

FREP Stand Development Monitoring Protocol

Introduction.....	2
Document Purpose	3
Goal of Stand Development Monitoring.....	3
Objectives of the Monitoring Process.....	3
Principles of Stand Selection	3
Indicators.....	4
Basic Stand Development Monitoring Survey Skills	5
Site Selection Criteria for Stand Development Monitoring.....	5
Getting Started: Planning for office and field.....	6
Planning and documentation (office).....	6
Field Procedures.....	9
Field Gear Checklist	9
Field Methods	10
Filling in the forms.....	11
Stand Development Monitoring Field Card – FS 1357	11
Data analysis	16
Data handling	16
Stand stocking.....	16
Species composition.....	17
Pest incidence.....	17
Site index	17
TASS/TIPSY stand volume projections	17
Data cataloguing and reporting.....	17
Cataloguing - FREP	17
Reporting – FREP IMS, RESULTS, and the SDM Milestone report.....	18
Help.....	18
References and additional information	19
Appendix 1.....	20
Appendix 2.....	21
Appendix 3.....	22
Appendix 4.....	30
Appendix 5.....	31

Introduction

The current silvicultural milestone for ensuring effective reforestation is the free-growing declaration. This licensee obligation to create a free-growing stand is one of the few measurable results in the *Forest and Range Practices Act* (FRPA). According to the Forest Practices Board Special Report No. 16¹, "...free-growing requirements ensure that reforested stands remain successfully reforested." Once a stand is declared free-growing the Crown takes over responsibility for the stand and assumes that it will remain healthy and productive until harvest. Timber supply reviews throughout the province base predictions of managed stand productivity, in large part, on the assumptions associated with free-growing designations. The free-growing declaration is the last mandatory entry of stand attributes used in the forest inventory system for stands between that early stage of development and possible harvest decades in the future. Under the Ministry's stewardship mandate, it is essential that the assumptions inherent in the free-growing declaration be tested to ensure validity of the systems that rely on it.

The stand development monitoring (SDM) protocol is designed to look forward from the current stand conditions and to look back to the stand's condition when it was last formally assessed; at free-growing. It is essential that the data collected with this protocol be of a standard that will allow for this two-way assessment. Data must be comparable to free-growing survey data so that it can be assessed for changes between the two assessment points, free-growing and SDM. Although this protocol is designed to re-examine free-growing stands, **this is not a free-growing survey**. Free-growing survey protocols were developed for use in stands aged 10-15.

The protocol assesses age class 2 and 3 stands, (i.e., age 20-60 years). Specific SDM damage criteria have been developed for these age classes and they are generally more lenient than free-growing damage standards (Appendix 3). The SDM damage criteria have considered the fact that competitive relationships between crop trees and brush species have had more time to be resolved in stands of this age. Also for SDM, whether a tree was designated as an acceptable species of conifer at the time of declaration is considered of less importance today, particularly in light of climate change. If a tree is currently healthy and of good form, it can be considered as "acceptable" under this protocol. Broadleaf species in this more liberal approach to species selection are not yet part of SDM but may soon be. Note that in order to compare current free-growing stocking to declaration values, trees must also be tallied following the preferred and acceptable designations used at the time of declaration. We tally trees both with and without the earlier preferred and acceptable designations under this protocol.

This protocol is not intended as a tool to evaluate licensee performance in meeting their obligations under FRPA. This protocol is designed to assess if free-growing stands are meeting timber productivity expectations and to update inventory labels to reflect current stand conditions.

There are over 2.5 million ha provincially of free-growing openings in the Reporting Silviculture Updates and Landstatus Tracking System (RESULTS) database. It is envisaged that this protocol will become a standard mid-rotation monitoring procedure. Over time a considerable

¹ Reforesting BC's Public Lands – An Evaluation of Free-Growing Success. 2003. Forest Practices Board. Special Report FPB/SR/16. 37 pp.

FREP Stand Development Monitoring Protocol

basis for comparisons will be developed between the condition of stands at the time of declaration and the current stand condition. However, care will need to be taken to ensure that equivalent values are compared. These comparisons will form a central component of managed stand productivity estimates in Timber Supply Reviews. This protocol will provide a powerful tool for monitoring stand development and checking management assumptions.

Document Purpose

This protocol provides background and procedures for designing, conducting and analyzing a stand development monitoring (SDM) project under the Forest and Range Evaluation Program (FREP).

Goal of Forest Health Stand Development Monitoring

The goal of this protocol is to provide a tool for monitoring and updating the inventory of managed stands and to test if free-growing stands are meeting timber productivity expectations.

Objectives of the Monitoring Process

When a stand is declared free-growing it is assigned an inventory label based on leading species composition, stocking, age and site index. This protocol is designed to check each of those attributes and **to derive an updated inventory label milestone to add to the current mandatory RESULTS milestones of regeneration delay and free-growing.** Another objective is to check for significant changes in well-spaced and free-growing density between declaration and this assessment. Such changes can be an indication of compromised forest health. A further objective of this protocol is to provide a mid-rotation check of TASS/TIPSY stand yield projections.

Specifically the following questions are addressed through this monitoring process:

- Is there a significant change in the number of well-spaced and free-growing (preferred and acceptable) species from the time of the free-growing declaration to the present?
- Is there a significant change in total stand stocking from the time of free-growing declaration to the present and, if so, is that change within the range that would be expected for stands at this stage of stand development?
- Is there a significant change in forest pest incidence from the time of the free-growing declaration to the present?
- Is there a significant change in the composition of leading species from the time of the free-growing declaration to the present?

Principles of Stand Selection

The single most important underlying sampling principle of this protocol is that stands must be selected from a sampling area (i.e., TSA or district) without bias. The tendency to want to target sampling on stands in areas where problems are already known to exist must be avoided. Such a bias defeats the purpose of this protocol and would limit the ability to make historical comparisons or predictions of the conditions of similar stands throughout the sampling area. Only when stands are randomly selected from throughout the sampling area is it possible to make inferences about that greater population.

FREP Stand Development Monitoring Protocol

This protocol is derived from more intensive FREP studies that were piloted in several timber supply areas. It is simplified from the original studies in order to be easier to implement. This protocol is flexible in terms of the timeline and resources required, in consideration of the larger district FREP monitoring strategy. Both the intensive studies and this protocol adhere to the same sampling standards and mainly vary in the complexity, scale, timing and intensity of sampling.

The basic sampling unit for this survey is the unique polygon (an opening or portion of an opening). A polygon is a unit that has uniform stocking standards, uniform silviculture and inventory labels, and has been declared free growing as a single entity.

The initial sampling design was created to monitor a sample of post-free growing stands in a TSA within one field season. This design required 60 randomly selected polygons, that were divided into two groups (declared 1987-1994 or 1995-2001), to be used as the basis for contrast and comparison. The age distinction was made because the legal free-growing requirement came into effect in 1987 and remained relatively unchanged until 1994 when minimum tree heights were introduced. In the future, a third group starting from 2005 that tracks stands declared after the implementation of the FRPA may be added.

In this protocol the sample population to draw from will be all polygons within a TSA surveyed for declaration from 1995 to 2001 inclusive, and which meet the minimum selection criteria described later in the site selection criteria section. Free-growing survey dates and actual declaration dates are not the same. We base comparisons on the last field survey used to declare stands.

The original design was relatively expensive to implement since it required intensive data collection over a single season. This protocol makes the benefits of monitoring more accessible to districts through their annual FREP activities and has the flexibility of acquiring the data over several years.

Indicators

There are several indicators that are used to assess managed stand development and stand-level forest health. The core indicators include:

- Leading tree species, height class, age and crown closure (Inventory label);
- Total trees;
- Well-spaced (WS) and free-growing (FG) tree density;
- Pest incidence including live and dead trees;
- Current site index; and
- BEC classification to site series (from FG declaration).

Some optional indicators include:

- Well-spaced density of preferred and acceptable tree species;
- Stand management treatments;
- Current stand volumes; and
- Current diameter class distributions.

Basic Stand Development Monitoring Survey Skills

This stand development monitoring protocol follows some of the basic silviculture survey procedures. Additional data are collected to meet the protocol objectives. Silviculture survey experience can be beneficial; however, it is not required to carry out the SDM protocol. The knowledge and skills that will be beneficial to completing this protocol are:

- Ability to identify forest health pests and diseases;
- Ability to identify tree species and plants (especially indicator plants);
- Ability to identify BEC zone, variant and site series;
- Knowledge of silviculture survey procedures and objectives; and
- General knowledge of inventory purposes and the impacts to timber supply.

One of the most important aspects of this protocol is forest health agent identification. It is highly recommended that regional forest health specialists be contacted and an orientation field session be completed to review survey procedures and the major forest health issues that may be encountered in the survey area prior to commencing the field portion of this protocol.

Site Selection Criteria for Stand Development Monitoring

Each district will be provided with a random list of at least **60** potential polygons generated from the current population of RESULTS polygons (a polygon is a unit that has uniform stocking standards, uniform silviculture and inventory labels, and has been declared free growing as a single entity). The lists will be located on the Forest Practices Branch FTP server at XXXXX or otherwise made available to the district.

From the list of 60 potential polygons, each district will select a sample of 30. Site selection criteria that were used to screen these 30 polygons include:

- Polygons must have been surveyed for free growing between January 1, 1995 and December 31, 2001;
- Polygons must be 10 hectares or greater in size and contiguous;
- Polygons must have a disturbance (harvesting) date of 1960 or later; and
- Polygons must have even aged stand conditions.

