Chapter 5: Scenario Planning

List of Tables

List of Figures

5. SCENARIO PLANNING

Chapter 5 of this Forest Management Plan describes forest management scenario planning within Forest Management Licence #3. The forest management scenarios are described and designed to provide benefits to the forest, wildlife, water, moose, and other ecological goods and services.

An overview of the Scenario Design is shown in Table 5.1. The development of the Baseline Scenario followed a stepwise process of incorporating the aspatial and spatial steps one at a time.

The Moose Emphasis Scenario was developed by building on the Baseline Scenario, with an effort to increase the quality of moose habitat, while maintaining other benefits.

Table 5.1 Scenario planning design overview.

		Forest Management Controls									Moose		
Category		Volume Flow	Operable Growing Stock	Overmature Seral Stages	Silviculture Ratios	Cover Type stability	Planned Blocks from Operating Plan (OP)	Transportation (roads)	Harvest Patches	Watersheds	Habitat Amount	Habitat Arrangement	Acvcess and Roads
Phase	Scenario Name												
Aspatial	Volume Flow	✓											
Aspatial	Operable Growing Stock	✓	✓										
Aspatial	Natural Range Variability	✓	✓	✓									
Aspatial	Silviculture	✓	✓	✓	✓								
Aspatial	Cover Type	✓	✓	✓	✓	✓							
Spatial	Planned Blocks	✓	✓	✓	✓	✓	✓						
Spatial	Roads	✓	✓	✓	✓	✓	✓	✓					
Spatial	Patches	✓	✓	✓	✓	✓	✓	✓	✓				
Spatial	Watershed	✓	✓	✓	✓	✓	✓	✓	✓	✓			
	BASELINE FOREST MANAGEMENT SCENARIO												
Moose	Habitat Amount	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Moose	Habitat Arrangement	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Moose	Access and Roads	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	MOOSE EMPHASIS FOREST MANAGEMENT SCENARIO												

The full details of scenario planning and modeling are very technical. Therefore, this chapter summarizes the scenario details and attempts to make scenario planning more readable to a general audience, not just to forest modellers.

Scenario planning is a method of exploring management alternatives and evaluating potential future forest conditions. A scenario defines a proposed management strategy, in terms of specific policies and practices, and the outputs of scenario modeling describe what is likely to happen if a certain course of action is pursued. Forest management scenarios are typically rich in detail, and the predictions are supported by science-based estimates of how natural systems change over time and react to harvesting and silviculture. A key advantage of scenario planning is that it allows forest planners to quantitatively estimate the benefits and potential impacts of management alternatives and compare them relative to each other to facilitate decision-making. The scenario planning process relies on computer modeling to manage the complexity that arises when combining information and management issues. It involves the analysis of different management strategies, goals, events, and practices that can be combined and compared in dynamic computer simulations. A preferred scenario represents a management approach that can balance values (ecological, economic, and social values), meet federal and provincial regulatory requirements, and is sustainable over the long term.

Scenario planning is an iterative process, involving rounds of analysis and consultation with the public, stakeholders, and various government departments to determine which scenario provides the best potential solution for obtaining the goals and values associated with a desired future forest. During the planning process, several innovative approaches were developed to estimate forest growth and succession, conduct biodiversity and spatial landscape assessments, model and track hydrological effects of harvesting and quantify other important indicators of forest sustainability. The focus of this chapter is to describe the scenario development process and explore some of the trade-offs among proposed management alternatives for FML #3.

5.1. MODELING CORE TEAM

A Modeling Core Team (MCT) was formed to assist with creating forest management scenarios. The Modeling Core Team was a small group of people focused on scenario design decisions and details of the development of the forest management scenarios.

Government, consultants, and industry team members were on the Modeling Core Team.

Government members of the MCT included:

- Andrew Grauman - Regional Forester (Western Region) – retired May 2019, therefore overlapped with David Chetyrbuk - Regional Forest Management Supervisor who represented the Western Region after Andrew retires
- Gerald Shelemy (Regional Biologist) Swan River, MB
- Jianwei Liu (Wood Supply Analyst) Winnipeg, MB
- Matthew Forbes Regional Forester (Western Region) as of Sept. 20th, 2019

Consultant members of the MCT included:

- Heather Tumber (ForSite consultants)
- Craig Robinson (ForSite consultants)

Industry members of the MCT included:

- Jeannette Coote – Mountain Forest Section Renewal Company
- Vern Bauman – Planner – Louisiana-Pacific Canada Ltd.
- Paul LeBlanc – District Forester - Louisiana-Pacific Canada Ltd.

The Modeling Core Team website was a hub to track details of the development of the Patchworks model, the scenario design decisions, and results of completed scenarios. The website was designed by ForSite consultants to allow team members to review information related to the wood supply modeling on their own time as it fits into their schedule. The website was used to review information and make decisions to keep the analysis moving forward. Team members commented and asked questions on. These comments and questions were seen by all members and provided a record of the discussion items during the analysis phase of the scenario development. Each phase of the analysis, changes to the datasets, and resolved issues were documented. This documentation facilitated the writing of Chapter 5 Scenario Planning by utilizing documentation and recorded the analysis process.

5.2. SCENARIO BACKGROUND INFORMATION

Scenario background information are important scenario items that are not a scenario control but are frequently referred to the later sections. These included:

- Estimating Future Forest Conditions
- Natural Range of Variability
- Harvest Disturbances and Wildfire Disturbances
- Managed Land Base vs. Unmanaged Land Base
- Current Cover Group vs. Cover Group
- Habitat Element Yield Curves
- Post-Harvest Transitions

5.2.1. Estimating Future Forest Conditions

Future forest conditions were estimated using the best information available. However, the accuracy of future predictions decreased with time. Future forest conditions 10 or 20 years from now will be more accurate than predictions 200 years from now.

The accuracy of future predictions also decreases with complexity. Simple predictions, such as stand age (*e.g.* 100-year old stand today will be aged 120 years, 20 years in the future) are more accurate than complex predictions (*e.g.* wildlife habitat 20 years in the future).

5.2.2. Natural Range of Variability

The Natural Range of Variability (NRV) attempts to describe what the forest would look like without human influence. Wild fire, insects, wind throw, and disease are the natural disturbance agents in the forest. These natural stand-replacing events have maintained all seral stages (young, immature, mature, and old) forest areas on the landscape.

In the boreal forest, wild fire and other disturbances have historically maintained ecosystems and their associated species. Therefore, NRV can be a historical tool that guides forest management. These concepts are well described in a short promotional video by FRI research in Hinton, AB:
http://lessonsfromnature.ca/

The Healthy Landscapes project https://friresearch.ca/program/healthy-landscapes-program was expanded to include FML #3 (Figure 5.1). The expanded project area totals 125 million hectares.

