COMPARING FOREST MANAGEMENT PRACTICES UNDER COMMUNITY-BASED AND CONVENTIONAL TENURES IN BRITISH COLUMBIA: AN ECOLOGICAL PERSPECTIVE

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Abstract

To shed empirical light on the debate surrounding the perceived ecological benefits of community forestry, I used multiple types of data to compare five community forests to geographically proximate conventional tenures. I used data generated from the BC Ministry of Forests RESULTS database to investigate proxy measures of ecologically sustainable forest management, including silviculture system usage, cutblock structural characteristics, and harvesting profiles. In addition, I conducted stakeholder interviews with fellow researchers to help inform the choice of proxy measures employed, as well as to provide a qualitative context for silviculture and harvesting data. Community forests are largely managing in a more ecologically sustainable manner than their counterparts. They are more likely to employ alternative silviculture systems, and out-perform their counterparts in certain measures of stand structure and representativeness of harvesting. However, variation exists among community forests, and some measures suggest areas in which improved management practices would be beneficial.

Keywords: community forestry; community natural resource management; ecological sustainability

To my family and friends, the foundation upon

which all of my pursuits are built.

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List of Acronyms

BC	British Columbia
BCTS	British Columbia Timber Sales
CF	community forest
CFA	community forest agreement
CVFC	Creston Valley Forest Corporation
FL	forest licence
FTA	forest tenures application
HPCF	Harrop-Procter Community Forest
LP	Louisiana-Pacific Corporation
LXCF	Likely-Xats'ull Community Forest
MCFC	McBride Community Forest Corporation
MoF	Ministry of Forests/Ministry of Forests and Range
PCoA	principle coordinates analysis
RCFC	Revelstoke Community Forest Corporation
RESULTS	reporting silviculture updates and land status tracking system
RNV	range of natural variability
TFL	tree farm licence
THLB	timber harvesting land base
TL	timber licence
WF	West Fraser Timber Corporation Ltd.
WTP	wildlife tree patch

Introduction

Management systems governing how natural resources are harvested represent a combination of our understanding of those ecosystems providing the resources in question and the related societal beliefs, attitudes, and practices surrounding our relationship with the environment (Lertzman, 2009). These systems have evolved out of a variety of different social institutions, based in both private ownership and government control as well as through user self-governance, all of which have unique approaches to resource management (Dietz et al., 2003). For instance, while government institutions may impose fines and jail time for resource use violations, locally-based institutions may rely on more subtle avenues of discipline (Dietz et al., 2003). That these different institutions also often possess divergent objectives (Berkes, 2007; Berkes, 2003) suggests that, while both successes and failures have been associated with each, outcomes may be inherently different.

Ecological issues surrounding resource management have become increasingly important to the public and policy makers in Canada and around the world in recent decades (Pokharel et al., 2010; Schlaepfer, 1997; Toman and Ashton, 1996). This trend holds true in British Columbia in particular, where these questions of the ecological impact of resource use are often held as more important than economic and social considerations. For instance, Kozac et al.

(2008) found that in forest dependent communities across the province, ecological issues such as sustaining biological richness, managing forests to reduce global warming, and sustaining the productive capacity of forests are consistently held by the public as more important than economic considerations.

The community forestry movement has emerged globally in recent decades in stride with this surge in ecological awareness, with the belief in the ability of locally, or community, managed forests to fulfill some of the change toward ecological sustainability being called for (Charnley and Poe, 2007; McCarthy, 2006). For instance, Charnley and Poe (2007) define community forestry as “forest management that has ecological sustainability and local community benefits as central goals”, and discuss community forestry's roots in countries around the world as a response to the ecological impacts of industrial forestry and as a means of achieving sustainable forest use. And Teitelbaum et al. (2006) note that there is consensus across the community forest literature in Canada that “the notion that the forest will be managed in a way that promotes long-term ecological health” is one of the main attributes of community forestry. While proponents of community-based forest management believe it will yield distinct results to status quo, industrial forestry, there is much debate as to whether these perceived benefits have, or will, actually come to fruition (McIlveen and Bradshaw, 2005/2006).

There is a need for further research and empirical evidence to better inform the debate surrounding the benefits of community forestry (Teitelbaum et

al., 2006; Kellert et al., 2000). In British Columbia in particular, while some preliminary investigation into the community forest program has been undertaken, little has been done empirically to assess the performance of community forests (Ambus, 2008), in particular regarding questions surrounding ecological sustainability. This empirical knowledge is important as community forestry becomes a global reality. The past two decades have seen the doubling of forests completely or partially under local control in the developing world (The Economist, Sept. 23, 2010), and in jurisdictions in developed countries, such as British Columbia, similar pushes are being made (BCCFA, 2010).

In an effort to contribute empirically to some of the questions surrounding community forest management raised above, in this study I address the hypothesis that community forestry results in a greater degree of ecological sustainability. I do this through a qualitative and quantitative comparison of forest practices between community forests and non-community based operations in British Columbia, Canada.

Ecological sustainability is used here largely in the sense elaborated by Callicott and Mumford (1997), who present it as a guiding conservation principle to be applied in unison with the preservationist approach to conservation, but to those areas that are explicitly under human use. Thus the term stands in contrast to other, more anthropocentric and utilitarian, 'sustainability' terms familiar to forestry in British Columbia, such as *maximum sustainable yield* and *sustainable*

development. Following Callicott and Mumford, important elements of what is meant here by *ecologically sustainable forest management*, then, are that:

(a) the health of the ecosystem providing the resource in question is not unduly compromised, where 'health' refers to an area-specific *ecological norm* represented by ecosystem states, and their associated species, structures, and functions, that are naturally expected in the area in question; and

(b) that the long term provisioning of the resource in question is not compromised, requiring the acknowledgement of *ecological constraints* to that provisioning.

Noss (1993) summarizes these two points well, in stating that “Managed forests should be compared in terms of how well they maintain all of their native components over time, not just those that are convenient for human society”.

As quantifying the concept of ecological sustainability, as I use it here, requires a comparison of areas being managed for timber extraction to ecological “norms”, an issue being increasingly considered by natural resource managers is raised: that of range of natural variability (RNV) (Landres et al., 1999; Dorner et al., 2002; Wong and Iverson, 2004). The RNV approach to forest management aims to maintain ecosystem health by ensuring the presence of structures and functions that have historically characterized a given area, and to which species are therefor adapted (Landres et al., 1999). Researchers have suggested that

these efforts help to prevent future reductions in forest attributes such as biological diversity and productivity (Wong and Iverson, 2004). While RNV relies on data illuminating past ecological conditions, typically on the scale of at least hundreds of years (Wong and Iverson, 2004), data of that nature were not available for this study. Instead, with the idea of RNV in mind, I compare harvested ares to current conditions taking only spatial (and not temporal) variability across timber harvesting land bases into account. This is done directly in some cases, through comparisons of harvested areas to timber harvesting land base profiles, as well as indirectly by assessing post-harvest forest retention levels. My goal, the same as that of applying RNV concepts to forest management, is to set the range of ecosystem attributes present as targets for forest management.

In assessing the ecological sustainability of a subset of CF's in BC, this research is one component of a broader SSHRC-funded interdisciplinary study, Community Forests as a New Model for Forest Management in British Columbia . The study investigates the extent to which community forestry in BC provides a viable alternative to conventional forest management, from economic, social, and environmental perspectives. Field research for this study was conducted by myself, as well as anthropologist Evelyn Pinkerton, policy scientist Murray Rutherford, and Jordan Benner, Ashley Smith, and Lauren Rethoret, Masters students in the School of Resource and Environmental Management at Simon Fraser University. Additional researchers who did not conduct field research but

were involved in other components of the project, included forest ecologist Ken Lertzman, archaeologist John Welch, and economists Ajit Krishnaswamy, Ron Trosper, and Thomas Maness.

Methods

Study Areas

All tenures included in this study are located in four forest districts in the Southern Interior Forest Region, and lie predominantly in Interior Cedar-Hemlock and Engelmann Spruce-Subalpine Fir biogeoclimatic zones, although Interior Douglas-fir, Montane Spruce, Sub-boreal Spruce, and Sub-boreal Pine-Spruce zones are also represented (Meidinger and Pojar, 1991). Our research group selected five community forests, out of the over 40 community-based operations in the province, in an effort to maximize the ecological similarity of study areas, minimize the impact of the recent mountain pine beetle epidemic (McGarrity and Hoberg, 2005) on study findings, and also for historical and sociological reasons including the southern interior being the location of some of the oldest and most established community forests.

For each of the five community forests included in the study, I selected a British Columbia Timber Sales (BCTS) operation and a “conventional” operator (licensees managing Tree Farm Licences, Forest Licences, or Timber Licences) for comparison based on proximity to each respective community forest (see Table 1). I included all tenures managed by each operator that fell within the same forest district as the community forest in question. BCTS is a provincial program which provides pricing and cost information for the forest industry in BC,

This is done through a system of contractors bidding on cutblocks which BCTS has planned and set up (BCTS, 2011). As sound forest management is central to the mandate of BCTS, and many of the stakeholders I interviewed used BCTS logging as a reference point for evaluating forestry, I have included them in my analysis.

Table 1: Triplets of conventional and BCTS tenures used as comparisons to each respective community forest included in the study

Community Forest	Conventional Tenure	BC Timber Sales
Revelstoke Community Forest Corporation (**RCFC**)	Louisiana-Pacific Corp. (**LP**) TFL/FL/TL	Okanagan-Columbia BCTS office
Likely-Xats'ull Community Forest (**LXCF**)	West Fraser Timber Co. Ltd.(**WF**) FL	Cariboo-Chilcotin BCTS office
McBride Community Forest Corporation (**MCFC**)	Carrier Lumber Ltd. FL	Kamloops BCTS office
Creston Valley Forest Corporation (**CVCF**)/Harrop-Procter Community Forerst (**HPCF**)	Tembec Inc. FL	Kootenay BCTS Office

The Revelstoke Community Forest Corporation (RCFC) operates Tree Farm Licence (TFL) 56, located north of the City of Revelstoke in the Columbia Forest District. While not formally part of the province's community forest program, this operation is none the less managed by the town of Revelstoke and is being treated as a CF. BCTS operations in this area are managed by the Okanagan-Columbia BCTS office, and the conventional operator included in this

area is the Louisiana-Pacific Corporation (LP), which manages TFL 55, Forest Licence (FL) A17645, Timber Licence (TL) T0597, and TL T0541. The Likely-*Xats'ull* Community Forest (LXCF), Community Forest Agreement (CFA) K1L, is located around the town of Likely and on the traditional territory of the *Xats'ull* First Nation, and lies within the Central Cariboo Forest District. The Cariboo-Chilcotin BCTS office manages timber sales operations in this district, and West Fraser Timber Co. Ltd. (WF) is included here as a conventional operator, managing FL's A20017, A31490, A20020, A20018, A20021, A55902 and A55906. In the Headwaters Forest District, the McBride Community Forest Corporation (MCFC) operates CFA K1H, which lies in the area surrounding the town of McBride. BC Timber Sales operations in this district are managed by the Kamloops BCTS office, and Carrier Lumber Ltd. is used as a conventional comparison (FL's A15429 and A70174). Finally, both the Creston Valley Community Forest Corporation (CVCF), which now holds a CFA but operated FL A54214 during the period for which data were collected for this study, and the Harrop-Procter Community Forest (HPCF), are located in the Kootenay Lake Forest District, along with the Kootenay Timber Sales Office. The conventional tenure to which both of these community forests are compared is Tembec Inc., which holds FL A20212.

Data Collection/Analysis

In order to compare the forest practices of community forests, BCTS, and conventional tenures, I collected data both through use of Ministry of Forests and Range silviculture and harvesting records associated with the Ministry's online reporting requirements for all tenure holders (BCMoF, 2008), as well as through semi-structured interviews with stakeholders in each area included in the study.

Quantitative Analysis

Obtaining useful provincial harvesting and silviculture data was difficult, and required significant assistance from MoF staff due to issues such as access restrictions to Ministry information databases, and data generation functions of these databases not being set up for research purposes. My efforts in this regard eventually led me to the MoF's Reporting Silviculture Updates and Land status Tracking System (RESULTS) database, used by the Ministry to track licensees' silviculture activities through electronic data submissions. This database best suited my research goals in that it stores harvesting and silviculture data on every forest disturbance each licensee in the province initiates, until a free-growing, or fully regenerated, stand is achieved (BCMoF, 2008). Data were obtained from RESULTS using the application's report-generating functions (a full

description of the RESULTS data generation procedure employed is included in Appendix A).

I compiled harvesting and silviculture data on a cutblock basis, and included all activities commenced by each licensee from January 1, 2000 up until January 1, 2010. This was done using the outputs of RESULTS report-generating functions, and through compiling values for a list of selected metrics (see Table 2). I chose metrics based on review of scientific literature discussing ecosystem health and ecological sustainability, tenure management plans, and stakeholder interviews. These proxy measures fall into the general categories of silviculture systems used, post-harvest stand structure, and ecological representativeness of harvest. In my efforts to assess the degree to which forest management activities are preserving area-specific ecological norms, these metrics compare characteristics of harvested areas directly to variability in different forest attributes across study areas in the case of representativeness of harvesting metrics, and more indirectly for silviculture system and stand structure metrics, by evaluating the degree to which management approaches support the maintenance of structure and function present.

Table 2: A description of the metrics used to characterize and compare harvesting and silviculture practices amongst licensees.

Metrics	Description
Silviculture Systems Used	The fraction of a licensee's total area across all cutblocks falling under a particular silviculture system. This metric is used to help characterize each licensees stand structural objectives and resource management goals. Silviculture systems included are clearcut (CLEAR), clearcut with reserves (CCRES), selection (SELEC), patch cut (PATCT), intermediate cut (IMCUT), retention (RETEN), and shelterwood (SHELT)
Average Disturbance Size	The mean disturbance area in hectares of all silviculture disturbances across all of a licensee's cutblocks.This metric is used to characterize how large an area generally experiences harvesting activities in each licensees cutblocks
Percent Area With No Reserves	This metric is used to characterize the percent of cutblock area, on average, in which no forest retention occurs. This metric is also used in an equivalent fasion for those areas under the clearcut with reserve silviculture system, in which case it is the mean fraction of each treatment area under the clearcut with reserve system that contains no forest retention.
Percent Area With Dispersed Reserves	This metric is used in an equivalent fashion to percent area with no reserves
Percent Area With Wildlife Tree Patches/Riparian Zones	This metric is used in an equivalent fashion to percent area with no reserves
Harvested Area By Leading Species	The fraction of total disturbance area represented by a particular leading tree species. This metric is used to compare each licensee's harvesting profile to the species profile naturally occurring in the area's timber harvesting land base
Harvested Area By Age Class	This metric is used in an equivalent fashion to harvested area by leading species
Harvested Area By Site Class	This metric is used in an equivalent fashion to harvested area by leading species
Harvested Area By BEC Classification	This metric is used in an equivalent fashion to harvested area by leading species

I conducted statistical analysis using R (Version 2.12-0 2010-10-16, R.app 1.35, http://cran.r-project.org/). I compared silviculture system choices using multinomial logistical regression (a model which predicts the probability of an event occurring, in this case, a particular silviculture system being employed), the results of which are reported in terms of log odds ratios. Log odds ratios here represent how much greater or lower the odds are for a CF to choose each alternative silviculture system over the clearcut system, compared to their counterparts. I compared average *disturbance area* associated with harvesting and stand structure characteristics (both for total area harvested and for clearcut with reserve blocks specifically) between tenures using the Wilcoxon rank-sum test, which determined whether CF's had significantly larger or smaller values for each metric than their counterparts. And finally, I compared metrics used to assess representativeness of harvesting across licensees, including harvest area by leading species, age class, site class, and BEC classification, using exploratory data analysis approaches. This was done, in light of the fact that all harvesting profiles differed significantly from associated THLB profiles, in an attempt to characterize those differences in a more illustrative manner. I used Chi-square distances to compare the degree of difference between the representativeness of each licensee's harvesting profiles. Chi-square distances are simply a method of representing the degree of similarity between two entities as physical distance. Following this, I employed Principle Coordinates Analysis (PCoA) to visualize these differences by producing ordination graphs which

arrange licensees in two-dimensional space in a manner that best captures chi-square distances between respective licensees, as well as between licensees and the THLB itself. It should be noted that, as THLB data for all licensee's operating areas were not available, district THLB data were used in this study.

