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FOREST AND RANGE EVALUATION PROGRAM

March 2011

Northern Interior Forest Region: Analysis of Stand-level Biodiversity Sampling Results in Six Predominant Biogeoclimatic Subzones

Prepared by:
Nancy Densmore, RPF

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Management of forest and range resources is a complex process that often involves the balancing of ecological, social, and economic considerations. This evaluation report represents one facet of this process. Based on monitoring data and analysis, the authors offer the following recommendations to those who develop and implement forest and range management policy, plans, and practices.

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EXECUTIVE SUMMARY

Over 500 harvested cutblocks were assessed for stand-level biodiversity attributes from 2006–2009 in the Northern Interior Forest Region of British Columbia. Quality and quantity of the tree retention and coarse woody debris was measured. Eighty percent of the cutblocks had retention (greater than 0.5% of the cutblock area). Overall retention was 13% of the gross area of the cutblocks.

The retained tree data from the samples in six predominant biogeoclimatic subzones was compared against timber cruise data from the same subzones. This comparison gives an indication of the types of decisions being made for tree retention within those areas. For example, in the ESSFmv subzone there was consistently high biodiversity quality (i.e., equivalent or higher than baseline) for large dead trees (≥ 10 m tall and ≥ 30 cm dbh) and large diameter trees (live or dead ≥ 50 cm dbh), both important ecological attributes providing for wildlife tree dependent species. However, in the ESSFmv, the number of tree species (a component of overall species diversity) retained in the ESSFmv cutblocks is, on average lower than that found from the timber cruise.

The volume of CWD left on the harvested areas of the cutblocks was similar or higher than that on the ground within retention patches for each of the six predominant subzones, a good indicator for maintenance of soil structure. However, the density of big pieces of CWD (≥ 20 cm diameter and ≥ 10 m long) is significantly lower for five of the six predominant subzones. Big pieces of CWD are important to maintain on sites for soil stability and wildlife habitat.

TABLE OF CONTENTS

List of Tables

List of Figures

1.0 INTRODUCTION

The purpose of this report is to improve understanding of a subset of stand-level biodiversity outcomes related to harvesting and retention forest practices at the regional level. The information presented here can facilitate discussions on biodiversity practices and highlight opportunities for continuous improvement of those practices.

Wildlife trees and coarse woody debris (CWD) are components of the biodiversity value noted in the Forest Planning and Practices Regulation under the *Forest and Range Practices Act* (*FRPA*). The Forest and Range Evaluation Program (FREP) is assessing how well these values are being maintained. Stand-level biodiversity, particularly the retention of live and dead standing trees and CWD within harvested cutblocks, is an important (if not essential) component of wildlife habitat maintenance (for species dependent on mature and old-forest characteristics) (Seip and Parker 1997; Fenger et al. 2006), and vital for maintaining other ecological functions, such as hydrologic functioning, soil condition, and species dispersal (Chapman 1995; Winkler et al. 2008; Kremsater and Bunnell 2009).

2.0 BACKGROUND AND METHODOLOGY

Data, totalling 510 cutblocks, was collected by British Columbia Ministry of Forests and Range forest district staff in the Northern Interior Forest Region during the 2006–2009 field seasons. The cutblocks for sampling were chosen randomly from the full population of potential cutblocks (defined harvest date and 2 ha or larger), as documented in the RESULTS (Reporting Silviculture Updates and Landstatus Tracking System) corporate data system. The samples are from cutblocks harvested between 1997 and 2007 (Table 1). These cutblocks were therefore representative of *Forest Practices Code of British Columbia Act* (FPC) cutblocks.[1]

In brief, the field survey utilizes modified timber cruise plots to assess tree retention and line transect plots for coarse woody debris. Both a tree and CWD assessment is done from every plot centre, which is randomly located, both within tree retention patches and in the harvested areas of cutblocks. Other collected information includes windthrow, invasive plants, and ecological anchors. The general retention patch information collected included patch location in relation to harvesting, size of patch, presence of riparian influence, and planned retention length (i.e., temporary: to be harvested prior to rotation end; and long term: to be retained throughout the rotation). The main reporting includes only the influence of long-term retention; however, a shadow analysis was done to assess the effect of the temporary retention. Further details on the survey methodology are found in the FREP stand-level biodiversity protocol (Province of British Columbia 2009).

A general overview of all sampled Northern Interior Region cutblocks is presented, followed by a summary of predominant biogeoclimatic (BEC) subzones within five of the six sampled zones. Only one cutblock in the Mountain Hemlock zone was sampled, and therefore no subzone summary is presented for that zone.

The tree indicator data is compared against timber cruise data from major licensee and British Columbia Timber Sales (BCTS) cutblocks derived from the Electronic Commerce Appraisals System (ECAS) (https://www.for.gov.bc.ca/hva/ECAS/index.htm) and the BCTS Official Notices Site (https://www23.for.gov.bc.ca/notices/init.do). A further description of the derivation of baseline data, plus BEC subzones for the FREP-sampled cutblocks are shown in Appendix 1.

Cruise plots are not normally established in areas designated for wildlife tree retention. The comparison between FREP-sampled retention and cruise plots therefore indicates the biodiversity choices made on the sampled cutblocks. A difference in an indicator average

Table 1. Samples by harvest completion year

Harvest year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Unknown	Total
% of samples	2.0	5.5	8.6	10.4	9.4	12.7	14.7	9.8	13.3	8.0	5.1	0.4	100

1 The effective date of the *Forest and Range Practices Act* was January 31, 2004; however, forest development plans (FDP, an FPC plan governing harvest) were being created up until December 31, 2005, and could be extended up until March 31, 2007. Cutting permits (i.e., a permit to harvest timber) originating from FPC FDPs extended beyond March 31, 2007. Two cutblocks from the Northern Interior Forest Region sample (harvested in 2007) originated from forest stewardship plans (FSP, a *FRPA* plan governing harvest).

between the cruise data and the FREP data for a BEC subzone likely indicates choices to establish retention areas that are to some extent different from harvested areas. Where dispersed retention is a common practice, the decisions of which single trees (or small groups of trees) to maintain can have an overall influence on the quality of retention. Retention choices are compared against the provincial wildlife tree management guidance (http://www.for.gov.bc.ca/ftp/hfp/external/!publish/web/wlt/policies/WT-Guidance-05-2006.pdf), which outlines good environmental choices for wildlife tree retention. For example, an overall average density of large trees that is higher than that found in the baseline supports the recommendation to bias retention towards areas with high-value wildlife trees.

A Kolmogorov-Smirnov two-sample test (K-S test) was used to assess the validity of the null hypothesis that the baseline and stand-level biodiversity retention data means are samples from the same distribution (or population). The K-S statistic (D) is the maximum separation of the two cumulative distributions. The K-S statistic is further described in FREP Report No. 17 (B.C. Ministry of Forests and Range 2008a).

A baseline for CWD on a harvested cutblock may be considered in many ways, such as the amount of wood on the ground soon after natural disturbance, before harvest, or in similar mature ecosystems. For FREP, the CWD indicators (volume and density of large pieces) are compared in the retention patches (unharvested forest) versus the harvest area (affected by logging).

Long-term success for dead-wood management (both standing and downed wood) means retaining the amount and type of dead wood necessary to:

- sustain deadwood-dependent organisms (e.g., many fungi and invertebrates); and
- maintain ecological function driven by input of dead wood (B.C. Ministry of Forests and Range 2010).

The FREP monitoring results provide insight into the amount and quality of live and dead wood left on sites in the context of levels in unharvested areas.

2.1 *Indicators Assessed*

Many different indicators can be compiled from the data collected. A subset of potential indicators is presented in this report. The indicators chosen are important for ecological retention value. For example, the density of large trees is tracked since size is a key attribute of high-value wildlife trees. Wildlife trees are habitat for over 80 British Columbia animal species, providing cover, nesting, denning, feeding, roosting, and perching sites (Wildlife Tree Committee 2008). The most valuable wildlife tree is large, old, damaged, or decayed. There is not enough time for a tree to develop these traits within a typical commercial harvest cycle, so it is important to maintain areas of old forest within harvested cutblocks (Fenger et al. 2006).

2.1.1 Retention patch size

Large retention patches (> 2 ha) provide closer to interior forest habitat conditions (considering wind, shade, and canopy interception) than small retention patches. Botting and deLong (2009) found that macrolichen and bryophyte species richness was not maintained in small retention patches compared to the surrounding forest, and suggested that larger patches (of 2 ha or more) would better maintain species diversity and allow for recolonization of the harvested area.

2.1.2 Retention patch location

A mixture of both internal and edge of harvest patch locations is suggested. Internal patches provide areas of cover within the harvest cutblock, potentially allowing more movement of small animals throughout the cutblock and easier recruitment of vegetation species. Edge patches have the potential of merging with forest cover outside of the cutblock, giving larger forested patches (even if temporarily) and often providing more linear retention from stream riparian reserves which can provide travel corridors. Although external, non-contiguous retention patches may provide biodiversity attributes, these patches do not provide direct benefits to the cutblock in terms of species or CWD recruitment and are therefore not recommended for provision of stand-level biodiversity.

2.1.3 Large snags (dead trees ≥ 30 cm and ≥ 10 m)

Large, dead trees (dead trees are also called “snags”) are important habitat for wildlife tree users. The B.C. Ministry of Forests and Range (2005) indicated that the minimum size of a dead tree to be functional for bird reproduction is 20 cm dbh and 10 m high. Observations of nesting use of stubs by birds in the southern interior of British Columbia indicated a preference for larger diameter (36–45 cm) trees (Harris 2001). The 30 cm diameter cut-off for this indicator was chosen because it met the functional dead tree description and was close to preferred diameters.

2.1.4 Large trees (live and dead; dbh ≥ 40 cm, ≥ 50 cm, or ≥ 70 cm)

Large size is one of the main considerations for determining a high-value wildlife tree (BC Ministry of Forests and Range 2006). For this report, a 40, 50, or 70 cm dbh or larger cutoff is used to define a large tree, depending on the baseline density of such large trees in the particular subzone.

2.1.5 Number of tree species

The *Biodiversity Guidebook* (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1995) states that: "The maintenance of the diversity of naturally occurring plant species is key to the maintenance of biological diversity within landscape units." This indicator looks at the number of tree species found on sampled cutblocks in the FREP biodiversity plots compared to that found in the timber cruise plots.

The cumulative distribution charts for tree species (see Section 4) show the data in a more "stepwise" fashion than the density of various other tree indicators since the data has a smaller range of possible answers (e.g., about 0–15 possible tree species versus about zero to several hundred possible large trees per hectare). The number of species found onsite is highly dependent on the sampling effort, particularly in areas with rarely occurring species (B.C. Ministry of Forests and Range 2008). Due to the extensive area surveyed during a typical timber cruise, the number of plots in the baseline data will likely be higher than the number of plots in FREP stand-level biodiversity monitoring for any particular subzone. Because of this discrepancy, a slightly higher number of species is likely to found in the baseline data.

Previous analysis (B.C. Ministry of Forests and Range 2008) utilized an estimate of number of species for the baseline and the FREP-sampled cutblocks with a "Chao2" biased correction. An anomaly of this correction is a possible extreme range of species occasionally assigned. The correction, used in the 2008 report on eight BEC zone assessments, showed no change in the difference between the average number of baseline tree species and the average number of FREP-sampled retention cutblocks for four of the eight zones. For three of the eight zones, there was an increase to the FREP-sampled retention of one tree species compared to the baseline with the correction applied. For one zone, there was an increase in the FREP-sampled retention average of two species compared to the baseline. Considering the potential discrepancy in the count of tree species from the bias correction, this assessment considers that a retention average must be lower than the baseline average by one or more tree species before considering that there is a difference.

As well as the general biological value of maintaining the full range of tree species, there is a hierarchy of habitat value amongst tree species. Good ecological choices of retention might therefore focus on the higher-value species. Important northern interior wildlife-tree species, considering the provision of a wide range of habitat attributes are western redcedar, black cottonwood, trembling aspen, western hemlock, and paper birch (Heemskerk et al. 2009). Douglas-fir, with its thick bark and large size, is also noted as an important northern wildlife-tree species in its distribution within the SBS zone. Work by Bruce Rogers (Rogers 2009; B. Rogers, pers. comm.) shows that northern Douglas-fir in dispersed retention is often dying directly or indirectly because of water stress. This mortality is variable and presumed dependent on microsite, root damage from harvesting, soil compaction, genetics, and, pre-harvest conditions. It is recommended that drought risk assessment and preferential maintenance of Douglas-fir within patches (even if dead pine) should be done to minimize such mortality. Because tree species vary between the subzone variants, the presence or absence of the important northern interior wildlife-tree species is only assessed in the SBSdw and ICHmc subzones (FREP samples and baseline cruise), which had sufficient samples in all subzone variants.

2.1.6 Coarse woody debris volume and density of big pieces

The coarse woody debris (CWD) indicators are volume and number of big pieces (considering both diameter and length). Big pieces of CWD are more valuable than short pieces of similar diameter; long pieces last longer (Stone et al. 1998) before decaying into soil, and while decaying can better perform habitat and soil stability functions compared with smaller pieces (Harmon et al. 1986). Big pieces of CWD, considering both length and diameter, are the most valuable ecological indicator. Large pieces decay slowest (higher volume of wood) and are most likely to provide long-term denning and feeding habitat opportunities. All pieces designated as big (10 m or longer and 20 cm diameter or bigger) are a minimum of 20 cm diameter at the point of transect crossing, meaning that the point of largest diameter on the log is also a minimum 20 cm, but likely larger.

