Field Guide: Sampling Fuels in the Context of the Next-Generation Canadian Forest Fire Danger Rating System (NG-CFFDRS)

Field Sampling Protocol and List of Attributes for Field Crews v2.0 (2026)

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Abstract

This document presents a field sampling protocol draft that aims at giving guidance on how to measure, estimate, calculate or model each of the fuel attributes that are currently envisioned to be needed in the Next Generation of the Canadian Forest Fire Danger Rating System (NG-CFFDRS; Fire Danger Group, 2021). The full updated list of fuel attributes is presented in Table 1.

We are hoping that this protocol becomes the national standard for NG-CFFDRS Fuel Attributes sampling, where sampled plots using this protocol could become part of a national database that can be used to improve mapping and modelling. The underlying equations of the NG-CFFDRS are still under development, and there are still some uncertainties around what stand level statistics (mean, SD, quadratic mean, quartile, etc.) will be used to best describe individual fuel attributes. With this in mind, we suggest that all raw data taken during field sampling be kept. If this cannot be achieved, plot level mean and standard deviation are minimums. The level of details in the different measurements is dependent on the objectives sought (e.g., detailed sampling for experimental burning studies versus quick estimation for a fire behaviour specialist on an incident).

This protocol draft proposes a plot layout (Figure 1), as well as fuel attributes measurements with related sampling methods and instruments. More detailed information about down dead wood sampling transects is also provided on Figure 2. Field forms supporting the proposed fuel sampling can be available upon request. The protocol is intended to be used for any forest fuels complexes, including post-disturbances, such as insect outbreaks. The development of this protocol was greatly influenced by the National Forest Inventory field sampling protocol (NFI Task Force 2008) and existing fuel sampling protocols (e.g., McRae et al. 1979, Alexander et al. 2004, and Lavoie et al. 2010). In this June 2023 version of the protocol, we propose slight changes from the 2021 and 2022 versions, aiming at reducing the amount of time spent measuring and to ensure better compatibility with the National Forest Inventory (NFI) ground plots protocol but also with the NFI compilation system and databases. This last consideration is motivated by the new Canadian Forest Service 5-year program (with some ongoing hires and infrastructure) called the Northern Forest fuels Mapping program[1], which aims at mapping fuels, both current Fire Behaviour Prediction (FBP) (Hirsch, 1996) and NG-CFFDRS Fuel Attributes.

[1] Previously referred to the Forest Mapping for Wildfire Resilience (FM4WR) Program.

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Fuel Sampling Protocol

1. Site Information

1.1 Introduction

A site assessment is required for each ground plot to provide a record of conditions at NG-CFFDRS ground plot locations including characteristics of the stand and information on site disturbance.

1.2 Objectives

- To collect site features information.

1.3 Procedure

1. Measure and record site features for the sample plot.
2. Identify and record position on the slope, relief, % slope, rear slope length, and slope direction, % rock cover, wetland class, and drainage class.
3. Provide percent cover estimates by species of the upper canopy, lower canopy, and the shrub layer.
4. Draw a diagram of disturbances and their extent as they affect the overall plot. This may include obstructions to plot measurements (e.g. cliff, large rock, etc.)
5. Note GPS coordinates of plot centre using a handheld GPS device

1.4 Considerations

1. The site information can be completed as the last field card at the plot. This gives crew members the chance to familiarize themselves with the environment and forest stand.

Field Cards for Site Information:

- Form 7

2. Plot Center

2.1 Introduction

The plot center is placed in the stand, or fuel complex, of interest. It is the reference point from which all other elements of the plot layout are positioned. The needed level of precision of its geographic location is driven by the expected usage of the measurements.

2.2 Objectives

- To record the geographic coordinates of the plot center.

2.3 Instruments

- Metal post
- Flagging tape
- Differential GPS unit
- Compass
- x2 50m measuring tapes

2.4 Procedure

1. Navigate to within 1 meter of the pre-determined plot location using a handheld GPS unit.
2. Place the plot center pin as close as possible to this point.
    a) Optional: Place the vertex transponder at plot center and trace out the 11.28m and 3.99m plot contours using spray paint.
3. Use an Emlid Reach RS2+ GNSS to record the geographic location at plot center.
4. Extend two 40m transect tapes in the N-S and E-W directions using a compass. Make sure the intersection of the two tapes aligns perfectly at plot center.

2.5 Conditions

- A buffer of 1 meter may be used to avoid placing plot center on or by an obstruction.

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3. Canopy Fuel Plot (Large Tree Plot)

3.1 Introduction

The canopy fuel plot is where we directly measure or record measurements of large trees. These measurements are used to estimate the fuel attributes of the canopy fuel strata. This is done using allometric equations and/or models. A fixed radius plot of 11.28 m which covers an area of 400 m^2 was selected for its simplicity of establishment and compatibility with other protocols (e.g., NFI).

3.2 Objectives

- To collect detailed information for canopy/large trees (≥ 9.0 cm at diameter breast height).

3.3 Instruments

- Caliper
- Diametric tape
- Vertex (or clinometer)
- Telescopic measuring ruler
- DBH measuring stick

3.4 Measurements

1. Diameter at breast height (DBH), measured for all trees ≥ 9.0 cm.
2. Stand density of trees ≥ 9.0 cm.
3. Species identification for each tree ≥ 9.0 cm.
4. Tree, stem, and bark conditions for all conifers ≥ 9.0 cm (hardwood species may be classified as either live or dead only).
5. Tree height measured for a minimum of 12 trees to ensure height measurements for all stand layers. Select 12 trees, based on an accurate representation of canopy height classes (across the range of diameters observed), and measure heights. Record whether the height was measured (M) or estimated (E).
6. Live (LCBH) and dead (DCBH) crown base heights for all coniferous stems with DBH ≥ 9.0 cm. The goal is to determine the end of crown continuity. If this is not an effective definition, then use your judgment to determine the LCBH and DCBH:
    a) LCBH: height of the first whorl (at the base of the stem) where three-quarters of the branches have needles (red or green).
    b) DCBH: height of the first whorl (at the base of the stem, except where the dead branches touch the ground) where three-quarters of the branches are dead but still baring twigs.

