Monitoring Vegetation in the Northwest Territories

A community-based protocol for the Northwest Territories Cumulative Impact Monitoring Program (NWT CIMP)

Cottongrass (*Eriophorum vaginatum*)

Trevor Lantz[1], Claire Marchildon[2], Jamie Leathem[3], Harneet Gill[1], Emily Cameron[1], and Chanda Brietzke[1]

[1]School of Environmental Studies, University of Victoria
P.O. Box 3060 STN CSC, Victoria, B.C. V8W 3R4

[2]Aboriginal Affairs and Northern Development Canada
P.O. Box 1500, Yellowknife, N.T. X1A 2R3

[3]Botany Department, University of British Columbia
6270 University Boulevard, Vancouver, B.C. V6T 1Z4

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Background and Objectives

Monitoring vegetation change is important because it can affect terrain stability, the quality and distribution of animal habitat, snow depth, and many other components of the environment. To track changes in vegetation and better understand their implications for northern planning, monitoring is required. This document describes a monitoring program developed by the University of Victoria (UVic) and the Northwest Territories Cumulative Impacts Monitoring Program (NWT-CIMP).

This sampling **protocol** is intended to capture the range of natural variability in the vegetation of different site types. Once this baseline has been established, it can be used as a means to assess the effects of disturbance and other environmental changes. Re-sampling baseline sites over time can also be used to monitor the recovery of areas impacted by human-caused activity.

Across the circumpolar north, both local and scientific observations suggest that terrestrial vegetation is changing. The techniques described in this manual can also be used to determine if undisturbed sites are changing in response to climate warming and other environmental changes.

Equipment Checklist

Potential equipment suppliers are listed in the References section.

- ☐ Protocol guidebook
- ☐ Protocol datasheets [see CD in the back pocket]
- ☐ Clipboard
- ☐ Pencils and permanent markers
- ☐ Compass
- ☐ Handheld **GPS**
- ☐ 50 m measuring tape (2)
- ☐ 5 m measuring tape
- ☐ **Diameter at breast height (DBH) tape**
- ☐ Small metal ruler
- ☐ Hammer (sledge or carpenters)
- ☐ 1.0 m sections of 3/8 inch rebar (5 per site)
- ☐ 1.5 m sections of 1/2 inch PVC pipe (5 per site)
- ☐ **Metal pigtails** (40)
- ☐ Flagging tape (brightly coloured)
- ☐ Height pole marked at 1.3m
- ☐ Aluminum tree tags
- ☐ Tree nails and wire
- ☐ 1 m x 1 m berry plot frame
- ☐ 1 m x 1 m **point frame**
- ☐ Digital camera
- ☐ Field notebook
- ☐ Clinometer
- ☐ Pocket **calipers**
- ☐ Ziploc freezer bags (medium and large sizes)
- ☐ Plant guidebook (see p. 40 for recommendations)
- ☐ Active layer probe
- ☐ **Plant press** with extra newspaper
- ☐ Trowel

Site Selection

This protocol is designed to compare vegetation among distinct site types and within site types through time. The criteria that you use to distinguish among site types will vary depending on the goals of your monitoring or research program. For example, if you are interested in vegetation effects on snow pack, you may decide to define site types using the structure of the dominant vegetation:

1) forest,
2) woodland,
3) tall shrub tundra,
4) dwarf shrub tundra,
5) herbaceous tundra,
6) wetland, etc.

You might also consider establishing your sites using an existing ecosystem classification system (see p. 40).

Whatever criteria you use, it is very important that in a given year you establish multiple sites in these (relatively homogeneous) site types. Once sites are established, they will be re-sampled at regular intervals that are related to the purpose of your monitoring.

If you are surveying multiple site types to assess differences between undisturbed and disturbed sites you may sample less frequently than if you are monitoring vegetation regrowth following disturbance. If you are investigating the impacts of disturbance, you will also need to establish sites in undisturbed areas to provide a basis for comparison.

To ensure that sampling adequately captures the variability in each site type, multiple sites should be distributed across the area of interest. A minimum of 6 sites is recommended for each site type examined. More sites will give more accurate results. Sites should be separated by at least 0.5 km and should never overlap. Ideally multiple site type are be sampled in a single year. Conditions vary year to year, which means that if sampling is not done in the same year, it is harder to determine if differences are due to the time of sampling or are inherent differences among site types.

Estimated Time

The initial plot set-up and data collection will require one or two full days with a team of two or three people. After the first year of plot establishment and data collection, the time required for subsequent re-sampling will be about 1 day with two people. Berry productivity is to be sampled every year and will require approximately 1.5 hours with two people.

Time of Year

Vegetation surveys should be conducted between July and early August. Although plots can be established in spring or fall, to maintain consistency in data collection from year to year it is best to re-survey at approximately the same time each year. For berry plots, the most accurate results will come from picking the berries at the same time each year (early to mid August).

Site Description & Metadata

It is important to record information about the overall character of the site (location, elevation, soil conditions, etc.) and provide a description of the data itself (when and by whom it was recorded) on the **Site Description Data Sheet**[1].

When you arrive at the plot, take note of your surroundings. As you are setting up your site, make sure to note the orientation (**azimuth**) of the grid, the position of the active layer transects and berry plots, and other important features. If you are re-sampling a site you should have GPS coordinates to assist with this. Also record any changes you may have noticed since you last visited.

Each new site should be given a site code, a unique shorthand name given to the plot for data entry purposes. For example: Tuktoyaktuk Upland Site #1 = TUK UL 1.

You should also record all of the information listed on the **Site Description Data Sheet**.

After you have completed all of the steps described in this protocol, it is a good idea to look over the Site Description Data Sheet to ensure you have not missed anything.

Plot Layout

Sampling the vegetation at each site involves establishing a 30 m x 30 m grid or 10 m x 90 m linear plot, divided into 9, 10 m x 10 m subplots (Figures 1-2).

[1] All the data sheets referred to in this protocol are included in the CD-ROM that accompanies this guidebook.

Data on the abundance of **functional groups** are collected in all 9 subplots, and data on the abundance of trees and plant community composition are collected in 4 subplots each. This guidebook contains a protocol for collecting these data.

Figure 2 shows the plot layouts and organization of data collection within each subplot. Plots should be established in the snow-free season in a relatively homogeneous area. If thermistors or frost tubes are installed, it is best to place them near the NW corner (outside the plot) where snow surveys will be conducted.

If you are sampling a linear feature (i.e., a seismic line), the 9, 10 m x10 m subplots should be arranged in a single line (1 x 9) along the feature. Subplot numbering should start at the NW corner (Figure 2). If you are not sampling a linear region, use the following procedure to create a 3 x 3 grid (Figure 2).

If time and resources are limited you can also set up sites with less than 9 subplots. To ensure that all variables are recorded establish a minimum of 4 subplots.

Figure 1: Oblique aerial view of a 30 m x 30 m CIMP vegetation monitoring grid near YaYa Lake, NWT, showing plot corners and the active layer course.