Sites should only be deleted from the list for very specific reasons (e.g., landslide, wildfire, TFL lands, etc), which must be documented. If a site does not clearly belong to the sample population, it can be deleted. Questions regarding whether a site is in or out of the defined criteria should be referred to the Resource Value Team (RVT). A site may be deleted from the population if any of the following criteria apply:

- Polygon is a partial cut or multi-layered stand;

FREP Stand Development Monitoring Protocol

- Polygon is within a TFL², woodlot, park, ecological reserve, or other portion of the non-timber harvesting land base; or
- Polygon access or conditions within the polygon making surveying unsafe.

Difficulty (e.g., air- or water-only) or expense in accessing a polygon is not considered sufficient reason to delete a polygon from the sample. Relying on easily accessible polygons may introduce bias into your sample and negatively affect the quality of your findings. Rejected polygons should be replaced from the pool of remaining potential samples on the list. Allow sufficient time to sample all of the polygons chosen for the year. These polygons may be sampled in any order but be careful not to miss any.

Plan the entire field season in advance, keeping in mind the seasonality of forest health issues, for optimal forest health pest and disease identification.

A minimum of 30 polygons should be sampled before a formal report on the status of managed stands in a TSA or district is produced. Allowing for resource constraints faced by districts, it would be acceptable to sample a minimum of 10 sites per year over a three year period. It is not recommended to go beyond a three year field sampling period in order to maintain consistency in the results. It is envisaged that districts will continue to sample stands and update reports after the minimum number of stands have been assessed and reported upon. SDM provides a valuable tool to assess managed stand productivity assumptions in the TSR.

Getting Started: Planning for office and field

Planning and documentation (office)

The initial office planning step for SDM is crucial. Potential sample polygons need to be researched using both electronic (RESULTS) and paper opening file information to ensure that the following five essential pieces of information are available:

- (1) A map showing location of polygon,
- (2) Well-spaced tree density,
- (3) Free-growing tree density,
- (4) Total tree density, and
- (5) The polygon inventory label.

If any of these values are missing the polygon should be dropped, as these values provide the baseline for comparison to current stand conditions. If discrepancies exist between the opening file and RESULTS, defer to the opening file. The minimum inter tree distance (MITD) used at declaration, the M-value, and the preferred and acceptable species should be available from the declaration report and should be recorded for SDM. Unlike the five essential values described above, the omission of these three values does not justify dropping the sample. If a MITD was not identified at declaration it is assumed to be 2m, and missing M-values are assumed to be 6

² Due to administrative differences, SDM on TFLs should be considered separately from TSA monitoring. There is no reason that the SDM protocol cannot be applied to a TFL but it should be done as an independent project.

FREP Stand Development Monitoring Protocol

under this protocol. Recording all relevant information before a decision to include a polygon is made will save on the time and expense of finding a polygon unsuitable in the field.

Office Procedures

- Obtain district-specific list of potential sample polygons (from FTP site or otherwise).
- Create a spreadsheet for tracking information such as acceptability, access, and conformation and source of free growing declaration.
- Pull electronic and paper files for the first 30 blocks (files maybe off site)
- Review opening files and RESULTS information to ensure the polygon is a candidate for sampling, meets the minimum size, disturbance date, access, even aged single layer, etc.
- Review the opening file and RESULTS information on the polygon to ensure all five essential pieces of information are available.
- Record the minimum inter-tree-distance (MITD), M-value and the preferred and acceptable species designations from the original free-growing survey where available.
- Determine (from RESULTS and the opening file) that there are no complicating factors (e.g., fire, landslide, etc.) that would compromise the use of the polygon for sampling.
- Document polygons on the spreadsheet, if accepted or not and why, how to access and from what source was it declared free growing.
- Check air and ortho photos and confirm polygon suitability.
- Using either ARC GIS or Mapview, create maps at 1:10,000 scale for survey planning purposes and a map at 1:25-50,000 for access purposes.
- Plan survey schedule (keeping in mind the timing of forest health issues in the field).
- Prepare a polygon map with 10 plots at a predetermined 100 by 100 metre grid (if using ARC GIS, input UTM points into GPS unit in the office; if using Mapview grid map by hand and input GPS point soon after field work completed). See attached map examples in Appendix 4.
- Prepare a FS 1357 field card for each plot with all the planning information filled in.

FREP Stand Development Monitoring Protocol

Office checklist for the SDM protocol	Done	Reviewed
1. Obtain filtered list of 60 potential free-growing polygons for sampling (from RESULTS query).		
2. Random selection of at least 30 polygons for current year.		
3. Obtain opening summaries from RESULTS and examine opening files for free-growing survey results and stand history for each potential sample polygon.		
4. Confirm sample suitability for at least 10 polygons per year. Document rejected polygons.		
5. Record MITD, preferred and acceptable species, etc from the original declaration and prepare field cards and summary data spreadsheet.		
6. Obtain air photos and create small scale block maps for survey planning. Determine potential plot layout.		
7. Determine accessibility options and set survey schedule.		
8. Obtain all the necessary field guides that will ensure accurate data collection in the field.		
9. Conduct surveys.		
10. Conduct quality control checks on field survey methods, plot data and field cards.		
11. Compile data, enter into spreadsheets, and provide plot and survey summaries for stand stocking, species composition, pest incidence, site index (optional), and stand volumes (optional).		
12. Update polygon record in the FREP IMS database with new stand inventory label, pest incidence, and other relevant stand data.		

Field Procedures

Field Gear Checklist

Use the following checklist to ensure all field gear is available.

Item	Got it?
SDM survey field data cards (FS 1357) or electronic data logger	☐
Airphoto or orthophoto and map with predetermined sampling lines and plot locations	☐
Compass	☐
GPS unit (for polygon location and mapping plot points)	☐
Hip chain	☐
Plot cord(s) suitable for 3.99 and 5.64 m plots, or loggers tape	☐
DBH measuring tape	☐
Carpenter's tape measure for intertree distances	☐
Clinometer (analog or digital, i.e., Vertex)	☐
Small hatchet or field knife	☐
Small swede saw, or folding saw	☐
Hand lens (5x or better)	☐
Pest field identification guide(s)	☐
FS 660 field card (free-growing damage criteria)	☐
Pest Management (or other colour) flagging tape	☐
Increment borer	☐
Calculator	☐
Camera	☐
Personal field and safety gear	☐

Field Methods

Field review of sample polygon:

1. Complete an ocular overview, flyby or walkthrough to confirm that there are no complicating factors (e.g., fire, landslide, etc.) that would compromise the use of the polygon for sampling.
2. Compare the air photos, orthophotos, contour maps and other supporting documentation to confirm polygon location, access, plot placement, etc.
3. Pre-determine offset distance if plot location happens to land in area that is unsafe or unsuitable to survey (e.g., move plot back 10 m because plot center was in a small pond).
Note: you can only offset once for a plot.

Field data gathering for each polygon:

1. For each sample polygon, predetermine the location of 10 – 3.99 m radius silviculture survey plots across the polygon using a 100 X 100m grid. An important principle to keep in mind is that of homogeneous polygons and sampling design. Our provincial inventory system assumes polygons are homogeneous. If we locate 10 plots on a systematic grid within a homogeneous polygon we will have sampled that stand sufficiently, regardless of the size of that polygon. **It is critical that survey plots all land within the same polygon as identified in the free-growing declaration so that current results can be compared to those from the original free-growing declaration.** The GPS co-ordinates of each plot should be recorded to facilitate placement on a polygon map following the survey. Use a predetermined method of identifying GPS plot center location following Silviculture Survey Manual recommended methods.
2. Label POC on flagging ribbon at starting point as SDM with the date, surveyors and distance and bearing to plot 1.
3. For each plot, all trees, including broadleaves, >130 cm in height are tallied by species and layer, excluding layer 4 (regeneration <130 cm in height). All plot data should be tallied on a FS 1357 field card. Since this protocol will typically be applied to stands aged 20-35, layer 4 trees in stands of this age are assumed to have little to no influence on final harvest volumes.
4. For each plot, all well-spaced and free-growing trees are tallied using the same minimum inter-tree distance that was used at the time of declaration. **Vegetative/brush competition is not considered** in the determination of free-growing status under this protocol as crop trees, at this stage of development, have generally established dominance. Thus the only difference between WS and FG in this protocol is the achievement of minimum height in layer 3 trees. Field data are collected ignoring the M-value cap. If desired, the M-value cap can be applied retroactively during data analysis.
5. The spatial orientation of designated well-spaced trees is determined so as to maximize the volume of the plot, within the constraint of the MITD (i.e., the biggest best trees should be selected as well-spaced).
6. Well-spaced and free-growing trees are tallied first regardless of the preferred and acceptable species designations applied in the original free-growing survey. This is an important departure from standard silviculture surveys and is done so that current stand stocking is tallied as optimistically as possible. All healthy green conifer trees in a plot are considered equal in this survey.

7. A second sweep of free-growing and well-spaced trees is conducted tallying only the tree species that were preferred and acceptable at the time of the original free-growing declaration. This second sweep is important for a retrospective assessment of free-growing. Once again use the MITD from declaration.
8. The tree species, height to the nearest 0.1 m, dbh to the nearest 0.1 cm, and height to live crown in m of all well-spaced trees as determined in step 5 are recorded on the SDM field card.
9. The SDM damage criteria are used to define healthy well-spaced and free-growing trees. Pest incidence is only recorded for trees that would not pass the SDM damage criteria. The SDM field card is designed so that individual tree data is tallied by species by layer and by damage agent for both live and dead trees.
10. For each plot, the tallest healthy tree of the dominant species in the polygon should be selected for site index assessment using the growth intercept sampling method³. This tree is selected from within a plot with a larger 5.64 m radius (measured from the same plot centre as the 3.99 m plot) to allow a greater choice of trees. If no healthy dominant tree is present in the larger plot, do not determine site index.

