

Protocol for Stand Health and Growth Monitoring

January 25, 2023

Introduction

The prevalence and severity of climate change driven forest health impacts is increasing. The health and productivity of managed stands is critical to a wide range of resource values, including hydrological green-up and watershed response, wildlife habitat, carbon capture and storage and timber. An extensive surveillance approach that complements current silviculture and inventory data is needed. Key information that allows silviculture policy specialists to assess whether stands created under certain treatment regimes remain on their expected trajectory and by inventory specialists and carbon accountants to ensure that future stand productivity and growth is within an acceptable range is required. At the same time, efforts are being made to listen to First Nation concerns about their traditional values on this same managed stand land-base. This survey provides an opportunity to: 1. Compare current conditions to expectations from a timber perspective based on the last status update; 2. Establishes the foundation for an extensive continuous inventory over time; and 3. Links both of the above to a simple assessment of critical First Nation values related to moose and culturally significant plant species.

The Stand Health and Growth Monitoring (SHAGM) protocol is designed to assess the health and productivity of managed stands between the ages of 20 and 40 years and provide a link to critical First Nation values on the same land. The protocol combines attributes of both silviculture surveys and timber cruising/inventory procedures, with an emphasis on forest health and the damage caused by biotic and abiotic disturbance agents. Data from this protocol is complementary though distinctly different to that collected under FAIB's YSM program. The SHAGM protocol will expand the area of mid-rotation managed stands surveyed providing critical information to fill the large knowledge gap associated with managed stand conditions. The recent development of a standardized approach to modelling RESULTS data from managed stands to determine individual opening yield curves provides a key quantifiable benchmark to compare SHAGM field data against. All stands sampled from FAIB's Vegetation Resource Inventory (VRI) between the ages of 20-40 that have a prior silviculture survey and can be modelled following FAIB's Managed Stand Yield Table protocol (the Dave Waddell approach) are eligible for sampling.

Objective:

To collect data on forest health, stand volume, and important FN values over a large sample population using a standardized mid-rotation assessment that can be collected by multiple stakeholders and that can be compared to the current standardized yield projection for stands aged 20-40 years. The intent is to integrate forest health, forest yield and FN value data from the outset and avoid the trap of information silos. This protocol can address the question of which forest health agents are having the greatest current volume impact. It can also provide a snapshot of how well the stand is currently adhering to the expected yield trajectory, taking into account the forest health agents present. The simple transparent nature of the protocol allows for multiple stakeholders to use the same data collection approach so that shared decisions can be based on mutually agreed upon current conditions

SHAGM damage assessment

SHAGM tree damage assessment procedures (Appendix 3) have been developed for stands aged 20-40. They consider the fact that stands of this age have passed through several significant development phases (ie., establishment, recruitment, etc.) and by this age the larger trees have a higher probability of remaining dominant and forming the final harvest crop. The SHAGM damage assessment focuses on these larger trees. The assessment captures the % of stem girdling and height on the bole of damage in the trees > 7.5 cm dbh. The combination of these two characteristics allows for an estimation of whether the damage is significant enough to result in a considerable loss of merchantable volume or an increased risk of mortality. SHAGM data can provide early warning signals of climate change driven forest health concerns that can be investigated in greater detail over time through other monitoring programs such as YSM.

Defining the Population

The population to be sampled consists of all forest openings in the Vegetation Resources Inventory (VRI) database aged 20-40 that are compatible with the FAIB MSYT Protocol (Dave Waddell's modelling approach for RESULTS data). All inventory polygons within the SHAGM Master List will be stratified by BEC zone and could be further broken down by First Nation Traditional Territory within a TSA.

Principles of Polygon Selection

Once the population is defined, and the random sample is drawn from VRI, the single most important sampling principle of this protocol is that openings must be selected 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 area of interest. Only when stands are randomly selected throughout the sampling area is it possible to make inferences about that greater population. The use of only those openings that reside within the RESULTS database in the SHAGM population ensures that all of the other additional information that the RESULTS database contains can be incorporated into data analyses. **This aspect of SHAGM allows for adaptive management, learning from past silviculture practices and correcting any possible mistakes in management decisions (i.e., species selection, site preparation, planting density etc.)**

The SHAGM sample population is restricted to polygons that are considered even aged (not partially cut). Stands will be selected on the basis of probability proportional to the size of the opening such that larger openings have a higher probability of being selected.

