SEISMIC LINE RECOVERY

Data Collection Manual & Methods

Version 1

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Assembled by:
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Polster Environmental Services Ltd. &
Echo Track Adventures

Northwest Territories Canada

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Acknowledgements

This manual was developed in part using collective information from the following sources, including the Northwest Territories Forest Vegetation Inventory Standards, British Columbia Ministry of Forests and Range, British Columbia Ministry of Environment, Yukon Government – Energy, Mines and Resources, Polster Environmental Services Ltd., and Echo Track Adventures.

Special thanks to Dave Polster and Don White who were instrumental in the design and implementation of the 2013 initial study. The data collected during the study provided a basis for the *Seismic Line Recovery Data Collection Manual & Methods* that supports the *Seismic Line Recovery Tally Card*. The manual and tally card were developed by Brett Pagacz, EDI Environmental Dynamics Inc. (EDI) with valuable input and review from Allison Patterson, Biostatistician & Data Analyst, EDI; Matt Power, Natural Resources Technologist, EDI; Dave Polster, Plant Ecologist, Polster Environmental Services Inc.; Don White, Forester, Echo Track Adventures.

Disclaimer

This manual is a compilation of several components that are integral to the ecological assessment of seismic lines. Due to the complexity of ecological interactions, particular components included in this manual require an understanding of ecology. To obtain accurate data collection on forest mensuration, vegetation and soils it is advisable that field crews include at least one member that is experienced in these areas of study.

1.0 Introduction to Data Collection Manual

The data collection manual (DCM) provides detailed descriptions of the methods for use in the field for data collection purposes, as part of the Government of Northwest Territories (GNWT) seismic line recovery study. The data collection manual was developed to support the *Seismic Line Regeneration Tally Card*. The DCM and tally card will be used to standardize data collection by various personnel in the public, private, and academic sector. The GNWT intends to use the data to address the following final study goals:

1. Develop succession pathways that can be used in planning;
2. Build models of recovery rates of seismic lines with different disturbance regimes and in different ecosystems to predict when lines can be taken off of disturbance maps;
3. Provide information towards improving best management practices for seismic operations in the NWT; and,
4. Provide data for RSF modeling, timber supply modeling and cumulative impact modeling

Based on analyses of data collected during the initial study in 2013, the following categories are included in this manual and the tally card:

1. Site Establishment
2. Overview
3. Plot Location
4. Site Features
5. Site Disturbance Regime
6. Soil Description
7. Forest Mensuration
8. Vegetation Cover & Abundance
9. Wildlife Indicators
10. Functional Recovery Scale

This is the first version of the DCM for the study of seismic line recovery in the Northwest Territories (NT). The categories listed above are intended to be completed in full on the *Seismic Recovery Tally Card*; however, depending on objectives of third party researchers or agencies, only some sections may be recorded.

On behalf of the GNWT, EDI developed a database to house the data collected on the tally cards. Upon request, a blank copy of this database may be provided by the GNWT for use by interested agencies working on or near seismic lines in NT. In return, the GNWT would like a copy of the tally cards and database for integration into a geodatabase and improved understanding of seismic line regeneration. The GNWT appreciates suggestions for improvement to the manual and tally card.

2.0 Getting Started

2.1 Site Establishment

2.1.1 Purpose

The purpose of this section is to provide guidance for standard site selection on and off seismic lines for the establishment of new plots. In the case where sites/plots have been established and are being revisited to collect additional data, proceed to Section 2.2.

2.1.2 Method

The sections below provide guidance on plot placement, type, and size, as well as specific information to collect and record on the *Seismic Line Recovery Tally Card* when establishing a new site.

Plot Placement

At each site, two plots will be established where one plot is within the disturbed area (i.e., seismic line) and one plot is within undisturbed vegetation adjacent to the disturbance (i.e., control). As a guideline, control plots should be placed a minimum of 50 m from the disturbance. Additional plots can be added where the disturbed area encompasses more than one vegetation community. For example, *Ledum – Vaccinium* community type vs. *Ledum – Alnus – Populus* community type. Below is a list of criteria for establishing new plots:

- Multiple disturbance plots should not share a common control site; each disturbance plot should be paired with its own control plot.
- Plots should be placed within homogenous vegetation, representative of pre-disturbance conditions.
- Plots can encompass transitional areas or the periphery of fire edges, as this will encompass natural disturbance trajectories.
- Intersecting seismic lines offer good landing sites for helicopters; however, plot placement should avoid these intersections. Plots should be established along the line, away from intersecting seismic lines.

Plot Type & Size

The standard plot size for all measurements in the seismic line recovery study, with the exception of forest mensuration measurements is 100 m^2.

- Plot area is defined by the width of the seismic line to the nearest metre by a maximum length of 20 metres (m) to equal a standard plot size of roughly 100 m^2. To determine plot area the equation is:
    - **Line width x (up to) 20 m = 100 m^2**
- With the exception of very narrow lines, this plot size meets the criteria of twice the minimal plot area and is expected to include all of the possible species that occur in the community being sampled.

- On the *Seismic Line Recovery Tally Card,* under "Site Features" enter the width (W) of the seismic line to the nearest metre (m) and total area (m^2). Total area should roughly equal 100 m^2 as per the equation provided above.

The standard plot size for collecting forest mensuration is 50 m^2. As part of forest mensuration, the collection of tree density data requires an additional 20 m^2 sub-plot to be established.

On the *Seismic Line Recovery Tally Card* under "Forest Mensuration" check off whether the forest mensuration plot and tree density sub-plot are circular (Circ.) or rectangular (Rec.) based on the following conditions:

- If seismic line width is greater than 8 m all plots and sub-plots will be circular - the forest mensuration plot will have a radius of 3.99 m (50 m^2). The tree density sub-plot will have a radius of 2.52 m (20 m^2); the centre stake used to mark the 100 m^2 standard site plot should be used for the plots (exceptions should be made where plots and sub-plots are suited elsewhere, within the area that captures a representation of the stand). Include flagging on all staked plot centres indicating the type and size of plot (i.e., forest mensuration circular plot and tree density circular sub-plot).
- If seismic line width is less than 8 m, the 50 m^2 plot will be rectangular and the 20 m^2 plot can be circular or rectangular - basic math is required to compute the dimensions of the plot while maintaining an area of 50 m^2 for the forest mensuration plot (i.e., 5x10 m, 2x25 m etc.) and 20 m^2 for the tree density sub-plot (i.e., 2x10 m, 4x5 m etc.). For permanent rectangular plots, record on the *Seismic Line Recovery Tally Card* (1) length and width of the plot to the nearest metre (m) (2) the direction of the nearest corner stake for the rectangular plot from the centre stake of the standard plot 100 m^2 by including the azimuths (in degrees) and distance (to nearest 0.1 m). Flag each corner of the plot and label as northwest (NW), northeast (NE), southwest (SW), and southeast (SE).

Plot Marking

Plots should be marked so that they are visible for future monitoring. Consideration should be made to accommodate potential frost heaving and snow accumulation, while minimizing impacts to the environment. Plots are established with a wooden stake at plot center. Bright colored flagging is tied to the stake and the plot name, date, and initials of the plot crew are clearly written on the stake with permanent black marker. Plot naming conventions should follow instructions outlined in Section 2.2.2; *Plot ID*. Alternatively, the plot center may be staked with a robust material, including "shot-hole markers" (aluminum tags soft enough to write on) to identify the plot ID.

Photos

If possible, use a camera with built in GPS to take photographs. This will allow photos to be georeferenced with coordinates. Record the photo number for the following photo reference points on the tally card: (1) aerial photo of the plot (2) general site conditions within the plot facing north, east, south, west, ending with a ground shot (3) plot stake placed in the ground where the center of the plot is marked, showing the plot ID, surveyor names, and date written on a tag or flagging tape (4) hand-held GPS display clearly showing the coordinates of the plot center and time the photo

was taken. Refer to individual sections within this manual for more information on photograph requirements. Additional notes can be recorded under Section 11.0, *Notes/Site Diagram* component of the tally card with reference to additional photo numbers.

Equipment

Equipment required to establish new sites includes:

- GPS and compass
- Five 1 m long wooden stakes/plot or alternative robust material
- Hammer
- Flagging tape
- Shot-hole markers (aluminum write-on tags)
- Permanent marker
- 50 m measuring tape
- Pruning saw
- Bright colored cord to mark boundaries of plot
- Digital camera
- Tally card

2.2 Overview

2.2.1 Purpose

This section provides a reference to the work that is to be completed as part of the seismic line recovery study; it includes a record of the project, region, paired plot ID, surveyors, and date of work.

