

Protocol for Stand Development Monitoring



Steps for field data collection and administration

June, 2010

This draft protocol is focused on piloting the field sampling methodology and the data collected. The field sampling aspect of this protocol may be revised in the fall based on this field season's piloting. None of the changes to the protocol compromise the integrity of the data captured in the SDM pilots to date. The data management aspect of this protocol to ensure optimum uptake from Forest Analysis and Inventory Branch, Research Branch and Forest Practices and Investment Branch requires further work which is planned for the fall and winter of this year. The final completed protocol is planned for implementation in 2011/12.

FREP Stand Development Monitoring Protocol

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Introduction

The current silvicultural milestone for ensuring effective reforestation is the free-growing declaration. The Ministry of Forests and Range 2010 Silviculture Survey Manual defines free growing trees as the subset of well spaced trees that are healthy, free of unacceptable levels of vegetation and conifer tree competition and meet the free growing heights. Free-growing trees comprise the stand of trees that we can expect to produce a commercially valuable crop tree. The free-growing assessment process is conducted at two levels: at the tree level and at the stratum level. The 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 SDM 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. Broadleaf species are not yet part of SDM in stands that have originally been managed for softwood timber. Broadleaf dominated stands within management units that have active broadleaf management, and a partitioned AAC, may be included provided they meet all of the other selection criteria. 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

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

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 envisioned that this protocol will become a standard mid-rotation monitoring procedure. Over time a considerable 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 that have been tied to free-growing stands.

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 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. Embedded within this goal is the desire to accurately capture the influence of forest insects and diseases and other natural disturbance agents on timber productivity.

Objectives of the Monitoring Process

The first objective of this protocol is to check 10+ years post declaration, each of the attributes that were determined at the free-growing milestone; leading species composition, stocking of total, well-spaced and free-growing stems, age and site index. An updated inventory label to add to the current mandatory RESULTS milestones of regeneration delay and free-growing will be produced in achieving this first objective.

The second objective of this protocol is to provide an operational mid-rotation assessment of stand yield that may be compared to projections from Ministry of Forest and Range (MFR) growth models (e.g. TASS/TIPSY, VDYP). These stand yield model projections are used in timber supply analyses of forest management units throughout BC.

Overarching both primary objectives is the goal to monitor the influence of forest insects, diseases and other natural disturbance agents on managed stand productivity and by so doing provide the data needed to develop more realistic managed stand growth 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?
- Are current stand volumes as measured in the field significantly different than those projected in growth models from both declaration and current stand attributes?

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.

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 inventory polygon (an opening or portion of an opening). These inventory polygons have a unique inventory label representing uniform species and stocking standards, and uniform silviculture treatments, and they have been declared or designated 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. The intensive study 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.

The SDM protocol will be included under district annual FREP activities and has the flexibility of acquiring the data over several years. The sample population is drawn from all polygons within a TSA surveyed for declaration from 1995 to 2001 inclusive, 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. SDM bases comparisons on the last field survey used to declare stands.

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

The SDM 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 District lists will be located on the Forest and Range Evaluation Program (FREP) sharepoint site at:

<https://sharepoint.forests.gov.bc.ca/frep/rv/timber/Forms/AllItems.aspx>

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 5 hectares or greater in size and contiguous;
- Polygons must have a disturbance (harvesting) date of 1960 or later;
- Polygons must not have received a silvicultural treatment in past 8 years; 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 population, it can be deleted. Questions regarding whether a site is in or out of the defined criteria should be referred to the SDM Team (SDMT). A site may be deleted from the population if any of the following criteria apply:

- Polygon is a partial cut or multi-layered uneven aged stand;
- Polygon has received a stand management treatment within the past 8 years;
- 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 TSRs.

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.

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 2 m, and missing M-values are assumed to be 6 in the interior and 4.5 on the coast, but check M-values against Target Stocking Standards (TSS). 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 located so as to cover as much of the polygon as possible. The distance from the POC to the first plot should be a random distance

between 20 and 100 m. For polygons less than 20 ha, establish plots on a 100 x100 m grid with the initial plot located at a random distance (between 20 and 100 m) from the POC. For polygons greater than 20 ha, establish 10 plots evenly spaced along a straight transect that traverses the greatest length possible within the selected strata (if using ARC GIS, input UTM points into GPS unit in the office; if using Mapview locate plots by hand and input GPS point soon after field work completed). To determine the inter-plot distance for the strata larger than 20 ha, divide the entire transect length by 10 and round to the nearest meter. The minimum acceptable distance between plots in smaller openings is 50 m and the maximum distance between plots in large strata is 150 m. Note:. The location of plots should be based on the greatest coverage of the strata. The straight transect can include a 'dog-leg' to help ensure optimum coverage. See attached map examples in Appendix 4.

- Prepare a FS 1357 field card for each plot with all the planning information filled in.

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, and stand volumes (optional).		
12. Update polygon record in the SDM dedicated TRIM folder.		

