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Coastal Forest Region Analysis of Stand-level Biodiversity Sampling Results in Six Predominant Biogeoclimatic Subzones

Prepared by:
Nancy Densmore, RPF

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Sustainability of Forest and Range Resources Through Science and Stewardship

MINISTRY OF FORESTS, MINES AND LANDS
FOREST AND RANGE EVALUATION PROGRAM

COASTAL FOREST REGION ANALYSIS OF STAND-LEVEL BIODIVERSITY SAMPLING RESULTS IN SIX PREDOMINANT BIOGEOCLIMATIC SUBZONES

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FREP Forest & Range Evaluation Program
BRITISH COLUMBIA

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 400 harvested cutblocks were assessed for stand-level biodiversity attributes from 2006–2009 in the Coastal Forest Region of British Columbia. Quality and quantity of the tree retention and coarse woody debris was measured. Ninety-three percent of the cutblocks had retention (greater than 0.5% of the cutblock area). Overall retention was 22.8% of the total gross area of all the sampled cutblocks.

The retained tree data from the samples in six predominant biogeoclimatic (BEC) subzones (CWHdm, ms, vh, vm, wh, xm) 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, the FREP data collected in the Coastal Western Hemlock (CWH) dm, ms, and xm subzones showed consistently high biodiversity quality (i.e., equivalent or higher than baseline) for two of the three tree indicators presented (e.g., two of; large snags, large trees and number of tree species). In comparison, the FREP data collected in the CWHvh subzone consistently showed lower biodiversity quality for all three tree biodiversity indicators.

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 and moisture-carrying capacity due to the input of organic matter. The density of big pieces of CWD (≥ 20 cm diameter and ≥ 10 m long) is low for the CWHdm, wh and xm, with 31% or less of the densities of big pieces of CWD as found in the retention patches. Big pieces of CWD are important to maintain for soil stability and wildlife habitat.

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1.0 INTRODUCTION

The purpose of this report is to enhance understanding of a subset of stand-level biodiversity outcomes related to harvesting and retention forest practices in the Coastal Forest Region. The information presented here can facilitate discussions between natural resource professionals 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 structure and moisture holding capacity, and species dispersal (Chapman 1995; Winkler et al. 2008; Stevens 1997, Kremsater and Bunnell 2009).

The wildlife tree and CWD data is compared to a baseline. For wildlife trees, the baseline is timber cruise data from the same subzones. Timber cruise plots, used for evaluating timber value, are not normally established in areas designated for wildlife tree retention. The comparison between FREP-sampled retention and cruise therefore indicates the biodiversity choices made on the sampled cutblocks. A difference in an indicator average 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 practise, 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 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, prior to harvest, or in similar mature ecosystems. For FREP, the CWD indicators (total volume and density of big 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.

2.0 BACKGROUND AND METHODOLOGY

The field data, totalling 405 cutblocks was collected by British Columbia Ministry of Forests and Range forest district staff in the Coastal 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 2008 (Table 1). These cutblocks were therefore representative of the *Forest Practices Code of British Columbia Act* (FPC) era.[1]

1 The effective date of the *Forest and Range Practices Act* (FRPA) 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., permit to harvest timber) originating from FPC FDP's extended beyond March 31, 2007. Analysis shows that very few cutblocks originating from Forest Stewardship Plans (FSP, an FRPA plan governing harvest) were showing up on the landscape until 2008. Two of the Coastal Forest Region 2007 harvest year cutblocks were from FRPA.

Table 1. Samples by Harvest Completion Year

Harvest Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Unknown	Total
Number of samples	11	17	26	31	33	54	46	76	48	51	9	1	2	405
% of samples	2.7	4.2	6.4	7.7	8.1	13.3	11.3	18.8	11.9	12.6	2.2	0.2	0.5	100%

In brief, the field survey utilizes modified timber cruise plots to assess tree retention, and line transect plots for CWD. Plots are located randomly. Three plots are established in the harvested area of the cutblock. The number of plots established within patch retention varies with the amount of retention on the cutblock. Both a tree and CWD assessment is done from every plot centre, which are randomly located 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 retention is expected to be harvested prior to rotation end; and long-term retention is to be retained throughout the rotation).

A general overview of all sampled Coastal Forest Region cutblocks is presented below, followed by a summary of six predominant biogeoclimatic (BEC) subzones (CWHdm, ms, vh, vm, wh, xm) within the Coastal Western Hemlock (CWH) zone. Small numbers of samples were also collected within the Coastal Douglas-fir, Engelman Spruce-Subalpine fir, Interior Douglas-fir and Mountain Hemlock zones. In general, this report includes only the influence of long-term retention; however a shadow analysis was done to assess the effect of temporary retention and is briefly discussed for the predominant subzones. Further details on the survey methodology are found in the FREP stand-level biodiversity protocol (Province of British Columbia 2009).

The tree indicator data is compared against timber cruise data from major licensee and British Columbia Timber Sales (BCTS) derived from the Electronic Commerce Appraisals System (ECAS) https://www.for.gov.bc.ca/hva/ECAS/index.htm and the Official Notices Site https://www23.for.gov.bc.ca/notices/init.do. The comparison of FREP cutblocks to cruise data is not a one-to-one comparison of a cutblock and its associated cruise. Rather it is the full curve of data for FREP-sampled retention in a particular BEC subzone as compared against as complete as possible dataset of cruise cutblocks from the same subzone. A further description of the derivation of baseline data, plus BEC subzones for the FREP-sampled cutblocks is shown in Appendix 1.

The CWD indicator data from the harvest areas of cutblocks is compared against a baseline of CWD derived from the retention patches (unharvested forest). 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 for a cutblock (both wildlife tree and CWD indicators), 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). The difference between the two curves is considered significant at $\alpha = 0.05$.

2.1 *Indicators Assessed*

Many different indicators can be compiled from the data collected. A subset of potential indicators is presented in this report. These are:

- percent retention
- retention patch size
- retention patch location
- large snags (dead trees ≥10 m tall and ≥30 cm dbh)
- large trees (live and dead trees; dbh ≥70 cm)
- number of tree species found
- coarse woody debris volume
- coarse woody debris density of big pieces

The indicators chosen are important for ecological retention value. For example, the density of large trees is tracked as an indicator since large 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).

Important wildlife tree traits such as decay, cavities or loose bark were not specifically noted in the FREP monitoring. FREP therefore provides an overview look at stand-level biodiversity. A more detailed assessment could look for such traits in relation to the habitat requirements of local wildlife species (Kiesker, 2000).

2.1.1 Percent retention

The percent retention of a cutblock is the total amounts of patch retention and dispersed retention (as basal area equivalent[2]) found on the cutblock divided by the total cutblock gross area. The cutblock gross area is inclusive of the harvested area plus all retention and small areas of (e.g.,) roads, rock or swamp internal to the cutblock boundary. 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 greater than 40% retention, (or larger landscape reserves,) are needed by sensitive (to harvesting) bird species.

2.1.2 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. Similarly, for a Vancouver Island site on BC's coast, Baldwin and Bradfield (2005) found that old-growth-associated bryophytes require fairly large forest remnants to sustain individual populations. They suggest that a 1 hectare retention patch is not large enough for this purpose.

2.1.3 Retention patch location

A mixture of both internal and edge of harvest patch locations is suggested. Internal patches provide areas of cover within the harvested 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 (i.e., patches that are some distance away from the edge of the cutblock) 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.

2.1.4 Large snags (dead trees ≥ 10 m tall and ≥ 30 cm dbh)

Large, dead trees (dead trees are also called "snags") are important habitat for wildlife tree users. The BC 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 tall. Observations of nesting use of stubs (trees cut, often at about 3 metres, to provide wildlife habitat while minimizing danger to forest workers) 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 (for bird reproduction) dead tree description and was close to preferred diameters.

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%. Since we do not have pre-harvest data, the basal area from retention patches on the same opening, or if no patches, the average basal area for all other retention patches in the same BEC subzone, are used for comparison.

2.1.5 Large trees (live and dead; dbh ≥ 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 the CWH zone assessed in this report, a 70 cm DBH or larger cutoff is used to define a large tree. Both live and dead trees are assessed here as both can provide immediate value for wildlife-tree users. A finer look at the data is possible, to assess the percentage of live versus dead large trees, and their potential value as current and long-term habitat.

2.1.6 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 in the FREP biodiversity plots, compared to that found in the timber cruise plots.

The cumulative distribution charts for tree species (see Section 4), shows 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 0–10 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 be 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 an occasional extreme range of species. The correction, used in the 2008 report on eight BEC zone assessments, showed no change in the difference between the overall (i.e., all FREP-sampled cutblocks or timber-cruise baseline data within the subzone) 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. For one zone, there was an increase in the FREP-sampled retention average of two species compared to the baseline. The overall species data is presented to one decimal place, allowing for theoretical portions of species. 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 there is a difference.

2.1.7 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). Long 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 their habitat and slope 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. Big pieces decay slowest (higher piece volume of wood and thus lower surface to volume ratio) 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 Coastal Forest Region Sample Cutblocks*

- 405 cutblocks sampled
- 93% of cutblocks had retention (376 cutblocks), 7% of cutblocks had no retention (29 cutblocks)
  - 34% (10 of 29 cutblocks) of the no-retention cutblocks were less than or equal to 5 ha in gross size
  - 7% (2 of 29 cutblocks) of the no-retention cutblocks retained a few trees but the % rounded to 0
- 9005.7 hectares (ha) total gross area (all FREP-sampled RCO cutblocks)
- 15.5% (1399.4 ha) of patch (long-term) retention
- 7.3% (657.9 ha) of dispersed retention (basal area equivalent (BAE)[3])
- 22.8% average retention
- 34% of retention constrained[4]
- 81.6% of patches are less than or equal to 2 ha
- 18.4% of patches are greater than 2 ha
- Average of 4.7 ecological anchors/ha[5] of retention, patch or dispersed (range 0 – 203)
- Average of 7.6% windthrow in the 376 cutblocks with retention measured[6]. Of these cutblocks, 65% had ≤ 5% windthrow; and 23% had ≥ 10% windthrow
- 36.8% of patches internal to cutblock boundaries; 62.2% on the edge of the cutblocks; and 3.6% external and non-contiguous to the cutblocks[7]
- Invasive plant species were found on 20% of the cutblocks.

3.2 *Percent Retention*

The overall percent retention of 22.8% 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 25.9% when the temporary retention (retention on block that is likely to be harvested prior to rotation end) is considered.

Table 2 below shows the percentage of cutblocks and percentage of gross harvested area by retention category.

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

% Retention Levels	No. Cutblocks	% Cutblocks	Gross Area (ha)	% Total Area
0	29	7.2	294	3.3
1-4	15	3.7	234	2.6
5-9	54	13.3	1411	15.7
10-14	99	24.4	1929	21.4
15-19	61	15.1	1449	16.1
20-24	39	9.6	877	9.7
25-29	32	7.9	782	8.7
30-34	15	3.7	405	4.5
35-39	18	4.4	384	4.3
40-49	14	3.4	382	4.2
50-59	13	3.2	338	3.8
60-69	2	0.5	92	1.0
70-79	4	1.0	135	1.5
≥80	10	2.5	295	3.3
Total	405	100	9006	100

3 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%. Since we do not have pre-harvest data, the basal area from retention patches on the same opening, or if no patches, the average basal area for all other retention patches in the same BEC subzone, are used for comparison. The actual area covered with dispersed retention was 2,235 hectares.

4 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.