3.5 Procedure

1. Standing at plot center, looking towards the outside of the plot just to the right (east) of Transect 1 (i.e. 0 degrees north magnetic), begin by measuring trees closest to plot center along bearing and then scanning clockwise (east).

2. With a caliper (tail towards the center of the plot), or a diametric tape, measure the DBH at 1.30 m for the highest side of the ground.
3. The number of trees ≥ 9.0 cm in the plot is counted while measuring DBH. Paint the tree number using spray paint (in areas this is permitted).
4. Identify species while measuring DBH.
5. Tree condition visually classified as:
   (1) Live
   (2) Dead with red needles (red stage)
   (3) Dead without needles (grey stage), but still baring small twig branches (i.e., <1cm)
   (4) Snag (other standing dead state)

   Stem condition visually classified as:
   a) Intact
   b) Broken (if broken, estimate height at break point)

   Bark condition visually classified as:
   a) Intact
   b) Peeling off on more than 30% of the stem (more than 30% peeling)
   c) Completely gone

6. Use the vertex or clinometer to record the height of trees (see NFI Ground Plot Guidelines). Do this for a minimum of 12 trees that represent the stand.
7. Use a telescopic measuring ruler, vertex, or clinometer to measure DCBH and LCBH.
   a) For LCBH: measure the height of the first whorl (at the base of the stem) where three-quarters of the branches have needles (red or green).
   b) For DCBH: measure the height of the first whorl (at the base of the stem, except where the dead branches touch the ground) where three-quarters of the branches are dead but still baring twigs.
8. OPTIONAL – For stem mapping, record the distance and azimuth from plot center to the measured stem. Do so for every tree (≥9.0cm diameter) within the 11.28m radius plot.

3.6 Conditions

- For height measurements, make sure to number the trees using spray paint. However, if this is not permitted in certain areas, you may use chalk or green spray paint (double check with park authority).
- When dead branches touch the ground, this means the DCBH is measured at zero.
- When live branches touch the ground, this means the LCBH is measured at zero.
- When measuring LCBH or DCBH on trees with blocked growth (from an obstruction or adjacent tree), measure as though the unobstructed whorls cover 100% of the stem.
- If a terrestrial LiDAR scanner is used, stem mapping is mandatory.

Field Cards for Canopy Fuel Plot:

- Form 2

4. Subcanopy Fuel Plot (Small Tree and Shrub Plot)

4.1 Introduction

The subcanopy fuel plot is where we directly measure or record measurements that serve to estimate the fuel attributes of some of the ladder fuel strata (subcanopy tree height and basal area). A round plot with a radius of 3.99 m and thus covering an area of 50 m² was selected for its simplicity of establishment and compatibility with other protocols (e.g., NFI).

4.2 Objectives

- To collect detailed information for subcanopy stems (DBH < 9.0 cm and height ≥ 1.3m).
- To collect detailed information for trees with DBH < 9.0 cm and height ≥ 1.3m
- To collect detailed information for shrubs of height ≥ 1.3m.

4.3 Instruments

- Vertex (or clinometer)
- Telescopic measuring ruler
- Caliper
- DBH measuring stick

4.4 Measurements

For Subcanopy Trees:

1. Tree height for all stems with DBH < 9.0 cm and height ≥ 1.3m.
2. DBH for all stems with DBH < 9.0 cm and height ≥ 1.3m.
3. Species identification for each tree with DBH < 9.0 cm and height ≥ 1.3m.
4. Tree, stem, and bark conditions for all conifers with DBH < 9.0 cm and height ≥ 1.3m (deciduous species may be classified as either live or dead only).
5. Live (LCBH) and dead (DCBH) crown base heights for all coniferous trees with DBH < 9.0 cm and height ≥ 1.3m. The goal is to determine the end of crown continuity. If this is not an effective definition, then use your judgment to determine the LCBH and DCBH:continuitéSidéfinition
    a. LCBH: height of the first whorl (at the base of the stem) where three-quarters of the branches have needles (red or green).
    b. DCBH: height of the first whorl (at the base of the stem, except where the dead branches touch the ground) where three-quarters of the branches are dead but still baring twigs.

For Shrubs:

1. Basal diameter (cm) and average height for all shrubs of height ≥ 1.3m or DBH and individual stem heights for all shrubs of height ≥ 1.3m.
2. Species identification for all shrubs of height ≥ 1.3m.
3. Condition for all shrubs of height ≥ 1.3m (classified as either live or dead only).

4.5 Procedure

For Trees:

1. Telescopic measuring ruler, vertex, or clinometer
2. Caliper (tail towards the center of the plot)
3. Identify species
4. Tree condition visually classified as:
   (1) Live
   (2) Dead with red needles (red stage)
   (3) Dead without needles (grey stage), but still baring small twig branches (i.e., <1cm)
   (4) Snag (other standing dead state)

   Stem condition visually classified as:
   a) Intact
   b) Broken (if broken, estimate height at break point)

   Bark condition visually classified as:
   a) Intact
   b) Peeling off on more than 30% of the stem (more than 30% peeling)
   c) Completely gone

5. Use a telescopic measuring ruler, vertex, or clinometer to measure DCBH and LCBH.
   a) For LCBH: measure the height of the first whorl (at the base of the stem) where three-quarters of the branches have needles (red or green).
   b) For DCBH: measure the height of the first whorl (at the base of the stem, except where the dead branches touch the ground) where three-quarters of the branches are dead but still baring twigs.