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)	
metal stakes (<50cm) to permanently identify plot centers	
Plot cord(s) suitable for 3.99 and 5.64 m plots, or loggers tape	
DBH measuring tape	
Carpenter's tape measure for inter-tree 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)	
SDM 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. Compare the air photos, orthophotos, contour maps and other supporting documentation to confirm polygon location, access, plot placement, etc.
2. 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, if after that single offset the plot location is still not in a representative part of the strata (it is on a road, or in a swamp etc.,) drop that plot and establish a replacement elsewhere within the strata on the 100m grid.

Field data gathering for each polygon:

1. For each sample polygon, predetermine the location of 10 – 3.99 m radius silviculture survey plots using either a 100 x 100 m grid or equally spaced on a transect that traverses the greatest length possible within the polygon. The distance from the POC to the first plot should be a randomly selected number between 20 and 100 m. In large strata the maximum inter-plot distance is 150 m and in small strata the minimum is 50 m. **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.** If during the field survey it becomes apparent that a polygon boundary has been crossed into a distinctly different stand type, that plot should be re-established at right angles into the body of the strata using the pre-established inter-plot distance. 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. GPS and label POC on flagging ribbon at starting point as SDM with the date, surveyors and distance and bearing to plot 1.
3. Identify plot centers with a metal stake (< 50cm) and flagging ribbon. Take GPS of plot.
4. For each plot, in the first clockwise sweep, all trees including commercial broadleaves, >130 cm in height are tallied by species and layer. All plot data should be tallied on a FS 1357 field card.
5. For each plot, in the second sweep all well-spaced (WS) and free-growing (FG) trees are tallied using the same minimum inter-tree distance that was used at the time of declaration. WS and FG trees tallied in this sweep are selected on the basis of being the biggest best trees of the currently preferred and acceptable species³ By focusing on the biggest, best trees we attempt to capture the cohort of trees that were considered FG and WS at declaration, 10+ years earlier. Maximizing the count of WS trees at the SDM stage would tend to capture more ingress. **We want to minimize the influence of ingress on WS and FG values at this stage.** The spatial orientation of the WS trees is set so as to maximize the size of the crop trees. **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

³ Refer to Reference Guide Standards for Forest Development Plan
http://www.for.gov.bc.ca/ftp/hfp/external/!publish/Stocking%20Standards%20for%20FDPs/Reference_Guide.xls

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 retrospectively during data analysis.

6. **Note:** Once this tally has been done in #5 it is critical to estimate what is the maximum number of well spaced trees that can fit into the plot, not focusing on just the biggest best trees but including ingress if these trees meet the WS and FG criteria. (Note: This WS estimate of current stocking provides valuable input into refining yield estimates for timber supply analysis.)
7. In an optional third sweep, only the free-growing and well-spaced tree species based on the preferred and acceptable species stated in the original declaration are tallied, again with an emphasis on the biggest best trees as in Step 5. **Note:** This sweep is only necessary if the species acceptability standards at the time of declaration were different from the current standards. This sweep is important for a retrospective assessment of free-growing. Once again use the MITD from declaration.
8. SDM damage criteria (see Appendix 3) 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. When root disease is encountered in an SDM plot, the healthy WS tree of a susceptible host species that is nearest to the infected tree, is the tree that is discounted from the current WS tally. **Note:** If in Step 7 the preferred and acceptable species are different from current standards this may affect which WS tree is discounted for root disease.
9. Starting at a bearing of 360° divide the plot into four quadrants on cardinal bearings. Again starting at 360°, record the species and dbh to the nearest 0.1 cm of every tree, healthy and not, live and dead, that is greater or equal to 7.5 cm dbh, including commercial broadleaves. Record values in the appropriate columns near the right side of the data card. Next record the height to the nearest 0.1 m (beside its respective dbh) of the first tree encountered in each quadrant sweeping in a clockwise direction. For unhealthy trees, trees which fail the SDM damage criteria, record the damage code in the far right column under HLC. If a quadrant contains no trees above the dbh threshold, repeat the sweep and take the height of the second tree from the quadrant containing trees above the threshold diameter and repeat this exercise until four heights are obtained. If no trees have a dbh of 7.5 cm or greater no dbh or height measurements are required. **Note:** The dbh measurement for all trees ≥ 7.5 cm can be done at the same time as the sweep for WS trees in Step 5. Numbering these trees sequentially in a clockwise sweep starting from N (360°) with flagging and a marking pen helps to keep track of trees identified for height measurements. Using different coloured flagging to identify WS from trees ≥ 7.5 cm dbh also helps keep track of trees and aids in final tally checks from plot center.
10. For each plot, the largest dbh healthy tree of the dominant species in the polygon should be selected for site index assessment using the growth intercept sampling method⁴. 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) following established standards. If no healthy dominant conifer tree is present in the larger plot, do not determine site index. In stands with more

⁴ Growth intercept method for silviculture surveys. 1995. BC Ministry of Forests. Silviculture Practices Branch.

than one dominant conifer species, attempt to capture SI estimates from the range of species, provided that over the 10 plot sample, three or more SI sample trees exist for each species. Only one SI estimate is taken per plot.

