



Final Report

Mackenzie TSA Type 2 Incremental Silviculture Analysis

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Executive Summary

For the Mackenzie Type 2 Incremental Silviculture Analysis, a total of seven learning scenarios were applied. Five scenarios met the objective of increasing timber supply: partial harvest within visually sensitive areas; late rotation fertilization on pine leading stands; repeat fertilization on pine leading stands; repeat fertilization on pine and spruce leading stands; and planting of genetically improved stock (genetic worth) on spruce and pine. In addition, an aspatial base case and a spatial base case were used as the benchmark for the learning and decision scenarios.

The decision scenarios combined late fertilization, repeat fertilization on pine and spruce as well as planting of genetically improved stock. Two decision scenarios were prepared: one where 100% of the candidate fertilization and genetic worth area was treated (decision scenario 1) and the second where 50% of the candidate fertilization and genetic worth area was treated (decision scenario 2).

Two alternative scenarios were also prepared to evaluate the impacts of different harvest flow objectives. Alternative 1 applied an even flow harvest flow objective, and alternative 2 applied a maximum short term harvest flow objective.

When each scenario was assessed individually and compared to the spatial base case, partially harvesting in VQO zones provided a 0.5% increase in timber supply in the long term; late fertilization provided a 4.2% increase in timber supply in the short to mid term; repeat fertilization of pine provided a 1.3% increase in the short and mid term and a 5.1% increase in the long term. Repeat fertilization of pine and spruce provided a 2.5% increase in the short to mid term and a 6.4% increase in the long term. Planting of genetically improved stock increased the long term timber supply by 6.6%.

Depending on the importance of gain on investment, employment, or short and long term harvest levels different decision or alternative scenarios best meet those values.

If balancing the needs for short term harvest, return on investment, employment opportunities while maintaining the highest long term harvest level, then decision scenario 1 (100% of the candidate area is treated with a harvest flow objective of increasing short term harvest flow, while allowing two or three declines to the long term harvest level) provides the most reasonable balance of the options available. Short term harvest flow is 28% higher than spatial base case and the long term harvest level is 17% higher than base case. The cost of investment is \$7/m³ and 73 full time jobs are created in the first five years. The decline to the long term harvest level is alleviated as the harvest flow can be maintained for a few decades prior the next decline, allowing the community to adjust to the employment losses.

If maximizing short term harvest, return on investment and short term employment opportunities while maintaining the highest long term harvest level, then alternative 2 (treating 100% of the candidate area with a harvest flow objective to maximize short term harvest flow) provides the greatest return on investment in the first 20 years of the planning horizon. Short term harvest flow is 53% higher than spatial base case, the cost of investment is \$3/m³ and 85 full time jobs per year are created over the first five years.

Prior to application of incremental silviculture activities, two uncertainties should be examined:

- volume gains associated with late fertilization on good, medium and poor sites; and
- volume gains associated with repeat fertilization on good and poor sites for pine, and good, medium and poor sites for spruce.

In addition, the following opportunities can be evaluated:

- concentration of incremental silviculture activities on the land base where multiple treatments apply;
- increase area treated on poor sites;
- incorporate haul distances to the manufacturing facility in the treatment cost;
- apply patch size targets; and
- implement road scheduling or harvest priority scheduling to more accurately represent operationally realistic harvest locations in the first 20 years.

1.0 Introduction

Evaluating the options for management of incremental silviculture opportunities is a challenging process, with many different options for increasing timber volume and wood quality being available. However, choosing the most cost-effective approach with the highest volume or quality gains in the short, medium and long term is more complex.

The BC Ministry of Forests has provided direction regarding the best use of resource dollars on incremental silviculture through the *Incremental Silviculture Strategy for British Columbia (Interim)*. This report recommends two types of silviculture analyses be completed: Type 1 - a short term strategy for the next five years and Type 2 - a longer term strategy that assesses the benefits of incremental silviculture on the short, medium and long term timber supply.

This Type 2 analysis evaluates the impact of incremental silviculture activities on the short, medium and long term timber supply of the Mackenzie Timber Supply Area.

2.0 Mackenzie Timber Supply Area

A considerable amount of the information contained in the following sections has been extracted from the Mackenzie Land and Resource Management Plan (LRMP, 2000) and the Mackenzie Timber Supply Review (TSR) Analysis Report (2001). These sections include: Area Description, Biophysical Description; Population and Communities; First Nations; and Social and Economic Description.

2.1. Area Description

The Mackenzie Timber Supply Area (TSA) is located entirely within the Mackenzie Forest District in northern interior British Columbia and covers approximately six million hectares. The Mackenzie TSA is one of thirteen TSAs in the Northern Interior Forest Region and is administered by the British Columbia Forest Service (BCFS) Mackenzie Forest District office located in Mackenzie.

The Mackenzie TSA is bounded by the Prince George TSA on the south and west, the Cassiar and Fort Nelson TSAs in the north and the Fort St. John and Dawson Creek TSAs in the east (*Illustration 1*).

The main features of the Mackenzie TSA are Williston Lake (a narrow 360 kilometre long man-made lake), the Rocky Mountain Trench, and the Rocky Mountains. Despite having diverse mountainous terrain and river valleys, the forests of the Mackenzie TSA are fairly homogeneous. The primary tree species are lodgepole pine and spruce, but forests are also comprised of subalpine fir, and several deciduous species. Cold temperatures dominate the climate in the TSA, with average daily temperatures below freezing for half of the year. Three-quarters of the annual precipitation falls as snow.



Illustration 1. Location of the Mackenzie TSA

2.2. Biophysical Description

There are five biogeoclimatic zones, making up 17 different biogeoclimatic variants within the Mackenzie TSA. After initiation of this analysis, the BC Ministry of Forests provided new biogeoclimatic mapping that identifies 22 different biogeoclimatic variants. This new map has not been incorporated into the analysis.

Based on the original mapping, the following biogeoclimatic zones and variants occur in the Mackenzie TSA.

- Boreal White and Black Spruce (BWBS) zone occurs at lower elevations in valleys mainly in the northern and western portion of the TSA, up to 1,300 metres. The BWBS is characterized by long, very cold winters and short growing seasons. The main tree species are white spruce, lodgepole pine and trembling aspen. Black spruce, balsam poplar, subalpine fir and birch also occur. The BWBS variants are: BWBSdk1, BWBS mw1, BWBSwk1 and BWBSwk2.
- Sub-Boreal Spruce (SBS) zone adjoins the BWBS zone, occurring from valley bottoms to about 1300 metres mainly in the southern portion of the TSA. The climate of this zone is characterized by severe, snowy winters and relatively warm, moist and short summers. Hybrid white spruce and subalpine fir are dominant climax tree species, while lodgepole pine, aspen and birch are often found as early seral species. The SBS variants are: SBSmk1, SBSmk2, SBSvk, SBSvk1 and SBSwk2.
- Spruce Willow Birch (SWB) zone is the most northerly subalpine zone in British Columbia and has the harshest climate of all forested zones in the province. Winters are long and cold, and summers are brief and cool. The SWB is located at middle elevations of the Rocky and Omineca mountains in the northern part of the TSA, above the BWBS zone. At lower elevations of this zone, the dominant species are white spruce and subalpine fir, with black spruce, lodgepole pine and trembling aspen also occurring. Upper elevations of this zone are dominated by subalpine fir with a minor component of black spruce, lodgepole pine and aspen. The only SWB variant is SWBmk.
- Engelmann Spruce–Subalpine Fir (ESSF) zone is the uppermost forested zone in much of the TSA, typically occurring above the SBS zone and the more southerly portion of the BWBS zone and below the Alpine Tundra zone. The ESSF has a relatively cold, moist and snowy continental climate. Growing seasons are cool and short, while winters are long and cold. Engelmann spruce and subalpine fir are the dominant climax tree species, while lodgepole pine is common after fires. The ESSF variants are: ESSFmc, ESSFmv2, ESSFmv3, ESSmv4 and ESSFwk2.
- Alpine Tundra (AT) zone occurs extensively at high elevations above the ESSF zones, occupying about one-third of the TSA. The climate is cold, windy and snowy with a short, cool growing season. By definition this zone is treeless and vegetation is dominated by shrubs, herbs, mosses and lichens. Much of the alpine landscape lack vegetation and is the domain of rock, ice and snow. The AT variant is ATp.

These biogeoclimatic variants are amalgamated into natural disturbance types (NDTs). Natural disturbance types describe how often forests die naturally and are replaced with new forest (called stand replacing events).

There are three natural disturbance types in the TSA: NDT 1 where stand replacing events are rare; NDT 2 where stand replacing events are infrequent; NDT 3 where stand replacing events are frequent and NDT 5 which includes Alpine and sub-alpine parkland.

The following table shows the relationship between the biogeoclimatic variants and natural disturbance types.

Table 1. Biogeoclimatic Variant by Natural Disturbance Type

Natural Disturbance Type	Biogeoclimatic Variants
1	ESSFwk2
2	ESSFmc, ESSFmv2, ESSFmv3, ESSFmv4, SBSvk, SBSwk2, SWBmk
3	BWBSdk1, BWBSmw1, BWBSwk1, BWBSwk2, SBSmk1, SBSmk2, SBSwk1
5	ATp

2.3. Population and Communities

As of 1996, the total population of the Mackenzie TSA was estimated at 6,360 people. The health of the forest industry is the major factor affecting changes in population, as increases or decreases generally correlate with growth or decline in forestry activities. Of the estimated total population in the TSA, 5,997 people or 94% reside in the community of Mackenzie. Other main population centres are the communities of Germansen Landing, Manson Creek, Fort Ware and Tsay Keh Dene.

The town of Mackenzie is located at the south end of the TSA, on the southeast end of Williston Lake, 30 kilometres north of Highway 97 and roughly 180 kilometres north of Prince George. The town of Mackenzie offers a number of services and amenities including recreation facilities, a hospital, access to college/university courses, and accommodation and meeting facilities. Other services available include finance, insurance, real estate, professional and retail services.

The communities of Germansen Landing and Manson Creek are located approximately 205 kilometres by road north of Fort St. James and 200 kilometres northwest of the town of Mackenzie, and have a collective permanent population estimated at 76 persons. The communities have a history rooted in mining, and along with present day placer gold operations, they serve a growing tourism industry (guide outfitting, general store, cabins) and several small farming operations.

2.4. First Nations

A number of First Nations Bands and/or their traditional territories reside within the Mackenzie TSA including: the Tsay Keh Dene (formerly known as the Ingenika Band); Kwadacha Band (formerly Fort Ware Band) of the Kaska Dena Council; Takla Lake Band and Nak'azdli Band of the Carrier Sekani Tribal Council which both have members within the Noostel Keyoh located near Germansen Landing, and the McLeod Lake Band. Two groups, the Kwadacha Band and Tsay Keh Dene Band, have communities located inside the TSA and members of the Noostel Keyoh reside in and around the communities of Germansen Landing and Manson Creek. The Gitksan and Wet'suwet'en Nations and members of the Treaty 8 Tribal Council (West Moberly) also claim portions of the TSA as traditional territory.

2.5. Social and Economic Description

The Mackenzie TSA is the most forest sector-dependent area in the province of British Columbia. As of 1996 (the most recent analysis available) the forestry sector was the largest single source of employment and employment income, accounting for about 65% of the employment and 71% of the income in the TSA. The timber industry in the TSA contributes significantly to provincial revenues. In total, timber

generates approximately \$105 million of government revenue annually from stumpage, as well as federal and provincial taxes out of the current Allowable Annual Cut (AAC) of three million cubic metres per year (m^3/yr).

Review of TSA employment figures between 1997 and 1999 show that 2,124 person years of employment are produced by the forest industry. Of this, 268 result from harvesting, 24 from silviculture, 1,266 from processing and the remainder 566 from indirect and induced employment.

The current AAC for the Mackenzie TSA, set in 2001, is 3,050,000 m^3/yr . The harvest level is apportioned largely to Slocan Forest Products Ltd. and Abitibi Consolidated Company of Canada. Other parties of smaller scale are the British Columbia Timber Sales Program, Tsay Keh Dene First Nation, and Akie Gataga Forest Ltd.

Abitibi Consolidated has a processing complex of two sawmills with a combined capacity of approximately 1.2 million m^3/yr , a pulp mill and a newsprint mill. Pope and Talbot operate a second pulp mill. Two sawmills with a combined capacity of 1.3 million m^3/yr are operated by Slocan Forest Products Ltd. There are also several re-manufacturing plants associated with these mills: M&T and East Fraser.

3.0 Provincial Silviculture Strategy

In 1999, the BC Ministry of Forests released the report *Incremental Silviculture Strategy for British Columbia (Interim)*. This strategy provides guidance to the application of available funds for incremental silviculture activities and provides context for the development of management unit strategies, stand level analyses and Forest Renewal BC required resource management plans (now funded under the Forest Investment Account).

Management unit strategies are designed to prioritize short, medium and long-term silviculture options to address identified issues and objectives.

There are two types of management unit strategies: **Type 1** and **Type 2**.

Type 1 strategies use existing TSR summary information to identify issues and opportunities for silviculture investment in a workshop environment. Once issues and opportunities have been identified and described as objectives, specific silviculture management regimes are assessed to determine feasibility towards meeting the objectives. These management regimes are ranked by the participants and form the basis for the Type 1 analysis.

Type 2 strategies use readily available information as well as forest level modelling to assess implications of the Type 1 silviculture management regimes on short, medium and long term timber supply, as well as short term employment and cost implications.

3.1. Type 1 Analysis

The following information is an excerpt from Sections 3 and 5 of the *Mackenzie TSA Silviculture Strategy (Type 1)*, February 1999.

Table 2 outlines the silviculture strategies identified in 1999.

Table 2. (Table 3-1 from Mackenzie TSA Silviculture Strategy, Type 1) Silviculture Strategies, Targets and Activities Identified in the Workshop as Feasible and Desirable for the Mackenzie TSA

ID	Strategy	Target	Activities
S1	Increase volumes of existing stands	Pl (25% G, M, 25% P) late rotation – harvest in decade 2	Fertilize
M1	Increase volumes of regenerating stands	Pl (25%, M, 25% P)	Fertilize: four applications at 15, 30, 45 and 60 years
M3b	Reduce green-up ages	Pre-87 repressed Pl	Space
L1	Maintain timber harvesting land base	Understocked pre-87 logging – origin stands	1 - fill plant 2 - brush and weed
L3	Increase volumes of regenerating stands	Pl, S	1 - improved seed 2 - fertilize: four applications at 15, 30, 45 and 60 years
Q1	Ensure clear timber	Pl	Prune two lifts
H1	Recruit/modify Pl lichen habitat (caribou)	Pl burns	Recruit

ID	Strategy	Target	Activities
H2	Recruit Pl lichen habitat	Timber harvesting land base	Survey Recruit
H3	Grizzly bear habitat	Disturbed habitat	Space

Note: (25%G, M 25%P refers to the site ranges including the lower 25% of good sites, all medium sites, and the upper 25% of poor sites).

"The ID of each strategy in Table 3-1 conveys the expected time of timber supply response (S-short term, M-medium term, and L-long term), or whether the strategy is timber quality oriented (Q), designed to address forest health (FH) or habitat (H) issues.

Figure 3-1 illustrates the timber supply responses of strategies selected in Table 3-1. Strategies S1, M1, M2 and L3 increase the existing and regenerating timber yields through fertilization. L1 ensures that the timber harvesting land base is not reduced in size by fill planting and brushing and weeding the understocked pre-87 logging-origin stands. M3b reduces green-up ages by spacing underperforming Pl."

Figure 3-1. Location of timber supply effects of the selected strategies.

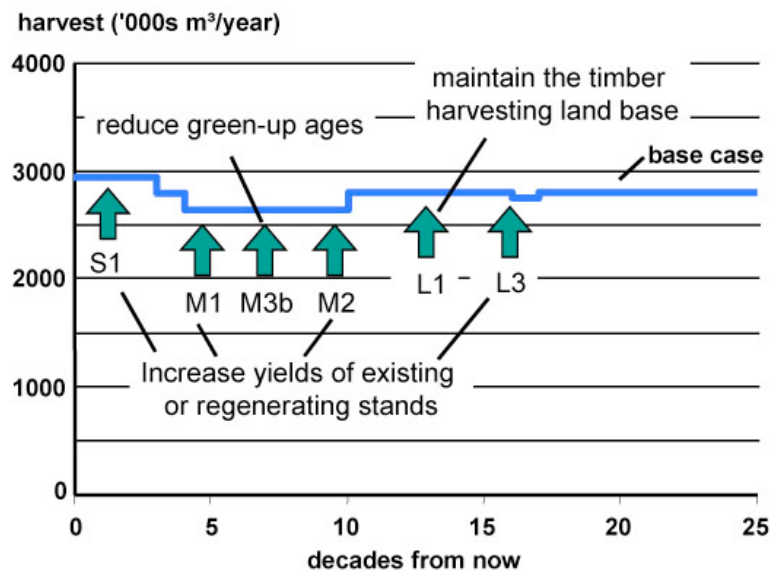


Figure 1. (Figure 3-1 from Mackenzie TSA Silviculture Strategy, Type 1)

In addition, Section 5 of the *Mackenzie TSA Silviculture Strategy (Type 1)*, February 1999 report ranks the activities.

"The rankings represent a balance between the participant's strategic concerns and the silvicultural opportunities available on the TSA in the next five years.

General surveys are necessary precursors to the remainder of the program and were not ranked.

Free-growing surveys of pre-87 disturbances, field sampling were ranked as priority 1, as were and fill-planting and brush/weeding of understocked pre-87 logging-origin stands. All of these activities implement strategy L1, the maintenance of the timber harvesting land base as represented in the TSR.

The project to recruit caribou habitat was ranked as number 2.

Ensuring that the entire timber harvesting land base was planted with improved seed was ranked third. This activity implements strategy L3, which is to increase the yield of future stands and increase timber supply in the long term.

Spacing pre-87 repressed PI was ranked fourth. The intent of this activity is to implement strategy Mb3, to reduce green-up ages and increase mid-term timber supply.

The fertilization program was ranked fifth. This program implements strategies S1, M1, M2, and L3, to increase yields of existing and regenerating stands.

Finally, spacing to enhance disturbed grizzly bear habitat is ranked sixth, and pruning to ensure a supply of clear logs (strategy Q1) is ranked seventh and last."

3.2. Type 2 Analysis

The Mackenzie TSA Type 2 Incremental Silviculture Analysis was initiated in 1999 with the objective of developing a comprehensive silviculture strategy for the Mackenzie TSA.

The outputs from this strategic planning initiative include:

- A fully rationalized incremental silviculture strategy for the Mackenzie TSA;
- A measure of the potential social benefits in the short term from silviculture jobs and in the long term from an improved timber supply;
- Performance indicators at the management unit level;
- Standardized analysis outputs so that budget allocations can be evaluated and weighed on a consistent basis, and
- Information that can be utilized by industry and government decision makers in their considerations with regard to tree improvement, silvicultural regimes, and partial cutting.

The *Mackenzie TSA Type 2 Incremental Silviculture Analysis Data Input and Assumptions Report* is available as a separate document. That document provides a comprehensive understanding of the information and data used to complete this analysis.

All assumptions listed in this document are for this analysis only, and should not be extrapolated to other circumstances, without an understanding of the implication of the extrapolation.

4.0 Analysis Approach and Methodology

4.1. Approach

In order to predict future harvest forecasts and forest inventory changes over time, the Tesera Scheduling Model (TSM) is used to obtain Type 2 analysis results.

TSM is proprietary software developed by Tesera Systems Inc. The Tesera Scheduling Model is supported and maintained by Tesera Systems Inc. through internal research and development and represents one of many tools Tesera uses to provide clients with professional products such as mapping, reporting and visualizations, as well as resource agency and public sector facilitation and decision support services.

Earlier versions of the model have been applied successfully to address a wide variety of resource management problems at land base scales ranging from individual landscape units of 80 to 100 thousand hectares in size to TSAs one to six million hectares in size. Some examples include the following:

- Robson Valley Enhanced Forest Management Pilot Project (one million hectares), prepared for the Robson Valley Forest District, BC Ministry of Forests, McBride, BC;
- Kidprice Landscape Unit Analysis (101,000 hectares), prepared for Northwood Inc., Houston, BC;
- Mackenzie LRMP Impacts Analysis (six million hectares), prepared for the Prince George Forest Region, BC Ministry of Forests, Prince George, BC; and
- Development of a Sustainable Forest Management (SFM) Plan for the Morice & Lakes Innovative Forest Practices Agreement (2.6 million hectares).

In addition to supporting this Type 2 analysis, Tesera Systems Inc. is currently involved in the Type 2 Incremental Silviculture Analysis for the Robson TSA as well as Natural Disturbance Modelling for the Robson and Mackenzie TSAs.

The Tesera Scheduling Model is a hybrid between simulation-based models and heuristic-based optimization models, drawing on the strengths of each approach towards solving forest management problems. Simulation-based models repeat the same process each time in order to reach a solution, whereas heuristic-based optimization models use a random search method to reach the best solution. A simulated annealing algorithm is used with the optimization component of the TSM to find near optimal solutions. The simulated annealing algorithm initially allows the model a high degree of randomness in a search for a solution. The willingness to accept random fluctuations is reduced over time in order to zero in on the best solution with the given parameters. Depending on a project's needs, either simulation or optimization modes may be used.

The model maintains the spatial location of forest stands, harvest units, special management areas, and other timber and non-timber related resource management zones. It is capable of providing estimates of timber supply, forest inventory and resource indicator changes over time. As well, it bridges the gap between strategic and operational planning, since analysis results can be displayed on a map, and harvest schedules are linked to treatment unit polygons.

Modelling assumptions and attribute data are input through tables similar to simulation based models such as the BC Forest Service Simulation Model (FSSIM) making it easier to prepare model inputs and understand results.

Examples of some of the graphical user interfaces (GUIs) developed for the scheduling model are shown in *Figure 2*, following.

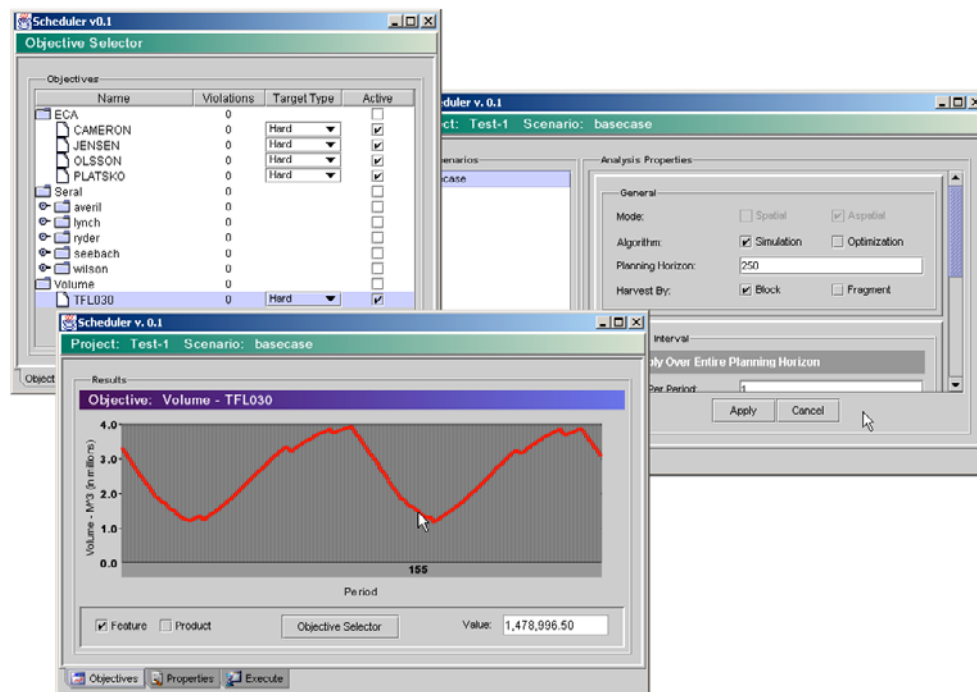


Figure 2. Sample GUIs – Tesera Scheduling Model

4.2. Methodology

Since the purpose of this analysis is to provide short and long-term forecasts of timber supply and to spatially locate areas for silviculture treatments, the spatial location of timber and non-timber related resource features must be explicitly maintained. As a result, the spatial resource inventories collected for the analysis are combined into a single resultant coverage that is used to represent the land base within Tesera's forest estate model. Due to the complexity of the inventories used, the Mackenzie TSA Type 2 resultant coverage consists of approximately 1.5 million discrete forested polygons that are explicitly tracked through time by Tesera's Scheduling Model.

4.2.1. Treatment Units

A critical component necessary for the successful implementation of an operationally relevant spatial analysis is a treatment unit coverage, also referred to as a Total Chance Plan. The treatment unit coverage delineates the land base into spatially discrete polygons that the model uses to schedule harvests or other forest management activities.

Figure 3, following, reveals a small portion of the treatment unit coverage used in the analysis. To be operationally meaningful, these treatment units must conform to the operational layout and engineering design specifications of the various logging systems that will be used to harvest timber. The treatment unit coverage developed for this analysis is computer generated using the Tesera Treatment Unit Model. The model utilizes information such as timber type, stand age, and slope to optimally delineate areas into operationally relevant treatment units (blocks). The blocks generated can be aggregated together to create larger contiguous units (e.g. for block size sensitivities), but they cannot be subdivided.

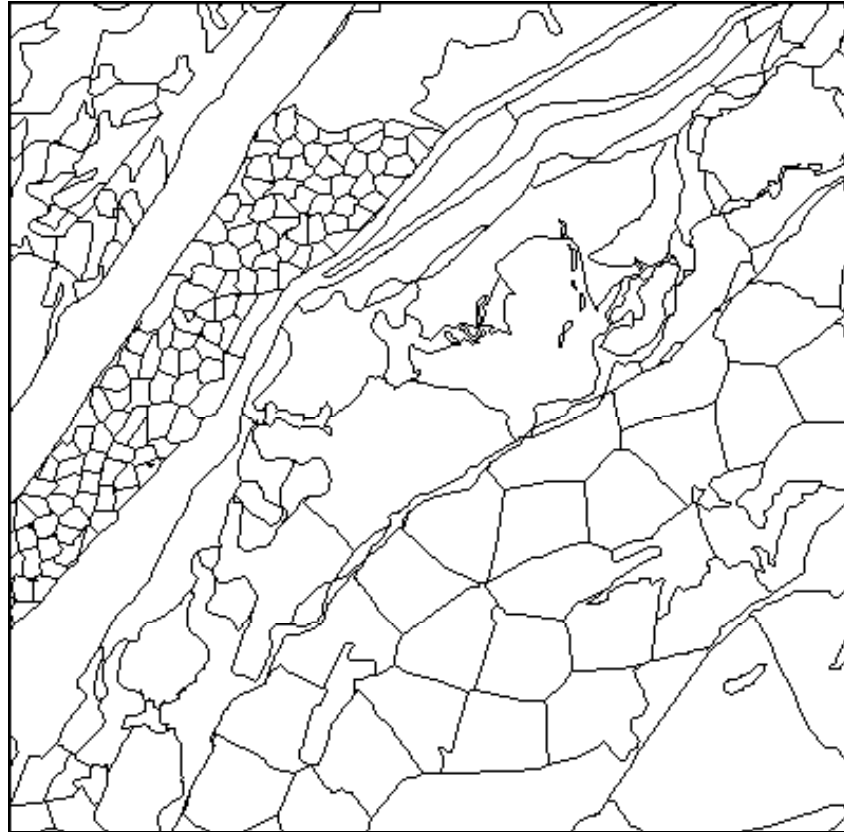


Figure 3. Example of the Treatment Unit Coverage

Another critical component is the spatial relationship between polygons. This is accomplished through an adjacency table that tells the model which polygons are neighbours. As a result, spatial harvest rules can be explicitly represented and the timber supply effects of harvest distributions and patterns are more accurately assessed.

4.2.2. Timber Growth and Yield

Provincially calibrated growth and yield models are used to create volume curves for this analysis and include the variable density prediction model (VDYP) and the table interpolation program for stand yields (TIPSY).

VDYP is an empirical yield prediction system supported by the BC Forest Service, designed to predict average yields and provide forest inventory updates over large areas (i.e. timber supply areas). It is intended for use in unmanaged natural stands of pure or mixed species composition.

TIPSY is a BC Forest Service computer program used to generate yield projections for managed stands using a model that simulates the growth of individual trees based on internal growth processes, crown competition, environmental factors and silvicultural practices.

VDYP outputs the existing volume curves for all current stands older the 40 years and for 40% of the stands aged 13 – 40 years (categorized as existing unmanaged in this analysis). TIPSY is used to calculate the managed stand yield tables for both base case and for scenarios such as genetic worth and fertilization.

Managed curves are assigned to all stands that are regenerated after harvest (categorized as future managed in this analysis) and all stands currently less than 13 years old (categorized as existing managed in this analysis). Managed stands are also assigned to 60% of the stands that are currently between 13 and 40 years (categorized as existing managed in this analysis).

4.2.3. Harvest Scheduling

In all scenarios, the harvest queue is established for each period based upon the relative oldest first method and projections are made using spatially sensitive sequential simulations. Each scenario is projected for a minimum of 250 years, utilizing five year periods (thus 50 periods). When the maximum sustainable harvest flow is achieved, the projection period is extended to 400 years to ensure that the THLB growing stock levels are sustainable in the long term.

4.2.4. Non-recoverable Losses

For modelling purposes, the approach most commonly used by analysts for implementation of non-recoverable losses is to allow the model to harvest the volume allocated to non-recoverable losses. In the Mackenzie TSA, 172,800 m³/yr is lost due to non-recoverable losses. For reporting purposes, this 'harvest' is not recorded as it is not intended to be part of the harvest flow. As a result, all sections of the report, including the maps, exclude the harvest of non-recoverable losses, unless otherwise stated.

4.2.5. Targets

In total, 447 explicit spatial targets are applied in the model. For the purposes of this analysis, targets are defined as either a minimum requirement (such as a seral stage) or a maximum limit (such as VQO allowable disturbance). There are 259 targets that apply to seral stage, 186 applying to VQO polygons and two applying to harvest flow (coniferous and deciduous).

4.3. *Potential Issues Affecting Timber Supply*

This section identifies those issues that have the potential to significantly influence available timber supply.

4.3.1. Forest Cover Inventory

Forest cover inventory is one of the critical sources of information forest estate models use to project forest attributes into the future. Using updated forest cover inventory that projects forest age to the date of the analysis and incorporates updates for disturbance and stocking since the inventory was collected are critical in order to obtain the most accurate analysis results.

This analysis uses a forest cover inventory updated to 1996 for disturbance and growth. As result, the initial ages and heights used in this analysis do not reflect the last eight years of disturbance – in essence, the model projection commences in 1996 rather than 2003. This shortcoming was recognized by the District stakeholders at the outset of this project but it was decided that a delay of the project to receive updated forest cover inventory files was undesirable and additionally would require data processing beyond the planned budget. Therefore, it was decided that proceeding with this known shortcoming in mind was acceptable.

As a result, it is highly unlikely that the first eight years of treatment units scheduled by TSM will mirror the operational realities that have occurred since 1996. Between 1996 and 2000, an average of 2.6 million m³/yr was harvested (TSR Analysis Report, 2000). Extending that average to 2003, 21 million m³ of forest has been harvested, which represents roughly 66,000 hectares of mature timber.

4.3.2. Forest Management Requirements

For this analysis, forest cover constraints are used to emulate management requirements of non-timber resource values and generally limit the amount of harvesting that is acceptable in a particular zone. Consistent with the TSR2 analysis, two types of forest cover constraints (minimum and maximum) are applied in this analysis. The minimum constraint refers to minimum area and/or volume retention criteria and maximum refers to maximum area disturbance criteria.

To ensure that older forests are maintained throughout the TSA, forest cover requirements are applied to each biogeoclimatic variant within each draft landscape unit. The biodiversity targets applied are minimum retention goals set by biodiversity emphasis option, landscape unit and biogeoclimatic variant. Similarly, to ensure that visual quality is maintained in visually sensitive areas throughout the projection, maximum allowable disturbance limits are set for each VQO polygon.

4.3.3. Species Composition of Regenerated Stands

For this analysis, it is assumed that all subalpine fir (balsam) stands regardless of site index will be regenerated to spruce leading stands. Spruce is considered a preferred species in Mackenzie TSA plantations and is assumed to yield more volume and better quality lumber than balsam.

All spruce stands are modeled to regenerate to a spruce and pine mixture. If stands are permitted to grow longer than minimum harvest age, then maintaining pure spruce stands would provide higher volumes than the spruce and pine mixture. Pine stands are assumed regenerate to 100% pine. All deciduous stands will be regenerated naturally to their original composition.

Table 3 reflects the change in species composition as natural stands are converted to managed stands. Depending on the level of natural regeneration of balsam, it is unlikely that the future forests will be 100% devoid of balsam. This is an important factor that could influence available timber supply in the Mackenzie TSA given the propensity of balsam stands in this area. It would be worthwhile to evaluate techniques to reflect natural ingress in future land use planning opportunities.

Table 3. Current and Future Species Composition

Leading Species	Current Species Composition % of THLB	Future Species Composition % of THLB
Balsam	14%	0%
Spruce	37%	44%
Pine	45%	52%
Deciduous	4%	4%

Although species conversion is shown to have a positive impact on available timber supply in the long term, due to regeneration of species with higher growth rates, the regeneration to spruce and pine can

result in unintended impacts on forest health factors. Provincially, discussions are underway on the potential impact of creating large expanses of forest containing pre-dominantly one or two species. These forests can be more susceptible to forest insects such as Spruce Leader Weevil, Warren's Root Collar Weevil (affects pine) and Mountain Pine Beetle. These potential insect and disease infestations can dramatically affect timber supply. However, due to the variable nature of insect and disease infestations, exact impacts on timber supply are not well known.

4.3.4. Poor Productivity Stands

TSR1 identified harvest of poor productivity stands as the primary reason for an increase in age harvested between years 180 and 210. These poor productivity sites are concentrated for harvest during that time period because minimum harvest age has not been reached for those stands. According to a TSR1 sensitivity analysis, a change in criteria for minimum harvest age from 95% of culmination mean annual increment (CMAI) to minimum volume would allow the existing Allowable Annual Cut to be maintained for an additional 60 years before declining to the long term harvest level.

The *Mackenzie TSA Silviculture Strategy (Type 1)* analysis also states that the influence of poor and low-site spruce stands on the TSR1 base case as well as minimum harvest ages should be investigated.

TSR2 altered the site index cut-off for low sites, as well as altered the methodology of calculating minimum harvest age. In TSR1, low site spruce site index cut-off occurred at 7.7 for stands between 41 and 120 years, where as TSR2 increased the low site spruce cut-off to 8.9 for conventional ground, 9.2 for conventional/cable ground and 10.3 for cable ground in all age classes. In addition, minimum harvest ages for managed stands decreased by approximately 20 years as a result of changing the minimum harvest age criteria from 95% of CMAI to a minimum volume criteria.

TSR2 analysis results state that between years 20 and 120, the area harvested is slightly higher as a result of harvest existing poor productivity stands.

Concentrated harvest of poor productivity stands is considered a potential timber supply issue for this analysis, as the vintage of the forest cover inventory used in this analysis (see *Section 4.3.1 Forest Cover Inventory*), is more similar to the forest cover inventory used in TSR1 than TSR2. Although the management assumptions have been altered between TSR1 and TSR2, the issue of concentrated harvest of poor productivity sites is being carried forward as a potential timber supply issue to ensure that this is considered in the analysis.

5.0 Scenario Definitions

Tesera Systems Inc. met with Mackenzie Forest District stakeholders to determine the appropriate silviculture scenarios. It was determined that seven learning scenarios would be assessed:

- aspatial base case;
- spatial base case;
- partial harvest within visually sensitive areas;
- late rotation fertilization on pine leading stands;
- repeat fertilization on pine leading stands;
- repeat fertilization on pine and spruce leading stands; and
- planting of genetically improved stock (genetic worth).

The aspatial base case and spatial base case are completed and used as the benchmark for assessing treatment response.

When the Type 2 Incremental Silviculture Analysis was initiated in 1999, it was anticipated that the current silviculture expenditure parameters would be provided in order to restrict annual silviculture investment within various treatment regimes. However, current silviculture expenditures were not provided, so this component of the analysis was not undertaken.

Also, it was anticipated that the decision support scenario would contain only those treatments with a significant response as well as a budget that would limit the amount of area treated. However, silviculture expenditures were not provided, so this component of the analysis was not undertaken. Instead, in January 2003, the Ministry of Forests directed that two decision scenarios be applied - one where 100% of the candidate fertilization and genetic worth area is treated, and a second where 50% of the candidate fertilization and genetic worth area is treated.

The Type 1 silviculture analysis identifies additional scenarios that will not be modelled:

- priority harvest on low site spruce;
- pruning; and
- juvenile spacing to create grizzly habitat.

It was determined by Ministry of Forests staff that priority harvest on low site spruce and adjustment of minimum harvest ages is no longer required for assessment within the Type 2 analysis since TSR2 altered the criteria for low site spruce as well as the minimum harvest ages in all analysis units (see *Section 4.3.4 Poor Productivity Stands*).

Since no criteria were provided for pruning or juvenile spacing to create grizzly bear habitat, these scenarios were not pursued.

6.0 Analysis Results and Discussion

The following section defines the:

- timber harvesting land base, which is the area of land available for harvest over the planning horizon;
- composition of the forest, which summarizes the species composition, age class structure and site index of the existing forest;
- timber supply results for different scenarios:
 - base case, which compares the Type 2 aspatial and spatial base case to the TSR2 base case;
 - partial harvest in visually sensitive areas, to assess the impact of alternative silviculture systems;
 - late rotation fertilization, which assesses the impact of fertilizing existing pine stands before harvest;
 - repeat fertilization for pine, which assesses the impact of fertilizing existing and future managed stands at year 20, 30, 40, 50 and 60;
 - repeat fertilization for spruce and pine, which assesses the impact of fertilizing existing and future managed stands at year 20, 30, 40, 50 and 60;
 - genetic worth, which assesses the impact of planting future stands with genetically improved stock; and
 - two decision scenarios, which assess the impact late fertilization, repeat fertilization on pine and spruce and genetic worth.

6.1. Timber Harvesting Land Base

Table 4, following, outlines the timber harvesting land base (THLB) for the Type 2 Incremental Silviculture Analysis. The criteria used to define the THLB are provided in the document *Mackenzie TSA Type 2 Incremental Silviculture Analysis Data Inputs and Assumptions*. The netdown order follows that used in TSR2 which is important when aspatial reductions are applied. A description of the netdown classifications is provided in Table 5, following.

Of the Mackenzie TSA land base, approximately 42 percent is considered Crown productive forest land (approximately 2.7 million hectares). This includes 1.7 million hectares of protected areas and special resource management wildland zones where timber harvesting is not permitted. Currently, 50 percent of the Crown productive forest land (or 21 percent of the total TSA land base) is considered available for harvesting (1.3 million hectares).

Table 4 shows that the Type 2 total land base is 1% smaller than the TSR2 land base, while the Crown Forest area is 2% smaller. The reductions applied in the Type 2 analysis are 3% greater than TSR2. Finally, the Type 2 THLB is 7% smaller than TSR2. The discrepancy in total TSA area is attributed to a difference in the mapping standards used in the analyses. The remaining area discrepancies are attributable to differences in the forest cover inventories used.

The inventory data used in TSR2 was based on a forest inventory completed between 1990 and 1997, and updated to January 1, 1999, for ownership, growth and denudation from harvesting or fire. For the Type 2 analysis, an older forest inventory was used, as is described earlier in *Section 4.3.1 Forest Cover Inventory*. This inventory was updated to 1996 for growth and denudation. As a result, the ownership classes (which define the Crown forest land base) are different. In addition, the stand age and heights are three years younger, which impacts reductions such as low productivity and problem forest types.

Based on the volume estimates from TSM, the current total volume in the THLB is 256 million cubic metres.

Table 4. Timber Harvesting Land Base Definition

Classification	Type 2 Crown Forest Area (ha)	Type 2 THLB (ha)	Percent of Type 2 Total TSA Area	Percent of Type 2 Crown Forest Area	TSR2 Crown Forest Area (ha)	Percent Difference Crown Forest	TRS2 THLB (ha)	Percent Difference THLB
Total TSA area	6,363,412		100.0%		6,410,643	0.7%		0.7%
Not managed by the Crown	226,807		3.6%		246,929	8.1%		8.1%
Non-forest	1,689,536		26.6%		1,635,867	-3.3%		-3.3%
Total forest area managed by the Crown	4,447,069		69.9%		4,527,847	1.8%		1.8%
Protected area and Willdland	1,755,134		27.6%		1,776,066	1.2%		1.2%
Crown Forest	2,691,935		42.3%	100.0%	2,751,781	2.2%		2.2%
Reductions:			0.0%					
Non-commercial forest	45,342	45,342	0.7%	1.7%	32,425	-39.8%	32,425	-39.8%
Inoperable areas	5,548	5,541	0.1%	0.2%	4,207	-31.9%	3,181	-74.2%
Current roads, trail and landings		8,220	0.1%	0.3%			9,463	13.1%
Special planning cells	14,237	14,198	0.2%	0.5%	19,550	27.2%	19,515	27.2%
Environmentally sensitive areas (ESAs)	399,177	354,734	5.6%	13.2%	448,216	10.9%	353,483	-0.4%
Balsam marginal stands	318,669	201,085	3.2%	7.5%	308,204	-3.4%	227,566	-11.6%
Spruce marginal stands	103,881	76,290	1.2%	2.8%	77,068	-34.8%	34,576	-120.6%
Pine marginal stands	140,007	109,404	1.7%	4.1%	212,975	34.3%	86,940	-25.8%
Deciduous marginal stands	27,457	23,153	0.4%	0.9%	76,285	64.0%	14,561	-59.0%
Deciduous north Peace Arm and far haul zone	72,662	53,002	0.8%	2.0%	105,433	31.1%	80,426	34.1%
Problem forest types (PFT)	56,414	34,089	0.5%	1.3%	116,372	51.5%	20,270	-68.2%
Sites with low volume	645,813	215,743	3.4%	8.0%	552,265	-16.9%	180,516	-19.5%
Sites with low productivity	140,978	71,738	1.1%	2.7%	127,513	-10.6%	62,342	-15.1%
Kerness power line		993	0.0%	0.0%			2,030	51.1%
Kerness mine site		1,173	0.0%	0.0%			1,450	19.1%
Riparian Areas	141,183	77,099	1.2%	2.9%			116,372	33.7%
Wildlife tree patch (WTP) areas		56,005	0.9%	2.1%			60,267	7.1%
Total current reductions		1,347,808	21.2%				1,305,383	-3.3%
Current timber harvesting land base (THLB)	1,344,127		21.1%	49.9%			1,446,398	7.1%
Future roads, trails, landings		51,748	0.8%	1.9%			65,088	20.5%
Future timber harvesting land base (THLB)	1,292,379		20.3%	48.0%			1,381,130	6.4%

Table 5. THLB Netdown Classifications and Descriptions

Classification	Description
Not managed by the Crown	private lands and other areas not that are not administered under a TSA wide Allowable Annual Cut such as woodlots
Non-forest	areas not occupied by productive forest cover (e.g., rock, swamp, alpine areas, and water bodies)
Protected area and wildland	areas designated under the LRMP as protected areas and wildland
Non-commercial cover	areas occupied by non-commercial tree or brush species
Inoperable	areas classified as unavailable for harvest for terrain-related or economic reasons. Characteristics used to define operability include slope and topography (e.g., presence of gullies or exposed rock).
Existing roads, trails, and landings	areas of forest land that have been removed from timber production due to access development and harvesting
Special planning cells	areas with special management objectives
Environmentally sensitive areas (ESA)	portions of the land base considered environmentally sensitive and/or significantly valuable for other resources
Balsam marginal stands	areas defined by the forest district as balsam-leading marginal stands
Spruce marginal stands	areas defined by the forest district as spruce-leading marginal stands and all black spruce-leading stands
Pine marginal stands	areas defined by the forest district as pine-leading marginal stands
Deciduous marginal stands	areas defined by the forest district as deciduous-leading marginal stands
Deciduous north of Peace Arm and far haul zone	all deciduous-leading stands in far zone and near zone north of Peace Arm
Problem forest types	stands that are physically operable and exceed low site or low volume criteria yet are not currently utilized or have marginal merchantability
Sites with low volume	old forest areas occupied by forest with volume below the threshold of economic operability.
Sites with low timber productivity	young forest areas occupied by forest with low timber growing potential
Kemess power line	areas occupied by the Kemess power line
Kemess mine site	areas occupied by the Kemess mine site
Riparian areas	areas otherwise available for timber production, a portion of which is assumed to be unavailable for harvesting to protect riparian and stream ecosystems
Wildlife tree patches	areas reserved within and along the edges of cutblocks for the maintenance of stand-level biodiversity, primarily for conservation or enhancement of wildlife

6.2. Composition of the Forest

Figure 4 shows the current species composition of the timber harvesting land base by leading tree species. Pine leading stands are the most prevalent in the TSA, followed by spruce, balsam, and deciduous leading stands. Forty-five percent of the timber harvesting land base (THLB) is composed of pine leading stands; 37% is spruce leading; 15% is balsam leading and 4% is deciduous leading. The percentage in pine will increase over time as spruce leading stands are harvested and are regenerated to 80% spruce and 20% pine. As well, balsam leading stands will decrease over time as they regenerate to spruce. This will affect the repeat fertilization responses.

Figure 4 and Table 6 show that at least 76% and 72% of the spruce and balsam are currently above minimum harvest age while over 66% and 54% of the pine and deciduous area are currently above minimum harvest age. Across all species, 70% of the THLB is currently above minimum harvest age, and available for timber harvest, subject to the forest cover constraints of seral stage and visual quality objectives.