2.2.2 Method

Sections outlined below are to be entered on the *Seismic Line Recovery Tally Card* under "Overview".

Project ID

Provide a descriptor name for the project you are working on. For example:

- GNWT wildlife habitat inventory
- Diavik species inventory

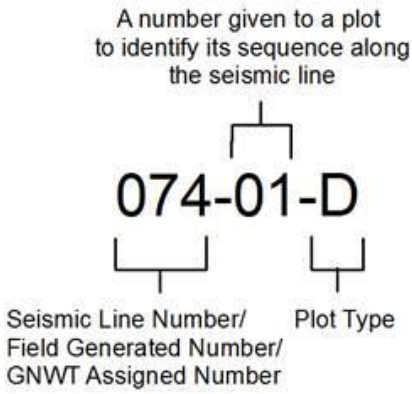
Region

Select the code for the name of the region where the site is located within NT, Canada. The five administrative regions in NT include:

- Inuvik (I)
- Dehcho (D)
- North Slave (NS)
- Sahtu (S)
- South Slave (SS)

Plot ID

Plots are to be named according to the following convention:



Plot ID includes 3 parts (two number sets and one letter). For example:

1. "074" = Seismic Line Number or Field Generated Number or GNWT Assigned Number. It's strongly advised that this value should be generated prior to fieldwork. Contact the GNWT on how to obtain this information.

2. “01” = Plot Number. Refer to section 2.1.2 Methods - *Paired Plot Sites* for more information on when multiple paired plots can be sampled along the seismic line.
3. “D” = Plot type. The letter is labeled as either “D” for disturbance plot or “C” for control plot

Surveyors

Record the first initial and last name of each surveyor present in the field that is involved in describing the site.

Date

Enter two digit codes for day, month, and year (i.e., DD-MM-YY).

Equipment

With exception to the tally card, no special field equipment is required to collect information on the site overview.

3.0 Plot Location

3.1 Purpose

The purpose of this section is to provide a description of the plot location for future monitoring and to record plot characteristics.

3.2 Method

Sections outlined below are to be entered on the *Seismic Line Recovery Tally Card* under "Plot Location".

3.2.1 Site Access

Provide a brief description of how the site was accessed and where the plot is located in reference to landmarks or natural features, such as mountains, rivers or lakes. Where appropriate, include the location of known roads or communities in relation to the site that can be easily identified and are unlikely to change. Include an estimate of distance to these points of reference and direction (i.e., compass bearing) where possible.

3.2.2 Latitude/Easting (Lat./East), Longitude/Northing (Long./North) & UTM Zone

Record the location of the plot center using a hand-held GPS. For easting/northing coordinates include UTM zone following the North American Datum of 1983 (NAD 83). For latitude/longitude, enter coordinates as decimal degrees. Coordinates should be recorded with 6 decimal places of accuracy. Photograph the face of the GPS unit and record this under "Photo".

3.2.3 GPS Accuracy (GPS Acc.)

Record the accuracy to the nearest metre (m) from the hand-held GPS at the time of marking the plot location.

3.2.4 Equipment

Equipment required to record elements for plot location includes:

- Hand-held GPS
- Digital camera
- Tally card

4.0 Site Features

4.1 Purpose

The purpose of this section is to describe the features of the site where the plot is located.

4.2 Method

Sections outlined below are to be entered on the *Seismic Line Recovery Tally Card* under "Site Features".

4.2.1 Line Width (Line Wid.)

Enter the width of the seismic line where the disturbed plot is located to the nearest metre (m). The width will be measured by running a measuring tape from one edge of the disturbance through the plot centre to the opposite edge of the disturbance. This measurement is to be oriented perpendicular to the direction of the line.

4.2.2 Line Direction (Line Dir.)

The direction that a seismic line runs can be anything from exactly north-south to east-west to northwest-southeast, etc. Using a compass with the correct declination, record the azimuthal direction of the line (in degrees). Include precise coordinates to capture the direction of the line in both directions. For example, if the line runs exactly north-south record $0^{o}/180^{o}$; if you are facing one way on the line and your compass reads 230^{o} then record $230^{o}/50^{o}$.

4.2.3 Photos

If possible, use a camera with built in GPS to take photographs. This will allow photos to be georeferenced with coordinates for future reference. Record photo number for the following: (1) aerial photo of the plot (2) general site conditions within the plot facing north, east, south, west, ending with a ground shot (3) plot stake placed in the ground where the center of the plot is marked, showing the plot ID, surveyor names, and date written on a tag or flagging tape (4) hand-held GPS to confirm the coordinates of the plot center and time the photo was taken. Additional notes can be recorded under Section 11.0, *Notes/Site Diagram* component of the tally card with reference to additional photo numbers.

4.2.4 Windrow (Wind.) Width (W) and Depth (Dep.)

If present within the plot, include a check mark on the tally card to indicate the presence of a windrow. Windrow material will resemble a berm. Include a measure of the average width (Wid.) and depth (Dep.) of the windrow to the nearest centimetre (cm). Include an overview photo of the windrow in the plot and record this under "Photos". If no windrow is present, leave this section blank.

4.2.5 Aspect

Using a compass with the correct declination, record the orientation of the slope in degrees (^{o}) for the general area in which the plot is located. North is 0, east is 90, south is 180, and west is 270. Specifically, aspect should be recorded in degrees to determine the orientation as north, northeast, east, south, southwest, west, or northwest. If there is no aspect enter "n/a".

4.2.6 Slope

Using a clinometer or similar instrument, record the percent (%) slope gradient of the site.

4.2.7 Elevation (Elev.)

Using a hand-held GPS (calibrated) or altimeter, record the elevation in metres (m) at plot centre.

4.2.8 Terrain

Indicate the surface topography of the terrain that best describes the plot. Codes to describe the terrain follow the NWT Inventory Field Sampling Manual, v 3.0, draft (GNWT 2014) and are provided in Table 1. On the tally card, record the corresponding code (provided below in brackets) for one of the following terrain classes:

- Even (1)
- Rolling (2)
- Gullied (3)
- Broken (4)

Table 1. Terrain codes and classes (Source: GNWT 2014).

Code	Terrain Class	Description
1	Even	Even terrain is relatively flat (< 2° slope), with little elevation change across the sample.
2	Rolling	Rolling terrain exhibits gradual undulation across the sample. Slopes within the sample area are generally < 17° (30%).
3	Gullied	Gullied terrain possesses slopes < 45° (100%) and ≥ 17° (30%). Often, gullied terrain was formed by flowing water over the soil surface at some point in the past.
4	Broken	Broken terrain consists of abrupt rises and ravines. Changes in elevation are common across the sample. These sites often contain slopes ≥ 45° (100%).

4.2.9 Meso Position (Meso Pos.)

Indicate the position of the plot on the landscape in terms of its location relative to the local catchment area (see Figure 1). Codes to describe the meso position follow the Northwest Territories Forest Vegetation Inventory Standards with Softcopy Supplements v. 4.1 (NTFVI; GNWT 2012) and are provided in Table 2. On the tally card record the code in brackets for one of the following meso positions:

- Crest (C)
- Upper Slope (U)
- Mid Slope (M)
- Lower Slope (L)
- Toe (T)
- Depression (D)
- Level (V)

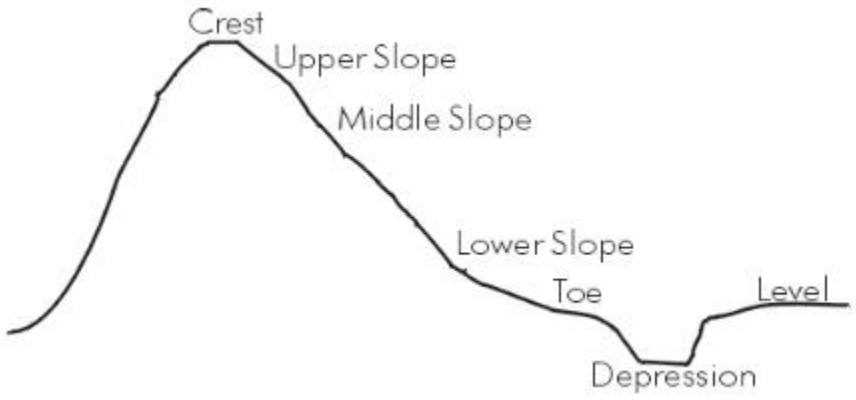


Figure 1. Meso position (Source: GNWT 2012).