11. Record the inventory label for each plot based on what can be seen from the plot center. Record species composition of leading, secondary and tertiary species to the nearest 10 %, record estimated average height and age of the leading and secondary species. Also record the estimated % crown closure.
12. Take a digital photo of the typical plot at some point during the 10 plot survey, also photograph any anomalous situations that the surveyors feel require feedback from the SDM development team.
13. Once you have finished the plot make an ocular sweep of the surrounding stand. In “Notes” please comment on whether this plot represents the surrounding stand. If not, please comment on how this plot is different from the surrounding stand.

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 should be confirmed during the SDM survey.

Described on the following pages is a comprehensive and detailed description of the information to be recorded on the FS 1357 field card. Helpful hints using the sample field card data in Figure 1 are also provided.

9. 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 or on biogeoclimatic subzone maps and handbooks. However, biogeoclimatic information should be confirmed during the walk-through.

10. 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.

11. UTM Co-ordinates: Record the Zone, Easting and Northing reading for this plot.

12. Plot No.: Record the plot number assigned to the plot.

13. Minimum Inter-Tree Distance (MITD): Distance used in original free-growing declaration.

When conducting a SDM survey, two sweeps of WS and FG trees are performed per plot. In the initial sweep the well-spaced and free-growing trees are tallied based on the current preferred and acceptable species designation using the MITD from declaration, if available, or the default MITD of 2 m. In a second sweep tally only the preferred and acceptable species from the original declaration to allow for retrospective comparisons. This sweep would only be done if the preferred and acceptable species at the time of declaration were considerably different than the current acceptable species criteria. Record in the notes section if the WS tally could have increased and by how many trees if WS trees were selected to maximize number rather than the biggest, best.

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 field form. Only conifers are tallied as WS and FG unless broadleaf management is actively pursued within the TSA.

15. Layer: There are three layers (1 –(>12.5 cm dbh), 2 –(7.5-12.5 cm dbh), 3 –(>1.3 m 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 >1.3 m tall are tallied.**

If filling out paper forms, we strongly suggest using dot tallies in the boxes below the total line of this column in accordance with the species and layer in which the trees are found and also for all other tree counts, live and dead. Use the “Totals” line at the top of the columns to sum the values (including zero values) in that column for each category and use this sum as a final check before moving on to the next plot.

Note that dot tallies are done in the boxes below the total line of this and the following columns in accordance with the species and layer in which the trees are found.

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 >1.3 m 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, based on current preferred and acceptable tree species without use of the M-value cap, 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, based on current preferred and acceptable tree species without the M-value, on the first line.

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 the damage criteria for other reasons, this can be recorded in "NOTES" but must be separated from the 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 these columns 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.

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 these two columns 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.

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 Volume Trees – Species: Record the abbreviation for the species of the selected tree including commercial broadleaf species. Volume trees are not limited by current preferred and acceptable rules. Volume trees are limited only to being in layers 1 and 2 (7.5 cm and greater). Record the dbh for both healthy and unhealthy, live and dead trees. For unhealthy/unacceptable trees, record the damage agent.

30. Data Volume Trees – DBH: Record tree diameter at breast height as expressed in cm to 0.1 cm accuracy for all trees, conifers and commercial broadleaves ≥ 7.5 cm dbh in the plot.

31. Data Volume Trees – Height: Record tree height to the nearest 0.1 m accuracy for the first tree ≥ 7.5 cm dbh encountered in each of the four cardinal bearing quadrants in the plot. Repeat sweep taking the second tree per quadrant until four height measurements are taken.

32. Data Volume Trees – Pest: If the measured tree is afflicted by an unacceptable pest as determined using the SDM damage criteria, note the applicable pest code.

Collecting pest information for layer 1 and 2 volume trees allows for the comparison of proportion of gross stand volume contributed by healthy trees as opposed to volume at risk of loss due to pest-caused damage or mortality.

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. In stands with more than one dominant tree species attempt to collect SI data for each species but only one SI tree is assessed per plot.

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 (see background of Inventory label in Appendix 5)

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

38. %: Record a visual estimate of the proportion of total trees visible from plot center 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: Estimate the age of the first leading species as recorded in field 37 using a combination of harvest date and the age at dbh of the SI tree for guidance.

40. Ht: (m) Estimate the average height of the first 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.

43. Age: Estimate the age of the second leading species as recorded in field 41 using a combination of harvest date and the age at dbh of the SI tree for guidance.

44. Ht.(m): Estimate the average height of the second leading 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 CI: 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 10%.