3.0 REGIONAL SUMMARY

3.1 *General Description of Northern Interior Forest Region Sample Cutblocks*

- 510 cutblocks sampled
- 81% of cutblocks had retention (411 cutblocks), 19% of cutblocks had no retention (99 cutblocks)
  - 30% (30 of 99 cutblocks) of the no-retention cutblocks were less than or equal to 5 ha in gross size
  - 31% (31 of 99 cutblocks) of the no-retention cutblocks retained a few trees but the percentage is rounded to 0
- 23 264 ha total gross area
- 11.2% (2596.3 ha) of patch (long-term) retention
- 2.2% (507.5 ha) of dispersed retention (basal area equivalent[2])
- 13.3% average retention
- 23% of retention constrained[3]
- 63% of patches are less than or equal to 2 ha
- 37% of patches are greater than 2 ha
- Average of 1.7 ecological anchors[4] per hectare of retention, patch or dispersed (range: 0–27)
- Average of 9% windthrow in the 414 cutblocks with retention measured.[5] Of these cutblocks, 57% were ≤ 5% and 29% ≥ 10%
- 43% of patches internal to cutblock boundary; 55% on the edge of the cutblock; and 2% external and non-contiguous to the cutblock
- Invasive species were found on 11% of the cutblocks

3.2 *Percent Retention*

The overall percent retention of 13.3% (shown above) is an average considering the total amounts of patch retention, dispersed retention (as basal area equivalent), and the total gross area sampled. This average increases to 14.6% when the temporary retention (retention on cutblock that is likely to be harvested before rotation end) is considered.

Table 2 below shows the percentage of cutblocks and gross harvested area by retention category. Work by the Centre for Applied Conservation Research at the University of British Columbia (Huggard and Bunnell 2007) links percentage of stand-level retention to forest bird response. The researchers concluded that many less sensitive (to harvesting) bird species decrease below the 15–20% retention levels. Some stands with less than 40% retention (or larger landscape reserves) are needed by sensitive (to harvesting) bird species.

Table 2. ***Distribution of retention levels in FREP-sampled cutblocks***

% retention levels	No. cutblocks	% cutblocks	Gross area (ha)	% total area
0	100	19.6	1997.1	8.6
1–4	70	13.7	2528.6	10.9
5–9	90	17.6	4318.3	18.6
10–14	99	19.4	6491.0	27.9
15–19	58	11.4	2926.7	12.6
20–24	33	6.5	2245.9	9.6
25–29	22	4.3	1315.2	5.6
30–34	11	2.2	495.5	2.1
35–39	6	1.2	163	0.7
≥ 40	21	4.1	782.4	3.4
Total	510	100	23267.7	100

2 Dispersed retention area is given as basal area equivalent area (i.e., a scaling down of the actual dispersed area). It can be thought of as converting dispersed retention to equivalent amount of patch area retention. For example, if a dispersed area contains 20% of the pre-harvest basal area, then reduce the actual area by 80%. Because pre-harvest data did not exist, for comparison purposes we used the basal area from retention patches on the same opening. If no retention patches were available, we used the average basal area for all other retention patches in the same biogeoclimatic subzone.

3 Retention is considered constrained for one or more of the following reasons: wet area, riparian management zone, riparian reserve zone, rock outcrop, non-commercial brush, non-merchantable timber, sensitive terrain or soil, ungulate winter range, wildlife habitat area, old-growth management area, recreation feature, visuals, cultural heritage feature.

4 Ecological anchors include features such as large hollow trees, large witches broom, active wildlife trails, and active feeding on wildlife trees.

5 Though 432 cutblocks had some level of retention, windthrow data was not collected on many with fairly minor levels of retention.

Sixty-six percent of the FREP-sampled gross area is from cutblocks with less than 15% retention; 4.1% comes from cutblocks with 35% or more retention. Almost 20% of the cutblocks, representing 8.6% of the total sampled area, had no retention. Over 4% of cutblocks, representing 3.4% of the sampled area, had 40% or more retention.

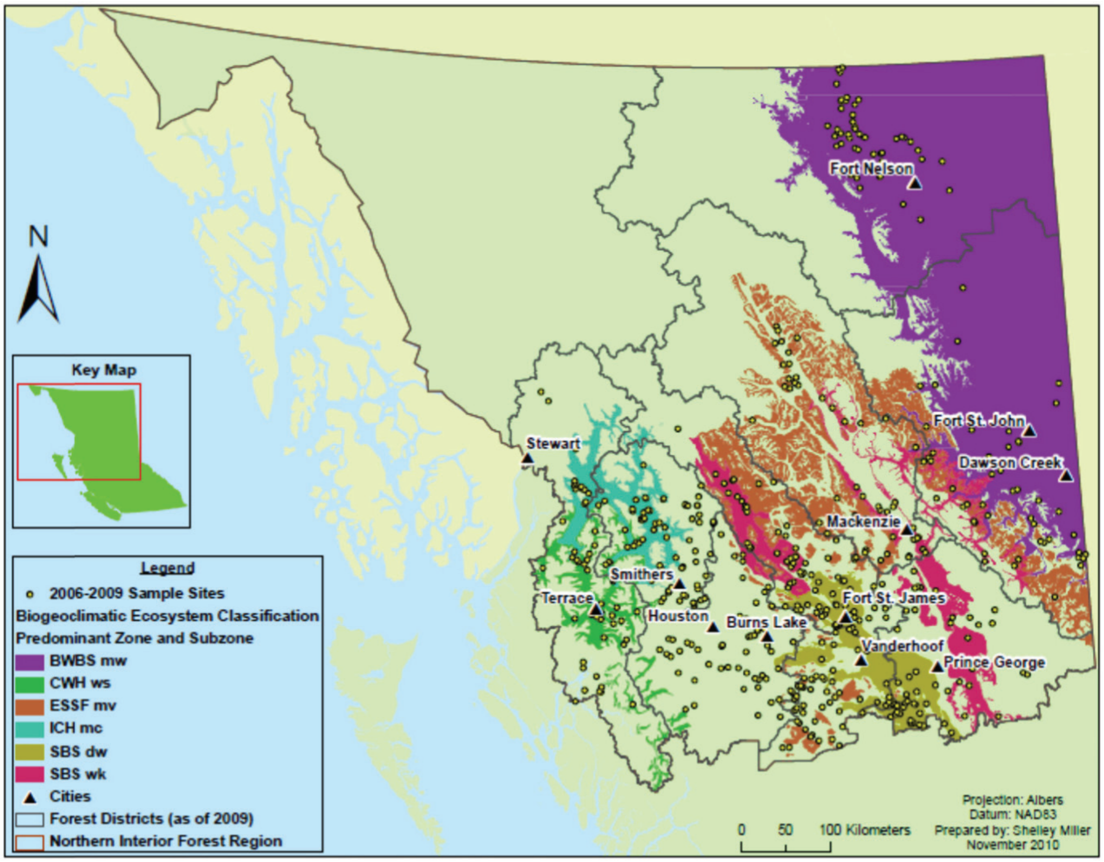

Figure 1. ***Northern Interior Forest Region stand-level biodiversity sample site locations 2006–2009 and predominant subzones. Data sources: Sample location data from FREP IMS and FREP staff; base mapping from the Land and Resource Data Warehouse.***

4.0 DETAILED ASSESSMENT BY SUBZONE

4.1 *Interpreting the Cumulative Distribution Charts*

The following subsections show cumulative distribution charts comparing average cutblock indicators calculated from baseline data to average cutblock indicators calculated from the sampled cutblocks. Indicator values are ranked from lowest to highest and presented as a cumulative distribution, where the rank of a particular value is given as the percentage of cutblocks with lesser or equal values of the indicator. Cumulative distributions for the baseline data and the resource stewardship monitoring sample data are presented separately (i.e., as two curves in each chart).

In general, a cumulative distribution retention curve equal to, or further to the right than the baseline curve, is good for biodiversity. If the retention curve is very similar to the baseline, this may mean retention areas are being chosen that represent the pre-harvest condition for the indicator in question. If the retention curve is further to the right than the baseline, this may mean retention areas are being chosen that contain a higher density of the indicator in question than the pre-harvest condition. In general, a retention curve that is shifted to the left of the baseline curve is bad for biodiversity (i.e., the retention indicators tend to fall below the baseline values).

Results are presented separately for the predominant biogeoclimatic subzones with the most data, both sampled by FREP and the cruise baseline). For subzone descriptions, please go to: http://www.for.gov.bc.ca/hre/becweb/resources/classificationreports/subzones/index.html

4.2 *Biogeoclimatic Subzone Summary*

Table 3 gives an overall summary of key biodiversity indicators within the six predominant subzones. The tree and CWD indicators are given as a percentage of average from the full FREP-sampled dataset compared to the average from the baseline timber cruise data (for the tree indicators) or retention patch data (for the CWD indicators). A more comprehensive look at the subzones is given in sections 4.3 through 4.8.

Table 3. Summary of sampled biogeoclimatic subzones[a]

	Cutblock size (ha)		Retention (average)				Windthrow	Retention patch location in relation to harvest boundary (%)			Retention patches > 2 ha		Tree indicator average as percentage of average baseline			CWD average in harvest areas as % of average in retention patches	
Subzone (sample size)	Average	Maximum	Total (%)	Patch (%)	Dispersed (%)	% of cutblocks with retention[b]	Average (%)	Internal[c]	On edge[d]	External[e]	% of total number of retention patches	% of cutblocks with a > 2 ha patch	Large snags	Large trees	No. tree species	CWD volume per hectare	CWD large pieces per hectare
BWBSmw (76)	58	332	9.9	9.1	0.8	86.8	6.9	49	51	0	32	50	78	134	79	91	24
CWHws (33)	36	177	17.0	16.0	1.0	66.7	14.0	43	57	0	46	46	134	39	75	138	44
ESSFmv (38)	50	158	9.5	8.3	1.2	84.2	9.2	39	59	2	33	47	123	258	68	129	38
ICHmc (38)	38	133	15.2	11.6	3.6	76.3	6.6	38	62	0	37	42	69	34	79	129	54
SBSdw (63)	55	324	14.4	10.5	3.9	92.1	10.0	43	55	2	47	51	40	109	106	90	38
SBSwk (47)	44	261	14.9	11.5	3.4	74.5	12.6	42	53	4	25	45	33	87	77	80	26

a For subzone descriptions please go to: http://www.for.gov.bc.ca/hre/becweb/resources/classificationreports/subzones/index.html

b Blocks with 0.5% or more retention.

c The internal patches provide areas of cover within the harvest cutblock, potentially allowing more movement of small animals and easier recruitment of understory species throughout the cutblock.

d The edge patches may merge with forest cover outside of the cutblock, giving larger forested patches (even if temporarily); edge patches often supply more linear retention from riparian reserves, which can provide travel corridors.

e The external and non-contiguous retention patches are least preferred for stand-level biodiversity since there is little likelihood of providing direct ecologic benefits to the harvested area.

4.3 *Boreal White and Black Spruce Moist Warm Subzone (BWBSmw)*

The BWBSmw data collected came from the Fort Nelson and Peace forest districts, representing the mw1 and mw2 biogeoclimatic variants. As noted in Table 3, retention was found in 87% of the sampled cutblocks and the average percent retention was 9.9%. This percent retention increases to 10.0% when the temporary retention (retention on cutblock that is likely to be harvested before rotation end) is considered. The minor change from the addition of temporary retention came from one small cutblock (6.6 ha gross area) with a 2.7 ha temporary patch.

4.3.1 Statistical analysis of BWBSmw indicators

Density of large dead trees (≥ 10 m tall and ≥ 30 cm dbh)

The average density of functional snags (dead trees 10 m or taller and 30 cm or larger diameter) found in the retention within the FREP-sampled cutblocks is 78% of that found in the cruise baseline. Figure 2 shows the 68 cutblocks of the total sampled 76 BWBSmw cutblocks that contained retention.

BWBSmw: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	182	11.5	6.3	17.2	1.3
Retention	68	9.0	0.0	15.9	1.9

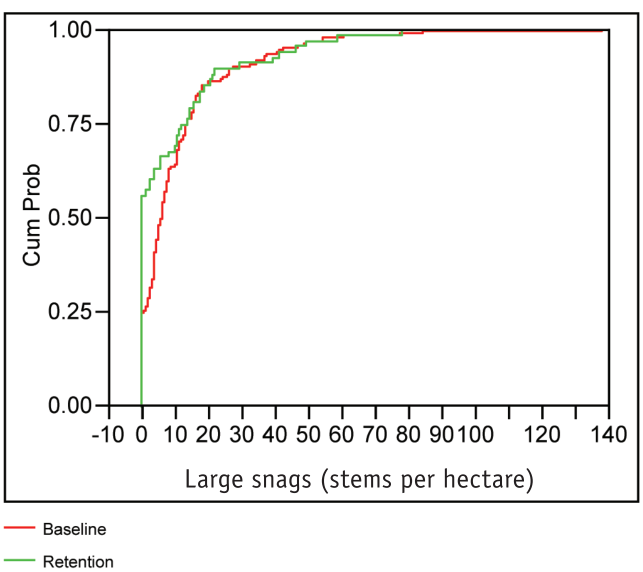

Figure 2. Cumulative probability for functional snags in the BWBSmw subzone.