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

6 Windthrow is not measured in strata that have no standing trees remaining.

7 This tally may include patches designated as temporary retention and likely to be harvested prior to rotation end.

Figure 1 shows that close to half of the FREP-sampled cutblocks had under 15% retention, an amount of retention that would not likely support the less sensitive to harvesting bird species (Huggard and Bunnell 2007). This relates to 43% of the total sampled gross area from cutblocks with less than 15% retention. Eighteen percent comes from cutblocks with 35% or more retention. Twenty-nine percent of the cutblocks, representing 3.3% of the total sampled area had no retention.

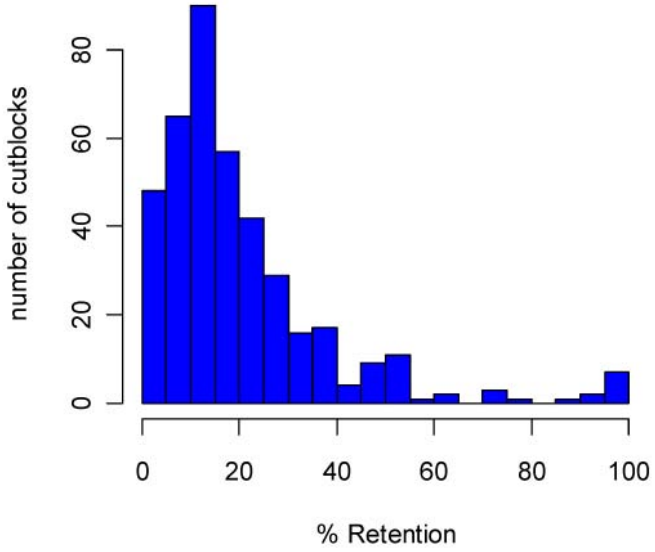

Figure 1. Count of FREP-sampled cutblocks in percent retention categories

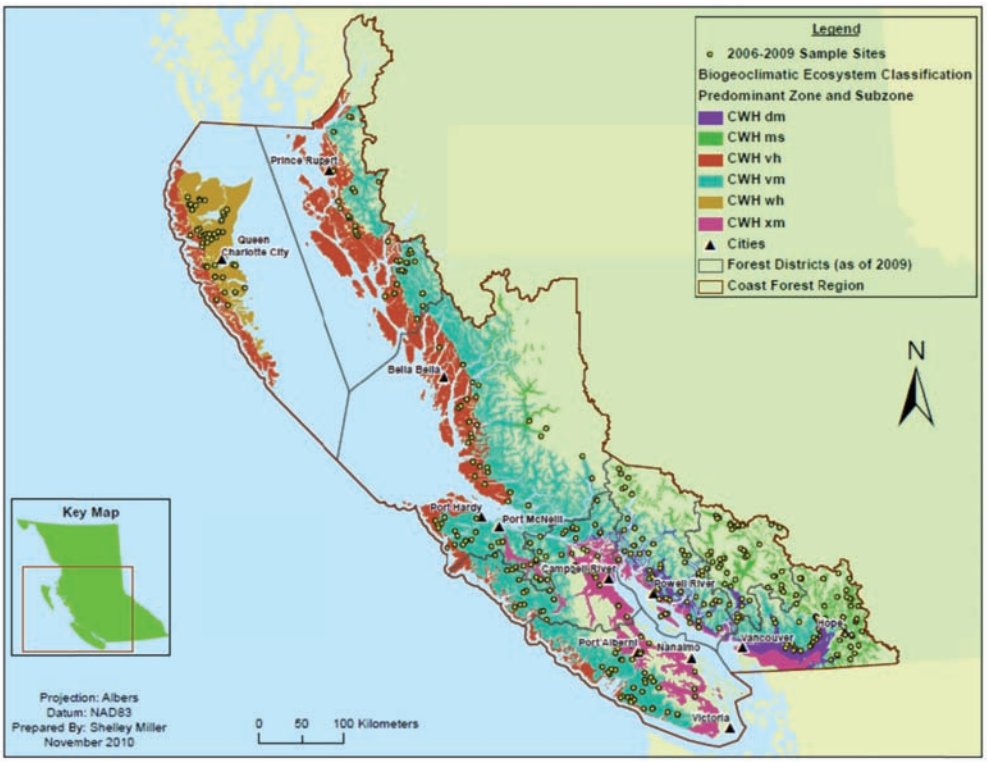

Figure 2. Coast Forest Region stand-level biodiversity sample site locations 2006-2009. Data Sources: Sample location data from FREP IMS and FREP staff, base mapping from the Land and Resource Data Warehouse.

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 the same indicators calculated from the sampled cutblocks. Indicator values are ordered from lowest to highest and presented as a cumulative distribution, where the order 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 may be cause for concern (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

	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[a] (sample size)	Average	Maximum	Total (%)	Patch (%)	Dispersed (%) BAC	% 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
CWHms (47)	21.3	137.2	32.9	18.3	14.6	93.6	6.4	33	66	1	17	42	100	59	88	167	80
CWHxm (35)	15.1	50.3	22.4	17.9	4.5	88.6	4.5	43	53	4	16	34	27	115	78	87	22
CWHdm (46)	19.7	127.8	19.1	11.6	7.5	95.6	5.6	46	52	2	16	30	62	91	80	112	27
CWHvm (138)	26.8	70.6	20.6	16.2	4.4	92	10.2	47	50	3	23	51	85	57	79	108	52
CWHwh (36)	22.3	54.4	15.1	15.1	0.0	94.4	10.6	18	73	8	28	42	56	60	91	141	31
CWHvh (52)	22.7	89.4	32.9	13.3	19.6	92.0	6.6	40	52	8	23	42	69	44	75	156	76

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 harvested 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 *Coastal Western Hemlock Dry Maritime Subzone (CWHdm)*

The CWHdm data came primarily from the Chilliwack and Sunshine Coast forest districts (87% of samples). The remainder of the cutblocks sampled came from the Campbell River and Squamish forest districts. As noted in Table 3, retention was found in 96% of the sampled cutblocks and the average retention was 19.1%. This retention increases to 21.4% when the temporary retention (retention on a cutblock that is likely to be harvested prior to rotation end) is considered. The minor increased retention came from two cutblocks, one commercially thinned (dispersed overstory retention equaling 10.1 ha BAE), and the other a 24 ha block with a 10.5 ha temporary patch, maintained for a second pass of harvesting.

4.3.1 Statistical analysis of CWHdm indicators

Density of large snags (≥ 10 m tall and ≥ 30 cm dbh dead stems per hectare)

The average density of large snags retained within the CWHdm FREP-sampled cutblocks is 62% of that found in the cruise baseline. Figure 3 shows the 44 cutblocks of the total sampled 46 CWHdm cutblocks that contained retention, with about 65% of the FREP-sampled cutblocks with zero large snags found, compared to about 30% of the cruise baseline.

CWHdm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	98	15.7	10.5	19.3	1.9
Retention	44	9.7	0.0	28.1	4.2

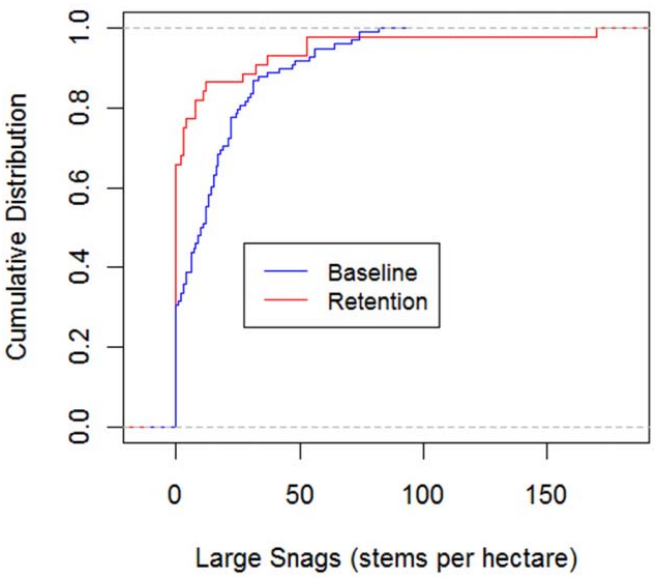

Figure 3. Cumulative probability for functional snags in the CWHdm subzone.

K-S test: $D = 0.3929$ (maximum difference at 3 large snags per hectare), p-value =0.0001699. The p-value indicates a highly 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.

To aid in interpreting cumulative distribution charts, the same data from figure 3, the first cumulative distribution chart of the report, is also presented as boxplots in figure 4.

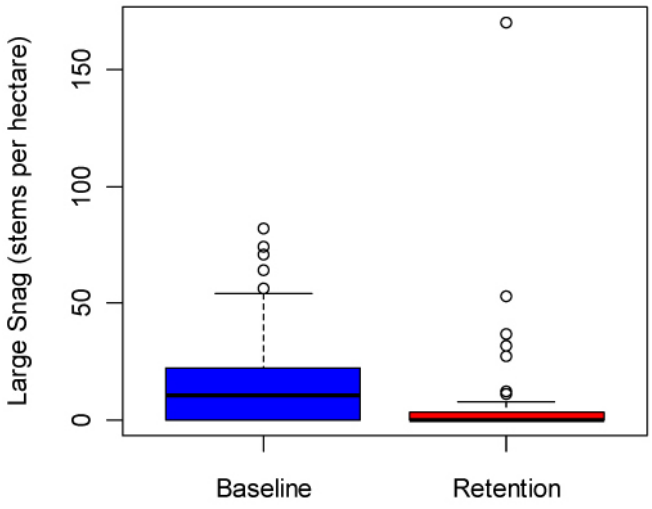

Figure 4. Boxplots of large snags in the CWHdm subzone

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

The average density of large trees (70 cm or larger dbh, live and dead) found in the retention within the CWHdm FREP-sampled cutblocks is 91% of that found in the cruise baseline. Figure 5 shows very similar data for the 44 cutblocks of the total sampled 46 CWHdm cutblocks that contained retention, compared to the baseline.

CWHdm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	98	16.2	12.0	17.3	1.7
Retention	44	14.8	12.0	14.6	2.2

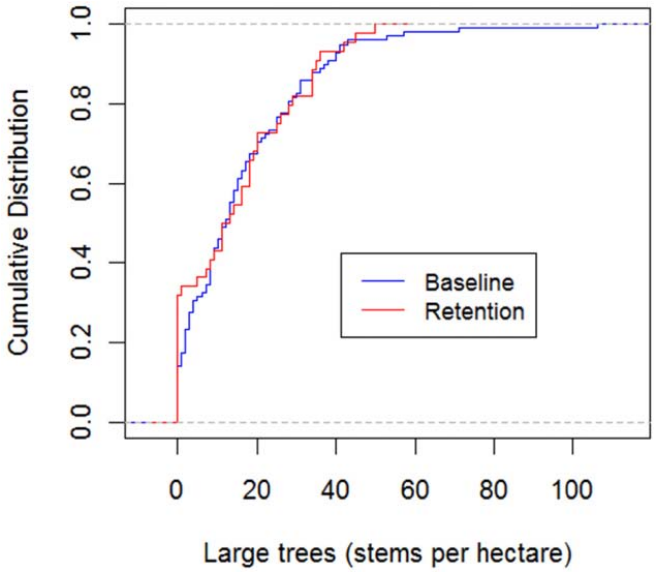

Figure 5. Cumulative probability for large tree density in the CWHdm subzone.

K-S test: D = 0.1753 (maximum difference at 0 large trees per hectare), p-value = 0.3081. The p-value indicates no significant difference between these two curves.

Number of tree species

The average number of tree species found in the CWHdm FREP-sampled cutblocks is 80% of the cruise baseline. Figure 6 shows the complete data set of cutblocks with zero tree retention cutblocks thus having zero tree species. Four percent of the sampled CWHdm cutblocks contained no trees, accounting for the 4% of cutblocks with zero tree species in the chart below.

