Integrated Silviculture Strategy

Bulkley Timber Supply Area

Modelling and Analysis Report

V 2.1

March 31, 2020

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Ministry of Forests, Lands, Natural Resource Operations and Rural Development

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1 Introduction

The Resource Practices Branch (RPB) of the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) aims to develop a new management unit planning framework; the Integrated Silviculture Strategy (ISS). The ISS is a sustainable forest management planning framework with the objective to integrate all aspects of landscape-level and operational planning for each Timber Supply Area (TSA).

The ISS will integrate Type 4 Silviculture Strategies with timber supply review (TSR) to reduce duplication and redundancies where possible by sharing inventories, management zones, analysis units, Timber Harvesting Land Base (THLB) definitions and management assumptions. It is expected that the ISS process will improve the linkages to landscape level fire management, the Cumulative Effects Framework, the Forest and Range Evaluation Program's (FREP) multiple resource values assessments (MRVA) and other regional, management unit level or landscape level plans and strategies.

2 Context

This document is the third of four documents that make up an ISS. The documents are:

1 Situational Analysis – describes in general terms the current situation for the unit. The Situational Analysis forms the starting point for the initial planning group meeting to identify opportunities.

2 Data Package - describes the information that is material to the analysis including data inputs and assumptions.

3 Modeling and Analysis report –provides modeling outputs and rationale for choosing the selected scenario.

4 Integrated Silviculture Strategy – represents the selected management scenario which is the basis for the first iteration of the ISS. It includes an investment strategy and provides treatment options, associated targets, timeframes and expected benefits.

When the ISS is complete, a spatial operations schedule will provide direction for harvesting and a land base investment schedule will guide Forest for Tomorrow Annual Operating Plans.

3 Analysis Assumptions

This analysis relied on many of the same analysis assumptions that were used in the latest TSR; however, the analysis assumptions were revised through stakeholder meetings to reflect current management in the Bulkley TSA. The Analysis assumptions are detailed in the Bulkley TSA ISS Data Package (FESL 2020).

3.1 Forest Level Analysis

This analysis is essentially an expanded timber supply analysis, which examines the availability of timber volume and other indicators over time. It involves testing and reporting on a variety of assumptions and management strategies. The analysis provides stakeholders with information about the relationship between a variety of possible management strategies and the supply of timber, habitat and other values.

Timber supply analysis is intended to ensure that current harvest levels are sustainable and do not threaten the availability of future timber volume. Sustainability is therefore the key concept in timber supply analyses in general. While this analysis does use this timber-based definition as a guideline to complete various scenarios, it also attempts to evaluate sustainability in terms of the wider range of biological, social, or economic values that are affected by timber harvesting.

3.2 Indicator Forecasts

A single forecast is not sufficient to depict the supply of various values in the Bulkley TSA due to the complexity of factors affecting the supply of timber and other values. There are uncertainties about how well the analysis assumptions reflect the realities of timber supply and other factors in the TSA and there are many options for setting harvest levels. Several forecasts are developed in this analysis to account for these uncertainties and options. The purpose of presenting different forecasts is to construct a complete understanding of the timber supply dynamics and the dynamics of other values in the Bulkley TSA. The following forecasts are presented in this report:

ISS Base Case: The ISS Base Case is the standard against which other forecasts are compared when assessing the effects of uncertainty or different management emphases on indicator values. In most analyses, the Base Case reflects the best available knowledge about current management, as well as immediate future activities and forest development.

Sensitivity Analyses: Sensitivity analyses are used to determine the risk associated with uncertainties in the assumptions of the analysis. These forecasts isolate an area of uncertainty and test the implications of using a variety of assumptions.

Learning Scenarios: Management objectives were developed for the Bulkley TSA through several stakeholder meetings. The objectives were developed for a broad set of values that were considered important to the stakeholder group: economic values, environmental values and social values. Strategies to achieve stated objectives were collated into logical scenarios for comparison against the ISS Base Case.

Selected Scenario: Scenario that may combine components from learning scenarios; the basis of the Bulkley TSA ISS.

3.3 Model

All analysis presented in this report was conducted using Forest Simulation and Optimization System (FSOS), a proprietary forest estate model developed by FESL and Dr. Guoliang Liu. FSOS has both simulation and heuristic (pseudo-optimization) capabilities. The time-step simulation mode was primarily used in this analysis. Time-step simulation grows the forest based on growth and yield inputs and harvests units of land area based on user-specified harvest rules and constraints that cannot be exceeded.

3.4 Sustainable Harvest

A reliable and objective indicator of sustainability is required to differentiate sustainable harvest levels from unsustainable harvest levels. Crashes in timber supply occur at pinch points when there is insufficient merchantable volume to satisfy the target harvest level. Timber supply analysts commonly use these crashes as an indicator of non-sustainable harvest levels. However, pinch points are directly related to how minimum harvest criteria are defined and may not reflect true constraints on timber supply.

Pinch points are useful as indicators of sustainability only if minimum harvest ages are equal or close to the culmination ages of mean annual increment (MAI). When minimum harvest ages are set close to culmination age, pinch points indicate that the model is attempting to harvest stands below culmination age. Pinch points are less effective indicators of sustainability when minimum harvest ages are set using other criteria, such as volume per ha, as in most scenarios this analysis. The stable long-term growing stock is the sole indicator of timber sustainability in this analysis. Short- and medium-term harvest levels are considered sustainable if they do not compromise the growing stock in the long term.

3.5 Determining the Harvest Level

Growing stock becomes stable when the rate of harvest equals the rate of growth of the forest. At low harvest levels stands are harvested after their MAI culmination age – provided that they have achieved their minimum harvestable volume – and the growing stock accumulates until an equilibrium is reached, often way into the future. If the harvest level is too high, the stands are harvested below their culmination age. This often causes a rapid decline of the growing stock until it can no longer support the desired harvest level.

Maximum sustainable even flow is the highest even flow harvest level that can sustain a stable growing stock. In the absence of significant logging history and constraints, this harvest rate would equal the long-range sustained yield harvest rate, where all stands would be harvested at their MAI culmination age. However, the presence of forest cover constraints, such as VQOs, can limit the ability of the model to harvest stands at culmination age. As a result, long-term harvest levels are typically somewhat lower than the maximum possible growth rate of the forest.

In this analysis the maximum sustainable even flow was established first. After this, the short-term harvest was elevated as high as possible without compromising the mid or the long-term sustainability of the harvest forecast. As a final step, higher long-term harvest levels were tested (subject to already established short-term harvest level and maximum sustainable even flow depicting the medium-term harvest level).

4 Analysis Results

4.1 ISS Base Case

The TSR analysis assumptions were revised through stakeholder meetings to reflect current management in the Bulkley TSA. Table 1 lists the core ISS Base Case assumptions.

Table 1: ISS Base Case assumptions

Objectives and overall assumptions	**Characterize current management to the extent practicable**
Land base assumptions	• Incorporate projected tenures in the analysis (FNWL); • Remove the Caribou WHA from the THLB; • Remove known NOGO nests and nest buffers from the THLB; • Remove all areas classified as pulp from the THLB; • Remove all areas classified as marginal sawlog located further than 1 km away from a road from the THLB; • Remove all areas classified as marginal sawlog located further than 5-hour cycle time away from Smithers from the THLB; • Marginal Timber in Planning Cell C7 is included in the THLB. • Revised low site classification; • Use most other TSR assumptions as they are; • THLB = 204,978 ha
Harvest assumptions	• Incorporate proposed harvest into the harvest forecast; • Use relative oldest first harvest rule; • Do not limit the harvest of marginal sawlogs in the timber supply model; • Incorporate natural disturbance in the NHLB.
Silviculture and log assumptions	• Use revised managed stand analysis units and yield curves; • Use the provincial site index layer as the site index source for managed stands; • Use TASS for modelling the growth and yield of managed stands; • Separate existing managed stands into eras to reflect differences in management; • Use generic industrial log sort specifications and market values to track production value from harvested managed stands
Habitat assumptions	• Report on suitable NOGO forage habitat in projected territories; • Report on suitable moose habitat; • Report on suitable Caribou habitat as inferred from Federal Government management direction. • Report on the ECAs for all 4th order watersheds in the TSA. • Report on the area of suitable Marten habitat in the TSA. • Report on the area of undesirable Grizzly Bear habitat in the TSA.

4.1.1 Harvest Forecast

Figure 1 illustrates the ISS Base Case harvest forecast; a harvest level of 615,900 m^3 per year can be maintained throughout the planning horizon. The harvest of marginal sawlogs was not controlled in the ISS Base Case. Figure 2 shows the predicted harvest by stand quality.

Figure 3 illustrates the predicted development of the growing stock for the ISS Base Case. The timber supply was tested for a period of 400 years (only 250 years shown) to ensure long-term sustainability.

The harvest forecast by stand type is shown in Figure 4. The harvest of existing managed stands is predicted to start in 35 years. By 70 years almost the entire harvest is forecasted to come from managed stands.

Figure 5 shows the harvest forecast by species. During the next 50 years the majority of harvest will consist of balsam and spruce. In the long term, the harvest is predicted to comprise almost entirely of spruce and pine. However; balsam is expected to remain a prominent species in the landscape as shown in Figure 6, depicting the predicted growing stock development on the CFLB by species.

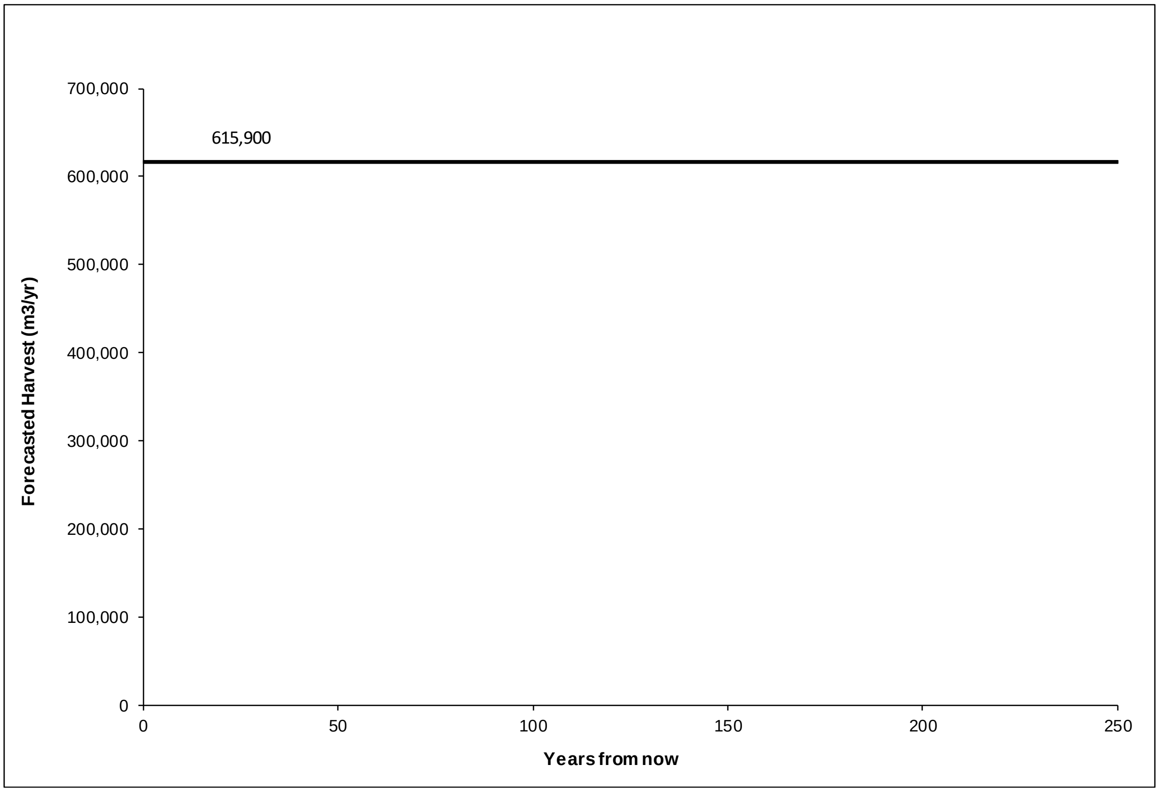

Figure 1: ISS Base Case harvest forecast

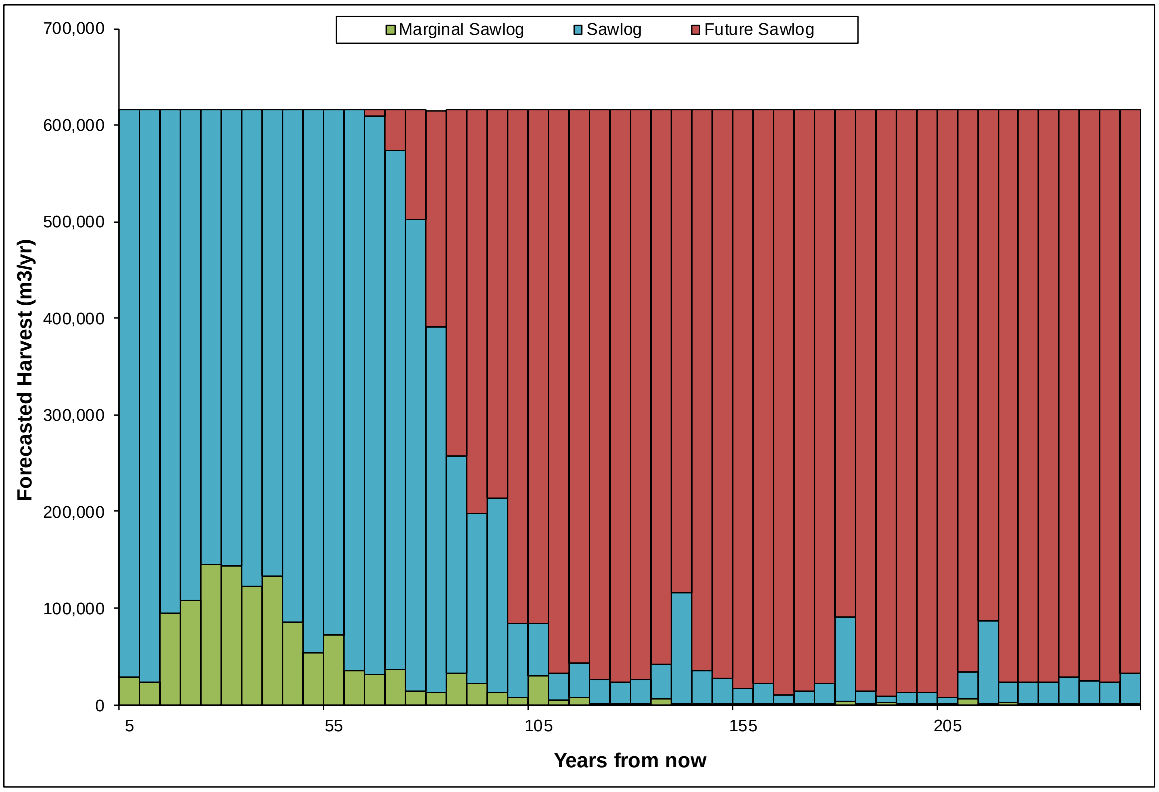

Figure 2: ISS Base Case harvest forecast by stand quality classification

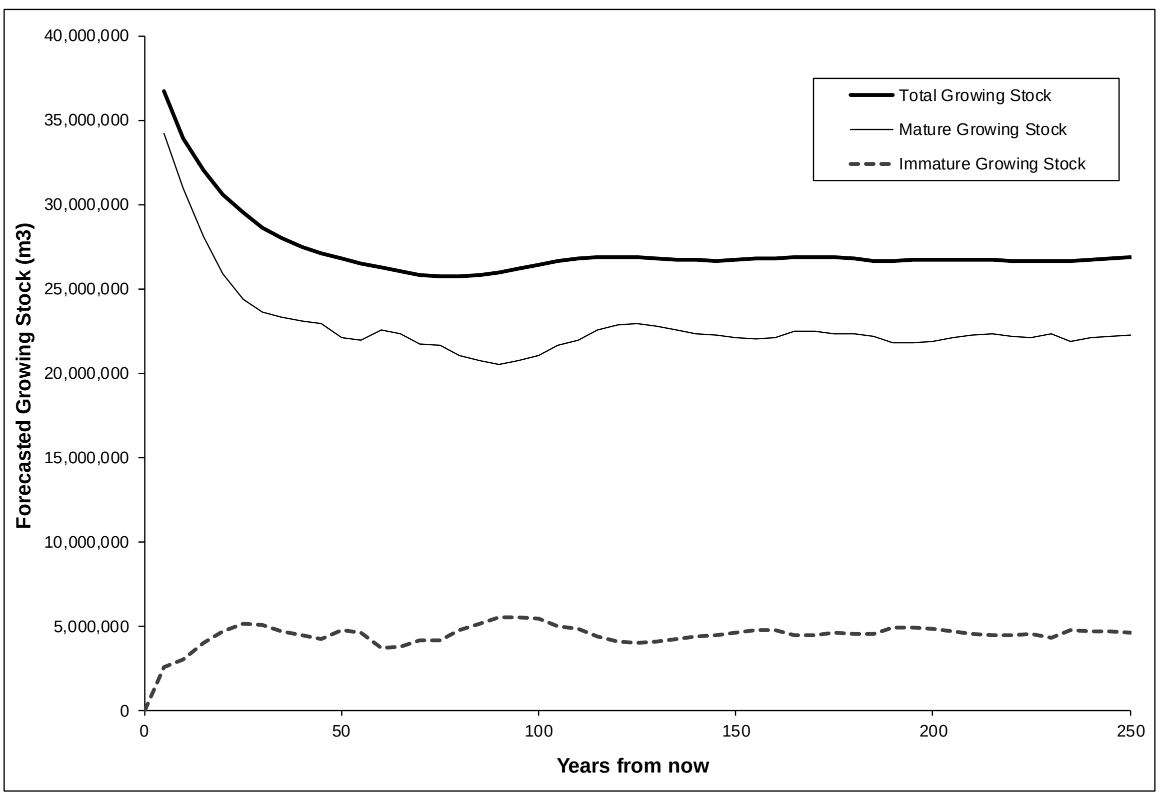

Figure 3: Predicted growing stock development, ISS Base Case

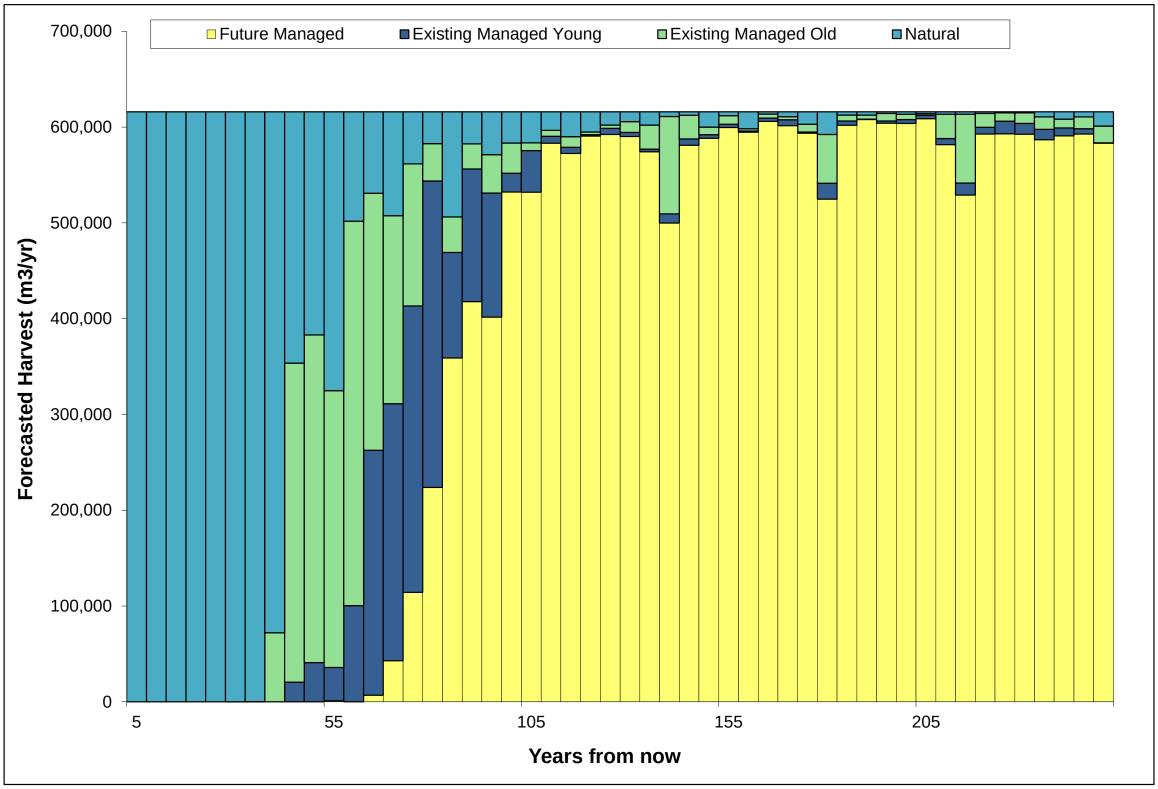

Figure 4: ISS Base Case harvest forecast by stand type

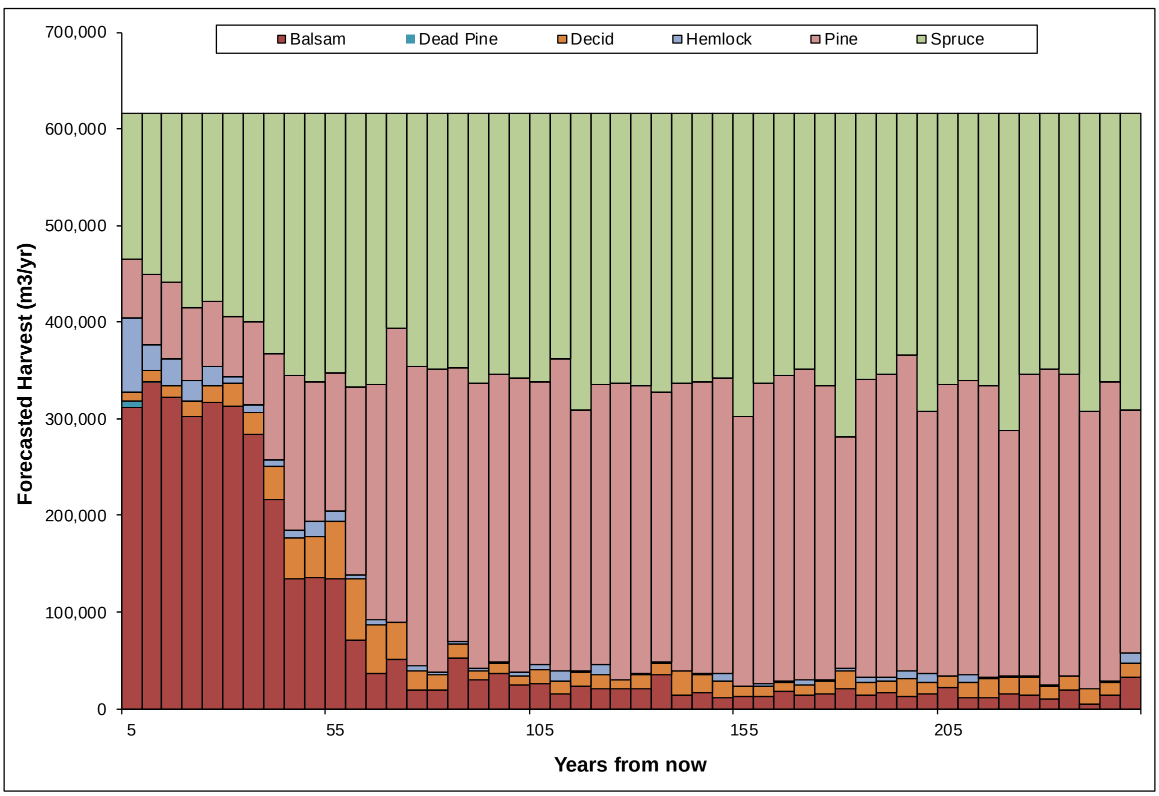

Figure 5: Harvest forecast by species, ISS Base Case

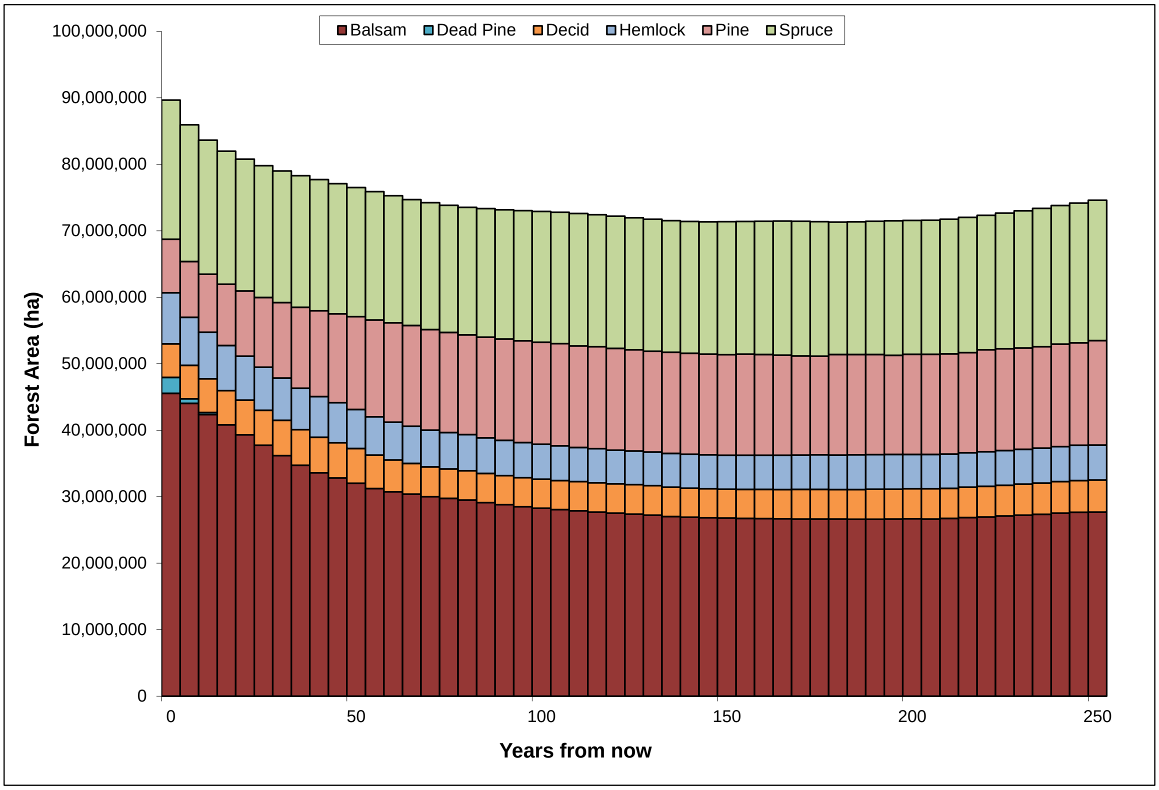

Figure 6: Predicted CFLB growing stock development, ISS Base Case

Figure 7 depicts the harvest forecast by age class. The harvest of old and mature stands (age classes 8 and 9) is expected to continue for approximately 30 years. During the transition period to managed stands, age class 5 stands (81 to 100 years) become more prevalent. In the long term, the harvest is predicted to depend mostly on age class 4 (61 to 80 years) and to some extent age class 3 (41 to 60 years) stands. This is also reflected in Figure 8 illustrating the predicted average harvest age. The average harvest age is high at first due to the harvest of older stands; however, it stabilizes after 100 years and settles at around 70 years.

Figure 9 illustrates the harvest forecast by vol/ha classes, while Figure 10 shows the predicted average harvest volume over time. In the long run, the average harvest volume is predicted to fluctuate between 250 and 300 m^3 per ha. This corresponds to an average annual harvest area between 2,000 and 2,500 ha (Figure 11).

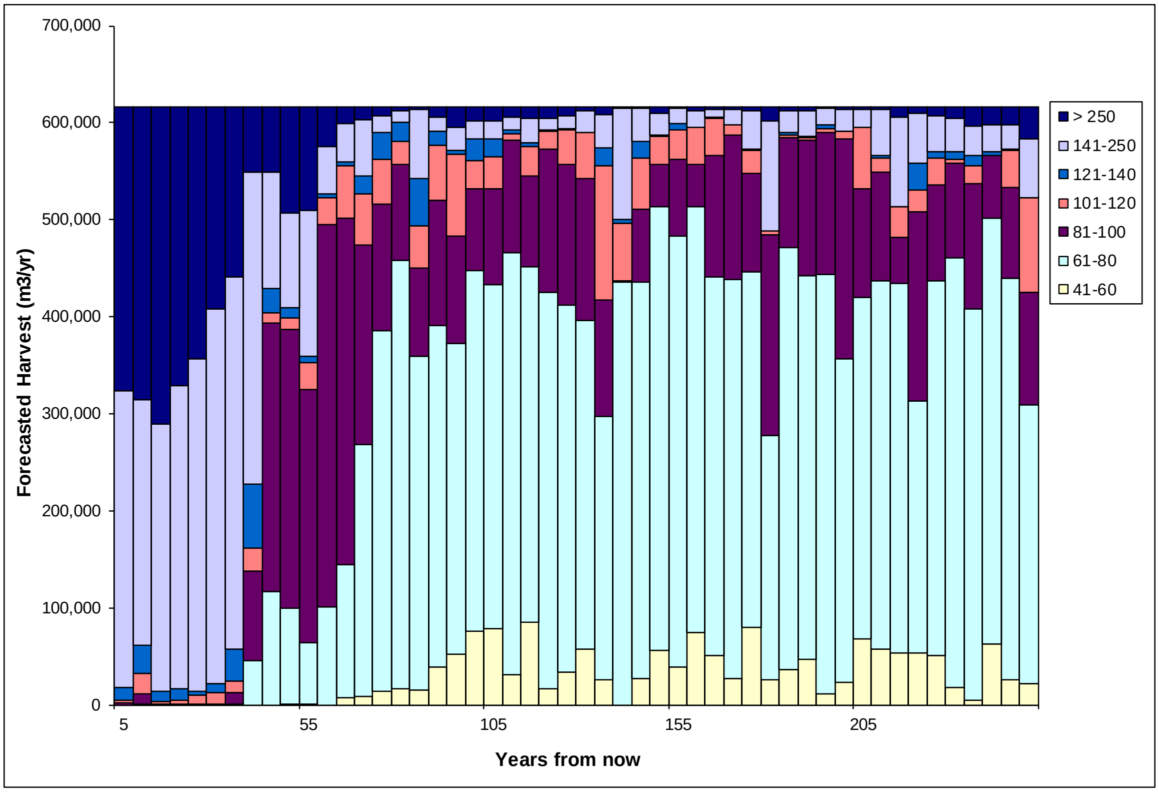

Figure 7: Harvest forecast by age class, ISS Base Case

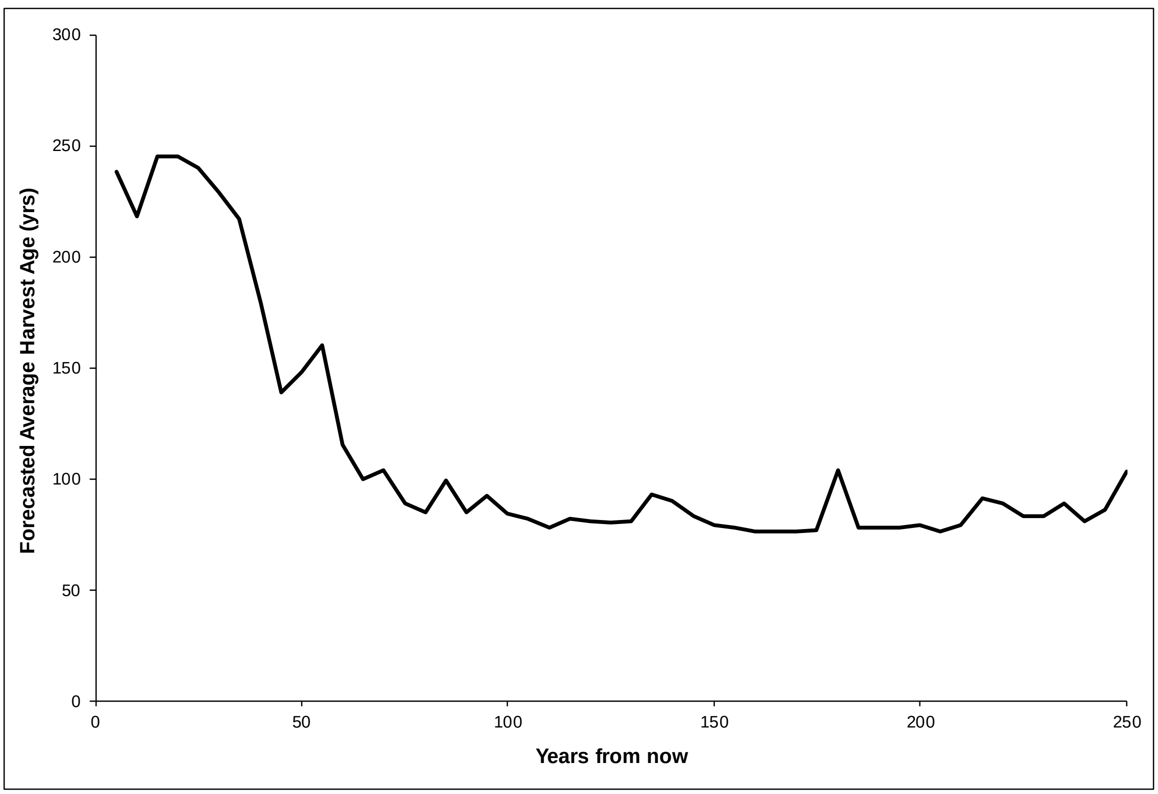

Figure 8: Average harvest age, ISS Base Case

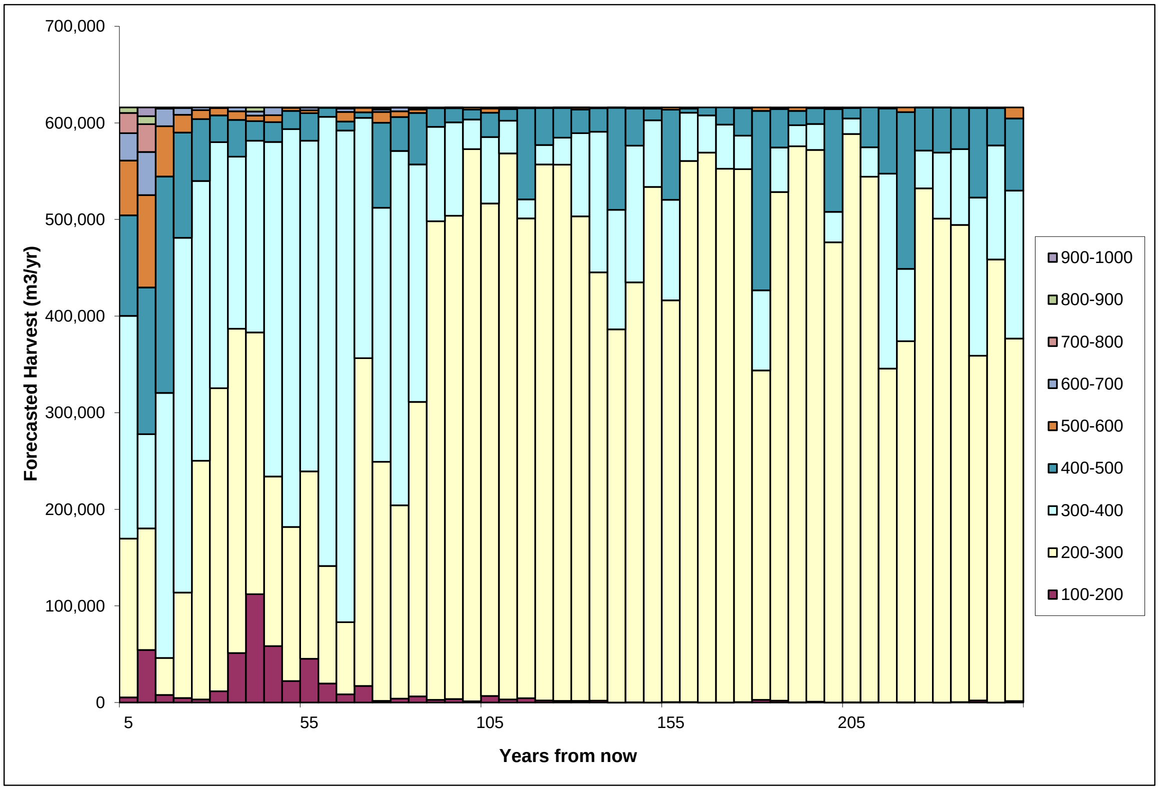

Figure 9: Harvest forecast by volume per ha class, ISS Base Case

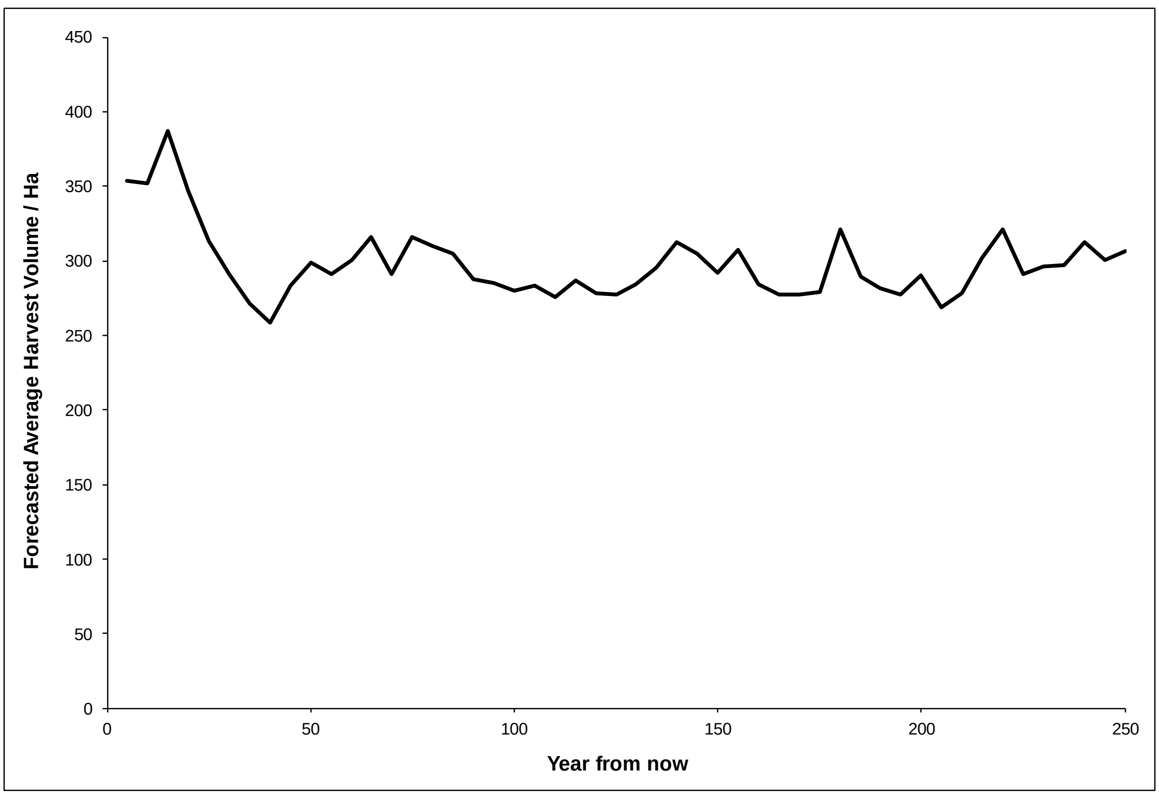

Figure 10: Predicted average harvest volume per ha, ISS Base Case

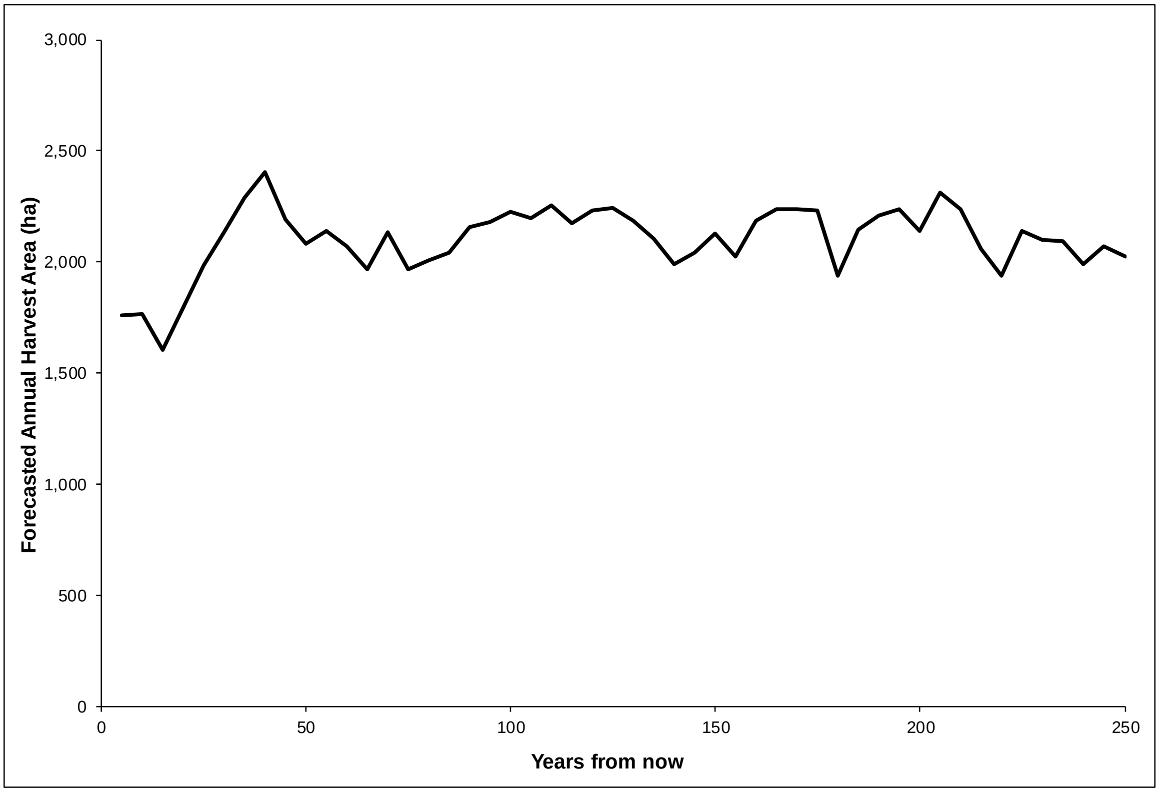

Figure 11: Predicted average harvest area, ISS Base Case

Almost the entire harvest is predicted to come from areas where ground-based harvesting is prevalent; however, some cable harvesting is also predicted (Figure 12).

Figure 13 and Figure 14 depict the predicted age class distribution over time in the THLB and the Crown Forested Land Base (CFLB) correspondingly. Over time age classes 1 to 4 are forecasted to cover approximately 80% of the THLB (Figure 13). Older age classes, especially age classes 8 and 9 are well represented in the Non-Harvestable Land Base (NHLB) and contribute significantly to the mature and old seral stages of the CFLB (Figure 14).

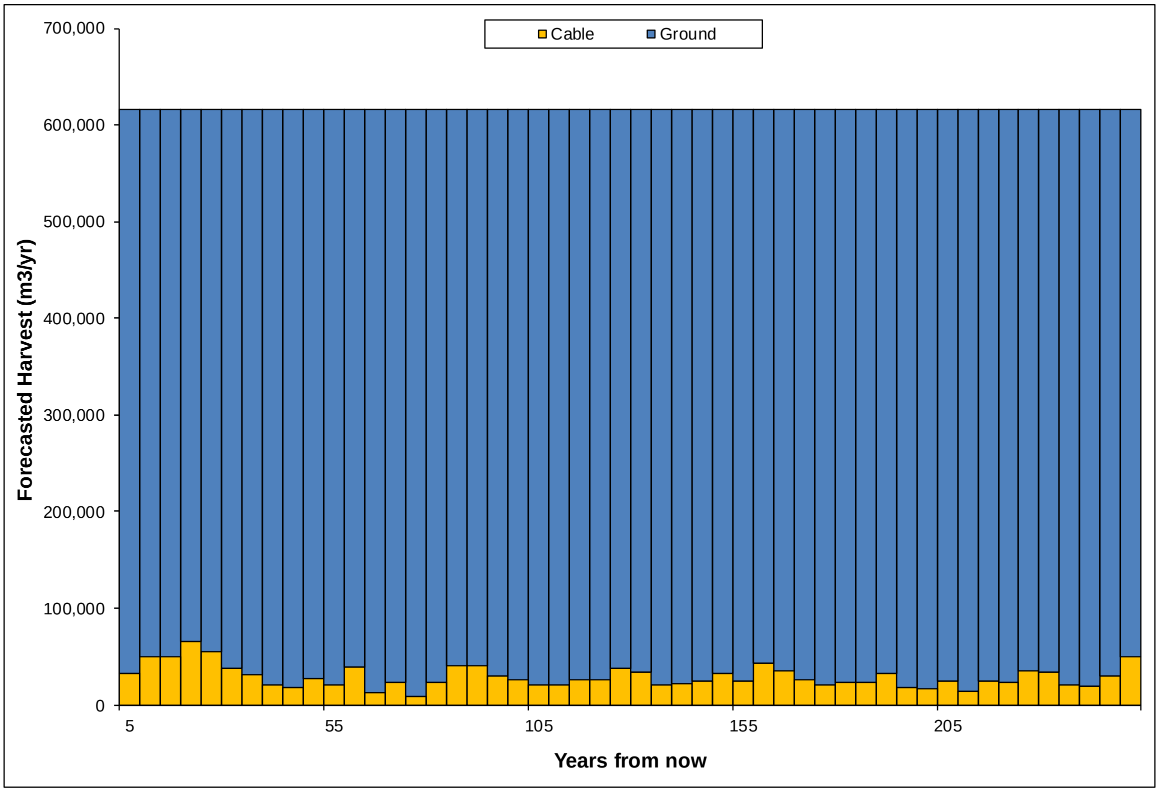

Figure 12: Harvest forecast by harvest method, ISS Base Case

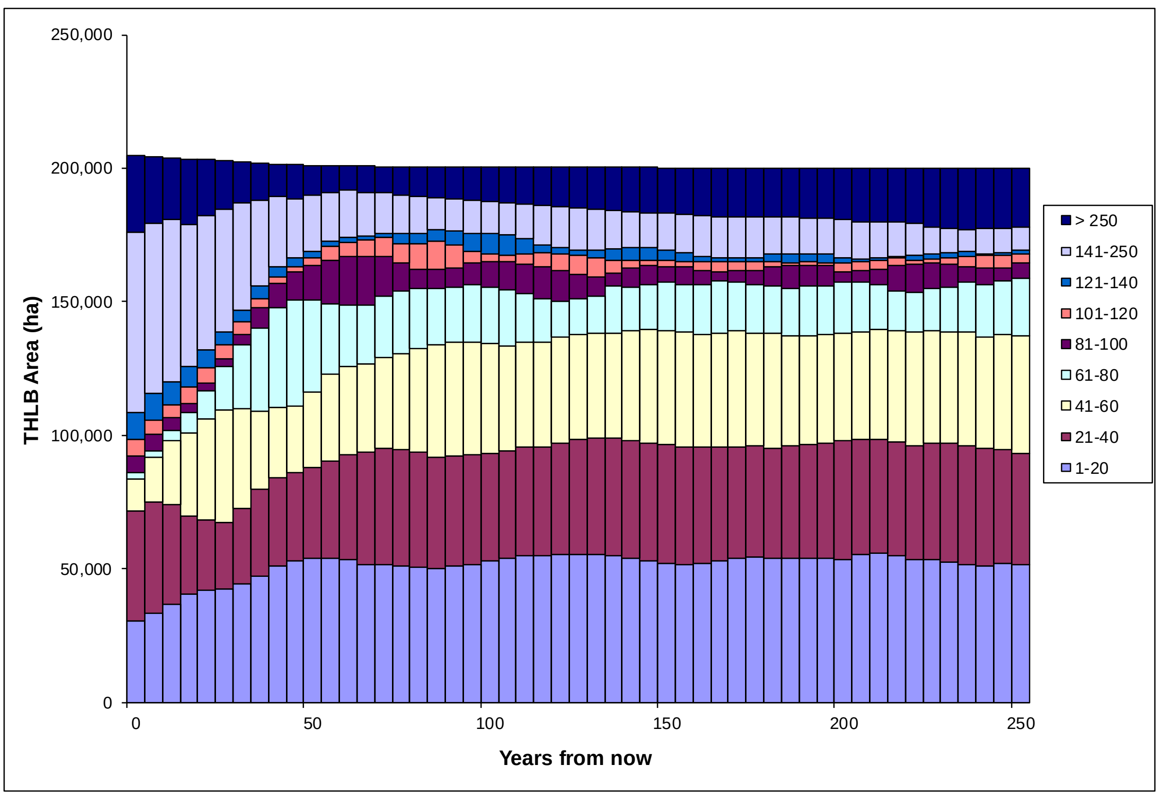

Figure 13: Predicted age class distribution over time on the THLB, ISS Base Case

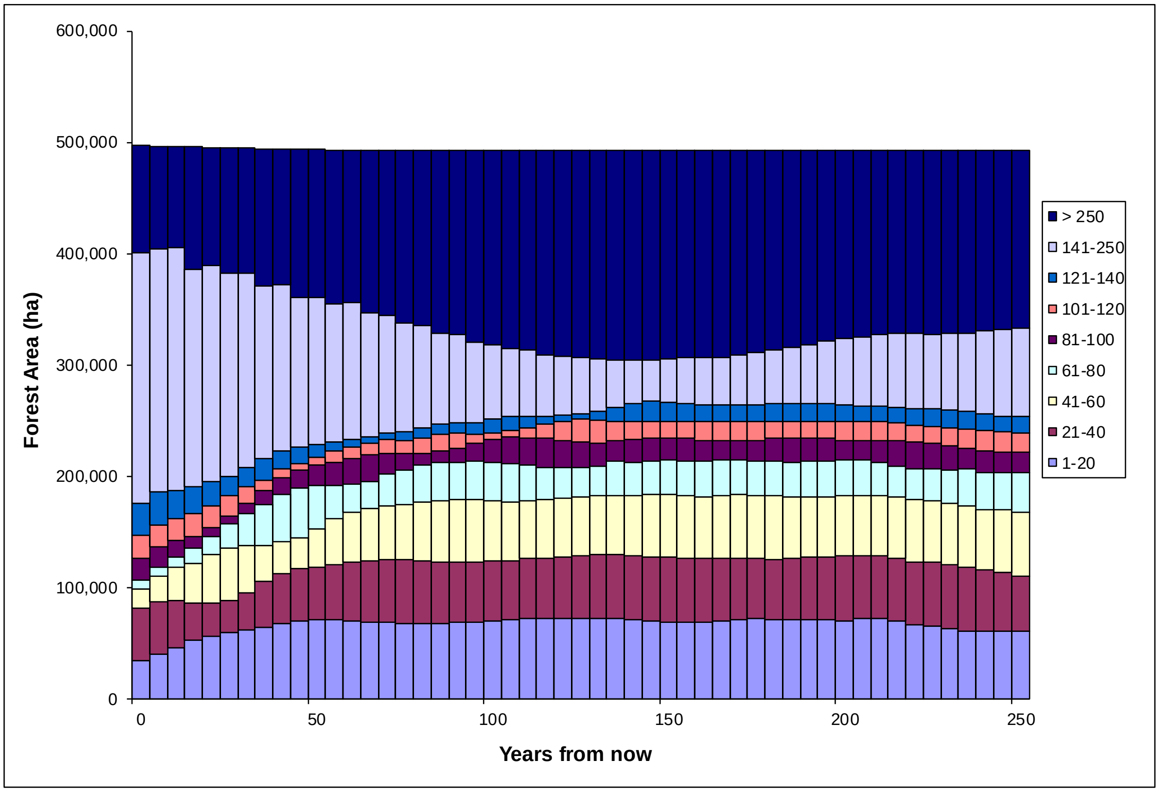

Figure 14: Predicted age class distribution over time on the CFLB, ISS Base Case

4.1.2 Moose Habitat

The desired future condition for moose was set to have the forested moose habitat divided into three seral stages within each fourth order watershed in the TSA (Table 2).

