BRITISH COLUMBIA

File: 18830-00

December 12, 2005

To: Assoc. of BC Professional Foresters

Dear Sir/Madam:

Re: Guidance on Landscape and Stand Level Structural Retention on Large-Scale Operations Associated with Mountain Pine Beetle Killed Timber

The attached guidance document presents my thoughts on retention associated with large-scale salvage of beetle killed timber. This information does not supersede established land use plans. It is intended to assist forest professionals in planning and the implementation of salvage operations.

The information presented is most pertinent to large operations and major tenure holders, and is not directly applicable to small tenures such as woodlots. However, I encourage woodlot operators to consider some of the concepts when salvaging pine.

This guidance piece is posted at the following website:
http://www.for.gov.bc.ca/mountain_pine_beetle/stewardship/

I sincerely hope that forest professionals will find this information valuable as we continue to address the forest management challenges associated with the mountain pine beetle infestation in the interior of our province.

Yours truly,

Jim Snetsinger
Chief Forester

Attachment

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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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Appendix A

Forest Stewardship in the Context of Large-Scale Salvage Operations:

An Interpretation Paper

Prepared for Larry Pedersen, Chief Forester
for consideration during Allowable Annual Cut determinations
for Lakes, Prince George and Quesnel TSAs

Prepared by the Forest Science Program of the BC Forest Service

May 31, 2004

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Acknowledgements

This paper is the result of a collective effort of many staff within the Forest Science Program of the British Columbia Forest Service.

We would like to thank Dr. Fred Bunnell of the Centre for Applied Conservation Biology at the University of British Columbia and Melanie Boyce of the Forest Analysis Branch of the BC Forest Service for insightful and constructive comments on earlier drafts.

Summary

All indications are that the current mountain pine beetle outbreak will have a significant impact on a large proportion of the pine forests in B.C. (Eng *et al* 2004). It is neither desirable nor possible to harvest all of the impacted pine forests. However, any further increases beyond current harvest levels must carefully consider all forest values. This document provides recommendations to the chief forester about methods to conserve forest values, to the extent possible, while mitigating timber losses.

Poorly planned and/or poorly executed large-scale salvage operations have the potential to cause significant negative effects on a variety of forest values (Lindenmayer *et al* 2004):

- salvage harvesting activities can undermine many of the ecosystem benefits of major disturbances;
- removal of large quantities of biological legacies can have negative impacts on taxa that require, or benefit from, those legacies;
- salvage logging can impair ecosystem recovery; and
- some taxa may be maladapted to the interactive effects of two disturbance events in rapid succession.

There are additional, specific and significant concerns about the potential for large-scale salvage operations to affect hydrological regimes at various scales (Foster et al. 1997).

Some contend that the magnitude of the current outbreak is at least partially the result of human influence on the pine forests in B.C., principally due to forest fire suppression (Stadt 2002, Taylor and Carroll 2003). If that is the case, it could be argued that it is incumbent on forest managers to attempt to mitigate the effects of the outbreak through appropriate management that includes well-planned and properly executed large-scale salvage operations. By diverting harvest from green to dead trees, the impact on forest values could be partially mitigated.

Others contend that the outbreak is a "natural" event (Hughes and Drever 2001). If that is the case then the large areas of partially dead forests created by the outbreak are within the 'range of natural variability' (Swanson et al. 1994, Wong and Iverson 2004). Regardless of the cause, large-scale salvage operations will result in conditions that differ from those that would be created by the outbreak alone and the combined effects will be outside the range of natural variability. In any case it is clear that society does not support managing for the entire range of natural variability, for example 1000 year floods, meteor strikes, etc. At the same time some management response to the outbreak is appropriate and likely requires a large-scale response.

The following is a summary of the key recommendations regarding forest stewardship. These recommendations are intended to inform the determination of the allowable annual cuts for the Lakes, Prince George and Quesnel timber supply areas:

