YUKON FORESTRY MONITORING PROGRAM

Field Manual and Monitoring Protocols

First approximation
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Yukon
Energy, Mines and Resources
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Acknowledgements

The monitoring protocols presented in this manual were compiled and edited from many sources including BC Ministry of Forests and BC Ministry of Environment, Canadian Forest Service – Pacific Forestry Centre, BC Forest and Range Evaluation Program (FREP), and the Kluane Ecological Monitoring Project. As such, there are no easily identifiable authors. All manuals, reports and publications used to prepare this field manual are listed in the references section in each chapter. The authors of these references are gratefully acknowledged as this existing work made it possible to compile a field manual for the Yukon. This manual was compiled by Aynslie Ogden, Yukon Forest Management Branch. Special thanks to Brad Hawkes, Canadian Forest Service – Pacific Forestry Centre and Roger Brown, Champagne and Aishihik First Nation for their invaluable assistance in the development of this manual.

First Approximation

This manual is a first approximation of methods for monitoring forested ecosystems in the Yukon. Monitoring is a critical element of sustainable forest management. The protocols herein are intended for use in various inventories and research projects and may be carried out by a number of different agencies. The intent of developing a manual is to standardize data collection methods and forms so that data can be more easily shared and compared amongst different projects.

Because this manual is a first approximation, we are interested in any and all feedback on the utility of this manual by those who are using it. We would also appreciate your suggestions for updates to this manual e.g. improvements to data collection methods and/or changes to the layout and readability of the manual and/or the design of the field data forms. We are also interested in suggestions for additional monitoring protocols that would be useful to add to this manual.

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1.0

Introduction to Field Manual

The purpose of this document is to provide detailed descriptions of the field data collection methods along with field data collection sheets for the following monitoring protocols:

1. Monitoring site establishment
2. Site description
3. Forest mensuration
4. Understory vegetation
5. Coarse woody debris
6. Fine woody debris
7. Tree fuels assessment
8. Fuel treatment prescription compliance and effectiveness monitoring
9. Soil description
10. Effectiveness of measures to conserve soil resources
11. Assessment of tree attributes for wildlife
12. "Lite" fuel treatment effectiveness monitoring
13. Effectiveness of measures to conserve stand level biodiversity

The manual is organized into 13 sections that correspond to the 13 protocols listed above. Other than the monitoring site establishment protocol, each protocol has a corresponding field data form. The monitoring protocols in this field manual are designed to be used in various inventories and/or research projects. Not all the field forms, nor all of the data fields on each individual field form, will be completed at every monitoring site. Rather, project objectives will determine which forms and fields need to be completed, and where and how plots will be located. Unless specified otherwise in the site-specific study design, Table 1 summarizes the protocols

that are recommended to be monitored at each of the following forestry monitoring site types (described in Section 2.0):

Table 1: Protocols that are recommended to be monitored at different forestry monitoring site types

Monitoring Protocol	Monitoring Site Type					
	FA – Fuel Treatment	BS – Beetle Salvage	FS – Fire Salvage	GH – Green Harvest	PF – Post Fire	SBB – Post Beetle
Site establishment	Yes	Yes	Yes	Yes	Yes	Yes
Site description	Yes	Yes	Yes	Yes	Yes	Yes
Mensuration	Yes	Yes	Yes	Yes	Yes	Yes
Understory vegetation	Yes	Yes	Yes	Yes	Yes	Yes
Coarse woody debris	Yes	Yes	Yes	Yes	Yes	Yes
Fine woody debris	Yes	Yes	Yes	Yes	Yes	Yes
Tree fuels assessment	Yes	Yes	Yes	Yes	Yes	Yes
Fuel treatment	Yes	No	No	No	No	No
Soil description	Yes	Yes	Yes	Yes	Yes	Yes
Soil conservation	No	Yes	Yes	Yes	No	No
Tree attributes for wildlife	No	Yes	Yes	Yes	No	No
"Lite" fuel treatment	Yes	No	No	No	No	No
Stand level biodiversity	No	Yes	Yes	Yes	No	No

The Forest Management Branch (FMB) has constructed a Microsoft Access database to store data that is collected using the field data forms provided in this manual. A blank copy of this database may be obtained from FMB for use by any research and monitoring programs undertaken in the Yukon that adheres to these protocols. As a courtesy to the developers of this manual and database, FMB would greatly appreciate receiving a copy of field data forms from any project that uses these field data collection protocols and a copy of the database from any project that uses the database as a tool for data entry and analysis.

2.0

Monitoring Site Establishment Protocol

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2.0 Monitoring Site Establishment Protocol

2.1 Purpose

The objective of this protocol is to provide instruction on how to establish a monitoring site.

2.2 Procedure

2.2.1 Single or Paired-Plot Monitoring Site

Be sure to consult your study design to determine what type of monitoring site you are installing and whether or not you are installing a single plot (Figure 1) or paired plot (Figure 2) monitoring site. General guidelines for installing a single plot or paired plot monitoring site are provided in Table 1. Paired plots will be installed where a treatment e.g. salvage harvest or fuel treatment, has taken place or is planned to take place and there is an interest in examining differences between treated and untreated sites.

Table 1: General guidelines for installing single plot or pairedplot monitoring site

	FA – Fuel Treatment	**BS – Beetle Salvage**	**FS – Fire Salvage**	**HB – Harvest Block**	**PF – Post fire**	**SBB – Post Beetle**
Single plot	No	No	No	No	Yes	Yes
Paired plot	Yes	Yes	Yes	Yes	No	No

2.2.2 Naming Convention for Monitoring Sites

The following convention should be used for naming monitoring sites. Each subplot in a monitoring site has a unique code. Table 2 provides alternative codes to be applied in naming the plot.

Monitoring Site Type – Location and Site Number – SubPlot – Treatment Type

For example: FA – HJ1 – N – T and BS – QC – OU3G – N – PT

Table 2: Codes for naming monitoring plots

Monitoring Site Type[1]	**Location**[2]	**Site Number**[3]	**Sub Plot**	**Treatment Type**[4]
FA – Fuel Treatment	HJ – Haines Junction	1	N – North	T = Treatment
BS – Beetle Salvage	MT – McIntosh	2	S – South	PT = Pretreatment
FS – Fire Salvage	CH – Champagne	3	E – East	U = Untreated
GH – Green Harvest	CA – Canyon	4	W – West	
PF – Post Fire	ME – Mendenhall	5		
SBB – Post Spruce Bark Beetle	BL – Barney Lake	6		
	MC – Marshall Creek	Etc.		
	QC – Quill Creek			
	MI – Minto			
	FL – Fox Lake			
	TE – Teslin			

Additional notes on naming monitoring plots:

1. If you are installing a paired plot in an area that has been harvested (or is scheduled for harvest) post beetle or post fire, please use beetle salvage (BS) or fire salvage (FS) monitoring site type code. The post fire and post spruce beetle attack codes are for areas that have not been harvested and are not scheduled to be harvested.
2. If you are establishing a plot at a location that is not noted in the above table, please assign an appropriate code and inform the author of this manual to ensure location code is added to this table.
3. If more than one monitoring site is located in one general location, number each monitoring site sequetially starting at number. If relevant, you may instead specify the operating unit as well as or instead of a site number (e.g. the north subplot of a beetle salvage monitoring site installed in the Quill Creek Operating Unit 3G prior to harvest, this would be named BS-QC-OU3G –N-PT).
4. Note treatment type only when you are installing a paired-plot. If an area where a plot is to be installed is scheduled for treatment (e.g. harvesting), but has not yet been treated, and you are establishing the plot to allow for pre and post treatment comparisons, select PT for treatment type.

2.2.3 Paired-Plot Monitoring Sites

Each paired plot monitoring site consists of two plots – one plot will be installed in treated area and one plot in the adjacent untreated area (Figure 2). This paired-plot methodology allows for comparisons to be made between the treated and untreated forest. In addition, the monitoring site will ideally be installed prior to treatment to allow for pre and

post treatment comparisons. It is essential that the each of the plots in a paired-plot are located nearby on a site with ecologically similar site conditions (e.g. matching slope, aspect, soil type, soil nutrient regime and soil moisture regime).

2.2.4 Establishing the Point of Commencement and Sub-Plot Centres

The field crew will need to first determine the point of commencement. Where there is one monitoring site per location, randomly locate the POC in the stand. Where there is more than one monitoring site per location, plot centers should be distributed evenly in the stand and should be spaced at a minimum of 200 metres apart. The outside edges of all of the plots should be at least one full tree length, preferably two, from the edge of adjacent cover types (50 metres preferable, 25 metres minimum). It may be easier to first locate the POC from the site plan map/ airphoto prior to locating it in the field. Once the POC is located, drive a 0.5 metre wooden stake into the ground with a maximum of 10 cm above the surface. Attach short flagging tape to the end of the wooden stake to mark its location. Then measure 25 m in each of the cardinal directions (north, south, east and west) and mark each of these subplot centre locations with a wooden stake. Label all stakes per Section 2.2.2. Begin description of site on the data sheet (ensure you take a GPS reading of the POC and follow photograph procedure noted under the Site Description Protocol).

2.2.5 Sub-Plots

As noted above, each monitoring plot consists of four subplots located in the four cardinal directions around the point

of commencement (See Figure 1). The total width / length of the four sub-plots within a single plot is 75 m x 75 m. Depending on the protocol that is being measured, data may be collected from four types of plots within each subplot as described below: fixed width circular plots, variable radius plots, fixed width rectangular plots and line intercept plots (transects).

Fixed width circular – Fixed width circular plots will be used to measure seedlings and saplings (part of the Mensuration Protocol) and to provide visual estimates of percent cover of understory vegetation (part of the Understory Vegetation Protocol) for all monitoring site types. Fixed width circular plots will also be used for the fuel treatment monitoring site type to measure trees under the Mensuration protocol and the Fuel Treatment Prescription Compliance and Effectiveness Monitoring Protocol. Fixed width circular sub-plots are often chosen over variable-radius (prism) plots because they capture a greater number of trees. These sub-plot centres will be located 25 metres from the point of commencement. Fixed width circular plots have a radius of 11.3 m (this is equal to 400 square metres). The size of these circular plots is based on recommendations in "Describing Ecosystems in the Field" (BCMoE, MoF 1998).

Variable radius – Variable radius (prism) plots will be used for all monitoring site types other than the fuel treatment monitoring site type for the forest mensuration protocol, and for the tree attributes for wildlife and tree fuels assessment protocols. Prism plots are generally chosen over fixed width circular plots because they capture fewer trees and therefore are quicker to install. These sub-plot centres will be located 25 m from the point of commencement. Choose a basal area factor (BAF) prism size that will provide 7 – 11 sample trees (greater than or equal to the minimum DBH)

per plot is ideal. Whichever prism is first selected must be used for all other plots in the same stand.

Fixed width rectangular – These plots will only be installed for tree fuels assessment protocol measurements when fixed width circular plots are used for the Mensuration Protocol. These fixed width rectangular sub-plots are 4 m x 25 m and are centered along the 25 m line intercept line (see Figure 1). The fixed width rectangular plot (100 m^2) is smaller than the fixed width circular plot (400 m^2) but is of a sufficient for all of the variables of interest to the Tree Fuels Assessment Protocol, and has been used by other studies in the region for tree fuels assessments (Garbutt 2007).

Line intercept or transect – Line intercept plots start 12.5 m from the POC and are located along quadrant axis lines. Understory Vegetation, Coarse Woody Debris, Fine Woody Debris, and Soil Conservation Protocols also use line-intercept plots.

2.2.6 Describe Site Access and Tie-Point

Describe how you accessed the site. Note where the vehicle was parked and the location of the tie point. Also note details of nearby buildings, and other permanent features. Note the GPS coordinates of the tie-point and the bearing and distance from the tie point to the plot. Make sure the tie point is distinct and easy to find. At the tie point flag the tree and write the plot number and bearing/distance to the plot on the flagging. Record this on the site description form.

2.2.7 Marking Sites Near High-Use Community Areas

For those sites located within high-use community areas (e.g. fuel treatment sites), it will be necessary to flag these sites conservatively (e.g. to not use a lot of flagging). Near to communities, most people will not want to see evidence of survey tapes and flagging and markers.

2.3 Equipment

- Compass
- Flagging tape
- Five 0.5m wooden stakes (per plot)
- 30m measuring tape and loggers tape
- Quadrat ropes (2 x 12.5 m ropes marked every 1 m, 5 m, and at the 11.3 m point and 2 x 11.3 m ropes and tent stakes to hold ropes in place)
- GPS
- Mallet

2.4 References

BC Ministry of Environment and BC Ministry of Forests. 1998. Describing Ecosystems in the Field. Land Management Handbook Number 25. http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/fmdte/deif.htm

Garbutt, R.W.; Hawkes, B.C.; Allen, E.A. 2007. Spruce beetle and the forests of the southwest Yukon. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC. Information Report BC-X-406. 68 p.

Figure 1: Single-plot monitoring site layout

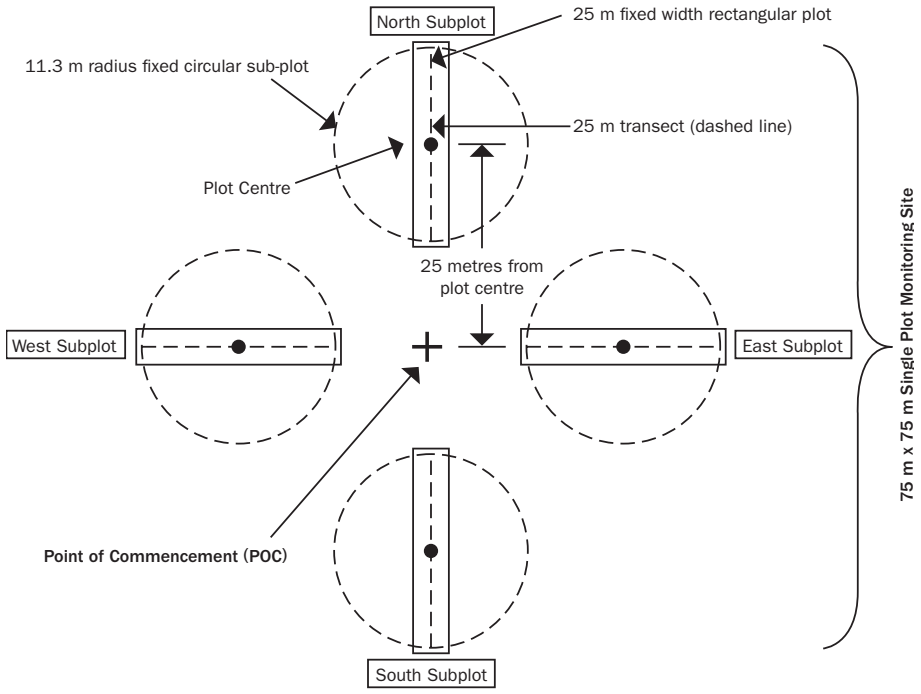
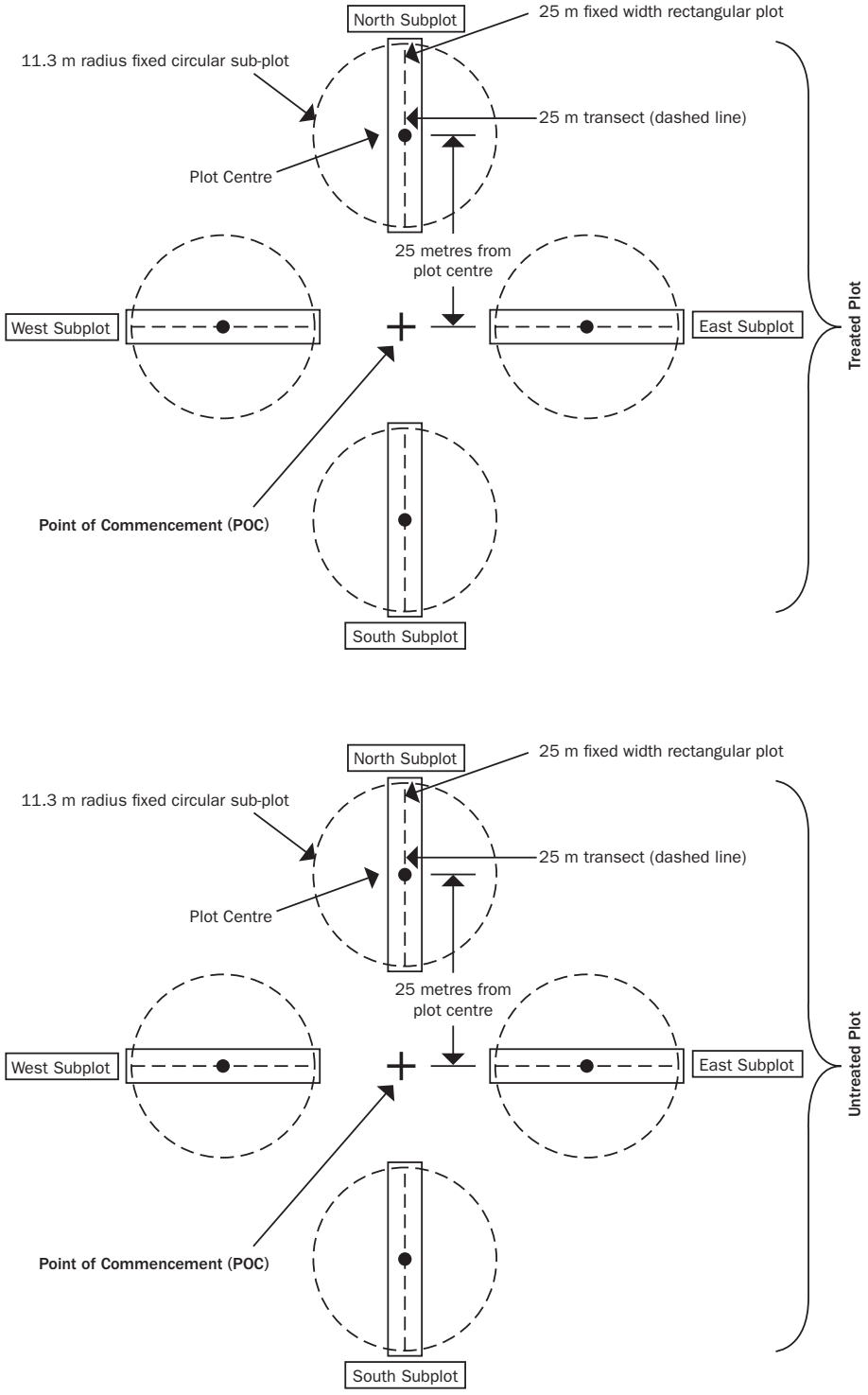


Figure 2: Paired-plot monitoring site layout



3.0

Site Description Protocol

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Yukon
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SITE DESCRIPTION

Date (M/D/Y) _____ 3.2.2

Field Crew _____

SIS Number _____

Plot Number _____ 3.2.1
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Location @ POC @ Subplot Centre

NTS Mapsheet _____ 3.2.3 Latitude _____

UTM Zone _____ Longitude _____ 3.2.4 _____

Easting _____ __ _____

Northing _____ _____

Site Information

Slope _____ 3.2.5 Aspect _____ 3.2.6 Elevation _____ 3.2.7

Site Position 3.2.8

Crest Upper Slope Middle Slope Lower Slope Toe Depression Level

Terrain Even Rolling Gullied Hummocky 3.2.11

Site Index _____ 3.2.14

Ecoregion _____ 3.2.9 **Vegetation Type** _____

Fuel Type _____ 3.2.13 **Soil Type** _____ 3.2.12

SITE DESCRIPTION

Access: 3.2.16

Location of Tie Point:

Easting _____

Northing _____

Tie Point to Plot:

Bearing _____

Distance _____

Vehicle Access/Parking:

Entered into Database? Yes ☐ No ☐

Protocols Completed 3.2.17

Site Description _____

Mensuration _____

Understory _____

CWD _____

FWD _____

Tree Fuels _____

Fuel Abatement _____

Soil Description _____

Soil Conservation _____

Wildlife Trees _____

Biodiversity _____

Comments:

3.2.15

Photographs:

3.0 Site Description Protocol

3.1 Purpose

The purpose of this protocol is to provide general description of the location and characteristics of each monitoring site location. Methods are similar to those in BCMOE and BCMOF (1998).

3.2 Procedure

3.2.1 Plot Number

Use the plot numbering convention noted in the Monitoring Site Establishment Protocol.

3.2.2 Field Crew and Date

The month/day/year on which the data on the form is gathered in the field will be recorded, along with the names of the field crew.

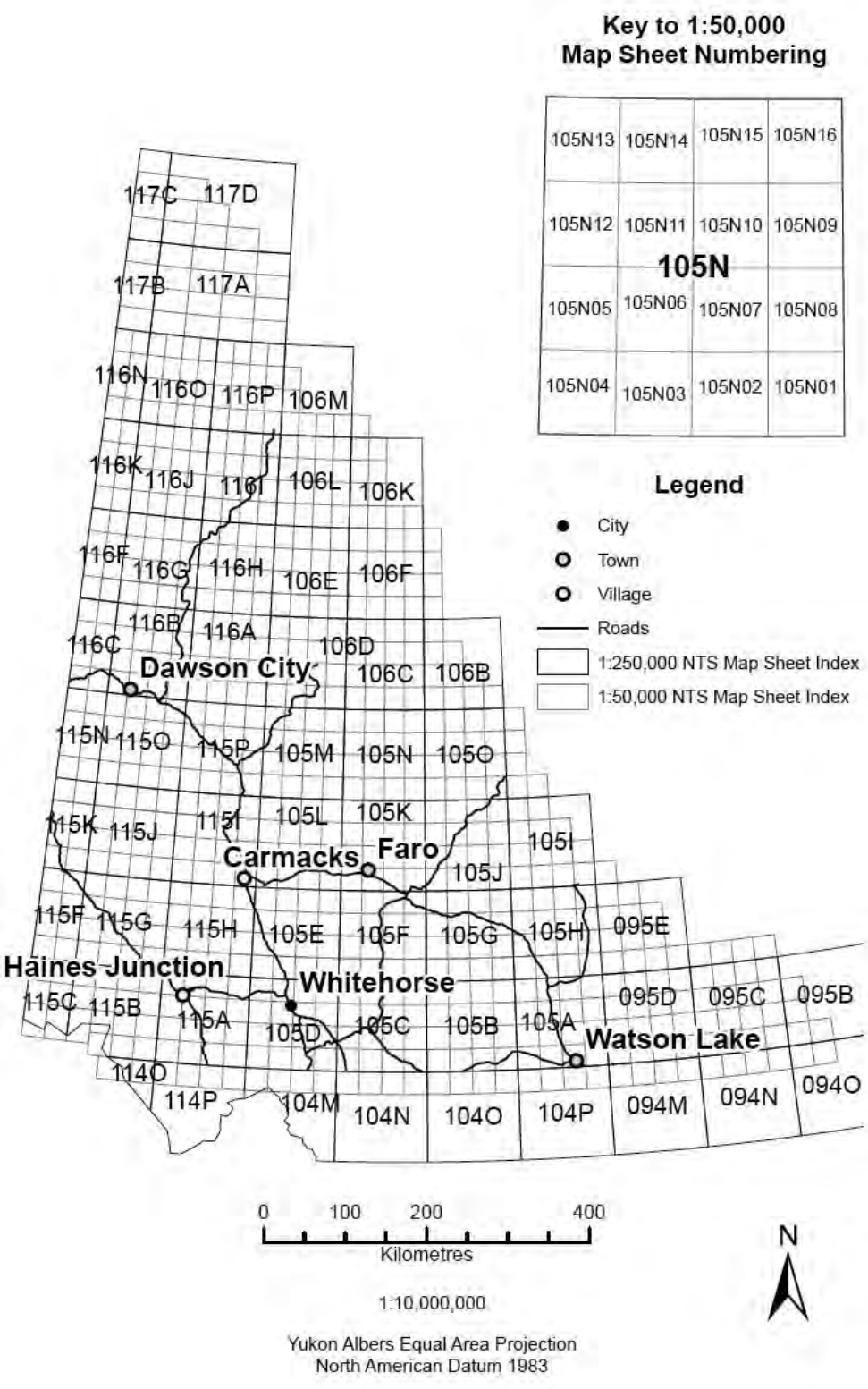
3.2.3 NTS Sheet

The 1:50,000 mapsheet on which the described site is located will be noted (Figure 1)

3.2.4 UTM, Latitude and Longitude

The UTM zone, easting and northing and the latitude and longitude will be recorded at the POC and at the centre of each subplot using a GPS (NAD 83).

Figure 1: Key to NTS map sheets



3.2.5 Slope

The percent slope gradient of the land at the site will be measured using a clinometer.

3.2.6 Aspect

Aspect measures the orientation of a slope by means of compass points and indicates whether the slope exposed to the north, south, east, or west, or any point between. If a slope is present, read the compass clockwise from east to south to west, and record the compass bearing. North is 0˚ East is 90˚, south is 180˚, and west is 270˚. Record the aspect in one of the following categories: north, northeast, east, southeast, south, southwest, west northwest, or flat. Remember to adjust the compass declination.

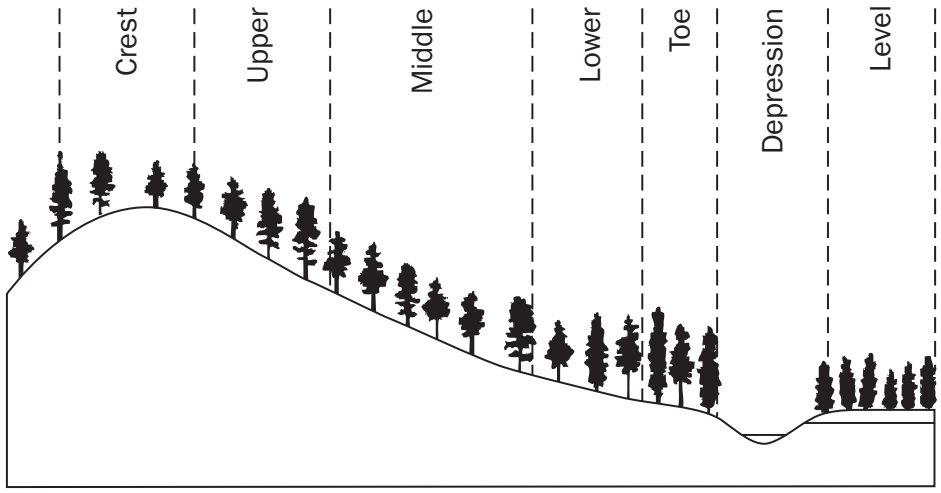
3.2.7 Elevation

The elevation of the land at the site will be recorded in meters by use of a hand-held GPS unit or altimeter, or derived from the 1:50,000 NTS sheet.

3.2.8 Site Position

Site position describes the relative position of the sampling site within a catchment area (crest, upper slope, middle slope, lower slope, toe, depression, level) (See Figure 2).

Figure 2: Site position. Source: BCMOF and BCMOE, 1998



3.2.9 Ecoregion

The ecoregion in which the site is located will be recorded. (See Figure 3). Additional information on Yukon Ecoregions can be found in Smith et al. (2004).

3.2.10 Ecosystem Classification

A biogeoclimatic ecosystem classifications system for the Yukon is currently under development. This information will be recorded once this classification system becomes available.

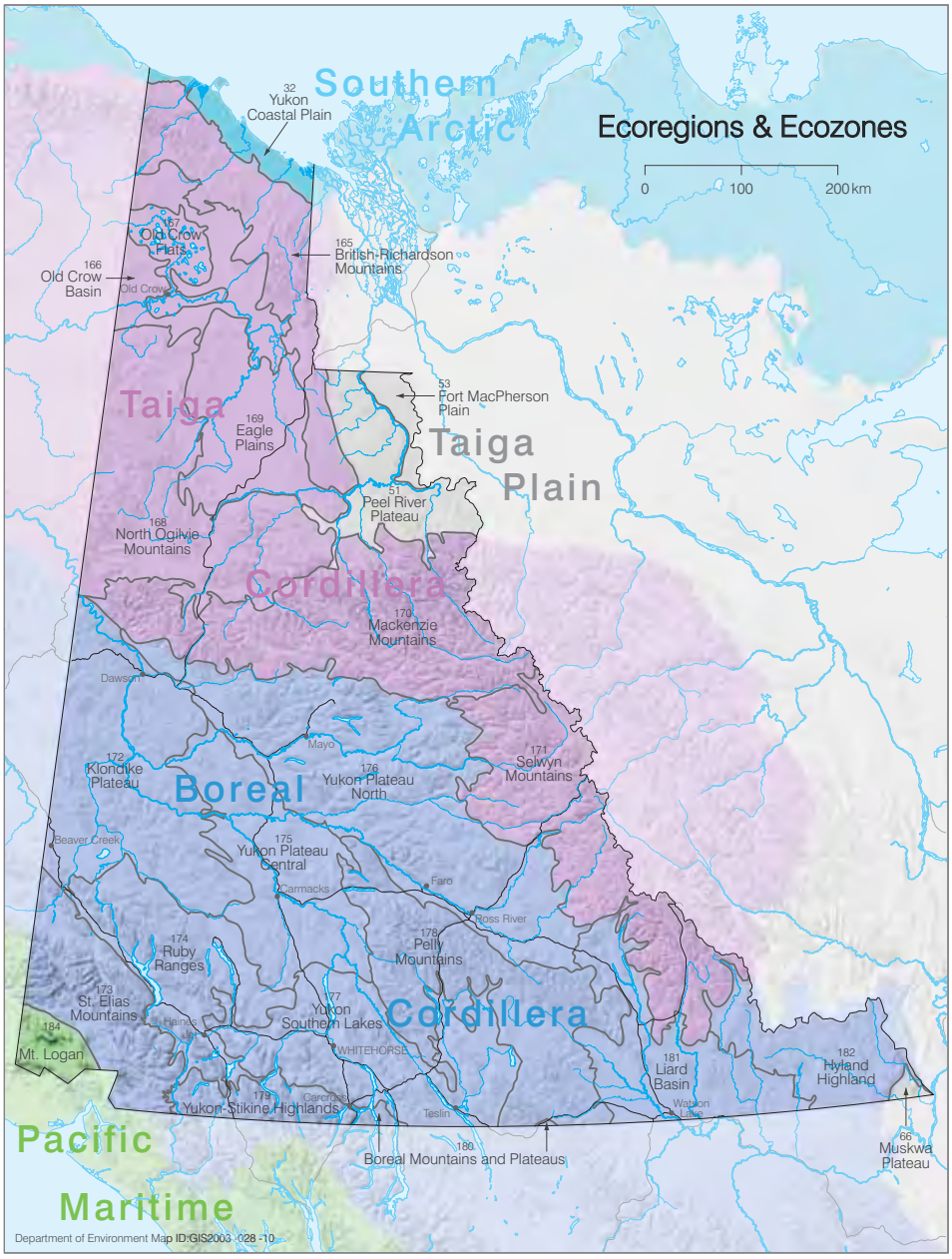
3.2.11 Terrain

The surface topography of the site will be noted (even, rolling, gullied).