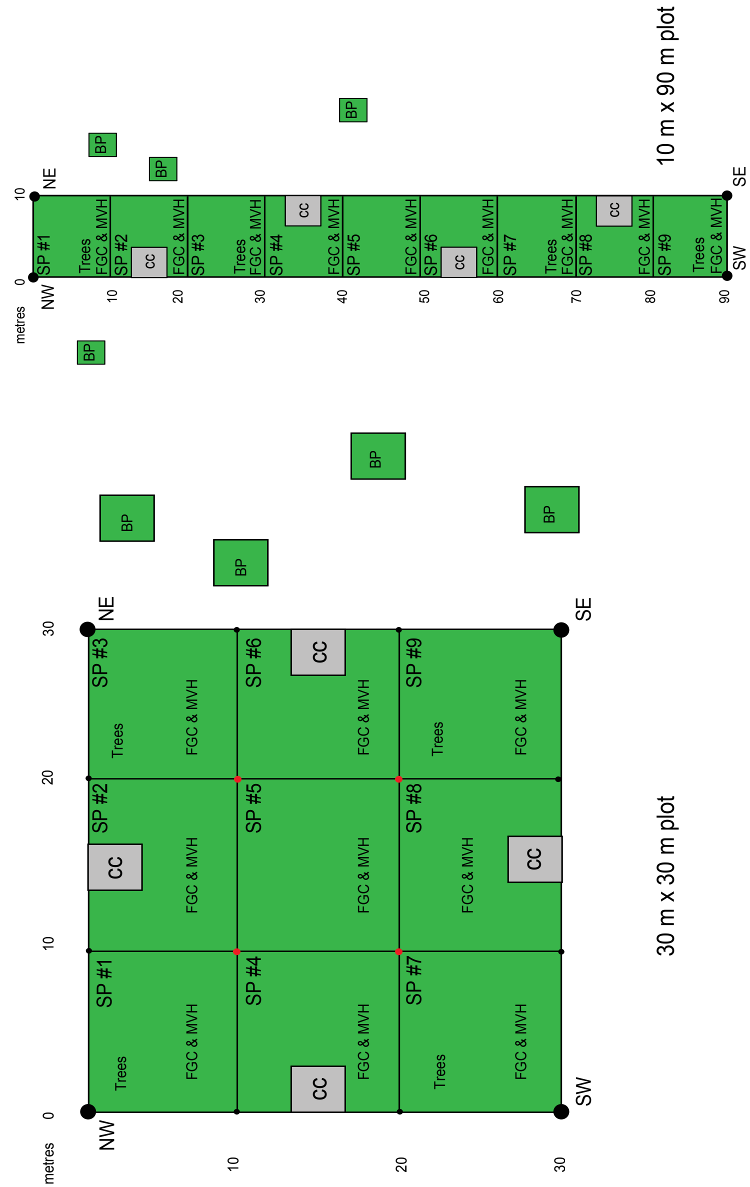


***Figure 2:** Grid (3 x 3) and linear (9 x 1) vegetation plot layouts showing: subplot (SP) layout, tree measurements in the four corner subplots, community composition (CC) quadrats in the four edge subplots, and percent cover of functional groups (FGC) and maximum vegetation height (MVH) in each subplot. The four to eight berry plots (BP) are located outside of the vegetation grid, but do not need to be clustered in the manner shown above.*

Follow the step-by-step instructions below to lay out the plot edges using a 50 m measuring tape and compass. You will also need 4 sections of rebar, 4 PVC pipes, and 12 temporary ***pigtails*** *(Figure 2).* ***When you are setting up the site, try to stay outside the plot so as to keep the number of times you walk through it to a minimum.***

1. Set the **declination** on your compass for the area where you are working by using the table below. To set the declination, insert the small metal key on the lanyard into the screw on the bottom of the compass and turn until the mark at the rear of the orienting arrow aligns with the required value (Figure 3). Declination values change over time, see the References section (page 40) for options for calculating the current values.

Location	Declination[1]	Location	Declination[1]
Yellowknife	17.5° East	Inuvik	24° East
Fort McPherson	23.5° East	Tuktoyaktuk	24.5° East
Norman Wells	22.8° East	Fort Simpson	20.5° East
Hay River	17.9° East	Fort Smith	15.5° East

Figure 3: *Setting the declination on a typical compass.*

[1] As of February, 2014.

2. Choose the northwest (NW) corner of the grid (Figure 4) so that the final 30 m x 30 m plot and active layer transect (Figure 19) are within a homogeneous area. Mark the location with a GPS and pound a length of rebar into the ground with a sledgehammer until it is flush with the ground surface.

3. To mark the second (NE) plot corner, have your partner stand at the NW corner of the plot and hold the end of the measuring tape. Ensure they are standing directly in front of the rebar you have just put in the ground. Walk in a straight line in an easterly direction[1] (Figure 4). Make sure that your line points generally eastward by having your partner use a compass to direct you left or right until you are in line with the compass bearing. Make note of this bearing.

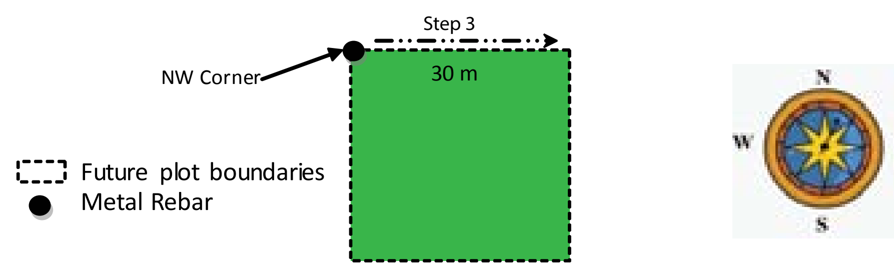


Figure 4: *Creating the first corner and measuring one side of the plot (Steps 2-3).*

Once you have walked 30 metres, double check the bearing carefully with your compass before marking the second corner with rebar. Wait until you have completed the plot before pounding the rebar fully into the ground. Once you have marked this corner, place flagged metal pigtails at 10 m and 20 m along the line you just walked.

[1] Note that this does not have to be straight east.

4. To mark the third (SW) plot corner, add 90° to the original bearing and measure 30 metres in along this southerly bearing from the first corner. Have your partner use their compass to keep you in line with this new bearing. This line should be at a right angle to the side laid out in Step 3. Mark the corner with rebar and place flagged metal pigtails at the 10 m and 20 m marks (Figure 5). Wait until you have completed the plot before pounding the rebar fully into the ground

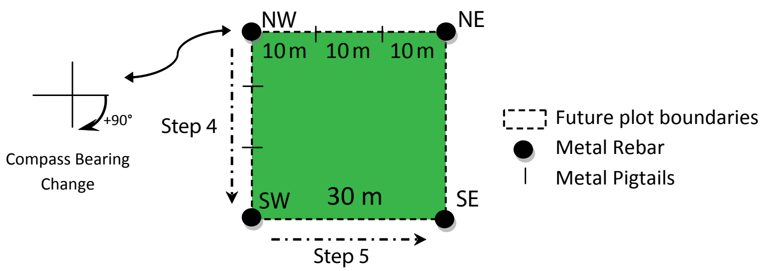


Figure 5: *Creating the second and third plot sides (Steps 4-5).*

5. To establish the last plot corner (SE), subtract 90° from the bearing used in Step 4 (making it the same as the easterly bearing used in Step 3) and measure 30 metres in this direction from the third (SW) corner. Have your partner use their compass to keep you along the new bearing. This line should run parallel to the one laid out in Step 3 (Figures 4 & 5).

6. Check the length of the final two sides. The measured distance should be within an allowable error of ±1.0 m (i.e., between 29.0 m and 31.0 m). When you are satisfied with your plot, place flagged metal pigtails at the 10 m and 20 m marks along these sides. You should now have 4 corners marked with rebar and two metal pigtails along each side (Figure 6).

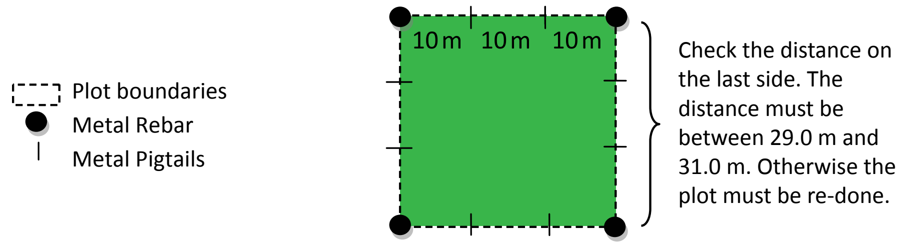


Figure 6: *Finishing and checking the final plot side (step 6).*

7. To permanently mark each plot corner, pound each 1 m section of rebar into the ground and slide a 1.5 m section of PVC pipe over the rebar and into the top 50 cm of soil. Flag the corner posts well.

