFI plot number or local plot number
    - Tree number
    - Bored Height
    - Tree species
    - Tree DBH
    - Bark thickness
    - Type (e.g. top height, leading species, second leading species, other major species or extra)
    - Comments indicating if the complete core was note included (for example, central portion is rotten or center of tree could not be reached by the increment borer).
15. The samples are to be couriered to the following location:

    c/o **Thierry Varem-Sanders**
    Natural Resources Canada
    Canadian Forest Service
    Northern Forestry Center
    5320 122 Street
    Edmonton, Alberta T6H 3S5
    Phone (780) 435-7292

For photos of core samples and commonly encountered issues from "bad" samples, refer to Appendix H.

Height and Age Information for NFI Reporting

Indexed Variables

Indexed variables for this section include:

- Network label
- Measurement date
- Measurement number
- Tree number

Boring Diameter Outside Bark

1. Measure the diameter outside of the bark at the location of boring.
2. Record the diameter outside bark to the nearest 0.1 cm.

Bored Height

1. Bored height is the height (above the high side ground level) where the boring was made.

2. Record the bored height to the nearest 0.1 m. The bored height in most instances will be 1.3 m (e.g. breast height).

Prorate Data Core Length

When a full boring is not possible, the actual measurements are recorded. In this case, the length of the increment core, from the outer edge inward, upon which the ring count was made.

Age Correction Method

Method to arrive at number of full years of tree growth below the boring height – in some cases it can be measured directly and in other cases it is a modeled estimate.

- D: measured directly
- **M**: modeled

Age correction

Number of full years of tree growth below the boring height, determined either directly on that tree or by means of a modeled estimate. Reported in years and may be entered in the Office.

Total Age

The total age, as determined by the CFS in the lab.

6. Small Tree Plot and Stump Measurements

Small Tree Measurement

A 3.99 m, fixed-radius, small tree plot is established to tally woody shrubs and small trees for the end purpose of compiling gross total biomass. The plot size is kept small to reduce measurement error since a large number of small units are being tallied.

Tallied vegetation includes woody shrubs and small trees with a DBH < 9.0 cm. Note that regeneration woody shrubs and small tree species without a DBH that are less than or equal to 1.3 m in height are clipped in the micro plots.

Procedure

1. At the plot center establish a 3.99 m fixed-radius plot. The edge of this plot may be marked temporarily to ensure accurate measurements. For square plots, the side length is 7.07 m.
2. Measure the live and dead trees with a measurable DBH that is < 9.0 cm. Record the DBH, using the DBH classes listed below. An easy way to measure the DBH classes is by using the same go-no-go tool that is used to measure the woody debris.
   - **1**: > 0.0 cm to 3.0 cm
   - **2**: > 3.0 cm to 5.0 cm
   - **3**: > 5.0 cm to 7.0 cm
   - **4**: > 7.0 cm to 9.0 cm
3. Measure the height of each stem in 1-m height classes.
   - **1**: > 0.0 m to 2.0 m
   - **2**: > 2.0 m to 3.0 m
   - **3**: > 3.0 m to 4.0 m
   - **4**: > 4.0 m to 5.0 m
   - **5**: > 5.0 m to 6.0 m
4. The measured vegetation must have their point of germination within the small tree plot to be measured as “in”. Note: dot tally columns on the field card are provided for convenience in recording.

Measured or Estimated Small Tree Height

1. Indicate whether the small tree height was an actual measurement or if it was estimated (modeled).
   - **M**: small tree height is an actual measurement
   - **E**: small tree height was estimated

Plots with Clumps of Trees or Sucker Growth from Stumps

In some instances, particularly with deciduous species, clumps of stems originating from a common root system or stump that is vegetatively alive are encountered. Some or all of these stems could potentially grow into trees at some time in the future. The sampling intent is to identify the stems which express apical dominance to the best judgment of the field crew.

Procedure

Count the number of stems that appear to express apical dominance. The intent is not to examine each stem in detail but to arrive at a reasonable assessment of numbers within each class.

Stump Measurement

The biomass of self-supporting stumps (defined as less than or equal to 1.3 m in length and 4.0 cm top diameter inside bark or greater) is to be measured in the small tree plot. The center of the stump must lie within the plot in order for it to be measured. Only stumps that are vegetatively dead are recorded.

Stems with heights > 1.3 m are measured as trees in the small or large tree plot.

Stumps, with roots detached from the ground, are to be treated as "woody debris".

Procedure

1. Select the stumps to tally in the 3.99 m radius, small tree plot. Stumps must have a 4.0 cm top diameter inside bark with a center point at the top of the stump that is inside the plot boundary.
2. In a clockwise direction from the north, record the following information for all stumps with a 4.0 cm or greater top diameter inside bark:
   - Species: to the level that it can be assessed by the field crew.
   - Frequency of stumps: if numerous stumps are in the plot (such as after spacing) record them by groups with the same characteristics.
   - Average diameter inside the bark.
   - Length: measure to the nearest 0.1 m (must be less than 1.3 m).
3. To measure the length of broken stumps, visually fold down the broken sections to compensate for the missing parts. Level out the wood on the cross section as you view it from the side to determine stem length.

Small Tree Plot Attributes for NFI Reporting

Attribute	Instructions for reporting
Network label	-NFI label that identifies the point on the network associated with the ground plot. -Enter a value between 1 and 1,600,000. -The ground plots, for the most part, should be located at the center point of the photo plot boxes on the 20 km x 20 km grid network.
Measurement date	-Enter the date of information capture in the field. -The format of entry must be (YYYY-MON-DD) and must be more recent than Jan1, 1995.
Measurement number	-Enter a measurement number between 0 to 999. -A newly established plot will have measurement number = 0. The first re-measurement would be 1, etc. -Measurement numbers must be consecutive.
Plot type	-Enter a three-character plot type: **STC** = circular small tree plot **STS** = square small tree plot
Plot size	-Describes the area of the small tree plot in ha. -Enter the plot size, correct to the nearest 0.001 ha. -The small tree and stump plot size should be between 0.005 to 0.040 ha.

Small Tree Number

1. Small trees are numbered consecutively in ascending order. Ideally, stems should be tagged so that their growth can be monitored during successive re-measurements.

Small Tree Genus, Species and Variety

For the purposes of this inventory, a tree is defined as a woody plant, usually with a single stem and a definite crown that is capable of reaching a mature height of 5.0 m somewhere within its natural range. Small trees have a DBH < 9.0 cm. Note that woody shrubs with a DBH < 9.0 cm will also be measured in the small tree plot. For woody shrub definitions, refer to the micro plot section of this document.

1. Enter a four-character scientific genus code. Use the first four letters of the scientific genus name. For a list of appropriate genus codes, refer to the NFI Design Document, Tree Species Code List Appendix or the appropriate list of woody shrubs applicable to the local area.
2. For unknown coniferous species, use the code, "GENC". For unknown hardwood species, use the code "GENH". For other unknown species refer to the coding conventions in the micro plot section of this document.
3. Enter a three-character scientific species code that corresponds with the abovementioned genus code. Use the first three letters of the scientific species name. For a list of appropriate species codes, refer to the NFI Design Document, Tree Species Codes List Appendix.
4. For unknown species code, use the code, "SPP".
5. Enter a three-character scientific variety code that corresponds with the abovementioned genus and species codes. Use the first three letters of the scientific variety name. For a list of appropriate species codes, refer to the NFI Design Document, Tree Species Codes List Appendix.
6. For unknown variety code, leave the field blank.

Small Tree Status

1. For each tree measured, indicate whether it is vegetatively live or dead:
   - **L**: Live
   - **D**: Dead

Small Tree DBH Class

Enter a one-digit small tree DBH class:

- 1: > 0.0 cm to 3.0 cm
- 2: > 3.0 cm to 5.0 cm
- 3: > 5.0 cm to 7.0 cm
- 4: > 7.0 cm to 9.0 cm

Small Tree Height Class

Enter a one-digit small tree height class for each stem.

- 1: > 0.0 m to 2.0 m
- 2: > 2.0 m to 3.0 m
- 3: > 3.0 m to 4.0 m
- 4: > 4.0 m to 5.0 m
- 5: > 5.0 m to 6.0 m

Measured or Estimated Small Tree Height

Indicate whether the small tree height was an actual measurement or if it was estimated (modeled).

- M: small tree height is an actual measurement
- E: small tree height was estimated

Office-compiled Attributes – Small Tree Plot, Species List for NFI Reporting

The following attributes will be compiled by the CFS based on reported NFI field-measured attributes.

- Small tree volume (m^3)
- Small tree biomass (kg of ovendry material)

7. Woody Debris Transect

Introduction

Woody debris is an important structural component of forest and stream ecosystems. It is linked to biodiversity and ecosystem processes by: providing habitat for a broad range of organisms, playing a key role in energy flow and nutrient cycling, and influencing soil and sediment transport and storage in streams. There is a growing interest in the collection of woody debris information because of the increased recognition of its ecological importance. In addition, there is a need for quantitative data to guide forest management practices.

Woody debris is defined as downed dead wood, which includes sound and rotting logs and uprooted stumps. It is usually described as dead, non-self-supporting, woody material in various stages of decomposition that is located above the soil.

For the purposes of this inventory, three classes of woody debris have been defined:

- Fine woody debris (FWD), pieces > 0 cm and ≤ 1.0 cm in diameter (collected at the micro plots);
- Small woody debris (SWD), pieces > 1.0 cm and ≤ 7.5 cm in diameter at point of intersection; and
- Coarse woody debris (CWD), pieces > 7.5 cm in diameter at point of intersection.

The guidelines in this section describe procedures for collecting SWD and CWD. The collection of FWD is explained in the micro plot section of this document. The three classes of woody debris and the ground sampling component location where they are collected have been summarized in Table 7.

Table 7. Woody debris diameter classes, method and location of collection.

Woody Debris Class	Diameter Class	Method and Location of Collection
Fine woody debris (FWD)	> 0 cm and ≤ 1.0 cm	- Fine woody debris pieces are collected after the shrub and herbs have been measured and clipped. FWD samples are collected, oven-dried and weighed. Only an average decay class is recorded for these pieces. - Collected at the shrub and herb micro plots.
Small woody debris (SWD)	> 1.0 cm and ≤ 7.5 cm	- SWD is tallied for 5 m along the transect line (Figure 2). For ease of tallying purposes, SWD sub-classes have been established. They are: Class 1: >1.0 cm to ≤ 3.0 cm Class 2: >3.0 cm to ≤ 5.0 cm Class 3: >5.0 cm to ≤ 7.5 cm - Only an average decay class for all SWD pieces is recorded. - Collected along the woody debris line transects.
Coarse woody debris (CWD)	> 7.5 cm	- CWD is tallied for 10 m along the transect line (Figure 2). For all pieces > 7.5 cm in diameter, the diameter and decay class by piece is recorded. - Collected along the woody debris line transects.

Woody Debris Definitions

Coarse woody debris (pieces larger than 7.5 cm in diameter):

- Dead woody material located above the soil in various stages of decomposition. CWD must be >7.5 cm in diameter (or equivalent cross section) at point of transect intersection.
- CWD must be non-self-supporting. Trees and stumps (intact in the ground) are considered self-supporting.
- Can also be in the form of felled and bucked logs or log decks.

Small woody debris (pieces larger than 1.0 cm in diameter):

- Dead woody material located above the litter layer, in various stages of decomposition. SWD must be >1.0 cm in diameter and ≤7.5 cm in diameter (or equivalent cross-section) at the point of transect intersection.
- SWD must be non-self-supporting. Trees and stumps (intact in the ground) are considered self-supporting.

Fine woody debris (pieces >1.0 cm in diameter):

- Dead woody material located above the litter layer, in various stages of decomposition. FWD must be ≤1.0 cm in diameter.
- FWD must be non-self-supporting. Trees and stumps (intact in the ground) are considered self-supporting.
- *Note: FWD is collected in sub-classes at the micro plots.

Measured woody debris includes the following:

- All pieces of WD greater than 1.0 cm where the centerline is crossed by the vertically projected transect.
- Fallen or suspended (not self-supporting) dead tree boles, with or without roots attached, that intercept the vertically projected sample line whether the transect passes above or below the WD. WD may be suspended on nearby live or dead trees, other coarse woody debris stumps, or other terrain features. Visually estimate immeasurable suspended WD at the intercept point.
- Fallen trees with green foliage that are no longer rooted to the ground.
- Fallen trees, large branches on the ground surface, and partially buried stumps with an exposed edge.
- Large fallen branches and fallen, broken tree tops that are horizontal or leaning.
- Pieces that are physically attached (lengthwise) are considered to be one piece.
- Recently cut logs.
- Uprooted (not self-supporting) stumps greater than 1.0 cm in diameter and less than 1.3 m in length, and any exposed dead roots greater than 1.0 cm.
- If an organic layer has developed over the wood, the WD in question must have > 50% of its thickness above the surrounding surface. WD is considered no longer above the soil when it is entirely buried beneath a layer of surface organic matter (forest floor) or mineral soil.

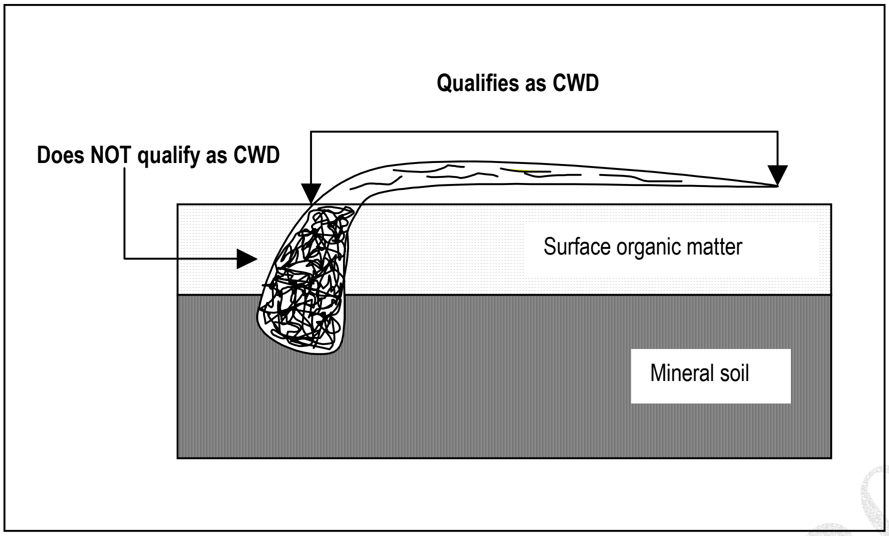


Figure 3. Side view of partially buried coarse woody debris.

Woody debris that is NOT measured includes the following:

- Live or dead trees (still rooted) which are self-supporting.
- Dead branches still connected to standing trees.
- Exposed roots of self-supporting trees.
- Self-supporting stumps or their exposed roots.
- A piece is no longer considered WD when the wood is decomposed to the point where it could be described as forest floor humus.
- Organic matter (surficial accumulations of organic material): organic layers ≥ 1 cm thick overlying layers of decaying wood.
- Large animal droppings.
- Buried wood: woody debris with > 50% below the surrounding surface.