- At the landscape level (10,000 to 100,000 hectares) at the very least, leave what was originally planned under existing landscape level plans (regional land use plans, land and resource management plans, etc). This includes provisions for old-growth management areas since areas with considerable dead pine are still of value to biodiversity and should be retained if no suitable replacement old-growth areas are available. Mixed species stands should be used wherever possible to contribute to the mature requirement; however, stands with some dead pine still provide biodiversity values.
- As a general rule, there should be little, to no salvage harvesting in the non–contributing land base (areas outside of the timber harvesting land base as assumed in the last timber supply analysis for the three TSAs).
- There should be no changes to the provisions made for riparian management areas (RMAs) and riparian reserve zones (RRZs). It will likely be desirable to remove some of the dead pine component from RMAs rather than other species if they occur. It will be important to carefully monitor the management of RMAs and RRZs over time because of the potential for excessive inputs of large woody debris into streams and the potential for increases in peak flow regimes may cause increased erosion and transportation of sediment and woody debris. As well, there should be no changes to the management of wildlife tree patches, wildlife habitat areas and other fine filter measures.
- Legacies of coarse woody debris should be left throughout the blocks. Higher levels of retention than those recommended under the *Forest and Range Practices Act* for harvesting in healthy forests will be appropriate because, under natural conditions, most beetle-killed stands would have very high levels of coarse woody debris.

- The creation of large openings (> 1,000 hectares) will be appropriate, provided that they are designed to respect existing land use planning objectives. In addition the legacies of unharvested areas within the openings should increase in proportion to the increasing size of the opening (up to 25% in the case of 1,000 hectare openings).
- The spatial distribution of legacies, including wildlife tree patches can be as important as the relative amounts remaining. Clearly wind firmness will become a significant issue but the legacies of live and dead trees that will be left will be valuable whether or not standing. It is important to ensure the legacies are representative of the "matrix" forests, for example reserve wet spruce or aspen forests if not able to maintain any mature pine forests.

Other related recommendations include:

- A large number of temporary access structures (roads, trails, landings, etc.) will be created over a very short period of time. Development of those structures should adhere to all existing regulations and they should be decommissioned as soon as possible after operations have ceased. Increased access resulting from improvements to permanent roads must be carefully managed to prevent negative effects on wildlife populations.
- To reduce adverse effects on peak flows and soil erosion, no harvesting should occur on unstable terrain, harvested area should be promptly and fully restocked, and all potentially 'compromising' access structures should be rehabilitated.
- Where ecologically acceptable, plant species other than pine to lessen future problems with mountain pine beetle outbreaks.
- Conducting salvage operations based on the premise of reducing fire risk is not recommended except in the wildland-urban interface.
- Monitoring programs should recognize the requirement for implementation monitoring (did we do what we said we were going to do?) and effectiveness monitoring (did our actions have the desired effect?). A well-planned monitoring program must be developed to include both of these aspects.

Introduction and Context

British Columbia is currently in the midst of the largest recorded mountain pine beetle outbreak in North America (Ministry of Forests 2004). In 2003, the outbreak was already significantly larger than the last major outbreak in the 1980s, which occurred on the Chilcotin Plateau (c.f. Wood and Unger 1996 and Ministry of Forests 2003).

In response to the potential loss of timber volume, the Ministry of Forests is considering increasing the allowable annual cut in three timber supply areas (TSAs): Lakes, Prince George and Quesnel TSAs. The proposed increases will primarily be directed at salvaging, rather than suppressing the spread of the beetle outbreak.

All indications are that the outbreak will have a significant impact on a large proportion of the pine forests in B.C. (Eng *et al.* 2004). It will not be possible, nor desirable to harvest all impacted pine forests, however, any further increases beyond current levels must carefully consider stewardship values. This document has been developed to provide recommendations about methods to conserve forest values, to the extent possible, while mitigating timber losses.

Poorly planned and poorly executed large-scale salvage operations have the potential to cause significant negative effects on a variety of forest values (Lindenmayer *et al* 2004):

- salvage harvesting activities can undermine many of the ecosystem benefits of major disturbances;
- removal of large quantities of biological legacies can have negative impacts on taxa that require or benefit from those legacies;
- salvage logging can impair ecosystem recovery; and
- some taxa may be maladapted to the interactive effects of two disturbance events in rapid succession.

There are additional, specific and significant concerns about the potential for large-scale salvage operations to affect hydrological regimes at various scales (Foster et al. 1997).

Some contend that the magnitude of the current outbreak is at least partially the result of human influence on the pine forests of British Columbia, principally due to forest fire suppression (Stadt 2002, Taylor and Carroll 2003). If that is the case, it could be argued that it is incumbent on forest managers to attempt to mitigate the effects of the outbreak through appropriate management that includes well-planned and properly executed large-scale salvage operations. By diverting harvest from green wood to salvage of dead trees the impact on forest values could be partially mitigated.