For Shrubs:

1. Basal Diameter: Record the basal diameter and average height of each shrub. Basal diameter is measured at the ground line or just above the root collar, whichever is higher.
   a) If a singular root collar is not immediately exposed, brush away the litter to expose it and measure the basal diameter.
   b) If basal diameter cannot be measured, collect the diameter at breast height and the height of the stem (refer to figure 4).
2. Shrub Species: Record the species of each shrub using the first three letters of the scientific species name or the NFI code.

4.6 Conditions

- Refer to the NFI Ground Plot Guidelines for DBH and basal diameter measurements.
- When measuring LCBH or DCBH on trees with blocked growth (from an obstruction or adjacent tree), measure as though the unobstructed whorls cover 100% of the stem.
- When measuring shrubs, suckering species may be difficult to accurately measure the basal diameter. Instead, collect the DBH for all stems of the shrub.

Field Cards for Subcanopy Fuel Plot:

- Form 3

5. Regeneration Plots (Microplot)

5.1 Introduction

These are 1 m² square plots. There are four regeneration plots placed along the DDW transects, with two microplots per transect.

5.2 Objectives

- To collect detailed information for tree seedlings.
- To collect images of the regeneration plot and from the regeneration plot towards plot center.

5.3 Instruments

- $1m^2$ quadrat (with PVC)
- PVC stick with height classes (< 15 cm; 15-59.9 cm; 60-129.9 cm)
- Measuring tape

5.4 Measurements

1. Tree seedling density per species per height classes (< 15 cm; 15-60 cm; 60-130 cm).

5.5 Procedure

1. Establish four 1 m^2 quadrats on the line transects used for woody debris. For microplots 1 (North) and 3 (East), place one corner of the quadrat at 10m, placing the opposing corner away from plot center. For microplots 2 (South) and 4 (West), place one corner of the quadrat at 30m, placing the opposing corner away from plot center.
2. Take a top-down picture of the regeneration plot at breast height.
    a. Take note of photo file name.
    b. Use the naming convention to label photo files for data submission: Plot number - REGEN - transect number - length along transect.
3. Take a picture towards plot center from the outer corner of the regeneration plot.
    a. Take note of the photo file name.
    b. Use the naming convention to label photo files for data submission: Plot number - PC - transect number - length along transect
4. Count tree seedlings contained in $1m^2$ quadrat (defined by a PVC frame) by height class and species.

Field Cards for Regeneration Plots:

- Form 4

6. Forest Floor Sampling

6.1 Introduction

Forest floor plots are used to determine biomass of fine woody debris, litter, live bryophytes, dead bryophytes, upper and lower duff. Forest floor samples are collected and analyzed to determine bulk density as well as the total depth of the organic layer.

6.2 Objectives

- To provide estimates of forest floor biomass and bulk density and total organic depth.

6.3 Instruments

- $1m^2$ quadrat (with PVC)
- Square frame of known dimensions (recommended size 20 cm x 20 cm)
- Pruning shears and bread/serrated knife
- Ruler / measuring tape
- Ziplock bags (large airtight freezer bags)
- Metal pigtail
- Shovel
- Flat object (plate, platter, clipboard, etc.)
- Edelman auger

6.4 Measurements

1. Average thickness of the various organic layers.

6.5 Collected Samples

Using the square frame collect samples from the following layers (if present) at each microplot:

- Fine woody debris (<1.0 cm diameter)
- Litter (leaves, needles, cones)
- Live bryophytes
- Dead bryophytes and upper duff (fermentation layer)
- Lower duff (humic layer)

In the event where the upper and lower duff are impossible to differentiate, sample the entire FH horizon and record the total thickness.

6.6 Procedure

1. Place the sampling frame on a sampling area that is most representative of the forest floor within the 1 m^2 quadrat. Avoid compacting the sample. Using a metal pigtail, probe the potential sampling area to check for buried stones, wood, or any other obstacle that could hinder the sampling process.
2. Remove all live herbs and shrubs from the square frame and discard.
3. Using a bread knife or similarly serrated knife, cut along the inner edges of the frame to the bottom of the organic layers or to a maximum depth of 20cm.

4. Separate the surrounding material by pulling it away from the outlined sample. Shears can be used to cut through roots along the sides and the bottom of the sample. This will facilitate the removal of the sample by exposing all four sides and bottom.
5. Carefully insert a flat object under the sample and lift the entire sample out of the ground.
6. With the sample still on the flat surface, take a picture with a ruler (or any other graduated instrument) for reference and note the image number on the form.
7. Separate the sample in the following groups and place each of them in a separate, airtight plastic bag (paper bags will dry the samples too much):
    a. Fine woody debris (dia. <1,0cm)
    b. Litter (leaves, needles, cones)
    c. Live bryophytes
    d. Dead bryophytes and upper duff
    e. Lower duff
8. Measure the thickness of each sampled layer. Starting from the litter layer to the bottom of the duff sample. Calculate and record individual layer thickness by measuring the four sides and averaging to the nearest 0.1 cm.
    a. In case the organic layer exceeds a depth of 20cm, measure and record the total depth of the organic layer using an Edelman auger or a shovel. This measurement is not used to calculate bulk density.
9. Label each bagged sample either by using a waterproof label or using a permanent marker using the following naming convention: “Organisation_plot number_treatment_microplot number_sample type_YYYY-MM-DD_initials". Example: CFS_1038489_OG_MP1_FWD_2025-07-16_MNO.

6. Conditions

- Samples should be kept in a cooler to avoid temperature changes that could dry out or cause mould in the sample.
- Sample parts (fine woody debris, litter, bryophytes, etc.) should be regrouped in a larger bag identified with the plot identification as well as the microplot number.
- Soil sampling frame size can be modified to accommodate thinner lor deeper soils. Frame size must be recorded to properly calculate bulk density.
- If a sample is too large for a single bag, multiple, well identified bags may be used. The naming convention mentioned above must be used and an indicator of the number of bags for the samples must be added to the label (ex: bag 1 of 2, bag 2 of 2). If large roots are present in the sample, they may be broken down as to avoid piercing or ripping the bag.
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Field Cards for Forest Floor Plot:

- Form 6

7. Surface Fuel Plot (Ecological Plot)

7.1 Introduction

The surface fuel plot is where we directly measure or record measurements that serve to estimate the fuel attributes of some of the surface fuel strata (surface vegetation and forest floor cover type). A round plot of a 5.64-m fixed-radius plot and thus covering an area of 100 m^2 was selected for its simplicity of establishment and compatibility with other protocols (e.g., NFI).