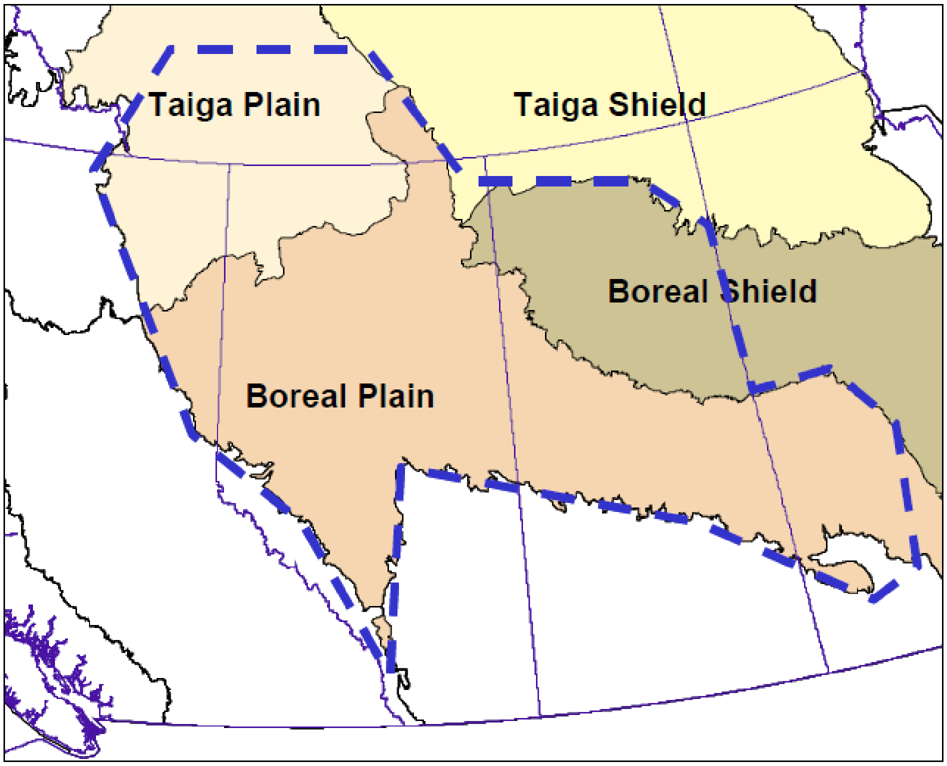


Figure 5.1 Healthy Landscapes project study area includes FML #3, which is in the Boreal Plain ecozone of Manitoba.

5.2.2.1 NRV Species Groups and Seral Stages

Prior to beginning the development of the Patchworks model, the species groups and the seral stage definitions were obtained from Andison 2019 to ensure that the definitions were aligned and could be used within the model. These broad species groups are used by the Healthy Landscapes project across the western boreal forest and are defined by the leading species of the stand. The corresponding Habitat Element Curve strata were aligned with the NRV broad species groups (Table 5.2).

Table 5.2 NRV broad species groups aligned with HEC strata.

NRV broad species groups	**HEC strata** (used in this plan)
White Spruce	SWD2, MWD2_M, MWD3_M
Black Spruce	SWD3, SWD4, SWD5
Pine	SWD1
Fir	n/a
Deciduous	HWD1, HWD2, HWD3
Mixed	MWD1_M, MWD1_N, MWD2_N

The Healthy Landscapes project uses 40-year age classes for all NRV analyses across the western boreal forest. Alignment with the 20 Year Forest Management Plan age classes are defined in Table 5.3. Note that the Modeling Core Team decided to modify immature and mature hardwood and hardwood mixedwood by 20 years (*i.e.* changed immature seral stage from 40 - 80 years to 40 - 60 years).

Table 5.3 NRV seral stage alignment with FMP age classes.

NRV seral stages	NRV Age Classes (years)	FMP Age Classes (years)	Stand Age (years)
Young	0 to 40 yrs	0 to 20 yrs	1, 2, 3...20 yrs
		20 to 40 yrs	21, 22, 23...40 yrs
Immature	40 to 80 yrs*	40 to 60 yrs	41... yrs
		60 to 80 yrs	61... yrs
Mature	80 to 120 yrs	80 to 100 yrs	81... yrs
		100 to 120 yrs	101... yrs
Old	120 + yrs	120 to 140 yrs	121... yrs
		140 to 160 yrs	141... yrs
		160 to 180 yrs	161... yrs
		180 to 200 yrs	181... yrs
		200 + yrs	201+ yrs

*immature deciduous was redefined by the Modeling Core Team as 40 - 60 years.

5.2.2.2 NRV Seral Stage Targets

Natural Range of Variation (NRV) provides a range of landscape scale patterns. A wood supply model can use NRV as a target (*i.e.* percent seral stage) to move towards. NRV can also be used as a tool to compare the current forest condition to the NRV historical range for the region. The NRV ranges help provide a benchmark for future landscape conditions to work towards. Using the NRV landscape ranges is a coarse filter approach to managing ecosystems and biodiversity.

The natural range of seral stages is expressed as descriptive statistics (*i.e.* median, minimum, maximum, and confidence interval) to accurately express the range of variation. A single number is insufficient to express the NRV range. This information is replicated in Patchworks to illustrate the natural range of variation in reports as a comparison or more importantly to use a part of the range as an objective in a scenario.

Boxplot information defines the simulated NRV ranges as a percentage of the land base area. These metrics included median, 25th and 75th percentiles, as well as minimum and maximum percentage of a seral stage across the landscape (Figure 5.2).

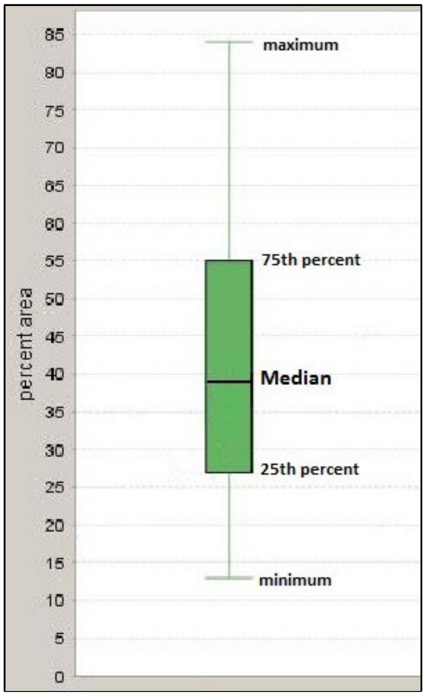


Figure 5.2 Boxplot seral stage ranges – annotated example.

The simulated NRV seral stage ranges developed for FML #3 by the Healthy Landscapes Program were displayed for softwood broad species groups in Figure 5.3, and deciduous and mixedwood in Figure 5.4. These ranges are a percentage of the land base by seral stages.

