Forest Practices Board

Biodiversity Conservation during Salvage Logging in the Central Interior of BC

Special Report

FPB/SR/35

November 2009

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Summary

British Columbia is engulfed in a province-wide mountain pine beetle outbreak. Salvaging value from the dead pine trees is a government priority. To facilitate the salvage effort, government increased the allowable annual cut (AAC) by 80 percent in the three most severely affected timber supply areas; the Lakes, Prince George and Quesnel TSAs, which are also the study areas for this project. The increased AAC led to concerns about the stewardship of non-timber values such as wildlife and biodiversity. To accommodate these concerns, the "timber uplift" (AAC increase) was to be accompanied by a "conservation uplift" (an increase in retention of mature forest structure in harvested areas).

Map of B.C. showing the study area

To help achieve the conservation uplift, the chief forester provided forest professionals with "Guidance on Landscape- and Stand-level Structural Retention in Large-Scale Mountain Pine Beetle Salvage Operations."[1] This guidance is not legally binding. It explains the chief forester's view of how the conservation uplift could be applied. At the landscape-level, the guidance was "that collaborative, multi-stakeholder, long-term landscape-level planning is the best option for managing increased retention." At the stand-level, the guidance was that retention of mature forest structure should increase as the size of harvested patches increased. The chief forester knew that salvage harvesting would, in some cases, create cutblocks that would join with previously harvested cutblocks, resulting in harvested patches that grew over time. His guidance was that retention levels should be assessed based on patches made up of adjoining cutblocks[2] that were harvested in the last 30 years.

The chief forester:

The chief forester of the government of British Columbia

Forest professionals:

Members of the Association of British Columbia Forest Professionals; and by association, the forest licence agreement holders that employ them

We:

The Forest Practices Board

We asked the question; have forest professionals responded to the chief forester's guidance on retention? At the landscape-level, we found that, while government had made some efforts to provide the information necessary for landscape-level salvage harvest and retention planning, no

[1] See Appendix 2 of this report.

[2] In his guidance the chief forester coined the phrase "functional opening" to describe harvested patches that coalesce and grow over time.

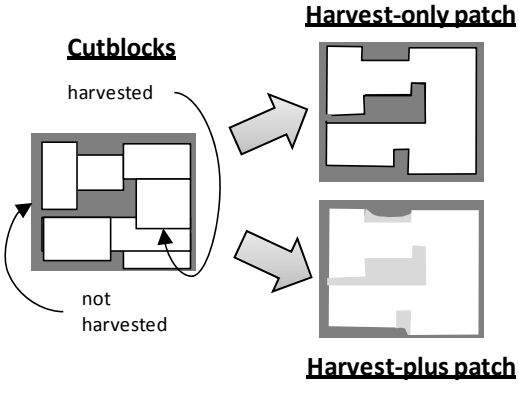
such planning was done in the study area.[3] In the absence of landscape-level planning we asked whether forest professionals had responded to the chief forester's stand level guidance when designing cutblocks. In order to do this, we examined government's records of what was retained in individual salvage cutblocks. Although we found that those records were incomplete and inconsistent, we were able to conclude that forest professionals have, in general, implemented the chief forester's stand-level guidance. On average, retention levels increased after the guidance was issued and retention levels were higher in larger cutblocks and were in line with the chief forester's recommendations. However, it remains to be seen whether all this retention will be maintained in the mid-or-long term, or whether some may be harvested as salvage logging proceeds.

We then asked "what was the landscape-level result of the salvage harvesting and retention that has occurred?" In order to answer this question, we needed a map of all harvest cutblocks showing where and when they had been harvested. Though such a map was not readily available, we were able to produce one using data available from the Ministry of Forests and Range (MFR).

We found that only 23 percent of the forest in the study area has been harvested, but that harvesting over the last 30 years has been heavily concentrated in the south-central part of the study area. The map of cutblocks was used to delineate patches for the purpose of evaluating the landscape level outcome of the salvage harvesting. Patches were defined in two ways.

The simple method of defining patches was to join adjacent cutblocks harvested in the last 30 years, to form harvest-only patches.

Another method of defining patches was also used.[4] That method included some unharvested forest, adjacent to and surrounded by the cutblocks, in the patch, to create harvest-plus patches.[5]



Schematic showing the relationship between cutblocks and the two types of patches

We found that much of the recent harvesting (after the chief forester's guidance in 2005) has resulted in the coalescing of individual cutblocks into large harvest-only patches. Over half of the harvest since 1978 is now in patches larger than 250 hectares

[3] Note that there are legal objectives for old forest retention, specific to the Prince George TSA, and spatially explicit landscape-level planning for old forest retention has been completed in the Lakes TSA and is essentially complete in the Quesnel TSA. However, the chief forester's guidance is specifically for "levels of retention over and above" this "standard old-growth retention."

[4] That method is the same as the one defined in the Order Establishing Landscape Biodiversity Objectives for the Prince George Timber Supply Area, except that order defines patches as being harvested in the last 20 years, whereas the chief forester's guidance specifies 30 years.

[5] It is very important to note that we defined the patches only for the purposes of evaluating the landscape-level condition. They are not "real entities" on the landscape.

and over one third is in patches larger than 1 000 hectares. At least seven very large harvest-only patches (more than 10 000 hectares in size) have emerged on the landscape.

On average, the large harvest-only patches contain much less mature forest structure than was recommended by the chief forester. The reason is that, though the recent salvage harvest cutblocks do have the recommended levels of retention, they represent only about 15 percent of the area of the patches. Half of the area of the patches was harvested before 1996, when there was almost no retention left in harvested areas.

As of 2008, the harvest-plus patches contain, within their boundaries, retained areas in cutblocks, and unharvested areas adjacent to the cutblocks, in amounts that meet the chief forester's recommendations for retention. As noted previously, we delineated these harvest-plus patches for the purpose of evaluating landscape condition. While they have no actual status, they do indicate an existing opportunity to meet the chief forester's guidance on retention levels.

It is likely that, as salvage harvesting continues, large patches of both types will continue to grow in number and size. It is also likely that, without landscape level planning for retention, the amount of unharvested mature forest in the large harvest-plus patches will diminish. In the areas west of Quesnel and northwest of Prince George, the landscape is rapidly transitioning from one that was dominated by small harvested areas in an un-harvested landscape to one that is largely harvested, with small unharvested areas remaining.

Has there been a conservation uplift? At the stand-level the answer appears to be yes. However, there was no planning for, or implementation of a conservation uplift at the landscape-level. Opportunity remains to do so, but that opportunity may be lost without quick action.

Board Commentary

This report raises issues about forest management and information management. While these issues are somewhat interconnected, we comment on them separately.

About forest management

It is widely believed that retaining mature forest structure during forest harvesting is an important tool for achieving the goals of maintaining wildlife habitat, biodiversity and ecosystem function. The chief forester indicated in his guidance document that special attention needed to be paid to this tool during large-scale salvage operations so that "planning and practices associated with protecting biodiversity are in step with the increased rate of salvage harvesting."[6]

An important factor in this issue is the unprecedented scale, both in area and in time, of the mountain pine beetle epidemic and the salvage harvesting response. There is simply no research or direct experience to guide an understanding of the ecological consequences of either. The closest to this circumstance that BC has ever come was during the 1980's when, in the Bowron River Valley, located north of Wells Gray Park, a single harvest-only patch[7] of 33 000 hectares was harvested in response to a spruce bark beetle outbreak. Unfortunately, almost no research has been done on the consequences of that harvesting. The available research[8] seems to support the consensus, at least amongst researchers advising the chief forester, that it would have been a good idea to have retained more mature forest structure during the salvage operation in Bowron.

The chief forester issued guidance, reflecting that idea, for the current salvage operations and there is evidence that the guidance is being followed – at the stand-level. However, at the landscape-level, large harvest-only patches have emerged with much less mature forest structure than recommended. This could have been prevented, had the landscape-level planning recommended by the chief forester, been done. There are a number of likely reasons why that planning was not done, not the least of which was an apparent lack of clarity about how the guidance should be applied. In addition, there would have been nearly insurmountable difficulties:

- involved in changing the implementation of the already more-or-less complete land use plans to superimpose new spatially explicit components (i.e., mature forest retention areas outside of cutblocks);

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[6] See Appendix 2 of this report

[7] See the summary for a brief description of how the harvest-only and harvest-plus patches are defined. A more detailed description is found in Section 4.2.2 of the main report.

[8] e.g., Nordin, L.J., J. F. Rex, D. A. Maloney, and P. J. Tschaplinski. 2008. Standardized approaches in effectiveness monitoring programs and regional relevance: lessons from the Bowron River Watershed Riparian Evaluation Project. Can. J. For. Res. 38(12): 3139–3150.

- reconciling increased retention with other stated government objectives such as recovering the greatest value from the dead timber and restoring the forest resources in areas affected by the epidemic; and

- achieving agreement on multi-licensee planning within the framework of existing replaceable volume-based tenures and the rapidly changing set of non-replaceable tenures.

Forest professionals did not plan to create the particular set of large harvested patches that exist in the study area. These patches emerged on the landscape as a consequence of an accumulation of decisions about where to place individual cutblocks. Those decisions were made based on a myriad of government and corporate objectives that rule the day-to-day life of professional foresters.

The situation seems to cry out for landscape-level planning. It is clear to the Board that it will not be possible to salvage harvest of all of the dead pine.[9] It is equally clear that it may not be particularly useful to simply retain stands of dead pine everywhere in the amounts required to meet the chief forester's recommended levels of retention. Given the circumstance where there is an over-abundance of what to take, it seems prudent to begin the decision-making process with the question "what should be left behind?" That decision should not be made only at the stand-level. It requires landscape-level context— a landscape-level plan.

We found that adequate opportunities remain to plan for landscape-level retention of mature forest structure in amounts that meet the chief forester's guidance; however, as salvage harvesting proceeds, these opportunities will diminish. There should be debate about what kind of retention and what level of retention is appropriate, in any given place. There should not be debate about the need for landscape-level decisions about what to retain during salvage harvesting. The time to act is now.

We note that, in the four years since the release of the chief forester's guidance, there has been some evaluation of the effectiveness of wildlife tree retention in meeting government's objectives for stand level biodiversity,[10] though none of it has been specifically directed at evaluating the implications of the chief forester's guidance. We are aware of only one evaluation, other than our own, of the landscape-level implications of salvage harvesting and that was for a single landscape unit in southern British Columbia.[11] We are concerned because, in the results based environment mandated by the *Forest and Range Practices Act*, ongoing and timely effectiveness evaluation is vital to properly managing the achievement of government objectives for wildlife and biodiversity at both the stand-level and landscape-level, particularly given the rapidly progressing salvage operation.

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[9] Even with very optimistic assumptions, it would take over 22 years to harvest all the dead pine (assuming pine harvest continues at 2008 rates and no more pine is killed). Current estimates of shelf-life for dead pine are 8 to 12 years.

[10] http://www.for.gov.bc.ca/ftp/hfp/external/!publish/frep/reports/FREP_Report_17.pdf

[11] http://www.forrex.org/publications/jem/ISS49/vol9_no3_MPBconference.pdf pages 115-119

It may be argued that the large harvested openings are in keeping with government's objectives for wildlife and biodiversity at the landscape level[12] because their sizes and shapes are similar to openings historically created by fires. However, it is a matter of significant uncertainty whether the amount of mature forest structure remaining within the openings, or the rate at which the openings are being created, are within the range of variability of the natural disturbance regimes in the study area. It may be more important to ask whether these openings are desirable rather than debate whether they have the attributes of natural disturbances.

About information management

Inventories of natural resources and human "footprints" on the land are vital to informed decision making. The creation and maintenance of these inventories is a time consuming and expensive task. For government, complications arise because of changes over time in legislative and reporting requirements, unclear or inconsistent business procedures and insufficient training for those providing data.

For this study, we needed a map showing where and when forest harvesting had occurred but a suitable map was not available. Creating the map required significant time and effort. Many others, charged with informing strategic level decisions (over large areas), would simply be unable to do so.

We also found incomplete forest harvest mapping and no readily available forest cover mapping for several of the tree farm licences within the study area. Though this was unlikely to have been particularly influential for the results of this report, for other questions and in other parts of the province, the issue would be very important.

For this study, we needed information about areas of mature forest within cutblocks. We found government has incomplete and inconsistent records of areas retained (reserved from harvest) in cutblocks.[13] This is significant for the administration of forestry on Crown land, as there are legal requirements to report wildlife tree retention areas and not to harvest them without appropriate exemptions.[14]

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[12] "The objective set by government for wildlife and biodiversity at the landscape level is, without unduly reducing the supply of timber from British Columbia's forests and to the extent practicable, to design areas on which timber harvesting is to be carried out that resemble, both spatially and temporally, the patterns of natural disturbance that occur within the landscape." *Forest Planning and Practices Regulation* Section 9.

[13] In the study area the government has maps of what has happened in harvest areas (Reporting Silviculture and Land Tracking System - Forest Cover Polygons) for less than half the harvest since 1996 (when requirements for wildlife tree retention began). In some of those maps there are problems that make it difficult or impossible to track the reserves.

[14] *Forest Planning and Practices Regulation* Sections 86 (3)(iv), 67 and 91(2).

We expressed concern about the issue of government's inability to track wildlife tree reserves as early as 2001[15] and again in 2004.[16] A year later we were assured that "a data storage protocol [was] under development" and that "the data [would] enable government and others to analyze trends in biodiversity conservation"[17] (note that at that time the government set the objective for biodiversity at the stand level "to retain wildlife trees"[18]).

