Mackenzie TSA

Type 1 Silviculture Investment Strategy
Final Report – DRAFT2
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This is an update to the February 1999 Type1 Silviculture Strategy produced Cortex Consultants Inc. The report also recognizes the strategies analyzed in the October, 2003 Type 2 Silviculture Strategy by Tesera Systems Inc.

The workshop and this report were commissioned by the Ministry of Forests and Range, Forest Practices Section, in September 2005. The project was completed by Forest Ecosystem Solutions Ltd. (Chris Niziolomski RPF) and B.A. Blackwell and Associates Ltd. (Rob Sandberg RPF) under contract no. 500655LVT077. Mike Fenger and Associates, represented by Scott McNay of Wildlife Infometrics Inc., contributed to the workshop and report under a separate contract with the Ministry of Environment.

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Executive Summary

A Type 1 Silviculture Investment Strategy (SIS) was completed for the Mackenzie Timber Supply Area (TSA) in March 2000. A Type 2 Silviculture Investment Strategy (SIS) was completed in March 2003, which did not factor in the Mountain Pine Beetle (MPB) epidemic.

Subsequently, the MPB epidemic is extending through the Mackenzie TSA and is expected to have a significant impact on timber supply. Currently, no MPB or expedited AAC has been established for the Mackenzie TSA. In 2001 the annual allowable cut (AAC) was increased from 2.99 million m^3 in to 3.05 million m^3.

Due to the anticipated impact of the MPB epidemic on timber supply and habitat in the Mackenzie TSA, the Ministry of Forests and Range (MoFR) commissioned an update to the Type 1 SIS in August 2005. This update, funded by Forests for Tomorrow (FFT), is primarily intended to deal with government-funded intensive and backlog silviculture opportunities, and reforestation of dead lodgepole pine (Pl)-dominated stands, which will not be salvaged.

General Strategy

The objectives of this silviculture strategy are:

- Mitigate the effects of the MPB epidemic on the timber supply through incremental silviculture.
- Manage the fire risk to timber supply caused by the MPB epidemic.
- Initiate a Review of Basic Silviculture Practices in the Context of the MPB Epidemic and Future risks of Pests and Diseases.
- Keep all options open for the future.

Product Objectives

Past silviculture strategies have often defined quality as the amount of premium logs and sawlogs within the future timber supply. In this strategy the focus is in producing a high quality timber supply – buffered from pests and fires through diversity – that can potentially provide products to different industries, such as sawmilling, pulp and paper, composite wood products, pellets etc. The quality in the context of this strategy is broadly based on inherent wood properties, such as specific gravity, knots sizes, fibre length, stiffness etc.

Major Silviculture Strategies

Timber Supply – Quality and Quantity

Incremental Silviculture Strategies

1. Fertilize mature spruce leading stands based on a comprehensive *TSA Fertilization Strategy.* This strategy would:

    - Develop localized candidate stand and site criteria.
    - Review the THLB and inventory for opportunity areas in consideration of other resource values and non- timber constraints.
    - Make recommendations for monitoring studies.

2. Fertilize immature spruce- leading stands.

    - Target stands according to the *TSA Fertilization Strategy*.
    - Repeated stand treatments should be considered.
    - Pine-leading stands should be incorporated in the ongoing review of candidate stands for treatment once the MPB epidemic subsides.

3. Non- Recoverable Losses Reforestation Strategy

    - Develop and implement a TSA- wide *NRL Reforestation Strategy* in concert with higher level planning objectives and in consideration existing licensee's harvesting rights.
        - a review of actual and expected natural infill by ecosystem
        - a review of potential NRL treatment strategies considering biological, economic, feasibility and safety factors
        - an analysis of seed needs to support potential artificial reforestation efforts
        - fire protection strategies
        - non- pine species retention strategies
        - development of a decision matrix for use in field assessment of NRL's
        - strategies for the surveying of immature pine stands in order to determine MPB impacts levels and the degree of other health factors

4. Backlog- NSR treatments

    - Complete the TSA backlog survey program.
    - Determine treatment priorities or reclassification options.

5. Backlog- Impeded Stand treatments

    - Evaluate sites to determine treatment priorities or reclassification options.

6. Repressed pine sites

    - Evaluate sites to determine treatment priorities or reclassification options. Treat high priority areas.

Basic Silvilculture Strategies

1. Revisit TSA stocking standards for those sites where natural regeneration is deemed unreliable or where there is traditionally a higher disease incidence.

    - Review target/ minimum stocking requirements.
    - Review preferred and acceptable species requirements.

2. Establish a diversity of tree species where ecologically feasible in order to attain full site occupancy and to buffer against future pest and disease losses.

3. When planting, where available utilize improved seed.

Habitat Supply

Overall objective is to mitigate impacts to environmental values especially considering the impending MPB epidemic. This can be done by developing a strategic, coordinated Non-recoverable losses (NRL) plan that locates areas for treatment and maximizes the benefit on the impacted values. A future Type 2/3 Silviculture Strategy can help in providing direction.

1. Underplant unsalvaged, non-recoverable loss areas where no reforestation responsibility exists. Priority areas:

    - Sensitive watersheds linked to high value fish streams and temperature sensitive streams.

2. Underplant in riparian and enhanced riparian areas.

    - Identify key areas for riparian and enhancement of riparian features through silviculture treatments.
    - Review the riparian reserves and inventory for opportunity areas in consideration of other resource values and non- timber constraints.

3. Thinning mid seral and mature forest to speed recovery of old growth structure.
    - Target potential treatment areas in non-pine OGMAs and WTPs.

4. Selected species habitat strategy

    - Incremental silviculture treatments can be specifically developed to speed recovery of habitat elements in short supply.
    - Review the selected species habitats and inventory for opportunity areas in consideration of other resource values.

5. Deciduous species and existing silviculture and harvest practices

- Use of deciduous species should be reviewed,
- Strategies to be developed, identify potential areas based on appropriate ecosystem type and habitat supply needs.

6. Climate change

   - Need to develop clear objectives and strategies for appropriate tree species to be planted at the landscape and forest level considering climate change.

7. Broadcast burning

   - Understory establishment following broadcast burning provides an effective tool to establish browse and berry production as well as manage fuel levels.

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1 Introduction

Incremental silviculture (treatments which are beyond major licensee's basic reforestation obligations) is part of a suite of management strategies that can have a significant influence on the future quality and quantity of timber supply and habitat.

A Type 1 Silviculture Investment Strategy (SIS) identifies issues, objectives, and treatment regimes using the most recent timber supply analysis and other existing data and is workshop based. A Type 2 SIS uses in-depth stand and forest-level modeling to further develop those strategies. Since the advent of the Forest Renewal BC (FRBC) Program, silviculture investment strategies have been completed in most management units in BC and have become the basis for public investments in incremental forestry.

A Type 1 SIS was completed for the Mackenzie Timber Supply Area (TSA) in February 1999 by Cortex Consultants Inc. A Type 2 strategy was produced by Tesera Systems Inc. in October, 2003. This strategy incorporated the changes resulting from Timber Supply Review (TSR) II in 2001 and the increasing impacts of the current Mountain Pine Beetle (MPB) epidemic.

In 2001 the annual allowable cut (AAC) was set at 3,050,000 m^3. Subsequently, the MPB epidemic has grown substantially and is having a significant impact on forest management in the district. At the time of this report the next timber supply review is postponed until 2011 as the Chief Forester believes that the current AAC is capable of accommodating increased salvage harvest levels. However, recent data is indicating that the MPB rate of spread is increasing and that rapidly increasing levels of pine mortality will eventually lead to mid-term harvest level impacts in the TSA. These impacts are expected to start as early as 10 years from now.

Due to the pending impact of the MPB on timber supply and habitat in the Mackenzie TSA, the Ministry of Forests and Range (MOFR) commissioned an update to the Type 1 SIS in August 2005. This update, funded by Forests for Tomorrow (FFT), is primarily intended to deal with government-funded intensive and backlog silviculture opportunities, and reforestation of dead lodgepole pine (Pl)-dominated stands, which will not be salvaged. However, due to the broad, integrated nature of silviculture and the magnitude of the MPB epidemic, there is also a need to consider and integrate other existing or planned mitigation initiatives. For example, the recently announced federal program on interface fire hazard abatement, ecosystem restoration, inventories and research and development needs to be considered. In addition, basic silviculture strategies, forest fire protection and strategic interventions to promote the salvage of specific stands should be considered. The key overall goal is to use this SIS update process to provide as much integrated, strategic direction to MPB mitigation as possible.

1.1 Methodology

The following process was used to prepare this strategy:

1. Identification of the key issues that should guide silviculture planning in the Mackenzie TSA. Analysis of the most recent timber and habitat supply information and assumptions.

2. Review and, where necessary, revision of the existing objectives relative to the key issues.

3. Review the existing key silviculture strategies and, where necessary, revision or deletion of regimes or development of new regimes to address the revised objectives and key issues.

4. Evaluation of the key scenarios and selection of a preferred strategy.

5. Development of an updated 5-year incremental silviculture program.

6. After stakeholder review, the consultants submitted the completed strategy to the MOFR.

A workshop was held in the Alexander Mackenzie Hotel, Mackenzie, B.C. on November 23, 2005 to facilitate the key aspects of the project. The sessions were lead by Chris Niziolomski RPF of Forest Ecosystem Solutions Ltd. (FESL) and Rob Sandberg RPF of B.A. Blackwell and Associates Ltd. Participants reviewed and discussed the key issues and objectives and helped identify or refine treatment opportunities. Mike Fenger and Associates Ltd., represented by Scott McNay RPF of Wildlife Infometrics Inc., represented the Ministry of Environment and contributed the habitat components at the workshop and within this report.

1.2 Growth and Yield and Financial Analysis

As this is a Type 1 project, very limited analysis was completed in the preparation of strategies. Stand-level growth and yield and financial analysis of selected regimes were used to discuss and help rank the most viable treatment options. Forest-level impacts of the key regimes were estimated using the stand-level responses and the estimated opportunity areas.

TIPSY (version 3.2) was used for stand-level growth and yield using inputs and assumptions from the most recent timber supply review and current forest practices.

For stand-level financial analysis the net present value (NPV) approach was used. The NPV of a treatment regime is the sum of its discounted revenues minus the sum of its discounted costs. By calculating NPV, treatment regimes with costs and revenues at different points in time can be compared. Limited sensitivity analysis was performed to show the impacts of changing key cost, revenue and discount rate assumptions. The appendices to this report include the key formulas, cost, revenue and employment assumptions that were used.

2 Summary of Basic Data and Timber Supply and Silviculture History

Information for this report was drawn from the following sources:

- Timber Supply Review (TSR) 2 (MOFR, 2001) including the Timber Supply Analysis Report and the Rationale for the Allowable Annual Cut Determination;

- Mackenzie TSA Type 2 Incremental Silviculture Analysis (Tesera Systems Inc, 2003);

- Provincial Level Projection of the Current Mountain Pine Beetle Outbreak: An Overview of the Model (BCMPB v2) and Results of Year 2 of the Project (MOFR, 2005).

2.1 Basic Data

The timber harvesting land base in the Mackenzie TSA is 1,446,398 ha (TSR 2). Table 1 shows how the total TSA area of 7,508,191 ha is classified into Crown Forest, non-forest, non-timber harvesting land base (NTHLB) and THLB. A more detailed netdown is provided in the Timber Supply Analysis Report.

Table 1 - Land Base Netdown for the Mackenzie TSA (MoF, 2001)

Total TSA Area	6,410,643 ha
Non-forest or not Crown	1,882,796 ha
Crown Forest	2,751,781 ha
NTHLB	1,305,383 ha
THLB	1,446,398 ha

Most significant netdown factors in the TSA that reduce the THLB are:

- Environmentally sensitive areas (ESA) 12.8%;
- Balsam marginal stands 8.3%
- Sites with low volume 6.6%;
- Riparian areas 4.2%;
- Pine marginal stands 3.2%;
- Deciduous far haul zone 2.9%; and
- Wildlife tree patches (WTP) 2.2%.The Mackenzie TSA is managed by the Ministry of Forests and Range.

Pl-leading stands cover approximately 45 % of the THLB, while the share of spruce and balsam-leading stands is 29% and 17% correspondingly (Figure 1).

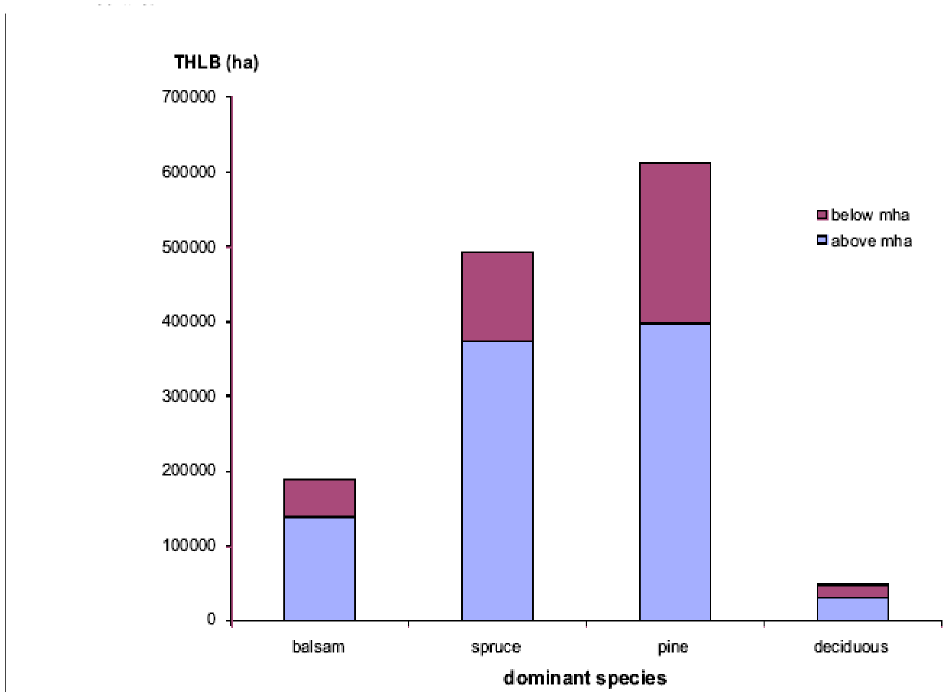

Figure 1 - Leading species in the THLB (Tesera, 2003)

A large portion (approximately 75%) of the pine leading stands is currently in older age classes (above minimum harvest age) which varies depending on harvest system, natural or managed forest between 50 and 190 years old, as illustrated in Figure 2. The older pine leading stands will be more susceptible to pine beetle attack.