8. To mark the inner subplot corners, walk a measuring tape between one 10 m pigtail and the corresponding 10 m pigtail on the opposite side of the plot and place flagged metal pigtails at the 10 m and 20 m marks. Repeat this step by measuring a line between the 20 m points and placing flagged metal pigtails at the 10 m and 20 m marks (Figure 7).

9. In total there should be 4 permanent corner markers (rebar and PVC), 8 temporary perimeter markers (pigtails), and 4 temporary internal markers (pigtails). Double check that you have identified the corners correctly by pointing your compass north and ensuring the most northwesterly corner is marked NW.

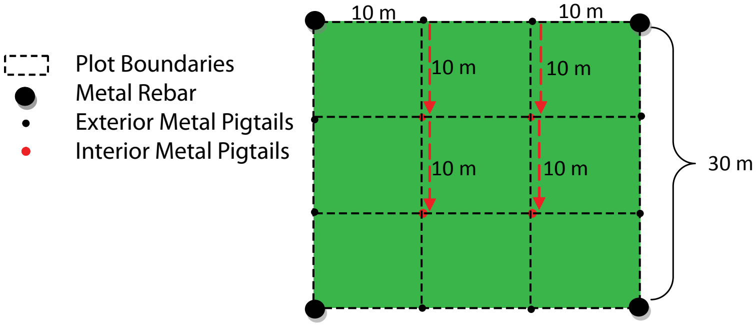


Figure 7: *Placing the centre pigtails.*

10. Mark all four corners of the plot using a GPS, naming them with the short form of the site name and the corner (e.g., Tuk UL 1 NW). Then, starting at the NW corner, create a track of the entire perimeter of the 30 m x 30 m plot by slowly walking the perimeter with your GPS turned on.

11. If the plot area has a **slope**, find the point on your partner's head that is level with your eyes, and then have your partner stand at the higher end of the slope with a compass. Hold your **clinometer** so the horizontal line crosses your partner's head at your eye level, and record the degree measurement on the **Site Description Data Sheet.** For an example of how to use the clinometer, see Fig. 13 on p. 27, but replace the top of the tree with eye level on your partner at the top of the slope.

Also record the **aspect** of the slope, which is the direction in which it faces. Your partner at the top of the slope is facing the aspect. They should take a compass bearing facing you at the bottom of the slope where you took the clinometer reading. Record this bearing on the **Site Description Data Sheet.**

To make some of the measurements described below you will need to stand inside the plot.
Try to avoid trampling the vegetation.

Mountain avens (*Dryas integrifolia*)

FUNCTIONAL GROUP COVER

Functional group cover is an estimate of generalized vegetation cover, which is measured on a subplot grid inside the 30 m x 30 m plot (Figure 11). The functional groups used in this protocol are:

1) **deciduous** trees
2) **coniferous** trees
3) tall shrubs
4) dwarf shrubs
5) forbs (including flowering plants, ferns and horsetails)
6) grasses and rushes
7) sedges
8) mosses
9) lichens
10) litter

(cont. next page)

11) exposed soil
12) standing water (see *Table 1*)

Follow the instructions below to set up your plot for measuring functional group cover. Use the ***Functional Group Cover Data Sheet*** *to record your results.*

1. Starting at the NW corner in subplot #1, extend your measuring tape to the first 10 m marker on one side of the plot. Place flagged metal pigtails at 2 m intervals (Figures 8 & 11). Collect the measuring

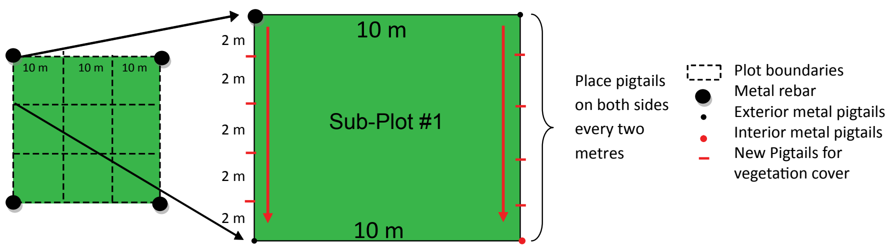


Figure 8: *Setting up the subplot grid to sample functional group cover.*

tape. You can also use a 10 m collapsible pole or rope marked at 2 m intervals laid out along the side of the subplot.

2. Repeat this procedure on the opposite side of the subplot, so that your measuring tape runs parallel to the line set up in the previous step. Place flagged metal pigtails at 2 m intervals. These pigtails are the

3. To create subplot **transects**, lay your measuring tape perpendicular to the lines you set up in steps 1 and 2 (Figure 9).

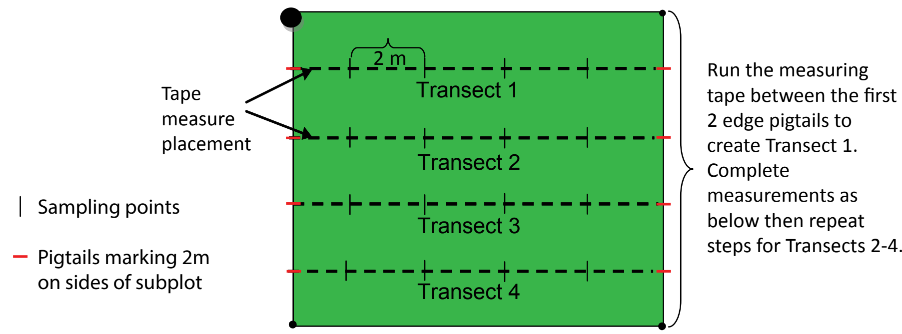


Figure 9: *Laying the measuring tape for the functional group transects.*
guides you will use to establish your sampling points.

4. At every 2 m interval on the transect (2 m, 4 m, 6 m, 8 m), take a metal pigtail and lower it vertically to the ground. Take care not to "aim" the pigtail at any particular plants by keeping it perpendicular to the ground. Every plant functional group touched by the pigtail on the way down to the ground is recorded on the **Functional Group Cover Data Sheet** using a 1 (present). Other functional groups should be marked with a 0 (absent). Use the images in Table 1 to identify the functional groups that you encounter. Imagine the pigtail extended vertically into the sky and record as a presence (1) which functional group(s) it would hit

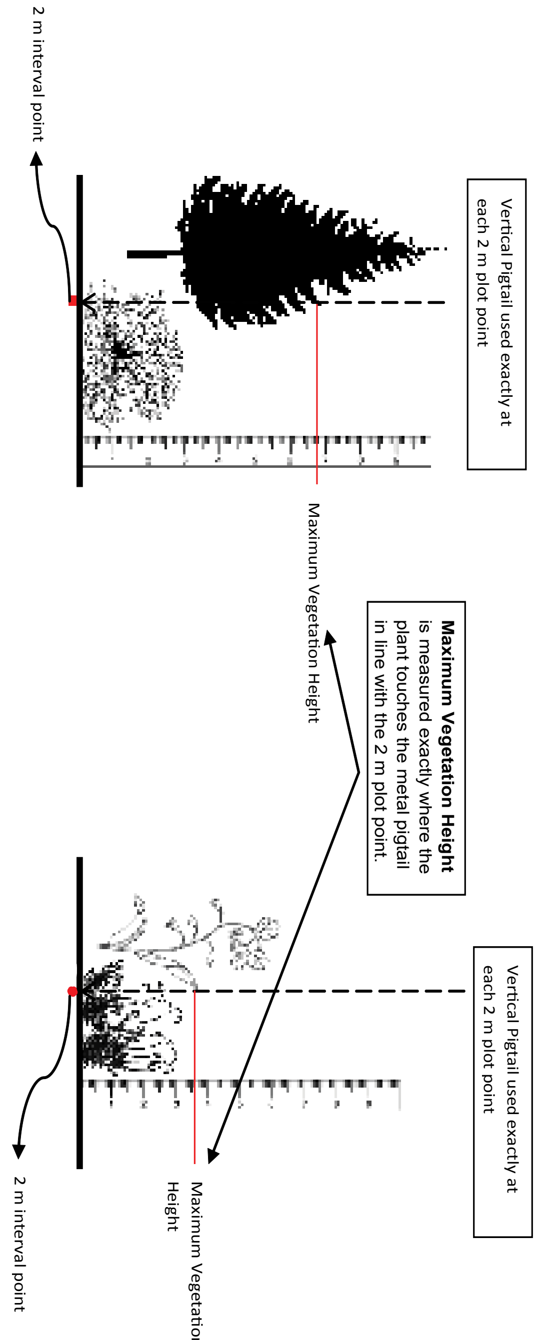


Figure 10: *Measuring maximum vegetation height in the functional group plots.*

(e.g., a tree or tall shrub) (Figure 10).

