STAND LEVEL FOREST MANAGEMENT FOR BIODIVERSITY AND ECOSYSTEM BASED MANAGEMENT ON HAIDA GWAII/QUEEN CHARLOTTE ISLANDS

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Stand level forest management for biodiversity and Ecosystem Based Management on Haida Gwaii/ Queen Charlotte Islands

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ABSTRACT

Ecosystem-Based Management (EBM) is gaining increasing legitimacy in the province of British Columbia as an integrated planning and operational framework that ensures social, economic, and ecological goals are achieved from activities in the forested landscape. Industry has expressed worry that the added restrictions imposed by EBM will represent an insurmountable loss of profitability. This study involves the analysis of site plans and timber cruise data for 14 randomly selected cut blocks on Haida Gwaii/ Queen Charlotte Islands (HG/QCI) in order to determine whether current management practices for stand level biodiversity are consistent with the Ecosystem Based Management (EBM) benchmarks. The quantity and quality of wildlife tree retention was examined. Percentage of wildlife tree retention was calculated using site plan records for all areas harvested between January 2004 and July 2006. Structural attributes were measured for a sub-sample of 14 blocks and compared to pre-harvest timber cruise data. The study found that on HG/QCI average per cutblock wildlife tree retention, calculated as a proportion of TAUP, would need to increase by 79 percent in order to meet the minimum EBM benchmark. No significant deviation in the quality of structural attributes and species composition of this retention was found relative to the pre-harvest stand. Unless levels of wildlife tree retention can be increased substantially, ecosystem-based management on HG/QCI remains a distant goal.

Key Words: Ecosystem-Based Management, Queen Charlotte Islands, Haida Gwaii, forest management practices, stand-level biodiversity, wildlife tree retention.

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LIST OF ACRONYMS

EBM	Ecosystem-Based Management
FPC	Forest Practices Code Act
FRPA	Forest and Range Practices Act
FSC	Forest Stewardship Council
HG/QCI	Haida Gwaii / Queen Charlotte Islands
LRMP	Land and Resource Management Plan
WTP	Wildlife Tree Patch
WTR	Wildlife Tree Retention
HLUV	Haida Land Use Vision

1. Introduction

For the past two decades, societal pressures have built progressively around the promotion of sustainability in the Canadian forest industry. Environmental groups and First Nations have galvanized broad societal support for forestry practices that protect and enhance ecological values such as biological diversity, ecosystem services, carbon and hydrological cycling at multiple scales (from stand, to watershed, to landscape levels). Improved understanding of ecosystem dynamics coupled with an evolving legislative and regulatory environment have enhanced accountability relative to past practices in the management of publicly owned forests with an emphasis on ensuring that ecological, economic, and social objectives are met.

Ecosystem-Based Management (EBM) has gained increasing legitimacy in the province of British Columbia as an integrated planning and operational framework that ensures social, economic, and ecological goals are achieved from activities in the forested landscape. In February 2006, Premier Gordon Campbell along with First Nations, industry, and environmental organizations announced the land use plan for the Central and North Coast that involved a commitment by all parties to transition to EBM by 2009 (Armstrong & Bourgeoise, 2006). Expectations are high that this will result in measurable improvements in the form of reduced environmental degradation and ecological impacts of forest resource utilization without compromising important contributions to social and economic wellbeing at the local and regional levels.

There are many reasons to respond to the recent trend with optimism. Most of the EBM guidelines to come into force enhance or extend existing levels of protection under the Forest Practices Code (FPC), and more recently under the Forests and Range Practices Act (FRPA).

At the stand level, EBM calls for increased structural retention that provides habitat and contributes to biodiversity.

There is also cause for concern. The forest industry claims that the restrictions imposed by EBM will signify an insurmountable loss of profitability that would cripple most players, particularly many of the smaller enterprises (Angus, 2006). Already hard-hit by a steady decline in market price, intense competition from abroad, a soaring Canadian dollar, and increasing costs of energy and labour, the forest industry claims the additional curtailment of volume implicit in the new EBM regime will result in major job losses, affect community welfare, and lead to eventual collapse of the industry.

Industry pragmatists are generally concerned with the lack of specificity and scientific rigour in some of the targets of EBM, and dismiss the initiative as a whole as economically and operationally unfeasible. Part of this concern stems from insufficient understanding regarding precisely the degree to which current practices differ from those proposed by the EBM framework, and to what extent they will need to adjust their current *modus operandi*. Though several papers highlight the relevance of EBM as a tool for sustainable forest management (Martin et al., 2003; Moola et al., 2004; Schlaepfer et al., 2002), and some have compared operational planning standards to those set out by an EBM framework (Moola et al., 2004), few have examined how current management practices affect the quantity of wildlife tree retention and the quality of structural attributes of that retention at the cutblock level (Machmer & Steeger, 2004).

On Haida Gwaii/Queen Charlotte Islands (HG/QCI), British Columbia, the debate over sustainability in the forest industry is particularly acute due to several factors, chief among which is the absence of a comprehensive Land and Resource Management Plan (LRMP). In

January 2006, a multi-stakeholder Community Planning Forum completed a set of Land Use Plan (LUP) recommendations that included a fundamental requirement to apply EBM principles to forestry activities on the islands. If the LUP is ratified as scheduled, there will be requirement to manage forests in HG/QCI according to EBM principles as early as 2007. There is a critical need to begin to explore the implications of this new framework on the strategic and operational environment of forest industry.

This study involves the analysis of operational-level planning records and stand-level timber cruise data in order to determine whether current stand-level management for biodiversity on HG/QCI is consistent with the parameters and criteria of Ecosystem Based Management (EBM). The specific objectives are: 1) to determine the level of wildlife tree retention relative to the EBM target and 2) to determine whether there is a difference in the structural attributes and species composition between the pre-harvest stand and its wildlife tree retention. Given the increasingly sanctioned importance of EBM forestry in British Columbia, and its importance as a framework for the HG/QCI land use plan, it becomes important to understand how close current stand-level forest management practices are to generating the results stipulated by an EBM framework on Haida Gwaii/Queen Charlotte Islands. The study demonstrates that in reference to ecosystem-based management principles and objectives, there is a significant deficit in stand-level retention of wildlife trees on HG/QCI. However, there does not appear to be a significant deviation in structural attributes and species composition between this retention and the pre-harvest stand.