We acknowledge that significant improvements have been made over time in the level and accuracy of reporting and that work is ongoing to continue that process of improvement. MFR has recently revised the manner in which reserves should be reported.[19] Nonetheless, important issues remain:

- Incomplete and inconsistent reporting of wildlife tree retention areas continue.
- There is no data about reserves in many cutblocks and where data does exist there are often problems with inconsistently applied reserve codes. Where responsibility has reverted to the Crown, government can have no expectation that information will be provided by licensees.

Recommendations

1) Government should seize the opportunity that exists to implement a landscape-level conservation uplift by proceeding without delay to:

   a) Clarify government's objectives for wildlife and biodiversity at the landscape-level in areas affected by large-scale salvage operations.

   b) Provide leadership in the process of making landscape-level decisions about what areas to retain during salvage harvesting.

   c) Evaluate the achievement of government's objectives for wildlife and biodiversity at the landscape-level, throughout the area of the salvage operations, before opportunities are lost to influence the decisions made as a result of recommendation 1)b).

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[15] Skaiakos Point Road Construction and Logging of Old-Growth Trees near a Proposed Hiking Trail by Sechelt Inlet. Complaint Investigation 990205, FPB/IRC/37, 2001.

[16] Implementation of Biodiversity Measures under the Forest Practices Code: Implications for the Transition to the Forest and Range Practices Act. Special Report FPB/SR/17, March 2004

[17] Response from Ministry of Forests to Special Report FPB/SR/17, March 2004.

[18] *Forest Planning and Practices Regulation* Section 9.1

[19] http://www.for.gov.bc.ca/his/results/RISS_ls_3a_ed_Oct1.pdf Section 5.7.3.5. It is unclear how the new method of reporting can be used to assess levels of wildlife tree retention areas and Board staff will work with MFR staff to resolve this issue.

The Ministry of Forests and Range should:

a) Use all available information to produce a disturbance/depletion map that shows all forest harvesting that has occurred, provides some estimate of the date of the harvest and indicates the source of the information. That map should be updated annually.

b) Take steps necessary to make available maps showing forest cover and forest harvesting on tree farm licences of sufficient detail for strategic level analysis.

c) Implement quality control procedures to ensure complete and accurate reporting of wildlife tree retention areas under Section 86(3)(a)(iv) of the *Forest Planning and Practices Regulation*.

d) Make explicit the reserve status of all mature forest areas previously reported as being in harvested blocks.

e) Complete the mapping of existing wildlife tree retention areas in harvested blocks where responsibility has reverted to the Crown.

The Forest Practices Board requests that government advise it, by March 31, 2010, of the steps being taken to address these recommendations.

Introduction

Background

British Columbia is engulfed in a mountain pine beetle outbreak that is affecting all of western North America. The Ministry of Forests and Range (MFR) estimates that, as of 2008, nearly half of the merchantable pine volume in British Columbia has been killed. MFR projects that by 2015 nearly 70 percent of the mature pine trees may die.[20]

BC forest managers have been dealing with this problem for more than a decade. During the early years, MFR encouraged foresters to attempt to control the outbreak in a number of ways, including increases in the allowable annual cut (AAC). By 2004, it was recognized that control was not possible in the worst hit areas in central BC. The focus of foresters shifted to salvaging the dead pine before it lost value as sawlogs. To help salvage efforts, AACs were further increased in the three most severely affected timber supply areas (TSAs), the Lakes, Prince George and Quesnel TSAs. In these areas, the combined AAC is now 80 percent higher than it was prior to the outbreak.

The potential for a rapid increase in the rate of harvest resulted in concerns about the stewardship of non-timber resources such as wildlife habitat, biodiversity and hydrological function. To accommodate these concerns the "timber uplift" was to be accompanied by a "conservation uplift." That is, in areas where extensive salvaging was going to occur, more mature forest structure would be left unharvested (retained) than was prescribed by law. The intent was to ameliorate impacts on both non-timber values and mid-term timber supply. This was acknowledged in the rationales for the AAC determinations published in October 2004.[21]

In December 2005, the chief forester issued "Guidance on Landscape- and Stand-level Structural Retention in Large-Scale Mountain Pine Beetle Salvage Operations."[22] This guidance, although not legally binding, details the chief forester's expectations about how the conservation uplift is to be applied. The chief forester's guidance states that "there is significant uncertainty about the effects of the 80 percent increase in harvesting[23] in the Lakes, Prince George and Quesnel TSAs, particularly with regard to non-timber values such as biological diversity and hydrologic function. Accordingly, I believe caution is warranted."

The chief forester said "that collaborative, multi-stakeholder, long-term landscape-level planning is the best option for managing increased retention that is balanced between the landscape and the stand". He went on to further specify the attributes of landscape-level planning that would represent the best option for acting cautiously (see discussion on page 16). The chief forester also provided stand-level guidance about how to plan for retention when designing individual cutblocks. The basis

[20] http://www.for.gov.bc.ca/hre/bcmpb/BCMPB.v6.BeetleProjection.Update.pdf

[21] in the AAC rationales for the 3 TSAs; for example: http://www.for.gov.bc.ca/hts/tsa/tsa24/tsr3/rationale.pdf

[22] See Appendix 2 of this report.

[23] note that the full AAC in the area has not been harvested in any year.

of the chief forester's stand-level guidance is that retention should increase with increasing patch (opening) size, as specified in Table 1. He was clear that the levels of retention in Table 1 should not be arbitrarily applied to any one patch. The amount of retention should depend on the ecological and administrative attributes of the landscape in which the patch occurs. However, Table 1 indicates "targets for stand-level retention around the generally desired percentage for a given [patch] size."

Table 1. Recommended proportion of stand-level retention based on opening size

Opening Size	Percent of Opening Un-harvested/retained
<50 ha	10%
50 – 250 ha	10 – 15 %
250 – 1000 ha	15 – 25 %
> 1000 ha	> 25 %

Copied from the chief forester's guidance

Prior to the beetle outbreak, forestry primarily resulted in patches in the two smallest size classes[24] in Table 1. Under the *Forest Practices Code of British Columbia Act* (the Code), cutblocks could not exceed 60 hectares in size without the approval of an MFR district manager.[25] But the chief forester knew that provisions under the *Forest and Range Practices Act* (FRPA),[26] brought into force in 2004, explicitly allowed cutblocks to coalesce over time when salvage harvesting. The allowable cut determinations, which resulted in the "timber uplift," referred to earlier, assumed that large patches would be created. Therefore, the chief forester indicated that retention levels should be assessed based on "contiguous areas harvested or disturbed within the last 30 years." He coined the phrase "functional openings" to describe these areas.

Throughout this report we use the word "patch" instead of "functional opening" and the word "cutblock" to describe an area where foresters have planned and created an individual opening in the forest. We do this for editorial reasons: it substantially simplifies the wording needed to make a clear distinction between the two kinds of "openings" discussed in the chief forester's guidance. The simple word "patch" is generally accepted by resource professionals in receipt of the guidance to mean what the chief forester defined as a "functional opening[27]".

chief forester's guidance	this report
functional opening	patch
(harvest) opening	cutblock

[24] There were some dramatic exceptions such as the "Bowron clearcut," created in the mid 1980s to salvage trees killed by the spruce bark beetle.

[25] *Operational and Site Planning Regulation*, Section 11(1)(b) and 11(3)(b)(i)(A)

[26] *Forest Planning and Practices Regulation*, Sections 64(2)(a)(i)(A) and 65(4)

[27] We note that the word "patch" is also used in the context of a "patch cut" silvicultural system, particularly on the coast of BC.

Objectives

This special report endeavors to answer the following:

1. Have forest professionals responded to the chief forester's guidance on retention?
2. What has been the landscape-level result of salvage harvesting?

Given the increased rate of allowable harvest, unintended landscape-level results are possible. We examined the landscape-level consequences of the accumulated decisions about stand-level harvest and retention.

The study area

The study area is the Lakes, Prince George and Quesnel TSAs (Figure 1). The 2004 AAC determinations for these TSAs, assumed that forest management would include a "conservation uplift" (as described above) and it was this assumption that prompted the chief forester to provide guidance on landscape- and stand-level structural retention in December 2005. Note that the guidance was provided to all forest professionals in the province. Many of the AAC determinations released since 2005 have encouraged its application where large scale salvage is being undertaken.

Forest harvesting in the study area is administered by five MFR District offices; Nadina for the Lakes TSA, Prince George, Vanderhoof and Fort St. James for the Prince George TSA and Quesnel for the Quesnel TSA. The total area of the five districts is 116 200 km.^{2} However, only 90 300 km^2 are in the TSAs that form the study area. The remaining 25 900 km^2 are tree farm licences, private land, woodlots and parks that are embedded in, but are not part of, the timber supply areas.

Since the release of the chief forester's guidance in December 2005, three licensees have reported over half (55 percent) the harvesting in the study area; Canadian Forest Products Ltd., West Fraser Mills Ltd., and Tolko Industries Ltd. Tolko only operates in the Quesnel TSA, but the other two licensees have operations in all 3 TSAs. BC Timber Sales[28] administered almost 20 percent of the harvest. Over 40 other licensees[29], including 5 First Nations and 2 community forests, were involved in harvesting the remaining 25 percent.

The study area has a reasonably diverse ecological makeup at its periphery, but it is dominated by the gently rolling plateaus of the sub-boreal-spruce biogeoclimatic zone[30] (Figure 2). Most of the salvage harvesting has occurred in this zone and in the sub-boreal-pine spruce zone. The forest in these zones is dominated by mature pine trees (Figure 3). There has been some variation in the level of mortality resulting from the outbreak across the study area. The hardest hit areas are in the southwest and mortality declines to the north and east.

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[28] An independent organization within the BC Ministry of Forests and Range that develops Crown timber for auction. http://www.for.gov.bc.ca/bcts/

[29] Many of these licensees also harvested areas administered by BC Timber Sales.

[30] http://www.for.gov.bc.ca/hre/becweb/index.html

A principle caveat for the report

The diversity in forest management and ecology within the study area results in variability in the answers to the questions posed in the objectives. We have spent substantial time and effort examining that variation and trying to understand its underlying causes.

Throughout the report, results are presented at a study area wide level and the level of variation in those results is discussed as appropriate. Results are presented to two significant digits. We do not present data or interpretations that identify specific districts, licensees or forest professionals. This level of reporting is appropriate for two reasons:

1. This is a special report on the issue and not an audit of practices. We hope to provide general conclusions that can be used to improve forest management, not to draw attention to particularly good or poor performers.

2. The data used in this report are suitable for strategic-level analyses but are neither sufficiently complete nor precise to draw conclusions about specific places. Issues of data quality are discussed throughout the report.

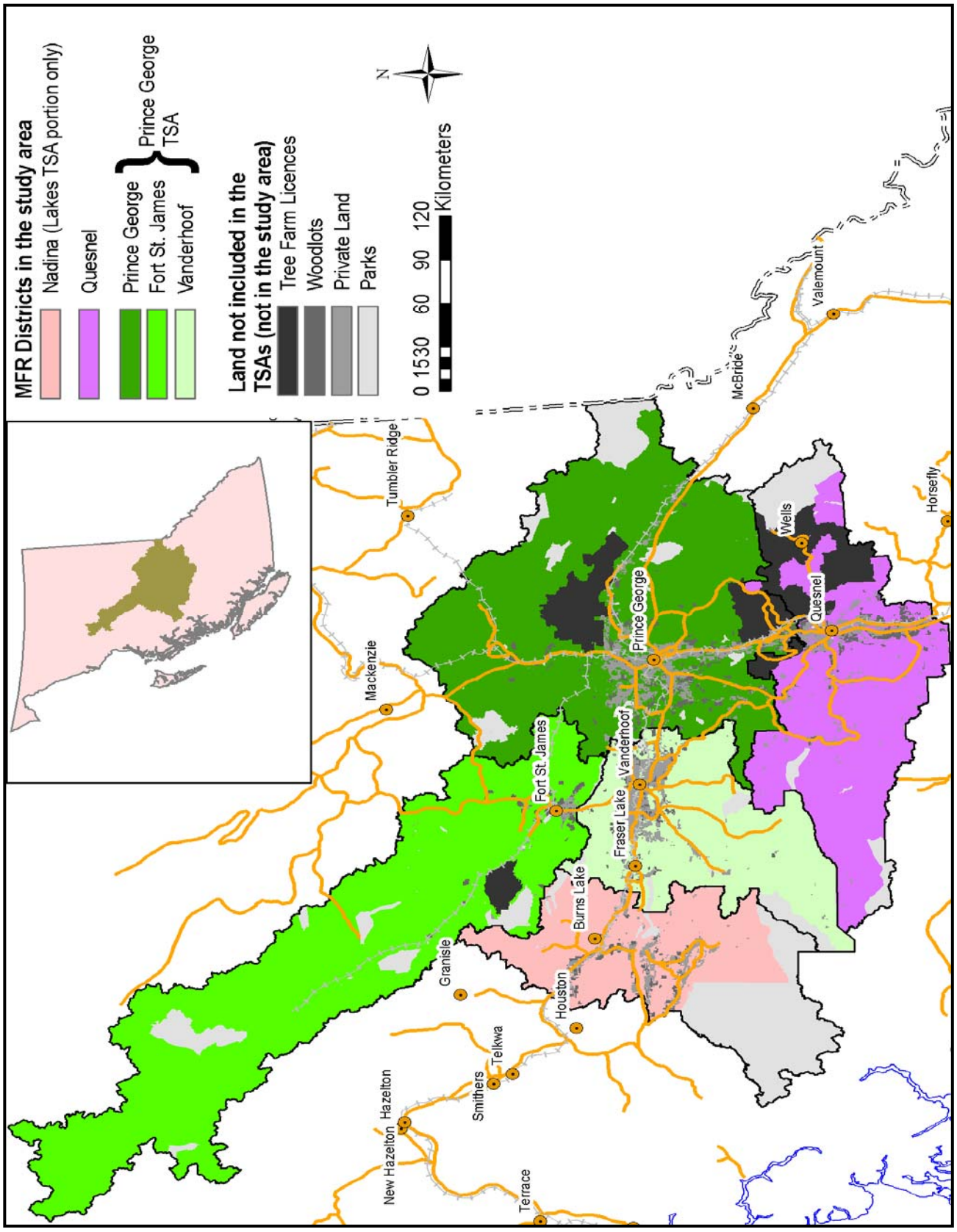

Figure 1. MFR Districts in the study area showing land not included in the study area.