Qualitative Analysis

Our research team conducted the majority of stakeholder interviews over a 3 month period in the summer of 2009, through five two-week long field visits to each of the community forests included in the study subset. We collaboratively interviewed a total of 75 subjects, averaging 15 interviews in each of the research areas. Interviews were done by two or more researchers in most cases, were recorded, and were transcribed by the research team or a transcription company. Stakeholders interviewed included a wide range of CF and conventional tenure staff, Ministry of Forest employees, and community members in each area. Our subjects included forest managers and loggers for each operation, as well as board members from each CF's board of directors. Other interview subjects included representatives from environmental groups and businesses in each area, woodlot owners, mill managers, tree planters, and forest users such as trappers.

I employed a grounded theory approach (Strauss and Corbin, 2008) as a rough guide during analysis of interview results, employing some of the methodologies described by Strauss and Corbin (2008). This involved coding

interview transcriptions in order to identify and classify common concepts related to forest practices, and characterizing sub-categories of these concepts. The purpose of this approach was to inform my selection of criteria to address through quantitative analysis, but also to provide a qualitative context for those results obtained through analysis of the RESULTS data.

During semi-structured interviews, I iteratively developed and employed a set of standard questions above and beyond unstructured dialogue with interviewees. These standard questions included:

(a) inquiry into interviewees' perspectives on how forest management should be evaluated from an ecological, or forest health, perspective;

(b) whether and how CF's differed from other tenures in the area in terms of forest management practices;

(c) what specific CF practices were viewed as representing ecologically sustainable forest management;

(d) what areas of CF management could be improved upon; and finally,

(e) how interviewees felt about the CF program provincially in terms of facilitating more ecologically-based forest management.

The purpose of asking interviewees to explain how they would evaluate forestry was to develop an understanding of local perceptions of successful forest management, and to contribute to information taken from scientific literature and tenure management plans used to inform my choice of sustainable

management metrics. As the social context of forest management, and local goals and objectives, are crucial in defining successful management (Pokharel et al., 2010), this is important in evaluating community forestry, and potentially developing future indicators that community forests may use. I used questions regarding comparisons between the forest practices of CF's and other tenures to add an additional dimension to the analysis of RESULTS data, allowing for comparisons of local perspectives and Ministry data. Through questions about sustainable practices of licensees', and areas needing improvement, I aimed to develop a sense of some of the obstacles community forests are encountering, what successes they are experiencing, and what conditions and situations may lead to each. And similarly, I explored interviewees' views surrounding Community Forest Agreements as a tenure type in an attempt to reveal elements of the tenure that do indeed facilitate more ecologically-based forest management, and those areas that may be improved upon.

Results

Qualitative Analysis

Interview results revealed trends both in how interview subjects believed forestry should be evaluated, as well as how each Community Forest performed in terms of the ecological sustainability of their management practices. In all cases, except for the Harrop-Procter Community forest, the majority of interview subjects, when responding in a general way, expressed the view that there were no major differences between community and non-community tenures in terms of forest management practices. However, in most cases when specific issues were being reflected upon, CF's were thought to be performing better than their counterparts, and were praised by the majority of interviewees. This was particularly evident for comments regarding harvesting, silviculture, and post-harvest structural features.

Throughout my interview results, I consider those responses I have reported on to be significant. They reflect the views of people who are most closely involved with those forestry operations being discussed, and who experience the outcomes and repercussions most intimately. Where interviewees responded in a consistent manner with regards to a particular issue, I have interpreted this as being significant even if only a few interviewees commented. As we made our interview pool in each community as inclusive and diverse as

possible, the fact that no dissenting views were raised in these instances is an important indication of community sentiment. In cases where interview subjects were divided in their perspectives on a particular issue, this is significant in identifying management practices for which there does not appear to be consensus in the community. In these instances, more discussion between community forest staff and community members may be required, and perhaps a refinement of approaches or strategies that better address the various interests in each community.

Evaluating Ecological Sustainability

Interviewee perspectives on how forest management should be evaluated fell into 4 general categories:

(a) harvesting and silviculture practices,

(b) the importance of particular post-harvest structural features,

(c) the environmental impacts of harvesting activities, and

(d) broad-scale management and planning approaches.

Some common themes emerged from the harvesting and silviculture practices that interviewees identified as important evaluation tools. Many interviewees across sectors and tenure types discussed silviculture system usage as an important determinant of the quality of forest management. Almost all who raised the issue believed that silvicultural alternatives to clearcutting were an indicator of quality stewardship (either exclusively or in conjunction with some

clearcutting). Interviewees also raised the importance of employing a diversity of prescriptions, as well as harvesting a diversity of species in a variety of different biogeoclimatic units. Similar concepts that were repeatedly raised were the issues of “cutting the profile” and avoiding high grading. These issues about silviculture systems and harvesting profiles were readily analyzed using data from the RESULTS database. Some issues surrounding harvesting and silviculture practices which were raised by interviewees were not readily analyzed through RESULTS. These included the harvesting method and equipment employed, and the idea that these choices should be informed by site-specific characteristics. Proper reforestation, minimization of waste, maintaining safe operating sites, and the harvest of non-timber forest products, were other evaluative criteria that emerged during interviews for which RESULTS data were not available.

Post-harvest structural features were also an important issue for interviewees. The most commonly raised points in this regard were the importance of retention for purposes such as structural diversity, coarse woody debris (CWD) recruitment, natural seed sources, and reserves for riparian protection, biodiversity, and wildlife habitat. These general themes were represented in RESULTS data in several variables (percent area designated as wildlife tree patch/riparian reserve, dispersed reserve, and no reserve area). While these RESULTS data were able to address some of the subtleties surrounding retention and reserves brought up by interviewees, such as whether

reserves were of dispersed or group types, other such subtleties were not assessable using RESULTS. This included aspects of stand structure such as the retention of ecologically important species, snags, and coarse woody debris, the removal of unhealthy trees, whether reserves were internally located in cutblocks, and connectivity. Finally, the importance of creating small openings was raised by interviewees, for reasons such as these smaller areas leading to blowdown prevention and decreased snowmelt, and this issue was represented in RESULTS using average disturbance size.

The environmental impacts of harvesting activities were brought up very often by interview subjects, but unfortunately not open to investigation in RESULTS. Most important for licensees here were the issues of soil disturbance and minimizing road/trail impacts. Visual quality was raised by some interviewees, but more often as something that should not be taken into account as an important element of management (e.g. in comparison to substantive environmental issues). The issue of avoiding blowdown was also raised several times.

Finally, many interviewee responses to the question of how to evaluate forestry fell into the general category of broad-scale management and planning decisions, the importance of managing for the long-term, and plan implementation. Those management approaches that interviewees expressed as being desirable included managing for resilience, managing for multiple values, the application of ecosystem-based management, and the precautionary

principle. Certification and monitoring were also seen as important elements of sound forest management, as well as the importance of taking into account fire hazard reduction and economic considerations.

Interviewee Responses – Revelstoke Area

In the Revelstoke area, 11 interviewees commented on whether there were differences between the forest management of the Revelstoke Community Forest (RCFC) and their counterpart. Seven of these interview subjects believed there were no such differences, with almost half of respondents stating that real differences are not caused by different tenures types, but by the nature of the individuals doing the logging. However, 2 of these 11 respondents did feel RCFC was “more sustainable”, or “better environmentally”, than their counterparts, with an additional 2 interviewees also voicing the opinion that both RCFC and LP were managing their operations better than BCTS in the area. RCFC staff, both managerial and operational, were identified by 3 interview subjects as very knowledgeable, and one interviewee asserted that the CF had generally raised standards in the Revelstoke area. Two other specific comments made by interviewees were that the CF is going beyond provincial requirements, and is successfully balancing environmental and economic issues.

In terms of specific issues surrounding harvesting and silviculture, interviewees had consistently positive opinions of RCFC's practices. Five of those 11 interviewees who commented on harvesting practices made specific reference to RCFC more closely harvesting the profile and not high-grading, and

5 stated that RCFC was more likely to employ alternative harvesting techniques such as longline and helicopter logging, than their counterpart tenures. One interview subject also commented that the CF was attempting to mimic local natural disturbances such as avalanches, for visual quality objectives. Nine interviewees commented on silvicultural issues in particular. Of these, 2 respondent felt all tenures in the area were doing mostly clearcutting or clearcutting with reserves. However, 5 believed RCFC was doing more partial cutting and employing a greater diversity of prescriptions than their counterparts, and basing these decisions on site appropriateness. One interviewee in particular characterized RCFC as making a “big move” to alternative silviculture systems. Finally, 2 of these 9 interview subjects stated that RCFC was doing a good job planting a diversity of species.

The 3 interviewees that commented on issues of post-harvest stand structure described both successes on RCFS's part, as well as areas requiring improvement. For instance, while 1 interviewee saw the CF as successfully leaving coarse woody debris and legacy trees, 2 interviewees believed RCFC was generally not doing enough to ensure stand structure reflected ecological issues. An example provided during one interview was that RCFC was not ground-truthing reserves, meaning they may end up in areas that were not ideal ecologically.

Three interview respondents spoke to the impacts of harvesting activities in the Revelstoke area. One of these 3 interviewees stated that RCFC was

minimizing the impact of road-building to a greater degree than their counterparts. In terms of the impact of harvesting on wildlife populations, 1 interviewee believed that although RCFC was harvesting with the goal of improving habitat in mind, there were cases where these efforts had instead degraded the habitat in question. Another area of potential improvement raised by 1 interview subject was the need for RCFC to do more to protect advanced regeneration.

Finally, 4 interview subjects discussed broad-scale management approaches. Of these, one interviewee believed RCFC was better managing for the long term that their counterpart operations, and 2 others praised RCFC for their forest health monitoring efforts and SFI certification. However, this was tempered by the opinion of 1 interview subject that the CF still needs to work more towards strategic planning and monitoring goals, and another who stated that the CF needs to develop more areas across their land base managed for values other than timber.

Interviewee Responses – Likely Area

Eight interviewees in the Likely area commented on whether or not there were general differences in management between the Likely-Xats'ull Community Forest (LXCF) and their counterparts. Five of these interview subjects felt that all tenures were managing in a status quo fashion due to factors such as financial constraints and the mountain pine beetle epidemic. These respondents suggested that, although LXCF aims to manage above and beyond provincial

requirements, it does not. However, the remaining 3 interviewees who commented believed LXCF was “more sustainable”, had a “different footprint” on the ground, and was more similar to woodlots than conventional tenures. These differences of opinion were reflected in the range of comments made regarding specific aspects of LXCF's management.

With regards to harvesting and silviculture, as with RCFC, interview subjects consistently praised LXCF's management. One interviewee believed the CF was more in touch with fine-scale ecological variation, and another stated LXCF was less likely to harvest healthy trees during salvage operations. All three interviewees who spoke to the issue of silviculture system use believed that LXCF employs more alternative silviculture techniques, and one respondent also stated that LXCF plants more of a diversity of tree species when conducting reforestation than their counterparts.

Eleven interviewees commented on post harvest stand structure, and again had largely positive comments regarding LXCF's practices. Seven of these 11 interviewees felt LXCF is retaining more forest structure, such as single trees, reserves, and coarse woody debris, than their counterparts, with only 1 respondent stating their was no difference is reserve levels between tenures. While one respondent stated specifically that LXCF was going above and beyond provincial reserve regulations, another made a similar comment regarding West Fraser (WF).

In terms of the impacts of harvesting activities, 4 interviewees had opinions regarding the CF's practices. One interviewee believed LXCF was more concerned about issues such as ground compaction than their counterparts, and another provided the example of bridges being used instead of culverts to demonstrate that the CF was exceeding provincial requirements. Two interviewees also spoke to examples of harvesting impacts that both LXCF as well as West Fraser were experiencing, namely blowdown.

Speaking to broad planning issues, the majority of the 5 interview subjects that responded had positive comments to make. Examples of this positive feedback were that LXCF is using longer rotations and investing more profits back into ecosystem health than their counterparts, and one respondent praised the CF for research into NTFP use. However, areas of potential improvement that were raised by two interviewees included LXCF not doing enough to practice ecosystem-based management, and not conducting any monitoring of harvesting impacts.

Interviewee Responses – McBride Area

There were particularly divergent views of the McBride Community Forest Corporation's (MCFC's) management performance in comparison to their counterparts and in relation to their successes and practices requiring improvement. General interviewee impressions of differences between tenures ranged widely, with 2 of the 6 interviewees who commented believing MCFC has “the best” forest practices and is a “much better steward” than other tenures in

the area, and 3 other respondents stating MCFC is “worse than conventional tenures”, with MCFC's small harvest program singled out in particular in this regard. The small harvest program was set up to create harvesting opportunities for local loggers, by allowing them to suggest potential small harvesting areas to the CF management board that do not necessitate the permitting and planning requirements of larger cutblocks. One interview subject also stated that there was no difference between MCFC and their non-community counterpart tenures.

The harvesting practices of MCFC generated many strong opinions from interviewees, who raised a range of important issues. Individual respondents raised points such as MCFC logging more slowly, and taking more site specific conditions into account than their counterparts, although one interview subject also stated that economic factors during the early years of the CF's history necessitated harvesting at too high a rate. Other positive evaluations of MCFC's harvesting practices included one interviewee highlighting their greater use of alternative harvesting methods such as skyline and highlead systems, and 2 other interviewees speaking to the generation of less waste, than their counterparts, although these comments appeared to be mainly addressing harvesting done outside of the CF's small harvest program.

Much of the criticism surrounding MCFC's harvesting was either explicitly made in reference to the CF's small harvest program, or appeared to have been in reference to this. These criticisms were largely related to the issue of high grading. In this regard, it was suggested by one interviewee that the small

harvest program would benefit from training for those conducting harvesting under these small harvest agreements. In addition, 2 other respondents identified examples of specific operational incidents, including some of these operators being suspended from the CF work for poor practices and inappropriate equipment being used. Concerns were by no means limited to the operational level, as 4 interviewees suggested that the MCFC board hasn't properly addressed the issue of CF high grading, and that the board could benefit from greater involvement of those who could contribute additional forest management knowledge. In spite of all this, one interviewee commented that the added flexibility afforded to those logging for MCFC under current management arrangements was welcome.

Finally, one other concern over harvesting decisions was brought up above and beyond the small harvest program. This involved an interviewee asserting that MCFC had not followed through with a Forest Practices Board recommendation to which they had previously agreed to abide by. The specifics of this recommendation involved a 10 year harvesting moratorium in the Interior Cedar-Hemlock zones between Prince George and Mount Robson Provincial Park.