Table 2. Meso position codes (Source: GNWT 2012).

Code	Meso Position	Description
C	Crest	Generally convex in all directions with no distinct aspect
U	Upper Slope	Convex surface with a specific aspect
M	Mid Slope	Slope profile neither concave or convex; generally straight surface with a specific aspect
L	Lower Slope	Area toward base of hill; generally concave surface with a specific aspect
T	Toe	Lowest area of the lower slope where there is a clear downslope separating the lower slope from the area below
D	Depression	Concave in all directions
V	Level	Horizontal surface with no clear aspect

4.2.10 Plot Size (Plot Sz.)

The standard plot size for all measurements in the seismic line recovery study, with the exception of forest mensuration measurements is 100 m^2. For additional information regarding plot size and type refer to Section 2.1.2, *Plot Type & Size*.

For areas affected by fire, provide a check mark on the tally card to determine if the plot is located on the "Edge" of an area most recently burned or "Inside" an area most recently burned. Plots determined as "Inside" will include sign of a recent burn (i.e., blackened tree bases). Plots determined as "Edge" will be within the vicinity of a recent burn; however there will not be evidence of similar fire characteristics observed within the plot.

4.2.11 Equipment

Equipment required to record elements for site features include:

- 50 m measuring tape
- Digital camera
- Clinometer
- GPS and compass
- Altimeter (optional)
- Bright colored chord to mark boundaries of the plot
- Tally card

4.3 References

Government of Northwest Territories, Forest Resources, Forest Management Division, Environment and Natural Resources (GNWT). 2012. Northwest Territories Forest Vegetation Inventory Standards with Softcopy Supplements, v. 4.1.

Government of Northwest Territories, Forest Resources, Forest Management Division, Environment and Natural Resources (GNWT). 2014. NWT Inventory Field Sampling Manual, v 3.0, draft.

5.0 Site Disturbance Regime

5.1 Purpose

The purpose of this section is to identify and describe existing disturbance features in the vicinity of the plot.

5.2 Method

Sections outlined below are to be entered on the *Seismic Line Recovery Tally Card* under "Site Disturbance Regime".

5.2.1 Paired Plot Type (Plot)

There are two types of plots to be established; disturbed plots are those located within the seismic line and control plots are located in undisturbed vegetation away from the line. Mark on the tally card whether the plot being sampled is on the seismic line (Distur.) or in the undisturbed vegetation adjacent to the line (Control).

5.2.2 Disturbance Type (Distur.)

For the disturbed plot, check off one of the following disturbance types on the tally card that best describes the type of disturbance:

- Seismic line
- Camp area
- Staging area
- Road
- Re-used (i.e., re-clearing or evidence of re-use)
- Airstrip
- Mulching
- Well-site (provide well-site ID for well-site)
- Other

Note: Plots within well-sites should be clearly identified on tally cards (with reference to oil and gas identification format).

5.2.3 Evidence of Mulching (Mulch.)

Circle Yes (Y) or No (N) if there is observable evidence of mulching in the plot, since the most recent disturbance. Mulching refers to a method of line clearing in which vegetation is "chopped" by specialized equipment and left on the ground. Evidence of mulching is the presence of broken stems of woody shrubs and trees across the line. "Bungee sticks" may be present, which are short stems sticking out of the ground, usually branchless and often without bark, with sharp and broken ends. Mulching may appear patchy within the plot as part of the initial disturbance or as a secondary disturbance within the plot.

5.2.4 Estimated Year of Mulching (Yr. of Mulch.)

If the line was mulched, record the year that mulching occurred (YYYY). This value will be derived from the estimated line age following methods in Section 7.2.5 *Forest Mensuration*. These years

should be the similarly recorded in both sections. Accurate seismic line ages should be obtained, if available, prior to fieldwork.

5.2.5 Percent of Mulch (% Mulch)

Where mulching is observed, estimate and record the percent (%) of surface area where mulch material is present within the plot to the nearest 10%. For example 10%, 20%, 30%, etc.

5.2.6 Evidence of Fire (Fire)

Circle Yes (Y) or No (N) if there is known and documented history (i.e., check fire records with the GNWT) or observable evidence of fire in the plot since the most recent burn.

5.2.7 Equipment

Equipment required to record elements of site disturbance regime includes a folding ruler or measuring tape and tally cards.

6.0 Soil Description

6.1 Purpose

The purpose of this section is to describe soil characteristics within the boundaries of the plot(s).

6.2 Method

Sections outlined below are to be entered on the *Seismic Line Recovery Tally Card* under "Soil Description".

6.2.1 Soil Moisture (Mois.)

Soil moisture refers to the ability of the soil to hold, release or receive water. Soil moisture depends on the soil properties and landscape position. Using the simplified scale provided in Table 3, record the soil moisture code on the tally card that is representative within the plot. Refer to Figure 3 for reference to slope position that relates to typical soil moisture classes.

Reminder: Use clues in the surrounding environment such as slope position, vegetation indicator species, and inferred hydrology to determine soil moisture. For example, if you are standing in a wetland, such as a bog or fen, the vegetation will include wetland indicator species (i.e., sphagnum) and the site will be wet, because the water table is at or above the soil surface. This is an example of "Very Wet (Hydric)" soil moisture and you would record "**hd**" on the tally card. It is important to note that wetlands can occur at different locations along a slope where there is a depression. If you are standing in an upland mixed forest dominated by white spruce/aspen/alder and there is no indication of standing water pockets/seepage into the ground, the soil moisture is likely "Moderate (Mesic)" and you would record "**m**" on the tally card. Alternatively, if you are standing in a forest dominated by pine, this indicates dry, sandy conditions and the soil moisture would be "Dry (Xeric)", therefore, you would record "**x**" on the tally card.

Table 3. Soil moisture codes and classes (Adapted from: GNWT 2012, YG 2008).

Code	Soil Moisture Class	Description	Primary Water Source
x	Dry (Xeric)	● Water removed very rapidly in relation to supply ● Soil remains moist for a brief time after precipitation	Precipitation
m	Moderate (Mesic)	● Water removed somewhat slowly in relation to supply ● Soil may remain moist for a significant, but sometimes short, period of time post precipitation ● Compared to a dry habitat, a mesic habitat is more moist	Precipitation with some limited seepage in coarser soils
hg	Wet (Hygric)	● Water removed slowly enough to keep the soil wet for most of the growing season ● Permanent seepage	Seepage
hd	Very Wet (Hydric)	● Water table at or above the soil surface all year	The water table

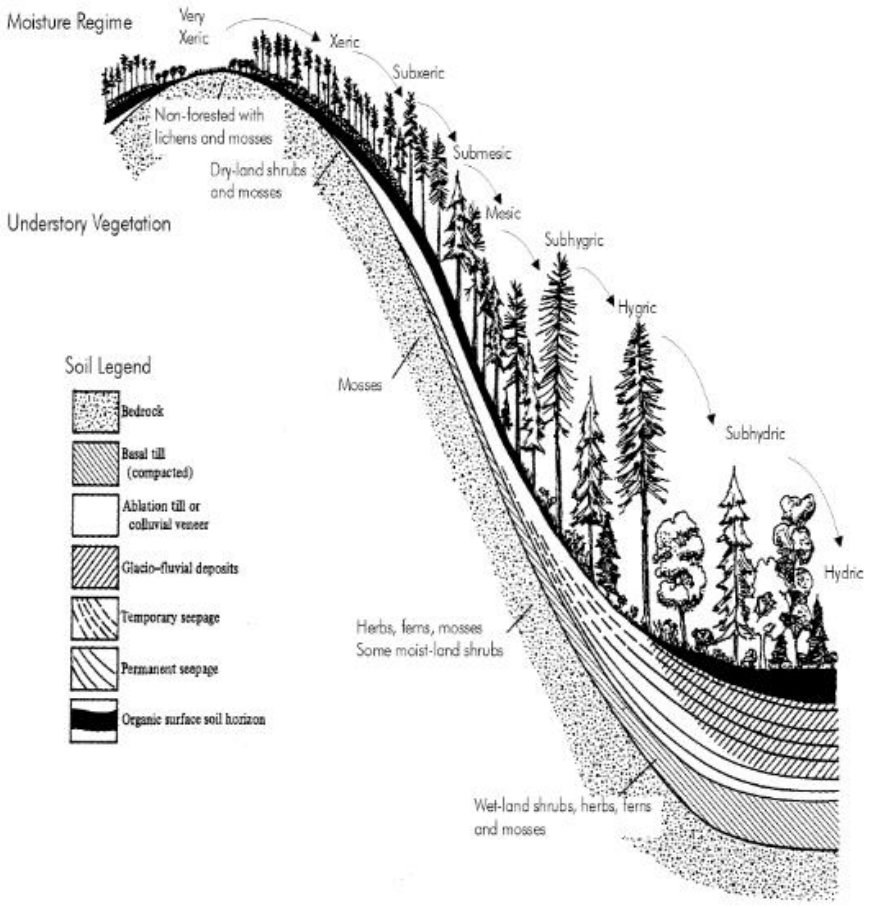


Figure 2. Soil moisture regime showing slope position (Source: GNWT 2012).