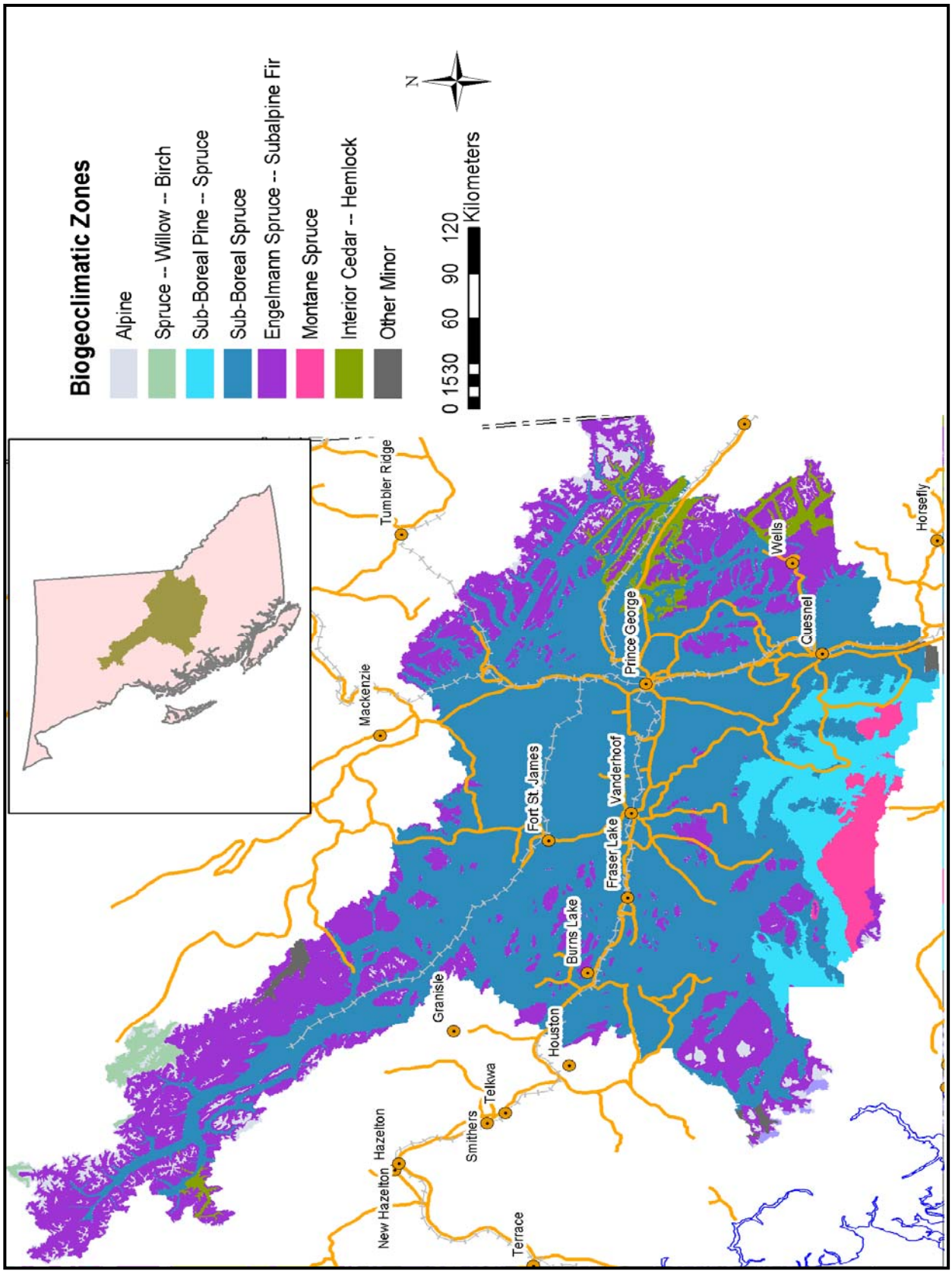

Figure 2. Biogeoclimatic zones in the study area.

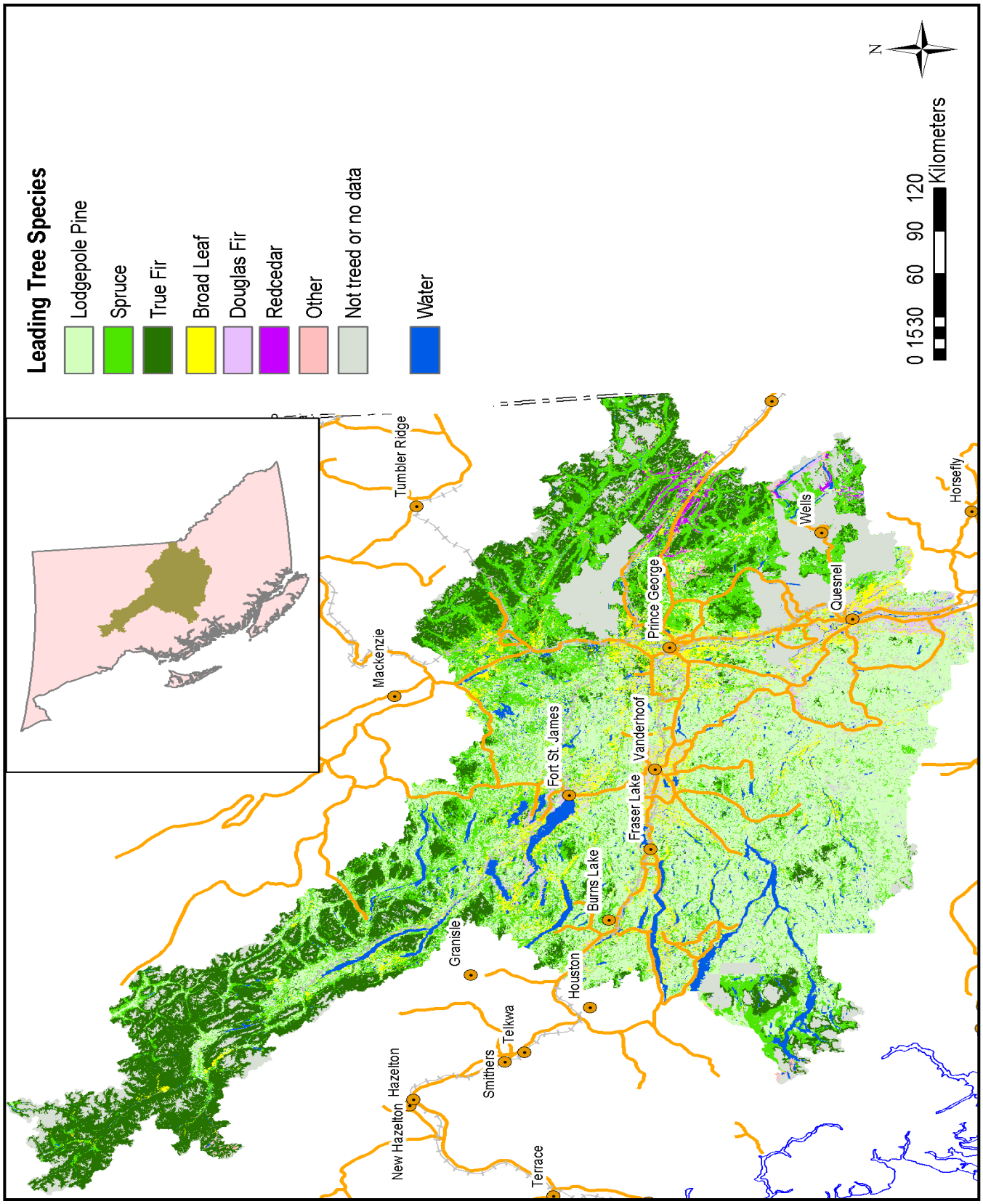

Figure 3. Leading trees species in the study area.

The Results of the Study

Have forest professionals responded to the chief forester's guidance?

The chief forester provided guidance to forest professionals for landscape-level and stand-level retention.

At the landscape level, he indicated that long-term planning involving multiple stakeholders is the best option for managing increased retention. Key attributes of the plans would be identification of both harvest and retention areas for as many years of operations as possible. Plans would be spatially explicit and consider the full range of forest values, and would be developed cooperatively so they would be honoured by all operators.

We found that government has made some efforts to provide the information necessary for landscape-level retention planning. For example, mapping exercises were completed for the Vanderhoof and Quesnel Forest Districts[31] that identified retention options and, in Vanderhoof, an analysis of timber supply and economics related to retention as conducted.[32] However, no landscape-level planning of salvage harvest and retention, as described by the chief forester, has been undertaken. We note that land-use plans are in place throughout the study area and that legal orders are in effect (or soon to be in effect in Quesnel) implementing aspects of old forest retention in those areas. Nevertheless, the chief forester is clear in his guidance that he is referring to levels of retention (and planning for that retention) that is "over and above...standard old growth retention" found in land-use plans. There have been two land-use plans recently completed in the study area, which make reference to the chief forester's guidance; the Quesnel Sustainable Resource Management Plan[33] and the Lakes North Sustainable Resource Management Plan.[34] However, neither plan has the attributes of a landscape-level salvage harvest and retention plan, as described by the chief forester.

The question remains "have forest professionals responded to the chief forester's guidance on stand-level (cutblock) retention as specified in Table 1?" Holders of forest licences report to government on operations at the cutblock level through the RESULTS database (Reporting Silviculture and Land Tracking System[35]). Part of what is supposed to be recorded in RESULTS is the location and size of wildlife tree retention areas.[36] In addition, a variety of other types of retained areas can be recorded. We assumed that RESULTS could be used to show whether forest professionals have responded at the cutblock or stand-level.

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[31] http://www.for.gov.bc.ca/hfd/library/documents/bib98258_Vanderhoof_and_Quesnel.pdf

[32] http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/MPB_ActionPlan_ProgressReport.pdf page 31

[33] http://ilmbwww.gov.bc.ca/slrp/srmp/north/quesnel/reports/QSRMP_Draft_February_14th_2007_for_CMC.pdf

[34] http://ilmbwww.gov.bc.ca/slrp/srmp/north/lakes_north/Docs/Lakes_North_SRMP_20090126.pdf

[35] http://www.for.gov.bc.ca/his/results/

[36] consistent with section 86 of the *Forest Planning and Practices Regulation*

We found substantial problems with the reporting of retained areas in RESULTS. Many cutblocks had no explicitly reported retention[37] but clusters of remaining mature trees were reported as being present within the blocks. In contrast, dispersed retention of wildlife trees was reported in many areas where examination of air photos showed none was present. We also found some inconsistent and seemingly inappropriate use of the coding for retained areas[38] that made it difficult to interpret the purpose of the retention. Inconsistencies in the way retention is reported in RESULTS made it impossible to use the reported values to determine whether areas have actually been reserved from harvest and, if so, for what purpose.[39]

Our solution was to use the amount of mature forest reported[40] as remaining in each cutblock to indicate the level of retention.[41] It is very important to note that in many cases mature forest remaining is not equal to the amount of retention identified by retention coding in RESULTS. These areas of mature forest should be considered "potential retention" until their status has been clarified.

For the study area, the RESULTS database contained[42] information about 7 200 cutblocks covering 310 000 hectares that were created between 2003 and 2008 (3 years before and 3 years during the guidance). Almost half those cutblocks (46 percent) were very small (<15 hectares). These small cutblocks contributed only 6 percent of the total area. Nearly three quarters of the small cutblocks had no reported mature forest remaining. We chose to ignore the small cutblocks in subsequent analysis because many of them are unusual administratively[43] and they represent a small proportion of the total area.

Of the remaining cutblocks; 2 200 were created prior to the chief forester's guidance (2003 to 2005) and 1 700 were harvested since the chief forester's guidance (2006 to 2008). These cutblocks represented a total of 160 000 hectares and 130 000 hectares, respectively. We summarized those data to answer two specific questions about forest professionals' response.

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[37] i.e. SILV_RESERVE_OBJECTIVE_CODE and SILV_RESERVE_CODE were blank.

[38] SILV_RESERVE_OBJECTIVE_CODE and SILV_RESERVE_CODE

[39] We are aware that many of these problems are specific to particular periods in time. Over time, there have been changes in legislative and reporting requirements, unclear or inconsistent business procedures and insufficient training for those providing data. Nevertheless, incomplete and inconsistent reporting of wildlife tree retention areas continues to at least July 2009.

[40] STOCKING_STATUS_CODE = MAT and STOCKING_TYPE_CODE = NAT. Note that this solution does not incorporate any dispersed retention.

[41] We were advised by MFR staff, knowledgeable with the issue, to adopt this solution and, in our own examination of the RESULTS reports we found mature forest remaining to be reasonably consistently reported.