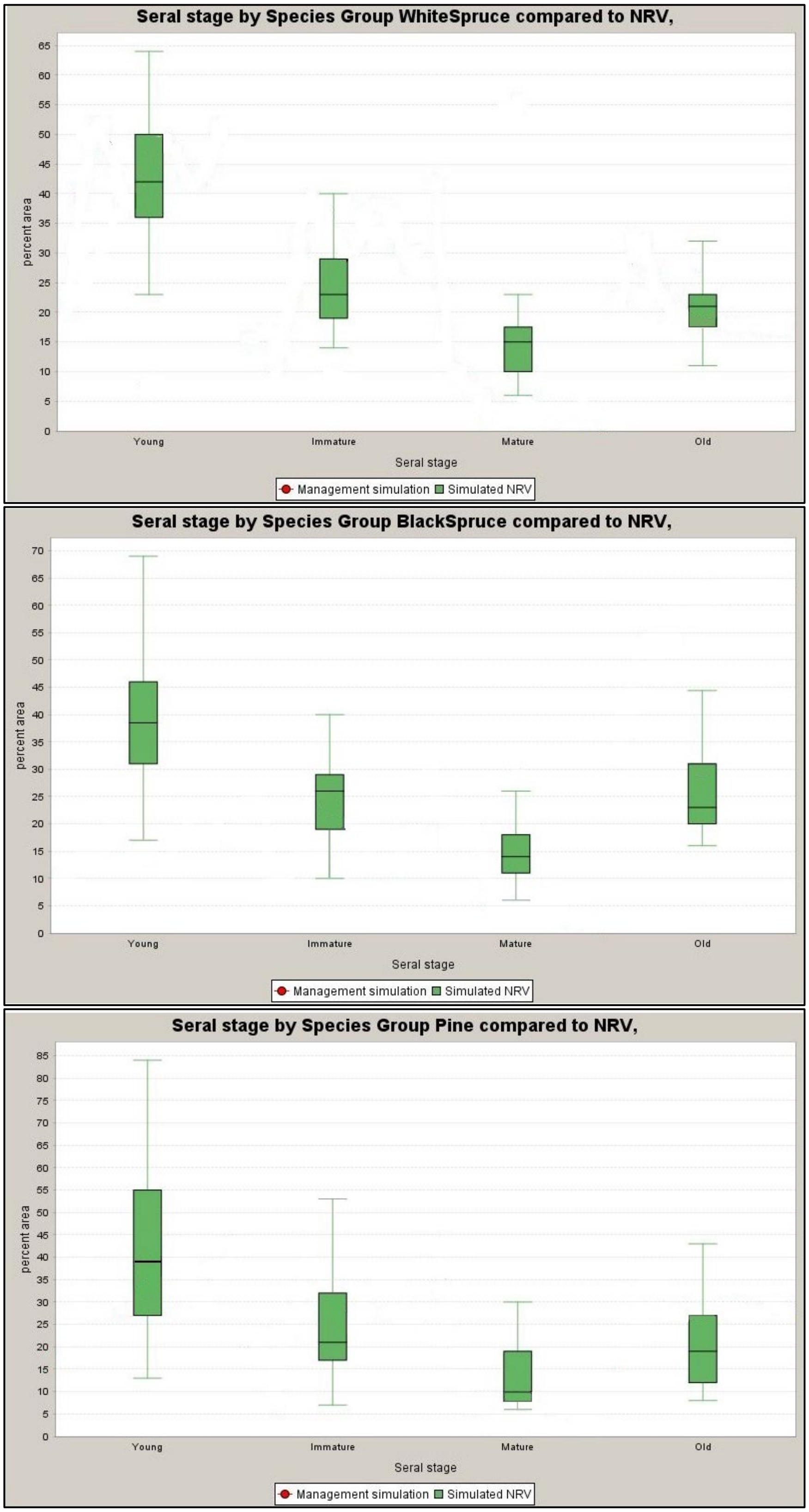


Figure 5.3 Simulated NRV seral stage ranges in FML #3 for white spruce (top), black spruce (middle), and pine (bottom).

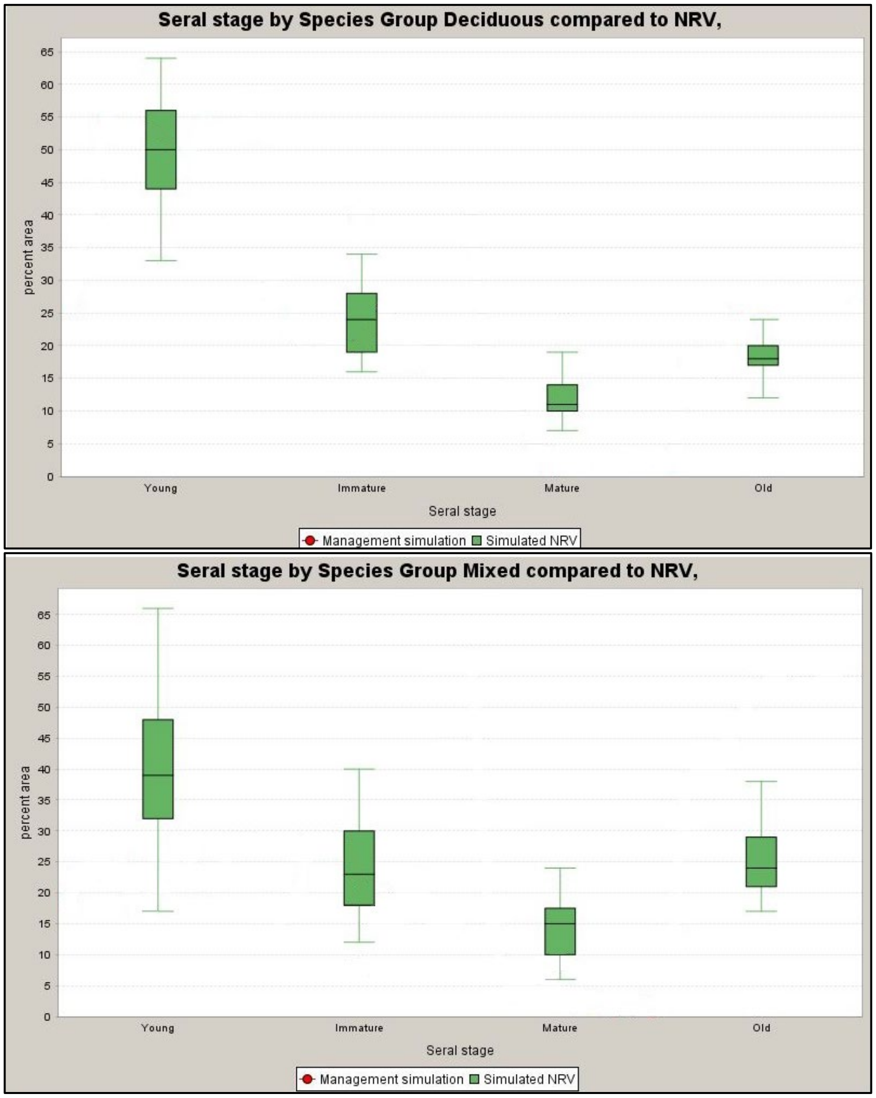


Figure 5.4 Simulated NRV seral stage ranges in FML #3 for deciduous (top) and mixedwood (bottom) broad species groups.

5.2.3. Disturbances – Harvest and Natural

In scenario planning, only future <u>harvest</u> disturbances were modeled. Wildfire disturbances cannot yet be modeled at the same time as harvesting. Insect and disease disturbances are likewise unable to be meaningfully modeled in conjunction with future harvest blocks.

5.2.4. Managed Land Base and Unmanaged Land Base

The total forested area in FML #3 is approximately 500,000 ha. 65% of the land base (325,528 ha) is managed land base (forest management area), while 35% of the land base (172,254 ha) is unmanaged (*e.g.* backcountry land use category, recreational land use category, protected areas, Wildlife Management Areas *etc.*).

Managed Land Base – management decisions such as harvest and silviculture treatments can be made on the managed land base. The managed land base will have harvest disturbances, which balances the age class structure of the forest. Maintaining all seral stages (*i.e.* young, immature, mature, and overmature) is an important feature for coarse-filter biodiversity, since different animals use different seral stages for their life requirements.

The **Unmanaged Land Base** - will not have any harvest disturbance or management decisions. We cannot reasonably model future disturbances such as fires, insects, or diseases that provide stand-replacing events. Therefore, we assumed the unmanaged landbase simply gets a modest amount (400 ha per year) of natural disturbance (stand-replacing fire, insects, or disease). Note that the unmanaged area is subject to natural trends, such as forest succession, which typically increases the softwood component of forest stands over time.

Many of the modeling reports in the scenarios are divided into managed and unmanaged land base metrics. This is an important distinction, since there is a different contribution of managed and unmanaged land base to the overall trends in FML #3.

5.2.5. Current Cover Group vs. Cover Group

Current cover group and **cover group** are two different ways to describe the cover groups (H-hardwood, N-hardwood mixedwood, M-softwood-mixedwood, and S-softwood cover groups). Both systems are detailed below. Forests stands are dynamic and can change cover group in an undisturbed stand over time due to forest succession. Disturbed (harvested) stands can change due to silvicultural treatments, such as planting softwood seedlings.

Current Cover Group represents the cover group of the stand within the Habitat Element Curves and represented natural forest dynamics. Current cover group can change over time, especially over a 200-year modeling run (Figure 5.5). For example, HEC strata MWD2_N stand starts as an N cover group (hardwood-mixedwood), but undisturbed the same MWD2_N stand increases the amount of softwood due to forest succession and will become a M cover group (softwood-mixedwood).