Table 2: Moose habitat in the analysis

Seral Stage	Stand Age	Share of Forested Area	BEC	Elevation	Forest Area
Early	0 to 40	1/3	SBS dk and SBS mc	<=1,000 m	93,905 ha
Mid	41 to 80	1/3			
Mature	80+	1/3			

Figure 15 depicts the predicted aggregated moose habitat over time in the TSA for the ISS Base Case. At the TSA level, the mature seral stage targets are overachieved, while the early and mid-seral targets are underachieved. Figure 16 shows an example of how the moose habitat seral stage targets were met in the Tenas Creek watershed, with 4,560 ha of forested area. The trend is similar to that of the total TSA with mature seral stage targets overachieved, and early and mid-seral targets underachieved.

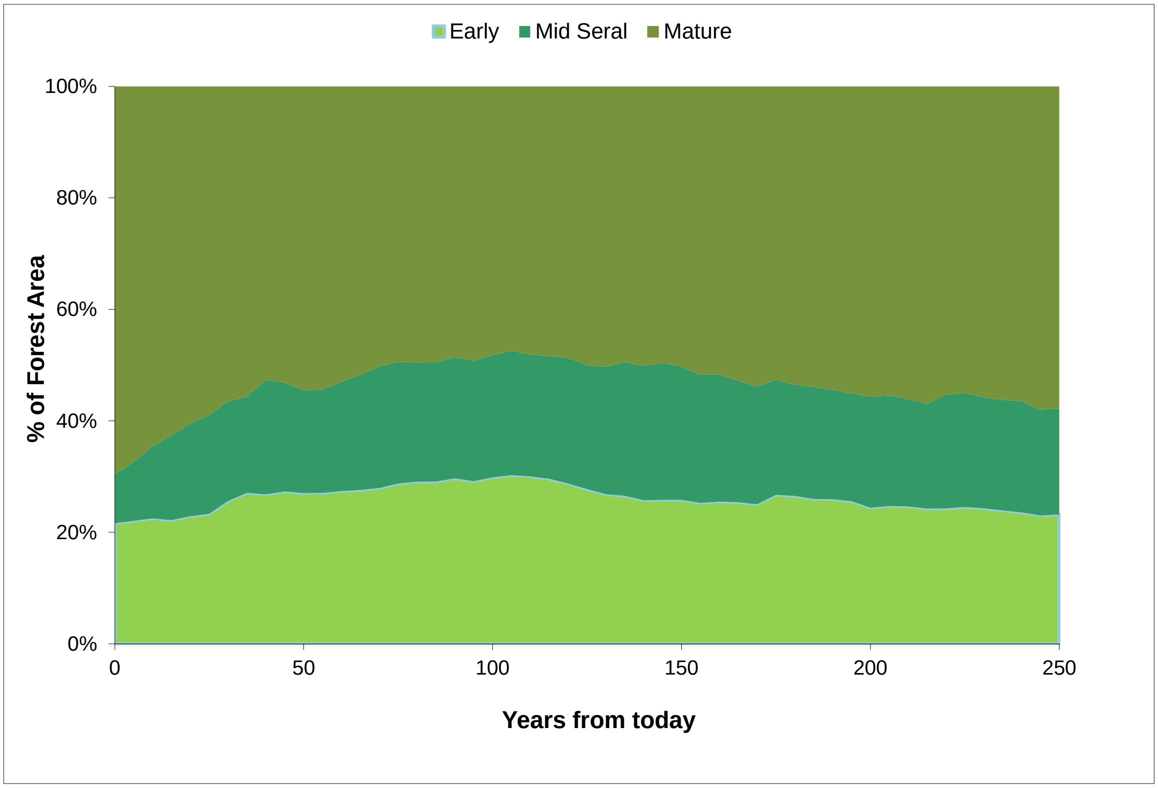

Figure 15: Moose habitat in the CFLB (93,905 ha); ISS Base Case

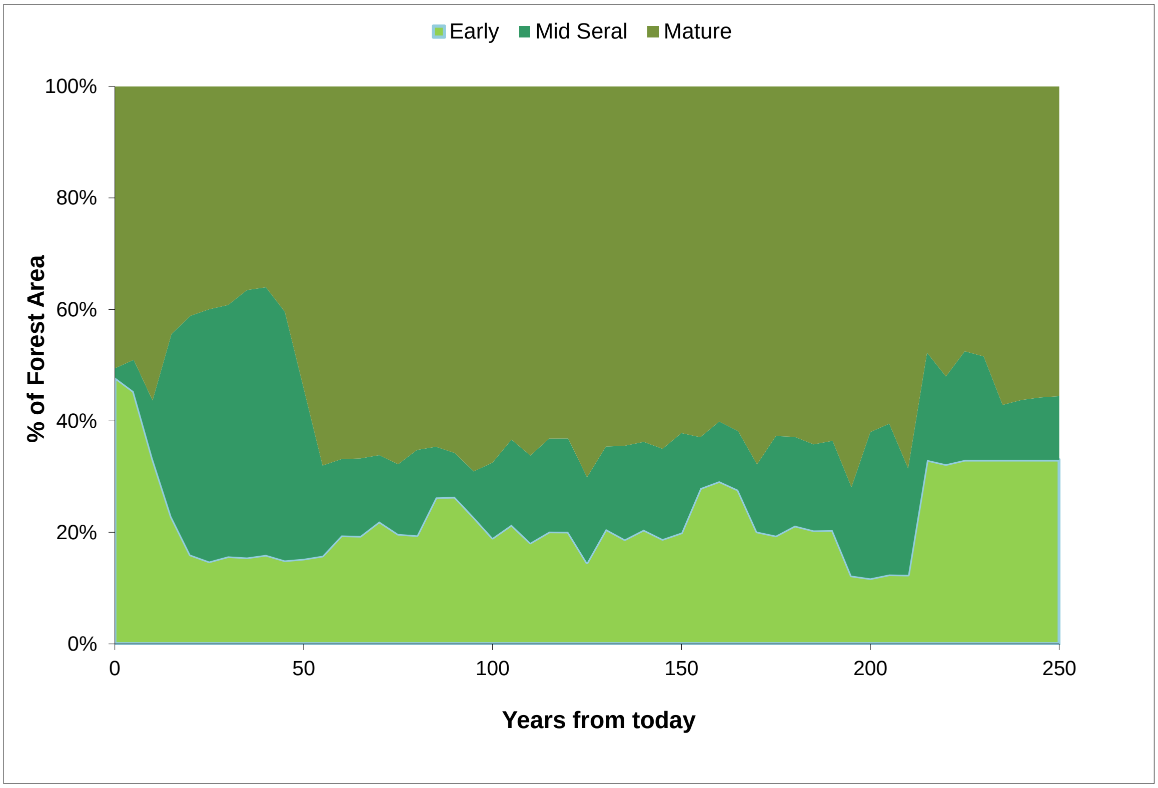

Figure 16: Moose habitat in the CFLB of Tenas Creek (4,560 ha); ISS Base Case

4.1.3 Northern Goshawk (NOGO)

Northern Goshawk (NOGO) forage habitat was accounted for by tracking the suitable forage habitat around existing nests (8,845 ha) and in projected territories (119,293 ha) in the analysis. A network of projected territories received from FLNRORD in Smithers. Their general criteria for developing the network was as follows:

- BEC Zones: CWH, ICH, SBS;
- Age Class: >60% greater than 80 years (age class 5 and greater);
- Territory Area: 2400 ha;

The CFLB area for the existing and projected NOGO territories was 128,138 ha in total. The target for each forage territory (circle) was 60% of forage habitat meeting the age required for habitat (81 and older).

The achievement of NOGO forage habitat was not controlled in the ISS Base Case; it was only reported as an indicator. Figure 17 illustrates the forecasted NOGO foraging habitat for the aggregated forested area within the existing and projected NOGO territories over the planning horizon. In the long run, approximately 60% of the forest remains as suitable NOGO foraging habitat. However, as the foraging habitat distribution is not controlled, individual territories may contain less than the desired foraging habitat. Figure 18 shows the predicted supply of suitable NOGO forage habitat for one projected NOGO territory. In this area, the foraging habitat is not maintained and only around 30% of the forest remains as suitable foraging habitat in the long term.

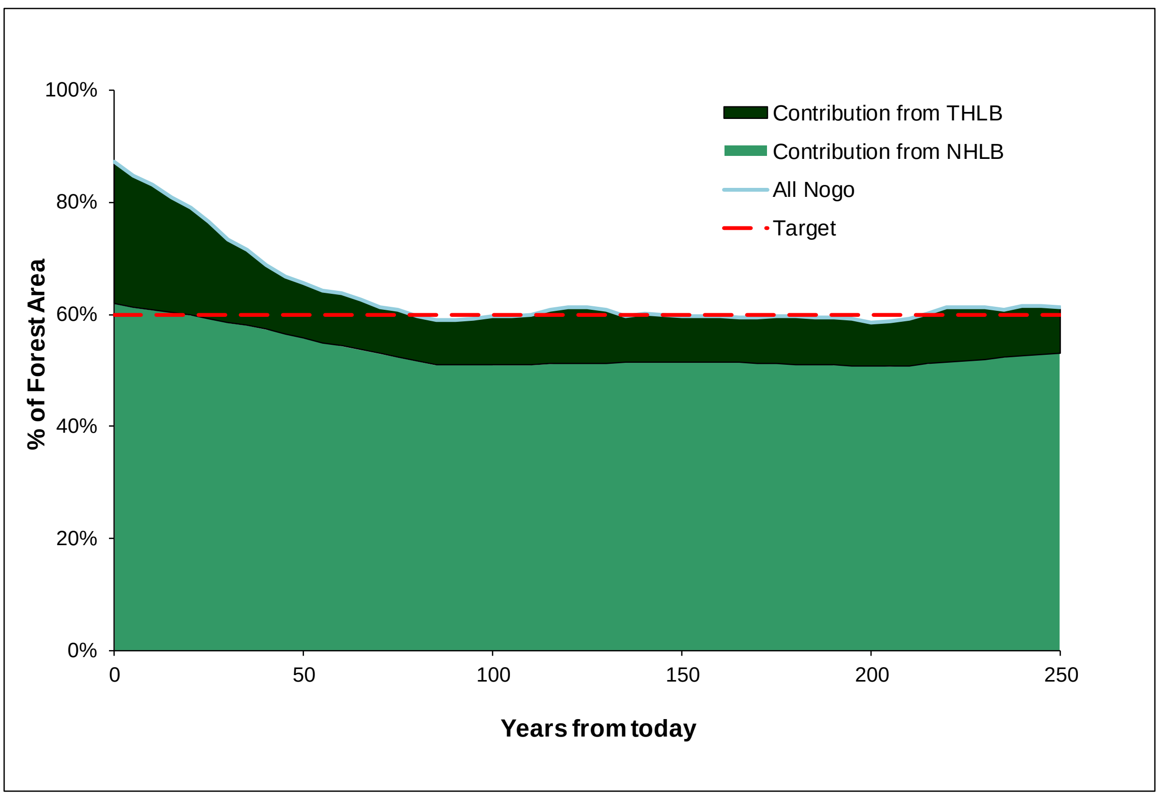

Figure 17: ISS Base Case; suitable NOGO forage habitat, all existing and projected NOGO territories

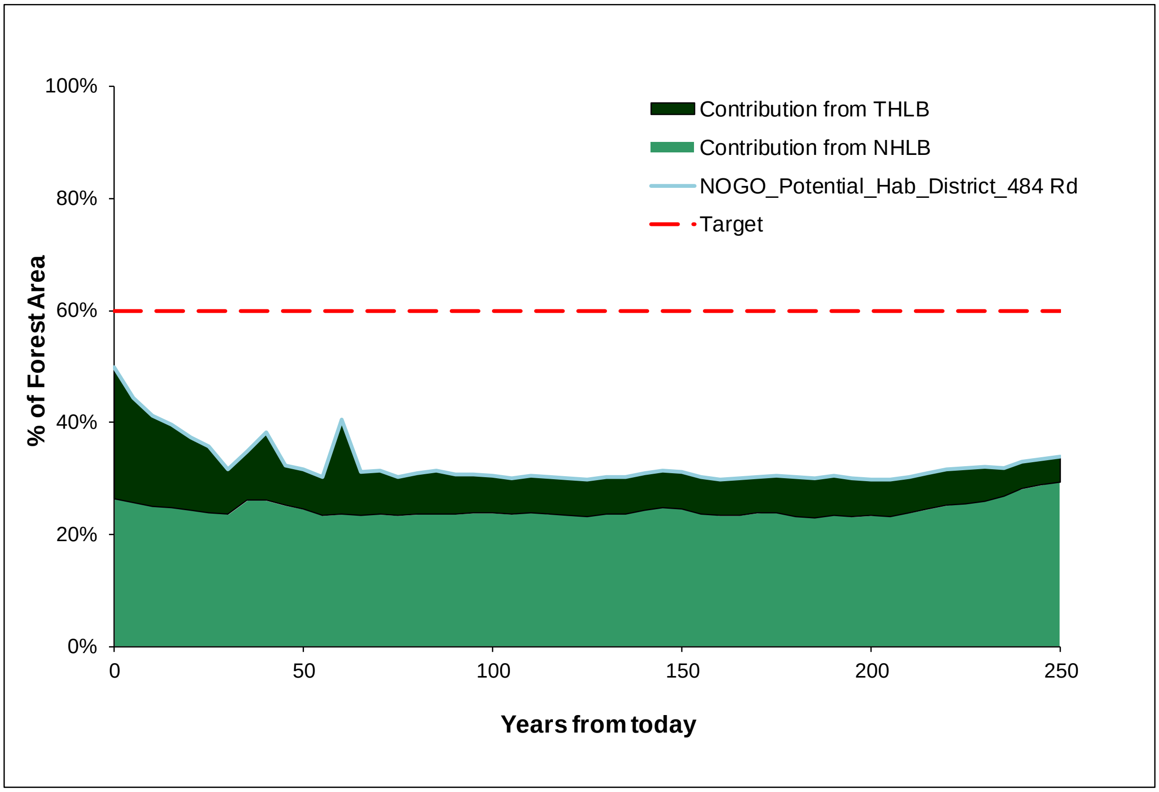

Figure 18: ISS Base Case; NOGO forage habitat, one projected NOGO territory

4.1.4 Watersheds

Equivalent Clearcut Area (ECA) was used as an indicator for watershed health. An ECA of 20% or less is considered desirable. The achievement of ECA was not controlled in the ISS Base Case; it was only reported as an indicator for all the 4th order watersheds.

Figure 19 illustrates the forecasted ECA for the aggregated forested area within 4th order watersheds. The TSA-wide average ECA remains below 20% throughout the planning horizon. However, as the ECAs are not controlled in individual watersheds, their ECAs may exceed the target of 20%. Figure 20 shows the predicted ECA for one 4th order watershed, where the 20% ECA target is not met.

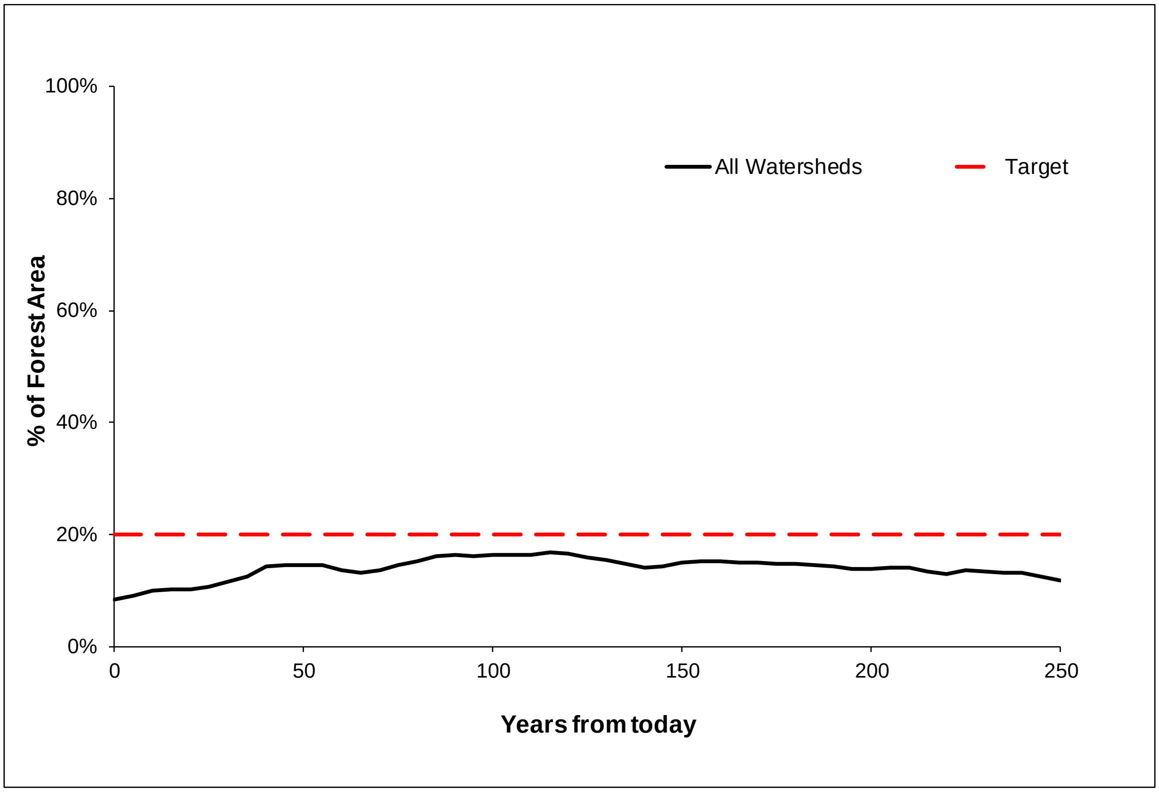

Figure 19: Average ECA over all 4th order watersheds, ISS Base Case

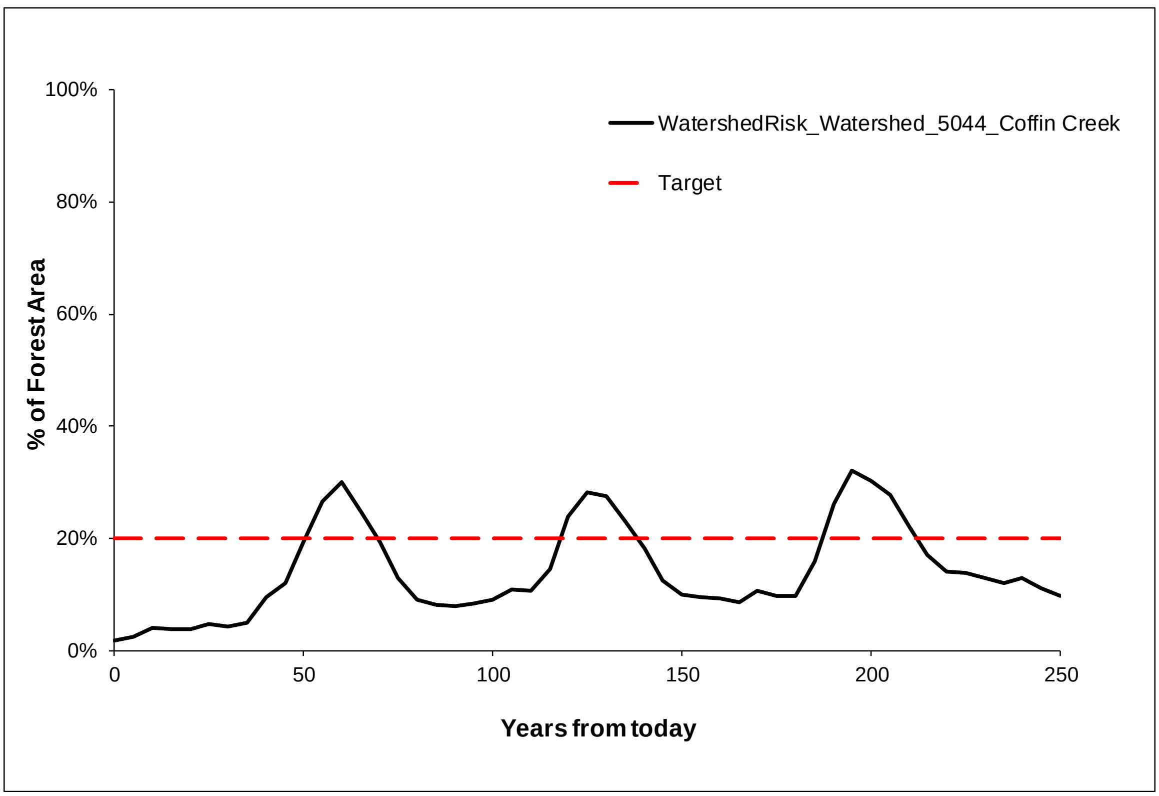

Figure 20: ECA in one 4th order watershed (Coffin), ISS Base Case

4.1.5 Woodland Caribou

The ISS Base Case included woodland caribou habitat as an indicator. The tracked habitat target was inferred from the Federal Caribou Recovery Strategy, i.e. 90% of the forested area within the mapped caribou habitat should be "undisturbed," which was interpreted to mean older than 140 years. The ISS Base Case does not meet the 90% target (Figure 21). Approximately 50% of the achieved area comes from the NHLB.

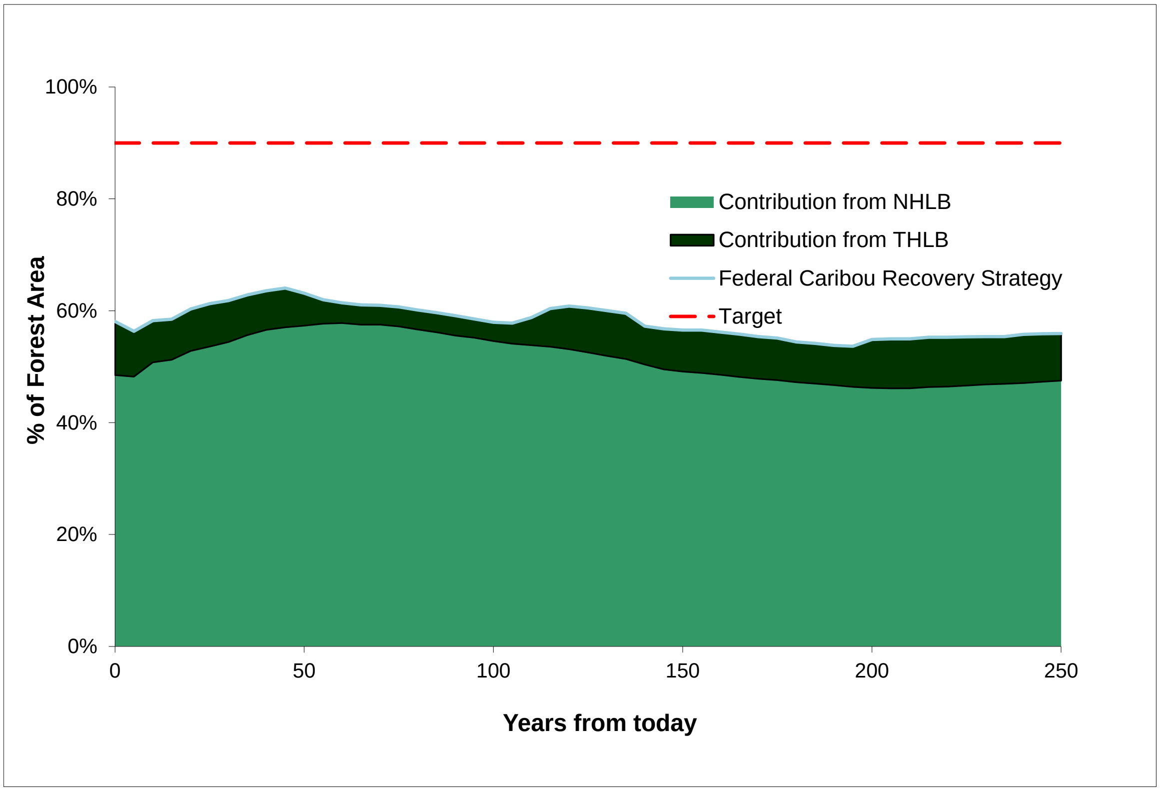

Figure 21: Suitable woodland caribou habitat; ISS Base Case

4.1.6 Marten

Coarse woody debris (CWD) is considered a critical component of suitable marten habitat. Late seral stage (older than 250, or 140 for SBSmc, SBSmc2 and SBSdk) was used in this analysis as a surrogate for CWD and marten habitat. Figure 22 illustrates the predicted marten habitat for the entire TSA. Most of the habitat is predicted to come from the NHLB. The decrease in the habitat in the NHLB is caused by the natural disturbance assumptions in the model.

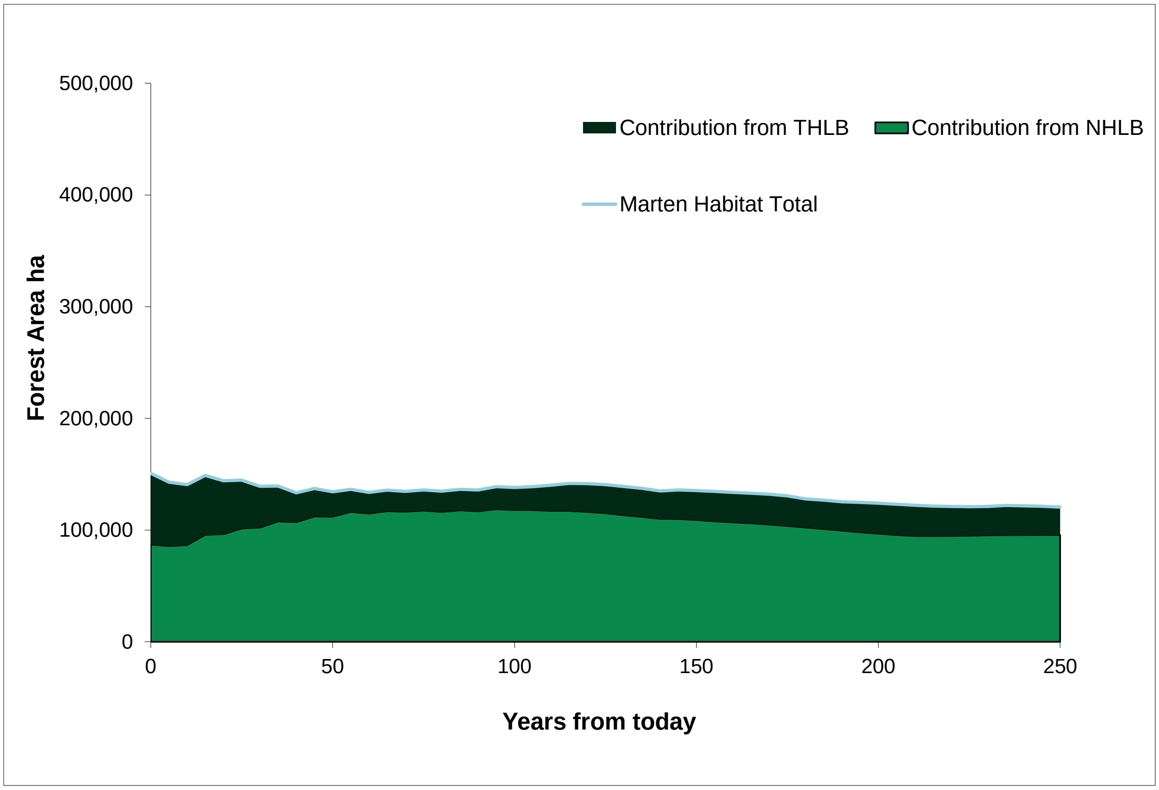

Figure 22: Predicted marten habitat for the Bulkley TSA; ISS Base Case

4.1.7 Grizzly Bear

The ISS Base Case did not track suitable Grizzly bear habitat. Rather, it tracked poor Grizzly habitat in each LU and BEC variant. Poor habitat was defined as more than 30% mid seral stage (41 to 80 year old stands) in each LU/BEC variant, as per the provincial cumulative effects protocol for grizzly bear.

Figure 23 shows the predicted area of poor habitat for the ESSF mc variant in the Copper LU. At times the mid seral area exceeds the target in this area.

Figure 24 illustrates the predicted area of poor Grizzly habitat for the entire Bulkley TSA in the ISS Base Case. The maximum target area shown in Figure 24 represents the aggregated maximum areas of all LU/BEC combinations (at 30%). The area of mid seral stage is predicted to increase modestly in the TSA over the next 100 years. In the long term, the mid seral stage area is forecasted to remain under 100,000 ha.

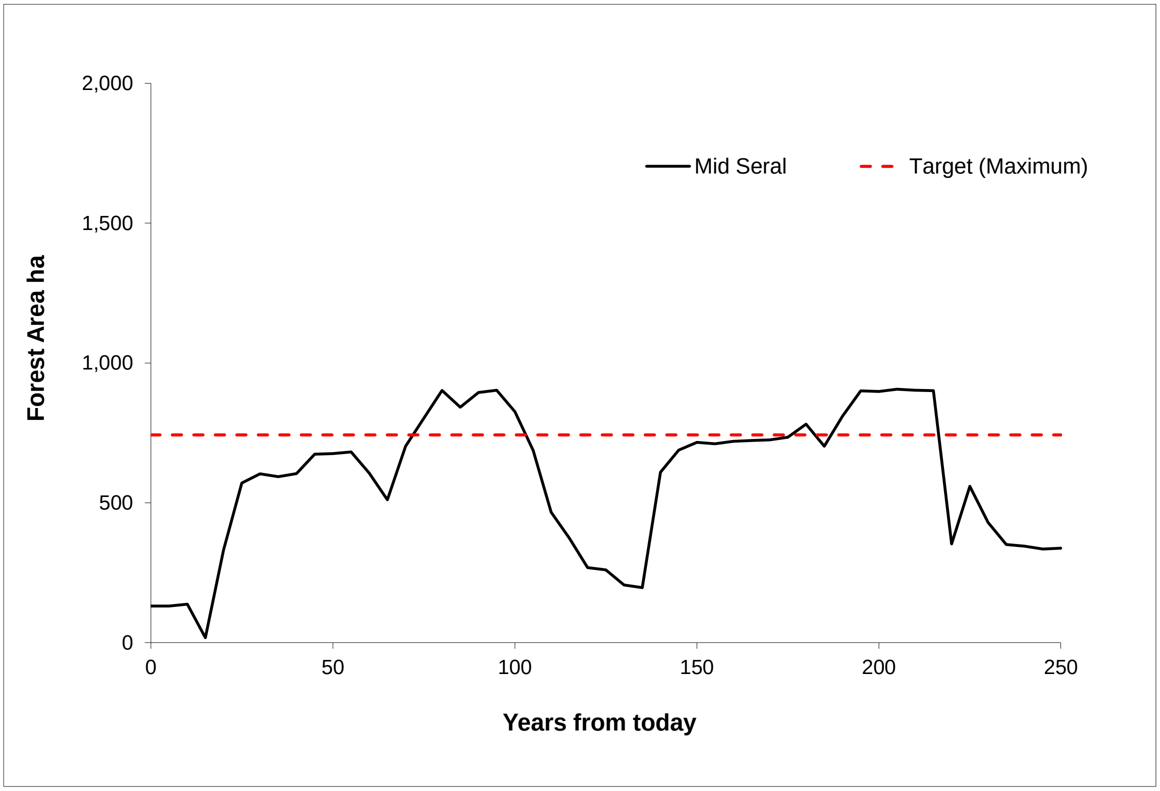

Figure 23: Forecast of poor Grizzly habitat in Copper ESSF mc

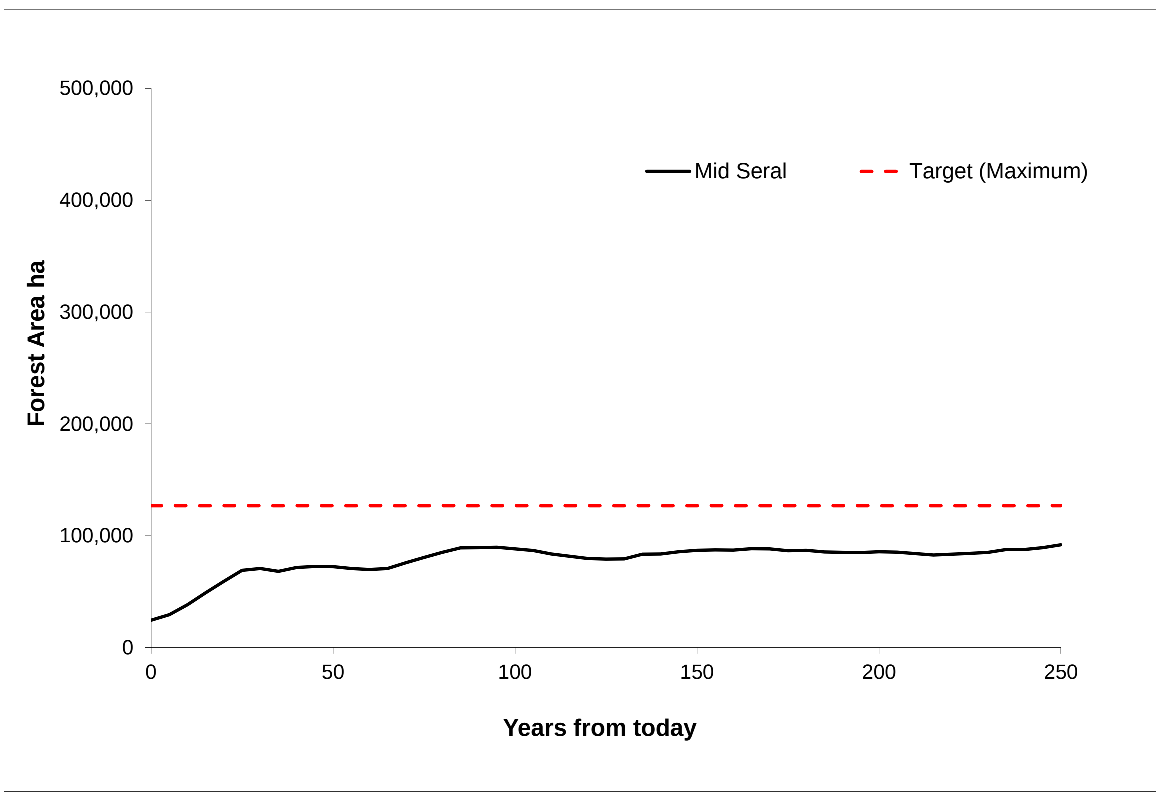

Figure 24: Forecast of poor Grizzly habitat in the Bulkley TSA, ISS Base Case

4.2 Sensitivity Analyses

Three sensitivity analyses were completed: the first included all areas classified as marginal sawlog and pulp in the THLB, while the second limited the harvest of marginal sawlog to 14% (86,000 m^3 per year) for the first 100 years. The third sensitivity analysis tested the impact of removing a portion of the Wildland Urban Interface (WUI) from the THLB for the purpose of dedicating it to wildfire prevention.

4.2.1 Include All Areas Classified as Pulp and Marginal Sawlog in the THLB

This sensitivity analysis tested the impact of including all the pulp and marginal sawlog areas in the THLB. In the ISS Base Case, all areas classified as pulp were removed from the THLB. In addition, all areas classified as marginal sawlog located further than 1 km away from a road and marginal sawlog areas located further than 5-hour cycle time away from Smithers were also removed from the THLB, except for the C7 planning cell, which remains in the THLB.

Including all the pulp and marginal sawlog areas in the THLB increased the size of the THLB by 39,111 ha (19%) to 244,089 ha. The harvest forecast increased by 17% (106,970 m^3 per year) (Figure 25). The harvest by stand quality classification is shown in Figure 26.

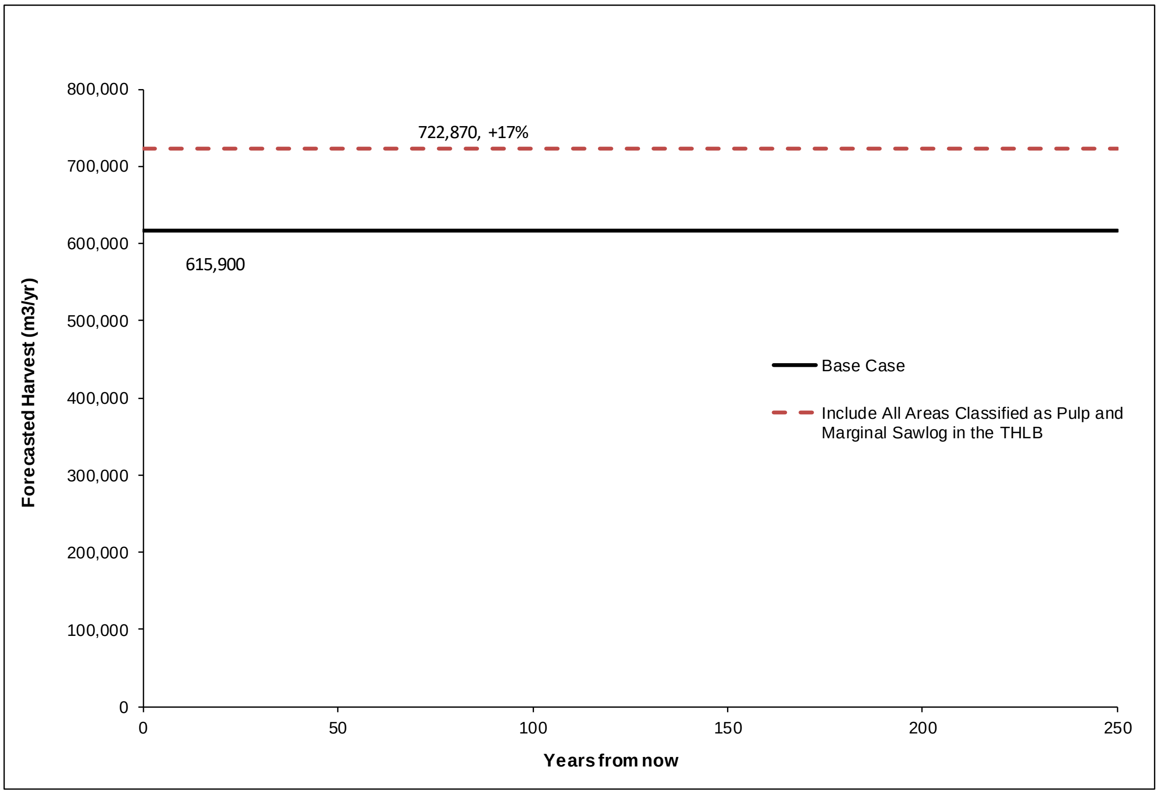

Figure 25: Harvest forecast; include all pulp and marginal sawlog areas in the THLB

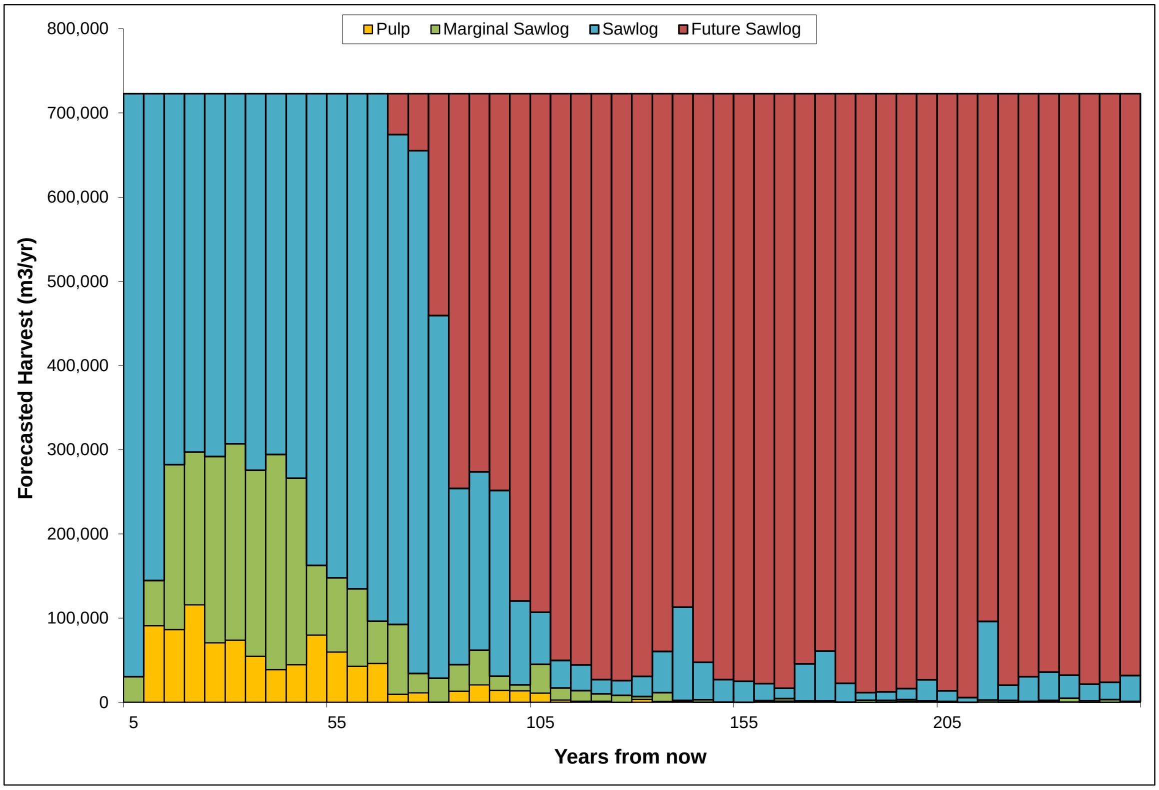

Figure 26: Harvest by stand quality; include all pulp and marginal sawlog areas in the THLB

4.2.2 Limit the Annual Harvest of Marginal Sawlog to Its Share of the THLB

In the ISS Base Case the share of marginal sawlog stands is approximately 14% of the THLB area. This sensitivity analysis tested the impact of limiting the harvest coming from the marginal sawlog stands to approximately 14% or 86,000 m^3 per year. The harvest was capped for the first 100 years.

Figure 27 illustrates the timber supply impact of limiting the share of marginal sawlog harvest in the ISS Base Case. The impact was minimal; the harvest forecast was reduced by 0.2%. Figure 28 shows the harvest forecast for this sensitivity analysis by stand quality classification.

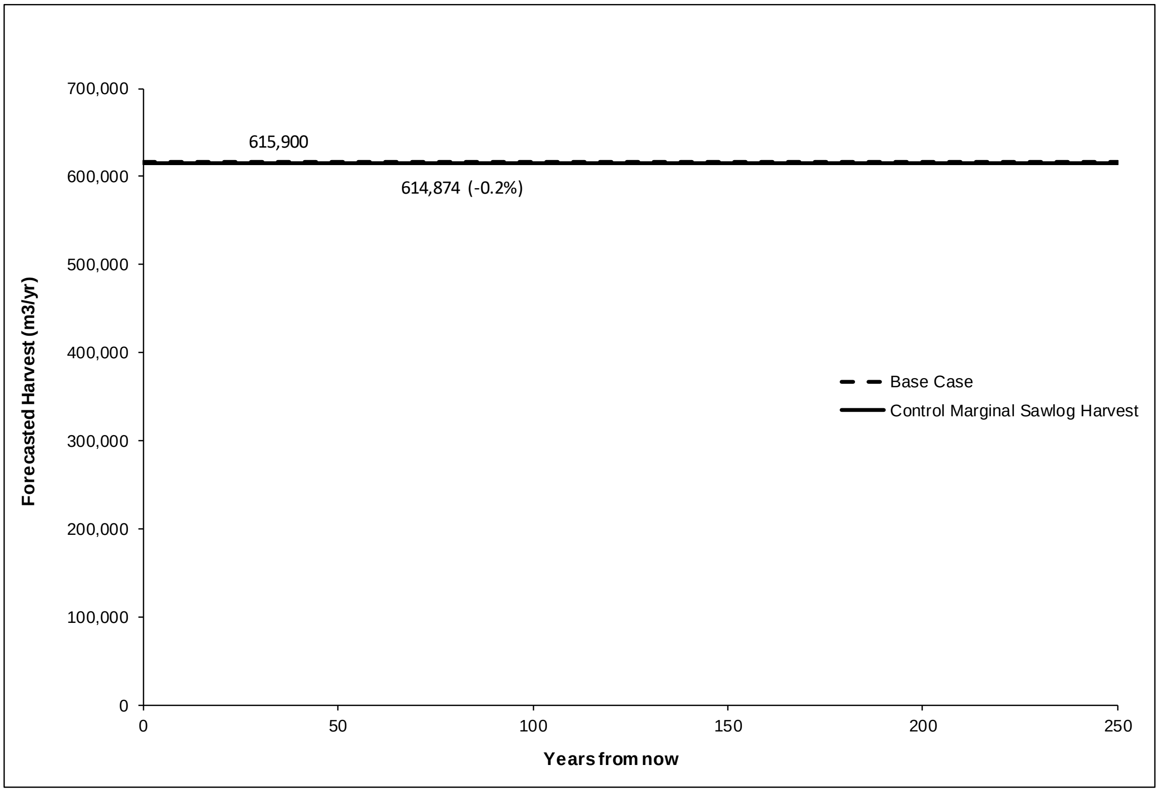

Figure 27: Limit the harvest of marginal sawlog stands to 86,000 m³ per year

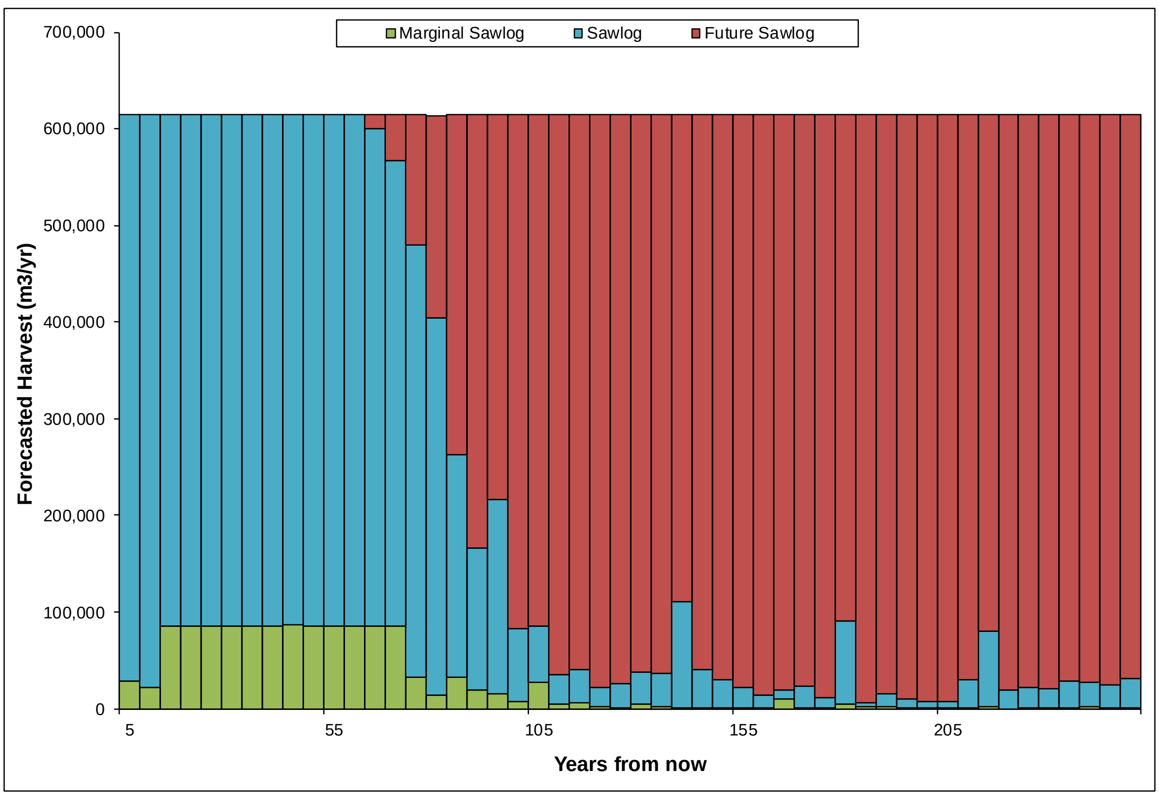

Figure 28 Harvest forecast by stand quality classification; limit the harvest of marginal sawlog stands to 86,000 m³ per year

4.2.3 Remove a Portion of the WUI for Fire Management

The Wildland Urban Interface is any area where combustible wildland fuels (e.g. vegetation) are found adjacent to homes, farm structures or other buildings. The Wildland Urban Interface Buffer consists of areas within two kilometres of a community with a density of between six and 250 structures per square kilometre.