- Low shrubs: Are defined as woody perennial plants shorter than 1.30 m, having multiple stems that branch from the base without a well-defined main stem.
- Herbs: All herbaceous species, including forbs (including ferns and fern allies), grasses, sedges, and rushes.
- Bryoids: Mosses, sphagnum, liverworts, hornworts, and non-crustose lichens.
- Litter: Leaf, needle, and general litter layers.

7.2 Objectives

- To collect percent cover estimates of vegetation per species (whenever possible) within the low shrub, herb, bryoid and litter layers.

7.3 Measurements

1. Percent cover estimates by species whenever possible. If species identification is impossible, evaluate the cover percentage by genus, group (ie: medium low shrub), or layer (low shrubs shorter than 1.30 m, herbs, bryoids, leaves litter, needles litter, and general litter).

7.4 Procedure

- For measurement of live vegetation and litter within the low shrub, herb, litter and bryoid layers, establish a 5.64-m fixed-radius plot, centered at ground plot center. Bryoid species growing on the sides of trees or on overhanging branches should not be recorded.
- The Bryoid layer can be evaluated as a percentage cover by species. If such an evaluation is impossible, it can be done at the group (mosses, sphagnum, lichen) level.
- For vegetation categories of very low coverage, an exhaustive list is not expected. Given the seasonal variation in flowering and vegetative production, plant categories of very low coverage (< 0.01%) can easily be missed. Concentrate on plant categories having > 0.01% coverage. By percent cover we mean the percent of the ground surface covered by the vertical projection of the crown of the plant onto the ground surface. Cover values for individual plant category in each vegetation layer will be estimated. Within each layer, overlapping crowns are not additive for the same plant category; consequently, a given category cannot have coverage > 100% in a single layer. Assessing cover by layer will sometimes result in total coverages > 100%.

7.5 Conditions/Notes

- Use the quadrat (1m x 1m frame) as a reference of 1% of ground covering of the ecological plot (100 m^2).

- One walk of the plot to identify categories, second walk of the plot to determine percent covers.
- From 1-10% range, make 1% adjustments.
- From 10-25% range, make 5% adjustments.
- From 25-100% range, make 10% adjustments.
- Twenty-five quadrats belong to a quarter of the ecological plot. When assessing the percent coverage of the plot, crews may estimate the number of quadrats of each category within a quarter of the plot and add the totals from each quadrat to produce an overall plot estimate.
- Species must be determined if field crew members are confident.
- The layers are: LS (Low Shrubs), HE (Herbs), BR (Bryoids), LL (Leaf Litter), NL (Needle Litter), and GL (General Litter)
- The groups are LLS (Low Low shrubs), MLS (Medium Low Shrubs), HLS (High Low Shrubs), LHE (Low herbs), MHE (Medium Herbs), HHE (High Herbs), MOS (Mosses), SPS (Sphagnum), LIC (Lichens)

Field Cards for Surface Fuel Plot:

- Form 5

8. Down Dead Wood Transects (Woody Debris)

8.1 Introduction

Down dead wood pieces are sampled along two 40 m transects centered on the plot center and oriented N-S and E-W (Figure 1).

8.2 Objectives

To collect load by species, diameter, decomposition stage (classes 1-5), position (touching the ground or elevated), and tilt angle for pieces > 3.0 cm only. Stratified by diameter classes (0.01-1.0 cm, 1.1-3.0 cm, 3.1-7.0 cm, 7.1-30.0 cm, > 30.0 cm).

8.3 Instruments

- Caliper
- Go-no-go gauge
- Measuring tape

8.4 Measurements

1. Quantify down dead wood (DDW) by size classes (0.01-1.0 cm or 1.1-3.0 cm).
2. Measure down dead wood in each transect segment for species, diameter, decomposition stage (classes 1-5), tilt angle, and position (touching the ground or elevated/raised) for pieces > 3.0 cm only.

8.5 Procedure

1. For the 5 m to 10 m segment and 30 m to 35 m segment, dot tally separately the DDW ≥ 0.01 cm and ≤ 1.0 cm (fine woody debris) from the > 1.0 cm and ≤ 3.0 cm (small woody debris) when they are crossing the line. A detailed view of the transects is presented in Figure 2. If the dot tally reaches 250 pieces in the fine and small woody debris segment, stop counting. Record the length of the segment measured.
2. For all the segments of the transects, measure DDW pieces diameter (using a caliper) and note the species, decomposition stage (decomposition class), position (touching ground or elevated), and tilt angle of each DDW > 30.0 cm crossing the line. For the 5 m to 35 m segments, measure the diameter and note the species, decomposition stage, position, and tilt angle of each DDW > 7.0 cm crossing the line. For the 5 m to 15 m segments and the 25m to 35 m segments, measure the diameter and note the species, decomposition stage, position, and tilt angle of each DDW > 3.0 cm crossing the line. Refer to the NFI Ground Plot Guidelines for rules and definitions.

8.6 Conditions

- Note that diameter classes are specific to NorthForM.

Field Cards for Down Dead Wood Transects:

- Form 1

9. Hemispherical Photos

9.1 Introduction

Hemispherical photos (HP) can be used to estimate Plant Area Index (PAI) in the plot. Refer to figure 3.

9.2 Objectives

- To collect 8 hemispherical photos in each plot along the DDW transect lines (at 10m, 15m, 25m, and 30m).