Objectives

1. To determine the gross total biomass of SWD, CWD and FWD.

General Procedures

1. Set out the two, 30.0-metre sampling transects.
2. Assess the transect conditions.
3. Measure and record SWD information.
4. Measure and record CWD information.
5. Set out the range micro plots and collect the FWD (refer to the micro plot section of these guidelines).

Detailed Procedures

Establishing the Woody Debris Transects

Small woody debris (> 1.0 cm diameter ≤ 7.5 cm) and coarse woody debris (> 7.5 cm) are measured along two, horizontal 30-metre line transects that intersect the plot center.

Procedures

1. Establish the first transect at a pre-selected, random azimuth intersecting the plot center.
2. Measure along the random azimuth with a tape to 30.0 metres, correcting all distances to the horizontal.
3. From the plot center outwards, mark the 5.0-m, 10.0-m, and 15.0-m marks along the transect, for example, with a small stick inserted in the ground, flagged with ribbon (temporary marking for quality control), or a small paint mark on the ground.
4. Locate the centers of the four micro plots at distances of 7.0 m from the plot center, as the transects are established.
5. Mark the pieces of coarse woody debris that cross the transect line. The marking should be minimal such as small paint dots or ribbon to assist quality assurance only. Care must be taken to ensure WD pieces are not moved or damaged so that quality assurance checks can be conducted.
6. Number a few of the larger CWD with log marking paint to aid re-measurement and quality control. The marking should be minimal such as small paint numbers or ribbon to assist quality assurance only.
7. Establish the second line at +90° from the first transect commencing, intersecting the plot center.
8. Record the azimuth of each line.
9. Measure the following SWD and CWD, from the plot center outwards, along the transect:
   - From the plot center to 5.0 m mark: measure all CWD greater than 30.0 cm.
   - From 5.0 m to 10.0 m: measure all CWD greater than 7.5 cm.
   - From 10.0 m to 15.0 m (end of transect): measure all SWD and CWD greater than 1.0 cm.
10. From the end of one transect to the opposite end, tally surface substrate information (refer to surface substrate procedures in the next section as well as Figure 4).
11. Continue measuring woody debris from the opposite end of the transect (at the 15.0 m mark) back to the plot center. This method saves redundancy of effort since the transect need only be traversed the minimum number of times in order to measure both woody debris and surface substrate.
12. For the CWD (pieces >7.5 cm in diameter), record standard measurements as per local woody debris measurement protocol.

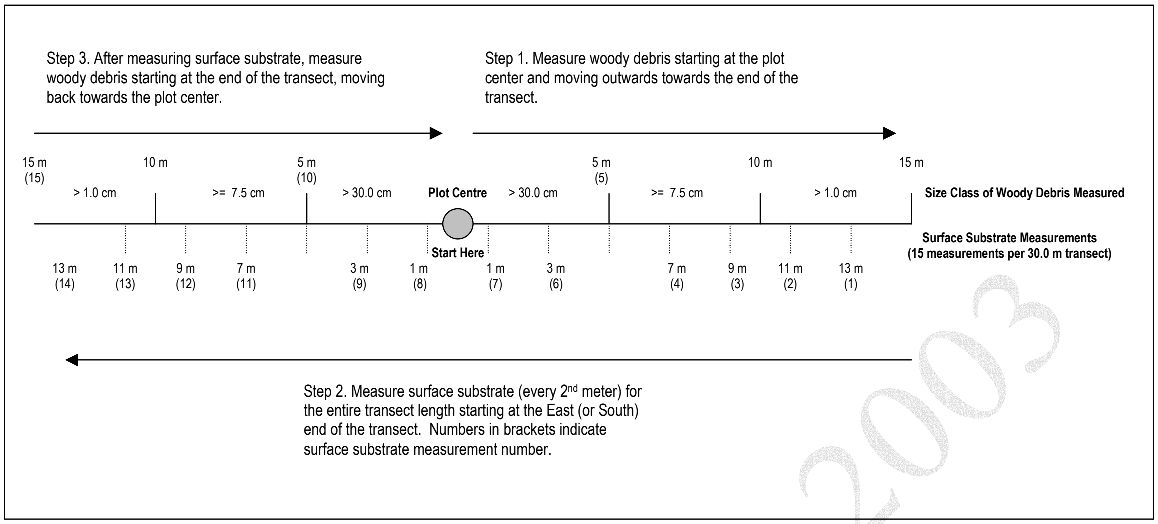


Figure 4. Measurement of surface substrate and woody debris.

13. For the SWD (pieces >1.0 cm diameter ≤7.5 cm), tally the pieces using the sub-classes listed below. Record the number of pieces in each diameter class (the equivalent area for odd-shaped pieces is in brackets). Measure the pieces using a go-no-go tool and tally using a dot-tally method. This will allow for more efficiency in the measurement process. Assign an average decay class for all pieces of SWD.
    - SWD Sub-class 1: >1.0 cm to ≤ 3.0 cm (>0.8 cm² to 7.1 cm²)
    - SWD Sub-class 2: >3.0 cm to ≤ 5.0 cm (>7.1 cm² to 19.6 cm²)
    - SWD Sub-class 3: >5.0 cm to ≤ 7.5 cm (>19.6 cm² to 44.1 cm²)
14. The following conditions should be noted when measuring SWD (> 1.0 cm to ≤ 7.5 cm in diameter):
    - Small woody debris includes wood chunks, bark and cones.
    - Small woody debris should only be measured if it is *above* the litter (L layer).
    - Odd shaped pieces will be estimated as an equivalent round diameter class.
    - Branches, roots etc. (≤ 7.5 cm) that intersect the transect (these may be attached to CWD) are to be measured as SWD or FWD as appropriate.
    - If a crown from a fallen tree is encountered, estimate the number of line intersects and record the average diameter for the group rather than individually measuring each intersection. Examples of woody debris accumulations and how to measure them can be found in the section following.
    - If aerial pieces are encountered only measure the piece if it is located in the shrub layer (e.g. < 1.3 m above ground).

Assessing the Transect Conditions

Normally, the full length of the transect will be sampled. However, because the transects are based on a random bearing, unsafe or difficult conditions may be encountered and you may be unable to sample the full length.

If the full length of the line cannot be sampled, record the distance that was actually sampled, and explain in the Comments section of the tally card why the remainder was not measured.

Possible transect conditions include:

- **Normal conditions** – Sample both 30.0 m transects using the procedures outlined in the previous section.
- **Anomalous conditions** – If the sample line intercepts an anomaly along the transect such as a stream, pond, avalanche chute, or a rock outcrop, continue to sample the line as long as it is safe to do so. If the debris is floating, the pieces are measured in their location at the time of sampling (make a note of this in the Comments section of the tally card).
- **Unsafe conditions** – If the sample line intercepts unsafe conditions, record the length of the line actually sampled in the field. For example, if a cliff was encountered at 19 m, record “horizontal length observed 19 out of 30”. Note in the comments section why a portion was not sampled.

Determining “in” or “out” Woody Debris

In order to be measured, the woody debris must be greater than 1.0 cm in diameter (or equivalent) at the point where the transect crosses the centerline. The centerline of the woody debris is the midline of any section of wood and may not correspond to the pith.

If the transect line appears to follow the centerline of the woody debris, decide whether it is “measured” (transect line crosses centerline of woody debris) or “not measured” (transect line does not cross centerline of woody debris).

Woody Debris Header Attributes for NFI Reporting

Attribute	Instructions for reporting
Network label	-NFI label that identifies the point on the network associated with the ground plot. -Enter a value between 1 and 1,600,000. -The ground plots, for the most part, should be located at the center point of the photo plot boxes on the 20 km x 20 km grid network.
Measurement date	-Enter the date of information capture in the field. -The format of entry must be (YYYY-MON-DD) and must be more recent than Jan1, 1995.
Measurement number	-Enter a measurement number between 0 to 999. -A newly established plot will have measurement number = 0. The first re-measurement would be 1, etc. -Measurement numbers must be consecutive.
Transect number	-Enter the transect number.
Transect length	-Enter the length of the transect to the nearest 0.1 m. In instances where transect has been partially sampled, enter the length of the transect that was sampled.
Transect azimuth	-Enter the azimuth of the transect in degrees (0 to 360).

Small Woody Debris Attributes for NFI Reporting

Attribute	Instructions for reporting
Small woody debris diameter class	-All small woody debris pieces must be > 1.0 cm in diameter and ≤ 7.5 cm in diameter. Small woody debris is sampled in the field using corresponding 'go-no-go' tool assigned diameter classes. -SWD diameter classes are as follows: **1**: > 1.0 cm to ≤ 3.0 cm **2**: > 3.0 cm to ≤ 5.0 cm **3**: > 5.0 cm to ≤ 7.5 cm
SWD tally of pieces by diameter class	-Dot tally of pieces of SWD by diameter class. The method has been implemented in order to speed up the process of measuring many small pieces. -Enter the number of pieces (**1 to 9,999,999**).
SWD decay class	-Small woody debris sampling decay class. An average decay class is assigned to all pieces of small woody debris. Decay classes are based on the majority condition of the entire piece. The five classes used to describe the WD condition are based primarily upon wood texture, and secondarily on other wood characteristics. -For detailed descriptions, refer to the decay class descriptions in the coarse woody debris section following. -Decay class 0 indicates that a decay class was unmeasured or combines all decay classes. -Permitted values include: **0, 1, 2, 3, 4, 5.**

Coarse Woody Debris Attributes for NFI Reporting – Round Pieces

Attribute	Instructions for reporting
Woody debris piece number	-Piece numbers are assigned in ascending order along the transect. -Necessary for tracking pieces during QA program. -Pieces reported in this table must be >7.5 in diameter.
Woody debris genus	-Woody debris genus codes are assigned using the codes listed in Appendix X of the NFI Design Document (Tree List). -Tree list genus codes use the first four letters of the scientific genus name. -If the genus cannot be determined, use the best available information: -For unknown softwood, use **GENC**. -For unknown hardwood, use **GENH**.
Woody debris species	-Woody debris species codes are assigned using the codes listed in Appendix X of the NFI Design Document (Tree List). -Tree list genus codes use the first three letters of the scientific species name. -If the species cannot be determined, use the best available information: -Where the GENUS is known but the SPECIES is unknown, use the first four letters of the scientific genus and species = **SPP**.

Woody debris piece diameter

1. Woody debris piece diameter is measured using calipers or diameter tape.
2. For coarse woody debris (pieces > 7. 5 cm in diameter) record, to the nearest 0.1 cm, the diameter (or equivalent) of the CWD perpendicular to the bole at the point where the transect crosses the CWD.
3. If the sample line intersects a curved or angular CWD more than once, measure each intersection as a separate observation.
4. If the diameter cannot be measured, estimate it.

5. If the cross section is oval rather than circular estimate an “equivalent diameter” that will more accurately suggest the cross-section area. If the cross section is hard to express as a circle (or equivalent as a circle), refer to the procedures for measuring odd-shaped CWD.
6. Estimate an “equivalent” diameter for the remaining portion of CWD where part of the wood has decayed and become part of the soil layer.
7. If a log has split open but is still partially held together, record the equivalent diameter as if the piece were whole. If a stem has shattered into a number of distinct unconnected pieces, record each piece that is larger than 7.5 cm in diameter at the point of sampling.
8. If the CWD is hollow, estimate the diameter equivalent to the remaining wood.

Woody debris decay class

Decay class by piece is only recorded for CWD (pieces > 7.5 cm in diameter). Record the decay class of the WD piece cross section using the classification scheme in Table 8. The emphasis is on the wood texture. Other criteria, such as portion on the ground, twigs, bark, shape, and invading roots, are guidelines to the wood texture.

1. Record the decay class of the CWD piece cross section that intersects the transect.
2. Use the classification scheme shown in Table 8.

Table 8. Woody debris decay class descriptions.

Woody debris decay class	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5
Wood texture	intact, hard	intact, hard to partly decaying	hard, large pieces, partly decaying	small, blocky pieces	many small pieces, soft portions
Portion on ground	elevated on support points	elevated but sagging slightly	sagging near ground, or broken	all of log on ground, sinking	all of log on ground, partly sunken
Twigs < 3 cm (if originally present)	twigs present	no twigs	no twigs	no twigs	no twigs
Bark	bark intact	intact or partly missing	trace bark	no bark	no bark
Shape	round	round	round	round to oval	oval
Invading roots	none	none	in sapwood	in heartwood	in heartwood

Tilt angle

The tilt angle is the angle, measured in degrees, between the central axis of the CWD and the horizontal plane at the crossing point. Tilt angle is only measured for pieces of CWD (> 7.5 cm in diameter).

Measure the angle the CWD makes with the horizontal, regardless of the slope of the ground. On sloped terrain, the slope correction of the transect will compensate for the angle of the terrain. Normally you can place a clinometer on the top surface of the CWD at the point of the intercept and record the angle in degrees.

Coarse woody debris, biomass and volume information – round pieces Office-compiled attributes for NFI reporting

The following list of attributes will be estimated by the CFS following submission of the field-collected attributes.

- Density (g/cm^3)
- Woody debris biomass of round pieces (g)
- Woody debris volume of round pieces (m^3)

Coarse Woody Debris Attributes for NFI Reporting – Odd-Shaped Pieces

Record any odd-shaped CWD encountered in the appropriate section of the tally card.

*Note: it is important that any CWD that is not round or oval in cross-section be recorded in this category. A different volume compilation formula is used because the measurement is made along the transect line, not at right angles to the centerline of the CWD.

Procedure

1. Record the species of the CWD.
2. Measure the full horizontal length and average vertical depth of the CWD along the transect (this gives a rectangular area equivalent to the cross-section along the transect). The length is the full distance along the line intersect. The depth of the cross-section is the average depth along the line intersect.
3. *Note: it is incorrect to measure the length and width, average the values, and record it as a circular cross section.
4. Example: An odd-shaped CWD is 25 cm x 40 cm.

- Consider the cross section as a rectangle and record the 25 and 40 in the accumulations section.
- Record the other information in the same way as in the "standard transect" section for round pieces.

Attribute	Instructions for reporting
Horizontal piece length	-Odd-shaped pieces are measured as a rectangle. The width and height of the rectangle, that represents a cross-sectional area of the piece along the plan formed by the line transect, are measured. -Report to the nearest 0.1 cm.
Vertical piece depth	-Report to the nearest 0.1 cm.

Measuring Accumulations

Piles or heavy accumulations of woody debris may be encountered along the transect where it would be impractical, time consuming and tedious to measure each piece individually. Examples of such situations include: felled and bucked timber, windthrow, logging debris or slash piles, and broken-off tree crowns containing many small branches or cones.

Procedures

1. Record the full horizontal length of the line intercept through the accumulation, and the average vertical depth of the accumulation, to the nearest 0.1 m. Visually compress the pile to measure the actual cross sectional area of wood, not the space between the pieces. Note that the horizontal and vertical cross section is the part which *is along the transect line*, not the average of the entire pile, and woody debris measured in this way is treated as rectangular in cross section.

2. Identify and record the species, as possible using the codes listed in the NFI Design Document, *Tree Species List Appendix*. Estimate the proportion of each, and record length and depth separately for each of the species.
3. If the mixture of species is complex or too difficult to identify, record the appropriate unknown species codes: **GENH** = unknown hardwood, **GENC** = unknown softwood, **GENX** = indeterminable as to whether the piece of woody debris is softwood or hardwood.