This sensitivity analysis assumed that within a 50 m buffer from homes, farm structures and other buildings, all coniferous forest would be converted to deciduous forest. It was further assumed that the areas within the 50 m buffer would not contribute to timber harvest and be removed from the THLB. The THLB was reduced by 1,979 ha or approximately 1%.

Removing the 50 m buffer from the THLB reduced the harvest forecast by 0.8% as illustrated in Figure 29.

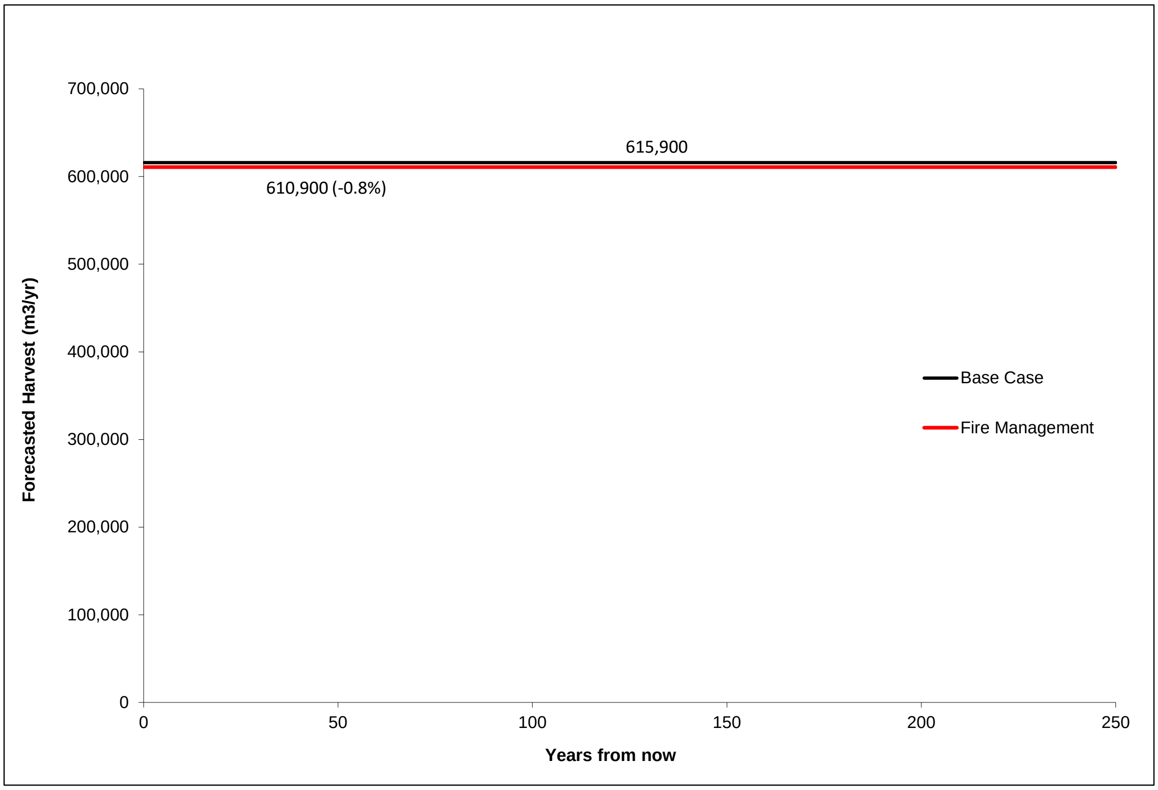

Figure 29: Harvest forecast; remove 50 m buffer around structures and buildings from THLB

4.3 Learning Scenarios

The following strategies were explored in this analysis:

4.3.1 Low Pine Log Quality Scenario

Assessments of existing managed stands in the interior of British Columbia have raised concerns over pine log quality at harvest compared to logs from mature natural stands for a given piece size. This is particularly the case for pine stands with low competing crop tree densities[1] on medium to productive

[1] Competing crop tree density is the sph of dominant and co-dominant stems of all commercial species assessed at a stand age of 20 to 30yrs.

sites and sites that commonly experience periodic heavy snow. The concern over the poor pine log quality prompted the silviculture working group to review the pine quality of managed stands in the Bulkley TSA and assess its potential impacts.

The impact of low Pl log quality at the forest level was tested by applying low log values to some stands. The stands that were considered to have potentially low pine log quality were defined as follows:

- Medium to good productivity; Pl SI>18m; or
- Medium productivity and snow risk; Pl SI 16-18, montane; and
- Expected competing crop tree densities of <1,200sph (judgement based on initial planting density, proportion of Pl vs Sx, relative Pl/Sx SI, relative Pl/Sx genetic worth).

Based on above criteria, low Pl log values were applied to the following ISS Base Case managed stand yield curves:

- Old Era; non-Pl leading yield curves for ESSFmc, ICHmc1, ICHmc2, SBSdk, SBSmc2_Dry_Fresh, SBSmc2-Moist-Wet, and
- Contemporary and Future Eras, all yield curves for ESSFmc, ICHmc1, ICHmc2, SBSdk, SBSmc2

Average prices were applied to the rest of the logs from managed stands.

Figure 30 shows the impact of using low Pl log values for the selected group of stands on the predicted per ha value of managed stands. The comparison in Figure 30 is based on the ISS Base Case harvest forecast. The initial ISS Base Case set up assumed average log values for Pl. Based on the review of these results, the Silviculture Working Group recommended that the low Pl log values be used as the reference in the ISS Base Case and all the further scenarios.

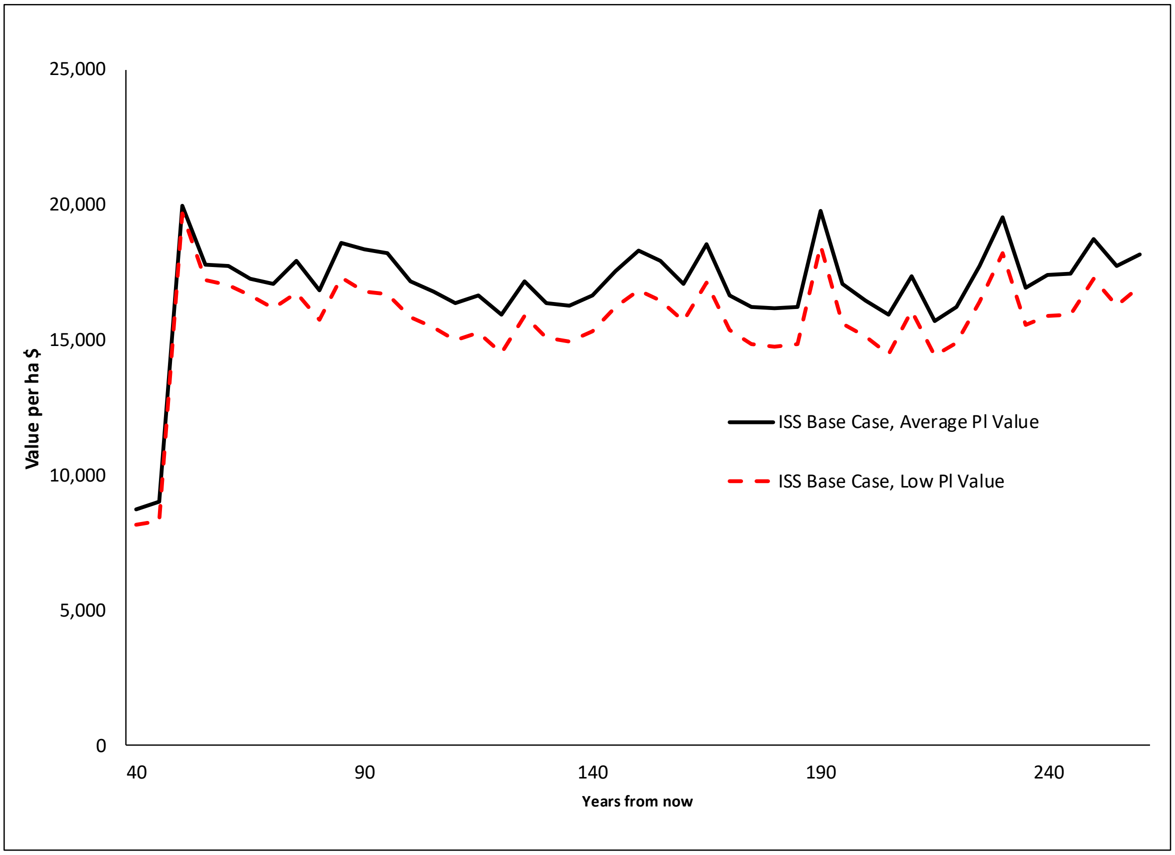

Figure 30: Value per ha forecast (managed stands) with low Pl log values compared to initial Pl log values used in the analysis

4.3.2 Volume and Value Scenarios

The THLB in the Bulkley TSA was zoned to direct silviculture investments; the zoning is described in the Bulkley ISS Data Package (Forest Ecosystem Solutions Ltd. 2020). Three zones were developed for areas to be managed primarily for timber production: green, yellow and red. Green depicts areas where investments in timber are generally recommended due to good site productivity, lower harvest costs and smaller anticipated risk. In the yellow zone caution is recommended, while the red zone denotes areas where timber investments should be avoided due to costs and risks. The zoning was developed for all THLB areas; core areas and ecosystem corridors were designated as red zones.

The volume and value strategies can resemble each other, because the regimes that are designed to produce larger logs often also contribute to increases in value. In this analysis, the differences between the volume and value strategies relate to variations in the species portfolio. In both strategies a portion of the existing old era Sx leading stands were fertilized every 10 years from 30 to 70 years. As discussed previously, the rest of the existing managed stands were not deemed suitable for fertilization due to concerns over Pl log quality.

A key strategy for volume and value production on medium and good sites is to establish a mosaic of ecologically suitable single species stands with enhanced densities specifically designed to optimize the production and value of each species on shorter rotations. The established Fd, Sw and Pl stands were fertilized every 10 years from year 30 to year 70.

The volume and value strategies are applied on green and yellow silviculture zones designated for timber production. Reduced stocking densities were assumed for many of the red silviculture zone sites to balance out the overall reforestation costs.

The species portfolio for each BEC unit was developed in consideration of forest health risks, and climate change using the Climate Change Informed Species Selection (CCISS) tool. Average expected genetic worth for each species from seed available under the Climate Based Seed Transfer (CBST) rules was used.

High future log prices were assumed for all enhanced (higher densities) regimes.

The value strategy includes planting of Cw on ecologically suitable sites; these stands are assumed to be spaced to favor Cw. No fertilization of Cw was assumed. Both the volume and value scenarios were tested using two different minimum harvest criteria:

1. Minimum volume per ha as per the latest TSR;
2. Minimum volume per ha as per the latest TSR and the age at which the 95% MAI culmination is reached.

The treatment assumptions and yield curve inputs for the volume and value strategies are described in the Bulkley TSA ISS Data Package (Forest Ecosystem Solutions Ltd. 2020).

4.3.3 Biodiversity and Habitat Scenarios

These scenarios tested the impacts on various indicators of setting and enforcing targets for moose habitat, NOGO forage habitat, ECAs and woodland caribou habitat. A combined biodiversity scenario and a coarse filter biodiversity scenario were also completed.

4.4 Learning Scenario Results

4.4.1 Stand Level Results; Volume and Value Scenarios

This section summarizes the stand-level log volume, log value and site value forecasts for timber regimes that were considered for the largest future managed stand analysis units in green and yellow silviculture zones.

Site value is the present value of all cash flows produced by an infinite series of identical rotations. It is the value one would pay for bare ground if the intent were to manage an infinite series of rotations under an assumed management regime. Site value differs from the net present value (NPV) of a single rotation because site value recognizes the cost of prolonging the start of the next rotation, while NPV of a single rotation does not.

For site value the results are presented for two discount rates: 2%; which is the current government standard, and a more conservative rate of 4%. The assumed silviculture costs are: incremental planting ($0.68 per tree), fertilization ($500 per application) and juvenile spacing to favour Cw ($2,500 per hectare).

4.4.1.1 Existing Managed Stands

The volume and value strategies for existing managed stands consist of fertilizing existing old managed Sw leading stands in portions of the green and yellow silviculture zones every 10 years from age 30 to age 70. Figure 31 illustrates the predicted volume and value responses of an old era, SBSmc2 dry-fresh Sx leading stand (the largest Sx leading old era analysis unit) to intensive fertilization; stands are fertilized two, three or four times depending on their current age. The results are shown with average log values. The responses are marginal, because average stands are not fully stocked and/or Sx dominated.

Figure 32 investigates the site value of the three silviculture regimes. Fertilization of average existing managed stands is not financially viable at a cost of $500 per ha per treatment as illustrated in Figure 32. However, if better than average stands (Sx stocking) can be find through field work, they may be viable treatment candidates.

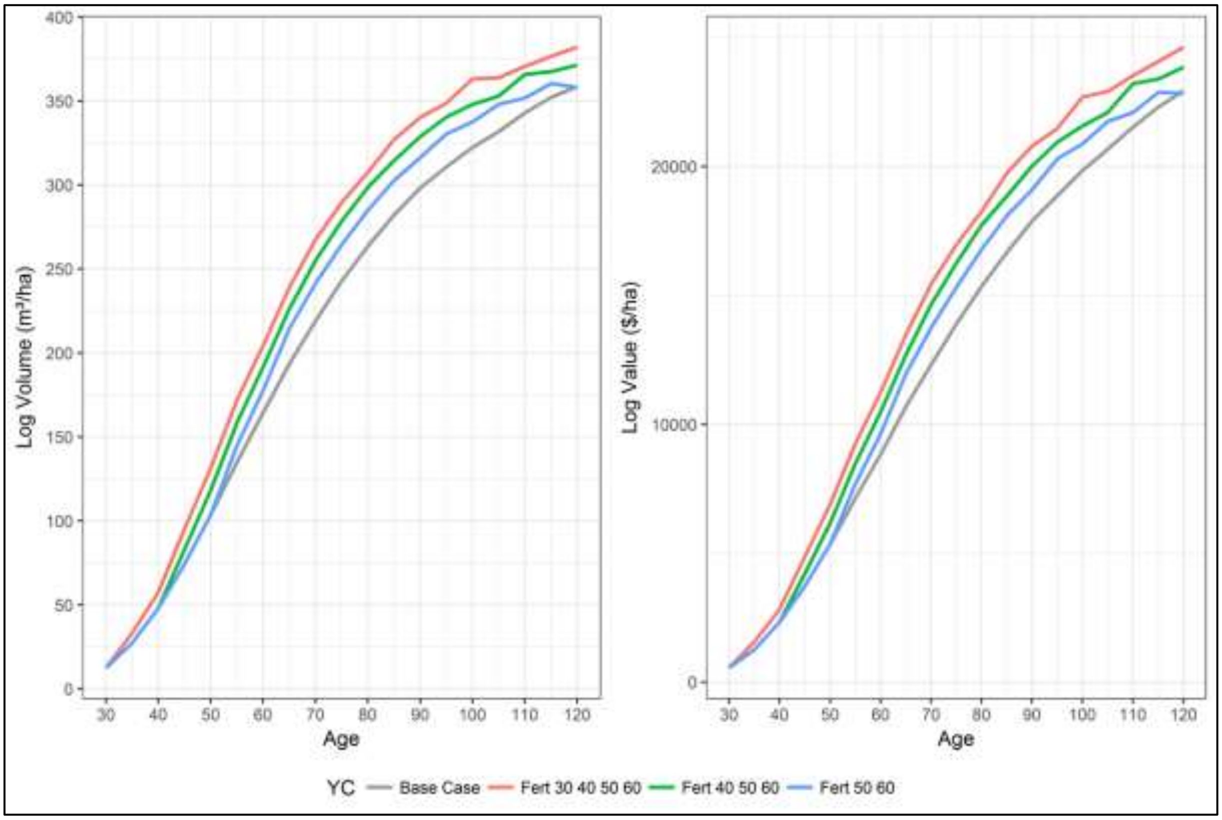

Figure 31: Predicted volume and value responses to fertilization; old era, SBSmc2 dry-fresh Sx leading

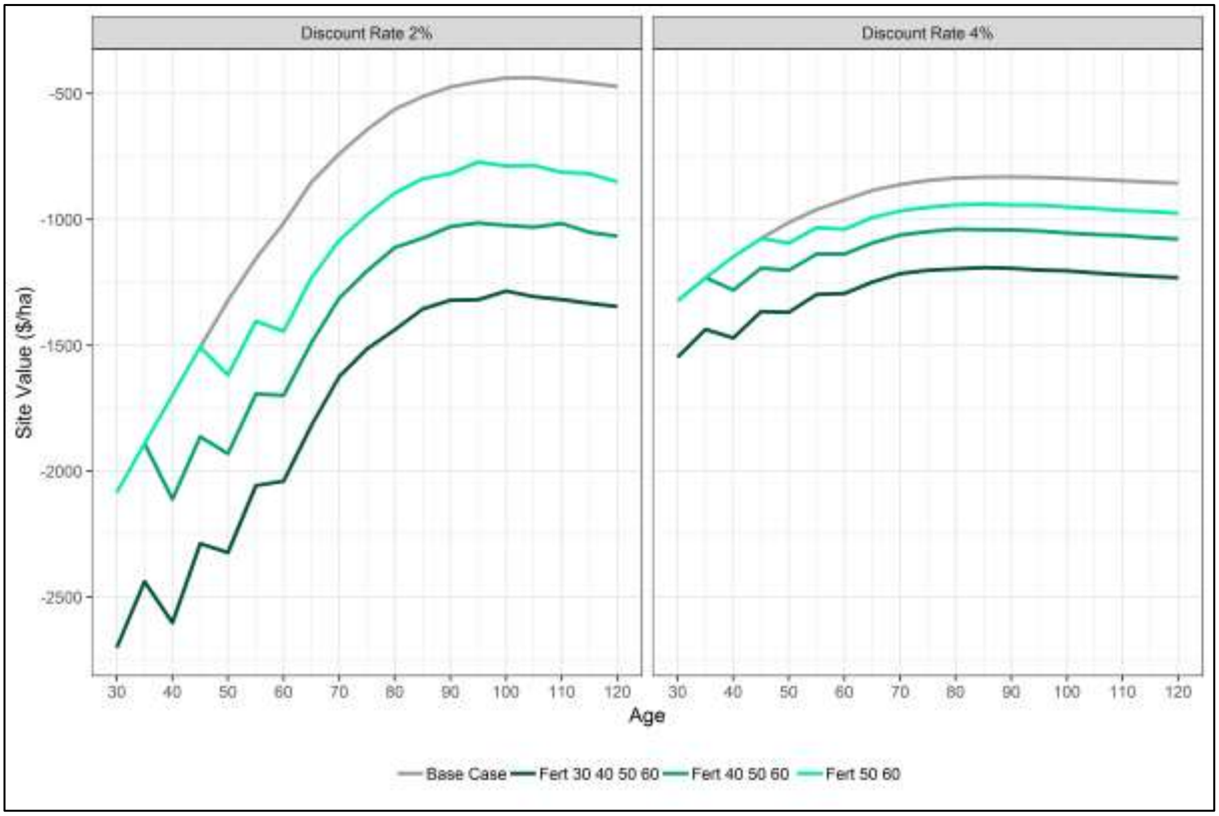

Figure 32: Site value for old era, SBSmc2 dry-fresh Sx leading

4.4.1.2 Future Stands

Volume and Value Strategies

Volume and value strategies are similar except for variations in species portfolios. For medium and good sites which are expected to be primarily managed for timber (green to yellow silviculture zones), the plan is to establish a mosaic of ecologically suitable single species stands with enhanced densities specifically designed to optimize the production and value of each species on shorter rotations. Further considerations are:

- Average expected genetic worth for each species from seed available under the Climate Based Seed Transfer (CBST) rules was used;
- The species portfolio for each BEC unit was developed with consideration for climate change through the use of Climate Change Informed Species Selection (CCISS) tool and consideration of forest health risks;
- High future log prices were assumed for all enhanced regimes;
- All enhanced Fd, Sw and Pl stands were fertilized every 10 years from year 30 to year 70;
- The value strategy includes planting of Cw on ecologically suitable sites; these stands are assumed to be spaced to favor Cw. No fertilization of Cw is assumed
- To balance out the overall reforestation costs, reduced stocking densities were used for many of the red silviculture zone sites

- Both volume and value strategies were tested using two different minimum harvest criteria in the forest level analysis:
    1. Minimum volume per ha as per the latest TSR;
    2. Minimum volume per ha as per the latest TSR and the age at which the 95% MAI culmination is reached.

"Unmixing the Mixes"

Where timber production is the key objective, the volume and value strategies employ the concept of "unmixing the mixes" at the stand-level. This strategy proposes to pursue species diversity and resiliency objectives at the landscape-level by establishing a mosaic of ecologically suitable single species stands. This is in contrast to the current management philosophy of establishing a mix of species on most areas. In the Bulkley TSA seven BEC units account for approximately 90% of THLB within the green and yellow silviculture zones. In the ISS Base Case these areas were reforested with mixed species planting with the following assumptions (Table 3).

Table 3: Bulkley TSA ISS Base Case current management regeneration assumptions for the most common BEC units

BEC Unit	Planted Stems per Ha	Species Planted (%)	Genetic Worth	Ingress Stems per Ha	Ingress Species
SBSmc2-dry-fresh	1,225	Sx(51)/Pl(49)	16/14	2,275	Pl/Sx/Bl/At
SBSmc2-moist-wet	1,225	Sx(51)/Pl(49)	16/14	2,275	Pl/Sx/Bl/At
ESSFmc-dry-fresh	1,250	Sx(62)/Bl(29)/Pl(9)	16/0/14	1,800	Pl/Bl/Sx
ESSFmc-moist	1,250	Sx(62)/Bl(29)/Pl(9)	16/0/14	1,500	Pl/Bl/Sx
ESSFwv-dry-fresh	1,400	Sx(58)/Pl(21)/Bl(21)	16/14/0	1,500	Pl/Bl/Sx
ICHmc1	960	Sx(84)/Pl(15)	16/14	2,490	Sx/Pl/Bl/At
SBSdk	1,400	Sx(87)/Pl(13)	16/14	2,300	Pl/At/Bl

As illustrated in the Bulkley TSA ISS Data Package (Forest Ecosystem Solutions Ltd. 2020), Sx and Pl have different height development patterns and on many sites this may lead to poor Pl log quality on short rotations. Also, these differential development patterns between species can lead to challenges with the timing of harvest of mixed species stands. Different rotation ages for different species are likely to reduce the potential for volume and value maximization in mixed species stands on shorter rotations. Figure 33 illustrates an example of two single species Pl and Sw stands growing on similar sites; the Pl is ready for harvest considerably earlier than Sx due to its shorter rotation.

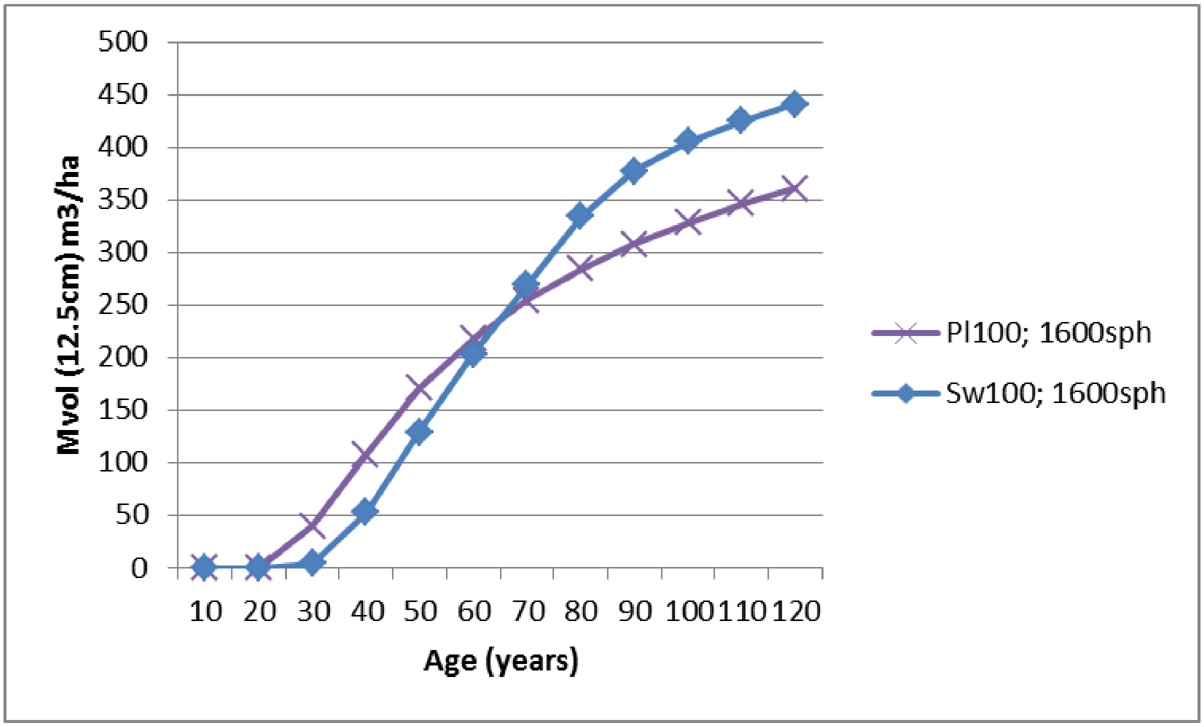

Figure 33: Managed Pl and Sw stands on SBSmc2 ss01

"Unmixing the mixes" can create species diversity and resiliency at the landscape level, while allowing for volume and value maximization. Figure 34 illustrates an example where mixed species are planted everywhere over time and space, while Figure 35 demonstrates an approach where the same species composition is achieved at the landscape level by planting small areas of single species. This approach on a landscape which also has a mosaic of non-timber emphasis sites (managed for other values and less intensively for timber) can be further augmented by spatial and temporal variation. The key for this kind of management is a zonation specifying timber and non-timber management emphasis areas together with use of harvest planning to create temporal and spatial patterns at the landscape level.

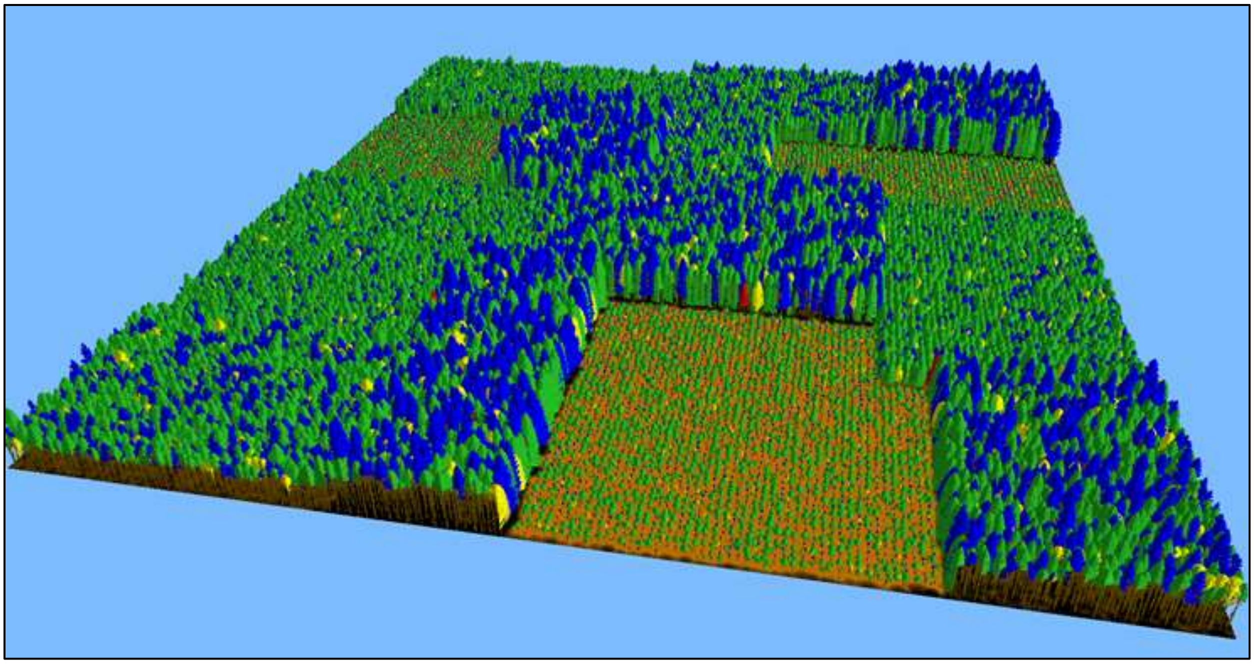

Figure 34: Mixed species planting everywhere over time and space

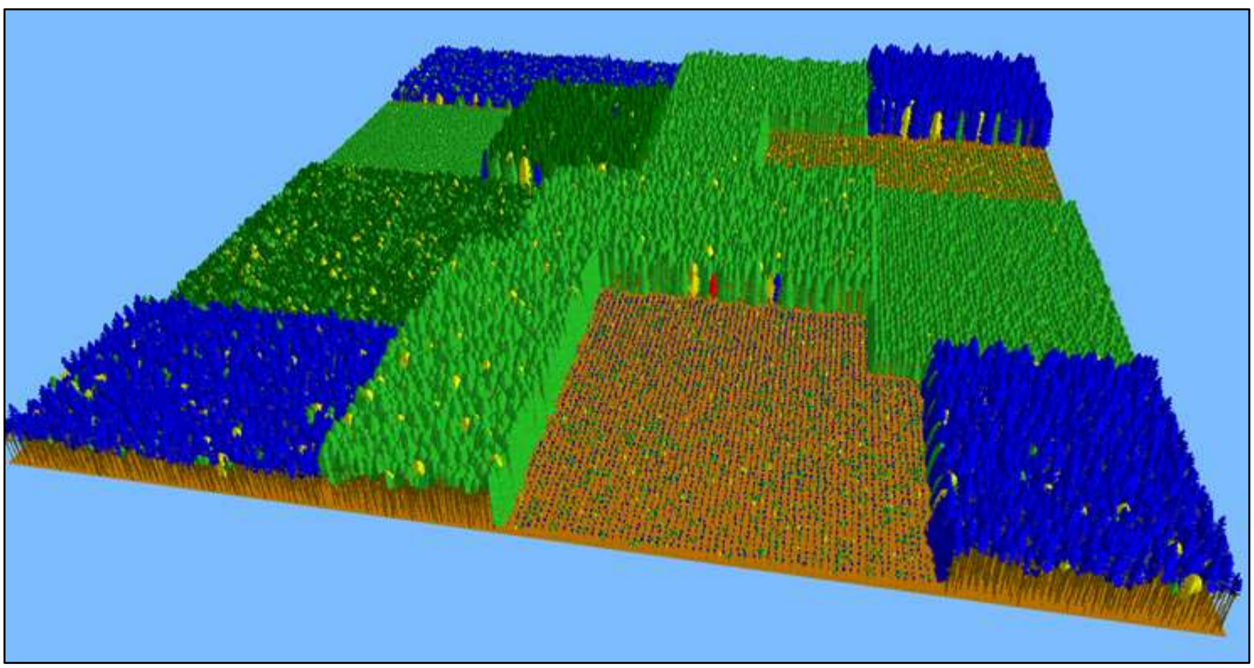

Figure 35: Single species planting to achieve the same landscape-level species portfolio objective

Table 4 shows the regime options which were considered for the volume and value strategies on green and yellow (and an example on the red) silviculture zones. Other BEC units and areas within the red silviculture zone were assumed to be regenerated as per the ISS Base Case. The objective on the timber emphasis sites is to establish a mosaic of ecologically suitable single species stands.

Table 4: Regime options for volume and value strategies

BEC Unit	Volume / Value	Sp1/Target Plant (sph)/ Treatments	Sp2/Target Plant (sph)/ Treatments	Sp3/Target Plant (sph)/ Treatments
SBSmc2-dry-fresh	Volume and Value	Pl/2000/ fert	Sx/1600/ fert	Fdi/1400/ fert
SBSmc2-moist-wet	Volume and Value	Pl/1800/ fert	Sx/1400/ fert	
ESSFmc-dry-fresh	Volume	Pl/1800/ fert	Sx/1400/ fert	
ESSFmc-dry-fresh	Value	Pl/1800/ fert	Sx/1400/ fert	Cw/1200/JS
ICHmc1	Volume	Sx/1600/ fert	Fdi/1400/ fert	
ICHmc1	Value	Sx/1600/ fert	Fdi/1400/ fert	Cw/1200/ JS
SBSdk	Volume and Value	Pl/1800/ fert	Sx/1400/ fert	Fd/1200/ fert
ESSFwv	Volume and Value	Sx/800	Pl/1200	Bl/800

Volume and Value Strategy Modelling Results for Selected Analysis Units

SBSmc2-dry-fresh Future

Figure 36 shows the projected log volumes and values for:

- Base Case (plant 1225 sph, 51%Sw/49%Pl);
- Regime planted to 1,600 sph of Sw and fertilized;
- Regime planted to 1,400 sph of Fdi and fertilized; and
- Regime with a plantation of 2,000 sph of Pl and fertilized.

An intensive Sw regime is projected to produce significant volume and value gains compared to the ISS Base Case as seen in Figure 36. Reforesting with an enhanced Pl regime including fertilization also increased the volume and value versus the Base Case; however, the increase is moderate. The intensive Fdi regime did not increase the projected volume of the stand until after 100 years; however, the stand value was higher than that of the Base Case.

Figure 37 investigates the site value of the three silviculture regimes. All regimes are financially superior to the Base Case at a discount rate of 2% with the Sw regime producing the best result. However, if the discount rate is increased to 4%, only the Sw and Pl regimes produce modestly higher site values than the base Case; Pl before year 60 and Sw before year 80.

Based on the analysis results, the Silviculture WG recommended the following silviculture regime for this analysis unit for both the volume and value strategy:

- 70% Sw regime, 20% Pl regime and 10% Fdi regime

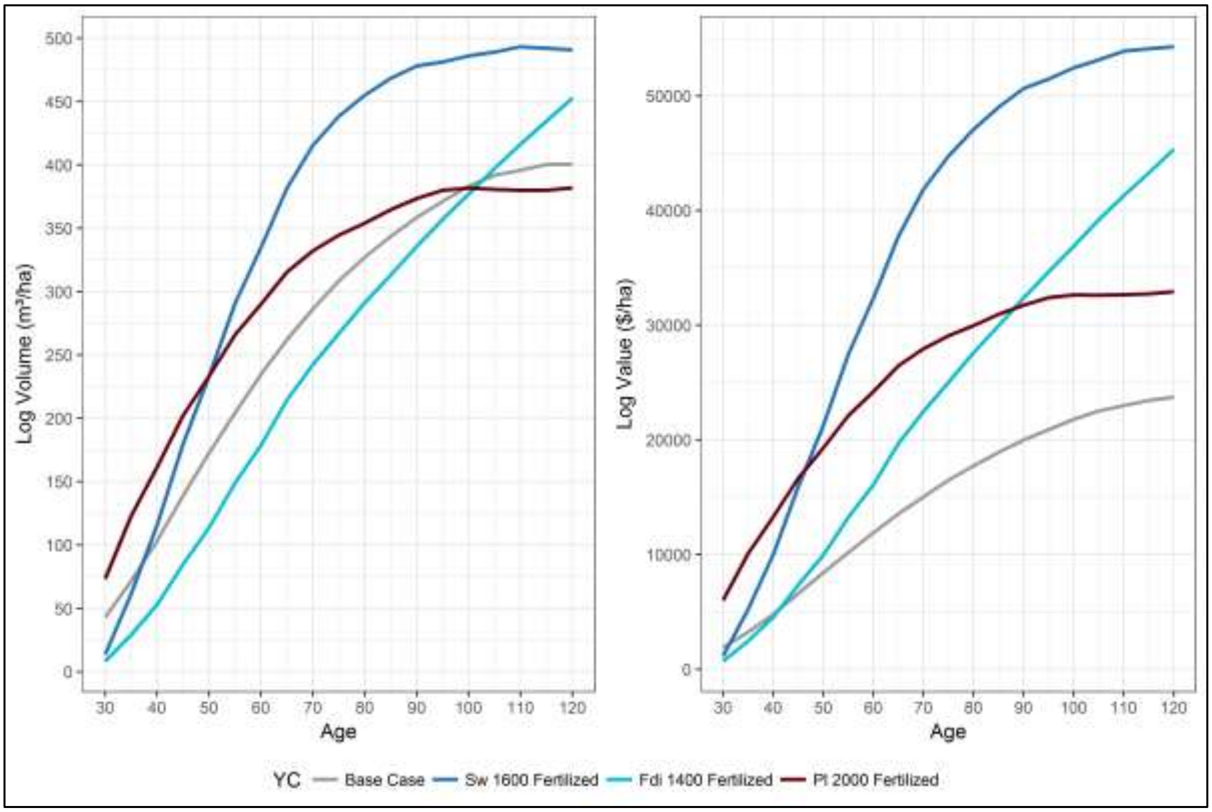

Figure 36: SBSmc2-dry-fresh

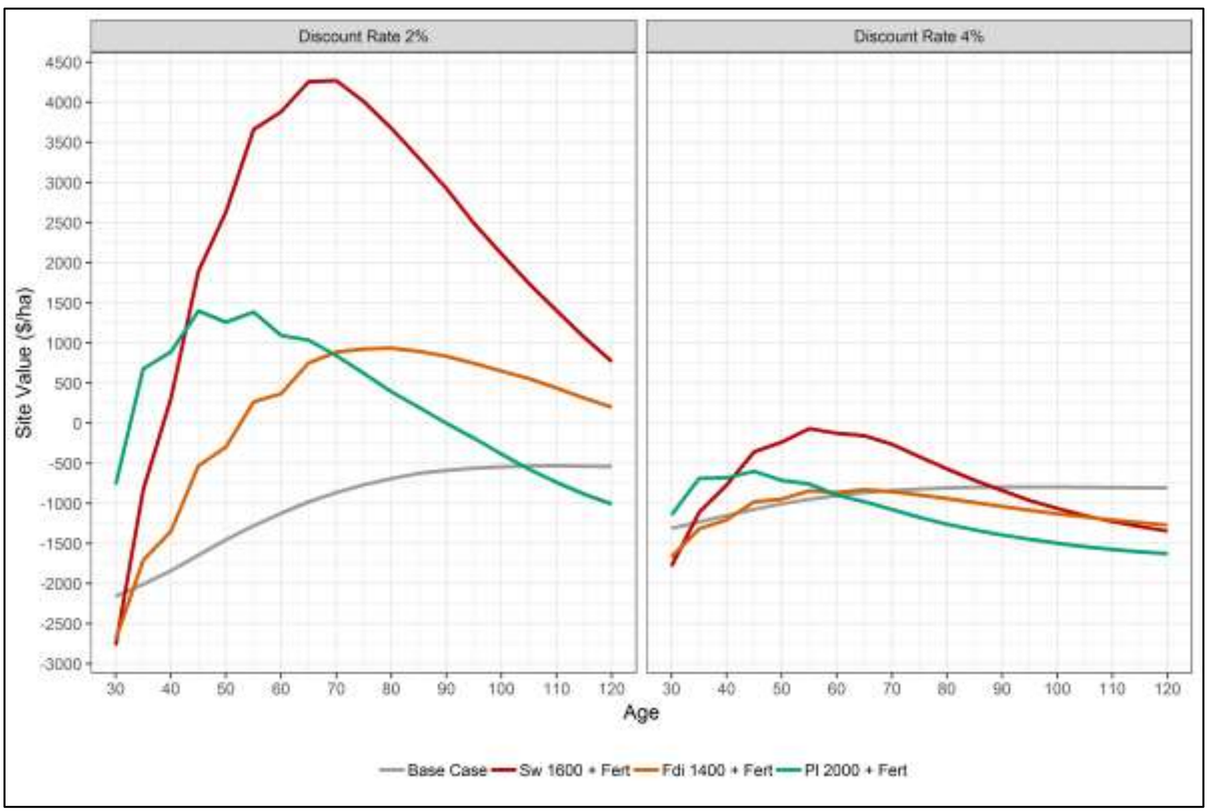

Figure 37: Site value for SBSmc2-dry-fresh

<u>SBSmc2-moist-wet Future</u>

Figure 38 shows the projected log volumes and values for:

- Base Case (plant 1225 sph, 51%Sw/49%Pl);
- Regime with a plantation of 1,800 stems per ha (sph) of Pl and fertilized; and
- Regime with a plantation of 1,400 sph of Sw and fertilized.

The enhanced Sw regime is projected to produce significant volume and value gains compared to the Base Case (Figure 38). Reforestation with the intensive Pl regime also increased the volume and value of the stand compared to the Base Case; however, the increase is less than with Sw.

Figure 39 investigates the site value of two silviculture regimes. Both regimes are financially superior to the Base Case at a discount rate of 2% with the Sw regime producing the best result. With a 4% discount rate the Sw and the Pl regimes show moderately better site values than he Base Case; Pl before year 60 and Sw before year 90.

Based on the analysis results, the Silviculture WG recommended the following silviculture regime for this analysis unit for both the volume and value strategy:

- 70% Sw regime and 30% Pl regime

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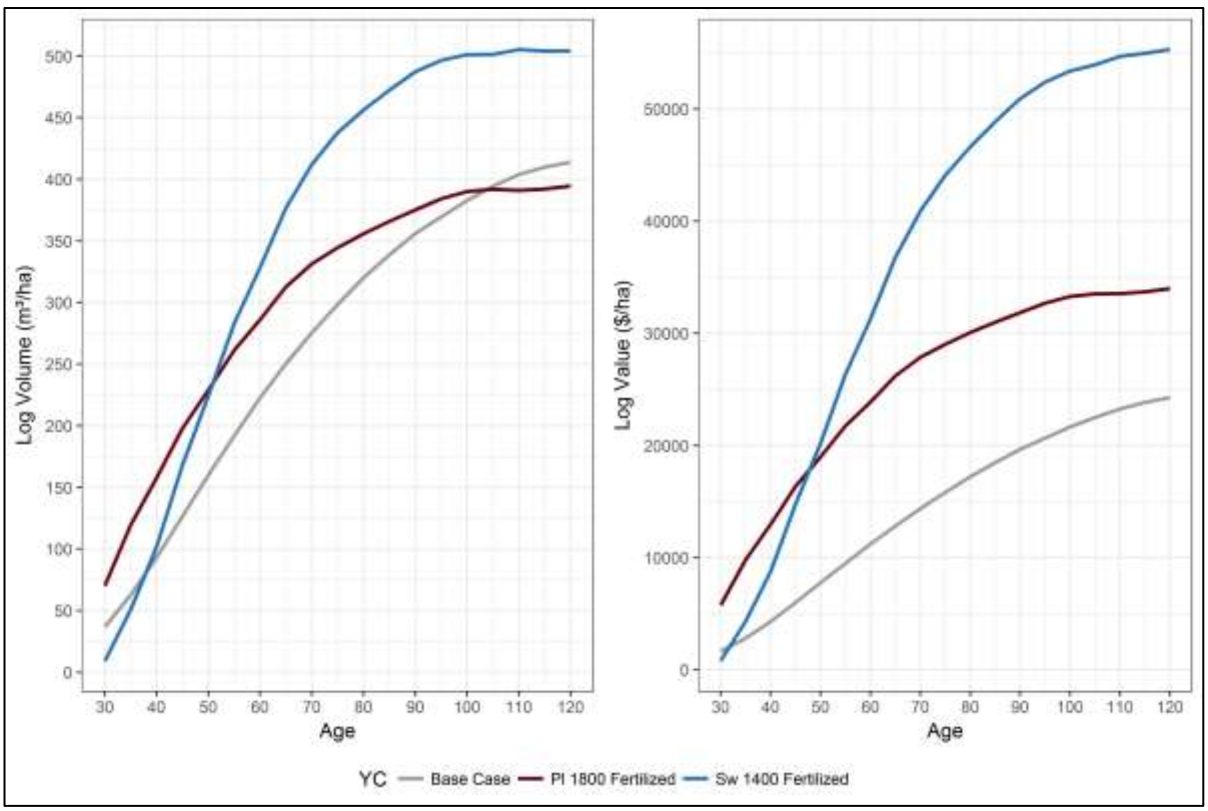

Figure 38: SBSmc2-moist-wet

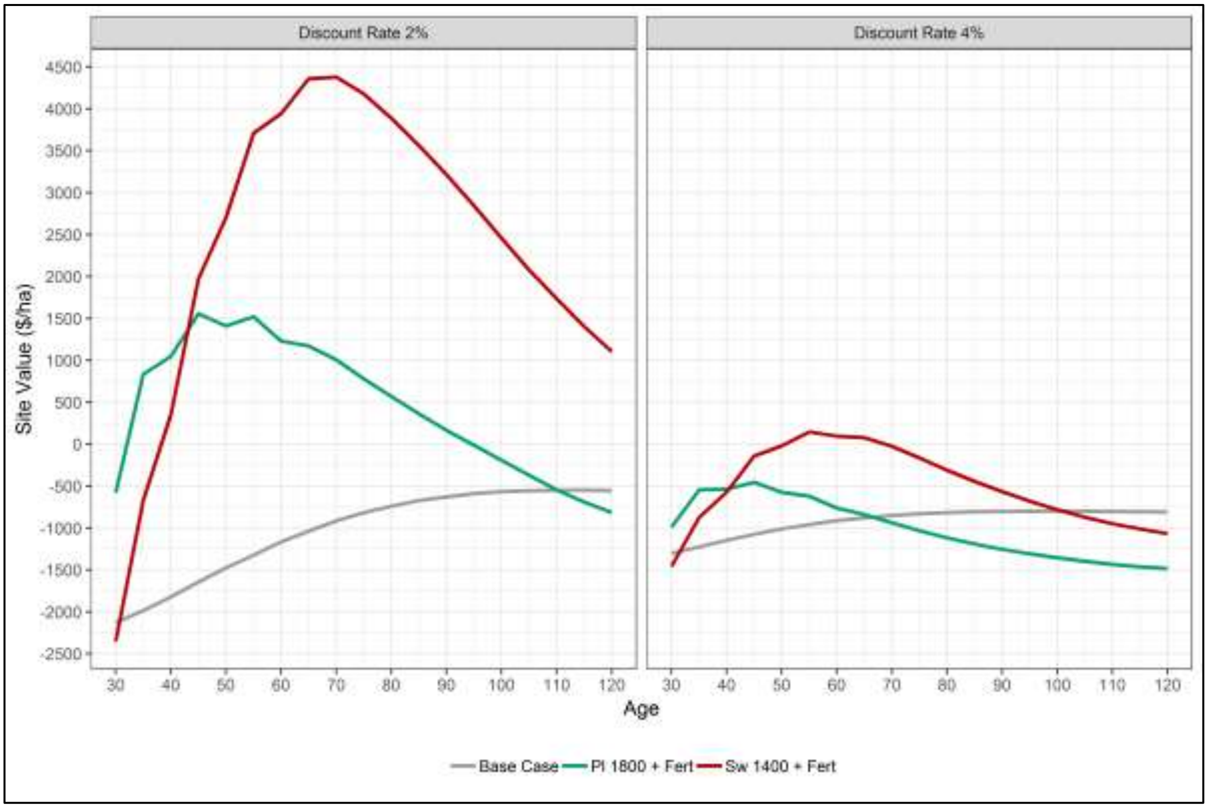

Figure 39: Site value for SBSmc2-moist-wet

<u>ESSFmc-dry-fresh Future</u>

Figure 40 shows the projected log volumes and values for:

- Base Case (plant 1250 sph, 62%Sw/29%Bl/9%Pl);
- Regime planted to 1,400 sph of Sw and fertilized;
- Regime planted to 1,200 sph of Cw and juvenile spaced to 900 sph; and
- Regime with a plantation of 1,800 sph of Pl and fertilized.