5. Record the maximum vegetation height (to the nearest cm) at the highest point where the pigtail would touch the vegetation (Figure 10). If there is no vegetation above the pigtail, record the maximum height of the vegetation touching the pigtail. This is a measure of canopy height. If you are sampling a forest or a woodland, this will be the height of the subcanopy. If vegetation height (excluding canopy trees) exceeds 2 metres, please use the clinometer to estimate height for the number of points in the plot that you were unable to measure. See page 26-27 for a description of how to use the clinometer.

Measurements should be taken starting at the soil surface. If a site is dominated by deep moss or lichen cover, please make sure that you are measuring from the top of this vegetation. If no vegetation exists at the point where the pigtail is dropped, record the point as exposed soil, and qualify whether the exposed soil is mineral or organic. If the point where the pigtail is dropped is submerged in water, record the point as standing water

6. Move the measuring tape to the next 2 m interval (Figure 9) and repeat steps 4 and 5.

7. For each 10 m x 10 m subplot, you should have lowered the pigtail to the ground 16 times (4 times per transect x 4 transects) (Figures 9 & 11).

8. Remove the temporary 2 m pigtails located on the perimeter side of the plot and leave the pigtails placed inside the plot. This way, you already have one side laid out for your next 10 m x 10 m subplot (subplot #2). See Figure 9 for an overview image of the plot at this point.

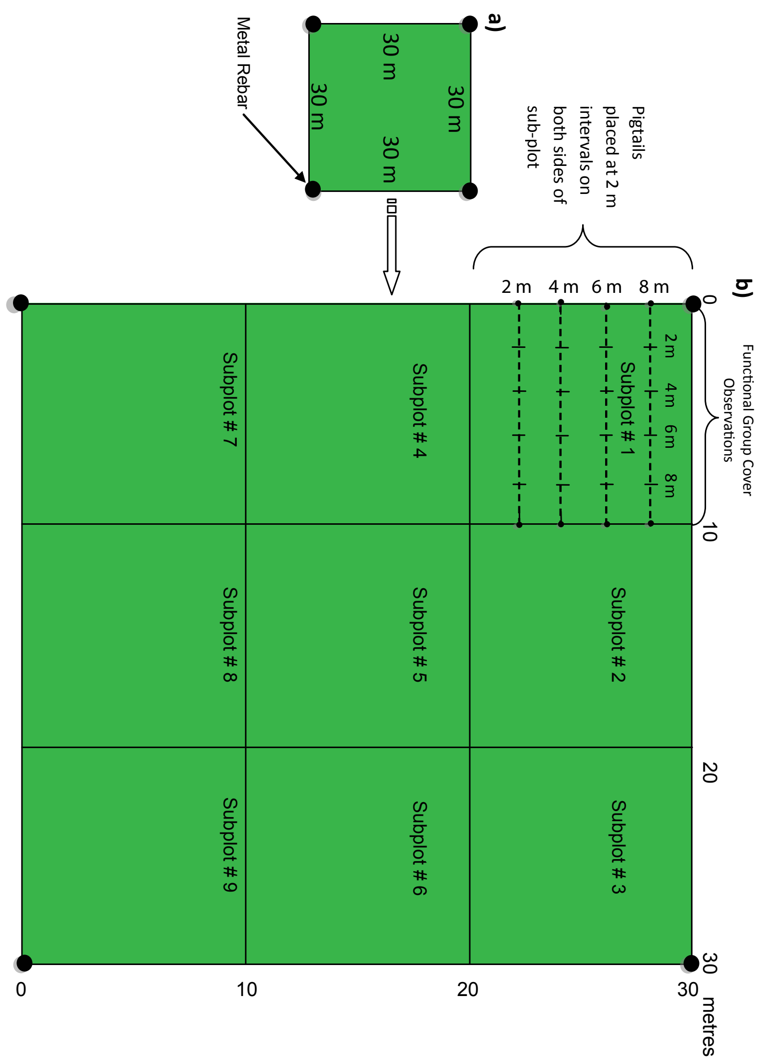


Figure 11: *Overview of the plot, with subplots and transect lines for the Functional Group Cover transects in subplot #1. Subplots are always numbered beginning in the NW corner, then West to East.*

Table 1. Descriptions of the Functional Groups used in this protocol and exemplar species.

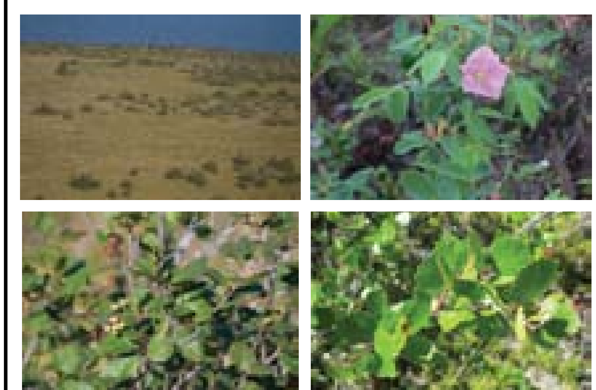
Deciduous Trees Single-stemmed woody plants with broad leaves that fall off before winter. ***Common species:*** cottonwood (*Populus balsamifera*), trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), Alaska birch (*Betula neoalaskana*)	
Coniferous Trees Single-stemmed woody plants with needle or scale-like leaves. With the exception of tamarack, leaves remain throughout the winter. ***Common species:*** black spruce (*Picea mariana*), white spruce (*Picea glauca*), alpine fir (*Abies lasiocarpa*), Jack pine (*Pinus banksiana*), lodgepole pine (*Pinus contorta*), tamarack (*Larix laricina*)	
Tall Shrubs Woody plants with multiple stems over 40 cm tall. All shrubs 40 cm tall or higher at the time of sampling fall in this category. ***Common species:*** willows (*Salix spp.*), shrubby birches (*Betula spp.*), shrubby alders (*Alnus spp.*), rose (*Rosa acicularis*), cinquefoil (*Potentilla fruticosa*), spiraea (*Spiraea beauverdiana*), soapberry (*Shepherdia canadensis*), red currant (*Ribes triste*), silverberry (*Elaeagnus commutata*)	

Table 1. Descriptions of the Functional Groups used in this protocol and exemplar species.