K-S test: D = 0.3171 (maximum difference at 0 large snags per hectare), p-value = 9.5 $\times 10^{-5}$. The p-value indicates a significant difference between these two curves. Compared to the cruise baseline, a larger percentage of the FREP-sampled retention had no large snags and thus an overall lower density of large snags in the retention areas compared to that found in the pre-harvest timber cruise.

Density of large trees (live and dead; ≥ 50 cm dbh)

The average density of large trees (50 cm or larger dbh, live and dead) found in the retention within the BWBSmw FREP-sampled cutblocks is 134% of that found in the cruise baseline. Figure 3 shows the 68 cutblocks of the total sampled 76 BWBSmw cutblocks that contained retention.

BWBSmw: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	182	8.4	4.3	11.3	0.8
Retention	68	11.3	4.9	16.0	1.9

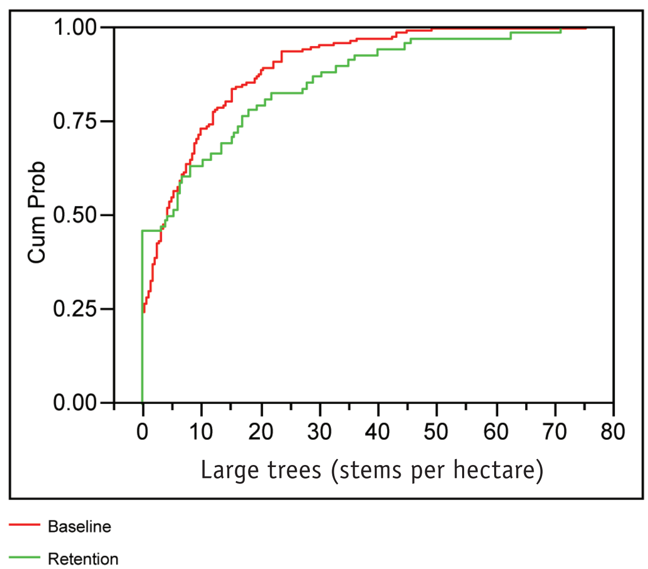

Figure 3. Cumulative probability for large tree density in the BWBSmw subzone.

K-S test: D = 0.2141 (maximum difference at 0 large trees per hectare), p-value = 0.021. The p-value indicates a marginally significant difference between these two curves. The K-S test points to the higher percentage of the FREP-sampled cutblocks with zero large trees compared to the baseline as the largest difference between these curves; however, where the FREP-sampled retention did have large trees, these were at a higher density than the baseline.

Number of tree species

The average number of tree species found in the BWBSmw FREP-sampled cutblocks is 79.4% of the cruise baseline. Figure 4 shows the complete data set of cutblocks with zero tree retention having zero number of species. Ten and a half percent of the sampled BWBSmw cutblocks contained no trees, accounting for the 10% of cutblocks with zero tree species in the chart below.

BWBSmw: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	182	3.9	4.0	1.3	0.1
Retention	76	3.1	3.0	1.7	0.2

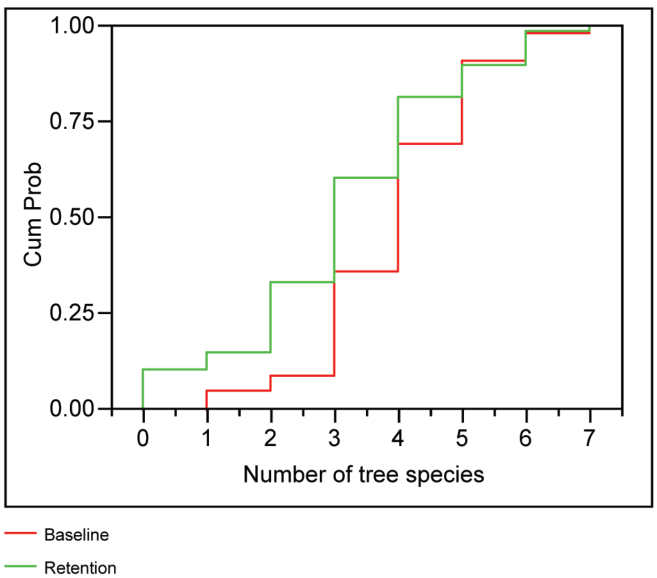

Figure 4. Cumulative probability for number of tree species in the BWBSmw subzone.

K-S test: $D = 0.2481$ (maximum difference at three tree species found per cutblock), p-value = 0.003. There is a significant difference between these two curves with the FREP retention generally having one fewer tree species per cutblock compared to the cruise baseline. This difference is not large, however, and may be accounted for by the lower sampling intensity in FREP compared to timber cruising (see Section 2.1.5).

Volume of CWD

The average volume per hectare of CWD found in the harvest areas within the BWBSmw FREP-sampled cutblocks is 91% of that found in the tree retention patches. Sixty-two of the 76 sampled cutblocks contained retention patches and therefore had data on CWD within patches. Figure 5 shows the full dataset of BWBSmw blocks, with the largest difference in CWD volumes seen in the higher density range.

BWBSmw: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	62	113.7	88.9	90.1	11.4
Retention	76	103.3	90.3	58.5	6.7

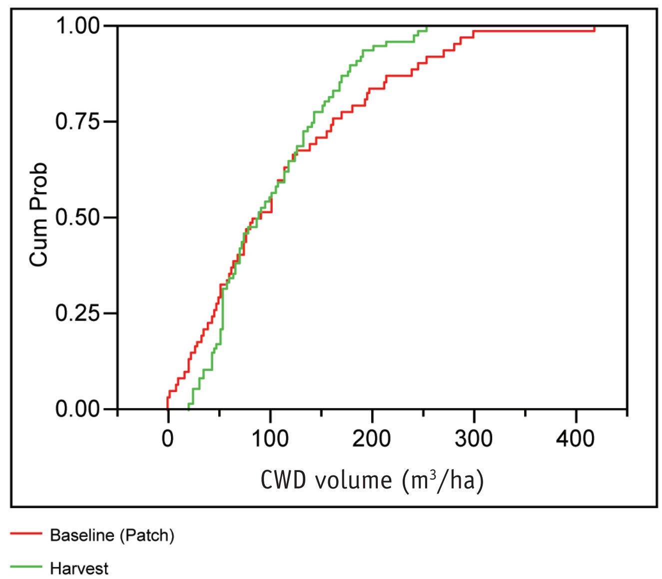

Figure 5. Cumulative probability for CWD volume in the BWBSmw subzone.

K-S test: $D = 0.1439$ (maximum difference at 193.4 m^3 of CWD per hectare), p-value = 0.4794. There is no significant difference between these two curves and the volume of CWD found on harvested sites is generally comparable to that found within retention patches.

Density of big pieces of CWD (≥ 20 cm diameter and ≥ 10 m long)

The average density per hectare of big CWD pieces (pieces 10 m or longer and 20 cm or bigger diameter) found in the harvest areas within the BWBSmw FREP-sampled cutblocks is 24% of that found in the retention patches. Figure 6 shows 50% of the harvest areas from the FREP-sampled population had zero large pieces of CWD found in sampling compared to about 20% of the retention patches.

BWBSmw: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	62	46.3	29.0	45.5	5.8
Retention	76	11.1	0.0	16.2	1.9

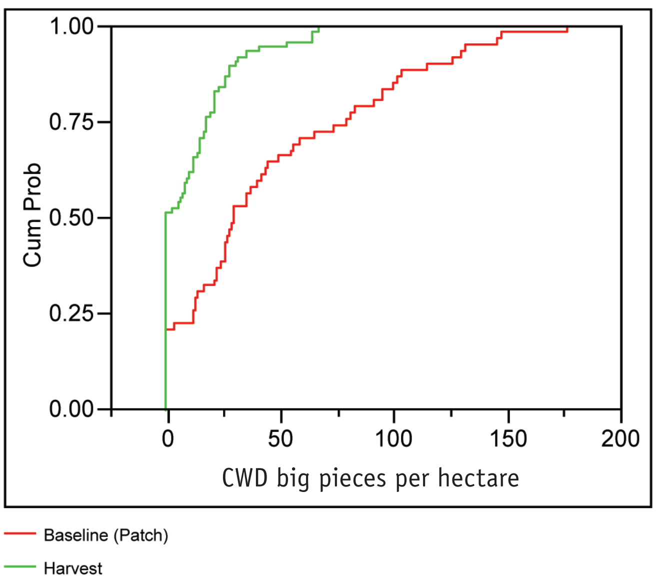

Figure 6. Cumulative probability for CWD big piece density in the BWBSmw subzone.

K-S test: $D = 0.4741$ (maximum difference at 22 big pieces of CWD per hectare), p-value = 4.3×10^{-07}. There is a significant difference between these two curves with the density of large CWD pieces being lower in the harvested areas compared to within retention patches.

4.3.2 BWBSmw discussion

The BWBSmw subzone had retention within 87% of the sampled cutblocks, with an overall average retention of 9.9%. Average windthrow was 6.9%, and there was a good mixture of retention patch locations both internal to harvest boundary and on the edge with essentially no retention patches external and non-contiguous to the harvest boundary.

The average density of large snags in the FREP-sampled retention was 78% of the cruise baseline. The average density of large trees increased from that found in the baseline (134%). The average number of tree species retained was 79% of that found in the baseline, but with less than one tree species difference generally; this small decrease may be due to the difference in sampling intensities between baseline and FREP. Volume of CWD on the harvested areas was similar to that found in the retention patches, though the density of large CWD pieces (as compared to the retention patches) is the lowest of the six predominant northern interior subzones. In addition, the low amount of dispersed retention (0.8%) will provide only minor inputs of future CWD.

4.3.3 BWBSmw consideration

Continue the good mix of retention patch locations (internal to, and on the edge of, the harvest boundary with minimal external and non-contiguous patches). Continue choosing retention areas containing representative or higher densities of large trees. Increase the density of big CWD pieces left on cutblocks. Look for opportunities to leave some level of retention within every cutblock (even if a low density dispersed trees). Increased amounts of dispersed standing retention could also be done to enhance current internal to cutblock biodiversity and provide a source of material for future CWD.

4.4 *Coastal Western Hemlock Wet Submaritime Subzone (CWHws)*

The CWHws data collected came from the Kalum and Skeena-Stikine forest districts, representing the ws1 and ws2 variants. As noted in Table 3, retention was found in 67% of the sampled cutblocks and the average percent retention was 17.0%. Percent retention increases to 20.7% when temporary retention (retention on cutblock that is likely to be harvested before rotation end) is considered. However, this additional temporary retention comes from a single cutblock in the Kalum Forest District that had a 43.5 ha temporary patch, and a total cutblock size of 65.4 ha.

4.4.1 Statistical analysis of CWHws indicators

Density of large dead trees (≥ 10 m tall and ≥ 30 cm dbh)

The average density of large snags found in the retention within the CWHws FREP-sampled cutblocks is 134% of that found in the cruise baseline. Figure 7 shows the 22 cutblocks of the total sampled 33 CWHws cutblocks that contained retention.

CWHws: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	55	18.4	18.3	13.5	1.8
Retention	22	24.7	18.9	24.1	5.1

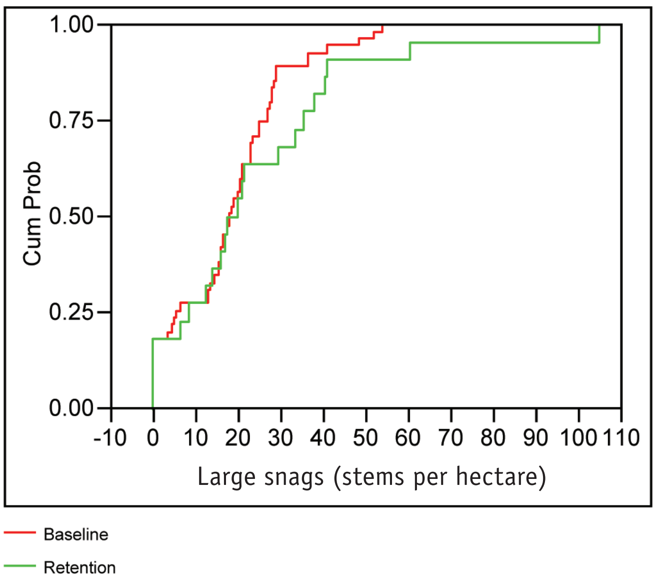

Figure 7. Cumulative probability for functional snag density in the CWHws subzone.

K-S test: $D = 0.2545$ (maximum difference at 29 large snags per hectare), p-value = 0.2604. There is no significant difference between these two curves with the density of large snags found in the FREP-sampled retention cutblocks being equivalent to the density seen in the cruise baseline.

Density of large trees (live and dead; ≥ 70 cm dbh)

The average density of big trees (live or dead trees, 70 cm dbh or larger) found in the retention within the CWHws FREP-sampled cutblocks is just 39% of that found in the cruise baseline. Figure 8 shows the 22 cutblocks of the total sampled 33 CWHws cutblocks that contained retention.