6.2.2 Soil Drainage (Drain.)

Soil drainage is characterized by the permeability and porosity of the soil which is dictated by soil texture and soil depth. Using the three broad drainage classes recognized by GNWT and provided in Table 4, record the drainage code on the tally card that is best represented within the plot.

Reminder: Observations of soil drainage are best made by digging a soil pit or in areas of exposed soil strata (i.e., roadcut). If this is not possible, use clues in the surrounding environment such as slope position, vegetation indicator species, and inferred hydrology to determine soil drainage. For example, if you are standing in a wetland such as a bog or fen, the vegetation will include wetland indicator species (i.e., sphagnum) and the site will be wet, because the water table is at or above the soil surface. This is an example of "restricted" drainage and you would record "**3**" on the tally card. If you are standing in an upland mixed forest dominated by white spruce/aspen/alder and there is no indication of standing water pockets/seepage into the ground, then water additions into the soil are likely from precipitation and water inputs are mostly equalled by losses. This indicates a moderate supply of moisture at the site. This is an example of "good" drainage and you would record "**2**" on the tally card. Alternatively, if you are standing in a forest dominated by pine this

indicates dry, sandy conditions with rapid percolation of water through the soil. The drainage for this site would be "excessive"; therefore, you would record "**1**" on the tally card.

Table 4. Soil drainage codes and classes (Source: GNWT 2014).

Code	Drainage Class	Description
1	Excessive	Soils are normally very dry due to the rapid percolation of water through the soil solum. Normally, this condition is associated with shallow and/or course textured soils, e.g. sands and gravels.
2	Good	Soils are somewhat dry to moist. Mottles may be present in the upper A, B and C horizons.
3	Restricted	Usually associated with organic soils, drainage is poor to absent. Soils are often gleyed or have free water at the surface for part of the year.

Additional information on soil drainage can be found in:

Haynes, R.H. (ed). 1998. Canadian System of Soil Classification. NRC Press, National Research Council of Canada, Ottawa, Ontario.

6.2.3 Soil Type

The soil type will be roughly determined by assessing the soil above and just below a depth of 30 cm in the soil profile. After removing the duff layer (i.e., dead leaf and plant litter on the surface of the soil), use a shovel to dig a hole that is representative of site conditions with the plot. Dig the hole to just below 30 cm from the soil surface and remove enough space in front of the soil profile to view the soil layers. Provide a check mark on the tally card for soil type "**M**" as mineral or "**O**" as organic by assessing the soil profile from the surface to 30 cm depth. Mineral and organic soils are defined as:

Mineral soils - are found below organic soils or where organic soils are not present, mineral soils can be found on the surface of the soil below the duff layer. Mineral soils are unconsolidated mineral materials that are made up of sand, silt, clay or loam fractions ≤2 mm diameter (BCMOF & BCMOE 2010).

Organic soils - are found above mineral soils in the soil profile. Organic soils are made up of dark organic materials that accumulate on the surface of the soil and often include decaying wood <10 cm thick and animal droppings, (BCMOF & BCMOE 2010).

Additional information on mineral and organic soils can be found in:

Haynes, R.H. (ed). 1998. Canadian System of Soil Classification. NRC Press, National Research Council of Canada, Ottawa, Ontario.

6.2.4 Permafrost Depth Collection

Circle Yes (Y) or No (N) if depth to permafrost was measured within the plot. It may not be appropriate or possible to collect this measurement at all plots. If this measurement could not be taken, provide a brief explanation on the tally card under "If No, Why?".

6.2.5 Depth to Permafrost (Dep.)

Record depth to permafrost (Dep.) to the nearest tenth of a metre (0.1 m) at 5 representative locations in the plot (A, B, C, D, and E) and calculate the average depth (0.1 m). Use a bluntly pointed aluminum rod 1 m long coupled by another 1 m long aluminum rod, totalling 2 m in length to collect depth to permafrost. This collapsible rod will fit easily in a helicopter.

6.2.6 Equipment

Equipment required to record soil characteristics may include:

- Shovel
- Soil knife
- Water bottle
- Sieve (2 mm)
- Measuring tape/folding ruler
- Collapsible 2 m long bluntly pointed aluminum rod
- Digital camera
- Tally card

6.3 References

British Columbia Ministry of Forests and Range and British Columbia Ministry of Environment (BCMOF & BCMOE). 2010. Field manual for describing terrestrial ecosystems. 2nd ed. Forest Science Program, Victoria, B.C. Land Manag. Handb. No. 25. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh25-2.htm.

Government of Northwest Territories, Forest Resources, Forest Management Division, Department of Environment (GNWT). October 2012. Northwest Territories Forest Vegetation Inventory Standards with Softcopy Supplements, v. 4.1.

Government of Northwest Territories, Forest Resources, Forest Management Division, Environment and Natural Resources (GNWT). March 2014. NWT Inventory Field Sampling Manual, v 3.0, draft.

Yukon Government, Energy Mines and Resources, Forest Management Branch (YG). 2008. Yukon forestry monitoring program. First approximation, Whitehorse, Yukon. http://www.emr.gov.yk.ca/forestry/pdf/monitoring_manual_jan2009.pdf.

7.0 Forest Mensuration

7.1 Purpose

The purpose of this section is to guide the record of tree and stand characteristics. Methods and descriptions have been adopted from British Columbia Ministry of Forests and Range and British Columbia Ministry of Environment (BCMOF & BCMOE 2010), Yukon Government, Energy Mines and Resources, Forest Management Branch (2008), Government of Northwest Territories, Forest Resources, Forest Management Division, Department of Environment (GNWT 2012), and Government of Northwest Territories, Forest Resources, Forest Management Division, Environment and Natural Resources (GNWT 2014).

7.2 Plot Size (Plot Sz.)

The standard plot size for collecting forest mensuration is 50 m^2. As part of forest mensuration, the collection of tree density data requires an additional 20 m^2 sub-plot to be established. For additional information regarding plot size and type refer to Section 2.1.2, *Plot Type & Size*.

7.3 Criteria for Tree Measurements

Collection of forest mensuration will include all trees (live and dead) within the plot that are ≥7 cm diameter at breast height (dbh), with the exception of tree density data. Tree density data will include all trees (live and dead) within the sub-plot with no restriction for dbh, as well as tall shrubs (≥1 m – 10 m) as described in Section 7.4.7.

7.4 Method

Sections outlined below are to be entered on the *Seismic Line Recovery Tally Card* under "Forest Mensuration".

7.4.1 Photos

If possible, use a camera with built in GPS to take photographs. This will allow photos to be georeferenced with coordinates for future reference. Plot photos should clearly illustrate forest and timber conditions. Record photo number under "Photos" that show (1) forest type within the plot (2) general site conditions within the plot facing north, east, south, and west.

7.4.2 Crown Cover

From plot centre, record crown cover (%) using a spherical densiometer. Four readings are required from a representative point, generally facing north, east, south and west. Record the average of all four (4) values in percentage (%). In cases where a densiometer is not available, visually estimate the crown cover in percentage (%) using the average cover obtained from the 4 directional readings.

7.4.3 Structure

Structure is a method of defining the physical arrangement, pattern or organization [of the forest] (GNWT 2012). This is mainly a regionally-based attribute (derived from air-calls), but can be applied at a localized scale (i.e., plot). Three categories will be used to classify the structure as described in Table 5 below. Refer to the Northwest Territories Forest Vegetation Inventory

Standards with Softcopy Supplements v. 4.1 (NTFVI; GNWT 2012) for a complete description and methodology to determine these categories.

On the *Seismic Line Recovery Tally Card,* record the code for structure that is most dominant within the plot.

Table 5. Codes and general descriptions of forest structure (Source: GNWT 2012).