Indicators:

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

- Leading tree species, height class, age (Inventory label),
- DBH and height of all trees ≥ 7.5 cm,
- Basal Area; and Gross volume (to 7.5 cm minimum dbh),
- Pest incidence including live and dead trees,
- % girdling and height on tree bole of damage and defects,
- Current site index,
- BEC classification to site series (from earlier RESULTS data),
- Presence of moose sign and browse, and
- Presence of key culturally significant plant species.

Basic Stand Health and Growth Monitoring Survey Skills

The SHAGM protocol follows some of the basic understanding of plot establishment and stand attribute measurement procedures. Silviculture and inventory survey experience can certainly help, however, it is not required to carry out the SHAGM protocol. The knowledge and skills that will be beneficial to completing this protocol are:

- Ability to identify tree species,
- Ability to identify forest health pests and diseases,
- Knowledge of basic plot establishment,
- Proficiency with the techniques of basic tree measurements,
- Ability to identify moose sign and evidence of browse, and
- Ability to identify key culturally significant plant species.

One of the most important aspects of this protocol is forest health agent identification. It is essential 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.

Defining Population from TSA List

The TSA List can be used to select the number of openings that can feasibly be assessed in one field season. Openings should only be rejected when they do not meet the selection criteria. In all cases the reason(s) why an opening is rejected for assessment must be documented.

A stand may be rejected from the sample if any of the following criteria apply:

- Opening is a partial cut or multi-layered, uneven aged stand –
- Access or conditions within the opening making surveying unsafe. –

Difficulty or expense required for access is not considered sufficient reason to reject an opening from the sample. Relying on easily accessible openings may introduce bias and negatively affect the quality of the findings.

A minimum of 30 openings should be surveyed before any formal reporting on the status of managed stands in an area of interest is produced. **It is envisioned that SHAGM surveys will be conducted by a range of stakeholders including District staff, First Nations, and other interested parties, all following the same standard survey procedures and working from the same sample population so that shared decision making based on mutual understanding of current managed stand conditions is fostered.**

Getting Started: Planning for office and field

Planning and documentation (office)

- (1) Potential sample openings are drawn from the Managed Stand Yield Table process developed by Forest Analysis Inventory Branch (FAIB) using Probability Proportional to Size sampling procedures. After the sample selection is determined, a webmap application has been developed to show both the location of the stand as well as the location of five randomly located plot centers.

Office Procedures

- Obtain the TSA or Traditional Territory list of inventory openings (from the SHAGM Regional Forest Health contact),
- Create a spreadsheet for tracking information such as acceptability, access, and confirmation source of prior silviculture survey and FAIB MSYT forecast,
- Check web-map and confirm that there are no complicating factors (e.g., fire, landslide, etc.) that would compromise the use of the opening for sampling.
- Check location of the 5 pre-selected SHAGM plot locations within the webmap). All cells within the polygon boundary *except* those that fall in areas excluded from the NAR (roads, landings, water bodies, etc.) are potentially eligible.
- As the plot locations are pre-determined, the location of the POC can be determined in the field at a convenient location.

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Office checklist for the SHAGM protocol	Done	Reviewed
1. Obtain TSA list of all potential 20-40 year old even-aged managed stands for BEC unit of interest		
2. Select 30 openings for current year using Probability Proportional to opening size		
3. Obtain opening summaries from RESULTS and examine opening files for the most recent silviculture survey results and stand history for each potential sample opening.		
4. Determine accessibility options and set survey schedule.		
5. Conduct surveys.		
6. Conduct quality control checks on field survey methods, plot data and field cards.		
7. Compile data, enter into SHAGM spreadsheets, and provide plot and survey summaries for stand stocking, species composition, pest incidence, site index, stand volume and presence of moose sign and culturally important plants.		