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 (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 team which is lead by Alex Woods, Northern Interior Forest Region, Smithers, and includes:

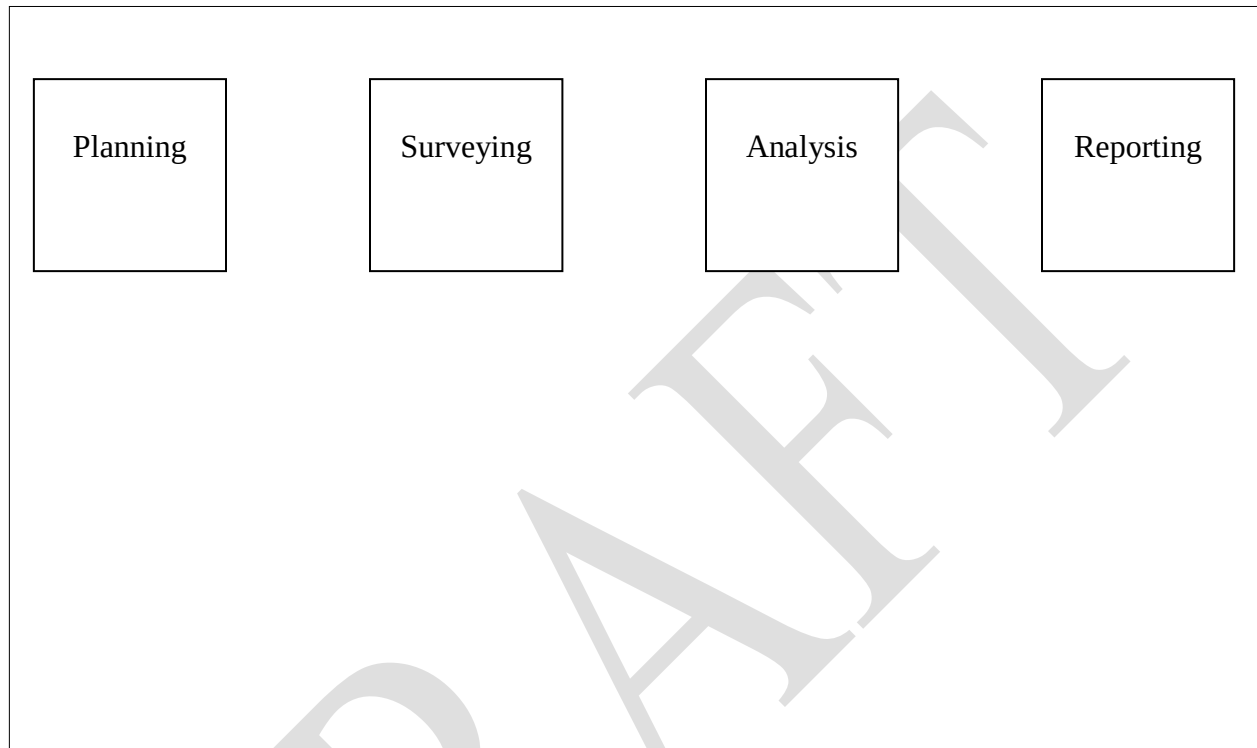
Kevin Astridge, Forest Practices and Investment Branch, Victoria
Frank Barber, Forest Practices and Investment Branch, Victoria
Michelle Cleary, Southern Interior Forest Region, Kamloops
Erin Havard, Northern Interior Forest Region, Smithers
Harry Kope, Forest Practices and Investment Branch, Victoria
Dave Weaver, Forest Practices and Investment Branch, Victoria
Ken White, Northern Interior Forest Region, Smithers
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

Appendix 1.

Process diagram for stand development monitoring.



Appendix 2.