As with RCFC and LXCF, interview subjects in the McBride area had mainly positive comments regarding MCFC's silviculture practices. For instance, all 6 respondents speaking to silviculture system use were of the opinion that the CF employs more alternative silviculture systems than their counterpart tenures.

Three interviewees also noted that MCFC employs more preferable planting practices than BCTS and Carrier, with examples such as MCFC planting a diversity of species and planting the profile given. One area of potential improvement that was raised by one interview subject was the need for the CF to improve upon the extent to which site-specific factors inform silviculture prescriptions.

Comments surrounding post-harvest structure on MCFC cutblocks centred around differences in criteria used to determine what trees would be retained. Three interviewees stated that conventional operators “take more out” than the CF. Other specific comments included that MCFC's counterparts only retain non-merchantable trees, while the CF uses broader criteria, and during salvage operations other operators remove healthy trees as well as those designated for salvage, while MCFC does not. It was also stated in one interview, though, that MCFC does not protect reserves to the same extent as their counterparts.

A common theme in interviewee comments regarding the impacts of harvesting activities, raised in three separate interviews, was that these impacts were dependent on who was actually doing the logging. In this context, MCFC was identified by 2 interview subjects as often having a greater environmental impact in terms of issues related to water quality and site contamination, due to practices such as skidding over creeks, and chemical spills. This being said, one interviewee also felt that MCFC was going above and beyond requirements for riparian management zones.

Finally, the nature of comments regarding broad planning issues was again dependent on whether interviewees were speaking of the CF as a whole, or the small business program in particular. For instance, one interviewee commented that MCFC has a less “commercial logging” mindset than their counterparts from a planning perspective, and another was of the opinion that MCFC employs the precautionary principle with regard to water management issues (which contradicts the operational-level critiques listed above). However, logging conducted under the small harvest program was identified by 11 different interviewees as entailing poor long term and landscape-level planning, with specific comments including a lack of appropriate silviculture obligations or written rules, and no monitoring being conducted by CF staff in order to ensure any standards are being met.

Interviewee Responses – Creston Area

In the Creston Area, 5 interviewees spoke to the issue of comparing CF management practices to their counterparts. Of these, 4 stated there was currently no difference in practices and 1 stated the CF was “much better”, but all 5 believed that any differences between CVFC and their counterpart tenures were contingent on CF management staff. In this regard, two of these interview subjects were of the opinion that there have been times when there is no difference between management strategies of CVFC and their counterpart tenures, and times when CVFC is performing much better.

In terms of harvesting in particular, interview subjects expressed mixed feelings regarding CVFC's practices. CVFC was thought to generally harvest less by one interviewee, and to be less focused on a strictly “timber paradigm” of timber revenue maximization by another, as compared to their counterparts. Other specific areas that engender positive feedback included one interviewee emphasizing the CF's practice of limbing in the bush in order to return nutrients to the soil, and another discussing the fact that the CF has been avoiding high grading. Some areas interviewees raised where improvements could be made included dealing with issues of blowdown, which was brought up on 2 separate occasions, and excessive waste, raised by one respondent. 3 interviewees also spoke to problems surrounding the mountain pine beetle epidemic, stating that this has shifted CF harvesting more towards higher impact techniques, and also that this issue has spurred logging that would not have otherwise occurred, and may not have been warranted.

Silviculturally, the trend described above for other CF's was mirrored for CVFC. All 5 interview subjects that discussed the use of silviculture systems stated that CVFC was employing more alternative and innovative systems than their counterparts. One area for which an interviewee suggested silviculture improvements could be made was for the CF to ensure that proper restocking occurred following clearcutting.

Responses speaking to post-harvest structure on CVFC cutblocks was consistently positive. One interviewee believed the CF retains more trees and

another stated the CF has smaller cutblocks than their counterparts. In addition, 2 respondents believed that both CVFC and Tembec exceed provincial requirements in areas such as levels of post-harvest CWD. Other specific positive practices noted by individual Interviewees included that CVFC is retaining a diversity of species and age classes in partial cuts, is retaining a representative amount of coarse woody debris on sites, and is going beyond coarse woody debris and wildlife tree patch levels required by the province.

Interviewees also had largely positive perspectives of CVFC's environmental impact, in areas such as water protection, site degradation, and forest health. Three respondents believed the CF is generally doing a good job of protecting watersheds, operating more carefully around waterways and having less of an impact on water quality than their counterparts. However, road building in a particular instance was believed by one interview subjects to have been done too close to a domestic water intake. Four different interviewees praised CVFC for minimizing impact to soil and residual trees, with one in particular noting that the CF takes more account of the conditions under which harvesting is conducted in order to minimize site degradation. However, one interviewee notes the CF was experiencing issues with blowdown. And finally, one interview subject stated the CF was generally addressing forest health issues successfully.

Interviewee Responses – Harrop-Procter Area

As was seen with other CF's, general comments surrounding the Harrop-Procter Community Forest's (HPCF) management were contradictory. While 1 of

the 2 interviewees that commented believed that HPCF was generally managing the same as other licensees, the second respondent pointed out that HPCF employs a more precautionary and ecosystem-based approach to forest management. Reflecting these latter remarks, comments regarding specific practices of the CF were largely positive.

In terms of harvesting and silviculture, 5 interview subjects expressed opinions regarding HPCF. Two interviewees believed HPCF was logging with future value in mind, by harvesting mainly smaller diameter and less healthy trees. However, it was also expressed by one respondent that practices were contingent on management staff, and that some past harvesting by the CF was poorly managed. In addition, 2 interview subjects stated that the CF employs the same mix of clearcutting and retention as other operators in the area.

There were many elements of post-harvest structure in blocks under HPCF management that were praised by interviewees. For instance, the CF was seen by one interviewee as having smaller cutblocks, and by another as having wider riparian management zones, than their counterpart non-community tenures. Other specific activities praised by individual interviewees included the CF topping, limbing, and leaving debris within harvested blocks for ecological reasons, employing ecological guidelines in determining reserve size and location, and retaining more wildlife trees than required. Alternative assessments of some of these practices, however, included one respondent believing that HPCF is leaving too much debris on the ground, resulting in fire hazard, and

another stating that the CF is in fact retaining too much, to the detriment of wildlife requiring more open forest habitat. Interviewees generally had little to say about the environmental impact of HPCF's harvesting, although one comment made was that CF harvesting was having a lesser impact on water quality than BCTS operations in the area.

From a planning perspective, interviewee feedback of HPCF's management was largely positive. The CF was viewed by 2 interviewees as excluding more of their land base from harvesting, and by two others as doing more to practice ecosystem-based management than their counterparts. Other positive comments included one respondent praising the CF for possessing Forest Stewardship Council certification, and even going beyond these resulting requirements, and another emphasizing that HPCF was conducting monitoring to assess understory response to selective cutting. One interviewees did note that fire management issues have not been addressed adequately.

Quantitative Analysis

Silviculture Systems

I considered seven of the most commonly employed silviculture systems in B.C. in my analysis, including clearcutting and six alternative systems. These included *clearcut with reserves*, *selection*, *patch cut*, *intermediate cut*, *retention*, and *shelterwood* systems. I analysed silviculture system data by *treatment area*, which is a defined area within a cutblock under one particular silviculture

prescription. Each treatment area represented one sample in my analysis, and each was weighted based on size in hectares. Sample sizes for each tenure are included in Appendix B. The Harrop-Procter Community Forest was not included in the qualitative analysis portion of my research due to a lack of harvesting and silviculture data available through the RESULTS database.

I use multinomial logistic regression here as a model to predict the probability of certain silvicultural decisions being made by tenure holders. The results of this model suggest that there were significantly higher odds that each community forest would employ alternative silviculture systems as opposed to clearcutting, when compared to both conventional and BCTS counterparts (see table 3 and figure 1). As discussed above, I made comparisons of how likely each tenure holder is to employ silvicultural alternatives to clearcutting in terms of log-odds ratios. I calculated these odds for each tenure holder in a given comparison using the ratio of “successes” to “failures”, or in this case, the ratio of samples in which alternative silviculture systems were used to samples in which clearcutting was used. I then used the ratio of odds for two tenure holders to represent how much more likely one tenure holder is of using an alternative silviculture system in a given treatment area. I use the logarithm of this ratio in order to produce negative values for cases in which CF's are less likely to employ alternative silviculture, in order to generate more easily interpretable results.

While all CF's were more likely than their counterparts to employ alternative silviculture systems, results for each particular system varied across

community forests. In the Revelstoke area, RCFC demonstrated significantly higher odds of employing *clearcut with reserves*, *selection*, *patch cut*, and *intermediate cut* systems than both BC Timber Sales and Louisiana Pacific, with the exception of having lower odds than LP of conducting intermediate cutting (log-odds ratios for each CF are listed in Table 3). LXCF had significantly higher odds of employing *clearcut with reserves* and *selection* systems than both BC Timber Sales and West Fraser. In the Headwaters District, while MCFC was found to have lower odds of employing the *selection* system than Carrier, it was significantly more likely to employ the *retention* system than both BCTS and Carrier. And finally, when compared to both their conventional counterpart and BC Timber Sales, CVCF showed significantly greater odds of employing *selection*, *patch cut*, and *shelterwood* systems. In addition, CVCF had greater odds than Tembec of employing intermediate cutting.

Table 3: Log odds ratio results from logistic regression model, with significant (α= 0.05) results shaded. The log odds ratio is the natural log of the odds ratio, which represents how much greater (+) or lower (-) the odds are for CF's to choose each of the listed silviculture systems over the *clearcut* system, compared to their counterparts.

	CCRES	SELEC	PATCT	IMCUT	RETEN	SHELT
RCFC						
BCTS	1.91	3.15	2.2	1.19	-	0.69
LP	0.83	2.16	2.66	-0.88	-	-0.81
LXCF						
BCTS	2.17	3.61	-	-	-	-12.28
WF	2.85	3.92	-	-	-	-12.89
MCFC						
BCTS	0.19	-2.49	-3.51	-	6.6	-2.00
Carrier	-1	-5.99	-	-	4.33	-
CVFC						
BCTS	0.78	5.59	6.64	2.11	2.77	5.46
Tembec	1.32	9.28	7.61	6.47	3.84	9.24

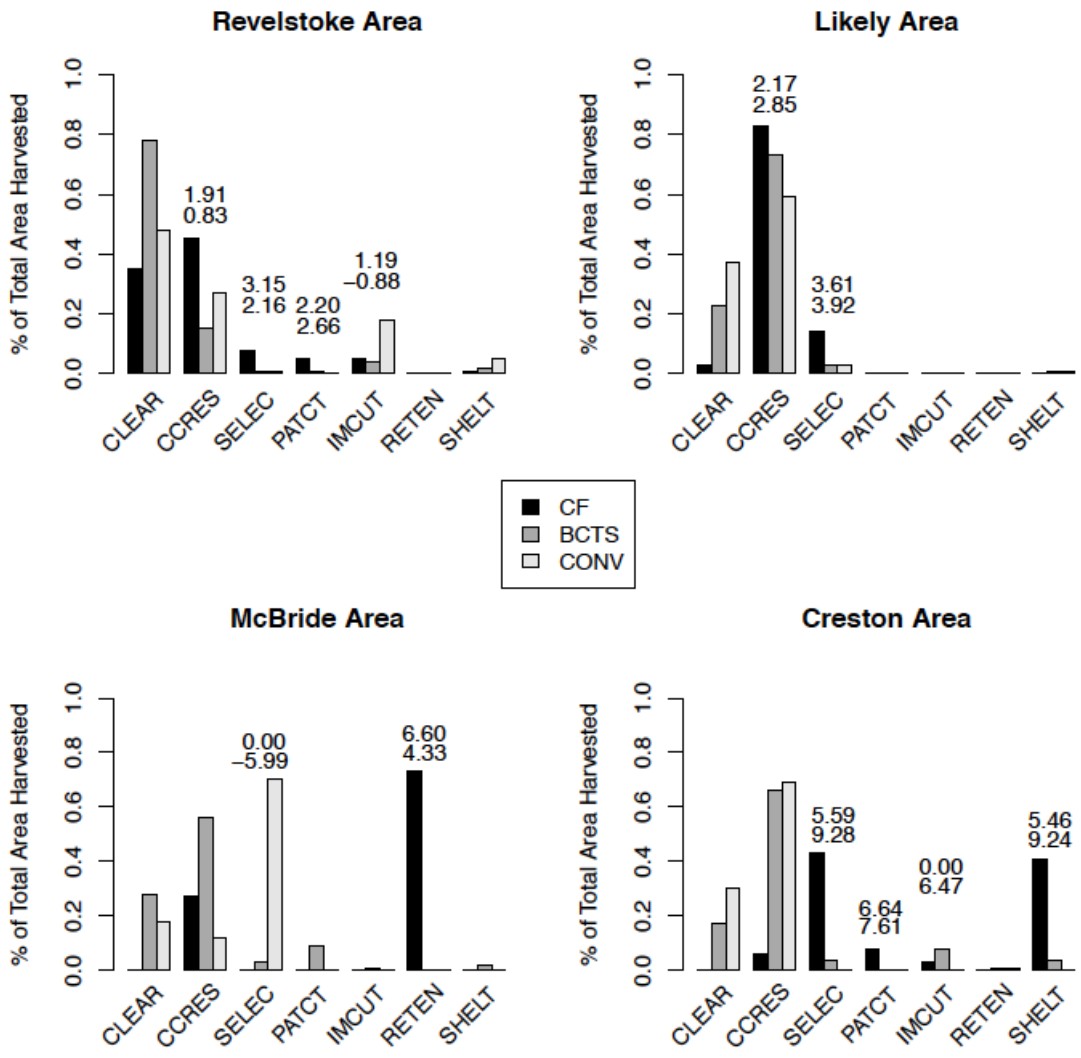

Figure 1: A comparison of silviculture system usage across tenures. Significant (α= 0.05) log odds ratios are included above columns, with those demonstrating higher/lower odds of CF's employing alternative silviculture taking positive/negative values respectively

Post-harvest Cutblock Structure

In comparing post-harvest structure among tenure holders, I collected data on cutblock averages for *disturbance area*, areas with no form of reserves, areas containing *dispersed reserves*, and *wildlife tree patch* (*WTP*) areas. Each cutblock represented one sample in the analysis, and results are reported in terms of whether significant differences existed between tenures being compared (see Table 4). *P*-values, which provided a numerical summary of Wilcoxon rank-sum test results and must fall below 0.05 (ie $\alpha = 0.05$) in order to demonstrate significance, are also provided in Appendix C. Sample sizes for each tenure holder are listed in Appendix D, and mean and standard deviation values are listed in Appendix E (for all cutblocks) and Appendix F (for areas managed under the *clearcut with reserves* system).

The results generated from comparing disturbance size and stand structure amongst tenures using the Wilcoxon rank-sum test were more varied than those comparisons of silviculture system use. For some metrics, such as *disturbance area* and *dispersed reserve area*, CF's generally performed in ways that represented more ecological sustainable management than their counterparts. However, in other cases, and particularly for *WTP area*, CF's consistently underperformed.