CWHdm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	98	4.0	4.0	1.4	0.1
Retention	46	3.2	3.0	1.2	0.2

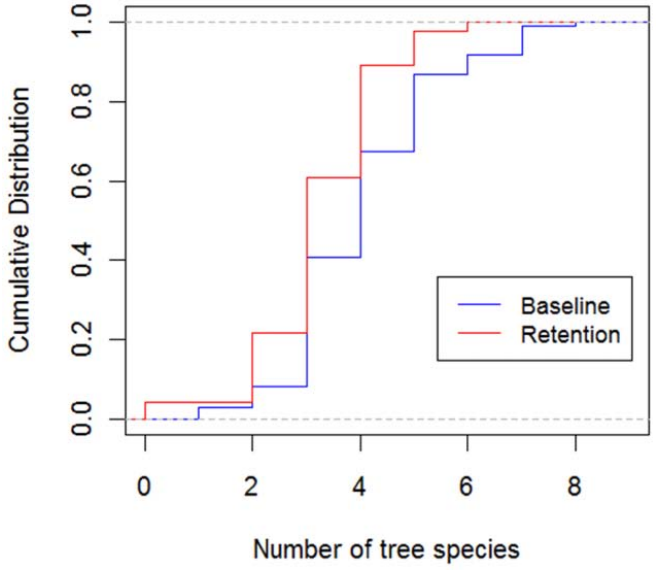

Figure 6. Cumulative probability for number of tree species in the CWHdm subzone.

K-S test: *D* = 0.2178 (maximum difference at four tree species found per cutblock), *p*-value = 0.1025. The *p*-value indicates no significant difference between these two curves with the FREP retention having a similar number of tree species per cutblock compared to the cruise baseline.

Volume of CWD (m^3/ha)

The average volume per hectare of CWD found in the harvest areas within the CWHdm FREP-sampled cutblocks is 112% of that found in the tree retention patches. Figure 7 shows similar CWD volume data from 45 sampled harvest area in the CWHdm cutblocks (one cutblock had missing harvest area CWD data), and the 40 cutblocks that had CWD data from within retention patches.

CWHdm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	40	239.6	188.8	195.5	30.9
Harvest	45	224.6	211.4	143.2	21.4

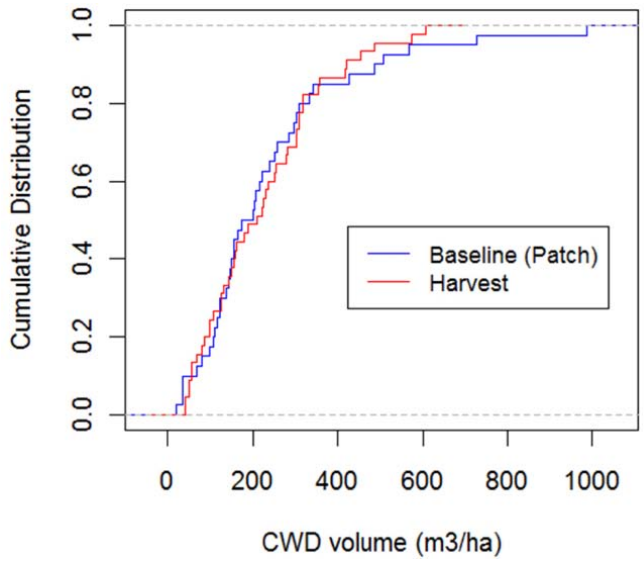

Figure 7. Cumulative probability for CWD volume in the CWHdm subzone.

K-S test: D = 0.1139 (maximum difference at 223 m^3 of CWD per hectare), p-value = 0.9464. The p-value indicates 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 pieces per hectare)

The average density per hectare of big CWD pieces found in the harvest areas within the CWHdm FREP-sampled cutblocks is 27% of that found in the retention patches. Figure 8 shows about 45% of the harvest areas from the FREP-sampled cutblocks had zero large pieces of CWD found in sampling compared to about 10% of the retention patches.

CWHdm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	43	47.2	37.0	53.3	8.4
Harvest	47	12.8	10.0	14.0	2.1

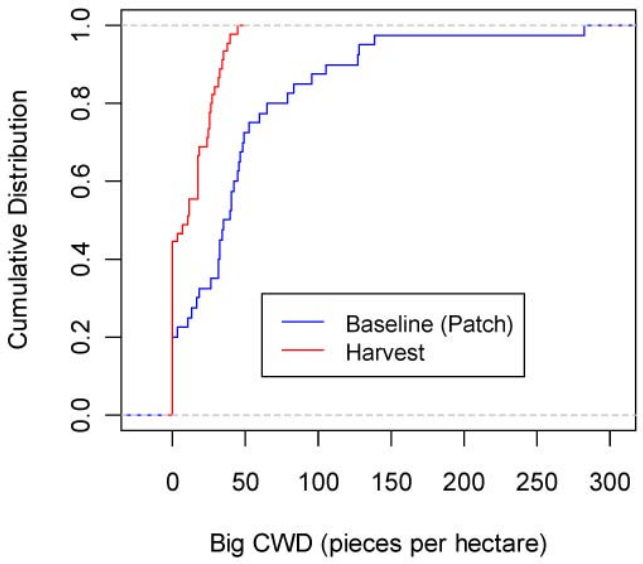

Figure 8. Cumulative probability for CWD big piece density in the CWHdm subzone.

K-S test: D = 0.494 (maximum difference at 29 big pieces of CWD per hectare), p-value = 6.371x10–05. The p-value indicates a highly 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 CWHdm discussion

The CWHdm subzone had retention within 96% of the sampled cutblocks, with an overall average retention of 19.1%. Average windthrow was 5.6%, and there was a good mixture of retention patch locations both internal to harvest boundary and on the edge, with two retention patches external and non-contiguous to the harvest boundary.

The average density of large snags in the FREP-sampled retention was 62% of the cruise baseline, with the major difference in the data distribution being a high percentage of the retention data with zero large snags. The average density of large trees was not significantly different than the baseline. The average number of tree species retained was also very similar to that found in the baseline. Volume of CWD on the harvested areas was similar to that found in the retention patches, though the density of big CWD pieces (as compared to the retention patches) is significantly lower than the baseline (27%). However, the average 7.5% dispersed retention will provide inputs of future CWD in the 33% of the FREP-sampled cutblocks that contained dispersed retention.

4.3.3 CWHdm 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 and tree species. A continuous improvement opportunity is to increase the density of large snags retained, in particular by decreasing the numbers of cutblocks which have zero large snags. Increase the density of big CWD pieces left on cutblocks.

COASTAL WESTERN HEMLOCK MOIST SUBMARITIME SUBZONE (CWHms)

The CWHms data came primarily from the Squamish and Chilliwack forest districts (89% of samples). The remainder of the sampled cutblocks came from North Island and the Sunshine Coast forest districts. The cutblocks were predominantly from the ms1 BEC variant, with 6% of sampled cutblocks from the ms2. As noted in table 3, retention was found in 94% of the sampled cutblocks and the average retention was 32.9%. This retention increased slightly to 33.1% when the temporary retention (retention on cutblock that is likely to be harvested prior to rotation end) is considered.

4.3.1 Statistical analysis of CWHms indicators

Density of large snags (≥ 10 m tall and ≥ 30 cm dbh, dead stems per hectare)

The average density of large snags retained within the CWHms FREP-sampled cutblocks is 100% of that found in the cruise baseline. Figure 9 shows the 43 cutblocks, of the total sampled 47 CWHms cutblocks that contained retention.

CWHms: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	46	19.1	11.0	20.4	3.0
Retention	43	29.8	11.0	42.0	6.4

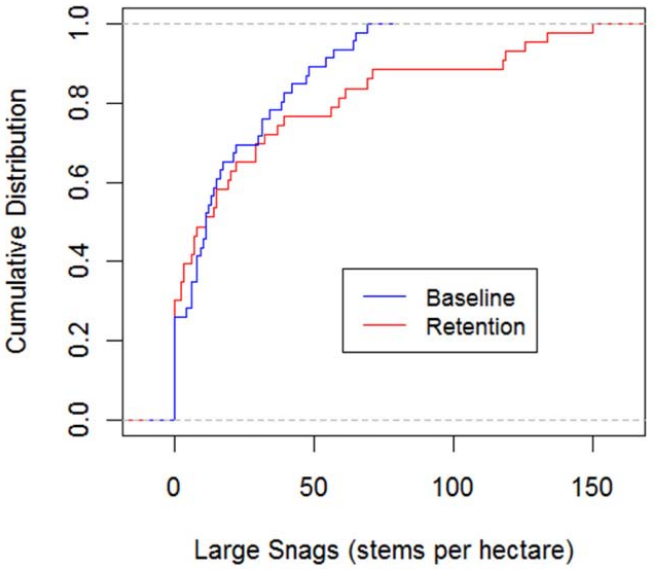

Figure 9. Cumulative probability for large snags in the CWHms subzone.

K-S test: D = 0.1456 (maximum difference at 54 large snags per hectare), p-value = 0.7337. The p-value indicates no significant difference between these two curves.

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

The average density of large trees found in the retention within the CWHms FREP-sampled cutblocks is 59% of that found in the cruise baseline. Figure 10 shows the 43 cutblocks of the total sampled 47 CWHms cutblocks that contained retention.

CWHdm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	46	38.6	27.5	35.6	5.3
Retention	43	22.6	15.0	30.4	4.6

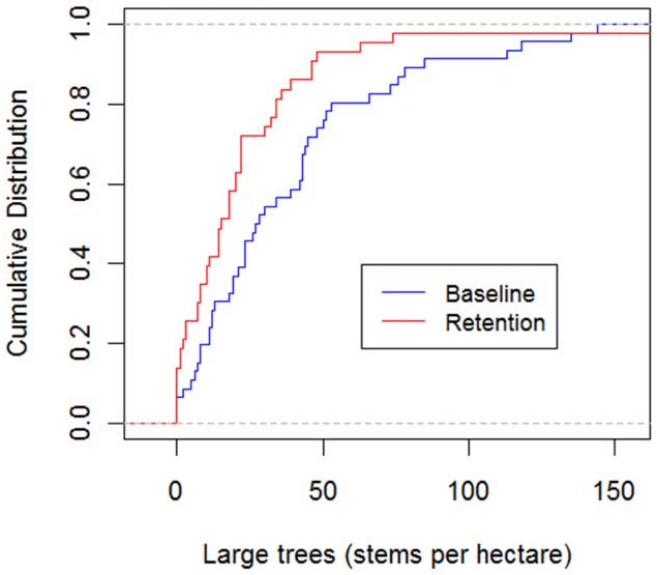

Figure 10. Cumulative probability for large tree density in the CWHms subzone.

K-S test: $D = 0.3296$ (maximum difference at 22 large trees per hectare), p-value = 0.01598. The p-value indicates a marginally significant difference between these two curves with the FREP sampled retention having a lower density of large trees compared to the cruise baseline.

Number of tree species

The average number of tree species found in the CWHms FREP-sampled cutblocks is 88% of the cruise baseline. Figure 11 shows 46 of 47 sampled cutblocks. One block was not included due to missing data. Six percent of the remaining CWHms cutblocks contained no trees, accounting for the 6% of cutblocks with zero tree species in the chart below.