[42] as of 2009-03-26

[43] Approved under the *Bark Beetle Regulation* or are small scale salvage openings and, as such, require no retention.

Since the chief forester's guidance:

1. have retention levels in cutblocks increased?

2. is more being retained in larger cutblocks as recommended Table 1?

We found no cutblocks were reported in RESULTS as being greater than 1 000 hectares, the largest size class in the chief forester's Table 1.

For the three smaller cutblock size classes, we found that the amount of mature forest in the cutblocks was noticeably[44] higher after the guidance than before (Figure 4). Since the chief forester's guidance (2006 to 2008), the amount of mature forest retained in cutblocks shows a noticeable[45] increase as cutblock size increases (Figure 4). For the smallest size class, the median[46] retention of 12 percent exceeds the chief forester's guidance of 10 percent. For cutblocks between 50 and 250 hectares, the median of 13 percent is in the middle of the range recommended by the chief forester. For cutblocks between 250 and 1 000 hectares, the median of 17 percent is somewhat above the bottom end of the range recommended by the chief forester.

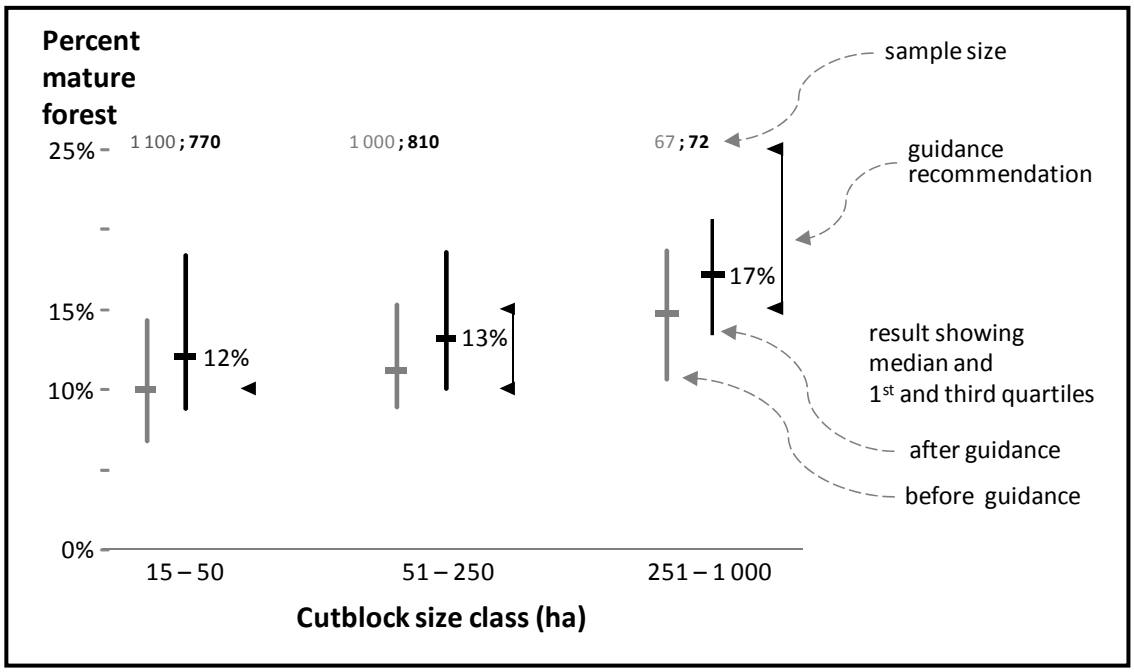

Figure 4. Summary of the amount of mature forest in cutblocks, reported in RESULTS, by cutblock size class for the 3 years before and the 3 years after the chief forester's guidance.

[44] $p<0.05$ Two Independent Sample Wilcoxon Rank Sum Test

[45] $p<0.05$ Two Independent Sample Wilcoxon Rank Sum Test

[46] The median value is used to characterize the amount of retention, rather than the mean, and rank-sum tests are used to examined differences because the distribution of values is highly right skewed, and stand-level guidance must be evaluated by performance at each sample point; i.e., over achievement in some cutblocks does not compensate for under-achievement in other cutblocks. The area-weighted arithmetic mean is somewhat higher in all cases.

These results could be interpreted as indicating that, in general, forest professionals, and by association the forest license agreement holders that employ them, have implemented the chief forester's stand-level guidance.[47]

These are results for individual cutblocks planned and created by forest professionals and they represent the response to the chief forester's guidance at the stand-level. The effect of this response on patches (the chief forester's "functional openings") at the landscape-level is presented in the next section.

What has been the landscape-level result of stand-level decisions about salvage harvesting?

The chief forester's guidance recognizes that cutblocks will coalesce on the landscape as salvage harvesting progresses and form patches that will grow in size over time. Without appropriate landscape-level planning, these patches will simply emerge at the landscape level. We wanted to know if the amount of retention in those patches conforms to the chief forester's guidance. In order to answer this question we needed to accomplish three tasks:

1. Obtain a map of where and when forest harvesting had occurred in the study area.
2. Use the map of harvesting to delineate patches.
3. Characterize the amount and type of retention in the patches.

Map of forest harvesting

When we began this project in 2007, there was no readily available map of forest harvesting. We first undertook to create a map showing forest harvesting that had occurred up to and including 2006. We chose 2006 because that is the last year for which high resolution satellite imagery is readily available for the entire study area. We queried three datasets available from MFR: RESULTS,[48] the Vegetation Resources Inventory[49] and satellite image change detection for the periods 2002 to 2004 and 2004 to 2006.[50] We also did manual interpretation of satellite imagery and aerial photography to fill some of

[47] These results may underestimate the positive response to the chief forester's guidance because the guidance was directed at harvesting in pine stands that have been moderately or severely infested by mountain pine beetles. The results presented here are for all harvesting. The vast majority of the harvesting in the study area since the guidance has been to salvage moderately or severely infested stands. However, it is not possible to know what the proportion is or which stands in particular fall into that category given the information available from the MFR.

[48] forest cover and opening polygons

[49] as described at http://www.for.gov.bc.ca/hts/vri/ using the history records

[50] Ann Morrison, MFR Forest Analysis and Inventory Branch, personal communication

the more obvious omissions. We updated that map to 2008, using data from RESULTS,[51] during the preparation of this report.

We identified a total of just over 2 million hectares of forest harvesting in the entire 11 million hectare areas shown in Figure 1 (a map showing the harvesting is provided separately at http://www.fpb.gov.bc.ca/MapOfForestHarvesting.htm). Just over 1.7 million hectares of that harvesting occurred in the study area (the TSA area within the districts shown in Figure 1). The additional 300 000 hectares of harvest that occurred outside the TSAs (on TFLs, woodlots, private land and within parks before they were designated), is still of interest because it may occur adjacent to harvesting in the study area and may affect the size of patches.

We compared our map of forest harvesting with the one recently provided by MFR[52] and found that they identified only 1.3 million hectares of logging over the entire area within the five districts (65 percent of what we found) and only 1.2 million hectares of logging within the study area (71 percent of what we found). These differences are substantial.[53]

We used our map of forest harvesting for this analysis.

We found that approximately 23 percent of the forest in the study area has been harvested. About 80 percent of the harvesting occurred since 1978, i.e., within the last thirty years, and therefore contributes to the patches as defined by the chief forester ("functional openings"). Harvesting in the last 30 years has been concentrated in the south central portion of the study area, and more specifically, northwest of Prince George and west of Quesnel (Figure 5).

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[51] obtained on 2009/03/27. We are aware that this will not contain all of the RESULTS submissions for 2008, which are not due until 2009/06/01. Therefore our map might be reasonably considered a map of harvesting to part way through 2008.

[52] WHSE_FOREST_VEGETATION.VEG_COMP_LYR_R1_POLY.HARVEST_DATE obtained 2009/04/14

[53] They appear to result largely from the following omissions in the MFR map:

- On land within the study area:
  - much of the older harvesting (before 1980) is not identified;
  - harvesting where precise identification of the date harvest is not possible is not identified; and
  - much of the more recent harvesting, shown in the RESULTS database, is not identified.
- On land within the five districts but outside the study area:
  - much of the harvesting on private land is not identified; and
  - much of the harvesting on tree farm licenses (TFLs) identified in the RESULTS database is not identified.

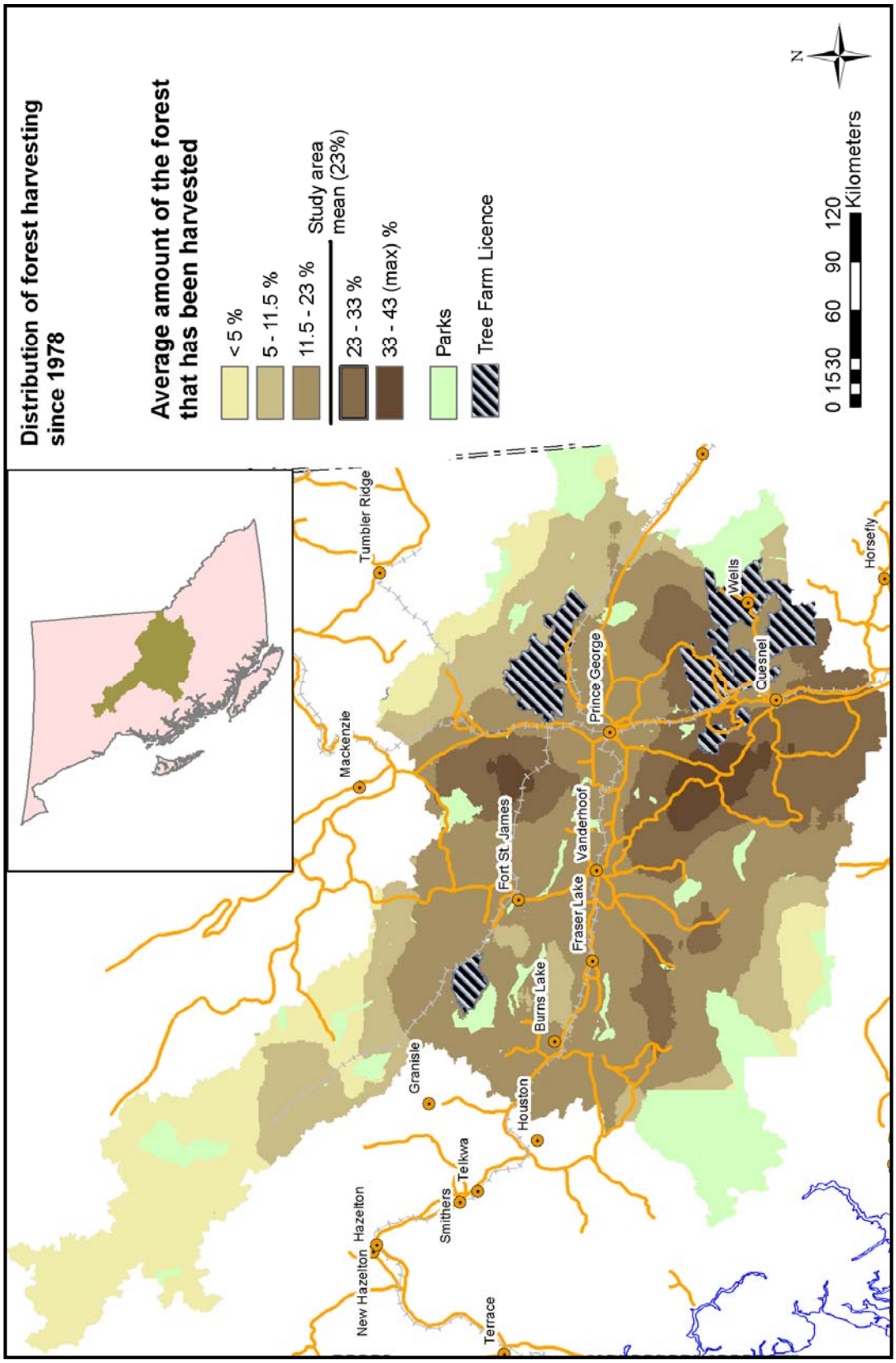

Figure 5. Average amount of the forest that has been harvested since 1978 (based on 5 kilometer diameter, circular, moving window).

Delineation of patches

The chief forester's guidance recognizes that "with respect to Table 1,[54] it will be a challenge to define the [patch] size if it 'grows' over time." He suggested that patches ("functional openings") be defined as "contiguous areas harvested or disturbed within the last 30 years (or a similar time frame), plus the retention areas within and adjacent to the [patch]." He also suggested that rather than simply assessing retention as defined by the wildlife tree retention area (WTRA) requirements of FRPA, retention should be assessed in aggregate over these patches. This can be interpreted a number of ways, particularly if the "retention areas" are not simply the WTRAs as required by FRPA. An obvious example is that, as patches grow in size, they may completely surround unharvested areas and the resulting patch might be considered to include those surrounded areas.

Delineating patches is not a new problem in natural resource management and a variety of methods have been used in British Columbia[55] and elsewhere.[56] No one method is conceptually "correct," it depends on the purpose for delineating the patches. We wanted to examine the implications of different interpretations of what the chief forester meant by "retention areas." We compared two methods of patch delineation that differ in restrictiveness in their interpretation of "retention areas."

1. Harvest-only patches. In this method we create patches by only joining together contiguous (touching) cutblocks harvested in the last 30 years. Here "retention areas" are restrictively interpreted as only those areas of mature forest structure remaining within the cutblocks.