Much of the stand structure data for RCFC suggest the community forest harvesting smaller areas and maintaining greater retention levels than their counterparts, but exceptions exist (see Table 4 and Appendix C). RCFC has smaller overall *disturbance areas* than LP, but there is no significant difference in

disturbance size between RCFC and BC Timber Sales. In terms of stand structure across all disturbances, RCFC possesses more area under *dispersed reserve* than BC timber sales and Louisiana Pacific, and less area containing no reserves than both of these counterparts. However, the CF has less area designated as *wildlife tree patch reserve* than BCTS. For areas managed under the *clearcut with reserves* system, the data suggest that RCFC has more dispersed reserve areas than both BC Timber Sales and LP. However, RCFC possesses more area under no form of reserve and less area designated as *wildlife tree patch area* than BCTS. As the *clearcut with reserves* system has accounted for much of RCFC's harvesting, this represents an area for potential improvement of forests practices.

In contrast to those results for RCFC, LXCF either underperformed or showed no significant difference when compared to their counterparts for all metrics used (see Table 4 and Appendix C). Comparisons between LXCF and their conventional and BCTS counterparts demonstrated no significant difference in disturbance area. Stand structure comparisons across all disturbances, as well as for clearcut with reserve blocks in particular, revealed less wildlife tree patch area, on average, than both counterpart tenures. In the case of LXCF, 83 percent of harvested areas were harvested using the *clearcut with reserves* system, making residual stand structure under this type of management very important to the community forest's overall operation.

In comparing the McBride Community Forest to BC Timber Sales and Carrier Lumber, the CF largely under-performed when compared to its counterparts (see Table 4 and Appendix C). The data again demonstrated no significant differences in size of *disturbance area* between community and non-community tenures. MCFC also averaged less designated *wildlife tree patch area* than both its counterpart tenures and more area under no form of reserve than Carrier Lumber. Within cutblocks in which the *clearcut with reserves* system was employed, which comprised 27 percent of harvested area, MCFC once again was found to have more area under *dispersed reserves* than Carrier, but less area designate as *wildlife tree patch* and more area under no reserve type than BCTS.

Finally, in the case of CVCF, results showed either no difference between the community forest and its counterparts, or CVCF under-performing (see Table 4 and Appendix C). Wilcoxon rank-sum test results indicate that *disturbance areas* were generally larger than those of BCTS. Across all cutblocks, CVCF had less area designated as *dispersed reserves* and *wildlife tree patch areas*, and more area under no reserve designation. Those CVCF cutblocks managed using the *clearcut with reserves* system were found to have more area under no reserves than Tembec. However, only six percent of the community forest's harvesting was done using this silviculture system.

Table 4: Wilcoxon rank-sum test results comparing disturbance characteristics across tenures. Each row represents a particular community forest, with columns detailing whether these CF's display significantly (α=0.05) higher (>), lower (<), or similar (=) values for each metric. Those entries with a checkmark/"x" are cases in which each respective community forest is harvesting using methods more/less associated with current ideas of sustainable forestry, such as smaller cutblock sizes and more/varied residual structure. The percent of each community forest's harvested area under the clearcut with reserve system is also shown, to provide a reference for the extent of those associated metrics.

		RCFC	LXCF	MCFC	CVFC
All Blocks	Disturbance Area	= BCTS < status quo ✓	= BCTS = status quo	= BCTS = status quo	> BCTS × = status quo
	No Reserve Area	< BCTS ✓ < status quo ✓	= BCTS = status quo	= BCTS > status quo ×	> BCTS × > status quo ×
	Dispersed Reserve Area	> BCTS ✓ > status quo ✓	= BCTS = status quo	= BCTS > status quo ✓	< BCTS × < status quo ×
	WTP Area	< BCTS × = status quo	< BCTS × < status quo ×	< BCTS × < status quo ×	< BCTS × < status quo ×
	% under clearcut w/ reserve	45	83	27	6
CCRES Areas Only	No Reserve Area	> BCTS × = status quo	= BCTS = status quo	> BCTS × = status quo	= BCTS > status quo ×
	Dispersed Reserve Area	> BCTS ✓ > status quo ✓	= BCTS = status quo	= BCTS > status quo ✓	= BCTS = status quo
	WTP Area	< BCTS × = status quo	< BCTS × < status quo ×	< BCTS × = status quo	= BCTS = status quo

Representativeness of Harvesting

In order to compare the ecological representativeness of harvesting between tenure holders, I characterized this harvesting by leading species, age

class, site class, and biogeoclimatic zone (the primary ecosystem classification system used in B.C., see Meidinger and Pojar, 1991). I then measured differences between each of these harvesting profiles and equivalent profiles of the timber harvesting land bases in which each tenure was located, using chi-square distance (which is simply a means of representing dissimilarity, where larger chi-square distances represent more dissimilarity). The timber harvesting land base in each forest district that harvesting profiles are compared to is the entire forested land base in that district available for the long term timber supply. As with Wilcoxon rank-sum test results, exploratory data analysis using chi-square distances (see Figures 2 – 5), as well as Principal Coordinates Analysis (see Figures 6 – 9), also demonstrated a large degree of variability in CF relationships to their counterpart tenures, depending on what metric was being compared, and what CF was being investigated (for a list of chi-square distances for all licensees and metrics, see Appendix G).

In the Revelstoke area, results varied by harvesting profile. Chi-square distances between tenures and the THLB varied from 1.11 to 1.28 for area by leading species (see Figures 2d and 6a), with RCFC possessing the largest distance and therefore following the THLB species profile the least. As compared to BCTS and LP, RCFC's harvest was more oriented towards both high-value species such as western redcedar (*Thuja plicata*), and lower-value species including western hemlock (*Tsuga heterophylla*), and subalpine fir (*Abies lasiocarpa*). In contrast, RCFC's counterparts, and LP in particular, harvested

more heavily toward only low-value lodgepole pine (*Pinus contorta*) (see Figures 2a and 6a). Chi-square distances varied from 0.55 to 1.42 for area by age class, with RCFC possessing an intermediate value of 0.99 (see Figures 2d and 6b). RCFC tended to harvest on the more extreme ends of the age class spectrum (both old and young stands), while their counterparts tended more towards intermediate age classes (see Figures 2b and 6a). In terms of area by site class, chi-square distances ranged from 0.50 to 0.68. Here, the smallest distance occurred between RCFC and the THLB, suggesting the CF is following the site class profile the closest (see Figures 2d and 6c). Again, RCFC tended to harvest both higher and lower site class values than their counterparts, whose values were more intermediate (see Figures 2c and 6c). And finally, chi-square distances between harvested and THLB BEC classifications ranged from 0.52 to 1.20, with RCFC possessing the largest distance from the THLB (see Figure 6d).

In comparing LXCF to West Fraser and BC Timber Sales, the community forest harvesting profiles were generally more dissimilar to THLB profiles than those of their counterparts. Chi-square distances representing differences in area by leading species ranged from 0.71 to 1.17, with the smallest distance, and therefore most similarity, occurring between LXCF and the THLB (see Figures 3d and 7a). All three tenures harvested much less interior Douglas-fir (*Pseudotsuga menziesii*) than was present on the land base, and harvested more heavily toward low-value lodgepole pine, and in the case of LXCF and WF, spruce (*Picea* spp.) (see Figure 3a). For area by age class, chi-square distances varied

from 0.66 to 1.17, with the largest distance, and least similarity, occurring between LXCF and the THLB (see Figures 3d and 7b). LXCF harvested much more in lower age class areas, and much less in higher age class areas, than both BCTS and WF (see Figures 3b and 7b). Chi-square distances representing differences in harvested and THLB area by site class ranged from 0.48 to 0.98, with the largest distance also associated with LXCF (see Figures 3d and 7c). All tenures, however, appeared to be harvesting intermediate site class areas (see Figure 3c). Chi-square distances for harvest area by BEC classification varied from 0.99 to 2.08, and again, the largest distance occurred between LXCF and the THLB (see Figure 7d).

In the McBride Area, results once again varied by harvesting profile. There were only slight variations in chi-square distances for area by leading species and area by age class (0.92 to 1.01 and 0.94 to 1.05 respectively), and in both cases, MCFC possessed the largest distance and therefore followed the THLB profiles the least (see Figures 4d and 8a/b). Here, MCFC harvested more heavily toward both high-value western redcedar, and lower-value western hemlock and spruce, while both BCTS and Carrier harvested more heavily towards lower-value Douglas-fir and lodgepole pine (see Figures 4a and 8a). Also, the CF harvested younger age classes more heavily, while their counterparts concentrated more on intermediate age classes (see Figures 4b and 8b). In terms of site class, chi-square distances ranged from 0.69 to 0.96, and here the smallest distance, and therefore most similarity, occurred between MCFC and the

THLB (see Figures 4d and 8c). All three tenures appeared to harvest more heavily toward intermediate site classes (see Figure 4c). Chi-square distances varied from 1.1 to 2.27 for area by BEC classification, with MCFC possessing an intermediate value of 1.64 (see Figure 8d).

The Creston Valley Community Forest had harvesting profiles that were generally more dissimilar to THLB profiles than those of their counterparts. The largest distances for area by leading species, age class, and BEC classification all occurred between CVCF and the THLB, with ranges of 0.71 to 1.15, 0.64 to 1.06, and 1.07 to 1.37 respectively (see Figures 5d and 9a/b/d). CVCF harvested more heavily toward both high-value western redcedar and western larch (*Larix occidentalis*), and lower-value lodgepole pine, while BCTS and Tembec harvested more heavily toward low-value species, and specifically lodgepole pine (see Figures 5a and 9a). All three tenures harvested more heavily toward areas with younger age classes (see Figure 5b). In terms of area by site class, chi-square distances ranged from 0.55 to 0.83. Here, the smallest distance occurred between CVCF and the THLB, suggesting the CF is following the age class profile the closest (see Figures 5d and 9c). All thee tenures harvested more heavily toward intermediate site classes (see Figure 5c).

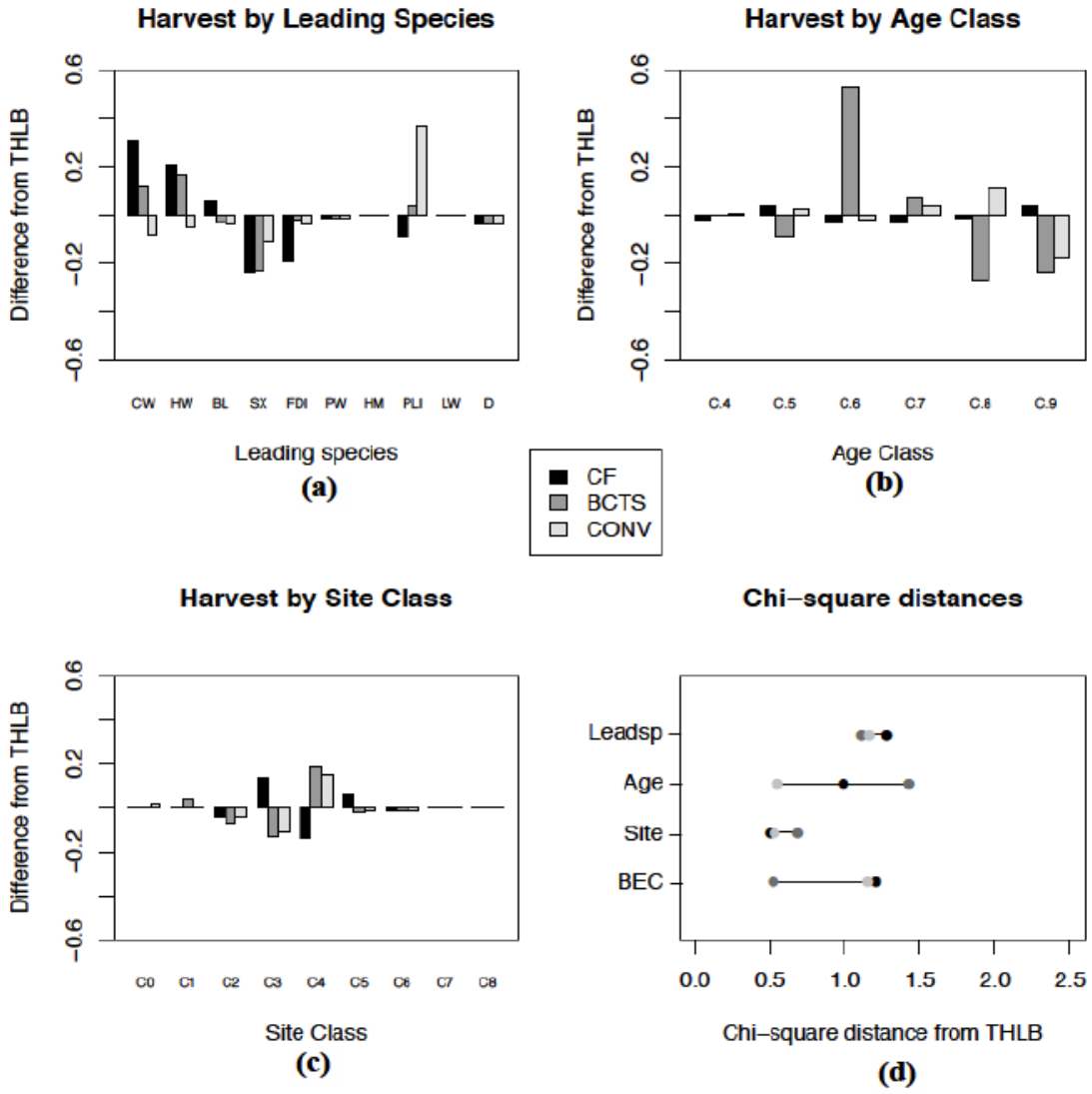

Figure 2: Revelstoke Area percent differences in harvesting and THLB profiles for area by leading species (a), area by age class (b), and area by site class (c). Positive/negative values reflect larger/smaller values than found in THLB for each category. For instance, negative values in graph (a) suggests the percent of total harvesting being done on land where that species is most abundant is less than the percent of the total THLB in which that species is most abundant. For (a), CW = western redcedar, HW = western hemlock, BL = subalpine fir, SX = spruce hybrid, FDI = interior douglas fir, PW = western white pine, HM = mountain hemlock, PLI = lodgepole pine (interior), LW = western larch, D = deciduous. For (b), C4 = 61 – 80 yrs, C5 = 81 – 100 yrs, C6 = 101 – 120 yrs, C7 = 121 – 140 yrs, C8 = 141-250 yrs, and C.9 = 251 yrs. For (c), C0 = site index (S.I) 0 – 2.4, C1 = site index 2.5 – 7.4, C2 = S.I. 7.5 – 11.4, C3 = S.I. 11.5 – 17.4, C4 = S.I. 17.5 – 22.4, C5 = S.I. 22.5 – 27.4, C6 = S.I. 27.5 – 32.4, C7 = S.I. 32.5 – 37.4, C.8 = 37.5 – 42.4. Graph (d) shows chi-square distances for each metric.