Filling in the forms

The following sections will lead you through the process of filling out the stand development monitoring field card and ensuring all relevant data is collected.

Stand Development Monitoring Field Card – FS 1357

Information to complete the first part of the *Stand Development Monitoring Field Card (FS 1357)* will generally be obtained from the opening file or RESULTS data summary for the opening. All information obtained during the office planning phase must be confirmed during the initial walk-through (i.e., if the sample stand is supposed to be Sx-leading and all you can see are Hw, you may be lost – and then again not necessarily, there could have been a big change in the leading species).

Described on the following pages is a comprehensive and detailed description of the information to be recorded on the FS 1357 field card. This card has a number in each one of the fields that corresponds with the following headings.

³ Growth intercept method for silviculture surveys. 1995. BC Ministry of Forests. Silviculture Practices Branch.

FREP Stand Development Monitoring Protocol

BRITISH COLUMBIA		STAND DEVELOPMENT MONITORING FIELD CARD		SURVEYOR NAME(S)		SURVEY DATE		PAGE OF	
MAPSHEET - OPENING NO.		POLYGON		LOCATION		DISTRICT		TSA	
POINT OF COMMENCEMENT/BEARING & DISTANCE TO THIS PLOT		UTM		ZONE		E		N	
PLOT NO. (5.93m)		MITD (ORIG)		FOREST HEALTH DAMAGE AGENTS		PREF/JACC.		PREFERRED SPP (ORIG)	
TREE SPP	LAYER	TOTAL TREES	TOTAL CON.	DEAD TREES	DEAD CON.	WS	FG	LIVE	DEAD
TOTALS									
1									
2									
3									
1									
2									
3									
1									
2									
3									
1									
2									
3									
1									
2									
3									
NOTES:									
ACCESS NOTES:									
INVENTORY LABEL									
Ldg Spp. % Age Ht(m) % Age Ht(m) % % % % %									
Minor Spp. Cr Cl									

Figure 1. Stand Development Monitoring Field Card (FS 1357).

- Surveyor Name(s):** Record the name(s) of the person who completed the survey.
- Survey date:** Record the date in which the survey data was collected in the field.
- Page:** Record the page number. Include all survey cards in a logical numbering sequence. There should be at least one page per plot for a minimum of 10 pages per polygon. The goal is to provide a logically organized package of survey cards to include in the finished report.
- Mapsheet - Opening No.:** The complete opening number is made up of both the mapsheet number and the opening number. Record the map sheet and opening number of the polygon being surveyed. This information may be located in the silviculture plan or prescription, opening file, corporate database or on the forest cover map.
- Polygon:** Each opening has one or more polygons as defined in the silviculture plan or prescription. Enter the number of the polygon being surveyed.
- Location:** Record the geographic location of the opening. This information may be located in the silviculture prescription, forest cover map, opening file, corporate database or from local knowledge. It should match any existing description or be corrected if the currently recorded location is misleading.
- District:** Record the name or abbreviation for the district. This information may be located in the silviculture prescription, opening file, corporate database, contract or from local knowledge. A map of the Forest Districts and Regions may be consulted.
- Timber Supply Area (TSA):** Record the name of the timber supply area the polygon falls within. In the case of sampling a Tree Farm License, this would be the TFL number.
- BEC:** Record the biogeoclimatic zone, subzone and variant of the polygon. This information can be located in the silviculture plan or prescription, in a corporate database and on biogeoclimatic subzone maps and handbooks. However, biogeoclimatic information should be confirmed during the walk-through.
- Point of Commencement:** For the first plot, record a written description of the location of the point of commencement in the field and the bearing and distance to the first plot. This location should be identifiable on an air photo and a map to ensure the strip lines and plots can be accurately positioned on a map at the completion of the survey. Subsequent plots should have bearing and distance from the previous plot recorded.
- UTM Co-ordinates:** Record the Zone, Easting and Northing reading for this plot.
- Plot No.:** Record the plot number assigned to the plot.
- Minimum Inter-Tree Distance (MITD):** Distance used in original free-growing declaration.

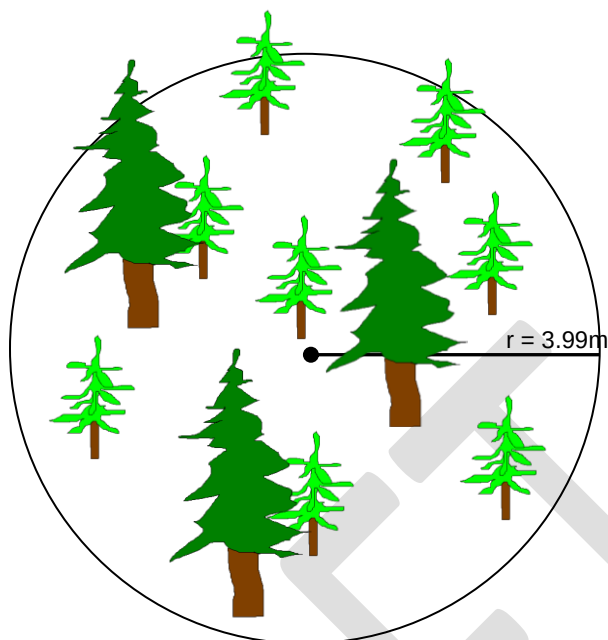


Figure 2. An example of tallying well spaced trees.

When conducting a SDM survey, two sweeps are to be performed per plot. The surveyor is expected to initiate both sweeps starting from a standard point. In this initial sweep, well-spaced and free-growing trees are tallied without regard to the preferred and acceptable species designations in the original declaration. The M-value cap is also ignored. A second sweep, tallying only the preferred and acceptable species from the original declaration is done to allow for retrospective comparisons. Fields 14-24 should be used for the first sweep while fields 25-26 are used for the second.

14. Tree Species: Record the coniferous and broadleaf tree species that occur in the plot starting with the most dominant in size and working down. Do not include non-commercial tree species (as defined by Forest Analysis and Inventory Branch). Refer to the RESULTS tree species codes for a list of the tree species, the codes and the common names of those species that are found in British Columbia. A list is also present on the FS 660 form. Only conifers are tallied as WS and FG unless broadleaf management is actively pursued within the district or TSA.

15. Layer: There are three layers (1 – mature (>12.5 cm dbh), 2 – pole (7.5-12.5 cm dbh), 3 – sapling (>1.3m tall and <7.5 cm dbh), that are tallied separately for each tree species in each plot.

16. Total Trees: Record the total number of live coniferous and broadleaf trees within the plot on the first line. This includes both acceptable and unhealthy unacceptable quality trees. Non-commercial tree species are not tallied under total trees. **Only trees >1.3m tall are tallied.** Note that dot tallies can be done in the boxes below the total line of this column in accordance with the species and layer in which the trees are found if using hardcopy paper data sheets for the all density values live and dead..

17. Total Conifers: Record the total number of live coniferous trees, including both acceptable and unacceptable quality trees in the plot on the first line. **All conifers > 1.3m tall are tallied.**

18. Dead Trees: Record the total number of dead trees, both standing and dead and down, within the plot on the first line.

19. Dead Conifers: Record the total number of dead conifers, both standing and dead and down, within the plot on the first line.

20. Total Well-Spaced (WS): Record the sum of the well spaced trees in the plot, without regard for preferred and acceptable tree species or the M-value, on the first line. Note that the only difference between FG and WS is the achievement of minimum heights in layer 3 trees.

21. Total Free-Growing (FG): Record the sum of the free-growing trees in the plot, without regard for preferred and acceptable tree species or the M-value, on the first line. Note that dot tallies are done in the

FREP Stand Development Monitoring Protocol

boxes below the total line of this column in accordance with the species and layer in which the trees are found.

22. Forest Health Damage Agents: Record the applicable pest code for the unacceptable forest health factors on **each** affected tree within the plot, not just on the well-spaced or free growing trees. Live and dead trees are tallied separately for each damage agent (see below). Refer to the *Damage Agent and Condition Codes FS 747* (Appendix 2) for a comprehensive list of forest health factors and their corresponding pest code. If a forest health factor is unknown or uncertain, describe and record the type of damage, obtain a sample, and consult either the *Field Guide to Forest Damage in British Columbia*, or the district or regional forest health specialist.

If a surveyor wants to record all pest incidence, beyond damage criteria for other reasons, this can be recorded in "NOTES" but must be separated from required data.

23. Forest Health – Live Trees: Record the total number of live trees affected by the forest health factors on the first line. Note that dot tallies are to be done in the boxes below the total line of this column in accordance with the species and layer in which the trees are found.

24. Forest Health – Dead Trees: Record the total number of dead trees affected by the forest health factors on the first line. Note that dot tallies are to be done in the boxes below the total line of this column in accordance with the species and layer in which the trees are found.

25. Preferred and Acceptable – WS: Record the sum of the well spaced trees in the plot, using the preferred and acceptable tree species listed in the original free growing survey and without regard for the M-value, on the first line. Note that dot tallies are done in the boxes below the total line of this column in accordance with the species and layer in which the trees are found.

26. Preferred and Acceptable – FG: Record the sum of the free-growing trees in the plot, using the preferred and acceptable tree species listed in the original free growing survey and without regard for the M-value, on the first line. Note that dot tallies are done in the boxes below the total line of this column in accordance with the species and layer in which the trees are found.

27. Blank field.

28. Preferred and Acceptable Species (Original): Record all preferred and acceptable tree species, using the two letter species code, used in the original free-growing survey.

29. Data WS Trees – Species: Record the abbreviation for the tree species of the selected tree.

30. Data WS Trees – DBH: Record tree diameter at breast height as expressed in cm to 1 decimal place.

31. Data WS Trees – Height: Record tree height as expressed in m to 1 decimal place.

32. Data WS Trees – Height to Live Crown: Record height of the tree bole from the ground to the base of the live crown as expressed in m to 1 decimal place.