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

 DAMAGE AGENT AND CONDITION CODES					
FIELD CODES	DESCRIPTION	FIELD CODES	DESCRIPTION	FIELD CODES	DESCRIPTION
A	ANIMAL DAMAGE	AP	PORCUPINE	DF	FOLIAGE DISEASES
AB	BEAR	AS	SQUIRREL	DFA	western pine aster rust <i>Colosporium asterum</i>
AC	CATTLE	AV	VOLE	DFB	delphinella tip blight <i>Delphinella</i> spp.
AD	DEER	AX	BIRDS	DFC	large-spored spruce-labrador tea rust <i>Chrysomyxa ledicola</i>
AE	ELK	AZ	BEAVER	DFD	spruce needle cast <i>Larix mediospora</i>
AH	HARE OR RABBIT			DFF	elytrodema disease <i>Elytrodema deformans</i>
AM	MOOSE			DFG	manzanita leaf blight <i>Marasmius</i> spp.
N	ABIOTIC INJURIES	NN	ROAD SALT	DFF	cottonwood leaf rust <i>Metaspora occidentalis</i>
NB	FIRE	NR	REDBELT	DFH	larch needle blight <i>Hypodermella laricola</i>
ND	DROUGHT	NS	SLIDE	DFI	pine needle cast <i>Lophodermella concolor</i>
NF	FLOODING	NW	WINDTHROW	DFM	larch needle cast <i>Meria laricola</i>
NG	FROST	NWS	windthrow-soil failure	DPP	fir-firweed rust <i>Pucciniastrum apitobi</i>
NGC	frost crack	NWT	windthrow-treatment or harvest related	DRR	Douglas-fir needle cast <i>Rhabdoclone pseudotsugae</i>
NGH	frost-heaved			DPS	dothistroma (red band) needle blight <i>Mycosphaerella pini</i>
NGK	shoot / bud frost kill			DSS	sitka spruce tip blight <i>Sirococcus strobilatus</i>
NH	HAIL	NY	SNOW, ICE, SNOW PRESS	POT	cedar leaf blight <i>Ditylenchella thujae</i>
NK	FUMIKILL	NZ	SUNSCALD	DL	LEADER OR BRANCH DISEASES
NL	LIGHTNING			DLA	demarcation canker <i>Demarcation pseudotsugae</i>
D	DISEASE			DLF	red flag disease <i>Potodermomyces balsamicola</i>
DB	BROOM RUST			DLK	conifer cytospora canker <i>Leucostoma kunzei</i>
DBF	fir broom rust <i>Metaspora caryophyllacearum</i>			DLP	diaporthe canker <i>Diaporthe tokoyae</i>
DBS	spruce broom rust <i>Chrysomyxa arctostaphyli</i>			DLS	sydowia tip dieback <i>Sclerophoma pithyophila</i>
DO	STEM DECAYS			DLV	aspen & poplar leaf and shoot blights <i>Venturia</i> spp.
DDA	white mottled rot <i>Ganoderma applanatum</i>			DM	DWARF MISTLETOES
DDS	white spongy trunk rot <i>Fomes fomentarius</i>			DMF	Douglas-fir dwarf mistletoe <i>Arceuthobium douglasii</i>
DDD	sulfur fungus <i>Laetiporus sulphureus</i>			DMH	hemlock dwarf mistletoe <i>Arceuthobium tagueae</i>
DDE	rust-red stringy rot <i>Echinodontium stictonum</i>			DML	larch dwarf mistletoe <i>Arceuthobium laricola</i>
DDF	brown crumbly rot <i>Fomitopsis pinicola</i>			DMP	lodgepole pine dwarf mistletoe <i>Arceuthobium americanum</i>
DDH	hardwood trunk rot <i>Phellinus igniarius</i>			DR	ROOT DISEASES
DDO	brown cubical butt & pocket rot of cedar <i>Postia sericeomollis</i>			DRA	annular root disease <i>Annularia ostoyae</i>
DDP	red ring rot <i>Phellinus pini</i>			DRB	black stain root disease <i>Leptographium wageneri</i>
DDQ	brown trunk rot (quinine fungus) <i>Fomitopsis officinale</i>			DRC	laminated root rot (cedar form) <i>Phellinus weirii</i>
DDQ	Schweinitz butt rot <i>Phaeolus schweinitzii</i>			DRL	laminated root rot (Fd form) <i>Phellinus weirii</i>
DDT	aspen trunk rot <i>Phellinus tremulae</i>			DRN	annular root disease <i>Heterobasidium annosum</i>
				DRR	rhizina root disease <i>Rhizina undulata</i>
				DRT	Schweinitz butt rot <i>Phaeolus schweinitzii</i>
					tormentosa root rot <i>Monotus tormentosae</i>

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FIELD CODES	DESCRIPTION	FIELD CODES	DESCRIPTION
DS	STEM DISEASE (CANKER OR RUST)	IDP	larch sawfly <i>Pristiphora erichsoni</i>
DSA	atropella canker <i>Atropella piciphila</i>	IDR	alder sawfly <i>Eriocampa ovalis</i>
DSB	white pine blister rust <i>Cronartium ribicola</i>	IDS	conifer sawflies <i>Neodiprion</i> spp.
DSB	commander blister rust <i>Cronartium comandrae</i>	IDT	Douglas-fir tussock moth <i>Oryia pseudotsugae</i>
DSE	scotty bark canker <i>Eurotium piceae</i>	IDU	satin moth <i>Leucome asale</i>
DSG	western gall rust <i>Endocrotonium harknessii</i>	IDV	variegated cutworm <i>Peridroma ascle</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 conflictor</i>
DSR	ceratocystis canker <i>Ceratocystis fimbriata</i>	IDZ	western false hemlock looper <i>Nepytia freemanii</i>
DSS	atalectiform blister rust <i>Cronartium atelectiformis</i>	IS	SHOOT INSECTS
DSY	cytospora canker <i>Valsa cordata</i>	ISB	western cedar borer <i>Trachytela blondeli</i>
I	INSECTS	ISE	European pine shoot moth <i>Pitya corylae</i>
IA	APHIDS OR ADELGIDS	ISG	gouty pitch midge <i>Cecidomyia piceinops</i>
IAB	balsam woolly adelgid <i>Adelges piceae</i>	ISP	pitch module moths <i>Pachyura</i> spp.
IAC	giant conifer aphid <i>Cinara</i> spp.	ISQ	western pine shoot borer <i>Eucosma sonomana</i>
IAG	Cooley spruce gall adelgid <i>Adelges cooleyae</i>	ISZ	Sequoia pitch moth <i>Synanthedon sequoiae</i>
IAL	larch cone woolly aphid <i>Adelges laricina</i>	IV	WEEVILS
IAS	spruce aphid <i>Elatobium abietinum</i>	IVC	conifer seedling weevil <i>Stenotermis carinata</i>
IB	BARK BEETLES	IVM	Magdalen 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	engraver beetles /ps	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, Pityophthorus</i> spp.	IVZ	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 fennica</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
IDD	western winter moth <i>Eranis vancouverialis</i>	TPM	planting — poor microsite
IDF	spruce budworm <i>Choristoneura fumiferana</i>	TR	PRUNING
IDG	forest tent caterpillar <i>Melicocoma dissalis</i>	TT	THINNING OR SPACING
IDH	green-striped forest looper <i>Malacosoma imitator</i>	V	VEGETATION PROBLEMS
IDJ	western blackheaded budworm <i>Aclia glomerata</i>	VH	HERBACEOUS COMPETITION
IDL	pine needle sheath miner <i>Zelleria neobischofi</i>	VP	VEGETATION PRESS
IDM	western hemlock looper <i>Lambdula foveolata</i>	VS	SHRUB COMPETITION
IDN	gypsy moth <i>Lymantria dispar</i>	VT	TREE COMPETITION
	birch leaf miner <i>Pteronotus picealis</i>		