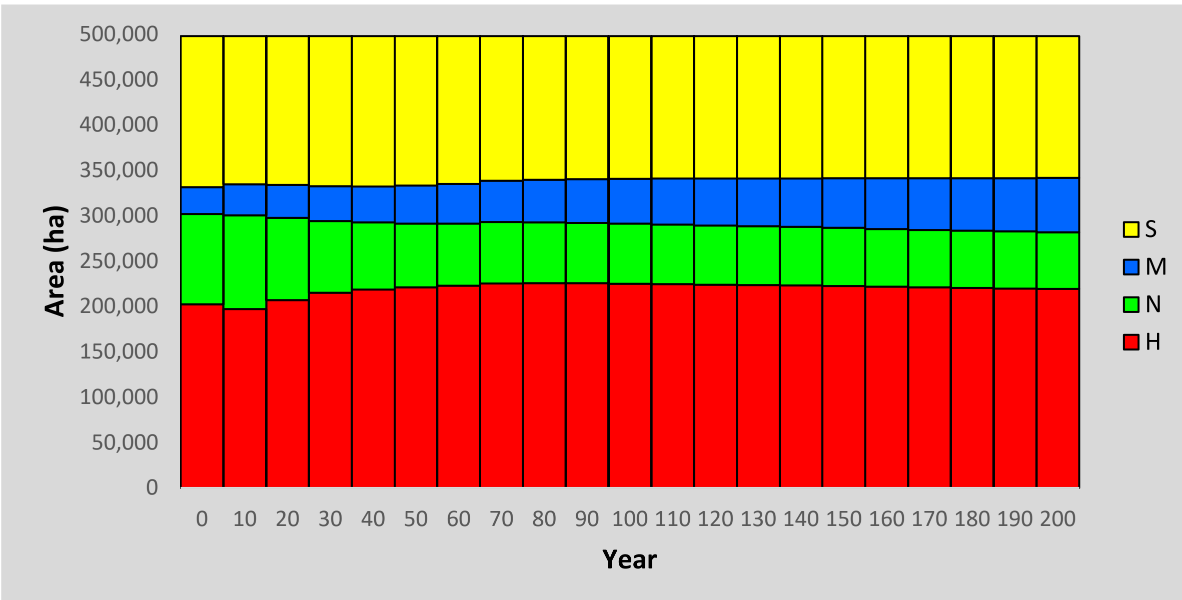


Figure 5.5 Current cover group area change estimates over 200 years in FML #3.

The softwood cover type (S) is projected to remain stable in the absence of any transitions related to management. Some of the H-hardwood cover group's area naturally transitions to a mixedwood type (N and M) over time, due to forest succession.

Cover Group is a more permanent classification by Habitat Element Curve strata. Cover group is assumed to stay the same (Figure 5.6), unless disturbed and silviculturally treated. For example, HEC strata MWD2_N starts as an N cover group (hardwood-mixedwood) and is harvested. If planted to softwood, the original MWD2_N can change HEC strata to a MWD2_M or a SWD2.

The following represents the Cover Group categories in the model:

- **S** (softwood) – HEC strata: SWD1, SWD2, SWD3, SWD4 and SWD5 (unmanaged only)
- **M** (softwood mixed) – HEC strata: MWD1_M, MWD2_M, MWD3_M
- **N** (hardwood mixed) – HEC strata: MWD1_N, MWD2_N, MWD3_N
- **H** (hardwood) – HEC strata: HWD1, HWD2, HWD3

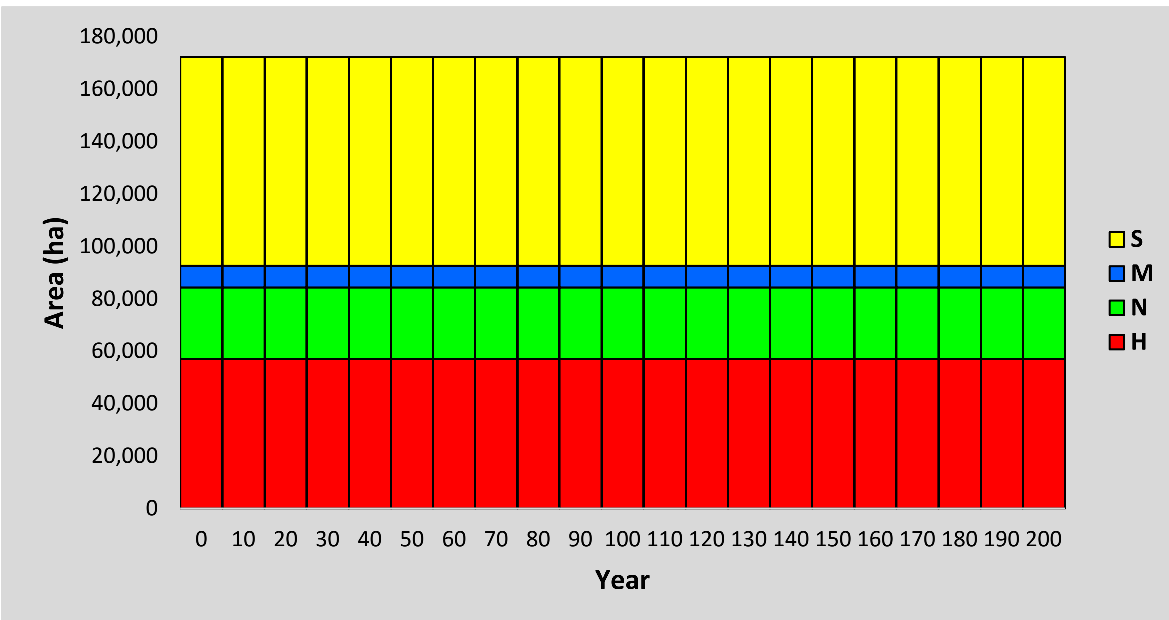


Figure 5.6 Cover group estimates over 200 years in FML #3.

5.2.6. Habitat Element Yield Curves

An identification and understanding of links between mapped inventory stands and habitat elements (*i.e.,* stems per hectare, diameters of live and dead trees, proportions of hardwood and softwood species within a stand *etc.*), are critical in order to insure the sustainable management of our forest in terms of forest product, wildlife and biodiversity.

The standard volume over age curve (yield curve) that is most often used in forest management planning does not usually account for these critical linkages to wildlife and biodiversity. Habitat Element Curves (HEC) fill this gap by including:

- snags over age;
- species composition over age;
- coarse woody debris over age;
- tree and snag diameter over age;
- shrub cover over age; and
- other metrics which have strong linkages to wildlife habitat and biodiversity.

Louisiana-Pacific Canada Inc. commissioned the development of empirical yield curves, based on ecosite conditions using plot level data from the Duck Mountain area. Later, an analysis of Canadian Forest Service (CFS) permanent sample plots was included. The PSP data consisted of measurements within mixedwood stands in nearby Riding Mountain National Park that featured periodic measurements over the last fifty years.
Given the quality and quantity of data, priority was given to construct a set of yield curves that not only forecasted changes in standard forest volume over time, but also described linkages between key stand attributes and habitat elements. In response, a suit of "process based" yield curves were developed. These process-based curves built upon the standard empirical yield curves to better forecast forest dynamics further into the future. The concept behind the process-based yield curves was to construct estimates of various stand conditions based upon simple growth inputs and allometric tree and stand functions. As the data and the purpose evolved to track habitat elements rather than only yield, the name Habitat Element Curves (HEC) was adopted in place of process-based yield curves. The HEC allow for modeling of not only growth and yield, but also stand characteristics that are used to model forest wildlife and biodiversity.

Essentially, the HEC model is a suite of growth curves developed for 13 ecological strata that describe and forecast various forest ecosystem characteristics (*e.g.* species composition, stems density, snag density, average tree diameter and height *etc.*)
over a range of stand development (0 to 400 years old).

The HEC are first partitioned by forest cover type, based on 1,467 Temporary Sample Plots collected during the creation of the Forest Lands Inventory for the Duck and Porcupine Provincial Forests in 2002. The forest cover partition includes four broad forest types, including: *hardwood*, *hardwood- mixedwood*, *softwood-mixedwood*, and *softwood.* The labels refer to the expected forest type at maturity. Secondly, the HEC are partitioned by soil moisture and texture combinations associated with known EcoSeries. This accounts for a variety of soil conditions, from dry/coarse soils to wet/organic soils. These sub-strata are stable over time and are a function of landform and soil type. Combining forest cover with EcoSeries yields 13 strata each having a separate series of habitat element curves (Figure 5.7).