CWHms: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	46	4.0	4.0	1.3	0.2
Retention	46	3.5	3.3	1.5	0.2

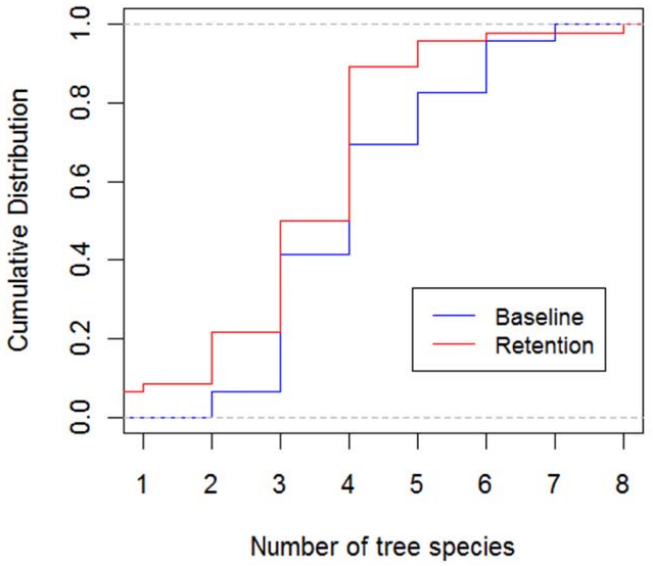

Figure 11. Cumulative probability for number of tree species in the CWHms subzone.

K-S test: $D = 0.1957$ (maximum difference at four tree species found per cutblock), p-value = 0.3421. The p-value indicates no significant difference between these two curves with the FREP retention having a similar number of tree species per cutblock compared to the cruise baseline.

Volume of CWD (m^3/ha)

The average volume per hectare of CWD found in the harvest areas within the CWHms FREP-sampled cutblocks is 167% of that found in the tree retention patches. Figure 12 shows the CWD volume data from 47 sampled harvest areas in the CWHms cutblocks, and the 43 cutblocks that had CWD data from within retention patches.

CWHms: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	43	194.3	144.9	158.6	24.2
Harvest	47	323.9	275.5	247.6	36.1

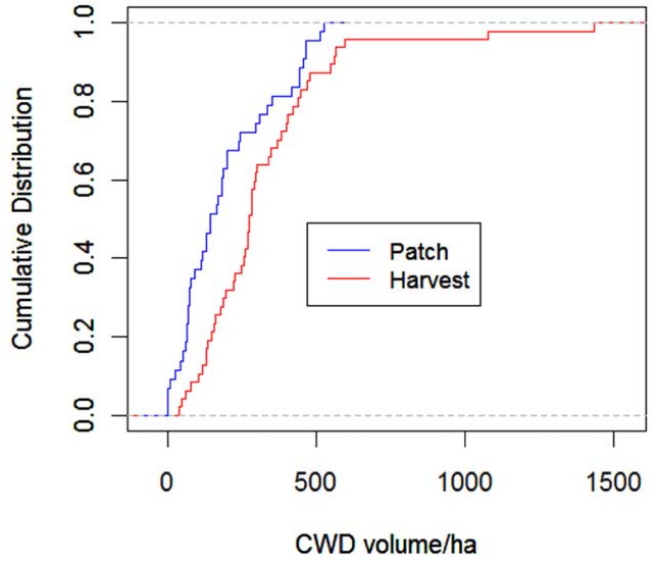

Figure 12. Cumulative probability for CWD volume in the CWHms subzone.

K-S test: $D = 0.3592$ (maximum difference at 243 m^3 of CWD per hectare), p-value = 0.006082. The p-value indicates a highly significant difference between these two curves with the volume of CWD found on harvested sites higher than that found within retention patches.

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

The average density of big CWD pieces found in the harvest areas within the CWHms FREP-sampled cutblocks is 80% of that found in the retention patches. Figure 13 shows that both the harvest areas and the patch areas had big pieces of CWD found on almost 80% of the samples.

CWHms: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	43	46.9	33	47.8	7.3
Harvest	47	37.7	27	42.0	6.1

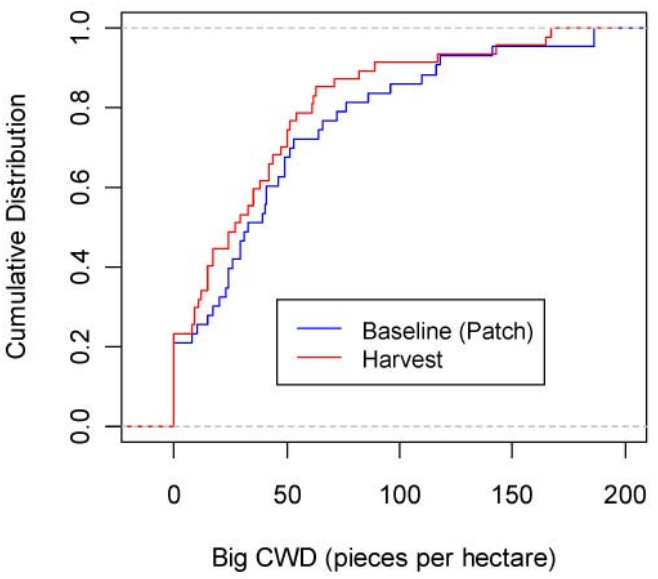

Figure 13. Cumulative probability for CWD big piece density in the CWHms subzone.

K-S test: $D = 0.1445$ (maximum difference at 17 big pieces of CWD per hectare), p-value = 0.7366. The p-value indicates no significant difference between these two curves with the density of big CWD pieces being similar in the harvested areas compared to within retention patches.

4.3.2. CWHms discussion

The CWHms subzone had retention within 94% of the sampled cutblocks, with an overall average retention of 32.9%. Average windthrow was 6.4%. The average density of large snags in the FREP-sampled retention was similar to the cruise baseline, as was the overall density distribution of all the sampled cutblocks. The average density of large trees was 59% of the baseline.
The average number of tree species retained was very similar to that found in the baseline. Density of big CWD pieces (as compared to the retention patches) is fairly high, compared to other subzones, at 65% of what was found in the patch retention. The average 14.6% dispersed retention may also provide future inputs of CWD.

4.3.3. CWHms consideration

Continue choosing retention areas containing representative or higher densities of large snags and numbers of tree species. Continue maintenance of good current and potential future CWD, both in terms of volume and density of big pieces of CWD. A continuous improvement opportunity is to increase the retention density of large trees for the site (e.g., ≥ 70 cm dbh live or dead).

COASTAL WESTERN HEMLOCK VERY WET HYPERMARITIME SUBZONE (CWHvh)

The CWHvh data came primarily from the North Coast and North Island-Central Coast forest districts (81% of samples). The remainder of the cutblocks sampled came from Haida Gwaii district and one cutblock from the Squamish forest district. The cutblocks were predominantly from the vh2 (i.e., central coast) BEC variant, but with 19% coming from the vh1. As noted in table 3, retention was found in 92% of the sampled cutblocks and the average retention was 32.9%. This retention increases to 41.5% when the temporary retention (retention on cutblock that is likely to be harvested prior to rotation end) is considered. The increased retention came from the addition of 30 ha of temporary retention patches in three cutblocks and the equivalent of 232.8 ha of retention (BAE) as dispersed retention in 9 cutblocks. The reasons for this temporary retention is largely unnoted, however shelterwood retention and visual objectives were mentioned for two of the cutblocks.

4.3.1. Statistical analysis of CWHvh indicators

The average density of large snags (dead trees 10 m or taller and 30 cm or larger diameter) retained within the CWHvh FREP-sampled cutblocks is 69% of that found in the cruise baseline. Figure 14 shows the 48 cutblocks of the total sampled 52 CWHvh cutblocks that contained retention.

Density of large snags (≥ 10 m tall and ≥ 30 cm dbh, dead stems per hectare)

CWHvh: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	84	49.3	39.0	33.3	7.3
Retention	48	34.2	15.0	46.2	6.1

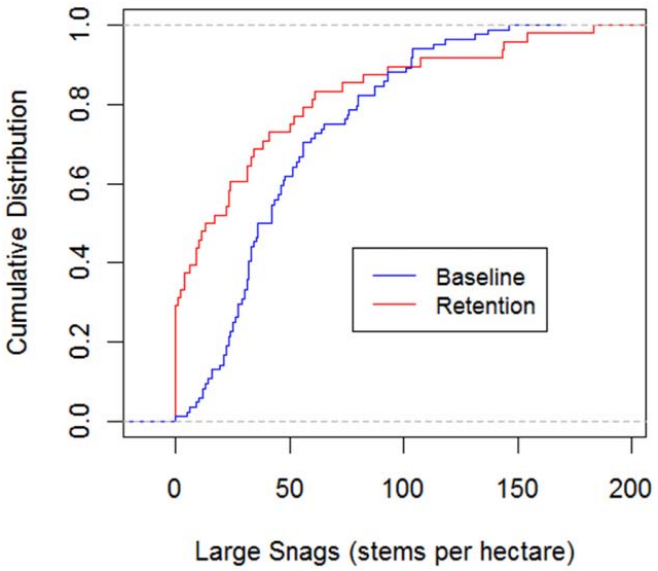

Figure 14. Cumulative probability for large snags in the CWHvh subzone.

K-S test: $D = 0.1496$ (maximum difference at 11 large snags per hectare), p-value = 4.254×10^{-5}. The p-value indicates a highly significant difference between these two curves with the density of large snags generally lower within the FREP sampled retention compared to the cruise baseline.

Density of large trees (live and dead; ≥ 70 cm dbh, stems per hectare)

The average density of large trees (70 cm or larger dbh, live and dead) found in the retention within the CWHvh FREP-sampled cutblocks is 44% of that found in the cruise baseline. Figure 15 shows the 48 cutblocks of the total sampled 52 CWHvh cutblocks that contained retention.

CWHvh: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	84	65.2	64.5	24.0	2.6
Retention	48	34.0	28.5	27.5	4.0

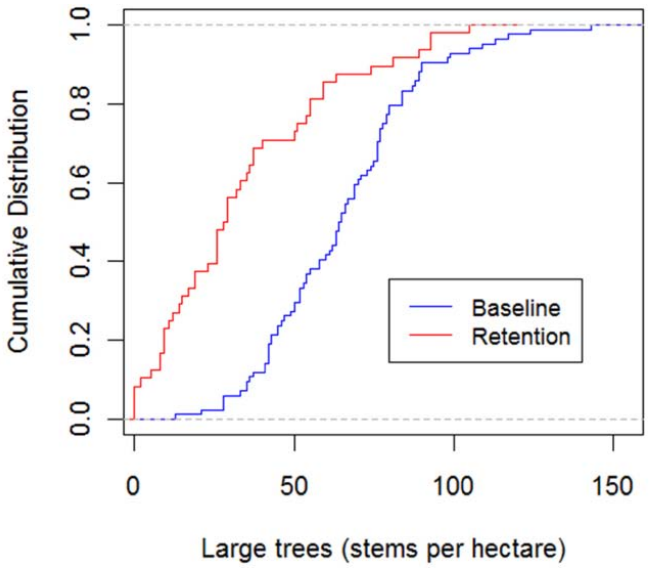

Figure 15. Cumulative probability for large tree density in the CWHvh subzone.

K-S test: $D = 0.5893$ (maximum difference at 40 large trees per hectare), p-value = 1.224×10^{-9}. The p-value indicates a highly significant difference between these two curves with the FREP sampled retention having a lower density of large trees compared to the cruise baseline.

Number of tree species

The average number of tree species found in the CWHvh FREP-sampled cutblocks is 75% of the cruise baseline. Figure 16 shows 51 of 52 sampled cutblocks. One cutblock was excluded due to missing data. Eight percent of the remaining CWHvh cutblocks contained no trees, accounting for the 8% of cutblocks with zero tree species in the chart below.