3.2.12 Vegetation and Soil Type

The vegetation type (e.g. V1) and soil type (e.g. S1) per Appendix B (Zoladeski et al. 1996) will be recorded.

Figure 3: Ecoregions. Source: Smith et al., 2004



3.2.13 Fuel Type

The fuel type, per the Canadian Forest Fire Behavior Prediction (FBP) System[1] will be recorded per fuel type codes in the footnote. Please note, FBP fuel types should only be recorded if there is a person on the field crew that has experience in designating FBP fuel types (e.g. the person has taken an advanced fire behaviour course). Alternately, a description of the stand and a photograph could be provided to someone who has the FBP training to assign the most appropriate FBP fuel type.

3.2.14 Site Index

Calculate and record site index (height at age 100).

3.2.15 Photographs

At each POC, a digital image should be taken in each of the four cardinal directions. A photo control post should be inserted into the beginning point of each 25 metre transect (see Figure 4). Note: it is extremely important that your record the photo number on the field form. If you can, set the camera to record the date and time the photo was taken directly on the photo and/or to name the photo per the date and time it was taken. Once the photo has been downloaded to the computer, relabel the name of the file using the following convention: PlotNumber_Subplot_SampleDate.jpg (e.g. FA-HJ1-T_North_2006.jpg).

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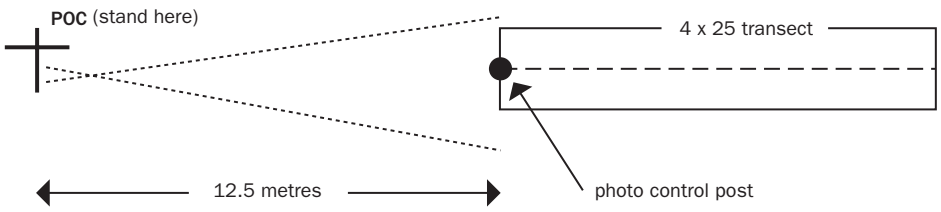
[1] Detailed fuel type descriptions can be found at http://www.nofc.forestry.ca/fire/research/environment/cffdrs/fbpfuels_e.htm

Figure 4: Photograph method



3.2.16 Site Access and Tie Points

Describe how you accessed the site. Note where the vehicle was parked and the location of the tie point. Also note details of nearby buildings, and other permanent features. Note the GPS coordinates of the tie-point and the bearing and distance from the tie point to the plot. Make sure the tie point is distinct and easy to find. At the tie point flag the tree and write the plot number and bearing/distance to the plot on the flagging.

3.2.17 Protocols Completed

Indicate which monitoring protocols were completed at the site.

3.3 Equipment

- Compass
- Clinometer
- Diameter tape
- GPS
- Flagging tape
- 30m measuring tape
- Field data form
- Digital camera
- Control post (for scale in photographs)

3.4 References

BC Ministry of Environment and BC Ministry of Forests, 1998. Describing Ecosystems in the Field. Land Management Handbook Number 25. http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/fmdte/deif.htm

Smith, C.A.S., J.C. Meikle and C.F. Roots (eds). 2004. Ecoregions of the Yukon Territory: Biophysical Properties of Yukon Landscapes. PARC Technical Bulletin No. 04 – 01. Agriculture and Agri-Food Canada, Summerland, British Columbia.

Zoladeski et al. 1996. Ecosystem Classification for the Southeast Yukon: field guide, first approximation. Yukon Renewable Resources, Canadian Forest Service, Department of Indian Affairs and Northern Development. Whitehorse, Yukon.

4.0

Forest Mensuration Protocol

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MENSURATION

Date (M/D/Y) _____ (3.2.2)

Field Crew _____

Plot Number _____ (3.2.1)
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Tree Number (4.2.4)	Species (4.2.5)	Diameter (4.2.6)	Age (4.2.7)	Height (4.2.8)	Tree Class (4.2.9)	Crown Class (4.2.10)	Beetle Attack Phase (4.2.11)	Chainsaw Damage	Conk	Blind Conk	Scar	Fork	Crook	Frost Crack	Mistletoe	Rotten Branch	Dead or Broken Top	Defect Location Summary

(4.2.12) and (4.2.13)

MENSURATION

Entered into Database? Yes ☐ No ☐

Fixed Area Plot? Yes ☐ No ☐ If FRP page _____ of _____

Variable Radius Plot Yes ☐ No ☐ If VRP, note BAF 4.2.1 _____

Tree Seedlings (<1.3 m tall)		
Species	**Tally**	**Total**
	4.2.3	

Saplings (>1.3 m tall and <7cm dbh)		
Species	**Tally**	**Total**
	4.2.3	

Crown Closure 4.2.14				
North	**South**	**East**	**West**	**Average**

4.0 Forest Mensuration Protocol

4.1 Purpose

The purpose of this protocol is to record the characteristics of individual trees. Methods are similar to those in BC MoE, MoF (1998).

4.2 Procedure

4.2.1 Plot Establishment

Forest tree measurements will be obtained at each of the subplots. Either a fixed-area circular plot or a variable-radius plot may be used. A fixed area plot is preferable in stands with the following characteristics: very open stands with widely spaced trees (e.g. fuel treatment areas) or clumps of trees or very dense stands where not all trees in a plot would be easily visible. Once selected, the same plot-type should be used consistently throughout the project. Consult Table 1 and the study design for the monitoring project you are working on for guidance on whether to establish a fixed-radius or a variable radius plot.

Variable Radius Plots – When traversing the stand, but before determining the plot location, the prism size should be selected. Sample trees are identified based on a prism sweep. Choose a basal area factor (BAF) prism size that will provide 7-11 sample trees (greater than or equal to the minimum DBH) per plot is ideal. Generally, the larger the trees or the denser the stand, the smaller the BAF required. Prisms with a BAF of 2, 3, 4, 5 are included in the field kit. Whichever prism is first selected must be used for all other plots in

the same stand. Please note the Basal Area Factor (BAF) on the field data form. See Figure 1 for instructions on how to calculate whether or not borderline trees are in the plot.

Fixed Area Plots – Fixed-area plots are 11.3 m radius (400 m^2) circular plots. The centre point for the plot is 25 metres from the point of commencement. To establish plot boundaries and identify sample trees, layout the provided quadrat ropes to measure out the plot to easily determine which trees are inside or outside of the plot.

Table 1: General guidelines for establishing fixed radius vs. variable radius plot*

	FA -Fuel Treatment	BS - Beetle Salvage	FS- Fire Salvage	HB- Harvest Block	PF -Post fire	SBB -Post Beetle
Mensuration - fixed radius	Yes	No	No	No	No	No
Mensuration - variable radius	No	Yes	Yes	Yes	Yes	Yes

*Note: Please consult study design for the monitoring project you are working on for guidance on whether to establish a fixed-radius or a variable radius plot

4.2.2 Criteria for Measurable Trees

Trees must be greater than 7 cm DBH. All live and dead trees are included.

4.2.3 Tally of Seedlings and Saplings

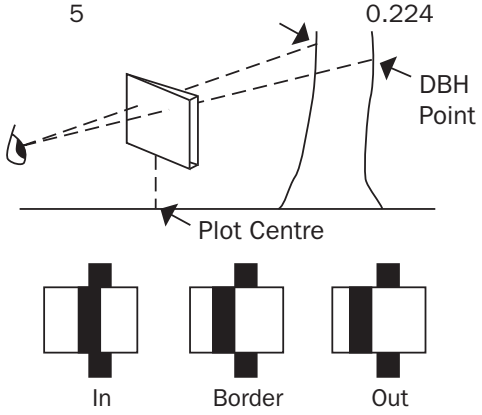
All trees less than 7cm dbh will be tallied within a 11.3m radius fixed-area plot (the centre point for the plot is 25 metres from the point of commencement). All trees will be tallied according to species and whether they are in the;

1. Sapling/pole/ advanced regeneration stage (i.e. greater than 1.3 metres tall but less than 7cm dbh), or the
2. Seedling/ regeneration stage (less than 1.3 metres tall).

An estimate of average height and general condition will be recorded for each grouping.

Figure 1:
Borderline tree calculation

Basal Area Factor (BAF)	Plot Radius Factor (PRF)
1	0.500
2	0.354
3	0.289
4	0.250
5	0.224



Borderline tree:

1. Measure the diameter of the tree
2. Measure the distance from the plot centre to the tree
3. The tree is in if:
   PRV * DBH > distance to tree
4. The tree is out if:
   PRV * DBH < distance to tree

4.2.4 Tree Tagging and Numbering

Assign numbers sequentially to each tree sampled. Start with the tree closest to due north of plot centre and proceed clockwise. Tag numbers on each tree including all live and dead standing trees. Numbers should be tagged on trees using an aluminum tag nailed to the tree with an aluminum nail. Aluminum nails do not injure the trees (KEMP, 2005).

The nail should be at least 5 cm long and at least 2 cm of the nail should be left to allow the tree to grow. After a few years the nails may need to be pulled out a little if the tree has grown. For safety reasons, do not put nails in trees that are within an area that is scheduled to be harvested (e.g pre-treatment monitoring site types), in lieu use paint to identify the selected tree; alternately, nails may be placed at the very base of the tree.

4.2.5 Species

Record the species name, for both live trees and dead trees (if possible). Please use species codes in Table 2.

Table 2: Tree species codes

Tree Species	
Trembling Aspen – *Populus tremuloides*	A
Balsam Poplar – *Populus balsamifera*	B
Subalpine Fir – *Abies lasiocarpa*	F
Larch – *Larix laricinia*	L
Lodgepole Pine – *Pinus contorta*	P
Black Spruce – *Picea mariana*	SB
White Spruce – *Picea glauca*	SW
White Birch – *Betula papyrifera*	W

4.2.6 Diameter

Using a diameter tape, or a set of tree calipers, determine diameter to the nearest cm at a height of 1.3 metres above the ground (DBH).

4.2.7 Age

Tree age at breast height, 1.3 m above the ground on the high side, will be measured for a rep-resentative number of trees in the plot. For dead trees, record an approximate age since mortality. The core must show the pith for the age to be accurate. Depending on the requirements of the project, counts may be done in the field using a hand lens. If greater

accuracy is required, place the core in a plastic straw labeled with the plot and tree number and determine age later in the office. In some cases a microscope may be required to achieve an accurate count.

4.2.8 Height

Determine tree height using a laser or a clinometer. If you are using a clinometer, ensure that you do not exceed a 45 degree angle.

4.2.9 Tree Decay Class

Assign a tree decay class designation to all standing trees per Figure 2.

4.2.10 Crown Class

Assign a crown class designation to all standing live trees per Table 3 (Source BCMOF, BCMOE, 1998):

Table 3: Crown class

D	Dominant Trees with crown extending above the general level of the layer; somewhat taller than the codominant trees, and have well developed crowns, which may be somewhat crowded on the sides.
C	Codominant Trees with crowns forming the general level of the crown canopy; crown is generally smaller than those of the dominant trees and usually more crowded on the sides.
I	Intermediate Trees with crowns below, but extending into the general level of the crown canopy; crowns usually small and quite crowded on the sides.
S	Suppressed Trees with crowns entirely below the general level of the crown canopy.

Figure 2: Tree decay classes Source: BCMOE and BCMOF, 1998

Gradual death: conifers	General description of tree	Wildlife uses and users	Stages of decomposition
1	**live/heathy** – no decay	nesting; roosting; perching; territory; large–limb eagle and Osprey nests; raptors; scavengers; Great Blue Heron colonies; Marbled Murrelet	
2	***live/unhealthy*** – internal decay or growth deformities (including insect damage, broken tops); dying tree	nests/roosts – PCEs[a] (strong excavators); SCUs[b]; large–limb nests; insect feeders	
3	**dead**[c] – hard heartwood; needles and twigs present; roots stable	nests/roots – PCEs (strong excavators); SCUs; bats; larger–limb nests; hunting/hawking perches; branch roots; insect feeders	
4	**dead** – hard heartwood; no needles/twigs; 50% of branches lost; loose bark; top usually broken; roots stable	nests/roots – PCEs (weakest excavators); SCUs; bats; insect feeders	
5	**dead** – spongy heartwood; most branches/bark absent; internal decay; roots stable for larger trees, roots of smaller trees beginning to soften	nests/roots – PCEs (weakest excavators); SCUs; bats; insect feeders; salamanders	
6	**dead** – soft heartwood; no branches or bark; sapwood/ heart sloughing from upper bole; lateral roots of larger ones softening; smaller ones unstable	SCUs; insect feeders; salamanders, small mammals	
7–8	**dead** – soft heartwood; stubs; extensive internal decay; outer shell may be hard; lateral roots completely decomposed; hollow or nearly hollow shells	insect feeders; salamanders; small mammals	
9	**debris** – downed stubs or stumps	insect feeders; salamanders; small mammals; amphibians; drumming logs for grouse; flicker foraging, nutrient source	

a This classification system does not apply to downed logs and/or coarse woody debris.
b PCE = primary cavity excavator.
c SCU = secondary cavity excavator.
d The stability of dead trees is influenced by cause of death. Dead trees can be unstable if killed by butt rot or root rot, depending on the species of the fungus. In general, *Phellinus* attack lends to instability; *Armillaria* attack must be assessed carefully on a site–specific basis.

4.2.11 Phase of Beetle Attack

If your plot is located in a spruce-beetle infested area (e.g. southwest Yukon), record phase of beetle attack. For white spruce, record whether the tree is green (unattacked), green attack, red attack, red dead, grey dead, old dead, other dead (per Table 4). The key feature used to note spruce beetle attack is the presence of brown boring dust. It is common to use a knife to look under the bark for galleries and/or larvae; however, since the intent of this monitoring program is to record the health of trees in the plots over the long term, bark should not be removed from live trees to aid in the assessment as it may provide an entry point for wood decay fungi. The following health status categories are from KEMP (2005). If the tree seems to fall between two status categories, choose the worst case scenario. For example, if a tree is half covered with red needles but half the tree looks green and healthy, classify it as red dead.

- *Unattacked* – Alive and healthy, few or no sap flows, needles are green, few bore holes.
- *Green attack* – Beetle attack, green stage. Many fresh sap flows from bore holes, some needles going yellow/green or orange, may have sawdust at base and yellow/green needles on the ground.
- *Read dead* – Beetle attack, red stage. Needles red, few yellow/green needles except on ground around tree base. Some red needles also on ground, sawdust on the ground but it may be old sawdust.
- *Grey dead* – Beetle attack, grey stage. All needles on ground are old red needles. The tree still has many small branchlets attached. Some of the branchlets have yellow bark.
- *Old dead* – Old and dead for at least 10 years, no needles under tree, bark off of lower and some

upper branches, fewer small branchlets, no colour in branches.

- *Other dead* – Tree death not attributable to beetle attack.

Table 4: Beetle attack phase codes

Code	Beetle Attack Phase
G	Green/Unattacked
GA	Green attack
RD	Red dead
GD	Grey dead
OLD	Old dead
OTH	Other dead

4.2.12 Pathological Indicators

Defects and pathological indicators are frequently signs of decay or rot in the wood. A description of the key indicators is provided below (Source: BCMOE and BCMOF, 1998).

- *Fork or 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.
- *Conks* – 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.

- *Blind conks* – Swollen knots are reliable indicators of 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.
- *Scars* – 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. 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. This category includes damage to conifers, and live or dead deciduous stems caused by felling trees, removing debris, burning piles, and pruning (chainsaw damage). If known, the cause of the scar will be noted. Damage from pruning (noted as chainsaw damage) may be observed on the bottom 3m of the bole. Note: this information is also being gathered under the prescription compliance protocol.
- *Frost cracks* – Frost cracks are caused by uneven expansion of moisture in the tree following a sudden and pronounced drop in temperature. They result in deep radial splitting of the trunk and are considered suspect. Usually originating at the base of the trunk, frost cracks may extend many metres up the tree. These cracks are often re-opened by wind stresses

or low temperatures; repeated healing of the wood produces considerable callous tissue, giving the wound a pronounced ribbed appearance

- *Mistletoe* – Mistletoe infection may be indicated by either abnormal swelling or malformation of the trunk,
  or by clusters of dead and broken branches on the trunk, or on swollen branches adjacent to the trunk. Infection on branches should be noted only where swelling has extended to within 30 cm of the trunk.
- *Rotten branch* – Large, rotten branches, typically on old-growth trees often indicate decay. Note only those branches that are greater than or equal to 10 cm in diameter at the base and that are clearly rotten (usually on overmature 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).

4.2.13 Defect Location

If a tree has pathological indicators, record the location on the tree using the codes in Table 5. In the last column of the field data form, indicate the defect location considering all indicators together.

4.2.14 Crown Closure

Measure crown closure using a spherical densiometer. Stand at plot centre and make four readings facing north, east, south and west. Record all readings and the average.

Table 5: Defect location codes.
Source: BCMOE and BCMOF 1998.

Code	Defect occurrence on tree
1	Lower third only
2	Middle third only
3	Upper third only
4	Lower and middle thirds
5	Middle and upper thirds
6	Lower and upper thirds
7	Entire tree

4.2.15 Calculating Key Statistics

Data must be entered into the Yukon Forest Inventory System to generate the following statistics:

- Mean DBH (All classes; Dominant/Co-Dominant)
- Mean height (All classes; Dominant/Co-Dominant)
- Stems per ha
- Basal area
- Gross total volume
- Merchantable volume
- Net merchantable volume
- Number of logs
- Log volume
- Dead standing stems per hectare
- Gross dead volume

Once this information has been generated please PRINT a copy of the output and add it to the field data forms.

4.3 Equipment

- Prisms
- Compass
- Clinometer
- Hypsometer
- Diameter tape
- Increment corer
- Digital camera
- Flagging tape
- Aluminum nails
- Aluminum tree tags
- Sharpie marker
- Hammer
- Tree marking paint
- Field data form
- GPS
- Quadrat ropes
- Spherical densiometer

4.4 References

BC Ministry of Environment and BC Ministry of Forests, 1998. Describing Ecosystems in the Field. Land Management Handbook Number 25. http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/fmdte/deif.htm

Kluane Ecological Monitoring Project (KEMP). 2007. Yukon Ecological Monitoring Protocols: 2007 Edition. ftp://ftp.zoology.ubc.ca/pub/krebs/field_manual2007.pdf

5.0

Understory Vegetation Protocol

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UNDERSTORY VEGETATION

Date (M/D/Y) _____ 3.2.2

Field Crew _____

Plot Number _____ 3.2.1
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Species List Complete ☐ Partial ☐

Transect 5.3.1					
Tree Species List	**Tally**	**Total /25**	**Grass - Species List**	**Tally**	**Total /25**
Tall Shrub List	**Tally**	**Total /25**	**Herb - Species List**	**Tally**	**Total /**
					25
Low Shrub List	**Tally**	**Total /25**	**Moss/Lichen - _ Species List**	**Tally**	**Total /25**
Leaf Litter Tally /25	**FWD Tally**	/25	**CWD Tally** /25	**Burn Tally**	/25

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UNDERSTORY VEGETATION

Entered into Database? Yes ☐ No ☐

Cover by Layer	Total /25
Tall Shrub	_____
Low Shrub	_____
Grass	_____
Herb	_____
Moss/Lichen	_____
Leaf Litter	_____
FWD	_____
CWD	_____
Burn	_____

Visual Assessment 5.3.2	
Species	**% Cover**

5.0 Understory Vegetation Protocol

5.1 Purpose

Field measures will assess the lower vegetation stratum layers. Two methods are used: transect and visual. The transect method uses methods from Garbutt (2007) that seek to remove observer bias and are able to provide a representative sample of understory vegetation characteristics that may be used to provide an indication of changes over time. The visual method involves doing a complete listing of vegetation within the plot, using methods are adopted from BC MOE and BC MOF, 1998; Johnstone et al., 2004 and Mcdonald and Fenniak, 2007.

5.2 Definitions

5.2.1 Tall Shrub Layer

Shrubs can generally be categorized into to groups (those greater than 50 cm and those under 50 cm tall). The tall shrub layer includes all woody plants 50 cm – 10 m tall including shrubs and advance tree regeneration and trees in poorly growing stands where the canopy is less than 10 m high. Shrubs are those species with perennial woody stems and typically include multiple stems originating from a central base. The latin name of species should be recorded.

5.2.2 Low Shrub Layer

The low shrub layer includes all woody plants less than 50 cm tall, except low (< 15 cm) woody or trailing plants which are considered part of the herb layer; includes dwarfed or immature shrubs normally considered to be in the tall shrub category. The latin name of species should be recorded.

5.2.3 Grass – Like Plants (Graminoids)

Grasses, (family Cyperaceae), rushes (family Juncaceae) and grasses (family Poaceae) are some what similar and can be grouped as graminoids or grass-like plants. If your graminoid species identification is weak, record observations using the following three categories: grass, rush or sedge and in early-successional forests, pay particular attention to the presence of *Calamagrostis canadensis* as heavy competition from this species can be lethal to young conifers.

5.2.4 Herbs

The herb layer includes all herbaceous species, regardless of height, and some low woody plants less than 15 cm tall. The latin name of species should be recorded.

5.2.5 Mosses, Liverworts and Lichens

The moss, liverworts and lichens layer includes all bryophytes, terrestrial lichens, and liverworts. The latin name of species should be recorded.

5.2.6 Leaf Litter

Leaf litter is a mixture of fallen and dead plant material on the forest floor, made up of leaves, bark, small stems and small branches (less than 0.5 cm in diameter) and may include these same materials in a burned state.

5.2.7 Fine Woody Debris

Fine woody debris (e.g., branches, twigs) includes woody stems above the soil surface greater than 0.5 cm and less than 7 cm diameter.

5.2.8 Coarse Woody Debris

Coarse woody debris (CWD) is dead woody material, in various stages of decomposition, located above the soil, larger than 7 cm in diameter (or equivalent cross-section) at the crossing point, which is not self-supporting. Trees and stumps (intact in ground) are considered self-supporting. Pieces of coarse woody debris may be suspended on nearby live or dead trees, other pieces of coarse woody debris, stumps or other terrain features.

5.2.9 Burned Area

Burned areas may be natural burns or the remnants of burn piles. Only note where the duff layer has been disturbed and mineral soil is exposed. This will be used to provide an estimate of the percent of the plot that has been disturbed by fire which has altered the characteristics of the seedbed.

5.3 Procedure

5.3.1 Percent Cover – Transect Measurements

The following measurements will be taken on the 25 metre line intercept transect. Each will begin at 12.5 metres from the point of commencement and radiate out in the four main cardinal directions (See Monitoring Site Establishment Protocol). A 25 metre central line will be established with a rope. Vegetation is tallied at every meter along the 25 meter transect. Every plant that impinges upon a rod vertically suspended from each meter point is identified and tallied. The latin name of species should be recorded. Often several species in different strata will be tallied at each point. Record the species of all vegetation by layer. The characteristics forest floor touched by the rod (CWD, FWD, leaf litter, burn) will also be noted. An estimate of percent cover will be made for each species and for the following groupings: tall shrub layer, low shrub layer, grasses, herbs, mosses and lichens, leaf litter, fine woody debris, coarse woody debris (total count / 25 x 100% to max of 100%) as well as for individual species (total count / 25 x 100%). Latin names, common names and indicator value of some common understory plant species found in the Yukon may be found in Table 3.

5.3.2 Percent Cover – Visual Estimates

Each monitoring site has circular sub-plots with a radius of 11.3 m (this is equal to 400 square metres/ sub-plot). For the visual estimate of percent cover, this fixed radius circular plot will be used. The centre of each sub- plot is located 25 metres from the point of commencement in each of the cardinal directions – north, south, east and west

(see Monitoring Site Establishment Protocol). To establish plot boundaries, layout the provided quadrat ropes.

Table 1: Percent cover classes

<1%
1-3%
4-10%
11-25%
26-50%
51-75%
>75%

The purpose of the visual method is to provide a complete listing of plant species in the 11.3 m radius plot. List all of the species that you observed in the plot. Traverse the entire plot in an increasing spiral or zig-zag pattern, noting each new species. Record the latin name of the species and record species by layer.

Once the species list seems complete, the next step is to record the percent cover of each species. Percent cover is estimated as the percentage of the ground surface covered when the crowns are projected vertically. Percent cover should be estimated by class (per Macdonald and Feeniak, 2007; Table 1). Follow the outside perimeter of the projected crown. For the tree layer, distinct holes in the canopy should be subtracted from the estimate. For other layers, small gaps that are not fully covered can be ignored.

Table 2: Dimensions of various areas in a 400 m^2 circular plot. Source: BCMOE and BCMOF 1998

Area of 400 m^2 radius circular plot	**Area (m^2)**	**% cover**
11.3m radius circular plot	400 m^2	100%
10m x 10 m	100 m^2	25%
5 m x 8 m	40 m^2	10%
2 m x 2 m	4 m^2	1%
63 cm x 63 cm	0.4 m^2	0.1%
20 cm x 20 cm	0.04 m^2	0.01%

- Viewing the layer obliquely, rather than vertically, can result in an over-estimation.
- Avoid biasing estimates because of crown density.
- For species with high cover values, mentally move the plants to a corner of the plot to estimate if they represent one-quarter, one-third, or one-half, or more of the plot.
- For species that almost cover the plot, mentally move them together and estimate how much of the area is not covered by the plants.
- For species with low cover, try making estimates for subsections in each quarter of the plot.
- Equating percent cover with equivalent dimensions relative to plot area can be very helpful. Table 2 gives examples of the relationship of dimensional area to percentage area for a 400 m^2 (11.3 m radius circular) plot.
- For several small scattered areas of coverage, think about the area covered by 0.5% (1 x 1 m in a 200 m^2 plot) and add up the total number of areas of cover that are roughly equivalent to these dimensions.
- Comparison charts (Figure 1) and the example percentage coverage diagram shown in (Figure 2) are other useful aids.

5.3.3 Unknown Species Identification

Where identifications cannot be made in the field, samples will be taken for later expert identification. Collect specimens of unknown species for verification, numbering them sequentially within each plot and recording the plot number, temporary name, and collection number on collection bags and pressing sheets. Record percent cover for unknowns on the form using the temporary name and collection number

in lieu of species name (e.g., moss 03). These procedures are extremely important if several persons are collecting data, or if a significant time lag occurs between field collection and office verification and coding.