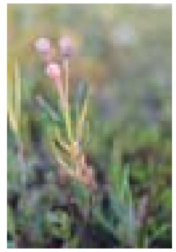
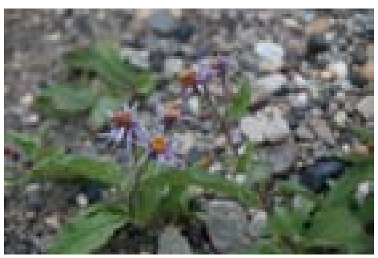
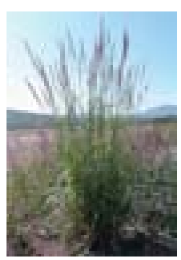
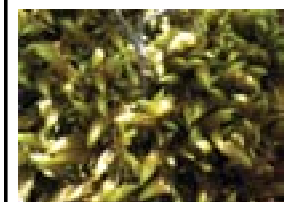
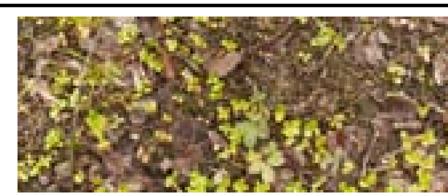
Dwarf Shrubs Woody plants less than 40 cm tall that can sometimes form a dense ground cover. All shrubs less than 40 cm tall at the time of sampling fall in this category. ***Common species:*** crowberry (*Empetrum nigrum*), Labrador tea (*Ledum decumbens*), cranberry (*Vaccinium vitis-idaea*), blueberry (*Vaccinium uliginosum*), bog cranberry (*Oxycoccus microcarpus*), bog rosemary (*Andromeda polifolia*), alpine bearberry (*Arctostaphylos alpina*), mountain avens *(Dryas integrifolia)*	   
Forbs Herbaceous (i.e. non-woody) plants. Annuals and perennials that typically have broad leaves. This group also includes the horsetails (*Equisetum spp.*). ***Common species:*** arnica (*Arnica alpina*), cloudberry (*Rubus chamaemorus*), fireweed (*Chamerion angustifolium*), horsetails (*Equisetum spp.*)	   
Grasses and Rushes Herbaceous (i.e. non-woody) plants with round stems and long narrow leaves. ***Common species:*** Arctic grass (*Arctagrostis latifolia*), bluejoint grass (*Calamagrostis canadensis*), red fescue *(Festuca rubra*)	 

Table 1. Descriptions of the Functional Groups used in this protocol and exemplar species.

Sedges Herbaceous (i.e. non-woody) plants with solid stems, triangular in cross-section, and long narrow leaves. ***Common species:*** cotton grasses (*Eriophorum spp.),* water sedge (*Carex aquatilis*), muskeg sedge *(Carex lugens*)	 
Mosses and Liverworts ***Common species:*** feather moss (*Hylocomium splendens*), peat mosses(*Sphagnum spp.*), juniper haircap moss (*Polytrichum juniperinum*)	 
Lichens Plant-like organisms made up of a fungus and algae growing together. These small organisms have a variety of growth forms, such as clubs, crusts, pelts, or hairs and are often crusty, leathery, or rubbery in texture. ***Common species:*** reindeer lichen (*Cladonia rangiferina),* Iceland moss (*Cetraria islandica*), cabbage lung lichen (*Lobaria linita*)	   
Litter Litter is dead plant material in various stages of decomposition. Common sources of litter include: dead cushion plants (ie. Mountain avens), tussocks, dead sedges and grasses, and leaf litter from tall and dwarf shrubs.	

Tree Growth

In the four 10 m x 10 m corner subplots (numbers 1, 3, 5, & 7 on Figure 18), you will collect detailed information on tree height and diameter. If there are no trees present in the corner plots, note this on the **Site Description Data Sheet**.

In this protocol we group trees into three different size categories. The type of data you collect will depend on the size of the tree. Table 2 describes the classification for trees based on diameter at breast height (DBH) and total tree height.

> ***DBH** is a measurement of the diameter of the tree at 1.3 m from the ground surface. To quickly locate breast height, label a straight stick or pole at 1.3 m.*

Table 2: *Size classification of trees*

Size Class	DBH (cm)	Height (m)
Large trees	≥ 5	≥ 1.3
Small trees	< 5	≥ 1.3
Very small trees	N/A	< 1.3

Follow the instructions below to record tree growth information. Use the **Trees Data Sheet** *to record your results.*

Very Small Trees

(If there are no very small trees, skip to the small trees section)

1. Starting in the NW corner in subplot #1, walk systematically in a grid pattern, moving east to west and west to east, searching for all trees less than 1.3 m in height.

2. Every time you find a very small tree, mark it on the tally section of the field sheet, grouped by sub-height (0-25 cm; 25-50 cm; 50-130 cm). Use a graduated measuring pole or ruler (marked at these intervals) so that you can quickly group the very small trees by height.

3. Tally the trees by species, as indicated on the **Trees Data Sheet**. Use the short form codes as shown in Table 3.

Table 3: *Tree species codes*

Code	Species (scientific name)	Species (common name)
Sw	*Picea glauca*	white spruce
Sb	*Picea mariana*	black spruce
Bl	*Abies lasiocarpa*	subalpine fir
Lt	*Larix laricina*	tamarack or larch
Pl	*Pinus contorta*	lodgepole pine
Pj	*Pinus banksiana*	jack pine
At	*Populus tremuloides*	trembling aspen
Ab	*Populus balsamifera*	balsam poplar
Ep	*Betula papyrifera*	paper birch
Ea	*Betula neoalaskana*	Alaska paper birch

4. Repeat steps 1-3 for the three remaining 10 m x10 m corner subplots (# 3, 5, & 7). If very small trees are extremely numerous (i.e., it would take all day to record this information), use your best judgement to select one or more plot(s) in which to record this data. Note that if very small tree data is recorded in a subplot, small and large tree data must also be collected.

Small trees

(If there are no small trees, skip to the large trees section)

In each 10 m x 10 m corner subplot, you will record information for small trees on the **Trees Data Sheet.** If small trees are extremely numerous (i.e., it would take all day to record this information) use your best judgement to select one or more plot(s) in which to record this information. Ensure that you choose the same plots where very small tree data were collected. Large tree data must also be collected for these plots.

1. Starting in the NW corner in subplot #1, walk systematically in a grid pattern and stop at the first small tree you encounter (greater than 1.3 m in height but less than 5 cm DBH). Use the height pole to determine height classification.

2. Create an entry on the **Trees Data Sheet**.

3. Using one of the numbered aluminum tree tags and a wire, attach the tree tag to a visible part of the tree trunk just above or just below breast height. Ensure the wire is not twisted too tightly against the tree. It should be loose to allow for tree growth, but not so loose that it could fall off. Record the number of the tag on the **Trees Data Sheet**.

4. Record the species of the tree using the codes in Table 2. Put this information on the same line as the tree tag number.

5. Using your height pole or a measuring tape, record the height to the top of the tree on the **Trees Data Sheet**. Height should be recorded in m, to the nearest cm (e.g., 1.42 m). If the tree is too tall to measure, use the clinometer procedure in the large trees section to measure the height (see pages 26-27).

6. Measure the DBH of the main tree trunk using the plastic pocket **calipers**. Slide the calipers apart and then squeeze the two ends tight to the trunk at breast height (1.3 m). Ensure the calipers are parallel to the ground and not on an angle. Record the number on the top and estimate to the nearest millimetre by reading the number on the bottom of the caliper scale. DBH should be recorded in cm, to the nearest mm (e.g., 1.3 cm). See Figure 14 for information about where to measure DBH in different situations.

7. Repeat steps 1-6 for all small trees encountered in the 10 m x 10 m subplot.

8. Repeat steps 1-7 for each of the three remaining 10 m x 10 m corner subplots (numbered 3, 7, and 9) or for those where very small tree data was collected.

Large trees

(If there are no large trees, skip this section).

All large trees in the 30 m x 30 m plot should be tagged and measured.

If large trees are extremely numerous, record tree information in the same corner sub plots that have very small and small tree data. Any corner subplot surveyed should be sampled for all three tree size classes.

1. Starting in the subplot in the NW corner, walk systematically in a grid pattern and stop at the first large tree you encounter (greater than 1.3 m in height and greater than or equal to 5 cm DBH).

2. Create an entry on the **Trees Data Sheet**.

3. Tag the tree with an aluminum tree tag and tree nail. Hammer the nail into the tree with the tag attached so it is secure, but not too deep (leave enough space between the tree and the nail head to allow for future tree growth) (Figure 12). Hammer the nail just above or just below breast height, so you can obtain an accurate DBH measurement in future site visits. Record the number of the tag on the **Trees Data Sheet**.

Figure 12: *Tree Tags. Use aluminum nails and hammer them into the tree just enough so they are secure.*

4. Record the species of the tree, using the codes in Table 2. Record this information on the same line as the tree tag number.

5. Use the **clinometer** to measure the height of each large tree. Standing at least 5-6 m away the base of the tree so that you can see the top, have your partner measure the distance from you to the tree using a measuring tape. You also need to record the distance from the ground to your eye level. Both distances should be recorded in m, to the nearest cm (e.g., 5.09 m) on the **Trees Data Sheet**.