2. Stand-level management for biodiversity

Consensus on the need to conserve biological diversity - the variety of plants, animals and other living organisms and their interactions - is broadly shared not only in the scientific community but across the gamut of civil society (McNeely et al., 1990; Burton et al., 1992; Pimm et al., 1995). Beyond the ethical imperative of preventing the extinction of other life forms, the utility of biological diversity and function to human beings globally is valued at several trillion dollars annually (Pimentel et al., 1997). Little doubt remains that the harvest and management of temperate old growth forest has the potential to disrupt and threaten existing biodiversity. Species of vertebrates, including the Queen Charlotte Goshawk (*Accipiter gentilis laingi*) and Marbled Murrelet (*Brachyramphus marmoratus*) are known to be threatened by the harvesting of mature-old growth forest on Haida Gwaii/Queen Charlotte Islands (Doyle, 2004), primarily through the loss of habitat. The Queen Charlotte Ermine (*Mustela erminea haidarum*) was designated as endangered in 2001 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) based on declining populations principally due to the loss of habitat (Reid et al., 2000). Keen's Long Eared Myotis is associated with mature and old growth forests in cool wet coastal montane climates (Firman et al., 1993), the loss of which threaten these rare bats.

One of the most important stand-level management practices to maintain biodiversity is ensuring the retention of sufficient live and standing dead trees (snags) (B.C. Ministry of Forests, 1995). Snags provide nesting and foraging habitat for a wide range of species (Lindenmayer & Franklin, 1997; B.C. Ministry of Forests, 1995). Approximately 70 species of vertebrates in British Columbia have been identified as critically dependent on live standing and snag wildlife tree habitat (Machmer & Steeger, 2004) [1]. It has been argued that greater retention of wildlife trees provides a proportional increase in benefits in terms of abundance, diversity and composition of species relative to pre-harvest levels (Moola et al., 2004). The greater the amount of permanent retention[2] remaining within logged areas, the greater the stability of post-harvest ecosystems and their similarity to pre-harvest species abundance and composition (Deal, 2001).

In addition to quantity of retention, there is a strong consensus among scientists that in order to ensure ecosystem integrity, the quality of the habitat selected for retention is as critical as the overall amount (David Suzuki Foundation, 2004). Wildlife trees used for habitat (nesting and foraging) have particular attributes that make them suitable as wildlife trees. They tend to be taller, both in terms of height and diameter, exhibit a range of cavities, cracks, and broad canopies often possessing mistletoe brooms in the humid temperate rainforests that are ideal for nesting.

As the total area of old-growth temperate rainforest diminishes, concern grows over the potential for losing already threatened species. In their recent study of wildlife tree retention in British Columbia Machmer & Steeger (2004) find insufficient quantity of wildlife retention and inadequate structural attributes of retention that is unlikely to meet the habitat requirements of wildlife tree dependent species. The lack of data on habitat requirements for many temperate forest species, particularly non-vertebrate taxa (Moola et al., 2004), poses a significant challenge in designing effective strategies to manage for biodiversity at the stand

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[1] Citing Steeger & Manchmer (1995), an earlier study by Bradford et al. (2003) provides a broader estimate of vertebrate species in British Columbia dependent on wildlife tree habitat at 80.

[2] Permanent retention includes wildlife tree patches and riparian reserve zones, and differs from all other types of retention by its continuity on the landscape beyond one harvest rotation period. Other retention may be harvested prior to this.

level. Nevertheless, guidelines for wildlife tree retention have been set to meet the objectives of biodiversity conservation in a range of legislative instruments.

2.1 Wildlife tree retention under the FPC

The Forest Practices Code of British Columbia Act (FPC) provides planning and operational standards for the management of forests in British Columbia. Only plans that have been prepared to the standards set within the FPC, and can demonstrate that the proposed action will "adequately manage and conserve the forest resources" in the area under consideration, will be approved by provincial decision-makers[3].

Policy direction for wildlife tree management in British Columbia was initiated in 1985. Since that time, wildlife tree management and biodiversity standards have been established by the FPC and a series of supporting documents. The *Biodiversity Guidebook* outlines the recommended processes for meeting FPC standards for wildlife tree management and biodiversity. The release of the *Provincial Wildlife Tree Policy and Management Recommendations* in 2000 provided added specificity for the management of wildlife trees. In the absence of higher level planning (a land use plan for example) The FPC has wildlife tree retention guidelines that vary by landscape unit and BEC variant (Biogeoclimatic Ecosystem Classification), calculated by considering the total area available for harvesting and the previously harvested areas without wildlife tree retention [4]. The average wildlife tree retention requirement specified by the FPC by landscape unit and forested subzones in HG/QCI is 6.6% ± 0.56 (see Appendix A, Table 3).

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[3] See Section 41(1)(b) of the Forest Practices Code of British Columbia Act

[4] See Provincial Wildlife Tree Policy and Management Recommendations p. 10-13 (B.C. Ministry of Forests & B.C. Ministry of Environment, 2000)

2.2 Wildlife tree retention under FRPA

In 2004 the Provincial Government of British Columbia introduced the Forest and Range Practices Act (FRPA) to gradually replace the FPC as the document that regulates forestry activities in British Columbia. Scheduled for full implementation by January 2007, FRPA represents a move away from prescriptive to more results-based approaches that regulate forest practices (Reader, 2006). In the results-based framework of FRPA there will be a reliance on forest professionals to make adequate decisions that meet stated resource objectives in the forested landscape. According to the Ministry of Forests, the new results-based framework will lead to "high-quality forest management" in which industry innovation is encouraged and accountability held by professionals (McDonald, 2004, p. 1).

Management guidance for wildlife tree retention was revised under FRPA to include a set of default requirements (B.C. Ministry of Forests, 2006b), where licensees have not developed alternative strategies. FRPA calls for a retention minimum of 7% of the total area of all cutblocks harvested annually, and a per cutblock retention level of 3.5% of the area of the cutblock (B.C. Ministry of Forests, 2006b). Under the professional reliance regime considerable flexibility exists to vary these targets, as long as the alternative is deemed to address the legislated objectives adequately.

3. Ecosystem-based management and biodiversity

Ecosystem-based management (EBM) has emerged as the dominant approach to managing natural resources (United Nations Environment Program, 2006; Quinn & Theberge, 2005). EBM has been defined as "an adaptive approach to managing human activities that seeks to ensure the coexistence of healthy, fully functioning ecosystems and human communities" (Coast Information Team, 2004a, p. 2). It represents a collaborative effort to incorporate best available science into management decisions to ensure that ecological integrity is maintained while providing for economic development. EBM requires integrated planning at multiple scales to ensure social, cultural, and economic objectives are achieved without compromising ecological integrity (Coast Information Team, 2004a; Slocombe, 1993).

