Monitoring Post-Free-Growing Stand Conditions in Five Timber Supply Areas Throughout British Columbia: What Are We seeing So Far?

FREP

EXTENSION NOTE #18

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Prepared by: Alex Woods, Wendy Bergerud, Stefan Zeglen, and Frank Barber

This extension note provides important information for forest managers and resource professionals involved in on-the-ground silviculture decision making and those tasked with province-wide policy development. It summarizes key stand level attributes from 266 randomly selected post-free-growing stands across five TSAs. This report describes how these stand attributes have changed since achievement of the free-growing milestone and discusses the implications of changes in stand conditions that could affect managed stand productivity.

BACKGROUND

Management of forest and range resources is a complex process that involves the balancing of ecological, social, and economic considerations. Set within this context, the objective of the Forest and Range Evaluation Program (FREP) is to determine whether forest and range policies and practices in British Columbia are achieving government's objectives for the 11 *Forest and Range Practices Act* resource values. To accomplish this objective, specific evaluation tools are designed by technical experts from government, industry, academia, and other agencies. These tools are then piloted and implemented by Ministry of Forests, Lands and Natural Resource Operations' field staff. One of the key components of forest policy related to the timber resource value is the free-growing milestone. The policy and practices associated with this milestone influence the initial stand conditions throughout the province and thus have a significant influence on preferred species composition, stand density and stocking, stand structure, and health over the life of a stand.

The free-growing milestone is used to ensure that young stands are fully stocked with healthy trees of ecologically

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To be a world leader in resource stewardship monitoring and effectiveness evaluations; communicating science-based information to enhance the knowledge of resource professionals and inform balanced decision-making and continuous improvement of British Columbia's forest and range practices, policies and legislation. http://www.for.gov.bc.ca/hfp/frep/index.htm

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suitable species. The obligation to achieve this early stand condition has been a legal requirement for stands harvested since October 1987. Stands harvested before this date are the direct responsibility of the Crown. Forest management in British Columbia is based on the fundamental assumption that once the free-growing milestone is reached stands will continue on a projected growth trajectory and provide a merchantable volume of timber at harvest.

Since 2005, FREP, in conjunction with the provincial forest health program, has led an evaluation to assess the condition of post-free-growing managed stands. The evaluation has been designed to determine whether free-growing stands are meeting timber productivity expectations and to assess the extent to which both biotic and abiotic damage agents are impacting stand health and productivity. The first step in this assessment was to develop a survey approach that would serve as both a proof of concept and an evidentiary foundation from which to build a standard post-free-growing monitoring tool. To accomplish this, evaluations took place in five timber supply areas (TSAs) across the province: (1) Lakes, (2) Clearwater District,[1] (3) Okanagan, (4) Kootenay Lake, and (5) Strathcona (Figure 1).

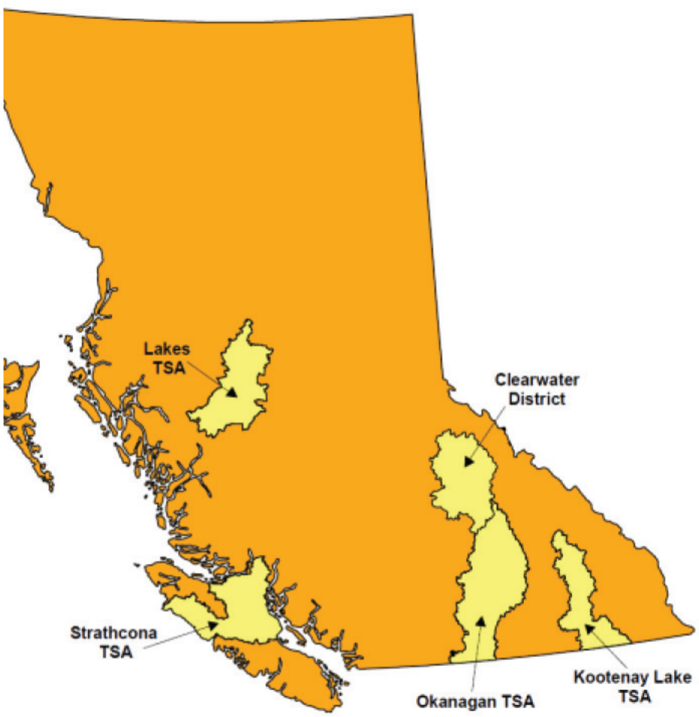

Figure 1. The five timber supply areas in which post-free-growing stands were surveyed.