Field Procedures

Field Gear Checklist

Item	Got it?
Survey field data electronic data logger	
Web map with predetermined sampling plot locations within selected opening	
Compass	
GPS unit (for polygon location and navigating to plot points)	
Aluminium stakes/large nails (<50cm) to permanently identify plot centers	
Plot cord(s) suitable for 5.64 m plots	
DBH measuring tape	
Vertex clinometer	
Small hatchet or field knife	
Pest field identification guide(s)	
SHAGM damage criteria	
Blue and pink flagging tape	
Increment borer	
Calculator	
Camera	
Personal field and safety gear	

Field Methods

Field review of sample polygon:

1. Review webmap to confirm polygon location, access, plot placement, etc.
2. Prior to going into the field predetermine locating the plot center using a GPS unit and follow the Silviculture Survey Manual recommended methods for plots located near the polygon boundary (Walk-through method).

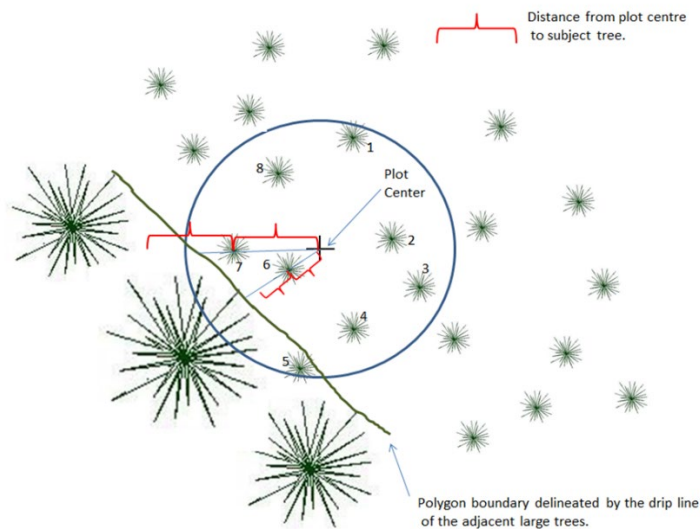
It is critical that all survey plots be located within the same opening as identified in the prior silviculture survey so that current results can be compared to the RESULTS forecast (FAIB's MSYT protocol).

3. Pre-determine offset distance if plot location lands in area that is unsafe to survey (e.g., move plot back 10 m because plot center was in a small pond).

Field data gathering for each polygon:

1. Create a POC and mark with blue and pink flagging ribbon at starting point as "SHAGM" with the date, surveyor's initials and approx. distance and bearing to the first plot. Record a GPS point for the POC. Record all plot data on a **digital** field card using the Survey 123 App.
2. Mark each plot center with an metal stake, spike (<50 cm) and blue and pink flagging ribbon (include plot number, date and surveyor's initials). Record a GPS point for the plot centre.
3. Starting at a bearing of 0° (North), sweep clockwise and record the height and dbh all trees ≥ 7.5 cm dbh within the 5.64 m radius and record whether it is alive or dead. DBH measurements are to the nearest 0.1 cm, heights to the nearest 0.1m. During this sweep, all trees ≥ 7.5 cm in DBH are marked with blue ribbon and numbered sequentially. This record includes **both** live and dead trees. Dead-and-down trees are to be tallied if their base/root-wad is within the plot and they appear to be of the same age cohort as the current stand.
4. Along with the measurements recorded in the first sweep, assess each tree in the plot for forest health factors and record by species. For trees with unacceptable stem damage, record the height of the damage. **Only record damage agents that have rendered the tree unacceptable according to the SHAGM damage criteria (see Appendix 3).**
5. For plots located close to the opening boundary where a portion of 5.64 m radius sweep crosses outside of the opening use the Walk-Through method as follows:

In the following diagram eight trees fall within the gross boundaries of the 5.64 m plot.



Tree numbers 1,2,3,4 and 8 would each be recorded as one stem/plot. Tree number 5 would be recorded as zero stems/plot as it falls outside the polygon. Tree numbers 6,7 require closer examination using the walkthrough method—if twice the distance from the plot center to the tree exceeds the distance from the plot centre to the polygon boundary (on the same bearing), the tree is tallied twice. Tree number 6 would be recorded as 1 stems/plot and tree number 7 would be recorded as 2 stems/plot.