33. Growth Intercept Sample: To determine site index using the growth intercept method, record the measurements and species here. Note that the sample tree should be selected from the population of trees found within the larger 5.64 m radius plot. Refer to site index training materials on the growth intercept method.

34. Notes: (Optional) Record site specific details that are relevant to the survey. Leader height, regeneration under 1.3 m, local anomalies within a stratum, presence of wildlife trees are but a few of the possible items that might be recorded. The notes can often be as valuable as the numerical values.

35. Access Notes: (Optional) Record the distance, in kilometers or hours, to the opening from a known location. The kilometers or hours should be listed by each of the individual modes of transportation. Record the estimated time required to travel to the opening from a known location. The time is to be recorded in hours and should be rounded off to the nearest ¼ hour.

36. Inventory Label

Background:

We produce inventory labels to concisely describe a few of the more important characteristics of the strata we survey. It is important to recognise an inventory label is a very general description. As such there are a number of liberties taking in the generalization of a very complex young forest into a rudimentary string of numbers and letters. Some surveyors may wish to collect data in a manner different than the methods described below. The inventory label data will be transferred to central Ministry of Forests and Range database. It becomes important that the data be recorded in a consistent manner in order to allow subsequent analysis.

As silviculture surveyors we receive our guidance on the creation of inventory labels from the Ministry of Forests and Range, Forest Analysis and Inventory Branch. The methods described below are considered their second most representative data source. Permanent sample plots are the only superior data source. The label describes “commercial” tree species. For the purpose of creating inventory labels the list of species considered “commercial” can be found in the reference RESULTS tree species codes and the FS 660.

Inventory labels are determined through a combination of visual observations and individual tree measurements from within the stratum. The estimates and measurements are periodically recorded on the FS 658 plot card. Collect at least three sets of observations or approximately one per four plots established to represent each stratum. These will be “roughly” averaged, (mathematically averaged and manually adjusted as the surveyor sees fit to best describe the stratum) and combined with data from other sources to generate an inventory label for the stratum.

Species composition is determined by ocular estimate. This method of visual observations is known to be most directly comparable to the methods by Forest Analysis and Inventory Branch on mature stands. The leading and second species should be determined during the walk-through stage of the survey process. The determination of species composition is based on tree density for young stands. Volume is used once merchantable volume is present. Merchantable volume, for this purpose, is considered trees with a dbh of 12.5 cm and greater. In practice this means species composition is based on volume only for layer 1 in multi-story surveys. All the rest are based on visually estimated tree density.

An important expression of the generality of the inventory label can be seen in the requirement for species composition to be rounded to the nearest 10% and expressed as a single digit, e.g. 40% = 4. The combination of all species must sum to 100% or 10.

Inexperienced surveyors often over estimate the minor species present. They also under estimate the proportion represented by small trees that may be visually obscured by larger trees. This is most common where dense layers of shade tolerant species naturally regenerate under the partial shade of larger and older planted trees. Age and height are recorded to the last completed year's growth.

37. Leading Spp.: Record the abbreviation for the most abundant species.

38. %: Record a visual estimate of the proportion of total trees present that are Leading Spp. The species composition is rounded to the nearest 10 percent and expressed as 1=10%, 4=40%. When combined, the species composition must equal 100%.

39. Age: Select a dominant or co-dominant tree of the leading species as recorded in field 37 and determine its age.

40. Ht: (m) Select a dominant or co-dominant tree of the leading species as recorded in field 37. Height is expressed in m to 1 decimal place.

41. 2nd Spp.: Record the abbreviation for the second most abundant species.

42. %: Record a visual estimate of the proportion of total trees present that are 2nd Spp. As with field 38, the species composition is rounded to the nearest 10 percent.

FREP Stand Development Monitoring Protocol

43. Age: Select a dominant or co-dominant tree of the 2nd species as recorded in field 41 and determine its age.

44. Ht.(m): Select a dominant or co-dominant tree of the 2nd species as recorded in field 41. Height is expressed in m to 1 decimal place.

45. Minor Spp.: For the purpose of data collection, minor species can be considered all those species not already recorded in fields 37 or 41 that represent 10% or more of the total species composition.

46. %: Fields 45 and 46 are treated as a matched pair. The percentage entered in field 46 corresponds to the species entered above it in field 45.

47. Cr Cl: Forest Analysis and Inventory Branch prefers that crown closure be determined from the visual observation from aerial photography. There are a number of “speckle” diagrams available to assist with calibrating ones estimate. Since recent aerial photographs are not always available we are forced to use ground based visual assessments. Figure 27a in the FS 660, Silviculture Survey Reference may be useful as a benchmark. It should be used with caution. While it may be effective for robust coastal stands, it often over estimates the interior stands whose crowns are smaller in diameter. Lower site index sites are also greatly over estimated. Crown closure is estimated to the nearest 1%.

Data analysis

Data handling

In the longer-term, it is envisioned that survey data will be handled, from field to final report, electronically with as little human intervention after entry as possible. Such a system might consist of a handheld-type data logger down-loading field data into a computer application that would analyze the data and produce standardized reports automatically. This would have the benefit of reducing data entry errors, maintaining format consistency, standardizing reporting, and automating data storage and retrieval.

For 2010, it is unlikely that this system will exist. Until it does, the interim solution will consist of a MS EXCEL workbook that will accept entry of SDM field card plot data and automatically calculate such items as stand stocking, species composition, pest incidence, and other items for each sampled polygon. An associated project summary spreadsheet will allow a comparative listing of all SDM polygon results alongside the original free-growing survey results. This summary will provide a basis for calculating stand volumes from TASS/TYPSY runs and for identifying the data fields required for acceptance into IMS and RESULTS. Districts will be provided the workbook when they undertake a survey project.

Stand stocking

A comparison of the stocking at the time of declaration to current stocking levels for well-spaced, free-growing, and total stems is straightforward provided the same MITD and preferred and acceptable species are compared. Data from the original free-growing declaration or designation provides the baseline to which current stocking can be compared. Using the data analysis function in MS EXCEL, compare the mean stocking value at declaration for each of the three stocking values (well spaced, free-growing, and total trees) to current values as determined from the 10 plot sample in each of the 30+ sampled stands. If some of the sample stands no longer contain minimum stocking densities as determined from the original declaration (700 fg sph in much of the interior, 500 fg sph on the coast) the proportion of stands that no longer pass the minimum stocking threshold should be reported.

Species composition

The percent leading species based on the inventory label from the original free-growing designation is compared to the current inventory label as determined during the field data collection as per standard silviculture survey methodology. The SDM RESULTS milestone will allow for comparisons between the three milestone reports for managed stands throughout BC.

Pest incidence

As the reporting of forest pest incidence has not been standardized in the free-growing survey procedure, it can be quite difficult to compare previous pest incidence to current levels. It is most important to accurately report current incidence. When available, earlier reports of pest incidence can be compared to current levels with the reminder that the permissible margin of error in silviculture surveys is up to 10% absolute difference. The SDM milestone report will provide the most accurate record of forest pests in managed stands throughout the province and will provide a baseline for future comparisons which will be so essential under climate change.

Site index

The reporting of site index has in the past similarly not been consistently applied. It is most important to correctly apply current Growth Intercept Site Index procedures to determine current site index.

TASS/TIPSY stand volume projections

Volume projections using TIPSY are conducted in the full TSA assessment protocol and are not being considered as a mandatory component of this protocol. If TIPSY stand projections are desired, the following steps should be followed. Conduct TIPSY runs using the “create from existing stand” option and the natural stand stem distribution. For the free-growing declaration TIPSY runs, total trees, including deciduous stems, are included as input along with site index as determined using the Growth Intercept Method from the current survey. The age since denudation from the free-growing declaration is used along with the stand age and density at declaration as the initial stand conditions. It is not always possible to iterate TIPSY to the exact stocking value. The leading inventory species at the time of declaration is used. Volumes are projected to a rotation age of 80 years to standardize comparisons.

Data cataloguing and reporting

Cataloguing - FREP

FREP has two methods of cataloguing data.

FREP Meta-data interactive search engine

- a) This method of data storage and retrieval is intended for those monitoring programs that are being developed and their protocol is incomplete or still being tested. These programs will have their data catalogued at this meta-data site. The form of the data is not restrictive and FREP staff can assist program leads in setting up Excel or Access data bases to store the data and produce an annual report consistent with other FREP program annual reports. Once a program’s protocol stabilizes and the continuity of data is assured, the full set of data will be migrated into the FREP Information Management System

FREP Stand Development Monitoring Protocol

(IMS). Note - Prior to entering data, training needs to be completed. Training is accessible at this site - <http://www.for.gov.bc.ca/hfp/frep/ims/training.htm>.

FREP Information Management System (IMS)

- b) Information from monitoring programs that are well established and where the protocols and methodologies are consistent and have been running solidly for several years, the collected information is recorded in this system.

The data collected by the FREP SDM protocol will be added to the FREP Meta-data system. Details on data storage and retrieval will be available by mid-2010.

Reporting – FREP IMS, RESULTS, and the SDM Milestone report

The SDM Milestone report will provide a powerful monitoring tool for forest management throughout BC. SDM data will be stored in the FREP IMS database along with the original free-growing declaration data for the same stand as reported in RESULTS. Once this milestone is created in the FREP IMS database and begins to be populated through this FREP protocol, most of the detailed data analyses that have been conducted in the larger Post Free-Growing FREP reports will be readily available to all MOFR staff. Areas where managed stands are clearly on track and meeting expectations will be easily identified as will areas of concern. Once the FREP IMS/RESULTS relational database for SDM data is created, the process of updating FREP SDM data will be routine for staff to perform.