Minimum harvest age (mha) is derived by applying minimum economic criteria within haul and logging system zones. In the near zone, conventional harvest stands require at least 140 m³/ha with a minimum diameter at breast height (dbh) of 25 cm and cable harvest stands require 200 m³/ha with a minimum dbh of 28 cm. In the far zone, conventional stands require 160 m³/ha and cable stands require 250 m³/ha. For natural stands, the minimum diameter is calculated based upon average of all stems, where as for managed stands, the minimum diameter is calculated based upon an average of the largest 250 stems per hectare.

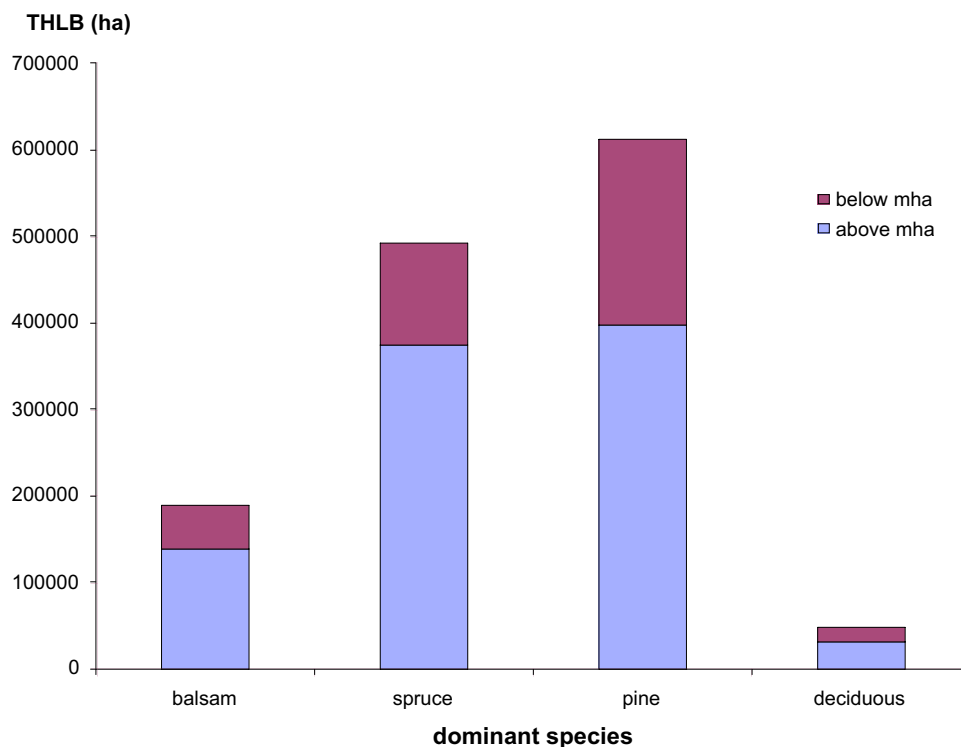


Figure 4. Area by Leading Species Above Minimum Harvest Age

Table 6. Area by Leading Species and Minimum Harvest Age

Leading Species	Area Above Minimum	Area Below Minimum	Total Area
	Harvest Age	Harvest Age	
Balsam	140,024	55,163	195,187
Spruce	374,423	117,088	491,511
Pine	396,726	204,150	600,876
Deciduous	30,728	25,824	56,552

Figure 5 and Table 7 depict the THLB area by analysis unit. Analysis unit categories are defined in the *Mackenzie TSA Type 2 Incremental Silviculture Analysis, Data Inputs and Assumptions*. Stands with similar site index and leading species are grouped together into analysis units. 21% of the THLB is pine with a medium site index, followed closely by spruce on medium sites at 19%. The third highest proportion are pine sites with good site index at 15%. Of coniferous dominated stands, the percent by site index class is as follows: good (25%), medium (47%), and poor (28%).

For the Type 2 silviculture analysis, late and repeat fertilization are applied to the medium site index classes as well as the lower 25% of the good site index classes and the upper 25% of the poor site classes.

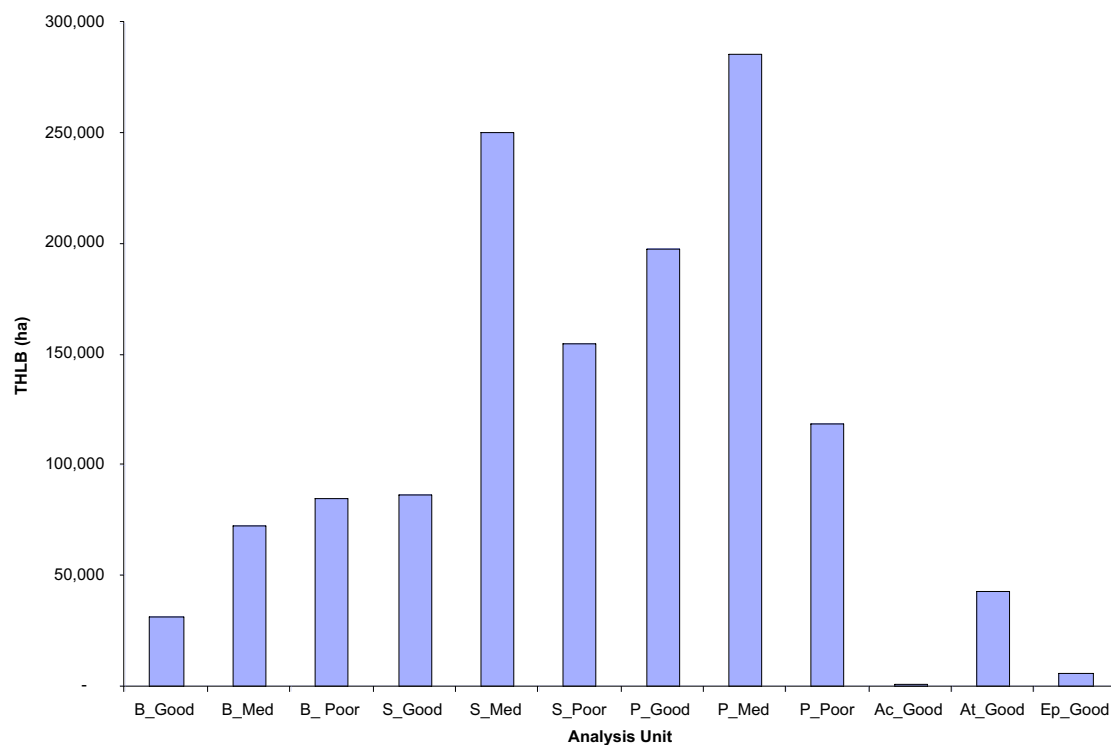
**Figure 5. Analysis Unit Distribution**

Table 7. Area by Leading Species and Analysis Unit

Analysis Unit	THLB (ha)	% Area
Balsam Good	31,530	2%
Balsam Medium	72,649	5%
Balsam Poor	85,226	6%
Spruce Good	86,755	7%
Spruce Medium	250,282	19%
Spruce Poor	155,082	12%
Pine Good	197,581	15%
Pine Medium	285,513	21%
Pine Poor	118,686	9%
Cottonwood Good	913	0%
Aspen Good	42,893	3%
Birch Good	5,907	0%

Figure 6, Table 8 and Illustration 2 show the current age class distribution for the forested land base in the Mackenzie TSA and how it is distributed within both the THLB and non-THLB.

Within the THLB, 17% of the area is less than 50 years old, 23% is between 51 and 100 years old, 29% is between 101 and 150 years old, 11% is between 151 and 200 years old, 18% is between 201 and 250 years and 3% is greater than 250 years old. There are no large age class gaps within the Mackenzie TSA.

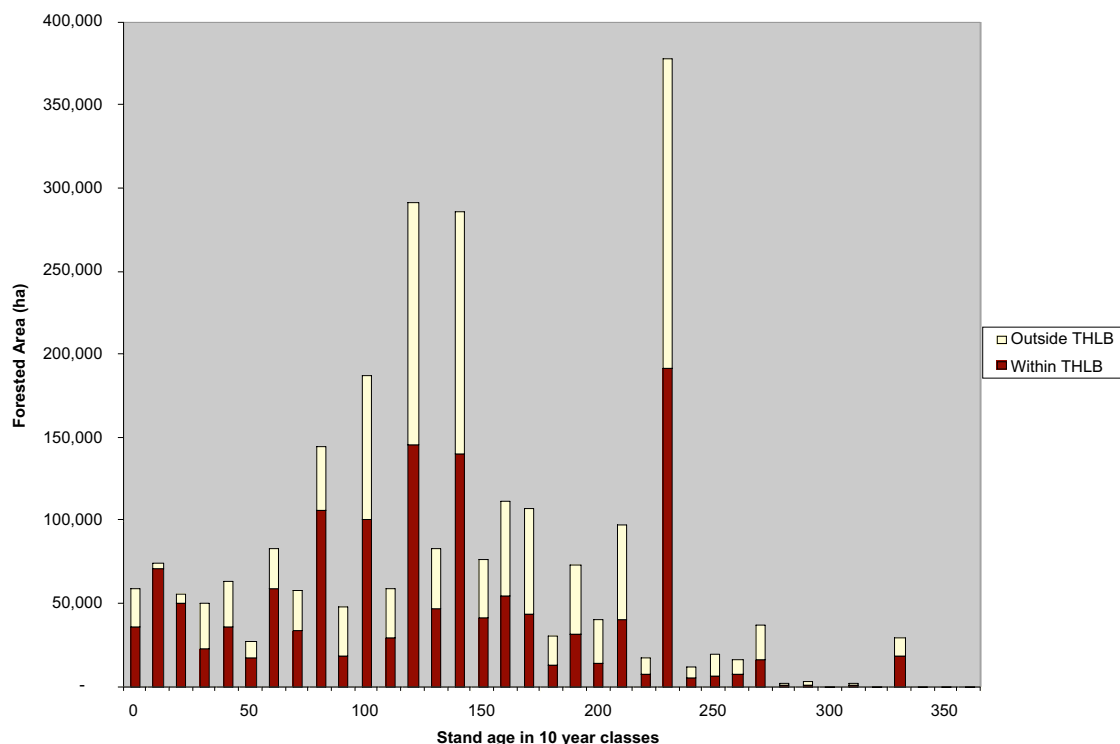
**Figure 6. Forested Land Base Age Class Distribution**

Table 8. Area by Leading Species and Age

Age	Area Within THLB (ha)	Area Outside THLB (ha)	Total Area (ha)
0	23,745	36,017	59,763
10	3,689	71,131	74,820
20	5,329	50,889	56,218
30	27,234	23,288	50,522
40	26,963	36,371	63,334
50	10,683	17,248	27,931
60	24,156	59,084	83,241
70	24,047	34,363	58,410
80	39,102	106,040	145,143
90	30,011	18,304	48,316
100	86,563	101,457	188,019
110	29,224	29,950	59,174
120	145,314	146,442	291,755
130	36,143	47,274	83,417
140	146,215	140,183	286,398
150	35,154	41,771	76,925
160	57,272	54,521	111,792
170	63,404	43,604	107,008
180	17,796	12,940	30,736
190	41,771	32,000	73,771
200	26,065	14,106	40,171
210	57,590	40,345	97,935
220	10,379	7,421	17,800
230	185,710	192,345	378,055
240	7,300	5,414	12,714
250	12,763	7,213	19,976
260	7,901	8,217	16,118
270	20,200	16,740	36,940
280	1,393	1,419	2,812
290	1,806	1,403	3,208
300	154	264	418
310	1,306	1,260	2,566
320	64	142	206
330	11,029	18,682	29,711
340	67	20	87
350	339	-	339
360	332	123	455

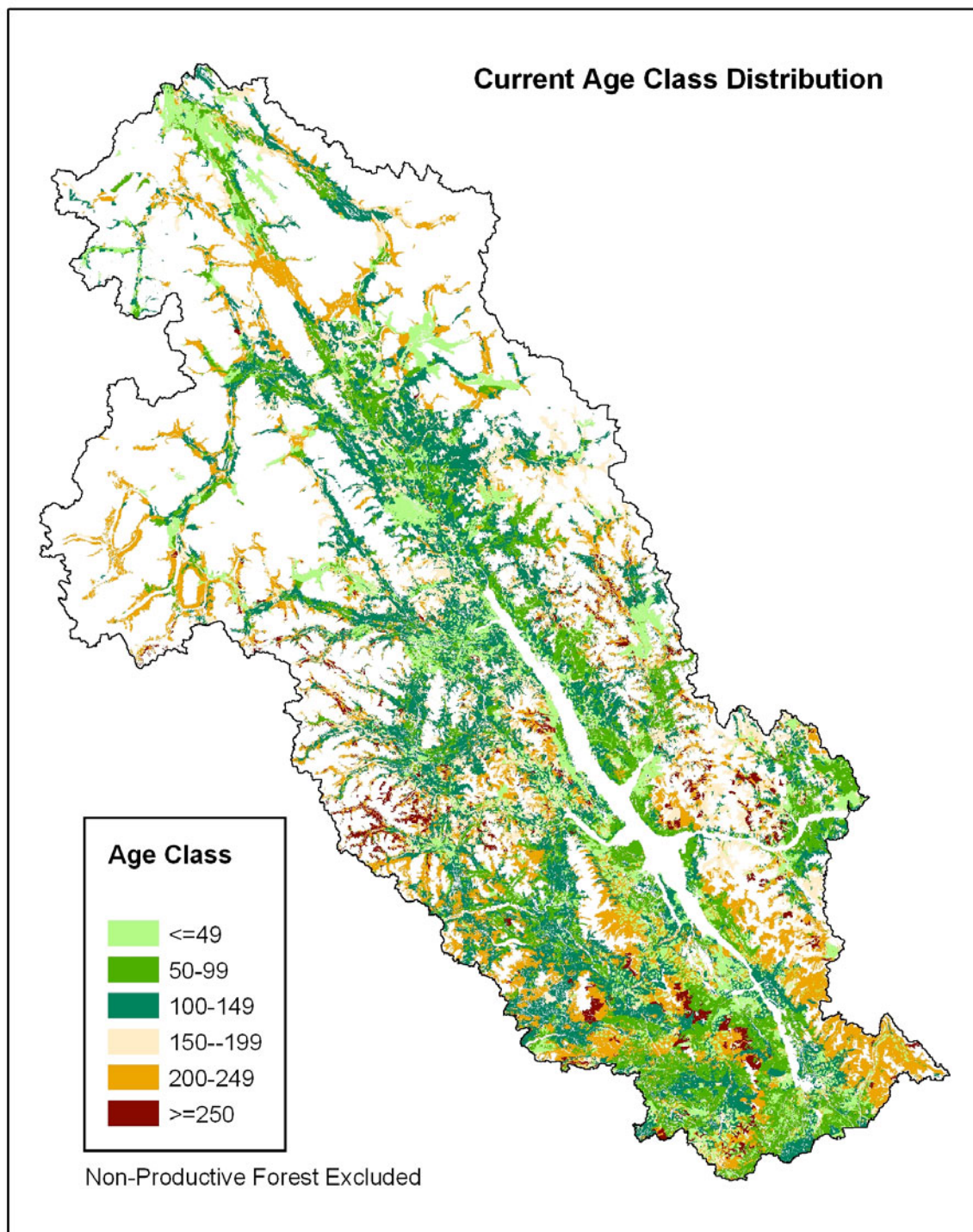


Illustration 2. Age Class Distribution Map for the Mackenzie TSA

6.3. Harvest Flow Objectives

In this analysis, three different harvest flow objectives are applied.

In order to compare results of this analysis with the TSR2 base case, the same harvest flow policy and initial harvest level are applied in the Type 2 aspatial and spatial base case scenarios. The British Columbia provincial harvest flow objective for TSR is to maintain the current Allowable Annual Cut (Mackenzie TSR1 2,997,363 m³/yr, including a deciduous partition of 50,000 m³/yr) for as long as possible without allowing declines to exceed 10% per decade and to achieve the long term harvest level as soon as possible. The long term harvest level must be a sustainable even-flow harvest rate where sustainability is demonstrated through stable growing stock levels over two full rotations of the THLB managed stand inventory. As well, harvest levels in the mid term should not fall below the THLB long run sustained yield (LRSY) based upon current inventory.

LRSY based upon current inventory is used as a worst case scenario of the lowest harvest flow possible if future stands grow at the same rate of natural stands. This assumption can only be successfully applied where there is an imbalance in age class distribution to older age classes at the beginning of the planning horizon. Although forest cover constraints will impact the achievable mid and long term harvest levels, it is anticipated that the forest cover constraints would need to be extremely restrictive in order to force the mid or long term harvest flow below LRSY based on current inventory.

The learning scenarios: partial harvest in visually sensitive areas, late fertilization, repeat fertilization on pine, repeat fertilization on pine and spruce as well as the genetic worth apply an adjusted even-flow harvest flow objective, where the short and / or the long term harvest flow can be increased above the spatial base case, with only one change not more than 10% per decade permitted prior to reaching the long term harvest level. The intent is to ensure a level harvest flow in the short and mid-term, compared with the long term.

The harvest flow objective for decision scenario 1 and decision scenario 2 is to increase harvest flow to a point where the decline to long term harvest level occurs in two to three small increments of not more than 10% per decade, distributed over a longer period of time before reaching the long term harvest level. The long term harvest level must be a sustainable even-flow harvest rate where sustainability is demonstrated through stable growing stock levels over two full rotations of the THLB managed stand inventory. Harvest levels in the mid term should not fall below the THLB long run sustained yield based upon current inventory. The intent of this harvest flow objective is to provide benefits in the short term by increasing the harvest flow, while maintaining a smooth transition to the long term harvest level, by ensuring the harvest flow remains static for a few decades prior to each decline. This provides communities time to adjust to the decreasing employment and revenue.

6.4. Learning Scenarios

6.4.1. Aspatial and Spatial Base Case

The base case harvest forecast is intended to identify the harvest flow based on current management practices. There are two base case scenarios: aspatial and spatial.

The primary purpose of completing the aspatial base case is to confirm that no significant bias is introduced into analysis results when a different forest estate model other than the BC Forest Service Simulation Model (FSSIM) is used. TSM has been benchmarked against FSSIM in two other analyses (the Robson Valley Enhanced Forest Management Pilot Project and the Morice & Lakes Innovative Forest Practices Agreement) with the results being reviewed and approved by the Ministry of Forests. The Morice & Lakes Innovative Forest Practices Agreement report *Benchmarking Tesera Scheduling*

Model to FSSIM, October 2002, provides additional information. Further, the BC Ministry of Forests has approved TSM as an appropriate forest estate model for use in timber supply analyses in British Columbia. Therefore, no significant model bias has been introduced into this analysis.

It is important to remain mindful that the forest cover inventory used for this analysis is of a different vintage than that used for TSR2 and therefore a direct comparison of model outputs may not be appropriate (see *Section 6.1 Timber Harvesting Land Base*).

The aspatial base case is designed to emulate as best as possible, the aspatial application of forest scheduling and forest cover constraints applied in TSR2 using FSSIM. Because TSM is inherently spatial by design, it must schedule explicit spatial units for harvest. However, by requiring TSM to schedule resultant fragments for harvest (instead of treatment units), this provides the most flexibility to the model for scheduling harvest units and will very closely resemble the aspatial scheduling queue used in FSSIM. Fragments are small polygons created when the input source maps are combined to create a resultant database.

In addition, the aspatial base case assesses the maximum disturbance limits in visually sensitive areas by visual quality objective class within each landscape unit. For example, all partial retention polygons in one landscape unit are combined, so that no more than 10% of the combined area may be less than three metres at any one time.

The spatial base case provides a benchmark against which the impacts of the various silviculture treatment regimes can be compared. In this scenario, TSM is required to schedule the harvest of treatment units in their entirety rather than permitting fragment level scheduling. This measure is intended to take advantage of the operationally relevant treatment unit coverage and more explicitly represents actual harvesting operations.

In addition, the maximum allowable disturbance in visually sensitive areas is applied on each visual quality class (VQO) polygon, rather than combining VQO Classes by LU.

Consistent with TSR2, explicit spatial adjacency (for example, one treatment unit can not be logged until the adjacent treatment unit is greater than three metres in height) or spatial adjacency approximation rules (for example, not more than 33% can be less than three metres at any one time) to account for adjacency green-up are not applied in this analysis. Spatial approximation rules are applied in visual quality objective polygons, and are described as a maximum allowable disturbance limit.

In addition, although TSM is able to limit the maximum block size, consistent with TSR2, no maximum block size is applied.

TSR2 stipulates that managing for patch size targets will create a landscape that meets the objectives behind maximum block size and spatial adjacency. However, TSR2 did not apply size targets. Consistent with TSR2, this analysis will not apply patch size targets.

In order to compare results of this analysis with the TSR2 base case, the same harvest flow policy and initial harvest level are applied in the Type 2 aspatial and spatial base case. The British Columbia provincial harvest flow objective for TSR is to maintain the current Allowable Annual Cut (Mackenzie TSR1 2,997,363 m³/yr, including a deciduous partition of 50,000 m³/yr) for as long as possible without allowing declines to exceed 10% per decade and to achieve the long term harvest level as soon as possible. The long term harvest level must be a sustainable even-flow harvest rate where sustainability is demonstrated through stable growing stock levels over two full rotations of the THLB managed stand inventory. As well, harvest levels in the mid term should not fall below the THLB long run sustained yield (LRSY) based upon current inventory.

The TSR2 base case forecast indicates that 2,997,363 cubic metres per year (m³/yr) are available for harvest at the beginning of the planning horizon. This increases at year 20, to the long term harvest level

of 3,305,000 m³/yr. The Allowable Annual Cut Determination in December 2001 set the harvest level for the next five years at 3,050,000 m³/yr for coniferous harvest of which 100,000 m³/yr is partitioned for deciduous harvest. See the report *Mackenzie Timber Supply Area Rationale for Allowable Annual Cut (AAC) Determination, December 1, 2001* for more information.

6.4.1.1. Results

The results section is divided into four parts. The first part describes the harvest flow, growing stock and timber supply dynamics for aspatial and spatial base case. Part two outlines the results of the spatial base case on the targets.

6.4.1.1.1. Harvest Flow

Figure 7 illustrates that both the aspatial and spatial base cases can not maintain the same harvest flow in the mid to long term as was projected in TSR2. The aspatial harvest flow is maintained at 2,997,363 m³/yr across the planning horizon. The aspatial base case harvest forecast is 9.3% lower than TSR2 in the mid and long term primarily due to a 7% THLB reduction resulting from the vintage of the forest cover inventory (see Section 6.1 Timber Harvesting Land Base). The spatial harvest flow is maintained at 2,997,363 m³/yr for 115 years, decreasing by 3.7% to 2,887,358 m³/yr from year 116 onwards. The spatial base case forecast is 9.3% lower than TSR2 in the mid term and 12.6% less than TSR2 in the long term.

The long run sustained yield (LRSY) based on managed stands for the aspatial and spatial base case is 3,582,068 m³/yr. LRSY is calculated assuming all stands have been converted to future managed stands. The culmination age is derived for each future managed curve (the age where the maximum mean annual increment is achieved), and the corresponding volume at culmination age is calculated for the THLB. The maximum volume per year in the THLB is then calculated by dividing the volume of the stand by the culmination age. The LRSY is the sum of all maximum volumes per year. The long term harvest level should not exceed the managed stand LRSY otherwise the harvest flow is considered unsustainable.

The LRSY is 13% higher than the aspatial base case and is 14.6% higher than the spatial base case. This calculation uses the long term harvest level inclusive of non-recoverable losses. See Section 4.2.4 for the methodology of incorporating non-recoverable losses in the analysis.

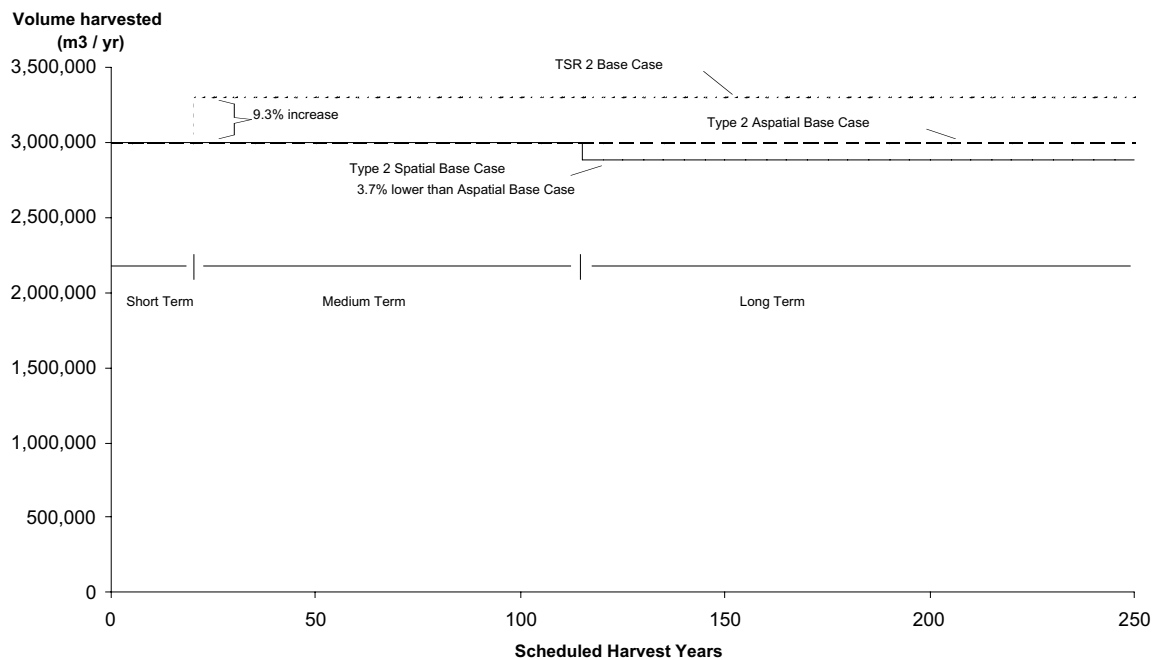


Figure 7. Base Case Conifer Harvest Flow Comparing Type 2 with TSR2

The 3.7% difference between aspatial and spatial base case can be attributed to the methodology for applying maximum allowable disturbance limits in visually sensitive areas. The aspatial base case permits VQO polygons in the same class (e.g. partial retention) in the same landscape unit to be combined; whereas the spatial base case requires that the maximum allowable disturbance be applied explicitly to each VQO polygon. The aspatial method follows the methodology used in TSR2 and provides increased flexibility for the application of maximum allowable disturbance. However, this technique allows the potential for any particular VQO polygon to be entirely harvested before the limit is reached at the landscape unit level. The technique used in the spatial base case ensures that each VQO polygon does not exceed the maximum allowable disturbance limits. This difference only impacts the long term harvest flow because, in the short and mid term, the TSM is able to locate timber for harvest in other areas of the district during those periods of time when VQO polygons may not be available for harvest.

Figure 8 outlines the spatial base case total conifer growing stock within the THLB. This is presented to confirm that the harvest flow maintains a sustainable growing stock across the planning horizon.

Figure 8 illustrates how THLB growing stock declines through the short and mid-term and stabilizes in the long term. An additional model run extending the projection period to a 400 year planning horizon verifies that the long term harvest level is sustainable and that overall long term growing stock is stable, with minor oscillations occurring between 100 and 400 years.

The aspatial base case total conifer growing stock within the THLB is a similar shape but with a slightly lower growing stock in the long term. The aspatial total conifer growing stock in the THLB has not been assessed to ensure that the growing stock is maintained over a 400 year planning horizon.

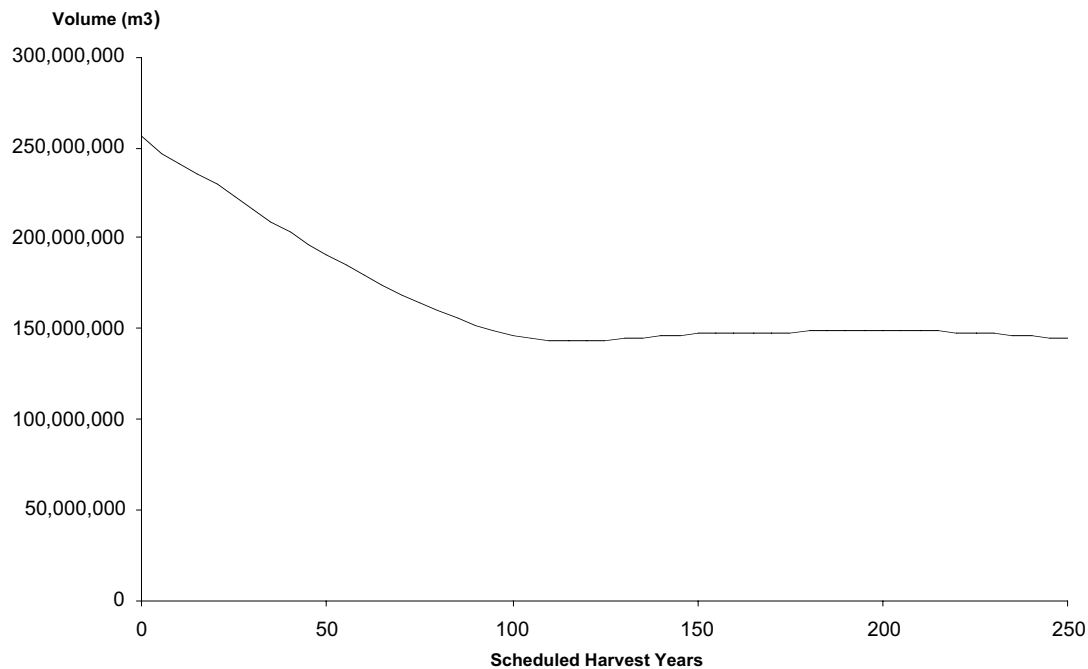


Figure 8. Type 2 Spatial Base Case Total Conifer Growing Stock in THLB

The harvest flow for the deciduous partition in the Mackenzie TSA is outlined *Figure 9*. The total deciduous growing stock in the THLB increases in an upward trend. The harvest flow and growing stock information is not provided for the remaining learning scenarios because the same harvest flow target of 50,000 m³/yr is met in all scenarios and the resulting growing stock levels are very similar.

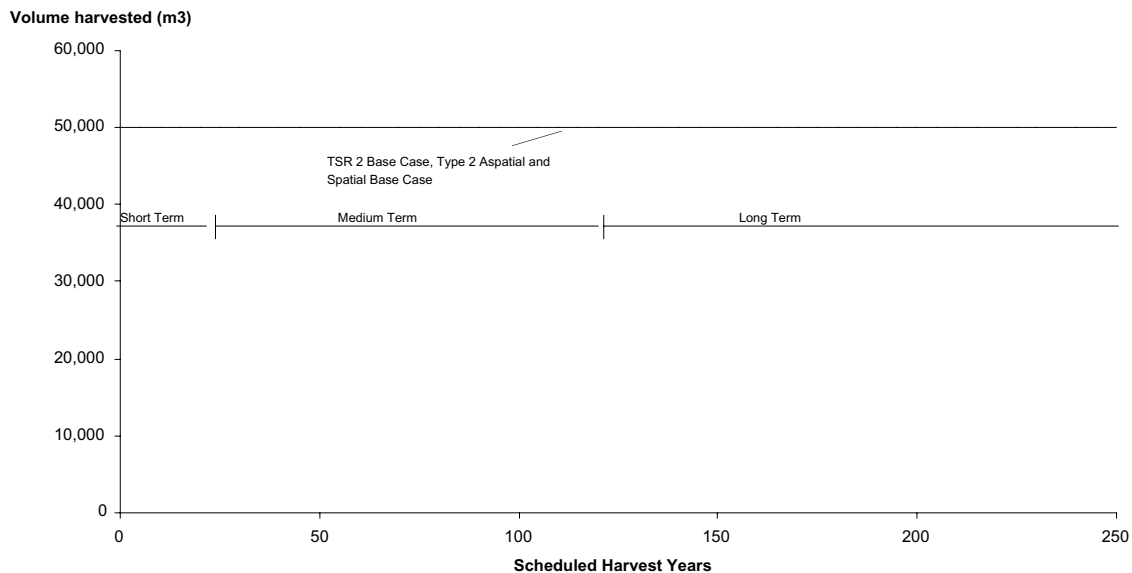


Figure 9. Type 2 Spatial Base Case Deciduous Partition Harvest Flow

Figures 10, 11 and 12 show the average harvest age per period, average harvest volume per hectare per period and average area harvested per period for the spatial base case. Average harvest age, average harvest volume per hectare and average area harvested are not provided for the learning scenarios to focus available funds on the decision scenarios.

Figure 10 shows that the average age of harvested stands for the first period (five years) is 239 years. This decreases to 187 years at year 30, with an increase to 223 years at year 35. The average harvest age then steadily declines to 151 years at year 100. From year 100 onwards, the average harvest age remains between 114 years at year 250 and 156 years at year 125. By year 100, harvesting of predominantly old forests has finished and forests are being harvested closer to their minimum harvest age. This is to be expected since the transition of harvest flow contribution from natural to managed stands is well underway at this point in the projection. In comparison, TSR2 has an initial harvest age slightly over 200 years old, declining to an average harvest age near 120 years in year 140.

Table 9 identifies that the average area weighted age at the beginning of the planning horizon is 122 years, and the area weighted minimum harvest age for natural stands is 107 years. After the first harvest, the managed stand minimum harvest age decreases to an area weighted age of 79 years. As the model harvests stands using the relative oldest first harvest rule, this table identifies that poor site spruce and poor site balsam on conventional ground in the near zone have the oldest relative age of 89 years and 76 years respectively. As a result, those stands located in areas that meet the targets (such as seral stage distribution) will be the first stands available for harvest.

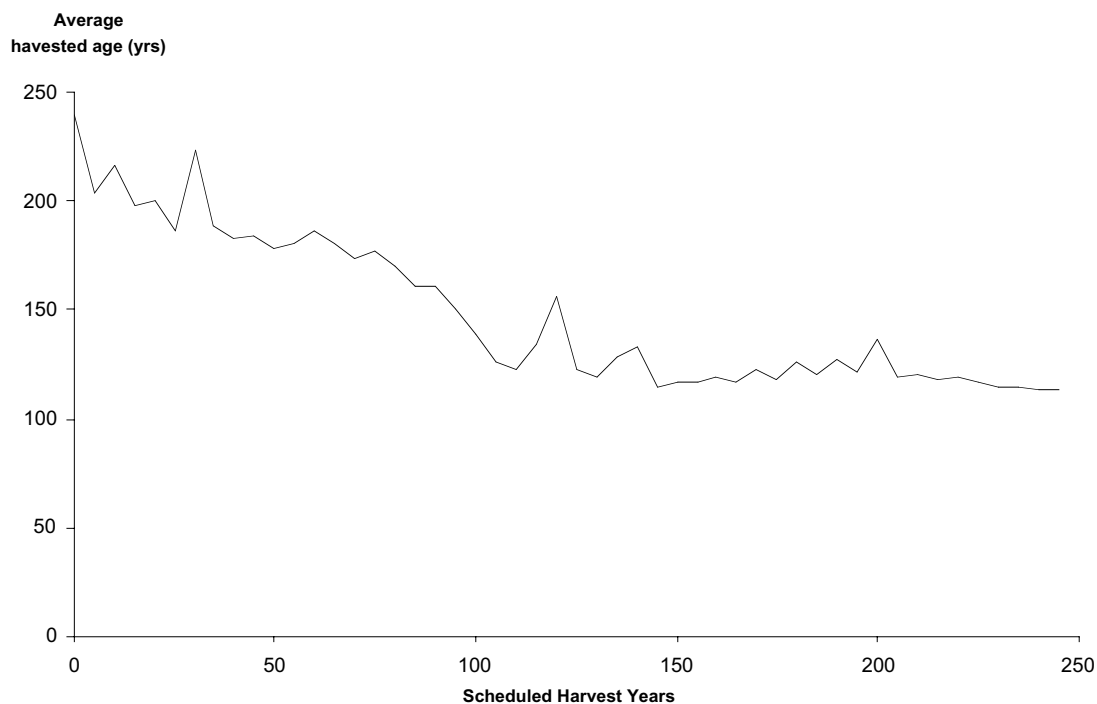


Figure 10. Type 2 Spatial Base Case Average Harvested Age

Table 9. Area Weighted Age, Minimum Harvest Age and Relative Age by Leading Species, Site Class, Haul Zone and Harvest Method

Harvest Method	Haul Zone	Leading Species	Site Quality	Future Operable	Area Weighted Average Age	Minimum Harvest Age	Relative Age
Conventional	Near	Spruce	Poor	97,876	229	140	89
Conventional	Near	Balsam	Poor	44,074	226	150	76
Conventional	Far	Spruce	Poor	10,016	220	170	50
Conv_Cable	Near	Spruce	Poor	37,151	218	170	48
Conventional	Far	Pine	Poor	4,889	149	110	39
Conventional	Near	Balsam	Medium	32,533	146	110	36
Conventional	Far	Spruce	Medium	4,385	145	110	35
Conventional	Near	Pine	Poor	88,080	134	100	34
Conv_Cable	Near	Balsam	Poor	36,799	216	190	26
Cable	Near	Spruce	Good	1,815	114	90	24
Cable	Near	Spruce	Medium	8,161	143	120	23
Conv_Cable	Near	Spruce	Medium	60,655	131	110	21
Conventional	Near	Pine	Good	161,178	80	60	20
Cable	Near	Spruce	Poor	2,901	219	200	19
Conv_Cable	Near	Spruce	Good	12,187	97	80	17
Conventional	Far	Spruce	Good	783	96	80	16
Conv_Cable	Near	Pine	Good	26,278	85	70	15
Conventional	Near	Spruce	Good	69,059	84	70	14
Conventional	Near	Spruce	Medium	168,070	102	90	12
Conv_Cable	Near	Pine	Medium	43,960	101	90	11
Conv_Cable	Near	Balsam	Medium	36,730	141	130	11
Conventional	Near	Pine	Medium	221,681	90	80	10
Conventional	Near	Deciduous	Good	41,612	70	60	10
Conv_Cable	Near	Pine	Poor	20,303	127	120	7
Conventional	Far	Pine	Medium	9,010	83	80	3
Conventional	Near	Balsam	Good	17,992	77	80	(3)
Conv_Cable	Near	Balsam	Good	12,416	86	90	(4)
Conventional	Far	Pine	Good	2,354	60	65	(5)
Cable	Near	Balsam	Good	5,295	83	110	(27)
Cable	Near	Pine	Poor	78	100	140	(40)
Conventional	Far	Balsam	Good	87	43	90	(47)
Cable	Near	Balsam	Medium	989	65	160	(95)
Conventional	Far	Balsam	Medium	15	33	130	(97)
		Other	Other	12,968	91	1000	(909)
Grand Total				1,292,379	122	107	

Figure 11 shows the average harvested volume per hectare. In the first period the average volume per hectare harvested is 320 m³/ha and varies from 287 to 330 m³/ha for the first 100 years. After year 100, the average volume per hectare decreases to its lowest volume at year 160 of 276 m³/ha before increasing again to remain near 300 m³/ha for the remainder of the planning horizon. The average volume per hectare harvested decreases somewhat over time as the forests are converted from primarily old forests to younger managed forests. The volume per hectare dramatically decreases between years 130 and 205. The rationale for this decline is discussed in more detail in relation to the area harvested per period (Figure 12).

While the average volume per hectare at harvest decreases by roughly 3% through the transition from natural to managed stands, it is interesting to note that the average age at harvest decreases by 45% as is shown in Figure 10. The analysis assumes that harvesting will focus on the oldest stands first (through the relative oldest first harvest schedule) and that managed stands grow at a significantly higher rate than natural stands. While natural stands are still being harvested, the volume in managed stands is able to increase to higher levels. As a result, when the harvest of managed stands increases, the volume per hectare remains fairly constant, but the harvest age decreases substantially.

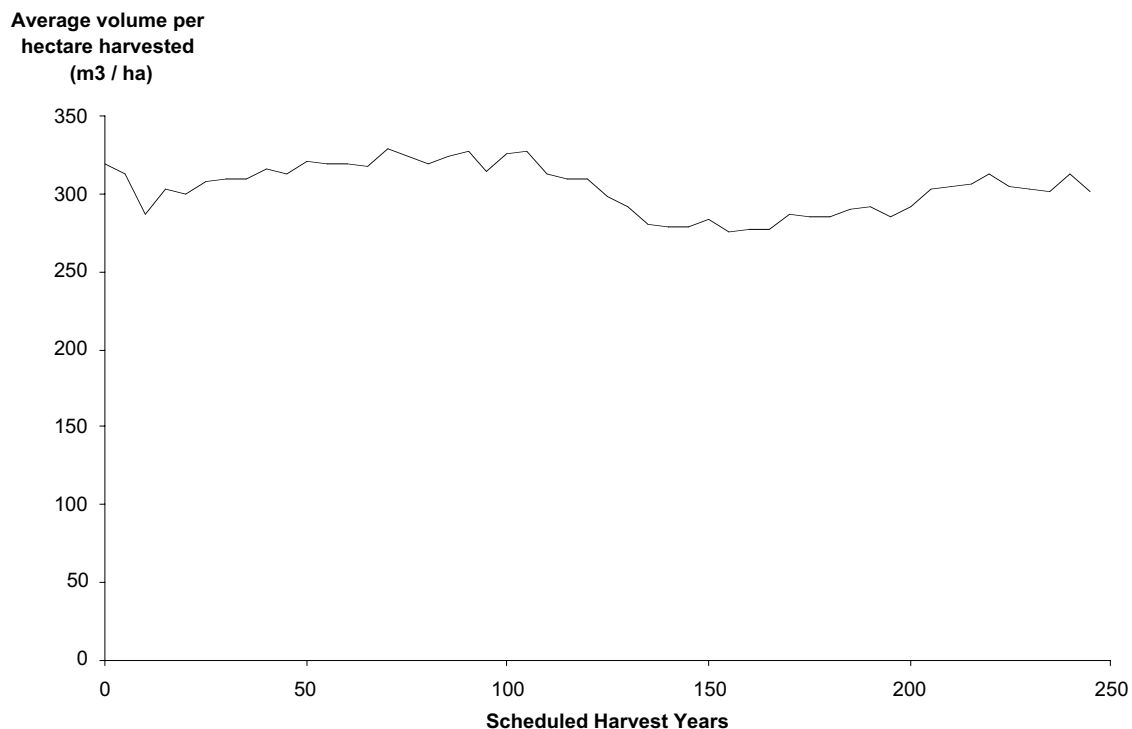


Figure 11. Type 2 Spatial Base Case Average Harvested Volume per Hectare

Figure 12 identifies the average area harvested each five year period. In the first period, 50,261 hectares is harvested. This increases to 56,089 hectares by year 15. This is consistent with Figure 11, showing the average volume per hectare harvested is low at 287 m³/ha. When the volume per hectare decreases, the area harvested must increase at a corresponding rate in order to maintain the harvest flow. Up to year 100, the average area harvested ranges between 48,800 and 56,090 hectares, averaging at 48,760 hectares. After year 100, the average area harvested increases to between 49,450 and 56,400 hectares, averaging at 52,700 hectares. Between years 130 and 205, there is an increase in the area harvested, and is consistent with a decrease in the volume per hectare harvested.

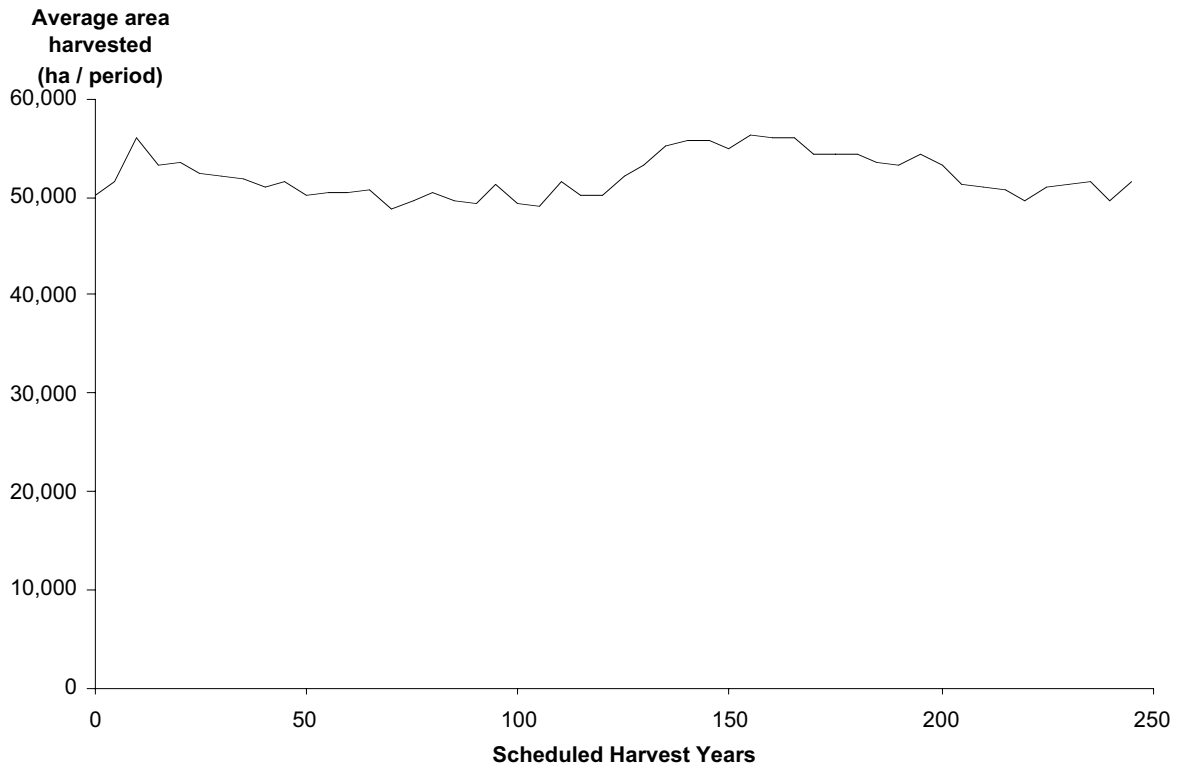


Figure 12. Type 2 Spatial Base Case Average Area Harvested

Figure 13 identifies the area harvested by period for pine, balsam and spruce. Please note that although this information discusses harvest of balsam over multiple periods, this is not entirely accurate. As a result of the regeneration assumptions (see *Mackenzie TSA Type 2 Incremental Silviculture Analysis*), stands that are currently balsam leading will be converted to spruce leading stands after the first harvest. As a result, after year 140, more than 80% of the balsam leading stands have been converted to spruce leading. By year 250, 95% of balsam leading stands have been converted to spruce leading.