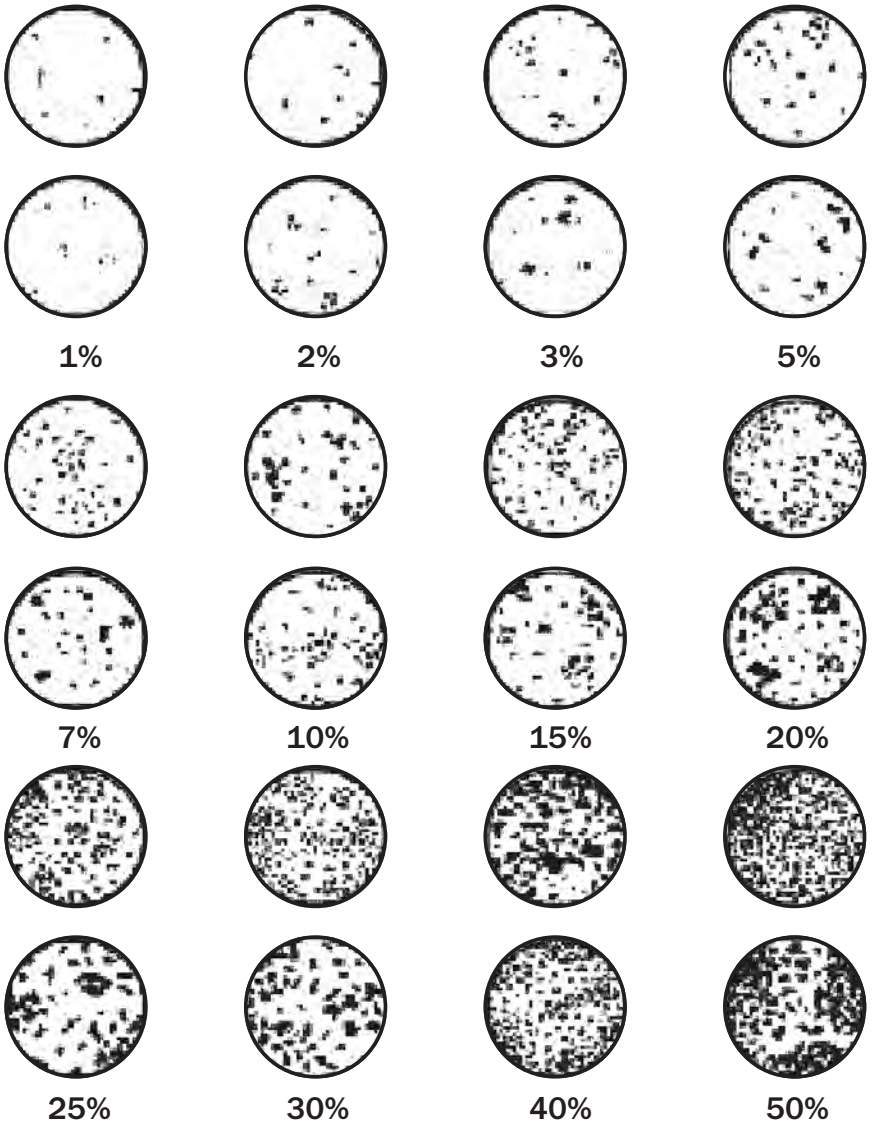
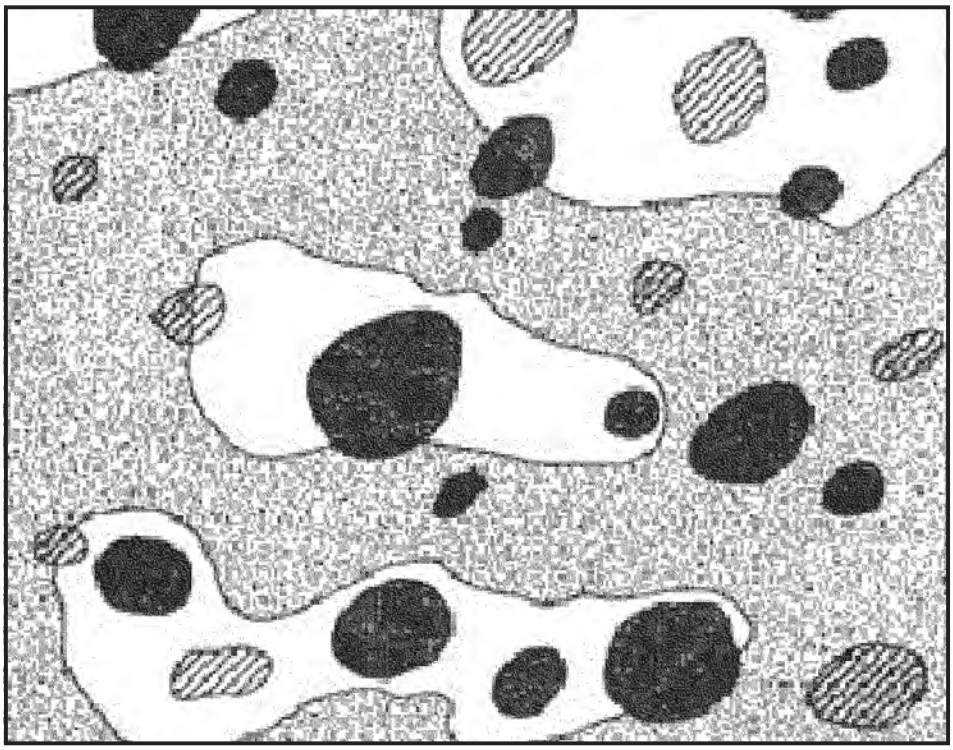


Figure 1: Comparison charts for visual estimates of percent cover. Source: BCMOE and BCMOF 1998.

Figure 2: An example of percent coverage in a plot, viewed from above. Source: BCMOE and BCMOF 1998.



Stratum	% Cover
Trees	10%
Shrubs	5%
Herbs	60%
Total Cover	70%

5.4 Equipment

- Plant identification guidebook
- Plant collection bags
  (for samples that are unidentifiable in the field)
- 25 m transect rope and stakes to secure rope
  at either end
- 1 m tall, small diameter steel rod
- Field data form

5.5 References

BC Ministry of Environment and BC Ministry of Forests, 1998. Describing Ecosystems in the Field. Land Management Handbook Number 25. http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/fmdte/deif.htm

Garbutt, R.W.; Hawkes, B.C.; Allen, E.A. 2007. Spruce beetle and the forests of the southwest Yukon. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC. Information Report BC-X-406. 68 p.

Johnstone et al. 2004. Decadal observations of tree regeneration following fire in boreal forests. Canadian Journal of Forest Research 34:267-273.

McDonald, S.E. and T.E. Fenniak. 2007. Understory plant communities of boreal mixedwood forests in western Canada: Natural patterns and response to variable-retention harvesting. Forest Ecology and management 242:34-48.

Table 3: Latin names, common names and indicator value of some common understory plant species found in the Yukon

Tall Shrub Layer (greater than 50 cm tall)

Latin Name	Common Name	Indicator – Moisture Regime	Indicator – Nutrient Regime
Alnus crispa	Green alder	Dry-fresh	Poor
Betula glandulosa	Scrub birch	Dry-moist	
Cornus stolonifera	Red-osier dogwood	Moist-wet	Medium
Juniperus communis	Common juniper	Dry	Poor-medium
Potentilla fructicosa	Shrubby cinquefoil	Moist -wet	
Ribes lacustre	Black currant / black gooseberry	Fresh-moist	Rich
Rosa acicularis	Prickly rose	Dry-fresh	Medium
Rubus idaeus	Raspberry	Dry-wet	
Salix spp.	Willow		
Sheperdia canadensis	Soapberry / soopolallie	Dry	Poor-medium
Viburnum edule	High bush cranberry	Moist	
Vaccinium uliginosum	Bog bilberry	Wet	Poor

Low Shrub Layer (under 50 cm tall, may included species from tall shrub list)

Latin Name	Common Name	Indicator – Moisture Regime	Indicator – Nutrient Regime
Arctostaphylos rubra	Red bearberry	Moist-wet	
Arctostaphylos uva-ursi	Bearberry	Dry	Poor
Dryas drummondii	Yellow mountain-avens	Dry-fresh	
Empetrum nigrum	Crowberry / mossberry	Moist	Poor
Ledum groenlandicum	Labrador tea	Moist-wet	Poor
Rubus chamaemorus	Cloudberry	Moist-wet	Poor
Rubus arcticus	Dwarf nagoonberry	Moist-wet	Poor
Vaccinium vitis-idaea	Lingonberry / low-bush cranberry	Dry-wet	Poor

Grasses

Latin Name	Common Name	Indicator – Moisture Regime	Indicator – Nutrient Regime
Calamagrostis canadensis	Bluejoint	Moist-wet	Medium
Carex spp.	Sedge	Moist-wet	
Elymus innovatus	Fuzzy-spiked wild rye / hairy wild rye	Dry-fresh	Rich
Festuca spp.	Fescue	Drought-resistant	
Hordeum jubatum	Foxtail		
Juncus spp.	Rush	Wet	
Poa spp.	Blue grass		

Herbs

Latin Name	Common Name	Indicator – Moisture Regime	Indicator – Nutrient Regime
Actaea rubra	Red baneberry	Fresh	Rich
Achillea millefolium	Yarrow	Dry-fresh	
Arnica cordifolia	Heart-leaved arnica	Dry-moist	
Cornus canadensis	Bunchberry	Dry-moist	
Epilobium angustifolium	Fireweed	Dry-fresh	Medium
Equisetum spp.	Horsetail	Moist-wet	
Equisetum scirpoides	Dwarf scouring rush	Moist	
Galium boreale	Northern bedstraw	Dry-fresh	
Geocaulon lividum	Bastard toad flax	Dry-moist	
Linnaea borealis	Twinflower	Dry-moist	
Moneses uniflora	One-flowered wintergreen	Fresh-moist	Medium
Lupinius arcticus	Arctic lupine		Nitrogen-fixing

Tall Shrub Layer (greater than 50 cm tall)

Latin Name	Common Name	Indicator – Moisture Regime	Indicator – Nutrient Regime
Alnus crispa	Green alder	Dry-fresh	Poor
Betula glandulosa	Scrub birch	Dry-moist	
Cornus stolonifera	Red-osier dogwood	Moist-wet	Medium
Juniperus communis	Common juniper	Dry	Poor-medium
Potentilla fructicosa	Shrubby cinquefoil	Moist -wet	
Ribes lacustre	Black currant / black gooseberry	Fresh-moist	Rich
Rosa acicularis	Prickly rose	Dry-fresh	Medium
Rubus idaeus	Raspberry	Dry-wet	
Salix spp.	Willow		
Sheperdia canadensis	Soapberry / soopolallie	Dry	Poor-medium

Lichens

Latin Name	Common Name	Indicator – Moisture Regime	Indicator – Nutrient Regime
Alectoria sarmentosa	Common witch's hair		
Cladonia borealis	Red pixie cup		
Cladonia pyxidata	Brown pixie cup		
Cladina sp.	Reindeer lichen / caribou lichen	Dry	Poor
Peltigera aphthosa	Freckle pelt		

6.0

Coarse Woody Debris Protocol

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COARSE WOODY DEBRIS

Date (M/D/Y) _____ 3.2.2

Field Crew _____

Plot Number _____ 3.2.1
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Tree Number	Species	Origin	Windthrown	Diameter	Decay Class	Tilt Angle	Length of Intact Piece
6.3.1	6.3.2	6.3.3	6.3.4	6.3.5	6.3.6	6.3.7	6.3.8

COARSE WOODY DEBRIS

Entered into Database? Yes ☐ No ☐

Fuel Calculator 6.3.9
Weight (t/ha)
Volume (m3/ha)

Comments:

6.0 Coarse Woody Debris Protocol

6.1 Purpose

The purpose of this protocol is to record the characteristics of coarse dead woody material. Methods are similar to those in BCMOE and BCMOF (1998) and Trowbridge et al. (1987).

6.2 Definition of Coarse Woody Debris

Coarse woody debris (CWD) is dead woody material, in various stages of decomposition, located above the soil, larger than 7 cm in diameter (or equivalent cross-section) at the crossing point, which is not self-supporting. Trees and stumps (intact in ground) are considered self-supporting. Pieces of coarse woody debris may be suspended on nearby live or dead trees, other pieces of coarse woody debris, stumps or other terrain features.

Coarse woody debris includes:

- downed horizontal or suspended (not self-supporting) dead tree boles with or without roots attached;
- fallen trees which still have green foliage if they no longer have roots attached (no living cambium) to the ground to keep them alive;
- woody pieces greater than 7 cm at the point where the sampling line crosses the piece;
- uprooted (not self-supporting) stumps greater than 7 cm in diameter at the crossing point and any of their exposed dead roots greater than 7 cm in diameter at the crossing point;

- fallen broken tree tops which may be horizontal or leaning, or large fallen branches; and,
- recently cut logs.

Coarse woody debris does not include:

- dead branches still connected to standing trees;
- self-supporting (not overturned) stumps;
- exposed roots of self-supporting trees or stumps;
- material that is buried beneath organic or mineral soil layers or has decomposed enough to be part of the forest floor; and,
- live or dead trees (still rooted) which are self supporting.

6.3 Procedure

All CWD will be measured that crosses the 25 m centre line. Measures for each piece intersected will include:

6.3.1 Tree Number

Assign numbers sequentially to each tree sampled.

6.3.2 Tree Species (if known)

Record the tree species for each piece. If the species can not be determined put “X” for unknown, “Xh” for unknown hardwood, or “Xc” for unknown conifer and for unknown spruce “Xs”.

6.3.3 Pre- or Post-Treatment Origin

The origin of the piece (pre-treatment = PR, result of treatment = T, post treatment=PO, or unknown=X) will be noted.

6.3.4 Windthrown

If the piece appears to have originated because of windthrow; indicate “Y”, if not indicate “N”, if unknown indicate “X”.

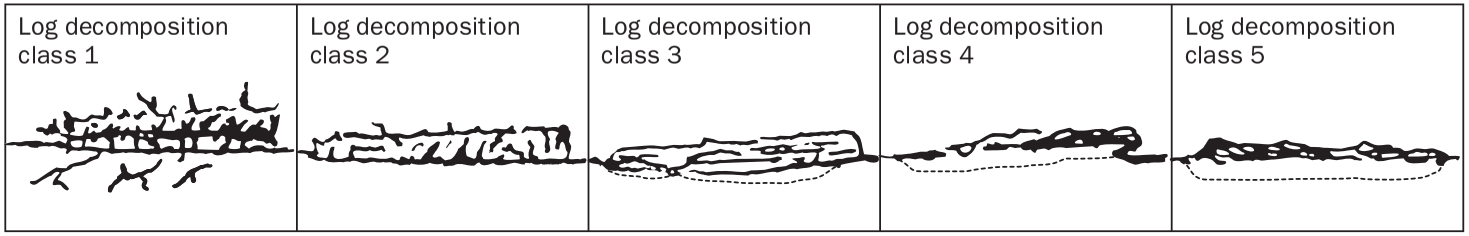
6.3.5 Diameter at the Intersection Point

Record the diameter of the piece perpendicular to the bole at the point where the sampling line is considered to intersect the central axis of the piece. Wrap a diameter tape around the bole, when possible, or use the reverse side of the tape to estimate the diameter. Calipers may also be used, and are often easier when coarse woody debris is in several layers. Measure the diameter to the closest 0.1 cm. If the CWD is hollow, estimate the diameter equivalent required to approximate the volume of the remaining wood.

6.3.6 Decay Class

Assign a decay class (1 to 5) based on the majority condition of the entire piece. The five classes used to describe the condition of coarse woody debris are based primarily upon wood texture, and secondarily on other characteristics. See for Figure 1 descriptions of classes.

Figure 1: Decay classes for coarse woody debris. Source: BCMOE and BCMOF, 1998



	Class 1	Class 2	Class 3	Class 4	Class 5
Wood Texture	Intact, hard	Intact, hard to partly decaying	Hard, large pieces, partly decaying	Small, blocky pieces	Many small pieces, soft portions
Portion on Ground	Elevated on support points	Elevated but sagging slightly	Sagging near ground, or broken	All of log on ground, sinking	All of log on ground, partly sunken
Twigs < 3 cm (if originally present)	Present	Absent	Absent	Absent	Absent
Bark	Intact	Intact or partly missing	Trace	Absent	Absent
Shape	Round	Round	Round	Round to oval	Oval
Invading Roots	None	None	In sapwood	In heartwood	In heartwood

6.3.7 Tilt Angle

Tilt angle refers to the tilt of the individual log away from the horizontal, regardless of the slope of the ground. A clinometer is placed on the surface of the piece at the point of the intercept measurement and the angle from the horizontal (in degrees) is recorded.

6.3.8 Length of Intact Piece

Record the length of each piece to the nearest 0.1 m. If a log has broken lengthwise but is still partially held together, record the equivalent length as if the piece were whole. If the end(s) of the piece are broken, visually fold in the broken sections to compensate for the missing parts. Piece length is from the largest end down to the 7.0 cm diameter limit.

6.3.9 Volume and Weight Calculation

Volume and weight of CWD is calculated using the Canadian Forest Service CWD/Fuel Calculator software program. Data is entered into the "Coarse Woody Debris Assessment" component of this program. Under the tab "Data Input: Site Information" tab enter the name of the plot/subplot and following fuel assessment options:

- Number of plots = 1
- Number of transects per plot = 1
- Transect length = 25 m

The remaining fields can be left blank. Then click on "Data Input: CWD Measurements". The program recognizes the

BC tree species codes e.g. white spruce = Sw, lodgepole pine = Pl. A complete listing of species codes can be found in the program help file. Enter the measurements for CWD. Then go the "Output" tab to get a volume (m3/ha) and weight (t/ha) of CWD on the site. More detailed instructions can be found in the program help file. Once this information has been generated please record the volume and weight on the CWD field data form and PRINT a copy of the output and add it to the data forms.

6.4 Equipment

- Compass
- Clinometer
- Two measuring tapes (minimum of 30 m each);
- 25 m transect rope and stakes to secure rope at either end
- Diameter tape and/or calipers
- Field data forms

6.5 References

BC Ministry of Environment and BC Ministry of Forests. 1998. Describing Ecosystems in the Field. Land Management Handbook Number 25. http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/fmdte/deif.htm

Trowbridge, R.; Hawkes, B.C.; Macadam, A.; Parminter, J. 1987. Field handbook for prescribed fire assessments in British Columbia: Logging slash fuels. Agriculture Canada, BC Ministry of Forests, Canadian Forest Service Pacific Forestry Centre, Victoria, BC. FRDA Handbook 001. PDF available at: http://www.for.gov.bc.ca/hfd/pubs/Docs/frh/frh001.pdf

7.0

Fine Woody Debris Protocol

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Plot Number _____ 3.2.1
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

FINE WOODY DEBRIS

Size Class	Size	Tally 7.3.1	Total
1	< 0.5 cm		
2	0.5 – 0.99 cm		
3	1.0-2.99 cm		
4	3.0 – 4.99 cm		
5	5.0 – 6.99 cm		

FINE WOODY DEBRIS

Entered into Database? Yes ☐ No ☐

Fuel Calculator 7.3.2		
FWD	**CWD**	**TOTAL**
Weight (t/ha)	**Weight (t/ha)**	
Volume (m3/ha)	**Volume (m3/ha)**	

Comments:

7.0 Fine Woody Debris Protocol

7.1 Purpose

The purpose of this protocol is to record the characteristics of fine dead woody material. Methods are similar to those in BC MoE, MoF (1998) and Trowbridge et al. (1987).

7.2 Definition of Fine Woody Debris

Fine woody debris (e.g., branches, twigs) includes woody stems above the soil surface that are greater than 0.5 cm and less than 7 cm diameter. Cones are not considered fine woody debris (they are considered to be part of the litter layer).

7.3 Procedure

7.3.1 Tally

Those pieces of fine woody debris that intersect the 25 m transect line will be measured. To assist in identifying pieces that intersect the transect line, run a small diameter steel rod along the transect line as a visual guide. There are five size classes to be tallied. The smaller size classes will be tallied along a shorter length and the larger pieces will be sampled along a longer length. See Table 1 for criteria for classes and transect length. Do not include needles or any living material (such as twigs and branches of dwarf shrubs). An estimate of the fine fuel volume in tonnes/ha will also be recorded.

Table 1: Fine woody debris size classes and sampling line length

Size Class	Size	Sampling Line Length
1	< 0.5 cm	Tallied in first 5 metres
2	0.5 – 0.99 cm	Tallied in first 10 metres
3	1.0 – 2.99 cm	Tallied in first 15 metres
4	3.0 – 4.99 cm	Tallied in first 20 metres
5	5.0 – 6.99 cm	Tallied along the entire 25 metres

7.3.2 Volume and Weight Calculation

Volume and weight is calculated using the Canadian Forest Service CWD/Fuel Calculator software program. Data is entered into the Fuel Loading Assessment component of this program. Under the tab "Data Input: Site Information" enter the name of the plot/subplot and following fuel assessment options:

- Number of plots = 1
- Number of transects per plot = 1
- Transect length = 25 m
- Number of depth-of-burn pins per transect = 0

The remaining fields can be left blank. Then click on the "data input: fuel load measurements" tab. Select woody fuel for the fuel type. This provides you with the option to enter both your coarse woody debris (> 7 cm diameter) and fine woody debris (< 7 cm diameter) data. Leave the section titled "Species and Diameters of Slash Pieces > 7 cm in Diameter" blank. Enter your data under the section titled "Intersection by Pieces < 7 cm". Under "Species Composition of < 7 cm (%) enter "U" and "100" under line A. While the program recognizes the BC tree species codes e.g. white spruce = Sw,

lodgepole pine = Pl; always select U for unknown species type since it is difficult to reliably determine the species of the FWD. Then select output. Under "Units" select t/ha and record this weight on your field data form. Then select m^3/ha under "Units" and record this volume on your field data form. More detailed instructions can be found in the program help file. Once this information has been generated please PRINT a copy of the output and add it to the data forms.

7.4 Equipment

- 25 m transect rope and stakes to secure rope at either end
- Small diameter steel rod
- Calculator
- Flagging tape
- Go-no-go gauge or diameter tape and/or calipers
- Field data form

7.5 References

BC Ministry of Environment and BC Ministry of Forests, 1998. Describing Ecosystems in the Field. Land Management Handbook Number 25. http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/fmdte/deif.htm

Trowbridge, R.; Hawkes, B.C.; Macadam, A.; Parminter, J. 1987. Field handbook for prescribed fire assessments in British Columbia: Logging slash fuels. Agriculture Canada, BC Ministry of Forests, Canadian Forest Service Pacific Forestry Centre, Victoria, BC. FRDA Handbook 001. PDF available at: http://www.for.gov.bc.ca/hfd/pubs/Docs/frh/frh001.pdf

8.0

Tree Fuels Assessment (Fire Hazard Rating and Spot Fire Potential) Protocol

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TREE FUELS ASSESSMENT

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Tree by Tree Assessment

Tree Number	Species	Height	Diameter	Crown Base Height Index (a)	Crown Base Height Actual	Live Crown Base Height Actual	Crown Density Index (b)	Crown Continuity Index (c)	Crown Fire Characteristic (a+b+c)	Sloughing Bark (1=yes 0=no)
4.2.4	4.2.5	4.2.8	4.2.6	8.3.1	8.3.1	9.4.9	8.3.2	8.3.3	8.3.4	8.3.7

TREE FUELS ASSESSMENT

Entered into Database? Yes ☐ No ☐

Stand Totals

Ground Fuel Hazard Rating	8.3.5
Dead Tree Density Index	8.3.6
Percentage of Trees in Stand with Loose bark	8.3.7
Spot Fire Potential Rating	8.3.7

Fire Hazard and Spot Fire Potential Ratings

Crown fuel charateristics				**Subtotals**
Crown base height	> 1 m	> 0.5 m 1 m	0.5 m	
Crown base height index	1	2	3	1 – 3
Crown density	low	medium	high	
Crown density index	1	2	3	1 – 3
Crown continuity	low	medium	high	
Crown continuity index	1	2	3	1 – 3
Stand totals				
Dead tree density (stems/ha > 7 cm dbh)	> 0 < 500	500 < 900	900	
Dead tree density index	1	2	3	1 – 3
Surface woody debris (tonnes/ha)	< 20	20 < 50	50	
Surface woody debris index	1	2	3	1 – 3
			total	5 – 15
Spot fire potential rating				
Loose bark trees (%stems > 7 cm dbh)	> 0 < 15	15 < 30	30	
Loose bark trees index	1	2	3	

Comments:

8.0 Tree Fuels Assessment (Fire Hazard Rating and Spot Fire Potential) Protocol

8.1 Purpose

This protocol uses methodology to determine fire hazard and spot fire potential that was developed by Rod Garbutt and Brad Hawkes of the Canadian Forest Service (Garbutt et al. 2007). This protocol was developed for the spruce-beetle killed forests of the southwest Yukon. With some modification it could be applied elsewhere in the Yukon. To be transferred elsewhere the methods for determining the crown fire characteristic rating would need to be revised; specifically methods for determining crown base height index, crown density index and crown continuity index.

8.2 Rationale

In the southwest Yukon, the spruce beetle epidemic has contributed significantly to the fire hazard by increasing surface and crown dead woody fuel loads. The dry climate and the resultant low moisture content of the surface woody fuels, combined with low crown base heights, has created an increase in probability of ignition and potential for crown fires. Garbutt et al. (2007) found a wide range of surface fine and coarse woody fuel loading (4-71 tonnes per hectare), reflecting the variability in stand ages and resultant levels of self-thinning as well as blowdown, breakage and dead crown breakdown. The slow progress of decay also ensures that the elevated fire hazard, represented by the suspended fine fuels and the additional needle tinder on the forest floor, will remain for many years. If, during this period, a lightning strike ignites the surface fuels in an area of moderate to high spruce beetle mortality, and the surface fire is intense enough to ignite the tree crowns, a wildfire of exceptional intensity is almost certain to follow.

Garbutt et al. (2007) found some of the unusual features of the spruce stands in the Southwest Yukon. Among these was the relative openness of the stands and the tendency for the lower crowns, in many instances, to sweep close to the ground. Another unique feature of these trees compared to those farther south is the network of fine branchlets that are often so dense that they are impenetrable to light. Because of the slow progress of decay, these branchlets are retained and remain highly flammable for many years after the needles have been shed. The potential for surface fires to be laddered upward increases as the gap between the ground and crown fuels is reduced, particularly if branches have sufficient fine branch density and vertical continuity to facilitate surface fire transfer upward into the remainder of the crown.

The crown fuel assessment is an attempt to estimate for all living and dead plot trees with DBH greater than or equal to 7 cm, how crown characteristics might influence crown fire development and spread. From these measures, combined with the density of dead trees and the local abundance of surface woody debris, an overall tree fire hazard rating system was developed. It is important to note that the rating system has not been supported by fire behaviour experimentation and as such may not reflect actual fire hazard. It is an estimate of relative hazard only. A stand with a high rating is not necessarily a high fire hazard stand, but is considered to be at a higher hazard than a stand with a lower score. Another factor in estimating fire behaviour and spread rate is the determination of spot fire potential ahead of the main fire front. Some factors that influence fire behaviour include aspect, slope, relative humidity, rainfall, temperature and wind speed. Since the plots were all on relatively flat ground, slope and aspect adjustments were not factors, and the weather cannot be used as part of a static assessment. Three or four years after trees die they begin shedding their bark. If a high intensity fire occurs while the bark is shedding, loose shards of flaming bark can be caught in the convection column and propelled in advance of the fire front, initiating new fires. We therefore used the number of loose bark trees as our measure of spot fire potential.

8.3 Procedure

Only conifers that are > 7 cm DBH, either dead or alive will be assessed in this protocol.

- Variable Radius Plots – If a variable radius (prism) plot was used for the tree mensuration protocol, all trees that were selected as being in the plot using the prism will be assessed under this protocol.
- Fixed Radius Plots. If a fixed radius plot was used for the tree mensuration protocol, not all of the trees in the plot will be measured under this protocol. Instead, a 4 x 25 m fixed-width rectangular plot will installed (centre line = transect line). All conifers falling within 2 m on either side of the 25 m line will be assessed under this protocol.

For the purposes of this fire hazard and spot fire potential assessment there are three separate protocols to measure fire hazard and one to measure spot fire potential. The first involves the loads of surface coarse and fine fuels which contribute to the chance of ignition and to the intensity of a surface fire. The second involves the tree crown characteristics including the distance from the ground to the base of the continuous crown, crown bulk density and crown vertical continuity. This protocol recognizes that the tree-borne fuels, especially those remaining in recently killed trees; contribute significantly to the laddering potential and intensity of a crown fire. The third protocol, which also contributes to crown fire intensity and spread, is simply the number of dead trees per hectare.

8.3.1 Crown Base Height Actual and Crown Base Height Index

The distance in centimeters from the ground to the lowest point of the lowest living or dead branch forming the base of the continuous crown gives a measure of ground fuel proximity. To be considered a branch must bear fine fuels in the form of, at least tertiary branchlets. These branch selection criteria are fairly subjective, especially in the more marginal situations with older grey trees, and in the more closed canopy stands where lower branches of even living trees have long since been shaded out. Remaining branches may be short with low branchlet density and there may be significant gaps between branches. Judgment must determine the lowest branch with sufficient fine fuel volume to be readily ignited and laddered upward. Record the actual distance on the form under the column "Crown Base Height Actual". In the column "Crown Base Height Index" assign the appropriate value of 1, 2 or 3 depending upon the distance. If the distance is ≤ 0.5 m it scores 3. Distances from > 0.5 ≤ 1 m score 2 and > 1 m score 1. See Figure 1 below for some examples.

Height from ground to lowest continuous crown:

3 = 0 – 0.5 meter
2 = 0.5 – 1 meter
1 = > 1 meter

8.3.2 Crown Density Index

Coarse and fine branch density is a relative estimate of the overall crown bulk density (loading per unit volume); factors that contribute to crown fuel consumption and crown fire

spread. It is also recorded as 1 (low), 2 (moderate) or 3 (high). See Figure 1 below for some examples.

8.3.3 Crown Continuity Index

The crown continuity estimate is a measure of the tendency for fire to be laddered upward, once it has become established in the lower crown. These are relative estimates, recorded as 1 (low), 2 (moderate) or 3 (high), and depend on the recorder being familiar with the range of local crown configurations and having some understanding of fire behaviour. To score 3 a tree crown must have many branches supporting fine branchlets that would readily ignite as fire moved upward. There must also be no crown gaps greater than one meter from the base of the crown to the top. Any lesser condition with coarser fuels or larger crown gaps is scored 2 or 1 depending upon the degree of departure from a crown which scored 3. See Figure 1 below for some examples.