9.3 Instruments

- 360-degree camera
- Camera pole
- Microfiber cloth

9.4 Measurements

1. Hemispherical photo along each of the DDW transects at the 10m, 15m, 25m, and 30m points (a total of 8 HPs) between peak daylight hours of 9:00 and 16:30.

9.5 Procedure

1. Along each of the DDW transects, locate the 10m, 15m, 25m, and 30m points.
2. Use the 360-degree camera and pole. Place the camera pole over the 10m, 15m, 25m, and 30m mark along the two transects.
3. Extend the 360-degree camera pole to a height of 1.8m. Capture image, ensuring that user face/head is not in the image.
4. Use Survey123 or equivalent field forms to document the photo file name immediately after capture.

9.6 Conditions

- If understory vegetation is blocking the camera, elevate the camera above the vegetation.
- Avoid direct sunlight (30cm allowance from transect to avoid direct sunlight).
- Ensure the lens is clean.
- Exposure should be checked after the photos and adjusted and re-taken if it's underexposed or overexposed.
- A 360 degree camera is used for both hemispherical photos and 360 photos. The resulting photos are used in two different processes which is why they are separated in this protocol.

Field Cards for Hemispherical Photos:

- Form 7

10. Capturing 360-Degree Photos

10.1 Introduction

360-degree photos can be used to identify fuel types.

10.2 Objectives

- To collect four 360-degree photos in each plot.
- Two photos collected at two separate locations: plot center and the most open crown closure point within the 11.28m radius plot.

10.3 Instruments

- 360-degree camera
- Camera pole
- Microfiber cloth

10. 4 Measurements

1. 360-degree photos at plot center and the most open crown closure point within the 11.28 m radius plot (a total of 4 photos).

10.5 Procedure

1. Before setting up your GNSS, locate plot center and extend the 360-degree camera pole to 1.5m height. Point the camera vertically at plot center and use the shutter button with the 10 second timer to capture the image.
2. Remain at plot center and capture a second image at 3m height using the same procedure as step 1.
3. Locate the most open canopy area of the plot and extend the 360-degree camera pole to 3m height. Point the camera vertically and use the shutter button with the 10 second timer to capture the image.
4. Remain at the most open canopy area and capture a second image with the pole extended to 3m. Angle the camera at a 45-degree angle. The user will move to keep the camera at the same location above the ground.

10.6 Conditions

- Ensure the lens is clean.
- Ensure the 3m pole is properly extended at 1.5 m and 3 m.
- A 360 degree camera is used for both hemispherical photos and 360 photos, The resulting photos are used in two different processes which is why they are separated in this protocol

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Field Cards for 360 Photos:

- Form 7

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Appendix A Table of NG-CFFDRS Attributes

Stratum	***Fuel attribute***	***Description***	***Units***	***Use in CFFDRS-2025***
Canopy fuels (or overstory fuels)	Plant area index (PAI) • Leaf area index (LAI): needed for better estimate of PAI for leafless conditions and disturbed stands • Wood (branch and stem) area index (WAI): semi-fixed part of PAI • Canopy closure (CC): maybe an alternate method to estimate PAI/LAI (guidance can be provided)	Plant area index for all vegetation with DBH > 0.1 cm (PAI = WAI+LAI) Leaf area index will be adjusted as a function of Proportion of tree species and Conifer conditions to account for seasonal and health related changes in the leaf/no-leaf states.	unitless	FBP/FMS: In-stand wind model, and solar radiation
	Canopy bulk density (CBD) • Canopy fuel load (CFL) (kg·m-2): needed to calculate CBD. • Stand overstory height (H) (m): needed to calculate CBD • Stand overstory trees diameter at breast height (cm): expected to be needed to estimate CBD from allometric equations • Stand density (stems·ha-1): expected to be needed to estimate CBD from allometric equations	CBD: Density of total live biomass dry weight (branchwood < 1.0 cm and foliage) canopy of conifers with DBH ≥ 3.0 cm (CBD = CFL/(H-CBH)) CFL: Total live biomass dry weight (branchwood < 1.0 cm and foliage) of conifers with DBH ≥ 3.0 cm. H: Height of overstory conifer trees (DBH ≥ 3.0 cm)	$kg \cdot m^{-3}$	FBP: Directly in crown fire intensity (CFL), spread, and consumption models. To determine type of crown fire (passive versus active) FMS/FBP: CFL maybe used for in-stand wind, surface fuel moisture modification
	Proportion of tree species in the canopy	It is the stand level proportion of basal area of overstory trees (i.e, trees with DBH ≥ 3cm) by tree species. Deciduous (or hardwood) species may be group as one species, in some situations it may be useful to separate the aspen genus from other deciduous. Coniferous	%	FBP/FMS: In-stand wind model FBP: Crown fire behaviour in mixedwood FMS: Solar radiation and surface fuel moisture adjustment

		species will need to be separated by species, or minimally by groups of species (e.g., tamarack, temperate pines, boreal pines, fir/spruces).		
	Condition of conifer trees	Stand level percentage of coniferous trees (i.e, trees with DBH ≥ 3.0 cm) per health condition (i.e., tree state) categories: 1. Live 2. Dead with needles (red state) 3. Dead without needles (grey state) 4. Other standing dead tree Other information on trees state may be pertinent to note, such as bark state (no loose bark, some/half loose bark, or no bark at all), and crown state (broken or not)	%	FBP/FMS: In-stand wind model FBP: Crown fire behaviour FBP: Crown fire consumption FMS: Surface fuel moisture
Ladder fuels	Stand effective canopy base height (eCBH) of coniferous species • Crown base height (CBH): needed for eCBH estimation • Subcanopy trees height (STH): needed for eCBH estimation	eCBH: distance between the top of the subcanopy conifer trees (DBH > 0.1 cm and <9.0 cm) and the lowest live branch of the overstory crowns (eCBH = CBH-STH) CBH: is the live crown base height (LCBH) of overstory conifer trees (DBH ≥ 9cm): height of the first verticil where three-quarters of the branches have needles (red or green), if continuity is present, whereas dead crown base height (DCBH): height of the first verticil where three-quarters the branches are dead but still baring twigs STH: is the height of subcanopy conifer trees (DBH > 0.1 cm and < 9.0 cm).	m	FBP: Directly in crown initiation and crown models