A review of the average age harvested, volume per hectare harvested and area harvested for the 400 year planning horizon, reveals that the large increase in area harvested is not repeated after year 250. Between years 250 and 400, the average age harvested ranges between 110 and 118 years; the volume per hectare harvested changes by no more than 5% from year 250, ranging from 287 m³/ha to 305 m³/ha and the area harvested increases by no more than 8% from year 250, ranging from 51,270 hectares to 55,840 hectares.

Figures 14 to 16 provide the percent harvest distribution of balsam, spruce, and pine harvested by site class. As identified in Figure 12, year 15 has a dramatic increase in area harvested. Figure 13 shows that the increase in area harvested at year 15 is a result of an increase in spruce harvested; while Figure 15 shows that a dramatic increase in poor site spruce is harvested at year 15.

Figure 13 also shows that the dramatic increase in area harvested between years 130 and 205 (as identified in Figure 12), results from an increase in spruce and balsam harvested. Figures 14 and 15 identify that poor site spruce and poor site balsam are heavily harvested during this time frame. These graphs also show that the harvest of poor site balsam and spruce is cyclical for the first two rotations, and the second increase in harvest of poor site balsam and spruce occurs primarily in second growth stands. Harvest of poor site balsam and spruce harvest almost entirely consists of the second harvest of these poor sites. Figure 16 shows that the harvest of pine in all site classes is relatively evenly distributed across the planning horizon.

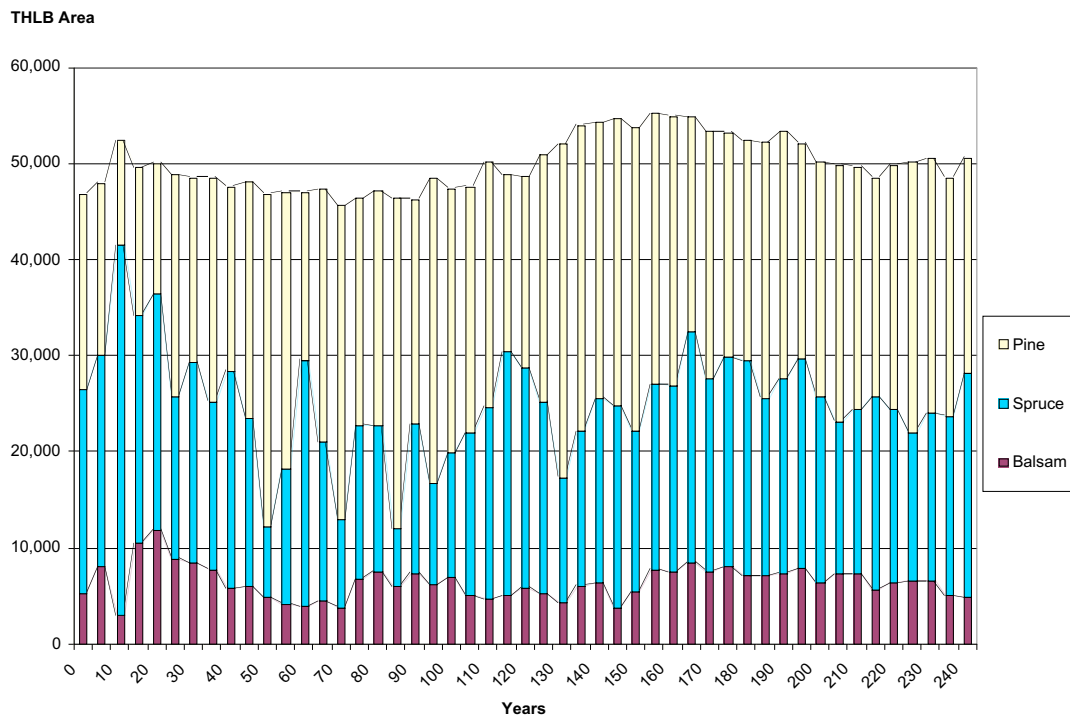


Figure 13. Area of Pine, Spruce and Balsam Harvested in the Spatial Base Case

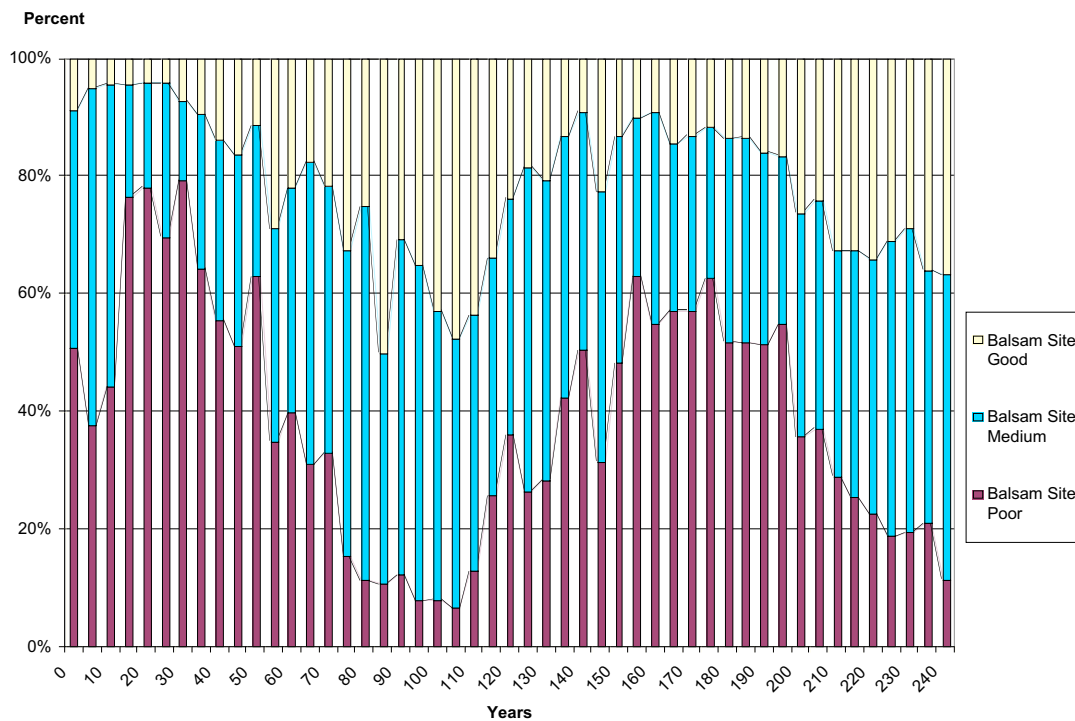


Figure 14. Percent Balsam Harvested in the Spatial Base Case by Site Class

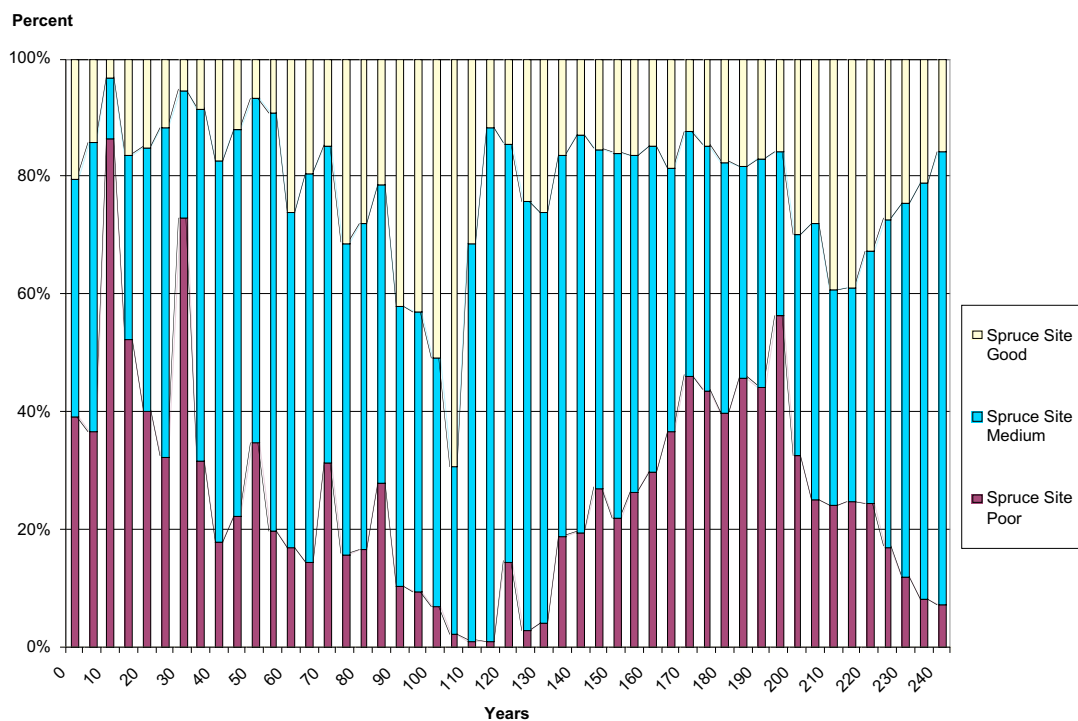


Figure 15. Percent Spruce Harvested in the Spatial Base Case by Site Class

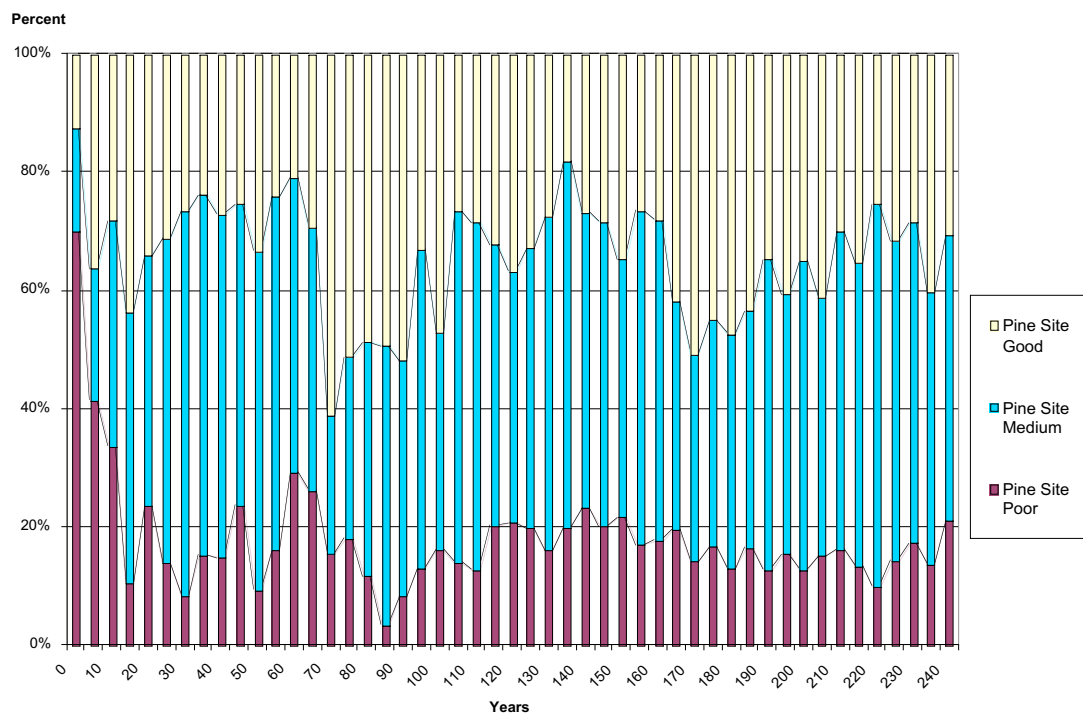


Figure 16. Percent Pine Harvested in the Spatial Base Case by Site Class

6.4.1.1.2. Indicator Target Results

A detailed assessment of impacts on targets is provided in *Section 6.6.3.3 Indicator Target Results*. This section identifies the number of targets that exceed the target limits by biogeoclimatic zone for seral stage and by VQO class for maximum allowable disturbance for this scenario.

At the beginning of the planning horizon, 54% of the THLB is unavailable for timber harvesting as a result of seral stage targets (66% of the targets), and 8% of the THLB associated with VQO targets (16% of the targets). By year 50, 16% of the future THLB is unavailable for timber harvesting of which almost 60% becomes available for timber harvesting between years 31 and 40. By year 100, 3% of the future THLB is available for timber harvesting, of which almost 50% of the area becoming available between years 71 and 80.

6.4.1.2. Discussion of Base Case Results

These figures illustrate an important timber supply dynamic that occurs in this harvest forecast – the harvest of poor productivity spruce and balsam stands.

In the first 60 years, a high concentration of poor site spruce and poor site balsam is harvested. These stands are the oldest stands relative to their minimum harvest age, and are the first stands to be targeted by the model for harvest, if they meet other target requirements, such as seral stage. Between years 11 and 15 a higher concentration of poor site spruce is harvested than in the surrounding periods, causing a sharp increase in the area harvested and harvest age with a corresponding decrease in volume per hectare. This increase in poor site spruce is a result of 11 old and mature plus old seral targets being met at year 10

(four in the ESSF, four in the BWBS, and three in the SBS). As spruce consists of almost 65% of the BWBS and ESSF zones this availability in area allows poor site spruce to be available for harvest.

Between years 130 and 205, there is a second sharp increase in the area harvested and corresponding decrease in volume per hectare harvested. However, in this situation, the average harvest age remains similar to the surrounding periods. During this time frame, poor site spruce and poor site balsam are a substantial component of the harvest. More than 95% of the poor site spruce and balsam harvested during this time period is receiving its second harvest. A review of the results across the 400 year planning horizon show that the dramatic increase in area harvested between years 130 and 205 is not repeated because all stands are now managed, so the relative ages are similar among leading species and site classes. As a result, the volume per hectare harvested and area harvested varies by no more than 5% from year 250 and the area harvested increases by no more than 8% from year 250.

6.4.2. Partial Harvest in Visually Sensitive Areas

For the purpose of modelling partial harvest silvicultural systems in visually sensitive areas, a group selection silviculture system is applied. With this system, it is assumed that managed stand regeneration within group selection openings regenerate at the same rate as stands regenerating in a larger clearcuts. Therefore, no modifications are required to the managed stand yield curves to account for possible decreases in regeneration growth rates within partially harvested areas.

In addition, it is assumed that partial harvesting is evenly distributed across each stand within each visual quality polygon.

6.4.2.1. Harvest Eligibility

Stands are eligible for harvest if the following criteria are met. First, the stands must achieve minimum harvest age as defined by the analysis unit assigned to them. Second, the total volume in the visual quality objective (VQO) polygon must be at least greater than or equal to the total volume that would be present if all stands were at their minimum harvest age according to the analysis unit assigned to them. This criterion is intended to ensure that the total biomass and visual texture of the VQO polygon remains largely constant throughout the planning horizon.

A third criteria identified in the *Mackenzie TSA Type 2 Incremental Silviculture Data Inputs and Assumptions* report was not applied due to model limitations for partial harvest silvicultural systems at the time of scenario preparation. This tool is now available. This criteria requires that harvest re-entry within a stand is not permitted until 75% of the stand has reached five metres (called visual effective green-up). The intent of this criterion is to ensure that harvest re-entry into a stand is not permitted until there is sufficient forest cover to block the view of harvesting activities, such as stumps, logging debris, skid trails and bare ground.

This is different than adjacency green-up in clearcut silvicultural systems. Adjacency green-up means that an adjacent treatment unit is not available for harvest until the treatment unit in question reaches a certain height. Visual effective green-up as it pertains to partial harvesting, means that a re-entry into a treatment unit is not permitted until a majority of the treatment unit meets the height requirements. This does not affect the models ability to harvest two treatment units adjacent to each other in the same time frame.

Even though the visual effective green-up height was not applied, the maximum allowable disturbance and the minimum volume requirements ensure that the VQO polygons are not harvested repeatedly in short periods of time.

6.4.2.2. Maximum Allowable Disturbance

In TSR2 where clearcut harvesting is prescribed, a level of maximum allowable disturbance is assessed on all visually sensitive areas in the TSA with the limits defined on the basis of the visual quality class. Consistent with TSR2, and following the criteria provided in Table 1 of *Procedures for Factoring Visual Resources into Timber Supply Analyses*, March 17, 1998, the maximum percent volume removal per entry is applied. See the *Mackenzie TSA Type 2 Incremental Silviculture Data Inputs and Assumptions* report for more information.

Table 10 provides the maximum percent removal by visual quality class.

Table 10. Percent Removal for Partial Harvest of VQO Zones

Visual Quality Objective Classes	Area Weighted Average Height (m)	Maximum Percent Removal
Preservation	18.8	10 %
Retention	16.9	20 %
Partial Retention	17.0	55 %
Modification	17.0	85 %
Maximum Modification	13.4	90 %

6.4.2.3. Results

Figure 17 shows that a 0.5% increase in the long term harvest level is possible when partial harvesting is applied within visually sensitive areas. The area where VQOs have been defined in the Mackenzie TSA is relatively small and concentrated in the southern portion of the TSA (23,956 ha or 2% of the current THLB). As a result, the change in available volume of applying this treatment is minimal because the majority of the TSA is responding in the same manner as the base case.

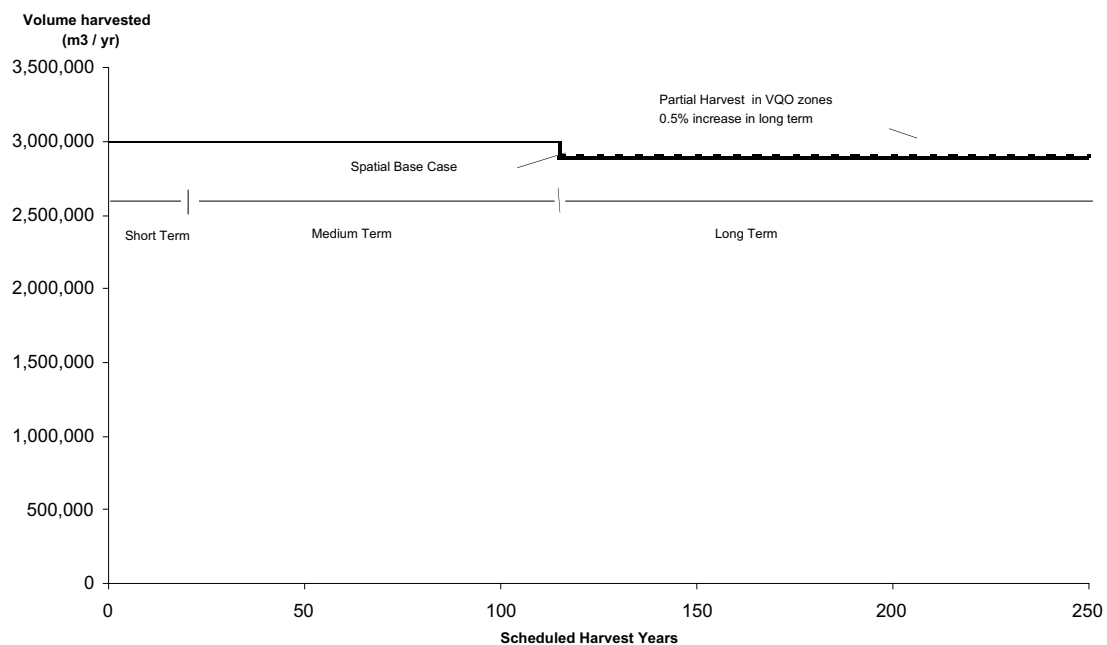


Figure 17. Partial Harvest in VQOs Harvest Flow Compared with Type 2 Spatial Base Case

Figure 18 provides the total coniferous growing stock within the THLB. This is presented to confirm that the harvest flow maintains a sustainable growing stock across the planning horizon. Figure 18 illustrates how THLB growing stock declines through the short and mid-terms and stabilizes in the long term. An additional model run extending the projection period to a 400 year planning horizon verifies that the long term harvest level is sustainable and that overall long term growing stock is stable.

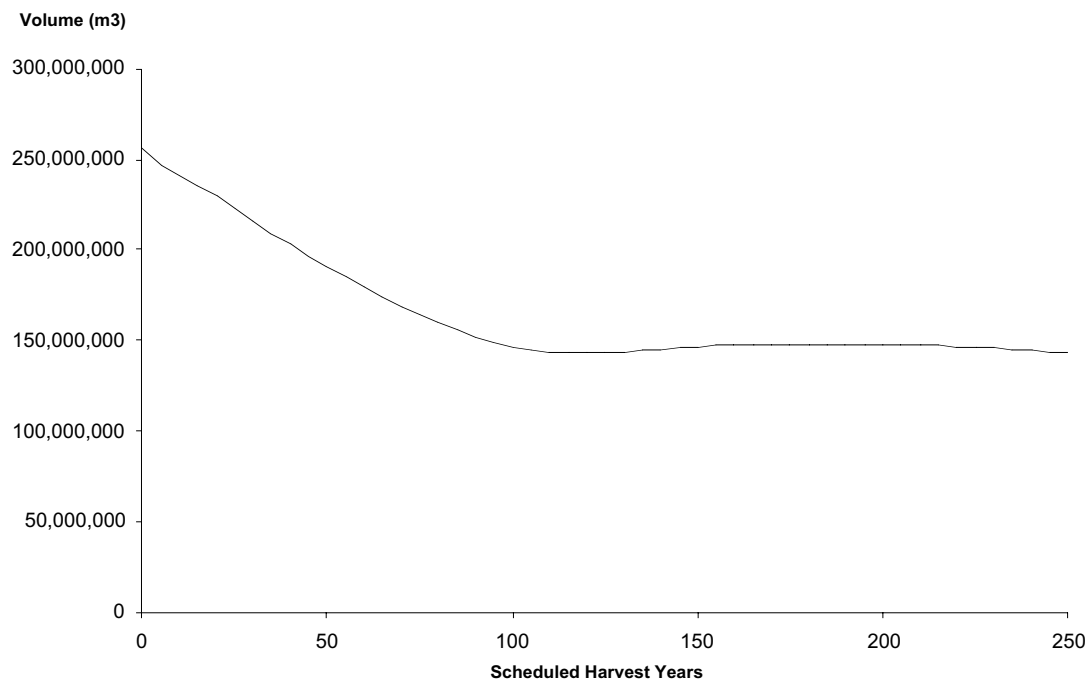


Figure 18. Partial Harvest Total Conifer Growing Stock in the THLB

A detailed assessment of impacts on targets is provided in *Section 6.6.3. Indicator Target Results* identifies the number of targets that exceed the target limits by biogeoclimatic zone for seral stage and by VQO class for maximum allowable disturbance for this scenario. At the beginning of the planning horizon, timber harvesting is unavailable in 54% of the THLB area associated with seral stage targets (66% of the targets), and 0.7% of the THLB associated with VQO targets is unavailable for timber harvesting (5% of the targets) when partial harvesting in visually sensitive areas is applied.

By year 50, 16% of the future THLB is unavailable for timber harvesting of which almost 60% becomes available for timber harvesting between years 31 and 40. By year 100, 3% of the future THLB is available for timber harvesting, of which almost 50% of the area becoming available between years 71 and 80. All VQO targets are met by year 31

Illustrations 3 and 4 provide examples of three dimensional image rendering to show the impact of partial harvesting at a rate of 80% volume removal per entry within a modification VQO. Note that this example is taken from the Robson Valley Enhanced Forest Management Pilot Project Scenario Planning Project where very similar partial harvest assumptions are applied using TSM. It should also be noted that an additional 5% volume removal is applied in this analysis for modification VQOs. One hundred and fifty years occur between the two partial harvest entries shown.

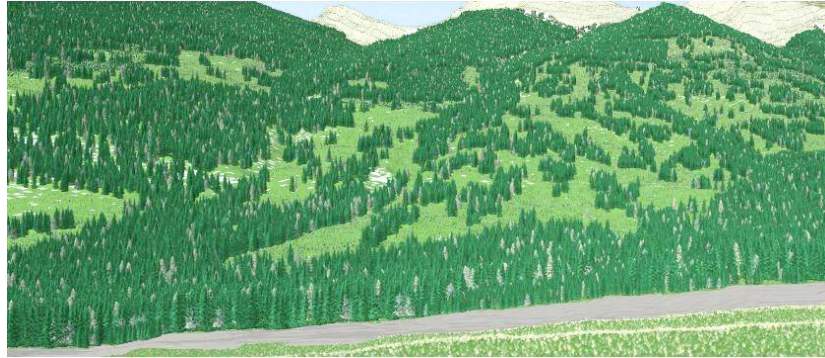


Illustration 3. Modification Partial Harvest 1st pass

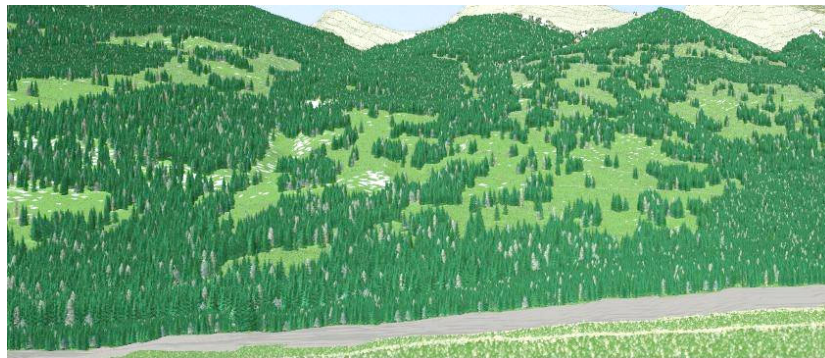


Illustration 4. Modification Partial Harvest 2nd pass

6.4.3. Late Rotation Fertilization Pine Leading

Late rotation fertilization is intended to provide an increase in volume shortly before harvest for a quick return on investment. As well, late fertilization can bridge harvest flow gaps in the short and midterm while having no impact on harvest flow in the long term.

6.4.3.1. Harvest Eligibility

The candidate area for treatment is all existing unmanaged pine leading medium site index sites (19% of the THLB), the lower 25% of existing unmanaged pine leading good sites (4% of the THLB), and the upper 25% of existing unmanaged pine leading poor sites (2% of the THLB). There are 321,483 hectares available for late rotation fertilization.

6.4.3.2. Treatment

TIPSY assumes a 15 m³/ha increase in volume when fertilization treatments are applied. Using TIPSY, new yield curves for these candidate areas are generated, reflecting a 15 m³/ha increase during specific age periods. For good sites, yield increases are applied between 80 and 220 years; and for medium sites, yield increases were applied 110 and 250 years. For poor sites, yield increases were to be applied between 130 and 210 years, however, this was inadvertently omitted. All candidate stands are placed on the late fertilization curves at the commencement of the planning horizon. Once the stands reach 80 years

old on good sites and 110 years old on medium sites, volume gains are realized until such time as the stands reach 110 years old on good sites, 250 years old on medium sites, or are harvested.

The treatment assumptions used in this scenario have not been confirmed with District staff to ensure that these volume gains are achievable.

6.4.3.3. Results

As late fertilization is only applied on existing stands, the response is only realized in the short and mid term before the forests are converted to managed stands. The base case forecast shows no gaps in timber supply (see *Section 6.4.1 Aspatial and Spatial Base Case*) or age classes (see *Section 6.2 Composition of the Forest*); as a result, this treatment increases the timber supply by 4% to 3,124,169 m³/yr in the short and mid term (*Figure 19*). The harvest flow decreases to the base case long term harvest level of 2,887,358 m³/yr at year 116. The rate of decline is 7% and is within the harvest flow objective that the maximum decrease is 10% per decade.

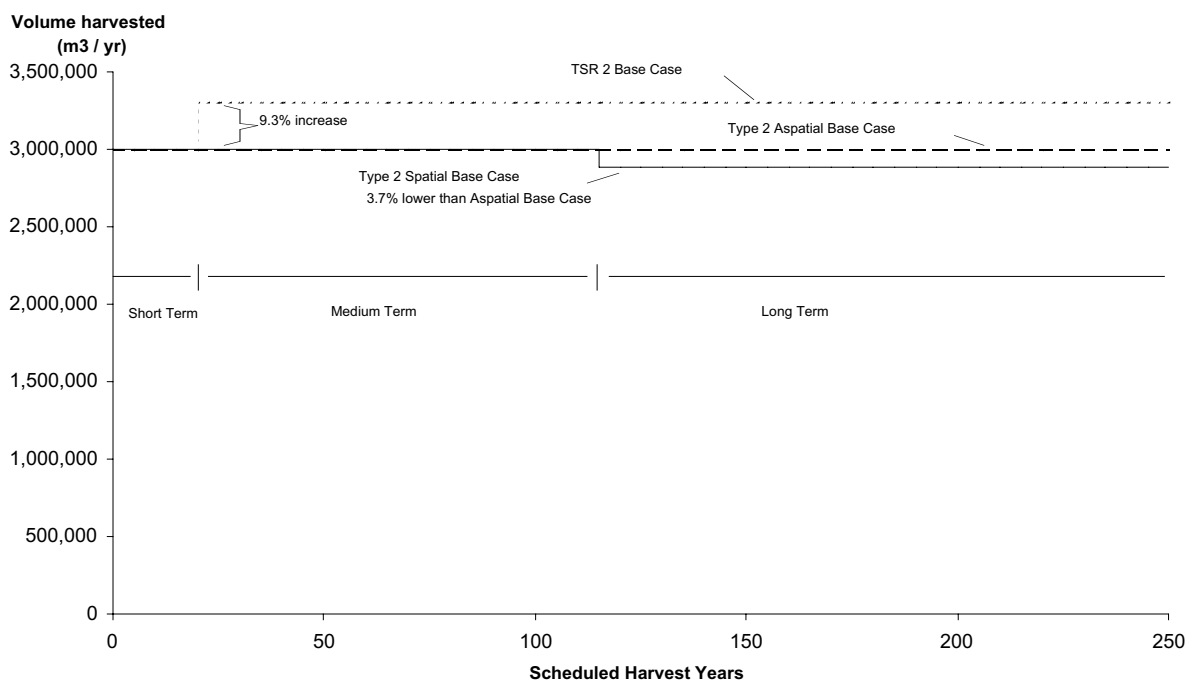


Figure 19. Late Rotation Fertilization of Pine Leading Stands Harvest Flow Compared with Type 2 Spatial Base Case

If volume gains had been applied to the highest 25% of poor site pine, an additional increase in harvest flow may have been realized. However, these poor sites account for only 2% of the THLB, so it is anticipated that the increase would be relatively small.

Figure 20 provides the total coniferous growing stock within the THLB. This is presented to confirm that the harvest flow maintains a sustainable growing stock across the planning horizon. Figure 20 illustrates how THLB growing stock declines through the short and mid-terms and stabilizes in the long term. An additional model run extending the projection period to a 400 year planning horizon verifies that the long term harvest level is sustainable and that overall long term growing stock is stable.

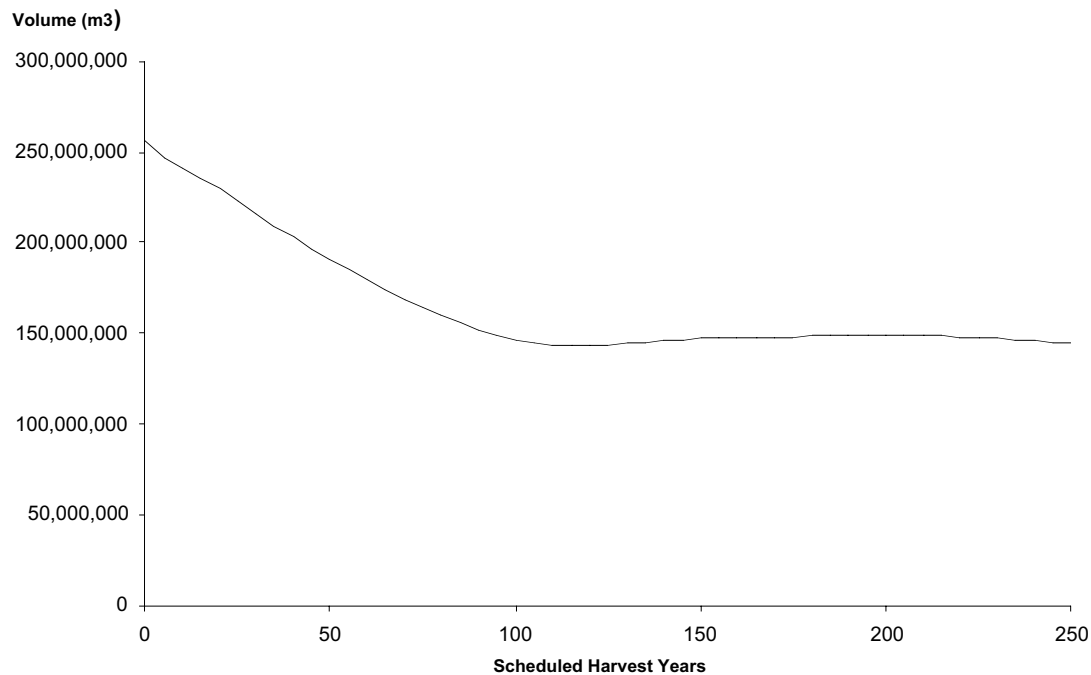


Figure 20. Late Fertilization of Pine Leading Stands Total Conifer Growing Stock in THLB

The area of late fertilization pine stands treated within the first 20 years is 29,484 hectares. Table 11 provides a breakdown of the area harvested in the first 20 years that received increased volume gains for late fertilization prior to harvest.

Table 11. Late Rotation Pine Area Fertilized and Harvested

Year	Area Treated
1 – 5	4,041 ha
6 – 10	9,933 ha
11 – 15	5,341 ha
16 - 20	10,169 ha
Total	29,484 ha

A detailed assessment of impacts on targets is provided in Section 6.6.3.3 *Indicator Target Results*. This section identifies the number of targets that exceed the target limits by biogeoclimatic zone for seral stage and by VQO class for maximum allowable disturbance for this scenario.

At the beginning of the planning horizon, 54% of the THLB is unavailable for timber harvesting as a result of seral stage targets (66% of the targets), and 8% of the THLB associated with VQO targets (16% of the targets). By year 50, 16% of the future THLB is unavailable for timber harvesting of which almost 60% becomes available for timber harvesting between years 31 and 40. By year 100, 3% of the future THLB is available for timber harvesting, of which almost 50% of the area becoming available between years 71 and 80.

6.4.3.4. Cost and Employment Benefits

The *Mackenzie TSA Silviculture Strategy (Type 1)*, February 2000, report provides costs (\$400 per hectare) and job creation estimates (0.1 job days per hectare) for late fertilization of pine.

These values were provided during workshop sessions in the Fall of 1999. The job creation estimates are based on TSR1 employment coefficients and have not been confirmed. TSR2 employment coefficients apply 0.01 full time person years of employment per 1,000 m³ of volume harvested, which is identical to the coefficient provided in TSR1. As no new information is available on employment coefficients, the values provided through the Type 1 analysis will be used.

Table 12 identifies the area treated for each five year period in the first 20 years, the cost per period, the employment gained per period and an investment assessment of this scenario.

The area treated for late fertilization pine stands within the first 20 years is 29,484 hectares, with 4,041 hectares being treated in the first five years.

Assuming a cost of \$400 per hectare, the average cost within the first 20 years may be \$12 million. Within the next five years, late rotation pine fertilization may cost \$1.6 million, with an average annual cost of \$323,280.

Assuming an employment coefficient of 0.1 job days per hectare, 2,948 job days (or 13 full time jobs) may be generated over the next 20 years. Within the next five years, 404 job days (or 1.8 full time jobs) may be created. Annually, an average of 80 job days may be created (or 0.3 full time jobs) for the next five years. Full time employment is defined as the number of job days divided by 222 work days per year.

The investment assessment is the volume gain compared with the money spent of applying late fertilization and is calculated by dividing the cost per period by the gain in volume harvested between the spatial base case and late fertilization. The incremental volume gain per period compared to the spatial base case is 634,030 m³. The area weighted average investment assessment for the first 20 years may be \$5/m³.

Table 12. Cost, Employment and Investment Assessment for Late Fertilization

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$ / m ³)
1 – 5	4,041 ha	1,616,400	404	2.55
6 – 10	9,933 ha	3,973,200	993	6.27
11 – 15	5,341 ha	2,136,400	534	3.37
16 - 20	10,169 ha	4,067,600	1,017	6.41
Total	29,484 ha	11,793,600	2,948	18.60

6.4.4. Repeat Fertilization Pine Leading

Repeat fertilization is designed to increase stand growth compared to unfertilized stands over an extended period of time, thereby decreasing rotation length.

6.4.4.1. Harvest Eligibility

The candidate area for treatment is all existing managed and future managed pine leading medium site index sites (21% of the THLB), the lower 25% of existing managed and future managed pine leading good sites (4% of the THLB), and the upper 25% of existing managed and future managed pine leading poor sites (2% of the THLB). There are 349,930 hectares of candidate area available for repeat fertilization of pine.

6.4.4.2. Treatment

Stands are fertilized at age 20, 30, 40, 50 and 60 with the maximum response occurring approximately 10 years after the last entry. Over time, the effect of fertilizer subsides and is eventually eliminated due to converging stand dynamics. In order to reap the benefit of this fertilization regime, harvesting must occur close to the maximum response point to receive the largest return on investment.

Les Herring, RPF, Research Silviculturist – Northern Interior Forest Region provided response curves for medium site index pine sites. This information has been extrapolated to good and poor sites. Field confirmation has not been completed to ensure that extrapolation of this response is reasonable.

The response of fertilization is relatively significant with the response reaching a 29% increase 10 years after the fifth application (at year 70). Refer to *Figure 21*.

Within each rotation stands are fertilized five times. Stands can also be harvested multiple times, that is, have multiple rotations over the planning horizon of 250 years. As a result, a stand could have up to 30 fertilization treatments over the planning horizon.

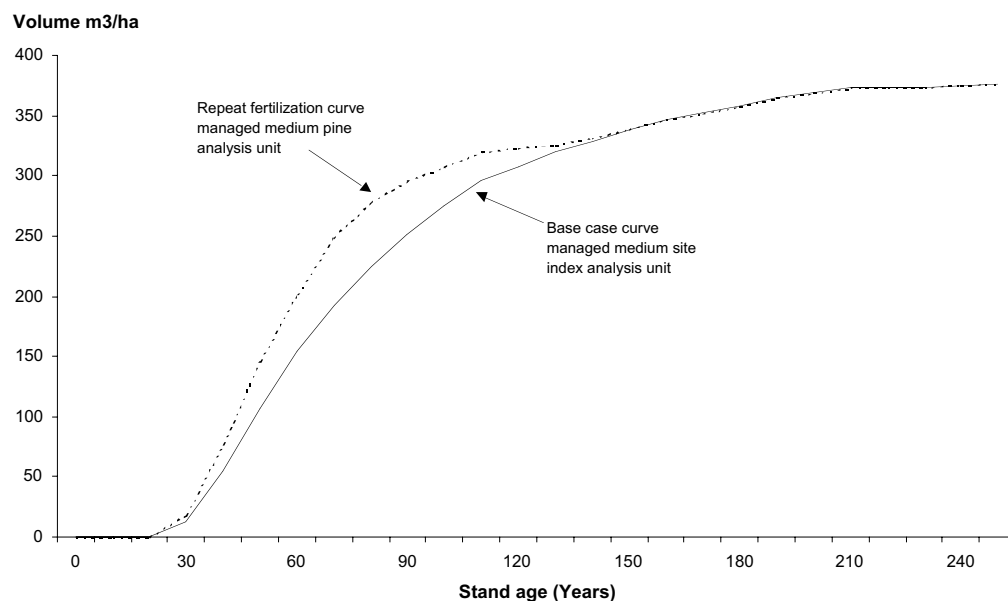


Figure 21. Fertilization Response Curve for Medium Site Index Pine Analysis Unit

6.4.4.3. Results

Figure 22 shows that repeat fertilization on pine causes the harvest flow to increase by 1.3% to 3,035,405 m³/yr over the spatial base case in the short and mid-term and 5.1% in the long term. As existing managed pine stands, as well as future managed pine stands are being treated, this provides the opportunity to increase timber supply across the planning horizon.

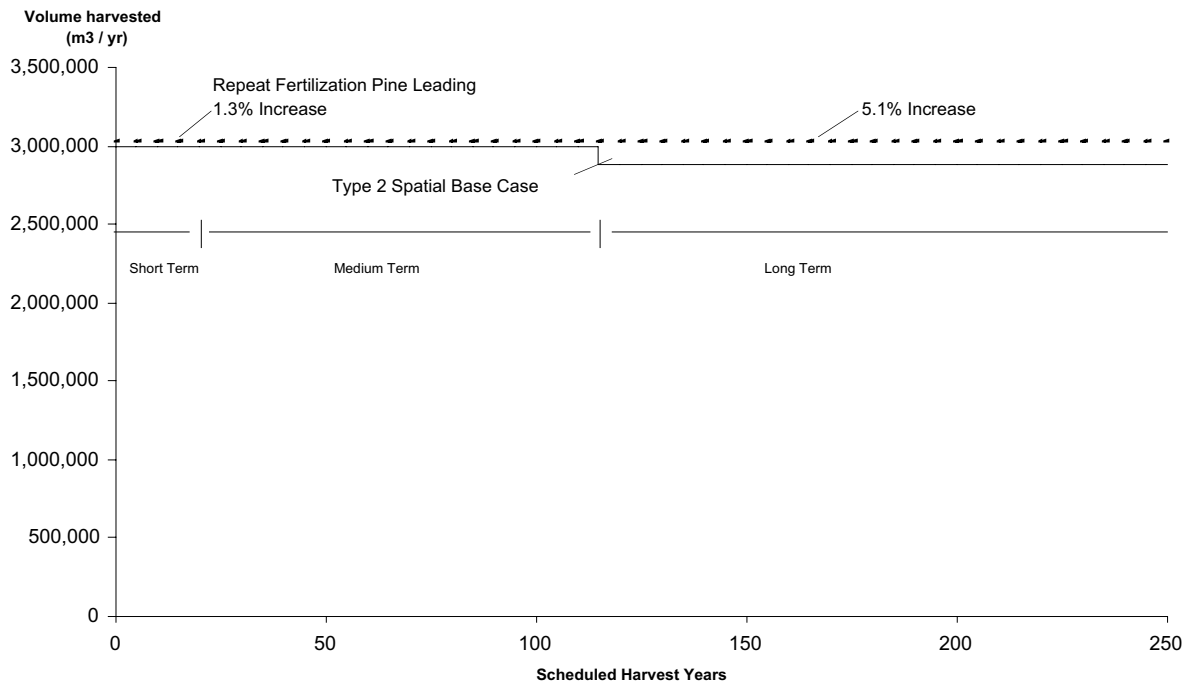


Figure 22. Repeat Fertilization Pine Leading Harvest Flow Compared with Type 2 Spatial Base Case

Figure 23 provides the total coniferous growing stock within the THLB. This is presented to confirm that the harvest flow maintains a sustainable growing stock across the planning horizon. Figure 23 illustrates how THLB growing stock declines through the short and mid-terms and stabilizes in the long term. An additional model run extending the projection period to a 400 year planning horizon verifies that the long term harvest level is sustainable and that overall long term growing stock is stable.

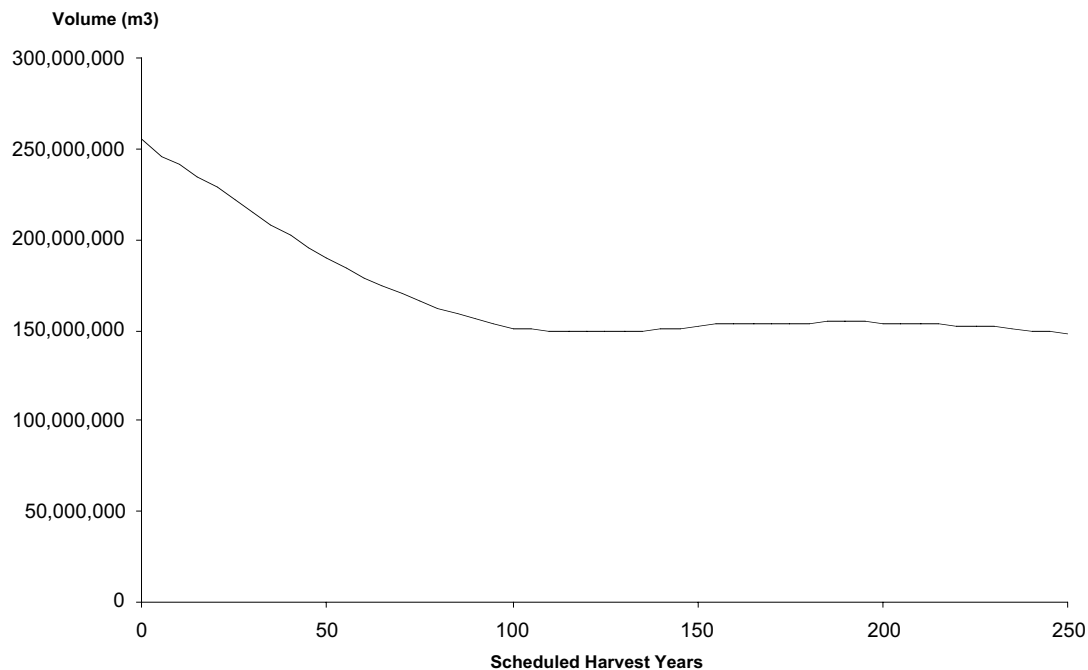


Figure 23. Repeat Fertilization Pine Leading Total Conifer Growing Stock in THLB

Table 13 shows the area of pine fertilized in each period for the first 20 years. This includes managed stands that are age 20, 30, 40, 50 or 60 between these time periods, as well as candidate stands harvested in the first five years that become eligible for fertilization at year 20. Within the first 20 years, 32,095 hectares of land base is fertilized, with 10,930 hectares treated twice. As a result, 43,025 hectares are fertilized. In year 20, 16,480 hectares of existing managed stands are fertilized, and 4,135 hectares were harvested in period 1 and available for fertilization at year 20.