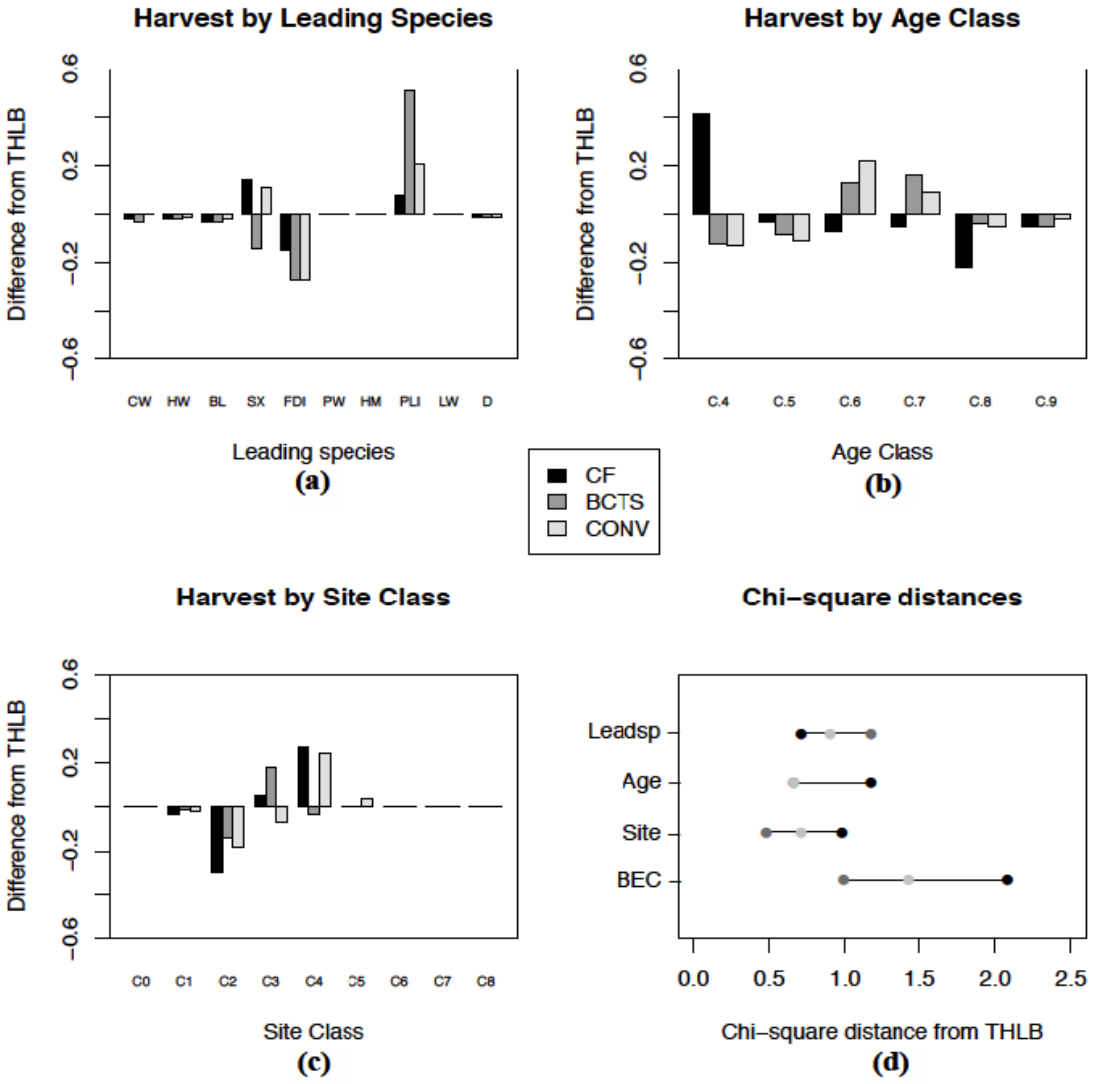

Figure 3: Likely Area differences in harvesting and THLB profiles for area by leading species (a), area by age class (b), and area by site class (c), with positive/negative values reflecting larger/smaller values than found in THLB for each category. Graph (d) shows chi-square distances for each metric. For x-axis category definitions, see Figure 2.

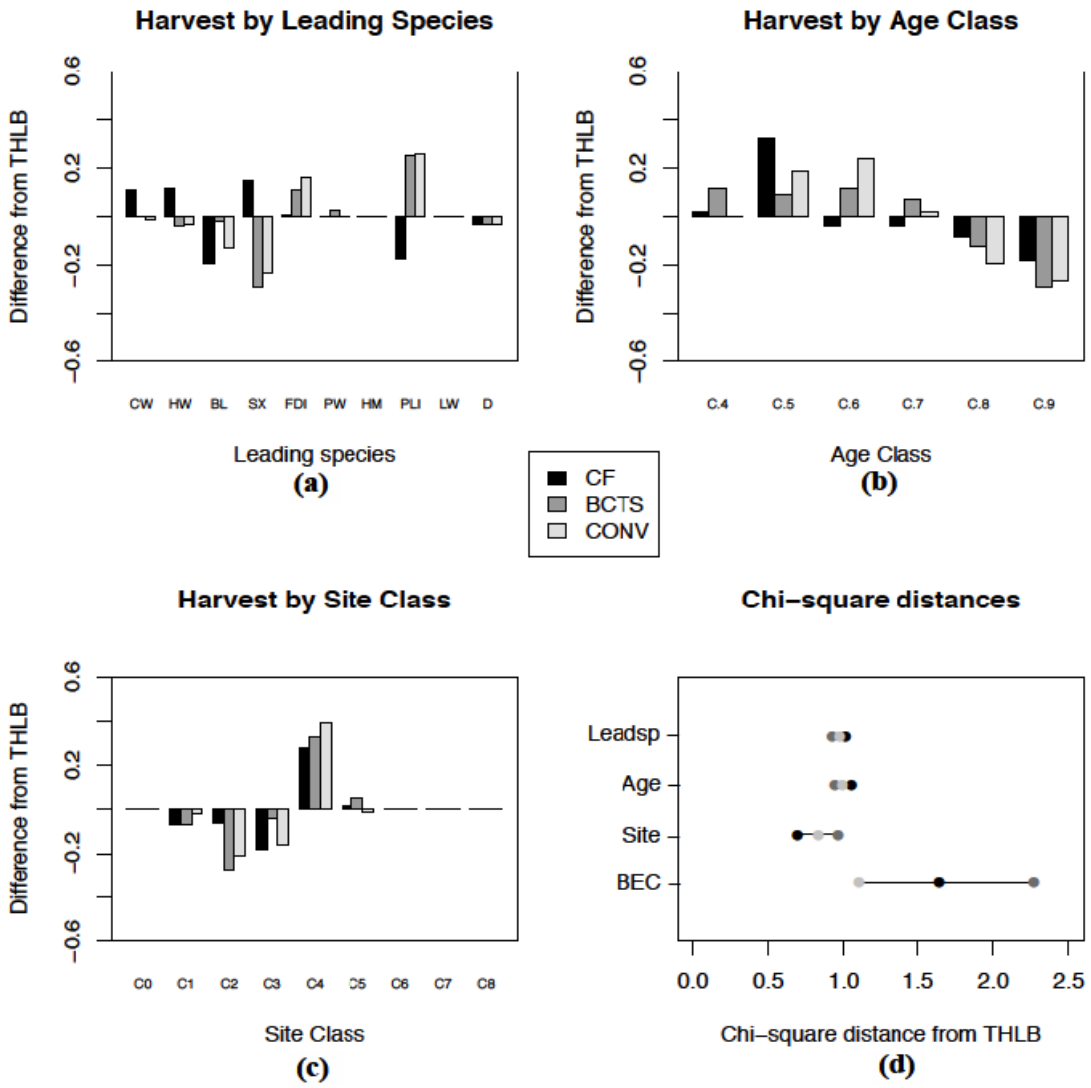

Figure 4: McBride Area differences in harvesting and THLB profiles for area by leading species (a), area by age class (b), and area by site class (c), with positive/negative values reflecting larger/smaller values than found in THLB for each category. Graph (d) shows chi-square distances for each metric. For x-axis category definitions, see Figure 2.

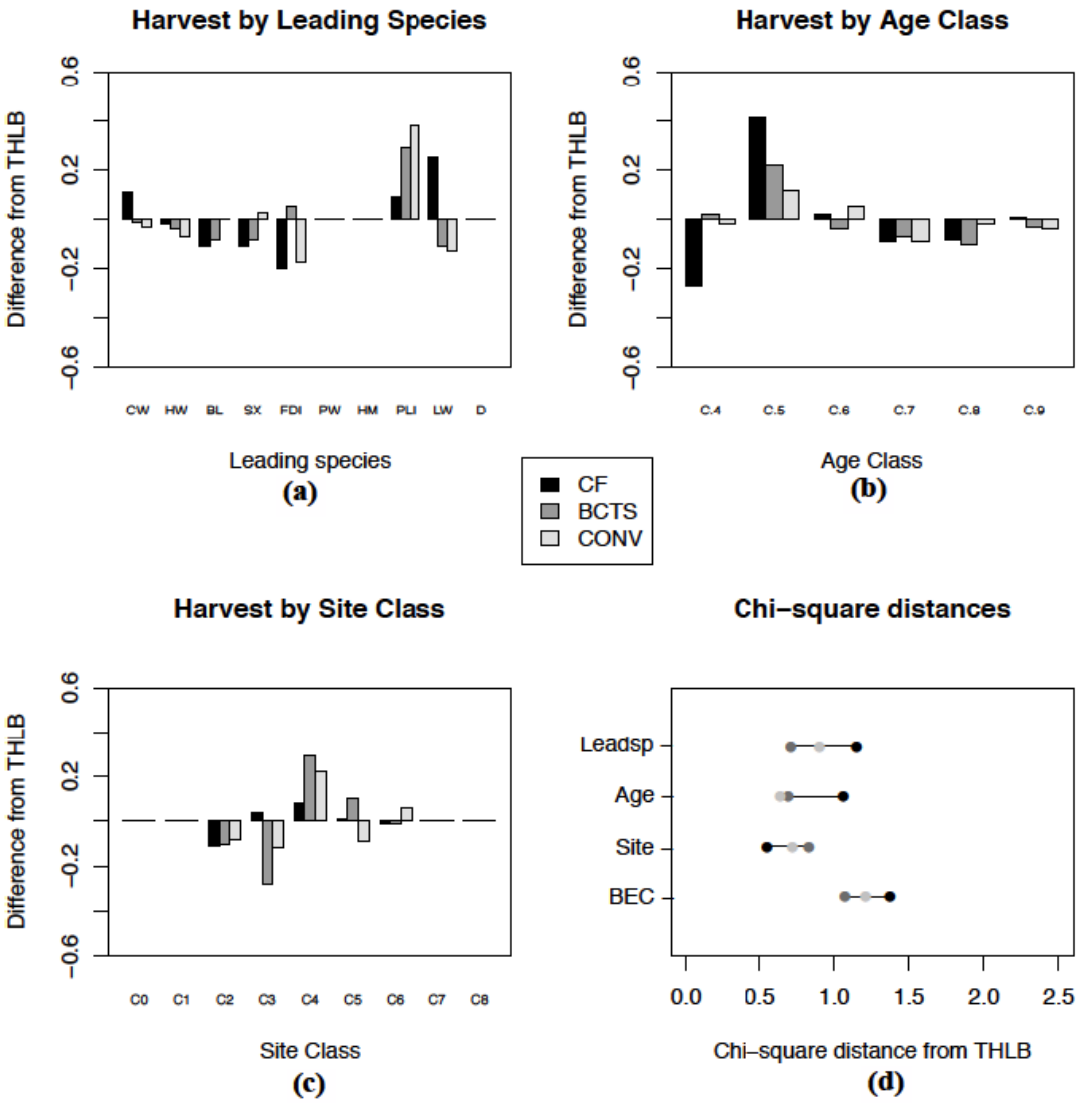

Figure 5: <u>Creston Area</u> differences in harvesting and THLB profiles for area by leading species (a), area by age class (b), and area by site class (c), with positive/negative values reflecting larger/smaller values than found in THLB for each category. Graph (d) shows chi-square distances for each metric. For x-axis category definitions, see Figure 2.

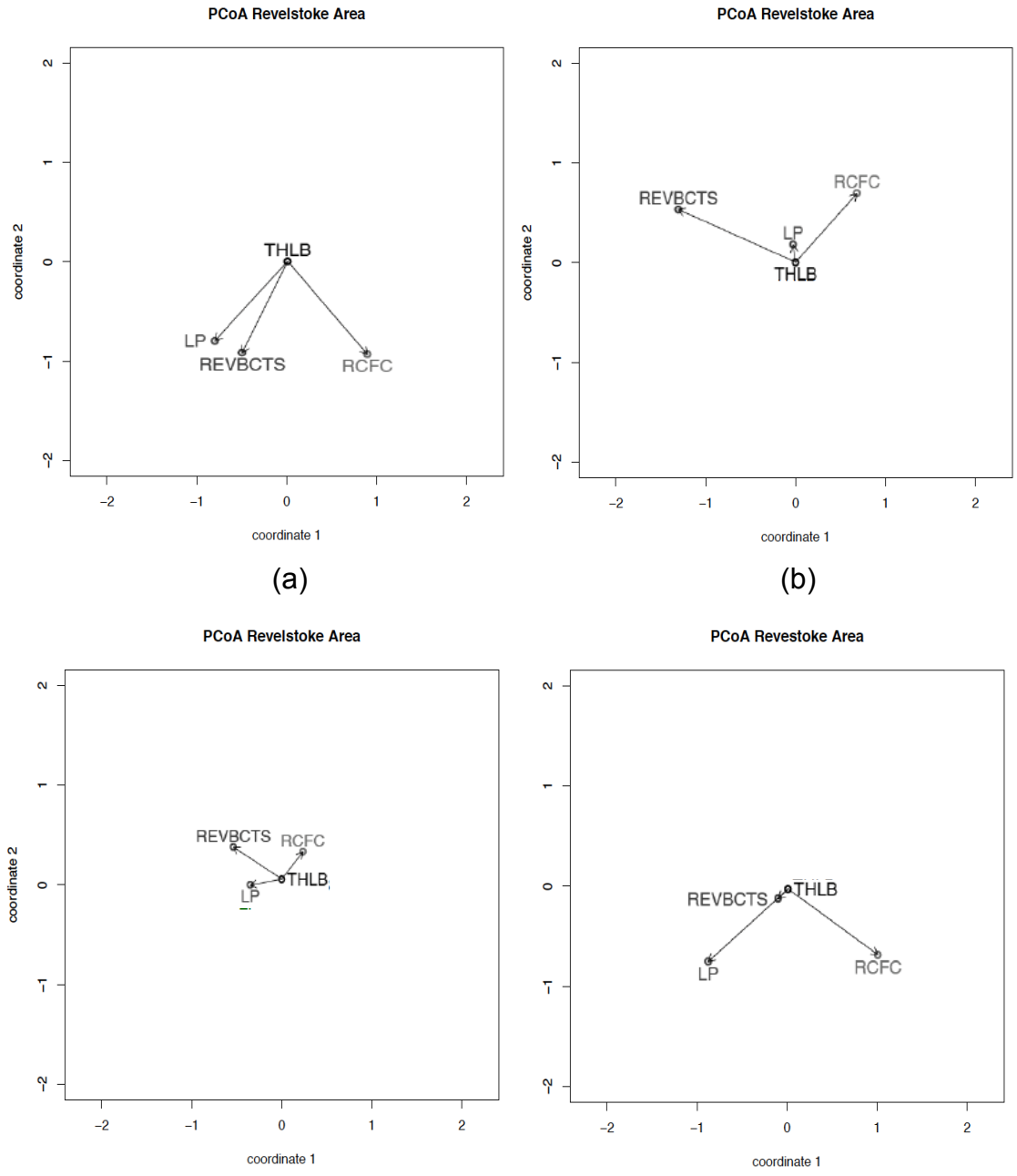

Figure 6: Principal Coordinates Analysis results for the Revelstoke area representing dissimilarity between timber harvesting land base (THLB) area and harvested area, by (a) leading species, (b) age class, (c), site class, and (d) BEC classification (RCFC = Revelstoke Community Forest Corporation, REVBCTS = BC Timber Sales, LP = Louisiana Pacific).