	Basal area of subcanopy trees species	It is the basal area of subcanopy trees (DBH > 0.1 cm and < 9.0 cm) by tree species. Deciduous (or hardwood) species maybe group as one species, in some situations it may be useful to separate the aspen genus from other deciduous. Coniferous species will need to be separated by species, or minimally be groups of species (e.g., tamarack, temperate pines, boreal pines, fir/spruces).	stems·ha^{-1}	FBP/FMS: In-stand wind model FBP: Crown fire initiation in mixedwood FMS: Solar radiation and surface fuel moisture adjustment
Ground and surface fuels	Tree seedling density per height classes (deciduous vs coniferous)	Tree seedling density per height classes (< 15 cm, 15.0-59.9 cm, and 60.0-129.9 cm), for deciduous and coniferous separately	stems·ha^{-1}	FMS: Litter moisture adjustment FBP: Sustained flaming model FBP: Surface fire spread models
	Surface vegetation	Surface vegetation cover per height classes (< 15 cm, 15.0-59.9 cm, and 60.0-129.9 cm) and by species	%	FMS: Litter moisture adjustment FBP: Sustained flaming model FBP: Surface fire spread models
	Downed woody debris load	Load by species, diameter, decomposition stage (rotten or sound), and position (touching the ground or elevated) for pieces > 3.0 cm only. Stratified by diameter classes (1.01-3.0 cm, 3.01-7.0 cm, 7.01-30.0 cm, > 30.0 cm).	kg·m^{-2}	FBP: Fuel consumption models

	Forest floor cover type	Forest floor cover per type: 1. Lichen 2. Grass 3. Sphagnum 4. Feathermoss 5. General Litter (e.g. bark, cones) 6. Needle Litter 7. Leaf Litter 8. Mixed (unidentified needle/leaf mix) 9. Other (e.g. rock)	%	FMS: Litter moisture adjustment FBP: Sustained flaming model FBP: Surface fire spread models
	Litter load	Weight of ground litter	$kg \cdot m^{-2}$	FBP: Fuel consumption models
	Organic layer depth	Depth of the ground organic layers (F and H)	cm	FBP: Forest floor consumption models
	Organic layer fuel load (bulk density)	Weight of the organic layers (F and H)	$kg \cdot m^{-2}$	FBP: Forest floor consumption models

Appendix B - Figures

UNCLASSIFIED - NON CLASSIFIÉ

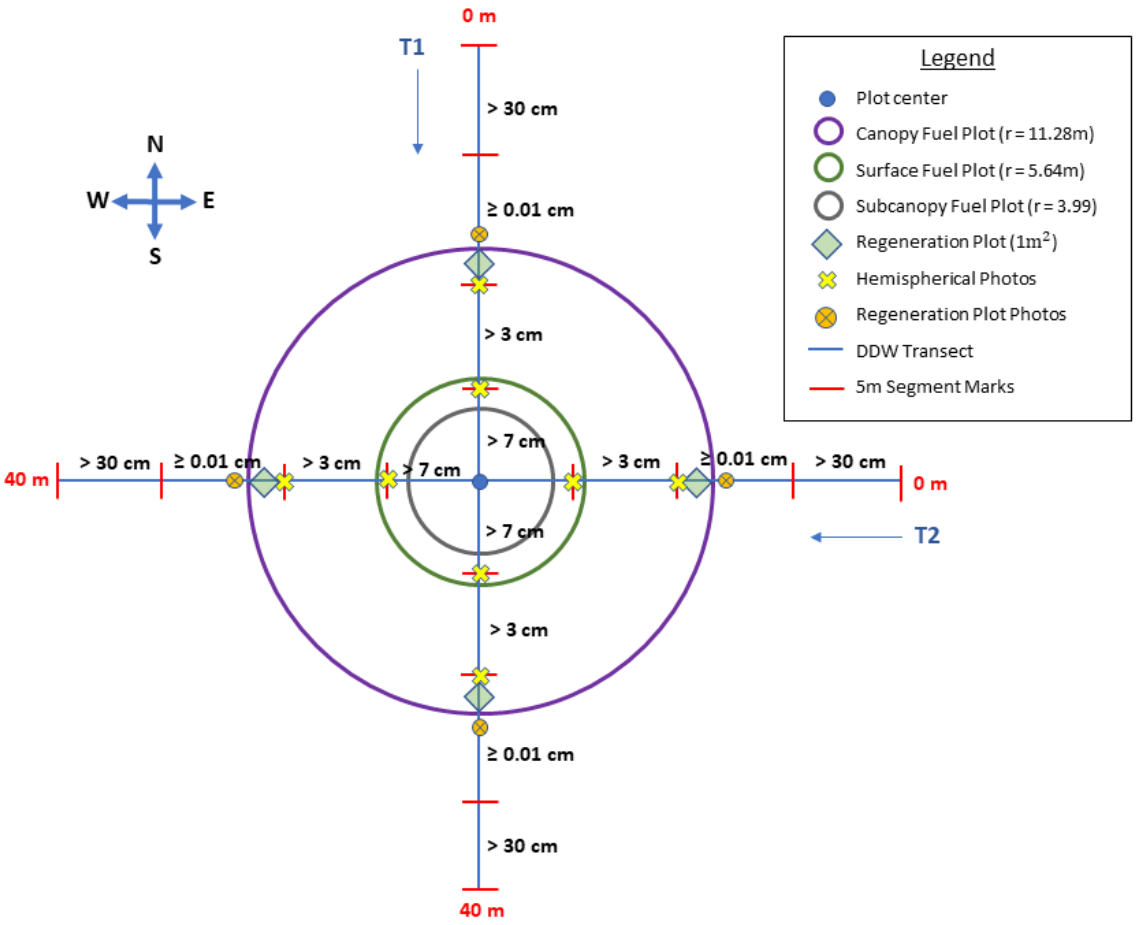


Figure 1 – Plot diagram displaying transect length and direction and plot diameters.