Both the enhanced Sw and Pl regimes are projected to produce significant volume and value gains versus the Base Case as seen in Figure 40. Use of the Cw regime resulted in a reduced projected volume per ha over time; however, the projected value of a Cw stand is higher than that of the Base Case.

Figure 41 investigates the site value of the three silviculture regimes. All regimes are financially superior to the Base Case at a discount rate of 2% with the Pl regime producing the best results before 60 years and the Sw regime after that. With a 4% discount rate, both the Sw and Pl regimes break even compared to the Base Case, while the Cw regime is not viable.

Based on the analysis results, the Silviculture WG recommended the following silviculture regimes for this analysis unit for the volume and value strategy:

- Volume: 70% Sw regime and 30% Pl regime,
- Value: 60% Sw regime, 20% Pl regime and 20% Cw regime

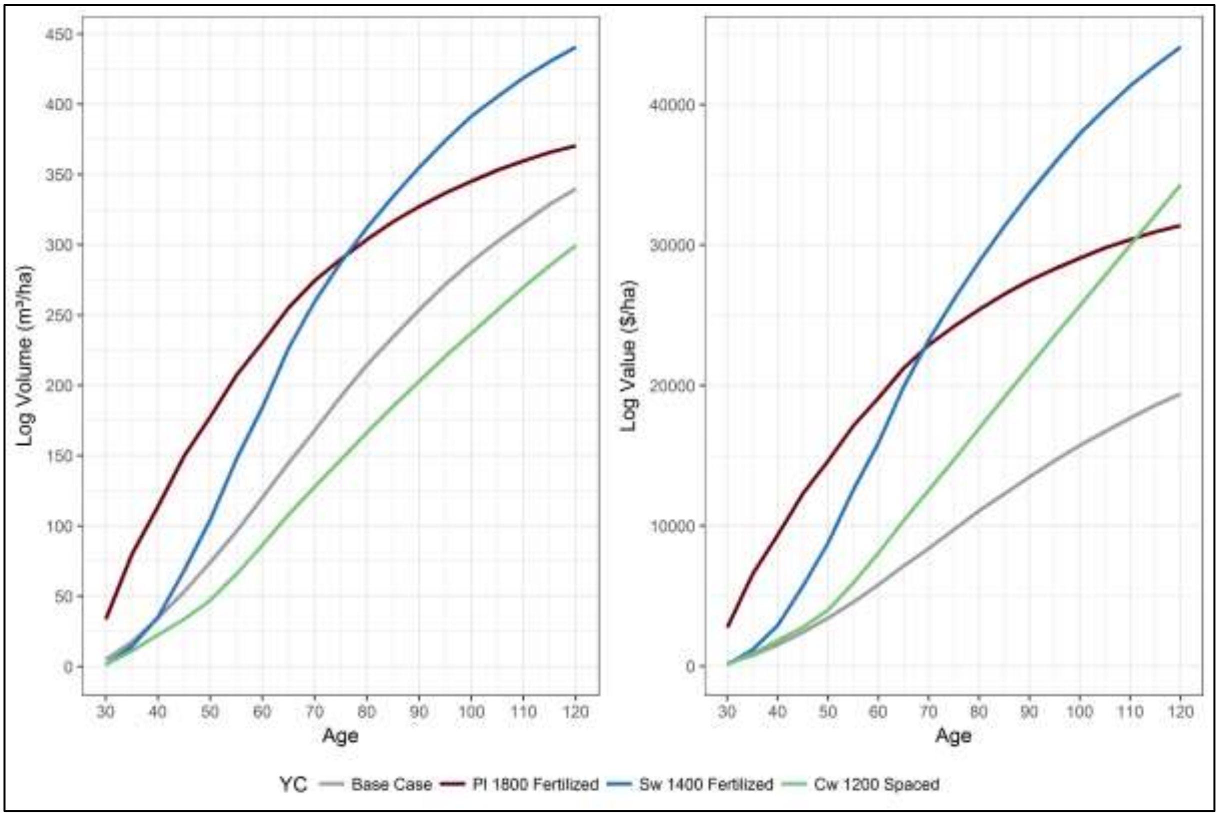

Figure 40: ESSFmc-dry-fresh

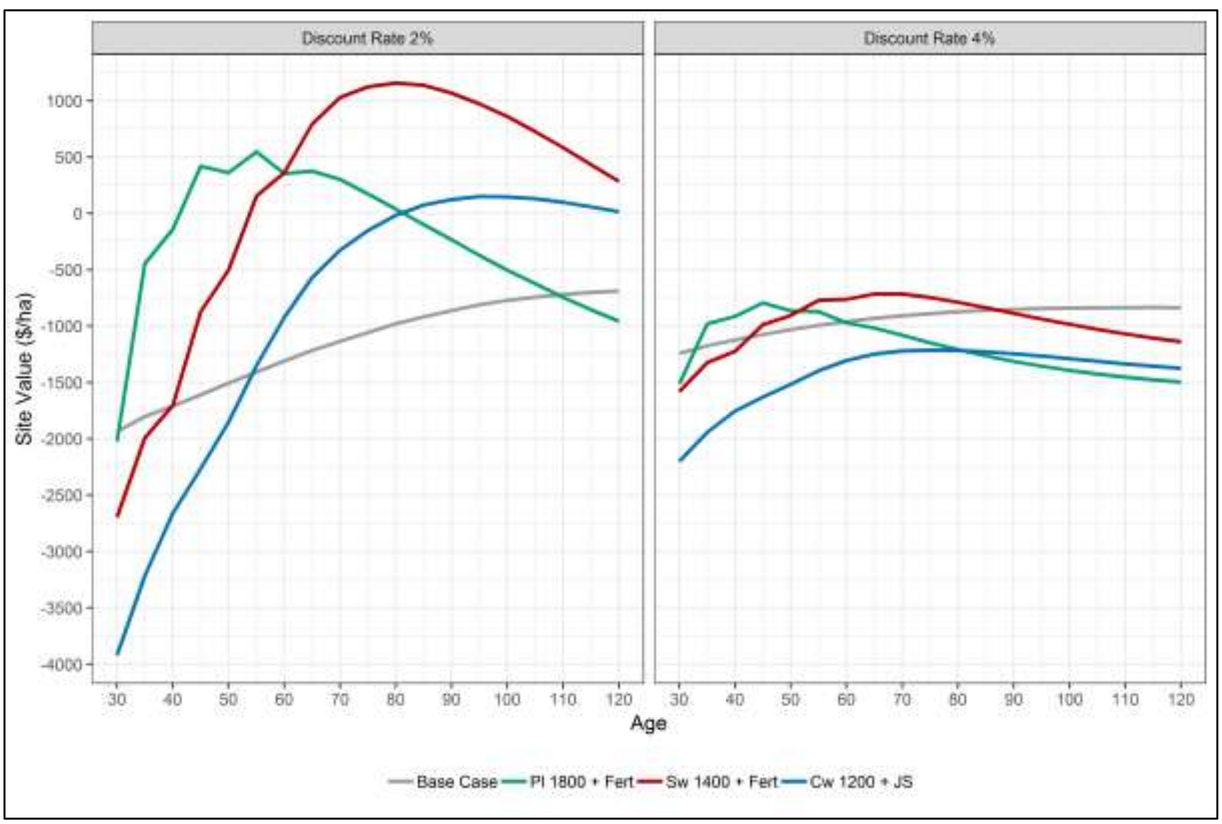

Figure 41: Site value for ESSFmc-dry-fresh

<u>ICHmc1 Future</u>

Figure 42 shows the projected log volumes and values for:

- Base Case (plant 960 sph, 84%Sw/16%Pl);
- Regime planted to 1,800 sph of Sw and fertilized;
- Regime planted to 1,200 sph of Cw and juvenile spaced to 900 sph; and
- Regime with a plantation of 1,400 sph of Fdi and fertilized.

The enhanced Sw regime is projected to produce significant volume (before 90 years) and value gains compared to the Base Case as seen in Figure 42. The Fd and Cw regimes result in similar to lower volumes before 80 to 100 years respectively but both result in significant improvements in value.

Figure 43 investigates the site value of the three silviculture regimes. All regimes are financially superior to the Base Case (Fd only better after 60 years) at a discount rate of 2% with the Pl regime producing highest site values before 70 years and the Cw regime after that. With a 4% discount rate the Sw and Cw regimes break even compared to the Base Case, while the Fd regime is not viable.

Based on the analysis results, the Silviculture WG recommended the following silviculture regimes for this analysis unit for the volume and value strategies:

- Volume: 90% Sw regime and 10% Fd regime,
- Value: 60% Sw regime, 20% Fd regime and 20% Cw regime

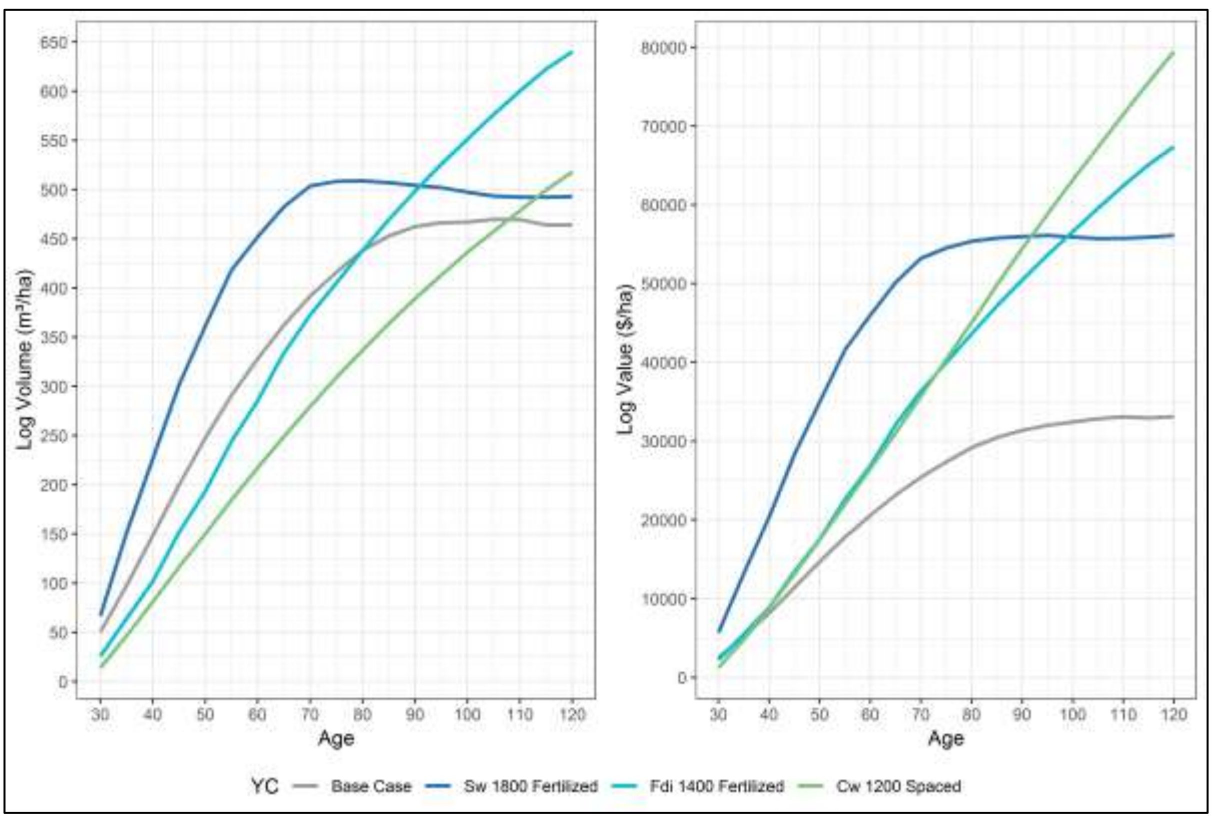

Figure 42: ICHmc1

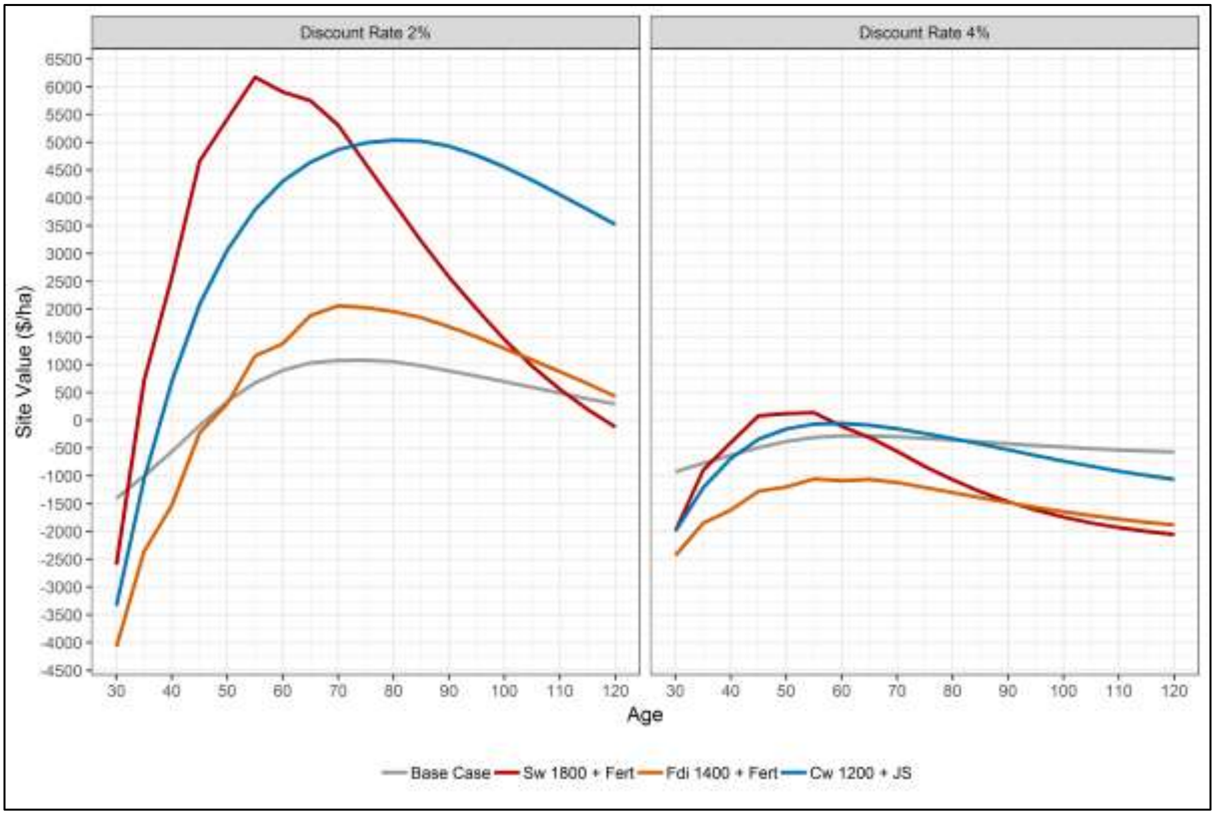

Figure 43: Site value for ICHmc1

<u>SBSdk Future</u>

Figure 44 shows the projected log volumes and values for:

- Base Case (plant 1400 sph, 87%Sw/13%Pl);
- Regime planted to 1,400 sph of Sw and fertilized;
- Regime planted to 1,200 sph of Fdi and fertilized; and
- Regime with a plantation of 1,800 sph of Pl and fertilized.

The Pl and Sw regimes are projected to produce significant volume and value gains over the Base Case as seen in Figure 44. The Fd regime did not increase the projected volume in the stand until after 90 years; however, the stand value was higher than that of the Base Case over the entire forecast period.

Figure 45 investigates the site value of the three silviculture regimes. All regimes are financially superior to the Base Case at a discount rate of 2% with the Pl regime producing highest site values before 55 years and the Sw regime after that. With a 4% discount rate the Pl regime is moderately viable compared to the Base Case before 70 years. Sx and Fd are moderately viable before 100 years..

Based on the analysis results, the Silviculture WG recommended the following silviculture regime for this analysis unit for both the volume and value strategy:

- 70% Sw regime, 20% Pl regime and 10% Fd regime

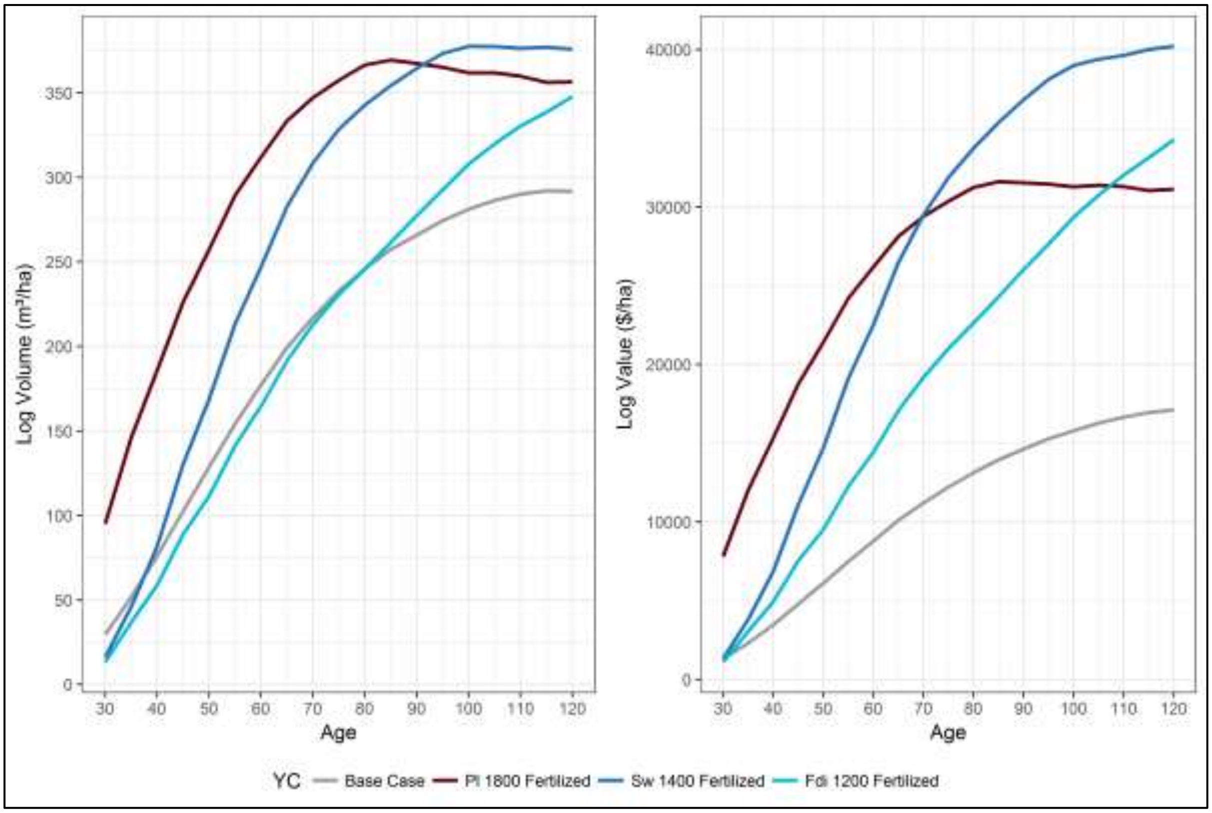

Figure 44: SBSdk

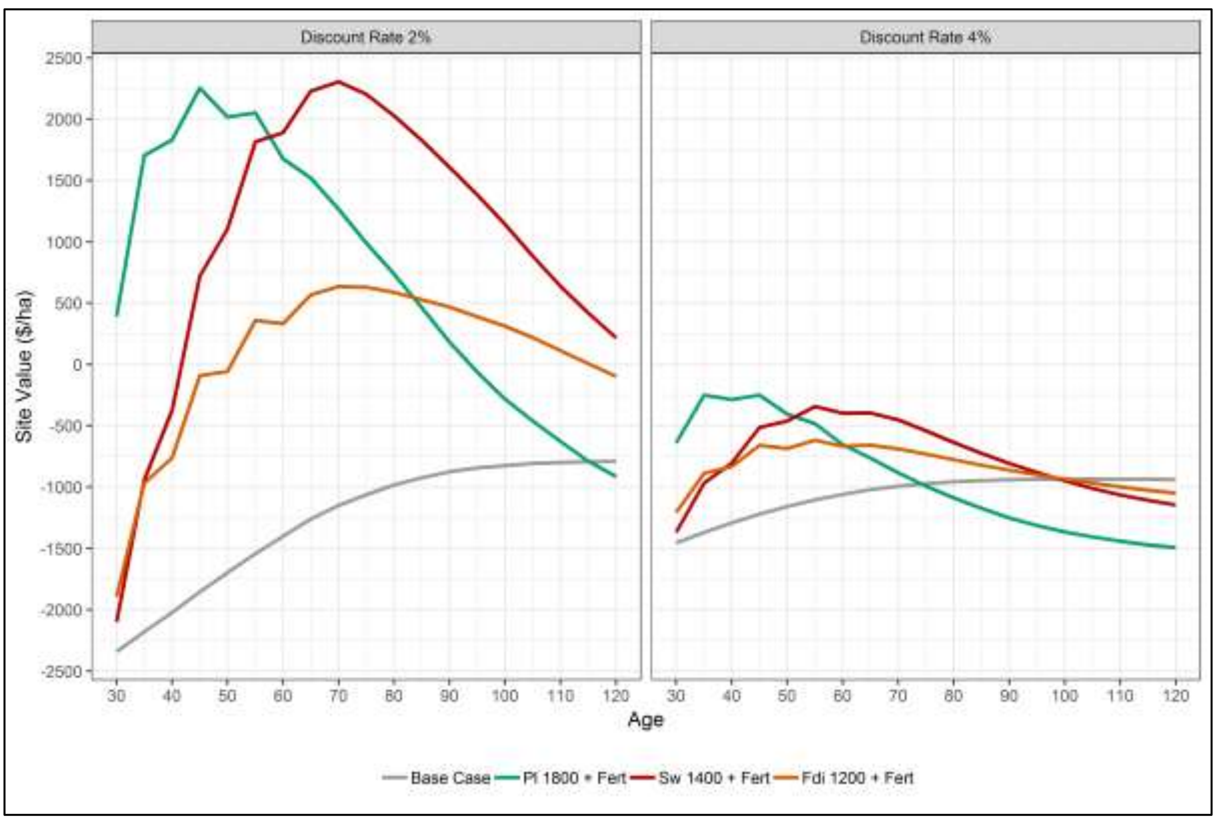

Figure 45: Site value for SBSdk

ESSFwv dry-fresh Future

Figure 46 shows the projected log volumes and values for:

- Base Case (plant 1400 sph, 58%Sw/21%Pl/21%Bl);
- Regime planted to 800 sph of Sw

The reduced Sw planting density regime and the Base Case have virtually the same volume and value forecasts.

Figure 47 investigates the site value of the alternative regime. With discount rates of 2 and 4% the low density Sw regime is vastly financially superior to the Base Case. This is an example of how reduced reforestation regimes on poorer quality sites can have little impact on timber volume and value but can help off-set higher reforestation costs on better sites.

Based on the analysis results, the Silviculture WG made the following decisions for the timber emphasis, yellow and green zones for both the volume and value scenarios for this analysis unit:

- 100% Sw regime

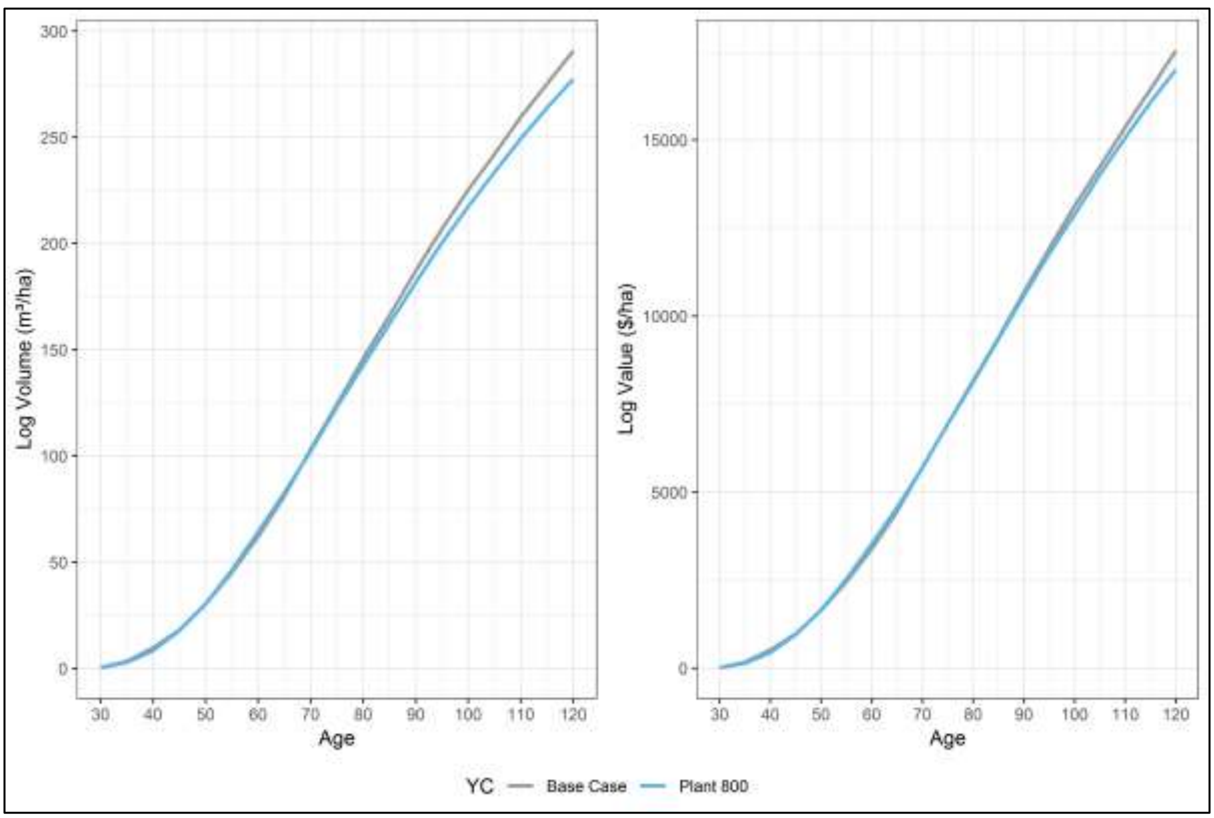

Figure 46: ESSFwv

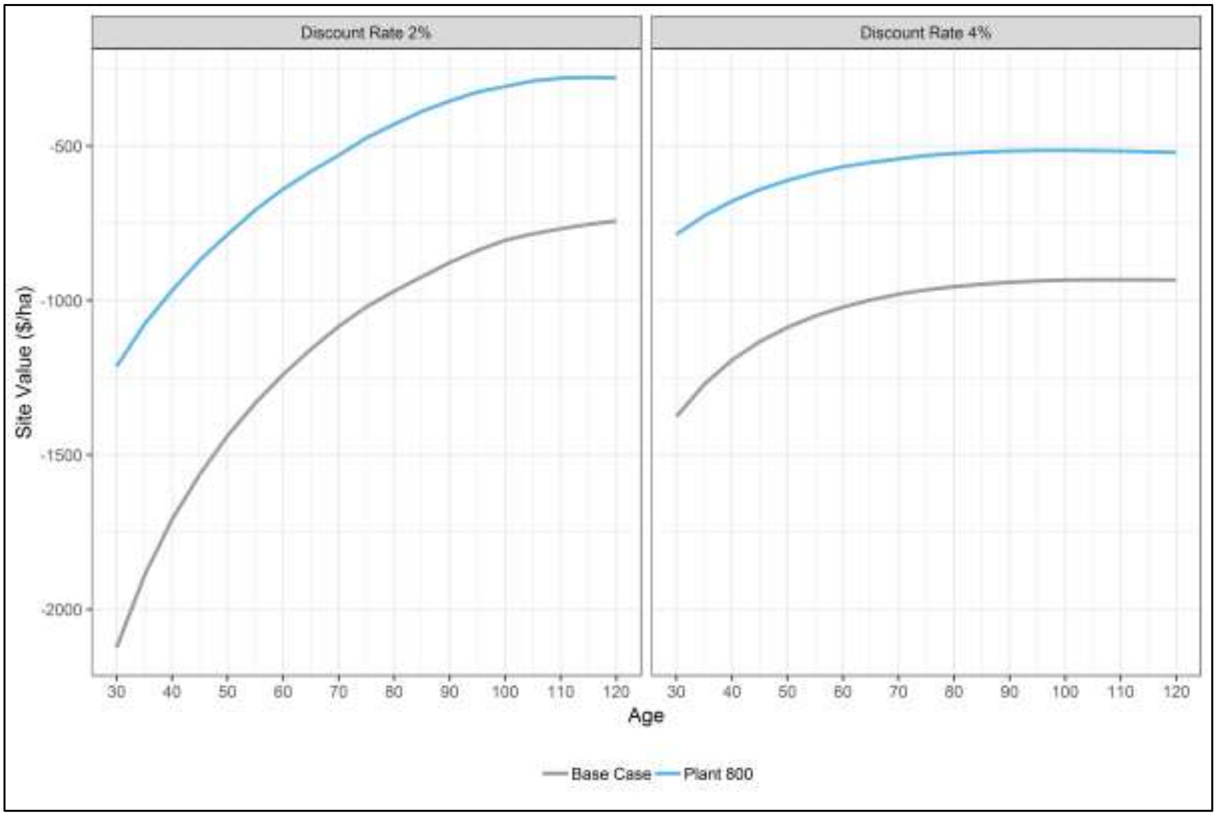

Figure 47: Site value for ESSFwv

4.4.2 Harvest Forecast over Time

4.4.2.1 Volume Scenarios

Figure 48 illustrates the harvest forecast comparison between the ISS Base Case and the two volume scenarios with two different minimum harvest criteria, one using the minimum volume per ha (latest TSR), and the other using the age where 95% of the MAI culmination is achieved in combination with the minimum volume per ha criterion.

If the simple minimum harvest volume per ha is used as the minimum harvest criterion the flat-line harvest forecast can be increased by 14.1%.

Setting the minimum harvest criteria at the age where 95% of the MAI culmination is achieved, generally increases the harvest ages modestly and results in a more moderate increase in harvest volume of 9.3% in the first 90 years of the planning horizon. The long-term harvest level is reached at year 91 and the increase in the predicted harvest volume in the long term is significant at 26.4%.

Figure 49 shows the forecasted harvest by yield type in the volume scenario using the minimum harvest volume as the minimum harvest criteria. Aggressive fertilization has some impact in speeding up the entry into managed stands; the harvest in these stands starts at year 30, 5 years earlier than in the ISS Base Case. If the 95% of the MAI culmination rule is enforced the harvest of managed stands commences at year 35 (Figure 50).

Favoring spruce for volume production has an impact on the predicted harvest by species. If the volume scenarios were to be followed it is likely that the share of spruce of the total harvest would increase at the expense of balsam and pine as shown in Figure 51. Note the introduction of Douglas-fir in the future managed stands. The harvest forecast by species remains similar if the 95% of the MAI culmination rule is enforced (not shown).

Figure 52 and Figure 53 illustrate the impact of minimum harvest criteria on the predicted volume per ha classes of the timber supply forecast. If the simple minimum harvest volume per ha is used as the minimum harvest criterion, the majority of the medium and long-term harvest is predicted to come from stands between 200 and 300 m^3 per ha (Figure 52). As noted above, setting the minimum harvest criteria at the age where 95% of the MAI culmination is achieved increases the harvest ages, which is also reflected in expected higher harvest volumes per ha (Figure 53).

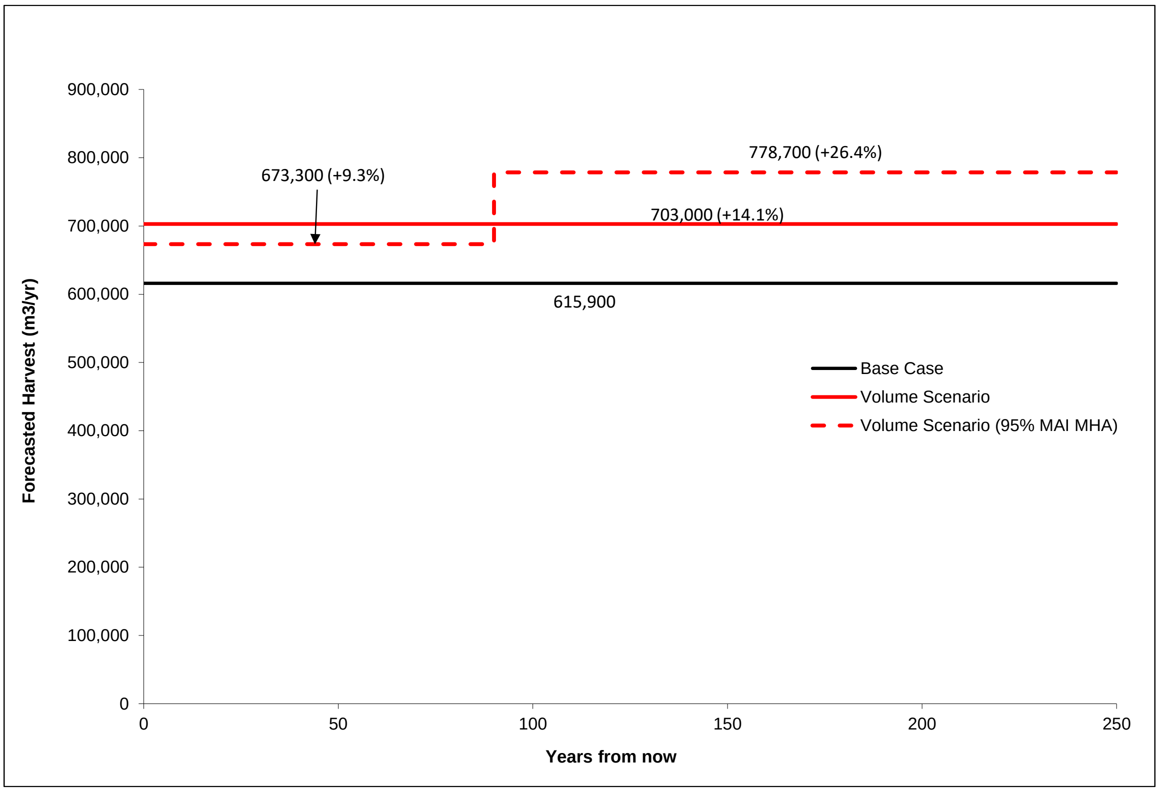

Figure 48: Harvest forecast, volume strategy; TSR minimum harvest criteria and 95% MAI culmination rule

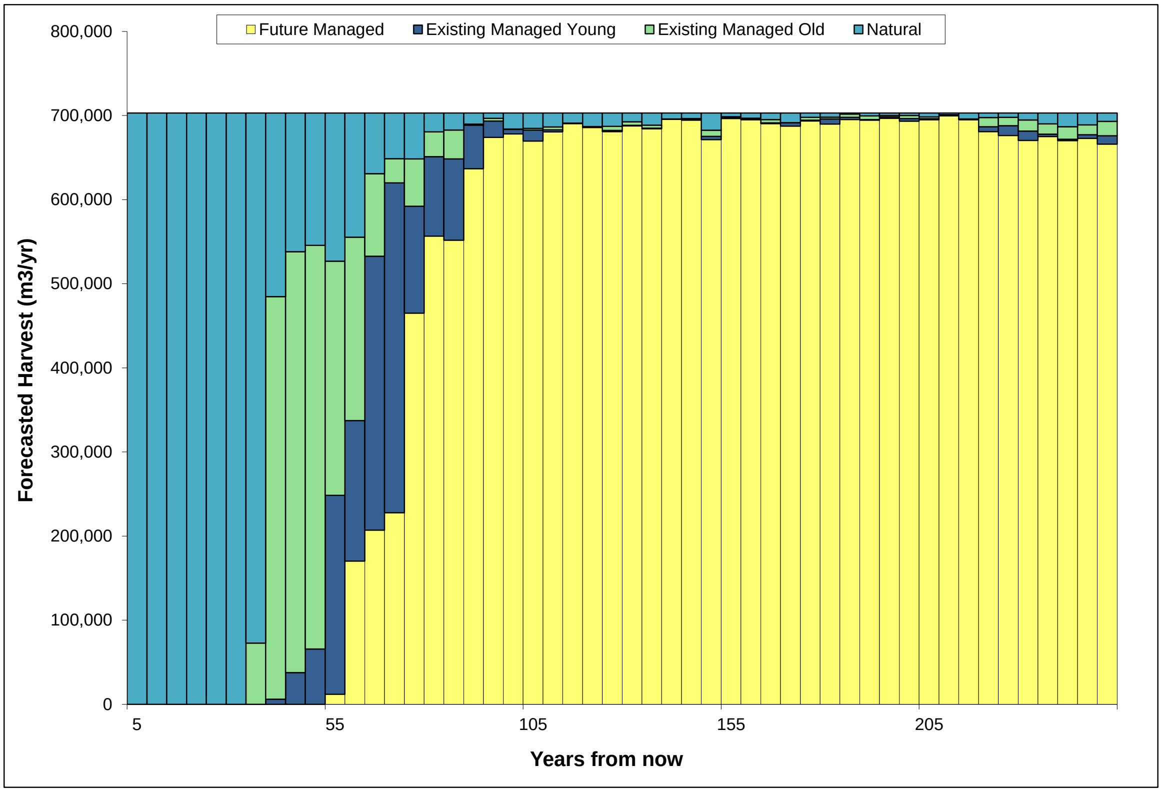

Figure 49: Harvest forecast by yield type, volume strategy; TSR minimum harvest criteria

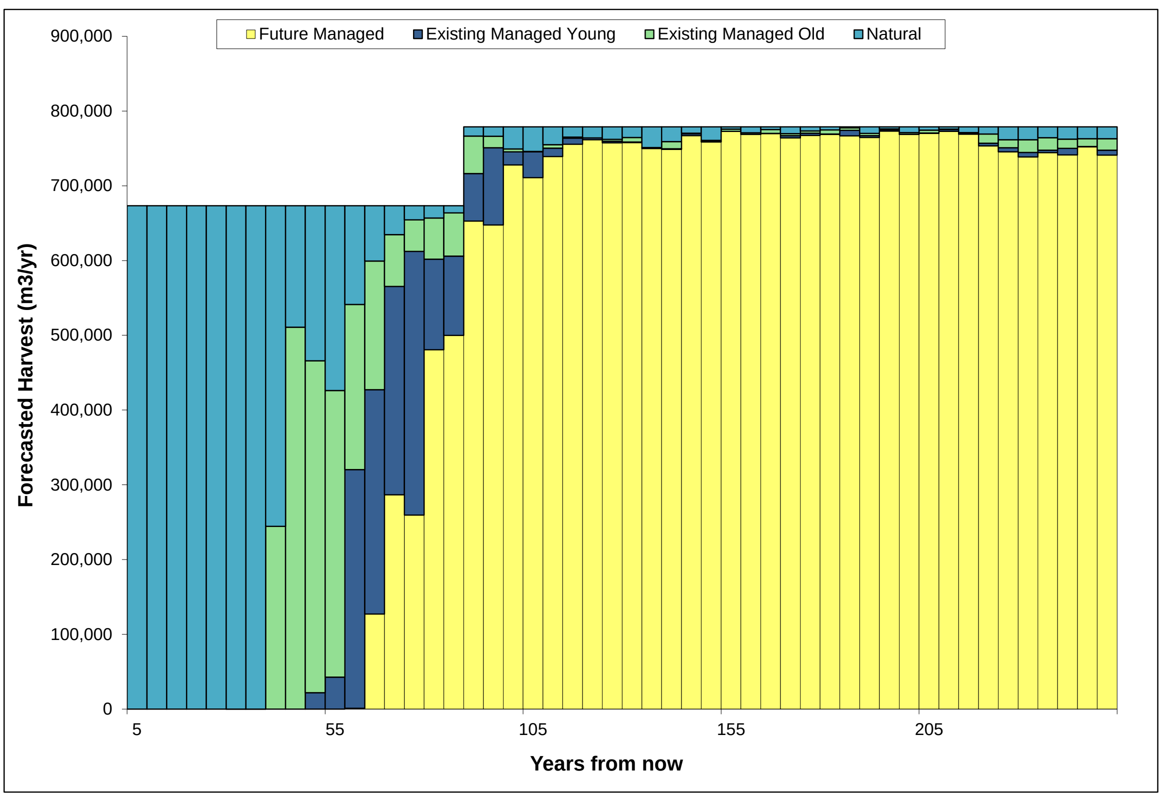

Figure 50: Harvest forecast by yield type, volume strategy; 95% MAI culmination rule

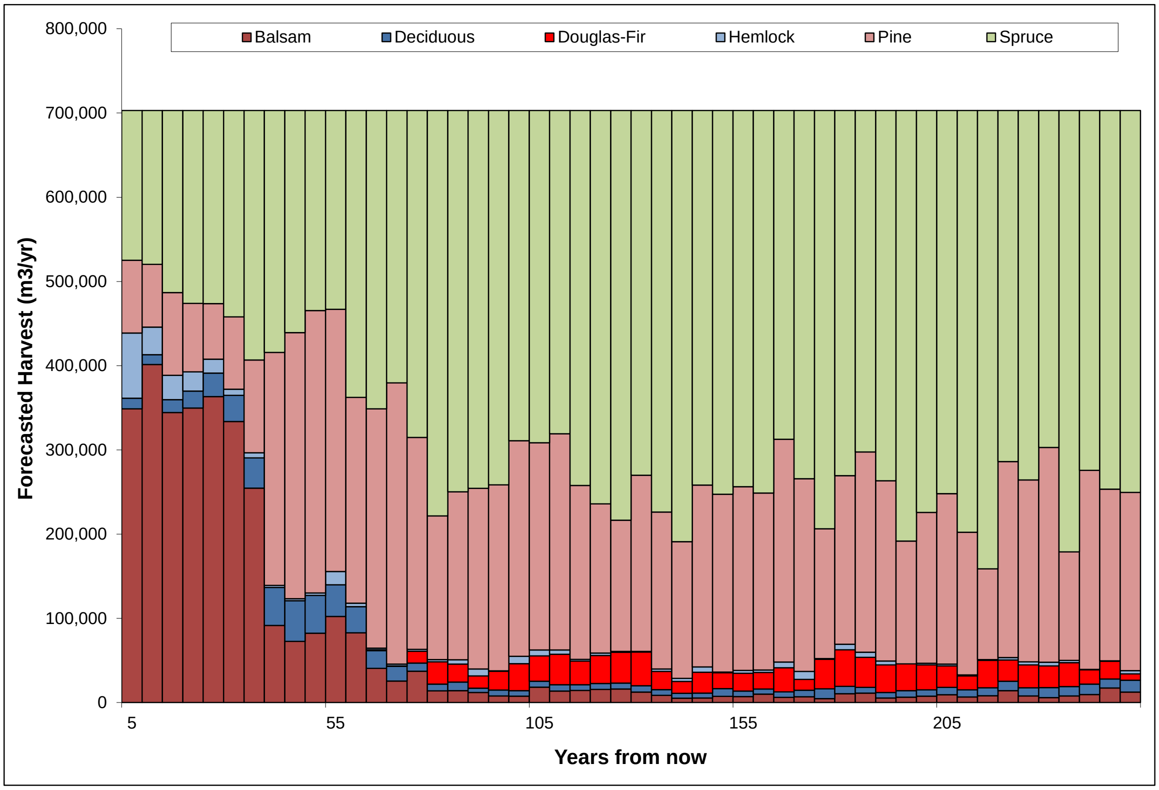

Figure 51: Harvest forecast by species, volume strategy; TSR minimum harvest criteria

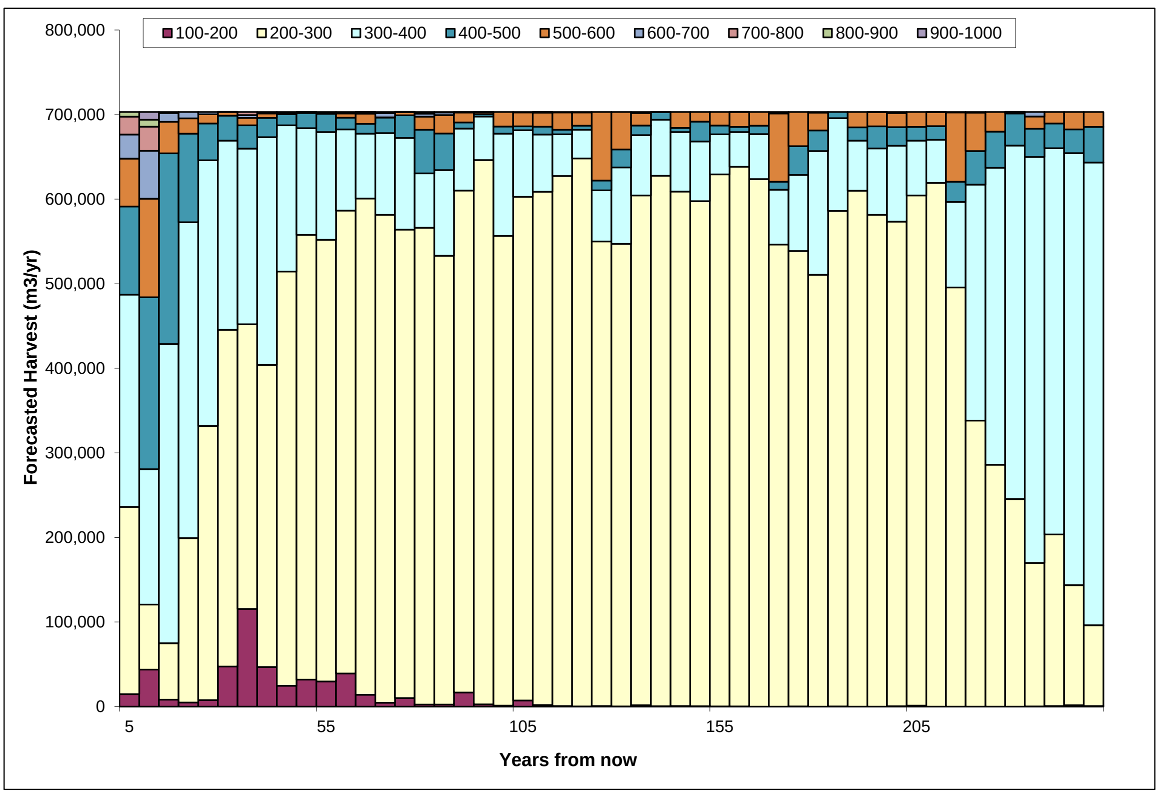

Figure 52: Harvest forecast by vol/ha class, volume strategy; TSR minimum harvest criteria

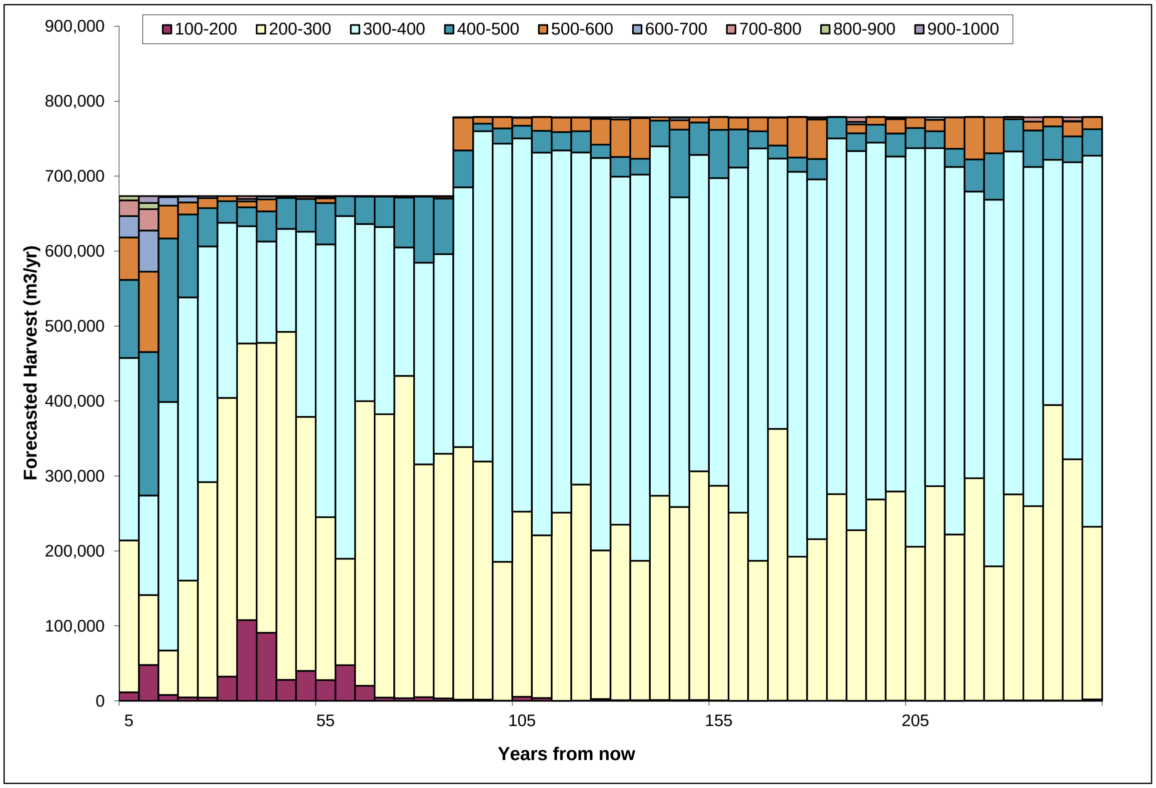

Figure 53: Harvest forecast by vol/ha class, volume strategy; 95% MAI culmination rule

4.4.2.2 Value Scenarios

Figure 54 illustrates a harvest forecast comparison between the ISS Base Case and the two value scenarios where silviculture treatments were incorporated in the analysis. Two different minimum harvest criteria were employed, one using the minimum volume per ha and the other using the age where 95% of the MAI culmination is achieved in combination with the minimum volume per ha criteria.