2. Harvest-plus patches. A less restrictive way of defining "retention areas" is to include unharvested forest, adjacent to and surrounded by the cutblocks. While the chief forester allowed this interpretation, he was not specific about how it should be implemented. We chose to delineate patches that incorporate this interpretation of "retention areas" using the method of delineating young forest patches described in the Prince George biodiversity order.[57] This method is based on the idea that harvesting has an influence on the surrounding area[58] and that the influence extends further as the size of the cutblock increases. An illustration of the method of delineating patches from cutblocks for a sample of the study area[59] is shown in Figure 6.

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[54] Note that our Table 1 is identical to Table 1 in the chief forester's guidance.

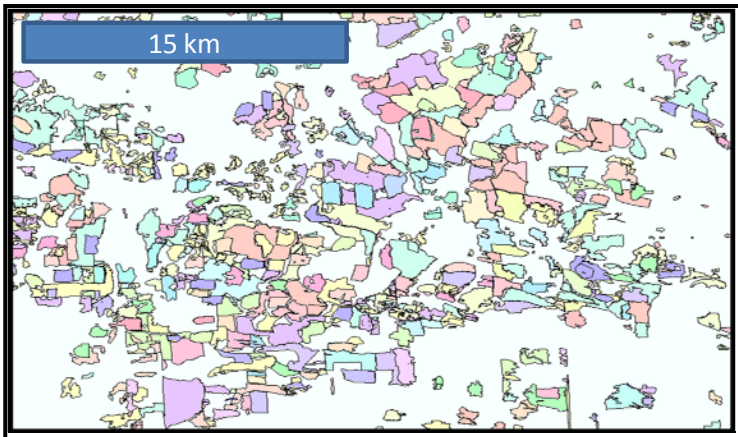
[55] For example, Heinrich, R. and D. Lewis. 2005. Analysis of Residual Forest Structure Left Following Wildfires within the Natural Disturbance Type (NDT) 3 in the Southern Interior of British Columbia: A Preliminary Review. prepared for Weyerhaeuser Canada Ltd.

[56] For example, Girvetz, E. and S. Greco. 2007. How to define a patch: a spatial model for hierarchically delineating organism-specific habitat patches. Landscape Ecology 22: 1131-1142

[57] Formally known as the Order Establishing Landscape Biodiversity Objectives for the Prince George Timber Supply Area. We apply this method to the entire study area, although it was developed only for the Prince George TSA. Note that in the Biodiversity Order, young patches are defined as less than 20 years old.

[58] Islands of unharvested area surrounded by harvesting, and unharvested peninsulas and isthmuses reaching into harvested areas in a patch.

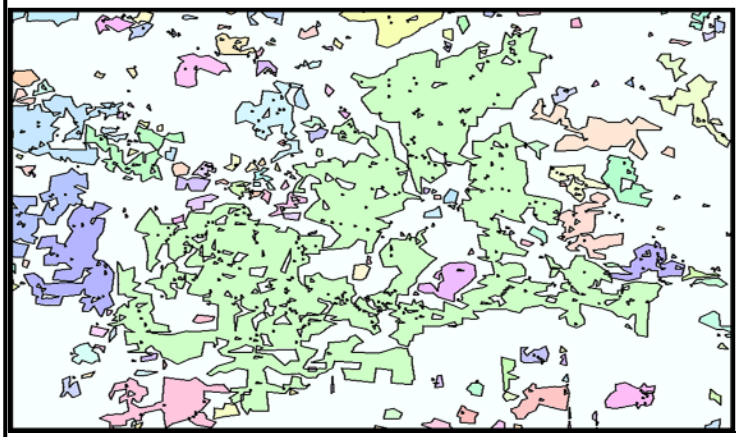
[59] Results for the entire study area cannot be portrayed at a scale suitable for presentation on 8.5X11 inch paper.



Cutblocks

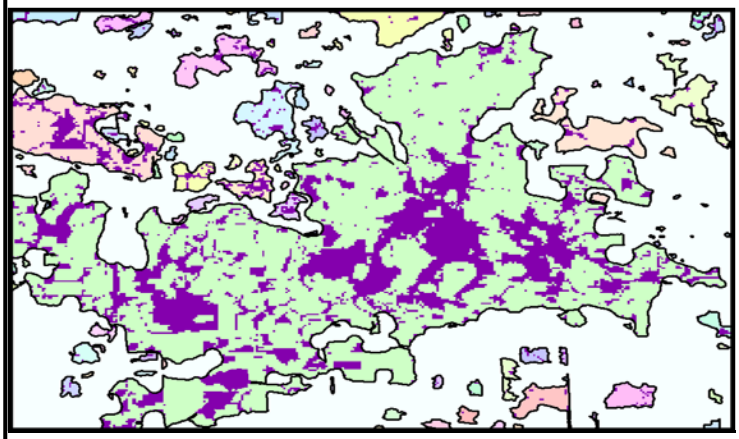
Blocks harvested in different years are outlined and shown in different colours.

These harvest blocks are the starting point for patch delineation.



Harvest-only patches = Contiguous areas of harvesting are joined together.

Each harvest only patch is shown in a different colour. The large green patch is over 16 000 hectares in size.



Harvest-plus patches = Contiguous areas of harvesting are joined with adjacent unharvested areas, that are influenced by harvesting, (shown in deep purple).

Patches , like the large green harvest-only patch, can become much larger because nearby patches are joined together. The large green harvest-plus patch extends south and west of the frame and is over 70 000 hectares in size.

Figure 6. Illustration of applying two methods of patch delineation to a portion of the study area.

The two methods of patch delineation have somewhat predictable results on the number of patches, the size class distribution of patches and the total area in patches The harvest-only patches have the same total area as the cutblocks themselves (1.6 million hectares) but there are less than half the number of patches (31 000) because many of the cutblocks are joined together. There are fewer still harvest-plus patches (18 000) because this method further aggregates areas. Harvest-plus patches have a total area of approximately 2.0 million hectares. The additional 400 000 hectares, over the harvest-only patches, is a result of including completely enclosed areas and peninsulas and isthmuses that are either unharvested or harvested before 1978.

Both methods of delineating patches result in a very different size class distribution than is found in the cutblocks themselves. Both methods have a relatively small number of large patches, compared to the cutblocks.

Table 2. Area (and percent of area) and number of patches by size class for the harvest-only and harvest-plus methods of delineating patches.

	Area in 1 000's ha		(% of area)		Number of patches	
Size Class (ha)	harvest-only		harvest-plus		harvest-only	harvest-plus
>10 000	130	(8)	500	(25)	7	18
1 001-10 000	410	(26)	580	(30)	180	210
251-1 000	360	(22)	330	(17)	760	680
51-250	470	(30)	390	(20)	5 000	4 200
<50	230	(14)	160	(8)	25 000	13 000
Total	1 600		2 000		31 000	18 000

Table 2 shows the resulting size class distributions of patches in the context of the size classes presented in the chief forester's guidance. Although none of the cutblocks reported in RESULTS were larger than 1 000 hectares, 34 or 55 percent[60] of the area in patches was in that size class, depending on the delineation method (Table 2). Note that in Table 2, we have added the patch size class of > 10 000 hectares, which does not appear in Table 1 of the chief forester's guidance. Depending on the delineation method, there are 7 or 18 patches of this size comprising 8 or 25 percent of the area in patches (Table 2). We contend that, because these patches are a more than an order of magnitude larger than the upper size limit in the chief forester's guidance, they warrant separate reporting.

The location of these large (1 000 to 10 000 ha) and very large (> 10 000 ha) patches is shown in Figure 7 and Figure 8 for the two different delineation methods. Note that both methods identify the Bowron clear-cut (southeast of Prince George and north of Wells) as being a very large patch. This area was harvested in the early 1980s to salvage timber lost from a spruce bark beetle outbreak. It still represents a patch as defined by the chief forester (having been harvested within the last 30 years). All of the remaining very large patches and most of the large patches are the result of recent harvesting because of the mountain pine beetle outbreak. We discuss the importance of this distinction between patches affected by guidance harvesting and those that are not in the next section.

[60] sum of the percentages for 1 001 – 10 000 ha patches and >10 000 ha patches.

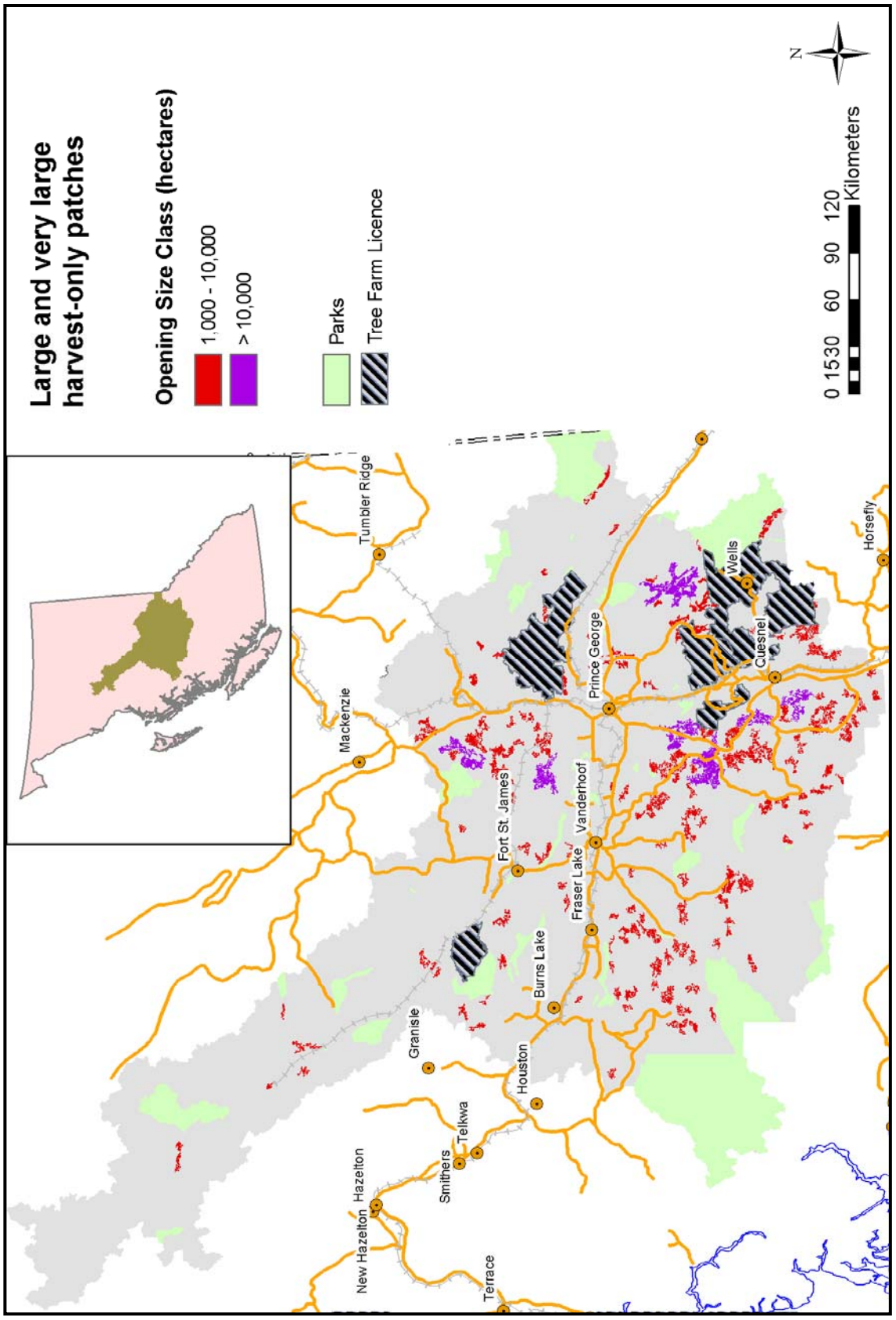


Figure 7. Large and very large patches identified using the harvest-only delineation method.