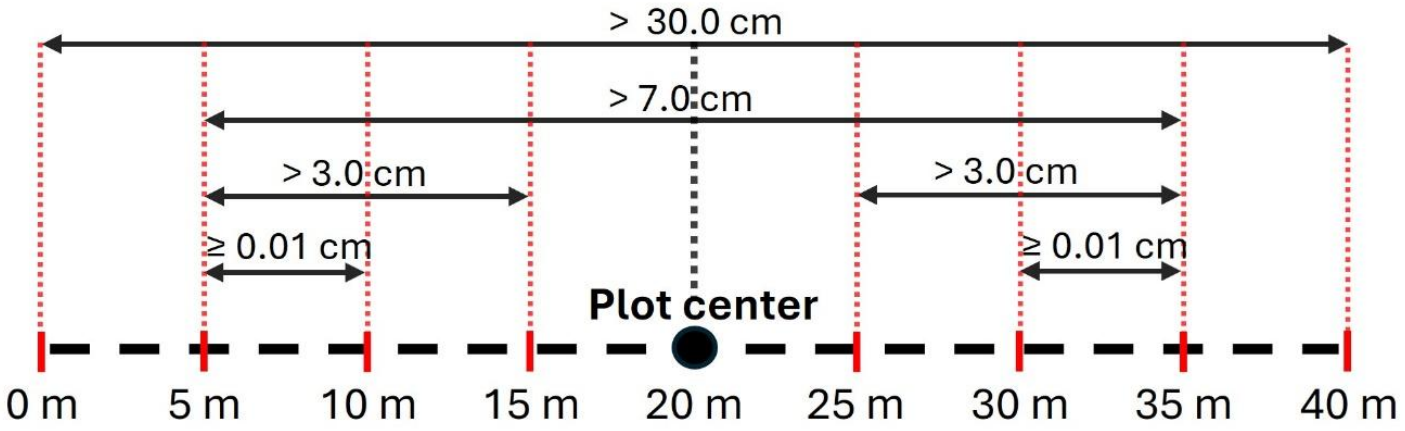


Figure 2 – Details of the down dead wood classes measurements along the 40 metre DDW transects

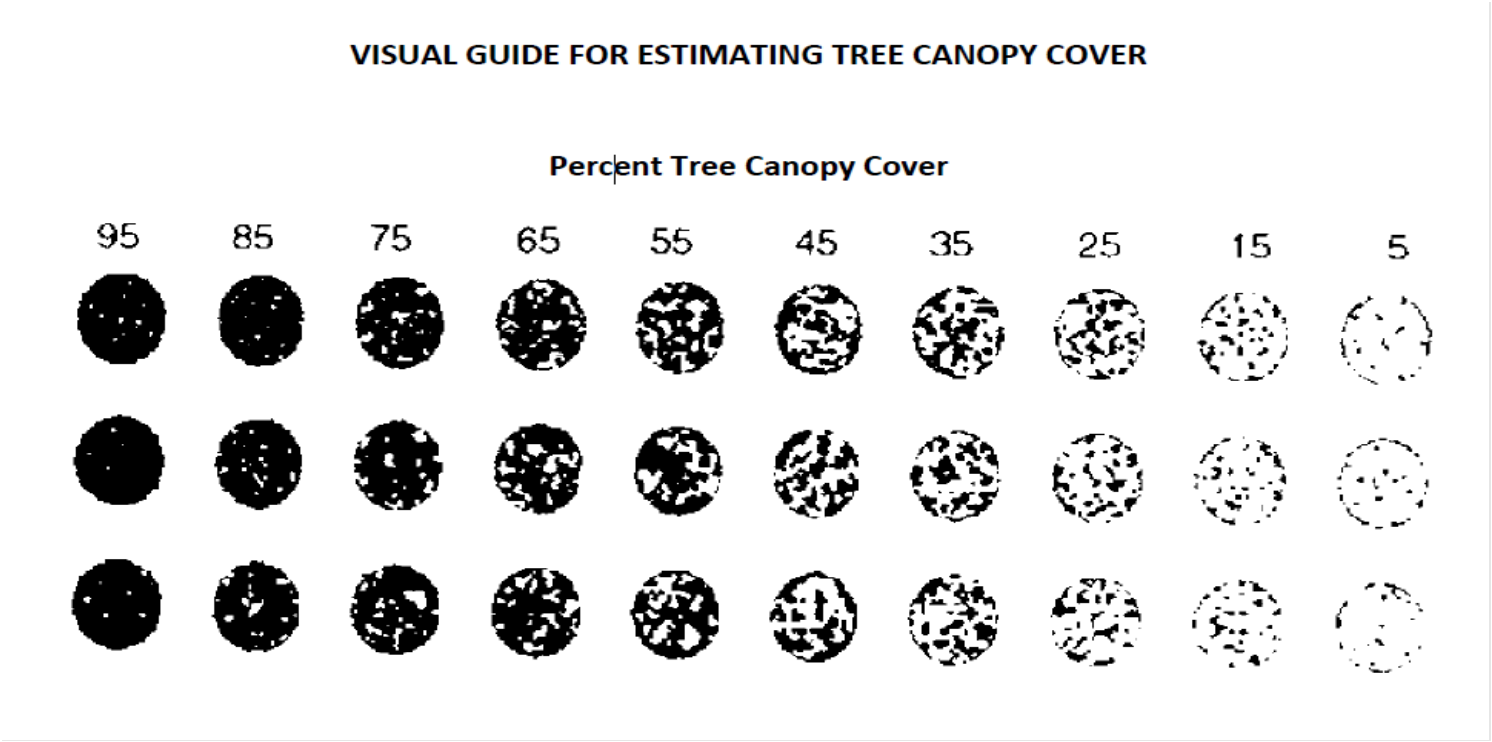
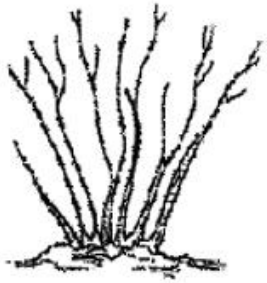