For these evaluations, a sample population that met all the following criteria was drawn from the RESULTS database:

- harvested post- 1960
- even-aged
- 15 ha or greater in area
- designated free-growing[2] from 1987 to 2001

This random selection process produced a sample of 266 forest stands.

One of the key questions these initial evaluations posed was: are these stands still adequately stocked with healthy productive trees? This extension note summarizes the findings from the first step in FREP's overall examination of post-free-growing stand condition. It focusses on the role that both biotic and abiotic damage agents are playing in post-free-growing stands in five TSAs across the province.

Further information about these intensive evaluations is available in the report titled Are free-growing stands meeting timber productivity expectations in the Lakes Timber Supply Area? (FREP Report No. 13; http://www.for.gov.bc.ca/hfp/frep/publications/reports.htm) and the pending Okanagan, Strathcona, and Kootenay Lake TSA reports. In these full reports, readers will find specific details about which forest health agents have had the greatest impact on stand densities and in which biogeoclimatic zones.

RESULTS

Stand Age

The average stand age at the time of free-growing declaration across all 266 sampled stands was just over 15 years (range: 5–43 years). Average stand age at the time of our survey varied from 24 years in the Sub-Boreal Spruce (SBS) zone to 28 years in the Interior Cedar–Hemlock (ICH) zone with an overall average of 27 years. The minimum stand age was 13 years, whereas the oldest was 62 years. Our surveys were conducted 4–22 years after the free-growing survey, with an average interval between assessments of 11 years.

1 Only the former Clearwater Forest District portion of the Kamloops TSA was sampled; however, reference is made to "five" TSAs for ease of reporting.

2 See: Powelson, A. 2011. How the use of the term "free growing" in British Columbia is linked to harvest date and assessment date. Forest Practices and Investment Branch, B.C. Ministry of Forests, Lands and Natural Resource Operations, Victoria, B.C.

http://www.for.gov.bc.ca/ftp/HFP/external/!publish/FREP/Indicators/Resource Values/Timber/How the use of the term Fg varies.pdf

Forest Health

Various forest health agents were observed throughout stands in the five TSAs. To simplify analyses and reporting, these were grouped into common pest damage associations. Abiotic damage caused by frost, snow press, or hail was the most widely distributed damaging agent, occurring in nearly two-thirds of sampled stands (Figure 2).

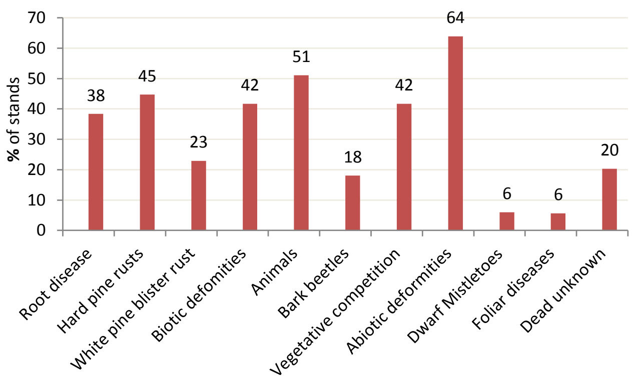

Figure 2. *Proportion of the 266 sampled stands over five TSAs affected by forest health agents, with damaging agents grouped on the basis of similarity and severity of damage.*

Root diseases, arguably the most serious damaging agent of managed stands given their persistence and impact, were found in over 38% of the sampled stands. Several less damaging insects and diseases, such as spruce leader weevil, pine leader weevil, and atropellis canker, were combined in our analyses into biotic-caused deformities; these deformities occurred in almost 42% of all stands. In cases where it was no longer possible to determine the cause of tree death, the category “dead unknown” was used, which occurred in just over 20% of stands (Figure 2).

Animal damage, including everything from bark stripping by black bears (Figure 3, top) to flooding damage caused by beaver dams (Figure 3, bottom), was the second most frequently encountered damage agent group. Although animal damage can lead to tree deformities, it was separated from other biotic agents causing deformities to illustrate its relative importance.

Figure 3. *Animal damage in managed stands: (top) bark stripping caused by black bears (J. Hodge photo); (bottom) flooding mortality attributed to beaver dams.*

Stands were divided into four damage agent incidence groups: (1) not present, (2) low, (3) moderate, and (4) high levels of the damage agent (Table 1). For ease of comparison, the same damage thresholds (i.e., < 10%, 10–20%, and > 20%) were used for all damage agents except root disease. These thresholds are based on a combination of incidence and damage severity, as informed by professional experience, and can be found in references including Stand Establishment Decision Aids[3]. Root disease at an incidence of 10%, for example, carries a far greater timber supply impact than that associated with hard pine rusts at the same incidence. If an individual tree had more than one damaging agent, only the most severe damage was recorded; the damage agent associated with a high probability of causing mortality took precedence.