8.3.4 Crown Fire Characteristic Rating

The numbers assigned to the three characteristics listed above were added and then averaged for each plot. The totals range from 3, the lowest hazard, to 9, the highest. These numbers represent relative hazard only and cannot be considered to reflect actual fire behaviour. In the event that a fire is started by lightning or other ignition source, stands with the higher rating are considered to have a higher probability of crown fire development and spread than stands with a much lower rating, especially if they are combined with a high loading of surface woody debris, a high density of dead trees and a high incidence of loose bark. See Table 1.

Figure 1: Examples of living and dead white spruce tree crowns assigned a range of fire hazard ratings according to crown characteristics. Source: Canadian Forest Service.

Hazard Rating: 3 Low Crown base height > 1 m = 1 Branch density low = 1 Vertical continuity low = 1	**Hazard Rating: 4 Low** Crown base height > 1 m = 1 Branch density low = 1 Vertical continuity moderate = 2	**Hazard Rating: 6 Mod** Crown base height > 1 m = 1 Branch density moderate = 2 Vertical continuity high = 3
		

Hazard Rating: 7 High Crown base height 0.5 – 1 m = 2 Branch density moderate = 2 Vertical continuity high = 3	**Hazard Rating: 9 High** Crown base height < 0.5 m = 3 Branch density high = 3 Vertical continuity high = 3
	

8.3.5 Surface Woody Debris Rating

Since most wildfires start as surface fires, the risk of subsequent crown fire activity will be greatly influenced by the amount of woody debris on the forest floor. The greater

the load of surface fuel, the greater the possibility that the flames will be laddered upward. The fine and coarse woody debris assessment protocols in this manual provide a methodology for how to measure of surface fuel loads for each plot. These protocols also provide a methodology for volume calculations using the Canadian Forest Service CWD/Fuel Calculator software program. To calculate the surface woody debris rating, the fine and coarse woody debris protocols must be completed, and volumes calculated using the fuel calculator software program. For the purposes of this study, the amount of surface fuel was assigned a hazard rating on an ascending scale from 1-3. Less than 20 tonnes/ha has been assigned a hazard rating of 1; ≥ 20 < 50 tonnes/ha, a 2; and ≥ 50 tonnes/ha, a 3. See Table 1.

8.3.6 Dead Tree Density Index

Crown fire initiation intensity and potential spread rate is greater in the dry crowns of recently killed trees than in live trees. Fire behaviour will, therefore, be influenced by the density of these dead crowns. Dead tree density has been rated on an ascending scale of 1-3. Stands with < 500 dead stems/ha of trees ≥ 7 cm dbh were rated as 1; ≥ 500 < 900 dead stems/ha were rated as 2; and ≥ 900 dead stems/ha, as 3. See Table 1.

8.3.7 Spot Fire Potential Rating

Sloughing bark on dead trees can influence spread rate by causing spot fires ahead of the main fire front. Loose bark incidence was recorded as 1 if there was loose bark, or 0 if there was no loose bark. The stand rating is determined by the percentage of stems/ha with loose bark. Stands with < 15% loose-bark trees were given a score of 1; ≥ 15 < 30%

loose-bark trees were scored 2 and ≥ 30% were scored 3. Because the incidence of loose bark was a spot fire potential rating rather than a fire hazard rating it stood alone, while the crown and dead woody fuel ratings are combined into a single number. See Table 1.

Table 1: Fire hazard indices and spot fire potential ratings.

Refer to photographic examples in Figure 1 for examples. Source: Garbutt et al. 2007.

Crown fuel charateristics				**Subtotals**
Crown base height	> 1 m	> 0.5 m ≤ 1 m	≤ 0.5 m	
Crown base height index	1	2	3	1 – 3
Crown density	low	medium	high	
Crown density index	1	2	3	1 – 3
Crown continuity	low	medium	high	
Crown continuity index	1	2	3	1 – 3
Stand totals				
Dead tree density (stems/ha > 7 cm dbh)	> 0 < 500	≥ 500 < 900	≥ 900	
Dead tree density index	1	2	3	1 – 3
Surface woody debris (tonnes/ha)	< 20	≥ 20 < 50	≥ 50	
Surface woody debris index	1	2	3	1 – 3
			total	5 – 15
Spot fire potential rating				
Loose bark trees (%stems > 7 cm dbh)	> 0 < 15	≥ 15 < 30	≥ 30	
Loose bark trees index	1	2	3	

8.3.8 Data Analysis

An example of the output table summarizing fire hazard rating and spot fire potential after ratings are determined is provided in Table 2.

Table 2: Example of output table summarizing fire hazard rating and spot fire potential after ratings are determined using Table 1. Source: Garbutt et al. 2007.

	Average crown characteristics ratings										
Plot No.	**Crown**	**Fine branch density**	**Vertical continuity**	**Subtotal**	**Woody fuel loading**	**No. dead spruce/ha**	**Dead tree rating**	**Total**	**Fire hazard rating**	**Loose bark (%)**	**Spot fire potential**
1	1.48	1.67	1.80	4.95	1	900	3	9.0	2	14	1
2	2.94	2.17	2.34	7.46	1	275	1	9.5	3	0	1
3	1.83	1.67	1.88	5.38	2	1000	3	10.4	4	42	3
4	2.19	2.11	2.42	6.72	1	350	1	8.7	2	8	1
5	1.22	1.15	1.11	3.49	1	675	2	7.5	1	39	3
6	2.17	2.30	2.39	6.87	1	550	2	9.9	3	17	2

8.4 Equipment

- Compass
- Clinometer
- Diameter tape
- Increment corer
- 25 m transect rope and stakes to secure rope at either end
- 2m measuring stick
- Digital camera
- Altimeter
- GPS
- Tree tags
- Field data forms

8.5 References

Garbutt, R.W.; Hawkes, B.C.; Allen, E.A. 2007. Spruce beetle and the forests of the southwest Yukon. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC. Information Report BC-X-406. 68 p.

9.0

Fuel Treatment Prescription Compliance & Effective Monitoring Protocol

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FUEL TREATMENT PRESCRIPTION COMPLIANCE AND EFFECTIVE MONITORING
Part 1

Stems per ha 9.4.3 Fuel Type 9.4.2

CONIFER TREES												
Tree Number	Species	Diameter	Height	Crown Base Height	Crown Height	Crown Diameter	Crown Spacing Index (1 to 5)	Distance to Nearest Stem	Is tree part of a clump (y/n)	Stem Damage - Chainsaw	Stem Damage - Pile Burning	Stem Damage - Felling
4.2.4	9.4.3	9.4.3	9.4.3	9.4.9	9.4.9	9.4.5	9.4.6	9.4.7	9.4.10		9.4.4	

FUEL TREATMENT PRESCRIPTION COMPLIANCE AND EFFECTIVENESS MONITORING
Part 1

Crown Spacing Index	
5	touching
4	0.1-0.5 meter
3	0.5 - 2 meters
2	2 - 4 meters
1	>4 meters

Entered into Database? Yes ☐ No ☐

CLUMPS 9.4.10

Clump Number	Nearest	North	South	East	West

CLUSTERS 9.4.10

Cluster Number	Seedlings		Saplings		Distance to Nearest Stem				
	Species	Tally	Species	Tally	Nearest	North	South	East	West

Yukon
Energy, Mines and Resources

Date (M/D/Y) _____ 3.2.2

Field Crew _____ 3.2.1

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

FUEL TREATMENT PRESCRIPTION COMPLIANCE AND EFFECTIVENESS MONITORING

Part 2: Stumps

STUMPS 9.4.8			
Size Class	Species	Tally	
		Live	Dead
0cm-10cm			
>10cm-15cm			
>15cm-20cm			
>20cm			

FUEL TREATMENT PRESCRIPTION COMPLIANCE AND EFFECTIVENESS MONITORING

Part 2: Stumps

Entered into Database? Yes ☐ No ☐

Comments:

9.0 Fuel Treatment Prescription Compliance and Effectiveness Monitoring Protocol

9.1 Purpose

The purpose of this monitoring protocol is twofold:

1. Prescription compliance monitoring – to compare the post-treatment characteristics of a stand that has undergone a fuel treatment to what was prescribed (e.g. prescription compliance), and
2. Effectiveness monitoring – to assess the effectiveness of the post-treatment characteristics of a stand in terms of mitigating or abating fire risk. Fire risk is the probability of fire (includes ignition probability, potential fire behavior and suppression effectiveness) and its consequence (includes ecological, social, and economic).

This protocol requires that all of the following protocols, as described in this manual, be completed:

1. Monitoring site establishment protocol
2. Site description protocol
3. Forest mensuration protocol
4. Understory vegetation protocol
5. Coarse woody debris protocol
6. Fine woody debris protocol
7. Tree fuels assessment (fire hazard rating and spot fire potential) protocol
8. Fuel treatment prescription compliance and effectiveness monitoring protocol
9. Soil description protocol

This protocol was developed for the spruce-beetle killed forests of the southwest Yukon. With some modification it could be applied elsewhere in the Yukon. To be transferred elsewhere the some modification to the tree fuels assessment (fire hazard rating and spot fire potential) protocol, specifically the methods for determining the crown fire characteristic rating, would need to be revised.

A streamlined version of this protocol is available that is designed to 1) assist in the development of fuel treatment prescriptions and 2) to monitor the effectiveness of fuel treatments in reducing the potential for the development of a crown fire. This "Lite" Fuel Treatment Effectiveness Monitoring Protocol is found in Section 13 of this manual.

9.2 Rationale

This monitoring protocol concentrates on determining the effectiveness of a fuel treatment in reducing the potential for crown fire initiation and spread. Fuel treatment prescriptions throughout the Yukon generally follow fuel treatment standards outlined in the Partners in Protection FireSmart manual (Vicars 2003). Fire behaviour modeling of crown fire initiation and spread suggest that significant reductions in these two key drivers of fire growth and size can be obtained using the fuel treatment guidelines outlined in the FireSmart manual.

In the southwest Yukon, fuel treatment prescriptions are developed by the Fuel Abatement Technical Working Group (FATWG). The prescriptions outline treatment objectives and methods that are designed to accommodate the variability in stand health, density and structure. Field personnel applying the treatments are expected to using

personal judgment in meeting the overall fuel treatment objectives to achieve a significant reduction in fire risk, and retain other forest values. The objectives for fuel treatments within the wildland urban interface(WUI) are: (1) to reduce canopy cover to 30-40% so that crown fire potential is significantly reduced; (2) to reduce woody fuel loading on or just above the forest floor to lower surface fire intensity and interrupt vertical fuel continuity with the lower portions of the forest canopy; (3) to encourage regeneration and release of understory white spruce and reduce stand density of larger diameter white spruce to reduce spruce beetle susceptible; and (4) to retain some diversity in stand structure and composition to maintain wildlife habitat, ecosystem functioning, aesthetics and traditional use opportunities while not compromising community safety from widlfires. Monitoring fuel treatment effectiveness is therefore critical to ensure that if other values are protected, that the post-treatment stand conditions are significant to reduce fire risk to communities.

The following fuel treatment objectives and methods have been identified by the Fuel Abatement Technical Working Group (FATWG, 2005):

1. **Overstorey:** desired spacing distance between tree crowns is 3 to 4 crown widths. This may be accomplished in a one or two-pass system. A two-pass system is where the stand will be initially treated, re-evaluated after a few years and possibly treated again. Criteria for overstorey tree removal and retention:

    - Selectively remove dead, dying and green-attacked mature white spruce as the first priority.

- Selectively remove live white spruce as required to achieve average desired inter-crown spacing.
- If present in the stand, retain 3 – 7 tall and large-diameter white spruce since these trees appear to be most windfirm. These white spruce are often taller than the surrounding mainly white spruce canopy. Provide a minimum of 5 metres separation from surrounding conifers in all directions.
- Retain all living aspen and balsam poplar.
- Retain 10 – 15 dead aspen/balsam poplar stems (snags) of mixed diameter per hectare if present.
- Identify and retain 3 – 5 spruce clumps per hectare. Provide correspondingly larger perimeter clearance (increased spacing) to increase stand diversity and isolate these clumps in regard to crown fire initiation.
- Retain and note any lodgepole pine (Pinus contorta) that is encountered.

2. Understory:

- Prune lower conifer branches and remove surface fuels and crown fuels up to 2 – 3 m above the ground, which are typically consumed in a vigorous surface fire (< 7 cm diameter).
- Cut, pile and burn as much of the surface woody and tree branch fuels < 7 cm on site as practical to recapture some of the available nutrients.
- In areas with scattered (15 – 20 stems per hectare) amounts of advanced coniferous

regeneration (2.5 – 7 metres tall), remove overtopping mature white spruce to increase the proportion of trees in the stand that are less susceptible to spruce beetle attack. This thinning technique should not significantly impact corwn fire initiation and spread since the sand density of these trees is low. Prune the lower branches of these short spruce to provide branch tip clearance of at least 0.5 meters above the ground.

- In areas with denser amounts (more than 15 – 20 stems per hectare) of advanced coniferous regeneration, selectively reduce excessive individuals to reach 15 – 20 individuals per hectare density as above. Remove overtopping mature spruce and prune as above.
- Retain 1 or 2 regeneration clusters per hectare, if they exist, and a minimum of 7 metre separation of these from adjacent coniferous crowns.

3. **Wildlife** (Note: hazardous trees are an exception)

- Retain 3 to 7 mature (over 30 cm DBH) white spruce per hectare as perches, habitat trees and, future coarse woody debris, provided they do not present an immediate hazard to workers.
- Retain up to 10 broken-top snags (i.e. older spruce 3 to 10 metres in height) per hectare as habitat trees, provided that these do not present an immediate hazard to workers.
- Retain all deciduous snags that do not present an immediate hazard to workers.

- Retain some existing downed and decaying logs; scattered and up to 50 per hectare. This will be evaluated within each stand to determine the proper consideration of both wildlife habitat and surface woody fuel reduction objectives.

4. Aesthetic

- Utilize clump and cluster thinning to add visual variety and reduce sight lines as appropriate. These will limit visual lines and act as sound barriers between residences and/or residences and roadways. This is useful in retaining a natural 'look' to the site.
- Avoid damage to live or dead deciduous trees and coniferous regeneration that are to be retained when felling trees, removing woody debris and burning piles.
- Consider planting of seedlings to accelerate successional development in the understory.
- Flush-cut stumps (cut as near as possible to ground level) to reduce visual impacts and the publics perception of "logging" within 20 metres of trails, residences and roadways.

Since 2005, FATWG has been working on updating methods for achieving fuel treatment objectives. The continual refinement of methods is consistent with the adaptive management framework of the Strategic Forest Management Plan. For the overstory, the importance of monitoring the stand to determine if follow-up treatments are required to address any additional mortality that may arise due to windthrow, exposure to sunlight, bark beetles, or root damage from fuel treatment operations is recognized and is now

being incorporated into fuel treatment planning. In addition, prescriptions may no longer require the retention of 3 – 7 tall and large-diameter white spruce. For the understory, pruning methods have been revised to require the retention of a short part of the branch near the tree bole to reduce damage from cutting with a chainsaw. In addition, prescriptions will now more clearly specify that the removal of surface dead woody fuels (< 7cm in diameter) and crown branches is required to reduce surface fire intensity. For aesthetic objectives, the consideration of planting of seedlings to accelerate successional development in the understory has been revised – in some cases a conifer understory is not desired for long-term fire risk reduction purposes from a crown fire initiation perspective.

9.3 Definitions

9.3.1 Fuel Loading

Fuel loading is the dry weight of combustible materials per unit area usually expressed in kilograms per square metre; the higher the fuel loading, the higher the fire intensity

9.3.2 Clump

A clump is an isolated, generally dense group of mature trees. Mature trees are defined as > 7 cm dbh. The crowns of trees in a clump are touching.

9.3.3 Cluster

A cluster is an isolated, generally dense group of immature trees. Immature trees are defined as either saplings (> 1.3 m tall and < 7 cm dbh), or seedlings (< 1.3 m tall).

9.3.4 Fuel Characteristics

Fuel characteristics commonly accepted as controlling crown fire initiation and spread are canopy fuel load, canopy bulk density and canopy base height (Cruz et al., 2003).

- Canopy fuel load (CFL) represents the potential energy available to be released from this fuel layer.
- Canopy fuel bulk density (CBD) describes the amount of fuel within a unit volume of the canopy.

When describing fuels the term crown and canopy have often been used interchangeably – crown describes fuels at the tree level and canopy at the stand level (Cruz et al., 2003).

9.4 Procedure

The procedures outlined below were developed with the assistance of Brad Hawkes of the Canadian Forest Service, Pacific Forestry Centre in Victoria BC. Steps 9.4.1 – 9.4.9 describes information that is to be collected in the field. Steps 9.4.10 – 9.4.12 describes analysis that will take place in the office using information gathered in the field. Figure 1 is a diagram depicting the measurements that are to be recorded.

9.4.1 Plot Establishment

The following measurements will be obtained from each of the 11.3 m fixed-radius circular sub-plots. The centre point for the plot is 25 metres north, south, east and west of the point of commencement. Measurements will be recorded for all conifer trees > 7 cm DBH unless otherwise noted.

9.4.2 Fuel Type

The fuel type, per the Canadian Forest Fire Behavior Prediction (FBP) System , will be recorded per fuel type codes in the footnote. Please note, FBP fuel types should only be recorded if there is a person on the field crew that has experience in designating FBP fuel types (e.g. the person has taken an advanced fire behaviour course). Alternately, a description of the stand and a photograph could be provided to someone who has the FBP training to assign the most appropriate FBP fuel type

9.4.3 Tree Species, Diameter, Height and Stems per Hectare

Record tree species, diameter and height. In completing the Mensuration Protocol, you will have already collected this information – this information should also be recorded on this field form. The approximate number of stems per hectare is determined by counting the number of stems within the 11.3 m radius (400 square meters) plot and extrapolating this to a hectare. If are using the Forest Inventory System (FIS) to analyze data collected for the Mensuration Protocol, the FIS will calculate stems per hectare for you. Table 1 describes the relationship between distance between stems, stems per hectare and crown diameters for various thinning regimes in lodgepole pine. These relationships will be developed for treated stands in the CATT.

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[1] Detailed fuel type descriptions can be found at http://www.nofc.forestry.ca/fire/research/environment/cffdrs/fbpfuels_e.htm

Table 1: Approximate number of tree stems per hectare related to crown diameter and proposed thinning regime.
Source: Vicars, 2003.

Crown Diameter	Density: 1 Crown Width		Density: 2 Crown Widths		Density: 3 Crown Widths	
	Distance between stems (m)	Stems per ha	Distance between stems (m)	Stems per ha	Distance between stems (m)	Stems per ha
1.0	2	2500	3	1100	4	625
1.5	3	1100	4.5	500	6	280
2.0	4	625	6	280	8	160
2.5	5	400	7.5	175	10	100
3.0	6	280	9	125	12	70
3.5	7	200	10.5	90	14	50
5.0	10	100	15	45	20	25
7.0	15	45	22.5	20	30	10
10.0	20	25	30	10	40	6

Note: Distances for "crown diameters" over 3 meters are intended as guidelines for clusters of trees.

9.4.4 Stem Damage (only done for post-fuel treatment)

This measurement will be made only for areas that have been treated (treatment type = T). Damage to conifers, and live or dead deciduous stems caused by felling trees, burning piles, and pruning (chainsaw damage) will be recorded. Note: this information is also being gathered under the mensuration protocol. The location of the damage on the tree will be noted using defect location codes (Table 6).

9.4.5 Crown Diameter (Conifers)

The diameter of the crown of all conifer trees in the plot will be measured. The diameter of the crown is recorded at its widest point.

9.4.6 Crown Spacing (Conifers)

For each coniferous tree in the plot, the distance from the edge of the crown to the edge of the nearest coniferous crown will be recorded according to the following index:

Distance from edge of crown to edge of the nearest crown:

5 = touching
4 = 0.1 – 0.5 meter
3 = 0.5 – 2 meters
2 = 2 – 4 meters
1 = > 4 meters

9.4.7 Stem Spacing (Conifers)

For each coniferous tree in the plot, the distance from the centre of the stem to the centre of the nearest conifer stem will be recorded at breast height. Record the actual distance in meters.

9.4.8 Stumps (not needed if pre-fuel treatment measurements are taken)

These measurements will be made only for areas that have been treated (treatment type = T) that were not measured prior to treatment as stump measurements are not needed

if pre-fuel treatment measurements are taken. The number of stumps in the plot will be tallied by size classes below (for all stumps, confer and hardwood). Use a diameter tape or calipers to measure stump diameter. . For each stump, the species will be noted as well as whether or not the tree was living or dead when the tree was cut.

Stump diameter size classes:

0 cm – 10 cm
> 10 cm – 15 cm
> 15 cm – 20 cm
> 20 cm

Be sure to record the average stump height in the comments section on the field data form as this will be important for stand reconstruction.

9.4.9 Crown Base Height and Crown Height (Conifers)

Crown base height and crown height will be recorded for all coniferous trees in the plot. The distance in centimeters from the ground to the lowest point of the lowest living or dead branch forming the base of the continuous crown is the crown base height. This measurement is used along with surface fire intensity to determine crown fire initiation. To be considered a branch, it must have fine fuels in the form of tertiary branchlets. The criteria used here to designate a branch is fairly subjective, especially in situations where there are a number of dead spruce trees that have been standing for a number of years, and in the more closed canopy stands where the lower branches of live trees have died due to shading by overstory crowns. These dead white spruce may be short with low branchlet density with

significant gaps between branches. Judgment must be used to determine the lowest branch with sufficient fine fuels to be readily ignited by a surface fire carrying the flames up into the overstory crown. This distance is recorded on the field forms (Garbutt, 2007). Crown height is calculated by subtracting the crown base height from the height of the tree.

9.4.10 Clumps and Clusters (only done for post-fuel treatment)

This measurement will be made only for areas that have been treated. In each plot, characteristics and spacing of clumps and clusters will be recorded.

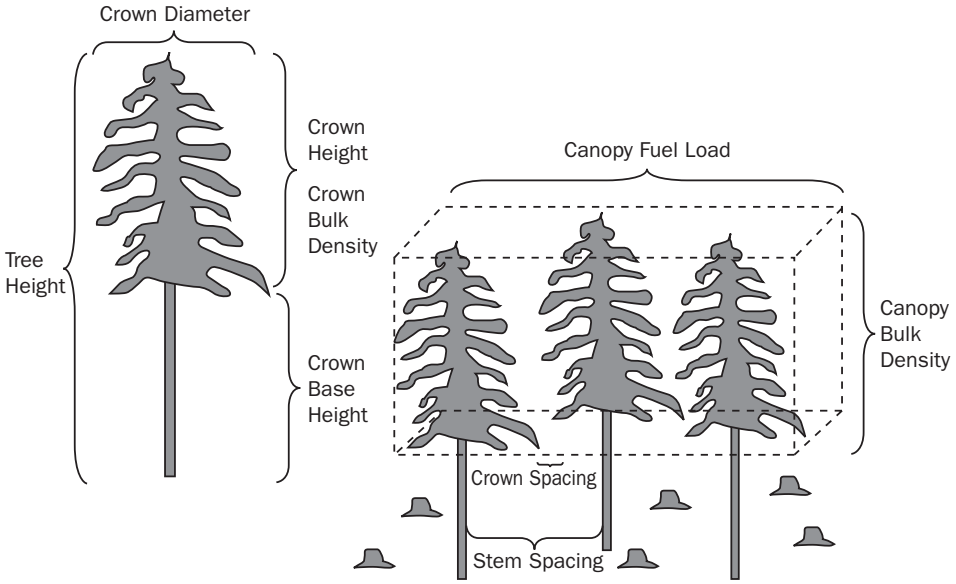
- Clumps – the tree numbers for each of the trees in each clump will be noted. For each clump, the distance from the edge of the clump to the nearest stem will be recorded. The distance from the clump to the nearest stem in the four cardinal directions will also be recorded.
- Cluster – the number of saplings (by species) and seedlings (by species) in each cluster will be noted. For each cluster, the distance from the edge of the cluster to the nearest stem will be recorded. The distance from the clump to the nearest stem in the four cardinal directions will also be recorded.

9.4.11 Canopy Fuel Load

Canopy fuel load (CFL) is measured by determining the crown fuel load of overstory trees within the plot. It is based on the loading of live needle foliage and fine branches < 0.5 cm

in diameter and requires measurements of crown base height, number of stems per ha, and tree species and tree weight equations by component. For dead spruce that needles have fallen but still have fine and medium branchlets (< 3 cm) remaining in the crown, another approach to determining canopy fuel load has to be used. Since the fine and medium branchlets have dried and are available to be consumed during a crown fire, this canopy fuel load needs to be used to determine the CFL for dead spruce trees. A spreadsheet is available from FMB to calculate CFL for both live and dead trees.

Figure 1: Diagram illustrating measurements required to estimate fuel characteristics of individual trees and stands



9.4.12 Canopy Bulk Density

Canopy bulk density (CBD) is measured by determining the crown fuel load of individual trees within the plot and then determining how this load is represented as a volume of the

crown canopy on a per hectare basis. Crown bulk density requires measurements of crown base height, number of stems per ha, and tree species and foliage branch weight equations. A spreadsheet and detailed instructions on how to calculate CBD for both live and dead trees is available from FMB.

9.4.13 Fire Behaviour Modelling

Once the above information has been collected, the stand fuel characteristics should be entered into a fire behaviour model. Fire behaviour should be modeled for pre- and post-treatment stand conditions for comparison purposes; however, it may not be possible to model the fire behaviour of pre-treatment stand conditions if measurements were not taken prior to fuel treatment. Pre-treatment stand conditions may be available from information that was collected during the development of the prescription; if this information is not available, it may be inferred by reconstructing stand conditions (e.g. from stumps within the treated stand, or from nearby similar stands). A methodology for stand reconstruction is available from FMB. The Crown Fire Initiation and Spread model (Alexander et al. 2006) will be explored to determine it's applicability in this context.

9.5 Equipment

- Hypsometer
- Loggers tape
- Diameter tape
- Calipers
- Data forms
- Forest mensuration data
- Quadrat ropes

9.6 References

Alexander, M.E.; Cruz, M.G.; Lopes, A.M.G. 2006. CFIS: a software tool for simulating crown fire initiation and spread. in D.X. Viegas, ed. Proceedings of 5th International Conference on Forest Fire Research, 27-30 November 2006, Figueira da Foz, Portugal. Elsevier B.V., Amsterdam, The Netherlands. CD-ROM. 13 p

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10.0

Soil Description Protocol

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Tables Page

Yukon
Energy, Mines and Resources

SOIL DESCRIPTION

Date (M/D/Y) _____ 3.2.2

Field Crew _____

Plot Number _____ 3.2.1
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Mineral Soil Horizons 10.2.3

Horizon	Depth	Colour	Texture	% Coarse Fragments					Roots	Mottles		Structure		pH
				Gravel	Cobbles	Stones	Total	Shape	Abundance	Abundance	Contrast	Class	Grade	

Comments:

Photographs: 10.2.1

SOIL DESCRIPTION

Soil Profile Diagram

10.2.1

Entered into Database? Yes ☐ No ☐

# of pits/plot 1 (@POC) ☐ **or 4 (@ each subplot)** ☐ 10.2.1

Moisture Regime 10.2.5

Nutrient Regime 10.2.6

Soil Type (e.g. S1) 10.2.12

Soil Drainage 10.2.7

Root Restricting Layer 10.2.9

Water Source 10.2.10

Surficial Material 10.2.13

Geomorphological Process 10.2.14

Rooting Depth 10.2.4

Rooting Zone Particle Size 10.2.8

Seepage Water Depth 10.2.11

Depth to Permafrost 10.2.3

Humus Form 10.2.2

Soil Classification 10.2.3

Organic Soil Horizons 10.2.2

Horizon	Depth	Roots Abundance	Mycelia Abundance	Fecal Abundance	pH

10.0 Soil Description Protocol

10.1 Purpose

The purpose of this protocol is to describe soil characteristics. Methods are similar to those in BCMOE and BCMOF (1998).

10.2. Procedure

10.2.1 Excavate and Photograph Soil Pit

Unless otherwise noted in the study design, excavate one soil pit for each plot. Locate the soil pit in a location that is relatively close to the POC and seems representative of the plot. Excavate pit (50 cm – 75 cm deep) leaving the face and sides undisturbed around the ground surface. While excavating, observe organic and mineral soil horizons depths; colours, structure, and textural changes; percentage and shape of coarse fragments; rooting abundance, depth, and restrictions; and mottling, seepage. Clean off face from top to bottom. Note horizon changes and mark with knife indentations.

Once the soil pit has been excavated, the face cleaned off and the horizon changes marked, a photograph of the soil pit should be taken. Please note that it is extremely important that your record the photo number on the field form. Also, set the camera to record the date and time the photo was taken directly on the photo. Once the photo has been downloaded to the computer, relabel the name of the file using the following convention – PlotNumber_Subplot_ Soil.jpg (e.g. FA-HJ1-T_North_Soil.jpg).

The study design may require you to dig a soil pit in each subplot for a total of four at each plot. In this case, locate the soil pit off the transect line in a location that is representative of the subplot. Indicate on the field data form if you have dug one soil pit (at the POC) or four soil pits (one in each subplot) for each plot.