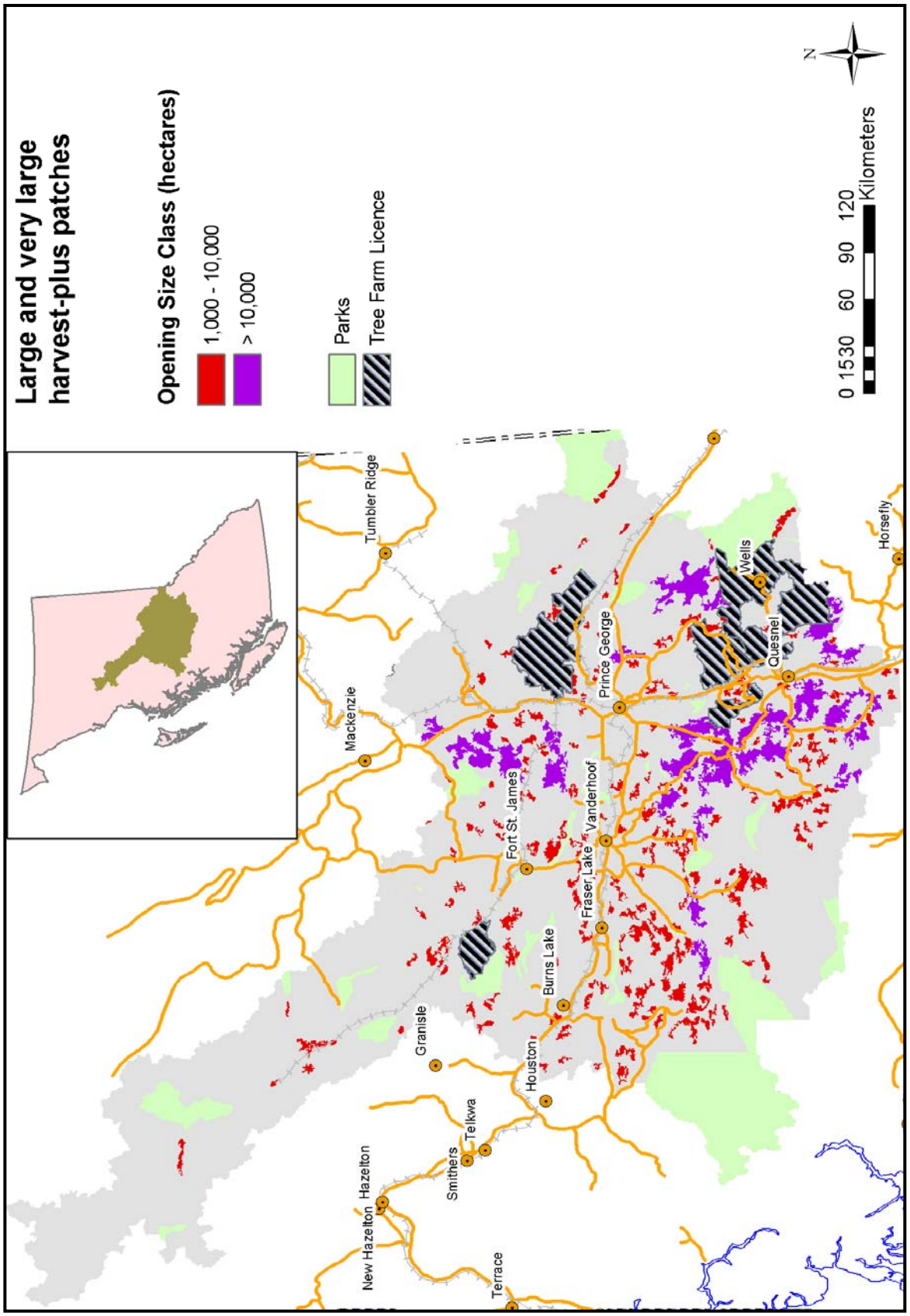


Figure 8. Large and very large patches identified using the harvest-plus delineation method.

Characterizing the amount and type of retention in the patches

We estimated the average percentage of mature forest remaining (retention) in each size class of patch for both patch delineation methods. For the unharvested areas captured in the harvest-plus patches (see Figure 6) we used an overlay with the Vegetation Resources Inventory map to estimate the amount of unharvested mature forest in each patch.[61] For the harvested blocks within the patches, it was not possible to know the mature forest remaining on a patch-by-patch basis because only about one third of the area harvested since 1978 has information in RESULTS about forest cover (and mature forest remaining). We estimated the average amount of mature forest remaining in each cutblock in each patch based on the time period in which it was harvested (Table 3) using the information available in RESULTS.

We examined the influence of cutblock size, the district of harvest and the date of harvest on variability in the estimate of the amounts of mature forest remaining in the patches. We found that, at the study area level, the only factor the results were sensitive to was the time period in which the harvesting occurred. The reason this influences the results is that areas harvested from 1978 to 1995 had very low levels of retention (< 1 percent of the cutblock). From 1996 onward to the guidance period, levels of retention averaged[62] around 12 percent because of the legal requirements of the Forest Practices Code (and in some circumstances the *Forest and Range Practices Act*). Since the guidance was released in December 2005, average retention levels in cutblocks has been around 15 percent.

Table 3. Area-weighted mean percentage of mature forest retained in cutblocks by time period of harvest.

Time period	Date range	% mature forest retained
Pre-FPC Code	<= 1995	<1%
FPC/FRPA	1996-2005	12%
Guidance	2006-2008	15%

Study-area wide estimates of the amount of mature forest remaining by patch-size class in the harvest-only and harvest-plus patches are presented in Figure 9. This figure shows the chief forester's recommended levels of retention for comparison. Figure 9 only shows the results for those patches affected by harvest since the release of the guidance. We defined those as patches where the amount of harvest since the guidance was more than 1/10 the minimum area in the size class. For example, a 1 000 to 10 000 hectare patch requires more than 100 hectares of harvest during the guidance period to be considered a patch affected by guidance harvest. The results for all patches are presented in tabular form in Appendix 1. Those results are similar to the results for the guidance

[61] The overlay with the Vegetation Resources Inventory map was required in order to exclude water bodies, meadows and other non-forested areas in our estimate of mature forest remaining. Ninety-seven percent of the forest in the unharvested areas was mature, that is, >60 years old.

[62] area-weighted mean

harvest patches shown in Figure 9. The results for any given patch will vary but we are not able to estimate that variance because we cannot obtain patch-wise estimates of in-block retention.[63]

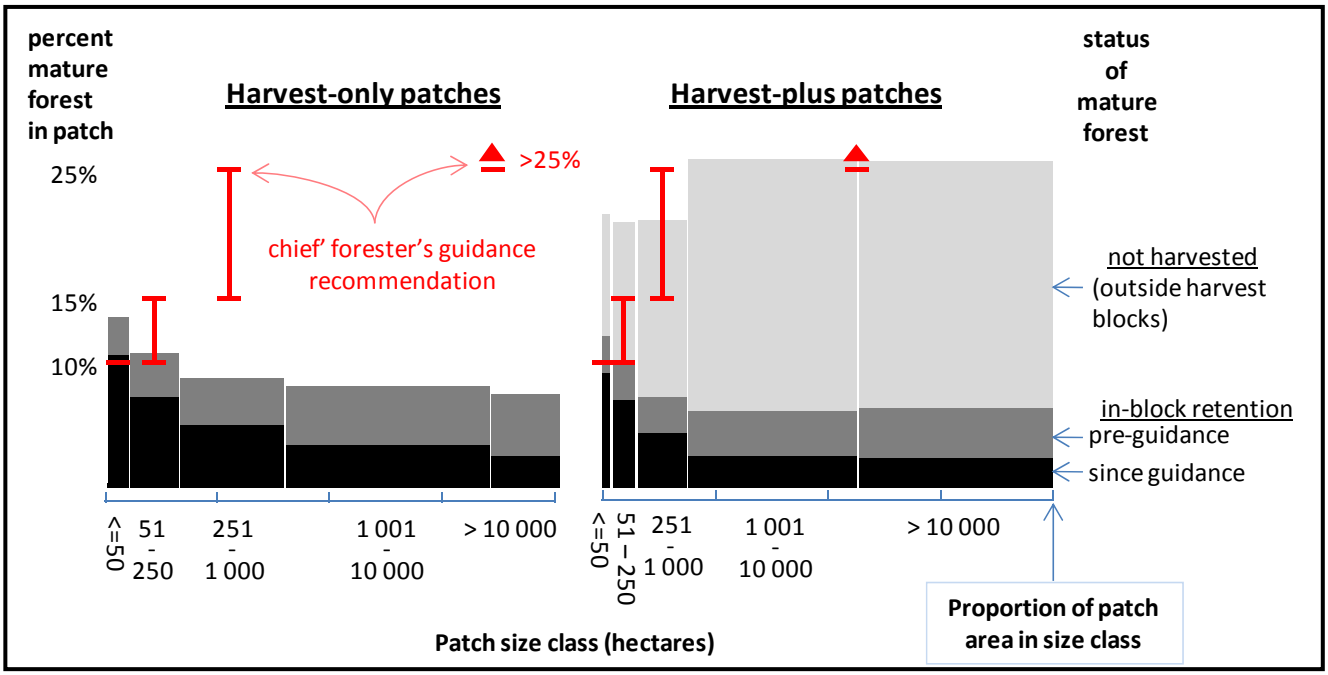


Figure 9. Percentage of mature forest in patches of differing size classes for harvest-only and harvest-plus patches affected by harvesting since the guidance. The status of the mature forest is divided into not harvested (in harvest-plus patches) and retention left in blocks harvested before and after the guidance. The width of the bars represents the proportion of the total area in patches in each opening size class. Retention percentages recommended by the chief forester are shown for comparison.

The largest three size classes of harvest-only patches make up about 85 percent of the area in harvest-only patches. Patches in these size classes have much less mature forest structure retained than was recommended by the chief forester. This may seem counter-intuitive given that the average retention level in cutblocks harvested during the guidance period was 15 percent. The reason is that, though the recent salvage harvest cutblocks do have the recommended levels of retention, they represent only about 15 percent of the area of the patches. Half of the area of the patches was harvested before 1996, when retention levels averaged less than 1 percent. The very low level of retention in the pre-code (pre-1996) cutblocks brings the overall retention down to the levels shown in Figure 9.

The harvest-plus method of patch delineation includes unharvested areas in the patches and therefore has higher percentages of mature forest than the harvest-only patches. As of 2008, the harvest-plus patches contain, within their boundaries, retained areas in cutblocks and unharvested areas adjacent to the cutblocks in amounts that meet the chief forester's recommendations for retention. It is very important to note that we delineated these harvest-plus patches for the purpose of evaluating landscape condition. While they have no actual status they are indicative of an existing opportunity to meet the chief forester's guidance on retention levels.

[63] see the discussion of the data limitation in RESULTS on page 17.

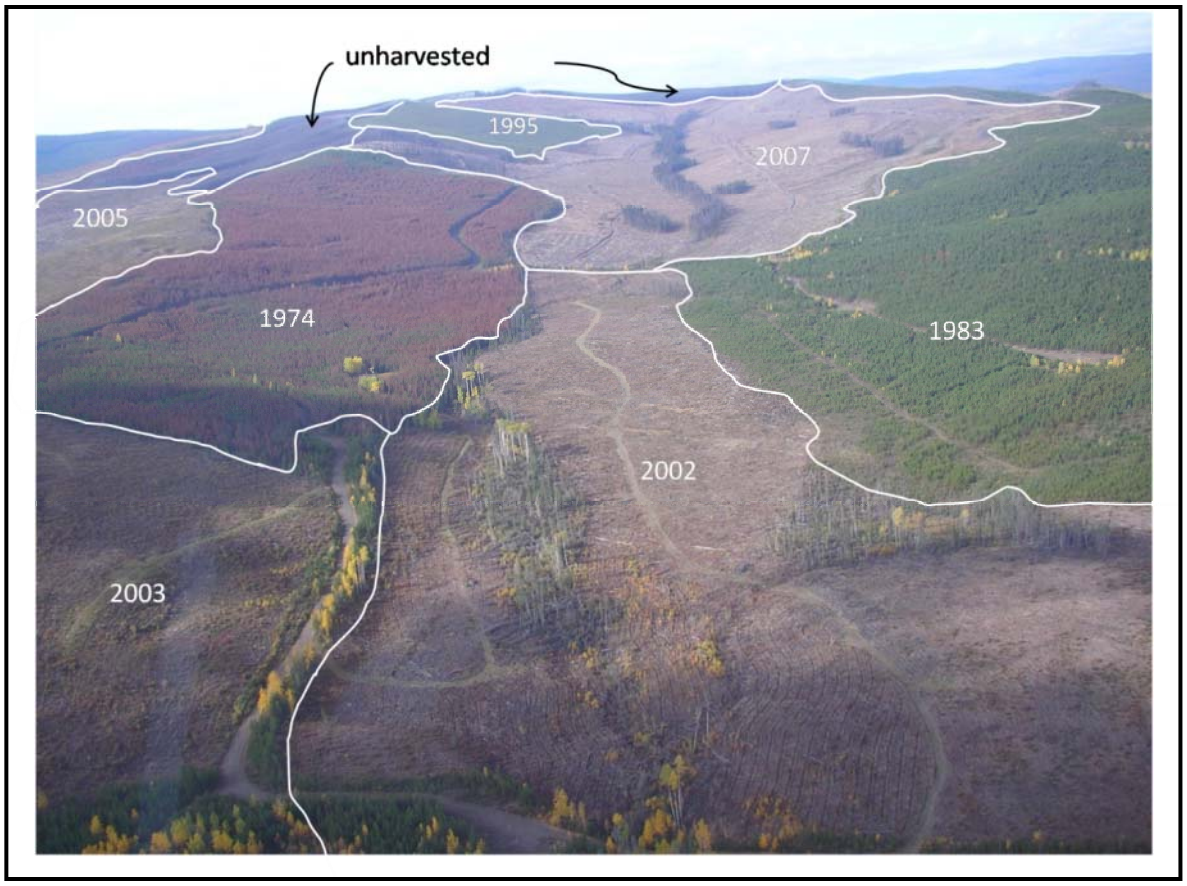


Figure 10. A portion of a very large patch showing dates of harvest. This area is part of a very large harvest-only patch and a very large harvest-plus patch.

Figure 10 illustrates some of the issues discussed above. The unharvested areas at the top of the hill are part of a harvest-plus patch and they contribute to the unharvested mature forest structure component of that patch. The block harvested in 1974, being more than 30 years old, is not included in the harvest-only patch but it is included in the harvest-plus patch. The remaining cutblocks are part of both a harvest-plus patch and a harvest-only patch. The 2007 cutblock has levels of retention that meet the guidance. It is bordered by some harvesting that occurred when there was no requirement for retention (1974, 1983, 1995). These cutblocks would likely contain less than 1 percent mature forest structure. This photo shows approximately 600 hectares. It is part of a 5 000 hectare harvest-only patch that would likely have overall levels of retention of less than 10 percent. It is part of the largest harvest-plus patch (94 000 hectares) that would have levels of retention and unharvested mature forest of approximately 25 percent. Note that most of the coniferous trees in the picture are lodgepole pine and almost all of those, over the age of 35 years, are dead.