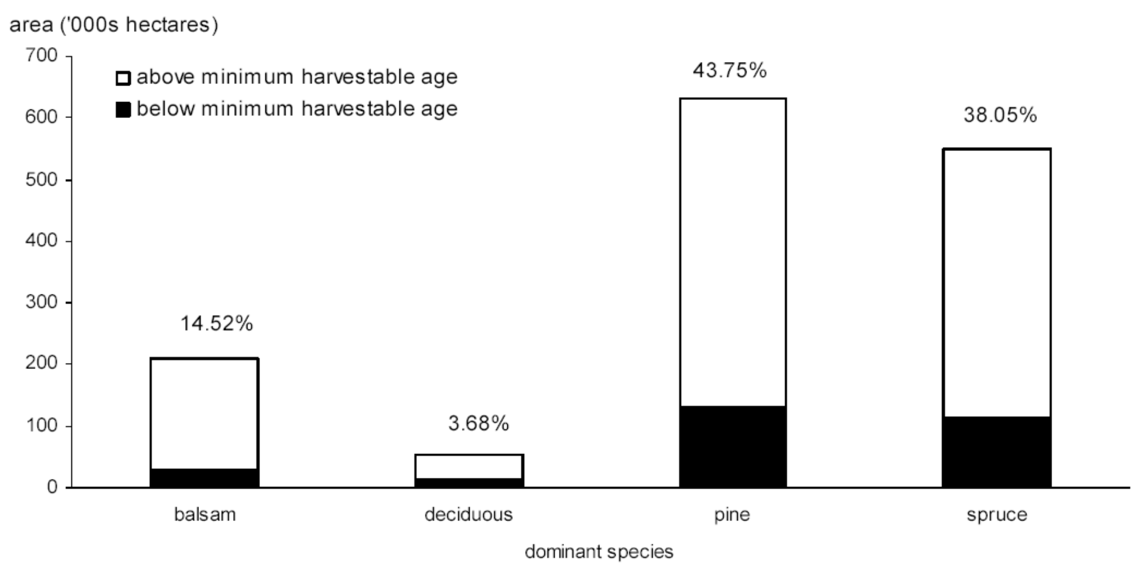

Figure 2 – Distribution of species above and below minimum harvest age (MOF, 2001)

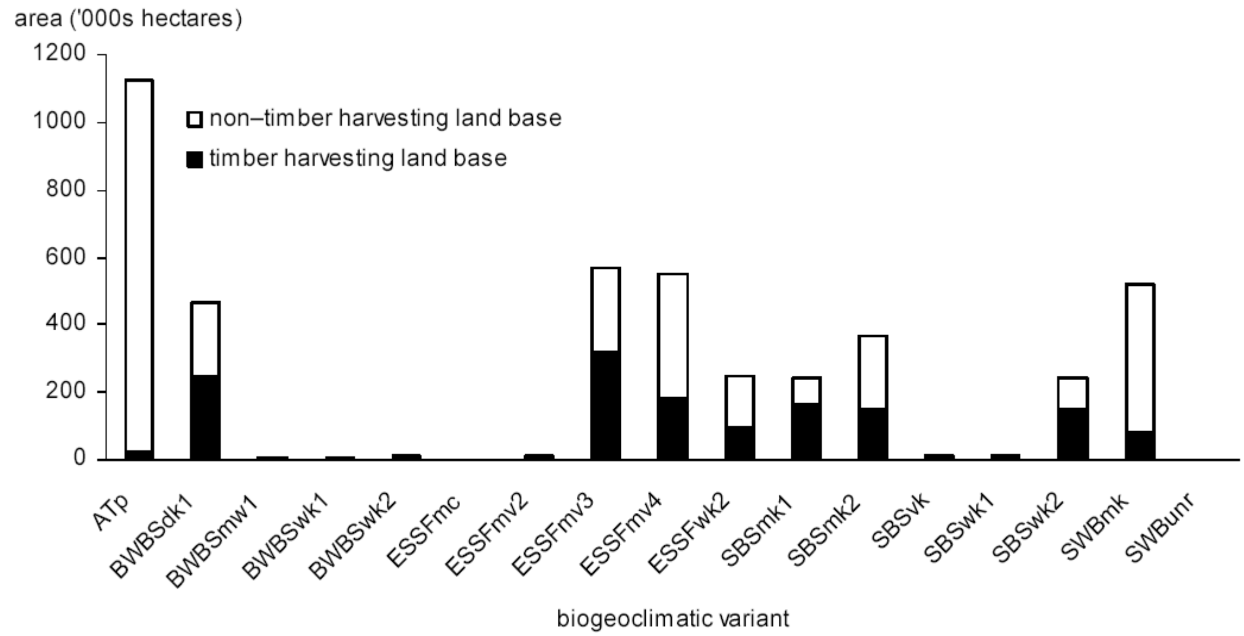

Figure 3 - BEC variants in the Mackenzie TSA (MOF, 2001)

The BEC variants in the Mackenzie TSA are dominated by ESSF and SBS types with the most common being ESSFmv3, ESSFmv4, SBSmk1, SBSmk2 and SBSwk2. There are also over 200,000 ha in the BWBSdk1 (Figure 3). Figure 4 illustrates the distribution of inventory site index class within the Mackenzie TSA.

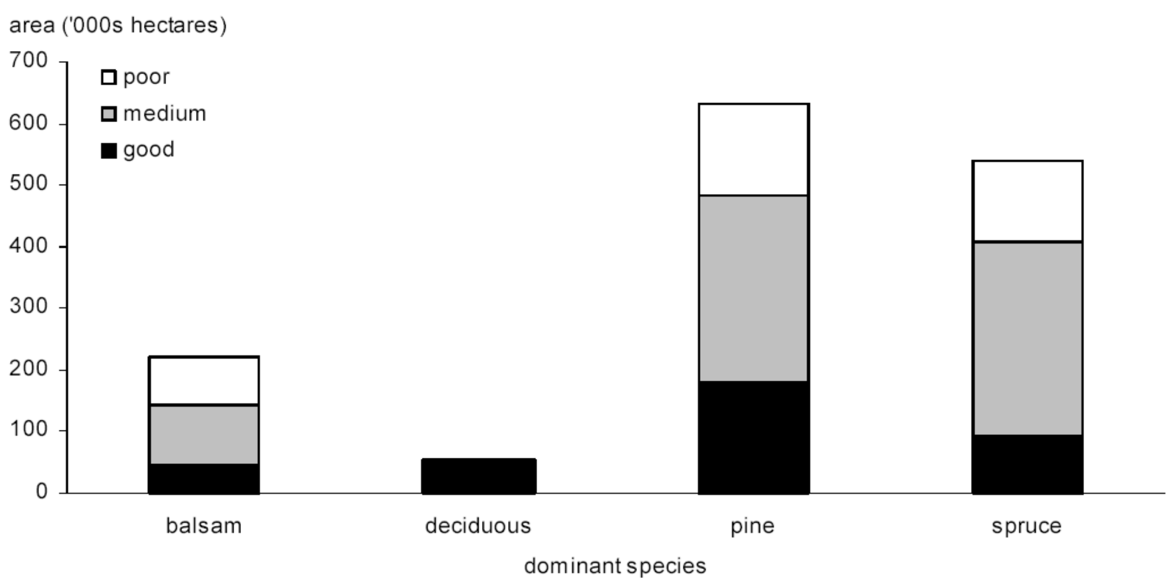

Figure 4 – Area by species and site productivity in the Mackenzie TSA (MOF, 2001)

2.2 Timber Supply

2.2.1 History of the Allowable Annual Cut

The Mackenzie TSA was established 1981. Since its creation the AAC has been determined several times (Table 2). The last two determinations (1996 and 2001) increased the AAC slightly based on the contribution of deciduous stands.

Table 2 - History of the AAC in the Mackenzie TSA (MOF, 2001)

Year	AAC (m^3)	Description
1981	2,900,000	
1989	2,951,121	
1996	2,997,363	50,000 m^3 deciduous partition
2001	3,050,000	100,000 m^3 deciduous partition

2.2.2 General Timber Supply Considerations

Timber supply projections are always subject to some level of uncertainty, which is typically assessed by the Chief Forester during a timber supply review. The uncertainties usually address questions regarding the accuracy of the size of the THLB, whether the current inventory is correct, and whether the growth and yield of existing and future stands suitably represents the current and future forest growth and volume.

The key timber supply issues as noted by the Chief Forester from TSR 2 (2001) are:

1) Review and redefine economic operability.
2) Monitor performance within deciduous leading stands.
3) Monitor performance within balsam leading stands.
4) Study TSA site productivity.
5) Complete a vegetation resource inventory.
6) Redefine the riparian inventory information.

It is understood from discussions with industry and government that since TSR 2, efforts have been initiated to address each of the issues above. By the time that TSR 3 begins the uncertainties associated with these issues should be reduced.

2.2.3 Mountain Pine Beetle Considerations

The uncertainties noted in TSR 2 remain valid since there has been no more recent timber supply analysis however a significant issue that is currently affecting forest management within the TSA is the spread of the MPB epidemic. The mountain pine beetle has reached the Mackenzie TSA much later than the central interior forest management units and as such is different than most affected units in that the peak of the attack is not predicted to occur for at least another 4 or 5 years.

Key MPB uncertainties to be considered for the Mackenzie TSA include:

- How long will the mountain pine beetle infestation last?

  Some of the recent expedited timber supply analyses have assumed no further spread of the mountain pine beetle. Other analyses have assumed that the infestation will last several more years, in some cases up to 2024, or until all the susceptible pine is dead. Clearly this uncertainty is significant because of its potential implications on future timber supply especially in the mid-term when the impact of uplift harvest takes effect. If the pine beetle infestation were to stop immediately, those management units with relatively little current attack would be spared from the potentially devastating mid term timber supply and economic impacts. However, this is not likely to occur in the Mackenzie TSA.

- Will the mountain pine beetle infested stands be economically viable for salvage?

  Timber supply analyses generally assume that a certain volume of beetle-infested timber will be salvaged during its shelf life (period after attack which the timber is expected to remain merchantable). In some cases, the salvage volumes are assumed to be significant and any large shortfalls in salvage will impact the medium term timber supply profoundly. Access and cost issues may prevent salvage in some cases, while in others there may not be adequate mill capacity. This is likely an issue for most of the management units affected by the MPB.

- What happens to stands that are not salvaged?

  Stands that will not be harvested during the "shelf life" will become non-recoverable losses (NRLs). Timber supply analyses usually assume that these stands regenerate naturally within an extended regeneration lag. However, there is significant uncertainty regarding the regeneration delay and they currently only represent best guesses at this time. The success of natural regeneration on non-recovered sites will be extremely variable and highly dependent on site conditions. Prompt rehabilitation of these NRL areas would ensure that these sites are brought back into production as soon as possible, which would have significant socio-economic benefit. This issue will be discussed at length later in this report.

- What will happen to mixed stands where all pine has been killed?

  Depending on the species composition of these stands they may still be economic to harvest, however some or many may not be. The stands that are uneconomic to harvest may remain unproductive and need to be rehabilitated or risk remaining as non-productive stands until they are naturally regenerated.

- What is the shelf life of beetle killed timber?

  The shelf life of beetle-killed timber is thought to vary depending on the climatic conditions and the types of forest products the timber could be utilized for. What the actual shelf life will be for many management units and the various site types within them is unknown.

- Is it reasonable to assume that the pine beetle attacks only mature pine leading stands?

  Most analyses attempting to predict the impacts of the mountain pine beetle infestation have assumed that only pine leading stands greater than 50 or 60 years of age have been attacked. Throughout the pine beetle impacted managements units there are anecdotal observations that the pine beetle has attacked significantly younger pine stands (eg. 30- 50 years old). The level of attack on pine stands less than 50 years old is largely unquantified. However, the potential impacts could produce an additional impact as there is a significant reliance on many of the immature pine stands in support of the mid term timber supply.

During the workshop the participants noted the uncertainty of shelf life of killed pine. Natural Resources Canada – Canadian Forest Service (CFS) through the Mountain Pine Beetle Initiative have been leading the research in this area. Lewis and Hartley (2005) noted based on their review of the available literature the following:

1. rapid decay in beetle killed wood in the first 2 years following mortality due to bluestain, reduced moisture content and checking,
2. as long as the bark remains intact - volume recovery from beetle killed pine is high (almost the same as green trees),
3. over the 2 years losses in volume are mostly due to additional breakage during felling and handling,
4. volume recovery from trees with loose bark is much lower but may still be adequate for many products, and
5. standing trees will likely fall to the ground before decay losses become substantial.

Lewis and Hartley (2005) also summarized wood quality and quantity variables as illustrated by Table 3.

Table 3 – Summary of wood quality and quantity variables relative to time-since-death and other tree and environmental variables.

Property	Change from green condition	Time-since-death	Variables that can influence property
Moisture content – sapwood	Reduced <20%	Dry subzones[1] = 12 months Wet subzones[2] > 24 months	Time of attack – late in season, moisture content drops to fibre saturation pint (30% mc) within 2 months
Moisture content - heartwood	No change	N/A	N/A
Checking	Checking develops in standing trees	Dry subzones[1] = 12 months Wet subzones[2] > 24 months	Wet subzones – checking may be straighter Cooler subzones – onset of checking may be delayed
Bluestain	40% of sapwood 100% of sapwood	2 months 9 months	For large diameter trees, bluestain affects less overall volume than for smaller diameter trees
Decay - standing trees	Initiation of sap rot	Dry subzones[1] = 10 years Wet subzones[2] > 7 years	Tree diameter – large trees = less proportional loss Moisture content – dry wood limits fungal development, most decay will be at the base of the tree where it contacts the ground Stand density – increased density = increased decay
Tree fall	40% of infected trees down	Dry subzones[1] = 10 years Wet subzones[2] > 7 years	Wet subzones – expect 90% down within 15 years Tree diameter – increased diameter = decreased fall rate Soil moisture regime – increased mortality rate = increased soil moisture = increased fall rate Increased MPB tree fall – increased risk to wind throw of entire stand

(Source: Lewis and Hartley, 2005)

Heightened uncertainty due to the MPB epidemic emphasizes the importance of current forest practices and their success in maintaining a predictable fibre flow. Current silviculture practices are used as assumptions in timber supply investigations and thus have an impact on our understanding of future timber supply trends. If basic silviculture does not provide for the quantity and quality of timber that will be desired, the more pessimistic timber supply forecasts may actually turn out to be optimistic. For this reason, an assessment of basic silviculture practices and their success was included in all workshops. While not part of the standard Type 1 requirements, this strategy will discuss basic practices where necessary and propose changes where current practices are not deemed to produce acceptable results. Also, we believe that basic silviculture prepares stands for future intensive silviculture opportunities so those practices should be reviewed if a new strategy is being developed.

2.2.4 Timber Supply Analysis Results

As noted previously in this report, the Chief Forester has determined the AAC in the Mackenzie TSA almost 5 years ago with no consideration of a future mountain pine beetle epidemic. Only endemic levels of mountain pine beetle induced losses were considered as part of the non-recovered loss volume reduction.

The analysis report for TSR 2 was released in April 2001 and at that time the base case analysis predicted a harvest level starting at the current AAC (2,997,363 m^3) and increasing 10% at 30 years to 3,305,000 m^3 which was maintained for the rest of the forecast horizon (Figure 5). Additional, initial harvest level scenarios were completed which showed that a highest even flow harvest of 3,305,000 m^3 could be maintained throughout the entire planning horizon as well as a high harvest over the first 50 years of 3,596,836 m^3 which is then decreased to the long term harvest of 3,305,000 m^3. These alternatives harvests illustrate the flexibility in the harvest scheduling in the Mackenzie TSA.

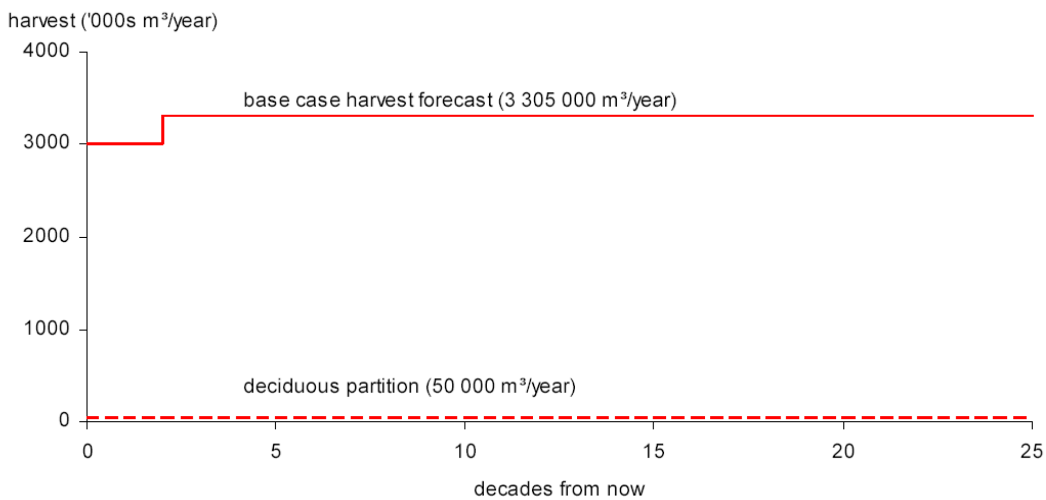

Figure 5 – Base case harvest level forecast for the Mackenzie TSA (MOF, 2001)

The base case harvest level represents the timber supply for the Mackenzie TSA following current management assumptions in 2001. While these results are dated some characteristics of the base case are reviewed to understand the timber supply dynamics for discussion of the potential impacts of the mountain pine beetle.