1. The data would have to be manually entered via online access – there is no licensee electronic system set-up for district staff to enter this update data (this not a huge issue, for district staff are presently updating data in the FREP IMS system either manually in their offices or via contracted service providers).
2. The data would have to be collected following the Silviculture Surveys Manual for the generation of an updated Full Inventory Label.
(This is not a major issue as long as the FH Monitoring protocol is consistent with the Surveys Manual procedures of collecting and producing an Inventory and Silviculture Label – *in reviewing the field procedures these labels will be produced with no modification*).

Help

For further information on planning, surveying and analyzing stand-level monitoring plots, contact any member of the SDM protocol committee which is lead by Alex Woods, Northern Interior Forest Region, Smithers, and includes:

Steve Baumber, Forest Practices Branch, Victoria
Michelle Cleary, Southern Interior Forest Region, Kamloops
Erin Havard, Northern Interior Forest Region, Smithers
Harry Kope, Forest Practices Branch, Victoria
Dave Weaver, Forest Practices Branch, Victoria
Stefan Zeglen, Coast Forest Region, Nanaimo.

References and additional information

Common Tree Diseases of British Columbia

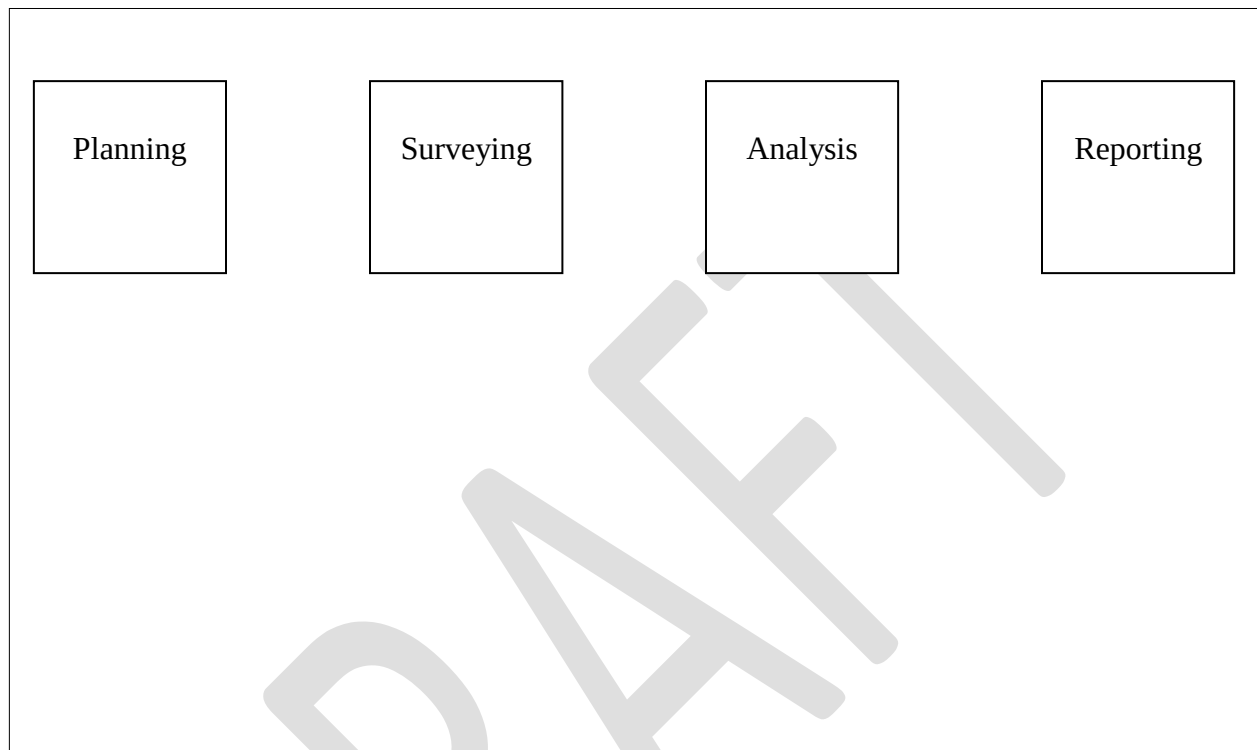
Diseases of *Populus* in British Columbia: A Diagnostic Manual

Field guide to forest damage in British Columbia

DRAFT

Appendix 1.

Process diagram for stand development monitoring.



Appendix 2.

Forest health damage agent and condition codes (FS 747).

FIELD CODES		DESCRIPTION		FIELD CODES		DESCRIPTION	
A		ANIMAL DAMAGE		AP		PORCUPINE	
AB		BEAR		AS		SQUIRREL	
AC		CATTLE		AV		VOLE	
AD		DEER		AX		BIRDS	
AE		ELK		AZ		BEAVER	
AH		HARE OR RABBIT					
AM		MOOSE					
N		ABIOTIC INJURIES		NN		ROAD SALT	
NB		FIRE		NR		REDBELT	
ND		DROUGHT		NS		SLIDE	
NF		FLOODING		NW		WINDTHROW	
NG		FROST		NWS		windthrow-soil failure	
NGC		frost crack		NWT		windthrow-treatment or harvest related	
NGH		frost-heaved					
NGK		shoot / bud frost kill					
NH		HAIL		NY		SNOW, ICE, SNOW PRESS	
NK		FUMECILL		NZ		SUNSCALD	
NL		LIGHTNING					
D		DISEASE		DF		FOLIAGE DISEASES	
DB		BROOM RUST		DFA		western pine aster rust <i>Coeloporium asterum</i>	
DBF		fir broom rust <i>Melampsorella caryophyllacearum</i>		DFB		delphinella tip blight <i>Delphinella</i> spp.	
DBS		spruce broom rust <i>Chrysomya arctostaphyli</i>		DFC		large-spored spruce-labrador tea rust <i>Chrysomya ledicola</i>	
DD		STEM DECAYS		DFD		spruce needle cast <i>Larix medioriparia</i>	
DDA		white mottled rot <i>Ganoderma applanatum</i>		DFE		elytrodema disease <i>Elytrodema deformans</i>	
DDS		white spongy trunk rot <i>Fomes fomentarius</i>		DFG		manesoma leaf blight <i>Manesoma</i> spp.	
DDD		sulfur fungus <i>Laetiporus sulphureus</i>		DFH		cottonwood leaf rust <i>Melampsorella occidentalis</i>	
DDE		rust-red stringy rot <i>Echinodontium tricoloratum</i>		DFI		larch needle blight <i>Hypodermella laricis</i>	
DDH		brown crumbly rot <i>Pontoporia pinicola</i>		DFL		pine needle cast <i>Lophodermella concolor</i>	
DDI		hardwood trunk rot <i>Phellinus igniarius</i>		DFM		larch needle cast <i>Meria laricis</i>	
DDO		brown cubical butt & pocket rot of cedar <i>Postia sericeomollis</i>		DFP		fir-fireweed rust <i>Puccinia larum apicola</i>	
DDP		red ring rot <i>Phellinus pinii</i>		DFR		Douglas-fir needle cast <i>Rhabdoclone pseudotsugae</i>	
DDQ		brown trunk rot (quinine fungus) <i>Fomitopsis officinale</i>		DFS		dothistroma (red band) needle blight <i>Mycosphaerella pinii</i>	
DDS		Schweinitz butt rot <i>Phaeolus schweinitzii</i>		PSS		sirococcus tip blight <i>Sirococcus strobelii</i>	
DDT		aspen trunk rot <i>Phellinus tremulae</i>		POT		cedar leaf blight <i>Dothymacella fluita</i>	
				DL		LEADER OR BRANCH DIEBACKS	
				DLA		dormer canker <i>Dermes pseudotsugae</i>	
				DLF		red flag disease <i>Potodermomyces balsamicola</i>	
				DLK		conifer cytospora canker <i>Leucostoma kuetzi</i>	
				DLP		diaporthe canker <i>Diaporthe tokyae</i>	
				DLS		sydowia tip dieback <i>Sclerophoma pithyophila</i>	
				DLV		aspen & poplar leaf and shoot blights <i>Venturia</i> spp.	
				DM		DWARF MISTLETOES	
				DMF		Douglas-fir dwarf mistletoe <i>Arceuthobium douglasii</i>	
				DMH		hemlock dwarf mistletoe <i>Arceuthobium lugense</i>	
				DML		larch dwarf mistletoe <i>Arceuthobium laricis</i>	
				DMP		lodgepole pine dwarf mistletoe <i>Arceuthobium americanum</i>	
				DR		ROOT DISEASES	
				DRA		armillaria root disease <i>Armillaria ostioyae</i>	
				DRB		blackstain root disease <i>Leptographium wageneri</i>	
				DRC		laminated root rot (cedar form) <i>Phellinus weirii</i>	
				DRL		laminated root rot (fir form) <i>Phellinus weirii</i>	
				DRN		annosus root disease <i>Heterobasidion annosum</i>	
				DRR		rhizina root disease <i>Rhizina undulata</i>	
				DRS		schweinitz butt rot <i>Phaeolus schweinitzii</i>	
				DRT		tormentous root rot <i>Inonotus tormentosus</i>	