Code	Structure	Description
1	Single Storey	• One distinct vegetation canopy • No more than ±3.0 m variation within the storey • Age variation is within ±20 years from the average age • Diameter classes generally follow a normal distribution
2	Multi Storey	• More than one distinct vegetation height layer and origin • More than ±3.0 m variation between each storey • Spread of average age variation is greater than ± 20 years
3	Complex	• High variations in height; canopy doesn't show distinct layering • Generally used to describe black spruce and/or larch or very old spruce stands that have begun to break up and display varying heights and conditions.

7.4.4 Sample, Tree No(s) & Stand Age

Stand age is determined by taking tree "Core" or "Disk" samples and counting the series of rings from the outer cambium of the sample inward to the "release date". The release date can be determined by noting a point (series of rings) that shows comparatively good growth. All samples must be taken as close to the germination point as possible. Core samples are taken within the plot and disk samples are taken outside of and adjacent to the plot. With the exception where a tree disk must be collected, a core is the preferred method for age determination. Only dominant or co-dominant trees should be sampled.

Note: Fires, fallen adjacent trees, and other factors can provide conditions that can initiate release in trees (i.e., better growth).

Increment core: An increment corer is used to collect age samples from live and representative trees within the plot (i.e., co-dominant or dominant). If using an increment corer, angle downward near the root collar to collect a sample. The pith must be penetrated to get an accurate age. If rot is present, the core is discarded and another tree must be sampled. If all trees have rotten cores, then collect a disk from outside the plot from as close to the germination point as possible. If tree ring counting is difficult in the field, the core may be collected and aged in the office at a later date using a hand lens or microscope. Ensure that core/disk samples are accurately labeled (including the straw containing the core) with plot ID and tree ID.

Tree Disk (destructive sampling): Collect tree disks from a section of the tree as close to the germination stage as possible.

On the tally card, include a check mark for "Core" or "Disk" depending on the collection made in the field. Record the tree number (Tree No[s]) for core or disk samples collected. The recorded tree number will correspond to the tree number under "Tree Inventory".

7.4.5 Line Year (Line Yr)

Line year is determined by (1) information available from the National Energy Board (NEB) or (2) the stand age as derived from Section 7.4.4. Where line year isn't available from the NEB, record the line year (YYYY) on the tally card based on the estimated "release date" as determined by the increment core or tree disk. On the tally card, include a check mark indicating if the age has been estimated (Est.) or is accurate (Acc.).

7.4.6 Line Year Category (Line Yr Cat.)

Assign a category using the line years listed below. Categories are provided in 10 year intervals. On the tally card, include a check mark next to the line year category:

- Year 0 – 10: Category 1
- Years 11 – 20: Category 2
- Years 21 – 30: Category 3
- Years 30+: Category 4

7.4.7 Tree Density

Tree density is recorded for all trees (live and dead) within the sub-plot with no restriction for dbh, as well as tall shrubs within heights of ≥1 m – 10 m. Refer to Section Section 2.1.2, *Plot Type & Size*, for sub-plot size and establishment procedures. On the tally card under "Tall Shrubs", record the number of individual stems of tall shrubs (include all shrub species as one category) present within the sub-plot, as well as trees, including deciduous (Decid.) and coniferous (Conif.) stems, for all species (Spp.) at three height intervals (1) <1 m (2) ≥1 m – <3 m (3) ≥3 m.

7.4.8 Tree Number

Tree number is provided numerically on the tally card. Once a tree has been recorded, the number on the tally card (under "Tree Inventory") is assigned to the tree within the plot. All mensuration data for each individual tree is recorded along the same row.

Where the plot is designated for future/permanent sampling, tree marking will be done with "shot-hole markers" (aluminum tags soft enough to write on) to identify the tree. Tags will be affixed to the tree and clearly marked with the following information:

1. Tree Number
2. Plot ID
3. Date
4. Surveyor Initials

7.4.9 Tree Species

Record tree species using the following codes provided in Table 6.

Table 6. Tree species codes (Source: GNWT 2012).

Tree species	Code
Trembling Aspen *(Populus tremuloides)*	A
Balsam Poplar *(Populus balsamifera)*	Po
Subalpine Fir *(Abies lasiocarpa)*	F
Larch *(Larix laricinia)*	L
Lodgepole Pine *(Pinus contorta)*	Pl
Jack Pine *(Pinus banksiana)*	Pj
Black Spruce (*Picea mariana)*	Sb
White Spruce *(Picea glauca)*	Sw
White Birch *(Betula papyrifera)*	Bw

7.4.10 Diameter at Breast Height (dbh)

Record the diameter of the tree as measured at breast height (1.3 metres) using a diameter tape to the nearest tenth of a centimetre (0.1 cm).

7.4.11 Height Calculations

Using a clinometer or hypsometer, record tree height measurements to the nearest 0.1 metre (0.1 m) for each tallied tree, including:

- *Total Height*: Record the total height (in metres) of the tree using a clinometer or digital hypsometer. In cases where leaning trees are tallied, the Pythagorean Theorem ($a^2 + b^2 = c^2$) can be used to obtain an estimated height measurement.
- *Height to Branches*: Record the total height (in metres) from the ground to the lowest point along the stem where the tree has an established branch system.
- *Height to Live Crown*: Record the total height (in metres) from the ground to the point where live branches form a continuous live branch system to the top of the tree.

7.4.12 Crown Class

Assign a crown class for all live stems in the plot as referenced in Table 7.

Table 7. Crown class codes and description (Source: GNWT 2012).

Code	Description
1	**Dominant (D)** trees with crown extending at least one height class (5 m) above the general level of the canopy, and receiving full light from above and partly from the side; dominants are larger than average, have well-formed crowns, which may or may not be crowded from the sides.
2	**Co-dominant (C)** trees that form the general height level of the crown and receive full light from above, none from the sides; usually with medium sized crowns, more or less crowded from the sides.
3	**Intermediate (I)** trees with heights below, but extending into the general stand height, normally receiving little direct light from above; none from the sides; usually with small crowns, which are considerably crowded on the sides.
4	**Suppressed (S)** trees that do not extend into the general stand height, normally receiving no direct light from either above or the sides.

7.2.13 Tree Class

Assign a tree class to determine the level of decay of the tree as per Table 8.

Table 8. Tree class codes and description (Source: GNWT 2014).

Code	Tree Class	Description
1	Healthy	Healthy trees must be living and exhibit no pathological indicators
2	Suspect	Suspect trees are living trees which exhibit one or more of the pathological indicators of decay (as outlined in Section 6.2.16)
3	Veteran	Veteran trees are living remnants of a former stand. They are often in poor health and may exhibit a variety of pathological characteristics. The age of a veteran tree is significantly older than that of the surrounding stand. A large surviving aspen overtopping spruce or an ancient spruce among a younger stand of aspen or spruce would be classified as a veteran. The proportion of veteran trees must not exceed 10% of the total stand crown closure, otherwise they are cumulatively considered an independent canopy layer.
4	Dead	A dead tree has no live foliage throughout the growing season and the cambium is no longer functional.

7.4.14 Tree Pathology

Record pathological indicators and location of tree defects for each tree tallied and measured. Trees must be viewed from all sides in upper, middle and lower sections of the trunk to ensure that indicators have been reliably assessed. Pathology/defects are recorded for each section of the stem (in thirds) as outlined in Table 9.

Table 9. Codes representing location of defect on tree (Source: GNWT 2012).

Code	Location of Defect on Tree		
	Lower Third	Middle Third	Upper Third
1	X		
2		X	
3			X
4	X	X	
5		X	X
6	X		X
7	X	X	X

Descriptions of pathological indicators are provided below (Sources: BCMOE 1998, GNWT 2014):

Blind Conk: "Swollen knots" are reliable indicators of internal decay. They appear as pronounced swellings or depressions around knots and are thought to represent an attempt to heal over decay emerging though a knot or branch stub. Bright yellow or buff-coloured material is found by chopping into basal branch stubs. Blind conks most often occur in the interior. They are similar in effect to normal conks, but lack the visible fruiting body of the fungi.

Conk: Fruiting bodies of stem decay fungi are reliable indicators of decay. They are typically thick, hard, and woody-like perennial structures that may appear anywhere on the main stem or branches, but that usually appear around knots and on the underside of dead branch stubs and live branches. Consequently, they are hard to spot, particularly when they occur on the upper stem. Moss covered branch stubs and burls often resemble conks, particularly when viewed from directly below. Because of this, it is sound practice to view the tree from all sides before making a decision. Remember that conks may appear anywhere on the trunk of an affected tree; therefore, look for conks on the upper as well as on the lower trunk.