If the simple minimum harvest volume per ha is used as the minimum harvest criterion, the flat-line harvest forecast can be increased by 13.4%.

Setting the minimum harvest criteria at the age where 95% of the MAI culmination is achieved generally increases the harvest ages modestly and results in less harvest volume in the short and medium terms; the increase compared to the ISS Base Case is 9.0%. However, the harvest is increased significantly at year 91 and remains 23.9% higher than that of the Base Case in the long term.

Favoring spruce and introducing cedar and Douglas-fir, where appropriate, to create value has an impact on the predicted harvest by species. If the value scenarios were to be followed, it is likely that the shares of spruce, cedar and Douglas-fir of the total harvest would increase at the expense of pine and balsam as shown in Figure 55.

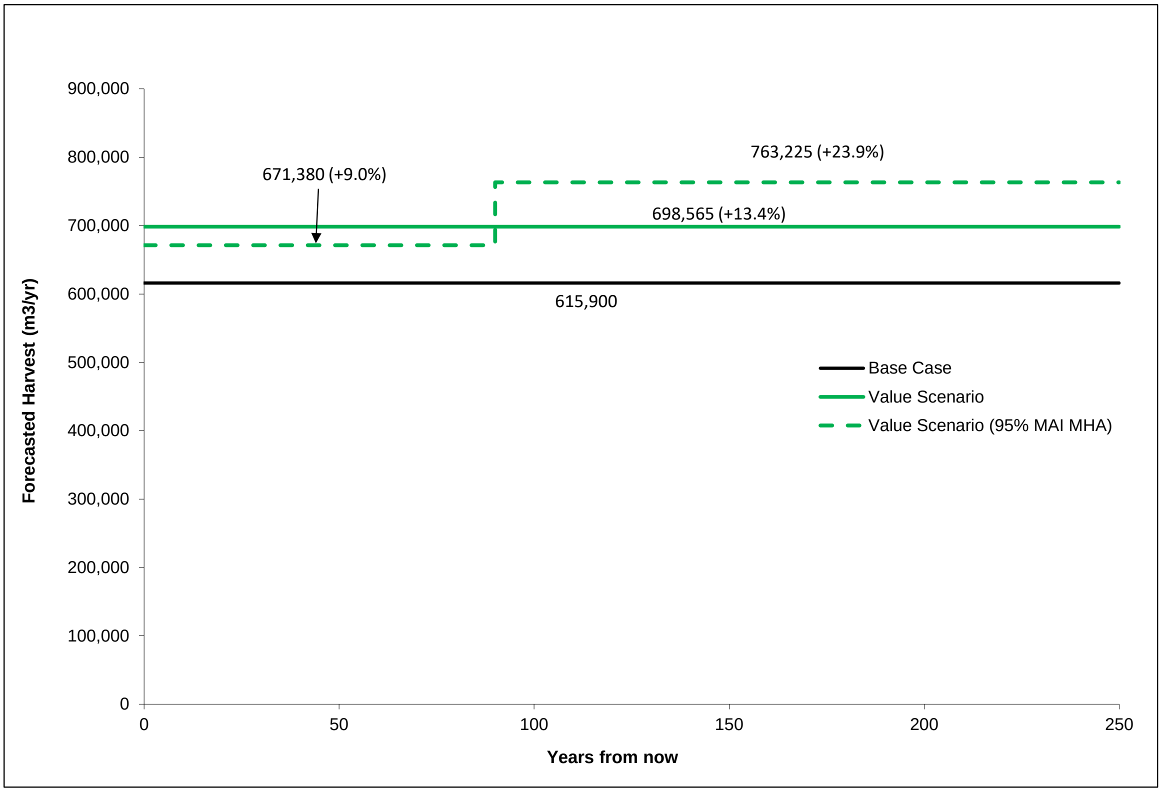

Figure 54: Harvest forecast, value strategy; TSR minimum harvest criteria and 95% MAI culmination rule

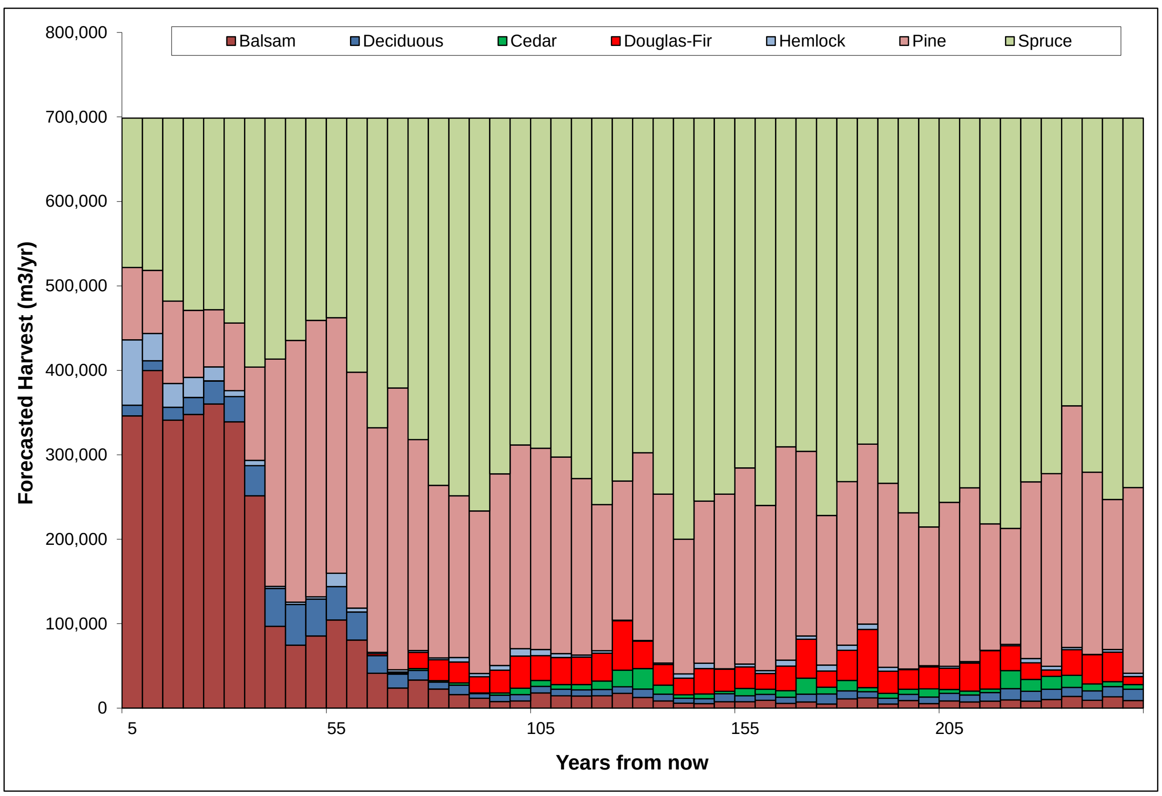

Figure 55: Harvest forecast by species, value strategy; TSR minimum harvest criteria

4.4.3 Habitat and Biodiversity Scenarios

4.4.3.1 Moose Habitat Scenario

This scenario attempted to meet the moose habitat targets in each 4th order watershed. The timber supply or other habitat indicators were not impacted.

Figure 56 depicts the predicted aggregated moose habitat over time in the TSA for the Moose Habitat Scenario, while Figure 57 shows an example of how the moose habitat seral stage targets were met in the Tenas Creek watershed, with 4,560 ha of forested area. As with the ISS Base Case, the mature seral stage targets (for moose) are overachieved at the TSA level as well as in individual watersheds. Early and mid-seral targets are generally underachieved.

The moose habitat targets of 33% mature/old seral (greater than 80 years old), 33% mid seral (41 to 80 years old) and 33% early seral (0 to 40 years old) are difficult to meet for the following reasons:

- Much of moose habitat is outside of the THLB (63%) and cannot be controlled through harvest;
- Seral stage targets by landscape unit and BEC variant in the TSA require that mature and old targets are met. In many cases, the requirement for mature and old seral stages far exceeds the 33% of older stands required for moose habitat.

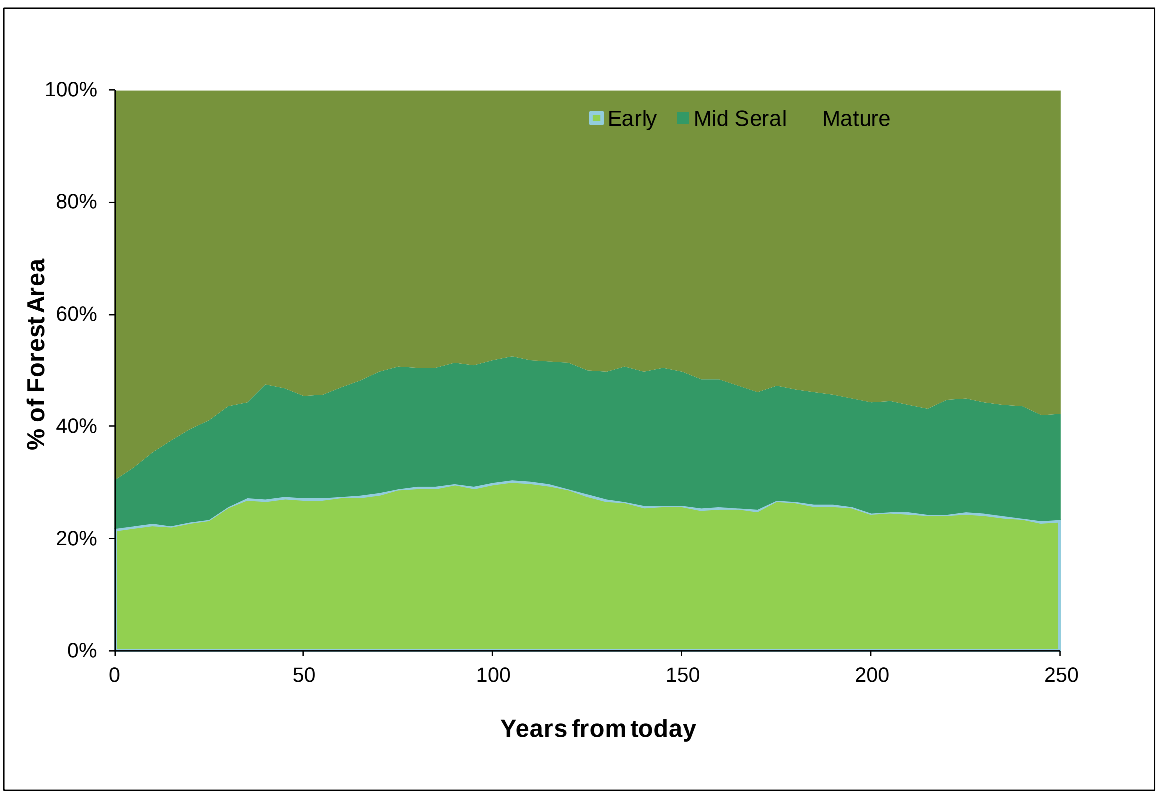

Figure 56: Moose habitat in the CFLB (93,905 ha); Moose Habitat Scenario

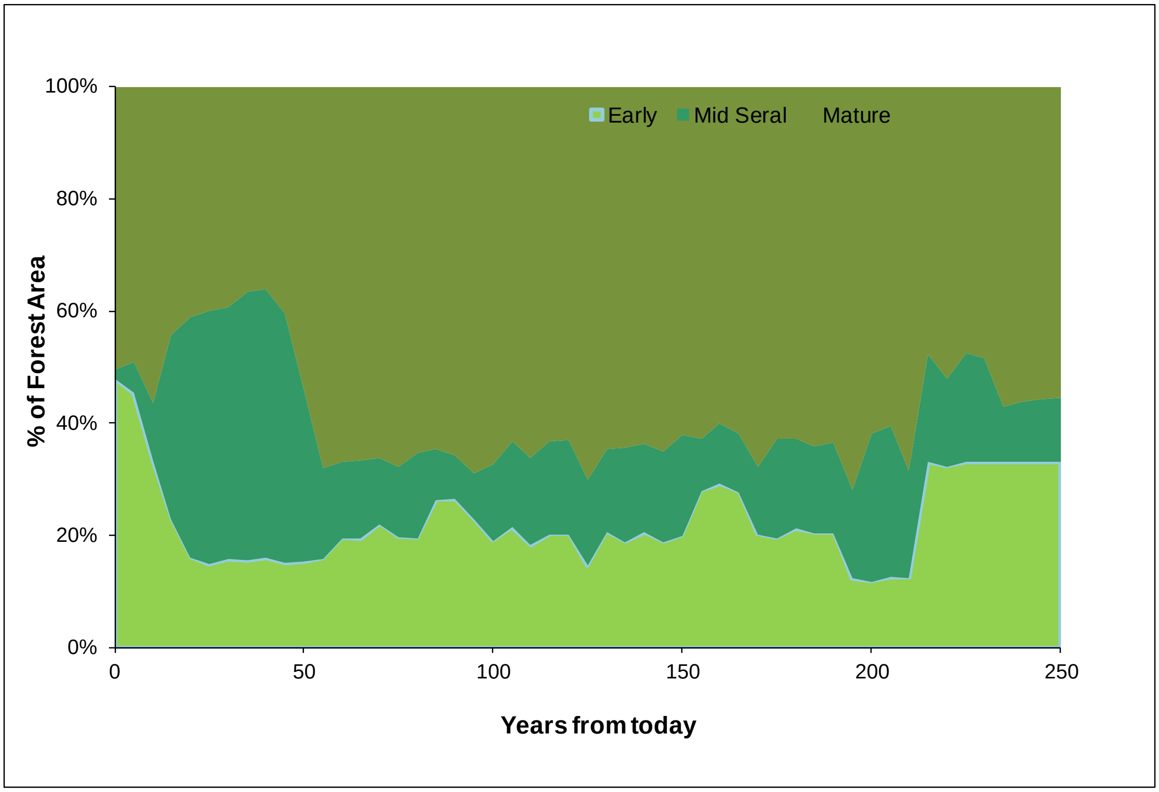

Figure 57: Moose habitat in the CFLB of Tenas Creek (4,560 ha); Moose Habitat Scenario

4.4.3.2 Northern Goshawk (NOGO) Forage Habitat Scenario

The NOGO forage habitat target within each projected territory was set at 60% and enforced in this scenario.

Enforcing the projected forage habitat requirements for NOGO reduced the timber supply by 4.9% (Figure 58). Figure 59 illustrates the achievement of NOGO forage habitat for all projected territories. Figure 60 shows the achievement of NOGO habitat in one projected territory; the forage habitat was not met in the ISS Base Case; however, it is met in this scenario aside from minor shortfalls caused by NHLB succession, as assumed in this analysis.

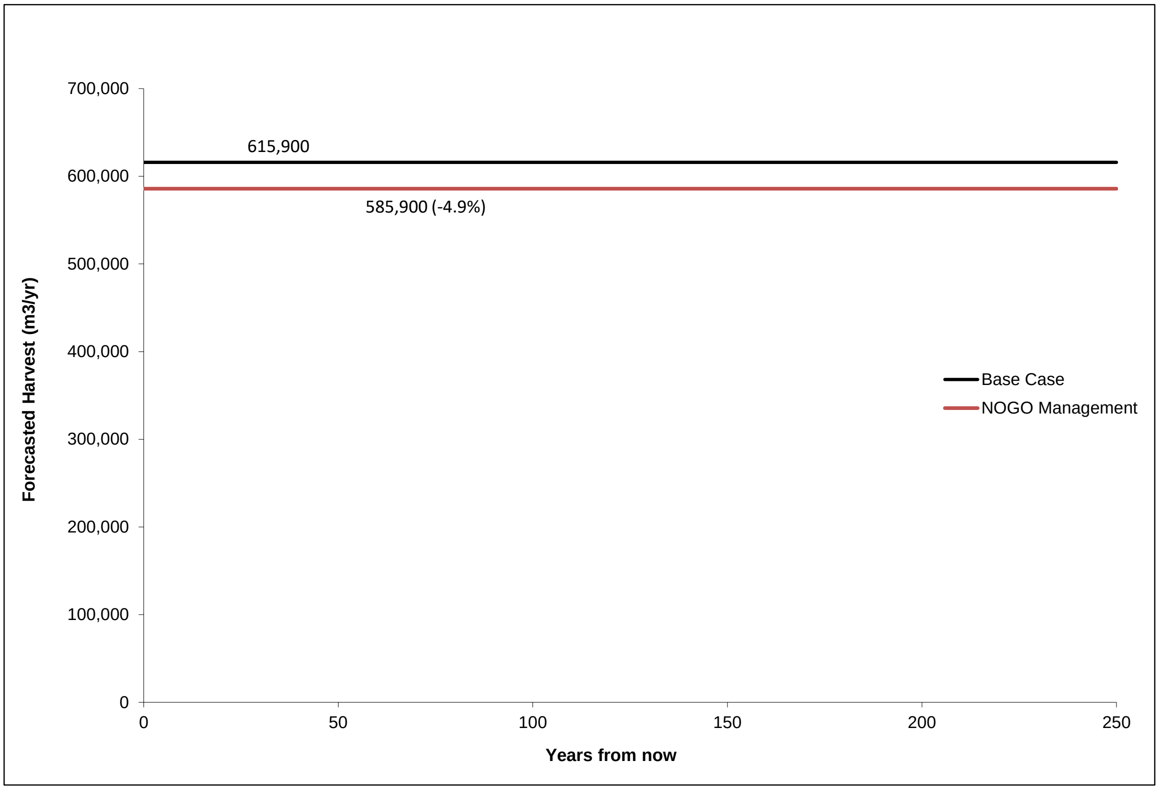

Figure 58: Harvest forecast; enforce NOGO forage habitat targets

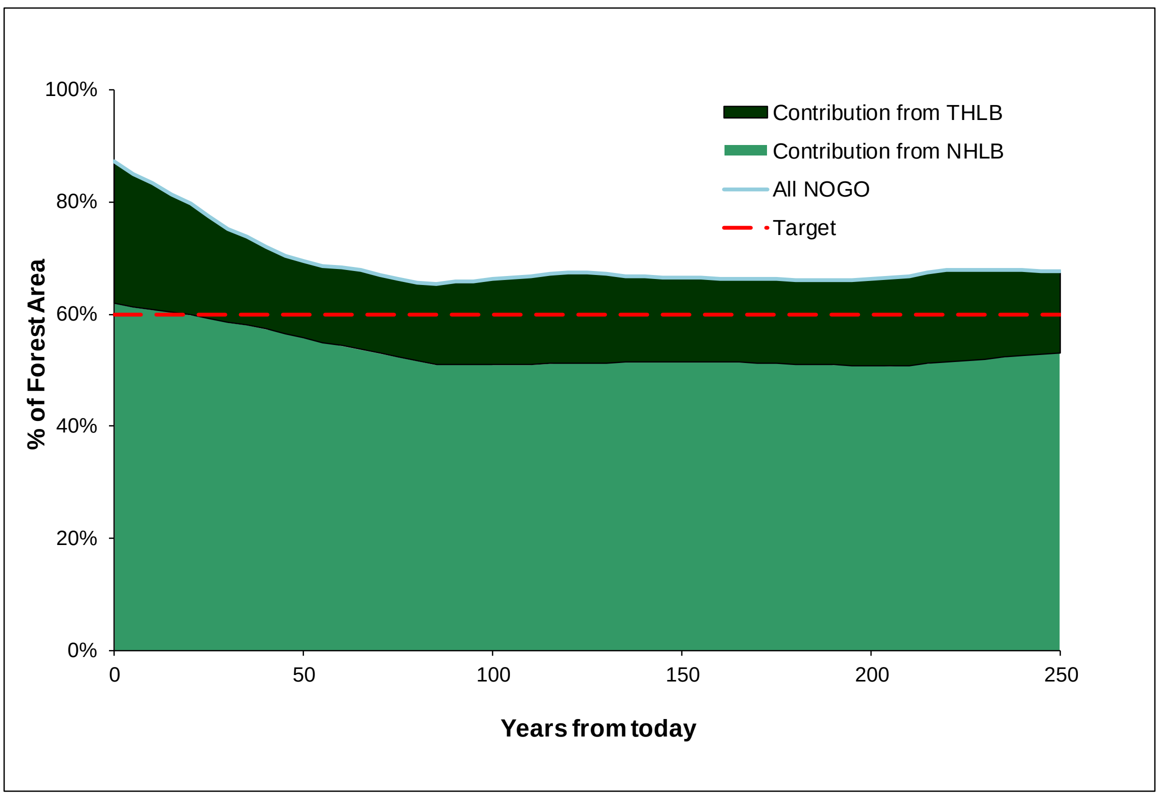

Figure 59: NOGO forage habitat; all projected NOGO territories, NOGO management

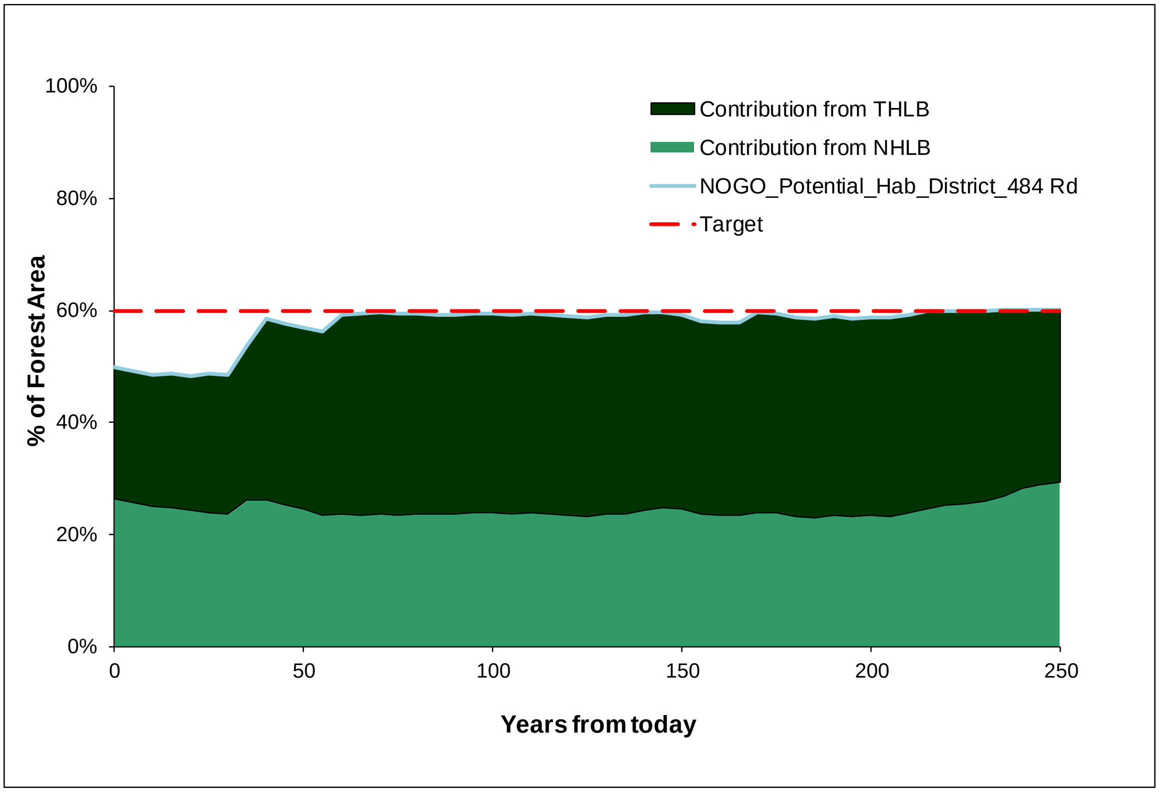

Figure 60: NOGO forage habitat; one projected NOGO territory, NOGO management

4.4.3.3 Watershed Scenario

Two runs were completed:

1. ECA target in each 4th order watershed was set at 20% and enforced.
2. ECA target in each 4th order watershed was set at 30% and enforced.

Setting the ECA target for each 4th order watershed at 20% reduced the timber supply by 0.3% (Figure 61). In the ISS Base Case, ECA targets were exceeded in some watersheds; however, enforcing the ECA constraint ensured that ECA targets were met in all watersheds.

Setting the ECA target at 30% for each 4th order watershed had no impact on timber supply.

Figure 62 shows the predicted ECA for one 4th order watershed (Coffin), where the maximum 20% ECA target is met, but was not met in the ISS Base Case.

Figure 63 illustrates the aggregated ECA value for all watersheds.

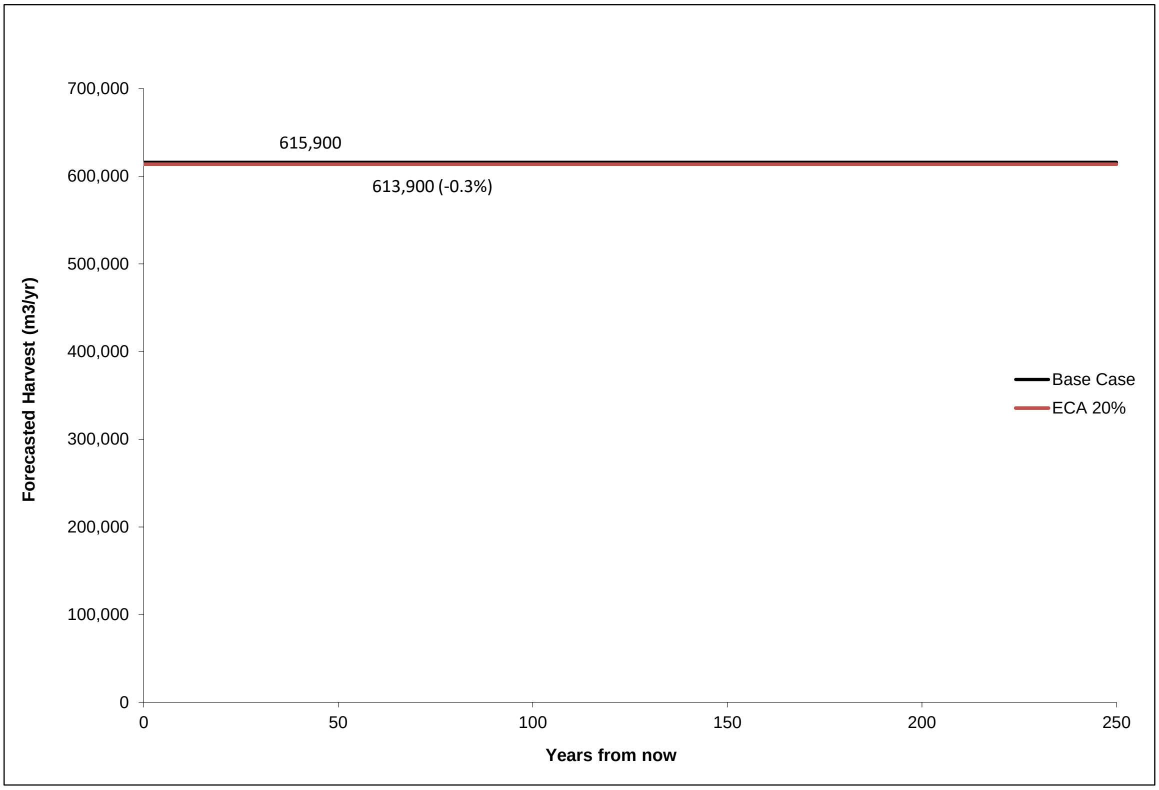

Figure 61: Harvest forecast; ECA target 20% for each 4th order watershed

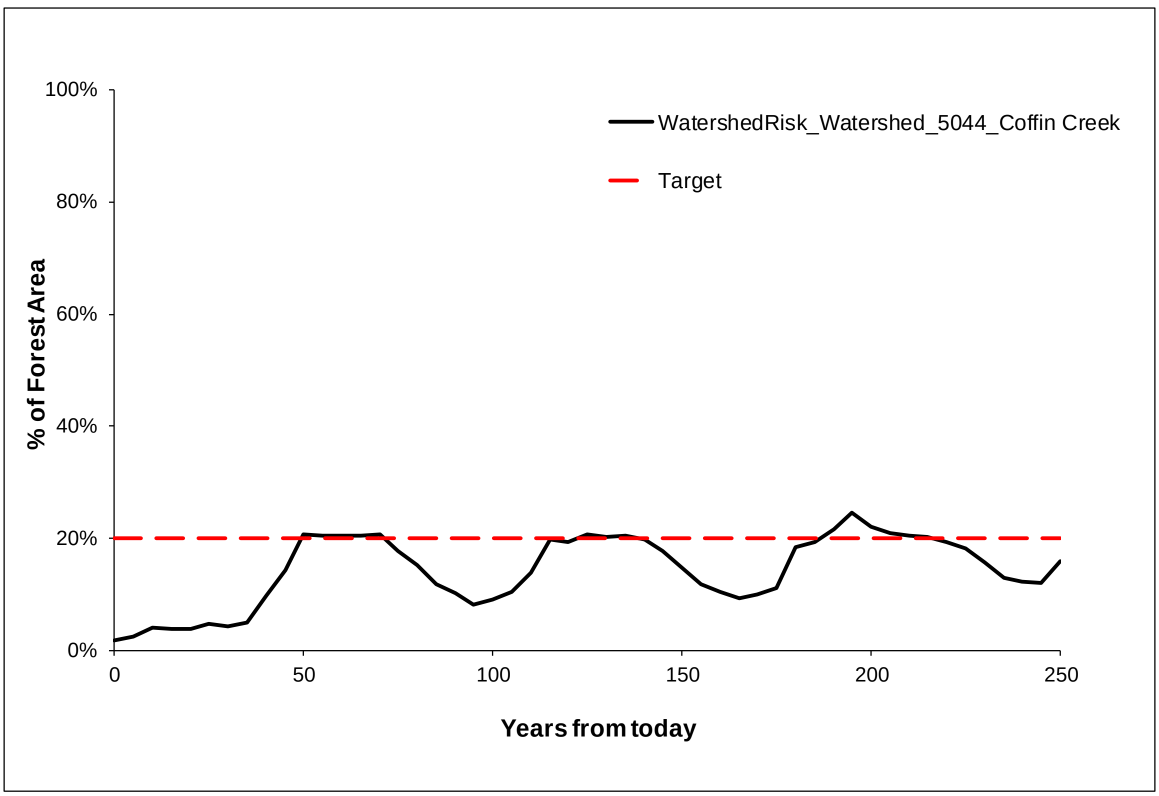

Figure 62: ECA in one 4th order watershed (Coffin); ECA target 20% for each 4th order watershed

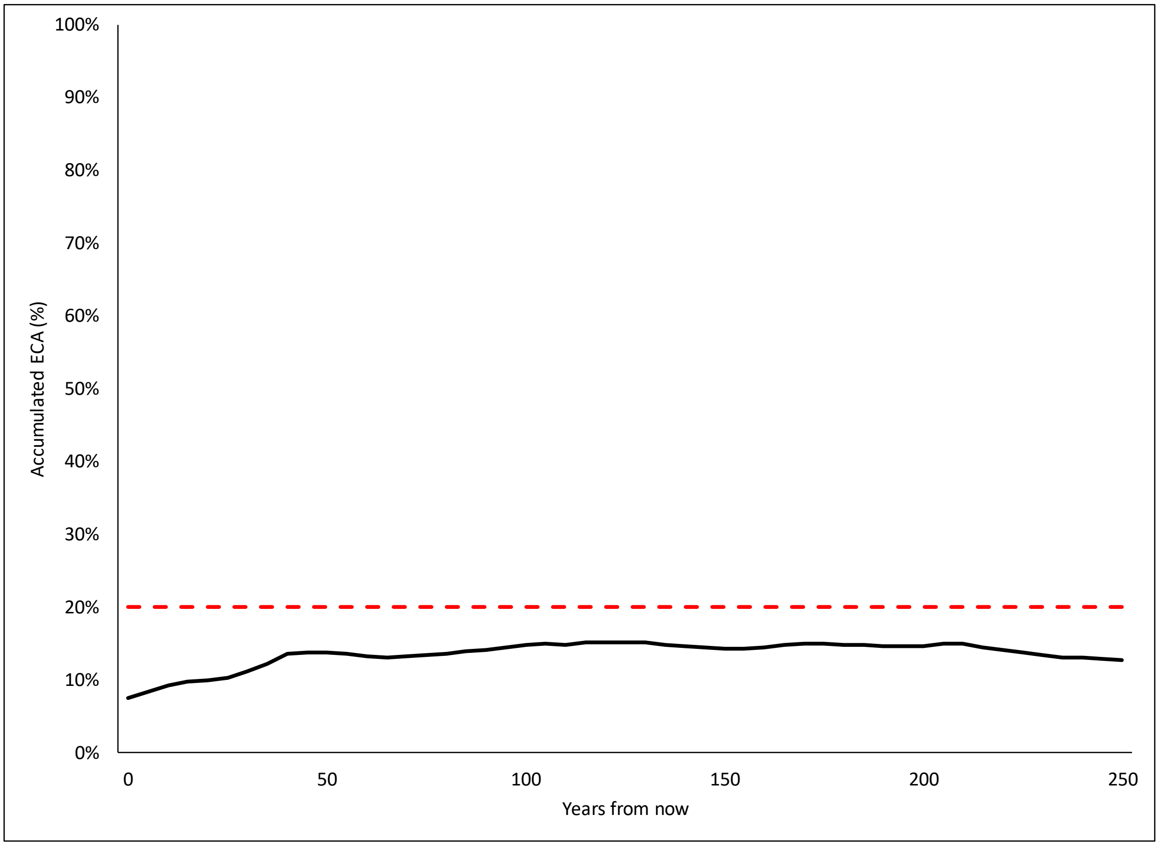

Figure 63: Forecast of aggregated ECAs in the Bulkley TSA; target 20% ECA

4.4.3.4 Woodland Caribou Scenario

The caribou habitat target was set at 90% of the forested area >140 years within the critical Woodland Caribou habitat as per the Federal Caribou Recovery Strategy. Enforcing this target reduced the ISS Base Case timber supply forecast by 7.5% as illustrated in Figure 64.

As shown in Figure 65, the Caribou habitat target is never met throughout the planning horizon. It reaches its peak of 79% at year 120, then declines but remains just above 75%. The habitat target in the model is not met because of the natural disturbance assumptions incorporated in the analysis. Natural disturbance reduces the NHLB habitat area and there is not enough THLB to make up the difference.

An additional analysis run was constructed to test the impact of turning off natural disturbance assumptions in the forest estate model. Excluding natural disturbance allowed the Caribou habitat target to be met in 115 years (Figure 66). While less THLB was reserved for Caribou habitat (Figure 66), the harvest forecast could not be increased.

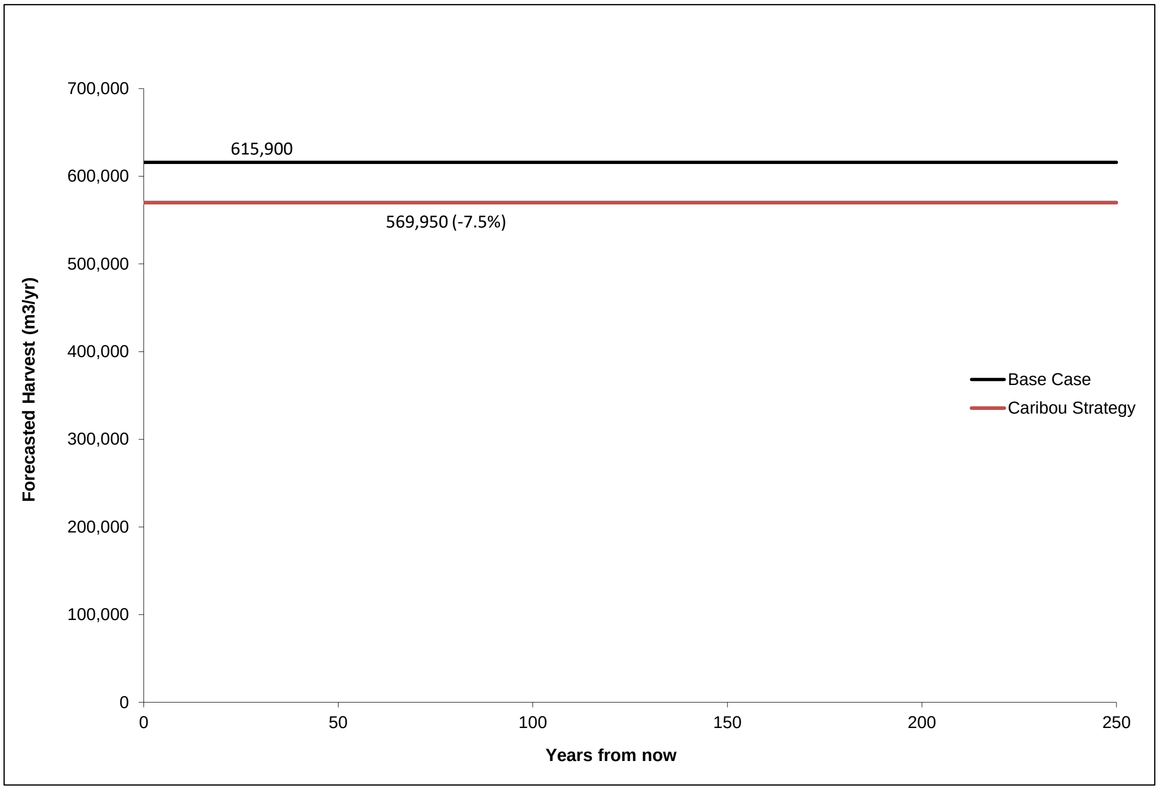

Figure 64: Harvest forecast; enforce Federal Caribou Recovery Strategy

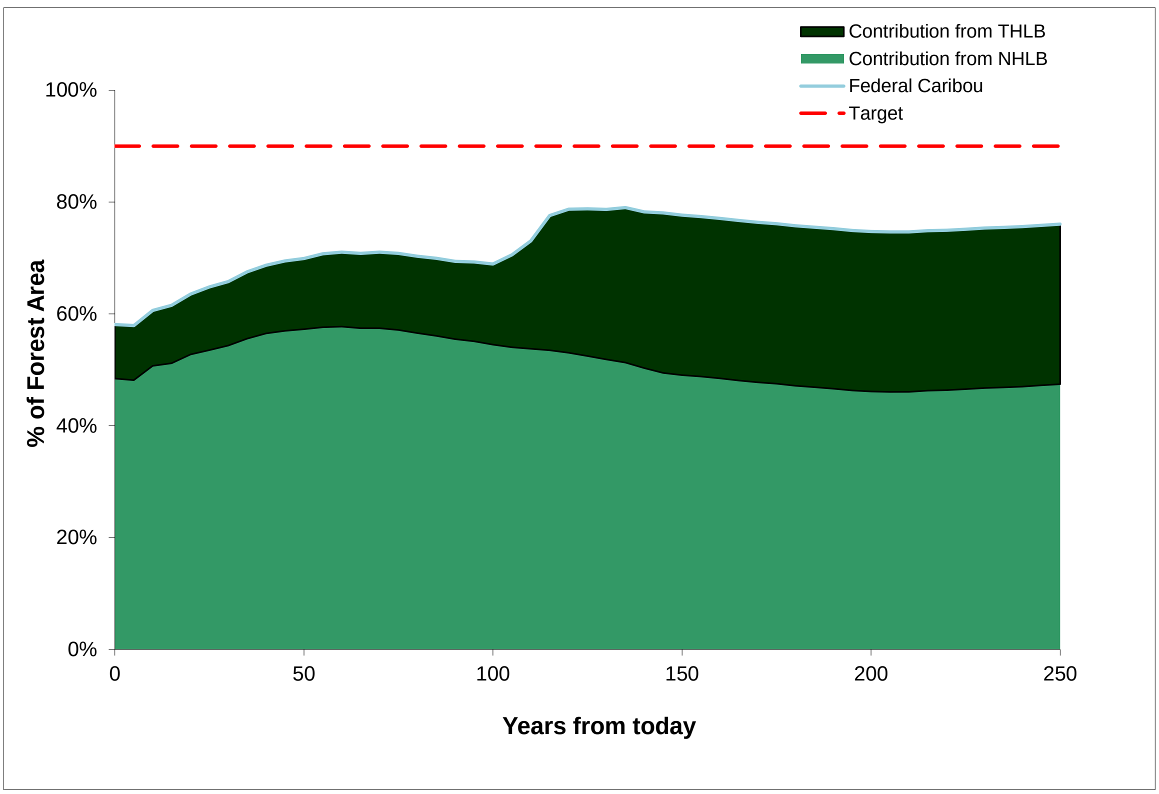

Figure 65: Caribou habitat; enforce Federal Caribou Recovery Strategy

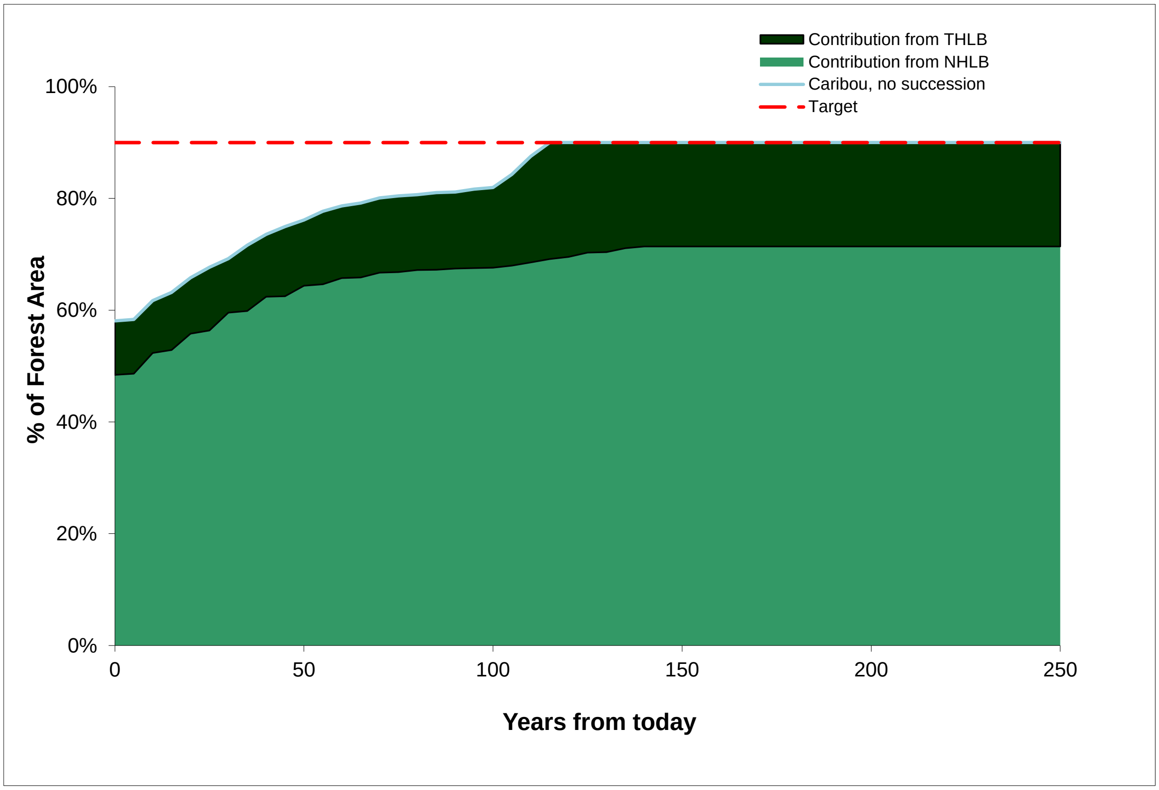

Figure 66: Caribou habitat; enforce Federal Caribou Recovery Strategy, no natural disturbance

4.4.3.5 Coarse Filter Biodiversity Scenario

In this scenario the core area and landscape corridor seral stage targets were maintained as in the base case; however, rather than following the LRMP direction, the Biodiversity Guidebook (Ministry of Forests, 1995) targets for early seral (max), mature plus old (min) and old (min) were used for all the other NDT/LU/BEC variant combinations.

Applying the Biodiversity Guidebook targets had no impact on timber supply.

4.4.3.6 Combined Wildlife Habitat Scenario

This scenario added the following to the ISS Base Case assumptions:

<u>Grizzly Bear</u>

Enforce max 30 % mid seral target by NDT/LU/BEC.

<u>NOGO</u>

Enforce the NOGO 60% suitable forage area target for each projected territory.

<u>Moose</u>

Moose objectives stem from wetlands and the forest area around them. The objective is to maintain a 100 m buffer of mature forest (>80 years) around wetlands and apply an additional 100 m buffer within which reduced stocking standards are used after harvesting.

All wetlands with mature forest around them were buffered by 100 m and this buffer was removed from the THLB. It was further assumed that outside the 100 m buffer, up to 200 m in distance, the harvested areas would be reforested using a reduced stocking standard. The reduced stocking standard was assumed to decrease future yields by 50%. The buffers reduced the size of the THLB by 4%.

Figure 67 illustrates the harvest forecast for the Combined Wildlife Scenario. The timber supply is predicted to be 12% less than that of the ISS Base Case at 542,050 m^3 per year during the first 85 years of the planning horizon. At year 86 the forecast is increased slightly to 546,200 m^3 per year.