Broken-off tree crowns containing many small branches or cones may be partially sampled along the transect. Each transect is individually assessed and a decision to take a sub-sample of the transect is made before establishing each transect. Partial sampling reduces potential errors and sampling time. For example:

- An Engelmann Spruce is encountered along the transect with numerous pieces that qualify as small woody debris (> 1.0 cm and ≤ 7.5 cm in diameter).
- The entire horizontal length of the line intercept through the tree is measured (e.g. 5 m of the line intercepts the tree).
- A sub-sample of the number of SWD pieces is actually counted (e.g. in 20 cm of the transect, 50 pieces of SWD were tallied).
- The total number of pieces in 5 m of the line intercept is calculated. (e.g. 50 pieces of SWD were counted in 20 cm of transect, therefore 5 m of transect would have approximately 1,250 pieces of SWD).

Coarse woody debris biomass and volume information – odd-shaped pieces and accumulations Office-compiled attributes for NFI reporting

The following list of attributes will be estimated by the CFS following submission of the field-collected attributes.

- Density (g/cm^3)
- Woody debris biomass of odd-shaped pieces or accumulations (g)
- Woody debris volume of odd-shaped pieces or accumulations (m^3)

Measurement of Fine Woody Debris

The protocol for sampling of fine woody debris can be found in the Micro Plot section of this document.

8. Surface Substrate

Introduction

In support of NFI requirements for the measurement of total ecosystem carbon stocks (TECS), a need was identified for the collection of data related to surface substrate. An evaluation of surface substrate classifies the ground surface within the ground plot into various types that create significant differences in micro-environment for vegetation establishment. These data will be used in analysis for reports on climate change, criteria and indicators of sustainable forest management, biodiversity and forest health.

The sampling of soil surface organics from one soil pit was deemed an inadequate sample for accurately determining the mass of surface organic C. The previous one-pit sample would be equivalent to measuring just one tree in a plot and assuming all other trees in the plot are the same size. In some forest types, the surface organic contents may be from 20 to 40% of the total ecosystem C and may change significantly, 10 to 20 years following a disturbance (e.g. post-harvest). In order to estimate accurate values of C, the surface substrate and variation in surface organic depth needs to be measured in the field.

For the measurement of surface substrate, the "surface" may include: organic matter, buried wood, decaying wood, bedrock, rock or cobbles and stones, mineral soil or water. Surface substrate definitions are described in Table 9. In many instances, an accurate evaluation may require a thorough investigation of the entire plot and a number of small excavations (with a large knife or small trowel) to determine the thickness of LFH horizons (down to mineral soil) and decaying wood.

Objectives

1. To determine the percent surface substrate for each ground plot, as measured along the woody debris transects.

General Procedures

1. Along the 30-metre woody debris transects, measure and record information for surface substrate type and depth (where applicable) every second meter along the woody debris transect (30 sample points in total for the two transects).
2. For deep organics, measure and record information for surface substrate every 4th m.

Detailed Procedures

1. Record the evaluation as the percentage of ground surface covered by each surface substrate type (the total should equal 100%). Enter 0.0 if a substrate is not present. Applicable surface substrates are defined in Table 9.
2. Surface substrate is measured every other meter, along the two 30-metre line transects intersecting the plot center.
3. Establish the woody debris line transects as per woody debris protocol.
4. Check the box applicable to the surface substrate type, for every 2nd metre along the woody debris transect.
5. For organic and buried wood surface substrate, measure and record the depth in cm, down to the mineral soil. Note that if an organic layer has developed over the buried wood, the buried wood must be > 10 cm thick otherwise it is classed as "organic matter". Where there is a combination of organic and buried wood, tally both types and measure the total cumulative depth of both (down to the mineral soil) and make a note of this condition in the comments section of the tally card.

6. Total the number of surface substrate occurrences in each category.
7. Note: in plots where the organic layer throughout the transect is greater than 40 cm thick, depth measurements need only be recorded every fourth meter of transect, and they would be recorded on the tally card as "organic, depth = 40 cm +" and then a note made in the comments section of the tally card denoting deep organics. The organics can then be further elaborated upon using the profile description from the soil pit.
8. If only a portion of the line falls in deep organics (e.g. a swamp) where the actual measurements would be difficult, an estimate should be made of the interim locations. The maximum depth that would be measured in thick organic layers would be to 40 cm (record the depth as 40 cm+).
9. Anomalous conditions: if the sample point along the transect lands in an anomalous site, such as a squirrel cache (organic), debris pile (decaying wood), or large ant hill (organic or mineral), the surface substrate is classified accordingly and a depth to mineral soil is still measured, where applicable. A note of the encountered anomalous conditions should be made in the comments section. If the sample point lands on a sound log, the sample point should be moved to just beside the log.
10. Surface substrate is measured concurrently with the woody debris measurement as per Figure 2 in the previous section on woody debris. Woody debris is tallied starting at the plot center, moving outwards to the 15-m mark. Surface substrate is also measured along the same transect but on the way back, through the plot center, and all the way to the other end of the transect. The woody debris tally is then completed starting at the far end of the transect, moving back to the plot center.

Surface Substrate Attributes for NFI Reporting

Attribute	Instructions for reporting
Percent surface substrate, organic matter	-Record the proportion of ground surface covered by organic matter. -Report to the nearest percent. -Total for all seven surface substrate classes must add up to 100%.
Average thickness, organic matter	-The average depth (cm) of the organic matter surface substrate (if present).
Percent surface substrate, buried wood	-Record the proportion of ground surface covered by buried wood. -Report to the nearest percent. -Total for all seven surface substrate classes must add up to 100%.
Average thickness of buried wood	-The average depth (cm) of the buried wood surface substrate (if present).
Percent surface substrate, decaying wood	-Record the proportion of ground surface covered by decaying wood. -Report to the nearest percent. -Total for all seven surface substrate classes must add up to 100%.
Percent surface substrate, bedrock	-Record the proportion of ground surface covered by bedrock. -Report to the nearest percent. -Total for all seven surface substrate classes must add up to 100%.
Percent surface substrate, rock	-Record the proportion of ground surface covered by rock. -Report to the nearest percent. -Total for all seven surface substrate classes must add up to 100%.
Percent surface substrate, mineral soil	-Record the proportion of ground surface covered by mineral soil. -Report to the nearest percent. -Total for all seven surface substrate classes must add up to 100%.
Percent surface substrate, water	-Record the proportion of ground surface covered by water. -Report to the nearest percent. -Total for all seven surface substrate classes must add up to 100%.

Table 9. Surface substrate classes and definitions.

Surface Substrate	Definition
Organic matter	Surficial accumulations of organic materials include the following: ▪ organic layers ≥ 1 cm thick overlying mineral soil, cobbles, stones or bedrock; ▪ layers of decaying wood < 10 cm thick; ▪ large animal droppings; and ▪ areas covered by mats of bunchgrasses (mats include L horizons),
Buried wood	The proportion of the ground surface covered by buried wood: ▪ class 5 woody debris with > 50% below the surrounding surface; ▪ does not include freshly fallen material that has yet to decompose; ▪ may be covered by mosses, lichens, liverworts, or other plants; ▪ if an organic layer has developed over the wood, buried wood must be > 10 cm thick otherwise it is classed as "organic matter".
Decaying wood	Fallen trees, large branches on the ground surface, and partially buried stumps with an exposed edge: ▪ does not include freshly fallen material that has not yet begun to decompose (e.g. decay class 1 and 2 logs). Note that if there is a recently fallen class 1 or class 2 log blocking measurement, move the sample point to just beside the log (see anomalous conditions); ▪ may be covered with mosses, lichens, liverworts, or other plants; ▪ if an organic layer has developed over the wood, decaying wood must have > 50% of its thickness above the surrounding surface, otherwise it is classed as "buried wood".
Bedrock	Bedrock includes exposed consolidated mineral material: ▪ may have a partial covering of mosses, lichens, liverworts, or other epilithic plants; ▪ does not qualify as bedrock if covered by unconsolidated mineral or organic material ≥ 1 cm in thickness.
Rock or cobbles and stones	Rock (cobbles and stones) include exposed unconsolidated rock fragments > 7.5 cm in diameter: ▪ may be covered by mosses, lichens, liverworts, epilithic plants (plants attached to an inorganic substrate); or an organic layer < 1 cm in thickness; ▪ does not include gravels < 7.5 cm in diameter.
Mineral Soil	Unconsolidated mineral material of variable texture not covered by organic materials: ▪ may have a partial cover of mosses, lichens, and liverworts; ▪ often associated with cultivation, tree tip-ups, active erosion or deposition, severe fires, trails, or late snow retention areas; ▪ includes small cobbles and gravel < 7.5 cm in diameter; ▪ areas of living grass or forb cover where mineral soil is visible between stems are classed as mineral soil, as are exposed Ah or Ae horizons.
Water	Streams or areas of open water in bogs or fens. Note: this does not include "casual" or non-permanent water. The sample point should be recorded to reflect the conditions at the time of sampling, e.g. a gravel or sandbar below the high water mark for a stream would be recorded as mineral soil.

9. Site Characteristics, Vegetation and Micro Plot

Introduction

An ecological plot with a 10 m radius, centered on the plot center, will be used to collect vegetation data from the tree and shrub layers and for the site characteristic descriptions.

Four micro plots, each with a radius of 0.56 m and an area 0.0004 ha are used for measuring gross total biomass of shrubs and trees < 1.3 m in height, herbs and grasses, mosses and lichens, as well as fine woody debris (woody material ≤ 1.0 cm in diameter). The following guidelines describe a methodology that can be applied for the clipping of the shrub and herb micro plots and the collection of fine woody debris.

These data are important as they can aid in ecosystem restoration and management decisions, forest health evaluations, biodiversity and animal habitat suitability. In addition, plant succession information, as interpreted from this information, can provide data to improve fire and fuel management decisions.

Objectives

1. To collect accurate information about plant species composition in NFI ground plots.
2. To identify, estimate and measure selected site features to provide a record of conditions at NFI sample plot locations.
3. To determine successional characteristics of the stand.
4. To describe forested as well as non-forested ecosystems.
5. To collect clippings of woody shrubs and small trees ≤ 1.3 m in height, herbs and grasses, mosses and lichens from micro plots for use in the estimation of gross total biomass.
6. To collect fine woody debris material (woody material ≤ 1.0 cm in diameter).
7. To sample the forest floor organics for analysis of gross total biomass, carbon and nitrogen.

Definitions

Where indicated, definitions are from *A Glossary of Terms Used in Range Management*, Society for Range Management (S.R.M.) 1989.

Forbs

Are any broad-leafed herbaceous plants except Gramineae (or Poaceae), Cyperaceae and Juncaceae families (S.R.M.) and, for forage measurement purposes, include ferns and fern allies, club mosses and horsetails.

Graminoids

Are grass or grass-like plants (sedges and rushes) such as *Poa*, *Carex*, and *Juncus* species (S.R.M.).

Shrubs

A plant that has a persistent woody stem and a relatively low growth habit and that generally produces several basal shoots instead of a bole. If differs from a tree by its low stature (generally less than 10 m) and non-treelike form (*Glossary of Range Terms*, Ministry of Forests 1994).

Stolon

A horizontal stem which grows along the surface of the soil and roots at the nodes (S.R.M.). A stoloniferous plant is a plant that has stolons.

General Procedures

1. Establish woody debris transects.
2. Establish shrub and herb micro plots.
3. Establish the main ecological plot boundary (10.00 m radius), centered on the plot center.
4. Describe the vegetation in the ecological plot before the site is trampled too much.
5. Record the site information, plot disturbance, plot origin, and plot treatment information (this may require the use of other collected data sources).
6. Clip and collect the shrubs and small trees < 1.3 m in height within the boundary of the micro plot (0.56 m fixed-radius plot).
7. Clip and collect the herbs and grasses, mosses and lichens.
8. Clip and collect fine woody debris (pieces ≤ 1.0 cm in diameter).
9. Collect the forest floor organic and bulk density soil samples (unless they are being collected at the soil pit).

Detailed Procedures

Main Ecological Plot and Micro Plot Establishment

1. The main ecological plot is a 10.00 m radius, centered on the plot center. If is used to collect vegetation data from the small tree and shrub layers (<1.3 m in height), and for site description.
2. In order to evaluate certain attributes like succession interpretation, it may be necessary to look beyond the 10.00 m radius, main ecological plot to an approximate radius of 25.00 m around the plot center, depending on the attribute, site variability, and topographic breaks.
3. Using the already established, woody debris transects, establish four micro plots at points 7.0 m (use horizontally corrected distance) from the plot center. Each micro plot has a radius of 0.56 m.
4. The micro plots are used to sample shrub and herbs, grasses, mosses and lichens and fine woody debris. They may also be used to sample the forest floor organics and bulk density soil samples (unless they are being collected at the soil pit).
5. The micro plots involve destructive sampling practices. For this reason, they may be offset 1 m from the woody debris transect or they may be placed at the end of the transects in a representative location (buffer) outside of the large tree plot, so that they do not interfere with the woody debris and shrub and herb quality assurance checking procedures administered by each inventory program. If the plots are not located along the woody debris transect, their location should be well noted in the Comments section of the tally cards.
6. Following the clipping of shrubs and herbs and the collection of the fine woody debris, mark the micro plot center with a metal stake and scribed tag to ensure that the same micro plot will not be clipped again in succeeding years.
7. Plans for the re-measurement of the micro plots have not been finalized yet. Currently, the proposed method for re-measurement is:
8. When it comes time for re-measurement, place the micro plot center **2 m outwards** from the previous micro plot center location. In other words, at establishment, the micro plot center will be located 7.0 m from the large tree plot center, along the woody debris transect. For the first re-measurement, the micro plot center will be located 9.0 m from the large tree plot center, along the woody debris transect. For the second re-measurement, the micro plot center will be located 11.0 m from the large tree plot center, along the woody debris transect.

Site Information Attributes for NFI Reporting

Attribute	Instructions for reporting
Network label	-NFI label that identifies the point on the network associated with the ground plot. -Enter a value between **1 and 1,600,000**. -The ground plots, for the most part, should be located at the center point of the photo plot boxes on the 20 km x 20 km grid network.
Measurement date	-Enter the date of information capture in the field. -The format of entry must be (**YYYY-MON-DD**) and must be more recent than Jan1, 1995.
Measurement number	-Enter a measurement number between **0 to 999**. -A newly established plot will have measurement number = 0. The first re-measurement would be 1, etc. -Measurement numbers must be consecutive.
Province	-Enter a code describing the province or territory that the data corresponds with. **BC**: British Columbia **AB**: Alberta **SK**: Saskatchewan **MB**: Manitoba **ON**: Ontario **QC**: Quebec **NS**: Nova Scotia **NB**: New Brunswick **PE**: Prince Edward Island **NL**: Newfoundland and Labrador **NU**: Nunavut **NT**: Northwest Territories **YT**: Yukon Territory
Ecozone	-Refer to terrestrial ecozone map (Environment Canada 2002). May be obtained from GIS coverage intersected with plot location data. **1**: Arctic Cordillera **2**: Northern Arctic **3**: Southern Arctic **4**: Taiga Plains **5**: Taiga Shield **6**: Boreal Shield **7**: Atlantic Maritime **8**: Mixedwood Plains **9**: Boreal Plains **10**: Prairies **11**: Taiga Cordillera **12**: Boreal Cordillera **13**: Pacific Maritime **14**: Montane Cordillera **15**: Hudson Plains

Attribute	Instructions for reporting
Latitude	-Record the latitude that describes the center point location of the ground plot (between **41.00000 to 84.00000**) in decimal degrees. -The latitude may not correspond exactly with the photo plot but it must be within 2 decimal places. -Typically the location of the grid point and reported to the nearest m. -Recorded from GPS information in the field.
Longitude	-Record the longitude that describes the center point location of the ground plot (between **–52.00000 to –142.00000**) in decimal degrees. -The longitude may not correspond exactly with the photo plot but it must be within 2 decimal places. -Typically the location of the grid point and reported to the nearest m. -Recorded from GPS information in the field.