Holding the clinometer up to your eye and keeping both eyes open, tilt your head and the clinometer upwards until the top of the tree is in line with the crosshair inside the clinometer's window.

While holding this position steady, read the degree measurement (the number on the left-hand side in the view of the clinometer, where each notch is 1 degree) to your partner. Have your partner record that number on the **Trees Data Sheet**.

This measurement, along with the distances recorded, will be used later to calculate the height of the tree. See Figure 13 for an overview of the clinometer measurements.

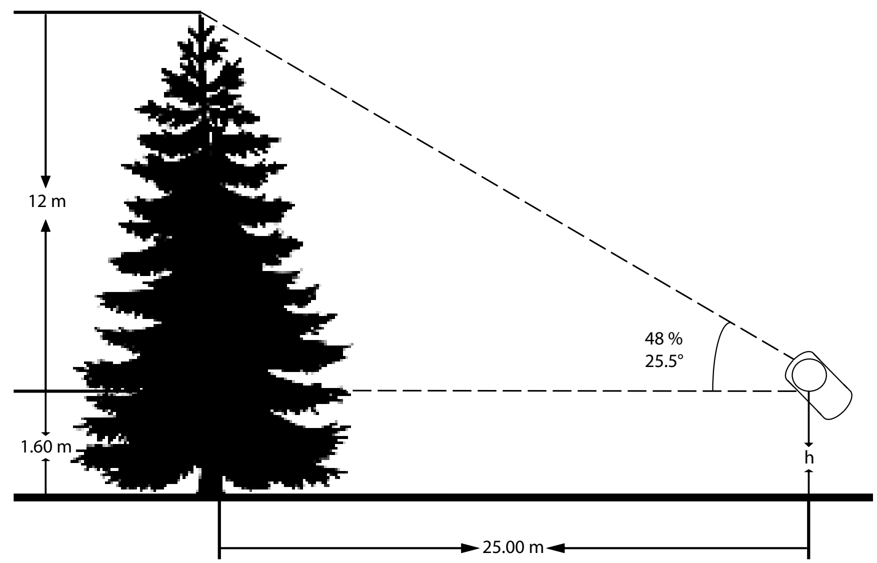


Figure 13: *Example of how to use a clinometer to determine tree height, where h is the height to eye level of the person using the clinometer.*

6. Use the calipers or a **DBH tape** to measure the diameter at breast height. Press the sharp end of the tape into the tree trunk at breast height. Wrap the tape straight around the tree, and record the measurement where the tape meets the zero point. DBH should be recorded in cm, to the nearest mm (e.g., 1.3 cm). Be sure not to wrap the tape around the tree on an angle as this will provide an incorrect measurement. If there is a branch or a knot, record DBH slightly above or below this point. See Figure 14 for information about where to measure DBH in different situations.

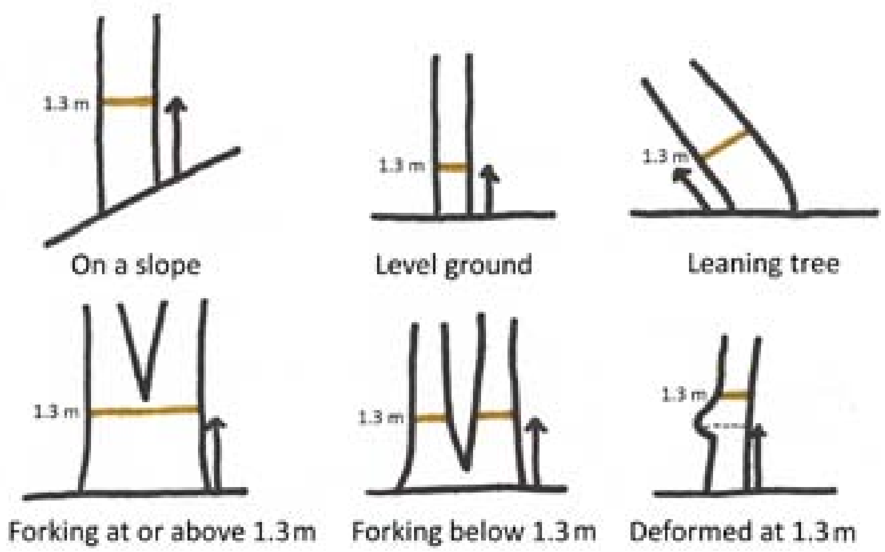


Figure 14: *Examples of measuring DBH in different circumstances.*

7. Repeat steps 1- 6 for all large trees encountered in the 10 m x 10 m subplot.

8. Repeat steps 1-7 for the entire 30 m x 30 m plot, or the subplots where very small and small tree data were collected if large trees are extremely numerous.

Berry Productivity

Berry productivity is measured by collecting berries in 4-8, 1 m x 1 m plots. These plots must be established close to the large 30 m x 30 m grid, but not inside of it. Record your data using the **Berry Plots Data Sheet**.

1. Visually survey the plot and surrounding area and complete the berry abundance table on the **Site Description Data Sheet**. If there are more than 10 berries/m^2, the species is considered dominant. If there are less than 10 berries/m^2, the species is considered sparse. If there are berry plants that have already, or not yet, produced fruit, the species is considered not in season. If you do not find any plants or berries, indicate that this species is not present.

For dominant species, establish two berry plots at each site. If a species is sparse (<10 berries/m^2), not in season, or absent from a site, establish one plot. If a berry species is not in season, try to choose a place with abundant plants that may give fruit in future years, and note this on the **Berry Plots Data Sheet**.

Berry plots should be established just outside of the 30 m x 30 m plot boundaries (at least 5 m away from any side) in areas where the chosen species is most productive.

Cranberry (*Vaccinium vitis-idaea*)

Cloudberry, nakal, aqpik, yellow berry (*Rubus chamaemorus*)

Crowberry, blackberry (*Empetrum nigrum*)

Blueberry, bilberry (*Vaccinium uliginosum*)

Figure 15: *Berry species. Two berry productivity plots should be established for each dominant species and one for each species that is sparse, not in season, or not present.*

2. Place the 1 m x 1 m berry **quadrat** onto the area and stake down the four corners with small metal plot markers.

3. Record a GPS waypoint while holding the GPS over the middle of the berry plot. Using the site code (e.g., TUK UL 1), add on BP X (short for berry plot). For example Berry Plot #1 at the Tuktoyaktuk Upland Site # 1 would be: TUK UL 1 BP 1.

4. Have your partner hold the zero end of the measuring tape over the centre of the berry plot and walk with the tape towards the closest corner plot marker of the 30 m x 30 m plot.

5. When you have reached the corner plot marker, record the distance on the measuring tape. Using your compass, stand directly over the corner plot marker and look back at your partner, who should be directly in line with the centre of the berry plot. Take a bearing by turning your compass dial so the red needle is housed within the larger red arrow outline, and read off the number at the top of the compass.

6. On your berry plot diagram, draw the berry plot location in relation to the larger 30 m x 30 m plot. On this diagram, write the distance and bearing to the corresponding corner plot marker on the diagram or off to the side (Figure 16). This will ensure you know where exactly the berry plots are in relation to the larger plot in future years. You should also record this information in the location portion of the table on the **Berry Plots Data Sheet**.

7. Tie flagging tape to one of the corner markers on your berry plot and label it with an aluminum plot marker using the site code in the format shown in step 3 above.

8. With a permanent marker, label a Ziploc bag for the plot by writing the species the berry plot has been established for (refer to Figure 15) and the plot code (refer to Step 3).

9. For the berry species that the plot has been established for (refer to Figure 15), pick every berry located within the boundaries of the 1 m x 1 m berry plot quadrat. As you pick each berry, it must be placed in the appropriately labelled Ziploc bag. Count and record the number of berries in each Ziploc bag. Take care not to crush the berries as you pick and sort them. The berries shown in Figure 15 are all "ripe". Collect all ripe and unripe berries together.