10.2.2 Decribe Organic Soil Horizons

Draw and label the organic soil horizons on the soil profile diagram. Record the organic horizon or layer designation. Two groups of master organic horizons are recognized: L, F, H ("upland") horizons, and O ("wetland") horizons. All contain > 17% organic C by mass. For organic soil horizons, record:

- Mycelia and fecal abundance (X= None, F=Few, C=Common, M=Many)
- Rooting abundance (X= None, F=Few, C=Common, M=Many)
- Horizon classification (Tables 1 and 2)
- Humus form. Humus forms are classified to order and group according to Towards a Taxonomic Classification of Humus Forms (Green et al. 1993) (Table 3)
- pH

10.2.3 Describe Mineral Soil Horizons

Draw and label the mineral soil horizons on the soil profile diagram. For each mineral soil horizon, record:

- Horizon depth
- Percent, shape and size of coarse fragments (Table 4)

- Determine colour using the Munsell colour chart. The notation for a specific colour should be in the order of hue, value/chroma.
- Structure, note class and grade (Table 5)
- Mottling – abundance, size and contrast (Tables 6 and 7)
- Texture - Soil texture is defined by the size distribution of primary mineral particles (2 mm diameter or less). The textural classes and codes are determined from the soil texture triangle by estimating the percentage of clay (less than 0.002 mm diameter) and sand (0.05 to < 2.0 mm diameter) (Table 8)
- Rooting abundance (x=none, F=Few, C=Common, M=Many)
- Horizon classification (Tables 9, 10)
- Soil classification using the Canadian System of Soil Classification. Codes for great groups and subgroups are given below along with a key to common soil orders. (Tables 11 and 12)
- pH using a pH test kit
- Note any additional important observations in comments (depth where seepage is observed, depth where mottling is observed in the comment box.

10.2.4 Rooting Depth

Rooting depth refers to the depth (cm) from the ground surface, which is the top of the uppermost soil horizon including organic horizons, down to the bottom of the rooting zone (i.e., the level at which the majority of roots stop; for example, the end of “plentiful” and beginning of “few” rooting abundance).

10.2.5 Moisture Regime

Ecological moisture regime, relative to certain macroclimatic conditions represented by a bioclimatic unit, signifies on a relative scale the available moisture supply for plant growth. The relative moisture regime relates to the capacity of a soil to hold, lose, or receive water. It is determined from the soils' properties and the position in the landscape, regardless of climate. Moisture regime categories are very xeric, xeric, subxeric, submesic, mesic, subhygric, hygric, subhydric, and hydric, and are described in Table 13.

10.2.6 Nutrient Regime

Soil nutrient regime indicates on a relative scale the available nutrient supply for plant growth. The aim of the assessment is to derive an estimate of the available nutrient supply for a site, which will characterize it relative to all other sites occurring within the respective bioclimatic unit. An estimate of nutrient regime is based on: soil mineralogy (bedrock source), soil texture and coarse fragments, humus form, soil organic matter content, soil porosity and aeration, soil depth, and groundwater and incidence of flooding. A more detailed description of these measurements can be found in the BC MoE and MoF Manual (1998). Nutrient regime classes are very poor, poor, medium, rich, very rich and saline, and are described in Table 14.

10.2.7 Soil Drainage

Drainage class describes the speed and extent to which water is removed from a mineral soil in relation to additions. Drainage classes are very rapidly drained, rapidly drained, well drained, moderately well drained, imperfectly drained,

poorly drained, very poorly drained, and are described in Table 15. Alternately, the drainage class key in the Ecosystem Classification Field Guide for the Southeast Yukon may be used (Zoladeski et al. 1996).

10.2.8 Rooting Zone Particle Size

The particle size distribution within the mineral portion of the rooting zone is used to make broad interpretations. After determining rooting depth, estimate the rooting zone particle-size class as a weighted average of the mineral horizons within the rooting zone. Where rooting is restricted to the organic horizons, use the organic material codes. Rooting zone classes are based on percent coarse fragments (> 2 mm) by volume, and texture class sizes by percent weight for sand (.05 to < 2 mm), silt (< .05 to .002 mm), and clay (< .002). See Table 16.

10.2.9 Root Restricting Layer

If present, enter a code from Table 17 for the type of root restricting layer and the depth (cm) from the ground surface down to the top of the layer.

10.2.10 Water Source

The most influential source of water on a site (determined by a qualitative assessment) is recorded using the codes in Table 18.

10.2.11 Seepage Water Depth

If seepage is present at the time of sampling, record the depth (cm) from the ground surface to the level of temporary or permanent subsurface water flow. Enter "NP" if not present.

10.2.12 Soil Type

Note the soil type (e.g. S1) per Appendix B (Zoladeski et al. 1996).

10.2.13 Surficial Material

The surficial material will be recorded per Table 19.

10.2.14 Geomorphological Process

The geomorphological process will be recorded per Table 20.

Table 1: Guidelines for differentiating between upland and wetland organic horizons. Source: BCMOE and BCMOF 1998.

Property	**L, F, and H horizons**	**O horizons**
Physiography	Sloping to level	Depression to gently sloping
Soil drainage	Very rapid to imperfect	Poor to very poor
Water table	Absent in organic horizons (may fluctuate in response to water input)	At or near ground surface for significant duration during the frost-free period
Origin of materials	Organic residues from plant communities typically associated with soil moisture regimes 0 – 6	Organic residues from plant communities typically associated with soil moisture regimes 7 – 8

Table 2: Organic horizons.
Source: Haynes 1998.

L	An upland horizon consisting of relatively fresh organic residues that are readily identifiable as to origin.
F	An upland horizon comprised of partly decomposed plant residues in which fragmented plant structures are generally recognizable as to origin.
Fm	Fibric horizon where fungal mycelia can be observed and plant residue with a tenacious consistency. (Mycogenous)
Fz	Fibric horizon where faunal dropping are typically numerous, plant residue with a loose or friable consistency. (Zoogenous)
Fa	Mycogenous and Zoogenous can occur in low number or can both be absent
H	An upland horizon comprised of well-decomposed plant residues in which plant structures are generally not recognizable.
O	A wetland organic horizon comprised of materials in varying degrees of decomposition.
Of	Horizon consisting largely of fibric materials that are readily identifiable as to botanical origin.
Om	Horizon consisting of mesic material with an intermediate stage of decomposition.
Oh	Horizon consisting of humic material which is an advance stage of decomposition.

Table 3: Key to humus forms. Source: Green 1993.

1a. Well to imperfectly drained sites; humus form not saturated for prolonged periods
  2a. Combined thickness of F and H horizons > 2 cm if Ah < 2 cm
    3a. > 50% thickness of F horizon(s) is Fm.....**MORS (R)**
      4a. Decaying wood > 35% of organic matter volume in humus form profile.....**Lignomor (LR)**
      4b. Decaying wood ≤ 35% of organic matter volume in humus form profile
        5a. F horizon > 50% of thickness of F and H horizon.....**Hemimor (HR)**
        5b. Hh horizon > 50% of thickness of F and H horizons.....**Humimor (UR)**
        5c. Hr horizon > 50% of thickness of F and H horizons..... **Resimor (RR)**
    3b. F horizon(s) includes Fz and/or Fa.....**MODERS (D)**
      6a. Decaying wood > 35% of organic matter volume in humus form profile.....**Lignomoder (LD)**
      6b. Decaying wood ≤ 35% of organic matter volume in humus form profile
        7a. Fa horizon > 50% of thickness of F horizons; or Fm horizon present.....**Mormoder (RD)**
        7b. Fz horizon > 50% of thickness of F horizons
          8a. F and H horizons greater than or equal to thickness of Ah horizon.....**Leptomoder (TD)**
          8b. F and H horizons less than thickness of Ah horizon.....**Mullmoder (MD)**
  2b. Combined thickness of F and H horizons ≤ 2 cm and Ah horizon ≥ 2cm.....**MULLS (L)**
    9a. Rhizogenous Ah horizon formed from decomposition of dense fine roots.....**Rhizomull (ZL)**
    9b. Zoogenous Ah horizon formed through actions of abundant earthworms.....**Vermimull (VL)**
1b. Poor to very poorly drained sites; humus form saturated for prolonged periods
    10a. Combined thickness of F, H, and O horizons ≤ 2 cm and Ah horizon > 2 cm..... **Hydromull (YL)**
    10b. Combined thickness of F, H, and O horizons > 2 cm if Ah < 2 cm
      11a. Thickness of F and H horizons ≥ O horizons
        12a. F horizon(s) is Fm.....**Hydromor (YR)**
        12b. F horizon(s) is Fm.....**Hydromor (YR)**
      11b. Combined thickness of O horizons greater than F and H horizons
        13a. Of horizon > 50% of thickness of O horizons .....**Fibrimor (FR)**
        13b. Om horizon ≥ 50% of thickness of O horizons .....**Mesimor (MR)**
        13c. Oh horizon > 50% of thickness of O horizons .....**Saprimoder (SD)**

Table 4: Size classes and type codes for coarse fragments.
Source: BCMOE and BCMOF 1998.

Size Class and Code	Diameter (cm)
G - Gravel	2 mm to 7.5 cm
C - Cobbles	7.5 cm to 25 cm
S - Stones and boulders	> 25 cm

Type codes: R = rounded; S = subrounded and subangular;
A = angular; T = thin, flat.

Table 5: Structure codes.
Source: BCMOE and BCMOF 1998.

Class	Code
Single Grain	SG
Blocky	B
Granular	GR
Platy	P
Massive	M

Grade codes: W = weak; M=moderate, S=Strong

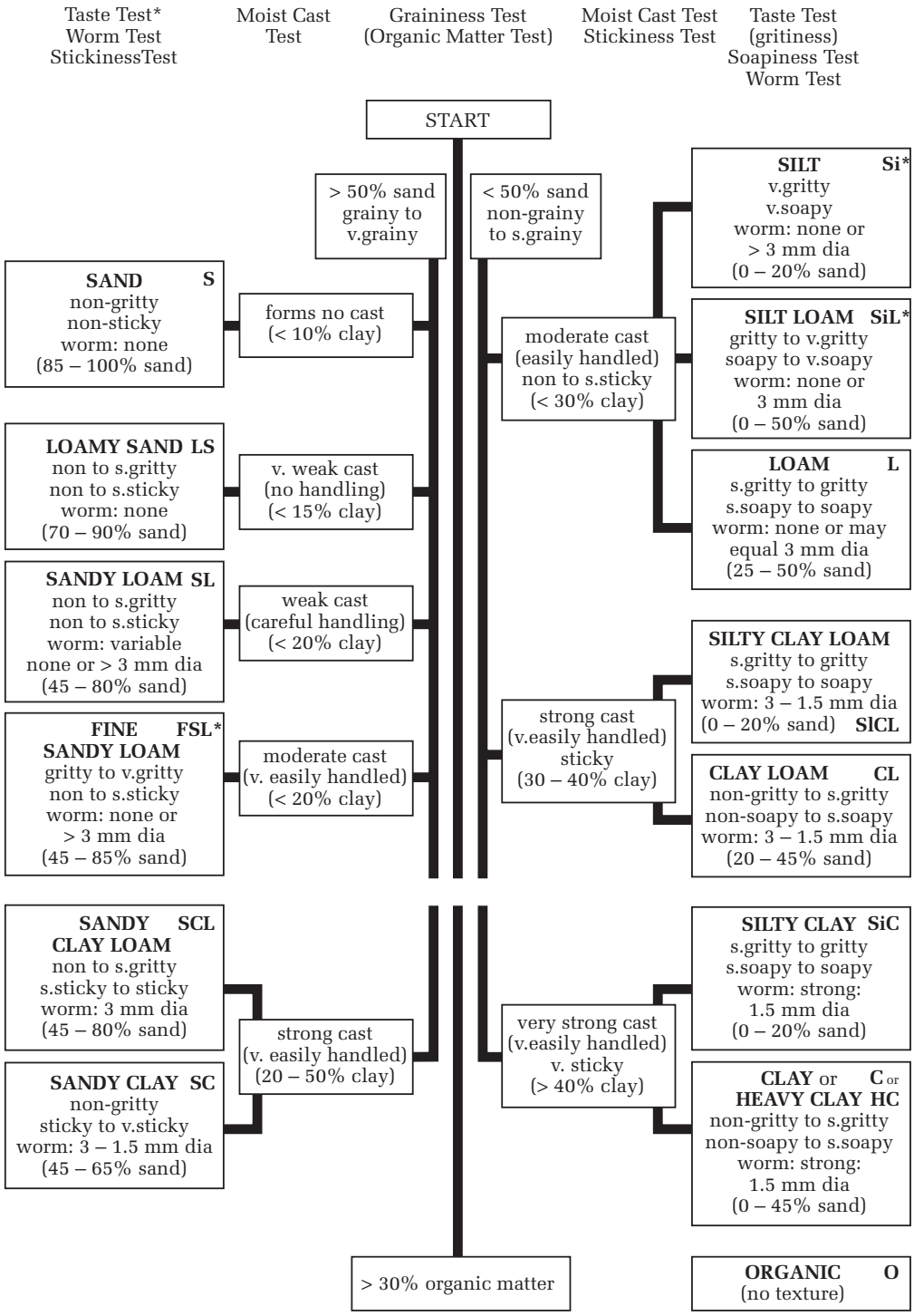
Table 6: Abundance and size codes for mottles.
Source: BCMOE and BCMOF 1998.

Abundance		
Code	**Class**	**% of exposed surface**
F	Few	< 2
C	Common	2 – 20
M	Many	> 20

Table 7: Contrast codes for mottles.
Source: BCMOE and BCMOF 1998.

Code	Description
F	Faint: Evident only on close examination. Faint mottles commonly have the same hue as the colour to which they are compared and differ by no more than 1 unit of chroma or 2 units of value. Some faint mottles of similar but low chroma and value can differ by 2.5 units of hue.
D	Distinct: Readily seen, but contrast only moderately with the colour to which they are compared. Distinct mottles commonly have the same hue as the colour to which they are compared, but differ by 2 – 4 units of chroma or 3 – 4 units of value; or differ from the colour to which they are compared by 2.5 units of hue, but by no more than 1 unit of chroma or 2 units of value.
P	Prominent: Contrast strongly with the colour to which they are compared. Prominent mottles are commonly the most obvious colour feature in a soil. Prominent mottles that have medium chroma and value commonly differ from the colour to which they are compared by at least 5 units of hue, if chroma and value are the same; by at least 4 units of value or chroma, if the hue is the same; or by at least 1 unit of chroma or 2 units of value, if hue differs by 2.5 units.

Table 8: Key to soil texture.
Source: BCMOE and BCMOF 1998.



* Silt feels slippery or soapy when wet: fine sand feels stiffer, like grinding compound or fine sandpaper.

Key to Abbreviations
s = slightly
v = very
dia = diameter

Measurement Conversions
3.0 mm = 1/8”
1.5 mm = 1/16”

Fine Fraction	**(particla diameter)**
SAND..... (S)	2 – .05 mm
SILT..... (Si)	.05 – .002 mm
CLAY..... (C)	< .002 mm

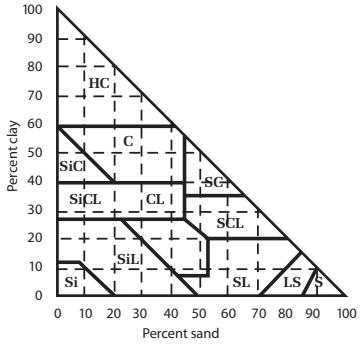


Table 9: Major mineral soil horizons
Source: Haynes 1998.

A	Mineral horizon, containing < 17% organic C by mass, that has formed at or near the soil surface in the zone of leaching or eluviation of organic materials in solution or suspension, or of maximum in situ accumulation of organic matter, or both.
B	Mineral horizon characterized by enrichment in organic matter, sequioxides, or clay; or by the development of soil structure; or by a change of colour denoting hydrolysis, reduction, or oxidation.
C	Mineral horizon comparatively unaffected by the pedogenic processes operative in the A and B horizons, except the process of gleying (Cg), and the accumulation of calcium and magnesium carbonates (Cca) and more soluble salts (Cs, Csa).

Table 10: Major mineral soil horizon modifiers.
Source: Haynes 1998.

b	Buried soil horizon.
c	Irreversibly cemented horizon (ortstein, placic, duric, and CaCO3 cemented layers are examples).
ca	Horizon > 10 cm thick of secondary carbonate enrichment in which the concentration of lime exceeds that in the unenriched parent material.
cc	Irreversibly cemented concretions.
e	Horizon characterized by the eluviation of clay, Fe, Al, or organic matter alone or in combination.
f	Horizon enriched with amorphous material, principally Al and Fe combined with organic matter. It must have a hue of 7.5 YR or redder, or its hue must be 10 YR near the upper boundary and becomes yellower with depth. When moist the chroma is higher than three or the value is three or less. It is used primarily with the Bf, Bhf, Bfg, and Bgf codes. The following f horizons are differentiated on the basis of the organic C content: • Bf 0.5 – 5% organic C • Bhf > 5% organic C
g	Horizon characterized by gray colours, or prominent mottling, or both, which indicates of permanent or periodic intense reduction. Chromas of the matrix are generally one or less. It is used with the Aeg, Bg, Bfg, Bgf, Bhfg, Btg, Cg, Ckg codes, and others. When used with the Ae, Bf, Bhf, and Bt codes, the limits set for the other modifiers must be met. The Bgf horizons are usually prominently mottled; more than half of the soil material occurs as mottles of high chroma. The Bgf horizons occur in Fera Gleysols and Fera Humic Gleysols and possibly below the Bfg of gleyed Podzols.
h	Horizon enriched with organic matter. It is used with the Ah, Ahe, Bh, and Bhf codes. Ah - An A horizon enriched with humified organic matter; at least one colour value unit lower that the underlying horizon, or 0.5% more organic C than the C horizon or both. Ahe - An Ah horizon that has undergone eluviation as evidenced by streaks and splotches of different shades of gray, and often by plated structure.

Table 10 continued…

	Bh - Contains > 1% organic C with less than 0.3% pyrophosphate-extractable Fe [Fe(p)] and a ratio of C : Fe(p) of 20 or more (very rare in British Columbia). Bhf - Defined under f above.
j	Used with e, f, g, n, and t to denote an expression of, but failure to meet, the specified limits of the letter code it modifies. It is placed to the right of the letter it modifies.
k	Denotes the presence of carbonate as indicated by visible effervescence when a dilute HCl solution is added.
m	Horizon slightly altered by hydrolysis, oxidation, or solution, or all three to give a change in colour or structure, or both. It is used with the Bm, Bmgj, Bmk, and Bms codes. It has: 1. Evidence of one of or more of the following: • higher chromas and redder hues than the underlying horizons; • enrichment or complete removal of carbonates either as Bmk or Bm; and/or • change in structure from that of the original material. 2. Illuviation too slight to meet requirements of a Bt or podzolic B. 3. No cementation or induration and lacks a brittle consistence when moist.
n	Horizon with distinctive prismatic or columnar structure, dark coatings on ped surfaces, and hard to very hard consistence when dry; the exchangeable Ca to exchangeable Na is 10 or less. It is used with Bn or Bnt codes.
p	Horizon disturbed by human activities, such as cultivation, logging, and habitation.
s	Horizon with salts, including gypsum, which may be detected as crystal or veins, or as surface crusts of salt crystals. It is used with any combination of horizon codes.
sa	Horizon > 10 cm thick with secondary enrichment of salts more soluble than Ca and Mg carbonates; the concentration of salts exceeds that in the unenriched parent material.
t	An illuvial horizon enriched with silicate clay. It is used with the Bt, Btg, and Bnt codes and may be modified by j.

Table 10 continued…

	To use Bt: • The horizon must be at least 5 cm thick. • If any part of an the eluvial horizon has < 15% total clay in the fine fraction (< 2 mm), the Bt horizon must contain at least 3% more clay and if > 40% total clay, then it must contain at least 8% more clay. If the eluvial horizon has > 15% and < 40% clay in the fine fraction, then the ratio of the clay in the Bt to that of the eluvial horizon must be 1.2 or more (e.g., Ae 25% clay; Bt at least 30% clay). • In massive soils, there should be oriented clay in pores and as bridges between sand grains. • If peds are present, clay films (skins) should be visible on ped surfaces and in pores.
u	Horizon that is markedly disrupted by physical (e.g., blowdown of trees, mass movement, etc.) or faunal processes (e.g., burrowing animals), but not from cryoturbation.
x	Horizon of fragipan character; loamy subsurface horizon of high bulk density and very low organic matter. When dry, it is hard and seems to be cemented; when moist is has moderate to weak brittleness. Air-dried clods slake (crumble) in water.
y	Horizon affected by cryoturbation. It is used with any combination of horizon codes.
z	A frozen layer, it may be used with any horizon or layer code.

Table 11: Simplified descriptions of major soil orders and subgroups in the Yukon. Source: Smith et al. 2004.

Soil Order	Occurrence	Description
Brunisol	Very common in Boreal Cordilleran Ecozone	Mildly weathered mineral soil, commonly forms under forest cover and grasslands in southwest and central Yukon. The most common subgroup of Brunisol in the Yukon is the Eutric Brunisol, which has a pH in the surface soil of> 5.5. Dystric Brunisols are less common acidic subalpine and alpine soils with pH < 5.5
Cryosol	Very common in all northern ecozones	Permafrost-affected soils, may be associated with wetlands, tundra or taiga forest conditions. Turbic Cryosols are mineral soils strongly affected by frost churning, which generates various forms of patterned ground. Static Cryosols lack this frost–churning process. Organic Cryosols are the soils of peatlands underlain by permafrost.
Regosol	Scattered throughout all ecozones	Regosols are soils that have not been weathered and area associated with active landforms such as floodplains, colluvial slopes, dunes, thaw slumps and debris flows. The soils do not exhibit horizon formation typical of other soils.
Luvisol	Restricted to ecoregions in southeastern Yukon	Luvisols are the soils associated with fine-textured soils under boreal and temperate forests throughout Canada. In the Yukon, they only develop at lower elevations on clay-rich glacial deposits under relatively mild and wet conditions such as are found in the Liard Basin, Hyland Highland and Muskwa Plateau ecoregions.
Organic	Scattered wetland soils of Boreal Cordilleran Ecozone	In soil taxonomic terms, organic refers to soils that are formed of decomposed vegetation (peat) rather than sand, silt and clay. Organics are associated with fen wetlands that are not underlain by permafrost.
Podzol	Rare	Podzols are associated with temperate, high rainfall forested areas. In the Yukon, they are occasionally found in Selwyn Mountains and Yukon Stikine Highlands ecoregions. All Podzols identified in the Yukon have been classified as Humo-Feric Podzols (i.e. those with enriched iron concentrations in the subsoil).

Table 12: Key to soil orders.
Source: Haynes 1998.

Key to Soil Orders (Soil Classification Working Group 1998)	
A.	Soils that have permafrost within 100 cm of the surface, or 200 cm if strongly cryoturbated. **..... Cryosolic Order**
B.	Other soils with:
1.	Organic horizons (more than 17% organic C by mass) that extend from the surface to one of the following: a. A depth of 60 cm or more if the surface layer is fibric material (Of) having a bulk density of < 0.075 g/cm^3. b. A depth of 40 cm or more if the surface layer consists of mesic or humic material (Om or Oh) having a bulk density $\geq$ 0.075 g/cm^3. c. A depth of more than 40 cm if composed of folic materials (L, F, and H), or at least 10 cm if a lithic contact or fragmental materials are present. Folic materials must be more than twice the thickness of a mineral soil layer if the mineral layer is less than 20 cm thick. OR
2.	One or more mineral horizons or layers within 40 cm of the surface in addition to the organic horizons (O) as follows: a. If a mineral horizon or layer thinner than 40 cm occurs at the surface, the underlying organic horizon or horizons must have a total thickness of at least 40 cm. b. If one or more mineral horizons or layers occur within 40 cm of the surface, the organic material must occupy more than 40 cm of the upper 80 cm of the control section. **..... Organic Order**
C.	Other soils that have both a vertic horizon and a slickenside horizon, the top of which occurs within 1 m of the surface. **..... Vertisolic Order**
D.	Other soils that have a podzolic B horizon and do not have a Bt horizon within 50 cm of the mineral surface. **..... Podzolic Order**
E.	Other soils that are saturated with water and under reducing conditions either continuously or during some period of the year as indicated either by direct measurements of the water table and the oxidation-reduction status, or by any of the following morphological features within 50 cm of the mineral surface:

Table 12 continued…

1.	For all but red soil materials (hue 5YR or redder and colour fades slowly on dithionite treatment). a. Chromas of 1 or less, without mottles, on ped surfaces or in the matrix if peds are lacking in materials that develop higher chromas under oxidizing conditions. b. Chromas of 2 or less, in hues of 10YR and 7.5YR, on ped surfaces or in the matrix if peds are lacking, accompanied by prominent mottles. c. Chromas of 3 or less, in hues yellower than 10YR, on ped surfaces or in the matrix if peds are lacking, accompanied by prominent mottles. d. Hues bluer than 10Y, with or without mottles, on ped surfaces or in the matrix if peds are lacking. **.....Gleysolic Order**
2.	Other soils that have a solonetzic B horizon. **..... Solonetzic Order**
F.	Other soils that have a chernozemic A horizon and any one of the following: 1. No Ae horizon. 2. A weakly expressed Ae horizon (Aej) with a dry colour value lower than 5. 3. An Ae horizon thinner than an overlying Ah or Ap horizon that does not appear to be eluviated. 4. An Ae horizon not more than 5 cm thick if the chernozemic A is eluviated (Ahe), as indicated by grey streaks and splotches when the soil is dry. **..... Chernozemic Order**
G.	Other soils that have a Bt horizon. **..... Luvisolic Order**
H.	Other soils that have either Bm, Btj, or Bfj horizons at least 5 cm thick, or a Bf horizon less than 10 cm in thickness. **..... Brunisolic Order**
I.	Other soils. **..... Regosolic Order**

Table 13: Soil moisture regime classes.
Source: BCMOE and BCMOF 1998.

Code	Class	Description	Primary water source
0	Very xeric	Water removed extremely rapidly in relation to supply; soil is moist for a negligible time after precipitation	precipitation
1	Xeric	Water removed very rapidly in relation to supply; soil is moist for brief periods following precipitation	precipitation
2	Subxeric	Water removed rapidly in relation to supply; soil is moist for short periods following precipitation	precipitation
3	Submesic	Water removed readily in relation to supply; water available for moderately short periods following precipitation	precipitation
4	Mesic	Water removed somewhat slowly in relation to supply; soil may remain moist for a significant, but sometimes short period of the year. Available soil moisture reflects climatic inputs	precipitation in moderate- to fine-textured soils and limited seepage in coarse-textured soils
5	Subhygric	Water removed slowly enough to keep soil wet for a significant part of growing season; some temporary seepage and possibly mottling below 20 cm	precipitation and seepage
6	Hygric	Water removed slowly enough to keep soil wet for most of growing season; permanent seepage and mottling; gleyed colours common	seepage
7	Subhydric	Water removed slowly enough to keep water table at or near surface for most of year; gleyed mineral or organic soils; permanent seepage < 30 cm below surface	seepage or permanent water table
8	Hydric	Water removed so slowly that water table is at or above soil surface all year; gleyed mineral or organic soils	permanent water table

Table 14: Nutrient regime classes.Source: BCMOE and BCMOF 1998.

	Oligotrophic	Submeso-trophic	Mesotrophic	Permeso-trophic	Eutrophic	Hyper-eutrophic
	A Very poor	B Poor	C Medium	D Rich	E Very rich	F Saline
Available nutrients	very low	low	average	plentiful	abundant	excess salt accum.
Humus form	Mor					
			Moder			
				Mull		
A horizon	Ae horizon present					
			A horizon absent			
				Ah horizon present		
Organic matter content	low (light coloured)					
		medium (inter. in colour)				
			high (dark coloured)			
C:N Ratio	high					
			moderate			
				low		
Soil depth	extremely shallow					
		very shallow to deep				
Soil texture	coarse textured					
			medium to fine textured			
% Coarse fragments	high					
		moderate to low				
Parent material mineralogy	base-low					
			base-medium			
				base-high		
Soil pH	extremely-med-acid					
			moderately acid-neutral			
				slightly acid-middly alk.		
Water pH (wetlands)	< 4 – 5	4.5 – 5.5	5.5 – 6.5	6.5 – 7A	7A+	
Seepage			temporary →		permanent	

Table 15: Drainage classes and codes.
Source: BCMOE and BCMOF 1998.