CWHws: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	55	39.9	37.1	20.9	2.8
Retention	22	15.6	9.9	15.6	3.3

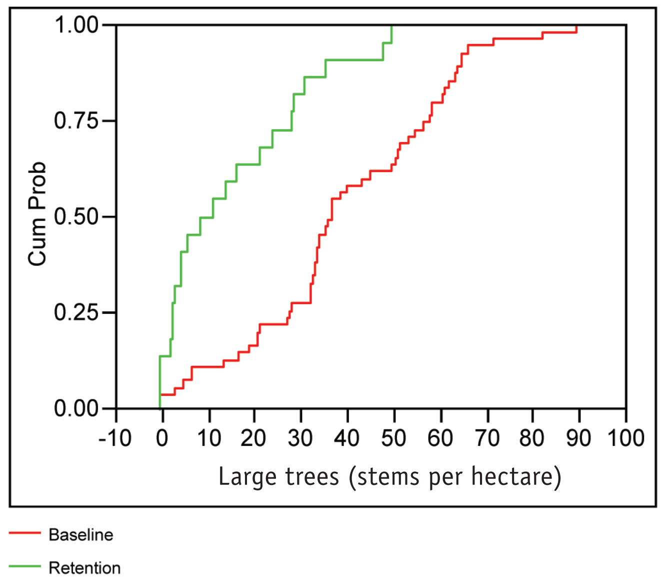

Figure 8. Cumulative probability for large tree density in the CWHws subzone.

K-S test: $D = 0.5909$ (maximum difference at 31 large trees per hectare), p-value = 3.4×10^{-05} There is a significant difference between these two curves with the density of large trees being lower in the FREP-sampled retention compared to the cruise baseline.

Number of tree species

The average number of tree species found in the retention within the CWHws FREP-sampled cutblocks is 75% of that found in the cruise baseline. Figure 9 shows the complete data set with cutblocks with zero tree retention having zero number of species.

CWHws: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	55	3.5	3.0	1.2	0.2
Retention	33	2.6	3.0	2.3	0.4

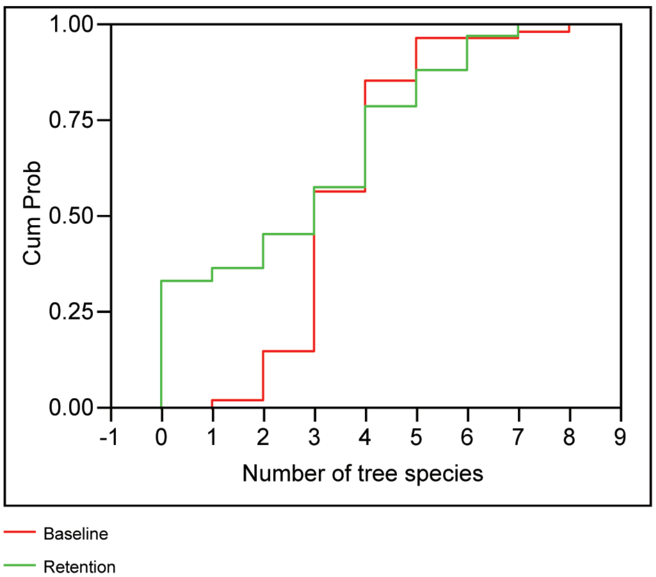

Figure 9. Cumulative probability for number of tree species in the CWHws subzone.

K-S test: $D = 0.3455$ (maximum difference at one tree species found per cutblock), p-value = 0.01456. There is a significant difference in these two curves with the FREP-sampled retention having fewer tree species found compared to the cruise baseline. This difference is largely due to one-third of the CWHws FREP-sampled cutblocks with no retention. Where retention was maintained in the cutblocks, there was good tree species diversity maintained.

Volume of CWD

The average volume per hectare of CWD found in the harvest areas within the CWHws FREP-sampled cutblocks is 138% of that found in the retention patches. Twenty-one of the 33 sampled cutblocks contained retention patches and therefore had data on CWD within patches. Figure 10 shows this full dataset with the CWD volume lower in the patches than in the harvested areas.

CWHws: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	21	298.1	212.0	254.4	55.5
Retention	33	412.2	337.5	259.6	45.2

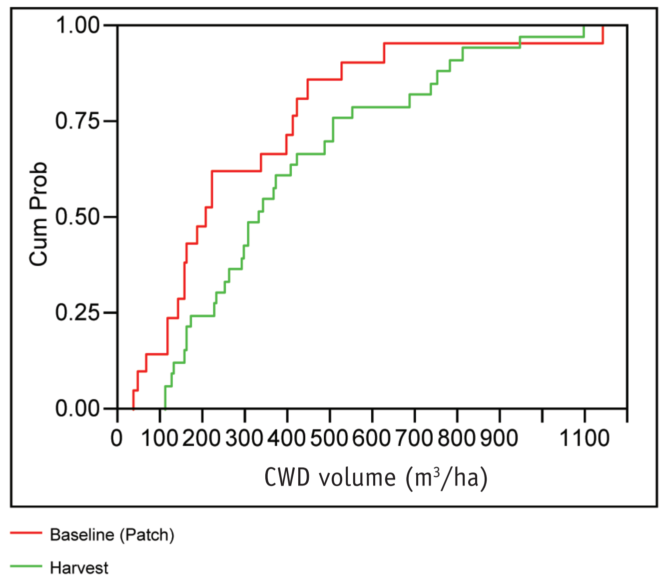

Figure 10. Cumulative probability for CWD volume in the CWHws subzone.

K-S test: $D = 0.3766$ (maximum difference at 226.6 m^3 CWD per hectare), p-value = 0.05247. There is a marginally significant difference in these two curves, with the harvest areas having higher levels of CWD volume compared to the retention patches.

Density of big pieces of CWD (≥ 20 cm diameter and ≥ 10 m long)

The average density per hectare of big CWD pieces found in the harvest areas within the CWHws FREP-sampled cutblocks is 45% of that found in the retention patches. Figure 11 shows lower density of big CWD pieces in the harvest areas compared to the patch areas.

CWHws: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	21	67.9	52.0	57.2	12.5
Harvest	33	30.3	23.0	31.1	5.4

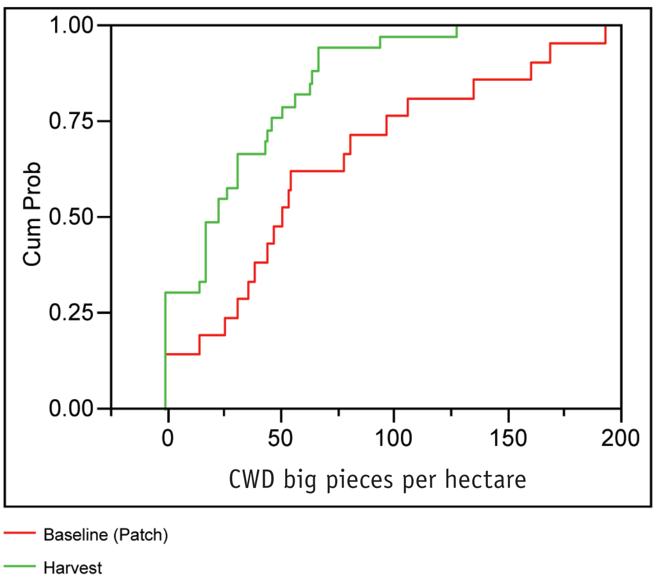

Figure 11. Cumulative probability for CWD big piece density in the CWHws subzone.

K-S test: $D = 0.381$ (maximum difference at 32 big pieces of CWD per hectare), p-value = 0.04823. There is a marginally significant difference in these two curves, with lower density of big CWD pieces found in the harvest areas compared to the retention patches.

4.4.2 CWHws discussion

The CWHws subzone had retention on 67% of cutblocks. Therefore, one-third of the sampled cutblocks had no retention (less than 0.5%). These cutblocks with no retention made up 20% of the gross area from the FREP samples. Despite the high percentage of zero retention cutblocks, the average retention (at 17%) was the highest of the six predominant northern interior subzones reported here. Average windthrow was 14%, also high compared to the other predominant subzones.

The average density of large snags within retention areas was higher (however, not a significant difference) than the cruise baseline. The percentage of large retention patches was good (second highest of the six predominant subzones) at 46%, potentially contributing to the high percent retention; however, these large strata seemingly did not help in retention of a representative number of big trees (≥ 70 cm dbh, live or dead) since the average density was low, at 39% of the cruise baseline. The retention of a variety of tree species representative of pre-harvest stands is good on those cutblocks having retention; however, the diversity of tree species is lowered significantly due to the large number of cutblocks with no retention left. The density of big CWD pieces is significantly lower on the harvested CWHws areas compared to the the retention patches.

4.4.3 CWHws consideration

Continue the good practice of maintaining similar densities of large snags in retention areas compared to natural stands. Increase the percentage of harvested cutblocks that have trees retained. This may be as simple as including, rather than excluding, adjacent “default” retention (e.g., riparian areas), and thus ensuring they are tracked and protected through the corporate systems (M. Moran, Kalum Forest District, pers. comm.). A continuous improvement opportunity is to retain wildlife tree patches with higher densities of large trees for the site, preferably with densities closer to pre-harvest conditions. Consider and manage for windthrow risk when designing retention areas.

4.5 *Engelmann Spruce–Subalpine Fir Moist Very Cold Subzone (ESSFmv)*

The ESSFmv data collected came from the Mackenzie, Peace, Fort St. James, and Vanderhoof forest districts, representing the mv1, mv2, mv3, and mv4 variants. As noted in Table 3, retention was found in 84% of the cutblocks and the average percent retention was 9.5%. There was no temporary retention found in the ESSFmv samples.

4.5.1 Statistical analysis of ESSFmv indicators

Density of large dead trees (≥ 10 m tall and ≥ 30 cm dbh)

The average density of large snags found in the retention within the ESSFmv FREP-sampled cutblocks is 123% of that found in the cruise baseline. Figure 12 shows the 33 cutblocks of the total sampled 38 ESSFmv cutblocks that contained retention.

ESSFmv: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	81	21.2	10.5	27.8	3.18
Retention	33	26.0	15.7	41.2	7.2

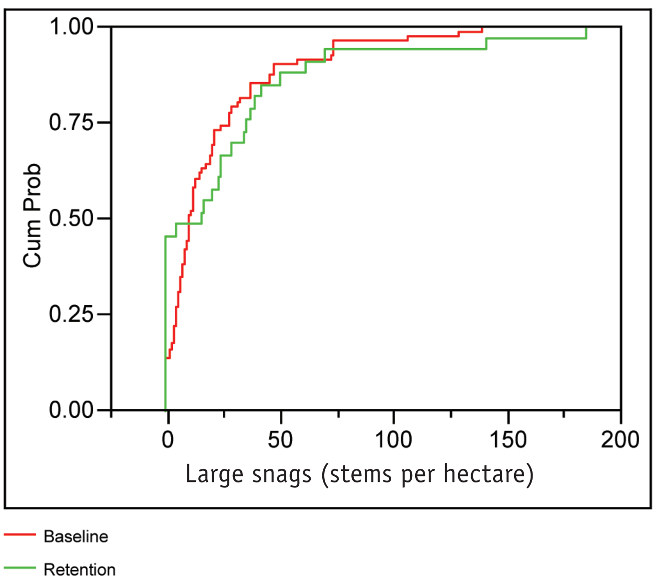

Figure 12. Cumulative probability for functional snag density in the ESSFmv subzone.

K-S test: $D = 0.3187$ (maximum difference at 0 large snags per hectare), p-value = 0.01706. There is a significant difference between these two curves largely due to the higher percentage of FREP-sampled cutblocks with no large snags found compared to the cruise baseline cutblocks. However, the top 50% of the data (in terms of the cutblocks with the higher densities of large snags) shows comparable or greater densities of large snags in the FREP-sampled retention.

Density of large trees (live and dead; ≥ 50 cm dbh)

The average density of large trees (50 cm dbh or greater, live or dead) found in the retention within the ESSFmv FREP-sampled cutblocks is 257% of that found in the cruise baseline.

Figure 13 shows the 33 cutblocks of the total sampled 38 ESSFmv cutblocks that contained retention.

ESSFmv: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	81	2.6	0.6	4.2	0.5
Retention	33	6.8	0.0	10.0	1.7

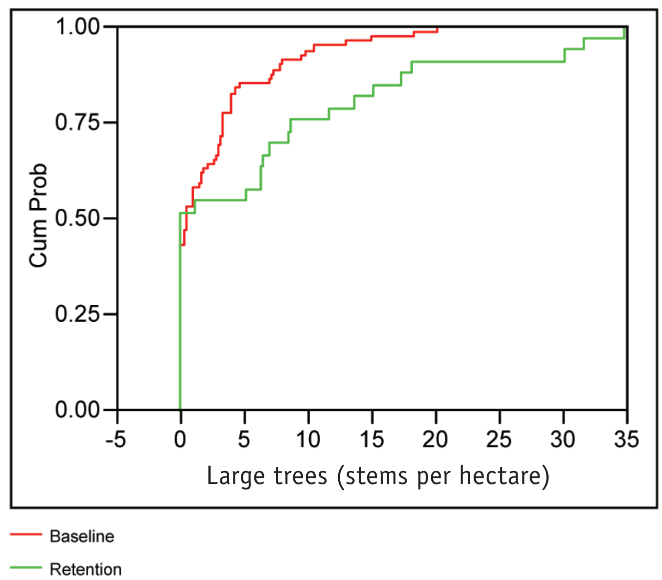

Figure 13. Cumulative probability for large tree density in the ESSFmv subzone.