Slope (%)

Record the slope gradient to the nearest percent. On uniform conditions, assess slope by averaging over a 100 m distance (50 m above and below the plot center). If there is a major topographic break in the slope, measure only to the break point.

Aspect (°)

Record the orientation of the downward slope (in degrees) using a compass bearing. Level ground (less than 2% slope) has no aspect; code as 999. If the aspect is "due north" the value is recorded as "0" degrees.

Elevation

Enter an elevation value in meters. It may be up to 5-digits in length. Accuracy of the measurement may be confirmed by consulting with a topographic map. Record an estimate of the accuracy of the value.

Land Base

Land base is a unique, one-letter identifier for the first level of the *Land Cover Classification System* from the NFI Design Document. It signifies the presence or absence of vegetation within the boundaries of the large tree plot. All NFI ground plots must be established in vegetated and treed conditions.

1. Enter a one-letter land base code.
2. Land base will be one of:
   - **V** = vegetated
   - **N** = non-vegetated
   - **M** = unreported

Land Cover

Land cover is a unique, one-letter identifier for the second level of the *Land Cover Classification System* from the NFI Design Document. It signifies the presence or absence of trees for vegetated plots and land or water for non-vegetated plots.

1. Enter a one-letter land cover code.
2. For vegetated plots, land cover will be one of:
   - **T** = treed
   - **N** = non-treed
3. For non-vegetated plots, land cover will be one of:
   - **L** = land
   - **W** = water.
4. For neither vegetated nor non-vegetated plots, M = unreported.

Landscape Position

Landscape position is a unique, one-letter identifier for the third level of the *Land Cover Classification System* from the NFI Design Document. It signifies the location of the plot relative to drainage.

1. Enter a one-letter landscape position code.
2. Landscape position will be one of:
   - **W** = wetland: Land having a water table near, at, or above the soil surface, or which is saturated for a long enough period to promote wetland or aquatic processes. These wetland processes are indicated by the presence of Organic or Gleysolic soils and hydrophytic vegetation. See wetland definitions later in this Appendix for a more complete description.
   - **U** = upland: A broad class that includes all non-wetland ecosystems that range from very xeric to hygric soil moisture regimes.
   - **A** = alpine: A polygon is considered Alpine when it is treeless (for practical purposes less than 1% tree cover can be included within the Alpine category), with alpine vegetation dominated by shrubs, herbs, graminoids, bryoids, and lichens. Rock, ice, and snow dominate much of the Alpine. Alpine does not typically include the parkland and krummholz forest types. Alpine is a classification level of Non-Treed areas above the tree line only.
   - **M** = unreported

Vegetation Type

Vegetation type is the fourth level of the *Land Cover Classification System* from the NFI Design Document. It signifies the distinct type of vegetated or non-vegetated condition of the land base within the plot.

1. Enter a two-letter vegetation type code.
2. Vegetation type codes are listed in Table 10.

Table 10. Vegetation type codes.

Plot Type	Code	Vegetation Type
Vegetated, treed plots	**TC**	Treed, coniferous
	TB	Treed, broadleaf
	TM	Tree, mixedwood
Vegetated, non-treed plots	**ST**	Shrub, tall
	SL	Shrub, low
	HE	Herb
	HF	Herb Forb
	HG	Herb Graminoid
	BY	Bryoid
	BM	Bryoid Moss
	BL	Bryoid Lichen
Non-vegetated plots	**SI**	Snow/Ice
	RO	Rock/Rubble
	EL	Exposed land
Water plots	**WA**	Water
Unreported	**MI**	Unreported

Density Class

Density class is a unique identification code for the fifth level of the *Land Cover Classification System* from the NFI Design Document.

1. Enter a two-letter density class code.
2. Density class will be one of the codes listed in Table11.
3. Note that "Open" has two definitions for open vegetated plots depending on the cover type. Shrub or herb cover is considered open between 26% and 60% crown closure whereas bryoid cover is considered open when crown closure is less than or equal to 50% of the plot.

Table 11. Density class codes.

Plot Type	Code	Vegetation Type
Vegetated plots	DE	Dense: >60% crown closure
	OP	Open: 26-60% crown closure (shrub/herb) or ≤50% crown closure (bryoid)
	SP	Sparse: <26% crown closure

Stand Structure

Stand structure is the structure of the prevailing forest cover in the plot.

1. Enter a four-letter stand structure code. Stand structure will be one of the following:
   - **SNGL** = Single storied
   - **MULT** = Two or more distinct canopy layers
   - **COMP** = Complex, non-distinct layers

Successional Stage

Succession is a series of dynamic changes in ecosystem structure, function, and species composition over time as a result of which one group of organisms succeeds another through stages leading to a potential natural community or climax stage (Dunster, 1996). For the purposes of this inventory, the succession stage represents a snapshot in time of the vegetation dynamics occurring in the plot.

Succession interpretations are based on the majority condition of the large tree plot. As the sample may cover more than one land cover type, the succession interpretation which best describes the plot location is recorded.

1. Enter a two or three-letter succession stage code from Table 12.

Table 12. Succession stage codes (Dunster, 1996).

Succession Stage	Code	Description
Early seral stage	ES	The period from disturbance to crown closure of conifer stands managed under the current forest management regime. Grass, herbs or brush are abundant. A period of high diversity, often suitable for a broad group of plants and animals.
Mid-seral stage	MS	The period in the life of a forest stand from crown closure to first merchantability, usually ages 15 to 40 years. Due to stand density, brush, grass or herbs rapidly decrease in the stand. Hiding cover may be present. A period of declining diversity, suitable for a narrower group of plants and animals.
Late seral stage	LS	The period in the life of a forest stand from first merchantability to culmination and mean annual increment (MAI). During this period, stand diversity is minimal, except that conifer mortality rates will be fairly rapid. Hiding and thermal cover may be present. Forage is minimal.
Mature seral stage	TS	The period in the life of the forest stand from culmination of MAI to an old-growth stage. This is a time of gradually increasing stand diversity. Hiding and thermal cover, and some forage may be present.
Old growth seral stage	OG	Represents the potential plant community capable of existing on a site and is determined by the frequency of natural disturbance events. This final stage continues on until stand replacement occurs and the secondary succession process starts again. In forests where there are long periods between natural disturbance events, the overall forest structure will tend to be more even-aged than forest types undergoing more frequent disturbances.

Office-Compiled Site Information Attributes for NFI Reporting

The following list of attributes will be compiled by the CFS based on reported Field-measured attributes.

- Plot-level, total large tree volume, standing live
- Plot-level, total large tree volume, standing dead
- Plot-level, total large tree volume, fallen live
- Plot-level, total small tree volume, live
- Plot-level, total small tree volume, dead
- Plot-level, annual gross volume increment
- Plot-level, large tree biomass
- Plot-level, small tree biomass

- Plot-level, shrub and herb biomass
- Plot-level, fine woody debris biomass
- Plot-level, small and coarse woody debris biomass

Plot Disturbance Attributes for NFI Reporting

Natural Disturbance Agent

For the purposes of this inventory, a natural disturbance agent is described as a discrete force that has disrupted the structure and/or composition of the plot vegetation during the last 10 years. In other words, the normal growth pattern and/or structure of the vegetation, resource, substrate availability or the physical environment (e.g. natural pattern of the landscape) in the ground plot has been altered.

1. Enter an agent of natural disturbance (up to 12-characters in length) as observed in the field. Agents of natural disturbance are listed in Table 13.

Table 13. Natural disturbance agent codes.

Attribute/Code	Description
FIRE	Plot has experienced a fire.
WIND	Vegetation in plot has experienced windthrow.
SNOW	Vegetation in plot has experienced significant snow damage
INSECT	Vegetation in plot has experienced insect attack. Note: it can take several years of defoliation to do permanent damage to the vegetation. The threshold for significant defoliation varies with the type of pest.
DISEASE	Vegetation in plot has experienced a disease outbreak.
EROSION	The wearing away of soil by any natural process that causes a removal of tree cover over a large portion of the plot.
ICE	Vegetation in the plot has experienced ice damage.
OTHER	Plot has experienced other disturbances. The code, “Other” can be replaced by a word that better describes the type of disturbance agent, e.g. “Flooding”.
UNKNOWN	Site Disturbance is unknown.

Disturbance Year

1. Enter a four-digit number the estimates the year of the disturbance event.
2. The disturbance year must be related to the disturbance agent and may be obtained by consulting historical management records.

Extent of Disturbance (%)

1. Enter a percent value (between 50 and 100%) for the extent of the disturbed area in the plot.

Extent of Tree Mortality

1. The percentage of the trees within the ground plot that have experienced mortality as a result of the natural disturbance.
2. Enter a percent value that describes the extent of the tree mortality that has occurred in the plot as a result of the natural disturbance. For example, 50% of the stems in the plot were damaged by fire and are now dead.

Mortality Basis

1. Mortality basis is a qualifier that goes with the extent of the tree mortality.
2. Enter a two-letter code for the mortality basis from the following:
   - VL = Volume
   - BA = Basal area
   - CA = Crown area
   - ST = Stem numbers
   - AR = Area

Specific Disturbance Agent

1. This field is for comments describing a notable disturbance event that has occurred during the last 10 years.
2. Examples of typical comments that might be entered in this field include: the name of the specific disturbance agent, e.g. "ARMILLARIA", "SPRUCE BUDWORM" or a number of specific erosion agents including:
   - Natural erosion caused by soil stability,
   - Erosion caused by surface water runoff,
   - Erosion caused by avalanche,
   - Erosion caused by harvesting operations (including roads),
   - Erosion caused by heavy equipment traffic,
   - Erosion caused by road construction (other than harvest roads),
   - Erosion caused by mining,
   - Erosion caused by forest fire,
   - Erosion caused by wind,
   - Other cause of erosion,
   - Cause of erosion not known.
3. Enter a specific disturbance agent or comment related to the specific disturbance agent, up to 100 characters long.

Plot Origin Attributes for NFI Reporting

Vegetation Cover Origin

1. Many vegetation cover origins may be present in the plot at the same time. For example, secondary succession may be present in addition to regeneration after harvest.
2. Enter the four-character codes corresponding with the vegetation cover origins present in the plot:
   - **SUCC** = The establishment of trees through secondary succession
   - **HARV** = Regeneration after harvest
   - **DIST** = Regeneration after disturbance other than harvest
   - **AFOR** = Aforestation, the establishment of trees on an area that was lacking in forest cover for some time or that was never forested
   - **UNK** = Vegetation cover origin is unknown

Type of Regeneration

1. Type of regeneration describes the natural or artificial method used in the continuous renewal of vegetation within the ground plot (e.g. the establishment of new, young trees).
2. Enter the three-character codes that describe the methods used for regeneration in the plot:
   - **NAT** = Natural regeneration
   - **SUP** = Natural regeneration with supplementary planting (< 50% of the area)
   - **PLA** = Planted regeneration
   - **SOW** = Seeded regeneration

Year of Regeneration

1. Regeneration year is an estimate of the year of regeneration. It must correspond with the vegetation cover origin.
2. It may be obtained by consulting historical information or management records.
3. Enter a four-digit (YYYY) year of regeneration.

Plot Treatment Attributes for NFI Reporting

Treatment Type

1. For the purposes of this inventory, treatment type describes an anthropogenic activity or silvicultural treatment that applies to the vegetation within the plot.
2. Enter the applicable two-letter treatment type(s) using the codes listed in Table 14.

Treatment Year

1. Treatment year is an estimate of the year of the treatment. It must be related to the Treatment Type and can be determined using historical or management records.
2. Enter a four-digit treatment year.

Treatment Extent

1. Treatment extent is expressed as a percentage of the total ground plot area that has an applicable treatment type.
2. Enter a two or three-digit treatment extent. Report treatment extent to the nearest percent.

Table 14. Treatment type codes.

Code	Treatment Description
CC	Clear-cut: the stand has been harvested in full, e.g. > 80% (by crown area) of the previous forest cover has been removed.
PC	Partial-cut: the stand has been harvested in part, e.g. < 80% (by crown area) of the previous forest cover has been removed.
DC	Deforestation: the long-term removal of trees from a forested site to permit other site uses. The cutting of trees followed by regeneration is not deforestation.
CL	Cleaning: including brushing and weeding, herbicide.
JS	Juvenile spacing: the retention of trees at fixed intervals with all the other trees being cut down.
PR	Pruning.
PT	Pre-commercial thinning: a silvicultural treatment to reduce the number of trees in young stands (improve spacing), carried out before the stems are large enough to be used or sold as a forest product. The intent is to concentrate growth per unit area on fewer stems, thus increasing mean stand diameter, retaining more live crown, creating opportunities for commercial thinning, accelerating stand operability, and improving wildlife habitat.
CT	Commercial thinning: a partial cut in older, immature stands, where trees have reached merchantable size and value, to provide interim harvest while maintaining a high rate of growth on well-spaced, final crop trees.
FT	Fertilization.
SP	Site preparation (mechanical/chemical).
PB	Prescribed burning.
OT	Other.

Describing Vegetation

1. Species codes consist of the first **four** letters of the genus and the first **three** letters of the species.
2. Each province is responsible for providing its field crews with master lists of vegetation species to ensure that the correct codes are being used. These master lists of micro plot vegetation species will be submitted to the NFI upon data submission.
3. If the genus is known but not the species, record all the characters (up to 7) in the genus. For example, if an unknown lichen of the *Cladonia* genus is collected, it is coded as CLADONI. A grass of the *Poa* genus would be coded as POA_ _ _ _. If the grass is known to be *Poa alpina*, it would be coded as POA_ ALP.
4. If the genus is unknown but the plant family is known, record the first 6 letters of the family name, and collect a specimen in an envelope for determination. For example, several species from the sunflower family could be recorded as ASTERA1 and ASTERA2, rather than as HERB1 and HERB2.
5. Assuming the species is unknown, use the following coding priority for vascular plants:
   - genus > family > non-Latin code such as “FERN”.
6. Since family names are not widely documented for lichens, liverworts, and mosses, the coding priority for these non-vascular unknown species is:
   - genus > non-Latin code such as “MOSS”.
7. As a general rule, the non-Latin unknown code uses 4 letters (MOSS), the family code uses 6 letters (ASTERA), and the genus code uses 7 (VACCINI) or fewer if there are not 7 available (POA, CAREX, SALIX). Refer to Table 15 for suggested coding conventions for collected unknown species.