FS 747 HSP 2005/02

FIELD CODES		DESCRIPTION		FIELD CODES		DESCRIPTION	
DS		STEM DISEASE (CANKER OR RUST)		IDP		larch sawfly <i>Pristiphora erichsonii</i>	
DSA		atropella canker <i>Atropella piniphila</i>		IDR		alder sawfly <i>Eriocampa ovata</i>	
DSB		white pine blister rust <i>Cronartium ribicola</i>		IDS		conifer sawflies <i>Neodiprion</i> spp.	
DSC		comandra blister rust <i>Cronartium comandrae</i>		IDT		Douglas-fir tussock moth <i>Orygia pseudotsugata</i>	
DSE		scotty bark canker <i>Erccella praeiosa</i>		IDU		satin moth <i>Leucomea salice</i>	
DSG		western gall rust <i>Endocroceum harknessii</i>		IDV		variegated cutworm <i>Peridroma saucia</i>	
DSH		hypoxylon canker <i>Entoleuca mammatum</i>		IDW		western spruce budworm <i>Choristoneura occidentalis</i>	
DSP		cryptosphaeria canker <i>Cryptosphaeria populina</i>		IDX		large aspen tortrix <i>Choristoneura conflictaria</i>	
DSR		ceratocystis canker <i>Ceratocystis fimbriata</i>		IDZ		western false hemlock looper <i>Nepytia freemani</i>	
DSS		atalectiform blister rust <i>Cronartium coleosporioides</i>		IS		SHOOT INSECTS	
DSY		cytospora canker <i>Valsa cordata</i>		ISB		western cedar borer <i>Trachylele blondeli</i>	
I		INSECTS		ISE		European pine shoot moth <i>Pityacontia buoliana</i>	
IA		APHIDS OR ADELGIDS		ISG		gouty pitch midge <i>Cecidomyia pinitropis</i>	
IAB		balsam woolly adelgid <i>Adelges piceae</i>		ISP		pitch nodule moth <i>Pistova</i> spp.	
IAC		giant conifer aphid <i>Cinara</i> spp.		ISS		western pine shoot borer <i>Eucosma zononana</i>	
IAG		Cooley spruce gall adelgid <i>Adelges cooley</i>		ISQ		Sequoia pitch moth <i>Synanthedon segoeae</i>	
IAL		larch cone woolly aphid <i>Adelges laricina</i>		IV		WEEVILS	
IAS		spruce aphid <i>Elatobium abietinum</i>		IVC		conifer seedling weevil <i>Stenomelus carinatus</i>	
IB		BARK BEETLES		IVM		Magdalis sp.	
IBB		western balsam bark beetle <i>Dryocoetes confusus</i>		IVP		lodgepole pine terminal weevil <i>Pissodes terminalis</i>	
IBO		Douglas-fir beetle <i>Dendroctonus pseudotsugae</i>		IVS		white pine weevil (on spruce) <i>Pissodes strobi</i>	
IBI		engraiver beetles (s)		IVW		Warren's root collar weevil <i>Hylobius warreni</i>	
IBM		mountain pine beetle <i>Dendroctonus ponderosae</i>		IVY		cylindrocephalus weevil <i>Cylindrocephalus</i> spp.	
IBP		twig beetles <i>Pityogenes</i> , <i>Pityophthorus</i> spp.		IWZ		Yosemite bark weevil <i>Pissodes schwarzii</i>	
IBS		spruce beetle <i>Dendroctonus rufipennis</i>		M		MITE DAMAGE (TRISETACUS SPECIES)	
IBT		red turpentine beetle <i>Dendroctonus valens</i>		T		TREATMENT INJURIES	
IBW		western pine beetle <i>Dendroctonus brevicornis</i>		TC		CHEMICAL	
ID		DEFOLIATING INSECTS		TH		HARVESTED	
IDA		black army cutworm <i>Aclia feneis</i>		TL		LOGGING	
IDB		two-year budworm <i>Choristoneura biennis</i>		TM		OTHER MECHANICAL DAMAGE (NON-LOGGING)	
IDC		larch casebearer <i>Colopha laricella</i>		TP		PLANTING	
IDO		western winter moth <i>Bramis vancouverialis</i>		TPM		planting — poor microsite	
IDE		spruce budworm <i>Choristoneura fumiferana</i>		TR		PRUNING	
IDF		forest tent caterpillar <i>Melanocoma diastris</i>		TT		THINNING OR SPACING	
IDG		green-striped forest looper <i>Melanophila metata</i>		V		VEGETATION PROBLEMS	
IDH		western black-headed budworm <i>Aclia glomerata</i>		VH		HERBACEOUS COMPETITION	
IDI		pine needle sheath miner <i>Zelleria haemibachi</i>		VP		VEGETATION PRESS	
IDL		western hemlock looper <i>Lambdina foveolaria lugubrose</i>		VS		SHRUB COMPETITION	
IDM		gypsy moth <i>Lymantria dispar</i>		VT		TREE COMPETITION	
IDN		birch leaf miner <i>Pterose pustula</i>					

Appendix 3.

STAND DEVELOPMENT MONITORING DAMAGE CRITERIA FOR EVEN-AGED (AGE CLASS 2 & 3) CONIFEROUS TREES

(Revision 5: 15 January, 2010)

INTRODUCTION

The FREP Stand Development Monitoring (SDM) protocol has been developed to assess stand performance, from a timber yield perspective, 10-30 years following free-growing declaration. The data gathered will help determine whether these stands are on a trajectory that will result in a productive mature stand. The results of a SDM assessment can be used as an evidentiary base to support Forest Practices and Planning Regulation section 97(6) which states “a free growing stand must also meet the requirements, 20 years after the commencement date or 5 years after the completion of the last of any brushing or spacing treatments, and that it will more likely than not be free of forest health concerns or vegetative competition that could result in its growth being impeded.”

SDM damage criteria are based on the free-growing damage criteria, but they have been tailored for determining the health status of stands at a later stage of development (i.e., even aged, age class 2 & 3). These damage criteria are designed to determine the damage to, and acceptability of, **individual** conifers across the province. These criteria do not apply to broadleaf species. SDM damage criteria, in general, are more lenient than free-growing damage criteria as there is more confidence in a tree's continued survival than there is at age 10-15 when stands are declared free-growing. The SDM damage criteria are based on the most current knowledge of forest-damaging agents, and are provided to help users exercise their professional judgment in identifying the "healthy" part of “healthy, well-spaced trees”.

The table below lists various types of damage, causal agents and species of trees. Agents and damage are often referred to by their codes listed on the Ministry of Forests Integrated Data Dictionary Pest_Species_Code list (partly listed on the *Silviculture Damage Agent and Condition Codes* (FS 747) field form). Tree species abbreviations are listed in the Forest Productivity Council publication *Minimum Standards for the Establishment and Remeasurement of Permanent Sample Plots in British Columbia (1999)*.

These criteria have been developed with a consideration to both future merchantability and survivorship in mind. These criteria are expected to be revised as SDM matures and as we learn more about the health and productivity of managed stands post free-growing. At the same time, climate change will increase host stress in many areas making trees more susceptible to pests and pathogens. Forest health agents previously considered benign may increase in incidence and severity, warranting their inclusion in these damage criteria.

SDM DAMAGE CRITERIA FOR EVEN-AGED (AGE CLASS 2 & 3) CONIFEROUS TREES (Revision 5).

PLEASE READ the preceding introduction before using the following table and figures.

LOCATION OF DAMAGE	TYPE OF DAMAGE	TREE BEING ASSESSED IS UNACCEPTABLE IF:	HOST SPECIES	LIKELY DAMAGE AGENTS & DAMAGE AGENT CODES	COMMENTS
STEM	Wound (including sunscald and girdling)	<ul style="list-style-type: none"> the tree has a girdling wound which is greater than 33% of the stem circumference, or the tree has a wound which is equal to or greater than 1m in length. 	All	Biotic causes: bear AB, cattle AC, hare AH, moose AM, porcupine AP, squirrel AS, beaver AZ, atropellis canker DSA Abiotic causes: sunscald NZ, logging TL, mechanical TM, fire NB, windthrow NW	A wound is defined as an injury in which the cambium is dead (e.g., sunscald) or completely removed from the tree exposing the sapwood. Measure the wound across the widest point of the exposed sapwood (or dead cambium when the tree is damaged by sunscald). Healed over wounds (=scars) are acceptable.
STEM	Insect mining at root collar	<ul style="list-style-type: none"> the tree is currently attacked by a bark-mining insect such as a weevil or a beetle and exhibits symptoms such as foliage discoloration, thinning and/or reduced height growth increments 	Pl, Sx	root collar weevil IWW, red turpentine beetle, IBT, lodgepole pine beetle IBL	Only trees that are symptomatic should be checked for insect infestation or mining damage. Non-symptomatic trees are presumed to be unaffected by insect mining.
STEM	Deformation (including crook, fork, browse, and dead or broken top)	<ul style="list-style-type: none"> the pith is horizontally displaced more than 30 cm from the point of defect and originates above 30 cm from the point of germination, or the tree has a fork in the lower 2/3 of the stem and the smaller of the stems is $>\frac{1}{4}$ the diameter of the main stem, or the tree has a dead or broken top at a point that is >5 cm in diameter. 	All All All	Biotic causes: Bear AB, cattle AC, deer AD, elk AE, moose AM, defoliators ID, spruce leader weevil IWS, lodgepole pine terminal weevil IWP, sequoia pitch moth ISQ, Abiotic causes: frost NG, hail NH, snow NY, drought ND, logging TL, mechanical TM, Deep planting TP	For horizontal displacement see Figure 1. For forking , see Figure 2.
STEM	Lean and sweep	<ul style="list-style-type: none"> the tree leans $>30^\circ$ from the vertical with or without growth correction (sweep) 	All	flooding NF, snow NY, slides NS, wind NW, mechanical TM	
STEM	Suppressed	<ul style="list-style-type: none"> the tree has a height to diameter ratio > 100 or, tree has $< 20\%$ Live Crown 	Pl, Py, Pw, Fd, Sx, Lw	Suppressed light environment, leading to high potential for competition induced mortality VT	Note: Only trees that are clearly not expected to reach rotation should be deemed unacceptable
STEM	Infection (including cankers and galls)	<ul style="list-style-type: none"> any infection occurs on the stem, except DSG DSG stem gall affects $>25\%$ of stem circumference 	All Pl, Py	comandra blister rust DSC, stalactiform blister rust DSS white pine blister rust DSB, western gall rust DSG,	Note: Wounds caused by rodent feeding around rust cankers should have stem rust recorded as the causal agent.
STEM	Bark mining	<ul style="list-style-type: none"> Any of the following signs are visible: pitch tubes, boring dust, exit holes on bark surface, galleries under the bark 	Pl, Sx, Fd	Douglas-fir beetle IBD, mountain pine beetle IBM, spruce bark beetle IBS, Ips pini	Stressed trees are susceptible to secondary bark and twig beetles.