The timing of the conversion of the harvest contribution from unmanaged to managed stands represents a key event in assessing timber supply dynamics for any management unit. The transition from older, unmanaged stands to younger, managed stands can be a critical period for volume availability if not controlled such that there is an abrupt transition where there is not enough future managed stands which have achieved a merchantable condition to support the existing harvest. For the Mackenzie TSA, the transition from unmanaged to managed stands occurs between 110 and 130 years in the future (Figure 6).

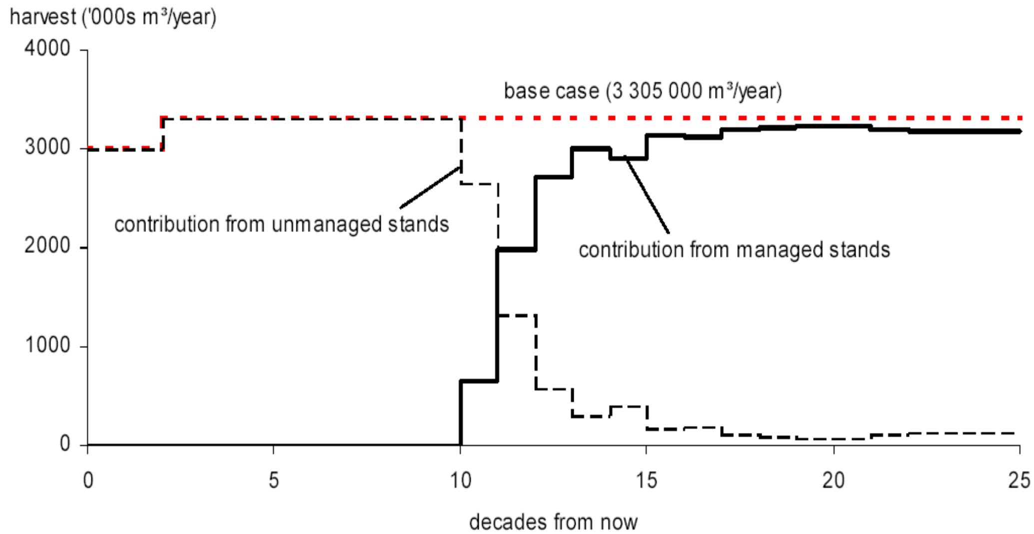

Figure 6 – Harvest contribution for the Mackenzie TSA – TSR2 (MOF 2001)

Another key characteristic of timber supply dynamics is the condition of growing stock for a management unit. The management of growing stock in timber supply analysis represents the sustainability of current and future harvest levels by tracking the amount of volume that exists within the management unit.

The growing stock for the Mackenzie TSA was illustrated by total growing stock, total merchantable growing stock, merchantable growing stock from unmanaged stands, and merchantable growing stock from managed stands (Figure 7). Total growing stock is the overall volume within the THLB of any age while the merchantable growing stocks represents the summed volume from all stands within the THLB, which are above their minimum harvest criteria. The resulting growing stock from the base case illustrates the maintenance of volume throughout the entire forecast period for both total and merchantable growing stocks.

Since there has been no timber supply analysis incorporating the mountain pine beetle epidemic for the Mackenzie TSA, these characteristics will be discussed in relation to provincial MPB projections based on the Year 2 results.

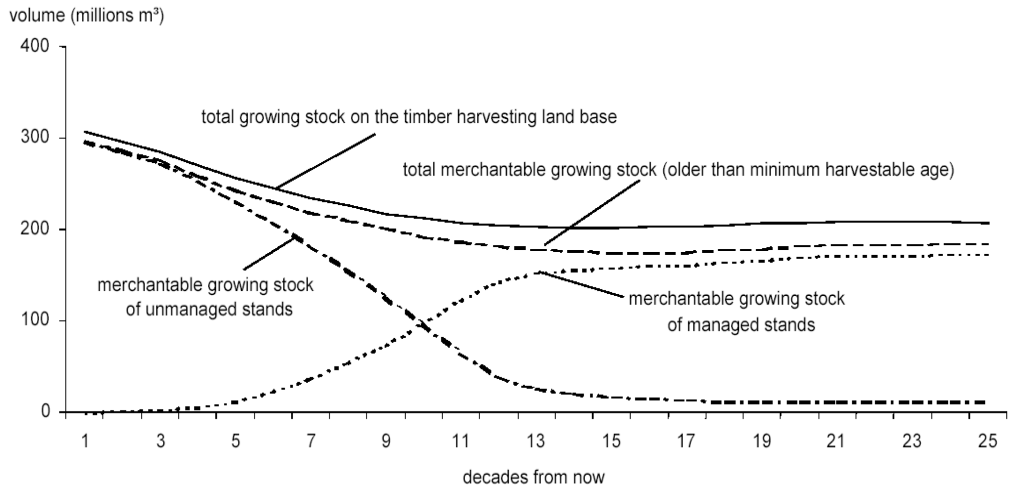

Figure 7 – Growing stock for the Mackenzie TSA – TSR 2 (MOF 2001)

2.2.5 Provincial Mountain Pine Beetle Projections – Year 2 Model Results for the Mackenzie TSA

For some management units the assumptions regarding mountain pine beetle dynamics including attack rates, spread rates, pine volume shelf life come from the Provincial-Level Projection of the Current Mountain Pine Beetle Outbreak: An Overview of the Model (BCMPB v2) and Results of Year 2 of the Project. These results were summarized for the Mackenzie TSA to illustrate preliminary predictions of mountain pine beetle induced pine stands mortality. While these results were modeled excluding harvest they offer insight into the magnitude of the attack and possibly a worst-case glimpse of estimated pine volume losses. As noted in the report:

> *While we cannot hope to accurately predict the exact progression of the infestation, we can project a range of possibilities, given a variety of assumptions and uncertainties. Our hope is that these projections will help managers make more informed decisions about provincial and national level policies. Used appropriately, the results may also help guide actions at a management unit scale.*

The following information presents basic data and assumptions as well as the results from the provincial mountain pine beetle projections summarized for the Mackenzie TSA. Readers are recommended to review the provincial mountain pine beetle report (http://www.for.gov.bc.ca/hre/bcmpb/BCMPB_MainReport_2004.pdf) for further information and background.

2.2.5.1 Mackenzie TSA Current Age Structure

Both the pine and non-pine species within the Mackenzie TSA are dominated by mature age classes (Figure 8). There is a consistent assumption throughout the mountain pine beetle affected management units that pine stands 60 years old and greater will be most susceptible to attack. This would consist of approximately 95% of the existing pine volume and 33% of the total volume of all species within the Mackenzie TSA. The area of pine greater than 60 years is approximately 86% of total pine and 43% of the total forested area for all species.

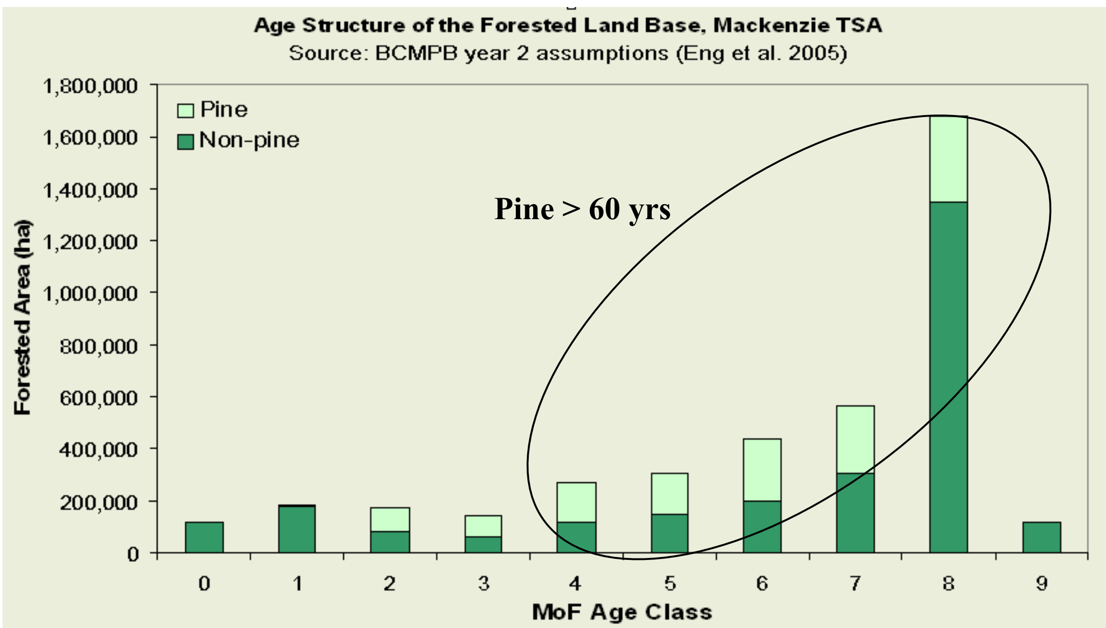

Figure 8 – Current age class structure for the Mackenzie TSA.

Another characteristic of determining susceptible pine stands is based on the pine composition in each stand. Figure 9 illustrates the forested area associated with various pine percentages in stands within the Mackenzie TSA. The total susceptible pine volume is determined based on the pine stands greater than 60 years old and a minimum of 1% pine by volume and in a climatically suitable biogeoclimatic zone (excludes pine in AT, BWBS, CDF, CWH, SWB).

In the mountain pine beetle model, the worst-case scenario predicts that over 95% of the susceptible pine on the timber harvesting land base will be killed by 2024. Uncertainties with this prediction include: the effect of cold winters in slowing the progression of the outbreak, proportion of pine trees killed by beetle are rarely more than 90% and over the entire management unit may be closer to 70%, and the effect of targeted harvest in pine dominated stands and non-recovered loss management.

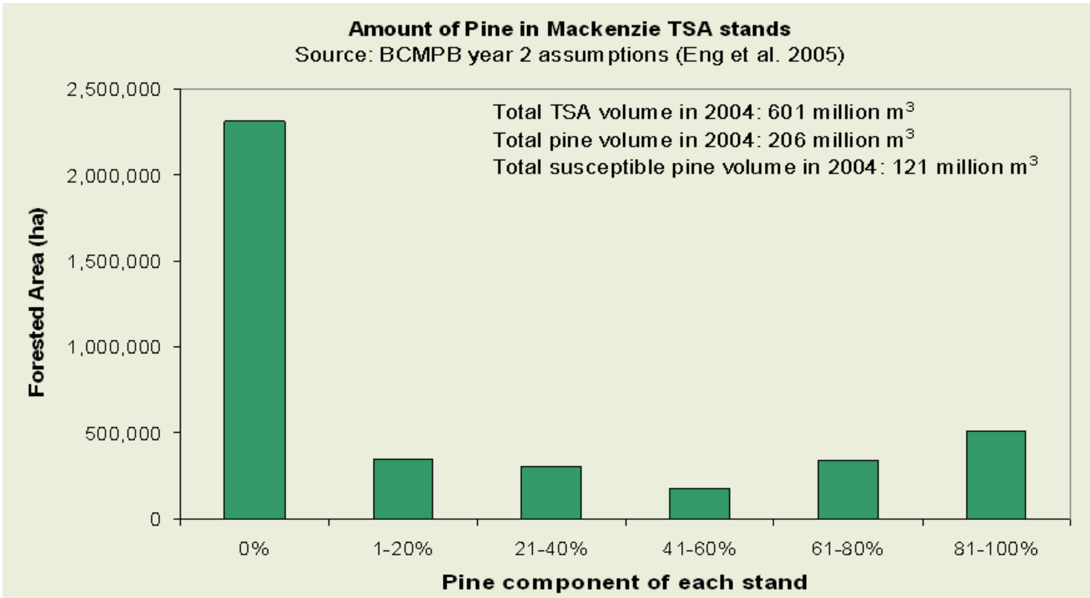

Figure 9 – Pine composition in the Mackenzie TSA.

The projected peak of pine volume kill in the Mackenzie TSA is forecasted to occur in 2011 (Figure 10). Being further from the center of the outbreak, the Mackenzie TSA, at the time of writing this report will not experience the peak in pine volume mortality for another 5 years in the future and currently the annual/cumulative kill are just beginning to appear.

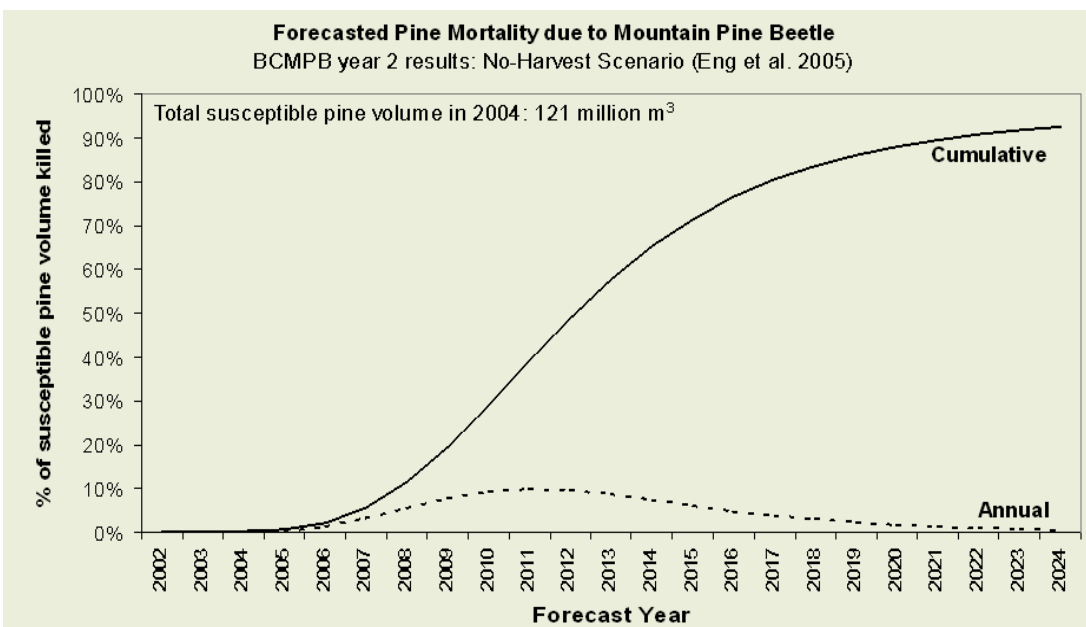

Figure 10 – Projected pine volume mortality for the Mackenzie TSA.

The Mackenzie TSA is projected to be in the bottom quarter of the management units in the province in terms of proportion of pine volume killed which is likely due to the variable quality and irregular beetle habitat (Eng et al. 2005) throughout the TSA.

Given that there has been no timber supply analysis for the Mackenzie TSA considering the mountain pine beetle epidemic, the cumulative mortality predictions were used to estimate potential maximum non-recoverable losses. These estimates are very coarse but are provided to investigate what a worst-case result may look like for the Mackenzie TSA.

For the purposes of this assessment, the cumulative mortality that was projected for the Mackenzie TSA (Figure 10) were used to determine a maximum theoretical loss rate for the Mackenzie TSA (Figure 11). This was accomplished by first shifting the cumulative mortality curve 5 years into the future to illustrate a preliminary loss curve (curve A) based on a basic shelf life assumption. To account for the losses within the timber harvesting land base, it was assumed that approximately two-thirds of the forested land would be THLB (curve B).