In addition to a focus on planning and implementation of forest management at the watershed and regional scales, EBM outlines stand-level practices to preserve ecological integrity with a particular degree of specificity. On the North and Central Coast region of British Columbia, the Coast Information Team developed a set of prescriptive elements for EBM forestry through a collaborative process and the contribution of multidisciplinary teams. Stand-level retention is highlighted as a fundamental component of operational forestry. In order to maintain old growth biological legacies that provide habitat and contribute to biodiversity (eg. wildlife trees, snags, CWD) and contribute to watershed targets for ecological representation, each cutblock must maintain at least 15% permanent retention (Coast Forest Conservation Initiative, 2006; Coast Information Team, 2004b)

There is a recognition that the complexity of ecosystems, compounded frequently by their non-equilibrum state, make it exceedingly difficult to predict a particular outcome in a given ecosystem (Reichman & Pulliam, 1996). Consequently, this is a considerable source of frustration for resource managers seeking to design a particular resource management strategy that incorporates the principles of EBM.

On Haida Gwaii/ Queen Charlotte Islands, EBM represents the consensus of First Nations, the Provincial Government, local government, non-government interests, and individual citizens on a set of goals and objectives for forest management. The HG/QCI Land Use Plan, currently pending ratification, is fundamentally based on the principles of EBM (Process Management Team, 2006). Specifically, the goals of the HG/QCI Land Use Plan include the protection and restoration of ecosystem integrity, preservation of spiritual and cultural values, enhancement of sustainable economic opportunities within the inherent limitations of the land, and the promotion of social and communal wellbeing (Process Management Team, 2006).

Some remain sceptical that the land use plan will bring about the implementation of EBM on HG/QCI, as success has not been widespread across the province. Moola et al. (2004) point out that few prescriptive elements of the EBM framework have been adopted by land use tables across the province. Two earlier studies[5] have examined logging practices in the Central and North Coast of British Columbia and compared them with standards set out by the EBM framework. Martin et al. (2003) conducted a comprehensive review of silvicultural prescriptions in the area of the Great Bear Rainforest Agreement to assess whether industry operations demonstrated a change towards EBM following ratification. They found that clearcutting remains the dominant silvicultural method, riparian management strategies do not adequately protect hydroriparian resources, and stand-level retention remains low. In a similar fashion, Moola et al. (2004) conducted an audit of silvicultural prescriptions for cut blocks approved between January 2002 and February 2003 and concluded that that in-block retention levels were low, and little effort had been demonstrated to protect small fish-bearing streams within managed forest stands. Both of these studies relied on analysis of operational planning documents acquired from corresponding licensees.

[5] Both funded by the David Suzuki Foundation.

Despite the broad recognition of EBM as a good conceptual basis for sustainable forestry, and widespread support from diverse members of civil society, some reject it categorically. Schlaepfer (1997) suggests that efforts to operationalize EBM "are awash in confusion and pseudoscientific buzzwords because they gloss over the concept's inherent characteristic of spatial and temporal vagueness" (p. 10)[6]. Many forest industry players argue that added operational restrictions make the development of an economically viable plan increasingly difficult (Angus, 2006). Moreover, they perceive themselves to already manage for ecological values identified by society through legislation (D. Morgan, personal communication, July, 2006)

Nevertheless, despite the conspicuous resistance by some industry players, four companies[7] on the Central Coast Region of British Columbia have committed to implementing EBM by 2009 (Armstrong & Bourgeoise, 2006). It would not be unreasonable to expect that, in addition to the public and regulatory pressures as incentives to adopt EBM forestry, these companies may have a prescient understanding of the 'social license' that EBM will provide to continue harvesting forest resources. The adoption of "beyond compliance" initiatives (Reader, 2006, p. 150) by many companies suggests an increasing awareness that it is no longer possible to rely on the license provided by adherence to regulatory and legislative frameworks. Many forest companies are currently exploring moving beyond compliance to build what Reader (2006) calls "reputation capital" (p. 151).

Moreover, adoption of EBM principles brings the forest industry significantly closer to achieving the suite of market benefits realized through voluntary certification. Certification of forest management practices, such as the Forest Stewardship Council (FSC), is designed and

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[6] Citing work by Fitzsimmons (1996)

[7] They are Canfor, Catalyst Paper, International Forest Products, and Western Forest Products.

overseen by non-governmental bodies and seeks to reward practices that meet a certain standard. Firms choose to adopt certified forest products because they expect direct market benefits such as price premiums or increased market share (Rickenbach & Overdevest, 2006). Certification operates as a signal to external stakeholders that a particular firm is meeting certain established standards of protection and production (Rametsteiner, 2002). In FSC certification, widely considered to be one of the most environmentally stringent certification processes, these standards are measured through 10 principles and 57 criteria indicators that are intrinsically linked or based on an ecosystem-based framework (Forest Stewardship Council, 2005).