6. The site index sample tree used in each plot should be the largest (based on DBH) healthy tree of the dominant conifer species within a 5.64 m radius sweep. Sample the selected tree for site index criteria using the growth intercept method¹. If there is no healthy dominant conifer tree present in the 5.64 m radius plot, do not record site index data. In stands with more than one dominant conifer species, attempt to capture SI estimates from the range of species present, provided that over the 5-plot sample, at least three SI sample trees exist for each species. Take only one SI estimate per plot.
7. Examine the entire 5.64m radius plot area for presence of moose dropping and record if present whether droppings were summer(paddies)/winter(pellets) or both.
8. Record presence of any major moose sign (mineral lick, major trail, rutt hole)
9. Record evidence of browse on 6 key forage spp (willow spp., red osier dogwood, highbush cranberry, subalpine fir, saskatoon, other)
10. Record presence of culturally relevant plants (devils club, soopolallie, cow parsnip, huckleberry, Labrador tea)
11. At some point during the 5-plot survey, take a representative digital photo of the stand. In addition, photograph any anomalous situations that may require feedback from the Regional forest health specialist.

¹ Growth intercept method for silviculture surveys. 1995. BC Ministry of Forests. Silviculture Practices Branch.

Filling in the Survey 123 forms

1. **Surveyor Name(s):** Record the name(s) of the person who completed the survey.
2. **Survey date:** Record the date in which the survey data was collected in the field.
3. **Feature ID number**
4. **Plot No.:** Record the plot number assigned to the plot.
5. **UTM Co-ordinates:** Record the Zone, Easting and Northing reading for this plot.
6. **Tree No.** (starting at tree closest to 360° and sweeping clockwise, sequentially, number only trees ≥ 7.5 cm dbh)
7. **Tree Species:** Record the coniferous and broadleaf tree species that occur in the plot. 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.
8. **DBH:** to the nearest 0.1 cm for all trees ≥ 7.5 cm dbh.
9. **Height:** to the nearest 0.1 m for all trees ≥ 7.5 cm dbh.
10. **Live/Dead**
11. **Forest Health Damage Agents:** Record the applicable pest code for the two most severe forest health factors on **each** affected tree within the plot, starting with the most severe and most likely to result in tree death. 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.
12. **% Girdling of Damage Agent:** Estimate to nearest 10% of stem circumference
13. **Height of Damage:** Record height to nearest 0.1m of damage
14. **Growth Intercept Sample:** Determine site index using the growth intercept method, record the measurements and species. Refer to site index training materials on the growth intercept method. In stands with more than one dominant tree species, collect SI data for each species but only one SI tree is assessed per plot.
15. **Moose droppings:** Within the 5.64m radius plots, If yes, summer, winter, both?
16. **Moose browse:** If yes, willow spp., red osier dogwood, subalpine fir, highbush cranberry, saskatoon, other.
17. **Significant moose sign:** If yes, mineral lick, heavy trail, rutt hole
18. **Culturally relevant plants present** If yes, devils club, soopalallie, cow parsnip, huckleberries, Labrador tea

Data analysis

Data handling

Survey data will be handled, from field to final report, electronically with as few interventions after entry as possible. This reduces data entry errors, maintains format consistency, standardizes reporting, and automates data storage and retrieval.

Managing SHAGM Excel Spreadsheets

1. Please save all completed SHAGM EXCEL spreadsheets for the polygons you have assessed onto the following site:

Reporting –RESULTS, and the SHAGM Milestone report

The SHAGM Milestone report will provide a powerful monitoring tool for forest management throughout BC. Once this milestone is created and begins to be populated most of the detailed data analyses that have been conducted in the larger Post Free-Growing assessments will be readily available to all interested parties. Areas where managed stands are clearly on track and meeting expectations will be easily identified as will areas of concern.

Help

For further information on planning, surveying and analyzing stand-level monitoring plots, contact your respective FLNRORD Regional forest health specialists.