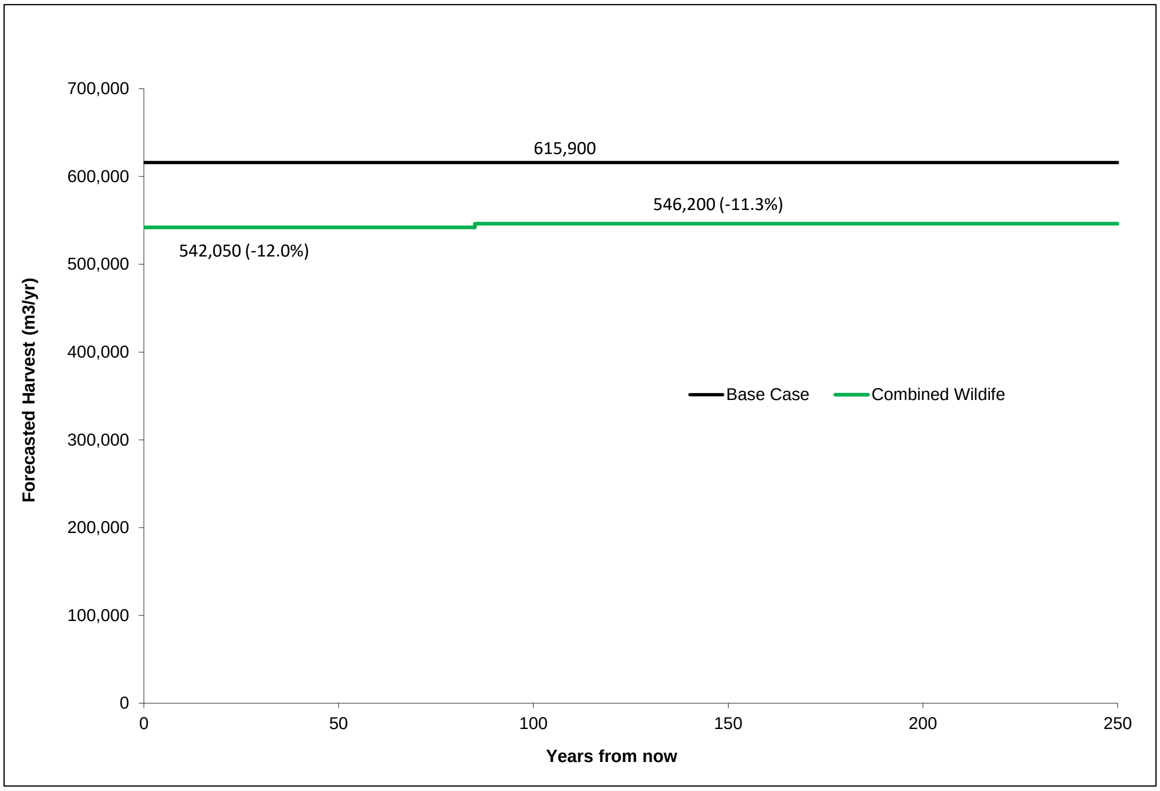

Figure 67: Harvest forecast; combined wildlife scenario

4.4.4 Timber Value over Time

4.4.4.1 Volume Scenarios

Figure 68 illustrates the total predicted harvested timber value comparison for managed stands (note that value was not tracked for natural stands) between the ISS Base Case and the two volume scenarios with two different minimum harvest criteria, one using the minimum volume per ha and the other using the age where 95% of the MAI culmination is achieved. The harvest of managed stands is not predicted to be significant until around year 40. This is also reflected in the total value, which starts accumulating at the same time. A good point for comparing total values between the scenarios is after 80 years, at which point the harvest becomes dominated by future managed stands, many of them reforested with higher densities. Note that the slight increase in harvest ages for the 95% of the MAI culmination scenario versus the Base Case minimum harvest criteria, lead to higher timber value over the longer term. This is because larger logs with good quality are assumed to be worth more than smaller logs of the same quality.

The same trend can be seen in Figure 69 depicting the predicted value per ha of managed stands.

Figure 70 and Figure 71 show the annual treatment areas and budgets by treatment type for the volume scenario where the simple minimum harvest volume per ha is used as the minimum harvest criterion. The trends and expenditures are similar, if the 95% of the MAI culmination rule is enforced (not shown). The initial treatment areas and costs are modest, consisting only of the treatment of existing managed stands. In the course of time the annual area treated increases from less than 1,000 ha to 6,000 ha

In the short term, the predicted fertilization costs are approximately $300,000 annually. As with the treatment area, the expenditures increase and reach over $3 million annually.

Note that the predicted long-term treatment areas and associated costs were not considered reasonable. Rather, the scenarios (volume and value) as tested are intended as bookend scenarios.

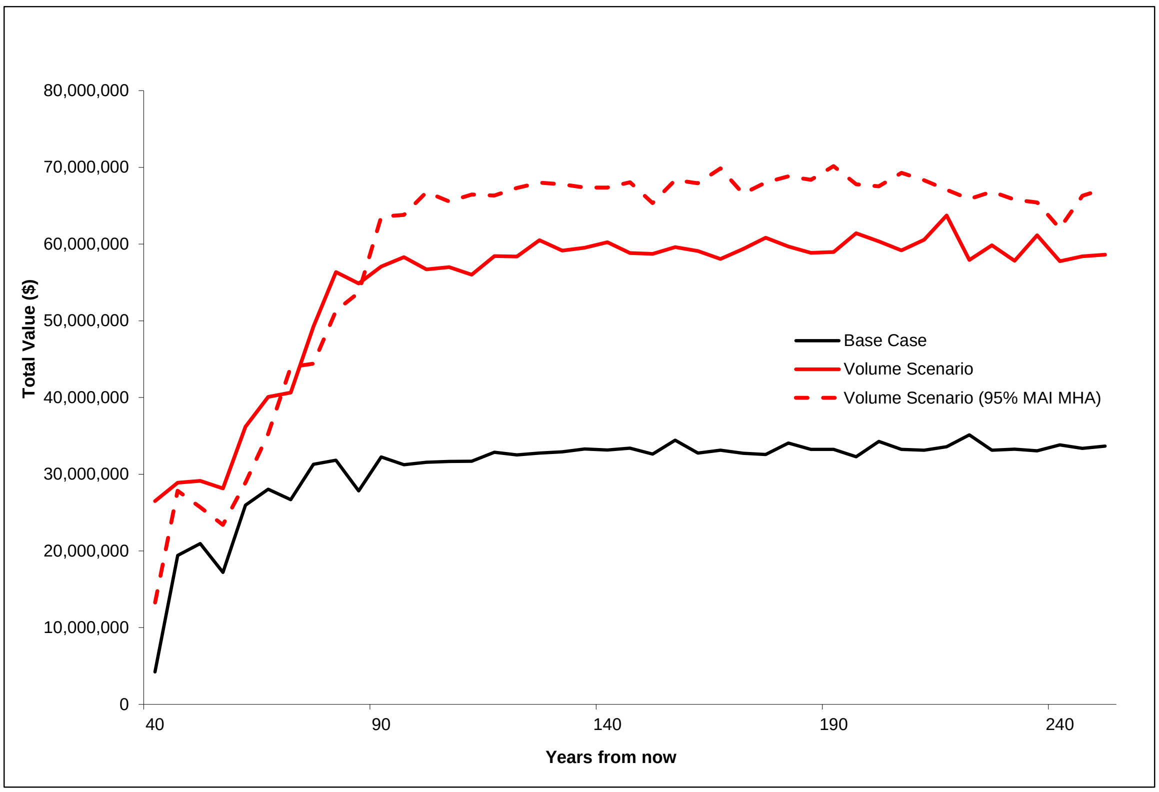

Figure 68: Total value forecast (managed stands); TSR minimum harvest criteria and 95% MAI culmination rule, volume strategy

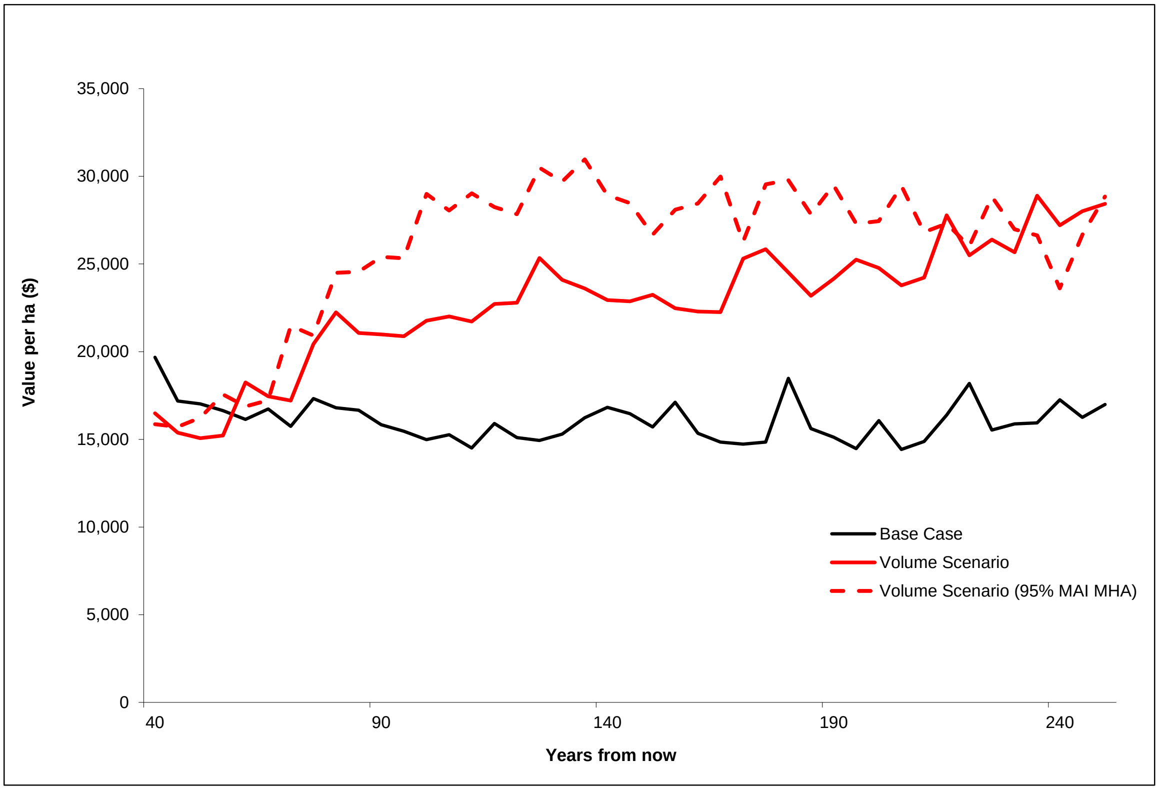

Figure 69: Value per ha forecast (managed stands); TSR minimum harvest criteria and 95% MAI culmination rule, volume strategy

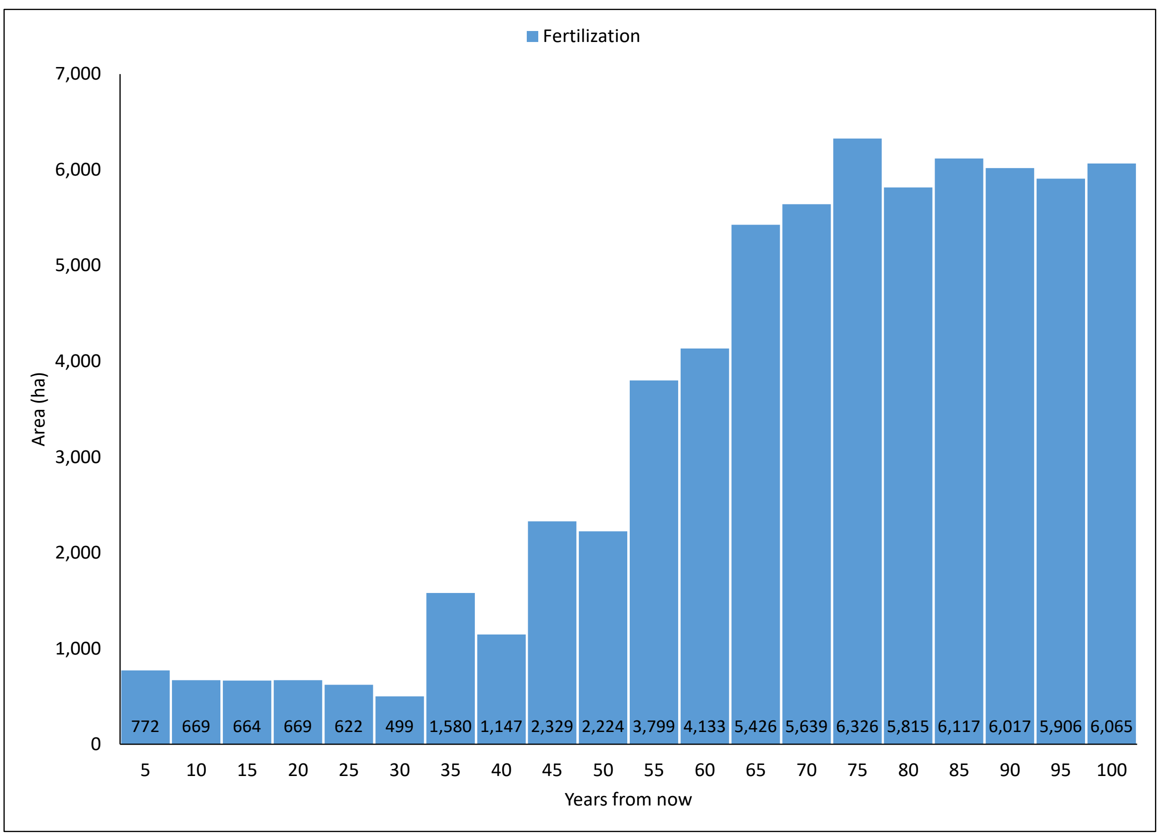

Figure 70: Treated area over time; volume strategy, TSR minimum harvest criteria

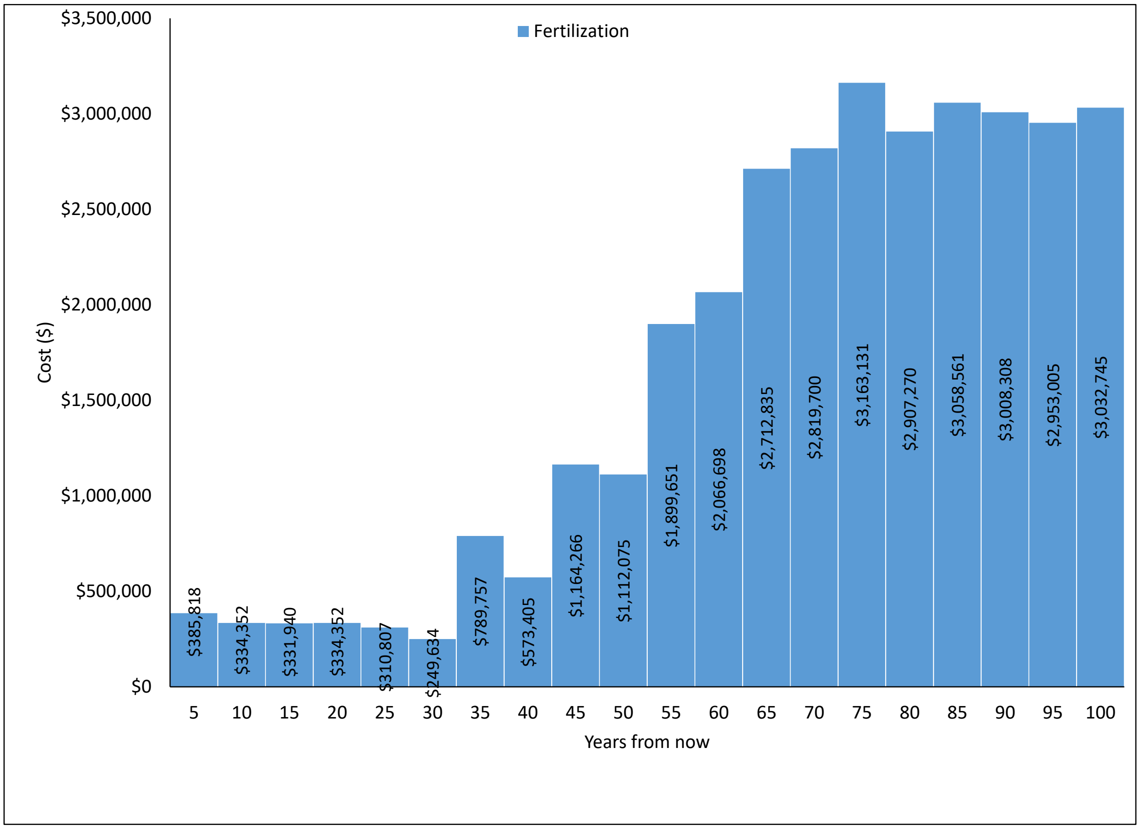

Figure 71: Treatment costs over time; volume strategy, TSR minimum harvest criteria

4.4.4.2 Value Scenarios

Figure 72 illustrates the total predicted harvested timber value comparison for managed stands between the ISS Base Case and the two value scenarios with two different minimum harvest criteria, one using the minimum volume per ha and the other using the age where 95% of the MAI culmination is achieved. The harvest of managed stands is not predicted to be significant until around year 35. This is also reflected in the total value, which starts accumulating at the same time. In the long run both value scenarios are predicted to provide more total value than either of the volume scenarios due to the species portfolio and the predicted differences in value between the species. As previously noted, the slight increase in harvest ages due to the 95% of the MAI culmination rule versus the Base Case minimum harvest criteria leads to higher timber value over the longer term.

The same trend can be seen in Figure 73 depicting the predicted value per ha of managed stands.

Figure 74 and Figure 75 the annual treatment areas and budgets by treatment type for the value scenario where the simple minimum harvest volume per ha is used as the minimum harvest criterion. The initial treatment areas and costs are modest, consisting only of the fertilization of existing managed stands similar to the volume scenarios. In the course of time, a modest amount of juvenile spacing occurs in the cedar leading stands.

In the short term the predicted fertilization costs are the same as in the volume scenarios, around $300,000 annually. If the 95% of the MAI culmination rule is enforced, the treatments areas and costs remain similar (not shown). Additional planting costs are the costs of planting higher densities on selected sites.

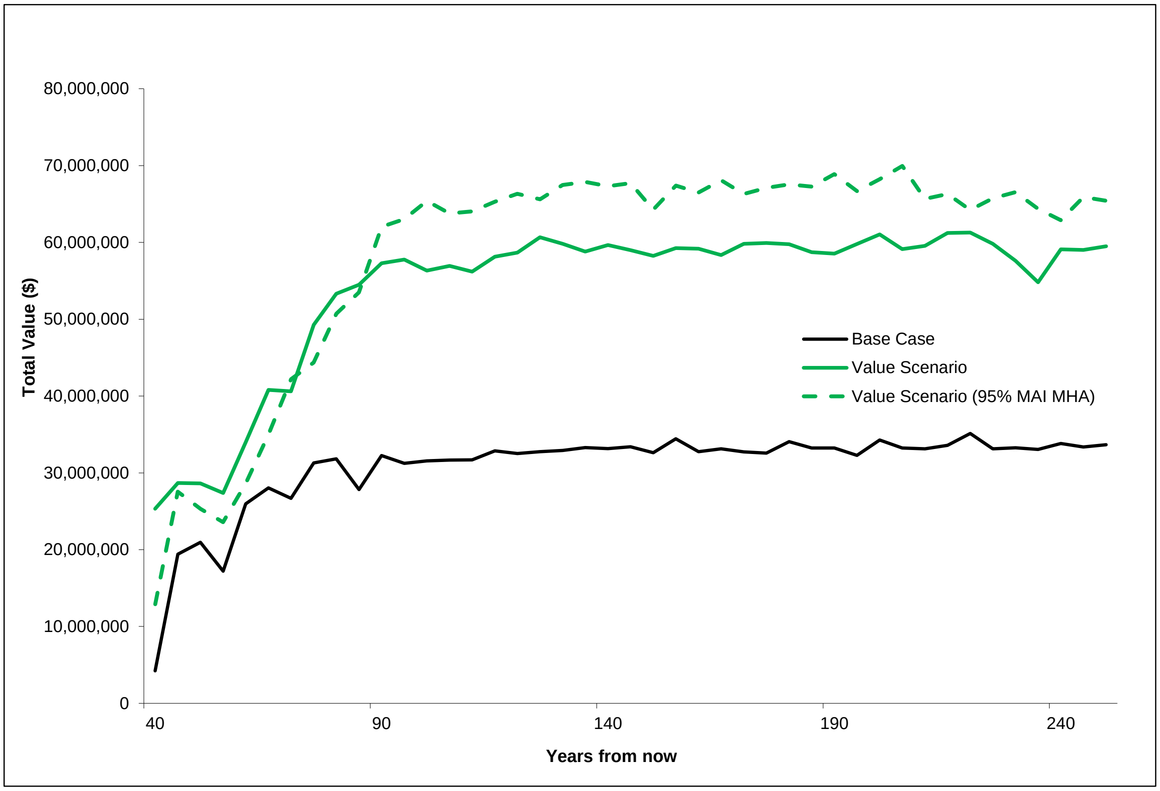

Figure 72: Total value forecast (managed stands); TSR minimum harvest criteria and 95% MAI culmination rule, value strategy

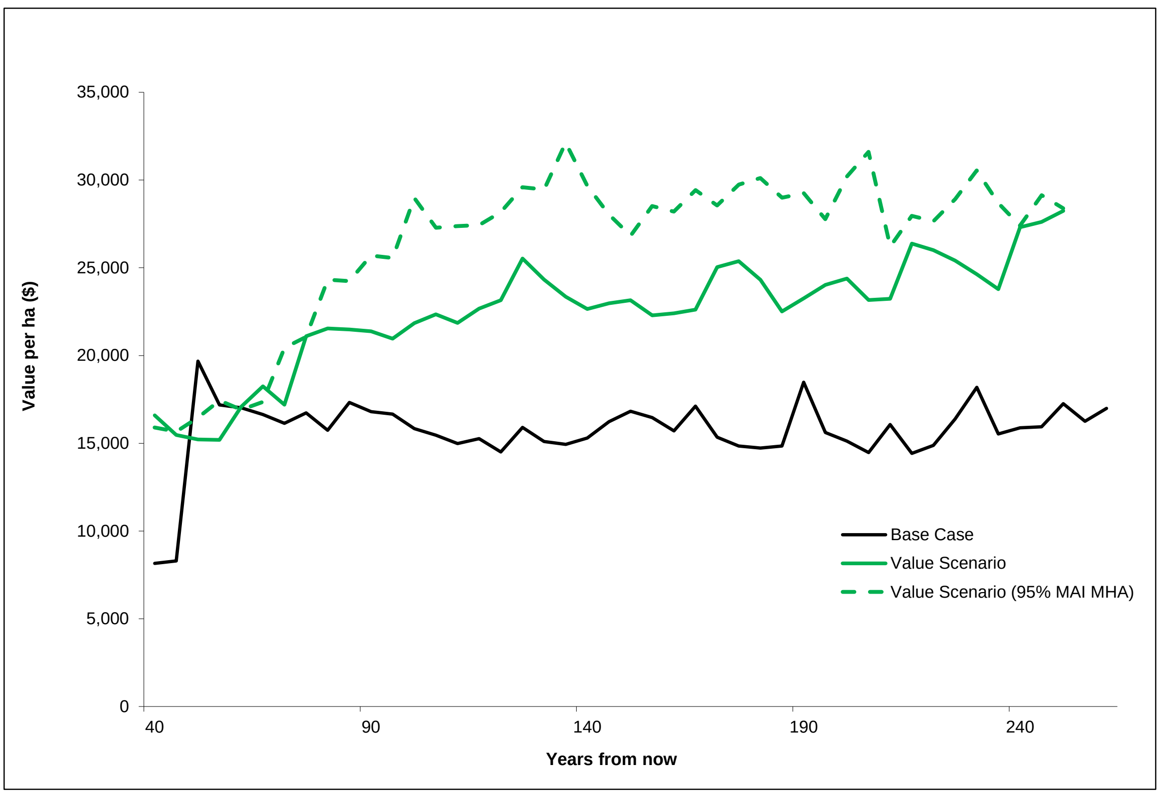

Figure 73: Value per ha forecast (managed stands); TSR minimum harvest criteria and 95% MAI culmination rule, value strategy

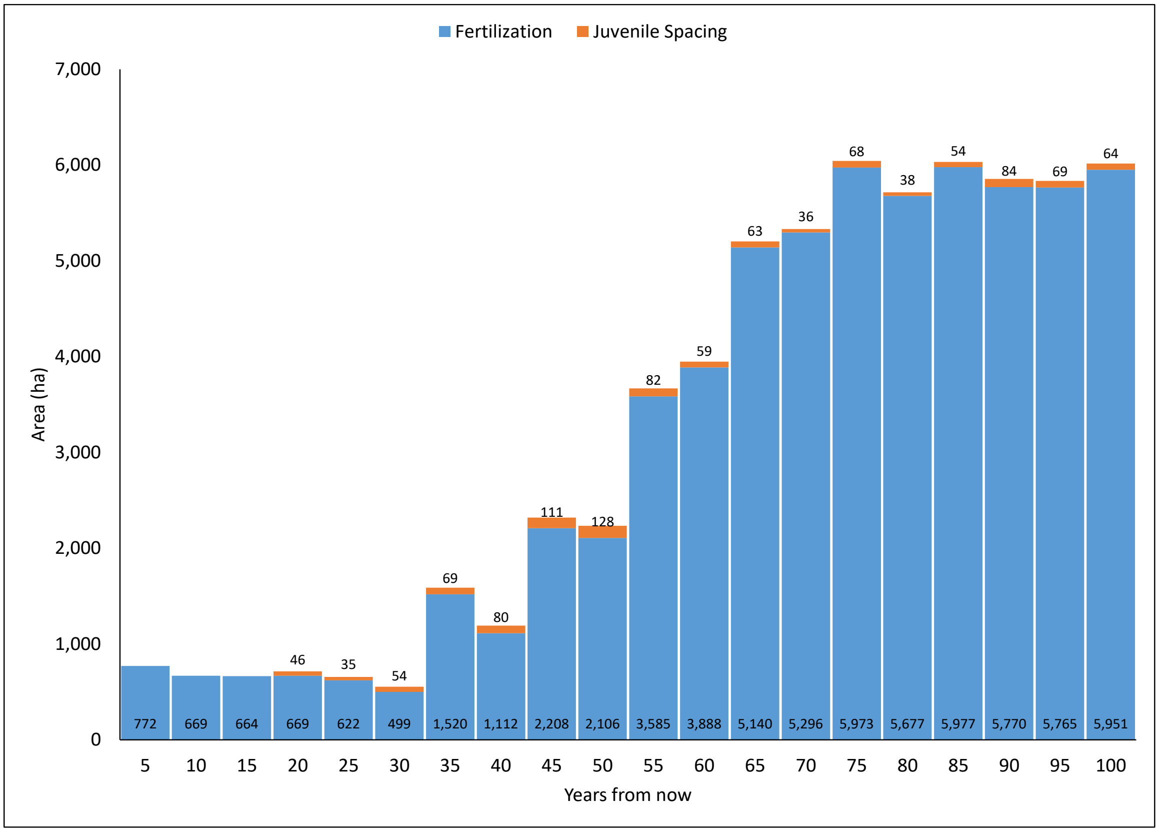

Figure 74: Treated area over time; value strategy, TSR minimum harvest criteria

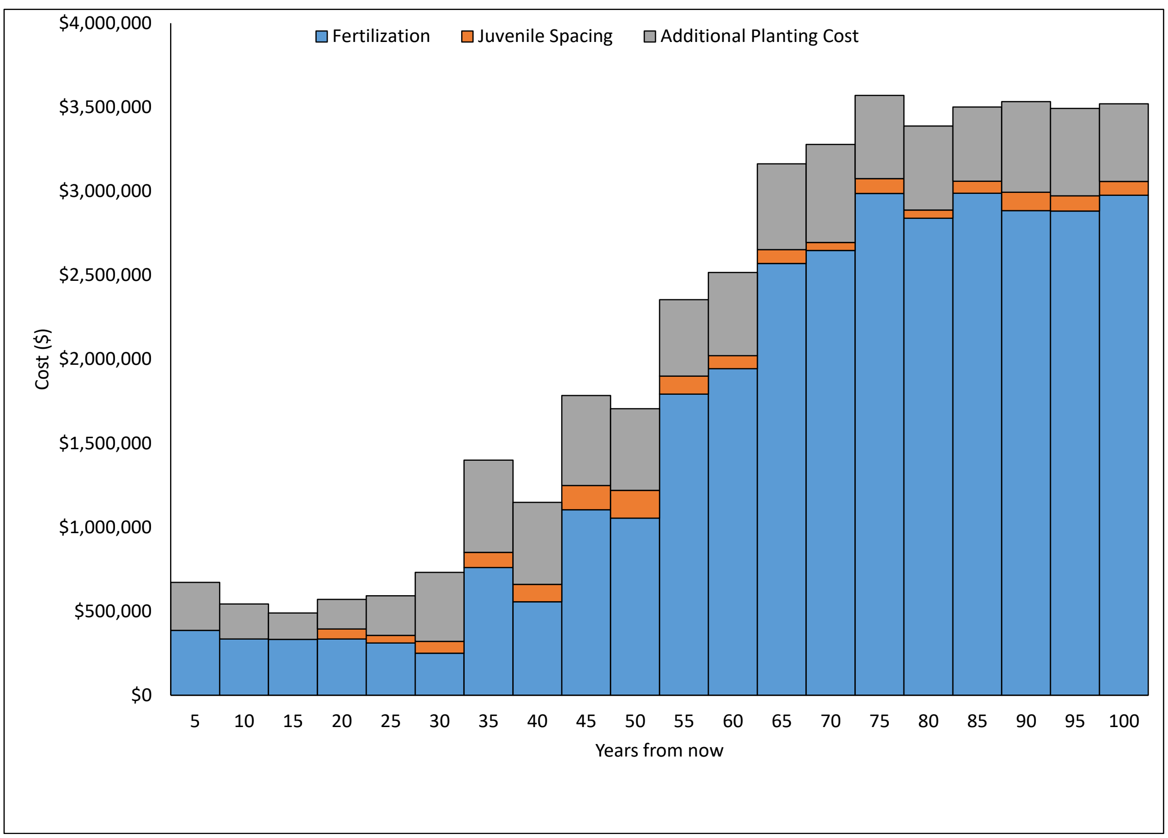

Figure 75: Treatment costs over time; value strategy, TSR minimum harvest criteria

4.4.4.3 Habitat and Biodiversity Scenarios

Figure 76 illustrates the total predicted harvested timber value comparison for managed stands between the ISS Base Case and selected habitat and biodiversity scenarios. As noted previously in this document, the harvest of managed stands is not predicted to be significant until around year 40. The total value of managed stands starts accumulating at the same time. While there are differences in the predicted total value of managed stands among the habitat and biodiversity scenarios, the differences are small and no trends are obvious. The same can be seen in Figure 77 depicting the predicted value per ha of managed stands for all habitat and biodiversity scenarios.

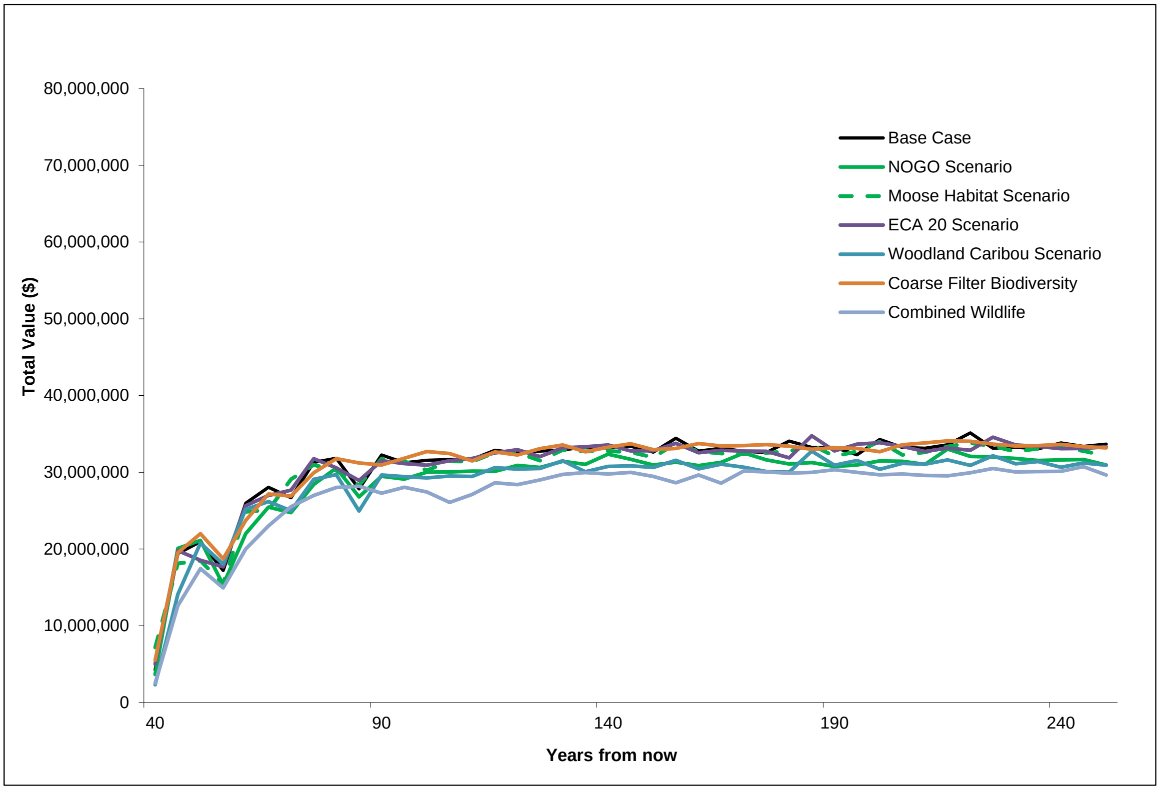

Figure 76: Total value forecast (managed stands); habitat and biodiversity scenarios

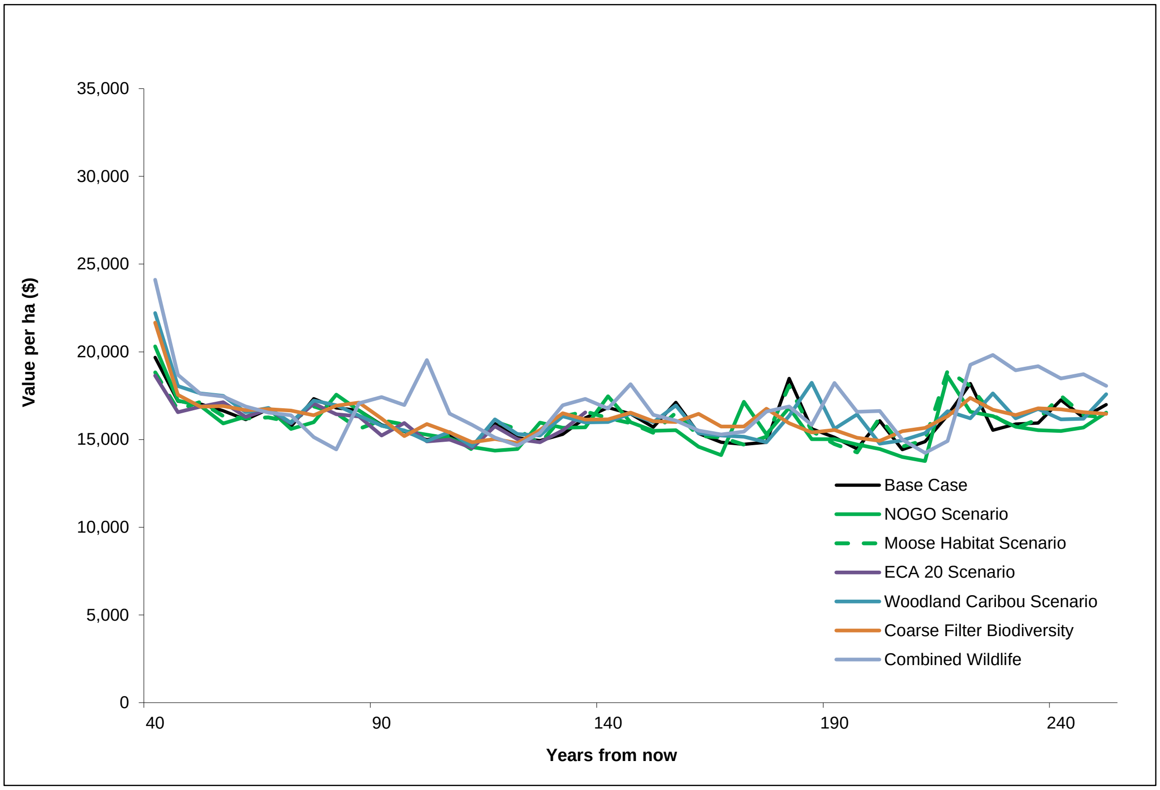

Figure 77: Value per ha forecast (managed stands); habitat and biodiversity scenarios

4.4.5 Habitat and Biodiversity Indicators over Time

The habitat and biodiversity indicators were tracked for most scenarios. The results are shown and discussed below.

4.4.5.1 Northern Goshawk

Figure 78 illustrates the suitable NOGO habitat for the entire TSA for the learning scenarios. The NOGO scenario and the combined wildlife scenario created most forage habitat, as expected; both enforced the NOGO forage targets. The differences in NOGO habitat among the rest of the scenarios were not material.

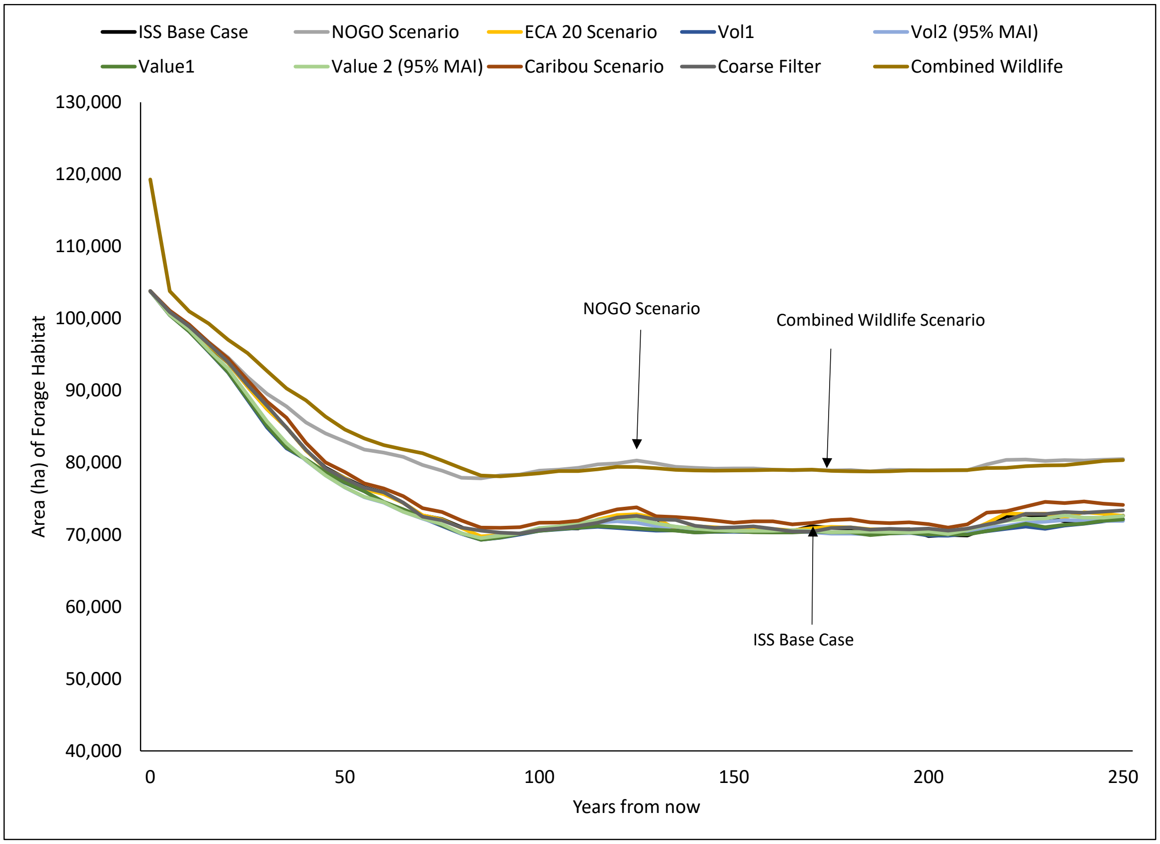

Figure 78: NOGO forage habitat; all predicted NOGO nesting units by scenario

4.4.5.2 Watershed Condition

Equivalent Clearcut Area (ECA) was used as an indicator for watershed health. An ECA of 20% or less is considered desirable. The achievement of ECA targets was controlled only in the ECA scenarios for all the 4th order watersheds in the TSA.

Figure 79 illustrates the forecasted ECA for the aggregated forested area within 4th order watersheds for the learning scenarios. While the TSA-wide average remains under 20%, there are differences among the various scenarios. The volume and value scenarios promote more intensive management and have a higher overall ECA. The combined wildlife scenario exhibits the lowest TSA-wide average ECA.

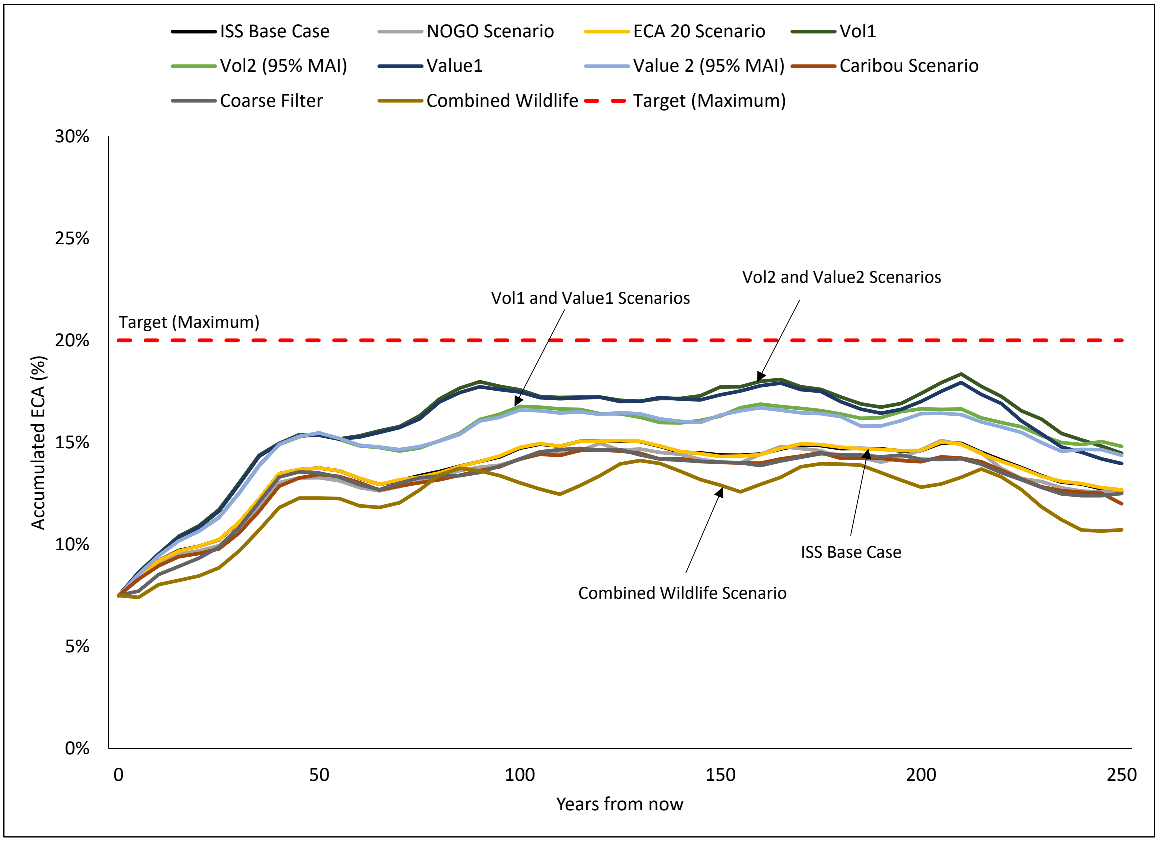

Figure 79: Aggregated TSA-wide predicted ECA by scenario

4.4.5.3 Woodland Caribou

This analysis included woodland caribou habitat as an indicator. The tracked habitat target was inferred from the Federal Caribou Recovery Strategy, i.e. 90% of the forested area within critical caribou habitat should be older than 140 years. Figure 80 illustrates the achievement of caribou habitat by scenario. Only the caribou scenario achieved significantly more caribou habitat compared to other scenarios. This was expected given that the habitat target was not enforced in any other scenario.

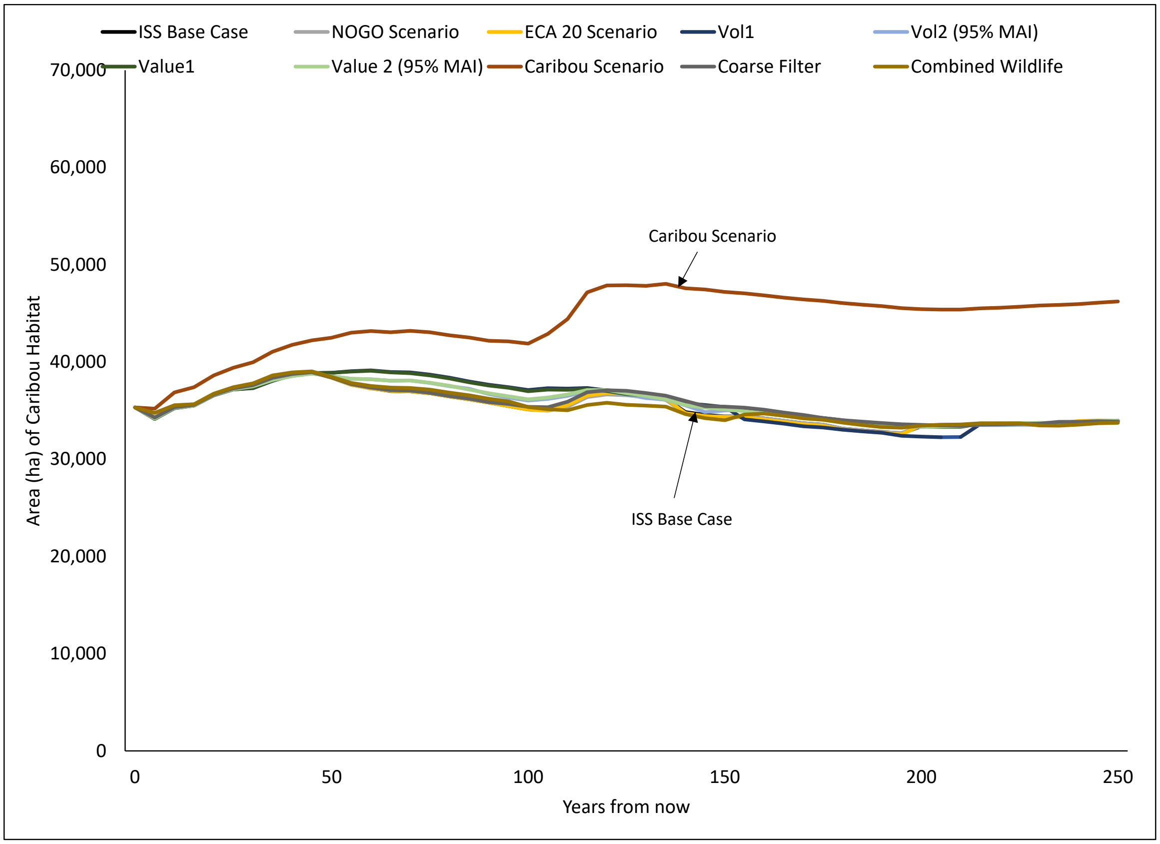

Figure 80: Forecast of woodland caribou habitat in the Bulkley TSA by scenario

4.4.5.4 Marten

Coarse woody debris (CWD) was considered an indicator for marten habitat; however, as there is no direct way to quantify CWD, late seral stage was used as a surrogate for marten habitat. Figure 81 illustrates the predicted marten habitat for the entire TSA by scenario. Most of the habitat is predicted to come from the NHLB. The scenarios where the harvest is constrained more are predicted to maintain higher level of marten habitat (caribou scenario, combined wildlife scenario, NOGO scenario).

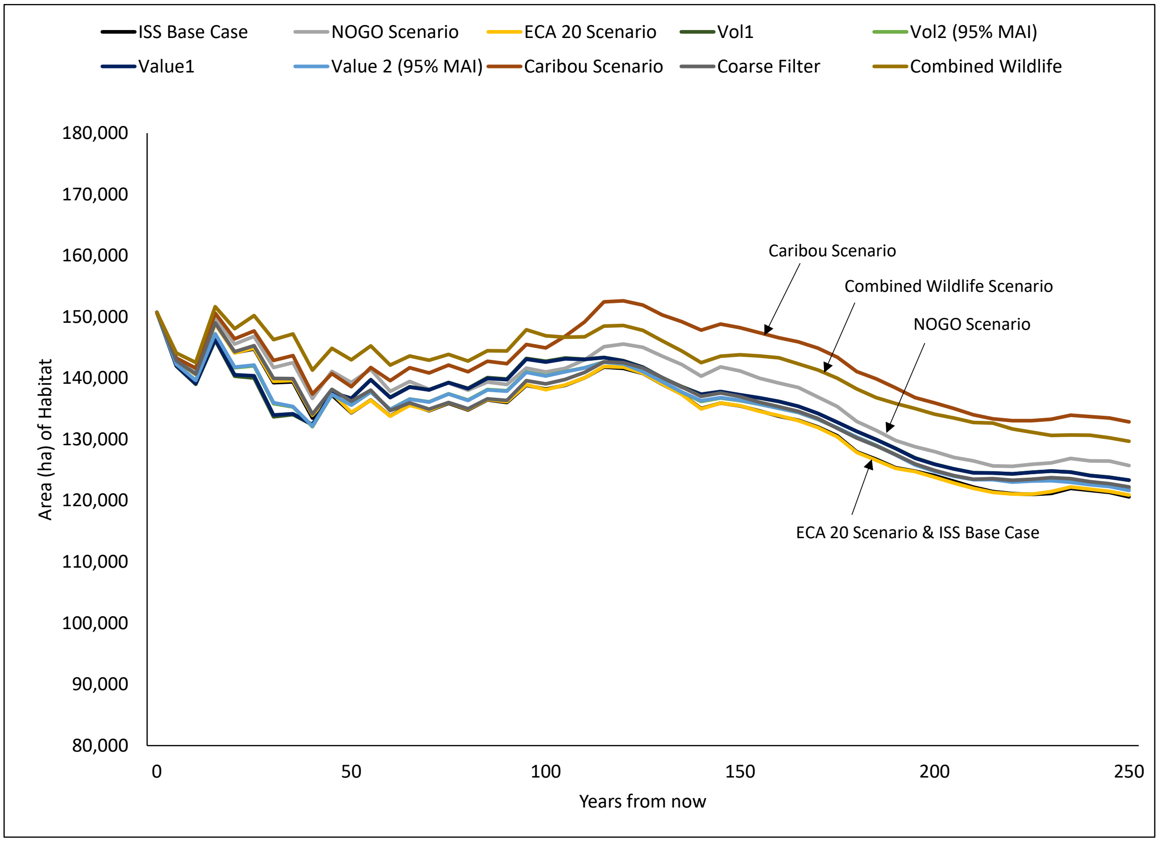

Figure 81: Forecast of marten habitat in the Bulkley TSA by scenario

4.4.5.5 Grizzly Bear

The analysis enforced unsuitable Grizzly bear habitat in one scenario (combined wildlife) and tracked it in other learning scenarios in each LU and BEC variant. Poor habitat was defined as more than 30% mid seral stage (41 to 80 year old stands) in each LU/BEC variant.