CWHvh: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	84	4.3	4.0	1.0	0.1
Retention	51	3.1	3.0	1.3	0.2

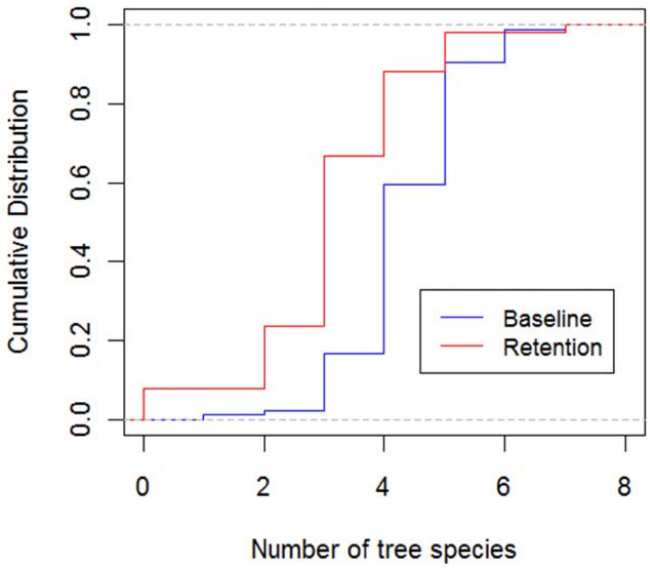

Figure 16. Cumulative probability for number of tree species in the CWHvh subzone.

K-S test: $D = 0.5$ (maximum difference at four tree species found per cutblock), p-value = 2.572×10^{-7}. The p-value indicates a highly significant difference between these two curves with the FREP retention having a lower number of tree species per cutblock compared to the cruise baseline. A portion of this decrease may be indicative of the higher sampling intensity in timber cruise compared to FREP sampling.

Volume of CWD (m³/ha)

The average volume per hectare of CWD found in the harvest areas within the CWHvh FREP-sampled cutblocks is 156% of that found in the tree retention patches. Figure 17 shows the CWD volume data from 42 sampled harvest areas in the CWHvh cutblocks (note that harvested area CWD is not included for the cutblock with temporary dispersed retention) and the 47 cutblocks that had CWD data from within retention patches.

CWHvh: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	47	329.6	265.9	351.0	51.2
Harvest	42	513.9	463.7	253.2	39.1

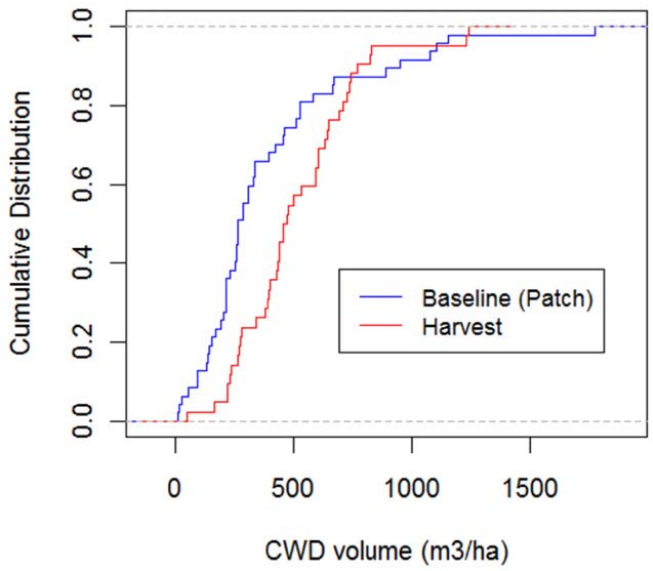

Figure 17. Cumulative probability for CWD volume in the CWHvh subzone.

K-S test: $D = 0.4215$ (maximum difference at 334 m³ of CWD per hectare), p-value = 0.0004532. The p-value indicates a highly significant difference between these two curves and the volume of CWD found on harvested sites is generally higher than that found within retention patches.

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

The average density per hectare of big CWD pieces found in the harvest areas within the CWHvh FREP-sampled cutblocks is 76% of that found in the retention patches. Figure 18 shows that both the harvest areas and the patch areas had big pieces of CWD found on over 80% of the samples.

CWHvh: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	47	61.7	48	54.7	8.0
Harvest	42	47.1	31.0	47.4	7.3

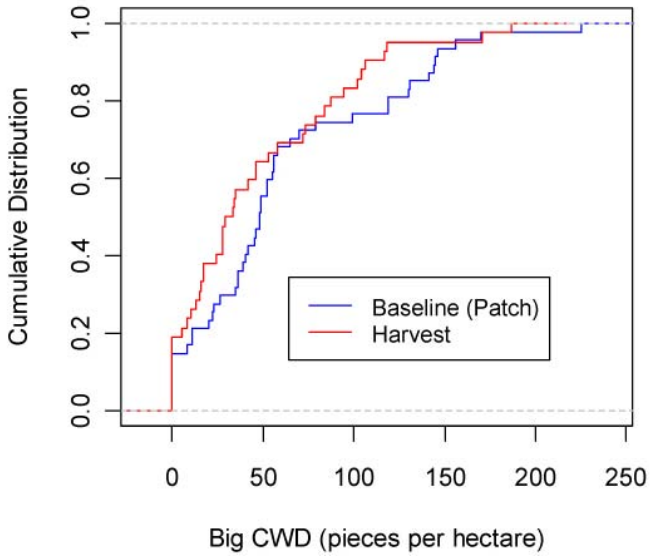

Figure 18. Cumulative probability for CWD big piece density in the CWHvh subzone.

K-S test: $D = 0.2523$ (maximum difference at 35 big pieces of CWD per hectare), p-value = 0.1188. The p-value indicates no significant difference between these two curves with the density of big CWD pieces being similar in the harvested areas and the retention patches.

4.3.2 CWHvh discussion

The CWHvh subzone had retention within 92% of the sampled cutblocks, with an overall average retention of 32.9%. Average windthrow was 6.6%. Eight percent of the retention patches are external and non-contiguous with the harvest boundary. This is the highest percentage of all the six predominant subzones (tied with CWHwh).

The average density of large snags in the FREP-sampled retention was 69% of baseline, with the major difference in distribution, being the higher percentage of the FREP cutblocks with zero large snags found, compared to the baseline cutblocks. The average density of large trees was 44% of the baseline. The average number of tree species retained was 75% of baseline. All three of these tree indicators were significantly lower in the FREP-sampled cutblock retention compared to the cruise baseline, though a portion of the decrease in tree species is likely due to differing sampling intensities in the two populations. The volume of CWD on the harvested areas was higher than in retention patches. Density of big CWD pieces (as compared to the retention patches) is high (compared to all the predominant subzones) and considered not significantly different at 76% of what was found in the patch retention. The average 19.6% dispersed retention may provide inputs of future CWD on the 29% of the blocks with dispersed retention.

4.3.3. CWHvh consideration

Overall retention is high in the CWHvh though retention quality could be improved, in particular for the density of large trees retained on site. CWD quantity and quality is high compared to the other subzones. There is also a large amount of dispersed retention, potentially providing for CWD recruitment in the future.

COASTAL WESTERN HEMLOCK VERY WET MARITIME SUBZONE (CWHvm)

The CWHvm data came primarily from the Campbell River, North Island-Central Coast, South Island, North Coast and Sunshine Coast forest districts (92% of samples). The remainder of the cutblocks sampled came from Chilliwack and Squamish forest districts. The cutblocks were predominantly from the vm1 biogeoclimatic variant, with 28% coming from the vm2. As noted in table 3, retention was found in 92% of the sampled cutblocks and the average percent retention was 20.6%. This percent retention increases to 22.0% when the temporary retention (retention on cutblock that is likely to be harvested prior to rotation end) is considered. The minor increased retention came predominantly from 43 ha of temporary patch retention in 30 retention patches over 10 cutblocks.

4.3.1. Statistical analysis of CWHvm indicators

Density of large snags (≥ 10 m tall and ≥ 30 cm dbh, dead stems per hectare)

The average density of large snags found in the retention within the CWHvm FREP-sampled cutblocks is 85% of that found in the cruise baseline. Figure 19 shows the 123 cutblocks of the total sampled 138 CWHvm cutblocks that contained retention.

CWHvm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	398	27.7	18.0	30.4	1.5
Retention	123	23.6	14.0	34.8	3.1

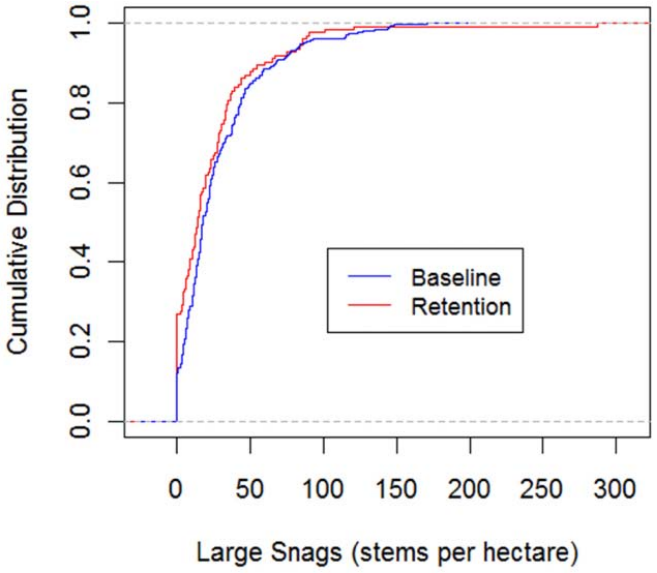

Figure 19. Cumulative probability for large snags in the CWHvm subzone.

K-S test: D = 0.1477 (maximum difference at 0 large snags per hectare), p-value = 0.03318. The p-value indicates a marginally significant difference between these two curves with a higher percentage of FREP sampled cutblock having zero large snags found (27%) compared to the cruise baseline (12%).

Density of large trees (live and dead; ≥ 70 cm dbh, stems per hectare)

The average density of large trees found in the retention within the CWHvm FREP-sampled cutblocks is 57% of that found in the cruise baseline. Figure 20 shows the 123 cutblocks of the total sampled 138 CWHvm cutblocks that contained retention. The retention curve on the left of the baseline curve is indicative of lower densities of retained large trees compared to the cruise baseline.

CWHvm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	398	52.3	56.0	33.9	1.7
Retention	123	36.4	32.0	29.8	2.7

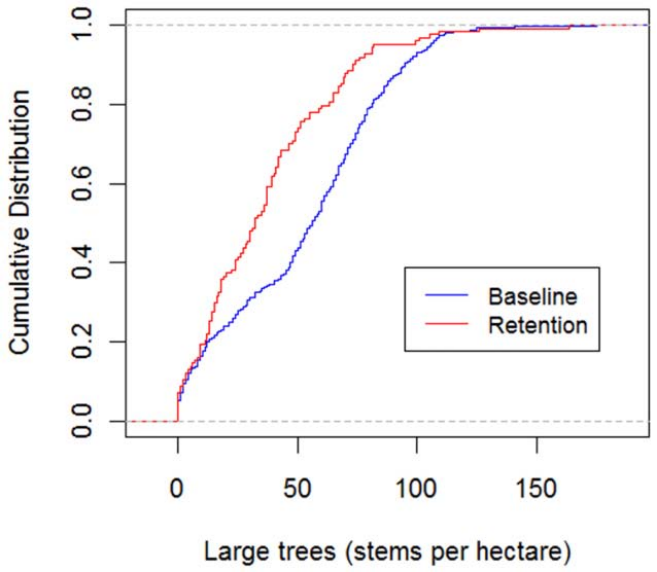

Figure 20. Cumulative probability for large tree density in the CWHvm subzone.