Discussion

We preface our discussion by reiterating that we have not reported on any "actual retention." We used estimates of amount of mature forest remaining in harvested areas that were averages over the entire study area based on the information provided in RESULTS. We had to do this because the RESULTS database has problems with incomplete and inconsistently reported data, as described on page 17. While these estimates are likely reasonably accurate, at this level, the amount of retention in any given patch may vary substantially from the average. As stated previously, some of the mature forest remaining in cutblocks has to be considered "potential retention" until the issues with the associated RESULTS records is resolved.

The chief forester's guidance indicated that retention should be planned for the rotation[64] if it is intended to contribute to ecological or hydrologic function. However, the chief forester also recognized that there was both an opportunity and a need to identify and retain areas that represented mid-term timber supply opportunities; that is, areas that could be harvested after salvage operations had ceased and, in some cases, after those areas have attained harvestable qualities (within the next 30 to 40 years). At a minimum, a clear identification in RESULTS of what has been reserved for these two types of retention is required.

The estimates of mature forest remaining in unharvested areas in the harvest-plus patches can be viewed as indicators of the state of the landscape at 2008, but these patches have no legal status. The unharvested areas in those patches may be harvested if and when they represent viable economic opportunities, unless there are other legal constraints — the unharvested areas are, at best, "currently retained."

We are encouraged by the evidence we found that, for the most part, forest professionals have implemented the chief forester's guidance at the stand-level. It would appear that more is being retained in harvested cutblocks now than before the guidance, and that more is being retained as cutblock size increases (Figure 4). Forest professionals have been retaining unharvested areas in cutblocks to meet objectives for stand-level biodiversity since the *Forest Practices Code of British Columbia Act* was brought into force in 1995. The quality of these retained areas and their ability to meet the objectives is not the topic of this report, but it has been addressed by others in the past[65] and is an ongoing subject of monitoring by the Forest and Range Evaluation Program.[66]

It is not particularly surprising that there has been no landscape-level planning of salvage harvest and retention completed, as recommended by the chief forester. Cooperative, spatially explicit, multi-stakeholder planning covering large areas and long time frames has been the holy grail of

[64] The length of time required for tree to attained harvestable size, typically 80 years in the affected area.

[65] e.g., Sulyama, R. and R.S. McNay. 2008. Quality of wildlife tree patches in the moist interior plateau of the Prince George Timber Supply Area. Wildlife Infometrics Inc. Report No. 264, Mackenzie BC.

[66] http://www.for.gov.bc.ca/hfp/frep/publications/reports.htm reports #1, #2, #7, #10, #17.

natural resource planners in British Columbia for decades. It is beyond the scope of this report to discuss the impediments to this type of planning.[67]

Here we are concerned with the unintended, landscape-level consequences of stand-level harvest planning. Patches, influenced by harvesting, have emerged on the landscape, which are as large as the areas intended for landscape-level planning (known as landscape units[68]). The largest of the very large harvest-plus patches has likely exceeded 100 000 hectares as of the writing of this report. Very large (> 10 000 hectares) patches represent eight to 25 percent of the area in patches, depending on the delineation method. These patches are an order of magnitude larger than the largest patch size category in the chief forester's guidance, the Prince George biodiversity order,[69] the Quesnel Forest District Enhanced Retention Strategy[70] and the supporting documentation for these policies.[71] Policy makers and natural resource managers need to turn their minds to the management of these patches.

Large harvested patches are, for the most part, new phenomena in British Columbia. From the mid-1970s until the salvage harvesting began, large harvested patches were relatively uncommon because forest management was based on the "cut-leave" system, in which relatively small cutblocks were dispersed on the landscape with intervening unharvested areas. This system was codified under the Forest Practices Code when the maximum cutblock size was set at 60 hectares.[72] This maximum size was brought forward into the *Forest Planning and Practices Regulation* (FPPR) of the *Forest and Range Practices Act* (2004). However, the *Forest* Practices Code allowed, and the FPPR continues to allow, cutblocks and patches of cutblocks to be larger than 60 hectares if the harvesting is done to salvage timber damaged by fire or insects or if the patch is is designed to be consistent with the attributes of a natural disturbance.

We are concerned about these large and very large (>10 000 hectares) patches because they are a somewhat unintended, and largely unforeseen, consequence of the salvage harvesting. Forest professionals did not plan to create the particular set of large and very large harvested openings that exist in the study area. These openings emerged on the landscape as a consequence of the accumulation of decisions about where to place individual cutblocks. Those decisions are made based on the myriad of government and corporate objectives that rule the day-to-day life of professional foresters.

We are aware that it will be difficult to change the landscape-level result, particularly if the restrictive definition of a patch (harvest-only) is used. The legacy of previous harvesting has resulted

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[67] See the Board report "Provincial Land Use Planning: Which way from here?" (Special Report FPB/SR/34 2008) and the Board commentary for this report.

[68] http://ilmbwww.gov.bc.ca/slrp/datamanagement/glossary/L.HTM

[69] http://ilmbwww.gov.bc.ca/slrp/srmp/north/prince_george_tsa/pg_tsa_biodiversity_order.pdf

[70] http://www.for.gov.bc.ca/dqu/policies/DQU%20Enhanced%20Conservation%20Strategy-%20Release%201.pdf

[71] e.g., Delong, S.C. 2007. Implementation of natural disturbance-based management in northern British Columbia. Forestry Chronicle 83:338-346.

[72] In the study area.

in much less retention than the chief forester recommended in patches defined this way. Leaving more now, as new cutblocks increase the size of the patches, has little overall impact. Difficulties like this are a long standing problem in forestry.[73] If a less restrictive approach to the definition of the patches is taken, for example that taken by the Prince George biodiversity order, options within each patch will be increased but the size of the problem will also be greater (c.f. Figure 7 and Figure 8). The question needs to be asked; should some or all of the "currently retained" areas (the not harvested category in Figure 9) that are within the patches be formally (legally) retained?[74] Note that the patches are useful indicators of landscape condition, but their boundaries are, to some extent, a bizarre result of the delineation method. If the large and very large patches are to be managed as actual entities, their shapes will need to be better defined.

It may be argued that the large harvested openings are in keeping with government's objectives for wildlife and biodiversity at the landscape level[75] because they resemble the effects of fires, the principle natural disturbance that has been studied in the area. The sizes and shapes of the openings are similar to openings historically created by fires. In fact, much larger fires probably occurred in portions of the study area in the past. However, it is a matter of significant uncertainty whether the amount of mature forest structure remaining within the openings, or the rate at which the openings are being created, are within the range of variability of the natural disturbance regimes in the study area[76]. There are very difficult problems associated with accurately specifying the range of natural variability in disturbance regimes.[77] In addition, the issues of climate change[78] and what has become known as the "future range of variability"[79] call into to question a slavish adherence to the management approach of "emulation of natural disturbances." It may be more important to ask whether these openings are desirable rather than debate whether they have the attributes of natural disturbances.

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[73] Wallin, D., F. Swanson and B. Marks. 1994. Landscape Pattern Response to Changes in Pattern Generation Rules: Land-Use Legacies in Forestry. Ecological Applications 4:569-580.

[74] In some cases these unharvested areas may already have harvest constraints such as old growth management areas or retention visual quality objectives. In other cases, they may be available for harvest. This needs to be part of the management considerations for a given patch.

[75] "The objective set by government for wildlife and biodiversity at the landscape level is, without unduly reducing the supply of timber from British Columbia's forests and to the extent practicable, to design areas on which timber harvesting is to be carried out that resemble, both spatially and temporally, the patterns of natural disturbance that occur within the landscape." *Forest Planning and Practices Regulation* Section 9.

[76] Summarized from Wong, C., B. Dorner, and H. Sandmann. 2003. Estimating historical variability of natura disturbances in British Columbia. BC Ministry of Forests Land Management Handbook 53.

[77] ibid.

[78] Klenk, N., G. Bull and J. MacLellan. 2009. The "emulation of natural disturbance" (END) management approach in Canadian forestry: A critical evaluation. The Forestry Chronicle 85(3):440-445.

[79] Thompson, J., S. Duncan and K. Johnson. 2009. Is there potential for historical range of variability to guide conservation given the social range of variability? Ecology and Society 14(1) article 18.

In large parts of the study area, the landscape is rapidly transitioning from one that was dominated by small harvested areas in an un-harvested matrix to one that is dominated by a harvested matrix with small unharvested areas. As this happens, all of the previously more-or-less academic conservation biology concerns like connectivity, fragmentation and amounts of interior habitat[80] will become real issues that managers and policy makers will need to deal with. A large body of advice on how to do this is available.[81] It would seem reasonable that these concerns need to be considered in the specific context of the ecological consequences of salvage harvesting on a spatial scale that has no precedent (globally). There has been some investigation of the effects of smaller scale salvage harvesting, but there is no experience available to guide the scale of salvage operations being undertaken. The best advice seems to be to implement the kinds of cautious management, recommended in the past, for harvesting "green" forests.[82] And leave a little bit more.

[80] e.g. Voller, J. and S. Harrison (editors). 1998. Conservation biology principles for forested landscapes. UBC Press. Vancouver, BC.

[81] e.g. Lindenmayer, D. and 28 others. 2008. A checklist for ecological management of landscapes for conservation. Ecology Letters, (2008) 11: 78–91.

[82] Lindenmayer, D., P. Burton, and J. Franklin. 2008. Salvage logging and its ecological consequences. Island Press, Washington, DC.

Conclusions

We asked the questions:

1. Have forest professionals responded to the chief forester's guidance on retention?

2. What has been the landscape-level result of salvage harvesting?

We conclude that, in general, forest professionals did implement the chief forester's stand-level guidance on retention. On average, more mature forest structure is being left in salvage cutblocks now than before the guidance. However, there was no response to the chief forester's landscape-level guidance to conduct cooperative, long-term, large-scale, spatially explicit planning of what will be harvested and what will be retained during salvage harvesting.

In the absence of landscape-level planning, large and very large patches of contiguous harvesting have emerged on the landscape. On average, those large and very large harvest-only patches have much less retention than is recommended in the chief forester's guidance. As of 2008, unharvested areas still existed, adjacent to and surrounded by many of the patches, that are sufficient to meet the chief forester's recommended levels of retention.

Recommendations

1) Government should seize the opportunity that exists to implement a landscape-level conservation uplift by proceeding without delay to:

   a) Clarify government's objectives for wildlife and biodiversity at the landscape-level in areas affected by large-scale salvage operations.

   b) Provide leadership in the process of making landscape-level decisions about what areas to retain during salvage harvesting.

   c) Evaluate the achievement of government's objectives for wildlife and biodiversity at the landscape-level, throughout the area of the salvage operations, before opportunities are lost to influence the decisions made as a result of recommendation 1)b).

2) The Ministry of Forests and Range should:

   a) Use all available information to produce a disturbance/depletion map that shows all forest harvesting that has occurred, provides some estimate of the date of the harvest and indicates the source of the information. That map should be updated annually.

   b) Take steps necessary to make available maps showing forest cover and forest harvesting on tree farm licences of sufficient detail for strategic level analysis.

   c) Implement quality control procedures to ensure complete and accurate reporting of wildlife tree retention areas under Section 86(3)(a)(iv) of the *Forest Planning and Practices Regulation*.

   d) Make explicit the reserve status of all mature forest areas previously reported as being in harvested blocks.

   e) Complete the mapping of existing wildlife tree retention areas in harvested blocks where responsibility has reverted to the Crown.

The Forest Practices Board requests that government advise it, by March 31, 2010, of the steps being taken to address the recommendations.

Appendix 1: Retention Estimates

Estimates of total area and retention by patch size class and retention type for different patch types (harvest only and harvest plus), harvest time periods (guidance harvest and all patches). Values are presented to the nearest hectare but should be interpreted at 2 significant digits only. Note that the total area for the harvest-only patches is less than the total in Table 2 because the areas presented here are for the study area only (within the TSAs) whereas the areas in Table 2 are based on the patch sizes for the all the land in the districts.

	Harvest-Only Patches					
	Guidance Harvest Patches			All Patches		
Patch Size Class	In-Block Retention		Total Area	In-Block Retention		Total Area
	Pre-Guidance	Guidance		Pre-Guidance	Guidance	
<=50	759	2,627	25,311	11,727	2,627	170,189
51 - 250	2,075	4,201	59,529	16,923	4,256	392,038
251 - 1 000	4,878	6,191	127,368	13,999	6,269	304,805
1 001 - 10 000	11,903	8,210	250,564	17,563	8,402	383,628
>10 000	4,167	2,152	84,633	4,427	2,154	117,495
Grand Total	23,782	23,382	547,405	64,639	23,708	1,368,155

	Harvest-Plus Patches							
	Guidance Harvest Patches				All Patches			
	Not Harvested	In-Block Retention		Total Area	Not Harvested	In-Block Retention		Total Area
		Pre-Guidance	Guidance			Pre-Guidance	Guidance	
<=50	1,558	473	1,457	16,072	7,594	8,299	1,457	125,956
51 - 250	4,584	1,195	2,884	41,337	19,086	13,468	2,931	321,104
251 - 1 000	12,152	2,608	3,744	88,240	32,766	10,113	3,826	270,127
1 001 - 10 000	59,981	10,726	7,280	302,357	88,941	17,772	7,539	485,707
>10 000	67,031	13,550	7,733	345,389	77,728	15,012	7,892	418,098
Grand Total	145,306	28,553	23,099	793,395	226,115	64,664	23,644	1,620,992

Appendix 2: Chief Forester's Guidance

The following is a copy of the pdf file found at
http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/cf_retention_guidance_dec2005.pdf

Guidance on Landscape- and Stand-level Structural Retention in Large-Scale Mountain Pine Beetle Salvage Operations

December 2005

Introduction

The purpose of this document is to share my thoughts with other forest professionals on the retention of forest structure in large-scale salvage operations of mountain pine beetle killed-timber. It is my hope that this paper will provide useful information; however, I would like to stress at the outset that this is not to be interpreted as direction. This paper is intended as guidance only and is not legally binding.