Collecting Unknown Species and Voucher Specimens

1. Collect a sample for any species that cannot be identified or for which a percentage should be recorded.
2. Depending on the project, voucher specimens may be required. Voucher specimens are samples collected, preserved, and stored to later verify identifications in the field.
   - For trees, low shrubs, and tall shrubs, collect representative samples of flowers, fruits/cones, bark, a branch with leaves (needles) showing branching patterns. Record the height of plants when they are not collected as an intact specimen; this would obviously apply to trees and most shrubs.
   - For herb-layer species collect the entire plant or as much of the plant as feasible, including roots and, in particular, any flowering structures.
   - For mosses and lichens, collect a “palm-of-the-hand”-sized sample. Try to include moss capsules and lichen apothecia.
3. The following points will ensure good-quality specimens:
   - Use appropriate containers: paper bags, envelopes, plastic bags (allow air in occasionally).
   - Press or process as soon as possible.
   - Keep different genera separated.
   - Keep moss/lichen samples separated and un-pressed to maintain their three-dimensional form.
   - Cross-reference to item number on field card.
4. Complete a waterproof plant label for each plant sample to be identified. Concentrate on microsite conditions directly associated with the plant, rather than duplicating general habitat or site information for the large tree plot. Typical microsite habitat information includes:
   - Soil or substrate conditions (humus, decaying wood, fibric organic soil, coarse-textured or fine-textured mineral soil, disturbed or recently mixed soil, soil moisture and nutrient conditions, salinity).
   - Drainage (seepage track, stream or pond margin, depressional hollow or shedding mound).
   - Exposure and other physical factors (growing in open exposed or in relatively protected/shaded conditions, in an avalanche or a slide track, exposure to periodic or frequent flooding from standing or moving water).
5. Record only the most applicable microsite conditions, such as in these examples: “associated with an exposed seepage draw in saturated nutrient-poor organic soil; growing in steep well-drained mor humus beneath a large canopy gap; on disturbed sandy mineral soil associated with overturned tree roots; in a rocky south-aspect grassy patch with coarse well-drained dark soil.”
6. In the descriptive notes, include diagnostic characteristics which may not be obvious from a casual look. Examples of useful additional descriptive information include:
   - Distribution and abundance (solitary individuals in a scattered pattern; common and growing in small clumps; several large clumps within the plot; continuous coverage).
   - Leaves (leaves feel slightly sticky; fresh leaves have a cucumber scent when crushed; blades have an undulating margin).
   - Associated species (with skunk cabbage and lady fern; within clumps of *Cladonia* spp., in patches with *Veratrum*, *Fauria* and *Sphagnum*).
7. Keep documentation on the labels as concise and applicable as possible. Do not allow labels to become separated from their relevant plant samples.

Table 15. Suggested coding conventions for collected unknown vegetation species.

Code*	Description
"*genus*"	code first 7 letters of genus
"*family*"	code first 6 letters of family
TREE	coniferous or deciduous tree
SHRU	coniferous or deciduous shrub
SEED	coniferous or deciduous seedling
HERB	herb (catch-all for herb-layer species)
LYCOPO or CLUB	clubmosses belong to one family *Lycopodiaceae* clubmoss
SELAGIN	lesser-clubmosses belong to one genus *Selaginella*
EQUISET or HORS	horsetails belong to one genus *Equisetum* horsetail
FERN	fern
GRAM	graminoid (grass, rush or sedge)
POACEA or GRAS	grasses belong to one family *Poaceae* grass
JUNCAC or RUSH	rushes belong to one family *Juncaceae* rush
CYPERA or SEDG	sedges belong to one family *Cyperaceae* sedge
SAPR	saprophyte or parasite
LICH	lichen
LIVR	liverwort
MOSS	moss

*CODE: add numbers to the codes for multiple samples. For example, CLADONI3, CAREX2, CYPERA3, VIOLAC2, HERB3, LIVR2, MOSS4.

Recording Species Codes

1. Record all vegetation growing in the micro plot, using codes based on the scientific names. A list of scientific names with codes should be provided by a local ecologist for an inventory project. Collect samples of any unknown species, bag and label them for later identification by specialists. Record the item number from the field card on the tagged plant sample as a cross-reference.
2. Maintain a systematic method of recording the species in the plot. The results are much easier to read and compile. One common method is to record species by strata, starting with the uppermost stratum, and within strata by abundance.
3. In some circumstances it may be necessary to collect the plant list at another time of the year to take advantage of peak floristic conditions.
4. Certain ecosystems are more difficult to sample (for example, alpine, sub-alpine meadows, wetlands, riparian edge communities, grasslands, rock outcrops, and disturbed sites with introduced weedy and non-native species). It may be necessary to have these plots sampled by specialists.

Estimating Percent Coverage by Layer

Percent cover is estimated as the percentage of the ground surface covered by a vertical projection of the crown of the plant onto the ground surface. When estimating percent cover, care must be taken not to bias estimates because of crown density. Except for distinct holes in the crown, the area within the perimeter of the crown is assumed to be fully covered. It is required that percent cover be recorded for each species in the plot. The values are estimates that will vary somewhat between individuals however; the relative cover values are required to provide information on species abundance.

Regarding species of very low coverage, it is not expected that an exhaustive list be recorded. It is easy to overlook a few species given the seasonal variation in flowering and vegetative production. Species of very low coverage, less than 0.1 percent can easily be missed by anyone. Focusing on the main substrate that, in most forested ecosystems, is the forest floor can save time and energy.

1. Initially, record an estimate of overall coverage (in percent) in each layer (all species), excluding any overlapping. Use this overall estimate as a value to help calibrate cover estimates for individual species.
2. Estimate the coverage for each species in the shrub/herb and moss layers within the micro plot.
3. If the total of individual species percentages in a layer is less than the overall total, adjust cover estimates for individual species or totals.
4. If the cover of a species overlaps within a stratum, then the total percentage may be considerably less than the sum of individual layer coverages, but never more. Do not sum the individual cover values to compute the overall coverage.
5. Vegetation layers and their respective descriptions/definitions are listed in Table 16.

Table 16. Vegetation Layer Codes.

Code/Layer	Description/Definition
1=Shrub layer	Includes all woody plants and trees < 1.3 m in height without a DBH. Shrub: A woody perennial plant differing from a perennial herb in that it has a persistent woody stem and a relatively low growth habit and that generally produces several basal shoots instead of a bole. It differs from a tree by its low stature and non-treelike form.
2=Herbaceous	Includes all herbaceous species regardless of height. Includes herbs, forbs, and graminoids. Herb: Any seed-producing plant whose above-ground parts are composed of non-woody tissue and are non persistent; includes forbs and grasses. Forb: Any broad-leaved, herbaceous plant other than those in the Poaceae (Gramineae), Cyperaceae, and Juncaceae families. Grass: Plants in the family Gramineae, whose characteristics include stems that are jointed at nodes, are hollow, have sheathing leaves, and inflourescences surrounded by glumes. Grass roots may be fibrous, rhizomatous, or stoloniferous. Many grasses have basal meristems, unlike other plants that have apical meristems. Includes sedges and rushes such as Poa, Carex and Juncus species.
3=Mosses, lichens and liverworts	Moss: A plant in the division Bryophyta, class Musci. Lichen: Plants found in the phylum Mycophycophyta in the kingdom Fungi. Lichens are symbiotic organisms created by the association of a fungus (usually an Ascomycete) with a green algae or a cyanobacterium.
4=Fine woody debris	Fine woody debris, e.g. dead and downed woody material ≤ 1.0 cm in diameter.

Clipping the Micro Plot

1. Clip all shrub and herb species at ground level in accordance with provincially applicable species list.
   - Clip herbs or shrubs if the germination point is within the plot.
   - A plant is considered “in” or “out” of the plot depending on the germination point where the plant enters the soil.
   - A stolon from a stoloniferous plant (such as wild strawberry) rooted within the plot is considered part of the plot. (Clip the stolon at the plot boundary if the stolon is rooted outside the plot perimeter.)

- A non-rooted stolon connected to a stolon rooted within the plot is considered part of the plot.
- If a plot splits a large clump of grass (where the germination point is not easily determined) then clip the portion within the plot.
- If the base of the forage is in standing water, clip the material below water line as the 2 cm height if practical. If not practical, clip the material at the water line and record an estimate of the potion clipped in the comments.
- Clip doubtful forb species.

2. The moss layer is collected separately. It is snipped using larger, angled shears or it can be pulled out. Care should be taken to clip the living mosses at the base of the green, photosynthetic material. The moss layer must be removed before the forest floor organic sample is taken. The brown part of the moss layer is included as part of the forest floor organic sample.
3. If slime molds and mushrooms are encountered, these will be included with the moss and lichen samples.
4. Place the clipped samples in collection bags. There should be four separate sample bags from the micro plots:
   - shrubs: includes all woody shrubs and small trees ≤ 1.3 m in height (one bag combined from all four micro plots)
   - herbs: includes herbs, forbs and graminoid species regardless of height (one bag combined from all four micro plots)
   - fine woody debris: all woody material ≤ 1.0 cm in diameter (one bag combined from all four micro plots)
   - mosses, lichens, slime molds and mushrooms (one bag combined from all four micro plots)
5. It is appropriate to air dry the sample before oven drying. To air-dry, leave the forage in paper bags open in a warm, dry room for several days as necessary to remove excess moisture. Rotate the forage in the bags to ensure even drying and to prevent decomposition.
6. Complete the sample labels and return the bags to the field office where they will be oven dried to a constant weight (70°C for 72 hours), weighed to the nearest 0.01 g and the information recorded.

Collection of Fine Woody Debris

1. Collect all fine woody debris less than or equal to 1.0 cm in diameter within each of the micro plots which is above the litter layer.
2. Clip pieces less than or equal to 1.0 cm at the plot edge. Collect all pieces less than 1.0 cm in diameter within the micro plot.
3. If a piece within the micro plot is less than or equal to 1.0 cm at one end of the piece and greater than 1.0 cm at the other end clip the piece at the larger end (greater than 1.0 cm diameter) and collect the portion less than or equal to 1.0 cm. For example, if a large woody debris piece located in the micro plot has fine branches less than or equal to 1.0 cm these would be clipped at the tree bole or at greater than 1.0 cm and collected.
4. Pieces that extend into the litter layer will be clipped at the surface of the litter layer.
5. Collect all pieces within one bag for all 4 micro plots for subsequent removal from the site and further measurement. Pieces may be cut into convenient sized portions to facilitate bagging the material.
6. Cones, bark, wood chunks and other debris less than or equal to 1.0 cm will also be collected.
7. If aerial pieces are encountered only collect pieces located in the shrub layer that less than 1.3 m above ground level.
8. Store the collected material in a cool dry place in a well ventilated bag to inhibit development of mould or fungal growth.

9. Place a label in each bag identifying the sample number and whether there is more than 1 bag for a sample (identify as 1 of 1, or 2 of 3, etc.).
10. The fine woody debris will, if necessary, be air-dried to remove excessive moisture. The sample will then be oven dried (55° C for 24 hours) and weighed and the information recorded.

Shrub and Herb Header and Summary Attributes for NFI Reporting

Shrub/herb Plot Number

1. Record a one-digit micro plot number between 1 and 4.
2. Micro plots should be numbered consecutively, clockwise, with the northernmost micro plot as number 1.

Shrub/herb layer ID

All vegetation is assigned to one of the following layers: shrub, herb, bryoid or fine woody debris (FWD). Note that the shrub layer includes **any woody shrubs or small trees ≤ 1.3 m in height that do not have a measurable DBH**. Small trees and shrubs greater than 1.3 m in height with a DBH < 9.0 cm will be measured in the small tree plot. When the plot includes two or more different stand types, the shrub and herb layers are assigned based on the majority condition found within the boundaries of the ground plot.

1. Record one of the following shrub/herb layer identification numbers:
   - **1** = Shrub layer, e.g. all woody plants and trees ≤ 1.3 m tall without a DBH.
   - **2** = All herbaceous species regardless of height. Includes herbs, forbs, and graminoids.
   - **3** = Bryoids, e.g. mosses, lichens and liverworts.
   - **4** = Fine woody debris, e.g. dead and downed woody material ≤ 1.0 cm in diameter.

Plot Type

1. Record a three-letter plot type code describing the type of plot used to collect the shrub and herb samples.
2. Plot type will be either:
   - **MPC** = circular micro plot
   - **MPS** = square micro plot

Plot Size

1. Record the size (area) of the micro plot to the nearest 0.001 ha.
2. Each micro plot, established according to these guidelines, will have an area of 0.0001 ha.

Shrub/Herb Genus

List all of the species found within the micro plot.
This does not include species of the FWD.
Species are listed in descending order of plot cover within the micro plot.
Record a four-letter code describing the first four letters of the scientific genus name.

Shrub/Herb Species

Record a three-letter code describing the first three letters of the scientific species name.

Shrub/Herb Variety

Record a three-letter code describing the first three letters of the scientific variety name.

Shrub/Herb Area Percent

Estimate the percent cover of each species within the micro plot. This estimate does not include the fine woody debris layer.
Species in the shrub/herb species list are listed in descending order of percent cover within the micro plot.
Record a percent cover value (between 1 and 100%) for each species listed.

Office-Compiled Shrub and Herb Header and Summary Information Attributes for NFI Reporting

The following list of attributes will be compiled by the CFS based on reported Field-measured attributes.

- Shrub/herb biomass by layer (kg of ovendry material)

10. Soil Measurements

Introduction

The objective of the NFI soils program is to measure total ecosystem carbon stocks (TECS) of Canada's forest. The method for determining TECS involves analysis of both the physical and chemical properties of the soils. The soil resource is a primary component of all terrestrial ecosystems, and any environmental stressor that alters the natural function of the soil has the potential to influence the vitality, species composition, and hydrology of forest ecosystems (USDA 2002).

Soils data can contribute to the assessment of:

- the potential for erosion of nutrient-rich soils and forest floors.
- factors relating to the storage and cycling of nutrients and water.
- the availability of nutrients and water to plants (dependent upon soil structure and texture).
- carbon sequestration (the amount of carbon tied up in soil organic matter).
- deposition of toxic metals from pollution.
- acidification of the soils from deposition of pollutants.

Data related to soil bulk density; organic carbon content; total nitrogen; available phosphorus; exchangeable potassium, calcium, magnesium, sodium; cation exchange capacity; pH; and carbonates. The data from these measurements will be used in analysis for reports on climate change, criteria and indicators of sustainable forest management, biodiversity and forest health. This section defines the procedural modifications to existing provincial monitoring inventory procedures to collect this additional data.

The sampling of soil from one soil pit was deemed an inadequate sample for accurately determining the variation in soil C content by depth. The previous one-pit sample would be equivalent to measuring just one tree in a plot and assuming all other trees in the plot are the same size. For this reason, multiple soil samples at multiple depths are being collected.

Objectives

1. To determine soil characteristics based on the Canadian System of Soil Classification (Agriculture Canada, 1998).
2. To collect four, forest floor organic samples and measure the depth of the sample collected.
3. To collect seven, 1.0 to 1.5-litre samples of mineral soil at approximate depths of 0 to 15 cm (four samples), 15 to 35 cm (two samples) and 35 to 55 cm (one sample) for each plot.
4. To measure the exact volume of each of the mineral soil samples extracted.