Table 13. Repeat Pine Area Fertilized

Year	Area Treated	Area Treated Twice
1 – 5	3,461 ha	
6 – 10	7,469 ha	
11 – 15	11,480 ha	3,461 ha
16 - 20	20,615 ha	7,469 ha
Total	43,025 ha	10,930 ha

Section 6.6.4 identifies the number of targets that exceed the target limits by biogeoclimatic zone for seral stage and by VQO class for maximum allowable disturbance for this scenario.

At the beginning of the planning horizon, 54% of the THLB is unavailable for timber harvesting as a result of seral stage targets (66% of the targets), and 8% of the THLB associated with VQO targets (16% of the targets). By year 50, 16% of the future THLB is unavailable for timber harvesting of which almost 60% becomes available for timber harvesting between years 31 and 40. By year 100, 3% of the future THLB is available for timber harvesting, of which almost 50% of the area becoming available between years 71 and 80.

6.4.4.4. Cost and Employment Benefits

The *Mackenzie TSA Silviculture Strategy (Type 1)*, February 2000, report provides costs (\$400 per hectare) and job creation estimates (0.1 job days per hectare) for repeat fertilization of pine.

These values were provided during workshop sessions in the Fall of 1999. The job creation estimates are based on TSR1 employment coefficients and have not been confirmed. TSR2 employment coefficients apply 0.01 full time person years of employment per 1,000 m³ of volume harvested, which is identical to the coefficient provided in TSR1. As no new information is available on employment coefficients, the values provided through the Type 1 analysis will be used.

Table 14 identifies the area treated for each five year period in the first 20 years, the cost per period, the employment gained per period and an investment assessment of this scenario.

Within the first 20 years, 43,025 hectares are fertilized, with 3,461 hectares fertilized within the first five years.

Assuming a cost of \$400 per hectare, the average cost with the first 20 years may be \$17 million. Within the next five years, repeat fertilization of pine may cost \$1.3 million, with an average annual cost of \$276,880.

Assuming an employment coefficient of 0.1 job days per hectare, 4,302 job days may be created over the first 20 years (or 19 full time jobs) may be generated over the next 20 years. Within the next five years, 346 job days may be created (or 1.5 full time jobs). Annually, an average of 69 job days may be created (or 0.3 full time jobs) for the next five years. Full time employment is defined as the number of job days divided by 222 work days per year.

The investment assessment is the volume gain compared with the money spent of applying repeat fertilization of pine and is calculated by dividing the cost per period by the gain in volume harvested between the spatial base case and repeat fertilization of pine. The area weighted average investment assessment for the first 20 years may be \$31/m³.

Table 14. Cost, Employment and Investment Assessment for Repeat Fertilization of Pine

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$ / m ³)
1 – 5	3,461 ha	1,384,400	346	7.28
6 – 10	7,469 ha	2,987,600	747	15.71
11 – 15	11,480 ha	4,592,000	1,148	24.14
16 - 20	20,615 ha	8,244,800	2,061	43.35
Total	43,025 ha	17,210,000	4,302	90.48

6.4.5. Repeat Fertilization Pine and Spruce Leading

Repeat fertilization is designed to increase stand growth compared to unfertilized stands over an extended period of time, thereby decreasing rotation length. Rotation length is determined by the amount of volume available for harvest, which translates into an increase in site index as increases in volume occur in conjunction with increases in height.

6.4.5.1. Harvest Eligibility

The candidate area for treatment is existing managed and future managed pine, spruce and balsam leading medium site index sites (45% of the THLB), the lower 25% of existing managed and future managed pine, spruce and balsam leading good sites (6% of the THLB), the upper 25% of existing managed and future managed pine, spruce and balsam leading poor sites (7% of the THLB). There are 746,350 hectares of candidate area available for repeat fertilization of pine and spruce. The candidate area is divided into 350,175 hectares of pine, 299,014 hectares of spruce, and 97,161 hectares of balsam that will be converted to spruce plantations after the first rotation, and will be fertilized in future rotations.

Existing managed stands will be fertilized as they reach the age requirements, while existing unmanaged stands are harvested in the first rotation, followed by fertilization in future rotations. Existing unmanaged balsam stands receive fertilization treatments in future rotations because they regenerate to 100% spruce, consistent with the TSR2 management assumptions.

6.4.5.2. Treatment

Stands are fertilized at age 20, 30, 40, 50 and 60 with the maximum response occurring approximately 10 years after the last entry. Over time, the effect of fertilizer subsidies and is eventually eliminated due to converging stand dynamics. In order to reap the benefit of this fertilization regime, harvesting must occur close to the maximum response point to receive the largest return on investment. The response of fertilization is relatively significant with the response reaching 29% increase 10 years after the fifth application. Refer to *Figure 21*.

Les Herring, RPF, Research Silviculturist – Northern Interior Forest Region provided response curves for medium site index pine sites. This information has been extrapolated to good and poor sites for pine and good, medium and poor sites for spruce. Field confirmation has not been completed to ensure that extrapolation of this response is reasonable.

Within each rotation, stands are fertilized five times. Stands can also be harvested multiple times, that is, having multiple rotations over the planning horizon of 250 years. As a result, a stand could have up to 30 fertilization treatments over the planning horizon.

6.4.5.3. Results

Figure 24 shows that the harvest flow can be increased by 2.5% to 3,071,802 m³/yr in the short and mid term and 6.4% in the long term. This provides the opportunity to increase timber supply across the planning horizon. Repeat fertilization of spruce stands provide an additional 1.2% increase over repeat fertilization of pine in the short and mid term.

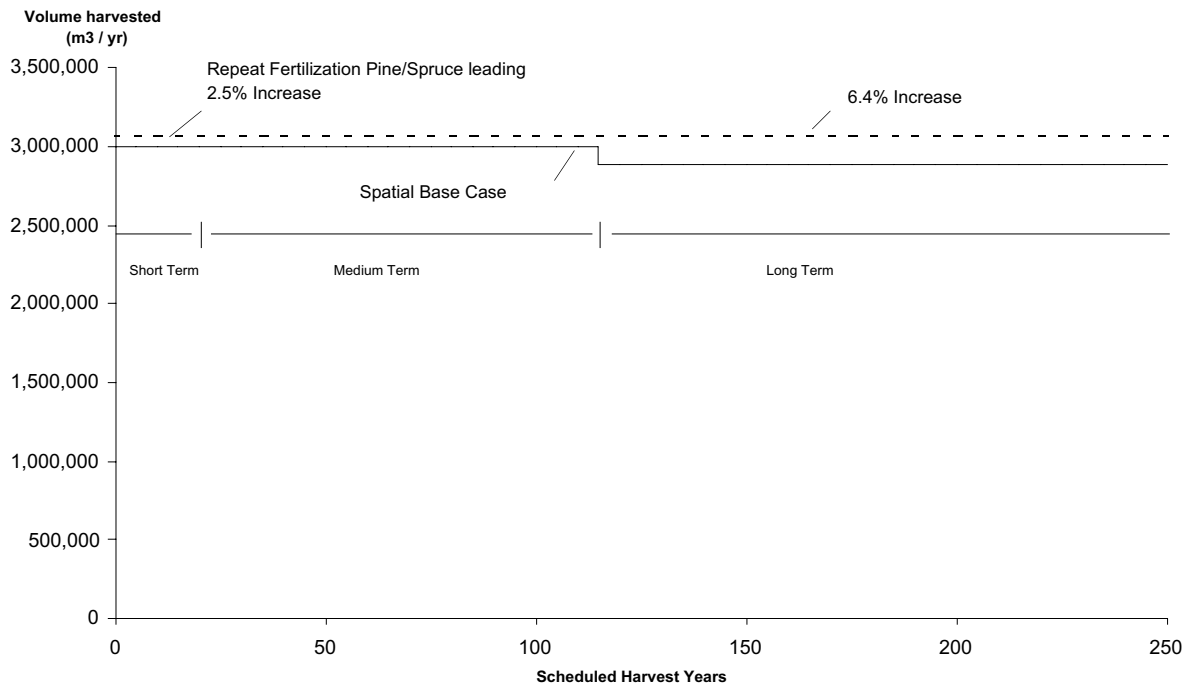


Figure 24. Repeat Fertilization Pine and Spruce Leading Species Harvest Flow Compared with Type 2 Spatial Base Case

Figure 25 provides the total coniferous growing stock within the THLB. This is presented to confirm that the harvest flow maintains a sustainable growing stock across the planning horizon. Figure 25 illustrates how THLB growing stock declines through the short and mid-terms and stabilizes in the long term. An additional model run extending the projection period to a 400 year planning horizon verifies that the long term harvest level is sustainable and that overall long term growing stock is stable.

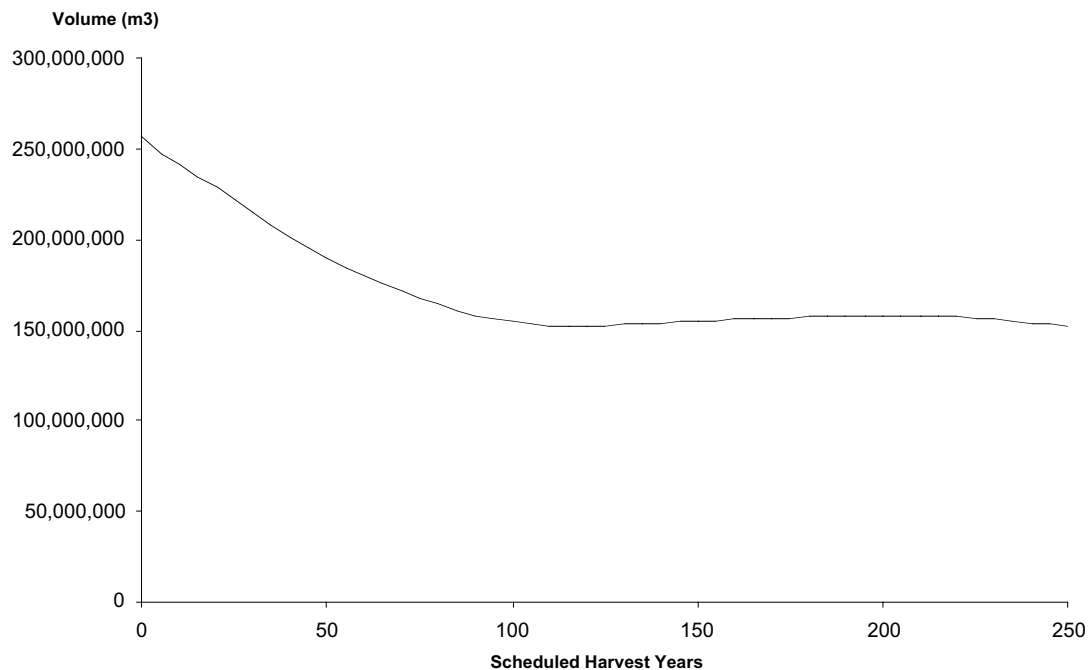


Figure 25. Repeat Fertilization Pine and Spruce Leading Species Total Conifer Growing Stock in THLB

Table 15 provides a breakdown of the area fertilized by period. This includes managed stands that are age 20, 30, 40, 50 or 60 between these time periods, as well as candidate stands harvested in the first five years, which become eligible for fertilization at year 20.

In year 20, 39,812 hectares of existing managed stands are fertilized, while 20,094 hectares are harvested in first five years that are available for fertilization at year 20. Within the first 20 years, 92,761 hectares of forest is fertilized of which 17,272 hectares are fertilized twice. As a result, a total of 110,033 hectares are fertilized.

Table 15. Repeat Pine and Spruce Area Fertilized

Year	Area Treated	Area Treated Twice
1 – 5	5,922 ha	
6 – 10	11,350 ha	
11 – 15	32,855 ha	5,922 ha
16 - 20	59,906 ha	11,350 ha
Total	110,033 ha	17,272 ha

A detailed assessment of impacts on targets is provided in *Section 6.6.3.3 Indicator Target Results*. This section identifies the number of targets that exceed the target limits by biogeoclimatic zone for seral stage and by VQO class for maximum allowable disturbance for this scenario.

At the beginning of the planning horizon, 54% of the THLB is unavailable for timber harvesting as a result of seral stage targets (66% of the targets), and 8% of the THLB associated with VQO targets (16% of the targets). By year 50, 16% of the future THLB is unavailable for timber harvesting of which almost 60% becomes available for timber harvesting between years 31 and 40. By year 100, 3% of the future THLB is available for timber harvesting, of which almost 50% of the area becoming available between years 71 and 80.

6.4.5.4. Cost and Employment Benefits

The *Mackenzie TSA Silviculture Strategy (Type 1)*, February 2000, report provides costs (\$400 per hectare) and job creation estimates (0.1 job days per hectare) for repeat fertilization of pine and spruce.

These values were provided during workshop sessions in the Fall of 1999. The job creation estimates are based on TSR1 employment coefficients and have not been confirmed. TSR2 employment coefficients apply 0.01 full time person years of employment per 1,000 m³ of volume harvested, which is identical to the coefficient provided in TSR1. As no new information is available on employment coefficients, the values provided through the Type 1 analysis will be used.

Table 16 identifies the area treated for each five year period in the first 20 years, the cost per period, the employment gained per period and an assessment of the benefit of this scenario.

The area fertilized within the first 20 years is 110,033 hectares, with 5,922 hectares being fertilized in the first five years.

Assuming a cost of \$400 per hectare, the average cost within the first 20 years will be \$44 million. Within the next five years, repeat fertilization of pine and spruce will cost \$2.3 million, with an average annual cost of \$473,760.

Assuming an employment coefficient of 0.1 job days per hectare, 11,003 job days may be created over 20 years (or 49 full time jobs). Within the next five years, 592 job days may be created (2.6 full time jobs). Annually, an average of 118 job days may be created (or 0.5 full time jobs) for the next five years. Full time employment is defined as the number of job days divided by 222 work days per year.

The investment assessment is the volume gain compared with the money spent of applying repeat fertilization of pine and spruce and is calculated by dividing the cost per period by the gain in volume harvested between the spatial base case and repeat fertilization of pine and spruce. The area weighted average investment assessment for the first 20 years may be \$47 per cubic metre.

Table 16. Cost, Employment and Investment Assessment for Repeat Fertilization of Pine and Spruce

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$ / m ³)
1 – 5	5,922 ha	2,368,800	592	6.36
6 – 10	11,350 ha	4,540,000	1,135	12.20
11 – 15	32,855 ha	13,142,000	3,285	35.31
16 - 20	59,906 ha	23,962,400	5,991	64.38
Total	110,033 ha	44,013,200	11,003	118.25

6.4.6. Genetic Worth

Genetically improved stock refers to seedlings that have been sowed from seeds of the best trees in the same seed planning zone. Planting of genetically improved stock is expected to increase height growth, which in turn increases volume.

6.4.6.1. Harvest Eligibility

The candidate area for treatment is 75% of future managed pine stands below 1,200 metres in elevation (30% of the THLB), 75% of future managed spruce stands below 1,200 metres (18% of the THLB) and 75% of future managed spruce stands above 1,200 metres (18% of the THLB). The entire candidate area is 853,682 hectares. There are 386,074 hectares of low elevation pine candidate area; 230,846 hectares of low elevation spruce candidate area, and 236,762 hectares of high elevation spruce candidate area.

Pine stands above 1,200 metres are not included in the harvest eligibility as they have not been evaluated for estimated gains with genetically improved stock. Although existing balsam stands get converted to 100% spruce after the first harvest, these stands are not planted with genetically improved stock as their location is considered unacceptable based on biogeoclimatic zones. Existing unmanaged and managed stands are not immediately eligible as only future reforestation efforts benefit from genetically improved stock.

6.4.6.2. Treatment

The treatment regime is based upon information received from the Tree Improvement Branch of the BC Ministry of Forests pertaining to genetic worth gains expected from planting Class A seed germinated stock. The Prince George Seed Planning Zone is used to evaluate the potential genetic worth values for lodgepole pine and white spruce Class A seed plantations. For lodgepole pine seedlings planted below 1,200 metres, a 7% increase in the primary trait, height growth, of this stock is assumed. For white spruce, the genetic worth increase for the primary trait is assumed to be 21% for low elevation (below 1,200 metres) and 16% for high elevation (above 1,200 metres).

6.4.6.3. Results

Figure 26 shows a 6.6% increase in harvest flow to 3,077,088 m³/yr in the long term, while maintaining a sustainable growing stock. The short and mid-term harvest levels do not increase. The substantial increase in the long term is a result of the large proportion of the land base being treated. Although stands are being regenerated with genetically improved stock in the short term, this gain is being distributed across the planning horizon and provides a higher long term gain.

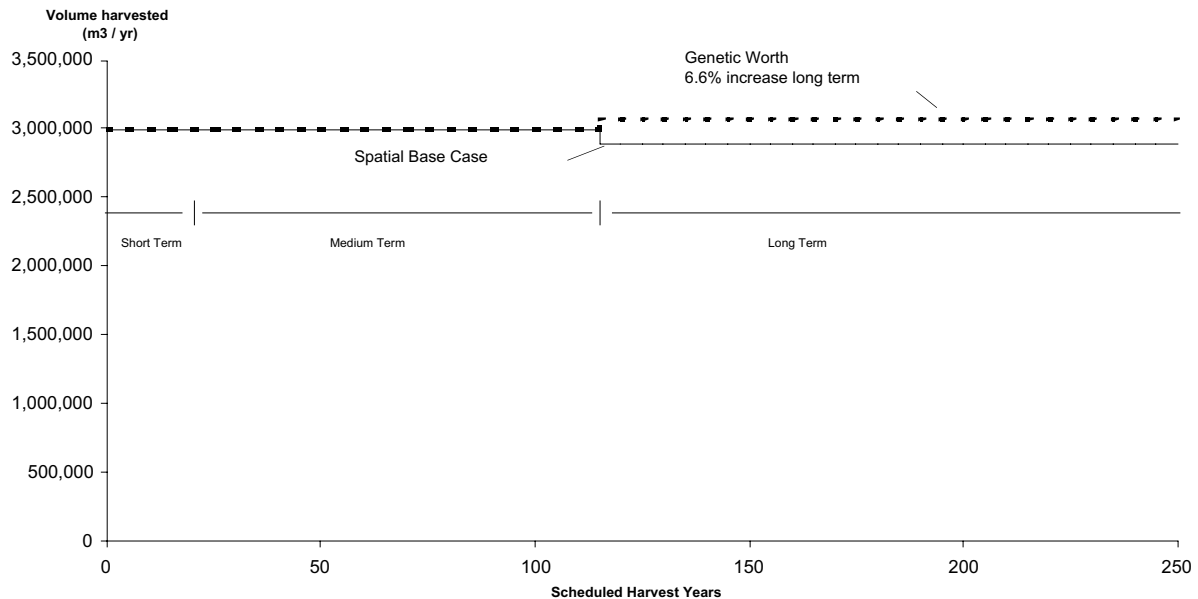


Figure 26. Genetic Worth Harvest Flow Compared with Type 2 Spatial Base Case

Figure 27 provides the total coniferous growing stock within the THLB. This is presented to confirm that the harvest flow maintains a sustainable growing stock across the planning horizon. Figure 27 illustrates how THLB growing stock declines through the short and mid-terms and stabilizes in the long term. An additional model run extending the projection period to a 400 year planning horizon verifies that the long term harvest level is sustainable and that overall long term growing stock is stable.

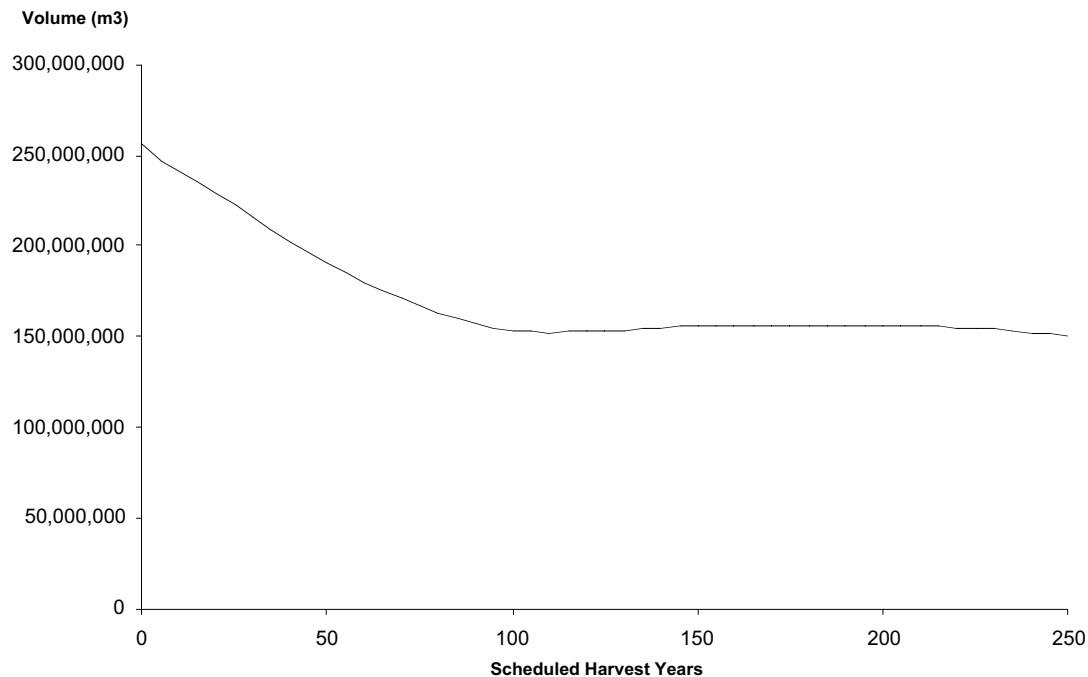


Figure 27. Genetic Worth Total Conifer Growing Stock in THLB

Table 17 provides a summary of the area planted with genetically improved stock. Within the first 20 years, 145,336 hectares are planted with genetically improved stock. Within the first five years, 32,567 hectares are planted of which 11,363 hectares of genetically improved pine is planted, and 21,204 hectares of genetically improved spruce is planted. The earliest opportunity to achieve a return on investment (that is, re-harvest a stand that has been previously planted with genetically improved stock) is 65 years. The longest time to achieve a return on investment is 235 years.

Table 17. Area Planted with Genetically Improved Stock

Year	Area Treated
1 – 5	32,567 ha
6 – 10	32,307 ha
11 – 15	46,032 ha
16 - 20	34,430 ha
Total	145,336 ha

A detailed assessment of impacts on targets is provided in *Section 6.6.3.3 Indicator Target Results*. This section identifies the number of targets that exceed the target limits by biogeoclimatic zone for seral stage and by VQO class for maximum allowable disturbance for this scenario.

At the beginning of the planning horizon, 54% of the THLB is unavailable for timber harvesting as a result of seral stage targets (66% of the targets), and 8% of the THLB associated with VQO targets (16% of the targets). By year 50, 16% of the future THLB is unavailable for timber harvesting of which almost 60% becomes available for timber harvesting between years 31 and 40. By year 100, 3% of the future THLB is available for timber harvesting, of which almost 50% of the area becoming available between years 71 and 80.

6.4.6.4. Cost and Employment Benefits

The Mackenzie TSA Silviculture Strategy (Type 1), February 2000, report provides costs (\$100 per hectare) and job creation estimates (2.0 job days per hectare) for planting of genetically improved stock. The cost and job creation estimates do not specify if they are additive to the existing cost of purchasing and planting seedlings. It is assumed that these costs and job creation estimates are additive to current planting costs.

These values were provided during workshop sessions in the Fall of 1999. The job creation estimates are based on TSR1 employment coefficients and have not been confirmed. TSR2 employment coefficients apply 0.01 full time person years of employment per 1,000 m³ of volume harvested, which is identical to the coefficient provided in TSR1. As no new information is available on employment coefficients, the values provided through the Type 1 analysis will be used.

Table 18 identifies the area treated for each five year period in the first 20 years, the cost per period, the employment gained per period and an investment assessment of this scenario.

Within the first 20 years, 145,336 hectares are planted with genetically improved stock, with 32,567 hectares planted in the first five years.

Assuming a cost of \$100 per hectare, the average cost within the first 20 years will be an additional \$14 million (above current silviculture costs). Within the next five years, planting genetically improved stock will require an additional \$3.2 million, with an average annual cost of \$651,340.

Assuming that two job days are created per hectare planted, over the next 20 years, 290,672 job days may be created (or 1,309 full time jobs). Within the next five years, 65,134 job days may be created (293 full time jobs). Annually, an average of 13,026 job days may be created (or 58 days full time jobs) for the next five years. Full time employment is defined as the number of job days divided by 222 work days per year.

The investment assessment is the volume gain compared with the money spent of planting genetically improved stock and is calculated by dividing the cost per period by the gain in volume harvested between the spatial base case and genetic worth. As the genetic worth harvest flow maintains the spatial base case harvest flow, in order to realize a higher gain in the long term, it is not possible to calculate the investment assessment in the first 20 years of the planning horizon. The amount of the short term gain can only be quantified if a different harvest flow objective is applied.

Table 18. Cost, Employment and Investment Assessment for Genetically Improved Stock

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$ / m ³)
1 – 5	32,567 ha	3,256,700	65,134	
6 – 10	32,307 ha	3,230,700	64,614	
11 – 15	46,032 ha	4,603,200	92,064	
16 - 20	34,430 ha	3,443,000	68,860	
	145,336 ha	14,533,600	290,672	

6.5. Discussion of Learning Scenario Results

Table 19 provides a summary of the harvest flows achieved under the different learning scenarios. Tables 20, 21 and 22 outline the cost, jobs created and investment assessment in the different learning scenarios.

Table 19 shows the largest increase in harvest flow in the short term results from applying late fertilization on pine. The largest increase in harvest flow in the long term results from planting of genetically improved stock, followed by repeat fertilization of pine and spruce.

Table 19. Harvest Flows for each Learning Scenario

Scenario	Harvest Per Year		% Change from Type 2 Base Case	
	Now till Year 115	Year 116 +	Now till Year 115	Year 116 +
TSR 2 Base Case	2,997,363	3,305,000		
Spatial Base Case	2,997,363	2,887,358		
Partial Harvest in VQOs	2,997,363	2,902,659	0.0%	0.5%
Late Fertilization	3,124,169	2,887,358	4.2%	0.0%
Repeat Fertilization Pine	3,035,405	3,035,405	1.3%	5.1%
Repeat Fertilization Pine and Spruce	3,071,802	3,071,862	2.5%	6.4%
Genetic Worth	2,997,363	3,077,088	0.0%	6.6%

Table 20 identifies that the most cost effective treatment is planting of genetically improved stock. The cost of employing fertilization treatments is entirely dependent on the size of the area treated, thus increases and decreases are proportional to the area fertilized.

Table 20. Cost of Incremental Silviculture Activities

Scenario	Area Treated		Cost Per Hectare	Average Annual Cost	Cost	
	1 - 5 Years	1 - 20 Years			Cost over 5 years	Cost over 20 years
Late Fertilization	4,041	29,484	400	323,280	1.6 million	12 million
Repeat Fertilization Pine	3,461	43,025	400	276,880	1.3 million	17 million
Repeat Fertilization Pine and Spruce	5,922	110,033	400	473,760	2.4 million	44 million
Genetic Worth	32,567	145,336	100	651,340	3.2 million	14 million

Table 21 identifies that the most job days are created through planting of genetically improved stock. With the assumption that full time employment is 222 days per year, the number of full time jobs created in the first year is: 0.3 for late fertilization, 0.3 for repeat fertilization of pine; 0.5 for repeat fertilization of pine and spruce and 58 for planting of genetically improved stock.

Table 21. Job Days Created During Incremental Silviculture Activities

Scenario	Area Treated		Jobs			
	1 - 5 Years	1 - 20 Years	Job Days Per Hectare	Average Annual Job Days	Job Days over 5 years	Job Days over 20 years
Late Fertilization	4,041	29,484	0.1	80	404	2,948
Repeat Fertilization Pine	3,461	43,025	0.1	69	346	4,302
Repeat Fertilization Pine and Spruce	5,922	110,033	0.1	118	592	11,003
Genetic Worth	32,567	145,336	2.0	13,026	65,134	290,672

Table 22 highlights that late fertilization on pine provides the best return on investment in the short term. Table 22 does not provide data for genetic worth as the harvest flow in the short term is identical to the spatial base case. Therefore, the amount of the short term gain can only be quantified if a different harvest flow objective is applied.

Table 22. Investment Assessment of Incremental Silviculture Activities

Scenario	Area Treated		Investment Assessment		
	1 - 5 Years	1 - 20 Years	Investment over 5 years	Investment over 20 years	Area Weighted Average Across 20 years
Late Fertilization	4,041	29,484	2.55	18.60	5
Repeat Fertilization Pine	3,461	43,025	7.28	90.48	31
Repeat Fertilization Pine and Spruce	5,922	110,033	6.35	118.25	47
Genetic Worth	32,567	145,336			

In the short term, late fertilization of pine provides the highest harvest flow, the lowest cost as well as the greatest return on investment, however, with the smallest increase in employment. It is important to note that the volume increases applied for late fertilization have not been verified in relation to operational reality. The 15m³/ha increase in volume is the default volume gain identified through TIPSy for fertilization. In addition, all candidate late fertilization stands are assigned to the revised yield curves at the beginning of the planning horizon. If the stands are between 80 and 210 years old for good sites, and 110 and 250 years old for medium sites, then volume gains are applied immediately and remain in place until such time as the stand ages beyond these limits or is harvested. As a result, a confirmation of volume gains and length of time associated with those gains should be assessed prior to silviculture investment.

Repeat fertilization of pine and spruce provides the second highest gain in harvest flow in the short term, and the highest gains in employment. However, in that same period, the cost and return on investment are the highest of all the learning scenarios. As the response curves from medium pine sites have been extrapolated to good and poor sites for pine, and good, medium and poor sites from spruce, this should be examined for operational relevance prior to silviculture investment.

6.6. Decision Scenarios

Following discussions with *Les Herring, RPF*, Research Silviculturist – Northern Interior Forest Region, the following scenarios are combined and applied in the decision scenario:

- late fertilization on pine,
- repeat fertilization on pine and spruce; and
- genetic worth.

Partial harvesting in VQO zones is not applied due to the small area associated with VQO zones and the limited timber supply gain (0.5% increase). Repeat fertilization on pine is already included in repeat fertilization in pine and spruce.

Two decision scenarios are implemented: decision scenario 1 treats 100% of the fertilization and genetic worth candidate area, while decision scenario 2 treats 50% of the fertilization and genetic worth candidate area. Two decision scenarios are applied to assess the impact of applying silviculture investment on a portion of the candidate area. The candidate area in decision scenario 2 is assigned so that each candidate area receives approximately 50% of the original candidate area. A random number generator is used to identify the specific polygons.

6.6.1. Harvest Eligibility

Late Fertilization

The candidate area for treatment is all existing unmanaged pine leading medium site index sites (19% of the THLB), the lower 25% of existing unmanaged pine leading good sites (4% of the THLB), and the upper 25% of existing unmanaged pine leading poor sites (2% of the THLB). Decision scenario 1 has 321,483 hectares available for late rotation fertilization. Decision scenario 2 has 160,848 hectares available for late rotation fertilization.

Repeat Fertilization for Pine and Spruce

The candidate area for treatment is existing managed and future managed pine, spruce and balsam leading medium site index sites (45% of the THLB), the lower 25% of existing managed and future managed pine, spruce and balsam leading good sites (6% of the THLB), the upper 25% of existing managed and future managed pine, spruce and balsam leading poor sites (7% of the THLB). Decision scenario 1 has 747,077 hectares of candidate area available for repeat fertilization of pine and spruce. There are 350,175 hectares of candidate area pine, 299,014 hectares of candidate area spruce and 97,161 hectares of candidate area balsam that will be planted to spruce and fertilized in future rotations. Decision scenario 2 has 373,811 hectares of candidate area available for repeat fertilization of pine and spruce. There are 164,323 hectares of candidate area pine, 160,687 hectares of candidate area spruce, and 48,801 hectares of candidate area balsam that will be planted to spruce and fertilized in future rotations.

Genetic Worth

The candidate area for treatment is 75% of future managed pine stands below 1,200 metres in elevation (30% of the THLB), 75% of future managed spruce stands below 1,200m (18% of the THLB) and 75% of future managed spruce stands above 1,200 metres (18% of the THLB). Decision scenario 1 has 855,511 hectares that can be planted with genetically improved stock over the planning horizon. The candidate

area is distributed into 386,712 hectares are of low elevation pine; 231,471 of low elevation spruce, and 237,328 of high elevation spruce. Areas differ slightly from the learning scenarios as a result of the assignment process used to select candidate area polygons. Decision scenario 2 has 428,124 hectares that can be planted with genetically improved stock over the planning horizon and are distributed as follows: 182,472 hectares of candidate area low elevation pine, 126,781 hectares of candidate area low elevation spruce and 118,871 hectares of high elevation spruce.

Total Candidate Area Treated

The total candidate area to be treated does not equal the sum of the areas for late fertilization, repeat fertilization on pine and spruce and genetic worth, as these treatments can apply over the same land base. The land base to be treated is 1,084,536 hectares, which is 84% of the future timber harvesting land base. When 50% of the area is fertilized, the total land base treated is 543,062 hectares, which is 42% of the future timber harvesting land base. *Table 23* outlines the area breakdown by scenario.

Table 23. Candidate Area Breakdown by Treatment in each Decision Scenario

Scenario	Decision Scenario 1 Area (ha)	Decision Scenario 2 Area (ha)
Genetic Worth	338,186	169,251
Repeat Pine/Spruce	105,745	53,214
Genetic Worth and Repeat Pine/Spruce	319,122	159,749
Late Fertilization and Repeat Pine/Spruce	123,280	61,724
Late Fertilization, Genetic Worth and Repeat Pine/Spruce	198,203	99,124
Total	1,084,536	543,062

6.6.2. Treatments

Late Fertilization

TIPSY assumes a 15 m³/ha increase in volume when fertilization treatments are applied. Using TIPSY, new yield curves for these candidate areas are generated, reflecting a 15 m³/ha increase during specific age periods. For good sites, yield increases are applied between 80 and 220 years; and for medium sites, yield increases were applied 110 and 250 years. For poor sites, yield increases were to be applied between 130 and 210 years, however, this was inadvertently omitted. All candidate stands are placed on the late fertilization curves at the commencement of the planning horizon. Once the stands reach 80 years old on good sites, and 110 years old on medium sites, then yield gains are realized, until such time as the stands reach 110 years old on good sites, 250 years old on medium sites, or are harvested.

The treatment assumptions used in this scenario have not been confirmed with District staff to ensure that these volume gains are achievable.

Repeat Fertilization for Pine and Spruce

Stands are fertilized at age 20, 30, 40, 50 and 60 years with the maximum response occurring approximately 10 years after the last entry. Over time, the effect of fertilizer subsidies and is eventually eliminated due to converging stand dynamics. In order to reap the benefit of this fertilization regime, harvesting must occur close to the maximum response point to receive the largest return on investment. The response of fertilization is relatively significant with the response reaching 29% increase 10 years after the fifth application. Refer to *Figure 21*.

Les Herring, RPF, Research Silviculturist – Northern Interior Forest Region provided response curves for medium site index pine sites. This information has been extrapolated to good and poor sites for pine and good, medium and poor sites for spruce. Field confirmation has not been completed to ensure that extrapolation of this response is reasonable.

Genetic Worth

The treatment regime is based upon information received from the Tree Improvement Branch of the BC Ministry of Forests pertaining to genetic worth gains expected from planting Class A seed germinated stock. The Prince George Seed Planning Zone is used to evaluate the potential genetic worth values for lodgepole pine and white spruce Class A seed plantations. For lodgepole pine seedlings planted below 1,200 metres, a 7% increase in the primary trait, height growth, of this stock is assumed. For white spruce, the genetic worth increase for the primary trait is assumed to be 21% below 1,200 metres and 16% for above 1,200 metres.

6.6.3. Results

Due to the complexity of the results for the decision scenarios, the results section is divided into four parts. The first part describes the harvest flow and growing stock for the two decision scenarios, and provides two alternative harvest flows. Part two summarizes the amount of area treated in the two decision scenarios and two alternative scenarios. The third part outlines the results of the learning and decision scenarios on the targets. Part four provides a summary of the change in harvest location between decision scenario 1 and the two alternatives, compared with the spatial base case.

6.6.3.1. Harvest Flow

Figure 28 identifies the harvest flow realized when 100% of the candidate area is fertilized (decision scenario 1) and when 50% of the candidate area is fertilized (decision scenario 2), compared with the spatial base case. Both decision scenario 1 and 2 provide a 28% increase in harvest flow in the short to mid-term, with a decline to a 17% increase above spatial base case for decision scenario 1 and a 7% increase above spatial base case for decision scenario 2 in the long term.

The harvest flow for decision scenario 1 starts at 3,840,000 m³/yr for 80 years, then decreases by 10% to 3,438,720 m³/yr until year 120, followed by another 2% decrease to 3,370,000 m³/yr from year 121 onwards. The long run sustained yield (LRSY) for decision scenario 1 is 4,223,377 m³/yr and is 16% higher than the long term harvest level. This calculation uses the long term harvest level inclusive of non-recoverable losses. See *Section 4.2.3 Non-Recoverable Losses* for the methodology of incorporating non-recoverable losses in the analysis. The long term harvest level should not exceed the LRSY otherwise the harvest flow is considered unsustainable.

Decision scenario 2 starts at 3,840,000 m³/yr for 50 years, then decreases by 10% to 3,438,720 m³/yr until year 120, then decreases by 10% to 3,080,000 m³/yr from year 121 onwards. The LRSY for decision scenario 2 is 3,903,109 m³/yr, and is 17% higher than the long term harvest level. This calculation uses the long term harvest level inclusive of non-recoverable losses. See *Section 4.2.3 Non-Recoverable Losses* for the methodology of incorporating non-recoverable losses in the analysis. The long term harvest level should not exceed the LRSY otherwise the harvest flow is considered unsustainable.

In comparison, the spatial base case starts at 2,997,363 m³/yr for 115 years, decreasing to 2,887,358 m³/yr from year 116 onwards. The LRSY is 3,582,068 m³/yr, which is 15% higher than the long term harvest flow. This calculation uses the long term harvest level inclusive of non-recoverable losses. See *Section 4.2.3 Non-Recoverable Losses* for the methodology of incorporating non-recoverable losses in the analysis. The long term harvest level should not exceed the LRSY otherwise the harvest flow is considered unsustainable.

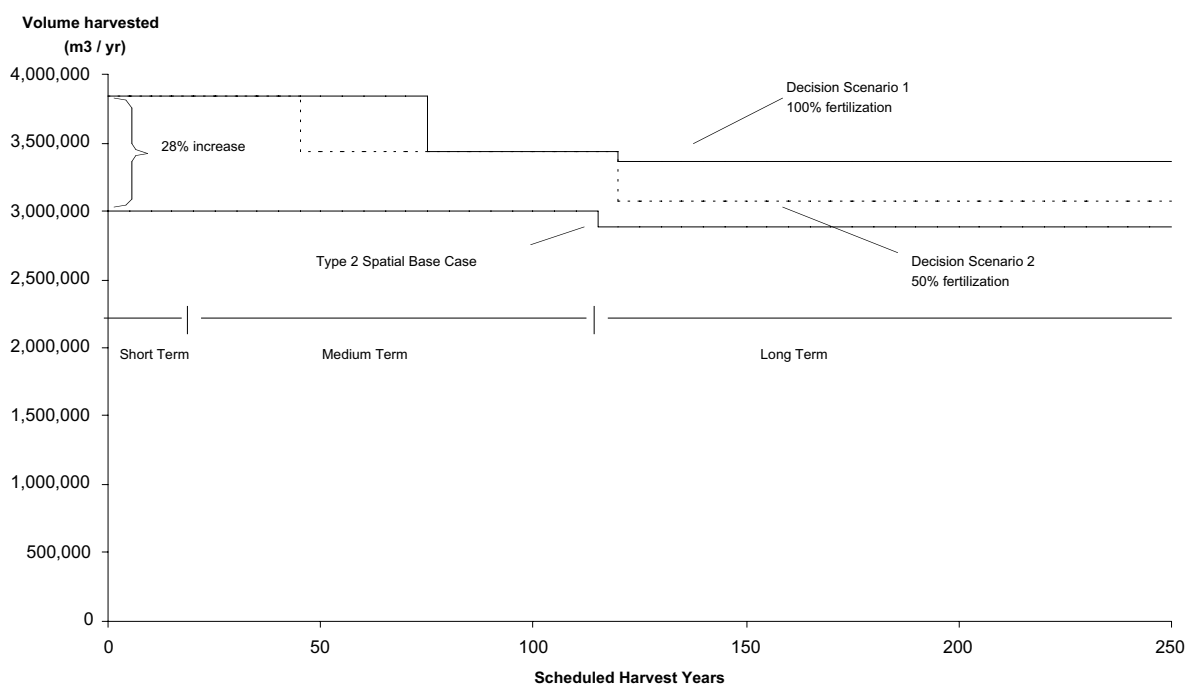


Figure 28. Decision Scenario Conifer Harvest Flow Compared with Type 2 Spatial Base Case

The difference in shape of the harvest flow graphs between the spatial base case and the decision scenarios results from a change in the harvest flow objective. The base case harvest flow objective is to maintain the current Allowable Annual Cut (Mackenzie TSR1 2,997,363 m³/yr, including a deciduous partition of 50,000 m³/yr) for as long as possible without allowing declines to exceed 10% per decade and to achieve the long term harvest level as soon as possible. The long term harvest level must be a sustainable even-flow harvest rate where sustainability is demonstrated through stable growing stock levels over two full rotations of the THLB managed stand inventory. As well, harvest levels in the mid term should not fall below the THLB long run sustained yield (LRSY) based upon current inventory.

The decision scenario harvest flow objective is to increase harvest flow to a point where the decline to long term harvest level occurs in two to three small increments of not more than 10% per decade, distributed over a longer period of time to reach the long term harvest level. The long term harvest level

must be a sustainable even-flow harvest rate where sustainability is demonstrated through stable growing stock levels over two full rotations of the THLB managed stand inventory. Harvest levels in the mid term should not fall below the THLB long run sustained yield (LRSY) based upon current inventory. The intent of this harvest flow objective is to provide benefits in the short term by increasing the harvest flow, while maintaining a smooth transition to the long term harvest level and ensuring the harvest flow remains static for a few decades prior to each decline.

Figure 29 provides the total coniferous growing stock within the THLB. This is presented to confirm that the harvest flow maintains a sustainable growing stock across the planning horizon. *Figure 29* illustrates how THLB growing stock declines through the short and mid-terms and stabilizes in the long term. An additional model run extending the projection period to a 400 year planning horizon verifies that the long term harvest level is sustainable and that overall long term growing stock is stable.

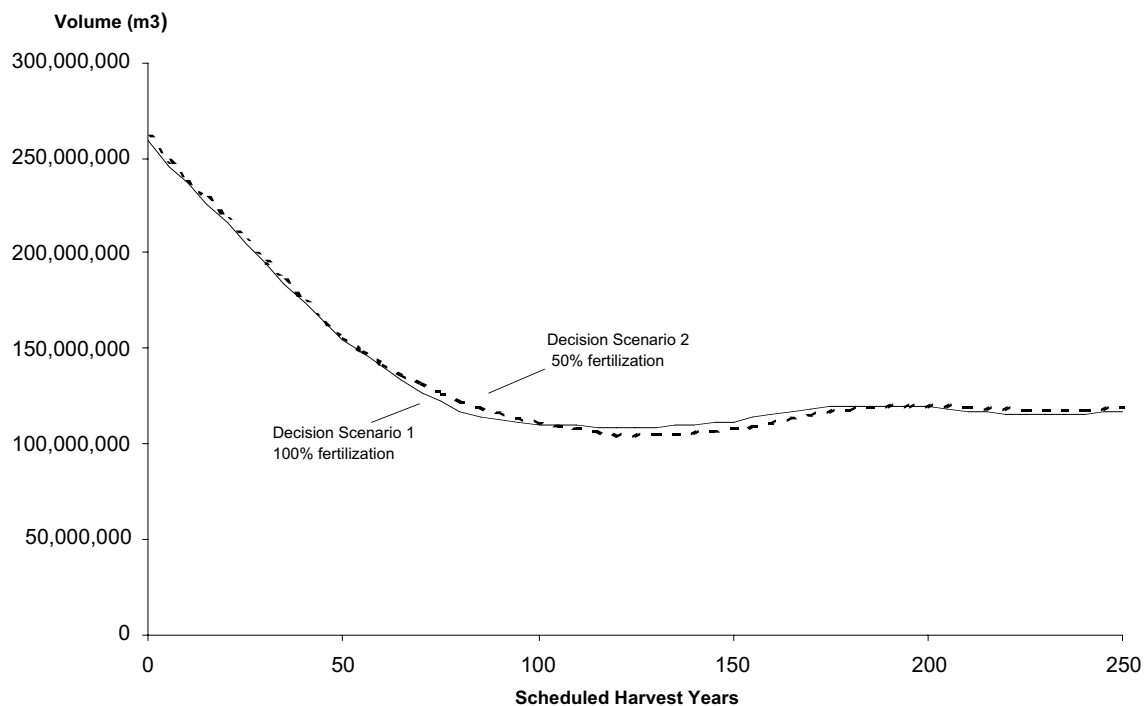


Figure 29. Decision Scenario 1 and 2 Total Conifer Growing Stock in THLB

In order to make a direct comparison with the spatial base case, alternative harvest flows for decision scenario 1 are provided in *Figure 30*. Alternative 1 is an even flow harvest forecast which identifies that 3,290,600 m³/yr can be maintained in perpetuity and follows the harvest flow objective used in the learning scenarios. Alternative 1 is 10% higher than the spatial base case in the short term, and 14% higher than spatial base case in the long term and is 7% higher than decision scenario 2. Alternative 2 maximizes the short term harvest flow and is 53% higher than base case in the short term, but declines steadily after 30 years to reach the same long term harvest level as decision scenario 1, 17% higher than spatial base case. Alternative 2 starts at 4,570,000 m³/yr for 30 years, then decreases by 10% to 4,069,720 m³/yr until year 40, then decreases by 10% to 3,668,868 m³/yr until year 50, then decreases by 8% to 3,370,000 m³/yr from year 51 onwards.