Others contend that the outbreak is a "natural" event (Hughes and Drever 2001). If that is the case then the large areas of partially dead forests created by the outbreak are within the so-called "range of natural variability" (Swanson *et al.* 1994, Wong and Iverson 2004). Regardless of the cause, large-scale salvage operations will result in conditions that differ from those that would be created by the outbreak alone and the combined effects will be outside the range of natural variability. In any case it is clear that society does not support managing for the entire range of natural variability (e.g. 1,000-year floods, meteor strikes, etc.). At the same time some management response to the outbreak is appropriate and likely requires a large-scale response.

Landscape and stand level planning

There are two key uncertainties regarding landscape and stand level planning, which must be considered in much of the following discussion:

- It is unclear when the outbreak will subside and what levels of live pine will be left on the landscape when it does.
- It is unclear exactly how the forest industry will approach the issue of large-scale salvage. This is particularly true with respect to the possible "new" uses of the dead pine that are being considered under the "requests for expression of interest" process.

Landscape level objectives

Planning large-scale salvage operations should not (Lindenmayer *et al.* 2004) and need not (Hughes and Drever 2001) be done in haste. The following discussion is predicated on the assumption that sufficient time and resources will be devoted to planning any large-scale salvage operation.

The fundamental question, at the landscape level (10 – 100,000 hectares), is what dead wood should be salvaged and what should be left behind? The simple answer to this question, elaborated in some detail below,

is: at the very least leave what was originally planning under existing landscape level plans (regional land use plans, land and resource management plans, etc). There are two reasons for this recommendation.

First, targets set for landscape level objectives are the result of agreements among environmental, economic and social concerns. Therefore, the targets set for environmental concerns may have been established based on trade-offs. Based on the existing agreements, it seems reasonable that, given the uncertainties and potential risks of salvage operations, the agreed-to parameters should not be reduced from those originally set for all the forest values prior to the outbreak.

Secondly, over the course of the outbreak in the province, there is estimated to be approximately 200 million m^3 of salvageable pine on the landscape in any given year (Eng *et al.* 2004). However, the total AAC for the interior (all units except the coast region) of the province is 56 million m^3 (http://www.for.gov.bc.ca/hts/aac.htm). Given the current harvest levels are well below that required to salvage all of the existing dead pine and that even with new markets not all the dead pine could possibly be utilized, substantial amounts of dead pine will be left on the landscape. Therefore increased salvage activities should be designed similar to originally planned activities (Stadt 2002).

As discussed below, it will not be possible to completely separate objectives or planning for landscape and stand level retention during planning for large-scale harvesting operations. There will be appropriate local variance in recommendations at both levels. However, we expect that most proposals to utilize the dead wood may project marginal economic viability. As a result there may be pressure to reduce the objectives and constraints designed to protect future forest values. Each proposal to reduce constraints should be evaluated on its own merits.

If the recommended approaches contained in this paper are adopted then the "footprint" caused by the combined green tree and salvage harvesting should not significantly exceed that which would have occurred in the absence of the outbreak – the "footprint" size would simply be reached sooner. Nonetheless, there will be a significant concern about the environmental impacts of the rapid increase in the rate of harvesting. That concern can be partially addressed by ensuring there is sufficient amount of unharvested "legacies" remaining.

In addition to increasing the amount of harvesting in the current operating areas (the timber harvesting land base), the infestation may provide opportunities to extend harvesting into some of the non-contributing landbase. This would only be appropriate where it could be clearly demonstrated that the harvesting will maintain or enhance non-timber objectives (e.g. ecosystem restoration and wildlife habitat improvement in parks). However, as a general rule it is recommended that no salvage harvesting should occur in the productive non-contributing landbase.

For the three TSAs where increased salvage harvesting is under consideration, these types of areas include:

- Environmentally sensitive areas (particularly steep and/or unstable slopes);
- Class A lake shore;
- Inoperable areas;
- Unmerchantable forest types;
- Cultural heritage areas; and
- Area-specific netdowns, such as riparian, wildlife habitat, wildlife tree, and old growth management areas.