3 Stand Establishment Decision Aids (or SEDAs) are extension notes that synthesize the latest information on silvicultural tools and practices. SEDAs are available online at: http://www.forrex.org/tools/sedas/

Table 1. *Number of stands affected by forest health damage agent groups by incidence class across 266 sampled stands combined for the five TSAs; data include the highest incidence values observed and the tally of stands where damage groups were not observed.*

Observed forest health damage								
	Not present	Low levels		Moderate levels		High levels		
Damage agent group	Number of stands	Number of stands	Threshold range (%)	Number of stands	Threshold range (%)	Number of stands	Threshold range (%)	Highest incidence (%)
Root disease	164	40	< 1	47	1–5	15	> 5	23.0
Hard pine rust	147	80	< 10	23	10–20	16	>20	45.9
White pine blister rust	205	59	< 10	2	10–20	0	> 20	12.7
Deformities	155	96	< 10	13	10–20	2	> 20	26.3
Animal	130	132	< 10	4	10–20	0	> 20	18.5
Bark beetles	218	47	< 10	1	10–20	0	> 20	19.8
Vegetative competition	155	73	< 10	24	10–20	14	> 20	50.0
Abiotic damage	96	158	< 10	10	10–20	2	> 20	30.8
Dwarf mistletoe	250	15	< 10	1	10–20	0	> 20	10.4
Foliar disease	251	15	< 10	0	10–20	0	> 20	5.1
Dead unknown cause	212	54	< 10	0	10–20	0	> 20	4.4

Stands were rarely found to be completely free of unacceptably damaged trees (only 16 of the 266 stands surveyed) (Figure 4). In the majority of stands surveyed (70%), less than 20% of total conifers were damaged by forest health agents. In 5% of assessed stands, 40% or more of total conifer trees were damaged to a degree that would make them unacceptable based on current free-growing damage criteria.

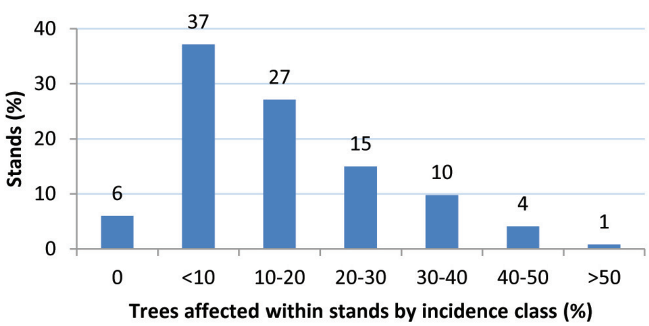

Figure 4. *Percent of the total surveyed stands affected by combined damage agents grouped into 10% incidence classes. Only the most severe damaging agent was recorded per tree, allowing for a summation of damage agent incidence per stand.*

Stand Density

Pooled results from the five TSA surveys show considerable differences among biogeoclimatic zones in stand density trends between the two assessments (Table 2). In both the Coastal Western Hemlock (CWH) and SBS zones, total stand densities did not change significantly. In the Engelmann Spruce–Subalpine Fir (ESSF), Interior Cedar–Hemlock (ICH), Interior Douglas-fir (IDF), and Montane Spruce (MS) zones, total densities have dropped by 32% or more since the free-growing survey.

What the data is showing so far is a roughly equal number of stands with increasing and decreasing stand densities for the ESSF and IDF (Table 2). The SBS has more stands increasing than decreasing, whereas the CWH, ICH, and MS have substantially more stands with decreasing density. Overall, more stands had a decrease in density than an increase.