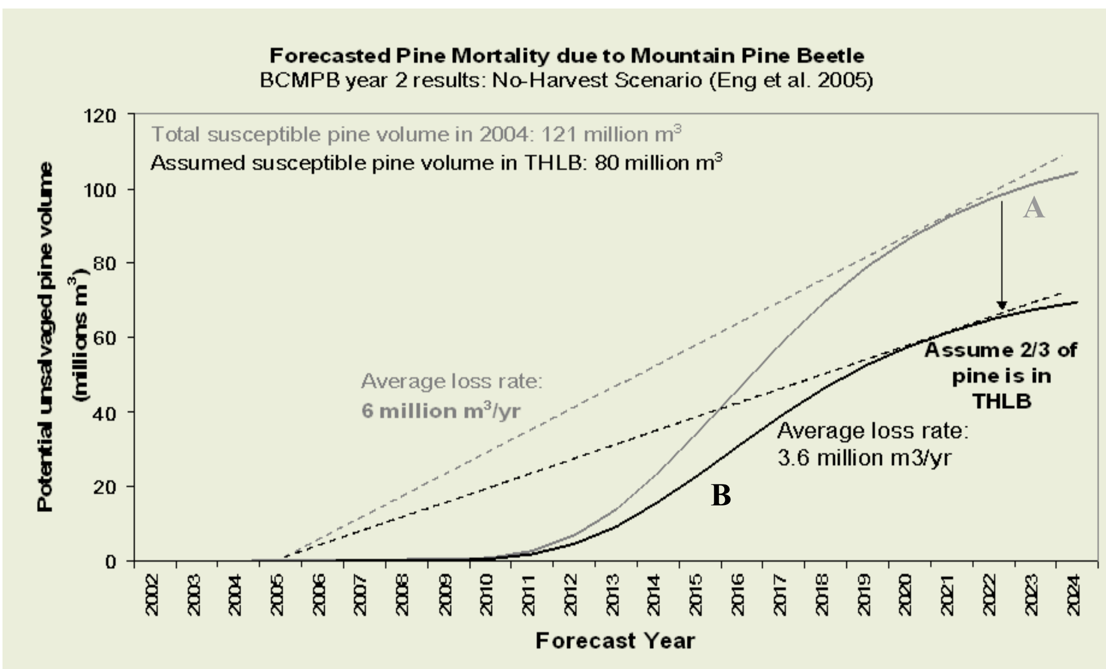

Figure 11 – Determination of average loss rate for the Mackenzie TSA.

The loss rate was calculated based on the average annual loss during 2005 to 2024, which is approximately 3.6 million m^3 for the Mackenzie TSA. The estimated maximum loss is 18% over the current AAC of 3,050,000 m^3/year, and even if the entire harvest in the TSA were shifted to pine susceptible stands, a theoretical loss of 550,000 m^3/year may still occur.

2.3 Silviculture History:

The following provides a brief description of the basic and intensive silviculture practices that have taken place in the Mackenzie TSA over the last twenty years:

2.3.1 Basic Silviculture Practices

Site Preparation- The Mackenzie Forest District has seen a number of site preparation techniques practiced on a variety of sites. Historically, prescribed burning was heavily used. However, the use of burning has declined in recent years due to concerns over air quality and increasing liabilities.

Mechanical site preparation (trenching, mounding) is still used today, but this activity is generally restricted to specific geographic regions and soil types. Drag scarification, once heavily used in the 1980's, is being reintroduced as a site prep tool as there is growing interest in and reliance on natural regeneration.

Reforestation- The licensees and the MOFR have, over the last 20 years, relied heavily on artificial regeneration as the primary tool for reforestation. Pine, spruce, and balsam fir are the leading planted species in the TSA. There is growing interest in managing for natural regeneration in cutblocks particularly on pine- dominated sites.

Brushing- Both manual and chemical brushing treatments are used throughout the TSA. Manual treatments include: bend and snap, girdling, and slashing. Chemical treatments include: foliar (manual/ aerial) and basal bark applications. There has been limited use of livestock (sheep) in the TSA. This has occurred primarily in the high elevation sites.

2.3.2 Intensive Silviculture Practices

Spacing- Historically, spacing treatments have occurred under the FDRA and FRBC programs. Treatments have been typically in pine-leading stands. The most recent spacing was performed between 1999 and 2001 (approximately 250ha). There has been a relatively small amount of area that has been spaced by licensees as part of their basic silviculture obligations.

Pruning- There has been a limited amount of pruning the TSA. This has occurred primarily on pine stands and has been funded under the FRDA, FRBC, and FIA programs.

Fertilization- Fertilization has occurred on a very small scale in the Mackenzie TSA. Aerial treatments have been mainly on immature pine (20- 30 year old stands).

Table 4 indicates the Mackenzie TSA- Forest Investment Account (FIA) silviculture activities since 2002.

Table 4 – FIA Activities since 2002

	2002		**2003**		**2004**		**2005**	
Activity	**Area (ha)**	**$**	**Area (ha)**	**$**	**Area (ha)**	**$**	**Area (ha)**	**$**
Brushing	34	28,624	0	0	0	0	0	0
Planting	0	0	0	0	0	0	0	0
Fertilization	0	0	0	0	0	0	0	0
Spacing	0	0	0	0	0	0	0	0
Surveys	9495	189,659	0	0	0	0	292,000	55,500
Total	**9529**	**218,283**	**0**	**0**	**0**	**0**	**292,000**	**55,500**

3 Summary and Analysis of the Key Issues Affecting the Quantity and Quality of Habitat and Timber Supply[1]

3.1 General Overview: Habitat and Environmental Values

3.1.1 Context

Depending on the forecast method used the current MPB epidemic is predicted to kill either all of the older pine at risk in the Mackenzie TSA or a significant portion of it. Logically this could have significant impacts on habitat and biodiversity.

Land and Resource Management Plans and the conservation emphasis areas have been impacted by MPB. Areas that were expected to serve as anchors for older and mature forest biodiversity, such as Parks, Old Growth Management Areas (OGMAs) and Ungulate Winter Ranges (UWRs) are in many areas no longer carrying the same amount of older forest. The assumptions that these conservation areas would provide mature and old growth for many decades no longer hold true.

3.1.1.1 Climate change

The rate of change in climate over the last 100 years is equivalent to the rate of change of the preceding 1000 years. Rapid change in climate is an overarching pressure on the forests affecting both timber and environmental values. State of Environment Reporting indicates that the interior of BC is experiencing greater changes in warming than the coast.

3.1.1.2 Ecology of lodgepole pine forests

Pine forests in the northern management units are generally classified as Natural Disturbance Type 3 (NDT 3) (Biodiversity Guidebook 1995). They evolved with both fires and the mountain pine beetle resetting the successional clock relatively frequently.

Wildlife and fish species have adapted to the natural range of variation over the millennia. The current MPB epidemic is considered unprecedented due in part to the climate change as well as fire suppression, which increased the mature and old pine components providing a historically enhanced supply of old and mature host trees for MPB. In NDT3, mature forest retention, strategically located in non-pine forests can provide mature and older forest habitat and help bridge older forest dependent species. How to bridge a supply of mature pine-lichen habitat for woodland caribou, already one of BC's most threatened species, is less understood.

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[1] This section includes written contributions from Mike Fenger of Mike Fenger and Associates Ltd. and Scott McNay RPF of Wildlife Infometrics Inc.

3.1.2 Key Landscape/Watershed Values Placed at Increased Risk

3.1.2.1 Changes to aquatic ecosystems and species, water quantity and quality

Changes in hydrology can be estimated by the equivalent clear-cut area (ECA) and road density. A high ECA and road density result in faster runoff and higher peak flows. This in turn may cause changes in stream channel morphology, bank stability and increase the sediment transport into streams. Road access also generally requires a great number of stream crossings, which channel the overland flow of water.

Absence of a tree over story increases soil temperatures and the temperature of the runoff can adversely affect wetland ecosystems and temperature sensitive species, such as salmon and bull trout. Speeding up the hydrological green-up and maintaining vegetation cover or planting into riparian ecosystems that have had the overstory removed can reduce this impact.

3.1.2.2 Loss of mature and old pine

The continuing loss of mid seral, mature and old forest (pine and pine mixed with other species) over the next 5 – 15 years will create vast areas of early seral forest. Mature and old growth areas where pine stands dominate will be in short supply and poorly distributed.

Many of the areas now being set aside as per the Provincial Old Growth Order will be adversely affected. These areas are being avoided in harvesting, however the resources are lacking to field check, monitor or respond to forest health considerations particularly in OGMAs. Where possible, OGMAs can be designed to minimize MPB risks by selecting mixed species stands, where these are available.

In some landscapes units there may be options for replacing MPB infested OGMAs with mid seral mixed species, spruce or fir stands stands. Silviculture treatments, such as thinning and pruning can bring mid seral stands into older seral condition more quickly to fill and bridge the mid term when older forest stands will be at their lowest point.

3.1.2.3 Reduced Landscape Connectivity

Clearcutting to remove infested pine from mixed stands, large clearcuts in pine-dominated watersheds, and intensive large-scale fires will reduce stand structures that serve to connect and distribute suitable old and mature habitat across a landscape. Loss of stand structure related habitat could cause disproportionate impacts to species at risk or those confined to isolated pockets of suitable habitat.

The need for landscape connectivity is especially acute in low Biodiversity Emphasis Landscape Units. Maintaining riparian-associated forested areas offers an option to retain landscape connectivity.

Areas managed for moderate or high biodiversity also benefit from additional management for connectivity. Retention and application of silviculture strategies in riparian areas will help provide connectivity. Maps and summaries of retention and pine mortality, condition of OGMAs, condition of riparian areas, condition of WTPs and other reserves by watershed need to be developed and identify any deficiencies and focus priorities for both retention and silviculture treatments such as under-planting.

3.1.2.4 Loss of large mature and over mature forest patches from the landscape

Larger young and older patch sizes are a characteristic of NDT 3 landscapes that traditionally experience large-scale disturbances. Managing to maintain a continuous supply of the various patch sizes over space and time poses a daunting task when overlaid by MPB patterns of infestation.

Salvage harvesting differs from what would occur in nature and the impacts to environmental values are part of the cumulative effects of past harvesting now layered on top of the MPB impacts. Landscape patterns persist for decades and impacts of poor design last and are not easily restored.

A strategy of large cut blocks should consider and incorporate within-block wildlife tree retention into cutblock and patch size considerations. A landscape level retention strategy, in light of the mountain pine beetle infestation, should identify large long-term mature forest leave areas.

3.1.2.5 Loss of green wildlife trees and coarse woody debris

Direct impacts of MPB infestation can enhance supplies of wildlife trees in the short to medium term followed by an extreme absence of standing and dead trees. Dead wood for dead wood obligate species will come from standing mature trees today that will die in the mid term and fall. Strategies to retain coarse woody debris, wildlife trees and wildlife tree supply through time need to be developed.

3.2 Mackenzie TSA Habitat Supply Situation

In order to investigate the habitat supply issues specific to the Mackenzie TSA, it is helpful to start with an analysis of the Mackenzie Land and Resource Management Plan (BC Govt., 2000). Within that plan, resource values are stratified by Resource Management Zone (RMZ). Each RMZ has a Resource Emphasis Option that indicates the relative amount of expected industrial resource development (i.e., protected, wildland, special, general, and enhanced management). When considering the MPB-based risk placed on these values by summarizing the amount of pine-leading forest stands in each RMZ, the highest risk values are:

Woodland caribou habitat - the loss and fragmentation of low-elevation range for woodland caribou (i.e., a species at risk in BC), in the mid- term, dominates the list (table 5). For this reason, and because woodland caribou are highlighted in the regional recovery plans, they require special consideration in this strategy.

Grizzly - this species is also likely to suffer from habitat loss and fragmentation in the mid - term. (Table 5).

Representation of old pine forests -it was noted during the workshop meeting that, in the Mackenzie TSA, many of the RMZs do not have defined Old Growth Management Areas (OGMA), indicating that representation of old, pine-dominated stands is at risk

The impact of the MPB on caribou and grizzly values will be exacerbated by timber salvage operations due to an expected increase in access roads and habitat fragmentation in the short-term. In Figure 12, for example, even before the MPB was taken into consideration, the northern caribou Recovery Implementation Group (RIG) assessed a significant decrease in habitat value (i.e., compare Figure 12a and Figure 12b) when predation risk associated with adjacent roads and early seral moose habitat. Roads and early seral moose habitat are anticipated to increase mortality risk to caribou through either change in predator abundance and hunting success and/or access by humans. This risk was especially significant given the uncertainty that exists around the interaction between MPB salvage and General Wildlife Measures associated with pending Ungulate Winter Ranges for caribou. Other planned, but as yet unimplemented winter ranges at risk were those identified through the Mackenzie Land and Resource Management Plan (i.e., the Lower Akie RMZ 12A and the Pesika RMZ 14A).

Loss of landscape connectivity is caused when barriers are created which restrict flow of resources around the landscape. In this particular area, mid-seral conditions (i.e., depending on stand density) may reduce the connectivity among habitats for caribou and grizzly in the mid-term.

Table 5 - Environmental values at risk due to mountain pine beetle in Resource Management Zones (RMZ) located in the Mackenzie Timber Supply Area in north-central British Columbia.

Resource Management Zone Characteristics						*Environmental Values*							
LU Name	***RMZ Name***	***RMZ Number***	***Hectares of PL leading stands***	***Pine-leading Rank***	***LRMP RMZ Designation***	***Water Quality***	***Caribou***	***Grizzly***	***Goat/Sheep***	***Visual***	***Trapping/Guide Outfitting***	***OGAMS***	***Barriers***
Blackwater	Blackwater	37	82370.15	High	Enhanced	B-L	B-M	ST-L		ST-L		MT-L	MT-L
Buffalohead	Khak'l Tse (Buffalohead)	11	75744.39	High	Enhanced	B-H		ST-H		ST-L		MT-L	MT-H
Osilinka	Osilinka	23	58252.55	High	Enhanced	ST-H	B-H	ST-H		ST-H	B-H	MT-L	MT-H
Chunamon	Chunamon	20	58219.92	High	Enhanced	ST-H	B-H	ST-H		ST-H		MT-L	MT-H
Collins - Davis	Collins - Davis	21	55049.48	High	Enhanced	ST-H	B-L	ST-H		ST-L	B-L		
Gaffney	Gaffney	35	51973.70	High	Enhanced	ST-L	B-H	ST-L		ST-L			MT-L
Mesilinka	Mesilinka	22	35445.74	High	Enhanced	B-H	B-H	ST-H				MT-H	MT-H
Akie	Lower Akie	12	15939.88	High	Enhanced	B-H	B-H	ST-H	B-H		B-L	MT-L	MT-H
Philip	Philip	42	75184.71	High	General					ST-H			
Ingenika	Ingenika	19	30927.53	High	General	B-H	B-L	ST-H		ST-H	B-L		MT-H
Klawli	Klawli	34	29910.22	High	General	ST-L	B-H			ST-H	B-L	MT-H	
Schooler	Schooler	26	19705.81	High	General	B-H	B-H	ST-L					
Lower Ospika	Lower Ospika	18	16692.74	High	General	B-H	B-L	ST-H				MT-L	MT-H
Omineca	Omineca	101	45522.21	High	Protected								
Frog-Gataga	Frog-Gataga	103	43231.02	High	Protected								
Finlay-Russel	Finlay-Russel	102	28647.76	High	Protected								
Chase	Chase	106	15653.46	High	Protected								
Fox	Nuhseha (Fox)	6	38186.49	High	Special	ST_L		ST-H		ST-H	B-L		MT-H
Pelly	Tse Baje "Russell Range"	9	32547.75	High	Special	B-H	B-L	ST-H	ST-L	ST-L	B-L	MT-H	MT-H
North Ingenika	Ingenika	19	20947.19	High	Special					B-H	B-L	MT-L	
Obo River	Yah-Hya "Johiah"	4	18167.40	High	Special	B-L		ST-L		ST-L	B-L	MT-L	MT-L
Thutade	Tu Dade "Above the Canyon"	7	44942.44	High	Special Mining and Wildlife	B-H	B-H	ST-L		ST-H	B-L	MT-H	MT-L