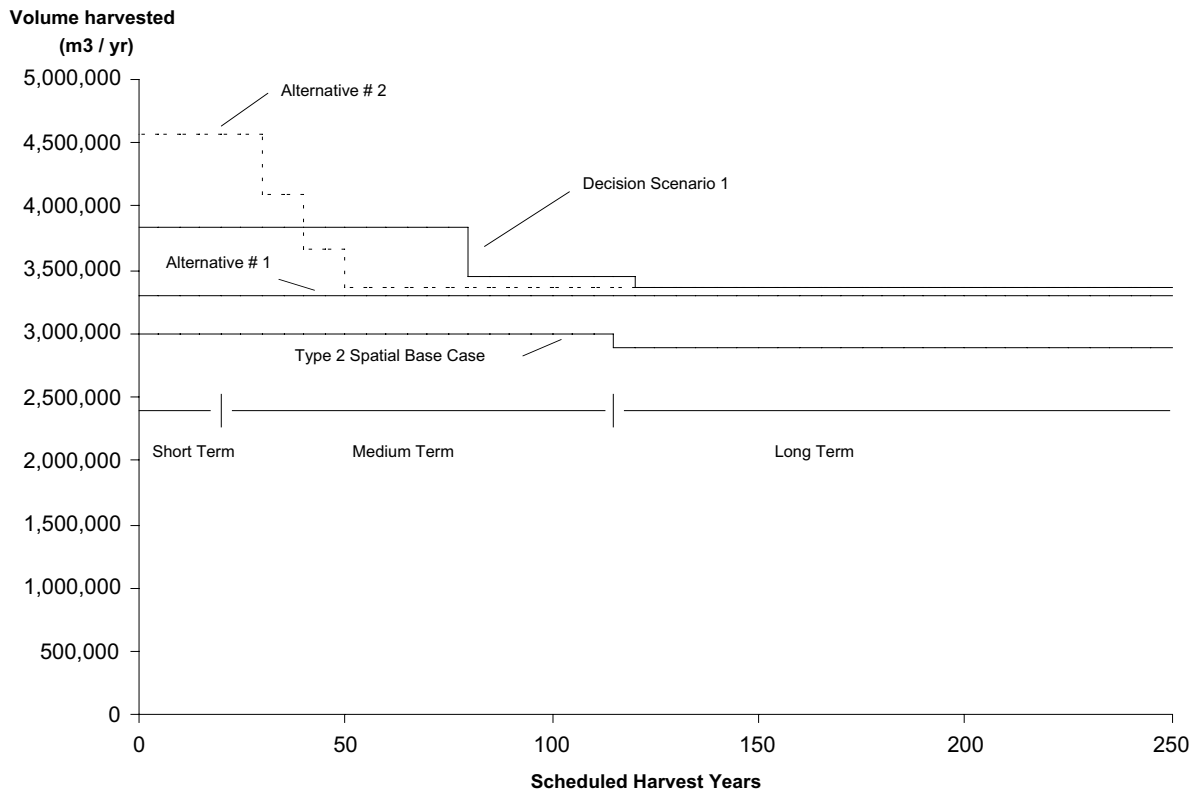


Figure 30. Alternative 1, 2 and Decision Scenario 1 Harvest Flows Compared with Type 2 Spatial Base Case

Figure 31 shows that these alternative harvest flows maintain the total conifer growing stock in the THLB. Alternative 1 allows more growing stock to remain in the THLB, while alternative 2 growing stock decreases more quickly than decision scenario 1, but reaches the same growing stock in the long term.

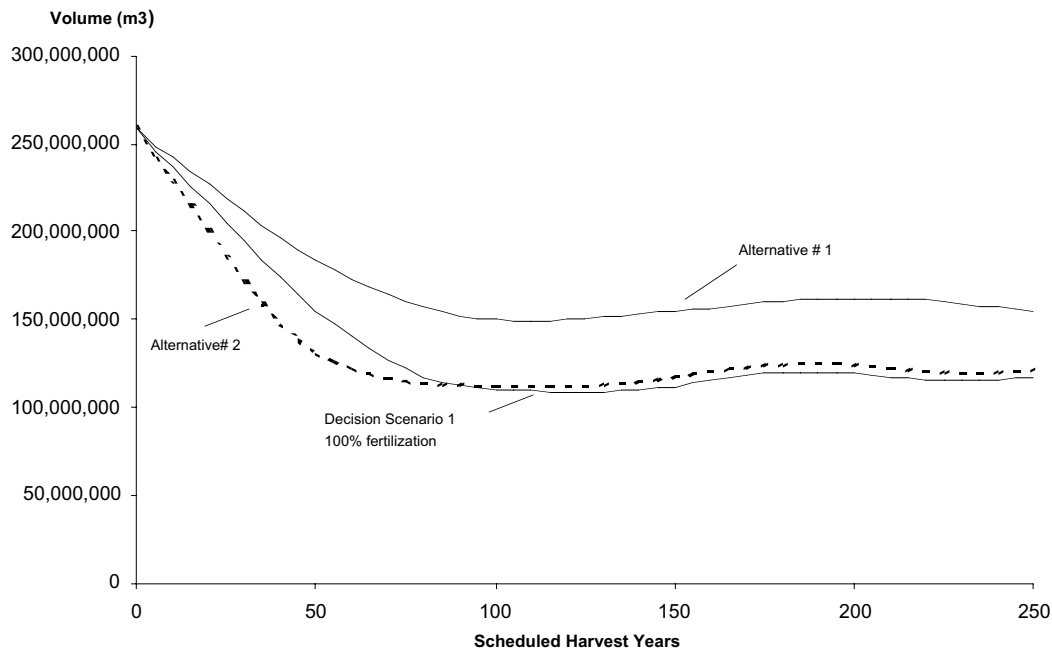


Figure 31. Alternative 1 and 2 Total Conifer Growing Stock in the THLB.

Figure 32 shows the deciduous harvest flow for the deciduous partition in Allowable Annual Cut for decision scenario 1 and 2. Although not shown, the deciduous growing maintains an upward trend. The deciduous harvest flow and growing stock are identical to the spatial base case as no treatments are applied to these deciduous stands.

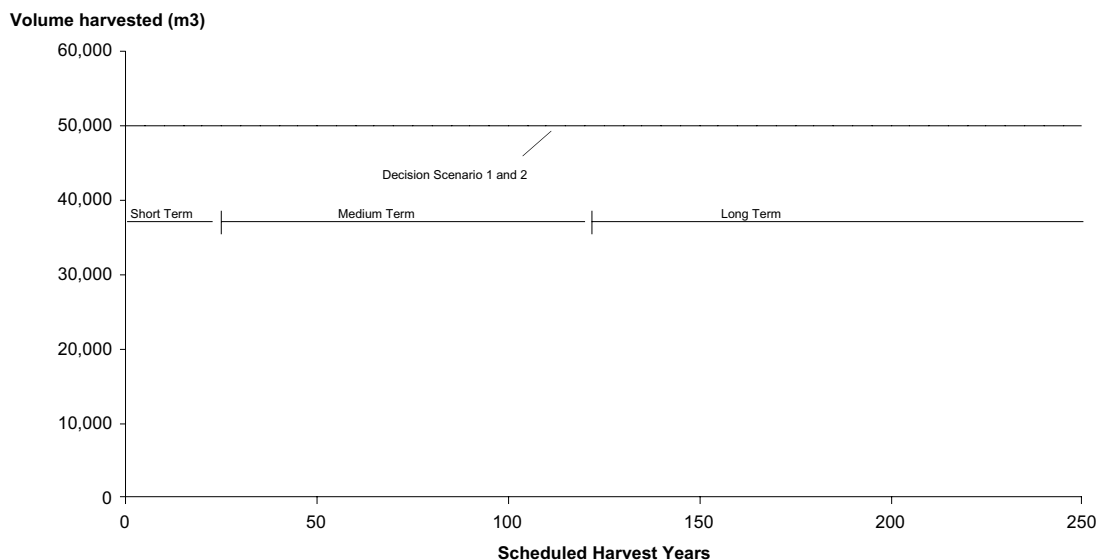


Figure 32. Decision Scenario 1 and 2 Deciduous Partition Harvest Flow

Figures 33, 34 and 35 provide the average age of harvested stands, the average volume per hectare harvested and the average area harvested per period.

Figure 33 demonstrates that the average harvested age for the first period (five years) is 233 years. This declines to 176 years at year 25, then increases to 207 years at year 35. There is a steady decline in the average harvested age until year 115, when it reaches 80 years for decision scenario 1 and 84 years for decision scenario 2. From year 116 onwards the average harvested age for decision scenario 1 remains between 83 years at year 130 and 111 years at year 125. Decision scenario 2 average harvested age range is slightly higher with the lowest being age 87 at year 130 and the highest being age 118 at year 125. In comparison, the spatial base case reaches the youngest average harvest age of 114 years at year 150.

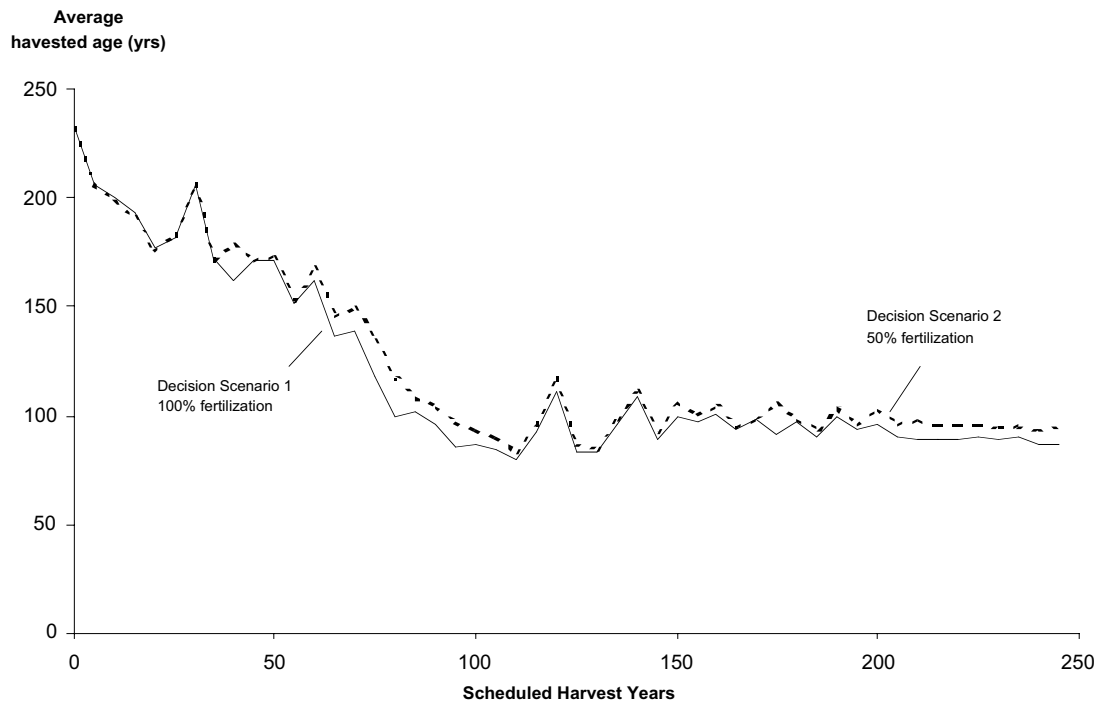


Figure 33. Decision Scenario 1 and 2 Average Harvested Age

Figure 34 shows that the average volume per hectare harvested is 320 cubic metres per hectare (m^3/ha) for the first five years and declines to 297 m^3/ha at year 20. The average volume per hectare harvested hovers around 300 m^3/ha to year 85, declining steadily to 247 m^3/ha at year 135. For decision scenario 1, the volume per hectare remains near 245 m^3/ha until year 175, before increasing to 291 m^3/ha at year 220, with an average of 270 m^3/ha . For decision scenario 2, the volume per hectare remains near 245 m^3/ha until year 185, before increasing to 290 m^3/ha at year 225, averaging 260 m^3/ha . In comparison, average volume per hectare harvested in the spatial base case remains near 300 m^3/ha .

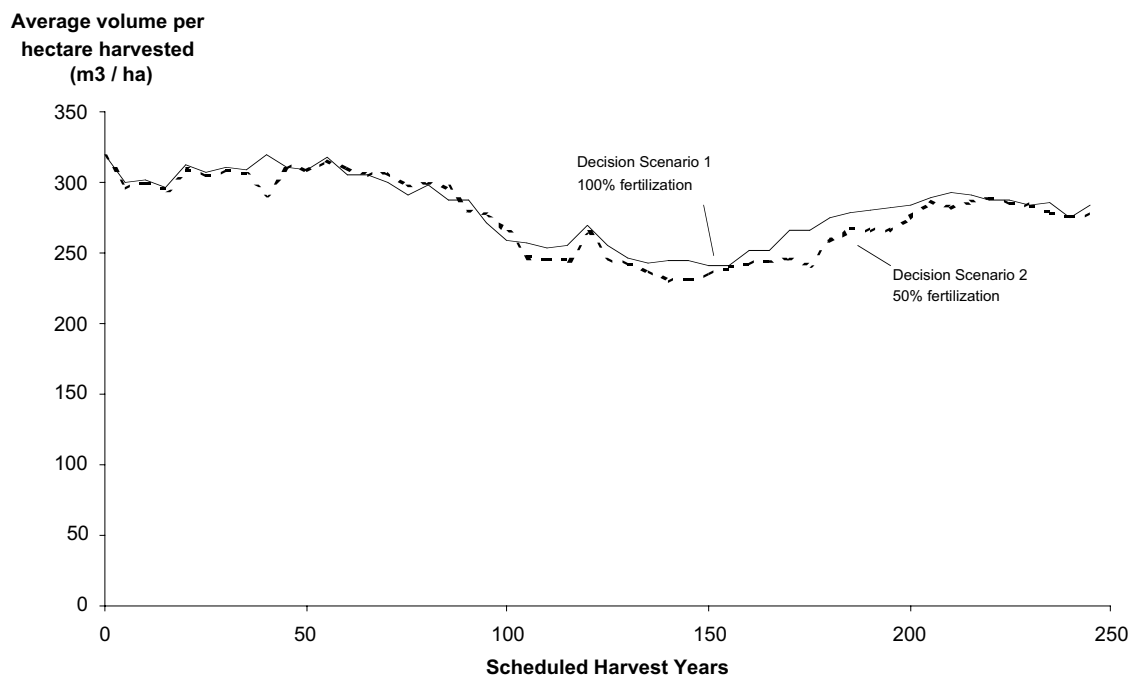


Figure 34. Decision Scenario 1 and 2 Average Harvested Volume per Hectare

Figure 35 identifies the average area harvested each five year period for decision scenario 1 and 2. In the first period, 63,438 hectares is harvested. This increases to 68,430 hectares by year 20. This is consistent with Figure 34, showing the average volume per hectare harvested is low at 297 m³/ha. When the volume per hectare decreases, the area harvested must increase at a corresponding rate in order to maintain the harvest flow. At year 55, the area harvested in decision scenario 2 decreases to 49,100 hectares because the harvest flow decreases. By year 85, the area harvested in decision scenario 1 decreases to meet decision scenario 2. For decision scenario 1, up to year 100, the average area harvested ranges between 61,240 and 68,430 hectares, averaging at 65,652 hectares. After year 100, the average area harvested increases to between 61,200 and 74,360 hectares, averaging at 67,580 hectares. Between years 100 and 180, there is an increase in the area harvested, and is consistent with a decrease in the volume per hectare harvested. After year 100, decision scenario 1 generally has more area harvested than decision scenario 2 as a result of a higher long term harvest level.

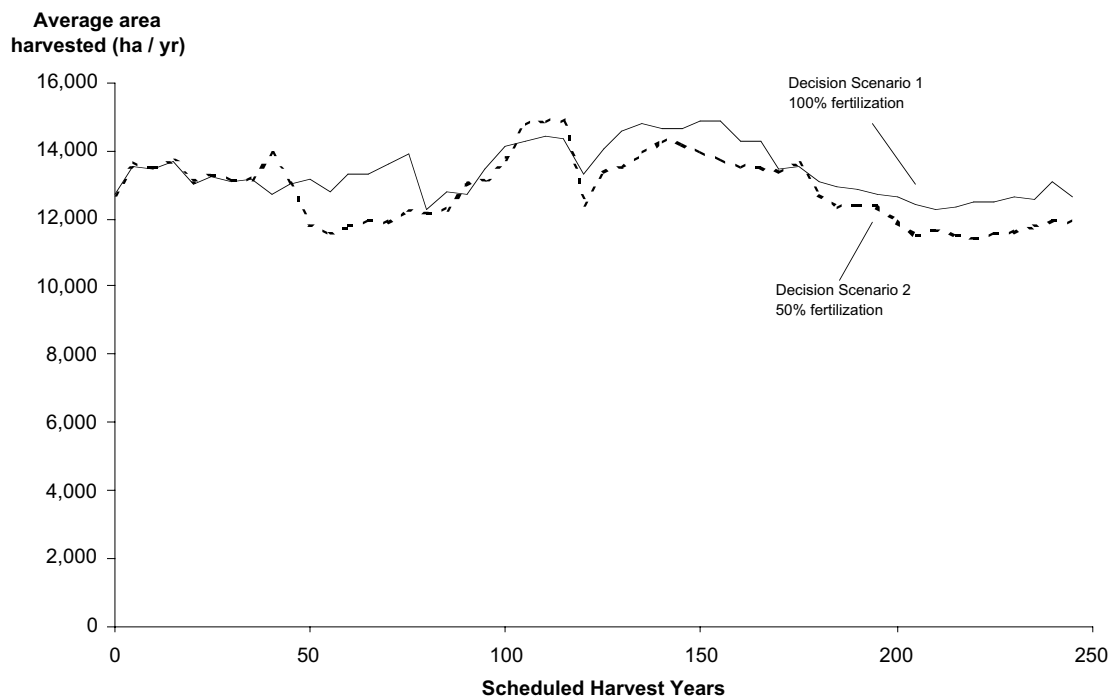


Figure 35. Decision Scenario 1 and 2 Average Area Harvested

Figures 36 to 39 show the distribution of area harvested by species and by site class. Please note that although the information presented describes harvest of balsam over multiple periods, this is not entirely accurate. As a result of the regeneration assumptions (see *Mackenzie TSA Type 2 Incremental Silviculture Analysis Data Inputs and Assumptions*), stands that are currently balsam leading will be converted to spruce leading stands after the first harvest. As a result, by year 140, more than 80% of the balsam leading stands have been converted to spruce leading. By year 250, 95% of balsam leading stands have been converted to spruce leading.

Figure 37 and 38 show that during years 1 to 60 and 100 to 180, a higher proportion of poor balsam and poor spruce sites are being harvested than in surrounding periods. The second increase in poor site balsam and spruce harvest almost entirely consists of the second harvest on these poor sites. Figure 39 shows that the harvest of pine in all site classes is relatively evenly distributed across the planning horizon.

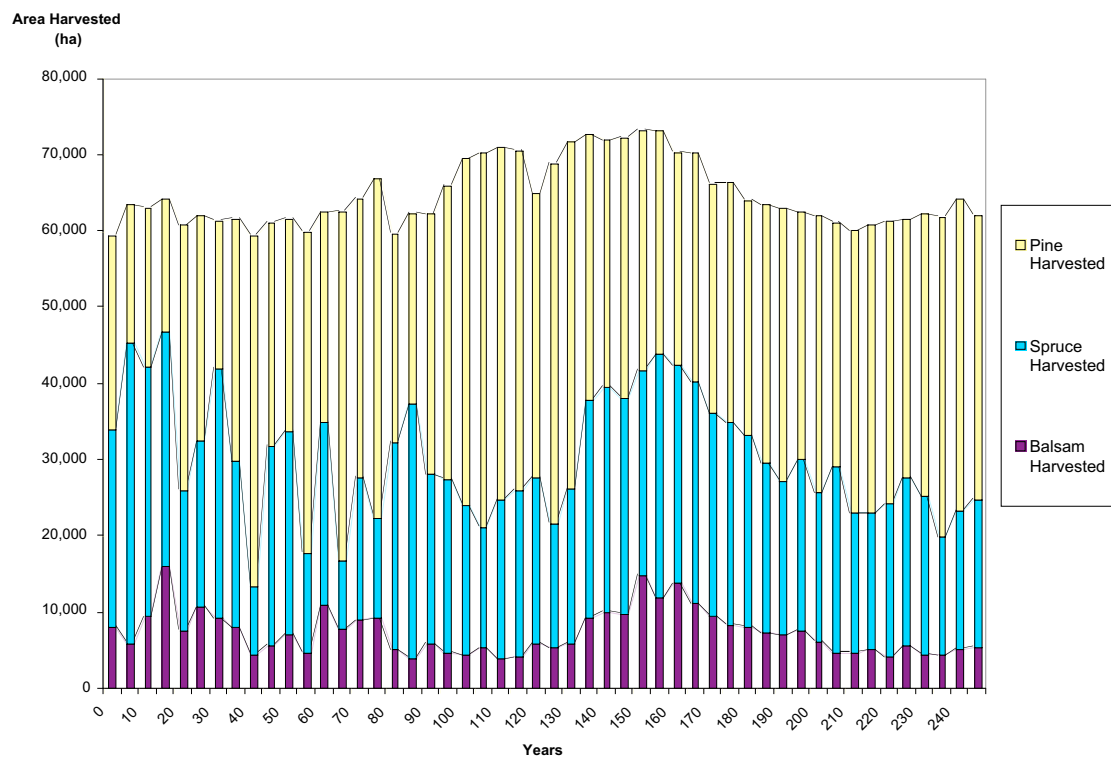


Figure 36. Area of Pine, Spruce and Balsam Harvested in Decision Scenario 1

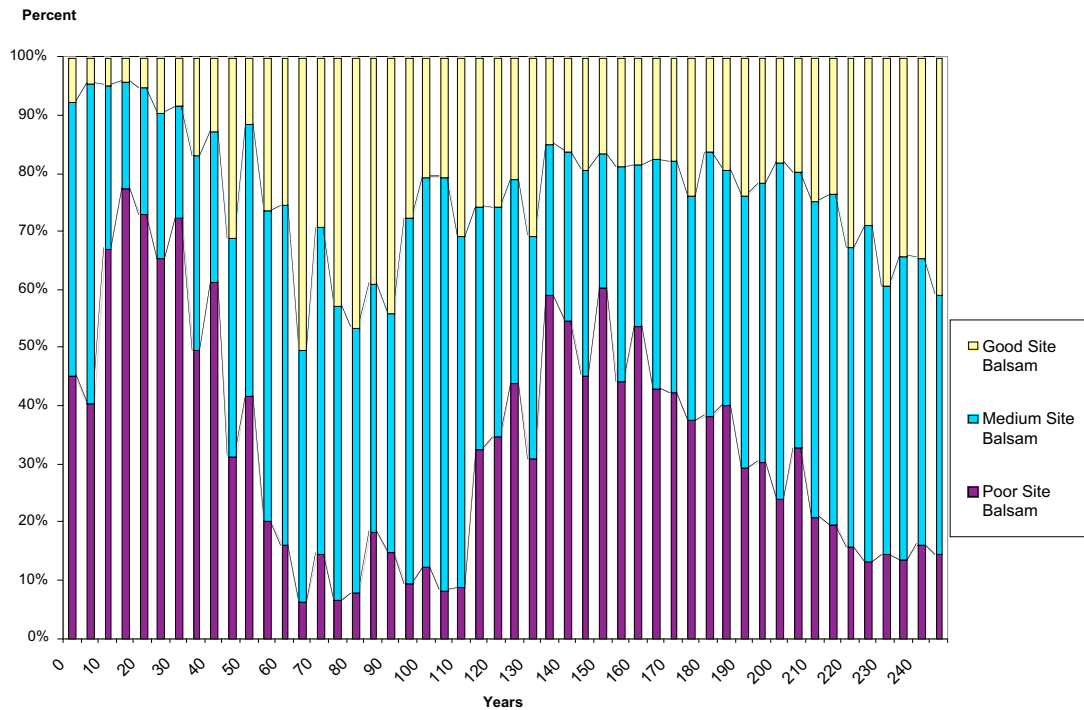


Figure 37. Percent of Balsam Harvested in Decision Scenario 1 by Site Class

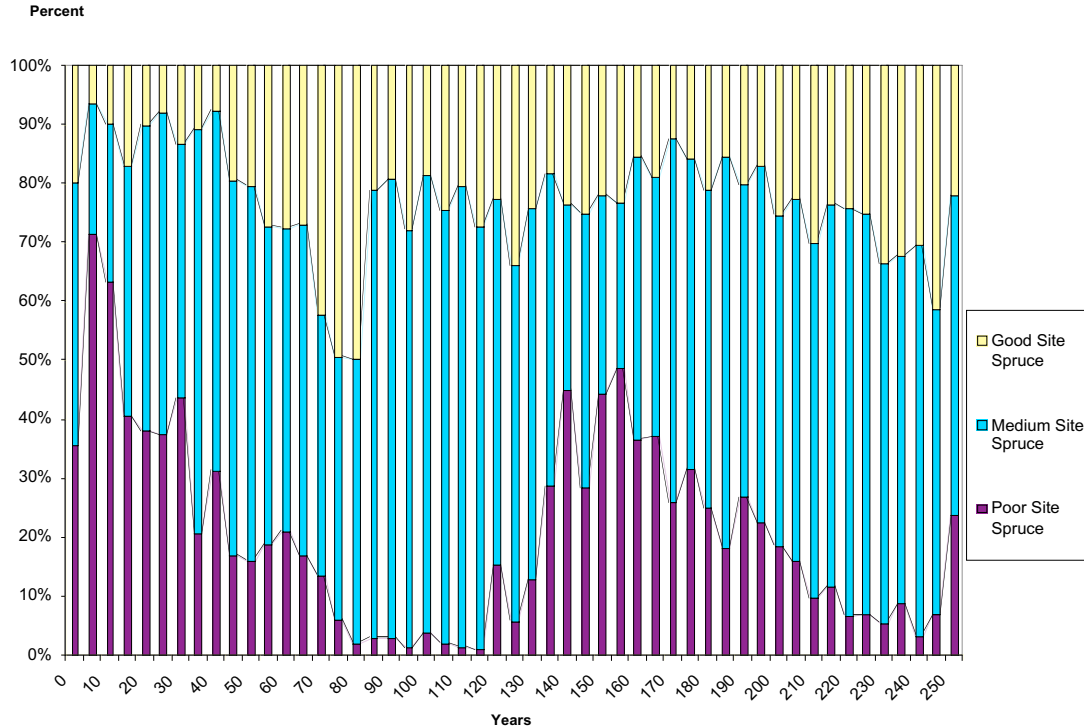


Figure 38. Percent of Spruce Harvested in Decision Scenario 1 by Site Class

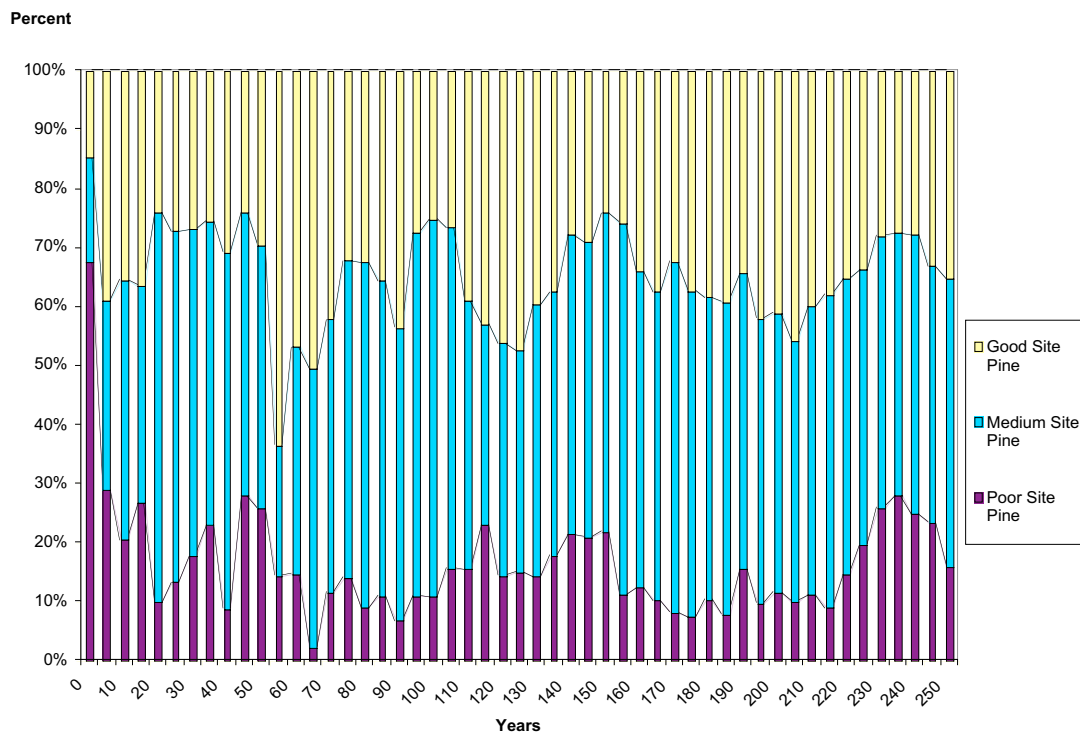


Figure 39. Percent Area of Pine Harvested in Decision Scenario 1 by Site Class

6.6.3.2. Area Treated

Table 24 shows the area of late rotation pine stands that are fertilized at the beginning of the planning horizon and harvested with the first 20 years. All candidate late fertilization stands are treated at the beginning of the planning horizon, however, only when existing natural stands are between 80 and 220 years old on good sites and 110 and 250 years old on medium sites during that time period, do they receive benefit from that treatment.

In decision scenario 1, a total of 36,882 hectares are harvested that benefit from a late fertilization treatment. In decision scenario 2, 18,690 hectares are harvested that benefit from a late fertilization treatment. Alternative 1 has 31,439 hectares harvested that benefit from a late fertilization treatment; while alternative 2 has 59,162 hectares harvested that benefit from a late fertilization treatment.

Table 24. Late Rotation Pine Area Fertilized and Harvested

Year	Area Treated (ha)			
	Decision Scenario 1	Decision Scenario 2	Alternative 1	Alternative 2
1 – 5	5,584	2,839	4,278	7,373
6 – 10	10,036	4,771	9,760	12,469
11 – 15	11,765	5,958	6,937	13,495
16 - 20	9,497	5,122	10,464	25,825
Total	36,882	18,690	31,439	59,162

Table 25 outlines the area of repeat fertilization in pine and spruce leading stands within the first 20 years. This includes existing managed stands that are 20, 30, 40, 50 or 60 years old during that time period as well as stands harvested in the first five years that will be available for the first fertilization treatment at year 20.

In year 20, decision scenario 1, alternative 1 and alternative 2 all have 39,812 hectares of existing managed stands fertilized. Decision scenario 2 has 19,400 hectares of existing managed stands fertilized. In decision scenario 1, an additional 27,089 hectares was harvested in the first five years that is available for fertilization at year 20. Decision scenario 2 has 13,781 hectares, alternative 1 has 22,310 hectares and alternative 2 has 34,199 hectares that were harvested in the first five years and are available for fertilization at year 20.

In decision scenario 1, 99,707 hectares of forest is fertilized, of which 17,272 hectares is fertilized twice, for a total of 116,979 hectares being fertilized. In decision scenario 2, 50,213 hectares of forest is fertilized, of which 8,414 hectares is fertilized twice, for a total of 58,567 hectares fertilized. Alternative 1 has 112,249 hectares of forest fertilized of which 17,272 hectares are fertilized twice and alternative 2 has 124,138 hectares of forest fertilized of which 17,272 hectares are fertilized twice. When compared with the repeat fertilization on pine and spruce learning scenario, this table shows that the maximum area available for treatment in the first 20 years is treated under decision scenario 1, alternative 1 and alternative 2.

Table 25. Repeat Pine and Spruce Fertilization in First 20 Years

Year	Decision Scenario 1		Decision Scenario 2		Alternative 1		Alternative 2	
	Area		Area		Area		Area	
	Treated	Twice	Treated	Twice	Treated	Twice	Treated	Twice
1 – 5	5,922		3,055		5,922		5,922	
6 – 10	11,350		5,359		11,350		11,350	
11 – 15	32,806	5,922	17,032	3,055	32,855	5,922	32,855	5,922
16 - 20	66,901	11,350	33,181	5,359	62,122	11,350	74,011	11,350
Total	116,979	17,272	58,627	8,414	112,249	17,272	124,138	17,272

Table 26, following, outlines the area planted with genetically improved stock within the first 20 years. In decision scenario 1, a total 178,205 hectares are harvested and subsequently planted with genetically improved stock, with 72% of the area being planted with spruce and 28% planted with pine. In decision scenario 2, a total of 89,648 hectares are harvested in the first 20 years and subsequently planted with genetically improved stock; 72% is planted with spruce and 28% is planted with pine. Alternative 1 has 155,198 hectares planted with genetically improved stock in the first 20 years, of which 72% is planted with spruce and 28% is planted with pine. Alternative 2 has 208,789 hectares planted with genetically improved stock of which 68% planted with spruce and 32% planted with pine.

Table 26. Stands Planted with Genetically Improved Stock in First 20 Years

Year	Decision Scenario 1			Decision Scenario 2			Alternative 1			Alternative 2		
	Total Area Planted	Area Planted Pine	Area Planted Spruce	Total Area Planted	Area Planted Pine	Area Planted Spruce	Total Area Planted	Area Planted Pine	Area Planted Spruce	Total Area Planted	Area Planted Pine	Area Planted Spruce
1 – 5	39,723	13,738	25,985	20,342	7,204	13,138	34,795	11,767	23,028	46,689	15,583	31,106
6 – 10	49,555	10,218	39,337	25,319	4,799	20,520	37,165	10,627	26,538	60,940	11,780	49,160
11 – 15	47,933	15,302	32,631	23,992	7,952	16,040	47,741	9,115	38,626	52,328	18,306	34,022
16 – 20	40,994	10,142	30,852	19,995	5,148	14,847	35,497	12,120	23,377	48,832	22,064	26,768
Total	178,205	49,400	128,805	89,648	25,103	64,545	155,198	43,629	111,569	208,789	67,733	141,056

The actual land base treated does not equal the sum of the areas for late fertilization, repeat fertilization on pine and spruce and genetic worth, as these treatments can apply over the same land base. Another complicating factor is that land harvested in year 1 may have late fertilization and genetic worth in year 1, and receives a repeat fertilization in year 20. As well, the land base treated for repeat fertilization does not equal the treatment area as the same stand can be treated twice.

Table 27 identifies the land base treated in each five year period for the first 20 years.

Table 27. Land Base Treated in Decision Scenario 1, Decision Scenario 2, Alternative 1 and Alternative 2

Year	Decision Scenario 1	Decision Scenario 2	Alternative 1	Alternative 2
1-5	47,401	24,291	41,778	55,230
6-10	65,884	32,995	53,582	78,262
11-15	79,199	40,040	77,248	84,095
16-20	78,485	38,783	72,271	93,489
Total	270,969	136,109	244,879	311,076

Table 28, following, identifies the percent of the treated land base that receives only one treatment type, and the percent of the treated land base that receives multiple treatments. As 100% of the late fertilization area receives a repeat fertilization treatment the following rotation, there are three possible outcomes for multiple treatments:

- late rotation, followed by repeat fertilization 20 years into the next rotation; or
- late rotation with planting of genetically improved stock in the next rotation, followed by repeat fertilization in 20 years; or
- planting of genetically improved stock followed by repeat fertilization in 20 years.

Table 28 shows, that on average, only 40% of the treated land base receives multiple treatments. Decision scenario 1 and 2 have the same proportion of area with multiple treatments. This confirms that the allocation of candidate area for decision scenario 2 is evenly distributed across the treatment types.

For decision scenario 1, decision scenario 2 and alternative 1, 65% of the land base containing multiple treatments is genetic worth and repeat fertilization; while 21% is late fertilization followed by repeat fertilization and 14% is late fertilization followed by genetic worth and repeat fertilization. For alternative 2, 58% of the land base containing multiple treatments is genetic worth and repeat fertilization; 25% is late fertilization followed by repeat fertilization and 16% is late fertilization followed by genetic worth and repeat fertilization. In alternative 2, the increase in repeat fertilization combined with genetic worth is a result of the increased area harvested in the first five years, and consequently fertilized between years 16 to 20, combined with the additional area of late fertilization that is harvested.

Table 28. Percent of Land Base in Multiple Treatments

Year	Decision Scenario 1		Decision Scenario 2		Alternative 1		Alternative 2	
	One Treatment	Multiple Treatments	One Treatment	Multiple Treatments	One Treatment	Multiple Treatments	One Treatment	Multiple Treatments
1-5	54%	46%	54%	46%	56%	44%	50%	50%
6-10	60%	40%	61%	39%	54%	46%	59%	41%
11-15	63%	37%	64%	36%	72%	28%	61%	39%
16-20	65%	35%	63%	37%	67%	33%	53%	47%
Total	60%	40%	60%	40%	62%	38%	56%	44%

6.6.3.3. Indicator Target Results

In total, 447 targets are applied in the model. Targets are a minimum requirement (such as a seral stage) or a maximum limit (such as VQO allowable disturbance). There are 259 targets that apply to seral stage, 186 applying to VQO polygons and two applying to harvest flow (coniferous and deciduous).

Tables 29 to 32 identify the area of THLB that exceed the target limits by biogeoclimatic zone for seral stage and by VQO class for maximum allowable disturbance. The column 'Last Year to Meet Target' refers to the length of time before the last target is achieved. For example, one or more specific landscape unit/biogeoclimatic variant combinations exceed the target until 191 years from now. Appendix A identifies the targets that are in violation at the beginning of the planning horizon and provides the length of time before the target is satisfied. The results are identical among all scenarios, except partial harvesting in visually sensitive areas, where the seral stage results are identical but the VQO results are different. This is expected as the targets are assigned based on age, and are not adjusted between scenarios, except in VQO zones of the partial harvest in visually sensitive areas scenario.

Tables 29 and 30 identify that 54% of the THLB (66% of the targets) is unavailable for timber harvesting at the beginning of the planning horizon due to seral stage targets. By year 50, 16% of the THLB is unavailable for timber harvesting of which almost 60% becomes available for timber harvesting between years 31 and 40. By year 100, 3% of the THLB is available for timber harvesting, of which almost 50% of the area becoming available between years 71 and 80.

At the beginning of the planning horizon, 29% of the THLB in the ESSF is unavailable for timber harvesting. The proportion in the ESSF decreases slightly to 26% by year 10. By year 40, only 11% of the ESSF old seral targets remain in contravention. Although only 2% of the BWBS is in contravention at the beginning of the planning horizon, this decreases by half within the first decade. Spruce consists of almost 65% of the BWBS and ESSF zones.

With respect to biodiversity emphasis and old seral stage targets, 20% of the THLB area in violation occurs in high biodiversity emphasis areas, 33% of the THLB area in violation occurs in intermediate biodiversity emphasis areas, and 47% of the THLB area in violation occurs in low biodiversity emphasis areas. For mature + old seral targets, 1% of the THLB area in violation occurs in high biodiversity emphasis areas, and 99% occurs in intermediate biodiversity emphasis areas.

Table 29. Area of THLB in violation: Old Seral, All Scenarios

BEC Zone	Total Number of Targets	Number of Targets in Contravention	Area in THLB (ha)	Area in THLB in Contravention (ha)					Last Year to Meet Target
				Year 0	Year 20	Year 50	Year 100	Year 150	
AT	44	43	19,963	19,963	19,963	19,423	18,649	11,839	191
BWBS	40	15	240,247	26,330	13,788	1,004	2,664	-	56
ESSF	53	47	513,838	380,293	335,503	139,044	-	7	221
SBS	58	41	455,947	208,496	162,715	29,554	13,869	474	201
SWB	15	15	60,062	60,062	60,062	11,802	4,109	-	111
Area not assigned a target	0	0	2,321	-	-	-	-	-	0
Total	210	161	1,292,379	695,144	592,031	200,827	39,291	12,320	

Table 30. Area of THLB in violation: Mature + Old Seral, All Scenarios

BEC Zone	Total Number of Targets	Number of Targets in Contravention	Area in THLB (ha)	Area in THLB in Contravention (ha)					Last Year to Meet Target
				Year 0	Year 20	Year 50	Year 100	Year 150	
AT	0	0	-	-	-	-	-	-	0
BWBS	28	5	117,011	4,573	1,004	-	-	-	31
ESSF	0	0	-	-	-	-	-	-	0
SBS	21	5	55,057	17	-	-	-	-	101
SWB	0	0	-	-	-	-	-	-	0
Total	49	10	172,068	4,590	1,004	-	-	-	

Tables 31 and 32 differentiate the THLB area in violation in VQO zones between the different scenarios. At the beginning of the planning horizon, 18% of the THLB associated with VQO targets (16% of the targets) are in violation when clearcut silvicultural systems are used. When partial harvesting is applied in VQO zones, only 0.7% of the THLB associated with VQO targets is unavailable for timber harvesting (5% of the targets).

Comparison of Tables 31 and 32 show that partial harvesting increases the opportunity for harvest in otherwise restricted VQO classes. Operationally, the VQO polygons still exceed the VQO class definition at the beginning of the planning horizon, but this does not limit harvest opportunities because it is assumed that partial harvesting, within the identified limits, is able to maintain the stand structure, thus ensuring that the current visual degradation remains unchanged as a result of harvesting.

Table 31. Area of THLB violation: VQOs in all scenarios, except Partial Harvest

VQO Class	Total Number of Targets	Number of Targets in Contravention	Area in THLB (ha)	Area in THLB in Contravention (ha)					Last Year to Meet Target
				Year 0	Year 20	Year 50	Year 100	Year 150	
P	6	1	153	39	39	-	-	-	26
R	34	3	3,867	109	57	-	-	-	26
PR	86	18	15,240	2,725	1,048	-	-	-	26
M	57	7	7,495	2,067	829	-	-	-	31
MM	3	0	99	-	-	-	-	-	0
Total	186	29	26,854	4,940	1,973	-	-	-	

Table 32. Area of THLB in violation: VQOs in Partial Harvest Scenario

VQO Class	Total Number of Targets	Number of Targets in Contravention	Area in THLB (ha)	Area in THLB in Contravention (ha)					Last Year to Meet Target
				Year 0	Year 20	Year 50	Year 100	Year 150	
P	6	0	153	-	-	-	-	-	0
R	34	0	3,867	-	-	-	-	-	0
PR	86	4	15,240	179	34	-	-	-	26
M	57	0	7,495	-	-	-	-	-	0
MM	3	0	99	-	-	-	-	-	0
Total	186	4	26,854	179	34	-	-	-	

A visual inspection of the target results demonstrates that, in general, a change in the harvest flow objective will not cause targets to maximize their permissible limits. In essence, once a target is achieved, there is ample opportunity to increase the harvest flow without causing the targets to be unduly impacted. Under alternative 2, some situations exist where the area in old and mature plus old seral is reduced in the mid-term as a result of the increased harvest pressure. This occurs primarily in BWBS biogeoclimatic zones, but ample area is still available to meet the targets.

6.6.3.4. Distribution of Harvest

Table 33, following, identifies the landscape units, biogeoclimatic zones and biodiversity emphasis areas where increased harvesting occurs in decision scenario 1, alternative 1 and alternative 2, compared with the spatial base case. Increases of greater than 5,000 hectares harvested, compared with the spatial base case, are reported in this table. The distribution of area harvested for the AT zone is not reported. Table 34 lists the corresponding landscape unit name to the number.

Table 33 and Figures 40, 41 and 42 show that in decision scenario 1, 45% of the additional area harvested occurs in the BWBS, specifically in the Fox, Akie, Buffalohead, North Ingenika, Ingenika, Mesilinka, and Osilinka landscape units. In alternative 1 and 2, this trend continues, with a 47% increase in area in the BWBS for alternative 1, and a 42% increase in the BWBS for alternative 2. In all cases, the BWBS of the Buffalohead landscape unit experiences a significant increase in harvesting compared with the spatial base case. The majority of the area increases occur in the landscape units within the medium haul zone.

ESSF has the second highest increase in harvest at 36% of the area for decision scenario 1, and 40% and 35% for alternative 1 and alternative 2 respectively. The Lower Ospika, Collins-Davis, Chunamon, Osilinka, Nabesche and Manson River landscape units are most heavily impacted. In all cases, the ESSF of the Osilinka landscape unit experiences a significant increase in harvesting compared with the spatial base case.

Harvesting in the SBS and SWB zones decreases in decision scenario 1, and alternative 1 compared with spatial base case representing a shift in harvest location from the SBS and SWB to the BWBS and ESSF. Alternative 2, however, increases harvesting in all BEC zones. This reflects the substantially higher harvest flow in alternative 2 compared with the spatial base case.

With respect to biodiversity emphasis, the highest percent increase in harvest compared with the spatial base case occurs in the low biodiversity emphasis areas across all scenarios. However, the percent area increase does not necessarily reflect the net area harvested (the amount of area being converted to early seral). The net area harvested is the sum of the actual area harvested across all biogeoclimatic zones within the same biodiversity emphasis. In some situations, the actual area harvested may decrease, while in other areas, it may increase. In alternative 1, the net area harvested across the high biodiversity emphasis areas increases by 25,848 hectares. As a result, the high biodiversity emphasis zones of alternative 1 have the largest conversion to early seral, primarily occurring in the Fox landscape unit. The largest increase in net area harvested in high biodiversity emphasis, across all three scenarios occurs in alternative 2, at 71,803 hectares.