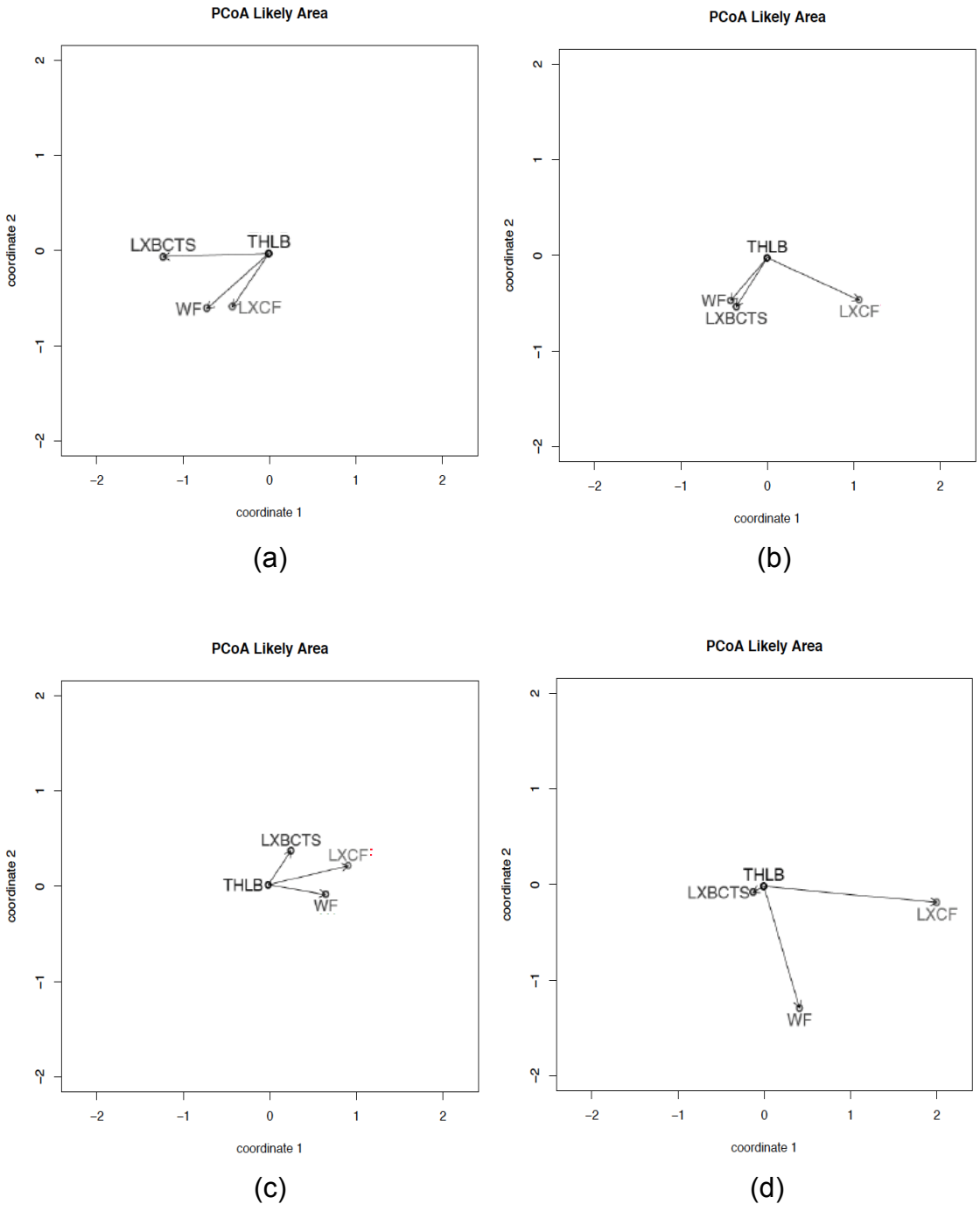

Figure 7: Principal Coordinates Analysis results for the Likely area representing dissimilarity between timber harvesting land base (THLB) area and harvested area, by (a) leading species, (b) age class, (c), site class, and (d) BEC classification (LXCF = Likely Xats'ull Community Forest, LXBCTS = BC Timber Sales, WF = West Fraser).

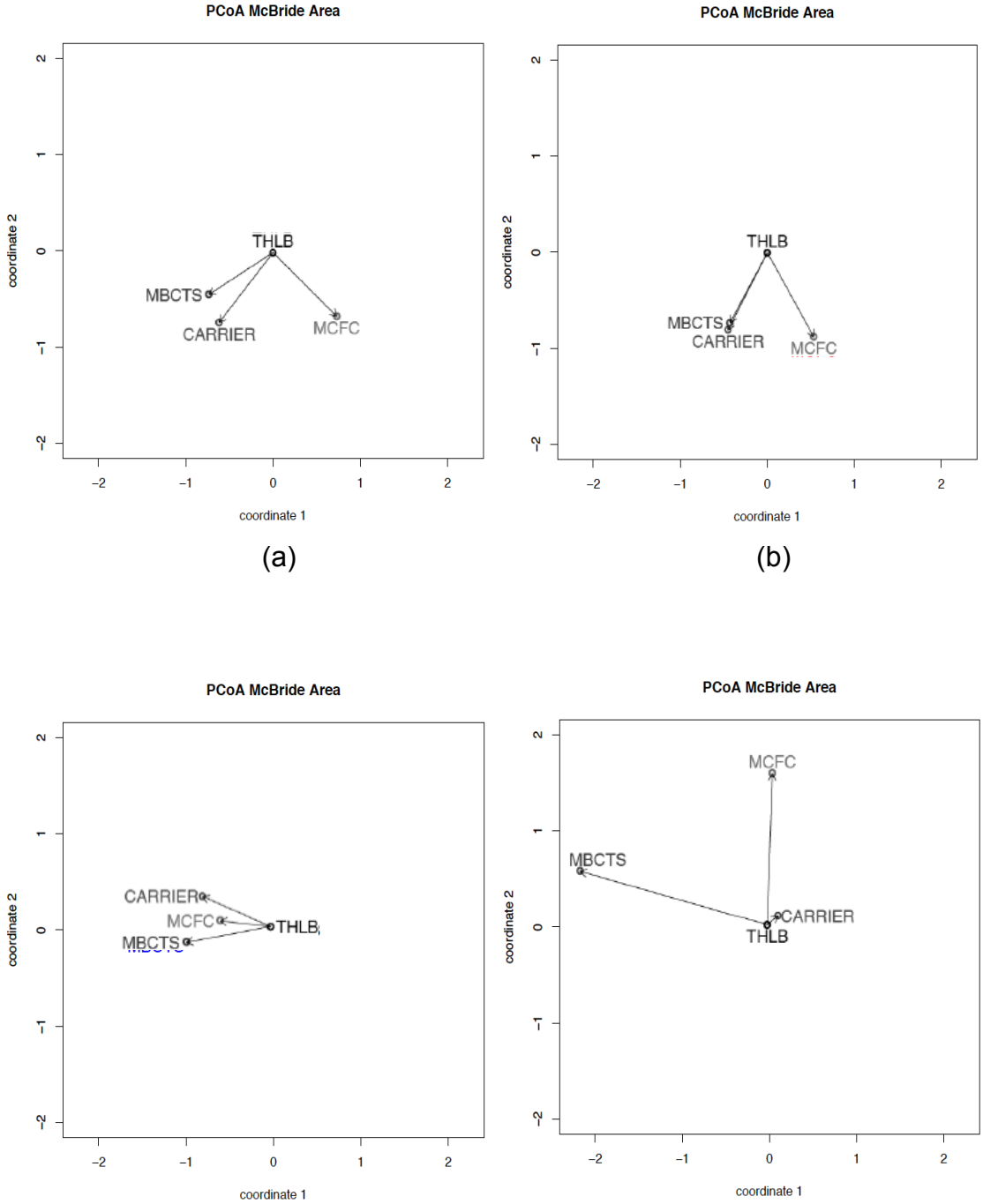

Figure 8: Principal Coordinates Analysis results for the McBride area representing dissimilarity between timber harvesting land base (THLB) area and harvested area, by (a) leading species, (b) age class, (c), site class, and (d) BEC classification (MCFC = McBride Community Forest Corporation, MBCTS = BC Timber Sales).

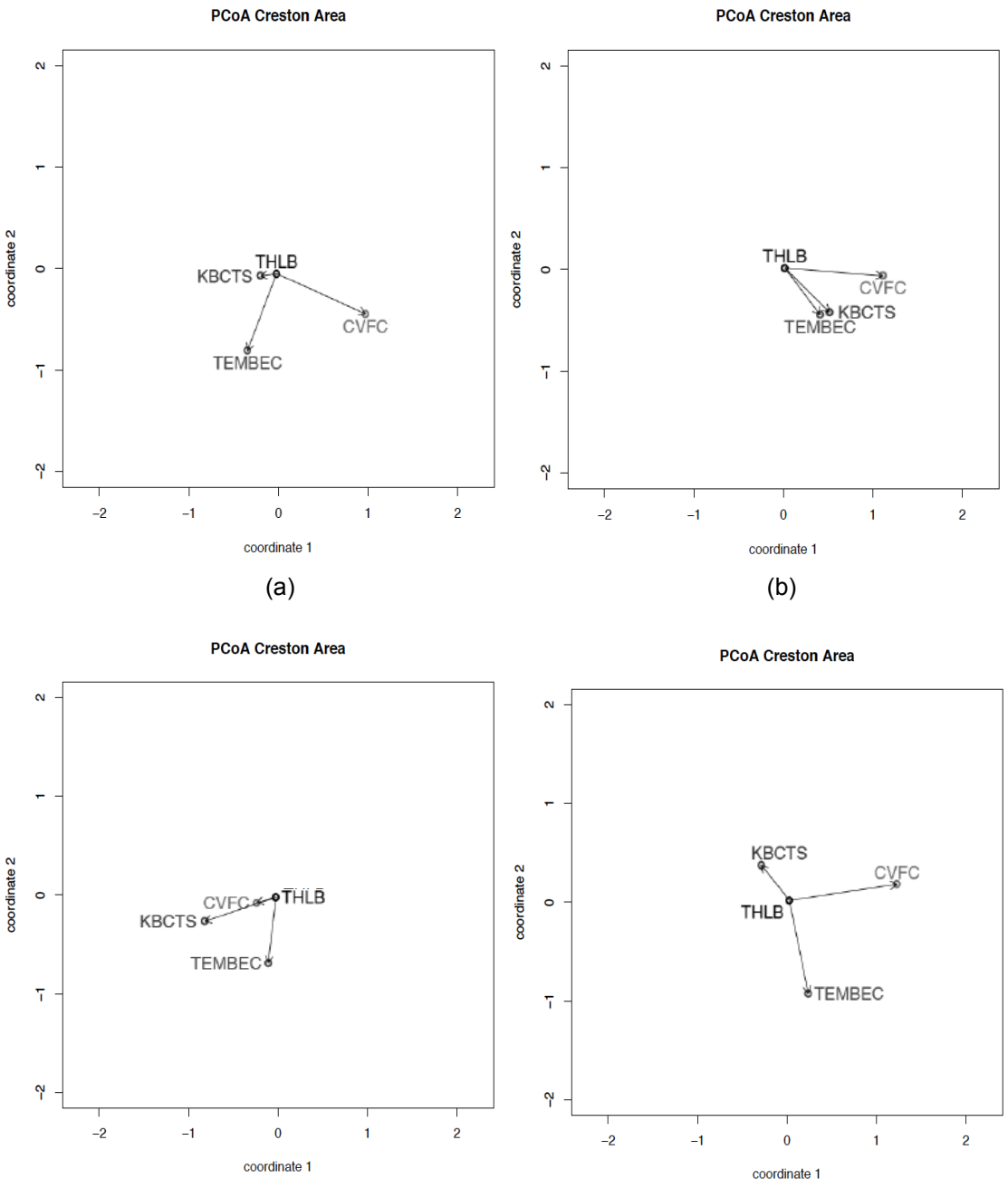

Figure 9: Principal Coordinates Analysis results for the Creston area representing dissimilarity between timber harvesting land base (THLB) area and harvested area, by (a) leading species, (b) age class, (c), site class, and (d) BEC classification (CVFC = Creston Valley Forest Corporation, KBCTS = BC Timber Sales).

Discussion

A recurring theme in discussions surrounding community forestry is the belief that local control of forest resources will result in more ecologically sustainable forest management (Charnley and Poe, 2007). I have investigated this supposition using a set of metrics that estimate the ecological sustainability of certain management outcomes. These metrics attempt to characterize the degree to which harvested land compares to the timber land base at large, in terms of various forest attributes and their natural range of variability across that land base. In the case of representativeness of harvesting metrics, I directly compare characteristics of harvested areas to variability in different forest attributes across study areas. For those metrics dealing with silviculture system selection and post-harvest cutblock structure, I make this comparison indirectly, by evaluating the degree to which management approaches support the maintenance of structure and function present.

While some trends emerged for all community forests included in my analysis, the differences in management outcomes to non-community tenures were unique in each case. Through both qualitative and quantitative analysis, I found that all community forests included in the study are more likely to select alternative silviculture systems as opposed to traditional clearcutting. My

quantitative analysis of post-harvest structural features of cutblocks showed community forests under-performing for many metrics. In the case of *disperse reserve* areas, however, community forests had higher average reserve levels than their non-community counterparts in many cases. Interview results support these findings for *disperse reserves*, and indeed suggest that this trend is true for more community forests and more post-harvest structural metrics than found through quantitative analysis. And finally, for those metrics assessing the representativeness of harvesting profiles, results also varied depending on what metric was being considered. Here again, my quantitative and qualitative analyses yielded different results. Based on quantitative analysis, I hypothesize that community forest harvesting profiles were generally less similar to timber harvesting land base profiles than those of their non-community counterparts. In some of these cases, I hypothesize that less representative harvesting may actually promote better ecological outcomes, such as preservation of old growth areas. In contrast to quantitative results, my interview responses more often suggested that CF harvesting was more representative than non-community management.

There are some previous examples of efforts to to compare ecological characteristics of forestry operations under different management systems. For instance, several studies have been conducted in Nepal, a country with a very active community-based resource management movement (Gautam, 2005). These research efforts have used metrics such as forest cover levels, stem

densities, and tree species diversity to measure forest condition and reversal of degradation (Webb and Gautam, 2001; Nagendra, 2002; Gautam, 2005). While the metrics employed in these studies evaluate some of the same attributes that I assess in this research, my approach is unique in terms of the methodologies used. Also, these studies have concentrated more on issues such as deforestation, productivity, and general biodiversity, while my research is more oriented toward evaluating area-specific ecological sustainability.

Silviculture Systems

We consider that the use of alternative silviculture systems, and more diverse silvicultural prescriptions in general, are one proxy for more ecologically sustainable forest management. It is notable, therefore, that data from the RESULTS database suggest all CF's included here are more likely than their conventional and BCTS counterparts to employ these alternative systems over traditional clearcutting. This is consistent with interviewee responses, which confirmed this use of alternative systems and more diverse prescriptions in general.