This concurs with Stadt (2002) who concluded that the outbreak does not fundamentally change things with respect to principles of Landscape Unit Planning. More specifically, the following recommendations should be implemented with regarding to landscape level planning:

- Consider dividing the old growth management areas (OGMAs): "budget" into spruce-dominated areas and pine-dominated areas. The pine-dominated areas would become "recruitment" areas or "wild young forests". OGMAs with considerable dead pine are still of value to biodiversity and should be retained if no suitable replacement OGMAs are available. It is possible that the outbreak is a harbinger of a future where climate change will result in much higher levels of mountain pine beetle infestation than we have experienced in the past. If that is the case then it may be useful to select "recruitment" areas that have advanced regeneration of species other than pine (e.g., spruce and/or balsam fir).
- It is desirable, although possibly difficult, to maintain mature plus old targets, in jurisdictions that have such targets (e.g. CCLUP Quesnel Forest District). Mixed species stands should be used wherever possible to contribute to the mature requirement; however, stands with some dead pine still provide biodiversity values.

- There should be no changes to the provisions made for riparian management areas (RMAs) and riparian reserve zones (RRZs). It will likely be desirable to remove some of the dead pine component from RMAs, rather than other species if they occur. It will certainly be important to monitor carefully the management of RMAs and RRZs over time because of potential for excessive inputs of large woody debris and possible increases in peak flow regimes causing increased erosion and transport of sediment and wood (e.g., McLennan 2003).
- Recommended changes in the management of wildlife tree patches are discussed below in the section on stand level retention. Clearly wind firmness will become a more significant issue but the legacies of live and dead trees that will be left will be valuable whether or not standing.
- There should be no changes to the management of wildlife habitat areas and other fine filter issues.
- In Quesnel where ungulate winter ranges are, or should be, Douglas-fir dominated, selective salvage of dead pine should be allowed provided there is little or no impact on the Douglas-fir component. In the Lakes and Prince George TSAs, any decisions about ungulate winter ranges should be made on a site-specific basis but, in general, no change should be made to their management.
- Harvesting in caribou habitat areas should be prohibited in those areas removed from the timber harvesting land base (primarily in the Itcha – Ilgachuz area) and only allowed in the "modified" zones to the limits already agreed to (Youds et al. 2002). There is considerable speculation about the impacts of both beetle attack and forest harvesting on the quality of caribou habitat. It is possible that the beetle damage and any subsequent harvesting could encourage the growth of terrestrial lichens used as a food source by caribou because of reduced crown closure. Conversely, it is possible that canopy removal may result in deeper snow packs that would restrict feeding opportunities. A precautionary approach would dictate that no harvesting in caribou habitat areas until this fundamental difference in the possible outcomes is resolved.

Stand level objectives

Some salvaging is already underway, however increased salvage levels will be initiated soon and will continue for many years. These operations will be occurring during the term of the outbreak and the beetle's impact will not be static. Therefore not all of the pine that may be killed will be dead when the salvage operations begin. Table 1 provides a matrix of stand characteristics to set priorities for salvage among stands. This matrix provides a "sliding" scale of the possible outcome (percent of volume that is pine) and the current state (percent of pine volume killed).

Table 1. Priority for salvage based on stand characteristics and level of beetle kill (modified from McLennan, 2003).

	Percent of Pine Volume Killed			
Percent of Stand Volume that is Pine	< 30 %	30 – 50 %	51 – 70 %	> 70 %
< 30 %	No	No	No	No
30 – 50 %	Low	Low	Low	Low
51 – 70 %	Low	Moderate	Moderate	High
> 70 %	Low	Moderate	High	High

Figures 1, 2, and 3 show the projected distribution of High, Moderate, Low and No priority salvage areas for 2004 in the Lakes TSA, the southwest portion of the Prince George TSA and Quesnel TSA, respectively.

An additional consideration should be that stands that are well-stocked with pole-sized regeneration of species other than pine should have a low priority for salvage because these stands will develop old growth features and commercial value faster than ones without a non-pine understory. The location of stands of this type may be predicted by relationships with the distance from non-pine seed sources.

Legacies of coarse woody debris (CWD) should be left throughout the blocks. It is recommended that, while the *Forest and Range Practices Act* default results for CWD may be suitable for harvesting in "healthy" forests, they are far too low for salvage operations. Much higher levels of retention would be appropriate because, under natural condition, most beetle killed stands would have very high levels of coarse woody debris. The targets for coarse woody debris retention should be closer to the recommended waste billing benchmarks, which vary by site: 9 m^3 on dry sites, 15 m^3 on mesic sites, and 25 m^3 on wet sites.