K-S test: D = 0.3161 (maximum difference at 43 large trees per hectare), p-value = 1.402 x 10^{-8}. The p-value indicates a highly significant difference between these two curves with the FREP sampled retention having a lower density of large trees compared to the cruise baseline.

Number of tree species

The average number of tree species found in the CWHvm FREP-sampled cutblocks is 79% of the cruise baseline. Figure 21 shows 134 of 138 sampled cutblocks. Four cutblocks were not included due to missing data. Eight percent of the remaining CWHvm cutblocks contained no trees, accounting for the 8% of cutblocks with zero tree species in the chart below.

CWHvm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	398	3.8	4.0	1.2	0.1
Retention	134	3.0	3.0	1.3	0.1

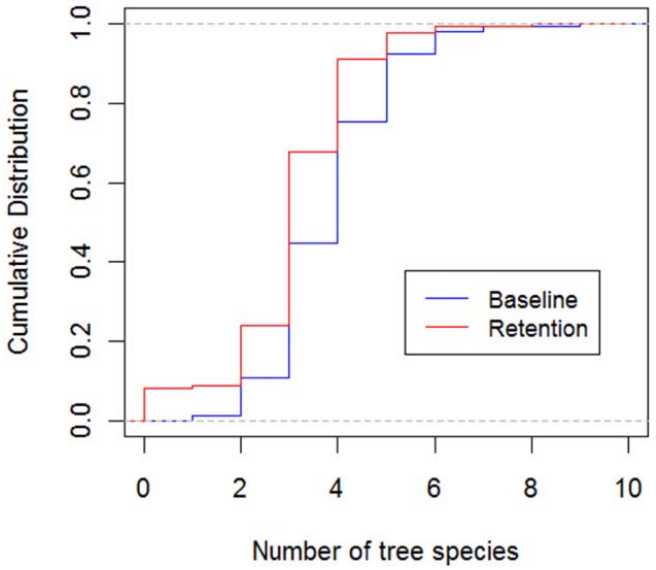

Figure 21. Cumulative probability for number of tree species in the CWHvm subzone.

K-S test: D = 0.2319 (maximum difference at three tree species found per cutblock), p-value = 4.165 x 10^{-5}. The p-value indicates a highly significant difference between these two curves with the FREP retention having a lower number of tree species per cutblock compared to the cruise baseline. However, a portion of the lower numbers of tree species in the FREP cutblocks may be due to the lower sampling intensity FREP sampling compared to the baseline cruise cutblocks.

Volume of CWD (m³/ha)

The average volume per hectare of CWD found in the harvest areas within the CWHvm FREP-sampled cutblocks is 108% of that found in the retention patches. Figure 22 shows the harvest data generally indicative of higher CWD volume than the baseline patch data.

CWHvm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	119	426.7	366.7	352.9	32.4
Harvest	137	459.9	453.2	242.3	20.7

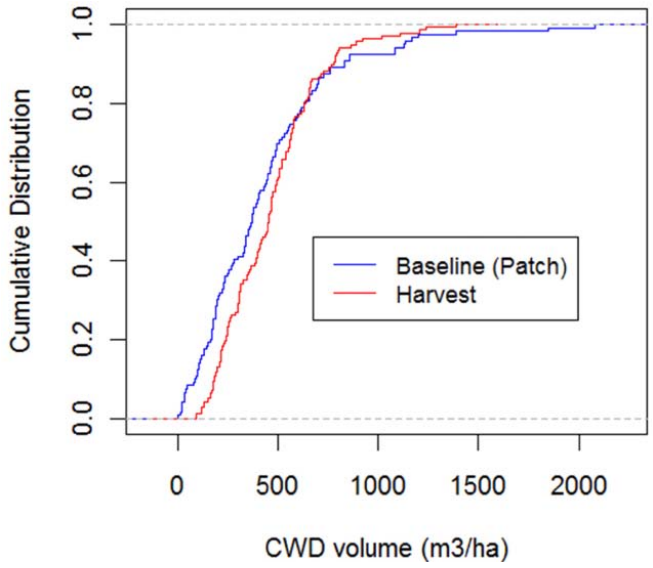

Figure 22. Cumulative probability for CWD volume in the CWHvm subzone.

K-S test: D = 0.1879 (maximum difference at 206 m³ of CWD per hectare), p-value = 0.02224. The p-value indicates a significant difference between these two curves and the volume of CWD found on harvested sites is generally higher than that found within retention patches.

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

The average density per hectare of big CWD pieces found in the harvest areas within the CWHvm FREP-sampled cutblocks is 52% of that found in the retention patches. Figure 23 shows that harvest areas had big CWD pieces found on about 75% of sites and the retention patch areas had big pieces of CWD found on over 85% of the samples.

CWHvm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	119	64.4	55.0	56.8	5.2
Harvest	137	33.6	17.0	38.6	3.3

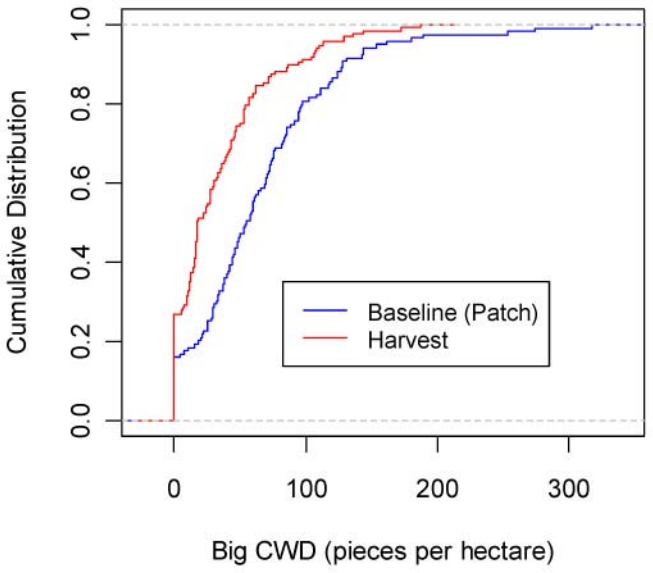

Figure 23. Cumulative probability for CWD big piece density in the CWHvm subzone.

K-S test: D = 0.3318 (maximum difference at 27 big pieces of CWD per hectare), p-value = 1.621 x 10^{-06}. The p-value indicates a highly significant difference between these two curves with the density of big CWD pieces being lower in the harvested areas compared to within retention patches.

4.3.2 CWHvm discussion

The CWHvm had the largest sample size, both for the FREP-sampled cutblocks and the cruise baseline, likely increasing the power of the statistical test and increasing the likelihood of a significant difference between the curves. The CWHvm subzone had retention within 92% of the sampled cutblocks, with an overall average retention of 20.6%. Average windthrow was 10.2%, higher than most of the other predominant subzones. There is a good mix of both internal retention patches and retention patches on the edge of the harvest boundary, with three percent of the retention patches being located external and non-contiguous to the harvest cutblock. The average density of large snags in the FREP-sampled retention was 85% of baseline (not significantly different). The average density of large trees was low, at 57% of the baseline. The average number of tree species retained was not significantly different at 79% of baseline. Volume of CWD on the harvested areas was equivalent to that found in retention patches. Density of big CWD pieces is 54% of what was found in the patch retention.

4.3.3 CWHvm consideration

Continue good mixture of retention patches both internal and on the edge of cutblock, with few retention patches external and non-contiguous to the cutblock. Increase the density of large trees for the site within the cutblock retention.

COASTAL WESTERN HEMLOCK WET HYPERMARITIME SUBZONE (CWHwh)

The CWHwh data came from the Haida Gwaii district. The cutblocks were predominantly from the wh1 biogeoclimatic variant, with 30% coming from the wh2. As noted in table 3, retention was found in 94% of the sampled cutblocks and the average percent retention was 15.1%. This retention increases to 26% when the temporary retention (retention on block that is likely to be harvested prior to rotation end) is considered. The increased retention came from 12 cutblocks with temporary patch retention totaling 76 ha.

4.3.1 Statistical analysis of CWHwh indicators

Density of large snags (≥ 10 m tall and ≥ 30 cm dbh, dead stems per hectare)

The average density of large snags found in the retention within the CWHwh FREP-sampled cutblocks is 56% of that found in the cruise baseline. Figure 24 shows the 35 cutblocks of the total sampled 36 CWHwh cutblocks that contained retention.

CWHwh: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	60	48.0	36.0	48.4	6.2
Retention	35	27.0	17.0	28.3	4.8

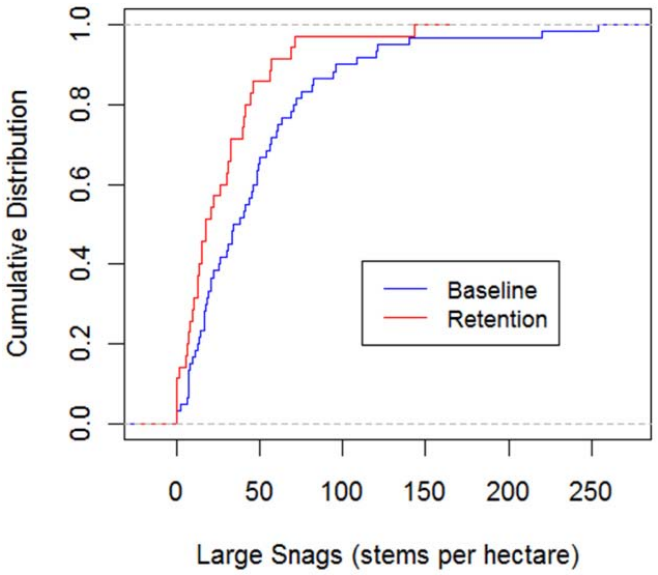

Figure 24. Cumulative probability for large snags in the CWHwh subzone.

K-S test: $D = 0.2643$ (maximum difference at 32 large snags per hectare), p-value = 0.09118. The p-value indicates a marginally significant difference between these two curves with a slightly lower density of large snags found in the FREP sampled cutblocks compared to the cruise baseline cruise.

Density of large trees (live and dead ≥ 70 cm dbh, stems per hectare)

The average density of large trees found in the retention within the CWHwh FREP-sampled cutblocks is 60% of that found in the cruise baseline. Figure 25 shows the 35 cutblocks of the total sampled 36 CWHwh cutblocks that contained retention.

CWHwh: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	60	49.4	44	29.9	3.9
Retention	35	29.4	27	22.2	3.8

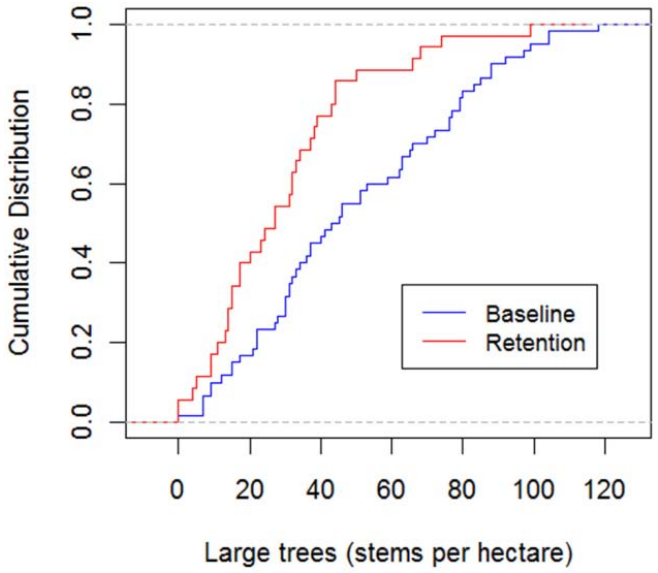

Figure 25. Cumulative probability for large tree density in the CWHwh subzone.