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 2.

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

Appendix 3.

STAND Health and Growth MONITORING DAMAGE CRITERIA FOR EVEN-AGED (AGE CLASS 2) CONIFEROUS TREES

INTRODUCTION

The Stand Health and Growth Monitoring (SHAGM) protocol has been developed to assess stand performance, from a timber yield perspective, for the critical mid-rotation age range of 20-40. The data gathered will help determine whether these stands are on a trajectory that will result in a productive mature stand. The simple, transparent nature of the data collection protocol will allow for multiple stakeholders to both collect and analyze the data which will facilitate shared management decisions on BC's managed forest land-base.

SHAGM damage criteria are tailored for determining the health status of stands at a later stage of development (i.e., even aged, age class 2). These damage criteria are designed to determine the damage to, and acceptability of, **individual** conifers. These criteria do not apply to broadleaf species. The SHAGM damage criteria are based on the most current knowledge of forest-damaging agents.

Agents and damage are 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 we learn more about the health and productivity of managed stands. 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.

SHAGM DAMAGE CRITERIA FOR EVEN-AGED (AGE CLASS 2) CONIFEROUS TREES

[illegible]

LOCATION OF DAMAGE	TYPE OF DAMAGE	Recorded as:	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"> % 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"> % 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"> > 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>
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. 	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	Recorded as::	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. 	<p>Se, Sx, Fd, PI</p> <p>Ba, Hw, Ss, Fd</p>	<p>annosus root disease DRN tomentosus root rot DRT,</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: 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>

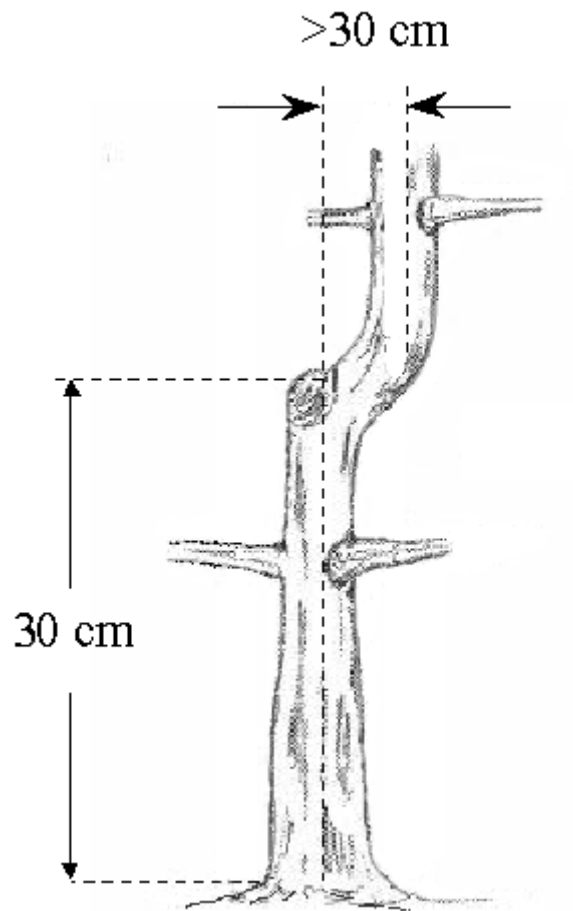


Figure 1. Determining horizontal displacement when assessing stem deformation. This is only done when the tree has five seasons' growth after damage occurs.