K-S test: $D = 0.2941$ (maximum difference at four large trees per hectare), p-value = 0.03468. There is a marginally significant difference in these two curves, with the FREP-sampled retention having higher densities of large trees (≥ 50 cm dead or live trees) compared to the cruise baseline.

Number of tree species

The average number of tree species found in the retention within the ESSFmv FREP-sampled cutblocks is 67% of that found in the cruise baseline. Figure 14 shows the complete data set with cutblocks with zero tree retention having zero number of species. There were no trees found on 13% of cutblocks, hence 13% of the cutblocks have zero tree species maintained. Note that 92% of the cruise baseline cutblocks had three or more tree species found compared to 60% of the FREP-sampled cutblocks.

ESSFmv: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	81	3.7	4.0	0.9	0.1
Retention	38	2.5	3.0	1.3	0.2

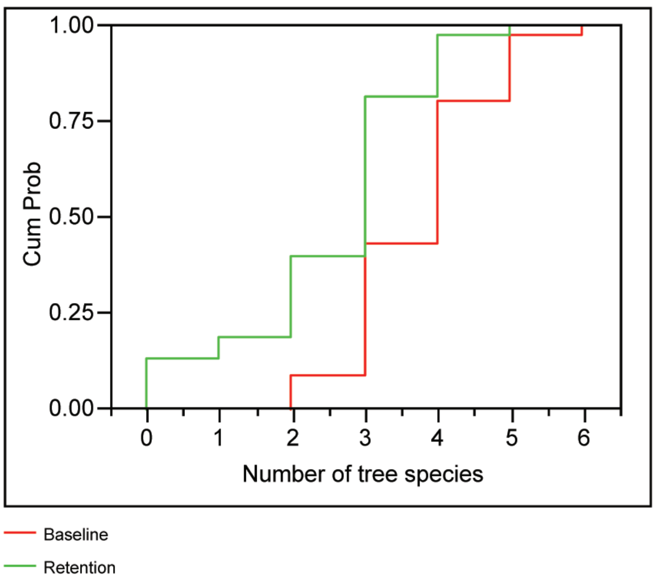

Figure 14. Cumulative probability for number of tree species in the ESSFmv subzone.

K-S test: *D* = 0.3837 (maximum difference at three tree species found per cutblock), *p*-value = 0.0009852. There is a significant difference in these two curves, with the FREP-sampled retention having fewer tree species found per cutblock compared to the cruise baseline.

Volume of CWD

The average volume per hectare of CWD found in the harvest areas within the ESSFmv FREP-sampled cutblocks is 129% of that found in the retention patches. Thirty of the 38 sampled cutblocks contained retention patches and therefore had data on CWD within patches.

Figure 15 shows this full dataset with the CWD volume generally lower in the patch areas compared to the harvest areas.

ESSFmv: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	30	88.1	84.3	51.1	9.3
Retention	38	113.8	112.2	62.4	10.1

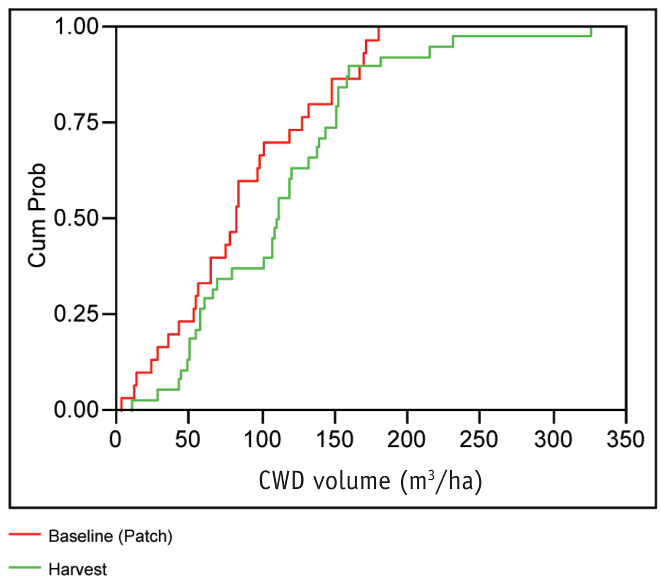

Figure 15. Cumulative probability for CWD volume in the ESSFmv subzone.

K-S test: *D* = 0.3316 (maximum difference at 102.7 m^3 of CWD per hectare), *p*-value = 0.05012. There is a marginally significant difference in these two curves, with higher CWD volume generally found in the harvest areas compared to the retention patches.

Density of big pieces of CWD (≥ 20 cm diameter and ≥ 10 m long)

The average density per hectare of big CWD pieces found in the harvest areas within the ESSFmv FREP-sampled cutblocks is 38% of that found in the retention patches. Figure 16 shows lower density of big CWD pieces in the harvest areas compared to the patch areas.

ESSFmv: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	30	40.9	35.0	32.9	6.0
Retention	38	15.4	5.5	22.5	3.7

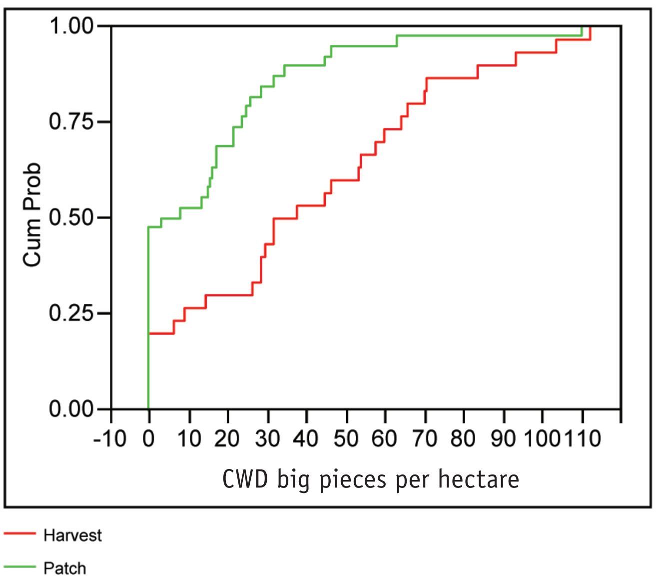

Figure 16. ***Cumulative probability for CWD big piece density in the ESSFmv subzone.***

K-S test: $D = 0.4895$ (maximum difference at 25 big pieces of CWD per hectare, p-value = 0.000649. There is a significant difference in these two curves, with a lower density of big CWD pieces found in the harvested areas compared to retention patches.

4.5.2 ESSFmv discussion

Retention was found on 84% of the sampled cutblocks, resulting in an overall average retention of 9.5%. Though this was the lowest average percentage of the six predominant northern interior subzones, there was good representation of large trees with densities higher (257%) than might be expected from pre-harvest conditions as represented by the cruise baseline. Tree species diversity is lower in the FREP-sampled retention compared to the cruise baseline. Frost hazard and brush hazard are both high in the ESSFmv and protection of advanced regeneration will minimize impact from both hazards (J. Amonson, Peace Forest District, pers. comm.). Leaving an overstorey of dispersed retention can provide frost protection to seedlings, as noted for hardwood overstorey by McCulloch and Kabzems (2009) and Delong (1997). Leaving larger CWD may also offer some protection against frost damage.

4.5.3 ESSFmv consideration

Continue practices of maintaining areas with good densities of large trees. A continuous improvement opportunity is to retain three or more tree species on most cutblocks, inclusive of deciduous trees. Maintain some level of retention in most cutblocks and retain a higher density of big CWD pieces in the harvested areas.

4.6 *Interior Cedar–Hemlock Moist Cold Subzone (ICHmc)*

The ICHmc data collected came from the Skeena-Stikine and Kalum forest districts, representing the mc1 and mc2 variants. As noted in Table 3, retention was found in 76% of the cutblocks and the average percent retention was 15.2%. This percent retention increases to 21.9% when the temporary retention (retention on cutblock that is likely to be harvested before rotation end) is considered. Two cutblocks had temporary patch retention, 5.3 ha in one and 44.3 ha in another. One cutblock had 46.9 ha of temporary dispersed retention (basal area equivalent) left for the second pass of a shelterwood silvicultural system.

4.6.1 Statistical analysis of ICHmc indicators

Density of large dead trees (≥ 10 m tall and ≥ 30 cm dbh)

The average density of large snags found in the retention within the ICHmc FREP-sampled cutblocks is 69% of that found in the cruise baseline. Figure 17 shows the 30 cutblocks of the total sampled 38 ICHmc cutblocks that contained retention.

ICHmc: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	89	42.4	38.2	25.4	2.7
Retention	30	29.4	13.5	39.2	7.1

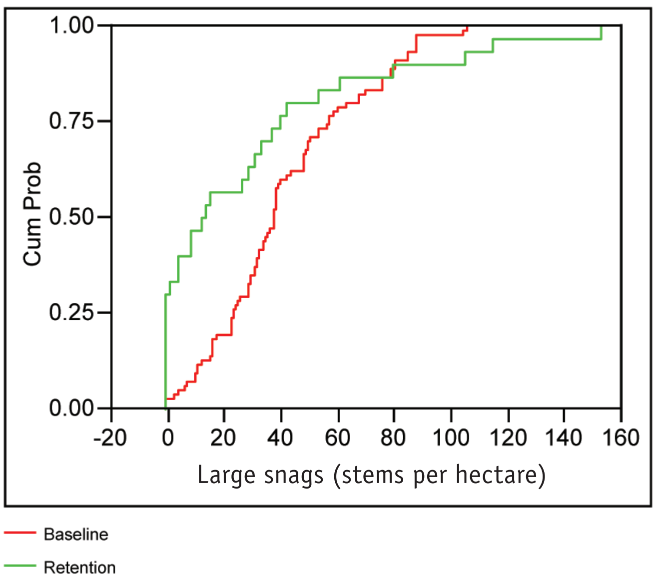

Figure 17. Cumulative probability for functional snag density in the ICHmc subzone.

K-S test: $D = 0.4097$ (maximum difference at 14 large snags per hectare), p-value = 0.001070. There is a significant difference in these two curves, with overall lower densities of large snags found in the ICHmc retention areas compared to the cruise baseline.

Density of large trees (live and dead; ≥ 70 cm dbh)

The average density of big trees found in the retention within the ICHmc FREP-sampled cutblocks is 34% of that found in the cruise baseline. The main differences in these two populations as seen in Figure 17 is the 40% of FREP-sampled cutblocks, which had no large trees found in the retention. Figure 18 shows the 30 cutblocks of the total sampled 38 ICHmc cutblocks that contained retention.

ICHmc: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	89	22.0	17.0	17.5	1.9
Retention	30	7.5	4.5	9.3	1.7

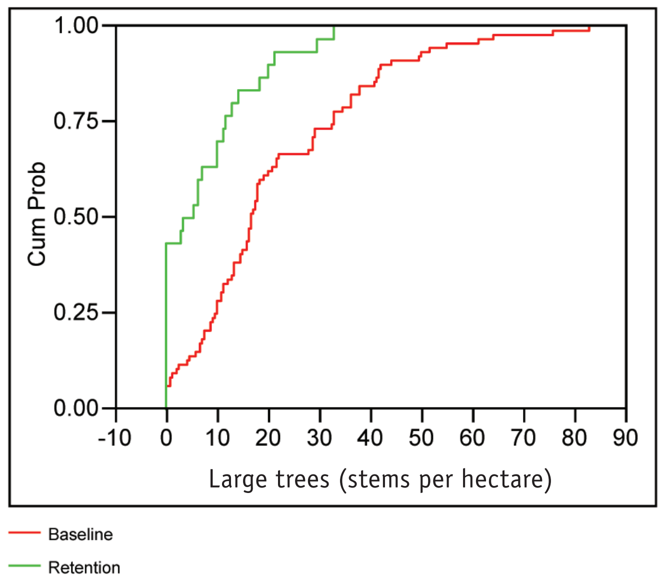

Figure 18. Cumulative probability for large tree density in the ICHmc subzone.

K-S test: $D = 0.4536$ (maximum difference at seven large trees per hectare), p-value = 0.0001959. There is a significant difference in these two curves, with the FREP-sampled retention having lower densities of large trees compared to the cruise baseline.

Number of tree species

The average number of tree species found in the retention within the ICHmc FREP-sampled cutblocks is 79% of that found in the cruise baseline. Figure 19 shows the complete data set with cutblocks with zero tree retention having zero number of species. Twenty-four percent of the sampled cutblocks had no retention found and therefore zero tree species. The 76% of cutblocks with retention had a distribution of tree species retention similar to that seen in the cruise data.