Table 2. *Stand density attributes compared by biogeoclimatic zone as recorded both at the free-growing milestone and observed during FREP surveys*[a]

	Biogeoclimatic zone						Total or mean
	CWH	**ESSF**	**ICH**	**IDF**	**MS**	**SBS**	
Number of stands	58	44	74	3	27	60	266
Total density at free-growing survey (stems per hectare)	2700	3860	5289	9250	4274	3544	4036
Total density at FREP survey (stems per hectare)	2947	2263	3596	4394	2908	3671	3190
Change in total density (%)	+9[b]	−41	−32	−52	−32	+4[b]	−21
Target free-growing density	900	1200	1200	1000	1200	1200	
Minimum free-growing density threshold	400–500[c]	700	700	600	700	700	
Well-spaced density at FREP survey (stems per hectare)	792	886	840	813	890	1137	909
Free-growing density at FREP survey (stems per hectare)	672	868	778	760	866	1078	846
Change in well-spaced density since declaration (stems per hectare)	+6 [b]	−154	−241	−351	−252	+35[b]	−113
Change in free-growing density since declaration (stems per hectare)	−80	−33[b]	−138	−116[b]	−188	+80	−63
Numbers of stands with decreasing/ increasing free-growing density	37/21	24/20	56/18	2/1	20/7	19/41	158/108

a. These data all represent simple means. Positive differences (+) signify that the density has increased from declaration to time of survey; negative differences (−) signify that the total density has decreased.

b. Value not statistically different than zero (i.e., no statistically significant change).

c. Minimum free-growing density threshold can range from 400–500 stems per hectare for coastal Douglas-fir.

The proportion of stands that continue to meet or exceed the minimum stocking threshold varies with the SBS-dominated Lakes TSA maintaining the most.

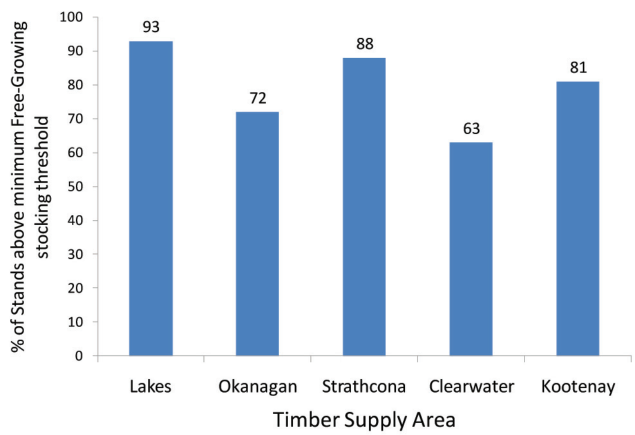

Figure 5. *Percentage of stands above minimum free-growing stocking threshold.*

Figure 5 illustrates the percentage of free-growing stands that continue to meet or exceed the minimum stocking thresholds of the free-growing milestone an average of 11 years after declaration, based on the mean decision rule.

Mean and median free-growing densities remain above the respective minimum stocking standards in all five TSAs and across all biogeoclimatic zones sampled (Figure 6); however, as demonstrated by the lower whiskers of the box plots[4] in Figure 6, some stands no longer meet the respective minimum stocking threshold because of the influence of biotic and abiotic forest health agents.

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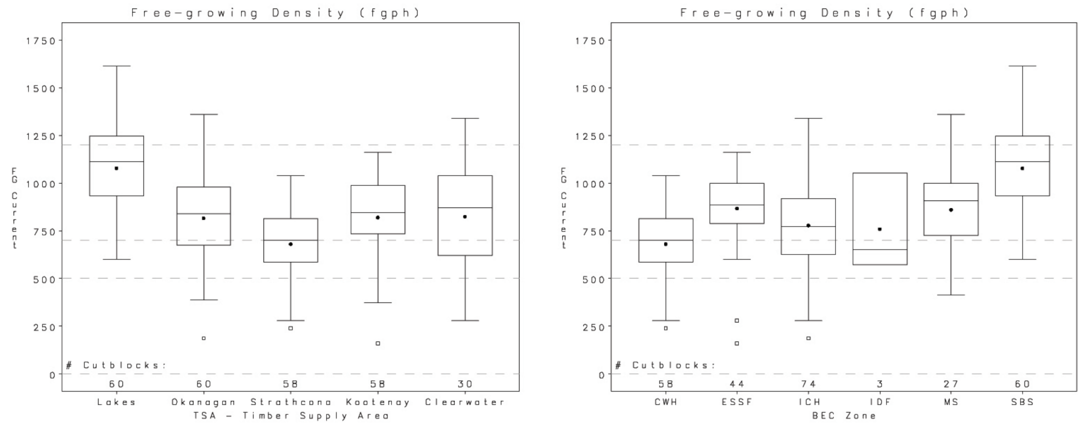

Figure 6. *Box plots of the mean and median free-growing density by TSA (left) and by biogeoclimatic zone (right) an average of 11 years after declaration.*[5]

Species Composition

Based on inventory labels, changes in leading species were evident in 20% or more of sampled stands, with the exception of the lodgepole pine-dominated Lakes TSA where no changes took place. The Clearwater Forest District had the highest percentage, with 27% of stands experiencing a change in leading species in the time since the free-growing declaration. Changes in leading species were attributed to both natural ingress and species-specific forest health agents (e.g., root disease or mountain pine beetle) killing preferred crop tree species.