Figure 1. Projected Salvage Priority in the Lakes TSA during 2004

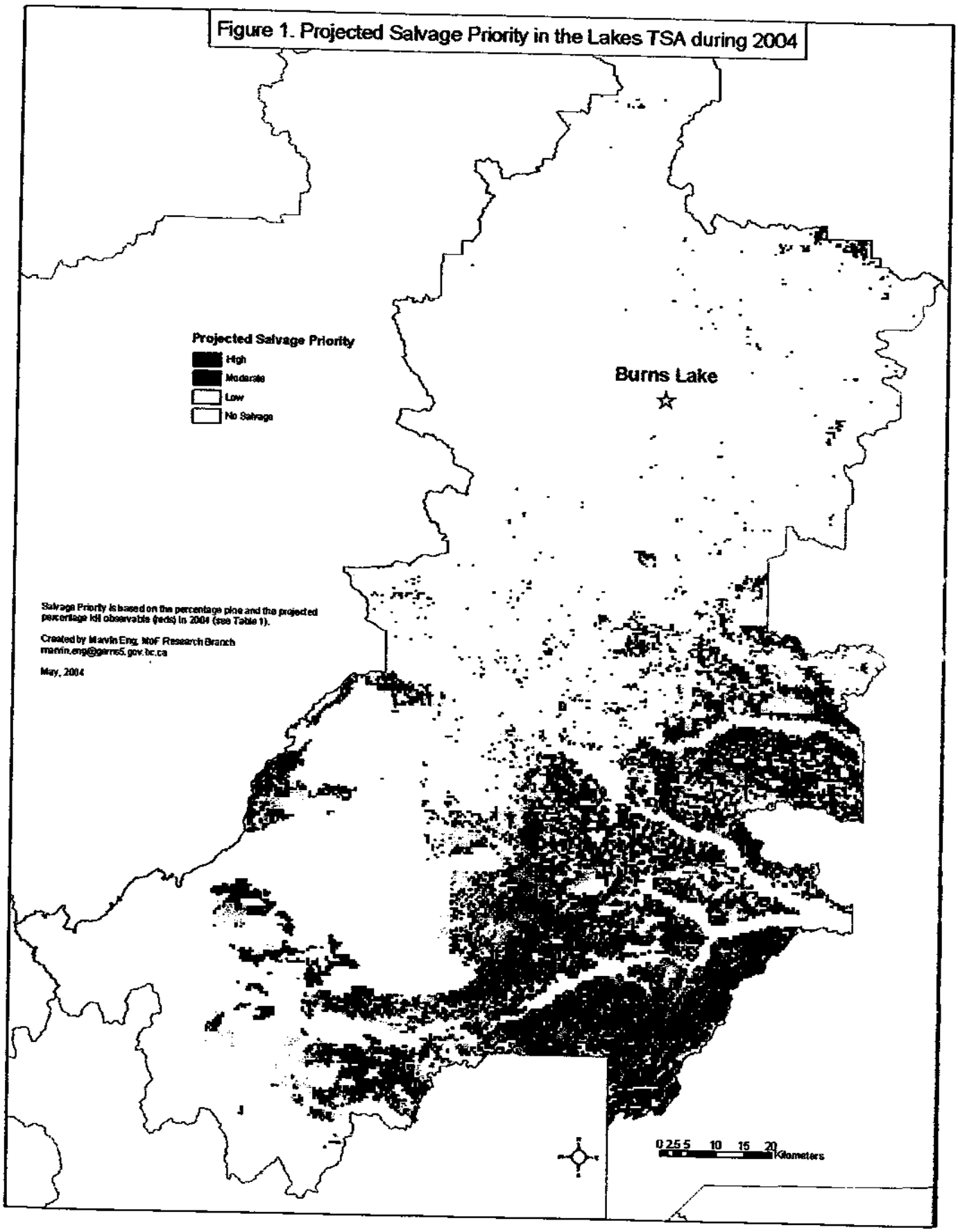
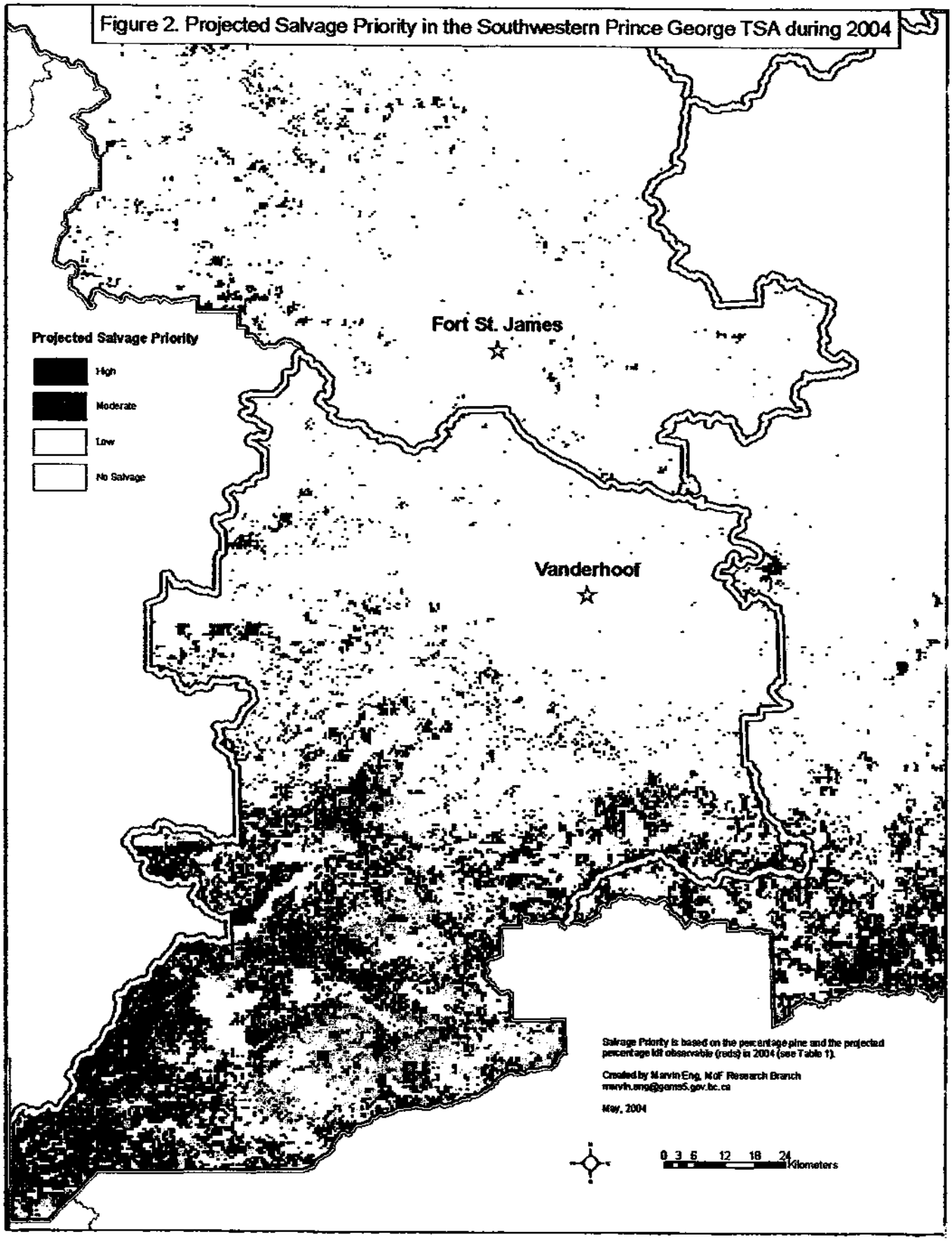