10. Repeat steps 1-9 for each of the remaining berry plots located outside of the 30 m x 30 m large plot (Figure 2). You should have between 4 and 8 berry plots in total.

11. Place the bags of berries in a cooler or freezer until you get back to the lab.

12. Once you are back at the lab, determine the fresh weight (wet weight) of the berries in each bag to the nearest milligram using an electronic balance and record it on the **Berry Plots Data Sheet.** Ensure the weight of the container is also recorded.

13. Dehydrate the berries from each bag in a drying oven for approximately 24 hours at 60°C in brown paper bags or coin envelopes. Ensure temperatures do not exceed 65°C as the berries may burn. If the oven has vents, ensure they are open in order to let the moisture out. Record the weight of the berries including the container once they have dried out. If you are uncertain whether or not the berries are fully dry, weigh them and record their weight, and then put them back in the oven for 4 hours. After this time, weigh them again, and if the weights have not changed, record this as the final weight and remove the berries from the oven. Discard dried berries once data have been recorded.

***Figure 16:** Complete plot layout showing how to measure the bearing and distance for berry plots.*

Community Composition

Community composition measurements are used to gain a more detailed understanding of which species of plants make up the surrounding habitat. Using a 1 m x 1 m **point frame**, you can get an estimate of plant species coverage.

1. Starting at subplot #2, place your 1 m x 1 m community composition point frame in the plot, lined up with the centre of the outside edge (see Figure 18).

2. Pin down the frame loosely where it lands, trying not to flatten the vegetation. If necessary, thread flattened branches up through the strings.

3. The point frame has 10 strings running the length of the point frame one way and 10 perpendicular strings that intersect (for a total of 100 intersection points – see Figure 17). Starting at the top left hand corner at the point where the first two strings intersect, lower a metal pigtail down to the ground in the same fashion as for the Functional Group Cover protocol (see page 16).

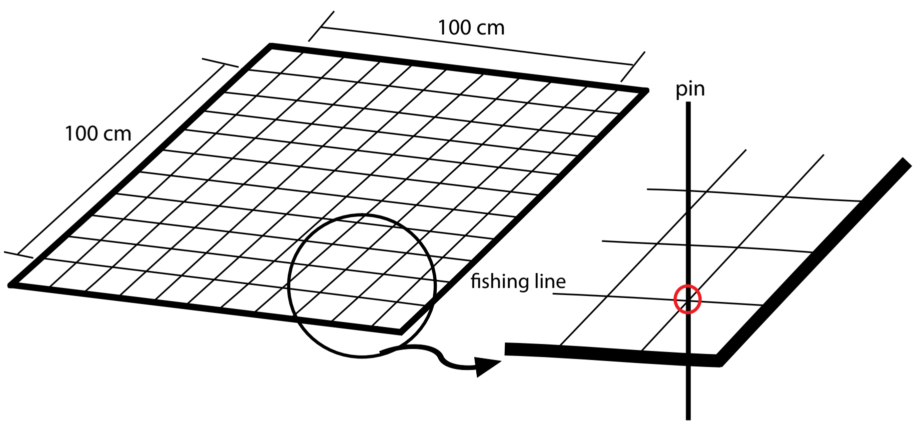


Figure 17: Point frame with inset showing position of pin at the intersection of two strings.

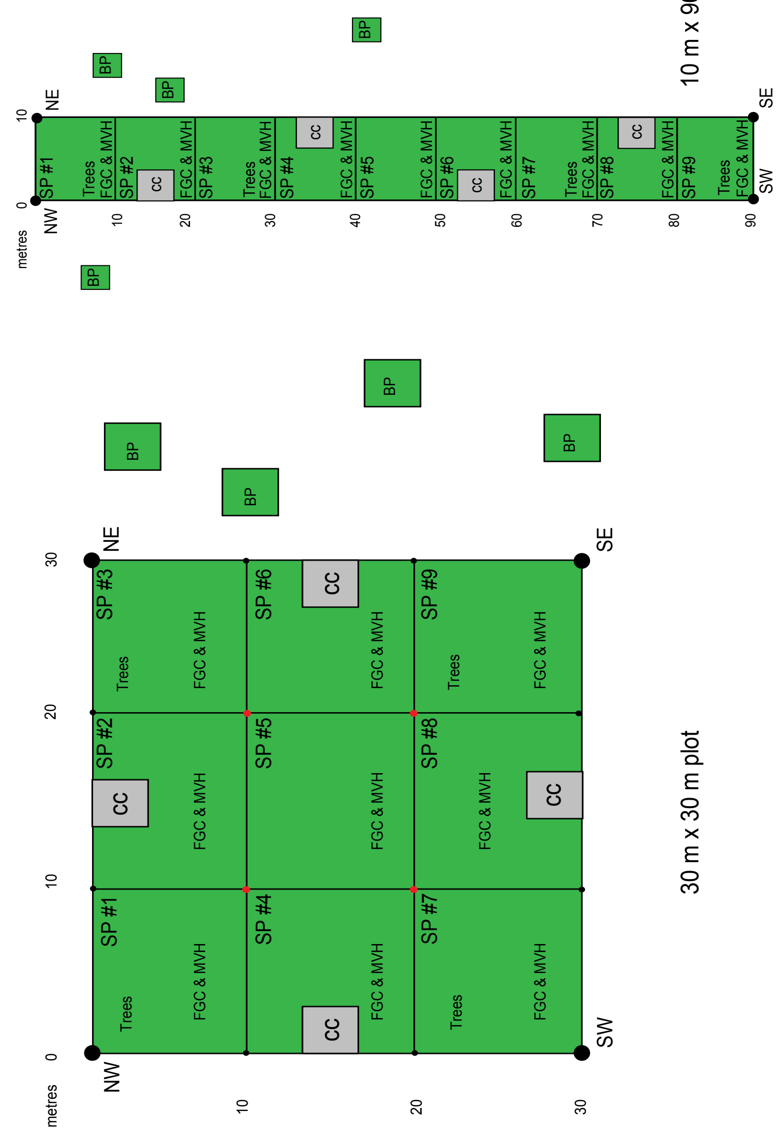


***Figure 18:** Diagram showing location of all berry (BP) and community composition (CC) plots, and types of data collected in each subplot for grid and linear layout.*

4. On the **Community Composition Data Sheet**, record all plant species visible in the point frame. Each time the pigtail tip touches a plant, add a tally mark for that species. You should also add a category at the end of the species list to record what the pin touches when it hits the ground (e.g., leaf litter, exposed soil). The pigtail will likely touch multiple species at each point. Be sure to look above the pigtail as well.

In order to fit the species names on the data sheet, abbreviate the names by recording the first three letters of the genus and the first three letters of the species. For example, *Ledum decumbens* would be recorded as Led dec.

5. Repeat step 4, 99 more times at each intersection of the strings as shown in Figure 17. When new species or ground layers are encountered, add them to the list. Otherwise, continue adding tally marks using the same rows.

6. If you cannot identify a species, collect a sample specimen from outside of the 30 m x 30 m plot, fill out a **Collection Chit** with the required information, and place them both in a **plant press**. If you do not have a plant press, place each collection in a separate Ziploc bag with a **Collection Chit.** If you cannot press plants right away, store the samples in a refrigerator until they can be pressed and mounted for identification. Do not wait more than a few days. Add the unique collection number or identifier on the **Collection Chit** to the species list on the **Community Composition Data Sheet** and add a tally mark every time the same plant is touched by a pin.

7. Repeat steps 1-6 for subplots 4, 6 and 8.

Active Layer Transect

As a part of the sampling protocol, you will also establish an active layer transect. Along this 75 m line you will record the thickness of the **active layer** (top layer of the ground that thaws every year above the **permafrost**). This transect will run along one side of the plot since 30 m is already laid out (Figures 1 & 19). If the active layer transect is not located within a homogeneous area of vegetation please make a note on the **Site Description Data Sheet** indicating where the vegetation changes, and to what type. Also record the overall type of microtopography of the site (flat, hummocky, etc).