ICHmc: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	89	3.7	3.0	1.6	0.2
Retention	38	3.0	3.0	2.3	0.4

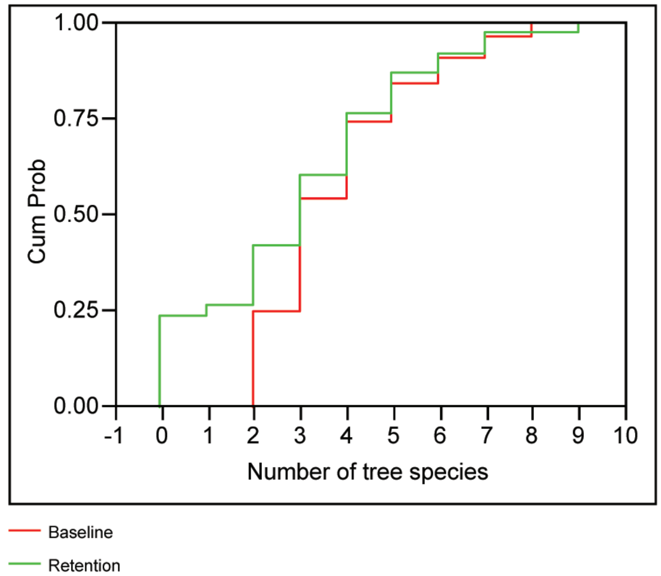

Figure 19. Cumulative probability for number of tree species in the ICHmc subzone.

K-S test: $D = 0.2632$ (maximum difference at one tree species found per cutblock), p-value = 0.05003. There is a marginally significant difference in these two curves, with slightly fewer tree species found in the FREP-sampled retention compared to the cruise baseline. This small decrease may be indicative of the higher sampling intensity in timber cruise compared to FREP sampling.

Table 4 shows the presence of valuable wildlife tree species is roughly comparable between the cruise baseline and the FREP cutblocks that contain retention.

Table 4. Percentage of cutblocks with valuable wildlife tree species[6]

BEC variant	Western redcedar		Cottonwood		Trembling aspen		Birch		Hemlock	
	FREP	Baseline	FREP	Baseline	FREP	Baseline	FREP	Baseline	FREP	Baseline
ICHmc1	14	11	0	4					71	100
ICHmc2	80	95	47	40	7	20	20	10	67	100

6 This table is only presented for subzones with sufficient sample size in all variants.

Volume of CWD

The average volume per hectare of CWD found in the harvest areas within the ICHmc FREP-sampled cutblocks is 129% of that found in the retention patches. Twenty-four of the 37 cutblocks with CWD data collected (one cutblock had missing CWD data for the harvest area) had retention patches and therefore CWD patch data. Figure 20 shows this full dataset with the CWD patch and harvest volumes being very similar for the lower volume areas.

ICHmc: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	24	245.3	214.7	200.6	40.9
Harvest	37	316.5	265.0	248.8	40.9

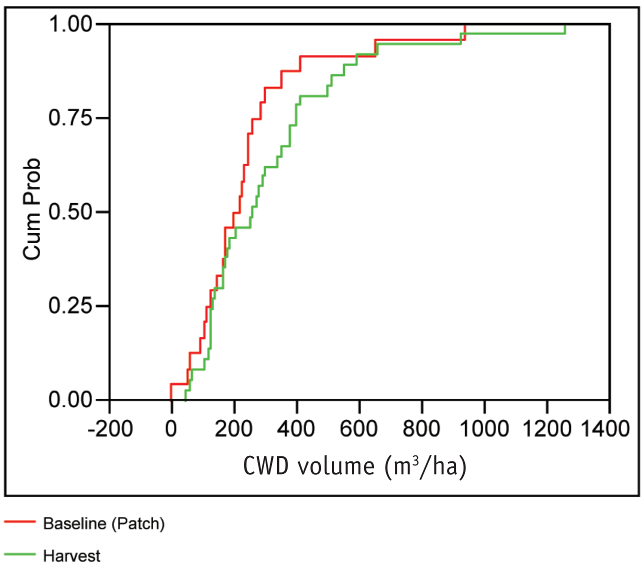

Figure 20. Cumulative probability for CWD volume in the ICHmc subzone.

K-S test: D = 0.2489 (maximum difference at 252.7 m^3 of CWD per hectare), p-value = 0.2725. There is no significant difference in these two curves.

Density of big pieces of CWD (≥ 20 cm diameter and ≥ 10 m long)

The average density per hectare of big CWD pieces found in the harvest areas within the ICHmc FREP-sampled cutblocks is 54% of that found in the retention patches. This percentage was the highest of the six predominant northern interior subzones. There is also potential for future CWD recruitment from the 3.6% of dispersed retention (basal area equivalent). Figure 21 shows lower densities of big CWD pieces in the harvest areas compared to the patch areas.

ICHmc: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	24	67.7	52.0	58.0	11.8
Harvest	37	36.8	30.0	31.5	5.2

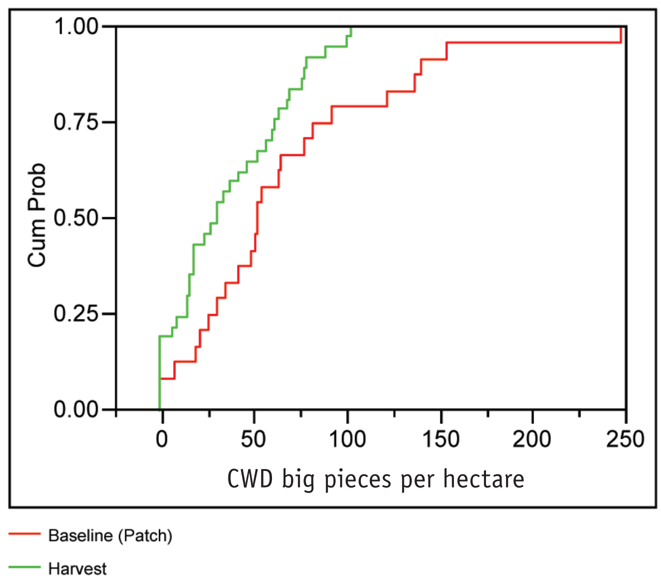

Figure 21. Cumulative probability for CWD big piece density in the ICHmc subzone.

K-S test: D = 0.3074 (maximum difference at 17 big pieces of CWD per hectare), p-value = 0.1276. There is no significant difference in these two curves.

4.6.2 ICHmc discussion

Retention was found on 76% of the FREP-sampled cutblocks. Despite the 24% of cutblocks with no retention, the overall average ICHmc retention is fairly high at 15.2%. However, the quality of the retention, particularly the density of large trees (at 34.2% of the average from the baseline), is the lowest of the six predominant subzones. Average windthrow was 6.6%, a relatively low average. Coarse woody debris quantity and quality was good, with the highest percentage of baseline amounts for density of large pieces of CWD as found in these six predominant northern interior subzones. In addition, the relatively high amount of dispersed retention (3.6% basal area equivalent) should contribute both to future CWD and current internal wildlife-tree user habitat.

4.6.3 ICHmc consideration

Continue good CWD management with similar amounts of big pieces of CWD within the harvested areas and retention patches and good potential CWD recruitment from the dispersed retention. A continuous improvement opportunity is to retain a higher percentage of wildlife tree patches with large trees for the site, in densities comparable to pre-harvest conditions. Increase the percentage of harvested cutblocks which have trees retained.

4.7 *Sub-Boreal Spruce Dry Warm Subzone (SBSdw)*

The SBSdw data collected came from the Fort St. James, Prince George, and Vanderhoof forest districts representing the dw2 and dw3 biogeoclimatic variants (only one cutblock sampled from the SBSdw1). As noted in Table 3, retention was found in 92% of the cutblocks and the average percent retention was 14.4%. There was no temporary retention found in the sampled SBSdw cutblocks.

4.7.1 Statistical analysis of SBSdw indicators

Density of large dead trees (≥ 10 m tall and ≥ 30 cm dbh)

The average density of large snags found in the retention within the SBSdw FREP-sampled cutblocks is 40% of that found in the cruise baseline. Figure 22 shows the 60 cutblocks of the total sampled 63 SBSdw cutblocks that contained retention.

SBSdw: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	291	42.5	33.0	38.3	2.2
Retention	60	17.1	4.7	29.2	3.8

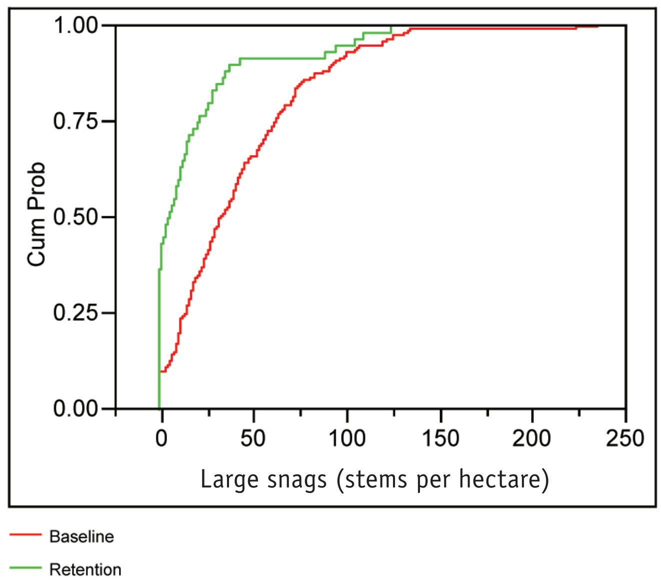

Figure 22. Cumulative probability for functional snag density in the SBSdw subzone.

K-S test: $D = 0.4285$ (maximum difference at 15 large snags per hectare), p-value = 2.3×10^{-08} There is a significant difference between these two curves, with lower density of large snags in the FREP-sampled retention compared to the cruise baseline.

Density of large trees (live and dead; ≥ 40 cm dbh)

The average density of big trees found in the retention within the SBSdw FREP-sampled cutblocks is 109% of that found in the cruise baseline. Figure 23 shows the 60 cutblocks of the total sampled 63 SBSdw cutblocks that contained retention.

SBSdw: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	291	18.3	9.6	28.2	1.7
Retention	60	20.0	6.9	32.1	4.1

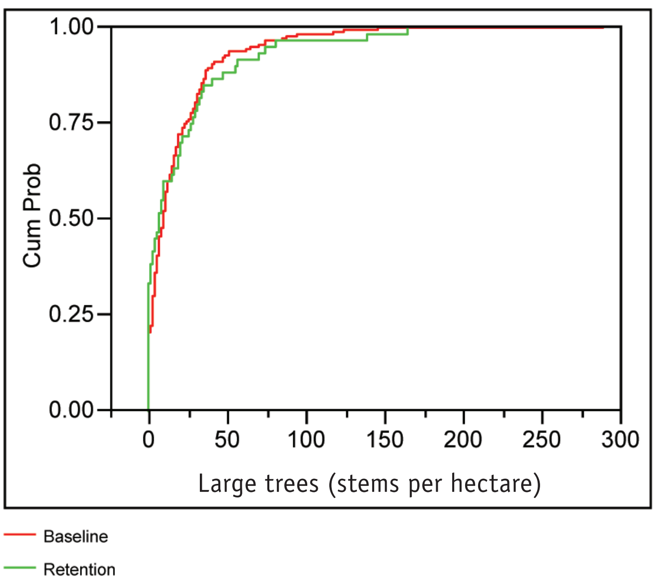

Figure 23. ***Cumulative probability for large tree density in the SBSdw subzone.***

K-S test: D = 0.157 (maximum difference at one large tree per hectare), p-value = 0.1718. There is no significant difference in these two curves.

Number of tree species

The average number of tree species found in the retention within the SBSdw FREP-sampled cutblocks is 106% of that found in the cruise baseline. Figure 24 shows the complete data set with cutblocks with zero tree retention having zero number of species. Five percent of the sampled cutblocks had no retention found and therefore zero tree species.

SBSdw: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	291	3.8	4.0	1.4	0.1
Retention	63	4.1	4.0	2.0	0.3

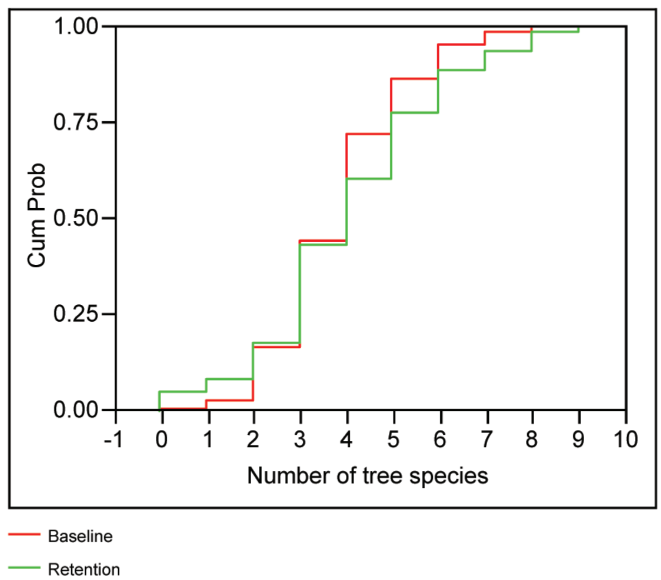

Figure 24. ***Cumulative probability for number of tree species in the SBSdw subzone.***

K-S test: D = 0.115 (maximum difference at four tree species found per cutblock), p-value = 0.4995. There is no significant difference between these two curves, which likely indicates that mature tree species diversity is being maintained or increased in the retained areas compared to the baseline.