Scar: Scars result from past injuries caused by external forces that have damaged the cambium or heartwood, exposing the tree to wood decay fungi. These scars are considered suspect if located on the main stem or root collar, unless they are of recent origin. They often signify decay.

Scars may be open or closed. Open scars are areas of exposed wood of varying size and shape from severe damage caused by fire, lightning, logging, machinery, etc. Closed scars may appear healed over, with slight to pronounced indentations of the bark, or there may be pronounced scar tissue or callous growth, often with abundant resin flow.

Fork/Crook: Forks or crooks that develop after an early injury to the top of the tree are reliable indicators of decay. The following are not considered forks: candelabra branches; natural branching in deciduous trees; small, sharply angled branches or spikes, unless associated with a noticeable offset or diameter change at the location; flattening of tree tops caused by wind or physiological conditions where no terminal leaders are evident.

Rotten Branches: Large, rotten branches, typically on old-growth trees often indicate decay. Note only larger branches that are clearly rotten (usually on over-mature trees). Do not include small, dead branches typically just below the live crown or on the lower trunk of open-grown trees.

Dead or Broken Top: These may be caused by wind, snow, mechanical damage from other falling trees, etc. Only note those not recent in origin (i.e., must be obviously weathered). At times, confusion may result when a fork or crook has developed as a result of a dead or broken top. If a new, single leader takes over dominance, a crook is often the result; if two leaders develop co-dominance, a fork will occur. The gray area will exist when it must be decided whether the indicator should be recorded as a dead/broken top or fork/crook. As such, crews should follow these general guidelines so consistent field calls can be made:

- If the dead top is still intact and is taller than the new leader(s), call the dead top; if it's shorter, call the fork/crook.
- If the dead top is no longer intact and there is a significant diameter change at the point of damage, call the dead/broken top

7.4.15 Tree Quality

Spiral Grain: Spiral grain is a growth characteristic of some trees and does not signify decay (BCMOE 1998). Spiral grain is the twisting of the grain and is often seen in exposed wood or in the direction of the bark fissures. Spiralling frost cracks and scars also indicate the presence of spiral grain (GNWT 2014). Record whether or not a spiral grain is present. Leave blank if absent and assign a one (1) if present.

Sweep/Lean: A sweep refers to a slight curvature or distortion of the trunk (BCMOE 1998). A lean differs from a sweep due to the fact that that the stem remains straight while being off a vertical access (GNWT 2014). Record the degree of the sweep/lean using the following codes (Source: GNWT 2014):

- 1: 1.0 – 4.9 degrees
- 2: 5.0 – 9.9 degrees
- 3: ≥10 degrees

7.4.16 Equipment

Equipment required to record forest mensuration includes:

- GPS and compass
- Permanent black marker
- Clinometer
- Hypsometer
- Diameter tape
- Increment corer
- Digital camera
- Flagging tape
- Spherical densiometer

- Measuring tape or collapsible ruler
- Pruning saw (for tree disk)
- Large straws (to collect tree core)
- Adhesive tape (to close straws)
- Shot-hole markers
- Heavy duty stapler or small nails and hammer
- Tally card

7.5 References

British Columbia Ministry of Forests and Range and British Columbia Ministry of Environment (BCMOF & BCMOE). 2010. Field manual for describing terrestrial ecosystems. 2nd ed. Forest Science Program, Victoria, B.C. Land Manag. Handb. No. 25. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh25-2.htm.

Government of Northwest Territories (GNWT) Forest Resources, Forest Management Division, Department of Environment. 2012. Northwest Territories Forest Vegetation Inventory Standards with Softcopy Supplements, v. 4.1.

Government of Northwest Territories (GNWT) Forest Resources, Forest Management Division, Environment and Natural Resources. 2014. NWT Inventory Field Sampling Manual, v 3.0, draft.

Yukon Government, Energy Mines and Resources, Forest Management Branch (YG). 2008. Yukon forestry monitoring program. First approximation, Whitehorse, Yukon. http://www.emr.gov.yk.ca/forestry/pdf/monitoring_manual_jan2009.pdf.

8.0 Vegetation Cover & Abundance

8.1 Purpose

The purpose of this section is to assess vegetation cover and abundance within the boundaries of the plot.

8.2 Reference Flora

The reference flora used to determine identification of plant species in the field is the *Flora of the Yukon Territory* (Cody 2000). Mosses, liverworts and lichens can be identified using *Mosses, Lichens, and Ferns of Northwest North America* (Vitt et al. 1988). All final nomenclature will follow E-Flora BC (Klinkenberg 2014).

Note: It is useful to cite the person or group of people (i.e., authority) who are responsible for publishing the name of the species being referred to. In botanical nomenclature, the authority is typically abbreviated following a recognized list of standard abbreviations and is not italicized. For example, the entity referred to as *Cladina mitis* (Sandst.) Hustich was first named by "Sandst." under another scientific name; however, the current name was determined by "Hustich". The authority for this species is specifically "(Sandst.) Hustich".

8.3 Definitions

Vegetation within a plot is categorized by determining the layers that are present within the plot. With the exception of the "Tree" category, all vegetation layers listed below in Table 10 may be present within a plot. Only one of the three tree categories may be included on the tally card by determining the dominant tree type present. Where possible, the categories and definitions follow the Northwest Territories Forest Vegetation Inventory Standards with Softcopy Supplements v. 4.1 (NTFVI; GNWT 2012).

Table 10. Vegetation layer codes and definitions.

Code	Vegetation Layer	Definition
Tree	Tree	Includes mature trees: • Coniferous –dominant tree type within the plot is coniferous (TC); **OR** • Deciduous–dominant tree type within the plot is deciduous (TD); **OR** • Mixed –tree type within the plot is strongly mixed coniferous and deciduous(TM).
TSh/AR	Tall Shrub/Advanced Regeneration	Includes woody plants >1 m tall and immature trees. Immature trees include saplings, poles, and advanced regenerating trees.
LSh/R	Low Shrub/ Regeneration	Includes woody plants and regenerating trees <1 m tall.
Herb	Herb	Includes herbaceous plants without a woody stem and ferns/fern allies.
Gram	Graminoid	Includes grasses and grass-like plants (e.g., *Carex* spp.).
Bryoid	Bryophyte	Includes mosses, liverworts, and hornworts.
Lichen	Lichen	Includes foliose or fruiticose terrestrial lichens (not crustose).

Total percent (%) cover of evergreen and deciduous vegetation is recorded as a measure of visual cover and protection of some wildlife (i.e., caribou and moose) from predators during winter and/or summer. In the summer, both types of vegetation provide cover and protection of wildlife from predators. During winter, evergreen vegetation is the only source of visual cover and protection for some wildlife. Evergreen and deciduous vegetation layers include **Trees and Tall Shrubs/Advanced Regeneration** (refer to Table 10). Definitions specific to evergreen (Evergr.) and deciduous (Decid.) vegetation are:

- **Evergreen** – plants that have leaves which persists and remains green year round.
- **Deciduous** – plants that lose their leaves seasonally, typically coinciding with winter; regrowth of the plants foliage occurs during the spring.

8.4 Method

Sections outlined below are to be entered on the *Seismic Line Recovery Tally Card* under "Vegetation Cover & Abundance".

8.4.1 Species List (Spp. List)

Mark on the tally card if the vegetation species data recorded is a complete observation of all species (Comp.) found in the plot or is a partial list of species (Part.; i.e., only includes dominant or indicator species).

8.4.2 Percent (%) Cover by Layer

Definitions and codes for vegetation layers are provided in Section 8.3; Table 10. For each vegetation layer present, estimate the percent (%) cover within the boundaries of the plot. To

measure percent cover, use a *visual estimate of percent cover*. All of the plant species found growing within the plot (i.e., rooted within the boundaries of the plot) are to be listed. To record percent cover, use the modified Braun-Blanquet cover abundance scale provided in Table 11 and refer to Figure 3 for a comparison chart on visual estimates of percent cover.

Record the total percent (%) cover for all vegetation layers present within the plot by summing the percent cover for each individual layer. The total sum should not exceed 100%.

Record the total (%) percent cover for all evergreen (Evergr.) and all deciduous (Decid.) vegetation present within the plot. Refer to Section 8.3 for definitions and explanation.

Table 11. Modified Braun-Blanquet Scale for Assigning Percent Plant Cover (Adapted from: Mueller-Dombois and Ellenberg 1974).