Code	Class	Description
x	Very rapidly drained	Water is removed from the soil very rapidly in relation to supply. Water source is precipitation and available water storage capacity following precipitation is essentially nil. Soils are typically fragmental or skeletal, shallow, or both.
r	Rapidly drained	Water is removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep gradients during heavy rainfall. Water source is precipitation. Soils are generally coarse textured.
w	Well drained	Water is removed from the soil readily, but not rapidly. Excess water flows downward readily into underlying pervious material or laterally as subsurface flow. Water source is precipitation. On slopes, subsurface flow may occur for short durations, but additions are equalled by losses. Soils are generally intermediate in texture and lack restricting layers.
m	Moderately well drained	Water is removed from the soil somewhat slowly in relation to supply because of imperviousness or lack of gradient. Precipitation is the dominant water source in medium- to fine- textured soils; precipitation and significant additions by subsurface flow are necessary in coarse-textured soils.
i	Imperfectly drained	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Excess water moves slowly downward if precipitation is the major source. If subsurface water or groundwater (or both) is the main source, the flow rate may vary but the soil remains wet for a significant part of the growing season. Precipitation is the main source if available water storage capacity is high; contribution by subsurface or groundwater flow (or both) increases as available water storage capacity decreases. Soils generally have a wide range of texture, and some mottling is common.
p	Poorly drained	Water is removed so slowly in relation to supply that the soil remains wet for much of the time that it is not frozen. Excess water is evident in the soil for a large part of the time. Subsurface or groundwater flow (or both), in addition to precipitation, are the main water sources. A perched water table may be present. Soils are generally mottled and/or gleyed.
v	Very poorly drained	Water is removed from the soil so slowly that the water table remains at or near the surface for most of the time the soil is not frozen. Groundwater flow and subsurface flow are the major water sources. Precipitation is less important, except where there is a perched water table with precipitation exceeding evapotranspiration. Typically associated with wetlands. For organic wetlands, also evaluate the soil moisture subclass, and when entering on the form, separate from drainage by a slash. For example, v/ac.

Table 16: Particle size classes.
Source: BCMOE and BCMOF 1998.

Code	Classa	Definitions
Coarse fragments ≥ 70%:		
F	Fragmental	Particles < 2 mm of various textures
Coarse fragments ≥ 35 and less than 70%:		
SS	Sandy-skeletal	Particles < 2 mm sandy
CLS	Coarse-loamy-skeletal	Particles < 2 mm coarse-loamy
FLS	Fine-loamy-skeletal	Particles < 2 mm fine-loamy
SIS	Silty-skeletal	Particles < 2 mm fine-silty or coarse-silty
CS	Clayey-skeletal	Particles < 2 mm clayey
Coarse fragments < 35 %		
S	Sandy	
CL	Coarse-loamy	
FL	Fine-loamy	
CSI	Coarse-silty	
FSI	Fine-silty	
FC	Fine-clayey	
VFC	Very-fine-clayey	
Organic Material Codes:		
F	Fibric	
M	Mesic	
H	Humic	
W	Woody	

Table 17: Codes for root restricting layers.
Source: BCMOE and BCMOF 1998.

Code	Description
C	Strongly cemented horizon
P	Clay pan or restriction due to fines
K	Compacted morainal material
L	Lithic contact
W	Excessive moisture; this refers to the depth where the roots are being restricted by excessive moisture, but does not require the presence of free water at the time of sampling
X	Excessive accumulations of chemicals within the profile which inhibit root growth (i.e., $CaCO_3$)
Z	Permafrost; characterized by temperatures never exceeding O°C ice cementation, ice lenses, or massive ice.
N	No root restriction evident.

Table 18: Water source codes.
Source: BCMOE and BCMOF 1998.

Code	Water Source
P	Precipitation
G	Groundwater
S	Snowmelt (prolonged through the growing season)
F	Stream sub-irrigation and flooding
M	Mineral spring
Z	Permafrost

Table 19: Surficial material codes and descriptions.
Source: BCMOE and BCMOF 1998.

Code	Name	Assumed Status (A=Active I=Inactive)	Description
A	Anthropogenic	(A)	Artificial or human-modified material
C	Colluvium	(A)	Products of mass wastage
D	Weathered bedrock	(A)	In situ, decomposed bedrock
E	Eolian	(I)	Materials deposited by wind action
F	Fluvial	(I)	River deposits
FG	Glaciofluvial	(I)	Ice contact fluvial material
I	Ice	(A)	Permanent snow, glaciers, and icefields
L	Lacustrine	(I)	Lake sediments; includes wave deposits
LG	Glaciolacustrine	(I)	Ice contact lacustrine material
M	Morainal	(I)	Material deposited directly by glaciers
O	Organic	(A)	Accumulation/decay of vegetative matter
R	Bedrock	(-)	Outcrops/rocks covered by less than 10 cm of soil
U	Undifferentiated	(-)	Layered sequence; three materials or more
V	Volcanic	(I)	Unconsolidated pyroclastic sediments
W	Marine	(I)	Marine sediments; includes wave deposits
WG	Glaciomarine	(I)	Ice contact marine sediments

Table 20: Geomorphological process codes and descriptions. Source: BCMOE and BCMOF 1998.

Code	Name	Assumed Status (A=Active I=Inactive)	Description
A	Avalanches	(A)	Terrain modified by snow avalanches
B	Braiding	(A)	Diverging/converging channels; unvegetated bars
C	Cryoturbation	(A)	Materials modified by frost heaving and churning
D	Deflation	(A)	Removal of sand and silt by wind action
E	Channeled	(I)	Channel formation by meltwater
F	Slow mass	(A)	Slow downslope movement of masses of cohesive or non-cohesive material
H	Kettle	(I)	Depressions in surficial material resulting from the melting of buried or partially buried glacier ice
I	Irregular	(A)	A single, clearly defined main channel channel displaying irregular turns and bends
J	Anastomosing	(A)	A channel zone where channels channel diverge and converge around many vegetated islands
K	Karst	(A)	Processes associated with the solution of carbonates
L	Seepage	(A)	Zones of active seepage often found seepage along the base of slope positions

Table 20 continued…

M	Meandering	(A)	Channels characterized by a regular channels pattern of bends with uniformed amplitude and wave length
N	Nivation	(A)	Erosion beneath and along the margin of snow patches
P	Piping	(A)	Subterranean erosion by flowing water
R	Rapid mass movement	(A)	Rapid downslope movement of dry, moist, or saturated debris
S	Solifluction	(A)	Slow downslope movement of saturated overburden across a frozen or otherwise impermeable substrate
U	Inundation	(A)	Seasonally under water because of high water table
V	Gully erosion	(A)	Parallel/subparallel ravines caused by running water
W	Washing	(A)	Modification by wave action
X	Permafrost	(A)	Processes controlled by the presence of permafrost
Z	Periglacial	(A)	Solifluction, cryoturbation, and processes nivation processes occurring within a single unit
LA	Loess	(A)	Accumulation of wind blown fine sediment (loess).
NP	Not present	(I)	No geomorphological process identified

10.3 Equipment

- Shovel
- Soil knife
- Water bottle
- Sieve (2 mm)
- Munsell colour charts
- Tape measure
- pH field test kit
- Photocopies of relevant soil type descriptions in Zoladeski et al. (1996)
- Canadian System of Soil Classification
- Field data form
- Digital camera
- Control post (for scale in photographs)

10.4 References

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11.0

Effectiveness of Measures to Conserve Soil Resources Protocol

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Tables Page

Yukon
Energy, Mines and Resources

EFFECTIVENESS OF MEASURES TO CONSERVE SOIL RESOURCES

Part 1: Cutblock Characteristics

Date (M/D/Y) 3.2.2

Field Crew _____

SIS Number 11.4.1

Plot Number 3.2.1

(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Permanent Access Structures			Regeneration		
PAS #	PAS Type	Area (Ha)	Plot # (eg NARR1, TASR1)	# Trees	SPH
	11.4.3.1				
Temporary Access Structures					
TAS #	TAS Type	Area (Ha)			
				11.4.3.1	
	11.4.3.1				
Other Disturbances: Landslides, Erosion, and or Drainage Alterations (Ha)					
Disturbance #	Disturbance Type	Area (Ha)			
	11.4.3.1				

Comments:

EFFECTIVENESS OF MEASURES TO CONSERVE SOIL RESOURCES

CWD form completed Yes ☐ No ☐ **Entered into Database?** Yes ☐ No ☐

FWD form completed Yes ☐ No ☐

Total cutblock area (ha)	11.4.3.1
Total area is PAS (ha)	11.3.6 and 11.4.3.1
Net area to be reforested (ha)	11.3.5 and 11.4.3.1
Total area in TAS (ha)	11.3.8 and 11.4.3.1
Percent of NAR successfully regenerated	11.4.3.1
Total area affected by landslides, erosion and/or drainage alterations	11.4.3.1

Cutblock sketch. Locate and label PAS, TAS, and other disturbances.
Note approximate location of NAR regeneration survey plots.

11.4.3.1

Yukon
Energy, Mines and Resources

Date (M/D/Y) _____ 3.2.2

Field Crew _____

Plot Number _____ 3.2.1

(Plot Type – Location – Site Number - SubPlot - Treatment Type)

EFFECTIVENESS OF MEASURES TO CONSERVE SOIL RESOURCES

Part 2: Paired Plot Measurements

Compaction		Forest Floor						Soil Disturbance					
Meters	Compaction	Organic Soil Horizon	Leaf Litter	FWD	CWD	Exposed Mineral Soil	Burned Soil	Wheel or Track ruts	Compaction	Repeated Machine Traffic	Gouges	Scalps	Burned
1													
2													
3						11.4.3.3							
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													

EFFECTIVENESS OF MEASURES TO CONSERVE SOIL RESOURCES

Part 2: Paired Plot Measurements

Entered into Database? Yes ☐ No ☐

Compaction		**Forest Floor**						**Soil Disturbance**					
Meters	Compaction	Organic Soil Horizon	Leaf Litter	FWD	CWD	Exposed Mineral Soil	Burned Soil	Wheel or Track ruts	Compaction	Repeated Machine Traffic	Gouges	Scalps	Burned
15													
16													
17													
18													
19													
21													
22													
23													
24													
25													

Comments:

11.0 Effectiveness of Measures to Conserve Soil Resources Protocol

11.1 Purpose

The purpose of this monitoring protocol is twofold: 1) to determine whether the standards in the approved site plan have been adhered to and 2) whether or not these standards were effective in conserving soil resources. To make this assessment, this monitoring protocol describes methods to quantify and describe the effectiveness of measures to conserve soil resources at the cutblock scale.

It is absolutely critical that information gathered here be interpreted in the context of site-specific measures that are put in place to conserve soil resources. Therefore, the elements of the approved site prescription that relate to soil conservation should be noted. In addition, it is important that site-specific information on soil characteristics is gathered to assist in the interpretation of the results of this protocol (see Soil Description Protocol). Procedures are largely taken from the BC FREP (2004) cutblock-level monitoring protocol for soil resource stewardship, the BC Soil Conservation and Soil Conservation Surveys FPC Guidebook (2001).

It is strongly recommended that the following protocols from this manual be completed alongside this monitoring protocol; site description and soil description. In addition, the coarse woody debris and fine woody debris monitoring protocols are also to be completed as they are an explicit component of this monitoring protocol (per Section 12.4.3).

11.2 Rationale

In recent years, the Strategic Forest Management Plans that have been adopted in the Yukon have incorporated an adaptive management framework. Adaptive management is a management approach that rigorously combines management, research, monitoring and means of changing practices so that credible information is gained and management activities are modified by experience. Strategic Forest Management Plans establish a number of objectives of forest management, and indicators are tools that help to determine whether progress is being made or not towards achieving these objectives. The results of indicator monitoring are used to determine when an adaptive management response is warranted. One objective of forest management is to conserve of soil resources. The following monitoring protocol collects information on indicators that describe the effectiveness of measures that are that are in place to conserve soil resources.

There are eight key indicator areas:

- Degree of divergence between standards in the approved site prescription and what is seen on the ground
- % of area of lost productivity due to access construction
- Area affected or potentially affected by landslides, drainage diversion (overland flow) or significant erosion within a cutblock
- Area affected by disturbance to natural drainage patterns resulting in water accumulation within a cutblock
- Dispersed soil disturbance (compaction, topsoil displacement) in the net area to be reforested

- Green tree retention
- Organic matter retention (coarse and fine woody debris)

11.3 Definitions

11.3.1 Access Structures

Access structures located within a cutblock are identified as either permanent or temporary in a site prescription.

11.3.2 Compaction

Any of these conditions is considered to be compacted soil: compacted mineral soil, puddled mineral soil, and compacted deposits of slash and organic debris. Mineral soil compaction is assessed relative to the conditions of adjacent undisturbed soil. Compaction of mineral soil occurs when accumulations of slash and woody debris are compacted and pressed into the mineral soil by repeated heavy machine traffic. Often the overlying accumulations are difficult to dig through or separate with a shovel; however, it may be necessary to sample the underlying mineral soil for evidence of compaction (in accordance with the three previous points), if there is any doubt about impacts to the soil. Any one of the following defines a compacted condition:

- The soil breaks apart in consolidated plates that are typically 1 cm or greater in thickness. This structure is not evident in the adjacent undisturbed soil.
- Loss of the normal structure evident in the undisturbed soil.
- A noticeable change in density. If the disturbed and undisturbed soils have the same moisture

content, their difference in density may be recognized by: a difference in resistance when a shovel is used to penetrate the soils, or a difference in resistance when blocks of soil 2.5 cm thick are crushed between the thumb and index finger.

- Compacted deposits of forest floor, fine slash, and woody debris, overlaying and partially imbedded in, or crushed into, the mineral soil that cannot be readily excavated with a shovel.

11.3.3 Dispersed Soil Disturbance

Dispersed disturbance is itself a general term referring to dispersed trails, gouges, and scalps. Dispersed trails include wheel and track ruts (normally created during the operation of ground-based equipment on wet soils of limited load-bearing strength) and compaction from repeated machine traffic.

11.3.4 Inordinate Soil Disturbance

Inordinate soil disturbance is defined as 30% or higher disturbance on areas larger that 0.2 ha.

11.3.5 Net Area to be Reforested (NAR)

The net area to be reforested (NAR) is calculated as follows: NAR = Total cutblock area – area occupied by permanent access structures.

11.3.6 Permanent Access Structures (PAS)

Permanent access structures include in-block roads, landings, gravel pits, borrow pits, quarries and permanent logging trails that are reasonably required for timber harvesting and other forest management activities. Permanent access structures are specifically identified in the site prescription. Permanent access may be required for repeated stand entries to carry out periodic harvesting of areas where partial cutting silvicultural systems or commercial thinning operations are prescribed. Such structures are not part of the net area to be reforested (NAR) and do not count towards soil disturbance.

11.3.7 Soil Disturbance

Soil disturbance is a general term referring to the following types of disturbance that occur on the NAR:

unrehabilitated temporary access structures, including excavated or bladed trails of a temporary nature, corduroyed trails, compacted areas, and dispersed disturbance.

11.3.8 Temporary Access Structures (TAS)

Temporary access structures are those on-block access structures that do not satisfy the criteria for being classified as permanent access structures are considered temporary. Temporary access structures are required only for a limited period during a specific forest management phase. The area they occupy is part of the net area to be reforested, and must be suitable for rehabilitation to enable the establishment of a commercial crop of trees. Temporary access structures include: excavated or bladed trails, main skid trails,

backspar trails, corduroyed trails, and other similar structures identified as temporary access structures in the site prescription, and roads, landings, gravel pits, or quarries identified as temporary access structures in the site prescription. Such structures count towards soil disturbance unless they have been rehabilitated

11.4 Procedure

11.4.1 Background Data Collection

The following information should be gathered before heading out into the field:

- SIS information on cutblock
- Site prescription (e.g winter/summer harvest, site prep, planting etc.), including maps
- Cutblock cruise summary
- Post-harvest inspection data (if available)
- Recent air photos of cutblock (if available)
- Determine what digital imagery is available of the cutblock in the GIS

11.4.2 Office Assessment of Cutblock Characteristics

Using air photos and/or satellite imagery (whichever provides the best resolution and has most recent coverage), make a preliminary assessment of the following:

- Total area of the cutblock
- Area of the cutblock in permanent access structures
- Net area to be reforested

- Percent of net area to be reforested that has successfully regenerated
- Area of the cutblock in temporary access structures
- Percent of the area in temporary access structures that has successfully regenerated
- Area of block affected by landslides, erosion and/or drainage alteration (overland flow or water accumulation)

It is critical that the assessment of the effectiveness of measures to conserve soil resources be made against the specifications in the site prescription. Therefore, it is critical that you document any specifications in the site prescription that relate to any of the above mentioned attributes.

11.4.3 Field Planning

Once this office assessment is complete, a walk-through survey of the block should be planned that incorporates an inspection of areas noted above to confirm measurements made from air photos and/or satellite imagery. As well, identify areas that appear to represent average conditions on the block, within the NAR, where transects for quantitative evaluation of soil disturbance and coarse woody debris will be carried out. The purpose of the field survey is to verify the location of permanent and temporary access structures, look at temporary access structures to determine whether the required rehabilitation has been achieved, identify areas that appear to have excessive disturbance.

11.4.4 Field Assessment

11.4.4.1 Confirm Office Assessment of Cutblock Characteristics

During the office assessment, the following measurements were made from air photos and/or satellite imagery. These measurements should be confirmed in the field:

- Total area of the cutblock
- Area of the cutblock in permanent access structures. To calculate determine the average width and the total length of each permanent access structure. A sketch of the block should be made that shows the approximate location of all permanent access structures. Each structure should be laebelled with a unique number (e.g. PAS1, PAS2, etc.)
- Net area to be reforested
- Percent of net area to be reforested that has successfully regenerated. There are a number of ways to assess regeneration success.

    1. You may use a 3.99 m plot cord to estimate stems per hectare (# trees in 3.99 m plot x 200 = SPH) at a number of plots throughout the net area to be reforested (ideally use an evenly spaced grid across the block. Number each plot NARR1, NARR2, and show the approximate location of each on the diagram. % NAR successfully regenerated = # plots successfully regenerated / total # plots * 100
    2. If you established mensuration plots using the protocol in this manual, you may also use these plots. Reference the Yukon Regeneration Survey

Manual and/or consult the Silviculture Forester for additional guidance on how to assess regeneration success.

- Area of the cutblock in temporary access structures. To calculate determine the average width and the total length of each temporary access structure. A sketch of the block should be made that shows the approximate location of all temporary access structures. Each structure should be labelled with a unique number (e.g. TAS1, TAS2, etc.)
- Percent of the area in temporary access structures that has successfully regenerated. Use a 3.99m plot cord to estimate stems per hectare (# trees in 3.99 m plot x 200 = SPH) at a number of plots within each TAS. Number each plot TASR1, TASR2, and show the approximate location of each on the diagram. % TAS successfully regenerated = # plots successfully regenerated / total # plots * 100
- Area of block affected by landslides, erosion and/or drainage alteration (overland flow or water accumulation). Note the length and width of affected areas by type.

A GPS, loggers tape, and hip chain can be used to confirm areas in the field. A sketch of the block should be made that shows the approximate location of all temporary and permanent access structures, other disturbances and regen survey plot locations, etc.

11.4.4.2 Paired-Plot Establishment

One or more paired-plot monitoring sites will be established to evaluate: forest floor characteristics, compaction,

dispersed soil disturbance, coarse woody debris retention and fine woody debris retention

Each monitoring site will consist of two plots – one plot will be installed in treated area (within the net area to be reforested) and one plot in the adjacent untreated area (where possible). This paired-plot methodology will allow for comparisons to be made between the treated and untreated forest. Ideally, measurements will be taken in the treated plot prior to harvesting to allow for pre and post treatment comparisons to be made. The Monitoring Site Establishment Protocol in this manual outlines detailed instructions for how to establish and name a monitoring site.

11.4.4.3 Paired-Plot Measurements

The following measurements will be taken along the 25 metre transect line in each of the four subplots. Establish the transect using a rope with markings every 1 m. The following measurements will be taken along the 25 m transect line:

- Compaction At every meter along the 25 m transect line suspend a rod and using a pocket penetrometer, record the resistance.
- Forest Floor Characteristics At every meter along the 25 m transect line suspend a rod and note the characteristics forest floor touched by the rod: organic soil horizons (LFH), leaf litter, fine woody debris, coarse woody debris, exposed mineral soil, burned soil (cause may be natural or burn piles). More than one characteristic may be noted at each measurement point. This will be used to provide an estimate of percent cover (# observations / 25 total possible observations * 100% = % cover).

- Dispersed Soil Disturbance At every meter along the 25 m transect line, tally the number of times dispersed disturbance is observed by disturbance type (Table 1). More than one characteristic may be noted at each measurement point. This will be used to provide an estimate of percent cover (# observations / 25 total possible observations * 100% = % cover).
- Coarse and Fine Woody Debris Retention Assess coarse woody debris retention along the 25 m transect line using the coarse woody debris and fine woody debris monitoring protocols contained in this manual.

11.4 Equipment

- Loggers tape
- Hip chain
- Pocket penetrometer
- 3.99m regeneration survey plot cord
- 2 m tape
- Shovel
- Clinometer
- Compass
- Digital camera
- Air photo
- Calculator
- 25 m transect rope and stakes to secure rope at either end
- Go-no-go gauge
- GPS
- Field data forms (including fine and coarse woody debris)

Table 1: Dispersed disturbance categories

Symbol	Category	Example
R	Wheel or track ruts	Machine traffic on wet soils
C	Compaction	Compacted mineral soil, puddled mineral soil, or compacted organics
T	Repeated machine traffic	Skid trails
G	Gouges	Gouges are excavations into mineral soil caused by harvesting activities. Examples include mound excavations; excessive ripper-plow trenches; poor screefing, mounding, or stumping; intermittent trail blading
S	Scalps	Scalps are areas where the forest floor has been removed by harvesting activities. Examples include aggressive patch scarification scalping during piling, or on skid trails or scalping during piling, scalping on skid trails, areas where the forest floor has been completely burned off.
B	Burned	Burn piles (does not include natural burns)
X	Not counted	Survey points not meeting the criteria of categories above, or that fall on large logs, boulders, or slash piles where the ground surface cannot be seen and reliable assessment cannot be made

11.5 References

BC Forest Resource Evaluation Program (FREP). 2005. Protocol for soil resource stewardship monitoring: cutblock level. BC Ministry of Forests, BC Ministry of Water, Land and Air Protection, and BC Ministry of Sustainable Resource Management. Victoria, BC.

BC Ministry of Forests. 2001. Soil Conservation Guidebook. Forest Practices Code Guidebook.

BC Ministry of Forests. 2001. Soil Conservation Surveys Guidebook. Forest Practices Code Guidebook.

12.0

Assessment of Tree Attributes for Wildlife Protocol

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Energy, Mines and Resources

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Field Crew _____

Plot Number _____ 3.2.1
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

ASSESSMENT OF TREE ATTRIBUTES FOR WILDLIFE

Tree Number	Species	Standing/ Fallen	% Bark Remaining (at breast height)	Crown Class	Height to Live Crown	Appearance	Crown Condition	Bank Retention	Wood Condition	Lichen Loading	Wildlife Use
12.2.1	12.2.3	12.2.5	12.2.6	12.2.7	12.2.8	12.2.9	12.2.10	12.2.11	12.2.12	12.2.13	12.2.14

ASSESSMENT OF TREE ATTRIBUTES FOR WILDLIFE

Entered into Database? Yes ☐ No ☐

Fixed Area Plot? Yes ☐ No ☐ If FRP page _____ of _____

Variable Radius Plot Yes ☐ No ☐ If VRP, note BAF_____

Comments:

12.0 Assessment of Tree Attributes for Wildlife Protocol

12.1 Purpose

The purpose of this protocol is to assess tree attributes for wildlife. Methods are similar to those in BCMOE and BCMOF (1998).

12.2 Procedure

12.2.1 Plot Establishment

Forest tree measurements will be obtained at each of the subplots. Either a fixed-area circular plot or a variable-radius plot may be used. A fixed area plot is preferable in stands with the following characteristics: very open stands with widely spaced trees (e.g. fuel treatment areas or partially harvested areas) or clumps of trees or very dense stands where not all trees in a plot would be easily visible. Once selected, the same plot-type should be used consistently throughout the project. Consult the table at the front of this monitoring manual and the study design for the monitoring project you are working on for guidance on whether to establish a fixed-radius or a variable radius plot. Consult the monitoring site establishment protocol and the mensuration protocol in this manual for instructions on how to establish the plot and identify plot trees. Note: If the mensuration protocol is part of your study design, please use the same plot trees.

12.2.2 Criteria for Measurable Trees

All trees greater than 7 cm DBH that have been selected during the Tree Mensuration Protocol will be measured. All live and dead trees, standing and fallen are included.

12.2.3 Species

Record the species name, for both live trees and dead trees (if possible). Please use species codes in the Table 1.

Table 1: Tree species codes

Tree Species	**Code**
Trembling Aspen – Populus tremuloides	A
Balsam Poplar – Populus balsamifera	B
Subalpine Fir – Abies lasiocarpa	F
Larch – Larix laricinia	L
Lodgepole Pine – Pinus contorta	P
Black Spruce – Picea mariana	SB
White Spruce – Picea glauca	SW
White Birch – Betula papyrifera	W

12.2.4 Diameter

Using a diameter tape, or a set of tree calipers, determine diameter to the nearest cm at a height of 1.3 metres above the ground (DBH).

12.2.5 Standing/Fallen

Classify the tree as standing or fallen using the codes and criteria in Table 2.

Table 2: Criteria for classifying trees as either standing or fallen. Source: BCMOE and BCMOF 1998

S	Standing trees or portions of trees with the root attached and self-supporting (i.e., the tree would remain standing if all supporting materials were removed).
F	Fallen trees (or leaning trees) or portions of trees with the root attached and not self-supporting, greater than 1.3 m in length.

12.2.6 Remaining Bark

Record, to the nearest percent, the percentage of bark remaining at breast height. Use the diameter tape to measure the total circumference and the portion of the circumference with bark remaining. The ratio of the two numbers multiplied by 100 equals the percent remaining bark. For example, if a tree with a 60 cm circumference has bark remaining on 15 cm, the percent remaining is 15 / 60 x 100 = 25%.

12.2.7 Crown Class

Assign a crown class designation to all standing live trees per Table 3.

Table 3: Crown class.
Source: BCMOE and BCMOF 1998.

D	Dominant Trees with crown extending above the general level of the layer; somewhat taller than the codominant trees, and have well developed crowns, which may be somewhat crowded on the sides.
C	Codominant Trees with crowns forming the general level of the crown canopy; crown is generally smaller than those of the dominant trees and usually more crowded on the sides.
I	Intermediate Trees with crowns below, but extending into the general level of the crown canopy; crowns usually small and quite crowded on the sides.
S	Suppressed Trees with crowns entirely below the general level of the crown canopy.

12.2.8 Height to Live Crown

For each live tree, measure height to live crown (effective portion of the live crown for growth) in metres. This is normally the height on the stem at which live branches occupy about three-quarters of the stem circumference. Enter negative one (-1) for trees with no "effective" crown (e.g., only a few green branches).

12.2.9 Visual Appearance

For each tree, enter a code (1-9) for the illustration in Figure 1 that best represents the appearance of the tree, using the shape of the tree stem as the dominant characteristic.

Figure 1: Visual appearance codes for wildlife trees. Source: BCMOE and BCMOF 1998.

Gradual death: conifers	General description of tree	Wildlife uses and users	Stages of decomposition
1	**live/heathy** – no decay	nesting; roosting; perching; territory; large–limb eagle and Osprey nests; raptors; scavengers; Great Blue Heron colonies; Marbled Murrelet	
2	***live/unhealthy*** – internal decay or growth deformities (including insect damage, broken tops); dying tree	nests/roosts – PCEs[a] (strong excavators); SCUs[b]; large–limb nests; insect feeders	
3	**dead**[c] – hard heartwood; needles and twigs present; roots stable	nests/roots – PCEs (strong excavators); SCUs; bats; larger–limb nests; hunting/hawking perches; branch roots; insect feeders	
4	**dead** – hard heartwood; no needles/twigs; 50% of branches lost; loose bark; top usually broken; roots stable	nests/roots – PCEs (weakest excavators); SCUs; bats; insect feeders	
5	**dead** – spongy heartwood; most branches/bark absent; internal decay; roots stable for larger trees, roots of smaller trees beginning to soften	nests/roots – PCEs (weakest excavators); SCUs; bats; insect feeders; salamanders	
6	**dead** – soft heartwood; no branches or bark; sapwood/ heart sloughing from upper bole; lateral roots of larger ones softening; smaller ones unstable	SCUs; insect feeders; salamanders, small mammals	
7–8	**dead** – soft heartwood; stubs; extensive internal decay; outer shell may be hard; lateral roots completely decomposed; hollow or nearly hollow shells	insect feeders; salamanders; small mammals	
9	**debris** – downed stubs or stumps	insect feeders; salamanders; small mammals; amphibians; drumming logs for grouse; flicker foraging, nutrient source	

a This classification system does not apply to downed logs and/or coarse woody debris.
b PCE = primary cavity excavator.
c SCU = secondary cavity excavator.
d The stability of dead trees is influenced by cause of death. Dead trees can be unstable if killed by butt rot or root rot, depending on the species of the fungus. In general, *Phellinus* attack lends to instability; *Armillaria* attack must be assessed carefully on a site–specific basis.

12.2.10 Crown Condition

Using one of the classes in Table 4 rate the condition of the crown in relation to a normal live crown.
Note: lower crown loss due to self-pruning is not counted as foliage or branch loss.

Table 4: Crown condition codes.
Source: BCMOE and BCMOF 1998.

Code	Description
1	All foliage, twigs, and branches present
2	Some or all foliage lost; possibly some twigs lost; all branches usually present; possible broken top
3	No foliage present; up to 50% of twigs lost; most branches present; possible broken top
4	No foliage or twigs present; up to 50% of branches lost; top usually broken
5	Most branches gone; some sound branch stubs remain; top broken
6	No branches present; some sound and rotting branch stubs, top broken

12.2.11 Bark Retention

Indicate the proportion of bark remaining on each tree, using the codes in Table 5.