Table 33. Location of Increased Harvest Compared with Spatial Base Case

Scenario	Comparative change in area harvested in first 50 years compared to spatial base case (all targets, including AT and YQOs)	Percent area of BEC Zone or BEO where harvest increased		Locations where increased harvest occurs	Net area harvested compared to spatial base case (areas include AT and YQOs)	% of THLB
Decision Scenario 1 100% Treatment of Candidate Area	178,519 ha or an average of 3,570 hectares per year	Ecosystem	% of Total			
		BWBS	45	7,12,13,21,32,36,39	134,845	10.4
		ESSF	36	30,31,38,39,41,73,79	63,176	4.9
		SBS	12	38,79,93	9,457	0.7
		SWB	6	7,16	445	0.0
		BEO	% of Total			
		Low	68	12,13,31,36,38,39,73,79,93	66,658	5.2
		Medium	10	32,41,30	54,397	4.2
		High	22	7,16	56,437	4.4
		Ecosystem	% of Total			
Alternative Flow 1 (Even Flow)	58,471 ha or an average of 1,169 hectares per year	BWBS	47	7,13,21,32,36,39	97,467	7.5
		ESSF	40	30,31,38,39,41,73	18,391	1.4
		SBS	8	38	40,622	3.1
		SWB	5	7	6,230	0.5
		BEO	% of Total			
		Low	71	12,13,31,36,38,39	10,414	0.8
		Medium	11	30,32,41	21,934	1.7
		High	18	7	25,848	2.0
		Ecosystem	% of Total			
		BWBS	42	7,12,13,21,32,36,39	153,993	12.0
Alternative Flow 2 (Max. Short-term)	261,682 ha or an average of 5,234 hectares per year	ESSF	35	30,31,38,39,41,72,73,79	84,393	6.5
		SBS	18	38,79,93	29,254	2.3
		SWB	5	7,16	2,848	0.2
		BEO	% of Total			
		Low	66	12,13,31,36,38,39,75,79,93	114,601	8.9
		Medium	11	30,32,41,65	73,573	5.7
		High	23	7,16,21,72	71,803	5.6

Table 34. Specific Landscape Unit Names and Numbers

Landscape Unit Number	Landscape Unit Name
7	Fox
12	Akie
13	Buffalohead
16	Thutade
21	North Ingenika
30	Lower Ospika
31	Collins - Davis
32	Ingenika
36	Mesilinka
38	Chunamon
39	Osilinka
41	Nabesche
65	Gillis
72	Eklund
73	Manson River
75	Blackwater
79	Gaffney
93	Philip

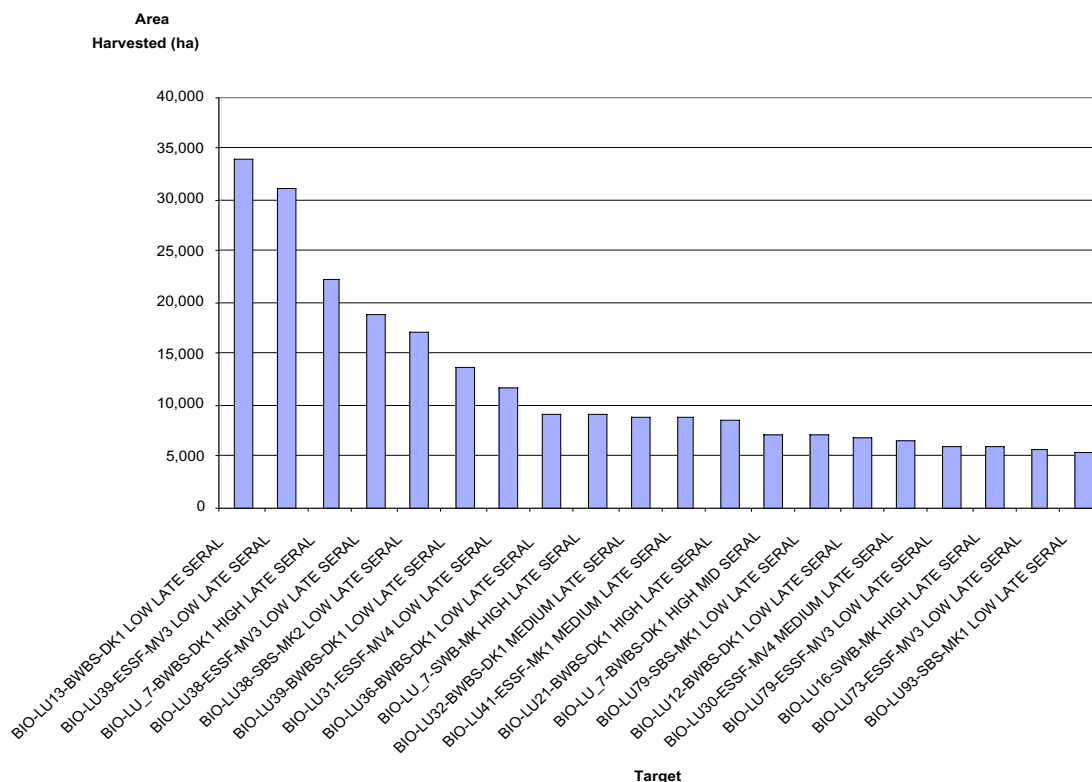


Figure 40. Targets with greater than 5000 Hectare Increase in Decision Scenario 1

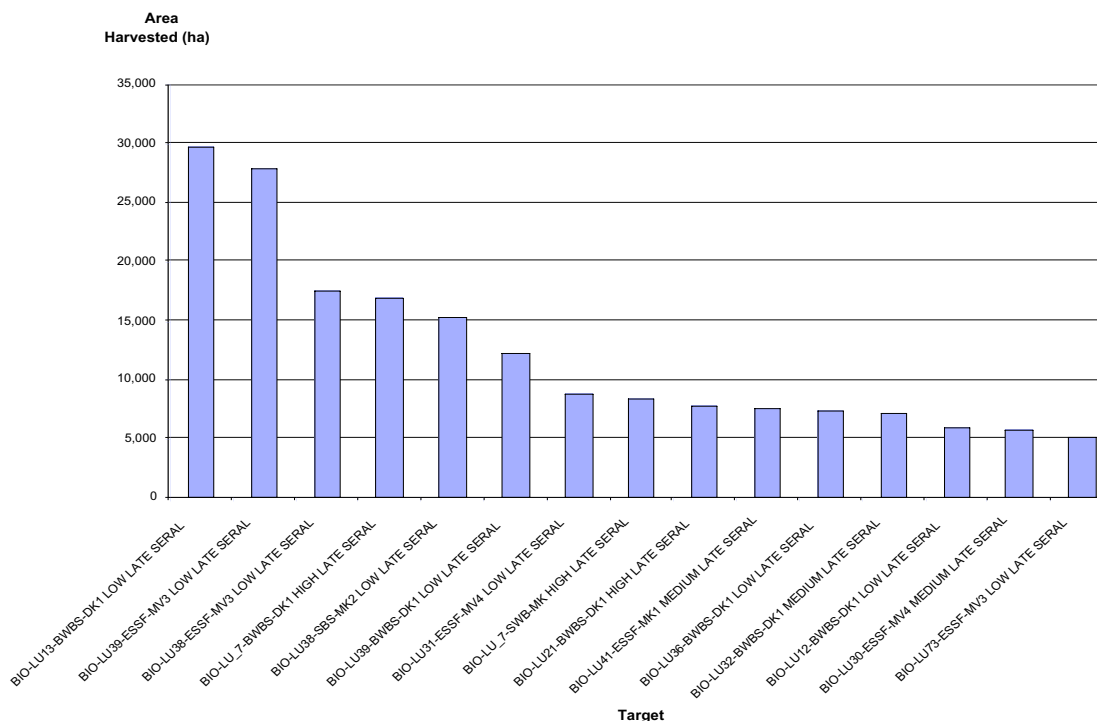


Figure 41. Targets with greater than 5000 Hectare Increase in Alternative 1

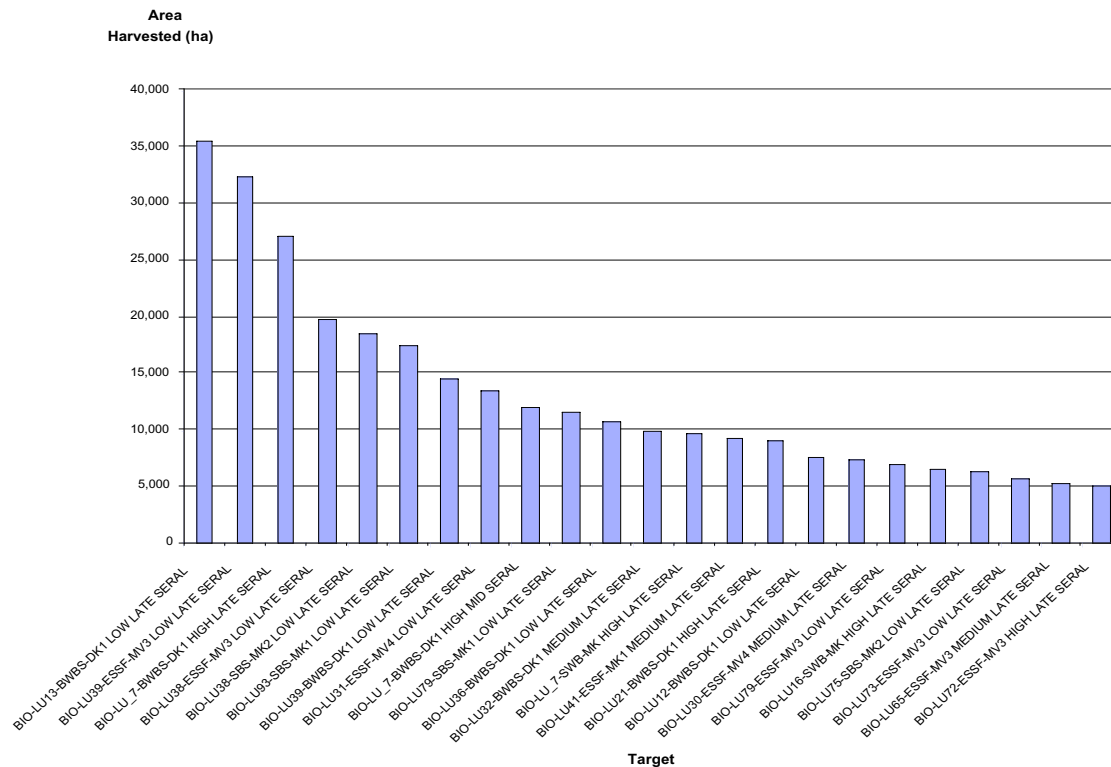


Figure 42. Targets with greater than 5000 Hectares Increase in Alternative 2

6.6.4. Cost and Employment Benefits

The *Mackenzie TSA Silviculture Strategy (Type 1)*, February 2000, report provides costs (\$400 per hectare for fertilization and \$100 per hectare for genetic worth) and job creation estimates (0.1 job days per hectare for fertilization and 2.0 job days per hectare for genetic worth) for the decision scenarios.

These values were provided during workshop sessions in the Fall of 1999. The job creation estimates are based on TSR1 employment coefficients and have not been confirmed. TSR2 employment coefficients apply 0.01 full time person years of employment per 1,000 m³ of volume harvested, which is identical to the coefficient provided in TSR1. As no new information is available on employment coefficients, the values provided through the Type 1 analysis will be used.

Tables 35 to 38 outline the cost implications, employment benefits and investment assessments associated with decision scenario 1.

In decision scenario 1, within the first 20 years, 36,882 hectares are harvested with late fertilization treatments, 116,979 hectares are applied repeat fertilization treatments and 178,205 hectares are planted with genetically improved stock. Within the first five years, 5,584 hectares are harvested with late fertilization treatments, 5,922 hectares applied repeat fertilization treatments and 39,723 hectares are planted with genetically improved stock.

Assuming a cost of \$400 per hectare for late and repeat fertilization, and \$100 per hectare for planting of genetically improved stock, the average cost with the first 20 years may be \$79 million. Within the next five years, the cost may be \$8.6 million, with an average annual cost of \$1.7 million.

Assuming an employment coefficient of 0.1 job days per hectare for late and repeat fertilization and two job days per hectare for genetic worth, 371,796 job days may be created over the first 20 years (or 1,475 full time jobs). Within the next five years, 80,597 job days may be created (or 363 full time jobs). Annually, an average of 16,120 job days may be created (or 73 full time jobs) for the next five years. Full time employment is defined as the number of job days divided by 222 work days per year.

The investment assessment is the volume gain compared with the money spent of applying these treatments and is calculated by dividing the cost per period by the gain in volume harvested between the spatial base case and decision / alternative scenarios. The incremental volume gain per period compared to base case is 4,213,185 m³. For decision scenario 1, the area weighted average investment assessment for the first 20 years may be \$/m³.

Table 35. Cost, Employment and Investment Assessment for Late Fertilization in Decision Scenario 1

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$/m ³)
1 – 5	5,584	2,233,600	558	0.53
6 – 10	10,036	4,014,400	1,004	0.95
11 – 15	11,765	4,706,000	1,177	1.12
16 - 20	9,497	3,798,800	950	0.90
Total	36,882	14,752,800	3,688	3.50

Table 36 Cost, Employment and Investment Assessment for Repeat Fertilization of Pine and Spruce in Decision Scenario 1

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$/m ³)
1 – 5	5,922	2,368,800	592	0.56
6 – 10	11,350	4,540,000	1,135	1.08
11 – 15	32,806	13,122,400	3,281	3.11
16 - 20	66,901	26,760,400	6,690	6.35
Total	116,979	46,791,600	11,698	11.11

Table 37. Cost, Employment and Investment Assessment for Genetic Worth in Decision Scenario 1

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$/m ³)
1 – 5	39,723	3,972,300	79,446	0.94
6 – 10	49,555	4,955,500	99,110	1.18
11 – 15	47,933	4,793,300	95,866	1.14
16 - 20	40,994	4,099,400	81,988	0.97
Total	178,205	17,820,500	356,410	4.23

Table 38. Cost, Employment and Investment Assessment for Decision Scenario 1

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$/m³)
1 – 5	51,229	8,574,700	80,597	2.04
6 – 10	70,941	13,509,900	101,249	3.21
11 – 15	92,504	22,621,700	100,323	5.37
16 - 20	117,392	34,658,600	89,628	8.23
Total	332,066	79,364,900	371,796	18.84

Tables 39 to 42 outline the cost implications, employment benefits and investment assessments associated with decision scenario 2.

In decision scenario 2, within the first 20 years, 18,690 hectares are harvested with late fertilization treatments, 58,627 hectares are applied repeat fertilization treatments and 89,648 hectares are planted with genetically improved stock. Within the first five years, 2,839 hectares are harvested with late fertilization treatments, 3,055 hectares applied repeat fertilization treatments and 20,342 hectares are planted with genetically improved stock.

Assuming a cost of \$400 per hectare for late and repeat fertilization, and \$100 per hectare for planting of genetically improved stock, the average cost with the first 20 years may be \$40 million. Within the next five years, the cost may be \$4.4 million, with an average annual cost of \$878,000.

Assuming an employment coefficient of 0.1 job days per hectare for late and repeat fertilization and two job days per hectare for genetic worth, 187,028 job days (or 842 full time jobs) may be generated over the next 20 years. Within the next five years, 41,273 job days may be created (or 186 full time jobs). Annually, an average of 8,255 job days may be created (or 37 full time jobs) for the next five years. Full time employment is defined as the number of job days divided by 222 work days per year.

The investment assessment is the volume gain compared with the money spent applying these treatments and is calculated by dividing the cost per period by the gain in volume harvested between the spatial base case and decision scenario 2. The incremental volume gain per period is 4,213,185 m³. For decision scenario 2, the area weighted average investment assessment for the first 20 years may be \$3/m³.

Table 39. Cost, Employment and Investment Assessment for Late Fertilization in Decision Scenario 2

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$/m³)
1 – 5	2,839	1,135,600	284	0.27
6 – 10	4,771	1,908,400	477	0.45
11 – 15	5,958	2,383,200	596	0.57
16 - 20	5,122	2,048,800	512	0.49
Total	18,690	7,476,000	1,869	1.77

Table 40. Cost, Employment and Investment Assessment for Repeat Fertilization of Pine and Spruce in Decision Scenario 2

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$/m ³)
1 – 5	3,055	1,222,000	306	0.29
6 – 10	5,359	2,143,600	536	0.51
11 – 15	17,032	6,812,800	1,703	1.62
16 - 20	33,181	13,272,400	3,318	3.15
Total	58,627	23,450,800	5,863	5.57

Table 41. Cost, Employment and Investment Assessment for Genetic Worth in Decision Scenario 2

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$/m ³)
1 – 5	20,342	2,034,200	40,684	0.48
6 – 10	25,319	2,531,900	50,638	0.60
11 – 15	23,992	2,399,200	47,984	0.57
16 - 20	19,995	1,999,500	39,990	0.47
Total	89,648	8,964,800	179,296	2.13

Table 42. Cost, Employment and Investment Assessment for Decision Scenario 2

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$/m ³)
1 – 5	26,236	4,391,800	41,273	1.04
6 – 10	35,449	6,583,900	51,651	1.56
11 – 15	46,982	11,595,200	50,283	2.75
16 - 20	58,298	17,320,700	43,820	4.11
Total	166,965	39,891,600	187,028	9.47

Table 43 outlines the cost implications, employment benefits and investment assessments associated with alternative 1.

In alternative 1, within the first 20 years, 298,886 hectares are treated, of which 31,439 hectares are harvested with late fertilization treatments, 112,249 hectares are applied repeat fertilization treatments and 155,198 hectares are planted with genetically improved stock. Within the first five years, 4,278 hectares are harvested with late fertilization treatments, 5,922 hectares applied repeat fertilization treatments and 34,795 hectares are planted with genetically improved stock.

Assuming a cost of \$400 per hectare for late and repeat fertilization, and \$100 per hectare for planting of genetically improved stock, the average cost with the first 20 years may be \$73 million. Within the next five years, the cost may be \$7.6 million, with an average annual cost of \$1.5 million.

Assuming an employment coefficient of 0.1 job days per hectare for late and repeat fertilization and two job days per hectare for genetic worth, 324,765 job days (or 1,463 full time jobs) may be generated over the next 20 years. Within the next five years, 70,610 job days may be created (or 318 full time jobs). Annually, an average of 14,122 job days may be created (or 64 full time jobs) for the next five years. Full time employment is defined as the number of job days divided by 222 work days per year.

The investment assessment is the volume gain compared with the money spent of applying these treatments and is calculated by dividing the cost per period by the gain in volume harvested between the spatial base case and alternative 1. The incremental volume gain per period is 1,466,185 m³. For alternative 1, the area weighted average investment assessment for the first 20 years may be \$15/m³.

Table 43. Cost, Employment and Investment Assessment for Alternative 1

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$/m ³)
1 – 5	44,995	7,559,500	70,610	5.16
6 – 10	58,275	12,160,500	76,441	8.29
11 – 15	87,533	20,690,900	99,461	14.11
16 - 20	108,083	32,584,100	78,253	22.22
Total	298,886	72,995,000	324,765	49.79

Table 44 outlines the cost implications, employment benefits and investment assessments associated with alternative 2.

In alternative 2, within the first 20 years, 392,089 hectares are treated, of which 59,163 hectares are harvested with late fertilization treatments, 124,138 hectares are applied repeat fertilization treatments and 208,789 hectares are planted with genetically improved stock. Within the first five years, 7,373 hectares are harvested with late fertilization treatments, 5,922 hectares applied repeat fertilization treatments and 46,689 hectares are planted with genetically improved stock.

Assuming a cost of \$400 per hectare for late and repeat fertilization, and \$100 per hectare for planting of genetically improved stock, the average cost with the first 20 years may be \$94 million. Within the next five years, the cost may be \$10 million, with an average annual cost of \$2 million.

Assuming an employment coefficient of 0.1 job days per hectare for late and repeat fertilization and two job days per hectare for genetic worth, 435,908 job days may be created over the first 20 years (or 1,964 full time jobs) will be generated over the next 20 years. Within the next five years, 94,708 job days may be created (or 427 full time jobs). Annually, an average of 18,942 job days may be created (or 85 full time jobs) for the next five years. Full time employment is defined as the number of job days divided by 222 work days per year.

The investment assessment is the volume gain compared with the money spent of applying these treatments and is calculated by dividing the cost per period by the gain in volume harvested between the spatial base case and alternative 2. The incremental volume gain per period is 8,727,185 m³. For alternative 2, the area weighted average investment assessment for the first 20 years may be \$3/m³.

Table 44. Cost, Employment and Investment Assessment for Alternative 2

Year	Area Treated (ha)	Cost (dollars)	Employment (job days)	Investment Assessment (\$/m ³)
1 – 5	59,984	9,986,900	94,708	1.14
6 – 10	84,759	15,621,600	124,262	1.79
11 – 15	98,678	23,772,800	109,291	2.72
16 - 20	148,668	44,817,600	107,648	5.14
Total	392,089	94,198,900	435,908	10.79

6.6.5. Discussion of Decision Scenario Results

Due to the complexity of the results for the decision scenarios, the discussion section is divided into three parts. The first part identifies the timber supply dynamics of the forests in the Mackenzie TSA. Part two identifies which treatments provide the most gain, and part three discusses the benefits gained from adjusting the harvest flow objective.

6.6.5.1. Timber Supply Dynamics

While developing a sustainable harvest flow for decision scenario 1, alternative 1 and alternative 2, the time period that most often provoked a harvest flow crash occurs approximately 85 years from now. *Figures 33, 34 and 35* identify that by year 85, the average harvest age and average volume per hectare are declining at a higher rate, and the average area harvested is increasing at a higher rate. This is due to the limited availability of timber above minimum harvest ages. During this time period, the transition from natural to managed stands, and corresponding minimum harvest age, is limiting the timber available for harvest. By year 115, the average age of harvest is 80 years for decision scenario 1, which is one year older than the area weighted minimum harvest age for managed stands. For decision scenario 2, the most common time frame for harvest flow crash occurs near year 115, where the average harvested age reaches 84 years. When the mid term harvest flow is increased or maintained for a longer period of time, there is not sufficient older timber to sustain the harvest flow while younger stands are unavailable for harvest.

Figures 33 to 39 show that an increase in poor site balsam and spruce harvested increases the area harvested and decreases the volume per hectare harvested. *Figures 37 and 38* specifically show that when the area in poor site spruce and balsam increases, so does the area harvested. For example, at year 20, the area harvested reaches 68,430 hectares, which corresponds to a large increase in poor site balsam harvested. Harvest is concentrated in poor site spruce and poor site balsam stands because they contain the highest relative age compared with the minimum harvest age and are the first stands targeted for harvest under the relative oldest first harvest rule (see *Table 9*).

For decision scenario 1 and 2, the area harvested increases between years 100 and 180. For decision scenario 1 the largest area harvested is 74,365 hectares at year 155 and decision scenario 2 has the largest area harvested in year 145 at 71,410 hectares. During this time period, the largest amount of poor site spruce and poor site balsam is harvested. More than 95% of the poor site spruce and balsam harvested during this time period is receiving its second harvest. However, this trend does not continue in future rotations. By the time these poor site spruce and balsam stands are available for a third harvest in the spatial base case, the harvest is more evenly distributed. As a result, the volume per hectare harvested and area harvested varies by no more than 5% from the volume per hectare and area harvested at year 250. It is anticipated that these same results exist for the decision scenarios.

Conversely, decision scenario 1 and 2 contain a sudden decrease in area harvested at year 125, with a corresponding increase in volume per hectare and age harvested. At that time, the amount of good site pine and good site balsam increases as these stands are harvested shortly after they reach minimum harvest age (second harvest for both species). The average age harvested is high as a result of a small portion of poor site spruce being harvested for the first time.

Please note that although the information presented above describes harvest of balsam over multiple periods, this is not entirely accurate. As a result of the regeneration assumptions (see *Mackenzie TSA Type 2 Incremental Silviculture Analysis Data Inputs and Assumptions*), stands that are currently balsam leading will be converted to spruce leading stands after the first harvest. As a result, by year 140, more than 80% of the balsam leading stands have been converted to spruce leading. By year 250, 95% of balsam leading stands have been converted to spruce leading.

With respect to potential issues affecting timber supply, *Section 4.3* identifies forest cover inventory, forest management requirements, species composition of regenerated stands and poor productivity stands as the issues most affecting timber supply. Three of these issues do not dramatically affect timber supply. The forest cover inventory causes the THLB to be smaller than TSR2, the forest management requirements cause a large proportion of the THLB to be unavailable for timber harvesting for the first 50 years, and the species composition of regenerated stands provides an increase in volume curves for balsam leading stands as a result of species conversion from balsam leading to spruce leading.

The factor most affecting timber supply is the large proportion of poor site spruce and balsam that is harvested in the first 60 years, and is re-harvested between years 130 to 205 for the spatial base case and between years 100 and 180 for the decision scenarios. This is a driving factor for transition to managed forests as it causes an increase in area harvested during that time period in order to meet the harvest flow. Even when fertilization and planting of genetically improved stock is applied, this does not decrease the dependency on these poor sites, but only permits these stands to be available for harvest earlier in the planning horizon.

Altering the genetic worth and repeat fertilization criteria to allow a greater proportion of poor sites to be treated may help increase the productivity of these sites so they become available for their second harvest sooner, thus, allowing the transition from natural to managed stands to be smoother and reducing the concentration of poor site harvesting between years 100 and 180.

6.6.5.2. Treatment Focus

Figure 28 identifies a 28% increase in harvest flow for decision scenario 1 and 2, compared with the spatial base case and can be realized in the first 50 years when 100% or 50% of the candidate area is treated.

In the first 50 years of decision scenario 1, 22% of the harvest is concentrated on medium pine sites (interpolated through *Figures 33 to 39*). In decision scenario 1, 100% of these stands receive an increase in volume as a result of late and repeat fertilization, with a portion receiving an additional benefit from genetic worth. While only 50% of these stands receive increases in volume in decision scenario 2, the volume gain achieved is sufficient to enable the harvest flow to be maintained at the same level as decision scenario 1 for the first 50 years. However, since only 50% of the candidate area is treated in decision scenario 2, this harvest level can not be maintained for the same length of time as decision scenario 1. As a result, the harvest flow must decline earlier in decision scenario 2 and reach a lower long term harvest level. The lower long term harvest level reflects the decrease in candidate area treated. Decision scenario 2 has a 7% increase in harvest flow compared with spatial base case in the long term, while decision scenario 1 has 17% increase compared to spatial base case in the long term.

Tables 24 to 28 identify the area treated for late rotation fertilization, repeat fertilization of pine and spruce as well as genetic worth of pine and spruce for decision scenario 1 and 2. *Table 28* specifically identifies that in decision scenario 1 and 2, 40% of the treated land base receives multiple treatments in the first 20 years, while the remaining 60% of the treated land base receives only one treatment. Altering the candidate area selection criteria for decision scenario 2 to focus on the 40% of the land base where multiple treatments occur may maximize the volume and harvest flow gains in the short, mid and long term.

Tables 29 to 32 demonstrate that the number of targets in contravention remains the same between the spatial base case and all scenarios because the targets are based on an age requirement, irrespective of gains in volume. Although 54% of the THLB is unavailable for harvest at the beginning of the planning horizon, it decreases quickly to 16% by year 50 and does not have a detrimental impact on short or mid term harvest flow. However, if adjacency and green-up are applied across the THLB, or patch size targets are assigned, the opportunities for seeking harvest elsewhere in the district during the first 40 years may become limited; thus reducing the short term harvest flow. Further discussion is provided under *Section 6.8.1 Patch Size Targets*.

Table 33 and Figures 40 to 42 show that in the first 50 years, decision scenario 1 concentrates harvest in certain biogeoclimatic zones and landscape units, compared with the spatial base case. The BWBS zone of the Buffalohead landscape unit receives the largest increase in harvest, followed closely by the ESSF

zone of the Osilinka landscape unit. As the harvest flow in decision scenario 2 is identical to decision scenario 1 in the first 50 years of the planning horizon, impacts on biogeoclimatic zones and landscape units will remain constant between decision scenario 1 and 2. The distribution of the increased harvest can affect the cost for delivering wood to the manufacturing facility and is currently not incorporated into the cost assessment. Additional evaluation regarding cost impacts on location of harvest can be accommodated with the existing model outputs. Further discussion is provided under *Section 6.8.3 Delivered Log Costs*.

Tables 35 to 42 show the cost and employment benefits associated with decision scenario 1 and 2. In the first 20 years, the area weighted average investment may be \$7/m³ for decision scenario 1 and \$3/m³ for decision scenario 2. Decision scenario 2 is less costly per cubic metre as the timber supply gain is equivalent between decision scenario 1 and 2, while the cost of treatment is less than one-half for decision scenario 2 as a result of less area being treated. However, when comparing the employment gains, decision scenario 1 provides twice the employment than decision scenario 2.

The harvest flow gain and cost per cubic metre show that decision scenario 2 provides the largest volume gain per dollar spent. The volume gain per dollar spent could be maintained for a longer period of time if efforts are made to concentrate treatments in locales where multiple treatments apply, as well as increase the candidate area in poor sites to allow for poor sites to become available for second harvest earlier in the planning horizon.

However, prior to investment further evaluation on treatment response for late and repeat fertilization should be considered (see *Section 6.8.2 Fertilization Treatment Response*). In this analysis, late fertilization utilizes the default fertilization assumption from TIPSy and repeat fertilization extrapolates the volume gains achieved on medium sites to good and poor sites for pine, and good, medium and poor sites for spruce.

6.6.5.3. Alternative Harvest Flow Objectives

Figure 30 highlights how different harvest flows can be achieved when different harvest flow objectives are utilized. An even flow harvest flow objective (alternative 1) creates a harvest flow that is 10% higher than the spatial base case in the short and mid term and 14% higher than spatial base case in the long term, while a maximum short term harvest flow objective (alternative 2) allows a 53% increase in harvest flow compared with the spatial base case in the short term and a 17% increase compared with spatial base case in the long term.

Alternative 1 distributes the benefits of silviculture investment across the planning horizon; as a result, the extent of the short term benefits for late fertilization is not realized. Alternative 1 provides a higher long term harvest level than decision scenario 2 (14% higher than spatial base case, compared to 7% higher than spatial base case), but a lower long term harvest level than decision scenario 1 and alternative 2, which is 17% higher than spatial base case. Alternative 1 provides the stability to ensure a relatively homogenous supply of employment over the planning horizon, while maintaining a long term harvest level that is higher than decision scenario 2.

Alternative 2 however, maximizes the return on investment for late fertilization by providing the highest short term harvest flow at 53%. In addition, the long term harvest level is equivalent to decision scenario 1, 17% higher than spatial base case. Alternative 2 ensures the maximum harvest flow gain as a result of silviculture investment.

Table 33 and Figures 40 to 42 show that increasing the harvest flow from the spatial base case concentrates harvest in certain biogeoclimatic zones and landscape units, similar to decision scenario 1. The distribution of increased harvest can affect the cost of delivering wood to the manufacturing facility

and is currently not incorporated in the cost assessment. Additional evaluation regarding cost implications of harvest location can be accommodated with the existing model outputs. Further discussion is provided under *Section 6.8.3 Delivered Log Costs*.

Altering the harvest flow objective affects the volume gain per dollar spent. Due to the lower short term harvest flow in alternative 1, the volume gain per dollar spent in the first 20 years may be \$15/m³; where as a short term maximization harvest flow in alternative 2, may provide a volume gain per dollar spent of \$3/m³ (see *Tables 43 and 44*). The investment cost for alternative 1 is high because the area treated is very similar to decision scenario 1, but the harvest flow is much lower. As a result, the volume gain per dollar spent is higher. Alternative 2 has the same cost per cubic metre as decision scenario 2 because the incremental volume increase in alternative 2 is equivalent to the decrease in area treated in decision scenario 1.

Employment gains in the short term are greatest with alternative 2 at 85 full time jobs per year over the next five years; however, these gains will decrease substantially over time. Alternative 1 has the benefit of maintaining relative constant employment opportunities over time, with 64 full time jobs per year over the next five years .

6.7. Maps

For the purposes of providing a visual representation of analysis results, two types of maps have been prepared (see *Appendix B*) for each learning scenario and the two decision scenarios:

- age class distribution over time (year 0, year 20, year 50, year 100 and year 250); and
- 20 year development plan.

The age class distribution map over time is useful to evaluate how different treatments will affect the land base over time, as well as assess the patch size distribution.

Please note that there are colour discrepancies between the main map and the insets. Where colours do not match, the inset represents the more accurate colour. The maps provided in *Appendix B* are specific to the spatial base case, decision scenario 1 and decision scenario 2. Hard copy and digital maps of the learning scenarios are available separately.

A review of the age class distribution maps for the spatial base case reveals a high concentration of large patches by year 250. Although this does not take into account the natural disturbance patterns, the patch size distribution based on age class is listed in *Table 45*. Review of the age class map for decision scenario 1 reveals the same results. As well, the development plan map for the spatial base case indicates that large cutblocks are predominantly created in the short term. Further discussion is provided under *Section 6.8.1 Patch Size Targets*.

Patches less than one hectare are ignored, as the treatment unit model does not delineate units less than one hectare, so all patches less than one hectare are slivers created during the creation of the resultant database. Patches less than one hectare account for 12,828 hectares, less than 1% of the THLB.

Table 45. Patch Size Distribution for Spatial Base Case

Patch Size Class (ha)	Productive Area in Size Class	% of Productive Area in Size Class
>1 and <40	662,697	22%
>= 40 and <80	429,262	14%
>=80 and <250	487,061	16%
>=250 and <1000	330,486	11%
>=1000	1,135,421	37%
Total	3,044,927	100%

The 20 year development plan identifies the treatment units that will be harvested within the next 20 years. This shows where harvesting occurs in the model, and may provide guidance for development planning.

The development plan map identifies that without accounting for road scheduling, short term harvesting can occur in locations that are not operationally realistic, such as the back end of watersheds where roads have yet to be built. This issue can be addressed through more thorough use of harvest scheduling priorities, or by applying the road scheduling tool of the Tesera Scheduling Model, see *Section 6.8.4 Road Scheduling*.

For mapping purposes, the area accounting for non-recoverable losses is not mapped. Currently, the tool most commonly used by analysts for implementation of non-recoverable losses is to allow the model to harvest the volume allocated to non-recoverable losses. For reporting purposes, this ‘harvest’ is not recorded as it is not intended to be part of the harvest flow. To be consistent with the harvest flow figures, mapping excludes areas harvested for non-recoverable losses.

The maps do not reflect what has been modeled in two situations: partial harvest in visually sensitive areas, and genetic worth.

For partial harvest in visually sensitive areas, the maps identify the area accounting for non-recoverable losses in addition to the harvested areas. In addition, after the partial harvest in visually sensitive area maps were produced, the harvest flow was lowered by 1.5% in the long term to provide a more sustainable growing stock between years 250 and 400. As a result, the age class distribution map for year 250 slightly over-represents age classes less than 135 years old.

For genetic worth, the harvest flow was lowered by 1.5% in the long term to provide a more sustainable growing stock between years 250 and 400 and is not reflected in the maps. As a result, the age class distribution map for year 250 slightly over-represents age classes less than 135 years old.

6.8. Future Opportunities

The following information is provided to highlight future analyses that could be completed to increase the completeness of this analysis, but is outside the scope of this project.

6.8.1. Patch Size Targets

Consistent with TSR2, this analysis does not apply constraints for green-up and adjacency, nor does it assign patch size targets. Review of analysis results in other project areas, such as the Robson Valley, has shown that explicit management of a three metre adjacency green-up and a maximum 60 hectare block size significantly reduces short term timber supply.

Cursory review of the map outputs reveal that the patch size distribution for all scenarios is heavily skewed to patches greater than 1,000 hectares.

Further evaluation of timber supply impacts on managing for patch size distribution and / or green-up and adjacency should be considered in order to most accurately reflect the timber supply gains achieved from the incremental silviculture activities. The Tesera Scheduling Model is capable of incorporating patch size targets.

6.8.2. Fertilization Treatment Response

Further evaluation of the treatment responses for late and repeat fertilization is necessary to ensure that the proposed treatment responses provided in this report adequately represent the treatment response expected in operations. Without further field assessments, the volume gains noted in this report may not be accurate.

In addition, assessment of increased treatment on poor sites may increase the productivity of those sites to a point where they are able to receive their second harvest earlier in the planning horizon, thus reducing the dependency of harvest on poor sites between years 100 and 180 for the decisions scenarios.

6.8.3. Delivered Log Costs

The shift in location of harvest activities across the TSA as a result of incremental silviculture activities is an important consideration when evaluating the cost / benefit ratio of the proposed silviculture investment. If harvest, and thus silviculture investment, occurs primarily in the far or medium haul zone where little road access exists, the value gained from incremental silviculture should be compared against the higher road development costs for accessing the area as well as longer haul costs associated with reaching the manufacturing facility. An assessment of delivered log costs for all scenarios can be evaluated using the current model outputs.

6.8.4. Road Scheduling

The ability for spatial simulation models to harvest specific geographic locations provides insight to the location and distribution of harvest. However, inclusion of a road scheduling tool into the spatial simulation model also provides the opportunity to ensure that the model harvests timber when specific cost constraints are met. As well, inclusion of road scheduling can also provide an output of road status (active versus inactive) by length for each time period. This can be used for evaluation of timber harvesting impacts on non-timber resource values, such as grizzly bear.

7.0 Conclusions

Application of fertilization treatments increases the short, medium and long term harvest flow. Planting genetically improved stock provides the highest timber supply gains in the long term (6.6% higher than spatial base case), followed by repeat fertilization of pine and spruce (2.5% in short and mid term; 5.1% in long term). In the short term, application of late fertilization treatments provides the highest timber supply gain (4% in the short and mid term).

Late fertilization of pine, repeat fertilization of pine and spruce as well as genetic worth for pine and spruce are combined to create the decision scenarios. Decision scenario 1 treats 100% of the fertilization and genetic worth candidate area, while decision scenario 2 treats 50% of the fertilization and genetic worth candidate area. Both decision scenarios utilize the same harvest flow objective to increase the short term harvest level but only allow two or three declines before reaching the long term harvest level.

Two alternative scenarios are provided that treat 100% of the late fertilization, repeat fertilization of pine and spruce and genetic worth candidate area but with different harvest flow objectives. Alternative 1 ensures an even harvest flow, while alternative 2 maximizes the short term harvest flow.

Depending on the importance of gain on investment, employment, or short and long term harvest levels different decision or alternative scenarios best meet those values..

If maximizing return on investment in the short term is of highest priority, then decision scenario 2 (treating 50% of the candidate area with a harvest flow objective of increasing short term harvest flow, while allowing two or three declines to the long term harvest level) and alternative 2 (treating 100% of the candidate area with a harvest flow objective to maximize short term harvest flow) provides the highest volume gain per dollar spent, in the first 20 years of the planning horizon at \$3/m³. Alternative 2 has the added benefit of providing the highest number of full time jobs in the first five years (85 full time jobs), while decision scenario 2 provides the lowest number of full time jobs in the first five years (37 full time jobs). The short term harvest level for decision scenario 2 and alternative 2 is 28% and 53% higher than the spatial base case, respectively. The long term harvest level for decisions scenario 2 and alternative 2 is 7% and 17% higher than the spatial base case, respectively.

If maximizing short term harvest flow is of highest priority, then alternative 2 (treating 100% of the candidate area with a harvest flow objective to maximize short term harvest flow) provides the greatest short term harvest flow at 53% higher than spatial base case. In addition, the highest employment occurs in the first 20 years, with 85 full time jobs provided in the first five years. As well, the same long term harvest level as decision scenario 1 can be maintained. However, the cost of investment is \$3/m³, and employment opportunities decline dramatically during the transition from natural to managed stands.

If maximizing short term employment is of highest priority, then alternative 2 (treating 100% of the candidate area with a harvest flow objective to maximize short term harvest flow) provides the highest employment in the first 20 years, with 85 full time jobs provided in the first five years. In addition, the short term harvest flow is highest (at 53% higher than spatial base case) and the same long term harvest level as decision scenario 1 can be maintained. However, employment opportunities decline dramatically to transition from natural to managed stands.

If maintaining a stable work force is of highest priority, then alternative 1 (treating 100% of the candidate area, with an even flow harvest flow objective) provides the most stable employment at 64 full time jobs for the first five years. However, the short term harvest level is only 10% higher than spatial base case, and only 14% higher than the spatial base case in the long term. As well, the cost of investment is highest at \$15/m³.

If balancing the needs for short term harvest, return on investment, employment opportunities while maintaining the highest long term harvest level, then decision scenario 1 (100% of the candidate area is treated with a harvest flow objective of increasing short term harvest flow, while allowing two or three declines to the long term harvest level) provides the most reasonable balance of the options available. Short term harvest flow is 28% higher than spatial base case and the long term harvest level is 17% higher than base case. The cost of investment is \$7/m³ and 73 full time jobs are created in the first five years. The impact of the decline to the long term harvest level is alleviated as the harvest flow can be maintained for a few decades prior the next decline, allowing the community to adjust to the employment losses.

If maximizing short term harvest, return on investment and short term employment opportunities while maintaining the highest long term harvest level, then alternative 2 (treating 100% of the candidate area with a harvest flow objective to maximize short term harvest flow) provides the greatest return on investment in the first 20 years of the planning horizon. Short term harvest flow is 53% higher than spatial base case, the cost of investment is \$3/m³ and 85 full time jobs per year are created over the first five years.

Prior to application of incremental silviculture activities, two uncertainties should be examined:

- volume gains associated with late fertilization on good, medium and poor sites; and
- volume gains associated with repeat fertilization on good and poor sites for pine, and good, medium and poor sites for spruce.

The volume gains associated with late and repeat fertilization are largely responsible for the dramatic increase in harvest flow in the short and mid term for decision scenario 1 and 2 as well as alternative 2. Harvest flow gains may not be realized if the volume gains have been over-estimated.

In addition, the following opportunities can be evaluated:

- concentration of incremental silviculture activities on the land base where multiple treatments apply;
- increase area treated on poor sites;
- incorporate haul distances to the manufacturing facility in the treatment cost;
- apply patch size targets; and
- implement road scheduling or harvest priority scheduling to more accurately represent operationally realistic harvest locations in the first 20 years.

When less than 100% of the candidate area is treated, concentrating incremental silviculture activities in locales where multiple treatments will be applied (for example, planting of genetically improved stock and repeat fertilization), has the potential to increase the harvest flow, through higher volume gains.

Applying late fertilization on poor sites as well as a higher concentration of treatment on poor sites for repeat fertilization and genetic worth may reduce the dependency of poor site spruce and balsam harvest between years 100 and 180 in the decisions scenarios by allowing these stands to become available for second harvest earlier in the planning horizon, assuming that the relative oldest first harvest rule is maintained.

The cost of investment as well as the incremental gain per dollar spent may be altered if the costs incorporate distance from the manufacturing facility. The current analyses provide a flat rate cost per hectares regardless of distance to the manufacturing facility.

Application of patch size targets may dramatically reduce the short term timber supply if applied in concert with the seral stage requirements. Currently, 54% of the THLB is unavailable for timber harvesting in the first 50 years due to seral stage requirements. However, model results are not impacted due to the flexibility of concentrating harvest in specific landscape units. Limiting the amount of area in large patches may cause the seral stage requirements to become binding.

Implementation of road scheduling or increased reliance on harvest priorities may affect the spatial location of harvest in the short term as a portion of the first 20 year harvest is concentrated in inaccessible areas.

Appendix A – Targets in Violation

The following table provides the productive, forested and THLB areas for each target (seral stage and visuals). In addition, the year at which the target is achieved in the different scenarios is provided.