Appendix 3.

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

(Revision 6: 11 June, 2010)

INTRODUCTION

The FREP Stand Development Monitoring (SDM) protocol has been developed to assess stand performance, from a timber yield perspective, 10+ 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.

[illegible]

LOCATION OF DAMAGE	TYPE OF DAMAGE	TREE BEING ASSESSED IS UNACCEPTABLE IF:	HOST SPECIES	LIKELY DAMAGE AGENTS & DAMAGE AGENT CODES	COMMENTS
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 IBI, <i>Pityogenes</i> & <i>Pityophthorus</i> IBP	<p>Note: pitch tubes can be associated with trees that have successfully repelled bark beetles, bark must be removed above pitch tube to confirm successful attack (successful galleries will be filled with frass and not pitch, contain adult beetles and/or larval galleries).</p> <p>Stressed trees are susceptible to secondary bark and twig beetles.</p>
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.	<p>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.</p>
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	<p>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</p> <p>See Figure 3</p>
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	<p>Note: To confirm infection the surveyor must observe signs of the pathogen as small dark streaks on dead foliage</p>
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 2 times the height of the infection on 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,	<p>Note: To confirm infection, the surveyor must observe mistletoe aerial shoots or basal cups on regeneration or on live or dead fallen brooms.</p> <p>Overtopping tree is a tree that is in an overtopping layer.</p>

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. The well-spaced tree that is netted down is the susceptible species that is closest to the infected tree. Note that the WS tree that is netted down may vary depending on the species acceptability rules being followed, those currently used or those used at the time of declaration. 	<p>All</p> <p>All</p> <p>Fd, Bg, Hw, Sx, Se, Lw</p> <p>Fd, Pl, Pw, Sx</p> <p>Se, Sx, Fd, Pl</p> <p>Ba, Hw, Ss, Fd</p>	<p>armillaria root disease DRA, blackstain root disease DRB laminated root rot DRL, annosus root disease DRN tomentosus root rot DRT,</p> <p>armillaria root disease DRA,</p> <p>laminated root rot DRL.</p> <p>black stain root disease DRB.</p> <p>tomentosus root rot DRT.</p> <p>annosus root rot DRN</p>	<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>

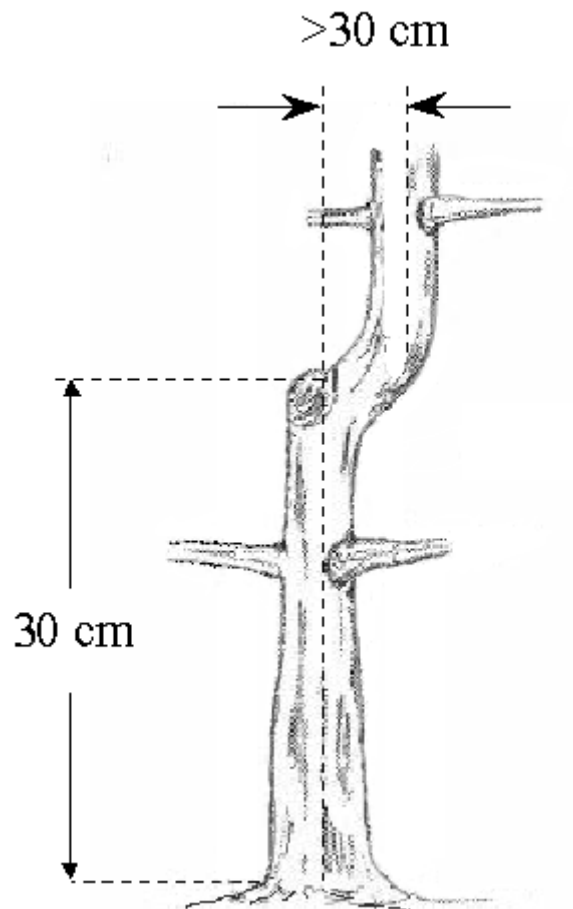


Figure 1. Determining horizontal displacement when assessing stem deformation. This is only done when the tree has five seasons' growth after damage occurs.