Figure 2. Projected Salvage Priority in the Southwestern Prince George TSA during 2004



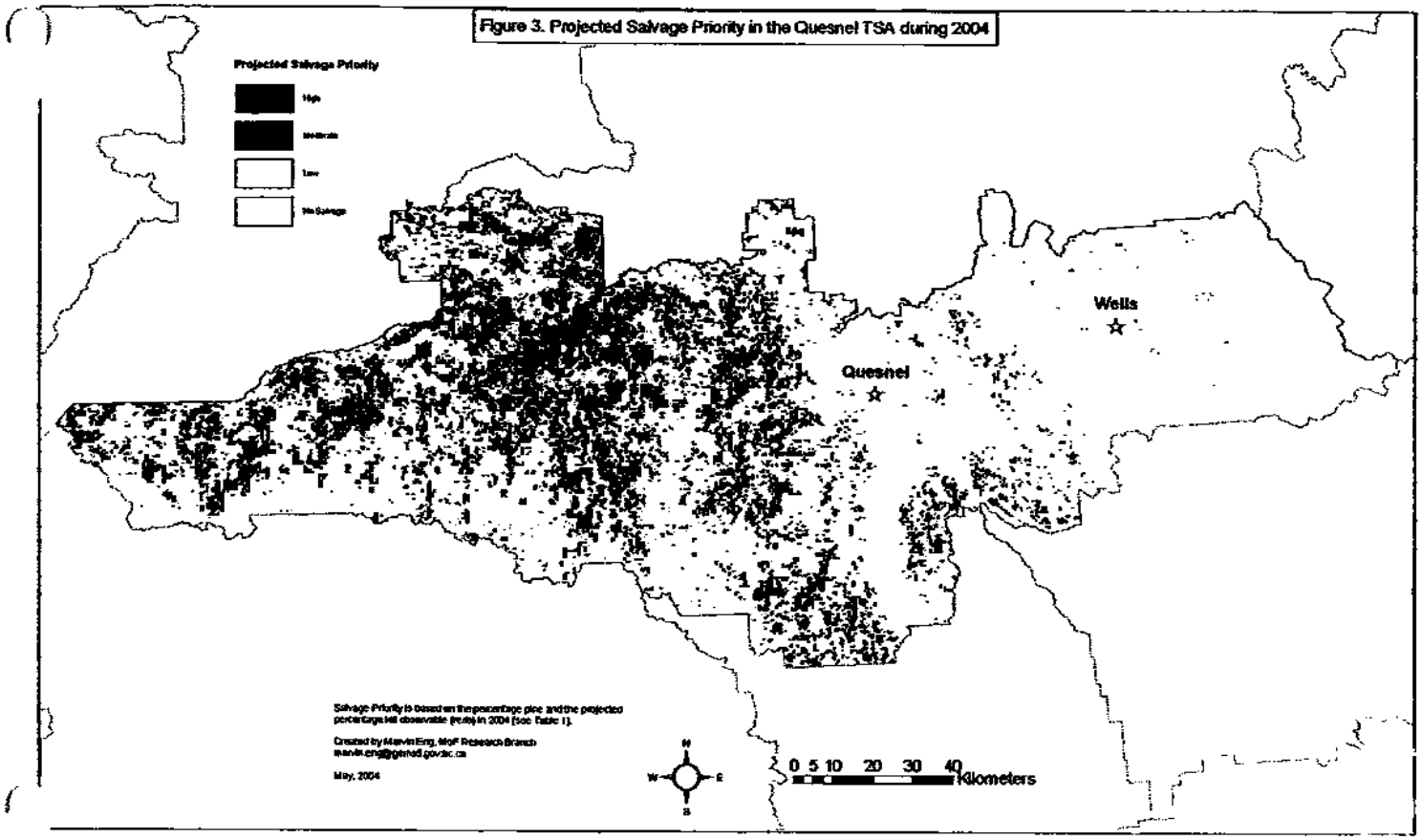


Figure 3. Projected Salvage Priority in the Quesnel TSA during 2004

Prior to the outbreak, the forest industry relied primarily on relatively small (< 60 hectare) openings that have created a mosaic of more-or-less uniform sized patches of young forest in an old matrix (that is now declining in size and in continuity). As a result of the mountain pine beetle outbreak, there is now a significant opportunity to create some large openings. The creation of large openings (> 1,000 ha) are within the range of natural disturbance levels, provided they are designed to respect existing land use planning objectives and that the legacies that are left increase in proportion to the increasing size of the opening (Table 2). Although there is provision for small blocks this should not encourage the development of small blocks in the context of large-scale salvage operations.

Table 2. Proposed proportion of un-harvested legacies (retention levels) left based on opening size.

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

There are several very important considerations and caveats related to the recommendations in Table 2:

- The spatial distribution of the legacies can be as important as the relative amounts remaining. The amount of live forest in the "matrix" is going to be significantly reduced. It is important to ensure the legacies are representative of the "matrix" forests (i.e. not to over emphasize the reservation of wet spruce forests or aspen forests at the risk of not maintaining any mature pine forests).
- Recommendations about stand level retention must be implemented with a full understanding of the implications at the landscape level. Separate landscape and stand level planning effects can not be specified as if they were independent. It is possible that stand level management that "aggressively" attempts to ameliorate the impact of the outbreak in one area could result in a relaxation of landscape level requirements in some other area. Moreover, at present little is known about how difficult or easy it will be to maintain these targets under large-scale salvage operations.
- It should also be noted that the above recommended "retention" levels are proposed for one rotation. Once the harvested matrix has matured, new planning may indicate the retained areas can or should be harvested.