Label	Age at which target is achieved		Productive Area (ha)	Forested Area (ha)	Current THLB (ha)	Future THLB (ha)
	Base Case and others	Partial Harvest				
BIO-LU_6-AT-HIGH LATE SERAL	141	141	28	28	-	-
BIO-LU_6-SWB-MK HIGH LATE SERAL	31	31	28,870	28,870	4,344	4,149
BIO-LU_7-AT-HIGH LATE SERAL	181	181	1,035	1,035	100	96
BIO-LU_7-ESSF-MV4 HIGH LATE SERAL	71	71	15,975	15,975	5,758	5,499
BIO-LU_7-SWB-MK HIGH LATE SERAL	31	31	57,760	57,760	16,868	16,143
BIO-LU11-AT-LOW LATE SERAL	121	121	227	227	6	6
BIO-LU11-ESSF-MV4 LOW LATE SERAL	51	51	6,280	6,280	555	530
BIO-LU11-SWB-MK LOW LATE SERAL	71	71	11,697	11,697	3,229	3,091
BIO-LU12-AT-LOW LATE SERAL	136	136	745	745	23	22
BIO-LU12-ESSF-MV4 LOW LATE SERAL	71	71	35,495	35,495	13,924	13,330
BIO-LU12-SWB-MK LOW LATE SERAL	101	101	13,720	13,720	3,616	3,454
BIO-LU13-AT-LOW LATE SERAL	151	151	3,064	3,064	221	211
BIO-LU13-ESSF-MV4 LOW LATE SERAL	71	71	73,697	73,697	29,581	28,446
BIO-LU13-SWB-MK LOW LATE SERAL	31	31	8,956	8,956	4,850	4,646
BIO-LU16-AT-HIGH LATE SERAL	86	86	5,610	5,610	293	280
BIO-LU16-ESSF-MC HIGH LATE SERAL	101	101	0	0	-	-

	Age at which target is achieved					
Label	Base Case and others	Partial Harvest	Productive Area (ha)	Forested Area (ha)	Current THLB (ha)	Future THLB (ha)
BIO-LU16-SWB-MK HIGH LATE SERAL	31	31	85,179	85,179	12,725	12,249
BIO-LU18-SWB-MK LOW LATE SERAL	31	31	9	9	-	-
BIO-LU20-AT-HIGH LATE SERAL	191	191	5,479	5,479	125	119
BIO-LU20-ESSF-MV4 HIGH LATE SERAL	51	51	26,114	26,114	5,667	5,418
BIO-LU20-SWB-MK HIGH LATE SERAL	31	31	10,923	10,923	1,560	1,489
BIO-LU21-AT-HIGH LATE SERAL	131	131	1,469	1,469	44	42
BIO-LU21-ESSF-MV4 HIGH LATE SERAL	71	71	14,132	14,132	5,914	5,661
BIO-LU21-SWB-MK HIGH LATE SERAL	91	91	1,020	1,020	581	555
BIO-LU23-AT-HIGH LATE SERAL	141	141	43	43	2	2
BIO-LU23-BWBS-DK1 HIGH LATE SERAL	6	6	13,090	13,090	7,483	7,192
BIO-LU23-ESSF-MV4 HIGH LATE SERAL	121	121	3,870	3,870	1,040	998
BIO-LU25-AT-HIGH LATE SERAL	116	116	9	9	9	9
BIO-LU25-BWBS-DK1 HIGH LATE SERAL	6	6	3,386	3,386	1,727	1,649
BIO-LU25-ESSF-MV4 HIGH LATE SERAL	116	116	871	871	330	315
BIO-LU26-AT-MEDIUM LATE SERAL	141	141	1,736	1,736	158	151
BIO-LU26-BWBS-DK1 MEDIUM LATE SERAL	6	6	7,631	7,631	3,810	3,646
BIO-LU26-ESSF-MV4 MEDIUM LATE SERAL	51	51	24,876	24,876	8,229	7,861

	Age at which target is achieved					
Label	Base Case and others	Partial Harvest	Productive Area (ha)	Forested Area (ha)	Current THLB (ha)	Future THLB (ha)
BIO-LU27-AT-HIGH LATE SERAL	121	121	1,990	1,990	169	162
BIO-LU27-ESSF-MV4 HIGH LATE SERAL	51	51	721	721	84	80
BIO-LU27-SWB-MK HIGH LATE SERAL	26	26	12,733	12,733	3,763	3,599
BIO-LU30-AT-MEDIUM LATE SERAL	161	161	11,670	11,670	1,346	1,288
BIO-LU30-ESSF-MK1 MEDIUM LATE SERAL	71	71	132	132	39	37
BIO-LU30-ESSF-MV4 MEDIUM LATE SERAL	21	21	42,008	42,008	15,339	14,725
BIO-LU30-SBS-MK1 MEDIUM LATE SERAL	141	141	0	0	0	0
BIO-LU30-SBS-MK1 MEDIUM MID SERAL	101	101	0	0	0	0
BIO-LU30-SBS-WK2 MEDIUM LATE SERAL	201	201	169	169	24	23
BIO-LU31-AT-LOW LATE SERAL	161	161	19,843	19,843	3,218	3,079
BIO-LU31-ESSF-MV4 LOW LATE SERAL	51	51	74,203	74,203	37,598	36,020
BIO-LU31-SBS-MK2 LOW LATE SERAL	21	21	24,705	24,705	15,047	14,528
BIO-LU31-SBS-WK2 LOW LATE SERAL	101	101	24,144	24,144	13,913	13,395
BIO-LU31-SWB-MK LOW LATE SERAL	31	31	90	90	52	49
BIO-LU32-AT-MEDIUM LATE SERAL	151	151	5,898	5,898	266	255
BIO-LU32-ESSF-MV4 MEDIUM LATE SERAL	51	51	23,733	23,733	5,963	5,714
BIO-LU32-SWB-MK MEDIUM LATE SERAL	46	46	5,483	5,483	2,183	2,088

	Age at which target is achieved					
Label	Base Case and others	Partial Harvest	Productive Area (ha)	Forested Area (ha)	Current THLB (ha)	Future THLB (ha)
BIO-LU33-AT-HIGH LATE SERAL	136	136	6,590	6,590	559	533
BIO-LU33-BWBS-DK1 HIGH LATE SERAL	31	31	681	681	490	468
BIO-LU33-ESSF-MV4 HIGH LATE SERAL	86	86	10,511	10,511	3,414	3,260
BIO-LU33-SBS-MK1 HIGH LATE SERAL	141	141	0	0	0	0
BIO-LU33-SBS-MK1 HIGH MID SERAL	101	101	0	0	0	0
BIO-LU33-SWB-MK HIGH LATE SERAL	31	31	9,408	9,408	4,027	3,846
BIO-LU34-AT-MEDIUM LATE SERAL	91	91	863	863	-	-
BIO-LU34-ESSF-MV4 MEDIUM LATE SERAL	6	6	9,315	9,315	2,000	1,910
BIO-LU35-AT-HIGH LATE SERAL	86	86	1,650	1,650	102	98
BIO-LU35-ESSF-MV3 HIGH LATE SERAL	26	26	12,350	12,350	4,607	4,400
BIO-LU35-ESSF-MV4 HIGH LATE SERAL	6	6	337	337	51	48
BIO-LU35-SBS-MK1 HIGH LATE SERAL	141	141	0	0	0	0
BIO-LU35-SBS-MK1 HIGH MID SERAL	101	101	0	0	0	0
BIO-LU36-AT-LOW LATE SERAL	126	126	7,459	7,459	845	807
BIO-LU36-ESSF-MV4 LOW LATE SERAL	6	6	30,028	30,028	13,028	12,482
BIO-LU36-SBS-MK1 LOW LATE SERAL	141	141	0	0	0	0
BIO-LU36-SWB-MK LOW LATE SERAL	111	111	1,975	1,975	686	655

	Age at which target is achieved					
Label	Base Case and others	Partial Harvest	Productive Area (ha)	Forested Area (ha)	Current THLB (ha)	Future THLB (ha)
BIO-LU38-AT-LOW LATE SERAL	116	116	19,181	19,181	2,827	2,699
BIO-LU38-ESSF-MV3 LOW LATE SERAL	6	6	56,094	56,094	31,585	30,350
BIO-LU38-ESSF-MV4 LOW LATE SERAL	91	91	8,284	8,284	4,731	4,550
BIO-LU38-SBS-WK2 LOW LATE SERAL	6	6	5,680	5,680	4,312	4,207
BIO-LU38-SWB-MK LOW LATE SERAL	91	91	9,385	9,385	4,225	4,047
BIO-LU39-AT-LOW LATE SERAL	106	106	20,648	20,648	5,174	4,962
BIO-LU40-BWBS-DK1 LOW LATE SERAL	11	11	73	73	56	55
BIO-LU40-SBS-MK2 LOW LATE SERAL	11	11	1,026	1,026	846	817
BIO-LU40-SBS-WK2 LOW LATE SERAL	51	51	846	846	539	519
BIO-LU41-AT-MEDIUM LATE SERAL	131	131	15,758	15,758	1,308	1,253
BIO-LU41-ESSF-MK1 MEDIUM LATE SERAL	31	31	41,197	41,197	16,561	15,874
BIO-LU41-ESSF-MV4 MEDIUM LATE SERAL	56	56	19,874	19,874	6,797	6,557
BIO-LU41-SBS-WK2 MEDIUM LATE SERAL	26	26	11,407	11,407	6,707	6,474
BIO-LU43-AT-MEDIUM LATE SERAL	186	186	6,910	6,910	777	743
BIO-LU43-BWBS-MW1 MEDIUM LATE SERAL	51	51	1,816	1,816	864	830
BIO-LU43-BWBS-MW1 MEDIUM MID SERAL	31	31	1,816	1,816	864	830
BIO-LU43-BWBS-WK1 MEDIUM LATE SERAL	46	46	3,102	3,102	1,036	995

	Age at which target is achieved					
Label	Base Case and others	Partial Harvest	Productive Area (ha)	Forested Area (ha)	Current THLB (ha)	Future THLB (ha)
BIO-LU43-BWBS-WK1 MEDIUM MID SERAL	26	26	3,102	3,102	1,036	995
BIO-LU43-ESSF-MV2 MEDIUM LATE SERAL	31	31	9,867	9,867	3,663	3,510
BIO-LU43-ESSF-MV4 MEDIUM LATE SERAL	56	56	30,289	30,289	9,379	8,982
BIO-LU44-AT-HIGH LATE SERAL	76	76	1,686	1,686	198	190
BIO-LU44-BWBS-WK2 HIGH LATE SERAL	56	56	574	574	181	174
BIO-LU44-BWBS-WK2 HIGH MID SERAL	21	21	574	574	181	174
BIO-LU44-ESSF-MK1 HIGH LATE SERAL	56	56	12,143	12,143	4,638	4,433
BIO-LU44-ESSF-MV2 HIGH LATE SERAL	221	221	62	62	7	7
BIO-LU44-ESSF-MV4 HIGH LATE SERAL	121	121	442	442	91	87
BIO-LU44-SBS-MK2 HIGH LATE SERAL	31	31	562	562	334	319
BIO-LU44-SBS-MK2 HIGH MID SERAL	1	1	562	562	334	319
BIO-LU44-SBS-WK2 HIGH LATE SERAL	61	61	17,585	17,585	9,178	8,843
BIO-LU49-AT-MEDIUM LATE SERAL	141	141	702	702	72	69
BIO-LU49-BWBS-DK1 MEDIUM MID SERAL	11	11	2,254	2,254	924	882
BIO-LU49-ESSF-MV3 MEDIUM LATE SERAL	31	31	6,283	6,283	2,179	2,081
BIO-LU50-AT-HIGH LATE SERAL	141	141	1,415	1,415	172	164
BIO-LU50-BWBS-DK1 HIGH LATE SERAL	31	31	2,712	2,712	1,303	1,244

	Age at which target is achieved					
Label	Base Case and others	Partial Harvest	Productive Area (ha)	Forested Area (ha)	Current THLB (ha)	Future THLB (ha)
BIO-LU50-ESSF-MV3 HIGH LATE SERAL	31	31	9,012	9,012	2,673	2,555
BIO-LU53-AT-MEDIUM LATE SERAL	91	91	1,497	1,497	142	135
BIO-LU53-ESSF-MV3 MEDIUM LATE SERAL	31	31	10,439	10,439	4,481	4,283
BIO-LU62-BWBS-DK1 LOW LATE SERAL	31	31	12	12	6	6
BIO-LU63-AT-MEDIUM LATE SERAL	71	71	1,382	1,382	66	63
BIO-LU63-ESSF-MV3 MEDIUM LATE SERAL	31	31	10,646	10,646	4,476	4,275
BIO-LU64-AT-LOW LATE SERAL	31	31	622	622	21	20
BIO-LU64-ESSF-MV3 LOW LATE SERAL	31	31	6,168	6,168	1,969	1,880
BIO-LU65-AT-MEDIUM LATE SERAL	31	31	1,251	1,251	128	124
BIO-LU65-BWBS-DK1 MEDIUM LATE SERAL	26	26	4,380	4,380	2,814	2,687
BIO-LU65-BWBS-DK1 MEDIUM MID SERAL	6	6	4,380	4,380	2,814	2,687
BIO-LU65-ESSF-MV3 MEDIUM LATE SERAL	31	31	22,895	22,895	7,153	6,837
BIO-LU67-AT-HIGH LATE SERAL	161	161	1,032	1,032	648	619
BIO-LU67-BWBS-DK1 HIGH LATE SERAL	31	31	4,787	4,787	2,635	2,526
BIO-LU67-ESSF-MV3 HIGH LATE SERAL	31	31	7,213	7,213	3,298	3,150
BIO-LU67-SBS-MK1 HIGH LATE SERAL	31	31	742	742	444	424
BIO-LU68-AT-HIGH LATE SERAL	161	161	508	508	144	138

	Age at which target is achieved					
Label	Base Case and others	Partial Harvest	Productive Area (ha)	Forested Area (ha)	Current THLB (ha)	Future THLB (ha)
BIO-LU68-BWBS-DK1 HIGH LATE SERAL	31	31	8,196	8,196	3,831	3,671
BIO-LU68-ESSF-MV3 HIGH LATE SERAL	31	31	3,403	3,403	1,307	1,249
BIO-LU68-SBS-MK1 HIGH LATE SERAL	46	46	30	30	18	17
BIO-LU68-SBS-MK1 HIGH MID SERAL	6	6	30	30	18	17
BIO-LU72-AT-HIGH LATE SERAL	141	141	1,203	1,203	227	217
BIO-LU72-BWBS-DK1 HIGH LATE SERAL	31	31	491	491	97	92
BIO-LU72-ESSF-MV3 HIGH LATE SERAL	31	31	13,476	13,476	7,389	7,103
BIO-LU72-SBS-MK1 HIGH LATE SERAL	31	31	1,005	1,005	481	461
BIO-LU72-SBS-WK2 HIGH LATE SERAL	31	31	31	31	25	25
BIO-LU73-AT-LOW LATE SERAL	141	141	207	207	46	44
BIO-LU73-SBS-MK1 LOW LATE SERAL	11	11	5,969	5,969	4,356	4,201
BIO-LU73-SBS-WK2 LOW LATE SERAL	31	31	1,252	1,252	968	933
BIO-LU74-AT-HIGH LATE SERAL	31	31	429	429	112	107
BIO-LU74-ESSF-MV3 HIGH LATE SERAL	31	31	3,250	3,250	1,579	1,508
BIO-LU74-SBS-MK1 HIGH LATE SERAL	31	31	2,337	2,337	1,207	1,153
BIO-LU75-AT-LOW LATE SERAL	141	141	747	747	207	197
BIO-LU75-BWBS-DK1 LOW LATE SERAL	26	26	207	207	99	98

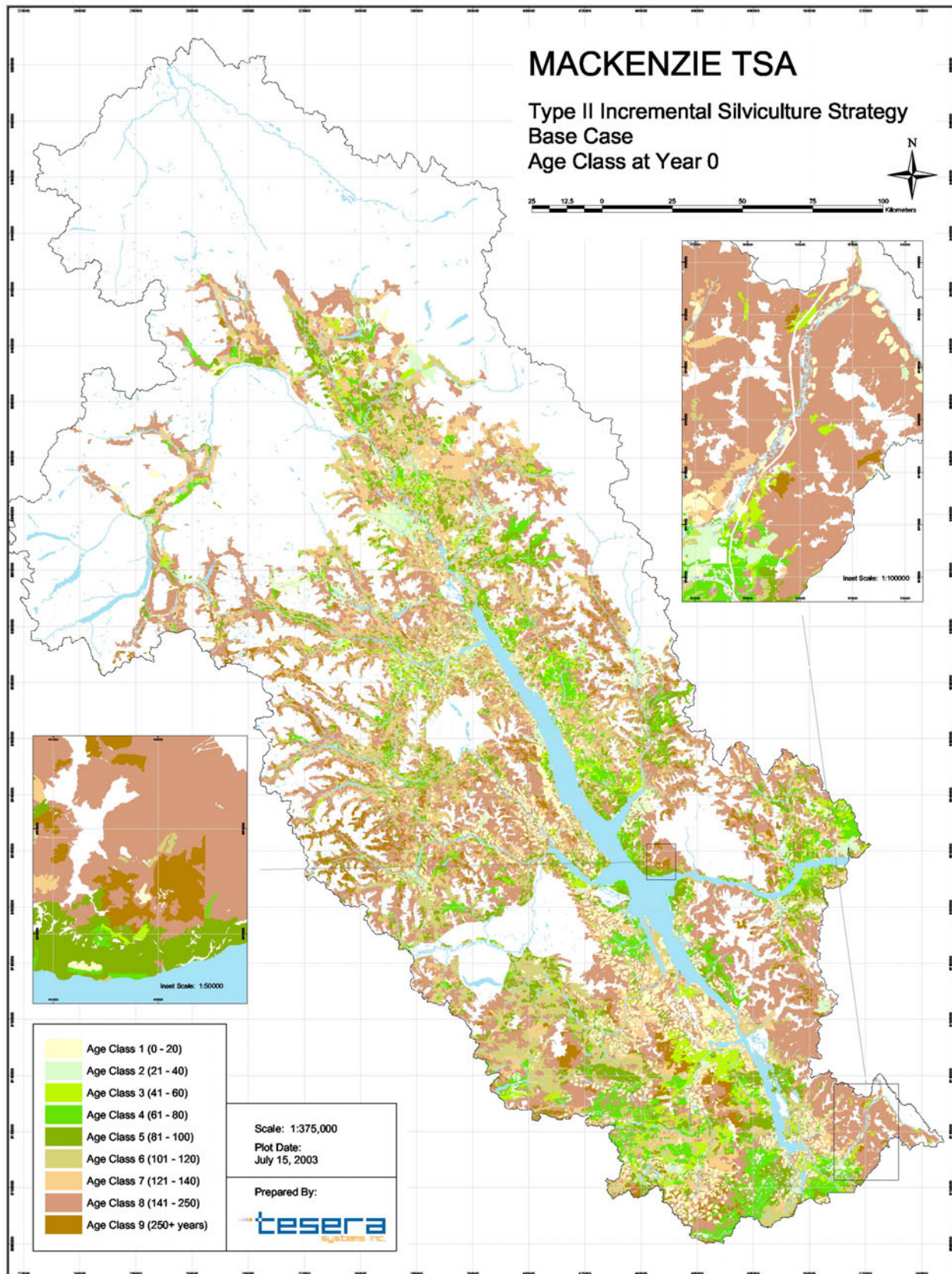
	Age at which target is achieved					
Label	Base Case and others	Partial Harvest	Productive Area (ha)	Forested Area (ha)	Current THLB (ha)	Future THLB (ha)
BIO-LU75-SBS-WK2 LOW LATE SERAL	31	31	59,289	59,289	47,692	46,099
BIO-LU76-AT-MEDIUM LATE SERAL	31	31	777	777	281	268
BIO-LU76-ESSF-MK1 MEDIUM LATE SERAL	31	31	42,817	42,817	26,261	25,101
BIO-LU76-SBS-MK1 MEDIUM LATE SERAL	21	21	3,098	3,098	2,497	2,415
BIO-LU76-SBS-MK2 MEDIUM LATE SERAL	11	11	16,704	16,704	14,606	14,084
BIO-LU76-SBS-VK MEDIUM LATE SERAL	31	31	8,711	8,711	5,720	5,465
BIO-LU76-SBS-WK2 MEDIUM LATE SERAL	31	31	13,760	13,760	11,420	11,005
BIO-LU77-AT-MEDIUM LATE SERAL	151	151	2,238	2,238	101	96
BIO-LU77-ESSF-MK1 MEDIUM LATE SERAL	36	36	44,589	44,589	13,438	12,923
BIO-LU77-SBS-WK2 MEDIUM LATE SERAL	16	16	22,893	22,893	11,852	11,420
BIO-LU79-AT-LOW LATE SERAL	121	121	935	935	146	139
BIO-LU80-AT-MEDIUM LATE SERAL	131	131	1,339	1,339	304	292
BIO-LU80-ESSF-MV2 MEDIUM LATE SERAL	121	121	3,176	3,176	1,315	1,258
BIO-LU80-ESSF-MV3 MEDIUM LATE SERAL	31	31	58,267	58,267	30,719	29,440
BIO-LU81-SBS-MK1 HIGH LATE SERAL	11	11	9,636	9,636	6,472	6,210
BIO-LU81-SBS-MK2 HIGH LATE SERAL	11	11	1,607	1,607	1,014	984
BIO-LU81-SBS-WK2 HIGH LATE SERAL	161	161	603	603	467	452

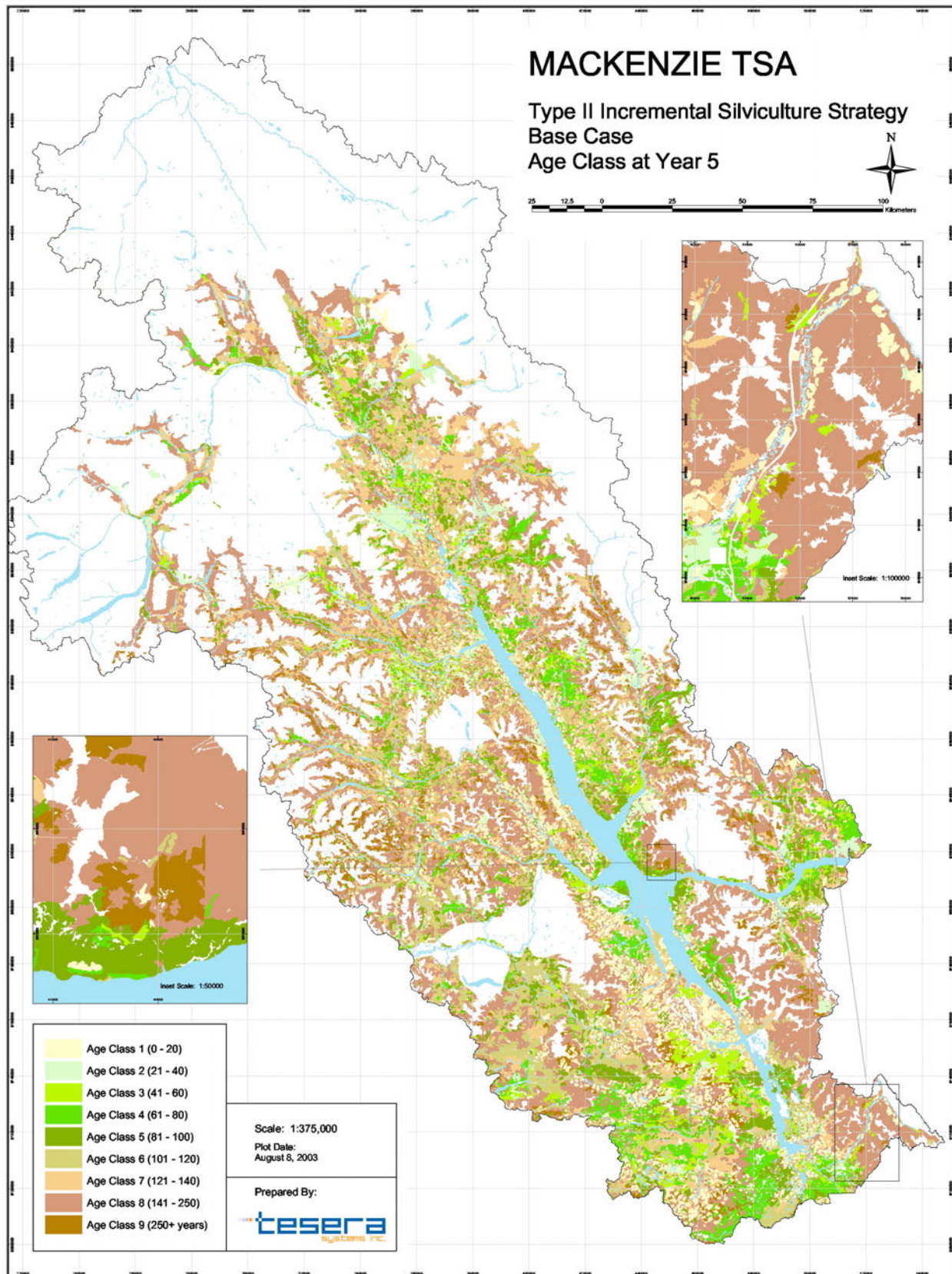
	Age at which target is achieved					
Label	Base Case and others	Partial Harvest	Productive Area (ha)	Forested Area (ha)	Current THLB (ha)	Future THLB (ha)
BIO-LU83-ESSF-MK1 MEDIUM LATE SERAL	31	31	1,952	1,952	186	177
BIO-LU83-SBS-MK1 MEDIUM LATE SERAL	31	31	1,873	1,873	1,200	1,146
BIO-LU83-SBS-MK2 MEDIUM LATE SERAL	31	31	3,881	3,881	3,108	2,983
BIO-LU83-SBS-WK2 MEDIUM LATE SERAL	31	31	4,885	4,885	2,990	2,868
BIO-LU86-AT-LOW LATE SERAL	31	31	320	320	21	21
BIO-LU86-ESSF-MK1 LOW LATE SERAL	21	21	29,926	29,926	11,710	11,198
BIO-LU86-SBS-VK LOW LATE SERAL	21	21	4,366	4,366	3,036	2,916
BIO-LU86-SBS-WK1 LOW LATE SERAL	96	96	7,926	7,926	6,587	6,324
BIO-LU86-SBS-WK2 LOW LATE SERAL	21	21	28,662	28,662	23,702	22,902
BIO-LU87-SBS-WK2 LOW LATE SERAL	16	16	26	26	19	18
BIO-LU89-AT-HIGH LATE SERAL	66	66	435	435	9	9
BIO-LU89-ESSF-MK1 HIGH LATE SERAL	21	21	12,815	12,815	5,690	5,442
BIO-LU89-SBS-WK1 HIGH LATE SERAL	21	21	248	248	209	203
BIO-LU89-SBS-WK2 HIGH LATE SERAL	21	21	5,414	5,414	4,516	4,392
BIO-LU92-SBS-MK1 MEDIUM LATE SERAL	31	31	4,101	4,101	3,211	3,094
BIO-LU93-AT-LOW LATE SERAL	181	181	413	413	241	232
BIO-LU93-ESSF-MV3 LOW LATE SERAL	31	31	58,193	58,193	40,209	38,749

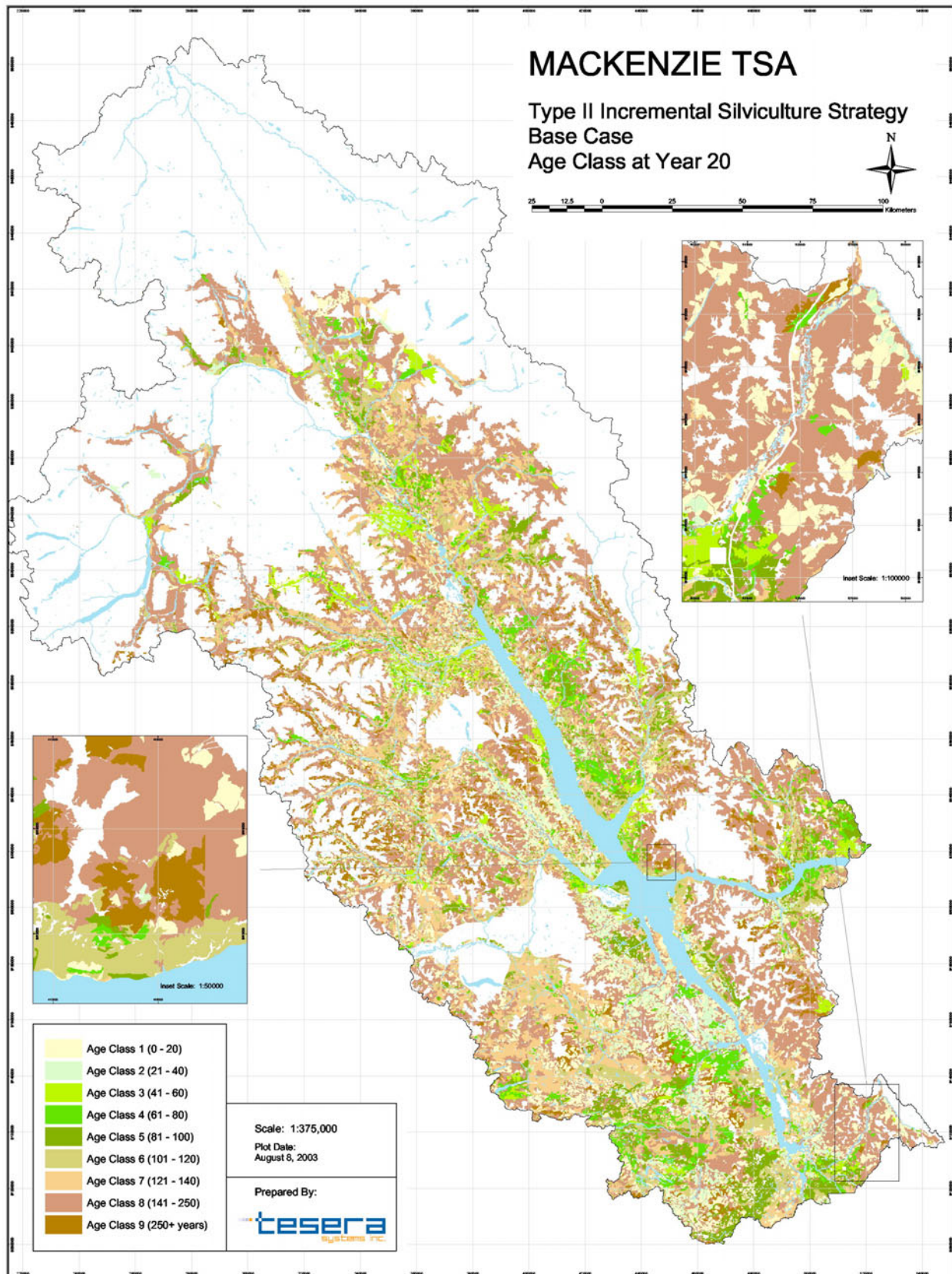
	Age at which target is achieved					
Label	Base Case and others	Partial Harvest	Productive Area (ha)	Forested Area (ha)	Current THLB (ha)	Future THLB (ha)
BIO-LU93-SBS-WK2 LOW LATE SERAL	31	31	5,179	5,179	3,479	3,337
BIO-LU94-SBS-MK1 MEDIUM LATE SERAL	11	11	6,477	6,477	3,646	3,520
Visual-104-Modification Early Seral	11	0	348	348	229	222
Visual-106-Retention Early Seral	26	0	48	48	46	44
Visual-111-Modification Early Seral	31	0	495	495	350	340
Visual-116-Modification Early Seral	11	0	262	262	246	240
Visual-121-Modification Early Seral	11	0	881	881	706	682
Visual-137-Modification Early Seral	21	0	339	339	271	264
Visual-141-Partial Retention Early Seral	21	0	25	25	20	20
Visual-155-Modification Early Seral	21	0	291	291	231	225
Visual-158-Partial Retention Early Seral	11	11	15	15	14	14
Visual-161-Partial Retention Early Seral	16	0	157	157	141	137
Visual-162-Partial Retention Early Seral	16	16	85	85	81	80
Visual-163-Partial Retention Early Seral	11	0	78	78	63	61
Visual-174-Preservation Early Seral	26	0	64	64	41	39
Visual-176-Partial Retention Early Seral	16	0	471	471	428	417
Visual-181-Partial Retention Early Seral	26	0	14	14	14	13

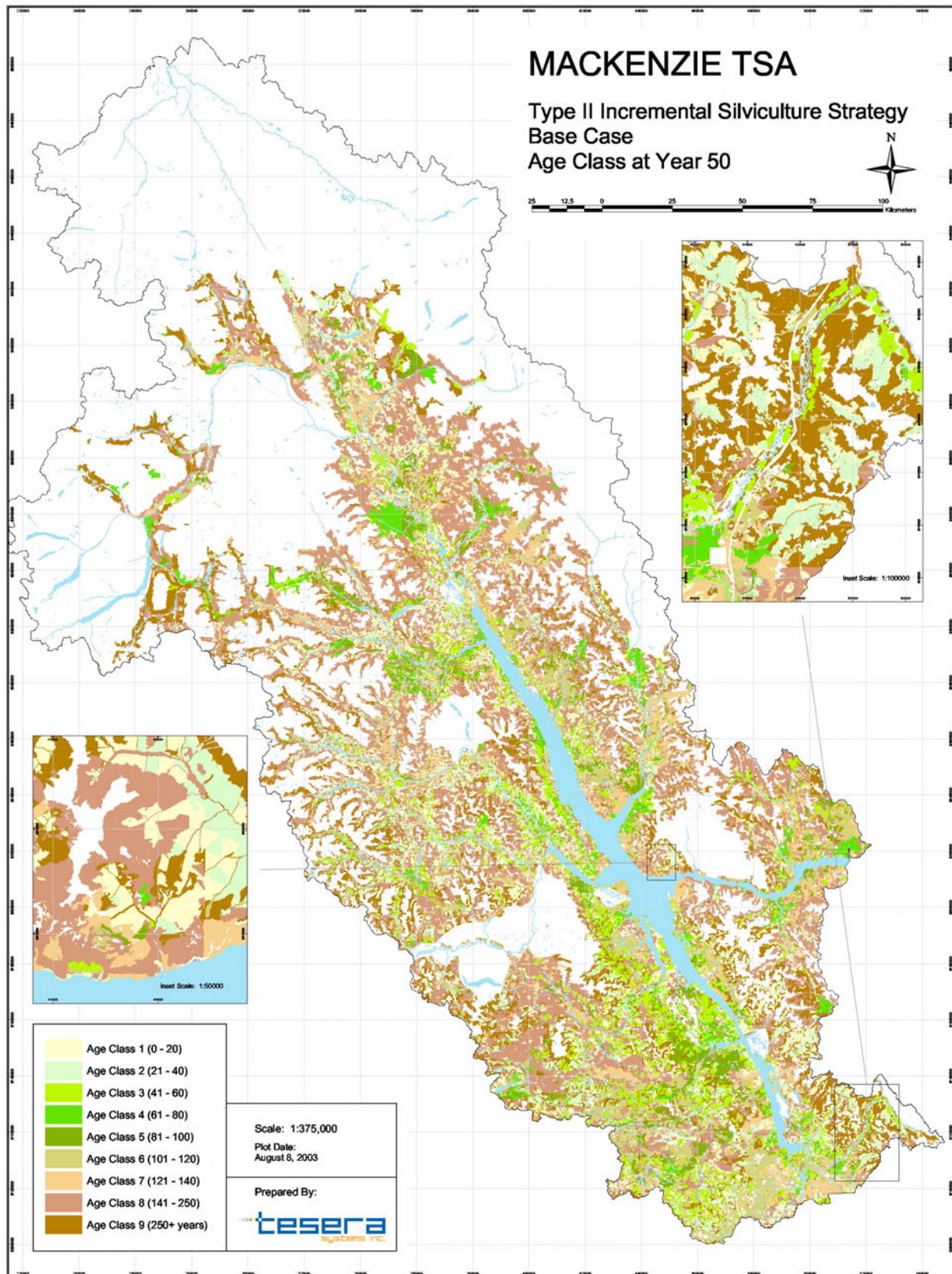
Label	Age at which target is achieved		Productive Area (ha)	Forested Area (ha)	Current THLB (ha)	Future THLB (ha)
	Base Case and others	Partial Harvest				
Visual-184-Retention Early Seral	6	0	310	310	54	52
Visual-191-Partial Retention Early Seral	16	0	237	237	226	218
Visual-204-Partial Retention Early Seral	16	0	703	703	627	608
Visual-206-Partial Retention Early Seral	1	0	189	189	145	140
Visual-211-Partial Retention Early Seral	16	0	2	2	1	1
Visual-212-Partial Retention Early Seral	26	21	36	36	35	34
Visual-29-Partial Retention Early Seral	21	0	479	479	233	226
Visual-30-Partial Retention Early Seral	21	0	357	357	231	224
Visual-4-Partial Retention Early Seral	26	0	250	250	71	69
Visual-5-Partial Retention Early Seral	26	0	372	372	91	88
Visual-61-Partial Retention Early Seral	21	0	391	391	334	324
Visual-65-Partial Retention Early Seral	21	16	54	54	52	51
Visual-67-Modification Early Seral	16	0	198	198	95	94
Visual-97-Retention Early Seral	26	0	20	20	14	13

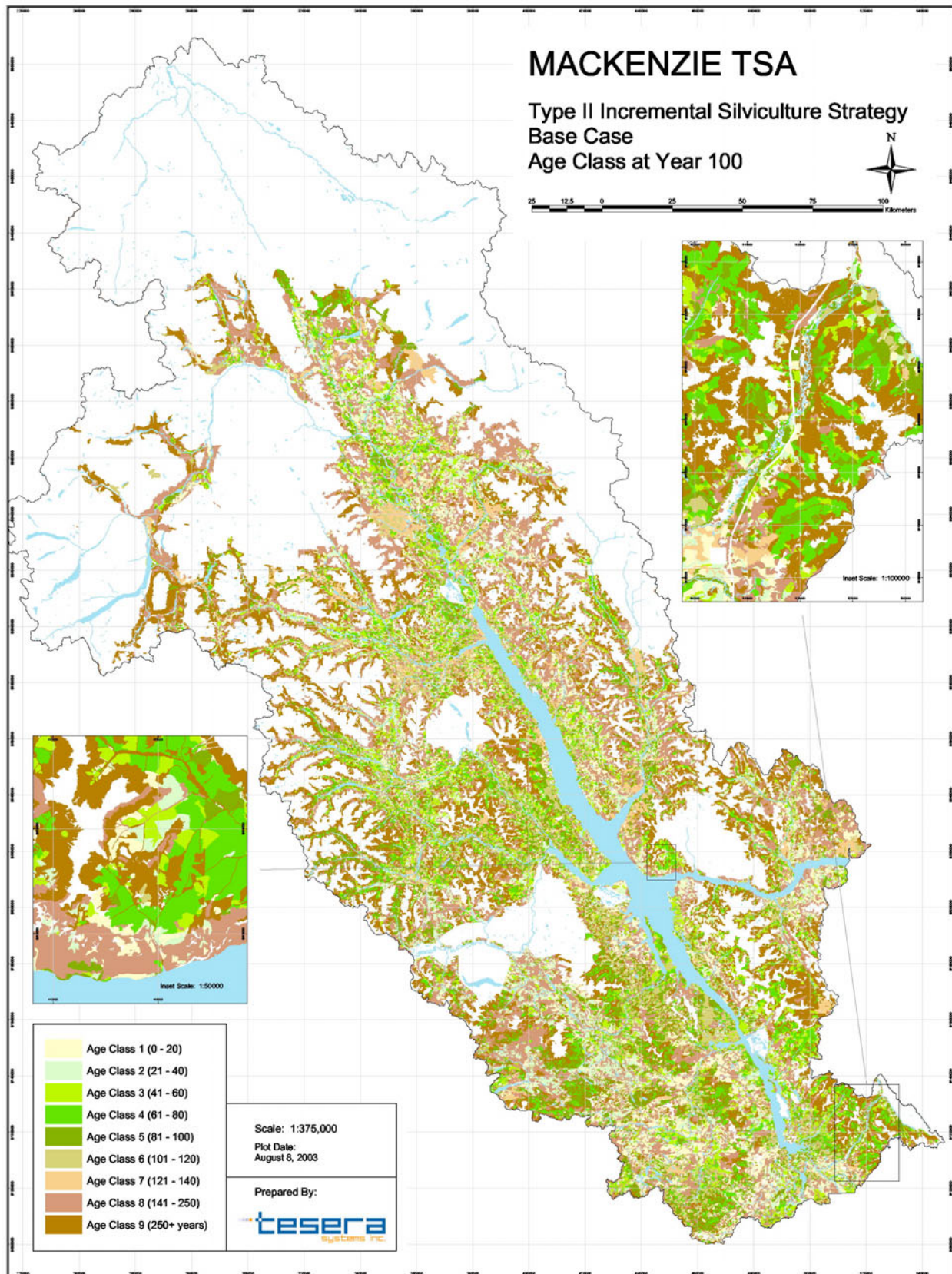
Appendix B – Maps for the Spatial Base Case, Decision Scenario 1 and Decision Scenario 2