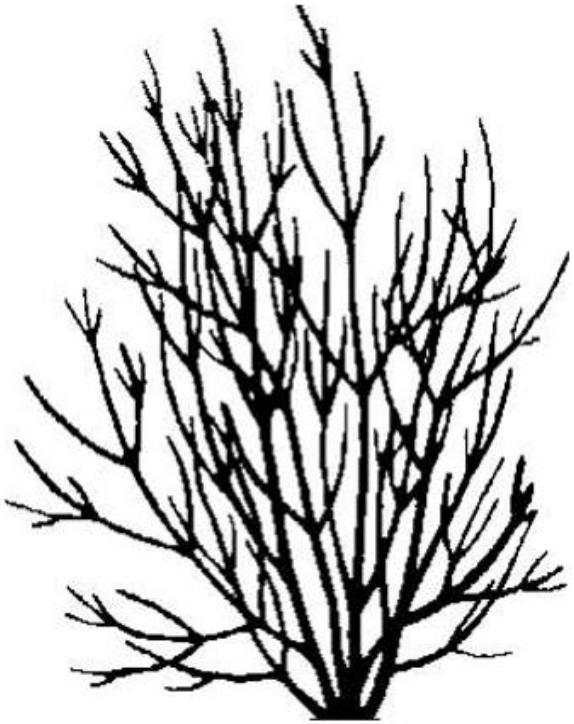
Figure 3 – Visual guide of percent cover



6 stems to tally



7 stems to tally



4 stems to tally



1 stem to tally

Figure 4 – Subcanopy basal diameter guide.

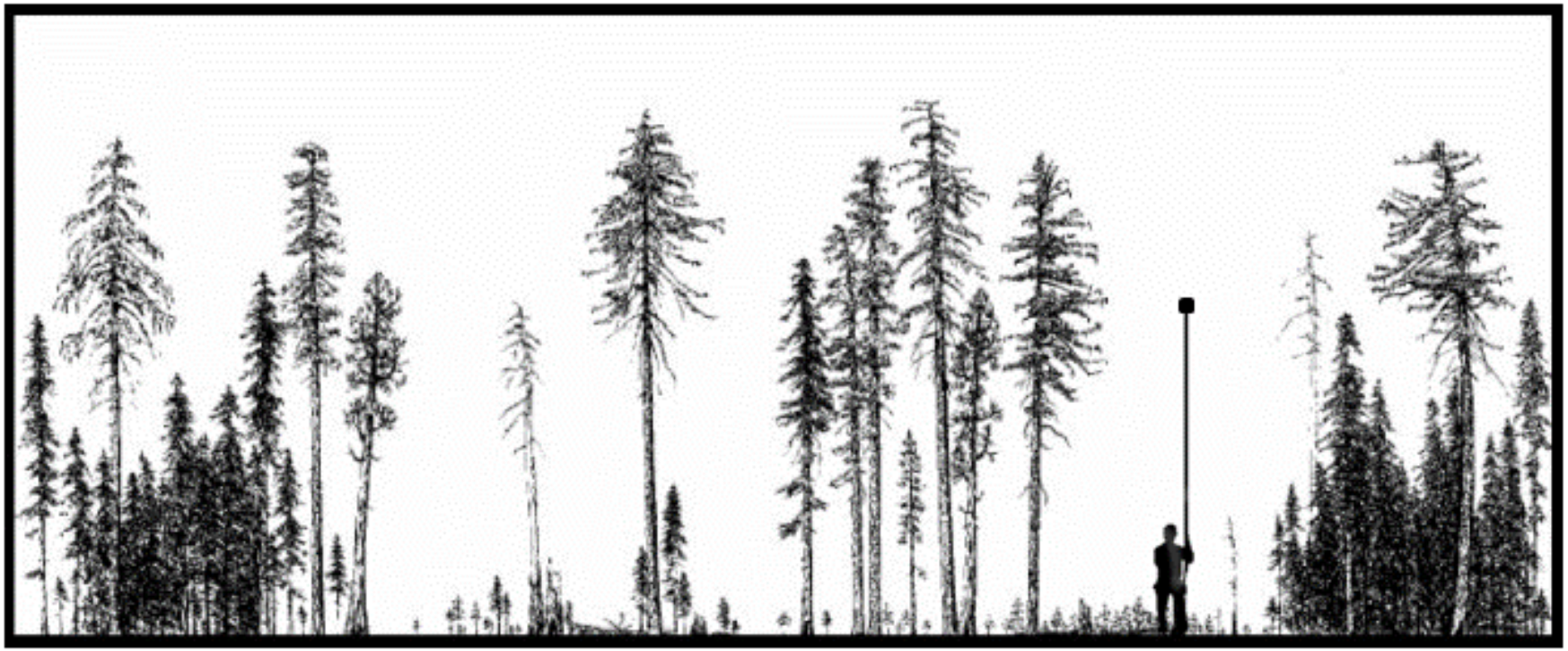
Appendix C - 360- Degree Photo Guide



First photo position. Use 360-degree camera at plot center with pole extended at 1.5m.



Second photo position. Use 360-degree camera at plot center with pole extended to 3m.



Third photo position. Use 360-degree camera in most open spot with pole extended to 3m.



Fourth photo position. Use 360-degree camera from the forest to an open spot with pole extended to 3m at 45 degrees.