FREP Stand Development Monitoring Protocol

				IBI, <i>Pityogenes</i> & <i>Pityophthorus</i> IBP	
LOCATION OF DAMAGE	TYPE OF DAMAGE	TREE BEING ASSESSED IS UNACCEPTABLE IF:	HOST SPECIES	LIKELY DAMAGE AGENTS & DAMAGE AGENT CODES	COMMENTS
BRANCH	Infection (cankers)	<ul style="list-style-type: none"> an infection occurs on a live branch less than 20 cm from the stem. 	Pw, Pl, Py	white pine blister rust DSB, comandra blister rust DSC, stalactiform blister rust DSS	
BRANCH	Gouting	<ul style="list-style-type: none"> any adelgid gouting occurs on a branch. 	Ba, Bg, Bl	balsam woolly adelgid IAB.	Gouting is defined as excessive swelling of a branch or shoot caused by balsam woolly adelgid, and is often accompanied by misshapen needles and buds. It is most common on branch tips and at nodes near the ends of branches. Consult a recent distribution map to identify the geographic extent of this pest.
FOLIAGE	Dothistroma	<ul style="list-style-type: none"> > 50% of tree foliage has been removed by Dothistroma in ICH, CWH, and SBS biogeoclimatic zones. 	All P	Dothistroma needle blight, DFS	See Figure 3
FOLIAGE	Douglas-fir tussock moth and hemlock looper	<ul style="list-style-type: none"> >60% of tree foliage has been removed due to hemlock looper or Douglas-fir tussock moth. 	Fd, Hw	Douglas-fir tussock moth (IDT), hemlock looper (IDL)	
FOLIAGE	Other defoliating insects and disease	<ul style="list-style-type: none"> >80% of tree foliage has been removed due to foliage disease. 	All other conifers Note: Lw	foliage diseases DF, defoliating insects ID	Note: Lw is a deciduous tree so defoliation has less impact, Repeated defoliation attacks will result in dead branches, apply the >80% rule to obviously dead branches, not just defoliated branches as with other conifer species See Figure 3
FOLIAGE	Elytroderma needle cast systemic infection	<ul style="list-style-type: none"> The top 2/3's of the tree is affected and the growth is clearly stunted. 	Pl, Py	Elytroderma needle cast DFE	Note: To confirm infection the surveyor must observe signs of the pathogen as small dark streaks on dead foliage
STEM OR BRANCH	Dwarf mistletoe infection	<ul style="list-style-type: none"> Any layer 1 and 2 tree with a Hawksworth rating >3 (Figure 4). any infection occurs on the stem or a live branch of layer 3 trees. a susceptible tree is located within 10 m of an overtopping tree, which is infected with dwarf mistletoe. 	Hw, Pl, Lw, Fd	Douglas-fir dwarf mistletoe DMF, hemlock dwarf mistletoe DMH, larch dwarf mistletoe DML, lodgepole pine dwarf mistletoe DMP,	Note: To confirm infection, the surveyor must observe mistletoe aerial shoots or basal cups on regeneration or on live or dead fallen brooms. Overtopping tree is a tree that is in an overtopping layer.

FREP Stand Development Monitoring Protocol

LOCATION OF DAMAGE	TYPE OF DAMAGE	TREE BEING ASSESSED IS UNACCEPTABLE IF:	HOST SPECIES	LIKELY DAMAGE AGENTS & DAMAGE AGENT CODES	COMMENTS
ROOTS	Root disease	<ul style="list-style-type: none">sign(s) or a definitive combination of symptoms of root disease are observed.infected tree found in plot. See comments for well-spaced tree net down calculation. The multiplier for all root disease infected trees is 1.	All Fd, Bg, Hw, Sx, Se, Lw Fd, Pl, Pw, Sx Se, Sx, Fd, Pl Ba, Hw, Ss, Fd	armillaria root disease DRA, blackstain root disease DRB laminated root rot DRL, annosus root disease DRN tomentosus root rot DRT, armillaria root disease DRA, laminated root rot DRL. black stain root disease DRB. tomentosus root rot DRT. annosus root rot DRN	<p>Signs are direct evidence of the pathogenic fungus including fruiting bodies, distinctive mycelium or rhizomorphs. Symptoms include foliar chlorosis or thinning, pronounced resin flow near the root collar, reduced recent leader growth, a distress cone crop, and wood decay or stain. An individual symptom is not sufficient to identify a root disease.</p> <p>Note: All conifer species are considered susceptible. All broadleaf species are considered not susceptible for survey purposes only.</p> <p>Note: Cw, Pl, Pw, Py, and all broadleaf species are considered not susceptible for survey purposes only.</p> <p>Note: All other conifers and broadleaf species are considered not susceptible for survey purposes only</p> <p>Note: Bg, Bl, Cw, Cy, Pw, Py, and all broadleaf species are considered not susceptible for survey purposes only.</p> <p>Note: Cw, Cy, Pw, Pl, Py, and all broadleaf species are considered not susceptible for survey purposes only.</p> <p>Example: How to apply net down for all root diseases. If root disease-infected trees are found in the plot: 1. In the first sweep, determine the total number of healthy, well-spaced trees using the prescribed minimum inter-tree distance (MITD) (e.g., 12 trees); 2. In a second independent sweep, determine the number of well-spaced infected trees using MITD (e.g., 1 infected tree); 3. From the number of susceptible healthy well-spaced trees found in step 1, subtract the number of well spaced infected trees. The result (e.g., 11 trees) is the adjusted number of healthy, well-spaced trees tallied for the plot.</p> <p>.</p> <p>.</p>

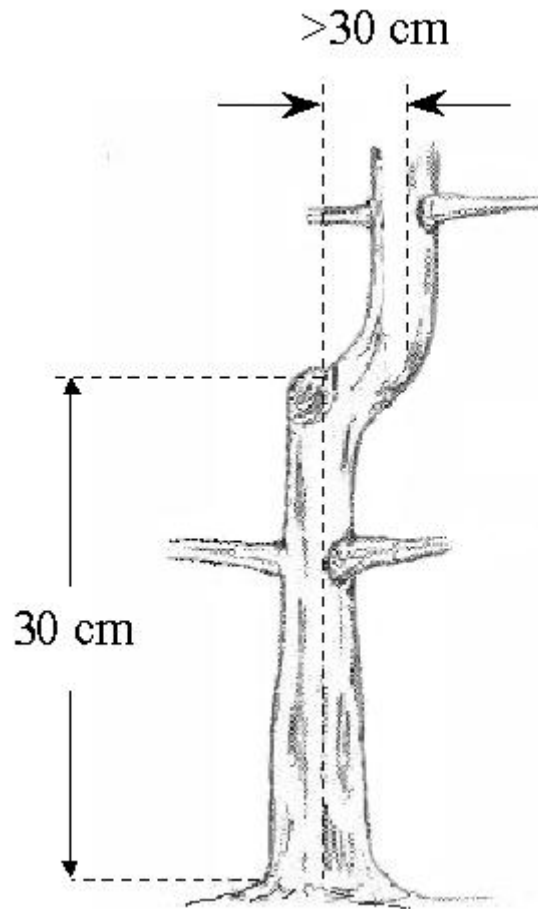


Figure 1. Determining horizontal displacement when assessing stem deformation. This is only done when the tree has five seasons' growth after damage occurs.

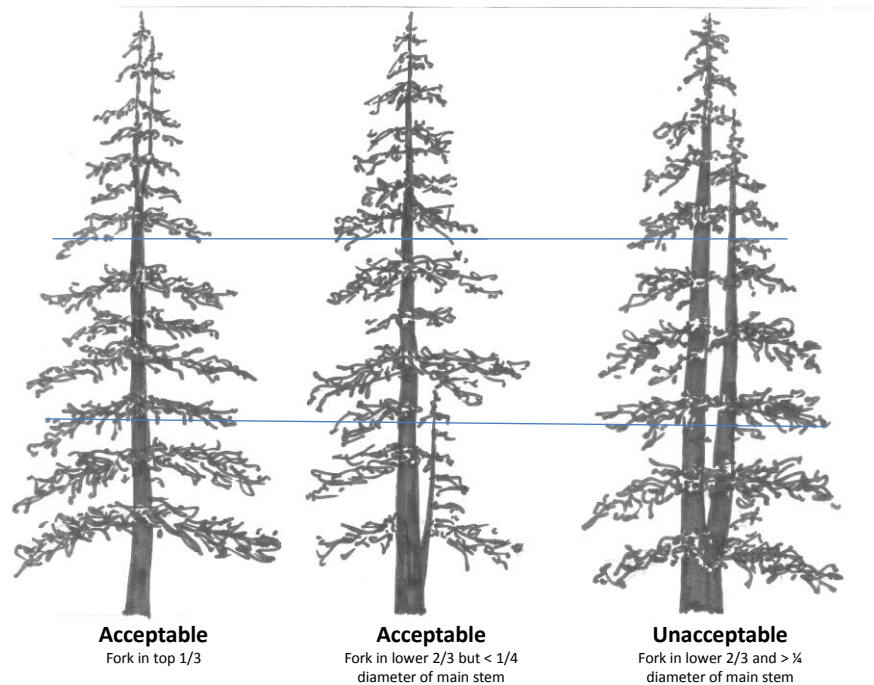


Figure 2. Acceptable and unacceptable forking in age class 2 & 3 conifers.