Figure 82 illustrates the predicted area of poor Grizzly habitat for the entire Bulkley TSA by scenario. The maximum target area shown represents the aggregated maximum areas of all LU/BEC combinations (at 30%). The lowest area of mid seral over time is predicted for the value and volume scenarios, while the coarse filter biodiversity scenario resulted in the highest mid seral forecast.

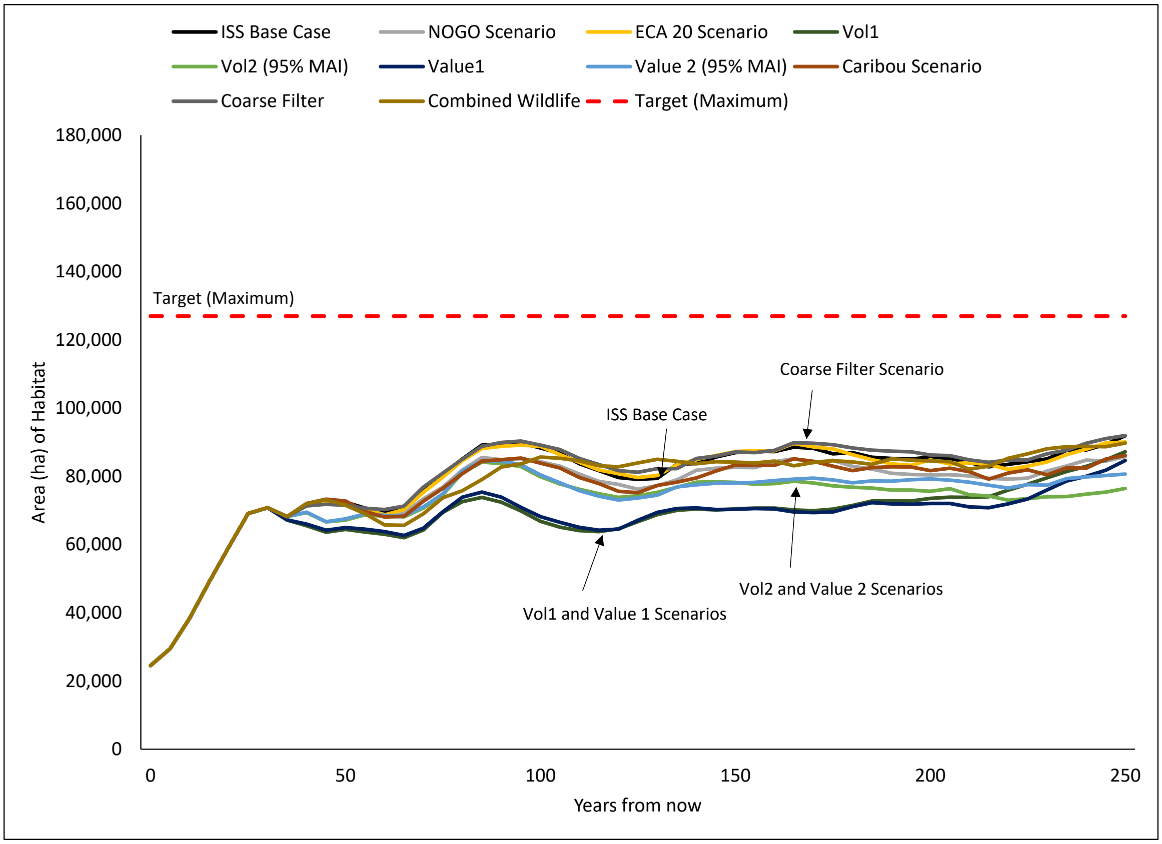

Figure 82: Forecast of poor Grizzly habitat in the Bulkley TSA by scenario

4.4.6 Learning Scenario Results Summary

Table 5 provides a summary of the scenario results for various indicators. The pluses and minuses depict a somewhat subjective classification of predicted indicator values for each scenario. More desirable outcomes are depicted with pluses, while minuses indicate less desirable results. All scenarios are compared to the ISS Base Case.

Table 5: Scenario results summary

Scenario	Indicator							
	Volume	Value	Moose Habitat	NOGO Forage Habitat	ECA	Caribou Habitat	Marten Habitat	Poor Grizzly Habitat
Volume	+++	+++	0	0	-	0	0	++
Volume 95% MAI	+(ST),++++ (LT)	++++	0	0	-	0	0	+
Value	+++	+++	0	0	-	0	0	++
Value 95% MAI	+(ST),++++ (LT)	++++	0	0	-	0	0	+
Moose	0	0	0	0	0	0	0	0
NOGO Forage	-	-	0	+++	0	0	+	+
ECA	0	0	0	0	0	0	0	0
Caribou Habitat	--	--	0	0	0	+++	++	+
Coarse Filter Biodiversity	0	0	0	0	0	0	0	0
Combined Wildlife	---	-	+	+++	+	0	++	0

4.5 Selected Scenario

The analysis results were presented to the Bulkley TSA ISS implementation group on November 7, 2019. The group agreed that the value scenario with some control over the harvest age of the managed stands should be the basis for the Selected Scenario and the Integrated Stewardship Strategy. The following changes were incorporated into the Selected Scenario:

- Concerns for Balsam and Pl at high elevations: There is a consensus that TASS does not represent natural ingress of balsam adequately and for this reason balsam is likely underrepresented in the modelling results. There was also a concern over the success of Pl reforestation at high elevations with significant heavy snow fall. As a result, the ESSFmc was split into upper and lower portions (based on an elevation of 1100m). New yield curves were developed for the upper and lower areas with revisions to natural ingress patterns and reforestation regimes with a priority of more Bl. Also, the upper portion of the ESSFmc was designated as red silviculture zone while the lower portion remained a yellow silviculture zone.
- The most recent projected NOGO territories were incorporated into the analysis file. Any projected territories that fall within the green and yellow silviculture zones were classified as red and excluded from intensive silviculture treatments. The NOGO forage targets were not enforced in the Selected Scenario.
- The goat winter range has been updated. As per the Chief Forester's direction after the previous TSR, goat winter range was not removed from the THLB in the previous scenarios. The final GAR order changes this. The selected scenario removed some goat winter range polygons from the THLB as per the GAR order (U-6-007).
- The intensity of fertilization of future managed stands will be reduced to achieve a more conservative, realistic long-term silviculture budget. Many stands were scheduled to be fertilized at least 4 times. Two fertilizations will be removed from the regimes.
- Selected Scenario has a value focus with 95% MAI culmination (more species diversity with a small component of Cw). It updated areas for zoning and treatment frequency as noted above. The strategy will provide descriptions of best management practises at the stand level.

4.5.1 Summary of Revised Future Managed Stand Yield Curve Framework for the Selected Scenario

Table 6 summarizes the revisions to the future managed stand regimes and species portfolios used for the selected scenario. These changes were designed to address the following objectives:

- Increase the Bl component in the future stands in the ESSFwv and the upper portion of the ESSFmc; and
- Reduce Pl in the upper portion of the ESSFmc due to concerns for snow damage; and
- Reduce reforestation costs within the red silviculture zone (ESSFwv and the upper portion of the ESSFmc) to balance out higher costs of the enhanced regimes.

Table 6: Revised Future Stand Regimes Chosen for the Selected Scenario

BEC Unit	Sp1/Target Plant (sph)/ Treatments (% Area)	Sp2/Target Plant (sph)/ Treatments (% Area)	Sp3/Target Plant (sph)/ Treatments (% Area)
ESSFmc-lower dry-fresh	Pl/1800/ fert (20%)	Sx/1400/ fert (60%)	Cw/1200/JS (20%)
ESSFmc-lower moist-wet	Pl/1800/ fert (30%)	Sx/1600/ fert (70%)	
ESSFmc-upper dry-fresh	Bl/800 (70%)	Sx/800 (30%)	
ESSFmc-upper moist-wet	Bl/800 (70%)	Sx/800 (30%)	
ESSFwv dry-fresh	Bl/800 (60%)	Sx/800 (30%)	Pl/800 (10%)
ESSFwv moist-wet	Bl/800 (60%)	Sx/800 (30%)	Pl/800 (10%)

4.5.2 Harvest Forecast

Figure 83 illustrates the Selected Scenario harvest forecast compared to the ISS Base Case harvest forecast; the harvest level of 662,260 m^3 per year, 8.0% higher than that of the ISS Base Case, is maintained for 90 years, when the long-term harvest level of 673,210 m^3 per year is reached. The long-term harvest level of 673,210 m^3 per year is 9.6% higher than the ISS Base Case harvest forecast.

Figure 84 illustrates the predicted development of the growing stock for the Selected Scenario. The timber supply was tested for a period of 400 years (only 250 years shown) to ensure long-term sustainability.

The harvest forecast by stand type is shown in Figure 85. The harvest of existing managed stands is predicted to start in 35 years. In 70 years almost the entire harvest is forecasted to come from managed stands.

Figure 86 shows the harvest forecast by species. During the next 50 years most of the harvest will consist of balsam and spruce. In the long term, the harvest is predicted to comprise almost entirely of spruce and pine with some small amounts of cedar and balsam harvest also predicted. Attempts to regenerate more upper elevation sites with Bl had a limited impact on the long term Bl harvest. Note the introduction of Douglas fir in the long term.

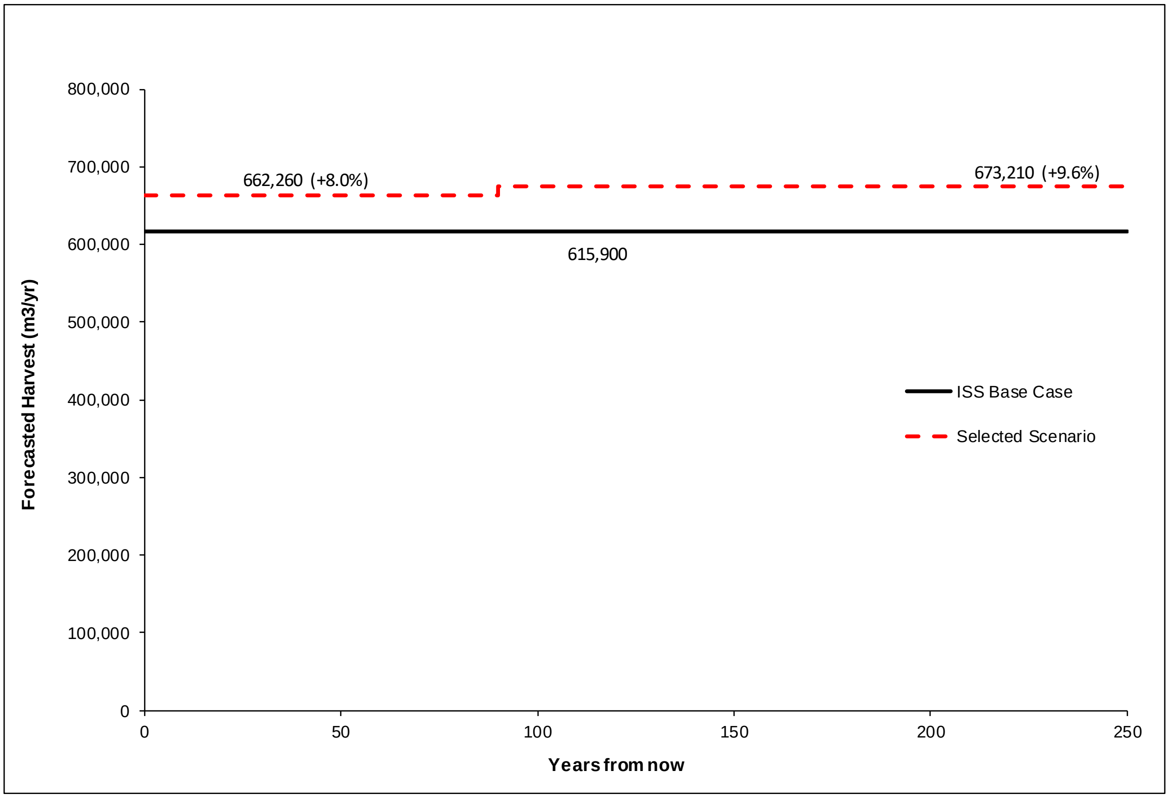

Figure 83: Selected Scenario harvest forecast

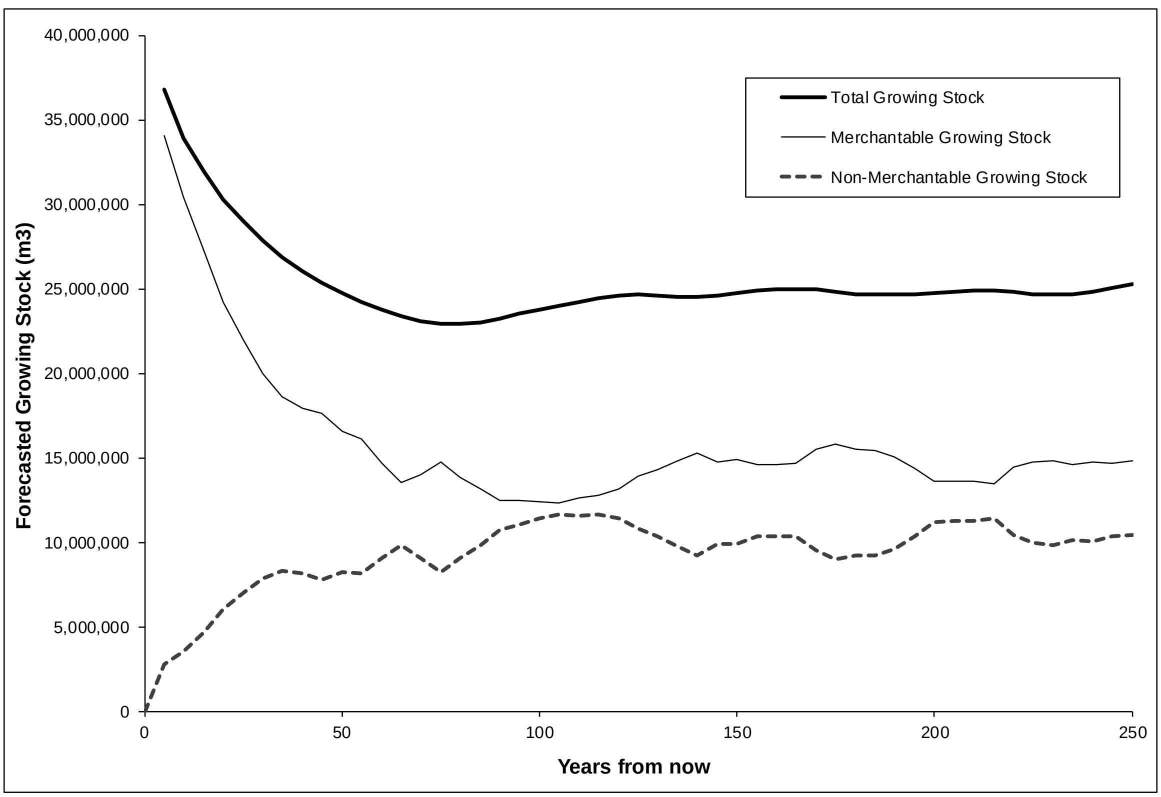

Figure 84: Predicted growing stock development, Selected Scenario

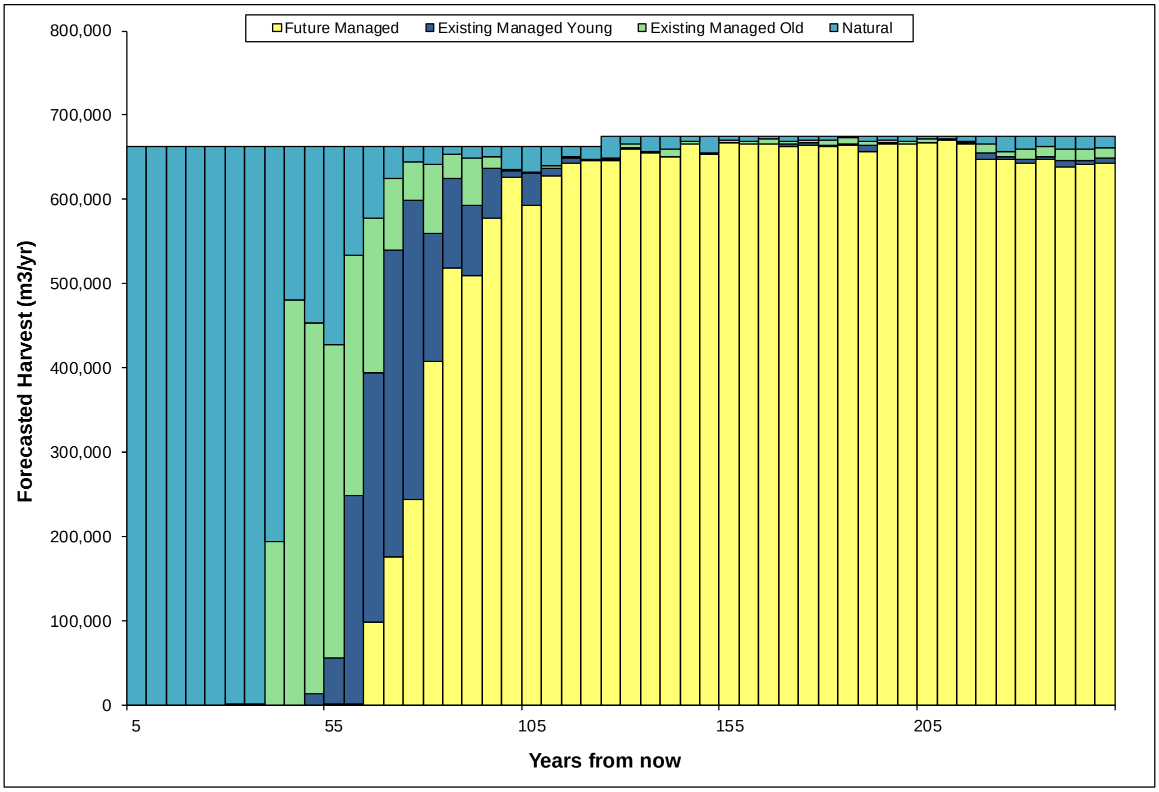

Figure 85: Selected Scenario harvest forecast by stand type

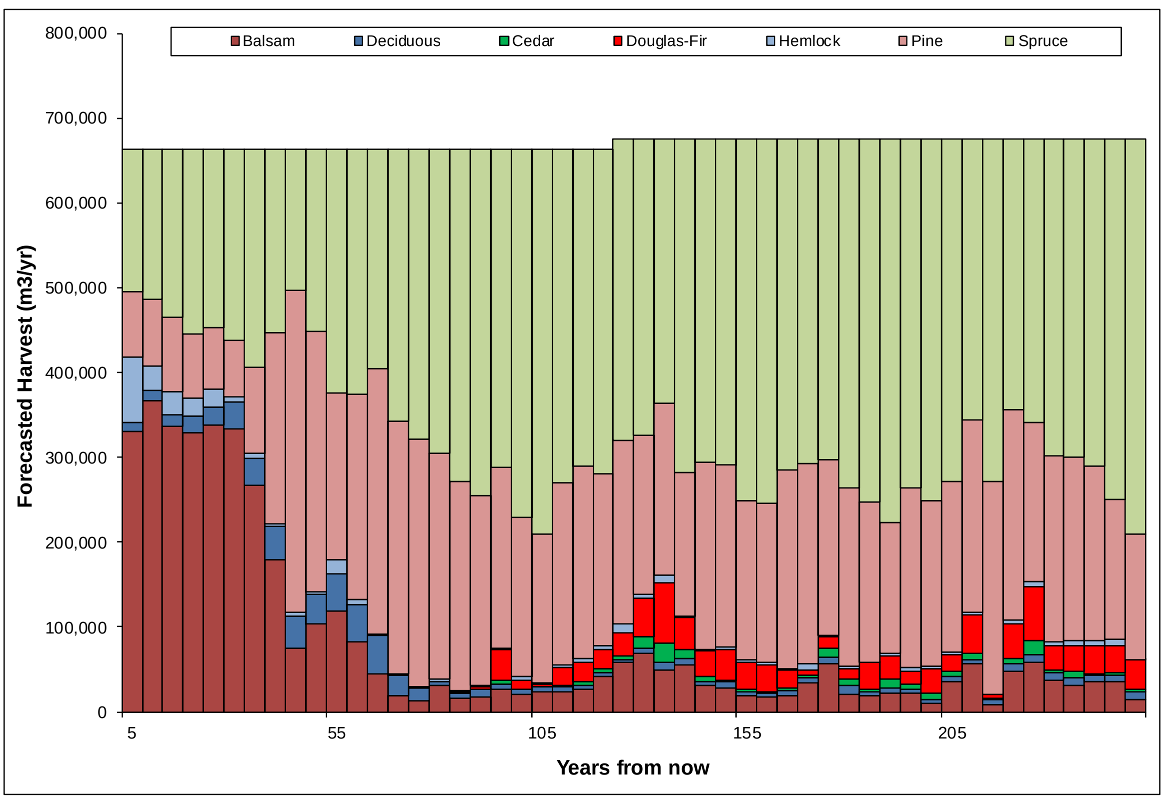

Figure 86: Harvest forecast by species, Selected Scenario

Figure 87 depicts the harvest forecast by age class. The harvest of old and mature stands (age classes 8 and 9) is expected to continue for approximately 35 years. During the transition period to managed stands, age class 4 and 5 stands (61 to 100 years) become more prevalent. In the long term, the harvest is predicted to depend mostly on age class 3 and 4 stands (41 to 80 years) and to some extent age class 5 (81 to 100 years) and older stands. The harvest forecast by age class is also reflected in Figure 88 illustrating the predicted average harvest age. The average harvest age is high at first due to the harvest of older stands; however, it stabilizes after 100 years and settles at around 75 years.

Figure 89 illustrates the harvest forecast by vol/ha classes, while Figure 90 shows the predicted average harvest volume over time. In the long run, the average harvest volume is predicted to fluctuate between 270 and 310 m^3 per ha. This corresponds to an average annual harvest area between 2,200 and 2,500 ha (Figure 91).

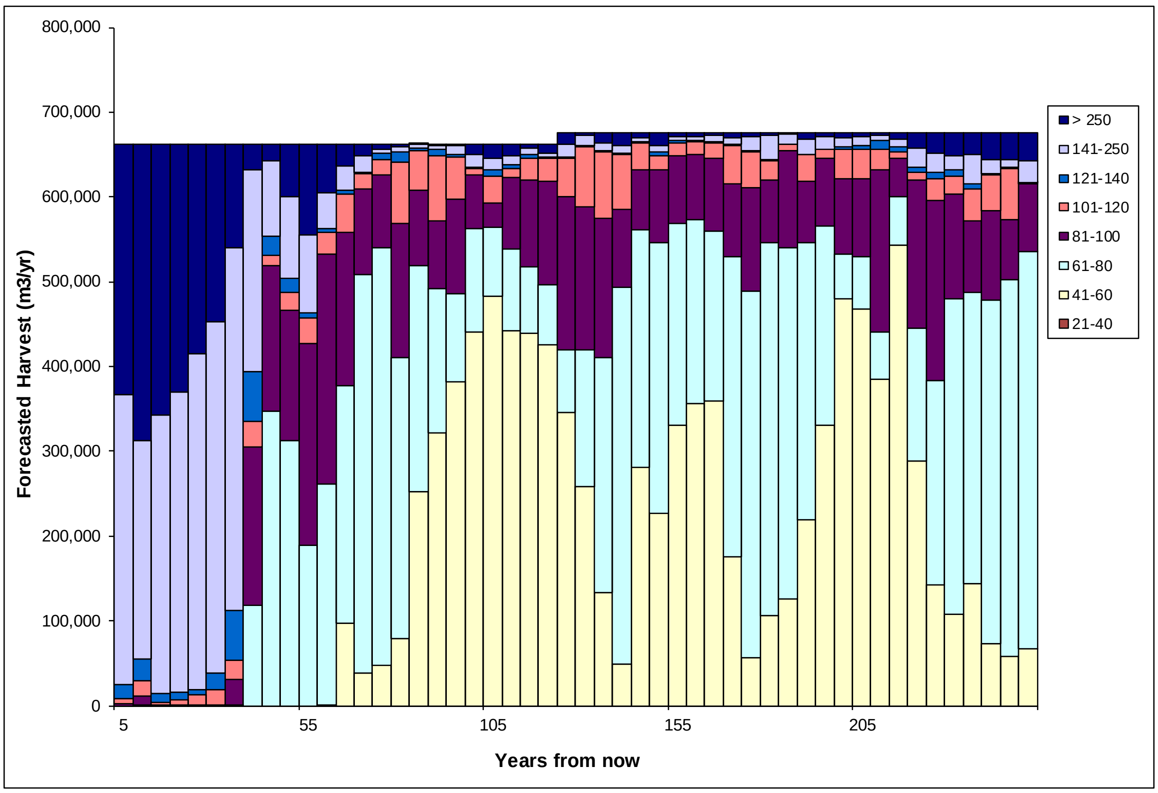

Figure 87: Harvest forecast by age class, Selected Scenario

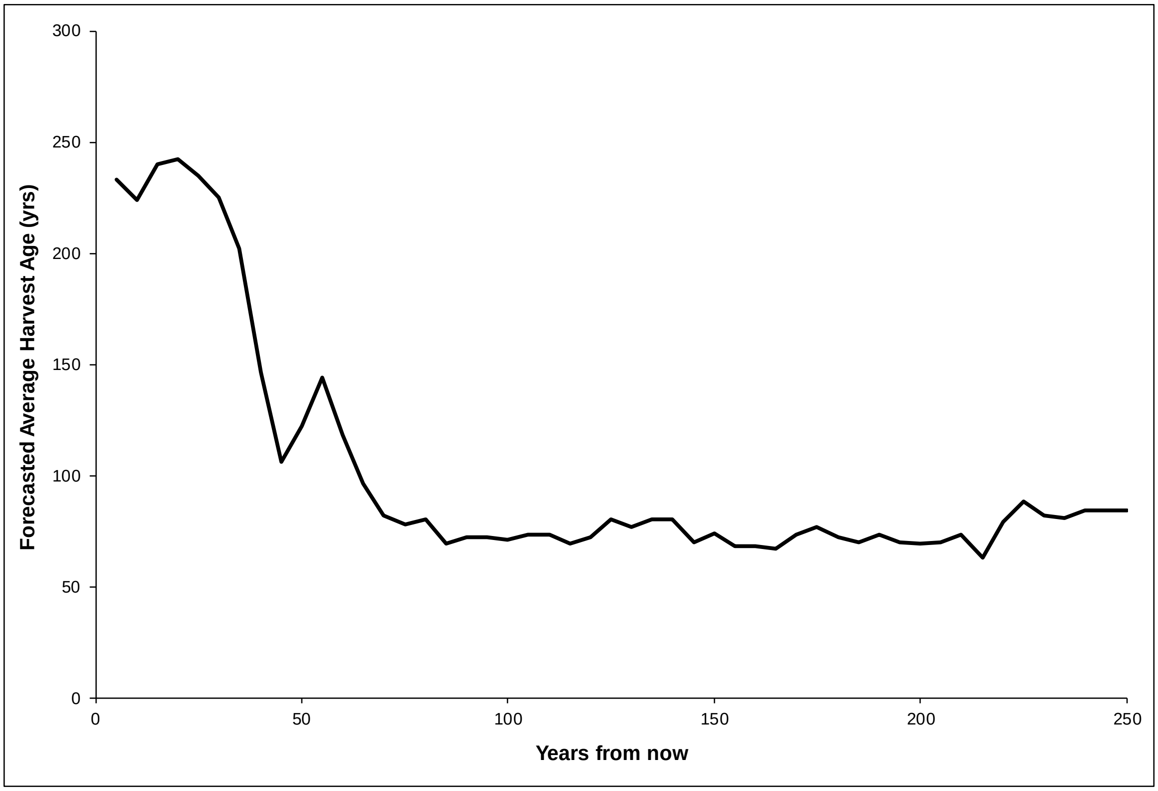

Figure 88: Average harvest age, Selected Scenario

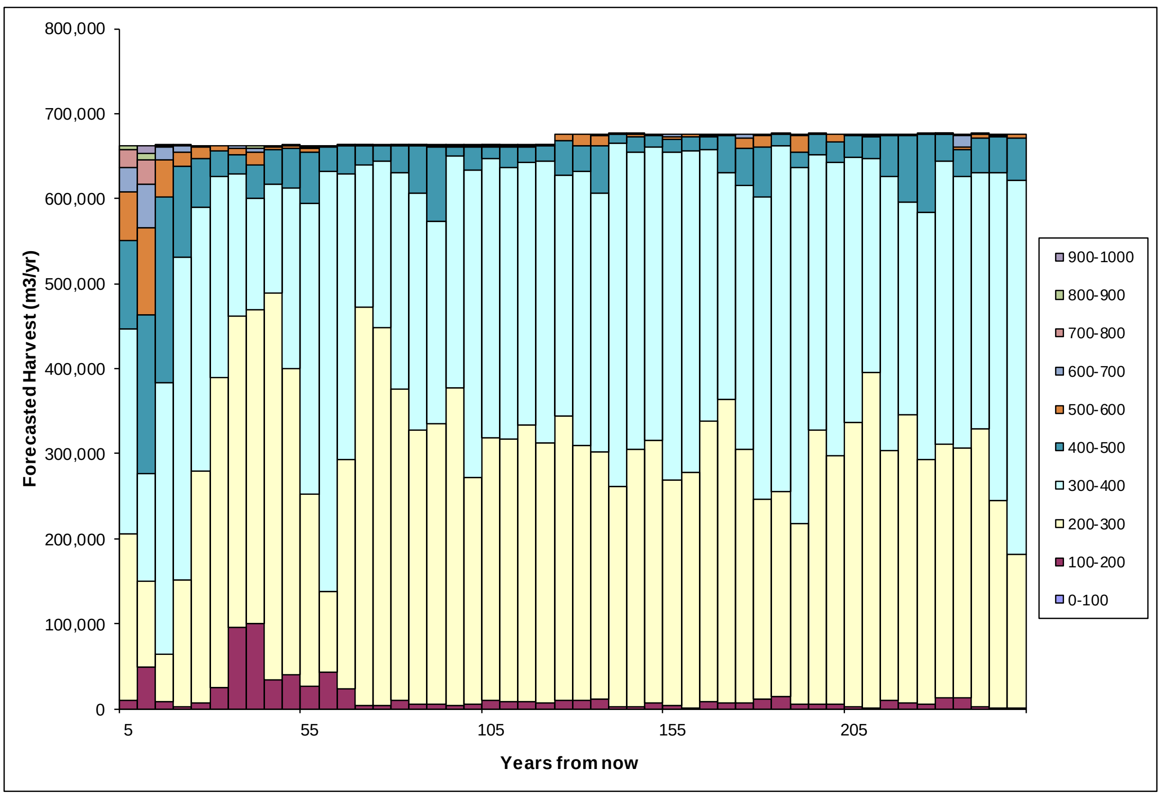

Figure 89: Harvest forecast by volume per ha class, Selected Scenario

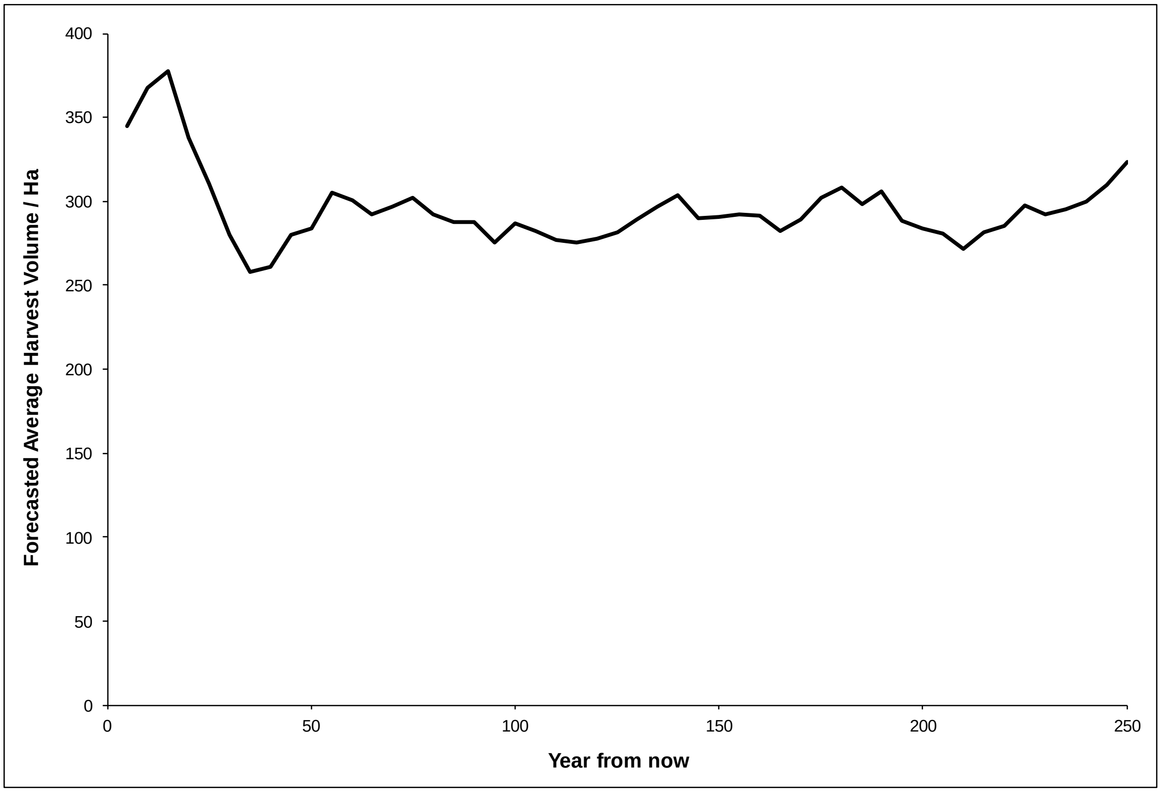

Figure 90: Predicted average harvest volume per ha, Selected Scenario

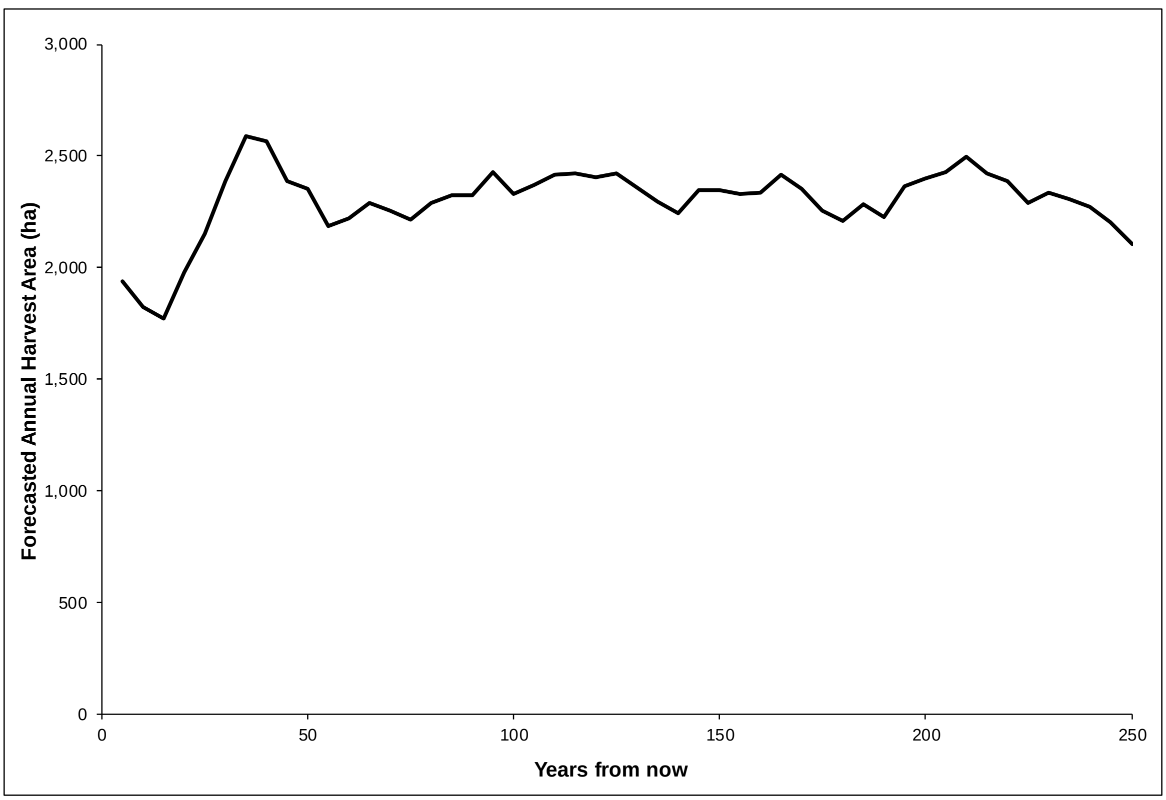

Figure 91: Predicted average harvest area, Selected Scenario

Figure 92 and Figure 93 depict the predicted age class distribution over time in the THLB and the Crown Forested Land Base (CFLB) correspondingly. Over time age classes 1 to 3 are forecasted to cover approximately 70% of the THLB (Figure 92). Older age classes, especially age classes 8 and 9 are well represented in the Non-Harvestable Land Base (NHLB) and contribute significantly to the mature and old seral stages of the CFLB (Figure 93).

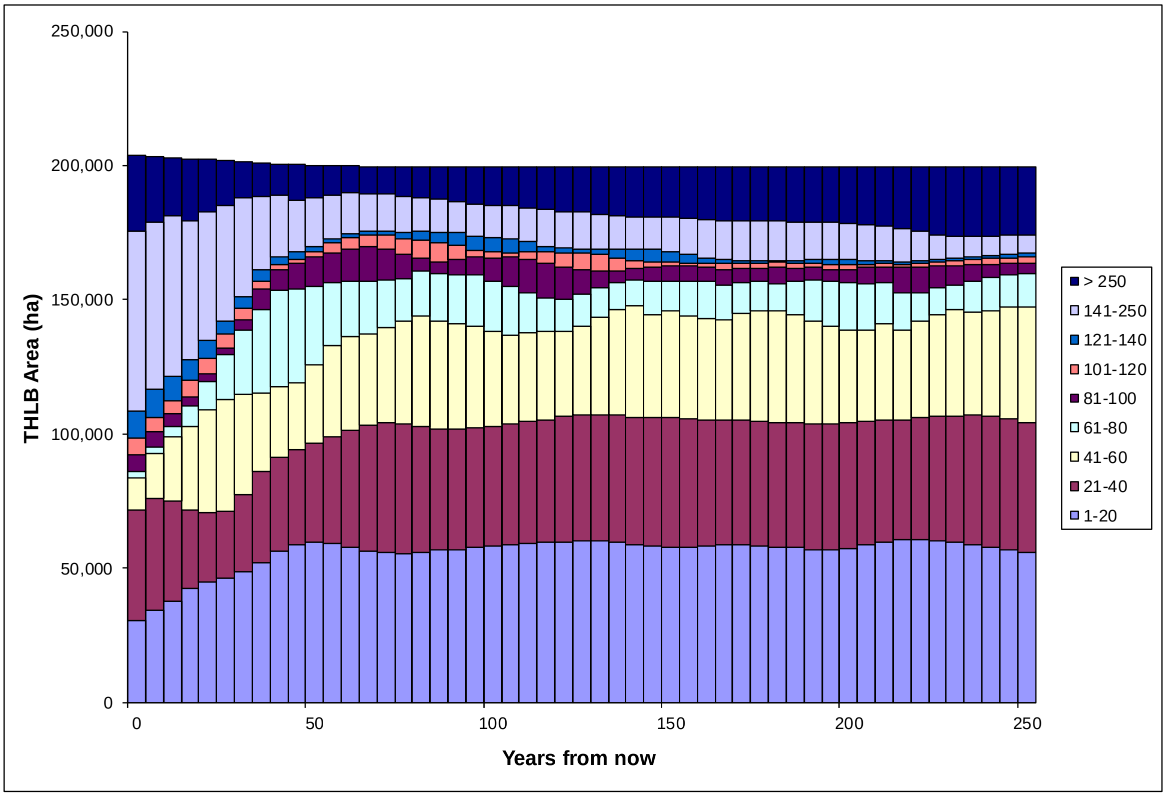

Figure 92: Predicted age class distribution over time on the THLB, Selected Scenario

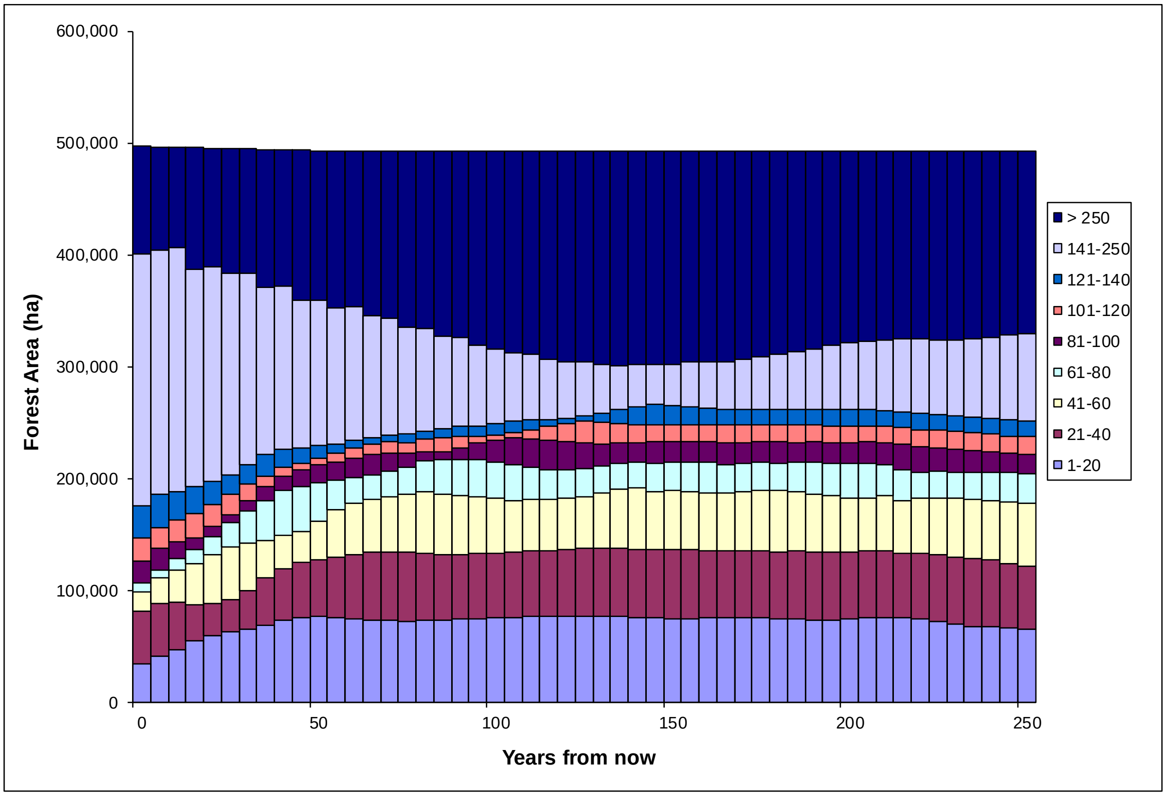

Figure 93: Predicted age class distribution over time on the CFLB, Selected Scenario

4.5.3 Timber Value over Time

Figure 94 illustrates the total predicted harvested timber value comparison for managed stands between the Selected Scenario and the ISS Base Case. The harvest of managed stands is not predicted to be significant until around year 40. This is also reflected in the total value, which starts accumulating at the same time.

The same trend can be seen in Figure 95 depicting the predicted value per ha of managed stands.

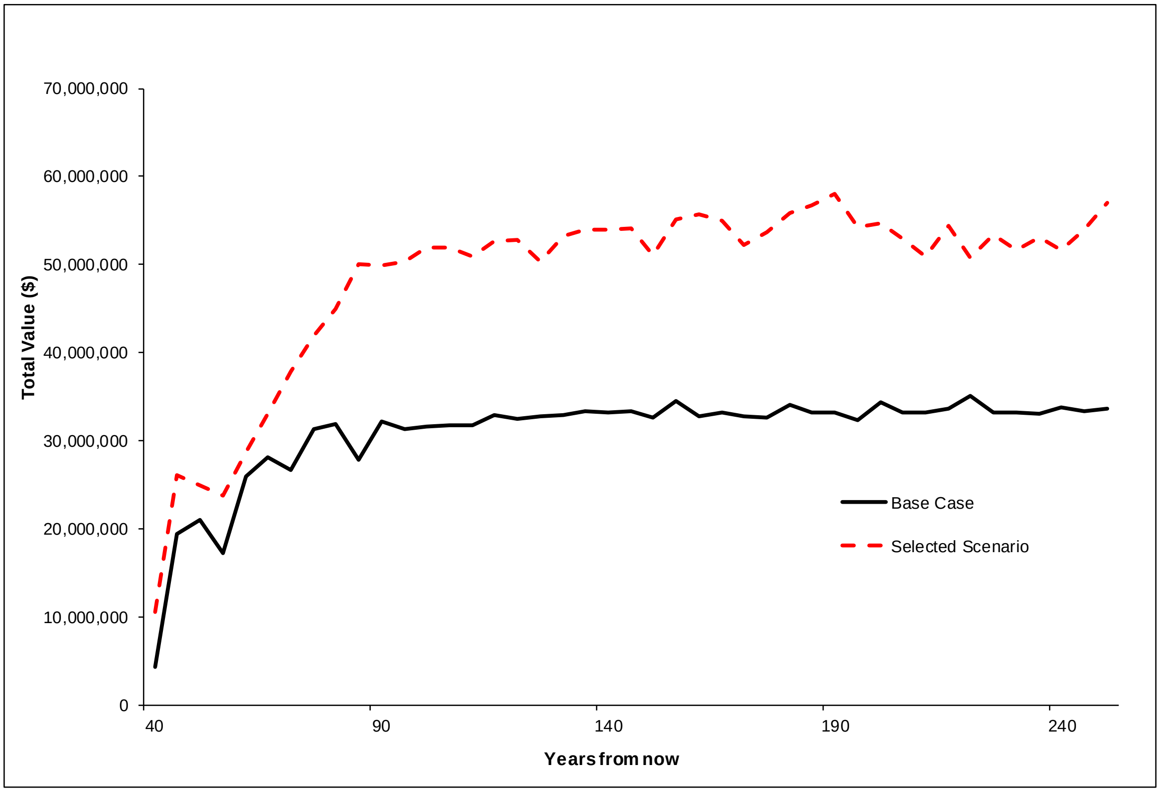

Figure 94: Total value forecast (managed stands); Selected Scenario

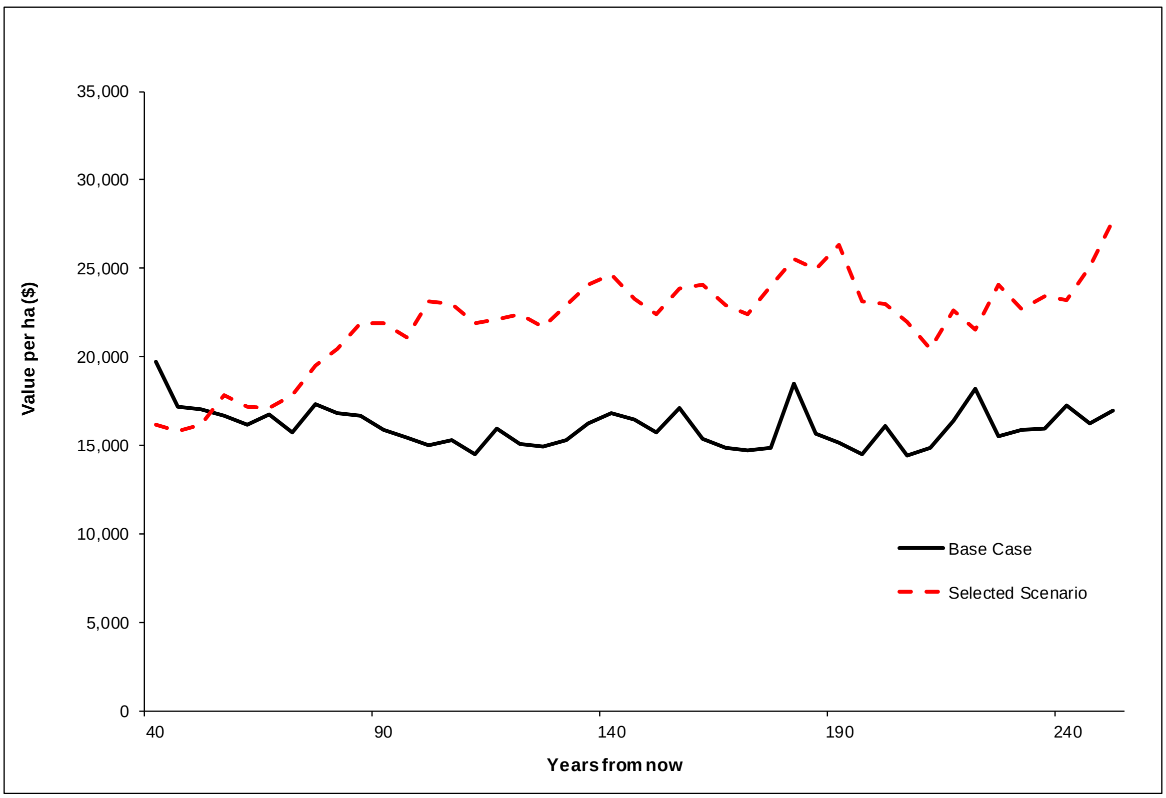

Figure 95: Value per ha forecast (managed stands); Selected Scenario

4.5.4 Treatment Areas and Treatment Costs

Figure 96 and Figure 97 show the annual projected treatment areas. They consist of areas planted with higher or lower planting densities, and fertilization and juvenile spacing areas. Some of the higher elevation, balsam dominated sites are planted with lower densities resulting in cost savings.