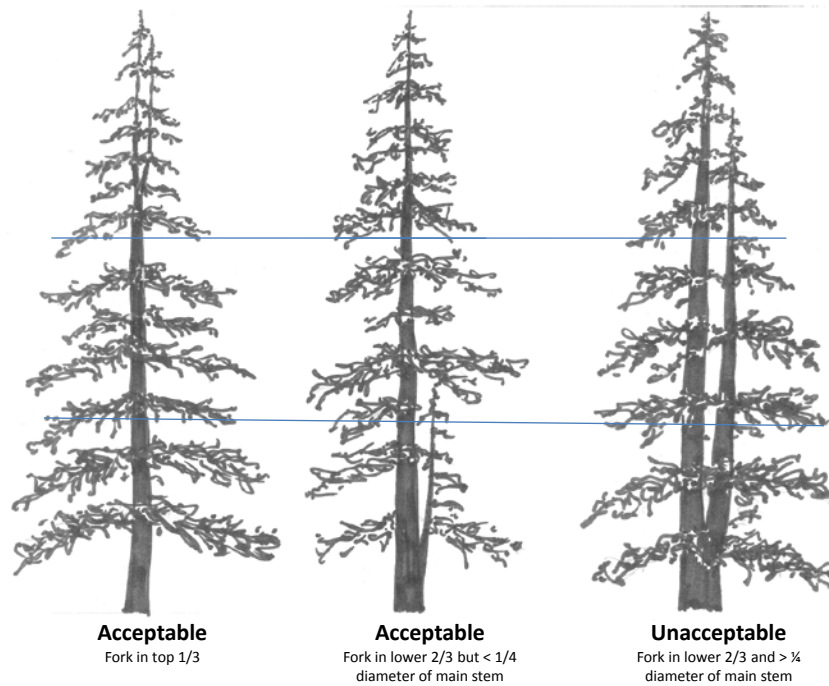


Figure 2. Acceptable and unacceptable forking in age class 2 & 3 conifers (damage code K).

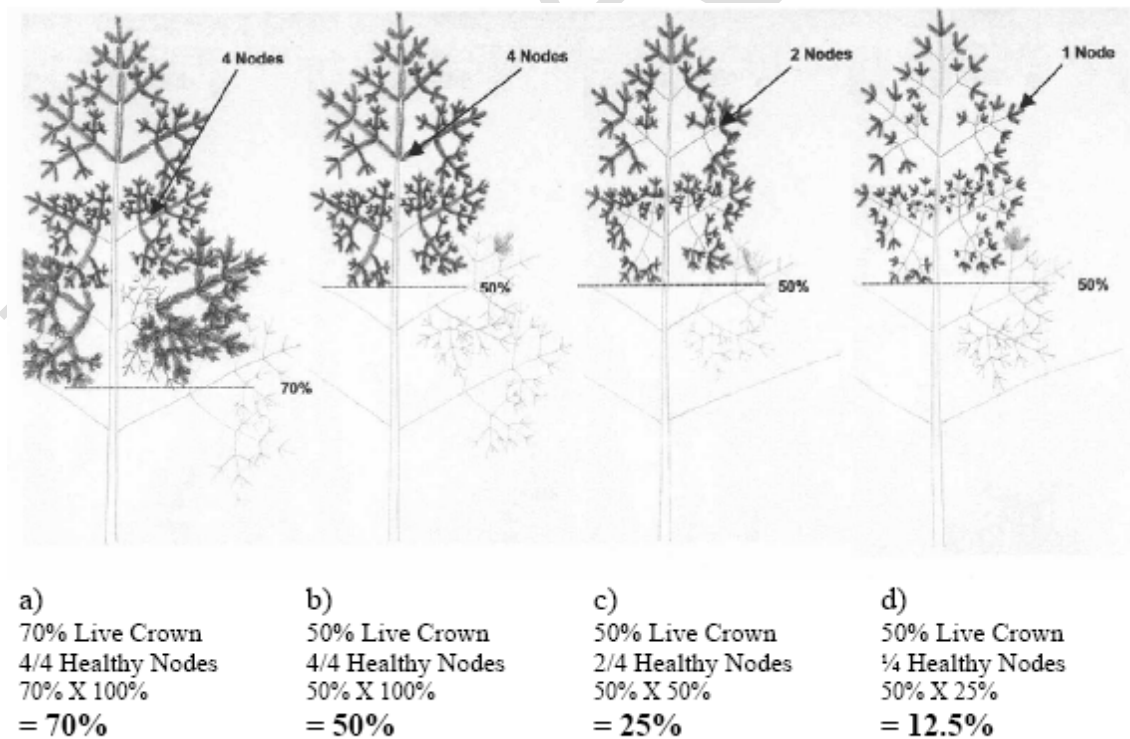


Figure 3. Calculating defoliation for Dothistroma-afflicted conifers.