Douglas-fir is an important wildlife tree species in the SBSdw. Table 5 shows the presence of Douglas-fir on FREP-sampled cutblocks containing retention, it appears that it is being preferentially maintained, as indicated by the higher percentage of FREP cutblocks containing Douglas-fir compared to the baseline. This is most prevalent in the dw2 variant. Cottonwood, trembling aspen, and birch are also valuable wildlife tree species with a generally increased presence in the FREP cutblocks versus the cruise baseline.

Table 5. Percentage of cutblocks with valuable wildlife tree species.[7]

BEC variant	Douglas-fir		Cottonwood		Trembling aspen		Birch	
	FREP	Baseline	FREP	Baseline	FREP	Baseline	FREP	Baseline
SBSdw2	80	64	25	5	40	43	20	21
SBSdw3	36	21	23	0	62	6	10	17

7 This table only presented where sufficient data in all variants.

Of the 30 SBSdw FREP-sampled cutblocks that contained Douglas-fir, 27 had fir in dispersed retention, 18 had fir in patch retention.

Volume of CWD

The average volume per hectare of CWD found in the harvest areas within the SBSdw FREP-sampled cutblocks is 90% of that found in the retention patches. Forty-five of the 63 sampled cutblocks contained retention patches and therefore had data on CWD within patches. Figure 25 shows this full dataset with the CWD patch and harvest volumes being very similar for the lower volume areas.

SBSdw: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	45	99.8	76.4	61.2	9.1
Harvest	63	90.3	81.8	52.5	6.6

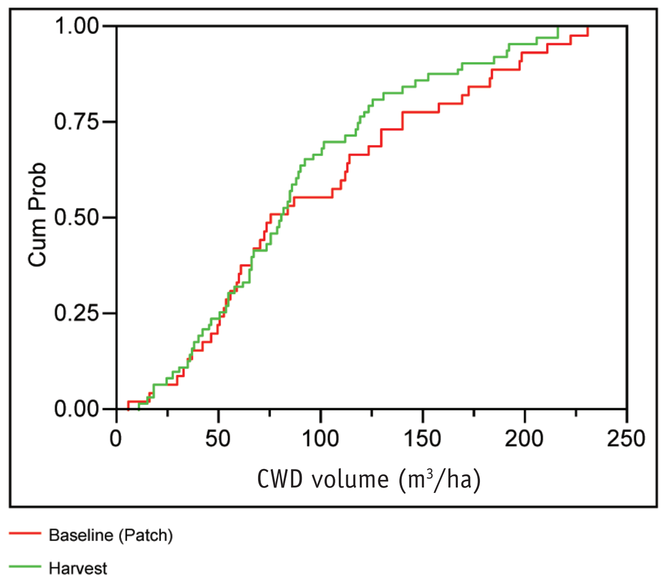

Figure 25. Cumulative probability for CWD volume in the SBSdw subzone.

K-S test: $D = 0.1429$ (maximum difference at 103 m^3 of CWD per hectare), p-value = 0.6576. There is no significant difference between these two curves, with similar volumes of CWD being found on the harvested areas compared to within the retention patches.

Density of big pieces of CWD (≥ 20 cm diameter and ≥ 10 m long)

The average density per hectare of big CWD pieces found in the harvest areas within the SBSdw FREP-sampled cutblocks is 38% of that found in the retention patches. Figure 26 shows lower density of big CWD pieces in the harvest areas compared to the patch.

SBSdw: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	45	41.2	34.0	34.1	5.1
Harvest	63	15.8	10.0	18.9	2.4

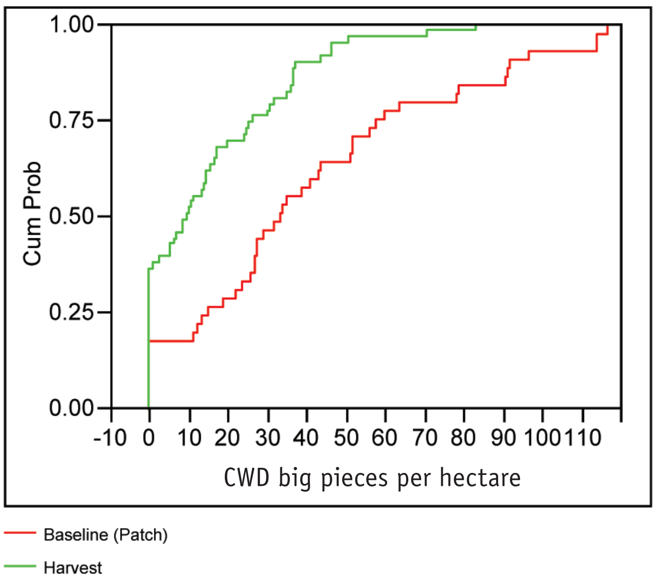

Figure 26. Cumulative probability for CWD big piece density in the SBSdw subzone.

K-S test: D = 0.4159 (maximum difference at 17 big pieces of CWD per hectare), p-value = 0.0002279. There is a significant difference between these two curves with the harvested areas overall have a lower density of large CWD pieces than that found in the retention patches.

4.7.2 SBSdw discussion

Average retention in the SBSdw is 14.4%, and retention is present on 92% of the FREP-sampled cutblocks, the highest percentage of cutblocks with retention on the six predominant northern interior subzones. Windthrow is 10%, starting to be a potential concern if valuable wildlife tree attributes are being lost. The density of large snags is potentially low but the density of large trees (live and dead ≥ 40 cm dbh) is representative of pre-harvest conditions. Tree species diversity is being maintained, and the presence of valuable wildlife tree species (aspen, cottonwood, birch, and Douglas-fir) is higher in the FREP-sampled retention compared to the retention. Where Douglas-fir is maintained in the FREP-sampled cutblocks, it is in dispersed retention for 90% of the cutblocks and in patch retention for 60% of the cutblocks; 37% of the cutblocks had fir in both types of retention. The density of big pieces of CWD in the harvest areas is 38% of that found in the retention patches. There is a source of future CWD recruitment from the average 3.9% of dispersed retention maintained within the cutblocks.

4.7.3 SBSdw consideration

Continue practice of having retention on more than 90% of the cutblocks, and maintaining retention areas with representative densities of large trees and the full diversity of tree species. Continue maintaining high-value wildlife trees such as aspen, cottonwood, birch, and fir. Consider the drought risk for Douglas-fir if it is left as dispersed retention and increase the amount of fir maintained in retention patches. A continuous improvement opportunity is to increase the densities of big pieces of CWD within the harvest areas. Windthrow management, such as patch orientation, will continue to be important in this subzone, though it is acknowledged that trees killed by the mountain pine beetle will eventually fall down.

4.8 *Sub-Boreal Spruce Wet Cool Subzone (SBSwk)*

The SBSwk data collected came from the Fort St. James, Mackenzie, Peace, and Prince George forest districts, representing the wk1, wk2, and wk3 variants. As noted in Table 3, retention was found in 74% of the cutblocks and the average percent retention was 14.9%. There was no temporary retention found in the sampled SBSwk cutblocks.

4.8.1 Statistical analysis of SBSwk indicators

Density of large dead trees (≥ 10 m tall and ≥ 30 cm dbh)

The average density of large snags found in the retention within the SBSwk FREP-sampled cutblocks is 33% of that found in the cruise baseline. Figure 27 shows the 44 of 47 sampled cutblocks that contained retention. A main difference in these two populations is the greater percentage (45%) of the FREP-sampled cutblocks (retention) that had zero large snags found, compared to about 8% of the cruise baseline cutblocks. Note that the mean and median number of cruise baseline large snags is highest in the SBSwk compared to the other five predominant subzones in the region, likely indicative of the heavy impact of the mountain pine beetle infestation in the SBSwk.

SBSwk: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	60	73.1	66.3	54.2	7.0
Retention	44	23.9	0.6	37.5	5.7

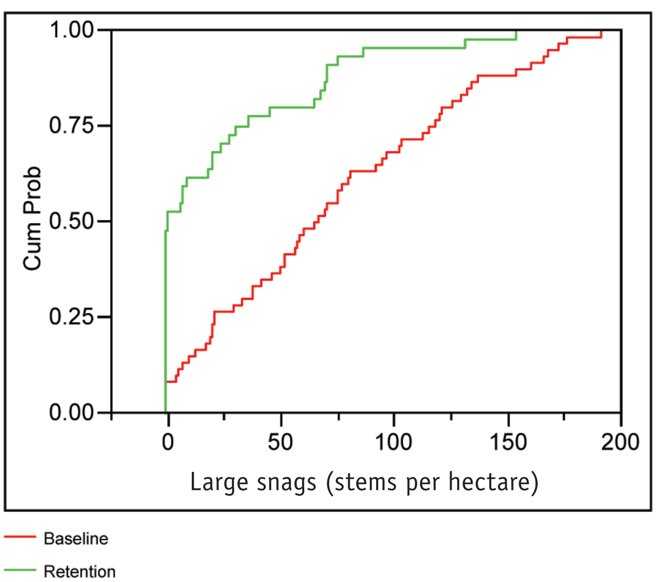

Figure 27. Cumulative probability for functional snag density in the SBSwk subzone.

K-S test: *D* = 0.4803 (maximum difference at nine large snags per hectare), *p*-value = $1.6\text{x}10^{-05}$ There is a significant difference between these two curves, with lower density of large snags being found in the FREP-sampled retention compared to the cruise baseline.

Density of large trees (live and dead; ≥ 40 cm dbh)

The average density of big trees found in the retention within the SBSwk FREP-sampled cutblocks is 87% of that found in the cruise baseline. Figure 28 shows data from the 44 of 47 cutblocks that contained retention. The largest difference in these two populations is seen in the cutblocks with lower densities of large trees (the first 40% of both the FREP retention cutblocks and the cruise baseline in terms of density of big trees) where the density is much lower in the FREP-sampled retention.

SBSwk: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	60	41.3	30.9	35.4	4.6
Retention	44	35.9	19.6	42.9	6.5

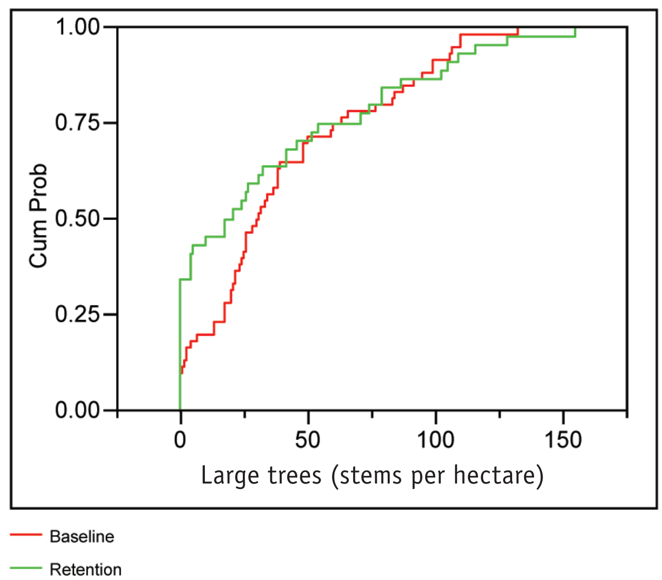

Figure 28. Cumulative probability for large tree density in the SBSwk subzone.

K-S test: *D* = 0.2545 (maximum difference at 10 large trees per hectare), *p*-value = 0.07454. There is a marginally significant difference in these two populations, with lower density of large trees being found in the FREP-sampled retention compared to the cruise baseline.

Number of tree species

The average number of tree species found in the retention within the SBSwk FREP-sampled cutblocks is 77% of that found in the cruise baseline. Figure 29 shows the complete data set with cutblocks with zero tree retention having zero number of species. Six percent of the sampled cutblocks had no retention found and therefore zero tree species. Note that 90% of the cruise baseline cutblocks had three or more tree species found compared to 62% of the FREP-sampled cutblocks.

SBSwk: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	60	4.0	4.0	1.3	0.2
Retention	47	3.1	3.0	1.8	0.3

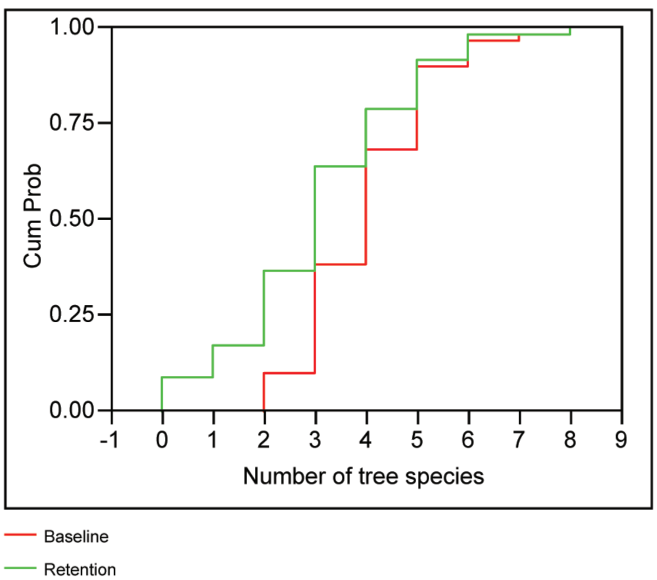

Figure 29. Cumulative probability for number of tree species in the SBSwk subzone.