Innovative or non-traditional (non-clearcut) silvicultural systems should be encouraged, where appropriate, to maintain some biological legacies. Some of these are already be used in harvesting areas with low levels of attack or low volume in pine.

Other issues

Access management

A large number of temporary access structures will be created over a very short period of time. Development of those structures should adhere to all existing regulations and they should be decommissioned as soon as possible after operations have ceased.

The network of permanent access structures will require expansion and upgrading. There is a significant public safety issue regarding improvements to public roads and bridges along with increased industrial traffic. More importantly, from a conservation perspective, the public will gain access to previously inaccessible or poorly accessed areas. They will develop an expectation for continued levels of access. Increased human access can be a very detrimental influence on wildlife habitat (Saunders *et al.* 1991, Forman 2003). Access management plans should be developed along with salvage operations to mitigate this potential damage.

Hydrologic stability and open slope failure

There is some concern that the rate of harvest in salvage operations, combined with previous harvesting and sanitation operations, may adversely affect peak flow characteristics and unacceptably increase erosion, sediment delivery and bedload movement. Additional concerns have been expressed about open slope failure as the mature root mat decomposes over the next 10 to 20 years. These issues are a real concern in spite of the generally more benign terrain and precipitation characteristics of the forests in question. The main issue results from proposed harvest rates that are well beyond the last data point on the graph of harvest vs. hydrology response. To help minimize these concerns, the following recommendations should be considered:

- ensure that harvested areas are fully restocked and that all potentially "compromising" access structures are rehabilitated,
- ensure that no harvesting occurs in unstable terrain and develop engineering solutions where required to maintain slope stability.

Future susceptibility to mountain pine beetle outbreaks

Clear cut harvesting over very large areas with very high levels of utilization will result in future forests that are highly susceptible to mountain pine beetle outbreaks. Large, "clean" clear cuts are not recommended. Where ecologically acceptable, plant species other than pine to lessen future problems.

Interactions with fire

Increased risk of fire in mountain pine beetle affected stands has been postulated by many but evidence in the literature is equivocal (e.g. Turner *et al.* 1999). Conducting salvage operations based on the premise of reducing fire risk is not recommended except in the wildland-urban interface.

Interactions with other planning processes

Landscape unit planning, Innovative Forestry Practices Agreement studies, implementation of LRMPs and Cariboo-Chilcotin LU plans (CCLUP) are ongoing. In the case of the CCLUP, the Biodiversity Committee is attempting to address the unfolding mountain pine beetle issue. All recommendations provided here need to be incorporated into those planning efforts. Nonetheless, it could be argued that, for the 3 TSAs (Lakes, Prince George and Quesnel), the current mountain pine beetle outbreak will have such an enormous impact that the outbreak should be the primary planning consideration for the immediate future. Therefore, the process should prioritize salvage operations first and then determine how much the non-pine stands can contribute to meeting the goals of the existing land-use planning objectives.

Monitoring

The current mountain pine beetle outbreak is clearly an extraordinary event and therefore it will require a significant commitment to monitoring the long-term effects. It is imperative that monitoring occurs not only to better manage future outbreaks but also to better manage the results of the current outbreak.
Monitoring programs should recognize the requirement for implementation monitoring (did we do what we said we were going to do?) and effectiveness monitoring (did our actions have the desired effect?). A well-planned monitoring program must be developed to include both of these aspects.

Implementation monitoring will principally be about determining whether or not forest practices are following the principles outlined in the recommendations contained in this paper. Effectiveness monitoring should concentrate on three topics:

- Forest growth and dynamics; primarily regeneration of pine in salvaged and not salvaged areas and release of the non-pine component of the stands affected by mountain pine beetle.
- Hydrological and riparian ecosystem changes; primarily responses of watersheds (discharge, temperature, nutrients, and fluvial geomorphology).
- Ecosystem responses as evidenced by changes in biodiversity (primarily vertebrate populations but also lichens and invertebrates) and ecosystem processes (primarily nutrient cycling and soil fertility).

Another final recommendation is that we should not miss the opportunity to build a mountain pine beetle data legacy to aid in the management of future outbreaks. This should include monitoring through time the:

- location and intensity (pine killed) of the infestation, and
- forest management responses of suppression attempts and salvage.

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