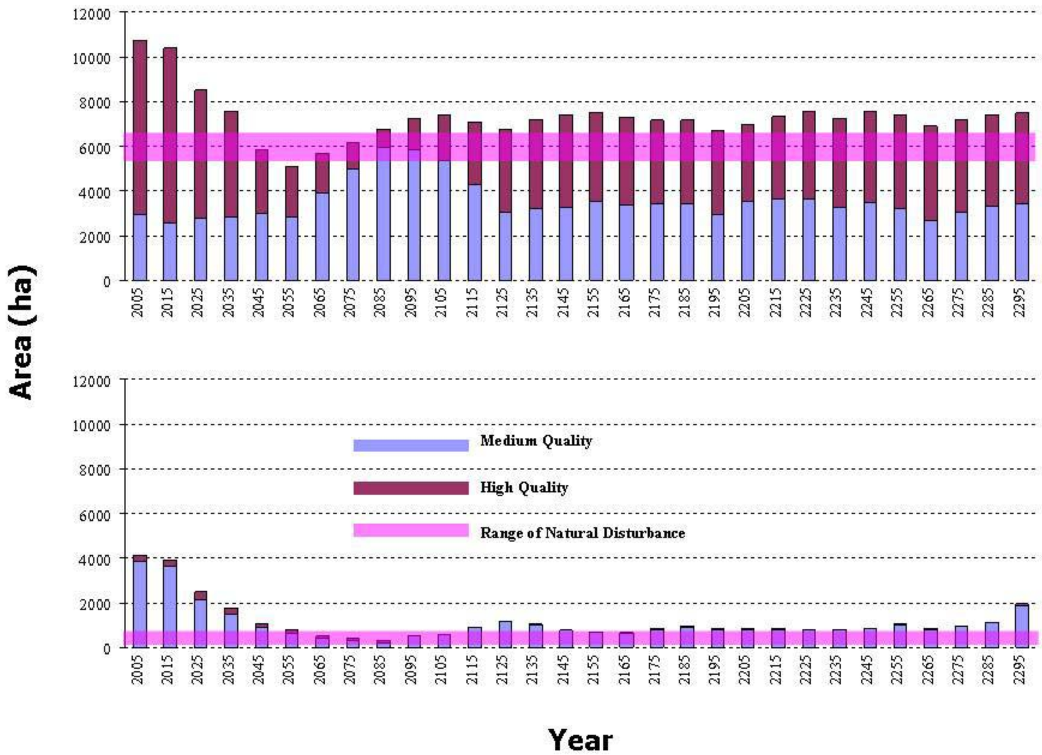

Figure 12. Habitat supply for northern caribou estimated from analyses depicting the amount of high and medium quality habitat in comparison to the amount expected under natural disturbance without the influence of predation risk (A, top graph) or with the influence of predation risk (B, bottom graph).

3.3 The following species are considered most impacted by loss of mature and older pine forests.

Table 6 - Species most impacted by loss of mature and old pine forest

Species/ Ecosystems	Forest dependency	Habitat supply implications
Salmon spp	• Cool stream, low sediment to spawning beds	Riparian management and sediment delivery, stream temperature management, hydrologic recovery, green up
Bull Trout	• Cool streams	Same as salmon
Caribou	• Pine over story structure • Terrestrial lichen • Minimal forest fragmentation	Habitat management and restoration of terrestrial lichen conditions is unclear but will undoubtedly focus on: a) silviculture strategies that retain terrestrial lichens further through a forest rotation and b) planning for episodic rather than chronic MBP-related salvage operations. Caribou recovery team is considering silviculture activities that prolong ground lichen.
Grizzly bear	• Road sensitive	Access management, rehabilitation roads
Fisher	• Stand structures Coarse Woody Debris (CWD) • Landscape connectivity	Continuity of habitats across landscape through time.
Northern goshawk	• Mature forest stands	Larger old mature forest stands
Pine marten	• Stand structure over story plus CWD • Landscape connectivity	Continuity of habitats across landscape through time.
Moose	• Riparian condition • Hiding cover	Hiding cover
Pine-leading Rare Plant Communities	• Mature/Old forest	Direct loss of the communities through harvesting

4 Timber Resources

Based on the recent timber supply analyses, a significant reduction in harvest will begin to take place within the next ten years and continue into the mid-term. This reduction is a result of the accelerated salvage harvest and the predicted losses due to unsalvaged timber.

4.1 Summary of Key Issues Affecting Timber Resources

- Health of Mature non-pine leading Stands
- Non-Recoverable Losses
- Future Markets for Forest Products
- Minimum Harvest Criteria and the Future Unbalanced Age Class Distribution
- Health and Quality of Existing Managed Stands
- Fire Hazard and Protection
- Basic Silviculture Practices

4.2 Non-Key Issues that were discussed at the workshop

- Backlog NSR
- Impeded Stands
- Repressed Pine
- Other Issues

4.2.1 Health of Mature non-pine leading Stands

After the MPB-related salvage is finished, most of the harvest will depend on mature stands of non-pine species. Increased reliance on non-pine species may present further risks due to other forest health agents that affect these species. For example, spruce beetle and balsam budworm (Choristoneura spp.) have recently attacked portions of the TSA. According to the TSA foresters, currently there are no significant epidemics outside of the MPB requiring mitigation. However, the significance of non-pine forest health issues and associated mitigation strategies must be considered to ensure that the assumed mature non-pine volume will be available in the future.

4.2.2 Non-Recoverable Losses (NRL)

It is uncertain how significant the NRLs will be for the Mackenzie TSA. Figure 11, illustrated a theoretical average loss of 3.6 million m^3 excluding harvesting. The most optimistic view would be that the entire harvest of 3,050,000 m^3 would target pine leaving 550,000 m^3/year unsalvaged. This estimation is a worst-case scenario from the perspective of the theoretical average loss and is optimistic based on current management that 100% of the harvest would capture all susceptible and attacked pine. This theoretical outcome is based on 100% of the current harvest shifting to preventative pine harvest and salvage excluding the effects of an uplift harvest in the future. For this report, unharvested dead stands are considered non-recoverable losses (NRLs). These NRLs will occur due to current biodiversity constraints and operational logistics in harvest scheduling and accessing the dead stands. NRLs may be significantly larger unless the salvage is efficiently scheduled to target the appropriate dead and dying pine stands relative to "shelf life".

NRLs can be from pure pine-leading stands to mixed stands with the non- pine volume being below the merchantable criteria. The mixed stands, depending on the distribution of pine within each stand, may present only limited opportunities for rehabilitation. Particularly, stands with a component of pine dispersed throughout, may not be possible to rehabilitate.

Left alone, it is uncertain how the NRL stands will naturally regenerate and grow. Areas with advanced understory regeneration should be thoroughly assessed to determine whether the existing regeneration is a) of sufficient in density and b) is of an acceptable (reliable) species composition, to form the next crop. The death of the pine overstory releases the understory, which could be supplemented by infill planting. The alternative is that if NRLs are promptly salvaged and reforested they will become managed stands sooner and will begin contributing to the timber supply. It is generally expected that the latter approach will lead to the greatest reforestation success. It should also be mentioned that by tying the reforestation of NRLs to salvage, results in the recovery of reforestation costs from timber harvest revenue.

The incremental cost of the delayed rehabilitation of NRLs is a significant management consideration. In addition, future funding may not be available and, above all, there could be uncertain regeneration performance. The increased costs of rehabilitation activities due to the following logistical considerations and reforestation uncertainties must be weighed:

- Access limitations or restrictions,
- Safety considerations for silviculture crews (remoteness, overhead hazards),
- Reduced productivity of workers within unsalvaged stands (obstacles),
- Performance and/ or survival of regeneration,
- The potential for damaged regeneration by rotting and falling trees, and
- Mechanical site preparation limitations (access, staging, mobility).

The workshop participants generally agreed there would be large areas of NRLs in the Mackenzie TSA. However, it is unclear where these areas will be. Several factors contribute to this uncertainty:

- The TSA is large with many areas currently undeveloped. Also, there many forest types currently considered marginally economic under a non - MPB scenario.

These stands would likely become uneconomical and NRLs once impacted by the beetle.

- The harvest levels are likely to increase in the short term. There will be opportunities for licensees to take advantage of the increased harvest by securing non- replaceable forest licenses. These licensees may be producers of non-sawlog products and therefore there will continue to be uncertainty as to where salvage opportunities will exist over the next 20 years.

- Due to the large areas of dead pine stands, the licensees are still trying to position themselves to best take advantage of the salvage opportunities. Decisions regarding which stands may not be harvested have not yet been made.

- The proposed changes to the interior log grading rules and scaling procedures (ie. loss of grade 3) may result in increased stumpage rates for some stands of dead pine timber. This may act as a temporary disincentive to the licensee to salvage some stands.

- Many licensee customers require a component of non- pine species therefore making it difficult for licensees to harvest only pine stands.

- Access to dead pine stands may be lacking or the costs maybe too high.

- Some licensees perceive that there is no security of tenure and as such there may not be as much incentive to consider long-term consequences of not harvesting dead pine and minimizing NRLs.

- There is a perceived lack of high-level direction and leadership, by government, that would address the situation and coordinate the salvage of dead pine stands and minimize the NRLs in the TSA.

A TSA level strategic planning initiative, with the objective to minimize the extent of NRLs and to determine where they will likely occur, must begin soon. This plan would first have to determine where the licensees would harvest within the next 5 to 10 years. The strategy should take an all-encompassing look at the TSA, its operable land base, the predicted self- life of dead timber, site and stand quality, and other integrated resource management (IRM) considerations to prioritize the salvage areas.

Policies concerning landscape level and stand level biodiversity that attempt to give operational direction, should be incorporated into the strategic plan as well.

It was noted that the inventory, planning, and treatment of NRLs *in immature stands* is currently seen as the highest priority in NRL management. This is held as the current view of participants until a more comprehensive TSA NRL management strategy is eventually produced.

The stakeholder group also expressed concern over one of the basic requirements for the reforestation of NRLs; the acquisition of sufficient amount of seed. Two points have been raised:

- There will be an overall lack of natural pine seed to artificially regenerate all of the NRL whether through planting or direct seeding techniques.

- Concerns have been raised over the quantity and viability of seed from dying stands of pine. Are the trees producing enough viable seeds per cone? What will be the germination success of these seeds in the nursery or on the forest floor? The latter is the main concern, as there remains uncertainty around the site conditions within NRL (eg. climatic, brush competition).

4.2.3 Future Markets for Forest Products

What can and will be produced from northern interior forests in the future is difficult to forecast. However, these predictions are important when assessing the prospects of future timber supply and determining appropriate incremental investments.

Throughout history, the B.C. forest industry has adapted by applying new technologies to produce products from a changing forest resource. The northern interior forest industry now produces solid wood products from smaller logs than ever before. It has also made a switch into producing more non-solid wood products such as medium density fibreboard (MDF) and oriented strand board (OSB). Recently, several companies have won licenses to harvest beetle infested and dying stands to produce OSB and biofuels. While these plants are being established to utilize salvage material, they will eventually be looking to secure fibre from green sources as well, once the MPB infestation is over.

When considering how industry will respond to the post-MPB wood supply, it is useful to look at forest operations in similar forest types in other parts of the world, such as in Scandinavia. There, some smaller wood can be economically utilized from thinnings of plantations established at higher initial densities. In this way forest managers have more options to decide what products are eventually produced from the forests.

Many forest products experts speculate that future timber product values will be based more on basic wood properties such as specific gravity, knots sizes, fibre length, stiffness etc. than on traditional criteria such as piece size. In addition, the abundance of small timber, which will make up a significant portion of the growing stock in the mid-term, will provide a strong incentive for the forest industry to develop uses for this wood. These developments challenge our traditional views of timber supply management.

It is certain that the stands of today will be heavily relied upon in the future. These stands will be required to provide high yields of high quality products. This does not mean that silviculture regimes should be biased towards improving the quantity of timber supply. However, it does suggest that silviculture investments should be designed to generate and maintain options for the future.

4.2.4 Minimum Harvest Criteria and the Future Un-balanced Age Class Distribution

Minimum harvest criteria (MHC) are primarily forest-modeling concepts without real operational applications; stands are usually harvested when they are considered operable (economically merchantable) regardless of their age. MHC must be considered in the context of managing the challenges facing the future timber supply for the TSA. Assumptions about future markets and operating costs have the biggest potential to impact future merchantability and therefore MHC. On the other hand, MHC can have a significant impact on timber supply analysis results and actual future harvest levels.

MHC used for the recent timber supply analyses in the Mackenzie TSA were based on the criteria presented in Table 7. The resulting minimum harvest ages for pine ranged between 50 and 190 years.

Table 7 – Minimum harvestable criteria used in TSR 2 for the Mackenzie TSA

Species	Haul Zone	Logging System	Minimum Volume
Pine	Near	Conventional	140
		Conventional/Cable	180
		Cable	220
Pine	Far	Conventional	160
		Conventional/Cable	220
		Cable	250

MHC are expected to be important in managing mid-term timber supply constraints such as adjacency, green-up and visual quality in MPB-impacted management units such as the Mackenzie TSA. In these units, large areas of similar aged stands will result from the reforestation of this MPB infestation. In order to minimize the mid-term timber supply impacts, some of these stands will need to be harvested as soon as they are economically merchantable so that not too many stands are harvested well past culmination age. On the other hand, significant harvesting of stands below culmination age would have a long-term negative impact on timber supply.

Finally, stand-level analyses of intensive silviculture investments such as fertilization show justification for reducing harvest ages for treated stands.

4.2.5 Health and Quality of Existing Managed Stands

The timber supply in the mid-term (>20yrs from now) is heavily dependent on harvesting currently young, managed stands. Many of these stands are pine leading. Over the last few years TSA foresters have observed MPB infestations in immature pine leading stands throughout the TSA. Currently the magnitude and frequency of the attack is uncertain.

Given the current assumptions in the Provincial Mountain Pine Beetle Analysis that only Pl >60 years old will be attacked, any significant mortality of younger pine will have an adverse effect on the mid-term timber supply.

As a result of the uncertain MPB impacts on young pine, incremental silviculture treatments on these stands in the TSA have been postponed until the current MPB epidemic passes.

Mackenzie TSA foresters also raised concerns over other forest health issues (non - MPB) in young stands throughout the TSA. There appears to be a notable increase of stem rusts in immature pine (both natural and managed stands). Rusts such as Cronartium spp. and Endocronartium spp. appear to be having negative effects on both stand productivity and wood quality of pine. Dothistroma in young pine stands in the wetter SBS ecosystems have also been getter worse over the last 5 years. Even if the young pine stands survive the current MPB epidemic, these forest health issues may impact timber supply and merchantability in the mid-term (the recent timber supply analyses makes no specific allowances for these factors).

The timing and magnitude of silviculture investments in these immature stands could have significant positive timber supply impacts. They are potential opportunity areas to improve the mid-term timber supply.

Inventory of the existing managed stands to confirm suitable quality (not too open grown with poor wood quality) and health (not afflicted by significant forest health agents) for silviculture investment is important. An assessment of the risks associated with future pest losses is also required. These assessments, particularly in non-pine stands, should begin right away with health inventories of pine stands to be done after the current MPB epidemic.

4.2.6 Increased Fire Hazard and Protection

Some experts feel there will be a significant increase in the landscape-level fire hazard due to the current MPB epidemic. This is an important consideration in forest planning and when developing silviculture investment strategies.

The fire hazard depends on the Natural Disturbance Type (NDT) of the area, climate, and the amount of fuel on the forest floor.

The following photographs illustrate the conversion of historic mixed severity fire regime to a stand replacement fire regime. These changes are a result of natural and man - caused influences. Many of the forests in the northern interior are currently experiencing similar changes irrespective of the current MPB epidemic.

Photo 1 – Mixed-Severity Fire Regime

Photo 2 – Stand Replacement Fire Regime

The trend in the development of fire hazard in the mountain pine beetle killed, unsalvaged areas is expected to be as follows.