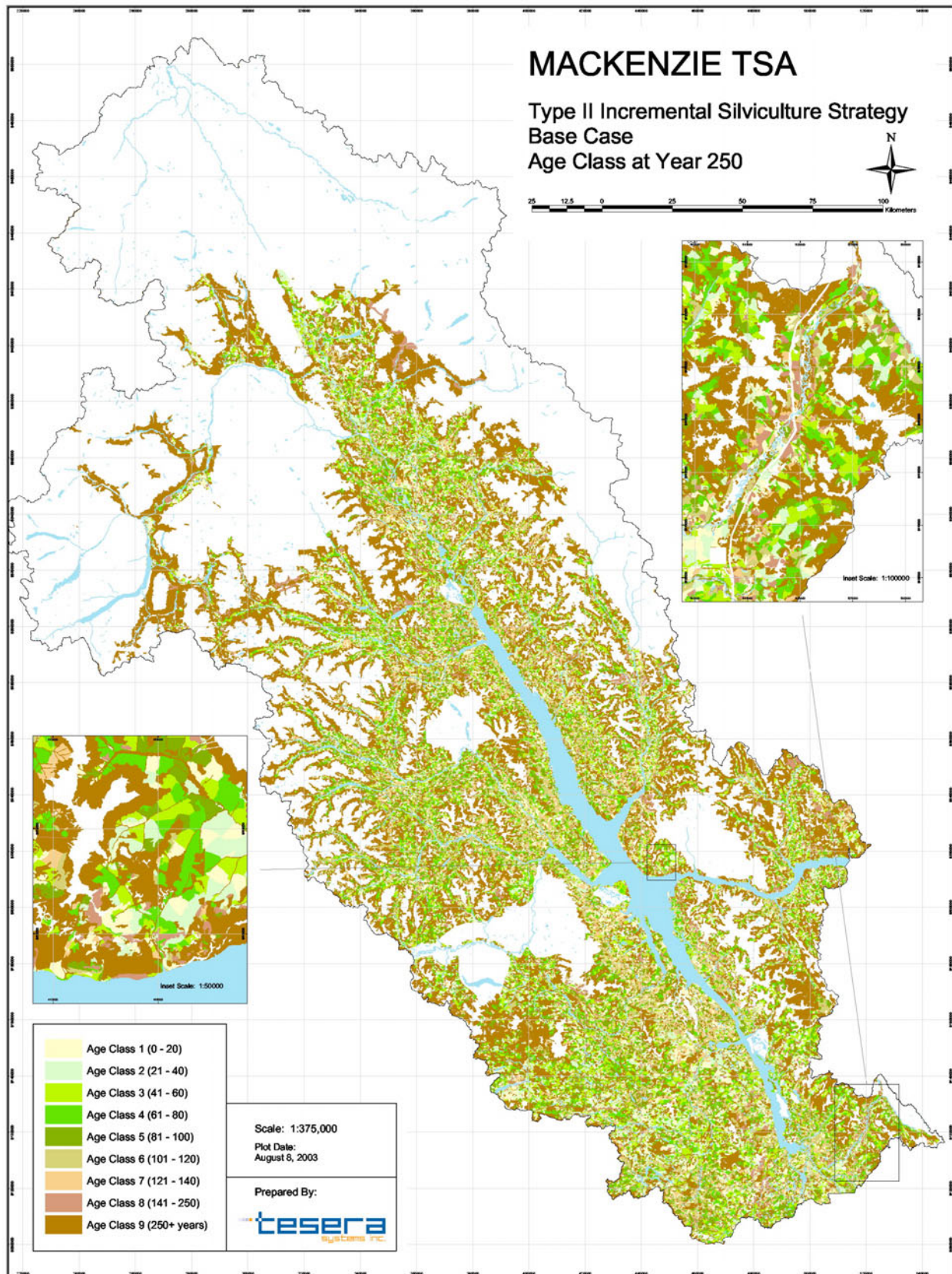


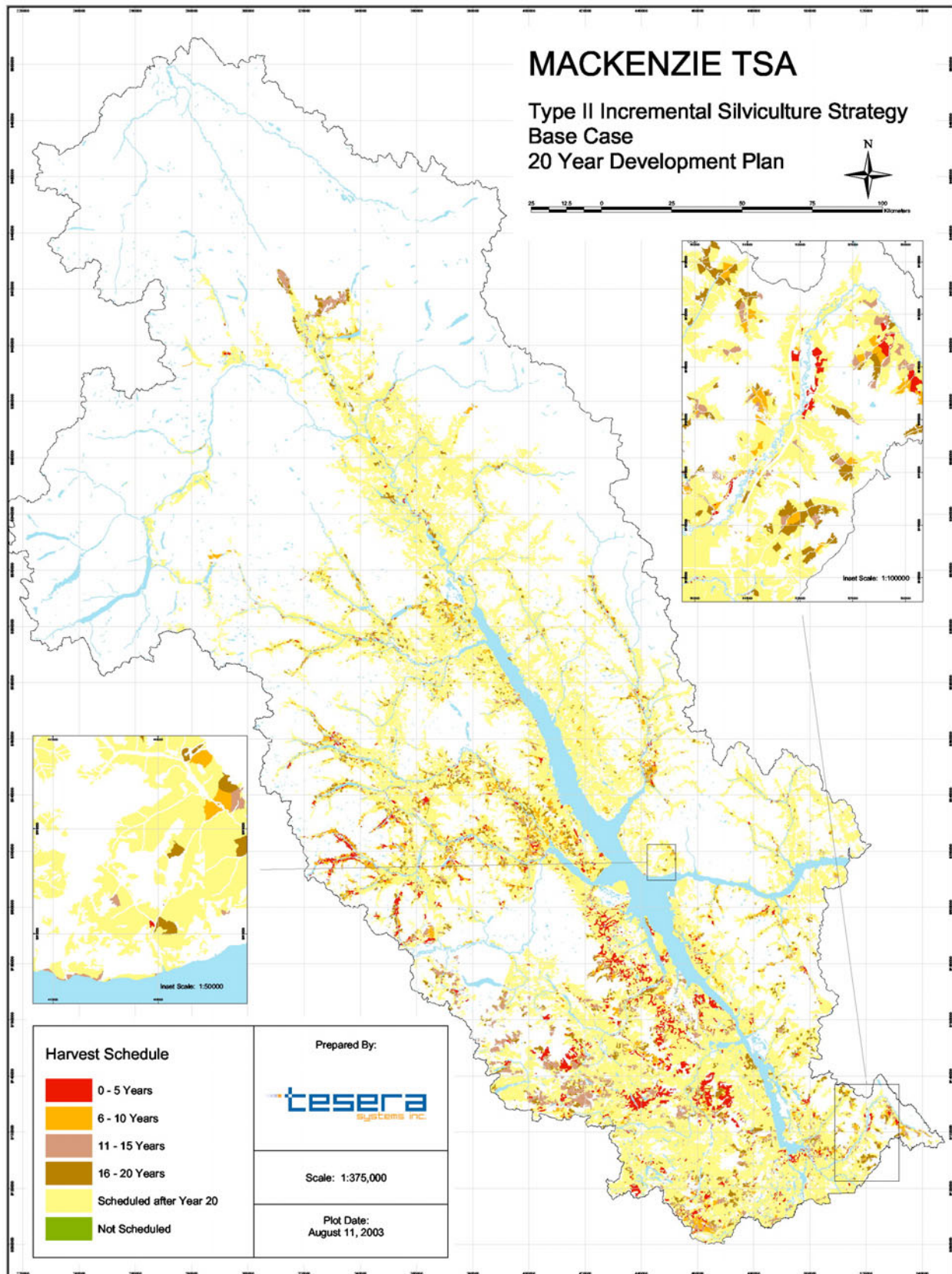


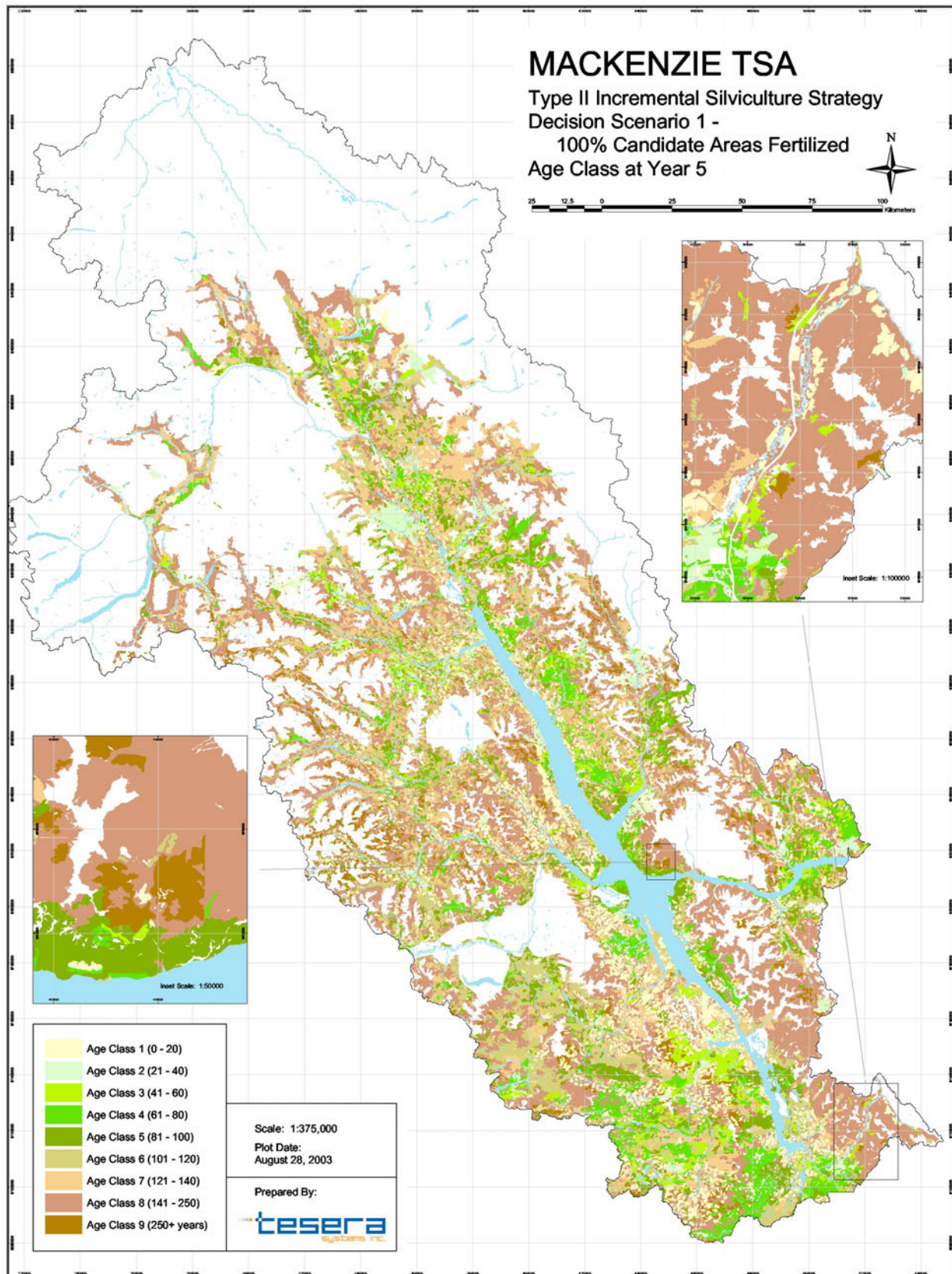


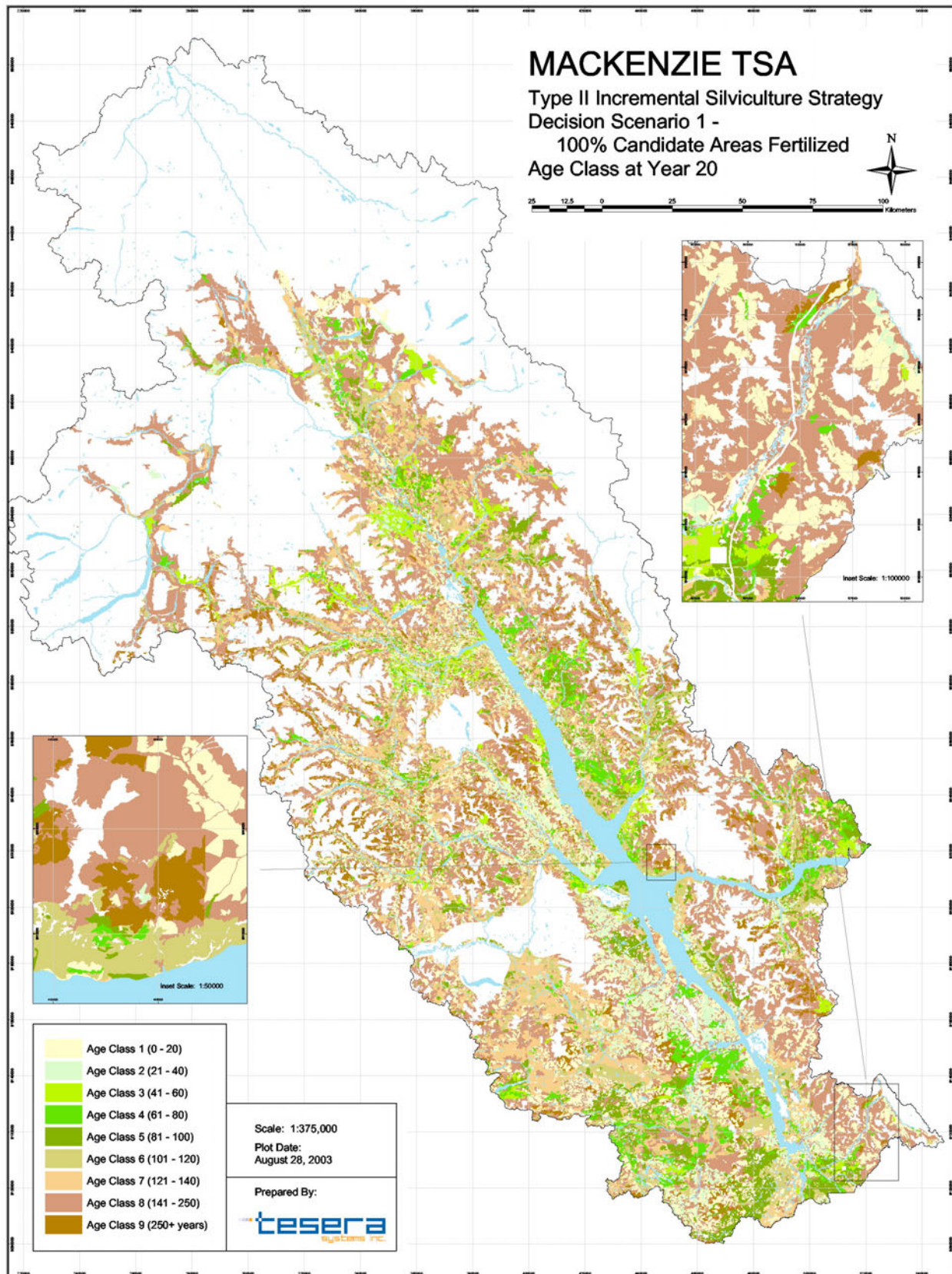


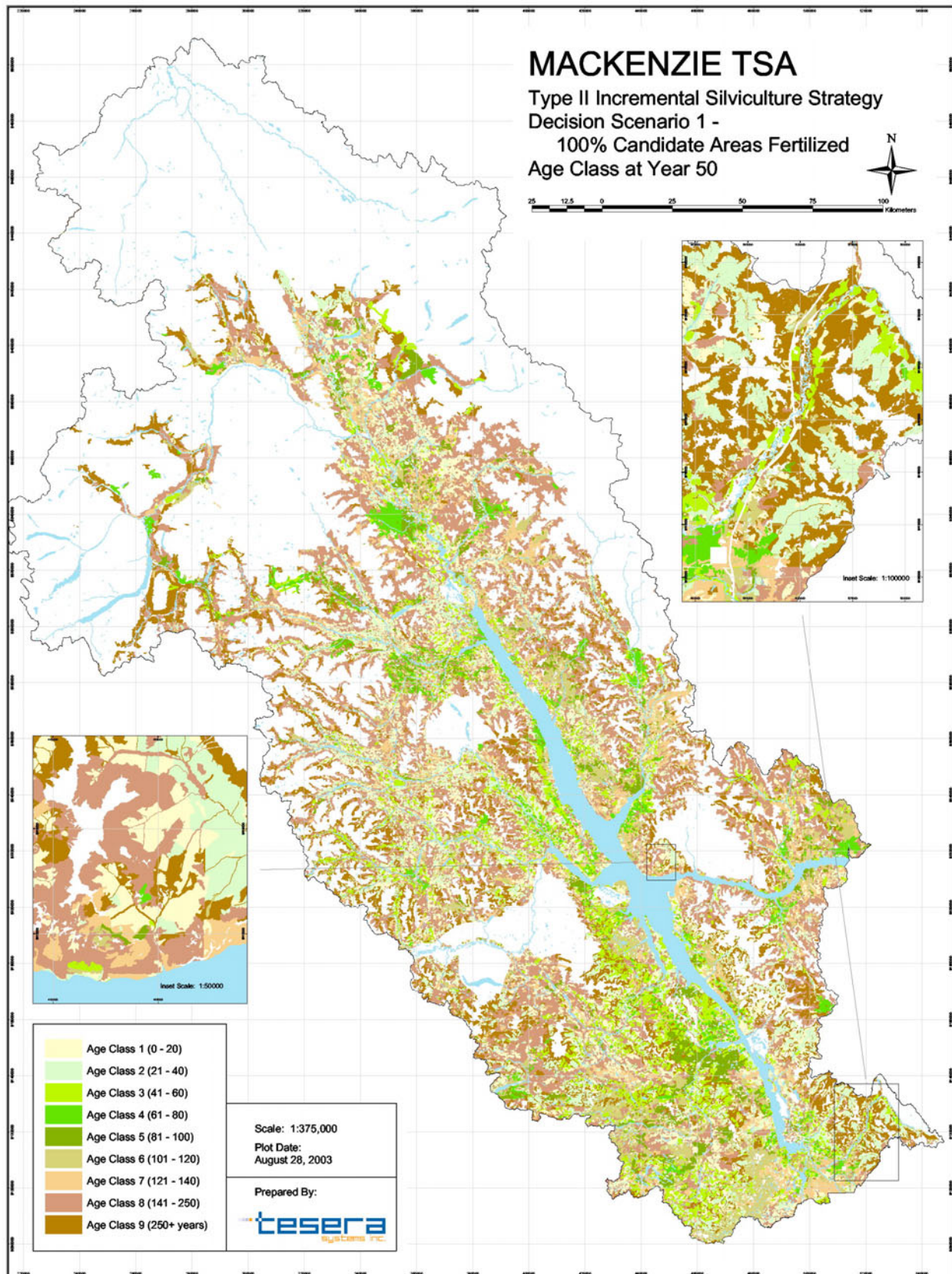


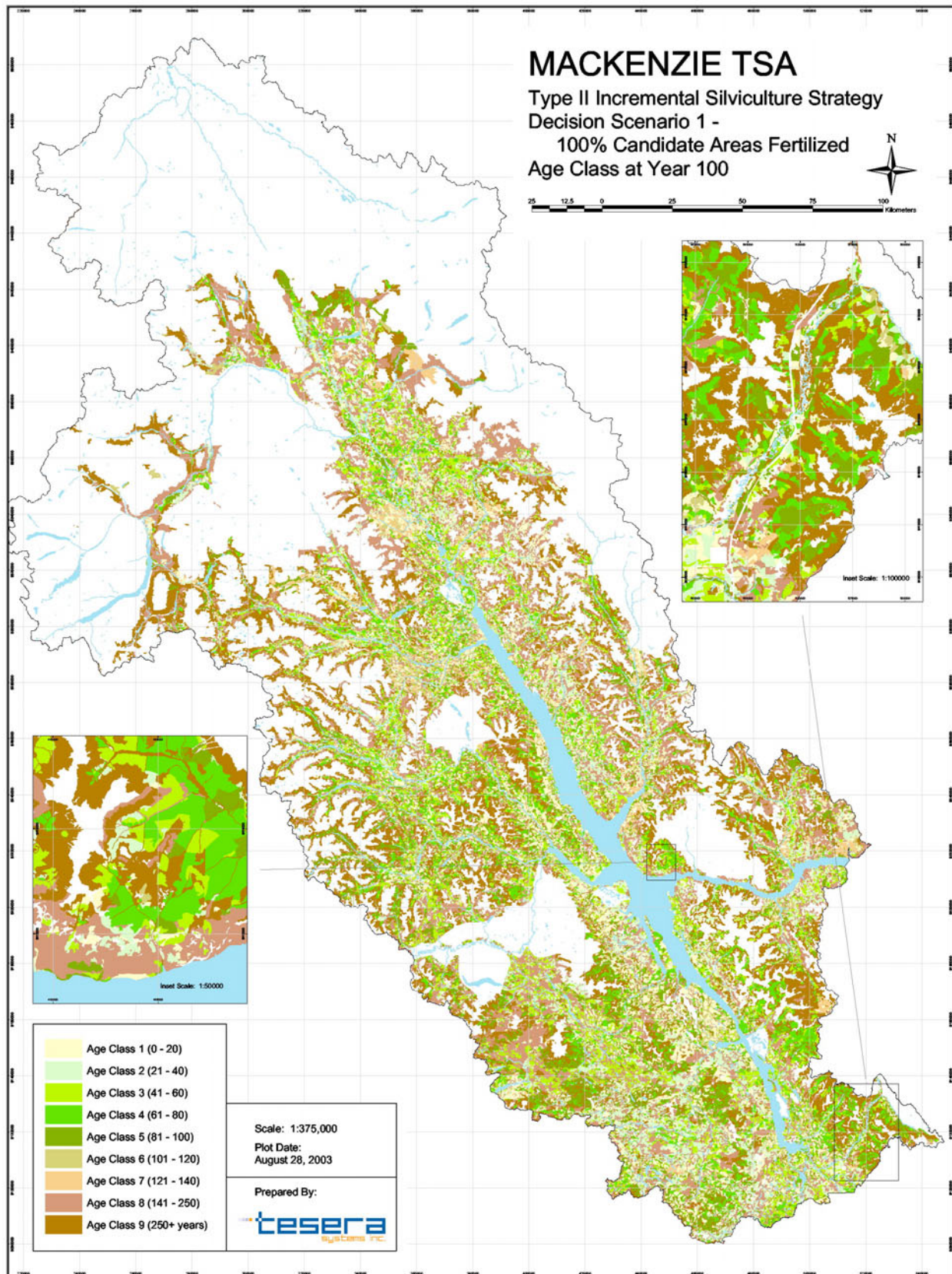


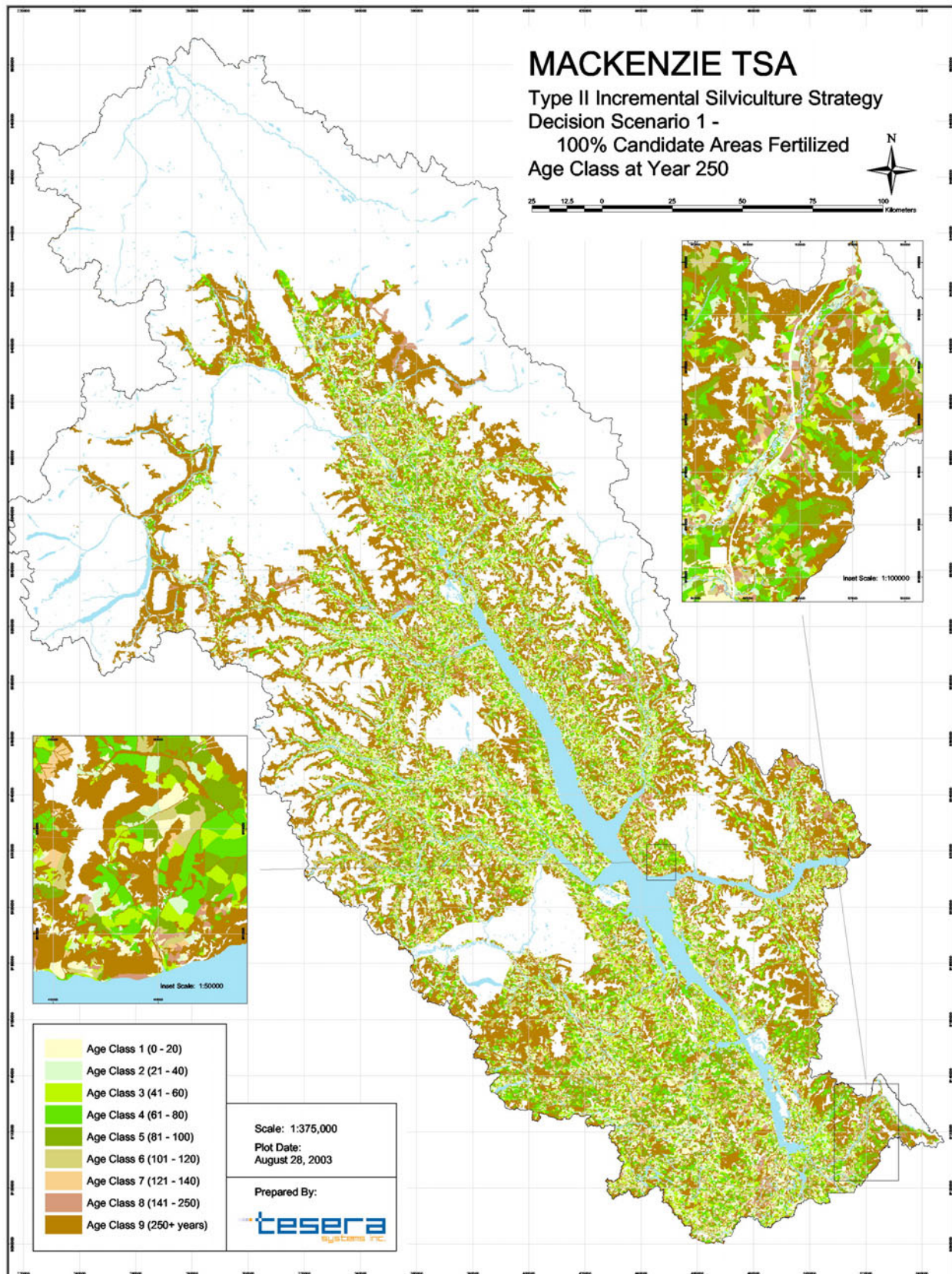


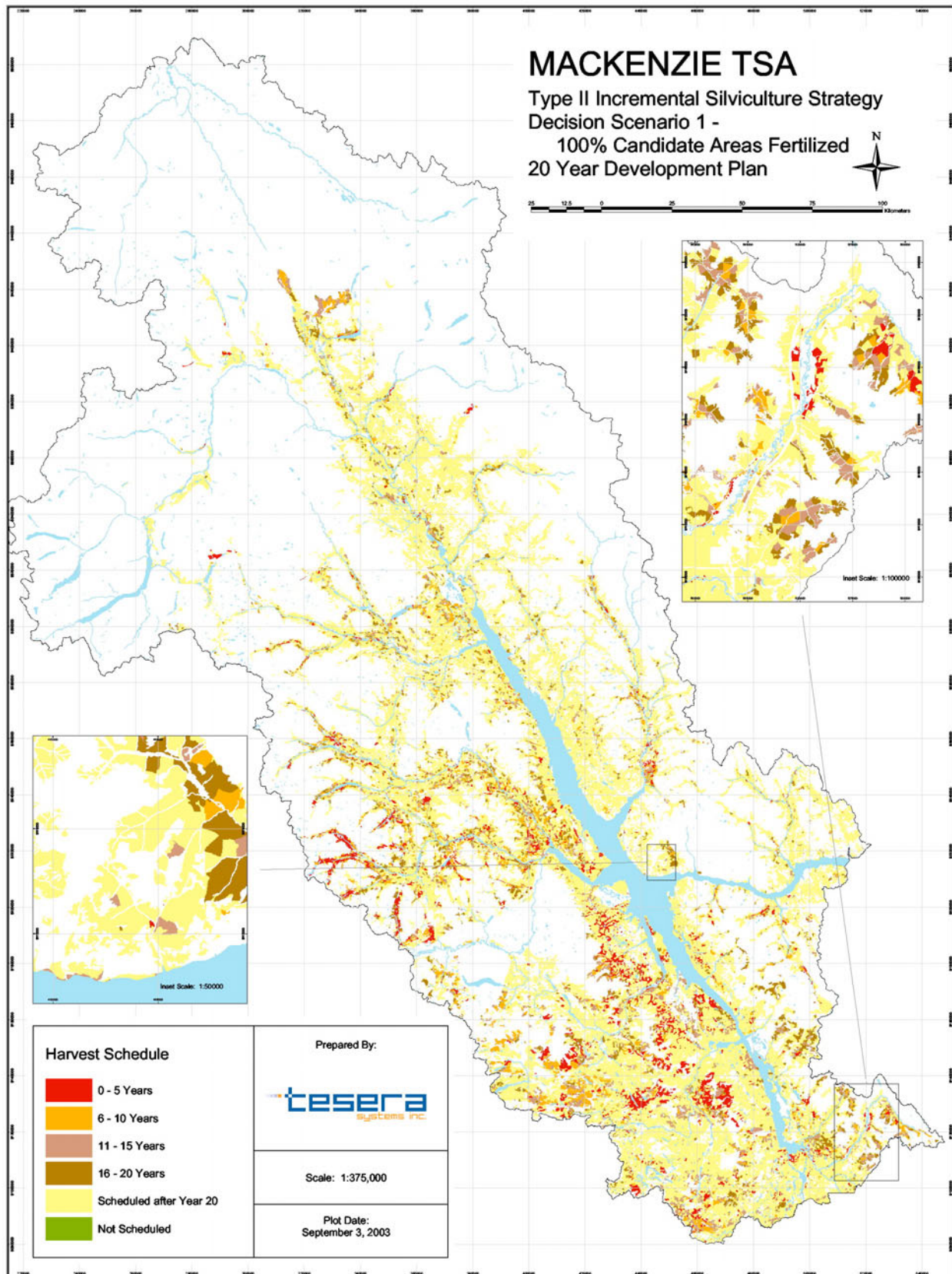


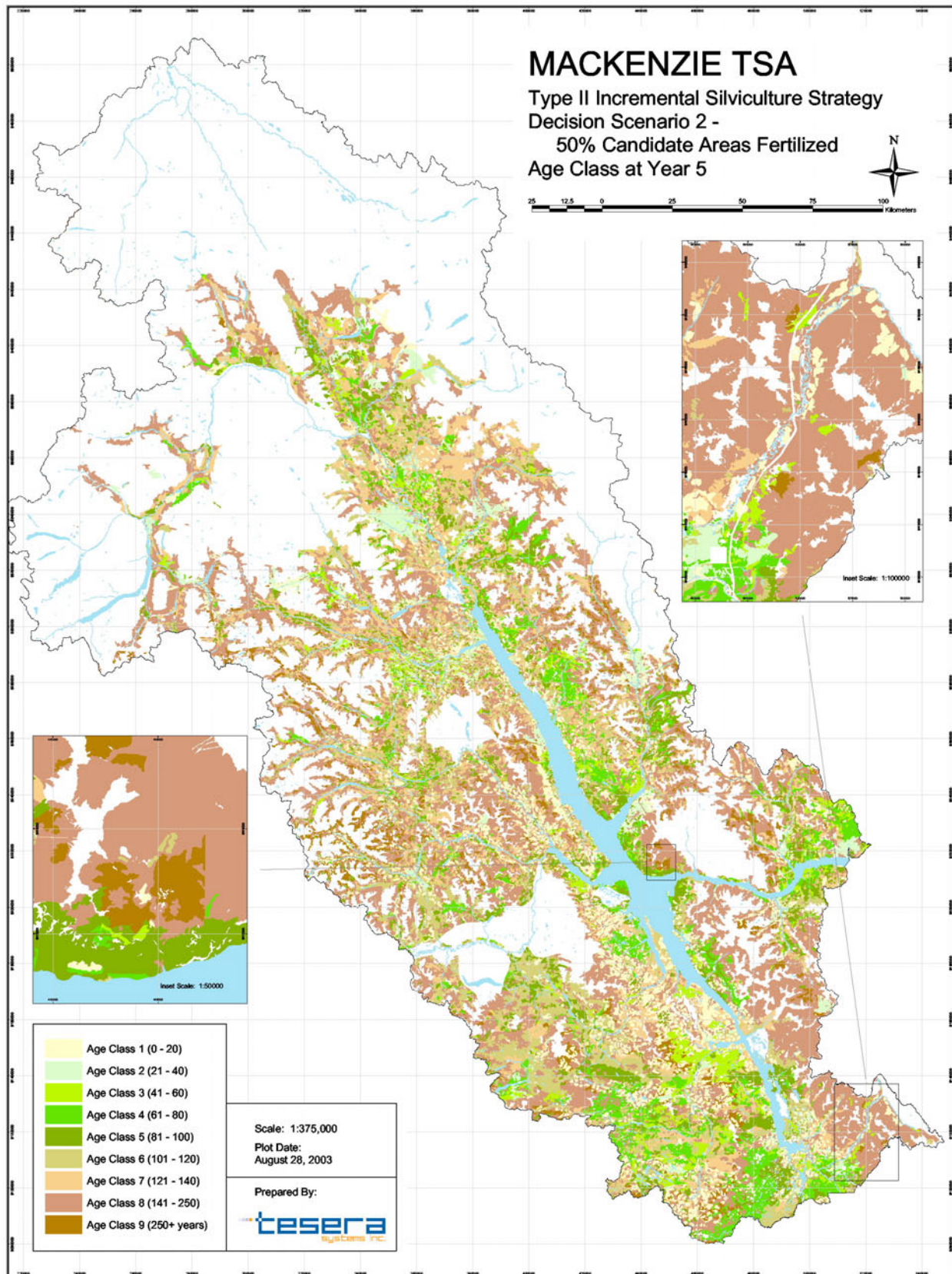


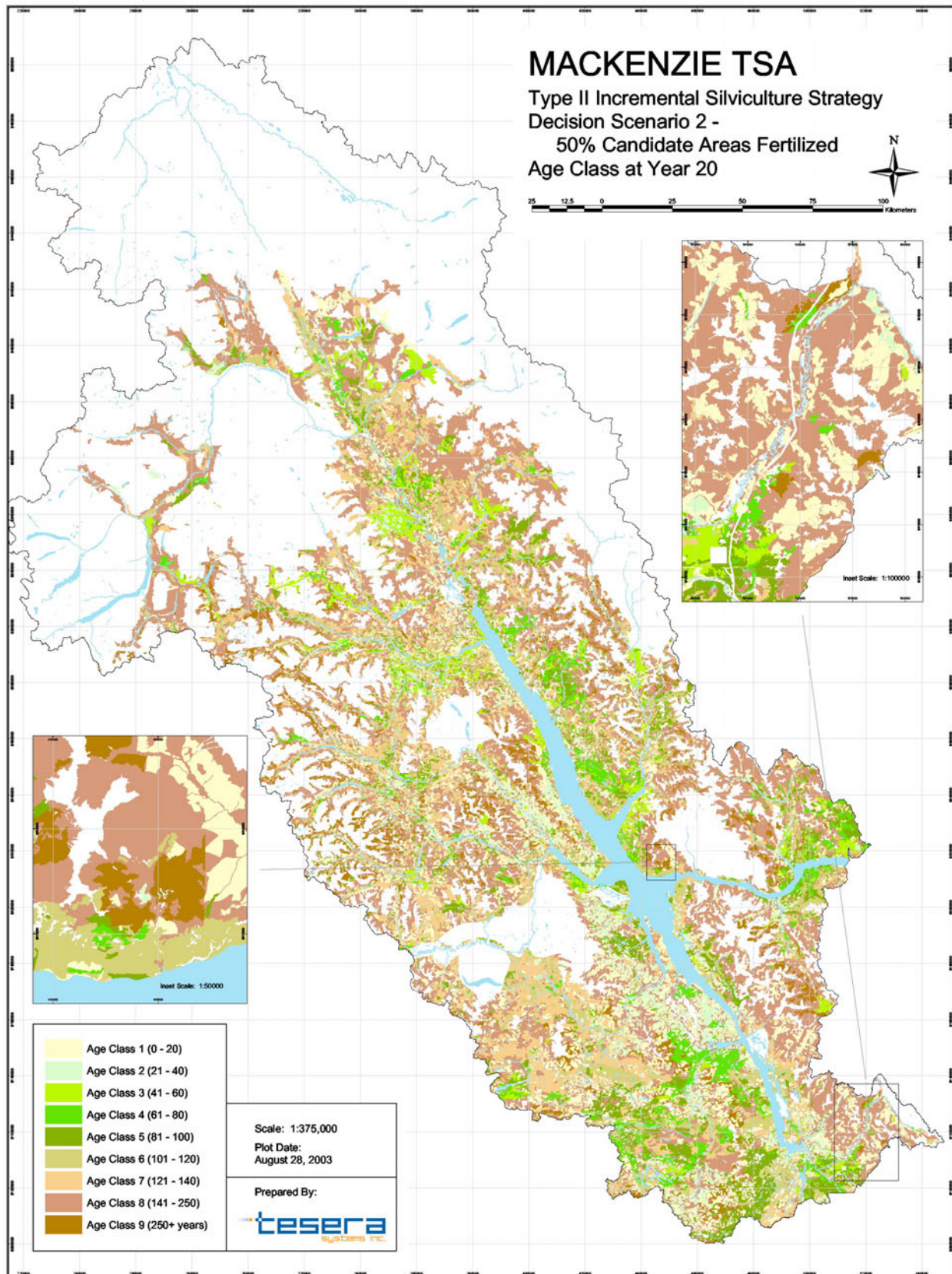


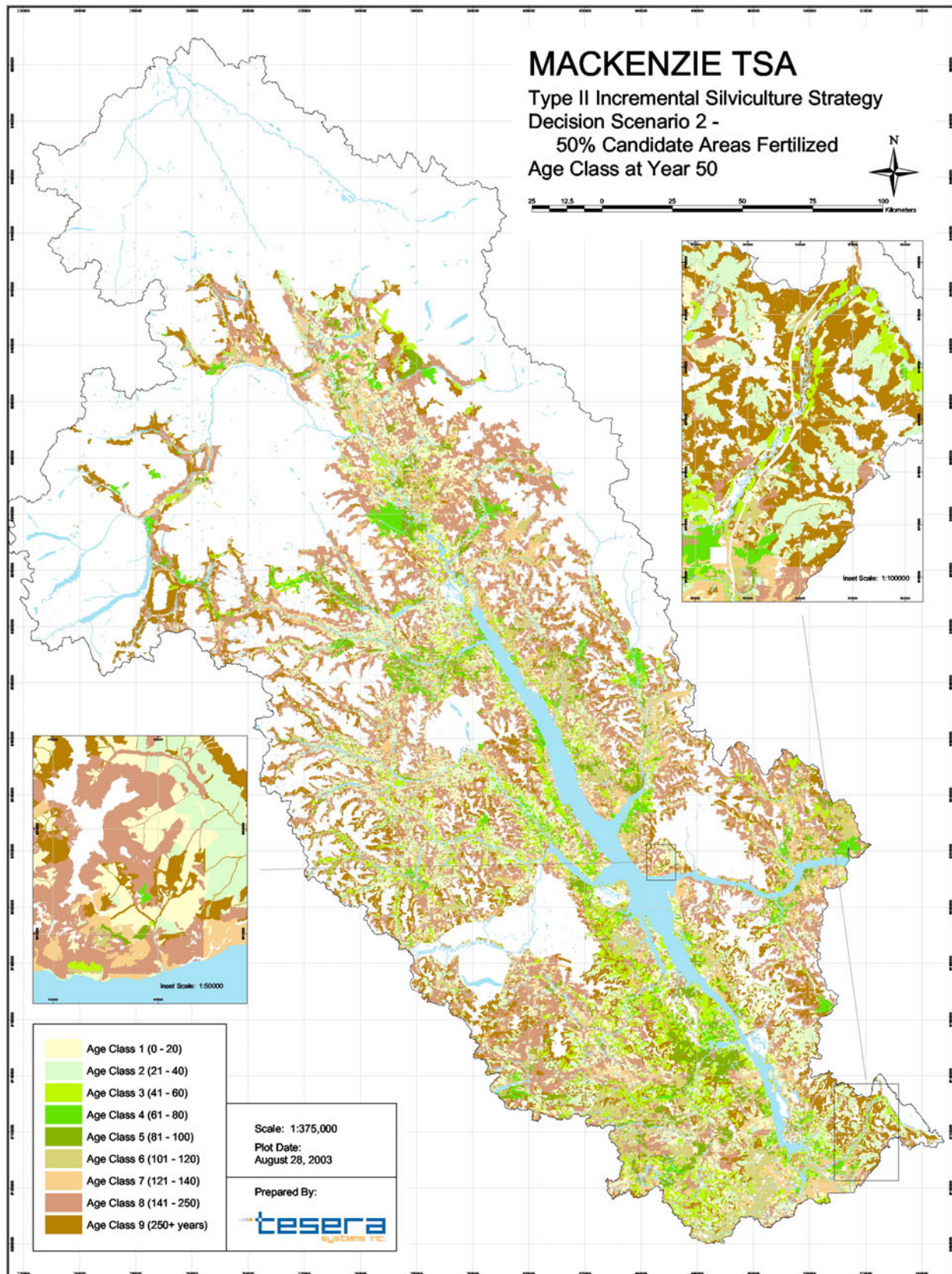


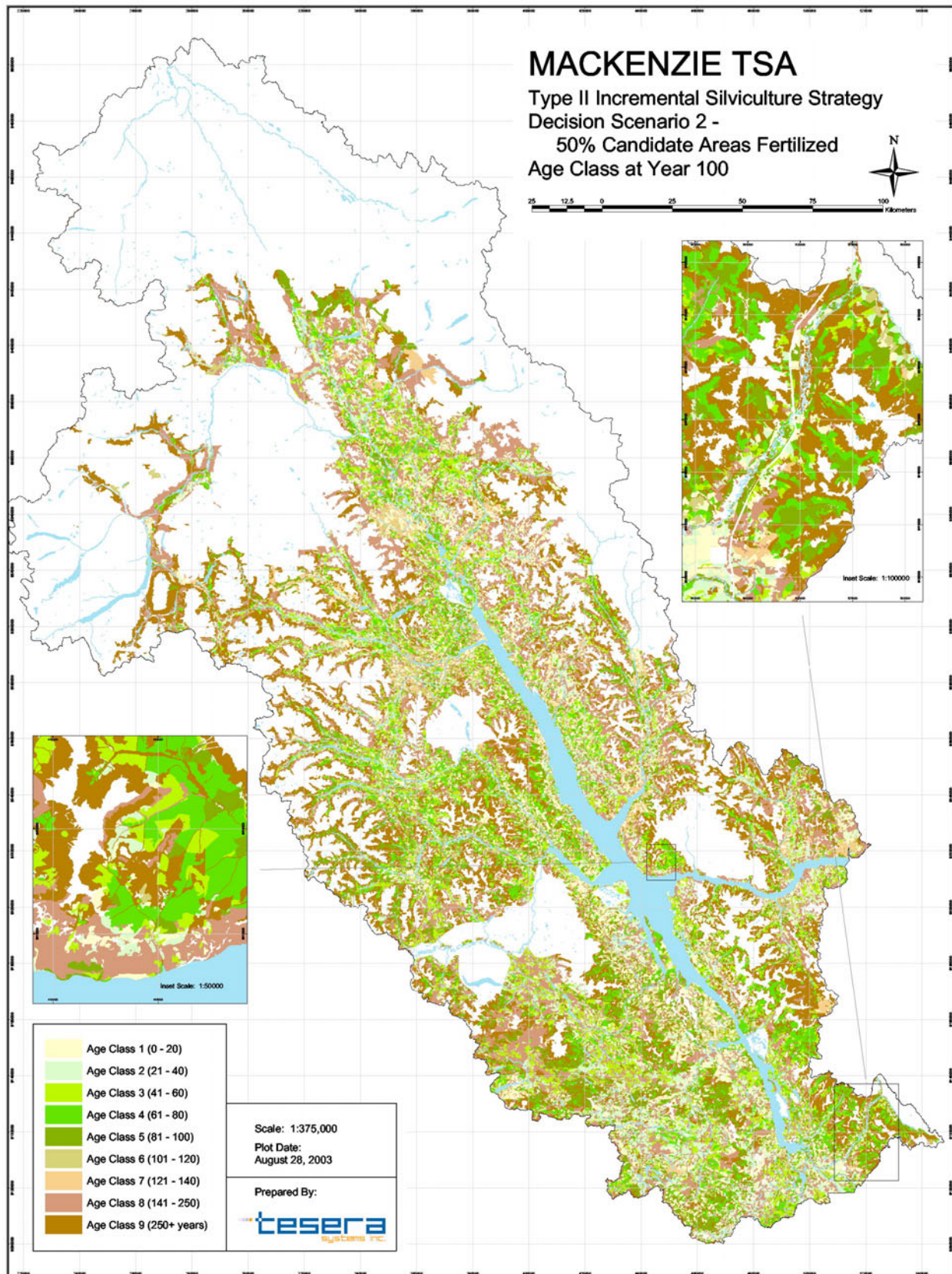


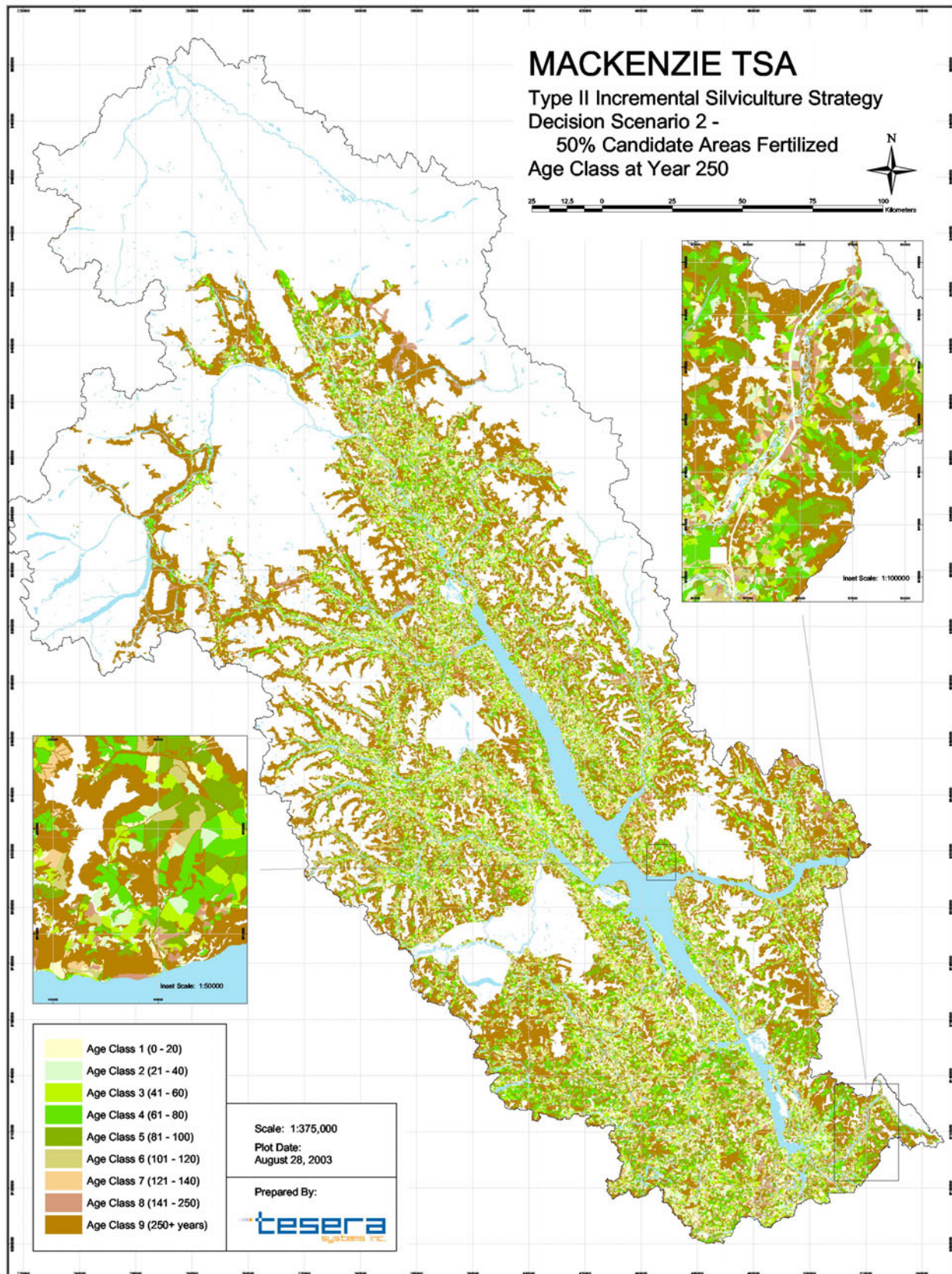


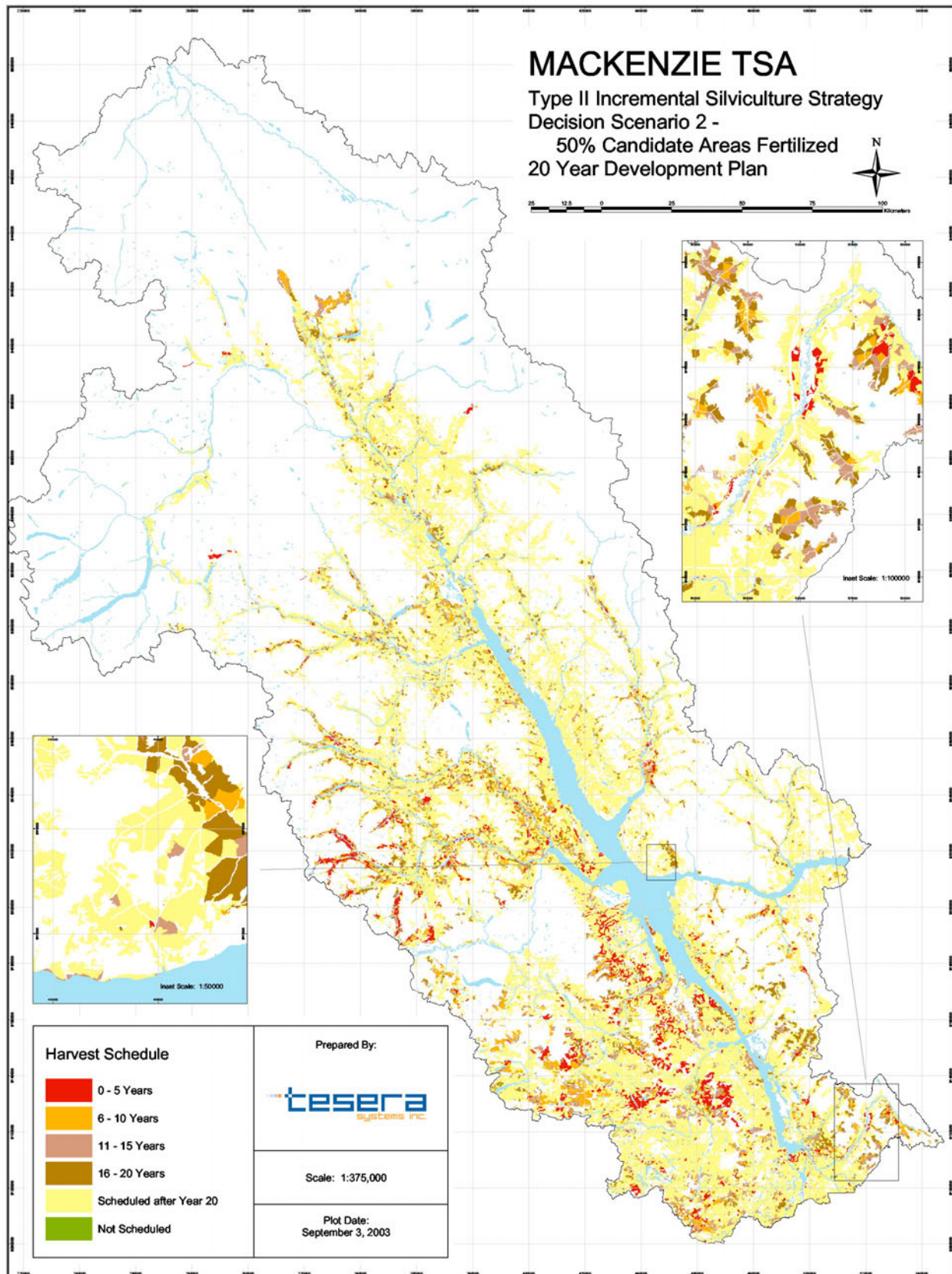












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