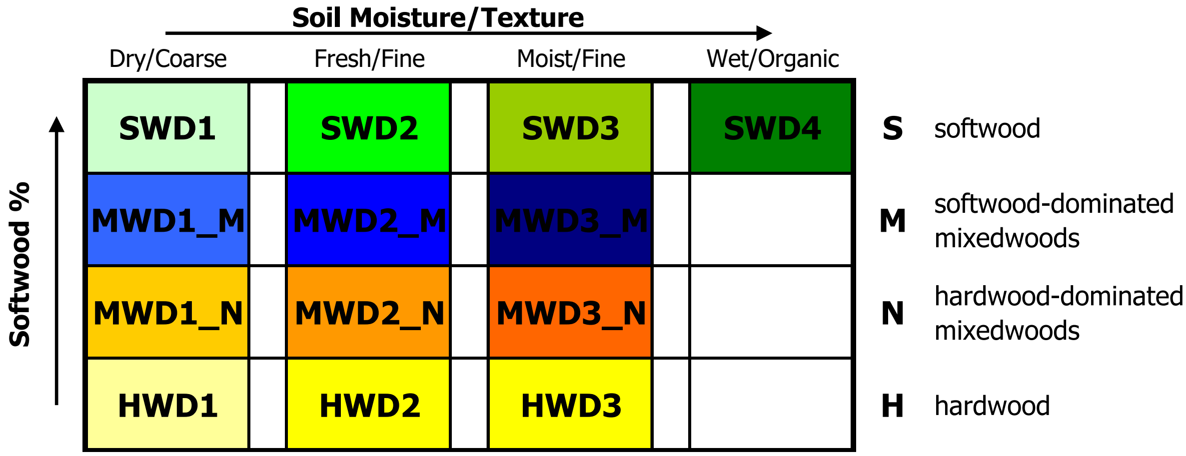


Figure 5.7 Habitat Element Curve (HEC) ecological strata used in all aspects of modeling in the 20 Year Forest Management Plan.

Therefore, there are three kinds of aspen forest: aspen on dry sand; aspen on fresh clay; and aspen on wet clay. Sub-dividing the forest types greatly enhances the 'ecological relevance' and strengthens the linkages to wildlife habitat and biodiversity. Tree volume, which is the only metric in a standard yield curve, is not strongly correlated to wildlife habitat or biodiversity.

To develop a model of stand development that could be used to account for forest successional trends over 100 years into the future, work by Dr. Norm Kenkel (University of Manitoba Ecology) was integrated into the HEC. Dr. Norm Kenkel quantitatively determined successional trends in boreal mixedwood forest from Permanent Sample Plots established and remeasured in the Riding Mountain area from 1946-1969, and a sub-set of PSPs were remeasured in 2002. These successional trends in stands aged 90 to 200 years old were utilized to guide the HEC for older stands.

Manitoba Conservation-Forestry Branch requested that the HECs be validated in 2005. Therefore, during the spring and summer of 2005 the HECs were tested to validate model components using independent data sources, including sets of temporary and permanent sample plot data from FML #3. Validation exercises included rigorous sets of statistical procedures that compared relationships and predictions from the HEC with actual observed data. This work was completed by August of 2005. The HEC model integrates all available data with expert opinion in a fashion suitable for the forest management model Patchworks.

5.2.7. Post-Harvest Transitions

Post-harvest transitions refer to the cover group (*i.e.* hardwood; hardwood-mixedwood; softwood-mixedwood; and softwood stands) that a stand regenerates to after harvest and renewal activities. Post-harvest transitions are a very sensitive model input and have a significant influence on the species composition of the future forest. The species composition of the forest is further influenced by wildlife habitat values, biodiversity, and other important forest values.

Silviculture survey data was used (*i.e.* Free-To-Grow plantation surveys at 14 years old (Table 5.4), and hardwood regeneration surveys for age 5 years (Table 5.5)) to provide a first approximation of post-harvest transitions for ages 5 to 14 years post-harvest. Data from 1996 to 2017 harvest blocks was used.

Table 5.4 Responses to plantation silviculture.

PLANTED: Based on data collected from blocks at harvest year of 1996 and above from FML #3					
	post-S	**post-M**	**post-N**	**post-H**	**Area (ha)**
pre-S	**62%**	29%	8%	1%	**2,436**
pre-M	31%	**44%**	21%	4%	**3,095**
pre-N	24%	48%	**23%**	5%	**8,020**
pre-H	8%	40%	33%	**19%**	**5,013**

Table 5.5 Responses to Leave-For-Natural silviculture.

	post S	**post M**	**post N**	**post H**	**Area (ha)**	**data sources:**
pre-S	**51%**	34%	10%	5%	**663**	all historical survey data collected from FMU 13 (survey years: 1986 to 1995)
pre-M	28%	**56%**	8%	8%	**967**	all historical survey data collected from FMU 13 (survey years: 1986 to 1995)
pre-N	1%	6%	**19%**	74%	**2,003**	data collected from blocks at harvest year of 1996 and above from FML-3
pre-H	1%	2%	6%	**91%**	**14,148**	data collected from blocks at harvest year of 1996 and above from FML-3

5.3. NO HARVEST MODELING

The 'no harvest' modeling showed how the forest changes in the absence of harvesting disturbance. This was valuable modeling that helped us understand and recognize trends that could potentially be masked within forest management scenarios.

5.3.1. Natural Forest Succession

The no harvest modeling clearly showed natural forest successional trends (Figure 5.8), increasing softwood at the landscape level. Some cover type H (hardwood) stands naturally succeed into the N cover type (hardwood-mixedwood) and later develop into an M cover type (softwood-mixedwood) as stands aged in the absence of disturbance.

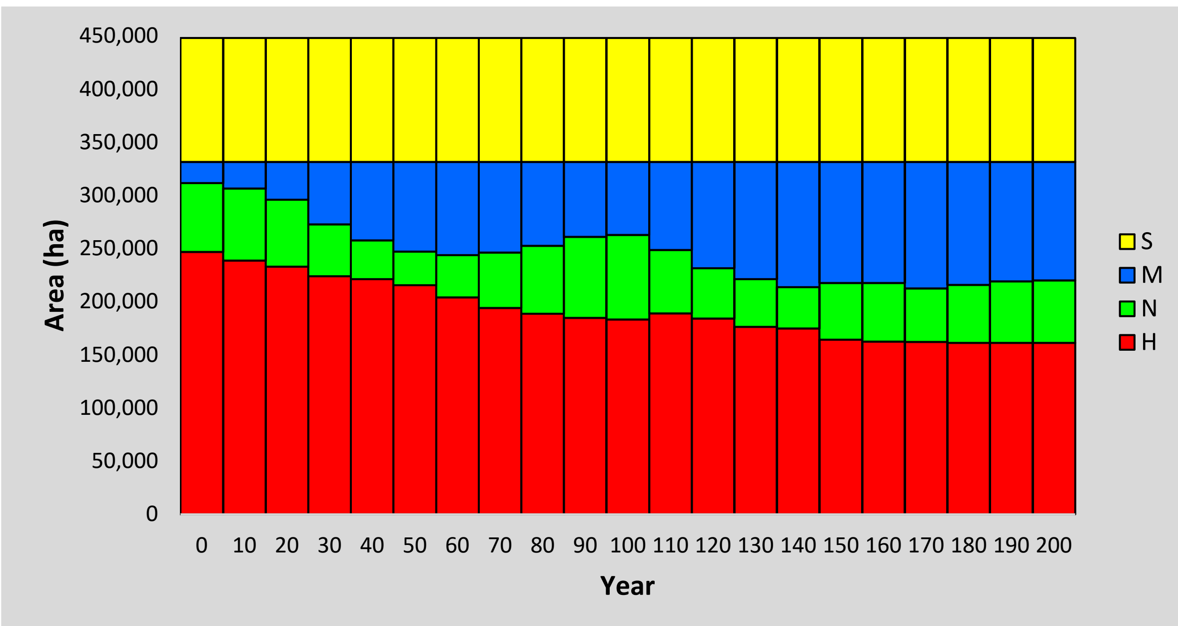


Figure 5.8 No harvest cover groups increase the amount of mixedwoods due to natural forest succession.