After the initial MPB attack, pine - leading stands will be subject to an increasing fire hazard: as the green needles turn red and the moisture content of the trees begins to decrease, the hazard rises. As the red needles fall from the trees over the following few years, the hazard decreases towards normal levels.

As witnessed in the southern Chilcotin (Chilco Lake fire in 2003), the fire hazard will increase slowly 5 to 20 years after the beetle attack: the dead stands begin to collapse to the forest floor in a random orientation. The development of this surface fuel fire hazard, concurrent with the regeneration of new conifers, creates a complex fire hazard (Photo 1 and Photo 4). The resulting fires are often difficult to control and may lead to catastrophic fires (Photo 5).

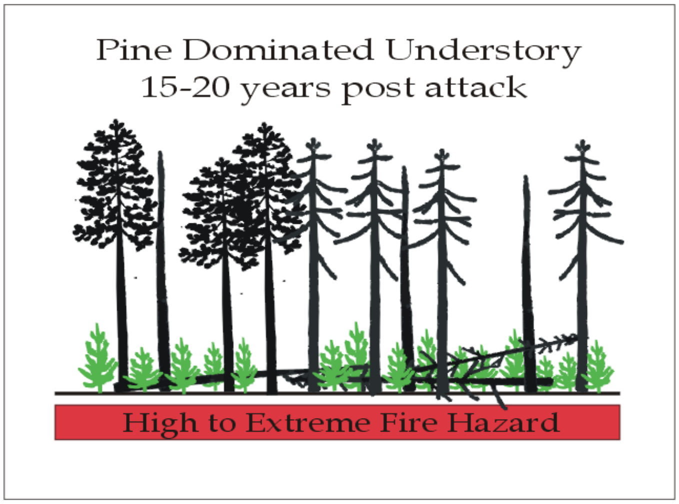

Photo 3 – Complex Fire Hazard 1

Photo 4 – Complex Fire Hazard 2

Photo 5 – Chilco Lake Fire 2003 (30,000 ha MPB in 1983)

Wildfires not only threaten public and private property, and life, but also put at risk existing mature and immature timber. In addition, fire threatens past and present silviculture investments. It is therefore prudent to consider the evolving fire hazard in the context of the MPB infestation and in silviculture investment planning.

Fire hazard mitigation should be an integral part of NRL treatment suite of strategies. The use of prescribed burning, the development of fuel breaks and coordinated harvest planning (salvage) should all be considered within this process. Strategically designed and appropriate placement of deciduous species at a landscape level may serve to reduce the spread of fire as well.

The Mackenzie stakeholders believe that the risks to timber, non- timber, and community resources are high. Policy changes are necessary to bring prescribed burning back as a forest management tool. In addition, consultation with the public will be required.

Finally, it should be noted that evolving Community Wildfire Protection Planning might have an impact on silviculture practices and objectives within the Wildland-Urban Interface (generally defined as a zone with a width of 2 kilometers outside the municipal, city or regional district boundaries).

Within this interface foresters will be challenged to meet both the needs of community protection and the TSA silviculture objectives. Foresters are urged to review the Ministry of Forests Protection Branch website link below for more information.

http:www.for.gov.bc.ca/protect/FuelManagement/CWPP.htm

4.2.7 Basic Silviculture

Over the past decade increasing global competition has forced the B.C. forest industry to rationalize its cost structure. As basic silviculture is considered a cost to licensees, reforestation costs have been included in this rationalization. Foresters are now challenged to meet their free growing targets in the most cost effective manner possible. In recent years this has meant an increased reliance on natural regeneration and combined strategies of natural regeneration with supplemental fill planting.

Given the current MPB epidemic and the health problems affecting many northern interior managed stands, some foresters may now have to focus their attention on the need to ensure that higher initial stocking densities are achieved in some ecosystems, while more mixed species reforestation may be required in others.

Although government does not directly fund basic silviculture (although there is an appraisal allowance), its success is critical to future timber supply. Basic silviculture also lays the foundation for tomorrow’s incremental treatments. For these reasons, an assessment of basic silviculture practices and their success was included in all workshops. Following are some of the concerns raised and questions discussed at the workshop:

- Are the average initial stocking densities sufficient to ensure the production of a reasonable volume of timber or fibre on a given site?

- Are the initial densities capable of providing the quality of timber or fibre for future markets? Quality in this context does not necessarily mean size. It can also mean density of wood, form, strength etc. Furthermore, are current stand establishment densities precluding opportunities for future silviculture investment or harvest opportunities?

- Will there be enough trees on site to buffer against future abiotic and biotic damaging agents?

- Should there be more of a mix of species, where ecologically feasible, to buffer against future abiotic and biotic damaging agents?

- Is the distribution of the crop trees within naturally regenerated stands sufficiently well-spaced and are the crop trees occupying the best sites to realize the maximum site productivity?

- Are the current TSR modeled regeneration delays reasonable given that more stands are now being left for natural regeneration?

With more emphasis on natural regeneration there will be a proportional decline in the use of improved seed, therefore a loss in its theoretical volume benefits. This is an important consideration, particularly in the Mackenzie TSA, where there is a growing availability of improved A - seed pine.

The stakeholder group discussed initial stocking densities, free growing densities and species composition. It was suggested that the following could be considered:

- There should be a review of the current TSA stocking standards particularly for those sites where ingress is not deemed reliable.

- More mixed species planting should be considered where ecologically feasible. Perhaps allow more deciduous species in the mix at free growing.

- Changes in stocking standards, particularly changes that would lead to increased initial stocking densities, would be an incremental cost to the licensees. Stocking standard reviews should not be considered without meaningful licensee input.

4.2.8 Backlog NSR

The MOFR currently estimates that there are 35,605ha of NSR in the Mackenzie TSA (FFT Website, 2006). The TSA stakeholders suggest that this figure likely represents current NSR, and not Backlog. It was further indicated that the actual amount of Backlog NSR is actually quite low, in perhaps the range of 200- 500 ha for the entire TSA.

While there does not appear to be a huge backlog problem in the TSA, there are likely many stands that are not growing at their fullest potential. Using more realistic yield projections for these stands may lead to a further reduction in the mid-term timber supply.

The Mackenzie Forest District is currently reviewing the backlog NSR areas and is in most cases reclassifying them. It is expected that the actual backlog NSR will be significantly less than indicated by current records.

The reforestation of backlog NSR areas was not seen as a high priority in the TSA. However, it was felt that if the ongoing survey and reclassification process identified candidate areas then these could be considered for backlog reforestation funding. Other reclassified areas will likely be left growing naturally, with recognition that in the TSR process lower yields will be realized from these stands.

4.2.9 Impeded Stands

There are no significant areas of impeded stands in the Mackenzie TSA. Where they occur, they are considered to be a high priority for treatment.

4.2.10 Repressed Pine Stands

These are stands that have naturally regenerated following disturbance (typically fire) with stem densities ranging from 10,000 to greater than 100,000 per hectare. As a result of root competition for moisture and nutrients below ground, and light competition above ground, these stands exhibit reduced height growth rates. The stands typically remain in a repressed state until they are disturbed by abiotic or biotic influences. Repressed stands are not considered part of the THLB, however, the sites can be productive and, as such represent site rehabilitation opportunities.

TSR 2 does not indicate the specific presence of repressed stands in the TSA. However, these may have been included in the 20,270 ha indicated as problem forest types. The stakeholders indicated that in fact repressed or over dense stands of pine exist in the TSA, but the full extent of this forest type is debatable. Potential treatments for these sites are surveys (specifically; reclassification or treatment recommendations), site preparation (burning, mechanical), and planting.

Generally, it was felt that prioritization of treatments in these stands should be considered in the context of the overall silviculture strategy. Treating of these stands is not a priority in the TSA when considering other opportunities and silviculture needs (eg. NRL rehabilitation).

There is also a growing interest in some repressed stands as a source of fibre for pellets or other alternative forest products. It should also be noted that preliminary results of the fertilization of repressed stands in the Cariboo (Newsome et al, 2003) indicate that repression might be treated with spacing and fertilizing regimes.

5 Development of Key Non- Timber Resources Strategies[2]

Impacts to environmental values due to the expanding MPB epidemic remain unquantified for the Mackenzie TSA but could be significant in the short and mid term based on some existing information and expert opinion.

Silviculture, as defined by the Ministry of Forests and Range, is:

> "…the art and science of controlling the establishment, growth, composition, and quality of forest vegetation for the full range of forest resource objectives. Successful silviculture depends on clearly defined management objectives, which is commonly focused on managing stands and forests purely for timber values. However, silviculture can also include the management of forests for wildlife, water, recreation, aesthetics, or any combination of these or other forest uses."
>
> http://www.for.gov.bc.ca/hfd/pubs/SSIntroworkbook/meansilv.htm

One of the goals of the FFT is to speed the recovery of environmental values, which along with timber values are likely to be impacted by the MPB epidemic in the Mackenzie TSA. These environmental impacts could be immediate in the case of changes in hydrology while other effects will be experienced over the mid term, such as supply of older forest stand structures. This section indicates how potential silviculture investments could mitigate habitat supply for the Mackenize TSA.

5.1 Habitat and Environmental Values

Many of the habitat and environmental concerns and issues are beyond the scope of a Type 1 silviculture strategy. However, possible solutions to consider outside the strategies are discussed later in this document. There are also silviculture treatments that effectively mitigate impacts to environmental values in areas where treatments would not normally be carried out. The following areas and silviculture treatments can be explored using local knowledge for the following values:

- Woodland caribou habitat (consistent with LRMP objectives);
- High value fish streams; (temperature sensitive streams where known)
- All riparian areas with high dead pine component;
- Old growth management Areas with a high percentage pine;
- Old growth management areas with younger stands present;
- Ungulate Winter Ranges;

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[2] This section includes written contributions from Mike Fenger of Mike Fenger and Associates Ltd. and Scott McNay RPF of Wildlife Infometrics Ltd. under contract to MOE. Some of the strategies presented in this section were not reviewed during the workshop but provided afterwards by MOE.

- Wildlife Tree Retention areas;
- Areas identified for enhanced retention; and
- Existing secondary roads and landings (increases THLB and reduces access and runoff).

5.2 Strategic and tactical planning to support biodiversity, silviculture and salvage harvesting

This section of the silviculture strategy seeks to identify silviculture opportunities to maintain and enhance habitat supply

In some cases, the supply of habitat can be sustained by avoiding the salvage of riparian areas, OGMAs, Wildlife Tree Reserves (WTRs), UWRs, and other areas designated for biodiversity management. Key habitat elements can be maintained by retaining live mature and old stands. Trees left today will support both habitat and timber supply in the future.
.

5.2.1 Habitat Strategy- underplanting non-recoverable loss areas (HS 1)

Natural regeneration is the best environmental treatment option in many NRL areas allowing reforestation through natural succession. Generally the areas that have the highest conservation emphasis and habitat vale and where underplanting for habitat is advisable are areas such as:

- High value fish streams
- Temperature Sensitive Streams

Given limited funding, identification of sensitive watersheds and riparian areas will need to be prioritized and only the most critical sites treated. However, it is understood by MOF silviculturists that the riparian areas may in fact be regenerating naturally better than non-riparian areas.

5.2.2 Habitat Strategy - under planting in riparian areas (HS 2)

It is possible to mitigate hydrological impacts through silviculture treatment within riparian areas. Riparian reserves and management zones including additional enhanced riparian areas (consistent with Chief Forester retention policy to retain 20% of THLB) represent potential areas for habitat impact mitigation through silvicultural investment. Treatments such as reforestation, underplanting and vegetation management can improve forest overstory conditions ultimately increasing shade, improving bank stability and set the stage for future supplies of large organic debris (LOD) and instream structures in the later mid and long-term. To maximize impact mitigation, silviculture treatments in riparian areas should be targeted towards high value fish streams and temperature sensitive streams (salmon, stream resident trout and species at risk bull trout), which have high pine content.

The effectiveness of silviculture treatments in improving stream bank stability depends on the condition of the stream reach and the health of surrounding forests. It should be expected that in areas with higher water tables, brushing treatments might be required to release existing established trees. This along with the planting of alternative species such as cottonwood, where ecologically appropriate, could accelerate shade conditions and enhance overall species diversity within riparian habitat areas.

Maintenance of existing functional older stand structures in riparian is paramount in riparian zones and danger trees are not to be removed, as these are some of the structures that are needed. Danger tree assessment and no work zones would protect these riparian features.

Not all riparian areas will benefit from accelerated regeneration, however actions that reduce stream temperatures for salmon, stream resident trout and species at risk (bull trout) can mitigate impacts. Planting of alternate species such as cottonwood where ecologically appropriate can accelerate recovery of shade conditions and promotes species diversity within riparian areas. These strategies should be targeted for riparian areas with high pine content where overstory trees will be at risk for MPB attack.

5.2.3 Habitat Strategy - under planting to speed hydrologic green-up of upland areas (HS 3)

High value fish stream, temperature sensitive streams and community watersheds can benefit from under planting in upland unsalvaged areas, as the maintenance of tree cover can affect the rate and the timing of runoff.

A general consideration for all under planting treatments is that a diversity of tree species should be established that are ecologically suited to the site and general conditions of the area (HS 8). In suitable ecosystems, planting of aspen and cottonwood may be desirable. These species provide important habitat for cavity excavators and insectivorous birds.

Spacing and pruning portions of the landscape provide increased habitat heterogeneity. Large areas of high stocking and density form barriers to movement for many species that cannot persist or move through large area of continuous low quality habitat.

5.2.4 Habitat Strategy- thinning mid seral and mature forests to speed recovery of old growth structure (HS 4)

Some old forest attributes and structural diversity can be developed more quickly through spacing of younger forests in non-pine OGMAs and WTPs than allowing those stands to age and develop through natural succession. While the amount of treatable area in the Mackenzie TSA is currently unknown, a Type 2/3 silviculture strategy could assist in identifying potential candidate stands and treatment areas. Old forest stand structures are expected to be at their lowest point when timber supply is also low. Thinning mid seral and mature forests could benefit these stands by providing future old growth management areas during the mid-term period when the supply of old growth may be significantly decreased.

5.2.5 Habitat Strategy- selected wildlife species (HS 6a, b, c)

Incremental silviculture treatments can be specifically developed to speed recovery of habitat elements, which are determined to be in short supply or at critical levels. Caribou, grizzly, fish species are expected to be impacted by the MPB epidemic and would likely benefit from silviculture treatments. The extent and location of habitat and potential treatment areas and the full extent of potential benefits would be investigated through a Type 2/3 silviculture strategy project.

It should also be noted that the species mentioned above are sensitive to roads and access and could benefit from road rehabilitation treatments. The location of areas that would benefit access management the most could also be investigated through an updated Type 2/3 assessment for the Mackenzie TSA. At this point, habitat treatment options for individual species would be site specific and will need to be developed using knowledge of species and habitat relationships.

5.3 Additional identified habitat issues

5.3.1 Inventory gaps

A spatial plan identifying high value conservation areas is required to plan a coordinated response to MPB and enhanced retention at the landscape level. This framework can help guide salvage activities, set priorities for reserving trees and silviculture strategies and identify timber and habitat supply challenges.

Field review of existing conservation emphasis areas will assist where to focus efforts. Prior to doing this, additional inventory needs should be addressed. The inventory needs include:

a) Identifying resident fish populations;
b) Species and ecosystems at risk (e.g., zones of high predation risk for woodland caribou), and
c) Candidate WHAs for Identified Wildlife. Identification of listed ecosystems and plant communities are needed to guide restoration away from these sites.

5.3.2 Deciduous species - existing silviculture and harvest practices (HS 7)

Given current uncertainties with climate change, environmental threats from MPB and the desire to reduce the risk associated with pests and attack of future stands; the use of deciduous species should be reviewed for the Mackenzie TSA. Strategies need to be developed to identify specific areas and, ecosystems where deciduous can be deployed to meet specific timber and/or habitat objectives.