While it is important to recover as much economic value as possible from our stands of dead pine before they deteriorate, it is also critical to ensure our planning and practices associated with protecting biodiversity values are in step with the increased rate of salvage harvesting.

In the fall of 2004, in response to the potential loss of timber volume due to mountain pine beetle infestation, Larry Pedersen, the previous Chief Forester of British Columbia, increased the allowable annual cut (AAC) in the Lakes, Prince George and Quesnel TSAs. The extent of the beetle infestation in these three TSAs means that the control strategy previously in effect was no longer effective, and the decision was made to move to a salvage strategy. The 2004 AAC increases are intended to facilitate harvesting of pine stands that have already been damaged by beetle infestation. As a result, forest harvesting will occur at a much faster rate than was contemplated when the AAC was set at levels designed to harvest the “healthy” forest.

Since taking over as Chief Forester, I have also had to consider timber supply implications in management units affected by the mountain pine beetle epidemic. I anticipate more such reviews will be completed in the years to come. I believe it is incumbent on me to inform forest professionals regarding the ecological principles that the previous Chief Forester and I have taken into consideration during the course of making AAC determinations in management units affected by the mountain pine beetle.

In this paper, I will discuss the issues and ecological principles considered by the previous Chief Forester and the reasoning behind his AAC determinations. In addition, I will provide my thoughts on the determination decisions and present information for consideration by resource professionals as they implement the large-scale salvage program.

Background and Issue

British Columbia is currently in the midst of the largest recorded mountain pine beetle outbreak in North America (B.C. Min. of For. 2004).

As part of the timber supply review process for the Lakes, Prince George and Quesnel TSAs, the previous Chief Forester asked for an Interpretation Paper to be written outlining the current understanding of the Ministry of Forests and Range about the implications of large-scale salvage operations (Eng 2004). The Interpretation Paper raised significant concerns about the environmental impacts of the rapid increase in the rate of harvesting associated with salvage. In order to manage the risks, the Interpretation Paper made a number of stewardship recommendations. A key recommendation was to increase the amount of retention in proportion to the size of salvage openings (up to 25% in the case of openings larger than 1000 hectares).

Based on this information, the previous Chief Forester assumed an additional 12% stand-level retention within forests that were classified as moderately or severely beetle attacked (i.e., greater than 31% of the stand is dead pine). This level of retention is over and above:

- standard stand-level retention (wildlife tree retention, and lakeshore, wetland and stream riparian retention); and
- standard old-growth retention.

The previous Chief Forester was well aware that his decision to rely on a timber supply analysis that assumed increased retention was an unusual situation within the timber supply world. Normally, a timber supply analysis is an extrapolation of current practices. Indeed, this is one of the previous Chief Forester's "guiding principles" for AAC determinations. However, in the Lakes, Prince George and Quesnel TSAs, the previous Chief Forester believed there were compelling reasons to allow for higher retention levels when salvaging beetle-killed wood.

When discussing the rationale for this aspect of his AAC determinations, the previous Chief Forester stated:

> "For the purpose of this decision, I have decided to reflect the stewardship recommendations [in the Interpretation Paper] as modelled in the base case. While I acknowledge that they are not mandatory, I feel it is appropriate to consider their implications in the decision in order to ensure that adequate opportunity is given to other government decision makers to consider how to respond to this new information. This seems more reasonable in the short term rather than precluding its consideration by implementing an uplift that would compromise their possible attainment."[1]

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[1] Quesnel Timber Supply Area: Rationale for Allowable Annual Cut Determination. http://www.for.gov.bc.ca/hts/tsa/tsa26/tsr3/rationale.pdf. Note that this quotation is repeated in the rationales for the 2004 allowable annual cut determinations for the Prince George and Lakes TSAs.

In November 2004, I took over as Chief Forester. I have since reviewed the circumstances surrounding the previous Chief Forester's AAC determinations for the Lakes, Prince George and Quesnel TSAs. I concur with the previous Chief Forester's assessment of the key recommendation in the Interpretation Paper.

Admittedly, "For operations of the scale anticipated in BC, there is no literature documenting effects of [large-scale] salvage." (Bunnell et al. 2004). On a small-scale, there is a large and growing body of literature that documents the benefits to non-timber values of retaining structure (in the form of live trees and standing and fallen dead trees) on harvested cutblocks.[2] The question is whether retaining additional structure will be equally effective in dealing with the risks associated with large-scale salvage. For the reasons set out below, I believe the answer is "Yes."

The 4.9 million cubic metres of total AAC uplift for the three TSAs represents a 27% increase in harvest levels over previous existing AACs. When this is combined with the previous AAC uplifts for controlling the beetle infestation, the harvest level is about 80% higher than it would have been if a healthy forest management scenario had prevailed. On the plus side, along with the rapid harvesting comes rapid reforestation, bringing about a certain amount of hydrologic recovery as the new seedlings grow and transpire. However, it is important to note that hydrologic recovery is not expected until the new trees are about 9 metres tall (B.C. Min. of For. 2001). Until then, there is a significant risk of hydrological problems.

Rapid harvesting also means that large percentages of watersheds will be harvested over a short period. This represents a departure from what is normally considered acceptable in watersheds, thus increasing the risk of stream instability, sedimentation and loss of biodiversity. I believe increased retention is likely the best option for minimizing these risks, particularly until these watersheds have reached hydrologic recovery. Retention may be particularly effective around sensitive areas (e.g., areas with high water tables) – maintaining an undisturbed forest floor with large amounts of dead wood and, where possible, live trees.

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[2] For an introduction to the subject, I suggest:

- Franklin, J.F., D.B. Lindenmayer, J.A. MacMahon, A. McKee, J. Magnsun, D.A. Perry, R. Waide, and D. Foster. 2000. Threads of Continuity. Cons. Biol. in Practice Volume 1, No. 1, pp. 8-16.
- Special Issue of Forest Ecology and Management. 2002. Volume 155, Issues 1-3, pp. 315-423.
- Coates, K.D. and P.J. Burton. 1997. A gap-based approach for development of silvicultural systems to address ecosystem management objectives. For. Ecol. Manage. 99:337-354.
- Seymour, R.S. and M.L. Hunter Jr. 1999. Principles of Ecological Forestry. In: Managing Biodiversity in Forest Ecosystems. M.L. Hunter Jr., editor. Cambridge University Press. pp. 22-61.

In reaching this conclusion, I am mindful of the following:

- Both harvesting and beetle infestation may result in increased peak flows and water yields, leading to elevated risks for streambank instability and sedimentation (Cheng 1989).
- Increased water yields are less likely to produce adverse effects if roads and other ground disturbance are absent (e.g., areas retained from harvesting) (Hetherington 1987).
- Hydrologic recovery is sped up by leaving live species to transpire water (e.g., understory shrubs, advanced regeneration or non-pine mature trees) (B.C. Min. of For. 2001).
- Regarding the wildlife species present in the three uplift TSAs, keeping non-pine tree species within salvage blocks will help retain about 60% of the terrestrial vertebrate species, bryophytes, lichens and non-pest invertebrates (Bunnell et al. 2004).
- Retained standing dead pine has been shown to remain standing for upwards of 10 years. During this time, it can help to sustain cavity nesting species and provide shade, thus slowing down spring snowmelt. Once the dead pine falls, it becomes coarse woody debris to provide habitat and shade for other species (Bunnell et al. 2004) (Hewlet 1982).
- Retained live pine is at high risk of becoming infested; however, until then, it will provide transpiration benefits and likely remain standing longer than pine that is already dead.

In summary, there is significant uncertainty about the effects of the 80% increase in harvesting in the Lakes, Prince George and Quesnel TSAs, particularly with regard to non-timber values such as biological diversity and hydrologic function. Accordingly, I believe caution is warranted.

Even in the absence of research specifically addressing the impact of large-scale salvage, I believe there is sufficient evidence to suggest that the risk to non-timber values decreases as the amount of retention increases at either the stand or landscape level (or in some cases both). The remainder of this paper sets out some options forest professionals may wish to consider when providing advice to licensees on the appropriate level of retention for large-scale salvage operations.

I will begin by looking at options at the landscape level. In particular, I believe that collaborative, multi-stakeholder, long-term landscape-level planning is the best option for managing increased retention that is balanced between the landscape and the stand.

I will then discuss options that can be used at the stand level. Stand-by-stand decisions on retention levels can be done without landscape-level planning, although for reasons I will address below, perhaps not as effectively.

Landscape-level Planning

The key to good planning for beetle salvage is to plan out many years for both the retention and harvest areas.[3] A potential benefit of this planning is a reduction in the amount of stand-level retention. For example, watersheds containing significant landscape-level retention (or inoperable areas that will not be harvested) may need less stand-level retention.

Such long-term landscape-level planning could potentially be undertaken within the implementation frameworks of the Vanderhoof, Lakes, and Prince George LRMPs, the Cariboo Chilcotin Land Use Plan, and the collaborative planning being done to meet the *Order Establishing Landscape Biodiversity Objectives for the Prince George Timber Supply Area*, October 20, 2004. Alternatively, licensee groups might wish to undertake such planning as part of their Sustainable Forest Management Plan (SFMP) work.

The primary issue is the placement of increased amounts of retention across management units, considering both stand-level retention (e.g., riparian areas and wildlife trees) and landscape-level retention (e.g., old growth, ungulate winter ranges, and wildlife habitat areas). Accordingly, I would recommend that forest professionals consider the following strategies.

Guidance for Landscape-level Planning and Operations

1. Plan out as many years as possible for both the retention and harvest areas.
2. Plans should be spatially explicit for landscape-level retention, considering the full range of values for conservation – visuals, ungulate winter ranges, wilderness tourism, etc.
3. Recognize that retention levels may vary by landscape unit in the plan in order to retain areas of non-pine species for mid-term harvest.
4. Develop the plan cooperatively so it is known and honoured by all operators harvesting in the management unit.
5. Complete salvage operations in the area as quickly as possible.

Stand-level Retention

In the Lakes, Prince George and Quesnel TSAs, we are contemplating salvage operations of an unprecedented spatial and temporal scale. However, I believe good stand-level planning can help reduce the potential negative effects on a variety of values (Lindenmayer et al. 2004). Ideally, retention will be spatially well-distributed within all harvested openings to provide vertical structure, a variety of wildlife habitats, and coarse woody debris over the long term.

Obviously, determining the amount and placement of retention within a particular cutblock will be based on a consideration of both the timber and non-timber

[3] For ease of analysis, the modelling of increased retention for timber supply was done on a block-by-block basis.

values found within the block and the sensitivity of these values to disturbance. Even so, I believe there are some principles that are generally applicable to all blocks. Accordingly, I would recommend that forest professionals consider the following strategies.

Guidance for Stand-level Planning and Operations

1. Retain areas with live trees as a first priority in order to maximize the potential to move water from the soil through evapotranspiration. For example, areas with advanced regeneration or areas with lower pine to non-pine ratios of mature stems. Cutblocks of particularly high mortality will rely on the maintenance of dead pine where insufficient live trees exist.
2. Maintain stand-level retention for the rotation. These retention areas are providing an important source of dead wood, standing and down structure, and intact forest floor, which assists with hydrologic stability and provides biodiversity and habitat value throughout the stand rotation – potentially "lifeboating" species until the newly regenerated stand matures sufficiently and provides higher levels of biological diversity. Having said this, I do note the possibility that a portion of the retained areas, particularly those chosen with advanced regeneration and a mixture of tree species, may achieve an operable status 30 or 40 years sooner than the salvaged component of the stands. This may provide a late mid-term harvest opportunity and have a relatively low impact on stand ecology since the regenerated stands will have attained hydrologic recovery.
3. Operable areas of non-pine species should be kept available to provide mid-term harvest opportunities. These areas should not be locked up as stand-level retention. It is important to balance the need for ecological conservation with the need to protect timber values.
4. Vary the amount of stand-level retention with the size of the cutblock based on opening size. To that end, I draw licensees' attention to Table 1 from the Interpretation Paper, which is reproduced here.

Table 1. Recommended proportion of stand-level retention based on opening size.

Opening Size	Percent of Opening Un-harvested/retained
<50 ha	10%
50 – 250 ha	10 – 15 %
250 – 1000 ha	15 – 25 %
> 1000 ha	> 25 %

5. With respect to Table 1, it will be a challenge to define the opening size if it "grows" over time. There are, therefore, two ways to assess the amount of stand-level retention. First, wildlife tree retention is assessed as defined by the requirements of FRPA. However, when considering this guidance document, retention levels should be assessed in a second way – for "functional" openings. Functional openings can be defined as contiguous areas harvested or disturbed within the last 30 years (or a similar time frame), plus the retention areas within and adjacent to the opening.
6. The retention levels outlined in Table 1 are only an average suggested for blocks of a similar size within an operating area. Retention levels should not be applied arbitrarily to any one size of opening since no two openings are the same. The amount of retention and its spatial distribution will be different as a result of differences in stand characteristics such as topography, LRMP direction, and environmental sensitivity. Accordingly, there is a range of targets for stand-level retention around the generally desired percentage for a given opening size.

Conclusion

In closing, the challenge of managing the impact of the beetle infestation will continue for several more decades. Though this guidance is not legally binding, it is important for me, as British Columbia's Chief Forester, to share my thoughts on this important resource management issue with other forest professionals.

Jim Snetsinger
Chief Forester

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