5.3.2. Age Class Changes with No Disturbance

No disturbance means no harvest or stand-replacing events occur. Therefore, we can only assume the land base simply gets older, until the all the forest is old (Figure 5.9). There are other disturbances in the boreal forest, such as fires, insects, or diseases that may cause stand-replacing events. None of these disturbances can be meaningfully estimated or modeled in conjunction with harvesting.

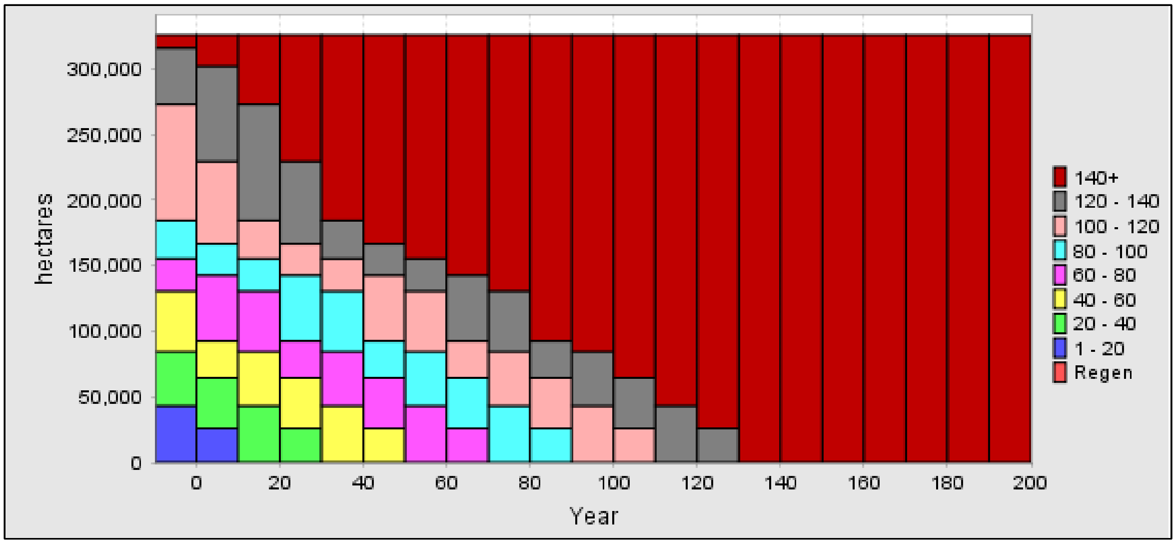


Figure 5.9 Forested land base becomes all old forest in the absence of disturbance.

5.4. BASELINE SCENARIO DEVELOPMENT - ASPATIAL CONTROLS

Aspatial controls are non-spatial and not location specific. Generally, aspatial items are landscape-wide across the entire land base. Aspatial controls were incorporated into the scenarios first. Later, spatial controls were added into the Baseline scenario. The development of the Baseline scenario's aspatial controls are documented in this section.

The aspatial controls used to create the Baseline Scenario include:

- Harvest Volume Flow (of softwood and hardwood)
- Growing stock (how much wood is in the entire land base)
- Old Forest Retention targets (how much area in old forest)
- Silviculture Treatments (planting softwood versus passive natural regeneration)
- Cover Type Stability (hardwood, mixedwood, and softwood)

5.4.1. Harvest Volume Flow

Several scenarios were run to explore the potential future harvest volume flow of softwood and hardwood. These volume flow scenarios were used to calibrate the Patchworks model. These volume flow scenarios helped us understand the potential maximum volume capacity of the forest, in the absence of non-timber and ecological objectives. These scenarios maintained the volume flow and growing stock objectives for both softwood and hardwood.

Even-flow volumes and non-declining yields were tested in order to help check model inputs and translation into the Baseline scenario. These tests represent the 'bookends' of the harvest flow analysis and are <u>not</u> viable forest management alternatives. Furthermore, these tests help us understand the maximum capacity of the forest, and whether or not the estimates are within a reasonable range. Some of the initial calibration work only considered volume harvested in order to test the yield curves and management options. The two types of maximum harvest volume flow scenarios considered were Even-Flow and Non-Declining Yield.

5.4.1.1 Even-Flow

Even-Flow – volume harvested from each planning period was compared to the final planning period at 200 years.

- **0%** – even-flow scenario with strict control of no variation over the planning horizon
- **5%** – allowed a 5% increase or decrease as compared to the final planning period
- **10%** – allowed a 10% increase or decrease as compared to the final planning period

The even flow results below show the 0%, 5% and 10% flow variations by Forest Management Unit for softwood (Figure 5.10) and hardwood (Figure 5.11) volumes.

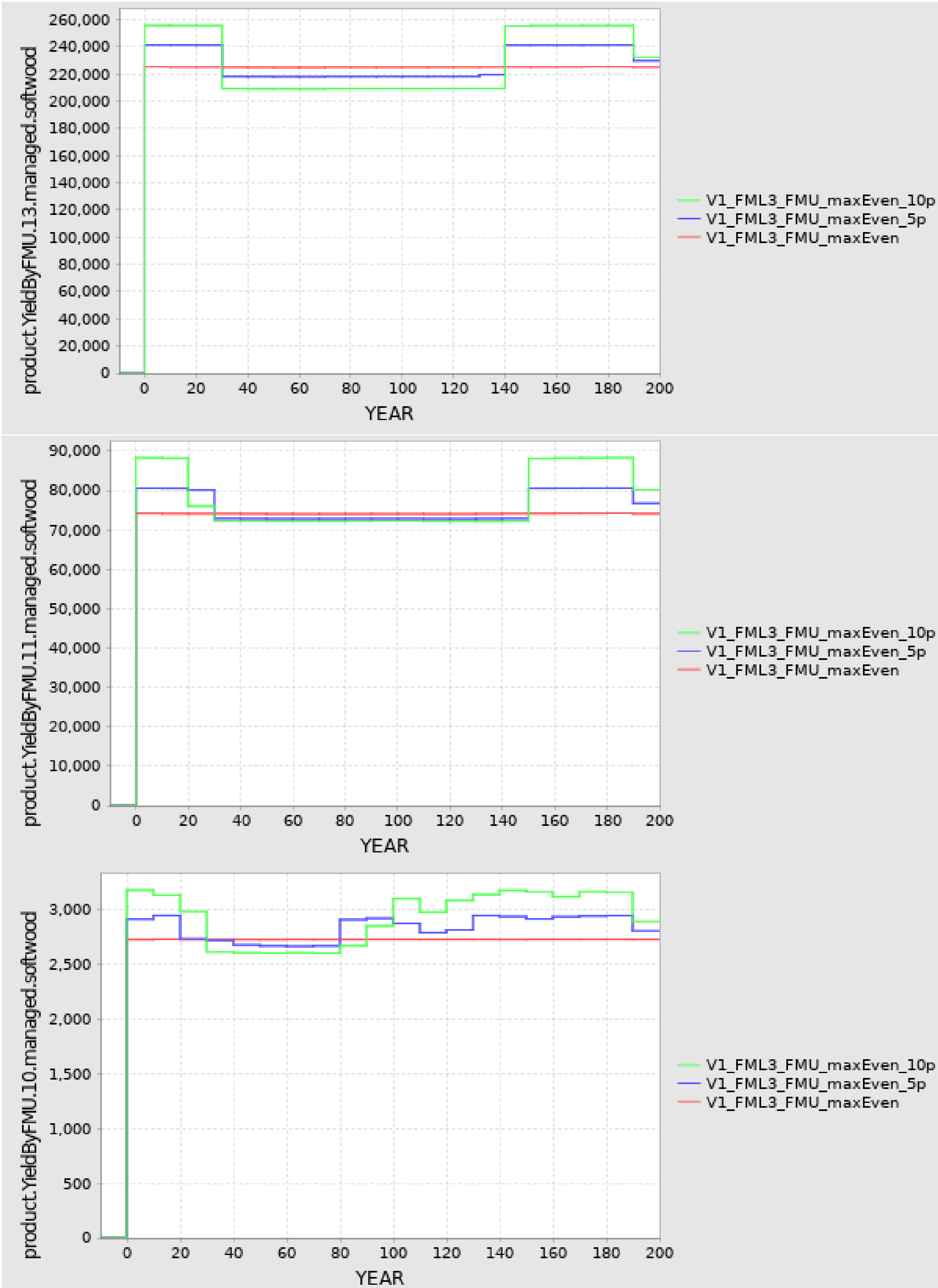


Figure 5.10 Even flow softwood volume results for 0%, 5%, and 10% variation of even flow for Forest Management Units 13 (top), 11 (middle), and 10 (bottom).