5.3.3 Climate change

Climate change means that tree species planted or naturally regenerated today will mature in a different climate, just as the trees we harvest today developed under different climatic conditions. Planting to diversify tree species is considered a wise investment as a hedge against climate change. Clear objectives and strategies need to be developed to identify specific tree species deployment targets at the landscape and forest levels.

5.3.4 Broadcast burning (HS 8)

Understory establishment following broadcast burning provides an effective tool to establish browse and berry production as well as manage fuel levels. Burning is expected to return terrestrial lichen succession to a more natural cycle than would otherwise occur. This may be an effective way to clear and restore productivity in dead non-merchantable stands, while providing post-fire habitat values.

5.4 Strategies to Mitigate the Habitat Supply Impacts of the MPB Epidemic

Table 8 - Strategies to Increase the Quantity or Quality of Future Habitat Supply in the Mackenzie TSA

Habitat Strategy	Treatments to mitigate impacts to habitat supply
HS 1	Reforesting unsalvaged areas habitat strategy (areas where no reforestation responsibility exists). This is consistent with finding the areas that the Chief Forester has recommended through policy enhanced conservation (20%). Some of these areas will benefit from prompt reforestation, benefiting both timber and environmental values Priority areas: • High value fish streams • Temperature Sensitive Streams
HS 2	Under planting in riparian areas habitat strategy. 4.2 percent of the TSA is in riparian (approximately 250,000 hectares of which perhaps 20% may contain pine (an estimated 50,000 hectares may benefit through silviculture treatments) Location of these riparian treatment area requires a Type 2/3 strategy.
HS 3	Upland under planting to speed hydrologic green-up habitat strategy • Which watersheds are most likely to benefit from prompt reforestation can be located through a Type 2/3 silviculture strategy.
HS 4	Thinning mid seral and mature forest to speed recovery of old growth structure habitat strategy • focus on non- pine leading WTPs and OGMAs
HS 5	Road rehabilitation habitat strategy • inblock roads • spurs
HS 6a	Woodland Caribou strategy *Objectives* • No salvage • No roads • Mitigate fire risk • Promote terrestrial lichen succession • Retain terrestrial lichens • Mitigate predation risk *Strategies* • Spatially plan large areas of NRLs to coincide with UWRs • Prescribed burning • Aerial direct seeding • Winter harvest • Selective herbicide use in moose habitat • Return roads to forest-producing land
HS 6b	Grizzly *Objectives* • Retain early-seral conditions *Strategies* • Clumped planting • Thin to release shrubs and forbs
HS 6c	Other selected species habitat strategies Incremental silviculture treatments can be specifically developed to speed recovery of habitat elements in short supply. • salmon • bull trout • fisher

	• northern Goshawk • marten • moose • rare plant communities
HS 7	Under planting stock- maximize diversity • Species diversity • Use clumpy stocking and vary stand density to increase diversity
HS 8	Re-introduction of understood burning to improve habitat conditions.

6 Development of Timber Resources Strategies

6.1 Opportunities to Mitigate Timber Supply Impacts due to MPB Epidemic

It is difficult to thoroughly assess the opportunities to mitigate the MPB impacts through incremental silviculture without a forest level incremental silviculture analysis (Type 2 and 3) that includes assumptions regarding the mountain pine beetle epidemic. The direction provided in the development of these timber resource strategies comes from TSR 2, which has no consideration of the mountain pine beetle epidemic and limited sensitivity analyses, the Provincial MPB model results (Year 2), and the Type 2 silviculture strategy that was completed in 2003. All other conclusions represent professional deduction through experience in forest level analyses.

Short Term (1-20 years)

Based on TSR 2 analysis results, the chief forester rationale and the subsequent AAC postponement order, the short-term harvest in the Mackenzie TSA is very robust. If anything, similar to other management units affected by the mountain pine beetle, there may be the need for an uplift to minimize the non-recovered losses. Over the next 5 years it is probable that the licensees and government will have the task of dealing with the salvage of large amounts of beetle killed pine stands. As such, there is a less of a need to try and increase the timber supply or mitigate the impacts of the MPB in the short term, as these impacts will not be generally experienced at the TSA level until the end of the short term, if then. Most timber supply impacts are not likely to be realized until the medium term in the Mackenzie TSA.

The short-term harvest levels of most management units are generally sensitive to changes in the size of the THLB and the changes in the growth and yield of existing stands. Also, in some cases the short-term timber supply can also be sensitive to uncertainties associated with integrated resource management (IRM) and visual quality objectives, mainly green-up. For the Mackenzie TSA, there is very little downward pressure sensitivity observed in TSR 2 and in fact, the short-term harvest could be increased up to 3,596,836 m^3/year for 50 years and then reduced to 3,050,000 m^3/year. This flexibility in the short-term harvest level will provide some lessening to the impact from the MPB, however it is not known how much of the short-term volume is dependent on pine volume. Theoretical net annual average volume loss associated with mountain pine beetle would be in the order of 550,000 m^3/year (Annual average loss - 3.6 million m^3 – Current AAC 3.05 million m^3) if the majority of the harvest were focused on susceptible pine stands.

Therefore, several generic opportunities are presented:

- Expand the THLB in the TSA

  It would be possible to increase the THLB in the Mackenzie TSA by extending harvesting operations to areas that are currently classified as non-harvestable including: non-commercial forest, economically inoperable, sites with low volume and productivity areas, which reduced the THLB by approximately 10% in TSR 2. While, the inclusion of these areas is not solely a silviculture issue, they do provide opportunities for increasing the THLB. Several ongoing projects: including a site index adjustment for the Mackenzie TSA and a revised assessment of economic operability should provide improved data and information for the Mackenzie TSA for the next TSR.

- Increase the growth and yield of existing stands in the TSA.

  Most pine leading stands in the TSA are currently predicted to be killed or damaged by the MPB therefore, any treatments which result in increases in the growth and yield of existing stands should initially be limited to non-pine leading forests. The productivity of these forests could be improved in the short term by late rotation fertilization treatments.

- IRM and Visual Quality Objectives

  In other management units within the province there have been allowances to relax green-up type rules to increase the short-term timber availability in certain management zones including: IRM and visual quality objectives. In TSR 2, both of these were not constraining to the short-term availability of timber and therefore is not expected to provide a measurable timber supply benefit for the Mackenzie TSA.

Medium Term (21 – 100 years)

Without a recent timber supply review for the Mackenzie TSA including the mountain pine beetle epidemic and recent definition of current management, it is difficult to accurately quantify the effect on mid-term timber supply. Experience from other pine beetle effected management units that have implemented an uplift in AAC, have shown varied mid-term timber supply effects. There is a significant amount of uncertainty associated with mountain pine beetle dynamics, management response, NRL reduction success and the resulting mid-term timber supply. While some analysis predict no change in mid-term timber supply, others have forecast an impact due to the accelerated harvest of beetle-infested timber and the mortality of those stands that will not get harvested. There is a potential for a mid-term timber supply impact in the Mackenzie TSA due to the excess of mature pine volume, relatively even flow predicted harvest level, and the estimated annual average volume loss associated with MPB (not including harvesting) of 3.6 million m^3/year.

Considering the potential for a mid-term timber supply impact, there are limited effective ways to considerably improve the mid term timber supply; if the TSA runs out of harvestable age classes and there are not enough young managed stands that would reach merchantability fast enough in any circumstances to alleviate the mid term timber supply trough.

There is a likelihood that unsalvaged areas may remain in the Mackenzie TSA after the MPB epidemic is over. While the amount of unsalvaged losses may not be as significant as predicted in other management units throughout the Northern Interior, prompt rehabilitation of these areas will be of utmost importance to mitigate against further mid term harvest reductions. Further mid-term risks include insect or disease epidemics, devastating fires or potentially poorly performing natural stands replacing the dead pine stands.

The following strategies/issues have the potential to impact the mid term timber supply in the Mackenzie TSA:

- Expand the THLB in the TSA; see the discussion under "Short Term"

- Increase the growth and yield of existing stands in the TSA; see the discussion under "Short Term"

- IRM and Visual Quality Objectives

  Visual quality objectives only cover 4% of the THLB and any changes regarding relaxing either a small negative impact or no impact on the medium term timber supply.

- Promptly rehabilitate and reforest all harvested and non-recoverable loss areas

  The medium term timber supply is dependent on the quick reforestation and survival of future managed stands. There is a risk to mid-term timber supply if a significant amount of stands remain unproductive (due to delayed reforestation on harvested sites or NRL stands or burns). Converting these stands to managed stands as soon as possible would provide a modest opportunity to increase the mid term timber supply.

- Old Forest and Biodiversity Targets

  TSR 2 showed no sensitivity in timber supply to biodiversity either using BEO (biodiversity emphasis option) with 45/45/10 – low, medium and high for all landscape units or LRMP assigned BEOs. It is also understood that biodiversity targets using natural disturbance units (NDUs) have been proposed for the Mackenzie TSA. If implemented, NDU objectives may have an impact on timber supply in the mid-term. If this occurs, there may be a need to relax the old forest targets to provide future timber supply flexibility.

- Minimum Harvest Ages

  In TSR 2, mid-term timber supply was insensitive to minimum harvest criteria. However, given the potential impacts associated with the mountain pine beetle epidemic there is a possibility that in the future, minimum harvest criteria could become limiting and at such time should be reviewed to allow for flexibility during periods of timber supply "pinch points".

Long Term (100 + years)

The long-term timber supply in the Mackenzie TSA is likely to be unaffected significantly by the MPB epidemic. Nonetheless, there are opportunities to increase the long-term timber supply in the Mackenzie TSA by expanding the THLB and increasing the regenerated stand volumes.

- Expand the THLB in the TSA; see the discussion under "Short Term"

- Increase regenerated stands volumes

  Regenerated stand volumes can be increased by using genetically improved stock and by repeat fertilizing of regenerated stands.

6.2 Objectives of the Mackenzie TSA SIS Strategy

Considering the general strategy information details and summary information regarding the Mackenzie described above, the objectives of this silviculture strategy are:

- Mitigate the effects of the MPB epidemic on the timber supply through the implementation of incremental silviculture and NRL treatments,

- Manage the fire risk to timber supply caused by the MPB epidemic,

- Initiate a Review of Basic Silviculture Practices in the Context of the MPB Epidemic and Future risks of Pests and Diseases, and

- Keep all options open for the future.

6.2.1 Mitigate the effects of the MPB epidemic on the timber supply

Broad strategies:

- Prompt rehabilitation of NRL areas
- Increase the growth and yield of existing non-pine leading stands
- Increase the growth and yield of existing managed stands

The primary goal of this project is to develop incremental silviculture strategies that will help mitigate the effects of the MPB epidemic on the timber (and habitat) supply for the Mackenzie TSA. Therefore, the over riding objective in this strategy is to rehabilitate large areas of unsalvaged beetle killed stands and cost effectively increase the production of fibre on the THLB in a way that ensures that timber quality attributes such as log form, wood density, knot size/frequency etc. are not compromised.

6.2.2 Manage the fire risk to timber supply caused by the MPB epidemic

Broad strategies:

- Prompt rehabilitation of NRL areas
- Prescribed burning
- Fire breaks, general planning considering fire risk

As discussed previously in this report, large fires pose a risk to the remaining mature forest, current and future silviculture investments, and communities within the Mackenzie TSA. Prompt rehabilitation of NRL areas will reduce the fire risk and along with additional tools such as prescribed burning and general fire risk planning considerations would be beneficial from a fibre supply protection perspective.

6.2.3 Review Basic Silviculture Practices in the Context of the MPB Epidemic and Future risks of Pests and Diseases

Broad strategies:

- Planting/regeneration densities, and
- Species composition.

Given the magnitude of the MPB epidemic and the challenges facing the Mackenzie TSA timber supply, basic silviculture strategies need to be reviewed. The emphasis on the review should be in reducing the risk of future disease or pest epidemics. Initial stocking densities and species composition are important attributes in this context, as they determine the growing stock to fill the mid term timber supply needs and provide for future intensive silviculture treatment and intermediate harvest opportunities as well. Adequate and diverse growing stock will buffer against pests and diseases.

6.2.4 Keep options open for the future

Broad strategies:

- Planting/regeneration densities
- Species composition
- Density control
- Fertilization

This silviculture strategy promotes the notion of keeping options open for the future. This notion applies to basic silviculture practices by promoting diversity within and between stands through regeneration densities and species composition. This will create a diverse wood basket and help buffer against future epidemics and fires.

Future markets for forest products are unknown. There is a trend for the utilization of smaller piece sizes, which is likely to continue or increase given the forecasted shortage of timber in the medium term. This strategy does not promote the production of volume at the expense of piece size; however, it encourages maintaining options for both piece size and biomass. This can be accomplished by ensuring adequate and diverse stocking and limiting density control to commercial thinning treatments, should the need arise later in the rotation.

Late rotational treatments are generally more justified financially than treatments in the earlier years of a stand since the revenue is realized from the stand much sooner. This holds true particularly for density management and fertilization treatments. Therefore, the concept of keeping options open is likely both a conservative and fiscally prudent approach to forest management, given the current pest and fire risks and the overall lack of financial resources.

6.2.5 Quality Considerations

Past silviculture strategies have often defined quality as the amount of premium logs and sawlogs within the future timber supply. In this strategy the focus is not on producing large sawlogs or premium logs, rather it is in producing a high quality timber supply – buffered from pests and fires through diversity - that can potentially provide products to different industries, such as sawmilling, pulp and paper, composite wood products, pellets etc.

The quality in the context of this strategy is broadly based on inherent wood properties, such as specific gravity, knots sizes, fibre length, stiffness etc. This may require in some circumstances higher planting densities especially in lodgepole pine plantations where natural ingress is limiting.

6.3 Analysis of Potential Silviculture (Timber) Strategies

The following basic and intensive treatment strategies were presented to the stakeholder group at the Mackenzie workshop:

- Basic silviculture strategies: planting vs. natural regeneration
- Basic silviculture strategies: initial planting densities
- Genetically improved seed
- NRL Reforestation Strategies
- Fertilization

- Density Management

The presentation of these strategies, using TIPSY 3.2 stand level modeling results and financial analysis, was intended to stimulate the discussion and review of a number of key concepts in basic and intensive silviculture planning. This was done in the context of the MPB epidemic and its impact on timber supply.

6.3.1 Identified Timber Strategies

The Mackenzie stakeholders were asked to provide the consultants with additional strategies and opportunities for review and discussion. These included:

- Cone collections
- Use of the NIFR "Red / Green " maps (DeLong) in silviculture and NRL planning
- Repressed stands
- Shelf life studies

Near the conclusion of the workshop the participants were asked to rank and provide the consultants with direction on the numerous strategies. Of the compiled list the following are the agreed upon preferred silviculture strategies:

1. NRL Reforestation Strategy
2. Backlog Strategy
3. Fertilization Strategy
4. Basic Silviculture Strategies
5. Repressed Stand Strategies

6.3.1.1 NRL Reforestation Strategy

Due to the many uncertainties surrounding the extent of NRLs, the effectiveness of natural reforestation in these areas, and the challenges of implementing treatments to artificially reforest or protect these areas, the stakeholder group felt that further study and strategic planning was required before large-scale reforestation can be initiated.

Given the current focus on salvaging dead pine stands using overlapping volume based tenures, the stakeholder group acknowledged that the first key challenge was to spatially identify NRL stands early enough to allow for effective planning and treatment. As a possible solution the group felt that this necessitates the strategic review of potential TSA NRLs. This review should be lead by the MOFR.

The workshop presented both stand level modeling and financial analysis of a handful of basic reforestation strategies for NRLs including natural regeneration (with extended regeneration delays and low, patchy stocking), planting and burning to promote natural regeneration of pine. Given the uncertainty surrounding the extent of NRL areas and the limited financial resources available, reforestation efforts should focus on the most valued and unconstrained sites, and those that have the ability to contribute positively to the future timber supply. It was generally felt that the reforestation efforts should be cost and safety conscious, and effective.