Scale	Numerical Value	Description
R	0.1	One or a few individuals, less than 1% cover
+	0.5	More than a few individuals, but still less than 1% cover
1	1	Several individuals, but still less than 1% cover
5	5	Percent cover values may range from 2.5% – 7.5%, either in one, a few individuals or many
10	10	Percent cover values may range from 7.5% - 12.5%, either in one, a few individuals or many
↓	↓	The above pattern applies for numerical values (for increments of 5) up to 95 percent cover.
95	95	Percent cover values may range from 92.5% - 97.5% cover, either in one, a few individuals or many

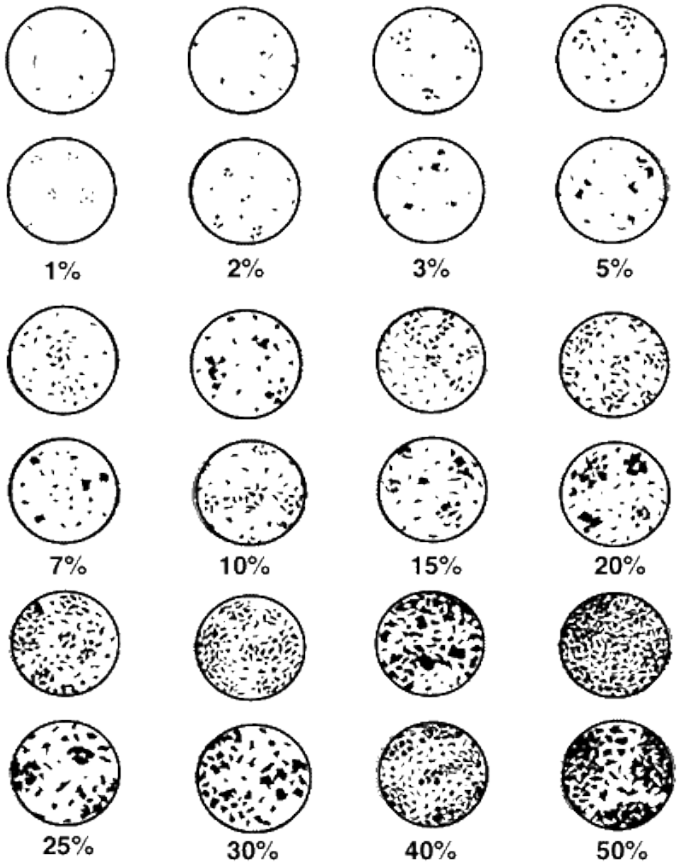


Figure 3. Comparison charts for visual estimation of foliage cover (Source: BCMOF & BCMOE 2010).

Additional information on measuring percent cover is provided in:

British Columbia Ministry of Forests and Range and British Columbia Ministry of Environment. 2010. Field manual for describing terrestrial ecosystems. 2nd ed. Forest Science Program, Victoria, B.C. Land Manag. Handb. No. 25. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh25-2.htm.

8.4.3 Species List

Record vegetation species by layer found growing in the plot. For entering the tree species, use the tree species codes provided in Table 6, 7.4.9 *Tree Species*. For all other vegetation, enter the scientific name of the species fully or use the 4-3-1 code (genus-species-subspecies or variety). Provide a check mark on the tally card if unknown specimens are collected for later verification by a specialist. Number the voucher specimen and record the plot number and temporary name for future cross-reference between specimen and data sheet.

8.4.4 Photos

Include photos of vegetation within the plot to show evidence of layers present and condition of vegetation at the time of the survey.

8.4.5 Arboreal Lichen Abundance Assessment

The arboreal lichen abundance assessment evaluates forest stands as potential forage by caribou. This assessment follows existing methodology outlined in the *Field Manual for Describing Terrestrial Ecosystems, 2nd Edition* (BCMOF & BCMOE 2010). Arboreal lichen refers to lichen growing on trees and is often referred to as "hair" or "beard" lichen.

To assess arboreal lichen abundance in the plot, observe branches within 0 m - 4.5 m of standing live and dead trees within the plot. Using an established ranking system, assign a rank (0-5) for arboreal lichen found on the trees. A 5 gram (g) clump of lichen is the standard unit of measure for one clump of arboreal lichen. Once 6 or more clumps are found on an individual tree an estimate of percent cover is easily used to determine arboreal lichen abundance. Table 12 provides the codes and class description for the assessment of arboreal lichen abundance. Additionally, refer to *Estimating the Abundance of Arboreal Forage Lichens* (Armleder et al. 1992) for reference photos of beard lichens (*Alectoria sarmentosa* and *Bryoria* spp.). The photo series can be used as a basis to estimate lichen abundance of similar arboreal lichen species.

Record the code for arboreal lichen abundance on the tally card to best describe the cover of all arboreal lichen species in the plot. Include the scientific name or 4-3-1 code (genus-species-subspecies or variety) for individual species of arboreal lichen observed on the trees under "Arboreal Lichen Abundance", as part of the "Vegetation Cover & Abundance" section of the tally card.

Note: a value of "0" can indicate zero presence of lichen on trees within a plot or no lichens < 4.5 m height on trees. A value of "1" would indicate low arboreal lichen cover, up to 5 g of lichen or 1-2 clumps. In contrast, a value of "5" would indicate abundant arboreal lichen cover with > 51% cover per tree.

Table 12. Arboreal lichen abundance codes and classes (Source: BCMOF & BCMOE 2010).

Code	Description
0	None
1	Rare: 1 or 2 clumps per tree
2	Occasional: 3 to 5 clumps per tree
3	Common: 6 clumps to 20% cover per tree
4	Very Common: from 21-50% cover per tree
5	Abundant: 51% or greater cover per tree

8.4.6 Percent (%) Cover Board

Cover board estimates are used to address sightline and horizontal cover as a measure of protection for some wildlife from predators.

Cover board estimates are made by placing a cover board in the center of the plot and standing away from the cover board at three 10 m increments (10, 20 and 30 m) to estimate the density of the vegetation at 0-1 m, 1-2 m, and greater than 2 m along the cover board. Record cover board estimates as a percentage of the board (of 100%) that is covered by vegetation. Following this protocol, measurements are made until all three distances are measured or the view of the cover board is completely obstructed resulting in 100%. Values are to be recorded from 0-100%, using

5% increments. Include 6 cover board estimates (A, B, C, D, E, and F) and the average of these estimates on the tally card. With the exception of "re-used" or secondary disturbances to the vegetation in the plot that might have occurred after the original disturbance, the location of cover board measurements should be standardized within the plot according to the following:

- (A) plot center facing up the line;
- (B) 1 m to the right of center facing up the line;
- (C) 1 m to the left of center facing up the line;
- (D) plot center facing down the line;
- (E) 1 m to the right of center facing down the line; and
- (F) 1 m to the left of center facing down the line.

Where, from the recorders relative perspective, any direction ≥ 270° and ≤ 90° generally facing north constitutes "facing up the line" and any direction≤ 270° and ≥ 90° generally facing south constitutes "facing down the line".

Note: If a game trail or other disturbance is present in the plot, substitute a cover board estimate to be included in this disturbance. Perform a cover board estimate facing both up and down the line within this feature and record the additional cover board estimate under the "notes" section.

8.4.7 Equipment

Equipment required to record details of vegetation cover includes:

- Field reference flora, *Flora of the Yukon Territory* (Cody 2000)
- Sample bags (clear plastic and brown paper)
- Permanent marker
- Plant press
- Cover board
- Digital camera
- Compass
- Tally card

8.5 References

Armleder, H.M., S.K. Stevenson, and S.D. Walker. 1992. Estimating the abundance of arboreal forage lichens. B.C. Min. For., Victoria, B.C. Land Management Handbook No. 7.

British Columbia Ministry of Forests and Range and British Columbia Ministry of Environment (BCMOF & BCMOE). 2010. Field manual for describing terrestrial ecosystems. 2nd ed. Forest Science Program, Victoria, B.C. Land Manag. Handb. No. 25. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh25-2.htm.

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Vitt, D. H., J.E. Marsh and R.B. Bovey. 1988. Mosses Lichens and Ferns of Northwest North America. Lone Pine Publishing, Edmonton, AB and University of Washington Press, Seattle, WA. 296 pp.

9.0 Wildlife Indicators

9.1 Purpose

The purpose of this section is to include anecdotal information on wildlife sign within the boundaries of the plot. Information on vegetation cover, abundance and density collected in sections 7.0 and 8.0 will be used as additional measures of browse availability.