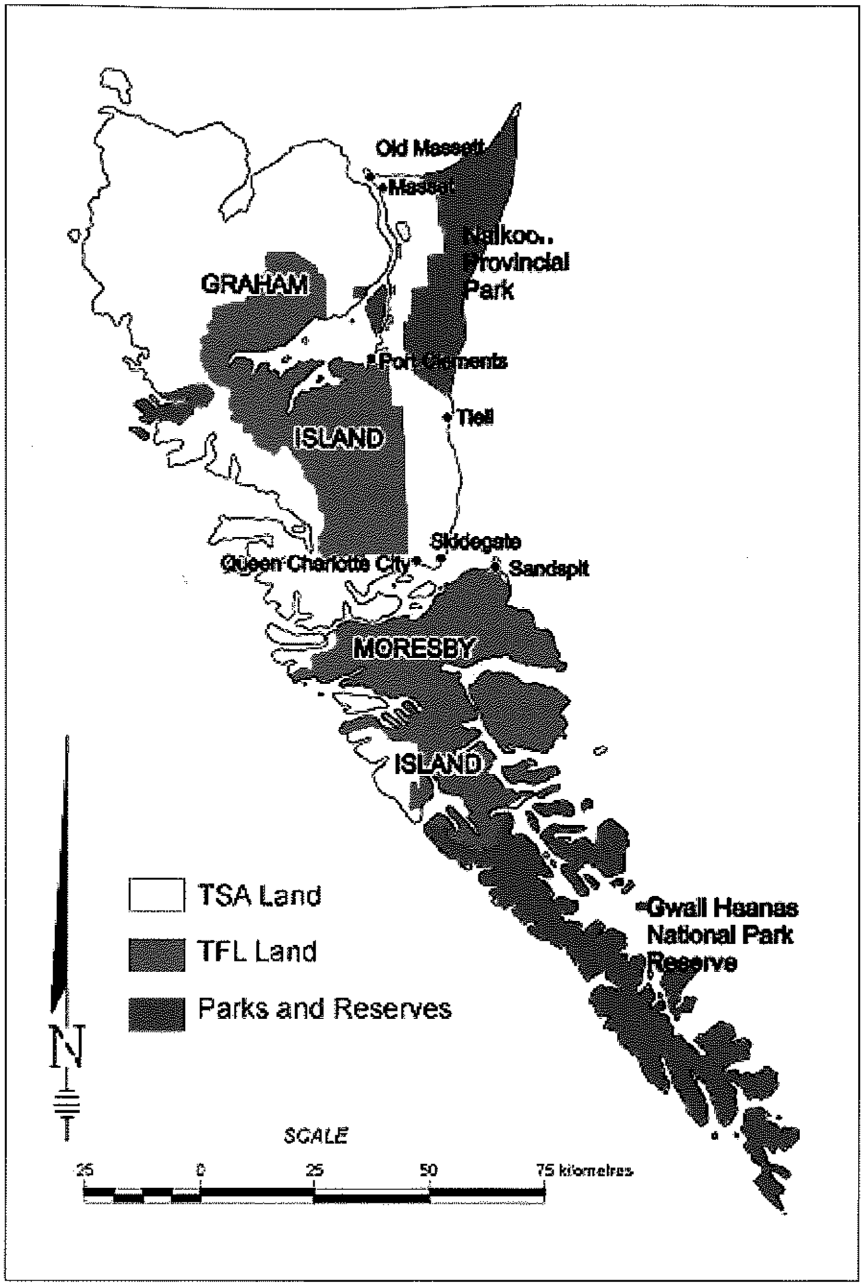

Figure 1 Haida Gwaii/ Queen Charlotte Islands distribution of public lands and tenure, showing the Timber Supply Area (TSA), the area of Tree Farm Licenses (TFL), and protected areas (adapted from http://www.for.gov.bc.ca/dqc/info.htm)

4. Methods

4.1 Case study Area: Haida Gwaii/ Queen Charlotte Islands

Haida Gwaii/ Queen Charlotte Islands (HG/QCI) is an archipelago of approximately 150 islands, 120 km off the northwest coast of British Columbia, possessing globally unique temperate old-growth rainforest and a suite of endemic flora and fauna (Holt, 2004; Doyle, 2004). Extending approximately 1 million hectares, parks and reserves account for 22 percent of the land area, tree farm licenses (TFL) account for 32 percent, and the Timber supply area (TSA) makes up the remaining 46 percent (Process Management Team, 2003). The distribution of forest tenure on HG/QCI extends across three forest management units, two of which are Tree Farm Licences (TFL)[8] (Figure 1). Currently, an annual allowable cut of 1.8 million m^3 is divided among four forest licensees, of which Western Forest Products (WFP) receives the greatest share at 1.2 million m^3.

The very wet maritime climate and mineral substrate results in ideal growing conditions for a variety of tree species, often covered in dense blankets of moss and epiphytic growth (Doyle, 2004). Stands are dominated by commercially valuable Western Red Cedar (*Thuja plicata*) and Yellow Cedar (*Chamaecyparis nootkatensis*), as well as Western Hemlock (*Tsuga heterophylla*) and Sitka Spruce (*Picea sitchensis*). Less commercially valuable Red Alder (*Alnus oregona*) is found along riparian zones and recent gap disturbances.

Known as Haida Gwaii to the Haida First Nation who have inhabited the area in excess of 10,000 years (Holt, 2004) and claim title to the archipelago, the area has been a staging ground for some of the most heated and publicized conflicts over lands and resources in

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[8] TFL 39 (Western Forest Products, formerly Weyerhaeuser), TFL 47 (Teal Jones Group), and the Queen Charlotte Timber Supply Area (BC Timber Sales and Husby Forest Products) A Haida tenure of approximately 120,000 m^3 per annum is presently under negotiations with the Provincial Government.

recent history [9]. Approximately 170,000 ha of forest have been logged since the turn of the 20th century (Process Management Team, 2003) As the area of old-growth forest available for harvesting decreases, conflicts increase in scale and intensity.

The Haida Land Use Vision (HLUV) reflects the concern of the Haida Nation over unsustainable practices of natural resource extraction. The Haida Nation asserts that the forest industry has for too long operated at a pace and scale that is unsustainable. Proposing to reverse this trend, the HLUV incorporates a consideration for ecosystem-based forestry (Council of the Haida Nation, 2004) as a way of ensuring more sustainable approaches to timber harvesting on HG/QCI. Little discussion remains over the fact that the success of commercial forestry in the medium to long-term will hinge on the ability of tenure holders to meet the needs and concerns of the Haida and non-first nations stakeholders regarding sustainable harvest of forest resources. Implicit in this is getting EBM forestry right.

4.2 Dataset

Data utilized in the analysis were collected from three sources. First, records for all areas harvested in HG/QCI between Jan. 1, 2004 and Jul. 1, 2006 were obtained from the Ministry of Forests RESULTS and FTA databases. A random sample of 14 cutblocks stratified by licensee was selected for field analysis from this population using a random number generator (Figure 2). The sample was stratified by a weighted representation of each licensee's total area operated during the aforementioned period.

Second, timber cruise data providing estimates of volume in pre-harvest stands were obtained from the Ministry of Forests ECAS[10] database for the 14 randomly selected blocks. Forest tenure holders have a legislated requirement according to the Forest Act to collect

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[9] The reader is referred to May (1990) and Isaac et al. (2005) for further discussion of this subject.
[10] "Electronic Commerce Appraisals System"

timber cruise data on an area prior to harvest in order to ensure the appropriate application of taxation in the form of stumpage. The sampling intensity of these cruise data is one plot per hectare with a sampling error objective of 15% at 2 standard errors (B.C. Forest Service Revenue Branch, 2006). It is important to understand that the reliability of estimates provided by cruise data are a function of the sampling intensity, the uniformity of timber on the area in question, and the adequacy of the volume equation and loss factors applied (B.C. Forest Service Revenue Branch, 2006). Several volume equations exist for the estimation of stand volume, all with particular strengths and shortcomings (Husch et al., 2003). Therefore two cruises of the same stand carried out to the same standards may yield different volumes (B.C. Forest Service Revenue Branch, 2006).