12.2.12 Wood Condition

Classify the texture (soundness) of the wood for each tree, using the codes in Table 6.

Table 5: Bark retention codes.
Source: BCMOE and BCMOF 1998.

Code	Description
1	All bark present
2	Bark lost on damaged areas only (< 5% lost)
3	Most bark present; bare patches; some bark may be loose (5 – 25% lost)
4	Bare sections; firm and loose bark remains (26 – 50% lost)
5	Most bark gone; firm and loose bark remains (51 – 75% lost)
6	Trace of bark remains (76 – 99% lost)
7	No bark (100% lost)

Table 6: Wood condition codes.
Source: BCMOE and BCMOF 1998.

Code	Description
1	No decay
2	Probable limited internal decay and/or deformities
3	Wood essentially hard; limited decay
4	Wood mostly hard, but decay spreading; soft wood present
5	Balance of hard and soft wood; spongy sections
6	More soft and spongy wood than hard wood
7	No more hard wood; all soft or spongy; powdery sections
8	Hollow shell; outer wood mostly hard or firm

12.2.13 Lichen Loading

Assess all standing live or dead trees for lichen loading on branches that are within 4.5 m of the ground or root collar. Assign a rating (0 – 5) based on comparison with photos in Estimating the Abundance of Arboreal Forage

Lichens (Armleder et al. 1992). A value of 0 indicates no lichens, whether it is a live tree with branches and foliage or a dead tree. If a tree has lichens but none are below the 4.5 m mark, rate as zero.

12.2.14 Wildlife Use

If wildlife are observed using sample trees or if there is evidence of use, record a code for the activity or type of use (Table 7) in the first column and the user (Table 8) in the second column (e.g., a feeding bird [FB], nesting amphibian [NA], denning mammal [DM]). If only the activity can be determined but not the type of user, indicate user as unknown [X]. If no evidence of wildlife use is observed, indicate with U (unusued). If a wildlife species using a sample tree can be positively identified, record the species

12.3 Equipment

- Compass
- Clinometer
- Hypsometer
- Diameter tape
- Increment corer
- Digital camera
- Flagging tape
- Tree tags
- Marker
- Field data form
- GPS
- Quadrat ropes

Table 7: Activity
Source: BCMOE and BCMOF 1998.

C	Cavity nest May be difficult to detect, but locations are somewhat predictable, and in season, the begging calls of nestlings are easy to detect; test a tree with a cavity nest by carefully striking it to determine if the nest is occupied; if possible, note species in the Comments section using the specific species code (see section "User" below). • Many woodpeckers prefer nesting in live hardwoods, often underneath branches. • Nuthatches and chickadees nest in broken-off standing dead trees, or in broken branch holes, often directly below the breakage point where stem rots have entered the tree and softened the heartwood. • Cavity nesters have perfectly round or oval nest holes. • The Pileated Woodpecker and the Common Flicker have oval nest holes. • Downy Woodpeckers, Chickadees, and Nuthatches have small round nest holes. • Brown Creepers have hammock nests under the loose bark. • Some ducks, owls, and squirrels nest in abandoned woodpecker holes.
O	Open nest Nests of eagles, hawks, owls, and herons are usually situated in the upper part or crown of live and dead trees; raptors and herons build large platform-style stick nests.
D	Denning/resting May be used by bears, squirrels, bats, marten, fisher, weasels, skunks, and raccoons. • Bears often hibernate in the hollow trunks of large standing trees, especially western redcedars. • Entrances to tree dens can be basal or arboreal.
F	Feeding Some examples of indicators are: • Pileated Woodpeckers excavate large rectangular feeding holes. • Red-breasted and Yellow-bellied Sapsuckers drill horizontal patterns of sap wells. • Three-toed and Black-backed Woodpeckers scale off bark to feed on insects. • Porcupines gnaw on large sections of bark (diagonal tooth marks are often apparent). • Rabbits, hares, and squirrels feed on the base of young trees (squarish "windows" or girdling at the base). • Squirrels cache cones or leave basal accumulations of cone bracts.

M	Mark tree Trees used mostly for communication of territorial boundaries and during courtship; examples of indicators include claw marks by grizzly or black bears, and antler rubbing by deer or elk.
P	Perching/roosting Some examples of indicators are: • Perch trees of aerial foraging and hawking birds are typically tall, with prominent dead branches which provide a good view of the surrounding area; especially common near riparian edges. • Plucking spots where raptors feed are identified by "whitewash" and remains of prey in the vicinity. • Roost trees are often in sheltered locations with natural or excavated cavities; roosting sites include cavities, hollows, beneath bark, and in foliage.
S	Squirrel cache
U	Unused

Table 8: User
Source: BCMOE and BCMOF 1998.

M	=	mammal
B	=	bird
R	=	reptile
A	=	amphibian
X	=	Unknown

12.4 References

BC Ministry of Environment and BC Ministry of Forests, 1998. Describing Ecosystems in the Field. Land Management Handbook Number 25. http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/fmdte/deif.htm

13.0

"Lite" Fuel Treatment Effectiveness Monitoring Protocol

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13.0 “Lite” Fuel Treatment Effectiveness Monitoring Protocol

13.1 Purpose

The purpose of this streamlined protocol is to install monitoring plots to 1) assist in the development of fuel treatment prescriptions and 2) to monitor the effectiveness of fuel treatments in reducing the potential for the development of a crown fire. This protocol draws from eight of the protocols contained in this manual and, as the alluded to in the title, is a “lite”version of several of these protocols. This protocol was developed with assistance from Brad Hawkes of the Canadian Forest Service.

This protocol was developed for the spruce-beetle killed forests of the southwest Yukon. With some modification it could be applied elsewhere in the Yukon. To be transferred elsewhere the some modification to the tree fuels assessment (fire hazard rating and spot fire potential) protocol, specifically the methods for determining the crown fire characteristic rating, would need to be revised.

13.2 Rationale

Over the next several years there will be a large number of fuel treatments located within the community and interface zones in the Champagne and Aishihik Traditional Territory and elsewhere in the Yukon. Because the installation of a complete monitoring site per the protocols in this field manual is time consuming, it would not be possible to install complete sites in all fuel treatments in the Yukon. Therefore, a “lite” version was developed that is quicker to install than the fully implementing the protocols contained

in this manual. Ideally, full plots will be installed; however, when it is not possible to do the standard full assessment protocol because of limitations on time and/or resources, this more streamlined protocol will enable a greater number of fuel treatments to be monitored. The data collected in this protocol will assist with the development of fuel treatment prescriptions and monitoring of the effectiveness of these treatments in reducing the potential for the development of a crown fire.

The monitoring plots under this protocol must be installed and measured prior to fuel treatments and re-measured on a regular basis after fuel treatments have been carried out (e.g. every five years). This is essential to document changes in understory vegetation, fine and coarse woody debris loads, stand structure, and the number of dead trees in the overstory. The reasoning for how the standard protocols were streamlined for this "lite" version is not discussed here.

It is critical that a specific target/threshold for each protocol attribute be defined (e.g. recommended crown bulk density and base height) to determine if a fuel treatment will be effective in its designed use (e.g. reducing the probability of crown fire development and spread). These targets/thresholds are not listed in this field manual but will be developed and reported in future reports/papers as the fire science on this subject is completed.

13.3 Procedure

The procedures outlined below reference eight of the monitoring protocols described elsewhere in this manual. Unless otherwise specified (below), these protocols should

be implemented as described. The procedures outlined below explain how these procedures have been streamlined for this "lite" version.

13.3.1 Monitoring Site Establishment Protocol

Refer to section 2.0 of this field manual with the following exceptions:

- 2.2.2 The standard procedure is to install one monitoring site per treatment. However, because the "lite" protocol may be used to collect data to assist with the development of the treatment prescription, more than one site is recommended to be installed per treatment area. The number of plots to be established in a treatment area will be based on what is recommended in the standard Yukon inventory guidelines and will be pre-determined. Consult the field sampling plan specific to your project for details on the number of plots to install in each treatment area.
- 2.2.2 Paired plots are not required for this protocol. Plots are only to be established where a treatment is planned to take place.
- 2.2.3 The location of the Point of Commencement will also be predetermined. Consult the field sampling plan specific to your project for details on the locating the Point of Commencement.
- 2.2.4 Each plot will consist of only one subplot, not four per the standard procedure. Only the North subplot will be installed as indicated in Figure 1.

13.3.2 Site Description Protocol

Refer to section 3.0 of the Field Manual and Monitoring Protocols.

13.3.3 Forest Mensuration Protocol

Refer to section 4.0 of the Field Manual and Monitoring Protocols with the following exceptions:

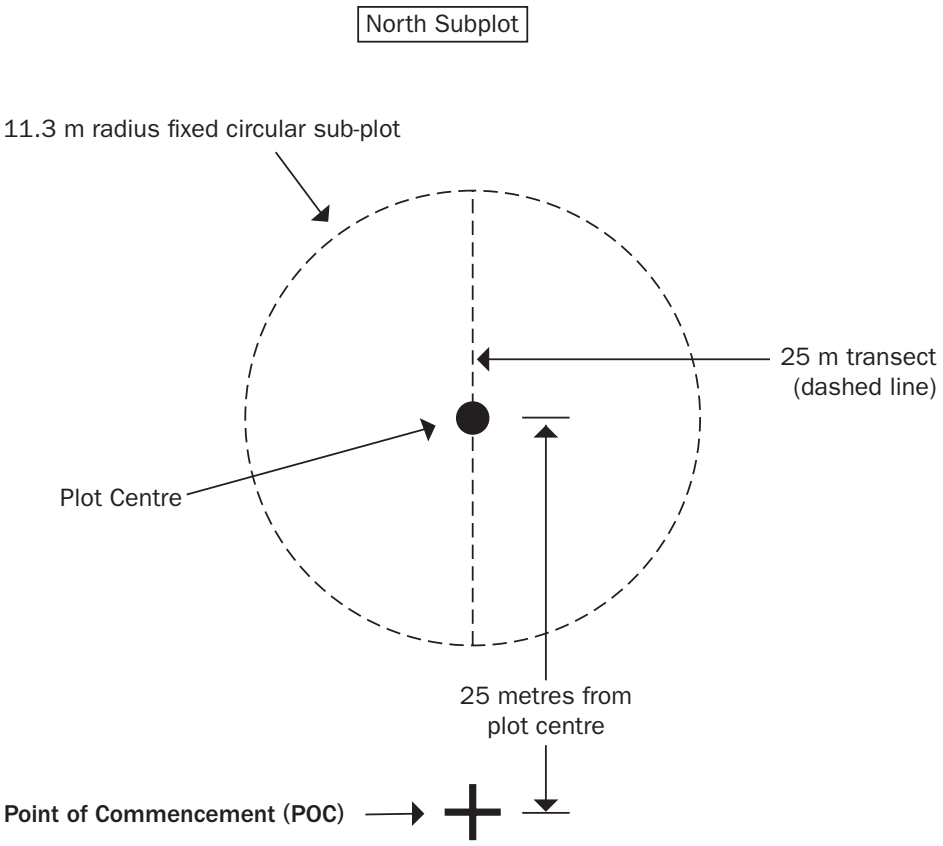
- 4.2.1 – Use a variable radius plot.
- 4.2.13 – Pathological indicators are recorded only if very significant.
- 4.3.14 – Only record the defect location of pathological indicators if they are very significant.

13.3.4 Understory Vegetation Protocol

Refer to section 5.0 of the Field Manual and Monitoring Protocols with the following exceptions:

- 5.3.1 – Do not record percent cover using transect measurements. This means that understory vegetation, leaf litter, fine woody debris, coarse woody debris, burned area will not be recorded along the transect line.
- 5.3.2 – For the purposes of the "lite" protocol, all that is required is the percent cover of understory vegetation species that are representative of site in the 11.3 m radius fixed area plot. A complete list of understory vegetation species is not required. Also record percent cover by the following five classes – tall shrub, low shub, grass, herbs, and mosses and lichens.

Figure 1: Fuel treatment monitoring subplot layout



13.3.5 Coarse Woody Debris Protocol

Refer to section 6.0 of the Field Manual and Monitoring Protocols except for the following two sections:

- 6.3.5 – Do not record tilt angle.
- 6.3.6 – Do not record length of the piece.

13.3.6 Fine Woody Debris Protocol

Refer to section 7.0 of the Field Manual and Monitoring Protocols.

13.3.7 Tree Fuels Assessment (Fire Hazard Rating and Spot Fire Potential)

Refer to section 8.0 of the Field Manual and Monitoring Protocols except for the following section:

- 8.3.7 – Do not record Spot Fire Potential Rating.

13.3.8 Fuel Treatment Prescription Compliance and Effectiveness Monitoring Protocol

Refer to section 9.0 of the Field Manual and Monitoring Protocols at the exception of a few sections where for the purpose of this protocol:

- 9.4.1 – Do not record measurements for conifer trees using a 11.3 m fixed-radius plot. Conifer tree measurements will be collected from the prism plot established in section 13.3.3 above.
- 9.4.3 – Do not calculate stems per hectare as this will be calculated from data collected from the prism plot established in section 13.3.3 above using the Forest Inventory System.
- 9.4.4 – Do not record stem damage.
- 9.4.8 – Do not record stumps.
- 9.4.10 – Do not record clumps and clusters.

13.4 Equipment

- Compass
- Clinometer
- Hypsometer
- Diameter tape
- Digital camera
- Flagging tape
- Tree tags
- Nails
- Hammer
- Field data forms
- GPS
- 25 m transect rope and stakes to secure rope at either end
- Plant identification guide
- Wooden stakes
- Mallet
- Large calipers

13.5 Field Data Forms

You may use the relevant field data forms found in Appendix A and just fill in the relevant sections outlined in this "lite" version of these protocols. Alternatively, contact the Forest Management Branch for a set of streamlined data forms.

Appendix A

Field Data Forms

Contents Page

Yukon
Energy, Mines and Resources

SITE DESCRIPTION

Date (M/D/Y) _____

Field Crew _____

SIS Number _____

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Location		@ POC	@ Subplot Centre
NTS Mapsheet _____	Latitude	_____	
UTM Zone _____	Longitude	_____	_____
	Easting	_____ __	_____
	Northing	_____	_____

Site Information

Slope _____ Aspect _____ Elevation _____

Site Position

Crest Upper Slope Middle Slope Lower Slope Toe Depression Level

Terrain Even Rolling Gullied Hummocky

Site Index _____

Ecoregion _____ **Vegetation Type** _____

Fuel Type _____ **Soil Type** _____

SITE DESCRIPTION

Access:

Location of Tie Point:

Easting _____

Northing _____

Tie Point to Plot:

Bearing _____

Distance _____

Vehicle Access/Parking:

Entered into Database? Yes ☐ No ☐

Protocols Completed

Site Description _____

Mensuration _____

Understory _____

CWD _____

FWD _____

Tree Fuels _____

Fuel Abatement _____

Soil Description _____

Soil Conservation _____

Wildlife Trees _____

Biodiversity _____

Comments:

Photographs:

Yukon
Energy, Mines and Resources

MENSURATION

Date (M/D/Y) _____

Field Crew _____

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Tree Number	Species	Diameter	Age	Height	Tree Class	Crown Class	Beetle Attack Phase	Chainsaw Damage	Conk	Blind Conk	Scar	Fork	Crook	Frost Crack	Mistletoe	Rotten Branch	Dead or Broken Top	Defect Location Summary

MENSURATION

Entered into Database? Yes ☐ No ☐

Fixed Area Plot? Yes ☐ No ☐ If FRP page _____ of _____

Variable Radius Plot Yes ☐ No ☐ If VRP, note BAF_____

Tree Seedlings (<1.3 m tall)		
Species	**Tally**	**Total**

Saplings (>1.3 m tall and <7cm dbh)		
Species	**Tally**	**Total**

Crown Closure				
North	**South**	**East**	**West**	**Average**

Yukon
Energy, Mines and Resources

UNDERSTORY VEGETATION

Date (M/D/Y) _____

Field Crew _____

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Species List Complete ☐ Partial ☐

Transect					
Tree Species List	**Tally**	**Total /25**	**Grass - Species List**	**Tally**	**Total /25**
Tall Shrub List	**Tally**	**Total /25**	**Herb - Species List**	**Tally**	**Total /**
					25
Low Shrub List	**Tally**	**Total /25**	**Moss/Lichen - _ Species List**	**Tally**	**Total /25**
Leaf Litter Tally /25	**FWD Tally**	/25	**CWD Tally** /25	**Burn Tally**	/25

UNDERSTORY VEGETATION

Entered into Database? Yes ☐ No ☐

Cover by Layer Total /25

Tall Shrub _____
Low Shrub _____
Grass _____
Herb _____
Moss/Lichen _____
Leaf Litter _____
FWD _____
CWD _____
Burn _____

Visual Assessment	
Species	**% Cover**

Yukon
Energy, Mines and Resources

COARSE WOODY DEBRIS

Date (M/D/Y) _____

Field Crew _____

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Tree Number	Species	Origin	Windthrown	Diameter	Decay Class	Tilt Angle	Length of Intact Piece

COARSE WOODY DEBRIS

Entered into Database? Yes ☐ No ☐

Fuel Calculator
Weight (t/ha)
Volume (m3/ha)

Comments:

Yukon
Energy, Mines and Resources

FINE WOODY DEBRIS

Date (M/D/Y) _____

Field Crew _____

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Size Class	Size	Tally	Total
1	< 0.5 cm		
2	0.5 – 0.99 cm		
3	1.0-2.99 cm		
4	3.0 – 4.99 cm		
5	5.0 – 6.99 cm		

FINE WOODY DEBRIS

Entered into Database? Yes ☐ No ☐

Fuel Calculator		
FWD	**CWD**	**TOTAL**
Weight (t/ha)	**Weight (t/ha)**	
Volume (m3/ha)	**Volume (m3/ha)**	

Comments:

Yukon
Energy, Mines and Resources

TREE FUELS ASSESSMENT

Date (M/D/Y) _____

Field Crew _____

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Tree by Tree Assessment

Tree Number	Species	Height	Diameter	Crown Base Height Index (a)	Crown Base Height Actual	Live Crown Base Height Actual	Crown Density Index (b)	Crown Continuity Index (c)	Crown Fire Characteristic (a+b+c)	Sloughing Bark (1=yes 0=no)

TREE FUELS ASSESSMENT

Entered into Database? Yes ☐ No ☐

Stand Totals

Ground Fuel Hazard Rating _____

Dead Tree Density Index _____

Percentage of Trees in Stand with Loose bark _____

Spot Fire Potential Rating _____

Fire Hazard and Spot Fire Potential Ratings

Crown fuel charateristics				**Subtotals**
Crown base height	> 1 m	> 0.5 m 1 m	0.5 m	
Crown base height index	1	2	3	1 – 3
Crown density	low	medium	high	
Crown density index	1	2	3	1 – 3
Crown continuity	low	medium	high	
Crown continuity index	1	2	3	1 – 3
Stand totals				
Dead tree density (stems/ha > 7 cm dbh)	> 0 < 500	500 < 900	900	
Dead tree density index	1	2	3	1 – 3
Surface woody debris (tonnes/ha)	< 20	20 < 50	50	
Surface woody debris index	1	2	3	1 – 3
			total	5 – 15
Spot fire potential rating				
Loose bark trees (%stems > 7 cm dbh)	> 0 < 15	15 < 30	30	
Loose bark trees index	1	2	3	

Comments:

Yukon
Energy, Mines and Resources

FUEL TREATMENT PRESCRIPTION COMPLIANCE AND EFFECTIVE MONITORING
Part 1

Date (M/D/Y) _____

Field Crew _____

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Stems per ha _____ Fuel Type _____

CONIFER TREES												
Tree Number	Species	Diameter	Height	Crown Base Height	Crown Height	Crown Diameter	Crown Spacing Index (1 to 5)	Distance to Nearest Stem	Is tree part of a clump (y/n)	Stem Damage - Chainsaw	Stem Damage - Pile Burning	Stem Damage - Felling

FUEL TREATMENT PRESCRIPTION COMPLIANCE AND EFFECTIVENESS MONITORING
Part 1

Crown Spacing Index	
5	touching
4	0.1-0.5 meter
3	0.5 - 2 meters
2	2 - 4 meters
1	>4 meters

Entered into Database? Yes ☐ No ☐

CLUMPS

Clump Number	Nearest	North	South	East	West

CLUSTERS

Cluster Number	Seedlings		Saplings		Distance to Nearest Stem				
	Species	Tally	Species	Tally	Nearest	North	South	East	West

Yukon
Energy, Mines and Resources

Date (M/D/Y) _____

Field Crew _____

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

FUEL TREATMENT PRESCRIPTION COMPLIANCE AND EFFECTIVENESS MONITORING

Part 2: Stumps

STUMPS			
Size Class	Species	Tally	
		Live	Dead
0cm-10cm			
>10cm-15cm			
>15cm-20cm			
>20cm			

FUEL TREATMENT PRESCRIPTION COMPLIANCE AND EFFECTIVENESS MONITORING

Part 2: Stumps

Entered into Database? Yes ☐ No ☐

Comments:

Yukon
Energy, Mines and Resources

SOIL DESCRIPTION

Date (M/D/Y) _____

Field Crew _____

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Mineral Soil Horizons

Horizon	Depth	Colour	Texture	% Coarse Fragments					Roots	Mottles		Structure		pH
				Gravel	Cobbles	Stones	Total	Shape	Abundance	Abundance	Contrast	Class	Grade	

Comments:

Photographs:

SOIL DESCRIPTION

Soil Profile Diagram

Entered into Database? Yes ☐ No ☐

# of pits/plot 1 (@POC) ☐ **or 4 (@ each subplot)** ☐

Moisture Regime _____

Nutrient Regime _____

Soil Type (e.g. S1) _____

Soil Drainage _____

Root Restricting Layer _____

Water Source _____

Surficial Material _____

Geomorphological Process _____

Rooting Depth _____

Rooting Zone Particle Size _____

Seepage Water Depth _____

Depth to Permafrost _____

Humus Form _____

Soil Classification _____

Organic Soil Horizons

Horizon	Depth	Roots Abundance	Mycelia Abundance	Fecal Abundance	pH

Yukon
Energy, Mines and Resources

EFFECTIVENESS OF MEASURES TO CONSERVE SOIL RESOURCES

Part 1: Cutblock Characteristics

Date (M/D/Y) _____

Field Crew _____

SIS Number _____

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

Permanent Access Structures			Regeneration		
PAS #	PAS Type	Area (Ha)	Plot # (eg NARR1, TASR1)	# Trees	SPH
Temporary Access Structures					
TAS #	TAS Type	Area (Ha)			
Other Disturbances: Landslides, Erosion, and or Drainage Alterations (Ha)					
Disturbance #	Disturbance Type	Area (Ha)			

Comments:

EFFECTIVENESS OF MEASURES TO CONSERVE SOIL RESOURCES

CWD form completed Yes ☐ No ☐ **Entered into Database?** Yes ☐ No ☐

FWD form completed Yes ☐ No ☐

Total cutblock area (ha) _____

Total area is PAS (ha) _____

Net area to be reforested (ha) _____

Total area in TAS (ha) _____

Percent of NAR successfully regenerated _____

Total area affected by landslides, erosion and/or drainage alterations _____

Cutblock sketch. Locate and label PAS, TAS, and other disturbances.
Note approximate location of NAR regeneration survey plots.

Yukon
Energy, Mines and Resources

Date (M/D/Y) _____

Field Crew _____

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

EFFECTIVENESS OF MEASURES TO CONSERVE SOIL RESOURCES

Part 2: Paired Plot Measurements

Compaction		Forest Floor						Soil Disturbance					
Meters	Compaction	Organic Soil Horizon	Leaf Litter	FWD	CWD	Exposed Mineral Soil	Burned Soil	Wheel or Track ruts	Compaction	Repeated Machine Traffic	Gouges	Scalps	Burned
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													

EFFECTIVENESS OF MEASURES TO CONSERVE SOIL RESOURCES

Part 2: Paired Plot Measurements

Entered into Database? Yes ☐ No ☐

Compaction		Forest Floor						Soil Disturbance					
Meters	Compaction	Organic Soil Horizon	Leaf Litter	FWD	CWD	Exposed Mineral Soil	Burned Soil	Wheel or Track ruts	Compaction	Repeated Machine Traffic	Gouges	Scalps	Burned
15													
16													
17													
18													
19													
21													
22													
23													
24													
25													

Comments:

Yukon
Energy, Mines and Resources

Date (M/D/Y) _____

Field Crew _____

Plot Number _____
(Plot Type – Location – Site Number - SubPlot - Treatment Type)

ASSESSMENT OF TREE ATTRIBUTES FOR WILDLIFE

Tree Number	Species	Standing/ Fallen	% Bark Remaining (at breast height)	Crown Class	Height to Live Crown	Appearance	Crown Condition	Bank Retention	Wood Condition	Lichen Loading	Wildlife Use

ASSESSMENT OF TREE ATTRIBUTES FOR WILDLIFE

Entered into Database? Yes ☐ No ☐

Fixed Area Plot? Yes ☐ No ☐ If FRP page _____ of _____

Variable Radius Plot Yes ☐ No ☐ If VRP, note BAF_____

Comments:

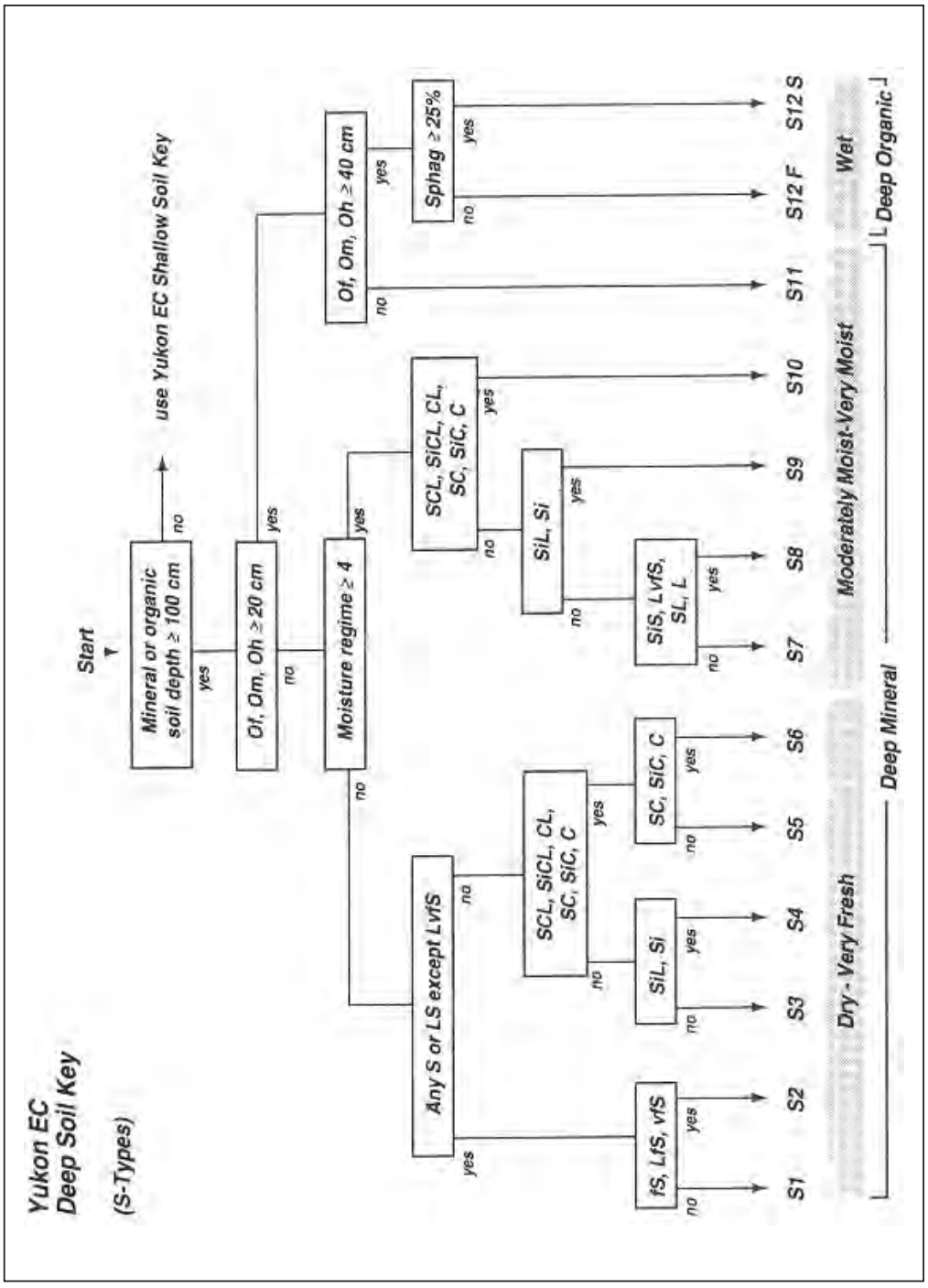
Appendix B

Keys for Vegetation and Soil Typing

Contents Page

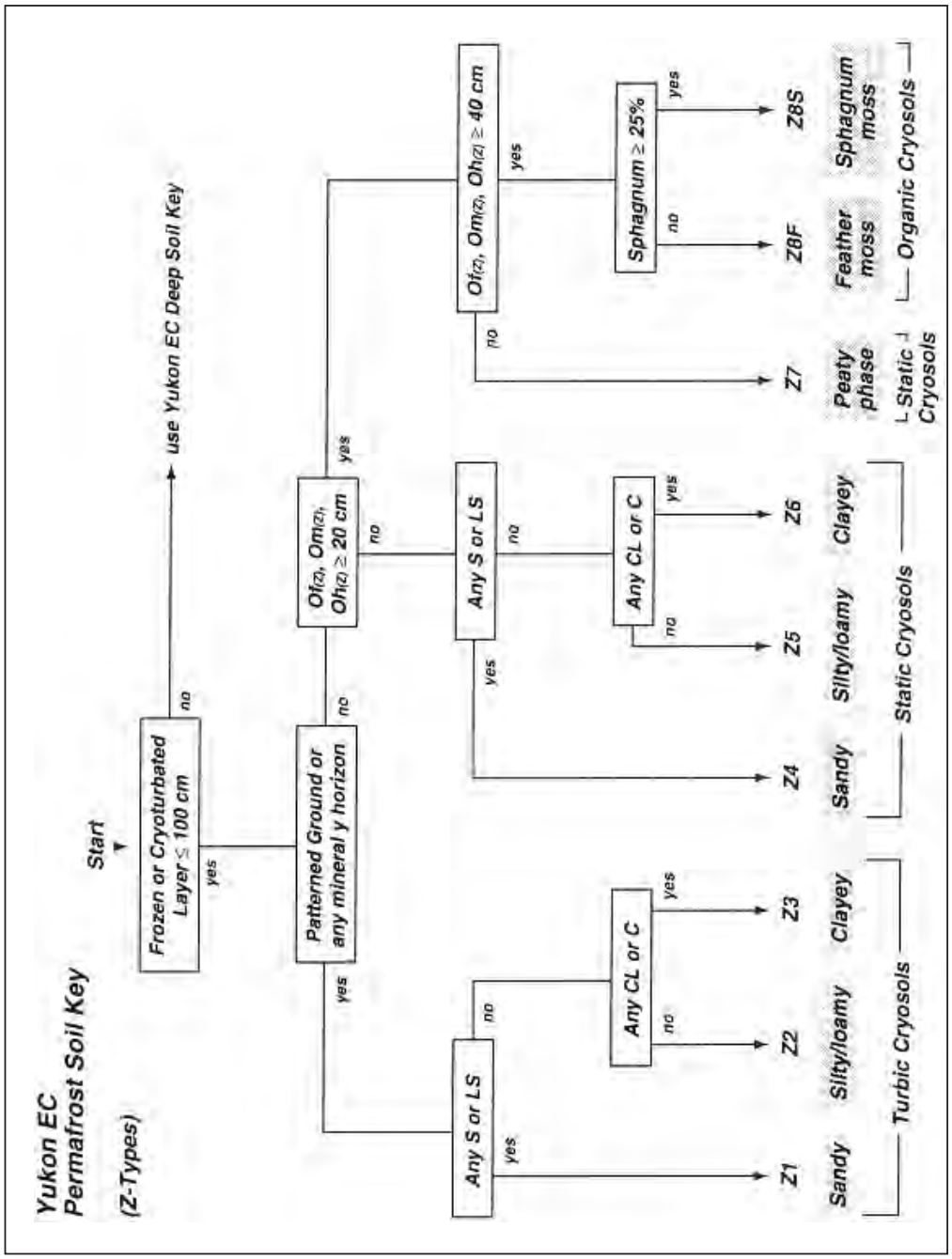
Deep soil key

Source: Zoladeski et al. 1996.