K-S test: $D = 0.2617$ (maximum difference at two tree species found per cutblock), p-value = 0.0541. There is a marginally significant difference in these two curves, though the sampling intensity difference could explain some of the lower tree species diversity within the FREP-sampled cutblocks.

Volume of CWD

The average volume per hectare of CWD found in the harvest areas within the SBSwk FREP-sampled cutblocks is 80% of that found in the retention patches. Thirty-six of 47 SBSwk FREP-sampled cutblocks had retention patches and therefore data on CWD amounts within retention patches. Figure 29 shows this full dataset with the harvest area CWD volume being higher for the lower half of the cumulative distribution compared to the patch CWD volume, and lower for the top half.

SBSwk: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	36	140.1	122.8	110.8	18.5
Harvest	47	112.2	112.4	52.9	7.7

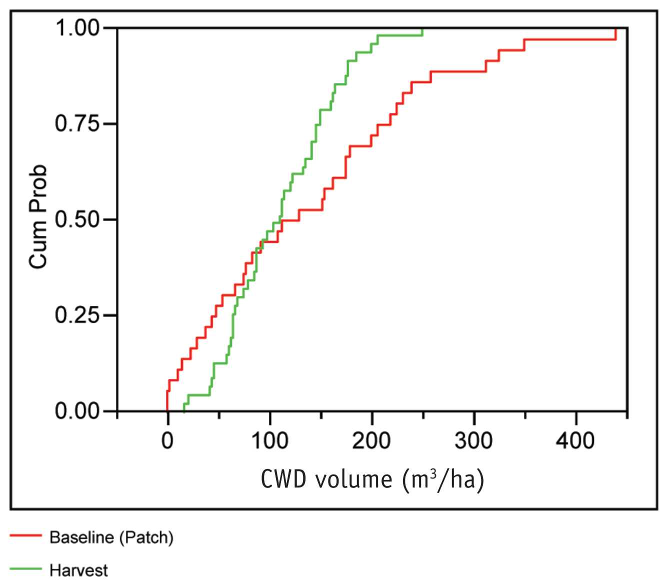

Figure 30. Cumulative probability for CWD volume in the SBSwk subzone.

K-S test: $D = 0.2595$ (maximum difference at 151.5 m^3 of CWD per hectare), p-value = 0.1285 There is no significant difference between these two curves.

Density of big pieces of CWD ($\geq$ 20 cm diameter and $\geq$ 10 m long)

The average density per hectare of large CWD pieces found in the harvest areas within the SBSwk FREP-sampled cutblocks is 26% of that found in the retention patches. The harvested areas overall have a much lower density of large CWD pieces than that found in the retention patches. Figure 30 shows data from the 36 of 47 FREP-sampled cutblocks that had patch retention.

SBSwk: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	36	62. 8	67.5	50.3	8.4
Harvest	47	16.1	0.0	27.4	4.0

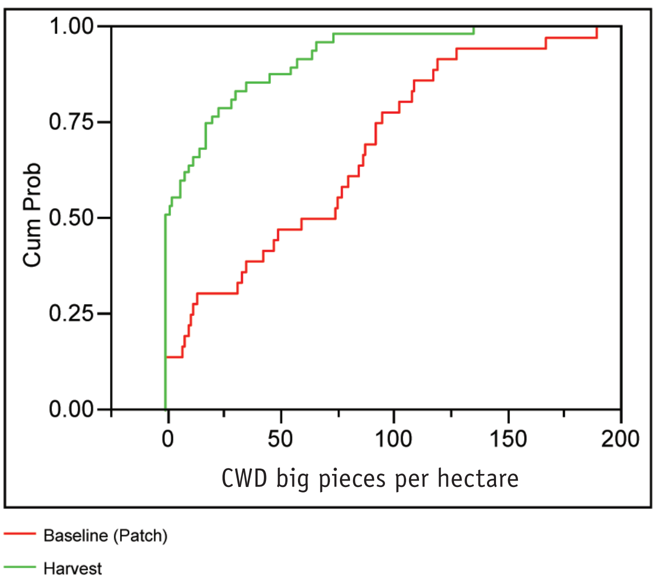

Figure 31. Cumulative probability for CWD big piece density in the SBSwk subzone.

K-S test: $D = 0.5242$ (maximum difference at 31 big pieces of CWD per hectare), p-value = 2.722×10^{-05}. There is a significant difference between these two curves, with lower densities of big CWD pieces in the harvested areas compared to the retention patches.

4.8.2 SBSwk discussion

Average retention on the SBSwk is 14.9% and 75% of cutblocks had retention. Average density of large snags was 33% of what was found in the cruise baseline, the lowest of the six predominant northern interior subzones. The timing of the mountain pine beetle infestation, plus the density of pine, are likely large contributors to this number.

The apparently low snag retention should be considered along with the SBSwk baseline having the highest average density of snags at 73 large snags per hectare (compared to both the ICHmc and SBSdw having an average baseline large snag of 42 large snags per hectare). Average density of large snags in the SBSwk retention was therefore similar to the retention within the other predominant ecosystems. The low median of SBSwk FREP large snag density indicates that essentially no large snags were found in plots on half of the sampled cutblocks. An emphasis of retention on live and likely non-pine trees is appropriate for mountain pine beetle salvage; however, the high ecological value of dead wood would support leaving some lower levels of dead pine on most cutblocks.

Average windthrow was 12.6%. The density of big trees (> 40 cm dbh live or dead) is 87% of the cruise baseline (marginally significant difference). The density of big pieces of CWD in the harvested areas is 26% of what was found in the retention patches. Four percent of patches were located external and non-contiguous with the cutblock boundary.

4.8.3 SBSwk consideration

Continue good mix of both patch and dispersed retention, and continue leaving large trees for the site on most cutblocks. Avoid the use of external non-contiguous retention patches for stand-level retention. A continuous improvement opportunity is to increase the density of large CWD on the harvested areas. Increase the percentage of cutblocks containing retention, even if low levels of dead pine. Windthrow management, such as patch orientation, will continue to be important in this subzone, though it is acknowledged that dead trees will eventually fall down.

5.0 WEIGHTING OF PERCENT RETENTION

A question coming out of this data is the difference in the retention of a small area of high-quality biodiversity versus a larger area of lower-quality biodiversity. The question of whether these are equivalent is best answered by research, with a likely outcome of "it depends." It will depend on what biodiversity outcome you are looking at. Large areas of lower site quality retention may serve the purpose of providing a seed source for understorey shrubs; however, without sufficient large dead trees, there will be decreased habitat value for primary cavity-nesting birds, which depend on trees of sufficient size and decay to allow for nesthole construction (Fenger et al. 2006). An exercise to weight the amount of retention by its quality is presented below. The table is an excerpt from Table 3 with the addition of quality weight and a weighted percent retention column. The quality weight is simply an average of the three tree indicator percentages (average value of the indicator from FREP retention data as a percentage of the baseline average). This weight is then applied to the percent retention for the subzone so that high-quality retention will result in an "increase" in the percent retention, whereas low-quality retention will decrease it.

Table 6. Impact of quality weighting on average percent retention. Average tree indicators from FREP retention presented as % of the average cruise baseline value.

BEC subzone	% Retention	Large snags (%)	Large trees (%)	Tree species (%)	Quality weighting	Weighted % retention
BWBSmw	9.9	78.4	134	79.4	0.97	9.6
CWHws	17	100[a]	39	75	0.71	12.1
ESSFmv	9.5	122.7	257.5	67.5	1.49	14.2
ICHmc	15.2	69.4[b]	34.2	79.2	0.61	9.3[b]
SBSdw	14.4	40.2[b]	100	100	0.80	11.5[b]
SBSwk	14.9	32.7[b]	86.8	77.4	0.65	9.8[b]

a If the K-S test indicates that the two curves (FREP retention data or baseline data) are not significantly different ($p \geq 0.1$), then the indicator is assumed to be 100%, or completely equivalent to the baseline.

b Note that the high baseline density of SBSwk large snags (due to mountain pine beetle mortality) may be an inappropriately high target within this weighting exercise. Using the ICHmc mean for baseline large snags will increase the SBSwk weighted retention to 10.9%. Using the ESSFmv (minimally impacted by MPB) mean for baseline large snags for the three MPB affected subzones, ICHmc, SBSdw, and SBSwk) increases their weighted retention to 12.8, 13.5 and 13.8% respectively.

6.0 SUMMARY

Various harvesting and retention outcomes occur throughout the Northern Interior Forest Region. In the six predominant subzones reported on here, the average retention ranges from 9.5% in the ESSFmv to 17% in the CWHws. The retention quality indicators also vary greatly. For example, the FREP data collected in the ESSFmv and the SBSdw showed consistently high biodiversity quality (i.e., equivalent or higher than baseline) for two of the three tree indicators presented (large snags, large trees, and number of tree species). In comparison, the FREP data collected in the ICHmc and SBSwk subzones consistently showed lower biodiversity quality for all three tree biodiversity indicators. Mountain pine beetle mortality affects the large snag indicator the most, and maintenance of pre-harvest densities of large snags may not be appropriate in salvage areas. However, the absence of any large snags within a significant portion of the retention cutblock data is a concern. This is indicated by very low median numbers of large snags for the FREP retention cutblocks, and is seen in the BWBSmw, SBSdw, and SBSwk. Even in areas of pure pine, some pine retention is recommended for habitat and biodiversity purposes (Bunnell et al. 2004).

The question of whether the actual retention or the quality-weighted retention is sufficient within a particular area or subzone can only be answered partially without knowledge of landscape-level retention levels and quality. However, to provide basic levels of stand-level retention for habitat needs of less sensitive to harvesting forest-dwelling birds a 15% stand-level retention has been suggested (Huggard and Bunnell 2007). When considering the impact of quality (as seen in the weighting data in Table 6), this level is not obtained as an average in any of the predominant subzones.

A consistent weakness in all subzones is the low density of big pieces of CWD. This is particularly an issue within the BWBSmw, ESSFmv, SBSdw, and SBSwk subzones. It is less of an issue in the CWHws or ICHmc. In the ICHmc in particular, higher densities of big CWD pieces (not significantly different than found within retention patches) and dispersed treed retention potentially providing CWD recruitment combine to give better CWD quality or potential quality.

APPENDICES

Appendix 1. Data Compilation

Number of cutblocks per biogeoclimatic subzone in FREP samples and baseline cruise cutblocks.

Subzone	FREP samples	Cruise baseline BCTS Official Notices Site[a]	Cruise baseline ECAS[a]
BWBSdk	11		
BWBSmw	76	112	70
BWBSwk	2		
CWHvh	1		
CWHvm	7		
CWHws	33	25	30
ESSFmc	16		
ESSFmv	38	42	39
ESSFwk	4		
ESSFwv	1		
ICHmc	38	58	31
ICHvc	2		
ICHvk	2		
MHmm	1		
SBSdk	42		
SBSdw	63	165	126
SBSmc	79		
SBSmk	41		
SBSmw	1		
SBSvk	6		
SBSwk	47	29	31

a Baseline used only for the predominant subzones; the description below is for the data acquisition of the full baseline data set.

The baseline used for tree data comes from timber cruise which is done by forest licensees to estimate the volume of timber to be harvested from a proposed cutblock. Timber cruise plot data is used (rather than summarized data). The plot data measures tree height, species, diameter, and tree class. The FREP tree data is taken from retention areas in harvested cutblocks, with the tree data being acquired using timber cruise survey methods.

All usable timber cruise data from the BCTS Official Notices Site were downloaded, without duplication, in 2006 (250 cutblocks), 2007 (670 cutblocks), and 2008 (1600 cutblocks). This BCTS site was the first source of electronic timber cruise raw data (tree information).

In 2008, after the ECAS data system began including electronic timber cruise raw data, this system was also used to acquire timber cruise data, and 1940 cutblocks of timber cruise data were added to the database. The ECAS system allowed for major licensee data to be included in the baseline. As with the Official Notices Site downloads, all useable data was acquired without duplication. Usable data was electronic files showing the raw tree data from the timber cruise, in a .dat or .ccp format, where BEC information could be confirmed.

There is not a one-to-one comparison of FREP cutblocks and their cruise data; rather the full curve of data for FREP-sampled retention in a particular ecosystem is compared against the curve of data for timber-cruised cutblocks from the same ecosystem. With the FREP data being chosen randomly from the full population of harvested cutblocks (> 2 ha within defined harvest completion date range), and the cruise data representing as close as possible, the full population of cruised cutblocks, this allows an overall comparison of the trees maintained in retention versus the trees being harvested in the ecosystem.

The raw timber cruise data was compiled by Amanda Linell Nemec using the SAS software program. The compiled data shows for each cruised cutblock, the same tree indicators as derived from the FREP data.

The FREP data, both tree data and coarse woody debris data, was compiled using a program written by BCStats. Equations for calculating CWD volume and piece density from the CWD line transect plots are from van Wagner (1982). Equations for calculating tree density are from the Cruise Compilation Manual (2009). Previous data compilations of FREP data were done by Amanda Nemec using SAS, which allowed full comparison of data as compiled by the two programs for quality-control purposes.

The statistics were calculated via the software "R," (R Development Core Team 2008) and the cumulative distribution charts were done either with "R" or the software package JMP.

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