There are also features of the RESULTS database that may cause certain silviculture practices to be misrepresented. For instance, when a licensee operates using small harvesting permits for which no site plans are required, no data is entered into RESULTS. On the one hand, this may mask ecologically

sustainable silviculture efforts on the part of CF's. For instance, one interviewee suggested that the community forest in their area used small scale *selection* as an initial effort to deal with mountain pine beetle infestations. However,even if several small-scale *selection* entries were initially used in an attempt to maintain surrounding forest cover, this would not be reported to RESULTS. If the entire area eventually had to be cleared of forest cover due to expanding MPB infestation, the only thing that would be reported would be the final harvesting using *clearcut* or *cleacut with reserves* systems. As this interview subject suggested conventional and BC Timber sales counterparts in the area would simply clearcut the entire stand to begin with, using RESULTS data would falsely represents both silvicultural strategies as identical. On the other hand, community forests may conduct a large fraction of their harvesting under small harvest licenses. If management practices under which this harvesting is carried out are of lower quality than those for cutblocks requiring site plans, RESULTS data would exaggerate the ecological sustainability of the community forest's approaches.

As a component of her Master's thesis, Ambus (2008) also compared silviculture system use between Community Forest Agreements (CFA's) and Tree Farm Licences (TFL's) in British Columbia. Across 11 CFA's, Ambus found that Community Forest Agreements employ *selection* and *patch cut* systems more often, but use *retention* and *shelterwood* systems less often, than TFL's. Ambus also found no difference between CFA and TFL use of *clearcut* and *clearcut with*

reserve systems. Ambus suggests that factors such as local ecological, economic, and social issues make it unlikely that all community forests will apply alternative silviculture systems more often than non-community tenures. Indeed, while the community forests that I have analysed are more likely to employ silvicultural alternatives to clearcutting, research including a much larger fraction of community forests in B.C. would need to be conducted to infer any province-wide conclusions.

To my knowledge, the silvicultural comparison I have made here is unique in the community forestry literature. While there are some parallels between my research and that of Ambus (2008), her analysis assessed forest tenures from an institutional perspective, through a comparison of Community Forest Agreements and Tree Farm Licenses specifically. My analysis, on the other hand, included *community-based* operations across tenure types (CFA's, TFL's, and Forest Licenses). These were compared to operations representing *both private and centralized government* approaches to management, which also include diverse tenure arrangements. My inclusion of both public and private counterparts to community-based management is important, as both of these management types are discussed in debates surrounding the benefits and drawbacks of community resource management (Dietz et al., 2003).

Post-harvest Cutblock Structure

I analysed some of the specific attributes of post-harvest cutblock structure, such as disturbance size and reserve characteristics, in an attempt to gain a more detailed picture of the differences in silvicultural approaches taken by each of the tenures in the study. My quantitative results show some of these attributes, such dispersed reserve levels, were managed for more successfully by community forests. However, non-community tenures performed better than community forests for other attributes, such as wildlife tree patch areas. As with results for silviculture system usage, there are also inconsistencies between quantitative and qualitative findings.

In terms of *disturbance area*, the majority of quantitative results showed no significant difference between community and non-community tenures. Managing for smaller *disturbance area* can be thought of as ecologically important from a variety of perspectives. For instance, smaller size has been associated with facilitating species re-establishment following disturbance (Outerbridge et al, 2009) and having a less significant impact on ecosystem resilience (Walker et al, 2004), while larger harvested areas are associated with negative impacts such as increased stormflow peak flows (Guillemette et al., 2005). The ecological consequences of disturbance size, however, will also be influenced by forest retention levels within the disturbance. If elements of stand structure are retained post-harvest in a disturbance area through alternative silvicultural approaches, many of the associated issues with larger disturbance

size can be mitigated (Beese et al., 2003). In the Creston area, as an example, although CVFC has a larger average disturbance size than BCTS in the area, the Creston community forest is more likely employ a silviculture system that incorporates retention throughout the disturbed area. This may explain why interviewees in Creston incorrectly believed the CF generally had “much smaller cutblocks” than their counterparts. All other community forests were found to have values for average disturbance size that were similar or smaller than those of their counterparts. As these community forests' harvesting was also more likely to occur under an alternative silviculture system, I hypothesize that they are doing more than their counterparts to maintain ecological attributes naturally present in pre-harvest stands.

Surprisingly, results specifically on the levels of structural retention within cutblocks was inconsistent with the results on silviculture system usage more generally. For instance, although all community forests were more likely than their counterparts to employ alternative silviculture systems that by definition included a greater degree of retention than clearcuttting, wildlife tree patch levels for all community forests were lower than those of their counterparts. Interviewee responses about post-harvest stand structure were also inconsistent with many of the stand structure findings generated through analysis of the RESULTS data. For instance, in the case of LXCF, while interviewees felt the CF managed for greater amounts of retention than their counterparts (which would seem to follow from their greater likelihood of employing both *clearcut with reserves* and

selection systems), RESULTS data showed LXCF either under-performing or having no statistical difference from their counterparts for all structural metrics. This trend is mirrored, to varying degrees, in the rest of the study areas.

One potential explanation for this is in the submission framework of RESULTS, and the reporting conventions of licensees. RESULTS was initially designed to handle reporting largely for a traditional clearcutting approach to forestry (BCMoF, 2009). Although this is gradually changing, reporting on alternative silviculture is often, as one interviewee put it, like trying to “fit a square peg into a round hole”, leading to licensees simply “trying to avoid it”. Some licensee staff members also indicated that their reserve information in RESULTS will often include errors due to differing interpretations regarding how data should be entered into the system. It is important, therefore, to ensure that those personnel responsible for a licensee's online submissions have the time and knowledge to enable proper and consistent reporting. This seems particularly true for CF's, who generally have smaller staff numbers, and rely more heavily on volunteerism. Also, the Ministry should do everything it can to make the reporting system as user-friendly as possible. These are important steps in enabling future research and monitoring applications for the RESULTS database, which has the potential to be a useful tool in encouraging more ecologically sustainable forest management in the province.

Another factor that may impact retention and reserve results involves differences inherent to the nature of the tenure arrangement of each licensee.

These differences may impact to what extent the level of reserves being managed for by a licensee shows up in RESULTS data. For instance, provincial reserve requirements for volume-based tenures, such as Forest Licences and Timber Licences, are attached to each specific cutblock being logged. However, reserve requirements for area-based tenures such as Community Forest Agreements are considered for the entire tenure area as a whole (Robin Hood, Personal Communication, April 25th, 2011). In other words, while all contributions to reserve areas for non-community tenures will theoretically appear in RESULTS, many community forest reserve areas will not.

Definitive conclusions surrounding the issue of levels of structural retention in cutblocks across tenures requires future research, for instance through gathering data directly from licensee site plans. Based on analysis of the RESULTS data, however, retention (particularly in the form of wildlife tree patches) is an area needing improved management on the parts of community forests. As this may be an issue of inconsistent online reporting conventions, the Ministry also has a role of facilitation to play here. There is, however, a notable amount of variation amongst CF's, and in the case of *dispersed reserve* area in particular, CF's in most cases managed for either significantly greater or comparable levels as compared to both their BC timber sales and conventional counterparts.

As with my comparison of silviculture system use, to my knowledge my use of post-harvest stand structure data is a novel approach to estimating the

ecological impact of forest management. In spite of those limitations discussed above, I found this approach to yield important results. In this sense, the development of online reporting databases specifically designed for *analysis* of collected data is important to future forestry and forest ecology research. My hypotheses regarding cutblock size, retention characteristics, and the maintenance of pre-harvest ecological attributes are important question for future research. Methodologies such as field studies or aerial and satellite imagery could be used to provide a more detailed picture of my findings.

Representativeness of Harvesting

My comparison of harvesting profiles is another example of the use of novel methodological approaches to comparing community and non-community forest management. This category of metrics estimates the degree to which harvesting reflects the diversity of species, age and site classes, and biogeoclimatic zones represented on the timber harvesting land base. I characterized the total land that each tenure holder harvested using ecological attributes such as leading species, and compared this to similar characterizations on the timber harvesting land base as a whole. I found that there is generally more dissimilarity between community forest harvest profiles and timber harvesting land base profiles than between non-community harvesting and the

THLB. The exception to this trend was with regards to site class, for which all CF's save LXCF had harvesting profiles most closely reflecting the THLB.

Assessing this degree of representativeness of harvesting is important, as over-harvesting elements in any of these areas can erode the foundations upon which both future ecosystem and economic health are built (Landres et al., 1999; Wong and Iverson, 2004; Green, 2007). In analysing harvest profiles across tenures, I used profiles for the overall district THLB as comparisons, since THLB profiles for individual licensees' land bases were unavailable. While there are potential benefits to this approach, such as addressing the importance of using a sufficiently large reference area to capture a full range of ecological variability (Wong and Iverson, 2004), there are drawbacks as well. The compositional profile on each licensee's land varies in the degree to which it reflects the overall profile of the district. Research in the future would benefit from tenure-specific comparisons.

In terms of harvested area defined by leading species, as discussed in my results section community forests over-harvested different species than their counterparts. Conventional and BCTS operations, on the other hand, were more similar to each other in this regard. For instance, while the McBride community forest harvested more western redcedar, western hemlock, and spruce than were represented in the timber harvesting land base, BC timber sales and Carrier Lumber both harvested more Douglas-fir and lodgepole pine. These trends are represented well in PCoA results (see figures 6a, 8a, and 9a). Interestingly, in

each of these cases CF's were shown to be over-harvesting a combination of a more valuable species, such as cedar (all CF's with the exception of LXCF) or larch (CVFC), and low-value species, such as hemlock. The trend with counterpart tenures in all four areas, on the other hand, was solely over-harvesting low-value pine, fir, and spruce (species value based on pricing data taken from MoF interior log market reports).

Several economic factors likely influence the decision by community forests to harvest higher-value species. As the community forests included in this study are still in the early stages of their operation, start-up costs add an extra burden to their financial viability. In addition, community forests may generally have more difficulty competing in the forestry sector than industrial tenures due to issues such as a lack of economies of scale (Ambus, 2008). Therefore this effort to capture more value in the species that community forests harvest likely arises out of a degree of financial necessity. An important question raised here, however, is whether those high-value species are being removed to a greater degree than low-value species (which appears to be the case for some CF's). The risk in these cases is, in parallel to the ecological impacts of more heavy harvesting of particular species, future economic options and viability may be undermined. This is a clear example of how ecological constraints can come to bear on the continued sustained provision of a given resource, and the crux of the concept of ecologically sustainable management. This balance between avoiding high grading and ensuring economic viability is an important one for the

long term ecological sustainability of community forestry, and therefore something that each CF should closely monitor.

The age class distribution of an area's forests, and the impacts of forest management on that distribution, is another important issue surrounding representativeness of harvest. Here again, the importance of maintaining the profile naturally present in an area is related to providing the natural range of ecosystem types necessary to support native species and ecological functioning (Noss, 1993; McRae, 2001, Wong and Iverson, 2004). In this sense, that CF's are generally following the THLB age class profile less closely than their counterparts would be interpreted negatively. However, another issue in BC is that of historical over-harvest of older forests, and a desire to conserve old growth areas and characteristics in BC's THLB (BCMoF, 2003). The large majority of disparity from THLB age class profiles in terms of CF harvesting is represented in 61-80 an 81-100 age classes, and in addition, in each area save Creston, CF counterparts were found to harvest above THLB profile levels in those age classes associated with definitions of old growth in BC more so than CF's were. This trend of CF's being distinct from both conventional tenure types is again well represented in PCoA results, particularly for LXCF, MCFC, and CVFC (see figures 7b, 8b, and 9b).

Licensees have incentives to select better site classes for harvesting, as these contribute more volume to annual allowable cut calculations and are also generally managed with shorter rotation lengths. However, as with age classes,

as well as biogeoclimatic zones, those species and ecological functions that depend upon attributes specific to areas of high productivity or certain biogeoclimatic features will necessarily suffer from any preferential harvesting to specific areas. As stated above, all CF's, with the exception of LXCF, have harvest profiles by site class most similar to THLB site class profiles. In terms of BEC zones, the opposite was true, as three of the four CF's had their harvesting profiles most dissimilar to THLB profiles.

Comparison of Qualitative and Quantitative Results

Some components of my analysis of RESULTS data supported interviewee perspectives surrounding each community forest's management practices. However, this was often not the case (see Table 5). Some potential explanations for these differences in quantitative and qualitative results have been discussed above. In the case of post-harvest stand structure, interview and RESULTS data mainly differed. The issues surrounding improper or incomplete RESULTS reporting practices may explain this difference to some degree. In addition, as reserves not associated with cutblocks will not be reported to RESULTS for area-based tenures (Robin Hood, Personal Communication, April 25th, 2011), community forests may be managing for more reserve areas than my analysis of RESULTS data suggests. For *disturbance area* results, silviculture system use may have influenced interviewee perceptions of disturbance size.

Table 5: A summary of hypotheses generated from interview results, and whether those hypotheses are supported by quantitative results for each metric used.

HYPTOTHESES FROM QUALITATIVE DATA	QUANTITATIVE SUPPORT							
	Silv. System	Dist. Area	Disp. Reserves	WTP Area	Lead Sp	Age Class	Site Class	BEC Zone
REVELSTOKE AREA								
CF harvest **more** ecologically representative than counterparts	-	-	-	-	NO	YES	YES	NO
CF employing **more** alternative silviculture systems than counterparts	YES	-	-	-	-	-	-	-
LIKELY AREA								
CF employing **more** alternative silviculture systems than counterparts	YES	-	-	-	-	-	-	-
CF managing for **more** retention and reserves than counterparts	YES	NO	NO	NO	-	-	-	-
MCBRIDE AREA								
CF harvest **less** ecologically representative than counterparts	-	-	-	-	YES	YES	NO	NO
CF employing **more** alternative silviculture systems than counterparts	YES	-	-	-	-	-	-	-
CF managing for **more** retention and reserves than counterparts	YES	NO	YES	NO	-	-	-	-
CRESTON AREA								
CF harvest **more** ecologically representative than counterparts	-	-	-	-	NO	NO	YES	NO
CF employing **more** alternative silviculture systems than counterparts	YES	-	-	-	-	-	-	-
CF managing for **more** retention and reserves than counterparts	YES	NO	NO	NO	-	-	-	-
CF has **smaller** *disturbance areas* than their counterparts	YES	NO	-	NO	-	-	-	-

In other words, even if a community forest has a larger average disturbance size than their counterparts, use of alternative silviculture systems that are associated with more post-harvest forest cover may give the impressions of smaller disturbance sizes in individual cutblocks. Finally, in regards to harvesting the profile, the use of district-wide timber harvesting land bases for comparison purposes may bias results against community forests and towards BC Timber Sales. Part of BC Timber Sales' mandate is to conduct representative harvesting, and their cutblocks occur throughout each district. As a result, they are more likely than community forests to be harvesting in a way that reflects natural diversity across the entire district land base, as CF harvesting is restricted to one small area of the overall district.

The use of both qualitative and quantitative approaches in the same research effort is important in that there are different benefits to each approach, and each can contribute to understanding an issue in different ways (Onwuegbuzie and Leech, 2005). Indeed, a combination of these methodologies has been used by other researchers comparing community and non-community forest management (Nagendra, 2002; Gautam, 2005). For my research in particular, qualitative investigation of each community forest not only helped to develop many of my research questions, but also helped to inform the answers to those questions. While there is variation in the extent to which my qualitative and quantitative data agree, each provides unique dimensions to understanding the particulars of each community forest and their counterparts.