General Procedures – Soil Classification

1. Classify soil according to CSSC standards.
2. Collect information and forest floor organic samples.
3. Collect information and soils for bulk density measurements.

Canadian System of Soil Classification Code

1. Enter the CSSC classification for the profile, including the Order, Great Group, and Subgroup (up to nine characters long).
2. The profile should be classified to the Subgroup level if possible but at least to the Order level (minimum).
3. Refer to the Canadian System of Soil Classification (1998) for reporting instructions and codes. For example, enter code GLCU.HR for Gleyed Cumulic Humic Regosol. Another example would be GLG.SO for Gleyed Gray Solod.

Profile Depth

1. Enter the total profile depth (in cm) to which the total carbon content is to be determined.
2. Total carbon content should be measured to a minimum depth of 60 cm when possible (depth starting at surface of the mineral soil) in mineral soils and to a total depth of 100 cm in organic soils.

Soil Drainage Class

1. Six classes of soil drainage are recognized.
2. Refer to Table 17 for drainage class descriptions. Enter a 1-digit code that best describes the drainage conditions in the plot (Agriculture Canada Expert Committee on Soil Survey 1983).

Table 17. Soil drainage class codes and descriptions.

Soil drainage class code	Description
1: very rapidly	Water is removed from the soil very rapidly in relation to supply. Excess water flows downward very rapidly if underlying material is pervious. There may be very rapid subsurface flow during heavy rainfall provided there is a steep gradient. Soils have very low available water storage capacity (usually less than 2.5 cm) within the control section and are usually coarse textured, or shallow, or both. Water source is precipitation.
2: rapidly	Water is removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep gradients during heavy rainfall. Soils have low available water storage capacity (2.5 – 4 cm) within the control section, and are usually coarse textured, or shallow, or both. Water source is precipitation.
3: well	Water is removed from the soil readily but not rapidly. Excess water flows downward readily into underlying pervious material or laterally as subsurface flow. Soils have intermediate available water storage capacity (4-5 cm) within the control section, and are generally intermediate in texture and depth. Water source is precipitation. On slopes subsurface flow may occur for short durations but additions are equaled by losses.
4: moderately well	Water is removed from the soil somewhat slowly in relation to supply. Excess water is removed somewhat slowly due to low perviousness, shallow water table, lack of gradient, or some combination within the control section and are usually medium to fine-textured. Precipitation is the dominant water source in medium to fine textured soils; precipitation and significant additions by subsurface flow are necessary in coarse-textured soils.
5: imperfectly	Water is removed from the soil sufficiently slowly in relation, to supply to keep the soil wet for a significant part of the growing season. Excess water moved slowly downward if precipitation is the major supply. If subsurface water or groundwater, or both, is the main source, the flow rate may vary bt the soil remains wet for a significant part of the growing season. Precipitation is main source if available water storage capacity is high; contribution by subsurface flow or groundwater flow, or both, increases as available water storage capacity decreases. Soils have a wide range in available water supply, texture, and depth, and are gleyed phases of well-drained subgroups.
6: poorly	Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen. Excess water is evident in the soil for a large part of the time. Subsurface flow or groundwater flow, or both, in addition to precipitation are the main water sources; there may also be a perched water table, with precipitation exceeding evapotranspiration. Soils have a wide range in available water storage capacity, texture, and depth, and are gleyed subgroups, Gleysols, and Organic soils.
7: very poorly	Water is removed from the soil so slowly that the water table remains at or on the surface for the greater part of the time the soil is not frozen. Excess water is present in the soil for the greater part of the time. Groundwater flow and subsurface flow are the major water sources. Precipitation is less important except where there is a perched water table with precipitation exceeding evapotranspiration. Soils have a wide range in available water storage capacity, texture, and depth, and are either Gleysolic or Organic.

Moisture Class

1. Enter a one-digit soil moisture code.
2. Refer to the descriptions in Table 18.

Table 18. Soil moisture class codes.

Soil Moisture Class Code	Description
1	Xeric: water removed very rapidly in relation to supply; soil is moist for brief periods following precipitation. The primary water source is precipitation.

2	Mesic: water is removed somewhat slowly in relation to supply; soil may remain moist for a significant, but sometimes short, period of the year. Available soil moisture reflects climatic inputs. The primary water source is precipitation in moderate to fine-textured soils and limited seepage in coarse-textured soils.
3	Hygric: water is removed so slowly that the water table is at or above the soil all year; gleyed mineral or organic soils. The primary water source is a permanent water table.
4	Unreported.

Genetic Materials

1. Landforms are described on the basis of genetic composition.
2. Enter a code from Table 19. Codes are from CSSC, 1998.

Table 19. Codes for soil parent material mode of deposition.

Soil Parent Material Mode of Deposition Code	Description
A	Anthropogenic ▪ artificial or human-modified material ▪ includes landfills, road fill and mine spoils
C	Colluvial ▪ deposits as a direct result of gravity (talus, landslide deposits) ▪ on steep terrain; below rock bluffs ▪ coarse fragments, angular, same rock type as bedrock ▪ coarse fragments > 35%, loosely packed, porous ▪ landslide and slope failure deposits
E	Eolian ▪ materials deposited by wind action
F	Fluvial ▪ river deposits
L	Lacustrine ▪ lake sediments; includes wave deposits
M	Morainal ▪ material deposited directly by glaciers
S	Saprolite ▪ rock containing a high proportion of residual silts and clays formed by alteration, chiefly by chemical weathering
V	Volcanic ▪ unconsolidated pyroclastic material
W	Marine ▪ marine sediments; includes wave deposits
UU	Unspecified Unconsolidated ▪ A layered sequence of more than three types of genetic material
R	Bedrock ▪ outcrops/rocks covered by less than 10 cm of soil
I	Ice ▪ permanent snow, glaciers, and icefields
B	Bog ▪ sphagnum or forest peat material
F	Fen ▪ sedge peat materials derived primarily from sedges with inclusions of partially decayed stems of shrubs formed in a eutrophic environment due to the close association of the material with mineral-rich waters

SW	Swamp ▪ a peat-covered or peat-filled area with the water table at or above the peat surface. The dominant peat materials are shallow to deep, mesic to humic forest and fen peat formed in a eutrophic environment resulting from strong water movement from the margins or other mineral sources
UO	Unspecified Organic Genetic Material

Humus Form

The following excerpt is taken from CanSIS (1982). Humus form is a pedon characteristic. For classification purposes, forest humus forms are grouped into those developed under well-drained to imperfectly drained conditions (terrestrial or upland humus forms), and those developed under poorly drained conditions or under conditions leading to saturation for most of the year (hydromorphic or semiterrestrial humus forms).

Subdivision is based essentially on those primary morphological features that reveal fundamental differences in genesis. These are the presence or absence of diagnostic organic horizons, and the degree of incorporation of fine humus into the mineral soil and the intensity of binding between organic and mineral fractions. Secondary morphological features (such as structure, thickness, and composition of horizons) and distinctive characteristics allow for further division.

Humus form represents the form of the organic and organic-enriched mineral horizons at the soil surface.

1. Enter a one or two-character humus form code from Table 20.
2. Humus form must be reported to at least the Order level (minimum).

Table 20. Codes for Humus Form.

Order	Group	Code
MULL (L)	Compact	LC
	Fine	LF
	Medium	LM
	Coarse	LC
Moder (D)	Mull-like	DM
	Typical	DT
	Raw	DR
Mor (R)	Fibrimor	R F
	HumiFibrimor	RH
	FibriHumimor	RM
	Humimor	RI
Peaty Mor (P)	Humic	PH
	Mesic	PM
	Fibric	PF
Anmoor (AM)	n/a	AM
Unreported (UR)	Unreported	UR

Soil Site Information – Office Compiled Attributes

- Ecoclimatic region code
- Ecoclimatic district
- Provincial ecosystem type
- Provincial ecosystem type reference
- Total carbon content of organic and mineral profile

- Carbon content (above mineral surface) of organic
- Carbon content below mineral surface

Soil Pit Features – Field Attributes

Soil Feature

Soil feature codes describe all of the features that are noted in a soil pit. They may include any of the codes listed in Table 21.

Table 21. Soil feature codes.

Soil Feature Code	Soil feature
W	Water table or seepage
M	Mottles (not applicable in organic soils)
R	Root-restricting pan
B	Bedrock
F	Frozen layer
C	Carbonates
N	Not applicable or no feature

Depth to Soil Feature

Observed depth in cm to soil feature(s), measured from "zero depth" to soil feature. "Zero depth" is mineral soil surface for mineral soils, and ground surface for organic soils.

Soil Pit Horizon Information – Field Attributes

Horizon Designation

The horizon designation is completed according to CSSC (1998) conventions.

Horizon Measurement

Horizon measurement is always by depth indicator and labeled "D".

Depth to upper horizon boundary

Measured from the top of the mineral soil surface (0) to the upper limit of the horizon. For organic matter, record as a **positive** value. Measure starting at the top of the organic layer (0 cm). For mineral soil, record as a **negative** value. Measure starting at the top of the mineral soil surface.

Thickness of horizon

The thickness of the horizon in cm.

Soil color

A description of the general color of the rooting-zone mineral soil. The soil color codes listed in Table 22 are based on the Munsell Color Chart codes.

Table 22. Soil color codes.

Soil color code	Soil color description
D	Dark, chocolate brown or black (Munsell color value < 4 when moist)
M	Medium, intermediate color (most commonly encountered)
L	Light, very pale soil (Munsell color value > 6 when moist)
N	Not applicable (bedrock, no soil)

Texture

The soil textural classes and codes in Table 23 are determined from the soil texture triangle according to CSSC classification rules. Texture is determined by estimating the percentage of clay (less than 0.002 mm diameter) and sand (0.05 to < 2.0 mm diameter).

Table 23. Soil texture codes.

Soil texture code	Soil texture description
C	Clay
SC	Sandy clay
SCL	Sandy clay loam
CL	Clay loam
Si	Silt
SiS	Silty sand
SiL	Silt loam
SiCL	Silty clay loam
L	Loam
SL	Sandy loam
LS	Loamy sand
S	Sand
VfS	Very fine sand
fS	Fine sand
mS	Medium sand
cS	Coarse sand
vcS	Very coarse sand

Percent Coarse Fragments, Gravel

Coarse fragment (CF) content, gravel (diameter < 7.5 cm or length < 15 cm). Percent CF content by volume of the mineral horizon.

Percent Coarse Fragments, Cobbles

Coarse fragment (CF) content, cobbles (diameter = 7.5 to 25 cm or length = 15 to 38 cm). Percent CF content by volume of the mineral horizon.

Percent Coarse Fragments, Stones

Coarse fragment (CF) content, stones (diameter > 25 cm or length > 38 cm). Percent CF content by volume of the mineral horizon.

Bulk Density

Bulk densities are calculated using equations that are appropriate to local conditions. Intermediate values required for forest floor organics bulk density reporting include: total volume, total oven dry mass, total oven dry live root mass. Intermediate values required for mineral soil bulk density reporting include: total volume, total oven dry mass, total oven dry mass fine soil (< 2 mm), oven dry mass gravel (2 mm to 75 mm), oven dry mass cobbles (75 mm 250 mm), oven dry mass organics. Bulk density is reported as g/cm^3.

Bulk Density Real

A field indicating whether the bulk density value represents an actual field measurement or whether it was estimated in the field. Also indicates the sampling method.

- **T**: Bulk density was truly sampled but method not specified
- **F**: Bulk density was estimated and not truly sampled
- **H**: Bulk density determined by hole excavation
- **S**: Bulk density determined from small-diameter cores (< 50 mm)
- **C**: Bulk density determined from large-diameter cores (60 to 100 mm)

Bulk Density Measurement Criteria

Bulk density measurement criteria for the entire horizon.

- **H**: Bulk density measurement of organic matter in horizon excluding live root mass.
- **T**: Total of all bulk density of samples.
- **N**: Not specified.

Office Compiled and Lab Determined Attributes

- Bulk density
- Carbon content of horizon
- Percent organic carbon content
- Measured organic carbon value or not
- Total nitrogen
- Available phosphorus
- Exchangeable K
- Exchangeable Ca
- Exchangeable Mg
- Exchangeable Na
- Cation exchange capacity
- pH
- Carbonates
- Pyrophosphate Al and Fe
- Silt content of mineral soil

- Clay content of mineral soil

Detailed Procedures – Soil Classification

See CSSC soil classification guidelines for procedures.

General Procedures – Soil Bulk Density Sampling

1. Establish the woody debris transects as per woody debris protocol.
2. Establish the four shrub and herb micro plots along the downed woody debris transects.
3. Excavate and sample the forest floor organic layer(s) from each of the four micro plots or at an equivalent, representative area nearby that is in or near the micro plot.
4. Excavate and sample mineral soil at three depths from one of the four micro plots or another suitable location.

Soil Bulk Density Attributes

The field sampling for bulk density collects information that is required for calculating soil bulk density. The interim field measures are:

- Soil depth
- Soil volume

Intermediate values required for forest floor organics, bulk density reporting are:

- Total volume
- Total oven dry mass
- Total oven dry live root mass

Intermediate values required for mineral soil bulk density reporting are:

- Total volume
- Total oven dry mass
- Total oven mass, fine soil (less than 2 mm), oven dry mass gravel (2 to 75 mm), oven dry mass cobles (75- 250 mm), oven dry mass organics.

Detailed Procedures – Soil Bulk Density Sampling

Forest Floor Organic Samples

Forest floor samples are collected from each of the micro plots, after all of the vegetation and moss has been removed. The forest floor is sampled as a complete unit using a sampling frame.

1. Make sure that all live vegetation, woody debris and green moss and lichens have been removed from the micro plot sampling area.
2. Place the 20 cm x 20 cm (inside dimensions) aluminum sampling frame over the sampling point, taking care not to compact the sample.
3. Using a sharp knife, handsaw, and/or clippers, carefully cut through the forest floor along the inner surface of the frame to separate it from the surrounding soil.
4. With a hand trowel, use inward scooping motions to the entire volume of forest floor from within the confines of the sampling frame. Discard any rocks or pebbles collected with the forest floor material.

5. Ensure that the forest floor sample extends to the point where it hits mineral soil.
6. Working over a tarp, place the entire forest floor layer into a pre-labeled sample bag. In some areas, more than one bag might be required to hold the sample. If so, label the bags with identical information, and then add “1 of 2”, “2 of 2” etc. respectively.
7. Measure the depth of the forest floor organic sample, in approximately four different locations within the excavation and record an average depth. This measurement will be used to calculate the volume of the excavation, and in turn, the bulk density of the forest floor organic layer.

Distinguishing Organic/Mineral Interfaces

1. Distinguishing the organic/mineral interface can be more difficult on sites with humus forms that are well mixed, e.g. a Moder humus over an Ah layer.
2. Technically, a soil horizon is classed as mineral soil when it contains an organic carbon content ≤ 17% by weight. For field purposes, the determination is usually made by hand—feeling for the presence of mineral materials in order to judge the organic/mineral interface.
3. Where the determination is unclear, make a best judgment call in the field and then note it on the tally card in the comments section. Appropriate measures will be taken in the lab processing of the samples.