9.2 Method

Sections outlined below are to be entered on the *Seismic Line Recovery Tally Card* under "Wildlife Indicators".

9.2.1 Sign

If present, record sign of wildlife within the plot as game trail, tracks, scat/pellet, bed site, tree rub, browse or other (i.e., antler).

9.2.2 Photos

Include photos of all wildlife sign to support observations.

9.2.3 Notes

Take notes to describe observations of wildlife or wildlife sign, such as species, number or extent. For example, cow moose and calf seen foraging on willow; one group of moose pellets; one caribou game trail; two moose bed sites; soapberry browse observed.

9.2.5 Equipment

Equipment required to record wildlife indicators include:

- Guide book for wildlife tracks and scat
- Digital camera
- Tally card

10.0 Functional Recovery Scale

10.1 Purpose

The purpose of this section is to provide the formulation of a Functional Recovery Scale (FRS) for systematic use by relatively untrained personnel to evaluate the relative recovery of seismic lines in Northwest Territories.

10.2 Method

Sections outlined below are to be entered on the *Seismic Line Recovery Tally Card* under "Functional Recovery Scale (FRS)" only if the plot is considered disturbed. For control plots, do not complete this section on the tally card.

The outcome of the FRS is to determine a level of functional recovery for a disturbed plot relative to its paired control plot located in adjacent undisturbed vegetation. The FRS includes 4 criteria with an associated rank from 1 to 5. By summing the values for each criterion the relative recovery of disturbed plots can be determined. The 4 criteria of the FRS include:

1. Line Visibility
2. Floristic Similarity
3. Structural Similarity
4. Successional Trajectory

Sections outlined below are to be entered on the *Seismic Line Recovery Tally Card* under "Functional Recovery Scale (FRS)".

10.2.1 Line Visibility

Assess how visible the seismic line is on the landscape from an aerial perspective. Refer to photos 1 and 2. Include a rank for the plot (disturbed) that the tally card is assessing. Record whether the assessment was made during the winter (Win.) or summer (Sum.). Summer surveys will be those that are within the plant growing season. By default, winter surveys will be those that are outside the plant growing season. Provide comments under "notes" to justify the rank selected.

Select a line visibility rank based on the following scale and provide this value in the score box:

- 1: Not grown in at all
- 2: Starting to grow in
- 3: Partly grown in
- 4: Mostly grown in
- 5: All grown in with only slightly visible lines or patches

Photos 1 & 2. The seismic line in the left hand photo can be clearly seen in stark contrast to the landscape around it. This line could be ranked as "1" or "2". The seismic line in the right hand photo has grown in, but is still somewhat visible within the surrounding landscape. This line could be ranked as "5".

10.2.2 Floristic Similarity

Inspect vegetation within paired plots on and off the line to determine if the type of vegetation "looks similar". Floristic similarity is ranked by comparing (1) tree species (2) understory vegetation. Record trees as coniferous, deciduous or mixed on the tally card for plot type (disturbed or control) being assessed on the tally card. Estimate the cumulative percent cover provided by coniferous and/or deciduous trees by following the guidelines for visual estimates of percent cover provided in Section 8.4.2, *Percent (%) Cover by Layer*. Provide comments under "notes" to justify the rank selected.

Select a floristic similarity rank based on the following scale and provide this value in the score box:

- 1: Vegetation type is ≤5% similar
- 2: Vegetation type is between 5-25% similar
- 3: Vegetation type is between 26-50% similar
- 4: Vegetation type is 51-75% similar
- 5: Vegetation type is ≥75% similar

Photos 3 & 4. Left photo shows disturbance from seismic construction and right photo shows undisturbed adjacent vegetation. In both photos, the vegetation type is floristically similar.

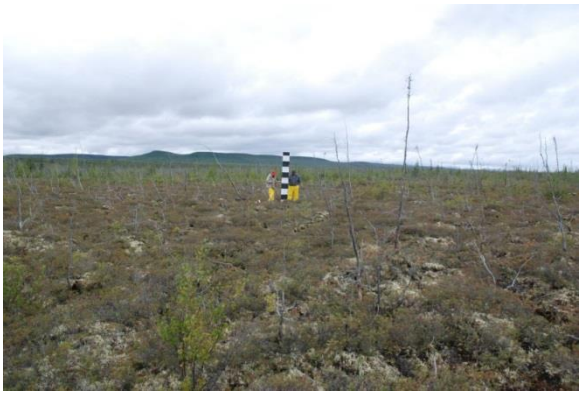
These two plots are not "structurally similar". In general, the vegetation in the left photo is younger, shorter in stature and less dense; however, because similar species occur within each plot they are considered to be floristically similar. The floristic similarity between these two plots could be "4" or "5".

10.2.3 Structural Similarity

Inspect vegetation within paired plots on and off the line to determine if the structure of the vegetation "looks similar". Structural similarity is ranked by estimating the density of the vegetation at 0-1 m, 1-2 m, and > 2 m along the cover board. Record cover board estimates as a percentage of the board covered by vegetation. Refer to Section 8.4.6, *Percent (%) Cover Board*, for more information on cover board data collection. Provide comments under "notes" to justify the rank selected.

Select a structural similarity rank based on the following scale and provide this value in the score box:

- 1: Structurally dissimilar (photos 1 & 2)
- 2: Mostly dissimilar
- 3: Moderately dissimilar
- 4: Mostly similar
- 5: Structurally similar (photos 5 & 6)



Photos 5 & 6. The left photo was disturbed by seismic construction and the right phot was undisturbed adjacent vegetation. In both photos, the vegetation type is floristically and structurally similar. The influence of a previous fire in both of these plots has re-set both plots, so that the disturbed and control plot are floristically and structurally similar. In addition, the line was cleared without removing the organic insulating layer, which played a role, in combination with fire, to permit similar floristic and structural recovery. The structural similarity between these two plots could be a "5".

10.2.4 Successional Trajectory

Assess whether the successional trajectory for the paired plots on and off the line are similar. This assessment must include an evaluation of the previous criteria. Line visibility, floristic similarity, and structural similarity will influence the ranking for successional trajectory. Where a pair of plots ranks low for line visibility, floristic and structural similarity, it will also rank lower for successional trajectory. A value of 1 indicates slow or delayed recovery with low potential for the disturbed plot

to recover to the state of the control plot. In contrast, a value of 5 indicates advanced recovery with high potential that the disturbed plot will recover to a similar state of the control plot. Provide comments under "notes" to justify the rank selected.

Select a successional trajectory rank based on the following scale and provide this value in the score box:

- 1: Successional trajectory completely different (photos 7 and 8)
- 2: Mostly different
- 3: Slightly different
- 4: Mostly the same
- 5: Successional trajectory similar (photos 3 and4)

Photos 7 & 8. The left photo shows a seismic line that has sunk as a result of a loss of permafrost insulation. This has changed the vegetation significantly from the black spruce forest (right photo - undisturbed) to a sedge and dwarf birch dominated stand (left photo - disturbed). The successional trajectory between these two plots could be a "1".

10.2.5 Recovery Status

Record the total score on the tally card by summing the score values for each of the 4 criteria as illustrated below.

FRS = Line Visibility + Floristic Similarity + Structural Similarity + Successional Trajectory

Determine the score and subsequent level of recovery that the plot fits into. Categories were developed to describe relative recovery of the seismic line where the plot was assessed and are provided below (Table 13).

Table 13. Recovery status score sheet for the seismic line recovery study.

SCORE	LEVEL OF RECOVERY
4 to 8	*Minimal recovery* – low recovery of the line with differences in vegetation floristics and structure between disturbed and control plot. Unlikely to recover to a similar state of the control plot. Does not provide adequate cover and forage for wildlife.
9 to 14	*Partial recovery* – somewhat recovered line with some differences in vegetation floristics and structure between disturbed and control plot, however, it is likely to recover to a similar state of the control plot and/or provide cover and forage for some wildlife.
≥ 15	*Near or complete recovery* – high recovery of the line with similar vegetation floristics and structure between disturbed and control plot.

**__Note__: Future analysis will determine if this level of recovery constitutes adequate cover and forage for wildlife (i.e., caribou and moose).*

11.0 Notes/Site Diagram

Record on the *Seismic Line Recovery Tally Card* under "Notes/Site Diagram" any additional notes and a supporting site diagram to assist in plot relocation/redesign, notable observations, and any relevant information.

12.0 Seismic Line Recovery Tally Card

Refer to the draft *Seismic Line Recovery Tally Card*.