Variation Between Community Forests

Each of the community forests included in my research performed differently with regards to the metrics I've used to approximate ecological sustainability. The stakeholders that we interviewed in each community provided a great deal of insight into what factors might be causing some of this variation. These factors include:

(a) the extent of management and operational capacity in each community;

(b) approaches to allocation of harvesting rights;

(c) issues surrounding forest health;

(d) economic considerations;

(e) and finally, the explicit goals of each community forest.

The capacity and resources of community forests were issues raised in all areas of the study. While interviewees in some areas expressed confidence in the managerial and operational expertise of their town's community forest, interview subjects in other areas felt this expertise was lacking. In general, our research group was often told by interviewees that the quality of a community forest's management was very contingent on its managerial and operational knowledge, and without this, management practices suffered. Both the province, as well the communities themselves, have a role to play in this regard. For instance, one solution raised by an interview subjects included holding local training sessions in order to make widely available that knowledge that did exist

locally. Another important point raised during interviews was ensuring as wide a knowledge base as possible is recruited to board and management positions. Similarly, the provincial government should do all it can to provide resources and information to communities, for instance training related to RESULTS submission procedures.

A related issue is that of how CF's contract out the harvesting of their cutblocks, and how this harvesting is regulated and monitored. Each community forest employed a different approach to allocating harvesting rights, and some appeared to be more successful at encouraging ecologically sustainable practices. In some instances, interviewees expressed concerns that systems of allocation allowed too much flexibility and not enough planning and oversight in relation to harvesting activities. In this regard, proper monitoring and and future adaptive management is crucial.

Forest health issues, and particularly the mountain pine beetle (MPB) epidemic in BC, also had an impact on the forest practices of CF's. While our research group chose sites in an effort to minimize the impact of MPB on study results, management practices in some cases were none the less effected. For instance, some interviewees stated that MPB salvage required a move toward higher impact harvesting techniques, and generally altered management practices for the worse. In the case of the Likely-Xats'ull Community Forest, one interview respondent in particular stated that the community forest hasn't logged one block in which forest health issues haven't been a major consideration,

impacting management decisions such as silviculture system choice and forest retention.

Based on issues such as tenure size, demand for lumber, and proximity to processing facilities, each CF may also have different economic capacity. In addition, some interviewees suggested that the land bases provided to community forests have already had much of the timber value removed from them through past industry logging, or else may include much less productive land than areas granted to other tenures in the province. This in turn may influence their flexibility in terms of management decisions and ability to adequately balance economic and ecological objectives. Indeed, interviewees in some areas specifically identified economic constraints as drivers of poor management decisions in the past.

The overall management goals of each community forest also differ in ways that may cause some of the variation seen in CF management outcomes. For instance, the Harrop Procter Community Forest was created in large part to protect the drinking water of the communities of Harrop and Procter, which no doubt provides motivation behind that CF's decision to require all its harvesting and silviculture to be ecosystem-based. Other CF's, such as Revelstoke, while no doubt aspiring to similar goals, may instead prioritize objectives such as enhancing the forest resources under their control.

Finally, other management issues emerged that were not assessable using quantitative analysis, but for which interviewees had consistent opinions.

Issue generating consistent praise from interviewees included the use of alternative, low-impact harvesting methods, better performance in terms of replanting than CF counterparts, planting a diversity of species, limbing and leaving coarse woody debris in the bush, and better mitigating impacts of harvesting such as ground compaction and decreased water quality. On the other hand, common areas in which CF's were believed to need improvement included some operational level issues such as mitigating blowdown, and also long term planning issues related to the need for more strategic planning and monitoring.

Conclusions

Here in British Columbia, it appears as though both communities as well as the provincial government have faith in the potential benefits of community-based forest management. Since the community forest program began in BC in 1998, 39 community forest and probationary community forest agreements have been issued, with another 15 invitations from the province for communities to apply currently pending (BCCFA, 2010). And during the course of this research, Forest Minister Pat Bell promised almost a doubling of provincial cut levels for community forests and other small tenures such as woodlots and First Nations licenses (Official Report of the Debates of the Legislative Assembly, 26 March 2009).

My goal here was to provide some empirical insight into the question of whether community forests differ from nearby conventional tenures across a range of indicators of ecological sustainability. Community forests included in my research did performed better than their non-community counterparts in many of the measures I used to estimate this concept of sustainability. However, there were also cases where there were no differences between community and non-community tenures, and areas in which community forests performed worse.

My results demonstrate community forests included in my research are more likely to employ silvicultural alternatives to clearcutting. Important questions arising out of this finding include to what extent this is true for all community forests across BC, and what area-specific factors influence this trend. The most recent edition of the Province's State of BC Forests report emphasises that silvicultural decisions are important in determining how forests contribute to ecological, economic, and social wellbeing, and that alternatives to clearcutting are important in balancing ecological and economic objectives (MoFML, 2010). The report also clearly states that, with the majority of forestry in the province occurring on Crown land, silviculture practices are highly dependent on government policies and funding (MoFML, 2010). My results, and the questions that arise from them, are therefore important to future policy decisions in the province.

I also hypothesize that the community forests considered here are in some ways doing more than their non-community counterparts to maintain ecological attributes present in pre-harvest stands. Further research is important in providing a more detailed understanding of this issue, using approaches such as field studies and aerial or satellite images. There were also cases for which some of my data suggested community forests were under-performing in comparison to their non-community counterparts. In this sense, further research into the accuracy of information in the RESULTS database is important, for instance by

comparing field study assessments of reserve and retention levels to those reported in RESULTS.

This raises the issue of the current configuration of the RESULTS database. Changes to RESULTS would make an important difference to the ability of this kind of research to make a useful contribution to forest management, as well as improving the quality of the data. First of all, changes to allow for easier access to data for monitoring and research purposes would be beneficial. Facilitating submission of more complex silviculture systems would help ensure activities associated with these are not underreported, and would be helpful to policy makers, researchers, and forest managers alike. Once again in the the Ministry's State of BC Forests report, the importance of sustainable forest management and thorough monitoring and assessment of current management practices is stressed (MoFML, 2010). A properly functioning resource like the RESULTS database may be invaluable in this regard. Due to logistical and financial constraints, while the later issue has been acknowledged by the Ministry, the chosen course thus far has been to leave the overall reporting system intact, and to instead change “reporting policy” (BCMoF, 2009). Additionally, many evaluative tools identified as important by interviewees were not available for analysis in RESULTS, such as impacts of harvesting including those on water quality, ground compaction, and blowdown, and would be useful additions to the system in instances where it would be practical to integrate these into the RESULTS framework.

My investigation into the ecological representativeness of harvesting profiles also produced important hypotheses. Firstly, I hypothesize that the community forests included in my research are largely harvesting in ways that are less reflective of overall THLB profiles. This question could be addressed with more precisions if profile data specific to licensee's management areas becomes comprehensively available. Here again, other research approaches such as the use of aerial and satellite images could be useful in complementing RESULTS data. Some of the components of community forest management identified as needing improvement by interviewees, such as long term planning and monitoring, are important in developing solutions to this issue of representativeness of harvesting. I also hypothesize that some cases of community forest harvesting involving dissimilarity to THLB profiles may in fact be useful in achieving particular ecological objectives. For instance, through avoiding older age classes and particularly those associated with old growth, community forests may be helping to reverse the historical trend of over-harvesting old growth forests in the province.

Community forests, like other forms of community resource management, represent an alternative decision-making system largely outside of those large spheres of centralized government and private institutions. The proponents of these community-based management efforts believe they have the potential to address some of the ecological problems experienced under centralized government and private resource control (Charnley and Poe, 2007). However, as

our research group learned through our interview process, community forestry represents different things for different people. And as community forestry is meant to reflect local perspectives surrounding resource management, differences in local priorities will no doubt result in different management outcomes. Indeed, it is important to acknowledged that there is no black and white set of results that community forestry will produce. However, my research demonstrates that when local knowledge and skills are present and capitalized on, community control of forest management can produce improved ecological results compared to the conventional industrial forestry model under which BC has historically operated. It would be beneficial for a study such as this one to be done in a wide-reaching manner, including the entire set of CF's across BC. This would help develop a more comprehensive understanding of the various approaches to community forest management, where successes have been achieved, and how difficulties may be overcome.

As a final note, while the community forest program in BC has the potential to effect positive change in the ecological impact of forestry in the province on land now under community management, it also holds this potential for land under control of other tenures. As one interviewee put it, the community forest in their town has raised standards in the entire area with regard to forest management. In this sense, the Community Forestry Program in British Columbia appears to have an important role to play in the evolving state of more ecologically-based forest management in the province.

Appendices

Appendix A: Results Data Generation Procedure (repeated for each licensee included in the analysis)

The RESULTS database allows users to access data across multiple cutblocks using “report generating” functions. Using the many different report types that the database can generate, users can specify certain constraints in order to access data for specific licensees during a specific time frame. The following is the report generating procedure I used to generate my quantitative data.

1. Permanent Access Structure (PAS) report generated, filtered by disturbance start date in order to included only activity falling within the study time frame. As other reports do not allow filtering by disturbance start date, further data filtered by matching opening ID numbers to PAS list. Mature Area (MAT_AREA) data collected from PAS report.
2. Wildlife Tree Path (WTR) report generated, NO_RESERVE_AREA, DISPERSED_RESERVE_AREA, and Wildlife Tree Patch/Riparian Reserve Area (WTP_RIP_AREA) collected.
3. OPENING report generated, PREV_AGE_CLASS_CODE, PREV_SITE_INDEX, and PREV_TREE_SPP1_CODE collected.
4. OPENING DETAILS report generated, PLANNED_GROSS_BLOCK_AREA, and DISTURBANCE_GROSS_AREA collected.
5. Standards Unit (SU) report generated, Biogeoclimatic Zone Code (BGC_ZONE_CODE), BGC_SUBZONE_CODE, BGC_VARIANT, and Biogeoclimatic Site Series (BEC_SITE_SERIES) collected.
6. DISTURBANCE report generated, SILVI_SYSTEM_CODE and TREATEMENT_AMOUNT collected.

Appendix B: Multinomial logistic regression sample sizes for each tenure holder

Tenure Holder	Sample Size (number of treatment areas)
Revelstoke Community Forest	204
Okanagan-Columbia BCTS office	192
Louisian Pacific	656
Likely-Xats'ull Community Forest	31
Cariboo-Chilcotin BCTS office	723
West Fraser	1142
McBride Community Forest	30
Kamloops BCTS office	183
Carrier Lumber	181
Creston Valley Community Forest	57
Kootenay BCTS Office	234
Tembec	284

Appendix C: Wilcoxon rank-sum test *p*-values, for comparisons between CF's and both BCTS and conventional counterparts

			RCFC	LXCF	MCFC	CVFC
All Blocks	Disturbance Area	BCTS	0.09	0.22	0.99	0
		CONV	0	0.47	0.08	0.17
	No Reserve Area	BCTS	0	0.43	0.18	0.01
		CONV	0	0.1	0.02	0
	Dispersed Reserve Area	BCTS	0	0.74	0.24	0
		CONV	0	0.06	0.01	0
	WTP Area	BCTS	0	0	0	0
		CONV	0.16	0	0	0
CCRES Areas Only	No Reserve Area	BCTS	0	0.3	0.01	0.26
		CONV	0.09	0.4	0.18	0.02
	Dispersed Reserve Area	BCTS	0	0.88	0.75	0.16
		CONV	0	0.6	0	0.07
	WTP Area	BCTS	0.04	0	0	0.23
		CONV	0.08	0	0.16	0.14

Appendix D: Wilcoxon rank-sum test sample sizes for each tenure holder

Tenure Holder	Sample Size (number of treatment areas)
Revelstoke Community Forest	145
Okanagan-Columbia BCTS office	166
Louisian Pacific	478
Likely-Xats'ull Community Forest	29
Cariboo-Chilcotin BCTS office	567
West Fraser	1070
McBride Community Forest	29
Kamloops BCTS office	160
Carrier Lumber	151
Creston Valley Community Forest	42
Kootenay BCTS Office	177
Tembec	168

Appendix E: Mean and standard deviation values of stand structures metrics for each tenure holder (across all cut blocks)

	Disturbance Area		No Reserve Area		Dispersed Reserve Area		WTP Area	
	mean	SD	mean	SD	mean	SD	mean	SD
Tenure Holder								
Revelstoke Community Forest	16.2	21.8	0.85	0.32	0.16	0.45	0.02	0.07
Okanagan-Columbia BCTS office	19.6	20.6	0.86	0.33	0.13	0.26	0.05	0.14
Louisian Pacific	23.4	28.3	0.95	0.2	0.03	0.16	0.02	0.11
Likely-Xats'ull Community Forest	23.3	25.6	0.86	0.74	0.17	0.37	0.03	0.15
Cariboo-Chilcotin BCTS office	34.7	47.7	0.87	0.16	0.05	0.15	0.07	0.1
West Fraser	28.5	37.7	0.67	0.45	0.23	0.39	0.12	0.23
McBride Community Forest	31.3	34.1	0.89	0.25	0.14	0.19	0	0
Kamloops BCTS office	24.7	23.8	0.76	0.53	0.22	0.36	0.08	0.15
Carrier Lumber	43	45.1	0.68	0.39	0.13	0.29	0.17	0.36
Creston Valley Community Forest	37.6	28	0.9	0.25	0.06	0.22	0.01	0.03
Kootenay BCTS Office	21.8	19.6	0.87	0.25	0.09	0.21	0.03	0.06
Tembec	33.8	33.6	0.72	0.34	0.22	0.38	0.05	0.08

Appendix F: Mean and standard deviation values of stand structures metrics for each tenure holder (areas under *clearcut with reserves* system only)

	No Reserve Area		Dispersed Reserve Area		WTP Area	
	mean	SD	mean	SD	mean	SD
Tenure Holder						
Revelstoke Community Forest	0.91	0.34	0.12	0.22	0.02	0.07
Okanagan-Columbia BCTS office	0.82	0.25	0.08	0.25	0.09	0.12
Louisian Pacific	0.94	0.13	0.01	0.07	0.04	0.09
Likely-Xats'ull Community Forest	0.87	0.84	0.23	0.41	0	0
Cariboo-Chilcotin BCTS office	0.88	0.15	0.58	0.16	0.08	0.1
West Fraser	0.75	0.33	0.11	0.24	0.18	0.31
McBride Community Forest	0.95	0.27	0.11	0.17	0	0
Kamloops BCTS office	0.68	0.37	0.22	0.36	0.11	0.18
Carrier Lumber	0.83	0.25	0	0.02	0.01	0.04
Creston Valley Community Forest	0.99	0.01	0	0	0	0
Kootenay BCTS Office	0.9	0.2	0.08	0.18	0.03	0.07
Tembec	0.65	0.39	0.29	0.43	0.04	0.8

Appendix G: Chi-square distances from THLB, for each metric and licensee listed

	CF	BCTS	CONV
Revelstoke Area			
Leading Species	1.28	1.11	1.16
Age Class	0.99	1.42	0.55
Site Class	0.5	0.68	0.53
BEC Classification	1.2	0.52	1.15
Likely Area			
Leading Species	0.71	1.17	0.9
Age Class	1.17	0.66	0.66
Site Class	0.98	0.48	0.71
BEC Classification	2.08	0.99	1.43
McBride Area			
Leading Species	1.01	0.92	0.97
Age Class	1.05	0.94	0.99
Site Class	0.69	0.96	0.83
BEC Classification	1.64	2.27	1.1
Creston Area			
Leading Species	1.15	0.71	0.9
Age Class	1.06	0.69	0.64
Site Class	0.55	0.83	0.72
BEC Classification	1.37	1.07	1.21

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