Figure 98 and Table 7 show the projected expenditures by treatment type for the Selected Scenario. The initial treatment areas and costs are modest, consisting only of the treatment of existing managed stands and planting of higher or lower densities. In the course of time, the annual area treated increases.

In the short term, the predicted fertilization costs are approximately $300,000 annually; however, they increase over time and reach $1 million in 70 years.

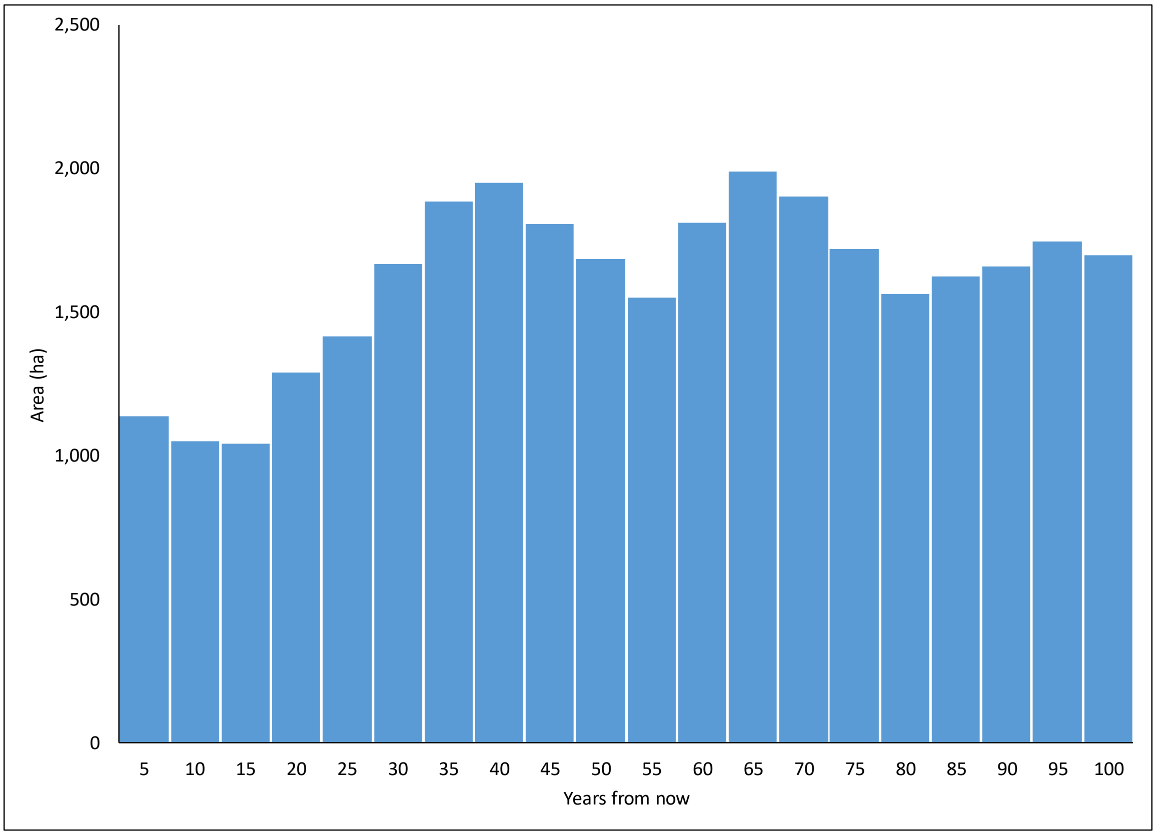

Figure 96: Planted area with higher or lower planting densities; Selected Scenario

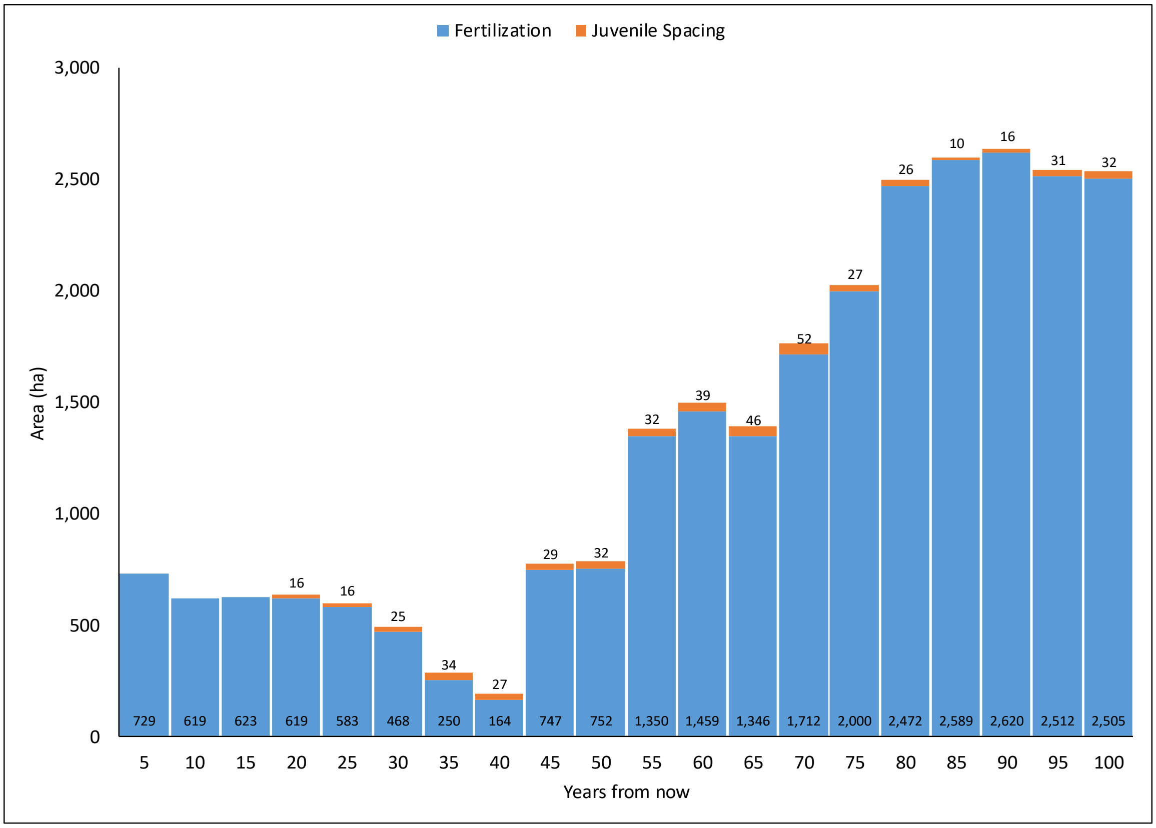

Figure 97: Fertilization and juvenile spacing areas; Selected Scenario

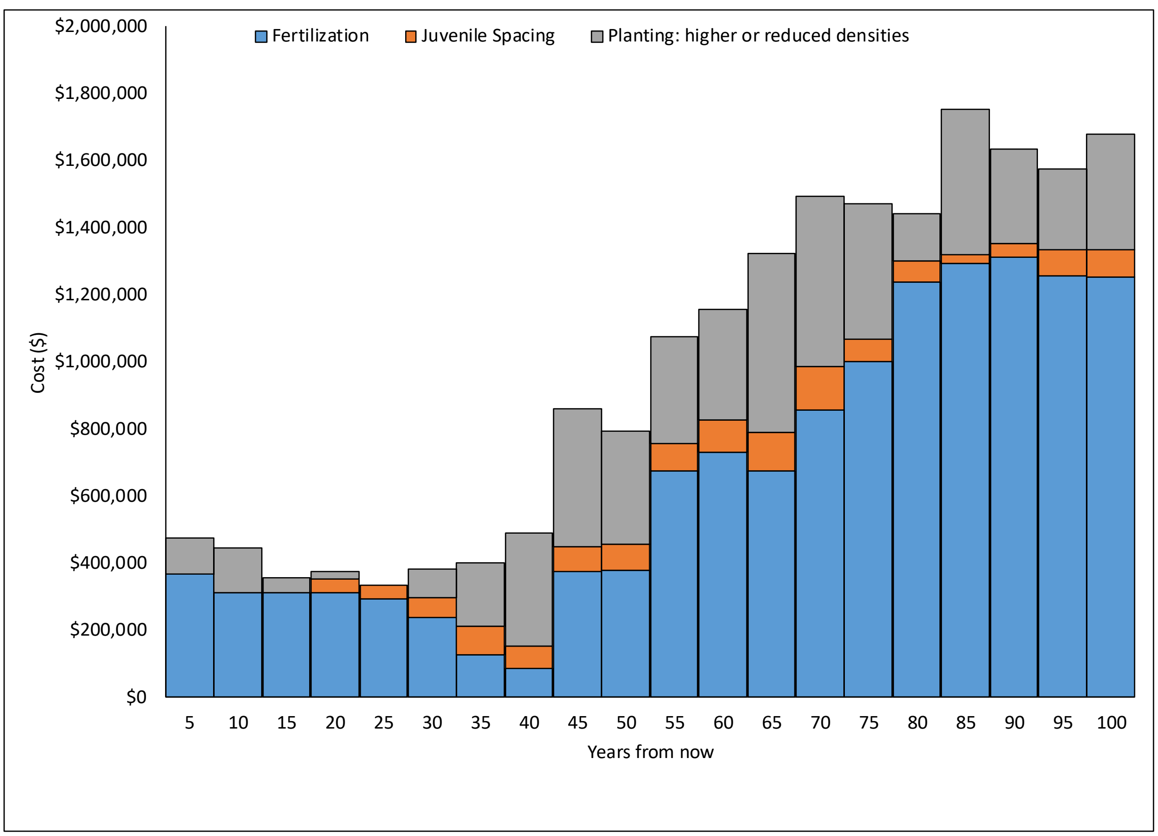

Figure 98: Costs of projected incremental silviculture; Selected Scenario

Table 7: Costs of projected incremental silviculture; Selected Scenario

Year	Fertilization	Spacing	Planting Higher or Reduced Densities
1 to 5	$364,362	$0	$108,099
6 to 10	$309,523	$0	$135,251
11 to 15	$311,583	$0	$41,360
16 to 20	$309,523	$41,033	$22,827
21 to 25	$291,523	$39,977	-$16,133
26 to 30	$234,113	$61,833	$84,497
31 to 35	$124,907	$85,865	$188,285
36 to 40	$81,896	$67,062	$338,630
41 to 45	$373,443	$72,605	$413,080
46 to 50	$375,835	$80,456	$336,349
51 to 55	$675,168	$79,144	$320,599
56 to 60	$729,533	$96,304	$328,683
61 to 65	$673,205	$115,576	$535,388
66 to 70	$856,117	$130,610	$505,979
71 to 75	$1,000,231	$67,546	$401,308
76 to 80	$1,235,977	$65,803	$139,538
81 to 85	$1,294,348	$23,811	$435,917
86 to 90	$1,309,791	$40,583	$282,821
91 to 95	$1,256,216	$77,781	$241,934
96 to 100	$1,252,271	$79,540	$348,355

4.5.5 Moose Habitat

As with the ISS Base Case the moose habitat targets of 33% mature/old seral (greater than 80 years old), 33% mid seral (41 to 80 years old) and 33% early seral (0 to 40 years old) were not met in the Selected Scenario. They are difficult to meet for the following reasons:

- Much of moose habitat as defined is outside of the THLB (63%) and cannot be controlled through harvest.
- Seral stage targets by landscape unit and BEC variant in the TSA require that mature and old targets are met. In many cases, the requirement for mature and old seral stages far exceeds the 33% of older stands required for moose habitat.

4.5.6 Northern Goshawk (NOGO)

Northern Goshawk (NOGO) forage habitat was accounted for by incorporating the forage habitat around existing nests and around projected territories in the analysis. A network of projected territories was received from FLNRORD in Smithers. The projected territories were updated for the Selected Scenario. In all the previous scenarios the maximum projected forage habitat within the THLB was 119,293 ha. The updated maximum forage habitat area for the TSA was reduced to 67,405 ha of THLB. The target for each territory (circle) was 60% of forage habitat meeting the age required for habitat (81 and older).

The achievement of the NOGO suitable forage target was not controlled in the Selected Scenario; it was only reported as an indicator. Figure 99 illustrates the forecasted NOGO foraging habitat for the aggregated forested area within the existing and projected NOGO territories over the planning horizon. In the long run, approximately 50% of the forest remains as suitable NOGO foraging habitat. However, as the foraging habitat distribution is not controlled, individual forage areas may contain less than the target foraging habitat. Figure 100 shows the predicted NOGO forage habitat for one projected NOGO territory. In this area, the foraging habitat is not maintained and most of it comes from the NHLB in the long term.

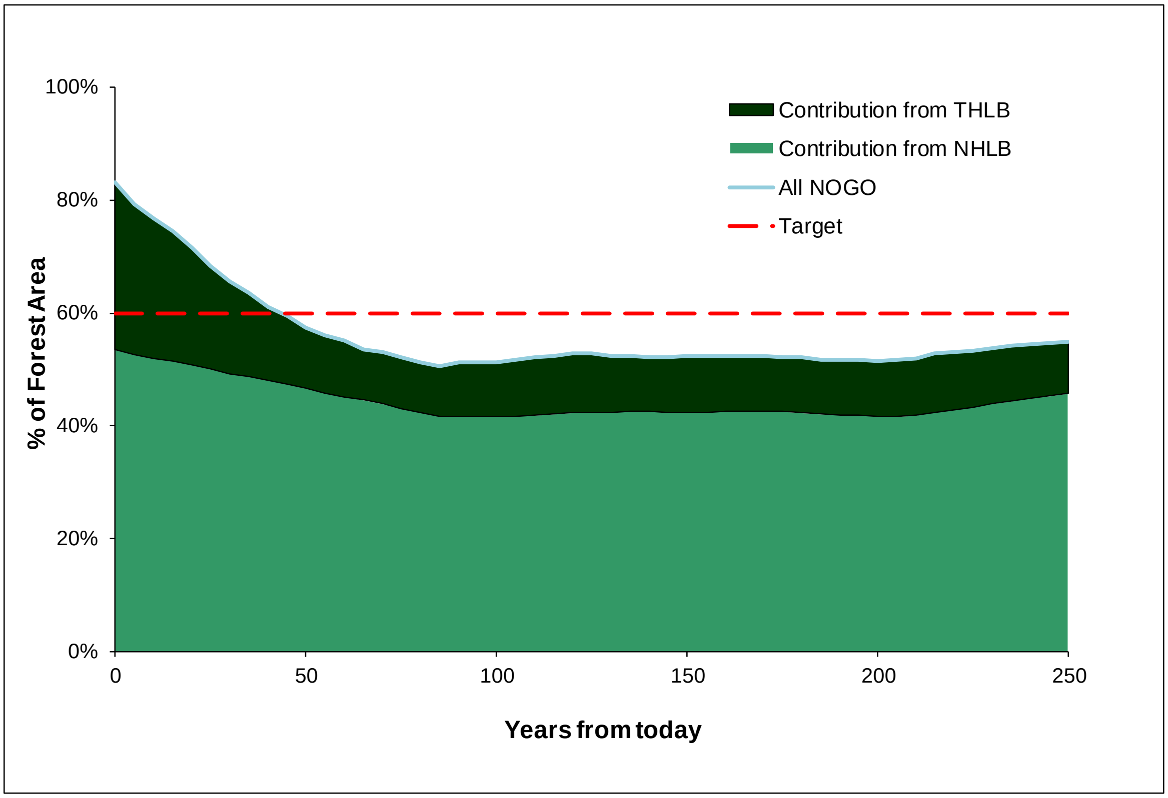

Figure 99: Selected Scenario; suitable NOGO forage habitat, all existing and projected NOGO territories

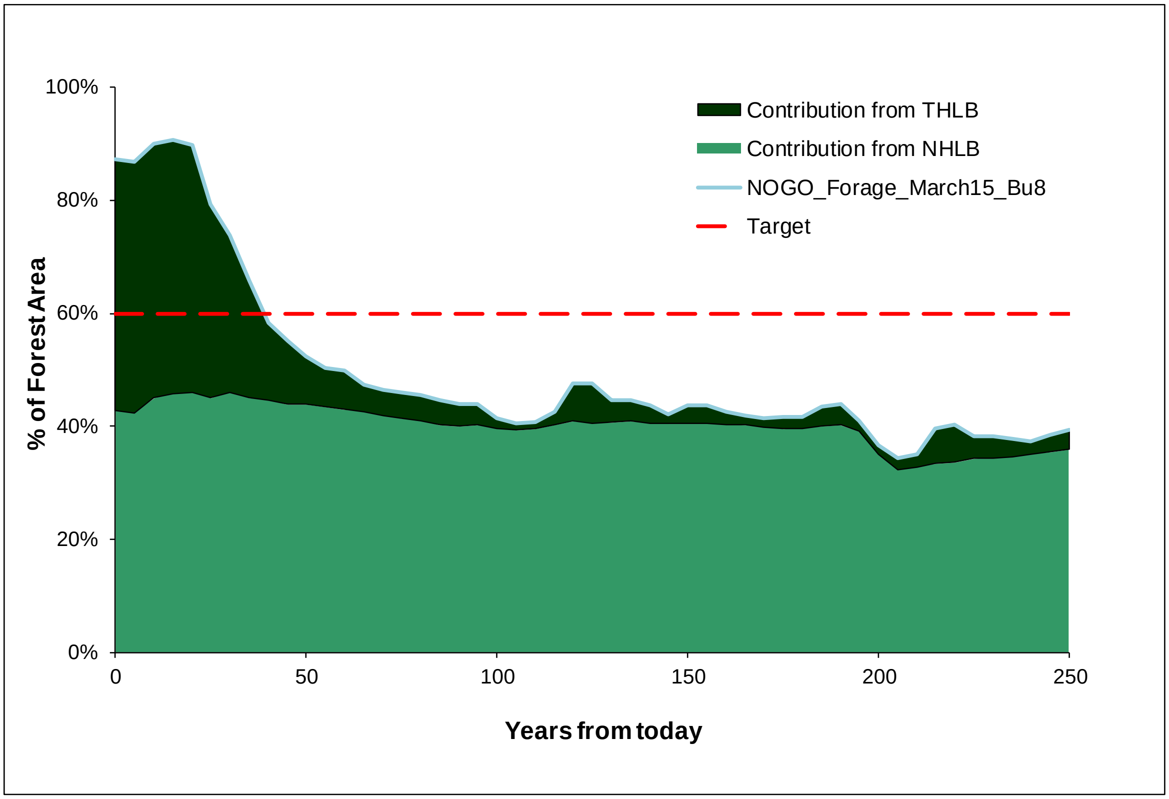

Figure 100: Selected Scenario; suitable NOGO forage habitat, one projected NOGO territory

4.5.7 Watersheds

Equivalent Clearcut Area (ECA) was used as an indicator for watershed health. An ECA of 20% or less is considered desirable. The achievement of ECA targets was not controlled in the Selected Scenario; it was only reported as an indicator for all the 4th order watersheds.

Figure 101 illustrates a comparison between the Selected Scenario and the ISS Base Case of the forecasted ECA for the aggregated forested area within 4th order watersheds. The TSA-wide average ECA remains below 20% throughout the planning horizon in both scenarios.

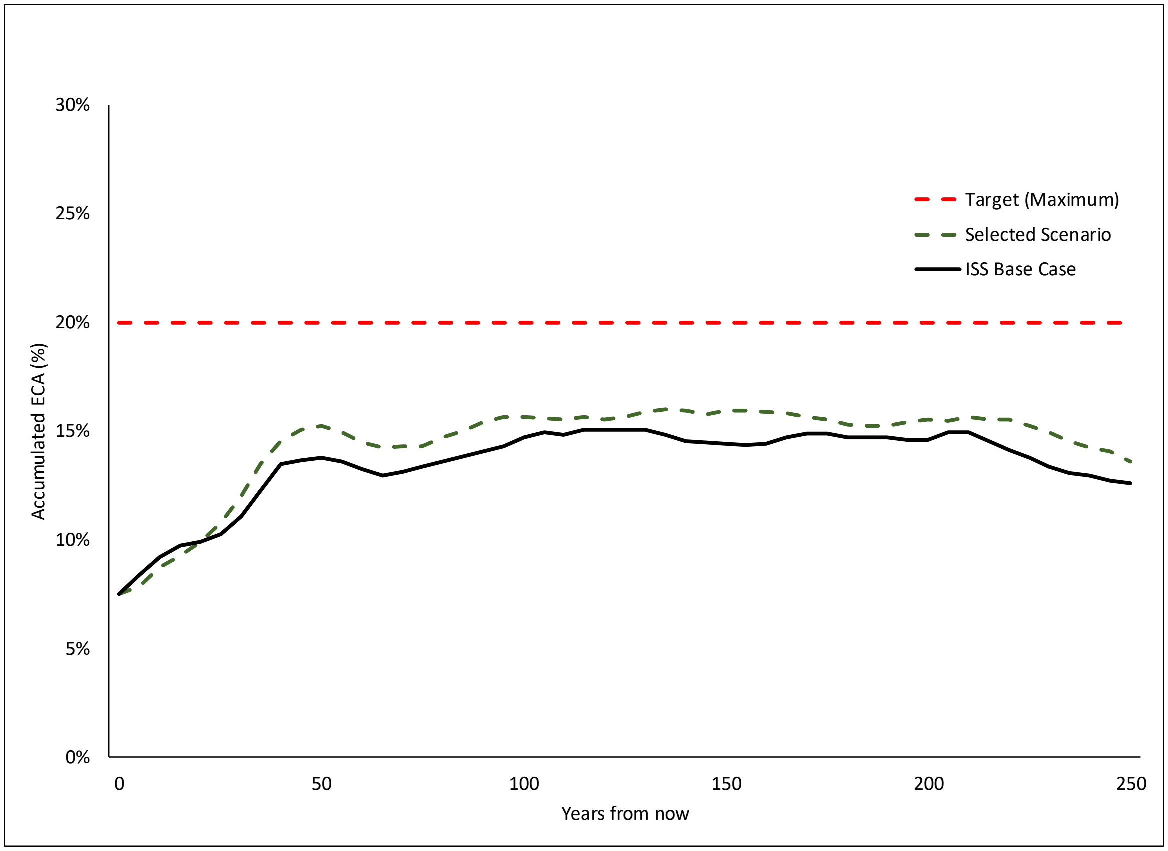

Figure 101: Average ECA over all 4th order watersheds, Selected Scenario

4.5.8 Woodland Caribou

This analysis included woodland caribou habitat as an indicator. The tracked habitat target was inferred from the Federal Caribou Recovery Strategy, i.e. 90% of the forested area within critical caribou habitat should be older than 140 years. Neither the ISS Base Case nor the Selected Scenario met the 90% target (Figure 102). Approximately 50% of the achieved area comes from the NHLB.

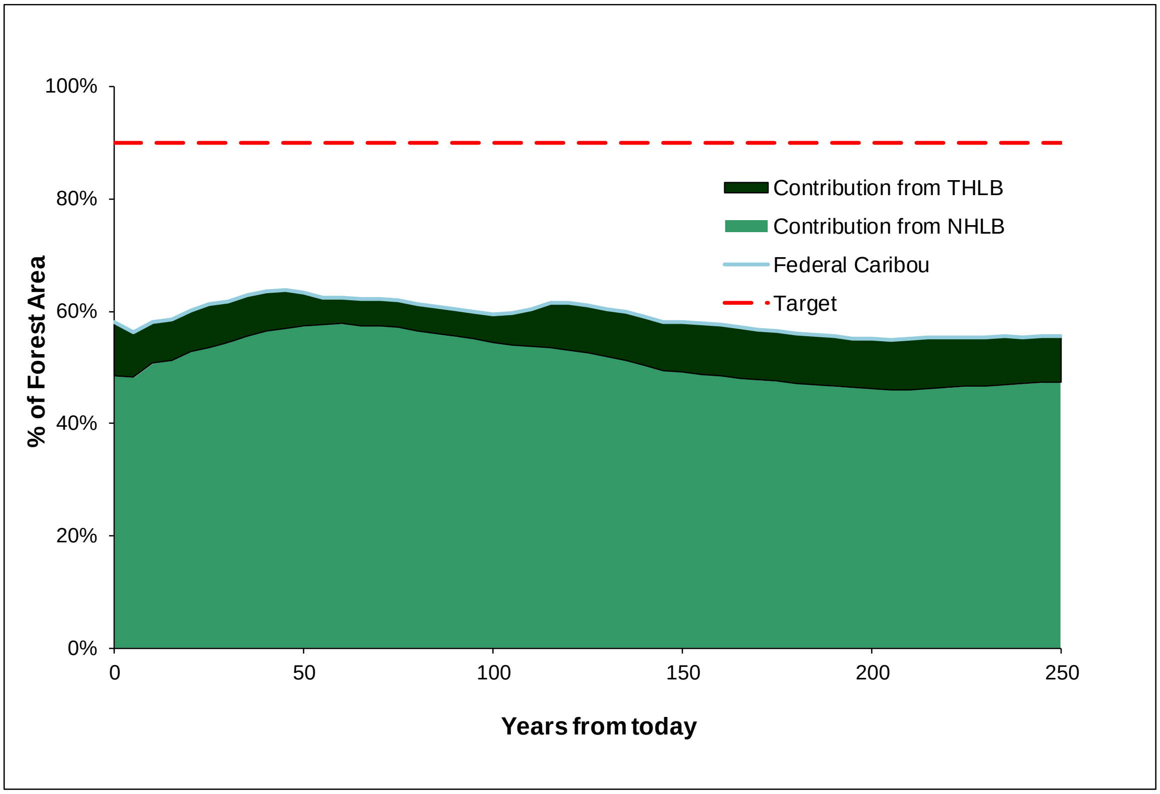

Figure 102: Woodland caribou habitat; Selected Scenario

4.5.9 Marten

Coarse woody debris (CWD) is considered a critical component of suitable marten habitat. Late seral stage (older than 250, or 140 for SBSmc, SBSmc2 and SBSdk) was used in this analysis as a surrogate for large volumes of CWD and therefore of marten habitat. Figure 103 illustrates the predicted marten habitat for the entire TSA. Most of the habitat is predicted to come from the NHLB. The decrease in the habitat in the NHLB is caused by the natural disturbance assumptions in the model. Figure 104 compares the achieved marten habitat in the selected scenario to that of the ISS Base Case.

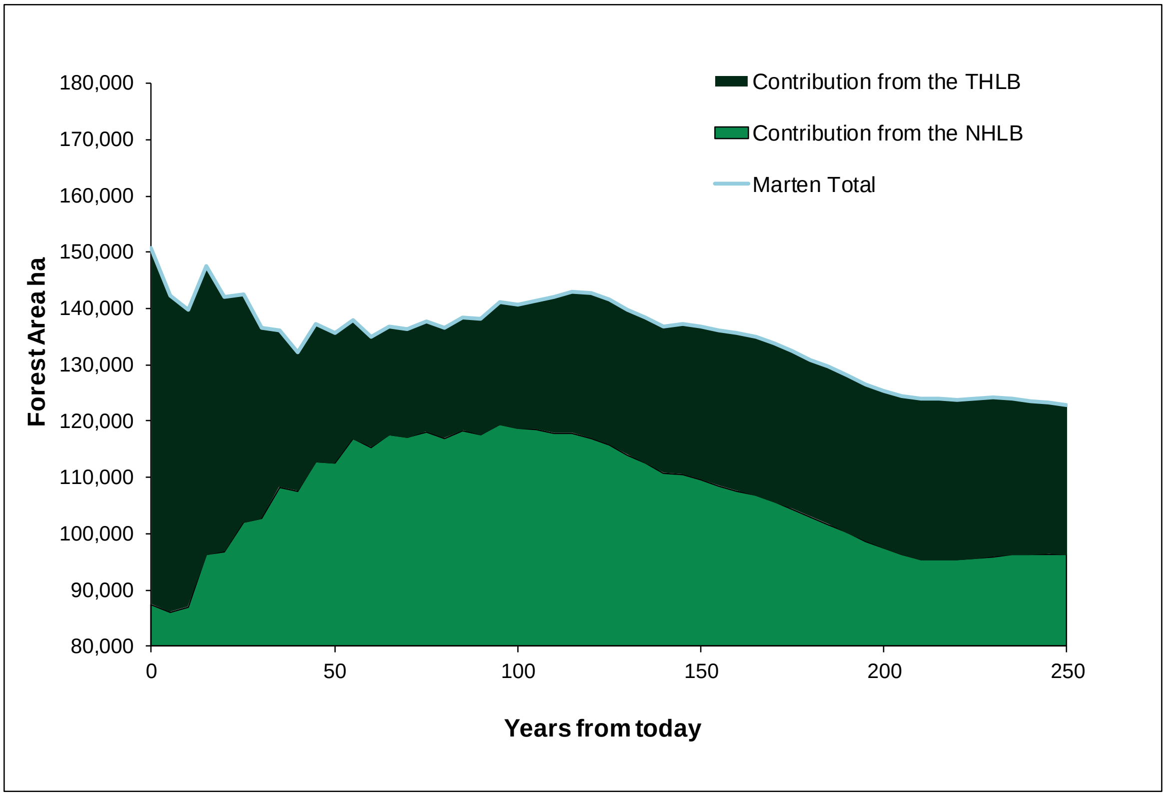

Figure 103: Predicted marten habitat for the Bulkley TSA; Selected Scenario

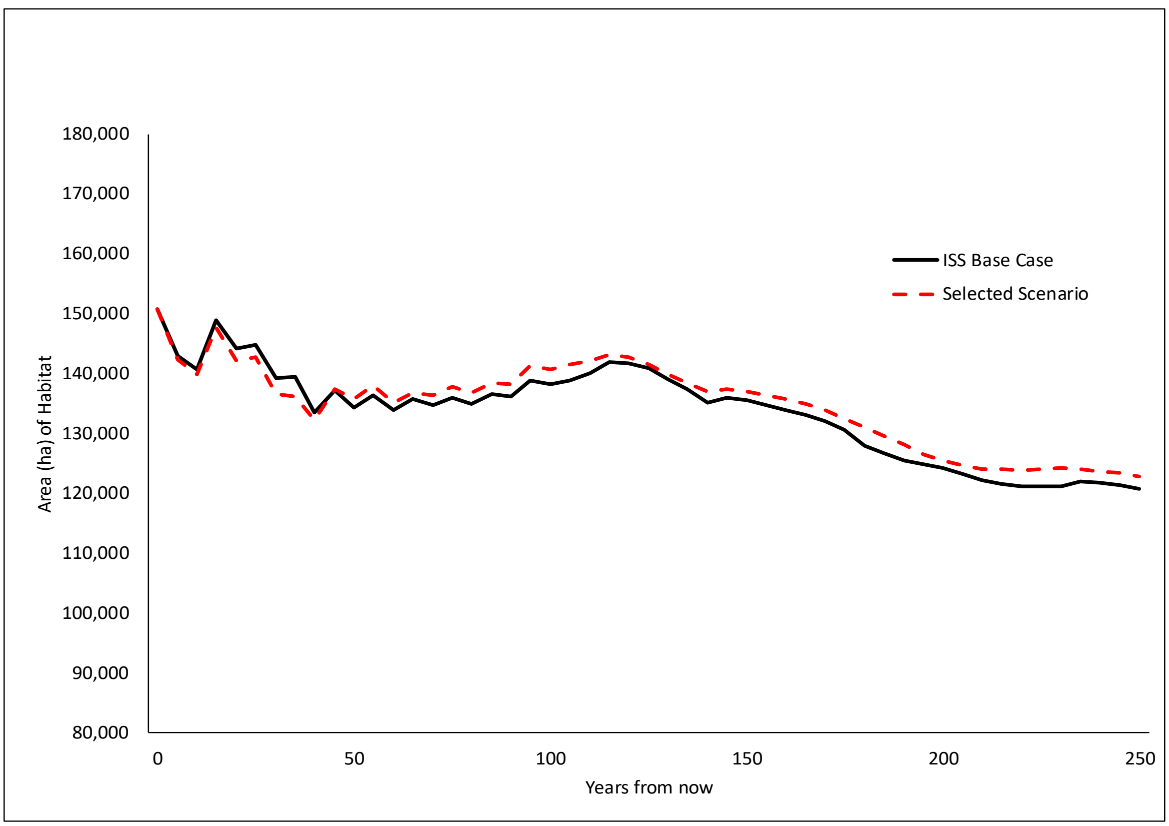

Figure 104: Predicted marten habitat for the Bulkley TSA; Selected Scenario and the ISS Base Case

4.5.10 Grizzly Bear

This analysis did not track suitable Grizzly bear habitat. Rather, it tracked poor Grizzly habitat in each LU and BEC variant. Poor habitat was defined as more than 30% mid seral stage (41 to 80-year-old stands) in each LU/BEC variant.

Figure 105 illustrates the predicted area of poor Grizzly habitat for the entire Bulkley TSA in the Selected Scenario compared to the ISS Base Case. The maximum target area shown in Figure 105 represents the aggregated maximum areas of all LU/BEC combinations (at 30%). The area of mid seral stage is predicted to increase modestly in the TSA over the next 100 years. In the long term, the mid seral stage area is forecasted to remain under 100,000 ha.

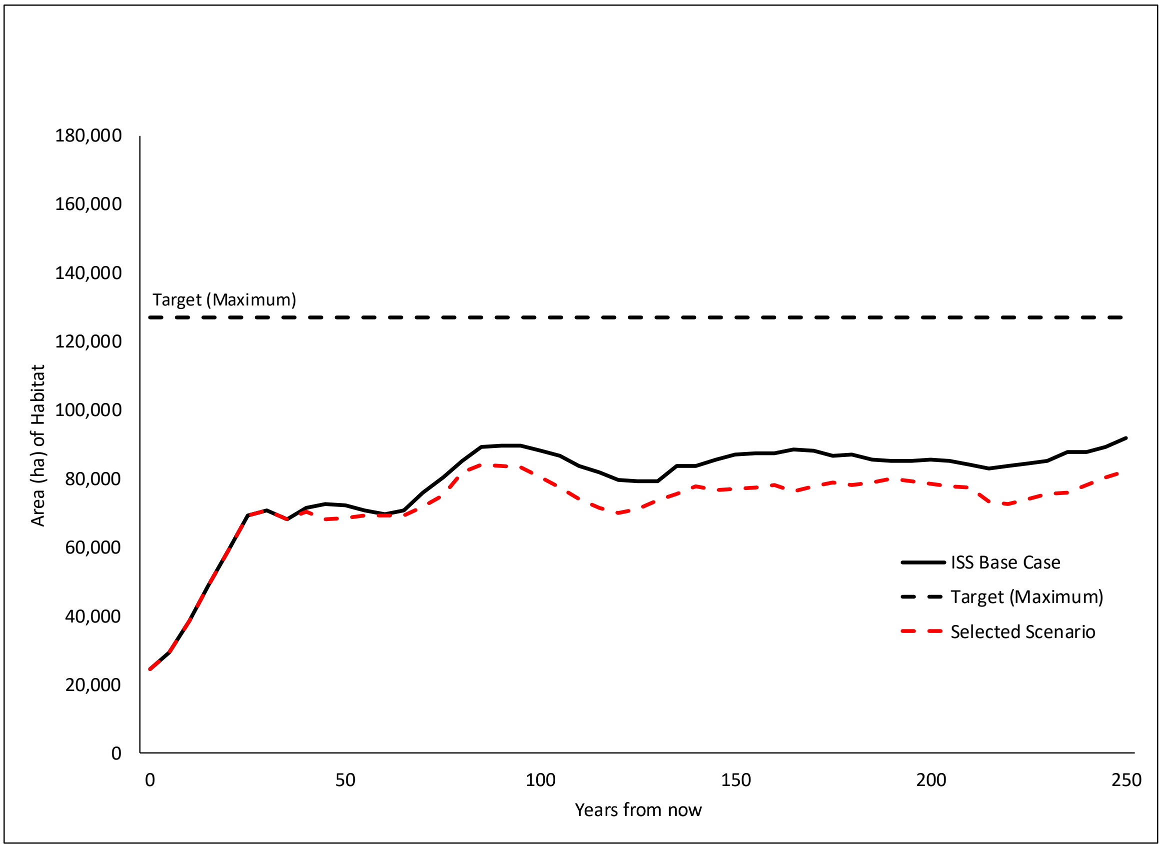

Figure 105: Forecast of poor Grizzly habitat in the Bulkley TSA, Selected Scenario

4.6 Sensitivity Analysis; Northern Goshawk Forage Areas

An additional sensitivity analysis using the most up-to-date projected NOGO territories in the model was completed to assess the potential timber supply impact of adopting the revised territories in resource management.

Figure 106 illustrates the predicted timber supply impact if the projected NOGO forage area targets are enforced. The short and mid-term harvest forecast is reduced by 2.8% and the transition to the long-term is delayed by 30 years. The long-term harvest forecast is reduced by 2.4%. The overall reduction is modest compared to the impact of the previous iteration of projected territories, which covered a significantly larger portion of the land base.

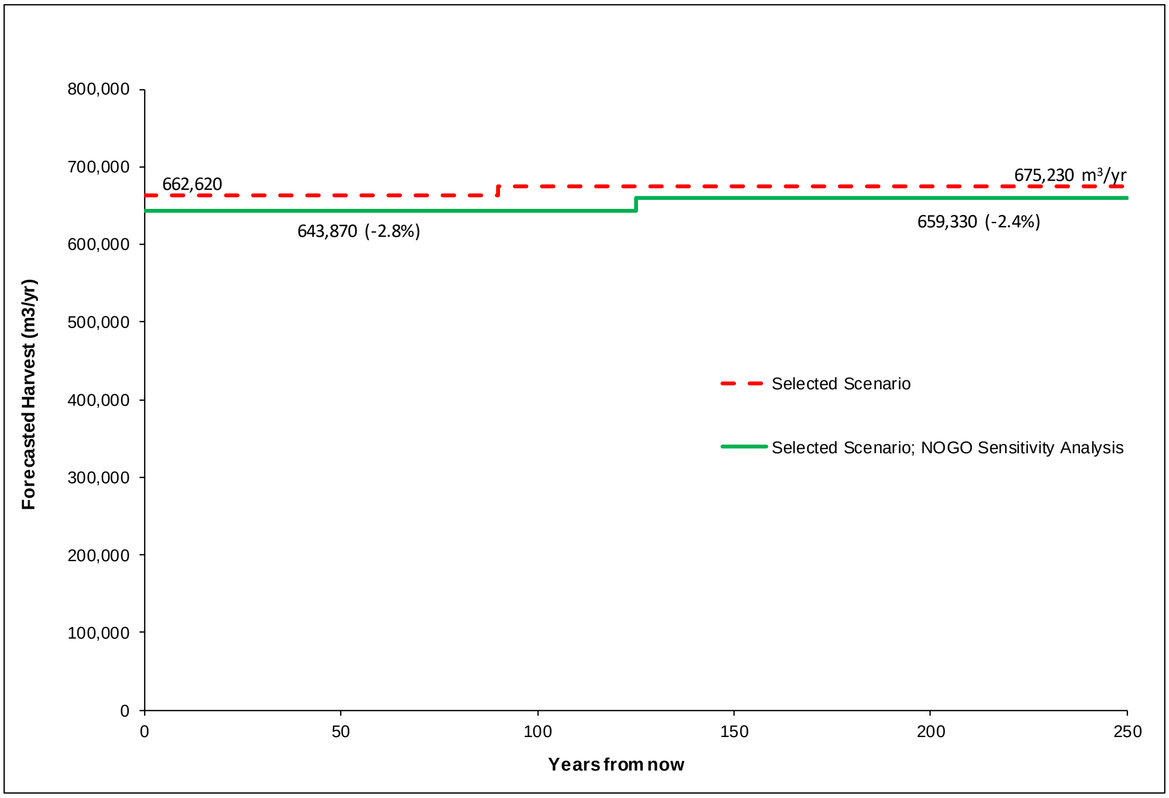

Figure 106: Sensitivity analysis; enforcing NOGO forage area targets in the Selected Scenario

As noted above, the achievement of NOGO forage habitat was controlled in this scenario. Figure 107 illustrates the forecasted NOGO foraging habitat for the aggregated forested area within the existing and projected NOGO territories over the planning horizon. The forage habitat remains at around 60% as per the target. The assumed succession of the NHLB reduces the forage habitat at times throughout the planning horizon.

As the foraging habitat distribution is controlled, individual territories also meet the forage targets as illustrated in in Figure 108. In this example the predicted NOGO forage habitat in one projected NOGO territory is mostly maintained. The reduction in forage habitat are caused by succession in the NHLB.

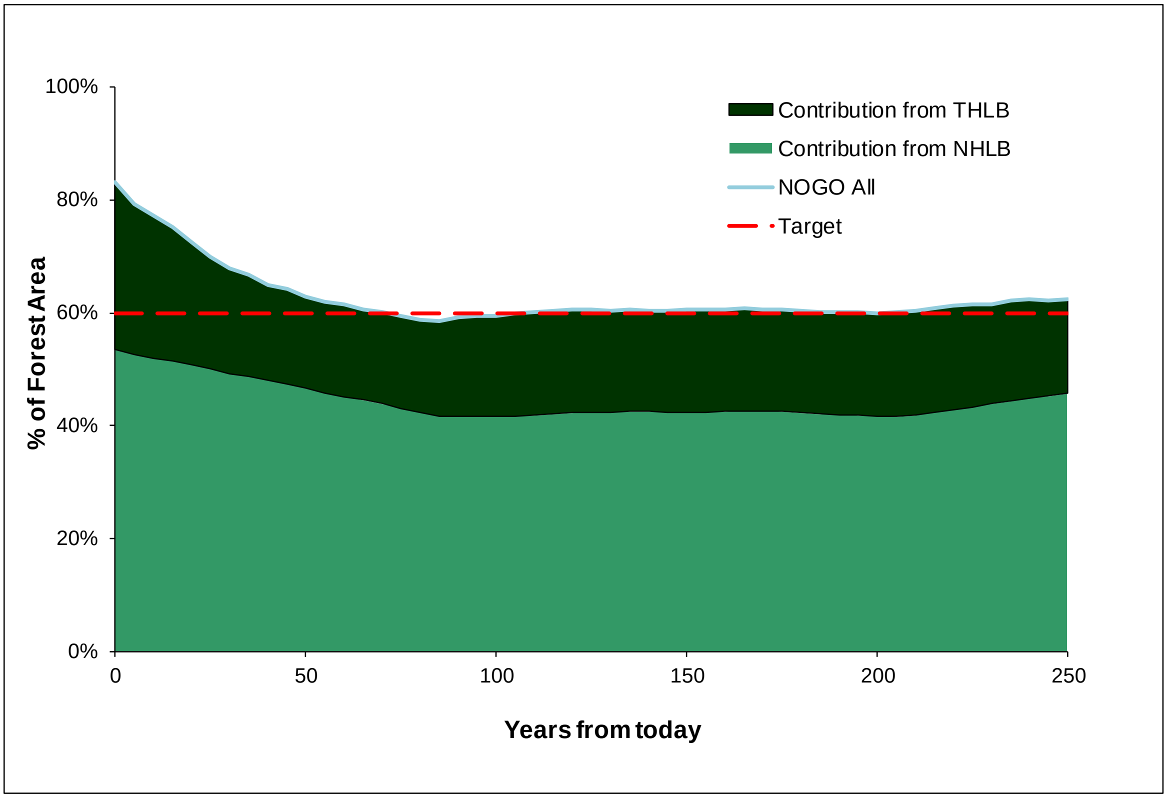

Figure 107: Selected Scenario NOGO sensitivity; NOGO forage habitat, all existing and projected NOGO territories

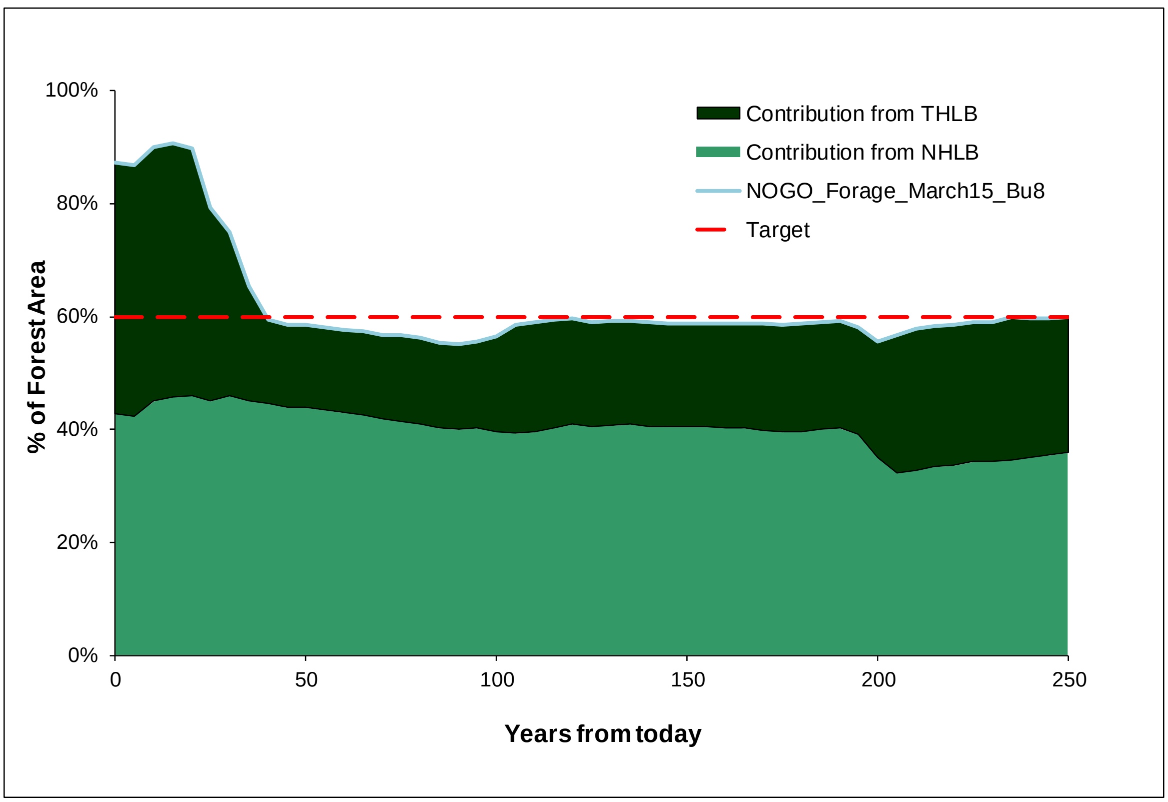

Figure 108: Selected Scenario NOGO sensitivity; NOGO forage habitat, one projected NOGO territory

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