Site Index

Site index (SI) estimates were not consistently reported in past silvicultural records because tools such as the growth intercept method and the site index by site series approximations were not available until 1997. Many early SI estimates were either qualitative (i.e., good, medium, or poor), or may have been converted from tables. The current Ministry growth intercept method has become the standard for estimating site productivity on Crown land. In areas where we could make meaningful comparisons, our field-sampled SI estimates based on the growth intercept method have tended to be the same or higher than those used in the timber supply reviews (TSRs). In the Lakes TSA, we found a mean SI of 20.2 m (SE 0.2) for lodgepole pine-leading stands, whereas the most recent TSR was based on a mean of 20.9 m. In the Okanagan TSA, the mean SI for lodgepole pine plantations was modelled as 17.6 m in TSR, whereas we found a mean of 21.6 m (SE 0.3). In the Strathcona TSA, western hemlock and Douglas-fir-leading plantations were modelled in the most recent TSR as having mean site indices of 25.2 m and 31.3 m, respectively, whereas our mean site indices were 29.4 m (SE 0.8) for western hemlock and 33.8 m (SE 2.3) for Douglas-fir.

STAND DEVELOPMENT MONITORING PROTOCOL

Building on the foundation of the five intensive evaluations, a Resource Stewardship Monitoring protocol has been developed (FREP Stand Development Monitoring Protocol; http://www.for.gov.bc.ca/ftp/HFP/external/!publish/FREP/Indicators/SDM Protocol 2011.pdf). This protocol has been piloted over the last 3 years and will begin broader implementation in 2011. Stand development monitoring assessments will help target forest health treatments and facilitate discussion and action to address reforestation outcomes/issues (e.g., refining reforestation strategies and FSP results and strategies, and providing inventory label and site index updates for young managed stands). Over the longer term, it is hoped that stand development monitoring will also provide:

- forest health data for Timber Supply Review rationales (has occurred in several TSAs);
- risk ranking/prioritizing locations for permanent Forest Analysis and Inventory Branch monitoring plots;
- yield estimates for young stands (including forest health affects and estimates of dead tree volume);
- data for refining forest health impact estimates; and
- independant data to help validate TIPSY yield curves.

5 For an explanation of box plots, see Biometrics Information 33 at http://www.for.gov.bc.ca/hre/biopamph/pamp33.pdf

SUMMARY

Forest Health

The data presented across the five TSAs and six biogeoclimatic zones sampled provide insights about how a combination of abiotic and biotic damage agents is impacting the health and productivity of our young stands. Over the five TSAs surveyed, the top five forest health agents, ranked in terms of incidence, were:

1. deformities and abiotic damage,
2. mammal damage,
3. hard pine rusts,
4. vegetation competition, and
5. root diseases.

Deformities and animal damage can, in part, be managed through species selection; however, to a degree, these losses must simply be monitored and accounted for in terms of lost timber value. Hard pine rusts can be managed by adjusting species composition and increasing planting density at the time of stand initiation. Vegetation competition can be reduced by more proactive site preparation and brushing treatments. Root disease incidence can be managed through proactive root disease inoculum reduction (stumping) before planting and through informed tree species selection decisions.

Stand Density

Many of the surveyed stands have undergone a loss of free-growing density since declaration. The extent of loss varies depending on the biogeoclimatic zone, with the greatest reductions occurring in the MS and ICH zones. It is important to recognize that free-growing densities are expected to decline over the longer term due to both biotic and abiotic causes. To maintain higher levels of stocking, increased initial planting densities and use of more resilient species mixes may be needed in some circumstances.

Species Composition

Four of the five TSAs experienced a change in leading inventory species in about 20% of sampled stands. An awareness that leading inventory species labels change over time in a notable portion of managed stands should help improve the accuracy of timber supply forecasts.

Site Index

By using the Ministry's growth intercept method, we are now getting more realistic expressions of actual site productivity in our second-growth stands. These revised estimates will provide the best estimates available for silvicultural and planning applications requiring the generation of yield estimates.

ACKNOWLEDGEMENTS

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