Mineral Soil Samples

Seven mineral soil samples will be collected for lab analysis.

- Mineral 1 (0 – 15 cm layer of mineral soil), **four** samples
- Mineral 2 (15 – 35 cm layer of mineral soil), **two** samples
- Mineral 3 (35 – 55 cm layer of mineral soil), **one** sample

Their exact volumes will be determined in the field in order to calculate their bulk densities. The soil samples may be collected at the micro plots, they can be excavated from the side of the soil pit after it has been described, or they can be taken in any other location that is deemed representative by the field soil scientist in charge of sampling. Refer to Figure 4 for an illustration of excavated samples and their depths.

1. Upon extraction of the forest floor layer, further clear an area of the surrounding organic material that is larger than the template (e.g. 50 x 50 cm) to begin excavation of the mineral soil samples.
1. Level an area about 20 x 20 cm and excavate a round hole inside the square for extracting the first soil sample. The hole should be approximately 14 cm in diameter (for a 10 cm deep sample) to allow for the extraction of at least 1.0 to 1.5 Litres of mineral soil.
2. During the excavation, extreme care must be taken not to compact the sides of the hole, as this will affect the bulk density of the sample. A good way to avoid soil compaction during excavation is to always keep the handle of the trowel pointed in towards the centre of the hole, with the blade of the trowel pointing outwards.
3. Using inward scooping motions when extracting the sample.
4. Work over a tarp and take care so that none of the sample is lost or spilled.
5. Extract the loose soil and gravel (< 7.5 cm) from the hole using the long-handled soupspoon and place in the 10-mm, heavy-duty bag.
6. Clean the face of the hole using the hand-clippers or knife. All roots extending into the hole must be clipped and included in the sample.
7. Using your fingers or knife, smooth the surface of the hole and make sure there are no voids, e.g. where coarse fragments may have been extruding. If there are voids, the dimensions of the hole must be extended to accommodate a reasonably smooth surface.

8. Using the 5-mm weight plastic bag, line the hole and fill the bag with the glass beads. Make certain the surface of the beads is flush with the top of the excavated hole.
9. Pour the beads into the 1.0-L graduated cylinder, to the nearest 100 mL graduation. The volume of the remaining 100 mL to 500 mL of beads can be measured using the 100 mL cylinder for greater accuracy. Record the total volume, to the nearest 10.0 mL on the tally card.
10. Mark the sample number, volume and depth on the tally card, label inside the sample bag and on the outside of the sample bag. Note: if large rocks were extracted but not included in the sample bag, make note of their volume on the bag and the tally card also.

Mineral Soil Excavation and Measurement, Second and Third Samples

1. Pick a feature in the excavated hole that marks the depth of the excavation. A golf tee or aluminium nail may also be used to mark the depth. **It is important to excavate samples at depths that are continuous with one another.**
2. Clear an area (to the marked depth) that is larger than the already excavated area (e.g. 50 x 50 cm) to allow for sampling at the next depth. This larger area can serve as the soil pit that needs to be dug for pedogenic layer description and coarse fragment content estimation.
3. Perform the second excavation using the same method as the first excavation. The second excavation should be between 15 cm to 35 cm (or 10 to 30 cm) in depth and should be approximately 1.0 L to 1.5 L of mineral soil. Record the sample number (e.g. sample 278), depth (e.g. 15 cm to 35 cm) and volume (e.g. 1620 mL) of the second excavation on the tally card; place a label inside the sample bag, and on the outside of the sample bag.
4. Perform the third excavation also using the same method. The third excavation should be between 35 to 55 cm in depth and should equal 1.0 to 1.5 L of mineral soil. Record the sample number, depth and volume of the third excavation on the tally card; place a label inside the sample bag, and on the outside of the sample bag.
5. Note: the second and third excavations will require extra care and effort to obtain. The top layer of the initial excavation surface should be cleared to a broad and level surface (e.g. 50 cm x 50 cm) before successive deeper holes are excavated.

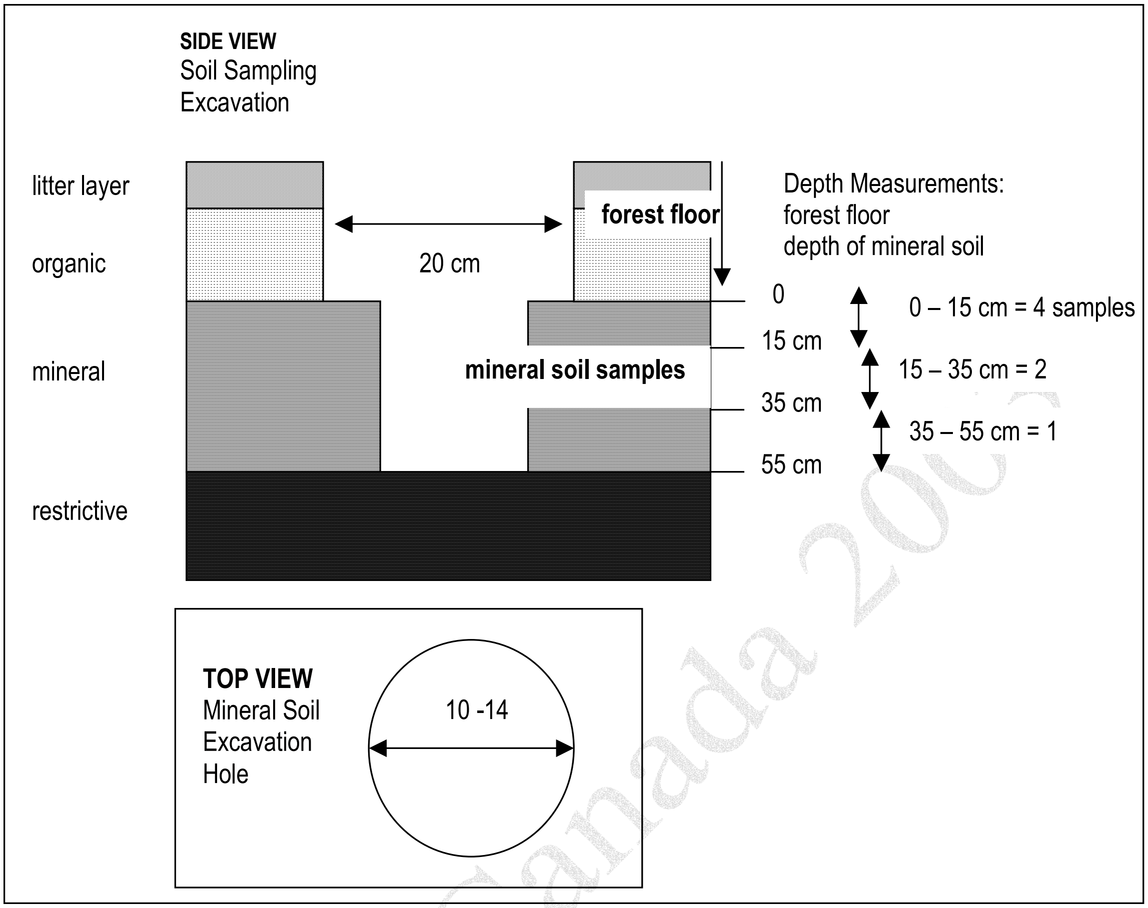


Figure 5. Mineral bulk density excavation sample depths.

Commonly Encountered Problems

Because of the many different types of soil found in the field, it may not always be possible to obtain soil core samples using the excavation method. Personal judgment may be required in determining the most appropriate way to collect samples. The following section provides some suggestions of how to overcome these problems.

Rocky Soils

In soils containing a high percentage of rocks, it may not be possible to excavate all of the samples to the required 55 cm. If this occurs, remove as much of the sample as possible, and make a second attempt either within the area where the forest floor has been removed or within the available soil sampling area (within a 1.5 m radius of the original soil sampling location). Make a maximum of five attempts. If a complete sample from the 0 to 15 cm depth can be obtained, collect that sample.

An alternative to this method would be to excavate a larger diameter hole that captures the boundary of the coarse fragment. Any rocks less than or equal to 7.5 cm in diameter are to be included in the sample. To avoid having to carry out the larger rocks (> 7.5 cm diameter, cobbles and stones) removed from the hole, any adhering soil could be cleaned off the rocks and then the adhering soil placed into the sample bag. The rocks would then be weighed to the nearest gram. The volume of the rocks could then be estimated assuming rock to have a density of 2.65 g/cm^3.

Very Sandy Soils (or very dry soils) – excavated walls collapse

If the excavated walls collapse when attempting to extract the sample, a tube probe method may be employed. A tube probe method is described in USDA 2002. It involves removing the forest floor from an area and hammering a tube probe into the ground. A shovel is used to dig around the soil coring head while it is still in place. The soil corer is tilted to one side and the blade of a shovel is inserted underneath the base of the core. The blade of the shovel is holds the sample in place as the corer is removed from the soil. Depending on the soil type, this technique may require some practice and/or the use of a partner.

Saturated or Wetland Soils and Deep Organics

Attempt to collect a sample using a soil corer. A soil coring method is described in USDA 2002. If this is not possible, or if compaction occurs, attempt the excavation method following.

1. Sampling of these sites should be conducted in the driest portion of the field season.
2. Using the 20 x 20 cm aluminum sampling frame, cut, collect and measure the total surface organics, in intervals (0-15 cm, 15-35 cm, 35-55 cm, 55-75 cm), to mineral soil / rock surface or 75 cm (whichever is encountered first) on only **one** of the micro plots. This sample is necessary in order to get at least one bulk density measurement and sample for all depths of the surface organics.
3. With each successive excavation, bale out as much water as possible and attempt to take the sample.
4. If the sample is incredibly wet and heavy, and bringing it back poses an undue hazard, then only bring back as much of the sample as possible. Make a note on the tally card, in the comments section, as to why the sample was unobtainable and how much of it (what thickness) was left behind.

Sloped Terrain

As much as possible, the soil bulk density sample should be taken on as level a surface as possible. In terrain located on a slope, the excavated hole should be located in the flattest location possible. This may mean clearing away a few centimetres of the Ae or Ah on one side to ensure a flat surface for sampling.

1. For the first excavation, measure the average depth of the hole after the few centimetres of Ae or Ah on one side have been cleared away.
2. Only use glass beads (not water) for the volume measurement.
3. Note in the comments section that the depth measurement was taken on a slope and the percent of the slope.

Importance of Obtaining Continuous Mineral Samples

1. The highest amount of carbon is located in the upper depths of mineral soil. For analysis purposes, it is important that the top two samples are continuous with one another.
2. Due to site-specific reasons, excavating at the specified depth increments may not always be possible. If excavating at the specified depths is not possible still attempt to take three continuous samples at successive depths.
3. Make note of why taking the samples at the targeted depths was not possible on the tally card in the comments section. Ensure the depth that the sample was taken at is noted on the tally card, the label inside the sample bag and on the outside of the sample bag.

Unobtainable Samples

1. If a sample was not obtained due to site-specific reasons, e.g. "hit bedrock after three other attempts at different locations in site" or "entire site filled with large coarse fragments", label an empty bag and send this back with the samples that were successfully obtained.
2. Make sure to note why the sample was not obtained on the tally card in the comments section and the label inside the empty sample bag.
3. Sending an empty sample bag, with the reason the sample was not obtained in the field, ensures the lab's staff is better able to keep track of the samples, e.g. the lab staff does not think that one of the samples was lost or is missing.

Quality Assurance of Bulk Density Samples

The bulk density procedures will involve destructive sampling. Extreme care must be taken in the sampling of mineral soils for bulk density measurements, as quality assurance for these procedures will not be possible.

It is suggested that the field crew member performing the bulk density sampling procedures perform a number of practice excavations before the actual data collection to ensure that consistency of methods is achieved.

Bulk Density Sampling in Organic Sites/Soils

Sampling in organic sites/soils will not be conducted this field season.

Soil Sample Labels

1. Pre-printed labels should be provided to each field crew. Completion of all items on the soil label is essential for proper processing of the sample by the laboratories. In previous programs, numerous samples have been discarded due to mistakes or inconsistencies on the labels.
2. If you encounter a situation where you need to make additional notes on the sample (e.g. a sample which was particularly unusual or required significant deviation from the standard methods), place a star (*) on the upper right hand corner of the label and make a note on the sample shipping form.
3. PROVINCE – Use the appropriate two-letter province code (refer to Table 2. in these guidelines). This will be used by the soil analysis laboratory for batching of samples (should be pre-printed on labels).
4. NFI NETWORK LABEL – The seven digit network label code.
5. DATE SAMPLED – Enter the date that soils were sampled on this plot.
6. CREW – Enter the initials of the crew collecting the samples.
7. LAYER TYPE – Circle the type of sample collected and the depth increment of the sample.
8. For mineral soils, the choices are:
   - Forest Floor (litter + humus/duff)
   - Mineral 1 (0 – 15 cm layer of mineral soil)
   - Mineral 2 (15 – 35 cm layer of mineral soil)
   - Mineral 3 (35 – 55 cm layer of mineral soil)

   For organic soils (e.g. a peatland or wetland soil with more than 40 cm):
   - Forest floor (only the litter is collected)
   - Organic 1 (0 – 15 cm layer of organic soil)
   - Organic 2 (15 – 35 cm layer of organic soil)
   - Organic 3 (35 – 55 cm layer of organic soil)

- Organic 4 (55 – 75 cm layer of organic soil)

SAMPLE SHIPPING

After samples have been collected, changes in the oxygen and moisture content within the sample bag can cause significant alteration sample chemistry. To prevent this from occurring, samples are to be shipped on a **weekly** basis to a regional soil lab (or the soil lab at Pacific Forestry, see details below) designated for your province. Do not keep samples longer than a week unless they can be stored in a refrigerated area. Ship samples using the most economical rate. There is no need to ship soil samples using expensive overnight delivery rates.

Shipping Forms

All crews must complete shipping forms for forwarding soil samples to a regional laboratory that has been approved to receive soil samples from regulated areas. The addresses for the regional labs are listed at the bottom of the shipping form. The shipping form should be filled out and photocopied so there are **three** copies on hand. Prior to shipping the samples, crews should completely fill out the shipping form and:

1. Send the original with the soil samples to the laboratory.
2. Mail one copy immediately to the laboratory in a separate envelope along with a copy of the shipping (tracking) information from the shipping service. The separate mailing of shipping forms will serve to notify the laboratory if a shipment of samples has been misplaced during transport.
3. Send the third copy to the NFI ground plot data co-coordinator for their records.

Note that a separate line must be completed for each sample collected. The laboratory staff uses information on the sample shipping form: to create an inventory of the samples, to assign lab numbers, and to help resolve inconsistencies on the sample label. A complete and accurate inventory of samples is critical to efficient and cost-effective processing of samples.

Please provide all information and ship samples WEEKLY to the appropriate regional office in which the samples were collected.