Third, site level records comprised of Site Plans (SP)[11] and maps for each of the 14 cutblocks were collected from respective licensees. In each cutblock, the wildlife tree patch (WTP) or wildlife tree retention (WTR) area was identified. Stand structure was characterized using sampling methodology adapted from the Protocol for Stand-level Biodiversity Monitoring developed by the FRPA Resource Evaluation Program (B.C. Ministry of Forests, 2006a). Variable radius plot locations were selected randomly for each patch prior to field visits. Sampling intensity was set at one plot per hectare to correspond with the timber cruise data. Navigation to plot centres was done using a compass and hip chain. Prism Basal area Factors (BAF) were selected to capture 6 to 10 trees per plot. BAF was held consistent throughout all the plots within a given block. Diameter at breast height, total stem height[12], species, and decay class were recorded for all trees in point sample plots established at a

[11] Formerly known as "Silvicultural Prescriptions"
[12] Total stem height was measured using a Vertex Hypsometer 111.

sampling intensity of one plot per hectare. Estimates of windthrow were obtained by visual assessment.

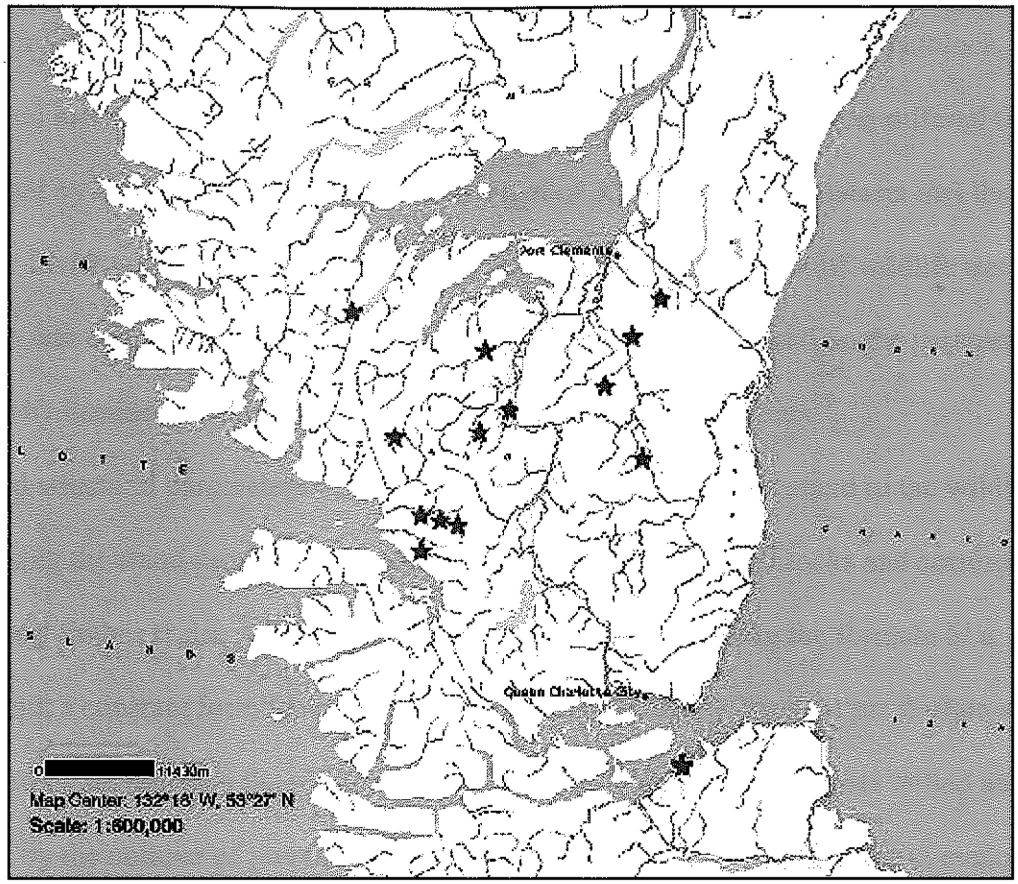

Figure 2 Location of sites for wildlife tree retention sampling, North Moresby Island and Graham Island, HG/QCI.

4.3 Analyses

Using the maps and site plans, the proportion of wildlife tree retention was calculated two ways: 1) by dividing the sum of permanent retention within or adjacent to the block by the total cutblock area (as per the biodiversity section of the SP documents), and 2) by dividing sum of permanent retention by total area under prescription (TAUP – as stipulated in the

Wildlife Tree Retention Management Guidance document)[13]. Only wildlife tree patch areas and riparian reserve zones were considered as permanent retention[14]. A one sample t-test was used to evaluate whether the mean wildlife tree retention between January 1, 2004 and July 1, 2006 differed significantly from the EBM minimum benchmark of 15% per cutblock. Additional one sample t-tests were conducted to evaluate whether the mean differed from the FPC target by landscape unit and the FRPA target of 3.5% or 7%. The dataset met the assumptions of normality and independence. An additional calculation of wildlife tree retention was conducted for each of the 14 field sampled blocks, based on the parameters reported by licensees in the biodiversity section of their SP documents[15].

Stand structural parameters were compared from the pre-harvest stand to the wildlife tree patch, using the stand parameters measured in the subsample of 14 blocks and corresponding pre-harvest timber cruise data. Volume per tree was estimated using the formula of a paraboloid, a constant form factor equation (Husch et al., 2003). Volume per hectare was calculated by multiplying the resultant volume factor by the number of trees tallied and dividing by the number of points sampled[16]. A paired samples t-test was used to evaluate whether pre-harvest stand and wildlife tree patch mean volume per hectare differed significantly. Additional t-tests were conducted to compare mean diameter at breast height and total stem height between pre-harvest stand and wildlife tree patch. The species composition of pre-harvest stands and wildlife tree patches by percentage of total volume was

[13] Refer to p. 4 of Wildlife Tree Retention Management Guidance (B.C. Ministry of Forests, 2006b); see also p. 6 of the Provincial Wildlife Tree Policy and Management Recommendations (B.C. Ministry of Forests & B.C. Ministry of Environment, 2000).

[14] Ideally dispersed wildlife tree retention should also be taken into account, however data was unavailable for the harvested areas in question during the period 2004-2006.

[15] This involved dividing the WTP by the sum of the net area harvested and permanent access structures. Only in one case did the calculation omit permanent access structure are from the divisor.

[16] See Husch et al. (2003) Section 14-1.8 for a more detailed discussion

compared. Lastly, the frequency and average diameter of wildlife trees by decay class were plotted to gain an understanding of the habitat structure of the patch. Statistical analyses were conducted using SPSS 11.0.