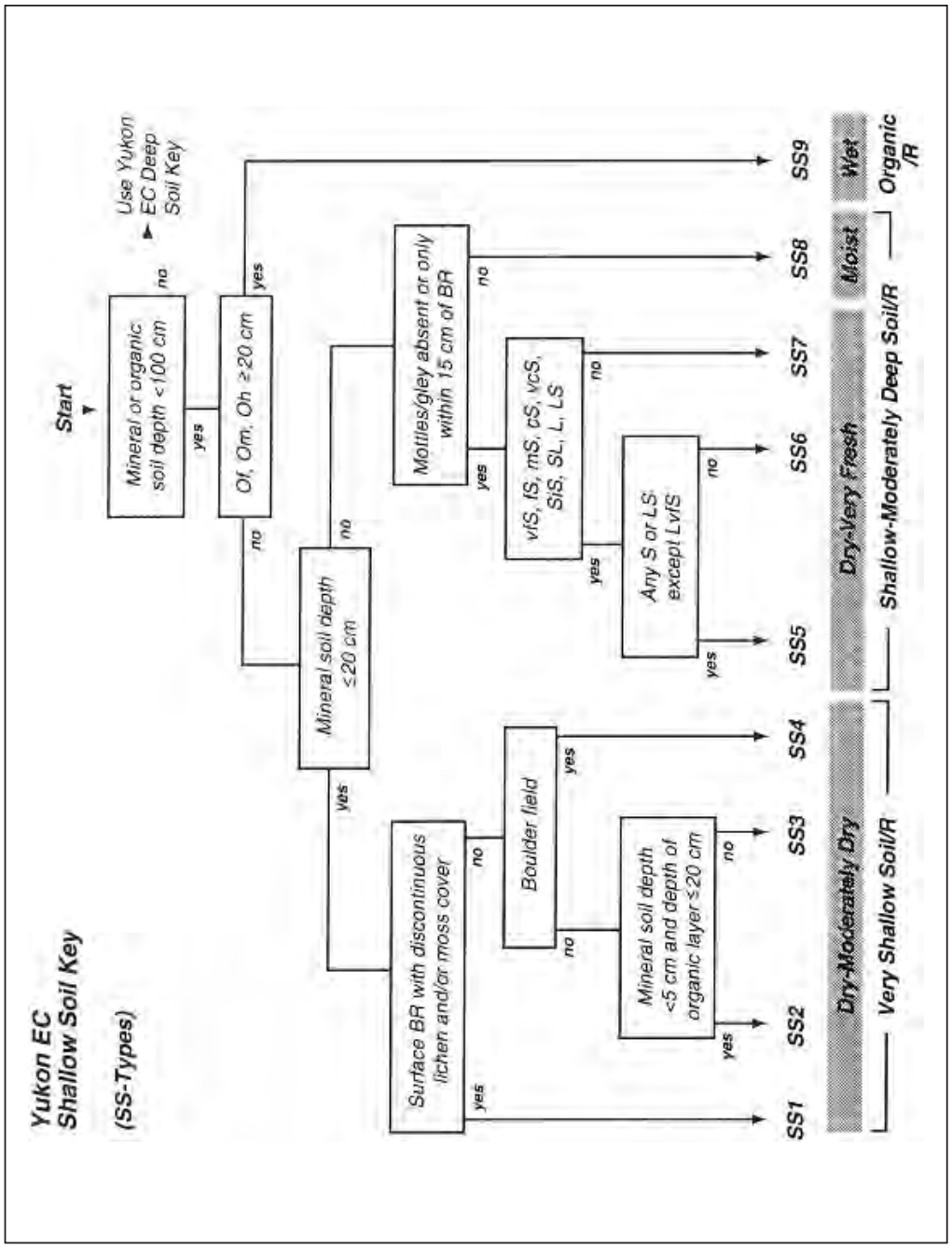
Permafrost soil key

Source: Zoladeski et al. 1996.



Shallow soil key

Source: Zoladeski et al. 1996.



Vegetation type keys

Overview of V-types

1. Treed (tree cover ≥ 10%)

A. Treed deciduous (Deciduous trees compose ≥ 75% of Canopy)

Tree cover ≥ 50%

- V1 Closed paper birch forest
- V2 Closed trembling aspen forest
- V3 Closed balsam poplar forest
- V4 Closed aspen-balsam poplar forest

Tree cover < 50%

- V5 Open paper birch forest
- V6 Open trembling aspen forest
- V7 open balsam poplar forest
- V8 Open aspen-balsam poplar forest

B. Treed coniferous (Coniferous trees compose ≥ 75% of Canopy)

Tree cover ≥ 50%

- V9 Closed alpine fir forest
- V10 Closed alpine fir-white spruce forest
- V11 Closed white spruce forest
- V12 Closed black spruce forest
- V13 Closed white spruce-black spruce forest
- V14 Closed lodgepole pine-spruce forest
- V15 Closed lodgepole pine forest

Tree cover < 50%

- V16 Open alpine fir forest
- V17 Open white spruce forest
- V18 Open black spruce forest (mineral soil)
- V19 Open black spruce forest (organic soil)
- V20 Open white spruce-black spruce forest
- V21 Open lodgepole pine-spruce forest
- V22 Open lodgepole pine forest
- V23 Open tamarack-spruce forest
- V24 Open tamarack forest

C. Treed mixed
(neither deciduous nor coniferous trees compose ≥ 75% of Canopy)

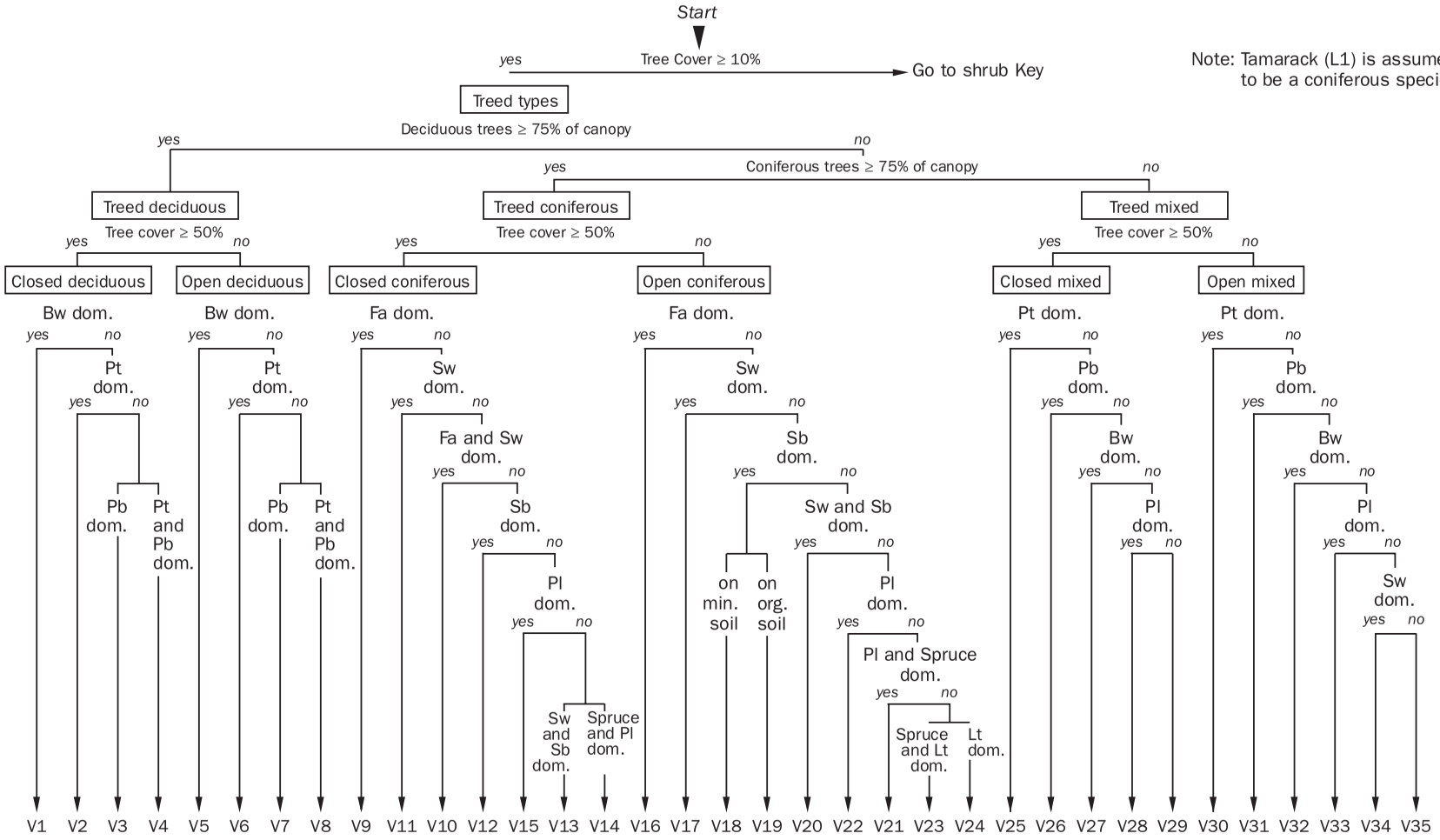
Tree cover ≥ 50%

- V25 Closed trembling aspen-spruce-pine forest
- V26 Closed balsam poplar-spruce forest
- V27 Closed paper birch-spruce forest
- V28 Closed lodgepole pine-aspen forest
- V29 Closed spruce-aspen forest

Tree cover < 50%

- V30 Open trembling aspen-spruce (pine) forest
- V31 Open balsam poplar-spruce forest
- V32 Open paper birch-spruce (pine) forest
- V33 Open lodgepole pine-aspen forest
- V34 Open white spruce-paper birch (aspen) forest
- V35 Open black spruce-aspen forest

Yukon Ecosystem Classification Key to Treed Vegetation Types



Appendix C

Introduced Plants of the Yukon

Contents Page

Appendix C: Introduced Plants of the Yukon

Source: Yukon Invasive Species Committee; Cody, 1996

Invasive-ness Rank	Family	Latin Name	Common Name	Occurrence*	Sightings
1	Poaceae	*Agropyron pectiniforme*	Crested Wheat Grass	C	
1	Poaceae	*Bromus inermis*	Smooth Brome	C	
1	Asteraceae	*Centaurea biebersteinii*	Spootted Knapweed	X	Haines Junction
1	Asteraceae	*Chrysanthemum leucanthemum*	Oxeye daisy	R	Whitehorse & Haines Rd
1	Asteraceae	*Cirsium arvense*	Canada thistle	R	Haines Junction & LaBiche
1	Poaceae	*Elytrigia repens*	Creeping Wild Rye		
1	Poaceae	*Hordeum jubatum*	Foxtail Barley	?	native but weedy invasive
1	Poaceae	*Leymus angustus*	Altai Lyme Grass	R	Carcross
1	Scrophulariaceae	*Linaria dalmatica*	Dalmatica Toadflax	X	known only from Rancheria

1	Scrophulariaceae	*Linaria vulgaris*	Greater Butter-and-Eggs		
1	Fabaceae	*Medicago falcata*	Lucerne	C	
1	Fabaceae	*Melilotus alba*	White Sweetclover	C	
1	Fabaceae	*Melilotus officinalis*	Yellow Sweetclover	C	
1	Poaceae	*Phalaris arundinacea*	Reed Canary Grass	?	some are native and other populations are introduced
1	Asteraceae	*Sonchus arvensis ssp. uliginosus*	Perennial Sow-thistle	C	
1	Asteraceae	*Tanacetum vulgare*	Common Tansy	R	Haines Junction, Whitehorse & Carcross
1	Asteraceae	*Taraxacum officinale*	Common Dandelion	C	
1	Fabaceae	*Vicia cracca*	Tufted Vetch	C	Dawson, Watson Lake, Whitehorse
2	Poaceae	*Agrostis gigantea*	Giant Bent	R	Dawson & Carmacks
2	Poaceae	*Agrostis scabra var. geminata*	Rough Bent	R	Gusty Lake
2	Fabaceae	*Astragalus cicer*	Chick-pea Milk-vetch	R	Haines Junction, LaBiche

2	Brassicaceae	*Brassica rapa*	Canola	R	Dezadeash Lake, Dempster, Mayo (includes B.campestris)
2	Poaceae	*Bromus carinatus*	California Brome	R	Carcross & Watson Lake
2	Brassicaceae	*Capsella bursa-pastoris*	Shepherd's Purse	C	
2	Fabaceae	*Caragana arborescens*	Siberian Peashrub	R	Whitehorse & Dawson
2	Chenopodiaceae	*Chenopodium album*	Lamb's-Quarter	C	
2	Ranunculaceae	*Clematis tangutica*	Golden Clematis		Haines Junction, Whitehorse & Carcross
2	Asteraceae	*Crepis tectorum*	Hawkweed	C	
2	Poaceae	*Elymus hispidus*	Intermediate Quack Grass	R	LaBiche
2	Poaceae	*Elymus sibiricus*	Siberian Wild Rye		Southeast Yukon
2	Poaceae	*Festuca rubra*	Red Fescue	?	
2	Lamiaceae	*Galeopsis tetrahit var.bifida*	Hemp-nettle	R	other
2	Boraginaceae	*Lappula squarrosa*	Stickseed, Bristly Sheepburr		
2	Brassicaceae	*Lepidium ramosissimum*	Branched Pepperwort	C	

2	Poaceae	*Lolium perenne ssp. multiflorum*	Perennial Rye Grass	R	introduced in mining reclaimation mixtures
2	Poaceae	*Lolium perenne ssp. perenne*	Perennial Rye Grass	R	Whitehorse, Watson Lake & Dempster
2	Asteraceae	*Matricaria matricarioides*	Pineapple weed	C	
2	Asteraceae	*Matricaria perforata*	Scentless False Mayweed	R	Ross River & other
2	Fabaceae	*Medicago sativa*	Alfalfa	C	Whitehorse
2	Fabaceae	*Onobrychis viciifolia*	Sainfoin	R	Whitehorse, Ross River
2	Plantaginaceae	*Plantago major*	Great Plantain		native and introduced populations exist
2	Poaceae	*Poa annua*	Annual Blue Grass		
2	Poaceae	*Poa compressa*	Flat-stem Blue Grass		
2	Poaceae	*Poa nemoralis*	Forest Blue Grass	?	
2	Poaceae	*Poa pratensis ssp.pratensis*	Kentucky Blue Grass	?	
2	Poaceae	*Poa trivialis*	Rough-stalk Blue Grass		
2	Polygonaceae	*Polygonum achoreum*	Leathery Knotweed	?	

2	Polygonaceae	*Polygonum aviculare*	Yard Knotweed		
2	Polygonaceae	*Polygonum buxiforme*	Prairie Knotweed		
2	Polygonaceae	*Polygonum convolvulus*	Black-bindweed		
2	Poaceae	*Puccinellia distans*	Spreading Alkali Grass		
2	Polygonaceae	*Rheum rhaponticum*	Rhubarb	C	
2	Polygonaceae	*Rumex crispus*	Curled Dock	R	Dawson
2	Caryophyllaceae	*Silene noctiflora*	Night-flowering Catchfly	R	km 96 Dempster
2	Caryophyllaceae	*Silene vulgaris*	Common Catchfly	R	Dawson
2	Asteraceae	*Sonchus asper*	Spiny-leaf Sow-thsitle		Haines Junction, Whitehorse, Dawson
2	Rosaceae	*Sorbaria sorbifolia*	Sorbaria	R	Dawson
2	Caryophyllaceae	*Stellaria media*	Common Chickweed	C	
2	Poaceae	*Thinopyron ponticus*	Eurasian Quack Grass		
2	Asteraceae	*Tragopogon dubius*	Goat's Beard	R	Haines Junction & Skagway Summit
2	Fabaceae	*Trifolium hybridum*	Alsike Clover	C	
2	Fabaceae	*Trifolium pratense*	Red Clover	C	
2	Fabaceae	*Trifolium repens*	White Clover	C	

2	Fabaceae	*Vicia americana*	American Vetch	?R	this native species has been introduced to Rancheria
3	Poaceae	*Agropyron sibiricum*	Siberian Wheat Grass		
3	Poaceae	*Agrostis capillaris*	Colonial Bent	R	Nisutlin Delta
3	Poaceae	*Alopecurus pratensis*	Field Meadow-foxtail		
3	Boraginaceae	*Amsinckia menziesii*	Small-flowered Fiddleneck	R	Whiteorse and Dawson
3	Caryophyllaceae	*Cerastium fontanum*	Common Mouse-ear Chickweed		
3	Caryophyllaceae	*Cerastium glomeratum*	Sticky Mouse-ear Chickweed	R	Dawson
3	Chenopodiaceae	*Chenopodium pratericola*	Desert Goosefoot	?	
3	Poaceae	*Dactylis glomerata*	Orchard Grass	R	Faro, Ross River
3	Poaceae	*Festuca arundinacea*	Tall Rye Grass	R	Whitehorse
3	Fabaceae	*Lotus corniculatus*	Garden Bird's-foot Trefoil	R	Faro
3	Papaveraceae	*Papaver croceum*	Poppy		Dawson & Mayo (includes P.nudicaule ssp. nudicaule – sensu Cody 1996)
3	Rosaceae	*Prunus padus*	Maytree or European Bird Cherry		Whitehorse, Watson Lake, Carmacks

3	Ranunculaceae	*Ranunculus repens*	Creeping Buttercup	X	Beaver Creek
3	Polygonaceae	*Rumex longifolius*	Door-yard Dock	R	other
3	Polygonaceae	*Rumex pseudonatronatus*	Field Dock	R	LaBiche
3	Asteraceae	*Senecio vulgaris*	Common Ragwort	R	Dawson, Whitehorse
3	Caryophyllaceae	*Spergularia rubra*	Red Sandspurry		
3	Asteraceae	*Taraxacum erythrospermum*	Red-seeded Dandelion		
3	Brassicaceae	*Thlaspi arvense*	Field Pennycress		
3	Fabaceae	*Vicia angustifolia*	Garden Vetch	R	Dawson
4	Aceraceae	*Acer negundo*	Manitoba or Ash-leaf Maple	R	Whitehorse
4	Brassicaceae	*Arabis caucasica*	Gray Rockcress	R	Haines Junction
4	Brassicaceae	*Arabis glabra*	Tower-mustard	?R	native and introduced populations exist
4	Asteraceae	*Artemisia biennis*	Biennial Wormwood	?R	Old Crow
4	Poaceae	*Avena sativa*	Oats		
4	Poaceae	*Bromus tectorum*	Cheat Grass	X	Dawson
4	Brassicaceae	*Camelina microcarpa*	Little-pod False Flax	R	Whitehorse

4	Caryophyllaceae	*Cerastium nutans*	Nodding Mouse-ear Chickweed	?R	Haines Junction, Francis Lake – native to BC possibly introduced
4	Brassicaceae	*Descurainia sophia*	Herb-Sophia		
4	Poaceae	*Festuca trachyphyllla*	Hard Fescue	R	Dawson, Pine Valley
4	Asteraceae	*Gnaphalium uliginosum*	Marsh Cudweed	?R	Carmacks & Mayo
4	Poaceae	*Hordeum vulgare*	Barley	R	Watson Lake & Other
4	Poaceae	*Phleum pratense*	Timothy		
4	Rosaceae	*Potentilla biennis*	Biennial Cinquefoil	X	Dawson, LaBiche
4	Polygonaceae	*Rumex acetosella*	Sheep Sorrel		
4	Poaceae	*Secale cereale*	Rye	R	Watson Lake
4	Chenopodiaceae	*Spinacia oleracea*	Spinach	R	Haines Junction
4	Scrophulariaceae	*Veronica longifolia*	Long-leaf Speedwell	R	Haines Junction
5	Poaceae	*Aira caryophyllea*	Hair Grass	X	Haines Junction - possibly a false report
5	Poaceae	*Alopecurus geniculatus*	Marsh Meadow-foxtail	R	Horseshoe Slough, Fort Selkirk
5	Asteraceae	*Anthemis cotula*	Stinking Chamomile	X	Dawson

5	Boraginaceae	*Asperugo procumbens*	German Mad-wort	X	Whitehorse
5	Poaceae	*Bromus japonicus*	Japanese Brome	X	Haines Junction
5	Poaceae	*Bromus racemosus*	Bald Brome	X	Dawson - called B.hordeaceus in the FOY but based on this species
5	Poaceae	*Bromus secalinus*	Rye Brome	X	Dawson
5	Asteraceae	*Centaurea cyanus*	Cornflower	X	Whitehorse
5	Asteraceae	*Chrysanthemum ircutianum*	Early Daisy	X	Dawson
5	Poaceae	*Deschampsia danthonioides*	Annual Hairgrass	X	Haines Junction & Dawson
5	Poaceae	*Deschampsia elongata*	Slender Hairgrass	X	Whitehorse & Dawson
5	Caryophyllaceae	*Dianthus plumarius*	Carnation	R	Haines Junction
5	Lamiaceae	*Dracocephalum thymiflorum*	Thyme-leaf Dragonhead	R	Dawson
5	Brassicaceae	*Erysimum cheiri*	Wallflower	R	Whitehorse
5	Euphorbiaceae	*Euphorbia esula*	Common Spurge	X	Dawson
5	Polygonaceae	*Fagopyrum esculentum*	Buckwheat	X	Larsen Airstrip
5	Asteraceae	*Gaillardia aristata*	Gailardia	X	Haines Junction
5	Polemoniaceae	*Gilia capitata*	Blue-headed Gily Flower	X	Dawson
5	Caryophyllaceae	*Gypsophila elegans*	Baby's Breath	R	Whitehorse & Ross River

5	Boraginaceae	*Hackelia deflexa*	Nodding Stickseed	?	
5	Asteraceae	*Helianthus subrhomboideus*	Stiff Sunflower	X	Dawson
5	Brassicaceae	*Lepidium sativum*	Garden Pepperwort	X	Dawson
5	Poaceae	*Lolium temulentum*	Poison Darnel	X	Dawson
5	Asteraceae	*Madia glomerata*	Mountain Tarplant	X	Dawson
5	Polemoniaceae	*Microsteris gracilis*	Slender Phlox	?R	Johnson's Crossing, LaBiche
5	Boraginaceae	*Myosotis scorpiodes*	True Forget-me-not	R	Whitehorse, Haines Junction
5	Brassicaceae	*Neslia paniculata*	Yellow Ball-mustard	X	Dawson
5	Apiaceae	*Pastinaca sativa*	Wild parsnip	X	Dawson
5	Poaceae	*Phalaris canariensis*	Common Canary Grass	X	Pelly
5	Boraginaceae	*Plagiobothrys scouleri*	Meadow Popcorn Flower	R	Dawson
5	Plantaginaceae	*Plantago aristata*	Large-bract Plantain	X	Dawson
5	Polygonaceae	*Polygonum fowleri*	Fowler's Knot-weed	X	Whitehorse & Carcross
5	Poaceae	*Polypogon monospeliensis*	Annual Rabbit's-Foot Grass	X	Dawson

5	Poaceae	*Psathyrostachys juncea*		R	Elymus junceus, found only beside Dezadeash Lake 2000
5	Brassicaceae	*Rorippa curvipes var.truncata*	Blunt-leaved Yellowcress	R	Ross River
5	Asteraceae	*Senecio eremophilus*	Desert Ragwort	R	Haines Junction
5	Poaceae	*Setaria viridis*	Green Bristle Grass	X	Whitehorse
5	Brassicaceae	*Sinapis alba*	White Mustard	X	Dawson & Canol
5	Brassicaceae	*Sinapis arvensis*	Corn Mustard	R	Dawson & Canol
5	Brassicaceae	*Sisymbrium altissimum*	Tall Hedge Mustard	R	Whitehorse & Dawson
5	Caryophyllaceae	*Spergula arvensis*	Corn Spurry	X	Dawson
5	Lamiaceae	*Stachys pilosa*	Hedge-nettle	?R	Dawson
5	Ranunculaceae	*Thalictrum dasycarpum*	Purple Meadow-Rue	R	Dawson
5	Ranunculaceae	*Thalictrum venulosum*	Veiny-leaf Meadow Rue	?R	Dawson
5	Fabaceae	*Trifolium cyanthiferum*	Bowl Clover	X	Dawson
5	Poaceae	*Triticum aestivum*	Wheat		
5	Urticaceae	*Urtica urens*	Burning Nettle	X	Dawson
5	Caryophyllaceae	*Vaccaria hispanica*	Cowcockle	R	Dawson
5	Scrophulariaceae	*Veronica arvensis*	Corn Speedwell	R	Haines Junction

5	Scrophulariaceae	*Veronica serpyllifolia*	Thyme-leaf Dragonhead	R	Haines Junction
5	Fabaceae	*Vicia villosa*	Wolly Vetch	X	Dawson
5	Poaceae	*Vulpia myuros*	Rat-tail Six-weeks Grass	X	Dawson
6	Brassicaceae	*Armoracia rusticana*	Horse-radish	F	based on a collection of Rorippa barbareifolia
6	Brassicaceae	*Camelina sativa*	Gold-of-Pleasure	F	based on a collection of C.microcarpa
6	Rubiaceae	*Galium palustre*	Common Marsh Bedstraw	F	Sidney Creek Canol Road
6	Polygonaceae	*Polygonum persicaria*	Lady's-Thumb	F	Mayo & Carmacks
6	Asteraceae	*Sonchus oleraceus*	Common Sow-thistle	F	
6	Verbenaceae	*Verbena hastata var. scabra*	Simpler's-Joy	F	Haines Junction

***Occurrence**

C	Common	*R*	Rare, known from only 1 or 2 localities
?	Possibly native	*X*	Possibly not persistent
F	Falsely reported	*P*	Possible but not yet documented