K-S test: $D = 0.3571$ (maximum difference at 44 large trees per hectare), p-value = 0.007112. The p-value indicates a highly significant difference between these two curves with the FREP sampled retention having a lower density of large trees compared to the cruise baseline.

Number of tree species

The average number of tree species found in the CWHwh FREP-sampled cutblocks is 91% of the cruise baseline. Figure 26 shows all collected cutblock data. Six percent of the CWHwh cutblocks had no retention, accounting for the 6% of cutblocks with zero tree species in the chart below.

CWHwh: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	60	3.3	3.0	0.8	0.1
Retention	36	3.0	3.0	1.3	0.2

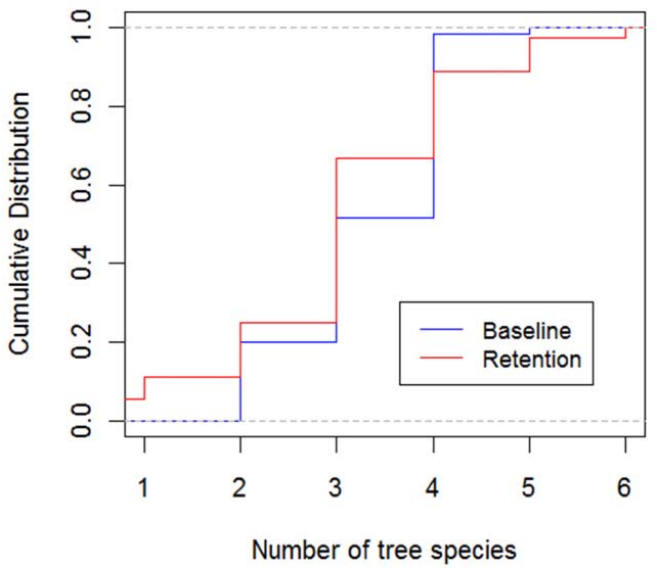

Figure 26. Cumulative probability for number of tree species in the CWHwh subzone.

K-S test: $D = 0.15$ (maximum difference at three tree species found per cutblock), p-value = 0.692. The p-value indicates no significant difference between these two curves with the FREP retention having similar numbers of tree species per cutblock compared to the cruise baseline.

Volume of CWD (m³/ha)

The average volume of CWD found in the harvest areas within the CWHwh FREP-sampled cutblocks is 141% of that found in the retention patches. Figure 27 shows the CWD volume data from 34 sampled harvest area in the CWHwh cutblocks and 34 cutblocks that had CWD data from within retention patches. Two blocks had missing harvest area CWD data and two blocks had no retention patches and thus no CWD patch retention data.

CWHwh: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	34	303.2	219.5	216.7	37.2
Harvest	34	426.6	339.2	273.6	46.9

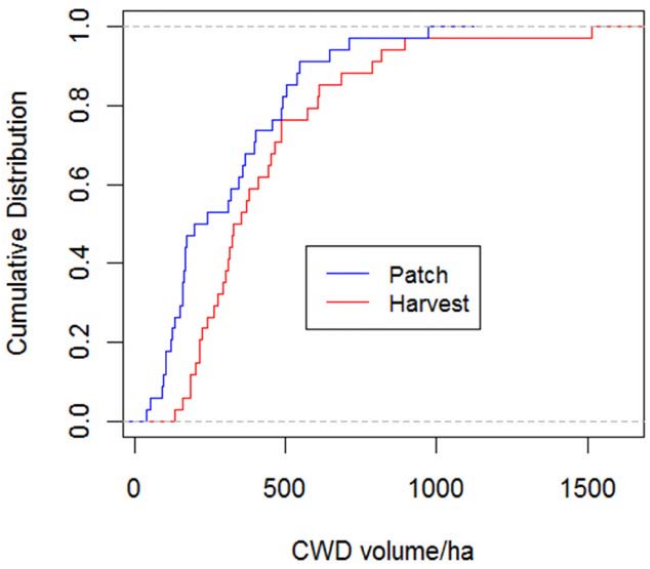

Figure 27. Cumulative probability for CWD volume in the CWHwh subzone.

K-S test: $D = 0.4118$ (maximum difference at 174 m³ of CWD per hectare), p-value = 0.006273. The p-value indicates a highly significant difference between these two curves and the volume of CWD found on harvested sites is higher than 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 found in the harvest areas within the CWHwh FREP-sampled cutblocks is 31% of that found in the retention patches. Figure 28 shows that the harvest areas had big CWD pieces found on about 55% of sites and the retention patch areas had big pieces of CWD found on over 85% of the sites.

CWHwh: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	34	65.0	51.0	53.8	9.2
Harvest	34	20.3	11.5	32.2	5.5

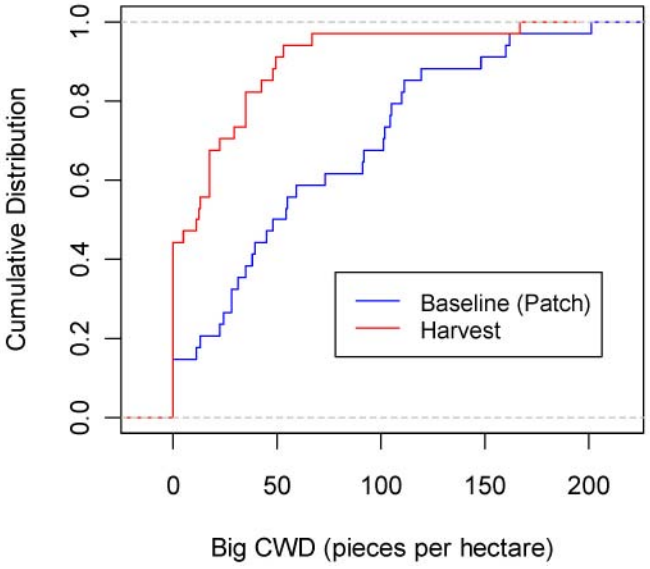

Figure 28. Cumulative probability for CWD big piece density in the CWHwh subzone.

K-S test: $D = 0.4706$ (maximum difference at 17 big pieces of CWD per hectare), p-value = .001074. The p-value indicates a highly significant difference between these two curves with the density of big CWD pieces being lower in the harvested areas compared to within retention patches.

4.3.2 CWHwh discussion

The CWHwh subzone had retention within 94% of the sampled cutblocks, with an overall average retention of 15.1%. Average windthrow was 10.6%, the highest of these six predominant coastal subzones. Eight percent of the retention patches are external and non-contiguous with the harvest boundary, this is the highest percentage of all the six predominant subzones (tied with CWHvh), and there is also a much lower percentage of internal retention patches (18% of patches internal), compared to the other predominant subzones. The average density of large snags in the FREP-sampled retention was 56% of baseline. The average density of large trees was 60% of the baseline. The average number of tree species retained was similar to the baseline. Volume of CWD on the harvested areas was higher than found in retention patches. Density of large CWD pieces in the harvest areas is low at 15% of what was found in the patch retention, and the absence of dispersed retention will minimize input of future CWD.

4.3.3 CWHwh consideration

Continue the good practise of maintaining the full range of tree species within retention. Look for retention opportunities that will increase densities of large snags and large trees retained on cutblocks. Decrease the use of retention patches that are external and non-contiguous to the cutblock boundary and increase the numbers of internal retention patches. Increase the density of big pieces of CWD maintained in the harvested areas of cutblocks.

COASTAL WESTERN HEMLOCK VERY DRY MARITIME SUBZONE (CWHxm)

The CWHxm data came primarily from the South Island and Campbell River forest districts (77% of samples). The remainder of the cutblocks sampled came from Sunshine Coast and North Island forest districts. The cutblocks were predominantly from the xm1 BEC variant, with 23% coming from the xm and 14% from the xm2. As noted in table 3, retention was found in 89% of the sampled cutblocks and the average retention was 22.4%. This retention increases to 25% when the temporary retention (retention on block that is likely to be harvested prior to rotation end) is considered. The increased retention came from two commercially thinned cutblocks, and half a hectare of temporary patch retention in a third cutblock.

4.3.1 Statistical analysis of CWHxm indicators

Density of large snags (≥ 10 m tall and ≥ 30 cm dbh, dead stems per hectare)

The average density of large snags retained within the CWHxm FREP-sampled cutblocks is 27% of that found in the cruise baseline. Figure 29 shows the 32 cutblocks of the total sampled 35 CWHxm cutblocks that contained retention. Almost 80% of the FREP cutblocks had zero large snags found as seen by the retention line going straight up from zero large snags per hectare for close to 80% of the samples.

CWHxm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	71	13.0	10.0	11.8	1.4
Retention	32	3.5	0.0	11.2	2.0

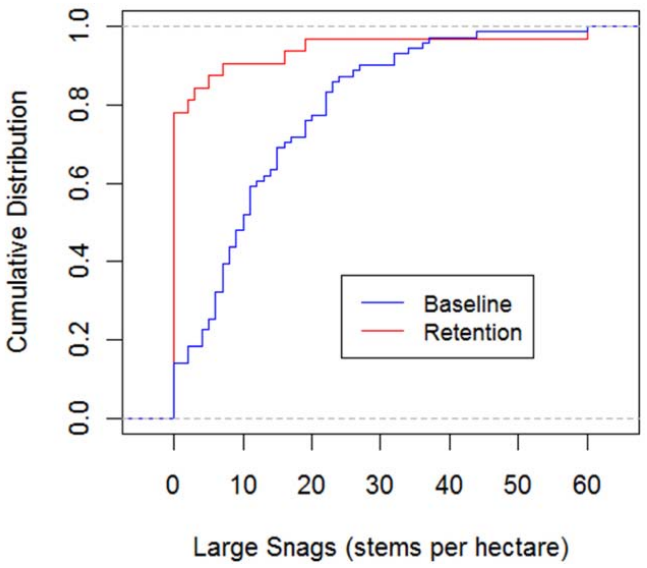

Figure 29. Cumulative probability for large snag density in the CWHxm subzone

K-S test: $D = 0.6607$ (maximum difference at 3 large snags per hectare), p-value = 8.683×10^{-9}. The p-value indicates a highly significant difference between these two curves with a much higher percentage of FREP sampled cutblocks with no large snags found compared to the cruise baseline.

Density of large trees (live and dead; ≥ 70 cm dbh, stems per hectare)

The average density of large trees found in the retention within the CWHxm FREP-sampled cutblocks is 115% of that found in the cruise baseline. Figure 30 shows the 32 cutblocks of the total sampled 35 CWHxm cutblocks that contained retention and very similar data in the two curves.

CWHxm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	71	11.8	6.0	13.8	1.6
Retention	32	13.6	4.0	19.2	3.4

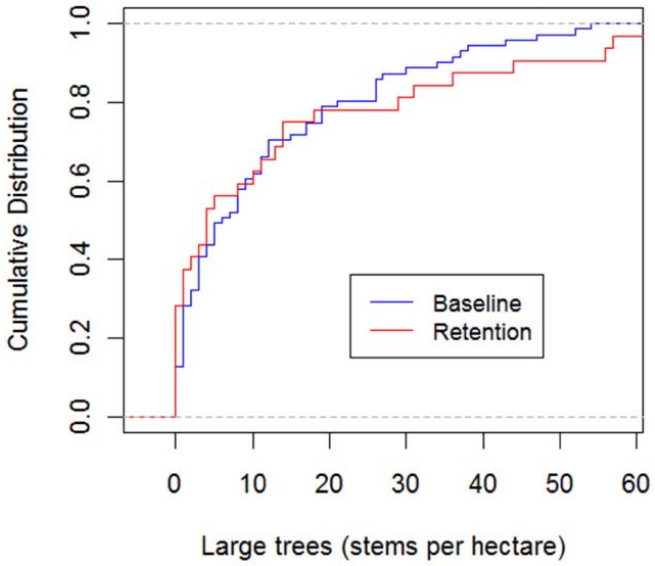

Figure 30. Cumulative probability for large tree density in the CWHxm subzone.