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: <ul style="list-style-type: none"> (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.

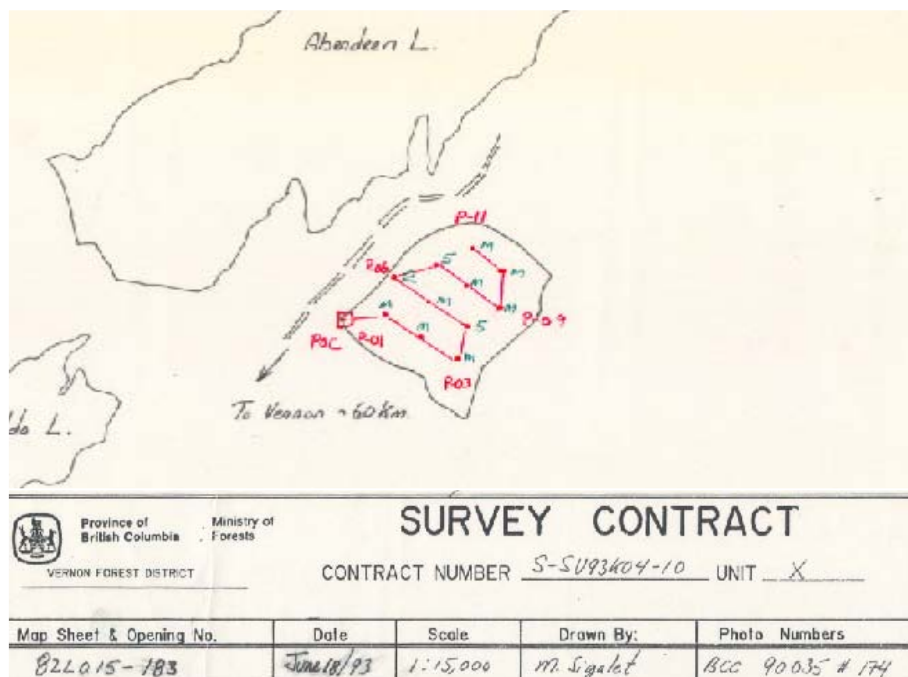


Figure 7. Original survey map with plot locations.

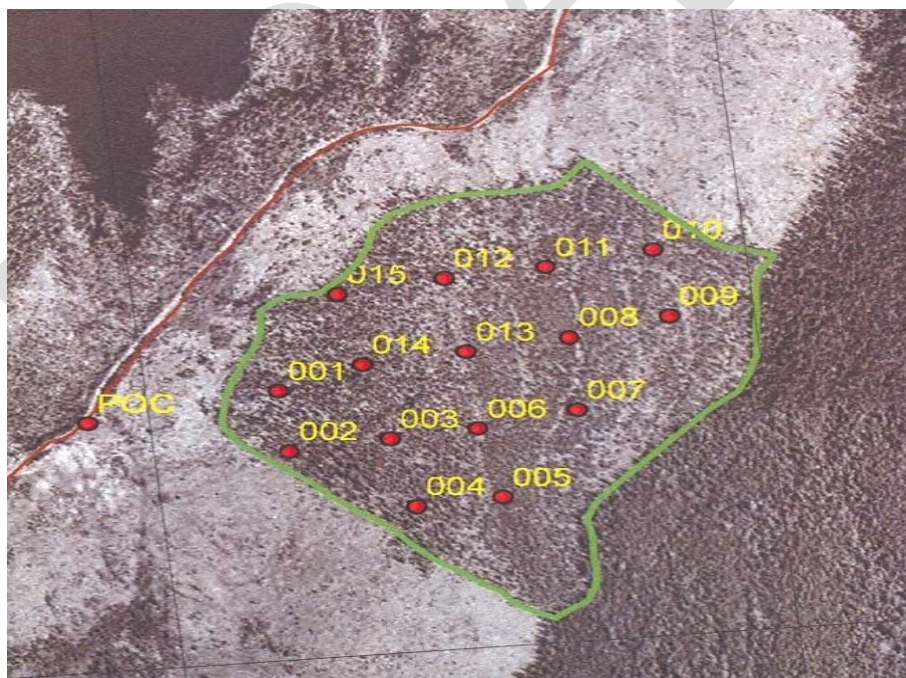


Figure 8. Air photo of survey polygon with plots identified.

Appendix 5.

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.