5. Results

5.1 Wildlife tree retention level

A total of 129 blocks were harvested between January 1, 2004 and July 1, 2006 representing an area of 3,402 hectares. Mean wildlife tree retention per cutblock during this period was positively skewed with a mean of 8.4 ±0.54 percent, and a range of values from 0 to 44 percent. The sample mean was significantly lower than the 15 percent target established by the EBM framework (t = -12.45, $p<.001$). Mean wildlife tree retention during this period was significantly greater than the average wildlife tree retention requirements specified by the FPC for forested areas by landscape unit in HG/QCI (t = 3.07, $p<.05$) , as well as the minimum retention target stipulated by FRPA (t = 8.79, $p<.001$) (Table 1).

Table 1 Comparison between mean wildlife tree retention per cutblock from 2004-2006 and retention targets for EBM (15), FPC (6.6), and FRPA (3.5)

Measure	Test Value	Mean Difference	t	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
Wildlife tree retention						Lower	Upper
(% of cutblock)	15	-6.74	-12.45	128	.000	-7.81	-5.67
	6.6	1.66	3.07	128	.003	.589	2.73
	3.5	4.76	8.79	128	.000	3.69	5.83

There was a significant difference (t = -2.99, $p<.05$) between the amount of wildlife tree retention calculated using the two methods described above[17] (Figure 3). The division of wildlife tree patch area by the smaller net area harvested yielded a greater average retention

[17] Refer to p. 4 of Wildlife Tree Retention Management Guidance (B.C. Ministry of Forests, 2006b); see also p. 6 of the Provincial Wildlife Tree Policy and Management Recommendations (B.C. Ministry of Forests & B.C. Ministry of Environment, 2000).

level. When calculated as a proportion of total area operated, 57 percent of cutblocks fall below their landscape specific retention targets under the FPC.

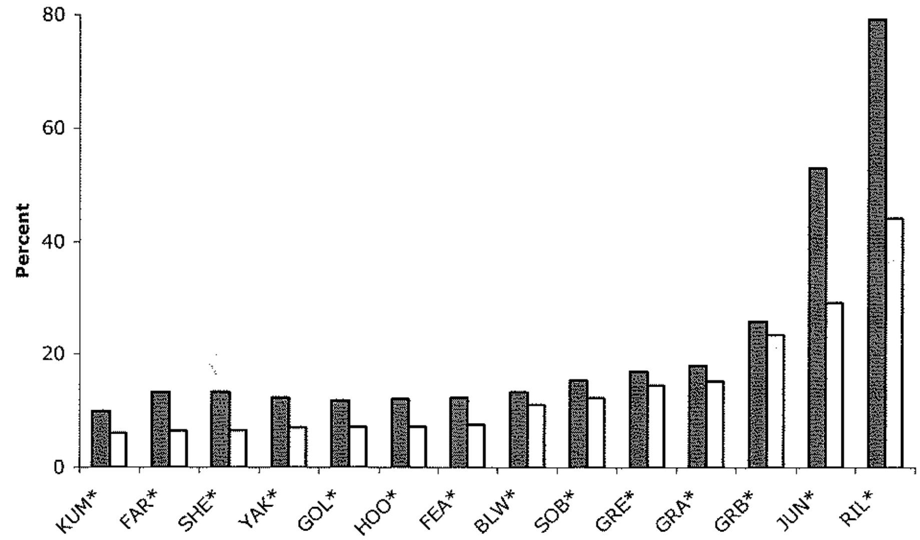

Figure 3 Wildlife tree patch retention for sampled cutblocks as a proportion of net area harvested (shaded bars) and as a proportion of total cutblock area (open bars).

5.2 Stand structure and composition

Stand structure and composition were found to be consistent from pre-harvest stand to wildlife tree patch. The pre-harvest stand total volume per hectare did not differ significantly from that of the wildlife tree patch . No significant differences were found in mean species volume per hectare between pre-harvest stand and wildlife tree patch (Table 2).

Mean stem diameter by species appears to be greater in the wildlife tree patch than in the pre-harvest stand, though this trend is not statistically significant (Table 2). In terms of mean stem height, the wildlife tree patch showed significantly lower heights for Sitka Spruce, Western Hemlock, and Western Red Cedar (Table 2).

Table 2 Comparison of means between pre-harvest stand and wildlife retention patch (stand means)

Measure	Species	Mean Difference	Std. Error	t	Sig.(2tail)	df
Volume (m^3 ha^{-1})	Ss	-67.42	± 58.63	-1.50	.294	6
	Hw	-55.80	± 37.10	-1.47	.166	13
	Cw	-137.35	± 90.35	-1.52	.154	12
	Cy	8.3	± 62.45	.133	.903	3
	Total	23.98	± 44.57	.538	.594	13
DBH (cm)	Ss	-2.93	± 8.10	-.362	.730	6
	Hw	2.03	± 4.44	.458	.654	13
	Cw	4.71	± 9.60	.491	.632	12
	Cy	6.46	± 7.48	.864	.451	3
	Total	2.50	± 3.93	.637	.528	13
Total height (m)	Ss**	-17.25	± 3.45	-5.00	.002	6
	Hw**	-12.28	± 1.36	-9.02	.000	13
	Cw*	-8.68	± 2.80	-3.15	.009	11
	Cy	-11.20	± 5.74	-1.95	.146	3
	Total					

Ss – Sitka Spruce, Hw – Western Hemlock, Cw – Western Red Cedar, Cy – Yellow Cedar.
* Significant at $p < 0.05$
** Significant at $p < 0.01$

Species composition by volume was not significantly different between pre-harvest stand and wildlife tree patch (Figure 4). Most of the stand volume (35%) was comprised of Western Red Cedar with Western Hemlock and Sitka Spruce making up 20% and 17% respectively (Figure 4). Live wildlife trees were much more abundant than snags in the retention areas, comprising 76 percent of the sample (Figure 5, Appendix A). The mean stem diameter of decay class 6 snags (90.2 ±13 cm) was greater than the mean for the live wildlife trees retained (53.2 ±3 cm and 44.2 ±4 cm for wildlife tree classes 1 and 2 respectively) (Figure 6, Appendix A). Approximately 30 percent of sampled wildlife tree patches possessed evidence of windthrow. Evidence of windthrow was exclusively confined to the edges of the retention area, and did not exceed 5 percent of the total retention area on average.