K-S test: $D = 0.1545$ (maximum difference at 0 large trees per hectare), p-value = 0.6683. The p-value indicates no difference between these two curves with the FREP sampled retention having a similar density of large trees compared to the cruise baseline.

Number of tree species

The average number of tree species found in the CWHxm FREP-sampled cutblocks is 78% of the cruise baseline. Figure 31 shows 34 of 35 sampled cutblocks. There was missing data for one block. Six percent of the remaining CWHxm cutblocks contained no trees, accounting for the 6% of cutblocks with zero tree species in the chart below.

CWHxm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline	71	4.1	4.0	1.0	0.1
Retention	34	3.2	3.0	1.5	0.3

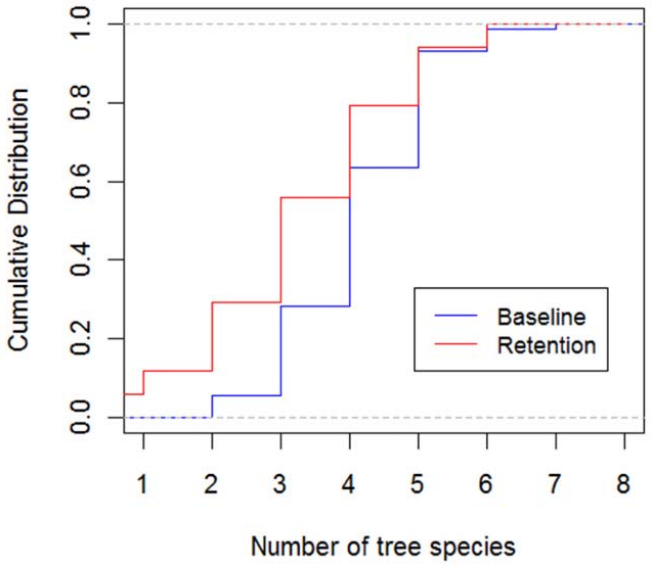

Figure 31. Cumulative probability for number of tree species in the CWHxm subzone.

K-S test: $D = 0.2771$ (maximum difference at three tree species found per cutblock), p-value = 0.05852. There is a marginally significant difference between these two curves with the FREP retention having fewer numbers of tree species per cutblock compared to the cruise baseline. Some of this difference may be due to the higher sampling density in the cruise baseline compared to the FREP cutblocks.

Volume of CWD (m³/ha)

The average volume per hectare of CWD found in the harvest areas within the CWHxm FREP-sampled cutblocks is 87% of that found in the tree retention patches. Figure 32 shows similar data in the two curves.

CWHxm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	26	185.8	182.1	103.3	20.2
Harvest	34	209.8	161.8	152.3	26.1

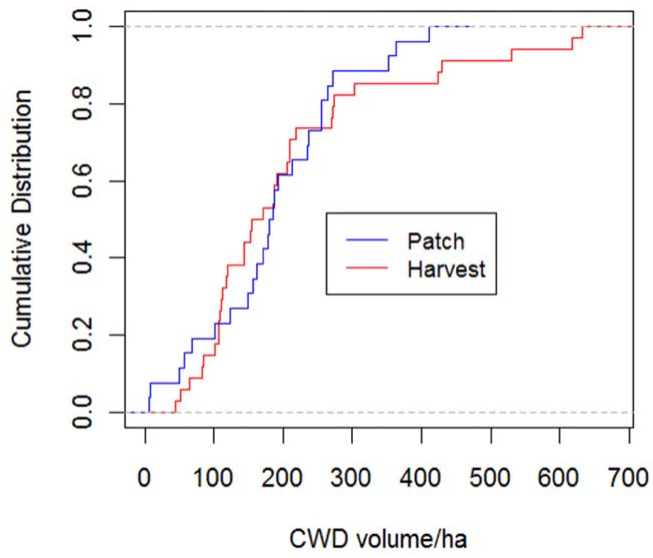

Figure 32. Cumulative probability for CWD volume in the CWHxm subzone.

K-S test: $D = 0.1923$ (maximum difference at 153 m³ of CWD per hectare), p-value = 0.5658. The p-value indicates no significant difference between these two curves and the volume of CWD found on harvested sites is similar 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 found in the harvest areas within the CWHxm FREP-sampled cutblocks is 22% of that found in the retention patches. Figure 33 shows that the harvest areas had big CWD pieces found on about 45% of sites and the retention patch areas had big pieces of CWD found on over 95% of the sites.

CWHxm: Means and standard deviations

	N	Mean	Median	Std Dev	Std Err Mean
Baseline (Patch)	26	43.1	34.5	38.2	7.5
Harvest	34	9.5	0.0	13.8	2.4

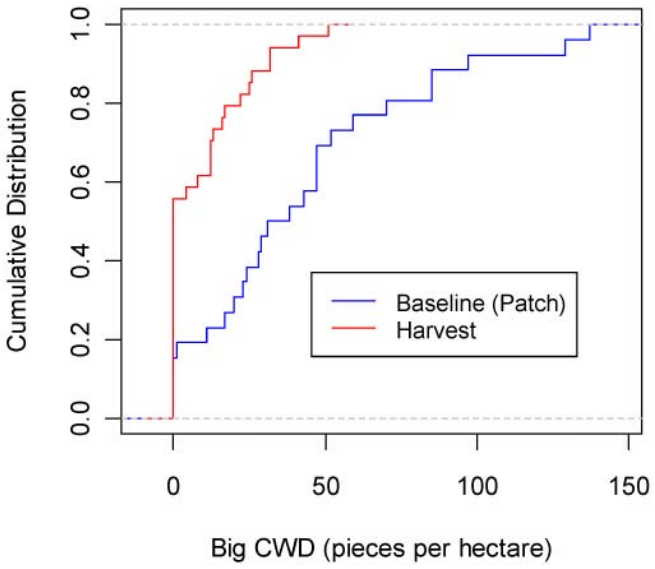

Figure 33. Cumulative probability for CWD big piece density in the CWHxm subzone.

K-S test: $D = 0.5339$ (maximum difference at 16 big pieces of CWD per hectare), p-value = 0.000449. There is a highly significant difference between these two curves with the density of big CWD pieces being lower in the harvested areas compared to within retention patches.

4.3.2 CWHxm discussion

The CWHxm subzone had retention within 89% of the sampled cutblocks, with an overall average retention of 22.4%. Average windthrow was 4.5%, the lowest of these six predominant coastal subzones. The average density of large snags in the FREP-sampled retention was 27% of baseline. The density of large trees is similar to baseline. The number of tree species retained was 78% of the baseline (not significantly different). Volume of CWD on the harvested areas was similar to that found in retention patches. Density of large CWD pieces (as compared to the retention patches) is lowest of the six subzones at 11% of what was found in the patch retention, though the presence of dispersed retention on 51% of the cutblocks (overall average 4.5%) may provide a future input of CWD.

4.3.3 CWHxm consideration

Continue the good practise of maintaining retention areas with densities of large trees and numbers of tree species similar to the pre-harvest stands. Look for retention opportunities that will increase densities of large snags. Increase the density of big pieces of CWD maintained in the harvested areas of cutblocks.

5.0 DISCUSSION: POTENTIAL OF ADDING QUALITY WEIGHTING TO PERCENT RETENTION

A question coming out of this data is the difference between 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 factors such as the landscape context, the extent of area in question and 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 snags, 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 explore weighting the amount of retention by its quality is presented below.

Table 4 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. This weighting exercise is an example for discussion and further thought. CWD has not been considered nor other data elements such as patch size and location which do not have explicit baselines but which impact the quality of biodiversity on a cutblock.

Table 4. 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[b]	Weighted % retention
CWHdm	19.1	62	100[a]	100	0.87	16.7
CWHms	32.9	100	59	100	0.86	28.4
CWHvh	32.9	69	44	75	0.63	20.6
CWHvm	20.6	85	57	79	0.74	15.2
CWHwh	15.1	56	60	100	0.72	10.9
CWHxm	22.4	27	100	77.4	0.68	15.3

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

b an average of the three tree indicator (large snags, large trees, tree species) percentages

6.0 SUMMARY

Various harvesting and retention outcomes occur throughout the Coastal Forest Region. In the six predominant subzones reported on here, the average retention ranges from 15.1% in the CWHwh to 32.9% in the CWHms and CWHvh. The retention quality indicators also vary greatly. For example, the FREP data collected in the CWH dm, ms, and xm subzones showed consistently high biodiversity quality (i.e., equivalent or higher than baseline) for two of the three tree indicators presented (e.g., two of; large snags, large trees and number of tree species). In comparison, the FREP data collected in the CWHvh subzone consistently showed lower biodiversity quality for all three tree biodiversity indicators.

The question of whether the actual retention or the quality-weighted retention is sufficient within a particular area or subzone can only be partially answered without knowledge of landscape-level retention levels and quality. However, to provide basic levels of stand-level retention for habitat needs of some 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), this level is obtained as an average in five of the six predominant subzones. Without considering quality weighting, the 15% average is seen in all six predominant subzones.

Overall tree retention (patch and dispersed) and CWD total volume retention, is high in the CWHms and CWHvh subzones. Higher relative densities of big pieces of CWD are also seen in those two subzones, compared to other predominant subzones. CWD total volume in the harvested areas of the cutblocks was equal or higher than that found within retention patches for all the predominant subzones. There are low levels of big CWD pieces in the CWHdm, wh and xm, though there is opportunity for future CWD recruitment in the dm and xm with dispersed standing tree retention and higher levels of patch retention.

The FREP-sample for stand-level biodiversity is randomly chosen harvested cutblocks. This relates to the timber cruise baseline (for the tree indicators) which comes from pre-harvest cutblocks which have current digital cruise plot information. This methodology should allow for representative cutblocks for both baseline and FREP within a BEC subzone where sample size is sufficient (e.g., above 30 blocks). Future analysis is possible with improved baseline data, in particular if paired timber cruise data can be obtained.

APPENDICES

Appendix 1. Data Compilation

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

BEC	FREP Samples	Cruise Baseline BCTS*	Cruise Baseline ECAS*
CDFmm	2		
CWHdm	46	40	58
CWHds	24		
CWHmm	6		
CWHms	47	28	18
CWHvh	52	52	32
CWHvm	138	132	266
CWHwh	36	38	22
CWHws	2		
CWHxm	35	55	16
ESSFmw	2		
IDFww	6		
MHmm	9		

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 (B.C. Ministry of Forests and Range – 2009). Timber cruise plot data is used (rather than summarized data). The plot data contains tree height, species, diameter, and tree class. The FREP tree data is taken from retention areas (both patch and dispersed) in harvested cutblocks, and the tree data is acquired using timber cruise survey methods.

All useable 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 plot data, this system was also used to acquire timber cruise data, and 1,940 cutblocks of timber cruise data were added to the database. Another 372 blocks of coastal ECAS data was acquired in 2010. 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. Useable 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 ($\geq$ 2 hectares 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 and charts were calculated and prepared using the software "R".

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