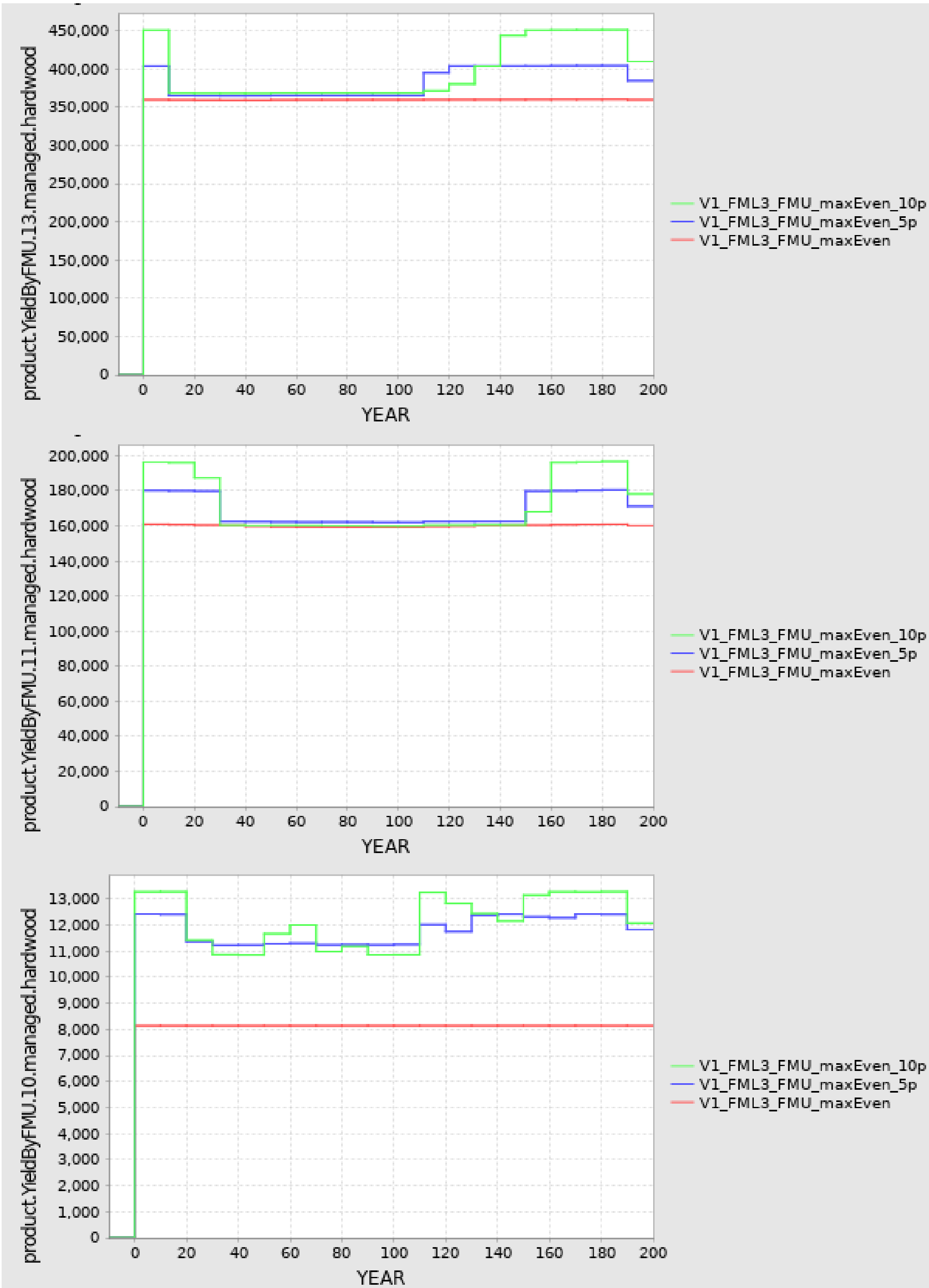


Figure 5.11 Even flow hardwood volume results for 0%, 5%, and 10% variation of even flow for Forest Management Units 13 (top), 11 (middle), and 10 (bottom).

Comparing even flow variations of 0%, 5%, and 10% shows that:

- An over-abundance of mature forest at the beginning of the planning horizon allows an increase in initial harvest levels if allowed some variation in flow; and,
- An increase in volume harvest at the end of the planning horizon is also realized in all cases when variation in flow is allowed.

The even flow scenarios (0% – red lines) are slightly lower than the 5% (blue lines) or 10% (green lines) variations. The lower volume from even flow is a result of moving the line to the lowest level over the 200-year planning horizon. The lowest level of available wood is in the middle of the planning horizon, when less natural mature and old forest are available for harvest.

Note that the FMU 10 hardwood even flow (0%) is significantly lower than the 5% or 10% variation, due to the very small amount of hardwood harvest. Approximately 35 hectares per year can be harvested in FMU 10, which excludes harvest in any stands greater in size than 35 hectares.

5.4.1.2 Non-Declining Yield

Non-Declining Yield – volume harvested from each 10-year planning period is compared to the previous 10-year planning period

- **0%** – non-declining yield was enforced by no change (0%) allowed between planning periods
- **5%** – an increase of 5% was allowed between planning periods
- **10%** – an increase of 10% was allowed between planning periods

The Non-Declining Yield flows present a different trend than even flow. Non-declining does not allow any change between planning periods. Therefore, there is no initial increase in harvest volume. The increase between planning periods is restricted to 5% and 10% and would occur later (*i.e.* 100 years or more from now) in the planning horizon for both softwood (Figure 5.12) and hardwood (Figure 5.13). The Forest Management Units with an older initial age class were more restricted by the Non-Declining Yield flow formulation. For example, FMU 11 violated the flow objective by decreasing slightly in the middle of the planning horizon. The model's preference is to quickly harvest the initial older age classes to allow the second rotation increase to be achieved sooner.