1. Looking northwards from the NW corner of the large 30 m x 30 m plot, set your compass to the bearing that runs from the SW to the NW corner. This bearing is opposite (180 degrees difference) to the one used to create the third corner of the 30 m x 30 m plot (see step 3 of the Plot Layout Section and Figure 19). With a measuring tape, walk 45 m away from the NW plot corner on this compass bearing.

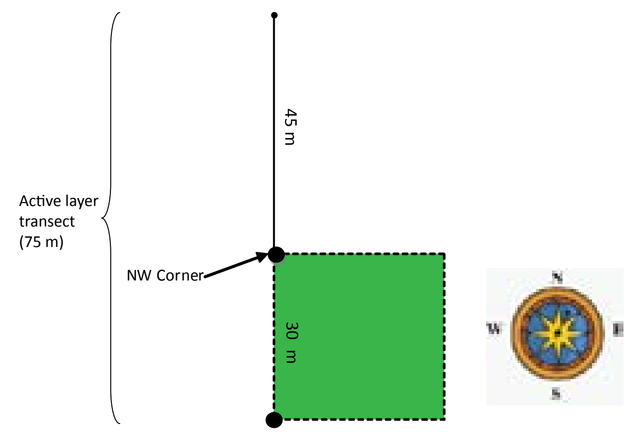


Figure 19: *Measuring the active layer transect.*

For a linear site, the active layer transect will run 75 m down one long side of the plot.

2. As you go, leave your measuring tape laid out. At the end of the transect, pound a piece of rebar into the ground and insert a piece of PVC pipe 50 cm into the ground as you did for the plot corners.

3. Your active layer transect will start from the SW corner of the plot, and extend 75 m to the end of the line you just laid out in steps 1-3 (Figure 19).

4. Starting at the SW corner of the plot (0 m), push the active layer probe straight into the ground until you hit frozen ground. From the top of the probe, measure the depth of the active layer by using the scale on the side of the probe. Record this information on the **Active Layer Data Sheet**. If measurements are made in terrain with **microtopography** (**hummocks** or **ice wedges**), make two measurements, one at the higher elevation and one at the lower elevation, and record where each measurement was made (i.e., top or trough).

5. Repeat step 4 every 5 m until you reach the end of the 75 m transect. You should have 16 measurements.

If there is a change in the vegetation type along the Active Layer Transect, please make note of this on the **Active Layer Data Sheet**.

ORGANIC LAYERS

Organic layer measurements are used to help assess the soil's impact on ecological processes like ground temperature and soil moisture. Organic layers are composed of decomposing vegetation. Organic layer horizons are dark brown or black in colour. The texture of the organic layer is more springy, or mushy, when compared with the components of mineral soil (silt, sand and clay). In peatlands, organic layers are usually composed of dead moss materials and range in colour from light brown to black, and may have a strong odor.

You will record organic layer thickness from the surface of the ground to the base of the active layer. In peatlands, the entire active layer is often made up of organic layers. This data will be collected along the active layer transect that has already been established. Record the microtopography of the locations where you take your organic layer thickness measurements. In hummocky terrain, restrict your measurements to hummock tops.

1. Start your measurements at the southwest corner of the 30 m x 30 m plot (0m).

2. Brush aside any litter or detritus that may be present on the surface of the ground

3. Insert a shovel/ trowel into the ground and remove soil so that you can see a clear profile of the soil on the side of the hole.

4. Insert the ruler into the hole and measure organic layer thickness from the surface of the ground to either the top of the mineral horizon, or the top of the active layer.

5. Repeat steps 2-4 every 7.5 m, until you reach the end of the 75 m transect. You should have 10 measurements of organic layer thickness.

Figure 20: *Soil profile showing organic soil overlying mineral soil (top). Mineral soil (middle). Organic soil (bottom)*

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University of Victoria Environmental Studies — The School of Environmental Studies, University of Victoria

References

The following field guides can be used to help you identify plants in the field.

Cody, W.J. 2000. *Flora of the Yukon Territory*. NRC Research Press, Ottawa, ON. 669 pp.

Contains identification keys, and describes 1,119 species, with illustrations and distribution maps. Includes most NWT species.

Porsild, A. E. and W.J. Cody. 1980. *Vascular Plants of Continental Northwest Territories, Canada.* National Museum of Natural Sciences, Ottawa, ON. viii + 667 pp.

Contains identification keys, and describes over 1,112 species with illustrations and distribution maps.

Johnson, D. et al. 1995. *Plants of the Western Boreal Forest and Aspen Parkland*. Lone Pine Publishing, Edmonton, AB. 392 pp.

Ecosystem Classification Group. 2012. *Ecological Regions of the Northwest Territories–Southern Arctic*. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT. x + 170 pp. + insert map.

The following websites can be used to obtain accurate and up-to-date declination values.

Natural Resources Canada: Magnetic declination calculator (http://geomag.nrcan.gc.ca/calc/mdcal-eng.php)

Requires the longitude and latitude of the location. More accurate than the website below.

Magnetic Declination (http://magnetic-declination.com/)

Tool enables search by settlement name, only includes settlements.

The following companies sell field equipment that you may need to complete this protocol.

Deakin Equipment (http://www.deakin.com/)

Based out of Vancouver, BC.

IRL Supplies (http://www.irl.bc.ca/)

Based out of Prince George, BC.

Universal Field Supplies (http://www.ufsupplies.ca/)

Based out of Mississauga, ON.

Cranberry (*Vaccinium vitis-idaea*)

Glossary

Active layer: the layer of soil above the permafrost that thaws in the summer.

Aspect: the horizontal direction (e.g., south) towards which a slope faces. A person standing at the top of the slope facing downhill is facing the aspect, and can take a compass bearing to someone standing at the bottom of the slope. This bearing is the aspect.

Azimuth: measurement of the horizontal angle of a line in reference to true north. Measured using a compass, the azimuth is the bearing taken from the SW to NW corner and continuing along the Active Layer Transect.

Calipers: an instrument used to measure thickness, as the distance between its two arms.

Clinometer: an instrument used to measure vertical angles.

Coniferous: trees and shrubs that produce cones and have needle-shaped or scale-like leaves. Most retain their leaves year-round.

DBH tape: a measuring tape that is wrapped around a tree trunk at breast height (1.3 m); the diameter side of the tape gives a direct measurement of tree diameter.

Deciduous: refers to plants whose leaves die and fall off seasonally (i.e., in fall and winter).

Declination: the angle between magnetic north and true north, which must be set so it is added to the bearing measured by a compass. Declination varies by longitude and latitude, and is manually set on a compass.

Functional group: a collection of organisms that share certain morphological, physiological, biochemical and behavioural traits, or occupy similar places in the environment or food web.

GPS (Global Positioning System): device that uses satellites to calculate the user's exact location, and to create points or track logs.

Homogeneous: an area that is uniform, the same.

Hummock: a rounded hump that occurs in tundra vegetation and bogs.

Ice wedge: a crack in the ground surface created by a narrow piece of ice extending downward, often visible on the surface as a change in vegetation, pooling of water, or a depression.

Metal pigtail: a thin metal stake with rounded edges and a curled top.

Microtopography: small-scale variations in the height and roughness of the ground surface.

Permafrost: soils that remain frozen year round.

Plant press: a device used to flatten and dry plants, by placing them between absorbent layers (e.g., newspaper), cardboard, and two wooden plates that are tightly bound together with flat straps. Heavy books with

Point frame: sampling quadrat with an internal grid; used to locate sampling points.

Protocol: procedure for the design and implementation of data collection, intended to standardize how data is collected so it can be replicated and compared by others.

Quadrat: a square of varying size used to isolate a particular area for sampling.

Slope: refers to the amount of inclination of a hill surface relative to the horizontal; a larger number indicates a steeper tilt. Can be measured using a clinometer.

Transect: a path along which data are collected at fixed intervals, or at random distances.

Vegetation structure: the way in which plants are arranged in 3-D space, usually measured in terms of vertical plant height and ground cover.

Pedicularis spp.

Notes

Notes

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