1. NAME – Record the shipper's name.
2. SIGNATURE – Sign your signature under the printed shipper's name.
3. SHIPPED VIA – Enter the method and name of the company used to ship the sample.
4. TRACKING NUMBER – Enter the tracking number assigned to the shipment. This information is used by laboratory supervisors to locate lost or missing shipments.
5. PROVINCE – Use the appropriate two-letter province code (refer to Table 2. in these guidelines). This will be used by the soil analysis laboratory for batching of samples (should be pre-printed on labels).
6. NFI NETWORK LABEL – The seven digit network label code.
7. DATE SAMPLED – Enter the date that soils were sampled on this plot.
8. CREW – Enter the initials of the crew collecting the samples.
9. LAYER TYPE – Circle the type of sample collected and the depth increment of the sample.
10. For mineral soils, the choices are:
    - Forest Floor (litter + humus/duff)
    - Mineral 1 (0 – 15 cm layer of mineral soil)
    - Mineral 2 (15 – 35 cm layer of mineral soil)
    - Mineral 3 (35 – 55 cm layer of mineral soil)

For organic soils (e.g. a peatland or wetland soil with more than 40 cm):

- Forest floor (only the litter is collected)
- Organic 1 (0 – 15 cm layer of organic soil)
- Organic 2 (15 – 35 cm layer of organic soil)
- Organic 3 (35 – 55 cm layer of organic soil)
- Organic 4 (55 – 75 cm layer of organic soil)

11. BAGS/SAMPLE – Enter the number of bags associated with a sample. For some forest floor samples, more than 1 bag may be needed to collect all of the material. The lab uses this information to make sure certain that samples consisting of multiple bags are processed together.
12. TOTAL NUMBER OF BAGS SENT – Enter the total number of bags contained in the shipment. The laboratory staff will compare the number on this shipping form to the number of bags that they receive in order to make sure that there are no samples missing.

Sampling of Organic Soils

***** Note: sampling of organic soils does not apply to the 2003 field season. Review of the protocol in this section, by each province/territory's soil specialist is requested, for the purposes of future implementation.*****

There is no unique 'best' approach to sampling wetland and organic soils. The method most appropriate in any particular situation depends on factors such as total organic matter depth, soil texture (fibric, mesic, or humic), and the position of the water table within the soil. Deep organics can only be retrieved by coring, yet coring methods generally work poorly in fibric surface layers. Sampling of deep organic deposits will therefore require a combination of excavation and coring, with the most appropriate depth for transition from one to the other depending on the situation encountered in the field.

Irrespective of the methodology used, sampling of organic soils should provide the following:

1. a measurement of total organic layer depth. If the average organic layer depth in the plot is >40 cm *(>100 cm if the surface substrate protocol is changed)*, this represents the only measurement of total organic matter depth within the plot.
2. A series of samples of known volume, to be used for bulk density determination and chemical analysis. Sample depths (cm; one sample per depth interval) are: 0-15; 15-35; 35-55; 55-75; 75-100; and 25-cm intervals thereafter, until the mineral substrate is reached (see p. 71 for criteria used in distinguishing organic / mineral interfaces). Depending on the exact position of the organic / mineral interface, the basal organic sample is likely to represent less than 25 cm depth. The interval represented by this sample should be recorded, and a separate sample of the underlying mineral material collected, either by coring or excavation.

The following sections outline different approaches to the sampling of organic soils. All methods retrieve samples of known volume that can be used for bulk density determination. Since the exact volume differs between methods, the method used and exact volume removed have to be recorded for each depth interval.

Forest floor excavation method

This method (or the organic matter excavation method described below) should be used for all surface horizons, even if deeper samples have to be retrieved by coring. The forest floor excavation method is not recommended for removing samples beyond the 15-35 cm depth interval, but represents a good means of collecting the 0-15 and 15-35 cm samples prior to coring deeper horizons.

1. The area sampled should be free of living biomass. (When using one of the microplots, the biomass has already been removed during microplot sampling). The soil surface after biomass removal represents 'zero depth' for organic soil sampling
2. Using a 10 x 10 cm aluminum sampling frame, collect a sample representing the upper 15 cm of organic soil. If the organic material is fibric and / or rooty, use a serrated bread knife to pre-cut the organic layer prior to inserting the frame to 15 cm depth (use clippers or a saw to sever large roots).
3. Excavate the area adjacent to one side of the sampling frame and use a serrated bread knife to cut along the bottom of the frame prior to removal of the sample.
4. Measure the depth of the excavation at four points. Assuming a depth of 15 cm, the sample volume is 15 x 10 x 10 cm = 1500 ml (1.5 L). If the average depth is different from 15 cm, record the depth represented by the sample and re-calculate the sample volume
5. Remove the 15-35 cm sample in the same manner. (You may have to remove surface material around the sampling area in order to insert the sampling frame to 35 cm depth). Assuming the sample represents the depth from 15-35 cm, its volume is 20 x 10 x 10 cm = 2000 ml (2 L)

Organic matter excavation

Note: I included this method because I thought it may be useful for sites with shallow organic soils (i.e. the 40–60/75 cm depth range), where excavation from the surface does not work but coring seems overkill (particularly if the soil pit they have to dig anyways can be used for sampling… assuming nobody disagrees with this practice).

This method is appropriate for surface horizons and in some cases may allow for sampling of the entire profile in shallow (< 75 cm OM depth) organic soils. Please note that the method is different from the excavation method recommended for mineral soils (p.72-75). Since the method described here involves lateral sampling from a previously dug pit, it could be combined with the soil pit used for classification, **provided the area sampled has not been trampled or otherwise compacted while digging the pit**. Alternatively, a shallow pit could be excavated in one of the micro plots. The method, as described here, requires fixed-size aluminum frames to remove samples from the targeted depth intervals. In an alternative version, one long template or frame is used to cut a continuous sample out of the side of the pit, and the material thus removed is subsequently sectioned into the required depth intervals. Any approach that yields samples of known volume representing the targeted depth intervals is acceptable.

1. Excavate a pit adjacent to the area to be sampled. The pit should be large enough to allow access to the sampling area and 35-55 cm deep (or as deep as is practical for organic matter excavation). Avoid trampling or otherwise compressing the area to be sampled. In fibric, rooty soils, a serrated bread knife, saw, or clippers may be required to penetrate the surface layers.
2. Clean one side of the pit with a serrated bread knife to expose a vertical section of the profile
3. Remove living biomass at the surface of the section. (If sampling within a micro plot, this has already been done during the biomass sampling). The soil surface after biomass removal represents 'zero depth' for organic soil sampling.
4. For the 0-15 cm sample, place a 7.5 x 20 cm aluminum frame next to the exposed surface, with the long axis extending from zero to 15 cm depth (5 cm of the frame will be exposed at the top of the profile). Using a serrated bread knife to pre-cut the soil, carefully insert the frame 10 cm into the side of the exposure, avoiding compression of the surrounding material (yielding a sample of 7.5 x 15 x 10 cm = 1125 ml). Carefully cut along the far side of the sample to remove it from the exposure, and place it into (a) plastic sample bag(s).
5. Measure the horizontal distance from the side of the exposure to the 'back' end of the cavity left by removal of the sample four times. If the average distance is not equal to 10 cm, re-calculate the sample volume before recording it

6. For removal of the 15-35 cm sample, place the 7.5 x 20 cm aluminum frame next to the exposed surface (with the long axis extending from 15 to 35 cm depth). Using a serrated bread knife to pre-cut the material, insert the frame ca. 10 cm into the side of the exposure. Carefully remove and bag the sample. (If inserted to 10 cm depth, the volume is 7.5 x 10 x 20 cm = 1500 ml; if not, measure insertion distance as described above and re-calculate the volume).
7. Use the same procedure for the 35 – 55 and 55 – 75 cm samples.
8. Use coring (next section) to sample below 75 cm depth.
9. When the organic / mineral interface (or permafrost table) is encountered during sampling, collect organic material up to the interface and record the depth represented by the last organic sample as well as its volume. Make a note of the type of boundary encountered.
10. When using this method to collect samples all the way to the organic / mineral interface, collect at least one sample (15 cm depth) of the underlying mineral soil. Use the mineral excavation method described on pages 72-73 if possible.
11. In shallow organic soils that have a low water table, it may be possible to sample multiple layers of the mineral soil. Collect as many depth intervals as is possible given the field conditions. 'Target layers' are 0-15; 15-35; and 35-55 cm from the organic / mineral interface (one sample per depth interval). Use the mineral excavation method described on pages 72-73 if possible.

Coring (unfrozen soils)

A Macaulay peat sampler, or Russian corer, is recommended for coring unfrozen organic soils. A version of this corer capable of collecting samples of 5 cm diameter to10 m depth is available from CFE industries ('Peat sampler' - catalogue # 26413 in the 2002 / 2003 catalogue; $1656.89). The corer can be operated manually by two people. It consists of a core barrel, a handle, and a series of extensions. Functionally, the instrument is best described as a sidewall sampler. The core barrel is semicircular in cross-section and has a heavy, pointed tip. It contains a sampling chamber that is 50 cm long and can be closed with a flap. The core barrel is pushed to the desired sampling depth, and then turned 180° by turning the handle at the peat surface. Because the flap that closes the sampling chamber extends beyond the cross-sectional area of the core barrel, it remains fixed in place and the core barrel turns around it, cutting a 50-cm long, semicircular sample out of the profile wall. The cross-sectional area of each sample is

$$A = \frac{\pi \times radius^2}{2}$$

i.e. 9.817 cm^2 for a sampling chamber with 5 cm internal diameter. To obtain the volume for an individual sample, multiply this number by the depth interval represented by the sample (i.e. a 25 cm sample retrieved by this method has a volume of 25 x 9.817 = 245.4 ml).

Make sure that appropriate depth intervals are marked on the coring equipment before going out in the field. If the handle and extensions are not pre-marked by the manufacturer, assemble the corer and place permanent marks (using e.g. electric tape) at 25-cm intervals (or closer) along the extensions. Any scheme that allows to keep track of the coring depth is appropriate. The description that follows assumes that the bottom of the sampling chamber represents depth 'zero' on the corer, i.e. the top of the sampling chamber represents the 50 cm mark, and so on along the extensions. Since extensions are inserted between the core barrel and the handle, the depth represented by marks on the handle depends on the number of extensions used. Keeping track of this while coring requires some practice, and coring teams should be given the opportunity to test the equipment and establish a protocol that works *before* going out to sample plots.

1. Since the corer does not work well in fibric or rooty materials, the 0-15 cm sample (and in many cases also the 15 – 35 cm sample) should be removed using either the forest floor or organic excavation method.
2. Attach the handle to the core barrel and close the sampling chamber.

3. Determine the ‘target depth’ to which the sampler should be pushed. For example, if the upper 35 cm of the organic matter profile have been collected by excavation, a reasonable target would be to collect the next two samples (35-55 and 55-75 cm, i.e. a total of 40 cm of the organic matter profile). Since the sampling chamber is only 50 cm long, it would not be possible to collect the full 75 – 100 cm sample at the same time.
4. Drive the core barrel into the ground by pushing down on the handle (without turning it!). In the example just mentioned (and assuming depth intervals have been marked on the coring equipment as described above), the sampler would be inserted until the 75 cm mark on the coring equipment is flush with the organic soil surface (i.e. the upper 10 cm of the sampling chamber are still visible above the base of the 35 cm excavated surface).
5. Turn the handle by 180° (clockwise in most designs)
6. Pull up on the corer. Wear work gloves with rubberized gripping surfaces and lift up using your legs rather than your back. In some designs, the sample chamber can open when the core barrel is above ground, leading to loss of material collected. To avoid this, one person should firmly grip the core barrel and hold the sampling chamber closed, while the second person pulls up on the handle / extension.
7. Remove excess material adhering to the corer that is not part of the sample.
8. Holding the corer horizontally, carefully open the sample chamber by turning the flap that closes it back 180°. This is best done by two people, with one person turning the flap and the other turning the corer in the opposite direction at the same time. If done correctly, the sample comes to rest horizontally on the flap.
9. Measure the length of the material removed, and cut it into the appropriate number of samples using a bread knife. Make sure to keep track of ‘top’ and ‘bottom’. In the example used here, the material removed should measure 40 cm, representing the 35-55 sample (at the ‘handle end’ of the sampling chamber) and the 55-75 cm sample (at the ‘nose end’ of the sampling chamber). Place the samples in appropriately labelled bags and record the volume of each sample.
10. Clean the sampling chamber using a wet rag or brush. Close the flap.
11. Determine the ‘target depth’ to which the sampler should be pushed during the next sampling. In the current example, coring to 125 cm depth would allow to recover the next two samples (75-100 and 100-125 cm). Insert an extension between the core barrel and handle if required for sampling to that depth.
12. Re-insert the corer into the same hole (point the part of the flap that sticks beyond the core barrel in the same direction each time), and push the sampler to the new target depth; turn the handle by 180°.
13. Pull up the corer and remove excess material adhering to the core barrel before opening the sample chamber. Collect samples as described above.
14. Keep coring until the base of the organic material is reached. Be careful when recording the volume of the basal organic sample, since it will probably not represent a full 25 cm depth interval.
15. Recover a sample of the mineral underlying the organic layers and collect it in a separate sample bag; record its volume. (Aim for a 10-cm section of mineral material). Since basal organic layers tend to be humic and highly compacted, recovery of these sections and the underlying mineral material may require bringing up partial sections (see section on commonly encountered problems below).

Commonly encountered problems

1. Material is too hard to push corer in a full 50 cm at a time.

Wherever possible, try coring in successive 50-cm intervals (except at top of the section where the requested sampling intervals may not make this practical). With the strength and body weight of two people, this should be possible in most situations. The following are exceptions that may be encountered:

- If the corer hits a buried tree or other object that cannot be penetrated, the original core hole may have to be abandoned. If this is the case, re-start the sampling from the beginning in a different spot.
- If the resistance is due to increasing density of the soil to be sampled, push the corer into the ground as far as it will go and bring up the material collected. Put it into the appropriate sample bag(s), and re-insert the corer back into the hole to repeat the process. When coring this way, it may take two or more corings to bring up the material that makes up one sample. If this is the case, still collect all material for the same sample in the same bag. Be extremely careful to keep track of the depth to which you core each time. **Read the section on partial sections below**.

2. Partial sections

This refers to cases when the corer comes up partially empty, or when less than full 50-cm intervals are cored at a time

- If the corer brings up less than the expected amount of material, check your notes to make sure you have pushed it in to the correct target depth. If correct technique has been used, collect the material brought up into the appropriate sample bag(s) and continue coring. Make a note in the comments sections suggesting likely reasons for the apparently incomplete sample. (Incomplete sections usually indicate that the material to be cored has very low bulk density. Very wet, watery material may be lost during coring, and some peatland sites contain a water lens underneath the surface layers.)
- If you core less than 50 cm at a time (usually because the material is too hard to push the corer to the desired target depth), sections brought up represent less than a full 50-cm interval of soil. In spite of this, the sampler will often bring up the full 50 cm, because of collapse of material into the core hole or sampling of a different side of the profile. Based on how far you pushed the corer in, you can calculate the length that the collected section should be – e.g. if you pushed the corer in 30 cm further than in the last coring, the section collected should be 30 cm long. Measure the material collected and **discard excess material at the top ('handle end') of the sample chamber**. Distribute the remainder into sampling bag(s) as appropriate.

Coring of frozen soils

There are several designs for motorized corers capable of retrieving samples from permafrost soils. The most commonly used of these is probably the CRREL auger. A corer for manually sampling frozen organic soils is described in Zoltai (1978).

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