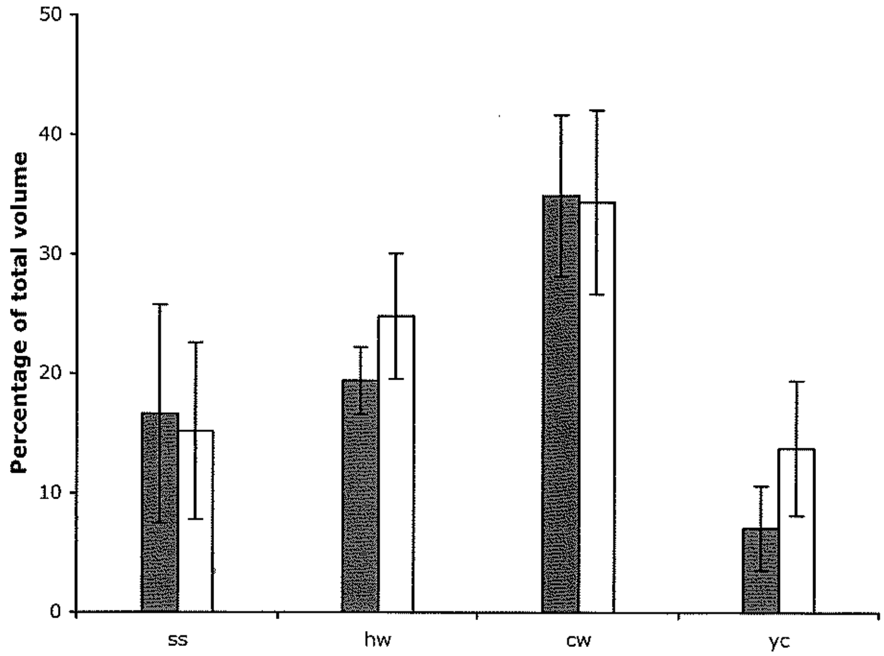

Figure 4 Relative abundance of species, expressed as a percentage of total volume per hectare, for pre-harvest stand (shaded bars) and wildlife tree patch (open bars), mean ± standard error

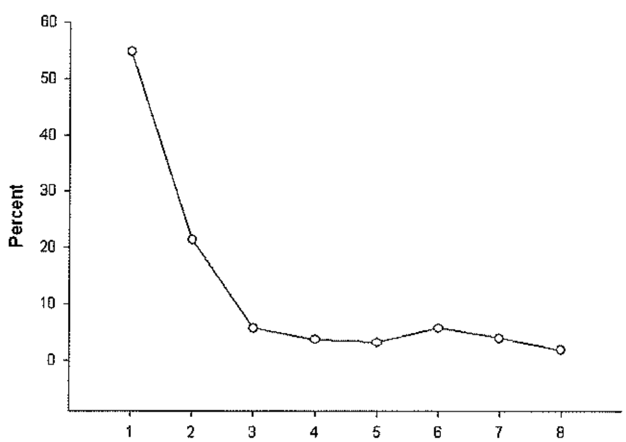

Figure 5 Cumulative distribution of stems by wildlife tree classes (decay classes) 1 through 8 (see Table 4)

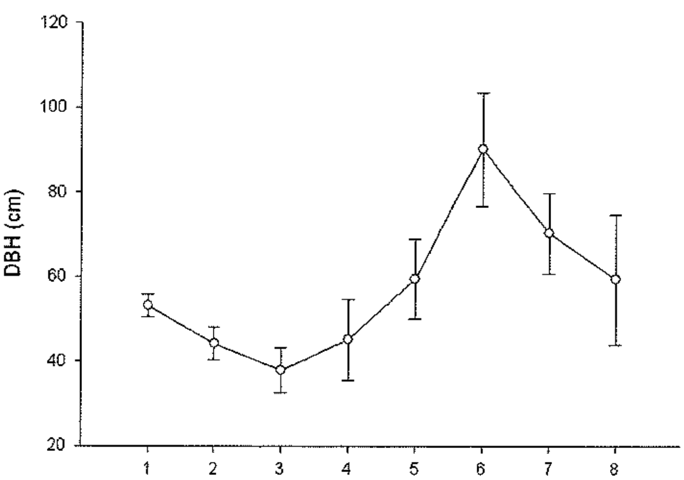

Figure 6 Mean stem dbh (cm) by wildlife tree classes (decay classes) 1 through 8 (see Table 4); error bars show std. error of mean.

6. Discussion

The mean level of per cutblock retention on blocks harvested from January 1, 2004 to July 1 2006 in HG/QCI was examined for consistency with various wildlife tree retention targets. For 129 blocks harvested in the period, the average wildlife tree retention of 8.4 ±0.54 percent was significantly lower ($p<.001$) than the EBM target of 15 percent. Average per cutblock wildlife tree retention, calculated as a proportion of TAUP, would need to increase by 79 percent in order to meet the minimum EBM benchmark. Mean wildlife tree retention on HG/QCI exceeded the average FPC requirements and FRPA targets over the past two years.

A discrepancy in the method of calculating retention results in inflated per cutblock estimates. The calculation of wildlife tree retention as a proportion of total area operated provides a much lower estimate of per cutblock retention than the use of net area harvested as the divisor. According to the former, 8 of 14 field sampled cutblocks fall below the landscape specific targets stipulated by the FPC (B.C. Ministry of Forests & B.C. Ministry of Environment, 2000). Though the FPC specifies a target level of retention for each landscape unit, there is no specificity regarding the calculation of the proportion of wildlife tree retention at the stand level. Due to the ambiguity of direction variable interpretations of the requirements lead to a discrepancy in the calculation of wildlife tree patch retention levels across cutblocks. It is important to point out that wildlife tree retention management guidelines under the FPC provide a considerable level of flexibility to vary retention strategies across the landscape, and hence it is unlikely that a constant level of wildlife tree retention would be found across all cutblocks. Nonetheless, every cutblock should have an area of wildlife tree retention (B.C. Ministry of Forests & B.C. Ministry of Environment, 2000).

While the data suggest a concern over quantity of stand-level retention for wildlife habitat on HG/QCI, it appears to indicate that the quality of structural attributes maintained is similar to pre-harvest conditions. No significant differences in stand structural quality, as determined by mean volume per hectare, are apparent between the pre-harvest stand and the wildlife tree patch. Mean stem diameter appears to be greater in the retention areas than in the preharvest stand, while mean stem height is significantly lower in the former. The partial significance of this relationship suggests the possibility that shorter broader stems are preferentially retained, though it is unlikely that this trend is the result of a deliberate strategy.