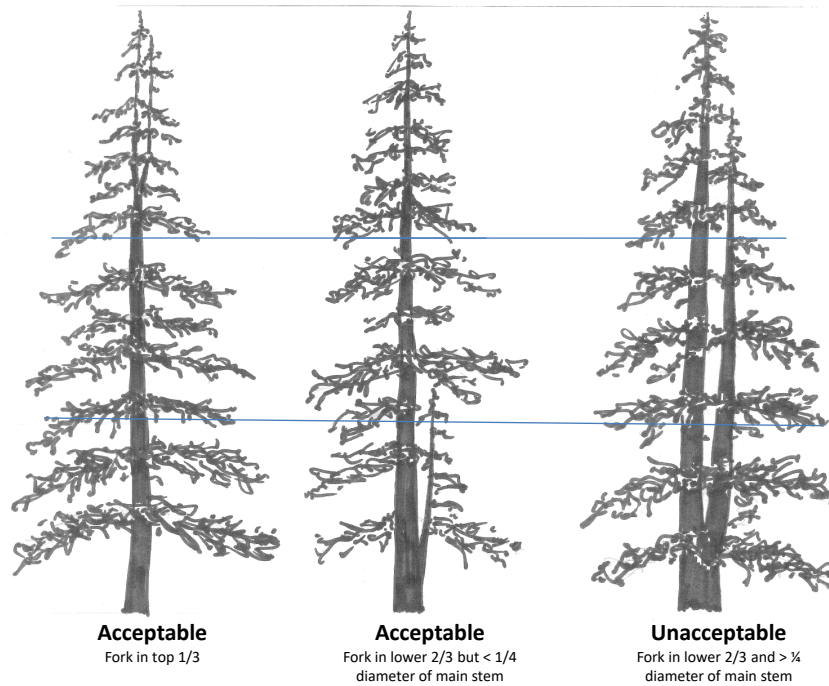
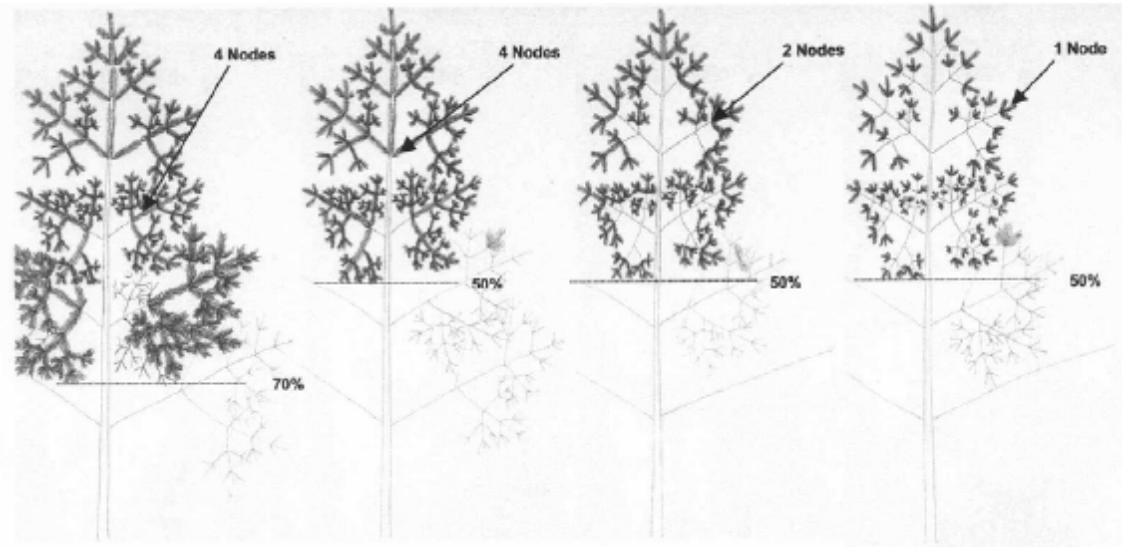


Figure 2. Acceptable and unacceptable forking in age class 2 & 3 conifers (damage code K).



a)
70% Live Crown
4/4 Healthy Nodes
 $70\% \times 100\%$
= 70%

b)
50% Live Crown
4/4 Healthy Nodes
 $50\% \times 100\%$
= 50%

c)
50% Live Crown
2/4 Healthy Nodes
 $50\% \times 50\%$
= 25%

d)
50% Live Crown
1/4 Healthy Nodes
 $50\% \times 25\%$
= 12.5%

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: <div data-bbox="251 468 699 751"> <div>(0) no visible infections</div> <div>(1) light infection (1/2 or less of total number of branches in the third infected)</div> <div>(2) heavy infection (more than 1/2 total number of branches in the third infected).</div> </div>	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.