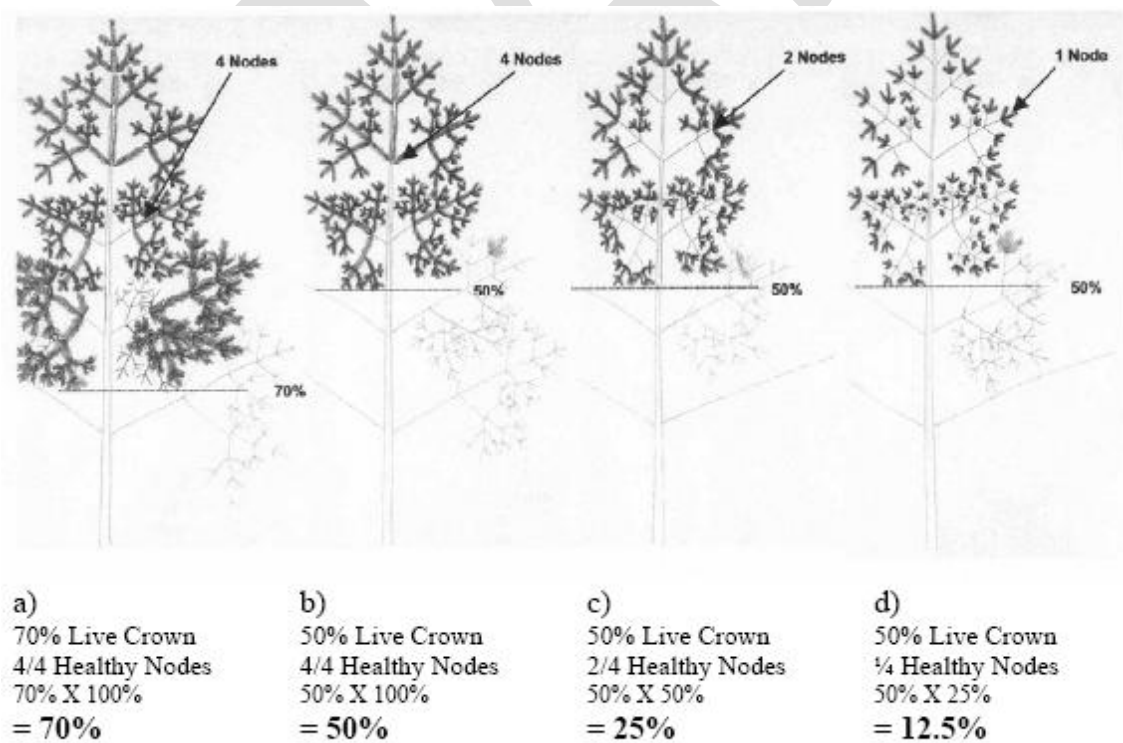


Figure 3. Calculating defoliation for Dothistroma-afflicted conifers.

Instructions	Example
Step 1 Divide live crown into thirds.	If this third has no visible infections, its rating is (0).
Step 2 Rate each third separately. Each third should be given a rating of 0, 1, or 2 as described below: (0) no visible infections (1) light infection (1/2 or less of total number of branches in the third infected) (2) heavy infection (more than 1/2 total number of branches in the third infected).	If this third is lightly infected, its rating is (1). If this third is heavily infected, its rating is (2).
Step 3 Add ratings of thirds to obtain rating for total tree.	The tree in this example gets a rating of: $0 + 1 + 2 = 3$.



Figure 4. The Hawksworth six-class dwarf mistletoe rating system.

Definitions

basal resinosis (pitching): copious exudation of pitch at the base of the stem at or below the root collar. This symptom often is associated with armillaria root disease or attack by Warren's root collar weevil.

decay: the disintegration of plant tissue. The process by which sound wood is decomposed by the action of wood-destroying fungi and other microorganisms.

fork: two or more leaders have originated from the loss of a leader or apical shoot. At free-growing age, a fork is considered persistent if it has not differentiated in height between competing leaders by more than 5 cm after five years of growth since the leader damage occurred. Forks may provide entry points for decay fungi, are points of weakness during felling, and may create waste in the highest value first log.

gall: nodule or lump of malformed bark or woody material caused by a variety of damaging agents, such as western gall rust and some insects.

gouting: excessive swelling of a branch or shoot, often accompanied by misshapen needles and buds. Most common at nodes on branches and frequently caused by balsam woolly adelgid on true firs (*Abies* spp).

Height to diameter ratio: height in meters divided by dbh in meters.

infection: characterized by a lesion or canker on stem or branches or by swelling around the entrance point of a pathogen.

injury: damage to a tree by a biological, physical or chemical agent.

scar: a wound completely healed-over by callus tissue

wound: an injury where cambium is dead (e.g., sunscald) or completely removed. Wounds often serve as entry points for decay fungi

Appendix 4.

Examples of original free-growing survey map and pre-survey SDM polygon with plot placements provided.

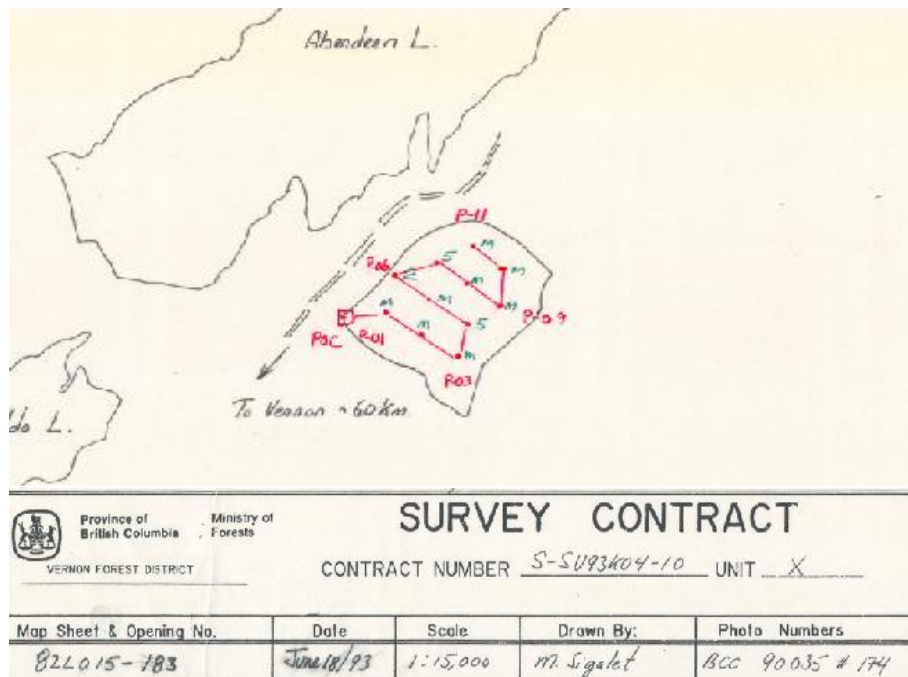


Figure 7. Original survey map with plot locations.

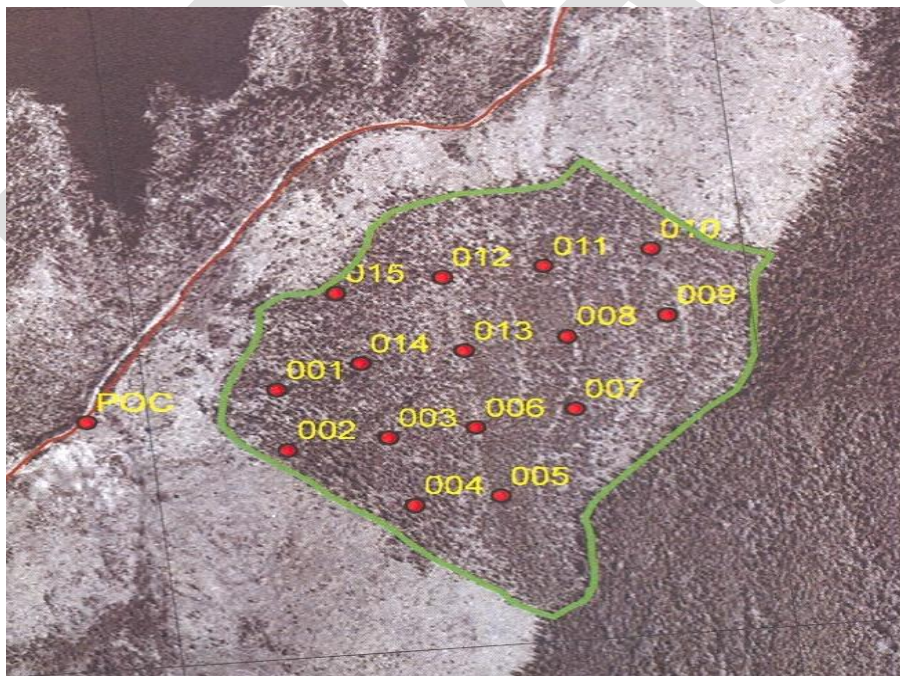


Figure 8. Air photo of survey polygon with plots identified.

Appendix 5.

Example of a project summary spreadsheet identifying data fields and survey results.

DRAFT