The NRL areas will have a great impact on the future timber supply in the TSA. Therefore, the prompt salvage, site preparation and reforestation of these sites should be considered the primary objectives of this strategy. This will require not only creative silviculture planning, but also innovative forest planning on the part of government. For instance, appraisal, forest protection, and environmental (i.e. burning and air quality) policies may have to be revisited in order to achieve consistency in meeting NRL rehabilitation objectives.

The development and implementation of a TSA- wide ***NRL Reforestation Strategy*** should be in concert with other higher- level planning objectives and in consideration of existing licensee's harvesting rights. The strategy should also include:

- a review of actual and expected natural infill by ecosystem,
- a review of potential NRL treatment strategies considering biological and economic feasibility and safety factors,
- an analysis of seed needs to support potential artificial reforestation efforts
- fire protection strategies,
- non - pine species retention strategies,
- development of a decision matrix for use in field assessments of NRLs,
- and strategies for the surveying of immature pine stands in order to determine MPB impacts levels and the degree of other health factors.

6.3.1.2 Backlog Strategy

The futures of the numerous backlog stands were discussed at the workshop. It was indicated that the district had recently completed a large backlog survey project and that the results had yet to be reviewed and recorded. The intention of the survey program was to facilitate the reclassification of backlog sites. This is the preferred way to deal with backlog NSR and impeded stands. However, participants stated that if opportunities for cost effective reforestation and brushing were identified then treatment of these stands could be justified.

6.3.1.3 Fertilization Strategy

Forest fertilization (both aerial and manual application techniques) appears to be one of the few intensive silviculture treatment options that will provide short to mid term timber supply benefits and it is (marginally) financially justified. By temporarily increasing the site productivity of the stand, an increase in the periodic volume increment in the stand can be realized. The cumulative growth response to fertilizer can reduce both the biological and economical ages to rotation. Periodic fertilizer applications can sustain this incremental volume gain over an extended period of time.

Until the current MPB epidemic subsides, there will not be fertilization treatments of pine-leading stands in the TSA. As a result, spruce- leading stands are the only candidates for fertilization treatment. Spruce has been demonstrated to response favorably to nitrogen fertilizer in the interior of BC under the right conditions. For example according to TIPSY 3.2, the predicted volume gain for a 29-year-old site index 20 m white spruce stand is 18% over 10 years. Both the mature (e.g. 60-80 years of age) and immature spruce stands (e.g. 20-60 years of age) are candidates for fertilization.

The following stand selection criteria are currently being used to identify candidate stands for fertilization:

Table 9 – Stand selection guide for forest fertilization – MOFR 2005

Stand selection guide for forest fertilization – 2005

Consider a stand's site conditions, health, biodiversity and potential for integrated resource management in the selection process. Stand level activities should be consistent with forest level objectives. Evaluate candidate stands according to biological factors. Those stands that are biologically acceptable should then be checked for operational feasibility to ensure they can indeed be treated and are suitable for treatment.

Species preference: Douglas-fir and spruce.

Age preference:	Age	Priority
	40-79	1
	15-39	2

Site index:
Douglas-fir responds on all sites.
Spruce, select sites with SI in the range from 15 to 24. Avoid sites poorer than SI =15 or SI greater than 24.

The live crown of the crop trees is greater than 30%, to utilize the added nutrients. This may be dominant and co-dominant trees or a spaced or thinned stand.

There should be room for crowns to expand, and the stand should be fully stocked.

The height/diameter breast height (dbh) ratio for Douglas-fir should be less than 85. Avoid fertilizing conifer stands with a height/dbh ratio greater than 100.

The following four operational factors should be considered during the evaluation of candidate stands.

Location: Choose sites closest to communities as distance to haul the fertilizer affects transportation costs. Also, costs of future harvests are partly determined by hauling distances to manufacturing plants and markets.

Access: Conditions of access also affect costs of transporting material and personnel in fertilizer operations, in addition to later expenses of hauling timber to manufacturing plants. Avoid areas, which require ferry flights longer than 2km.

Slope: Costs of future management and harvesting usually increase as terrain becomes steeper.

Furthermore, flying over steep or irregular, contoured land may not be conducive to efficient and uniform aerial distribution of fertilizer.

Project and Block Size: Project and block sizes affect efficiency and cost of operation. Large-scale programs (e.g., >300 ha) are generally more cost effective than small-scale.

Based on a brief review of these criteria, the TSA group indicated that there is only limited area of pure mature spruce- leading stands in the TSA suitable for fertilization. They also questioned whether there would be value in treating these stands for short-term volume gains when the major timber supply deficit is forecasted in the mid- term.

The participants concluded that there would be a larger opportunity to treat younger managed spruce- leading stands. However, limited concern was raised over the spruce leader weevil (Pissodes strobe (Peck)) and its behavior in fertilized stands. Despite the recent research completed by Brockley (et al, 2005) showing that the fertilizer induced height increment out weighs the negative impacts of the weevil, some in the participants continue to have reservations over an implementation of a large scale fertilization program in the TSA until conclusive results are found. Therefore, these concerned foresters would like to see a more conservative approach in scheduling of treatments for these young stands.

The recommendation from the workshop was to produce a *fertilization strategy* prior to the implementation of a TSA wide operational fertilization program. This strategy would identify and rank candidate stands for treatment priority. Consideration of stand and ecological attributes, identification of integrated resource management constraints, and operational/logistical constraints are required to identify the candidate treatment areas and to develop a fertilization program. Finally, the fertilization strategy would support ongoing screening trails to better document fertilizer responses in the TSA forests.

6.3.1.4 Basic Silviculture Strategies

The objective of reforestation is the timely establishment of crop trees using either artificial or natural means (or a combination of both). By rapidly occupying a site with a sufficient number of trees, the maximum productivity of the site can be realized. Also, maintaining a sufficient level of growing stock through rotation helps to ensure that favored stand quality attributes are available in sufficient volumes. Above all, the establishment and maintenance of sufficient stocking provides mitigation against pests, disease, and fire risks.

Planting or a reduction in regeneration delay will tend to decrease economic or biological rotations. This is an important consideration in the context of a declining timber supply. Artificial regeneration may also allow the utilization of improved seed, therefore the realization of theoretical incremental volume gains.

Planting can target the preferred microsites. It can also help the site to become fully occupied with crop trees. These opportunities may be lost through increased reliance on natural regeneration.

Financial analyses (e.g. NPV) of basic reforestation options typically show that where possible, the use of (free) natural regeneration is the often the best financial decision. However, a typical NPV analysis does not consider the risks of reforestation failures and related opportunity costs.

Because of increasing disease incidence in young stands, particularly pine stands; the workshop participants suggested that stocking standards should be reviewed in the TSA. This review would identify those sites where natural regeneration is deemed unreliable and propose higher stocking levels.

6.3.1.5 Repressed Pine Strategy

The management of repressed stands was raised at the workshop. There appears to be uncertainty as to whether or not these stands are being impacted by the MPB. If so, then these stands could be considered within an overall NRL Reforestation Strategy. It, however, was felt by the group that rehabilitation treatments in these stands, if considered, would be a low priority.

6.4 Strategies to Increase the Quality and Quantity of Future Timber Supply

Table 10 - Intensive Strategies to Increase the Quality and Quantity of the Future Timber Supply in the Mackenzie TSA

<table>
<tr><td>Short-term:</td><td>Fertilize mature spruce- leading stands to generate short-term volume gains and larger log sizes.
• Aerial
• Manual (for small areas with good access)

Fertilization operations should follow a comprehensive TSA Fertilization Strategy (which would include mature and young spruce stands)
This strategy would:
• develop localized candidate stand and site criteria,
• review the THLB and inventory for opportunity areas in consideration of other resource values and non- timber constraints,
• make recommendations for monitoring studies</td></tr>
<tr><td>Mid-term:</td><td>Fertilize immature spruce- leading stands
• Aerial
• Manual

• Target stands according to the TSA Fertilization Strategy
• Repeated stand treatments should be considered
• Pine-leading stands should be incorporated in the ongoing review of candidate stands for treatment once the MPB epidemic subsides

Non- Recoverable Losses Reforestation Strategy
Develop and implement a TSA- wide NRL Reforestation Strategy in concert with higher level planning objectives and in consideration existing licensee's harvesting rights. The strategy should also include:

• a review of actual and expected natural infill by ecosystem
• a review of potential NRL treatment strategies considering biological, economic, feasibility and safety factors
• an analysis of seed needs to support potential artificial reforestation efforts
• fire protection strategies
• non- pine species retention strategies
• development of a decision matrix for use in field assessment of NRL's
• strategies for the surveying of immature pine stands in order to determine MPB impacts levels and the degree of other health factors

Note: as an interim measure, the reforestation of NRLs in immature stands could be addressed.

Backlog- NSR treatments
• complete the TSA backlog survey program.
• determine treatment priorities or reclassification options (reassign new yield curve)

Backlog- Impeded Stand treatments
• Evaluate sites to determine treatment priorities or reclassification options</td></tr>
</table>

	Repressed pine sites Evaluate sites to determine treatment priorities or reclassification options. Treat high priority areas.

Table 11 - Basic Strategies to Increase the Quality and Quantity of the Future Timber Supply in the Mackenzie TSA

Mid-term:	Revisit stocking standards for those sites where natural regeneration is deemed unreliable or where there is traditionally a higher disease incidence. • Review target/ minimum stocking requirements • Review preferred and acceptable species requirements Establish a diversity of tree species where ecologically feasible in order to attain full site occupancy and to buffer against future pest and disease losses When planting utilize improved seed, when available, to benefit from increased yields.

7 Five Year Incremental Forestry Program

This section outlines and summarizes potential treatment areas (Table 12), resulting budgets (**Table 13**) and job outcomes (**Table 14**) for the Mackenzie TSA incremental silviculture program.

Table 12 - Proposed Treatment Areas

Activity	Priority	Year 1 ha	Year 2 ha	Year 3 ha	Year 4 ha	Year 5 ha	Totals ha
NRL Reforestation Strategy (HS1 and HS3)	**A**	100,000	0	0	0	0	0
NRL Reforestation-immature	**A**	0	2,000	2,000	2,000	2,000	8,000
TSA Fertilization Strategy	**A**	50,000	0	0	0	0	0
Backlog Surveys-reclassification or treatment scheduling	**A**	200	200	200	200	200	1,000
Riparian underplanting*	A	80	200	200	200	200	800
Caribou winter range*	A	200	500	500	500	500	2,000
Backlog-Impeded treatments	**B**	200	200	200	200	200	1,000
Backlog -NSR treatments	**B**	50	50	50	50	50	250
Fertilize-immature spruce	**B**	2,000	5,000	5,000	5,000	5,000	22,000
Fertilize- mature spruce	**C**	0	500	0	0	0	500
Repressed stand Surveys	**C**	0	0	0	0	0	0
Repressed stand Treatments	**C**	0	0	0	0	0	0
Total		2,450	8,650	8,150	8,150	8,150	35,550

*** these activities were not prioritized during the Mackenzie TSA workshop and were provided afterwards by MOE. They represent proposed treatment options for habitat supply, which should be assessed in relation to all potential treatments and benefits.**

Priority: A = high, B = medium, C = low

Table 13 - Proposed Budget

Activity	Priority	Year 1 $	Year 2 $	Year 3 $	Year 4 $	Year 5 $	Totals $
NRL Reforestation Strategy (HS 1 and HS 3)	A	100,000	0	0	0	0	**100,000**
NRL Reforestation-immature	A	0	2,400,000	2,400,000	2,400,000	2,400,000	**9,600,000**
TSA Fertilization Strategy	A	50,000	0	0	0	0	**50,000**
Backlog Surveys-reclassification or treatment scheduling	A	6,000	6,000	6,000	6,000	6,000	**30,000**
Riparian underplanting*	A	40,000	100,000	100,000	100,000	100,000	**440,000**
Caribou winter range*	A	40,000	100,000	100,000	100,000	100,000	**440,000**
Backlog-Impeded treatments	B	165,000	165,000	165,000	165,000	165,000	**825,000**
Backlog -NSR treatments	B	45,000	45,000	45,000	45,000	45,000	**225,000**
Fertilize-immature spruce	B	850,000	2,125,000	2,125,000	2,125,000	2,125,000	**9,350,000**
Fertilize- mature spruce	C	0	212,500	0	0	0	**212,500**
Repressed stand Surveys	C	0	0	0	0	0	**0**
Repressed stand Treatments	C	0	0	0	0	0	**0**
Totals $		**1,296,000**	**5,153,500**	**4,941,000**	**4,941,000**	**4,941,000**	**21,272,500**

*** these activities were not prioritized during the Mackenzie TSA workshop and were provided afterwards by MOE. They represent proposed treatment options for habitat supply, which should be assessed in relation to all potential treatments and benefits.**

Priority: A = high, B = medium, C = low

Table 14 - Job Outcomes

Activity	**Priority**	**Year 1 Person Days**	**Year 2 Person Days**	**Year 3 Person Days**	**Year 4 Person Days**	**Year 5 Person Days**	**Total Person Days**
NRL Reforestation Strategy	A	200	0	0	0	0	200
TSA Fertilization Strategy	A	100	0	0	0	0	100
Backlog Surveys- reclassification or treatment scheduling	A	30	30	30	30	30	150
Riparian underplanting	A	80	330	330	330	330	1400
Caribou winter range	A	80	330	330	330	330	1400
Backlog- Impeded treatments	B	500	500	500	500	500	2,500
Backlog -NSR treatments	B	100	100	100	100	100	500
Fertilize- immature spruce	B	200	500	500	500	500	2,200
Fertilize- mature spruce	C	0	50	0	0	0	50
Repressed stand Surveys	C	0	0	0	0	0	0
Repressed stand Treatments	C	0	0	0	0	0	0
Totals (person days)		**1,290**	**1,840**	**1,790**	**1,790**	**1,790**	**8,500**

*** these activities were not prioritized during the Mackenzie TSA workshop and were provided afterwards by MOE. They represent proposed treatment options for habitat supply, which should be assessed in relation to all potential treatments and benefits.**

Priority: A = high, B = medium, C = low

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Appendices

Coniferous Log Values Used in the Stand-level Analysis for Mackenzie Type 1 SIS Update (Nov 2005)

The following tables present 'Base', 'Steep' and 'Flat' log prices for SPF used in the analysis. Prices are FOB at the mill. 'Base' prices approximately represent the average current prices. 'Steep' prices assume future higher premiums for larger logs. 'Flat' prices assume less than current premiums for larger logs.

Table 15 – Coniferous log values used at workshops

SPF		Peeler/ House log	S/L	Pulp
Set 1	**Base**	$70	$45	$28
Set 2	**Steep**	$90	$45	$28
Set 3	**Flat**	$50	$45	$28

Silviculture Treatment Costs and Employment Assumptions

Table 16 – Treatment costs and employment assumptions.

Silviculture Treatment	Cost ($) Low		Cost ($) Base		Cost ($) High		Employment (days/ha)
	$/ha	$/unit	$/ha	$/unit	$/ha	$/unit	
Surveys (Regen and FTG)	80	-	120	-	160	-	0.2 to 0.4
Site Preparation		-		-		-	1 to 2.3
Drag (for natural regen.)	150		175		200		
Burning (for natural regen. Low and base are for slashburning. High is for burning NRL's)	400		700		1000		
Mounding and Disc Trenching (for planting)	300		500		700		
Chemical (for planting)	275		400		600		
Planting (per tree including seedlings and planting; low = low genetic worth seed with prep. med= low genetic worth seed with no prep., high= high genetic worth seed with no prep.)		0.44		0.54		0.56	1 to 2
Planting of NRL's		0.54		1.00		1.40	1 to 2
Fill Planting (including seedlings)	400	-	600	-	700	-	1 to 2
Brushing (Low is for chemical- aerial, base is for chemical-ground, high is for manual)	350	-	450	-	650	-	1 to 2.5
Aerial Fertilization (costs per treatment)	250	-	375	-	450	-	0.1
Manual Fertilization (costs per treatment)	250	-	375	-	450	-	1 to 1.5
Juvenile Spacing	400		600		800		1 to 2