The species composition of pre-harvest stands was consistent with the species composition of wildlife tree patches suggesting a relatively unbiased selection of wildlife retention. Though the trend lacks statistical significance, likely due to a small sample size, the abundance of Sitka Spruce and Western Red Cedar decreases in the wildlife tree patch, while Western Hemlock and Yellow Cedar appear to be preferentially retained.

Live wildlife trees (categories 1 and 2) comprised more than 75 percent of the stems in the retention patches. This is consistent with earlier studies examining retention across the region (Machmer & Steeger, 2004; Bradford et al., 2003). Effectively addressing wildlife habitat requirements necessitates the retention of a variety of wildlife tree classes (Machmer & Steeger, 2004; Bradford et al., 2003). Wildlife tree classes 1 and 2 are not generally considered to contribute significant wildlife habitat value in the short term, other than perching and nesting sites for raptors (Bradford et al., 2003). The mean stem diameter of snags was significantly greater than that of live trees in the retention patch. By reducing the proportion of snags retained, the wildlife tree patch loses potentially significant increases in volume. The biased retention of live trees is likely attributed to the cautious application of

Workers Compensation Board regulatory requirements around unsafe trees. Greater scrutiny around selection of dangerous trees may result in considerable structural benefits to stand level wildlife tree retention.

Though windthrow around wildlife tree retention is often cited as a source of concern (B.C. Ministry of Forests & B.C. Ministry of Environment, 2000), and earlier silvicultural assessments have found windthrow to be the most significant threat to cutblock level retention on HG/QCI (Von Schilling, 2003), the study found no significant evidence of windthrow. Visible investments in tree-crown modification on several of the sampled blocks may have played a role in mitigating against this hazard to stand level retention.

7. Conclusions

Ecosystem-based management on HG/QCI remains a distant goal with respect to quantity of retention. Average per cutblock wildlife tree retention from January 2004 to July 2006 was significantly lower than that stipulated by the EBM framework. A selection bias in retained structure however is less evident, indicating that with respect to quality current practices are effective in retaining structure that is similar to pre-harvest stand conditions. Concerns over the relative abundance of snags exist, but a precise indication of how this affects vertebrate species habitat requirements is not yet possible, partly due to the paucity of data on species habitat requirements (Bradford et al., 2003).

Structural retention is an important component of stand-level management for biodiversity (Sullivan et al., 2001; Franklin et al., 1997; Pojar et al., 1999), particularly through the provision of critical habitat for a variety of wildlife tree-dependent species.The adequacy of wildlife tree retention targets under the FPC has been called into question in previous studies (Bradford et al., 2003; Machmer & Steeger, 2004). With the advent of much less onerous

FRPA requirements we appear to be moving further away from addressing the effectiveness of wildlife tree retention in maintaining and promoting stand level biodiversity.

Ecosystem based management provides an opportunity to address the weaknesses in stand level biodiversity management while providing social licensing through "reputation capital" (Reader, 2006). Companies become increasingly well positioned to increase their potential financial benefits through the possibility of independent certification. Over the past 5 years, 74 percent of the largest 38 forest companies in the U.S. voluntarily engaged in collaborative ecosystem based management arrangements (Brody et al., 2006), further strengthening the perception that EBM not only makes ecological and socio-political sense, but business sense as well[18].

In order to increase the accuracy of the findings in this study, it would be important to engage in a more comprehensive examination of current stand-level forest management practices. An expanded sample size and examination of additional criteria would allow for a more nuanced picture of forest management practices and their ability to implement and address EBM principles and goals. Finally, there is a critical need to address the knowledge gaps in specific habitat requirements for many temperate forest species, particulary in HG/QCI due to its relatively high degree of endemicity. This would allow for the development and implementation of more effective strategies to conserve and enhance biodiversity at the stand level.

[18] Differences in the implications of private ownership versus public tenure are not sufficient to discount this comparison. See Berry (2006) for further discussion.

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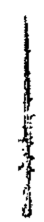
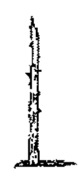
APPENDIX A

Table 3 Queen Charlotte Islands Forest District average wildlife tree patch retention by landscape unit based on Table 20b of the Biodiversity Guidebook (B.C. Ministry of Forests, 1995).

Landscape Unit	% WTP retention
Eden Lake	6.7
Gudal	3.0
Hibben	3.5
Honna	6.0
Ian	5.3
Louise Island	7.5
Lower Yakoun	9.5
Masset Inlet	7.0
Rennell	3.7
Sewell	9.0
Skidegate Lake	9.3
Tasu	6.7
Tlell	7.0
Yakoun Lake	8.0
Average	**6.58**

* Averages based on forested BEC subzones CWH and MH.

Table 4 Conifer wildlife tree classes (WTC); classes 1 and 2 are live trees, 3 to 8 snags. Adapted from http://www.for.gov.bc.ca/hfp/values/wildlife/WLT/index.htm

Gradual death: conifers	General description of tree	Wildlife uses and users	Stages of decomposition
1	**live/healthy** – no decay	nesting; roosting; perching; territory; large–limb eagle and Osprey nests; raptors; scavengers; Great Blue Heron colonies; Marbled Murrelet	
2	**live/unhealthy** — internal decay or growth deformities (including insect damage, broken tops); dying tree	nests/roosts — PCEs[a] (strong excavators); SCUs[b]; large–limb nests; insect feeders	
3	**dead**[c] — hard heartwood; needles and twigs present; roots stable	nests/roots — PCEs (strong excavators); SCUs; bats; large–limb nests; hunting/ hawking perches; branch roots; insect feeders	
4	**dead** — hard heartwood; no needles/twigs; 50% of branches lost; loose bark; top usually broken; roots stable	nests/roots — PCEs (weaker excavators); SCUs; insect feeders	
5	**dead** — spongy heartwood; most branches/bark absent; internal decay; roots stable for larger trees; roots of smaller trees beginning to soften	nests/roots — PCEs (weakest excavators); SCUs; bats; insect feeders; salamanders	
6	**dead** — soft heartwood; no branches or bark; sapwood/ heartwood sloughing from upper bole; lateral roots of larger ones softening; smaller ones unstable	SCUs; insect feeders; salamanders; small mammals	
7–8	**dead** — soft heartwood; stubs; extensive internal decay; outer shell may be hard; lateral roots completely decomposed; hollow or nearly hollow shells	insect feeders; salamanders; small mammals	
9	**debris** — downed stubs or stumps	insect feeders; salamanders; small mammals; amphibians; drumming logs for grouse; flicker foraging, nutrient source