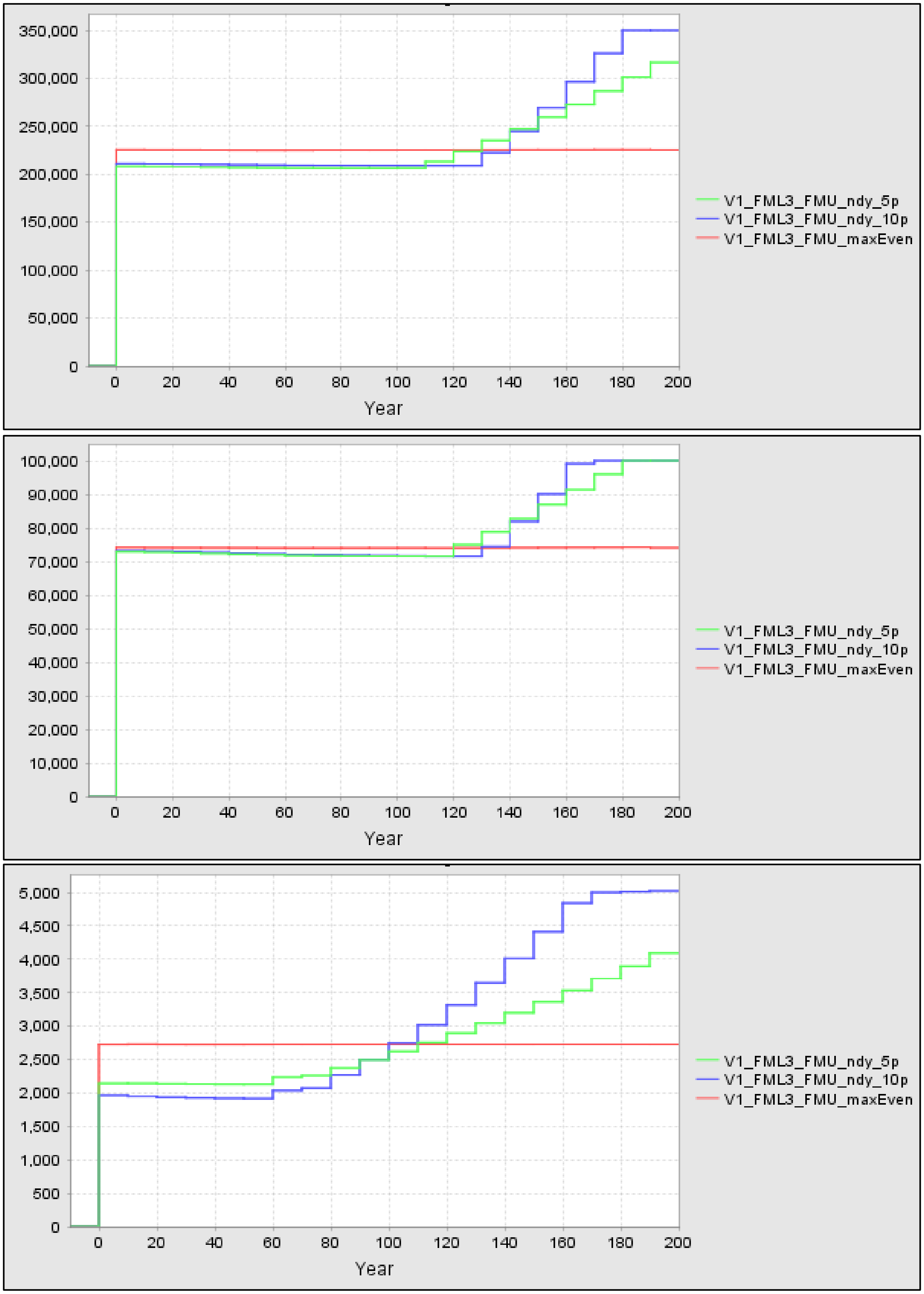


Figure 5.12 Non-declining yield softwood volume results for 0%, 5%, and 10% variations for Forest Management Units 13 (top), 11 (middle), and 10 (bottom).

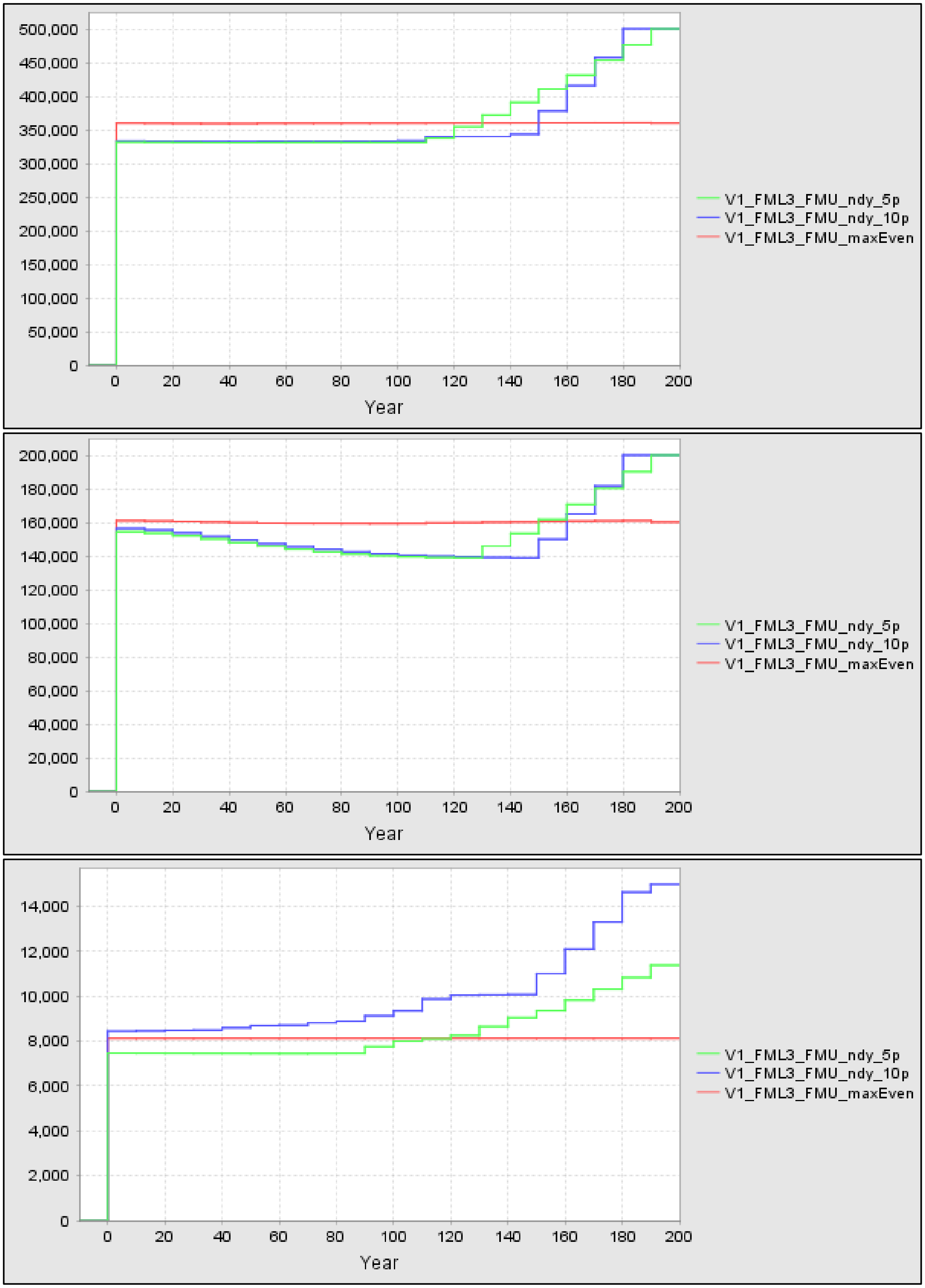


Figure 5.13 Non-declining yield hardwood volume results for 0%, 5%, and 10% variations for Forest Management Units 13 (top), 11 (middle), and 10 (bottom).

In all Forest Management Units, the initial Non-Declining Yield volume flow results in a lower harvested volume initial as compared to the even flow.

5.4.1.3 Harvest Volume Flow Decision

The Modeling Core Team chose even flow harvest volume over non-declining yield harvest volume. Even flow harvest volume had three choices of even flow, 0%, 5%, and 10% variation. The team chose 10% even flow variation to be utilized as a foundation for the Baseline Scenario.

5.4.2. Growing Stock Results

Growing stock is the amount (volume) of wood across the entire area. Total growing stock was evaluated versus operable growing stock. Total growing stock is the volume of all wood on the landscape, while operable growing stock is only the merchantable or harvestable volume of all wood on the landscape.

Growing stock constraints were added to the even flow volume scenarios to ensure sustainability over the planning horizon. The closing inventory constraint helps communicate to the model that a sustainable amount of growing stock must be maintained. A 50-year non-declining growing stock constraint was enforced in the final planning periods (*i.e.* 150 to 200 years from now), to ensure that there was no declining trend. This constraint also prevents the model from liquidating all remaining yield.

Two types of growing stock objectives were defined and tested:

- **total residual growing stock** – hardwood and softwood volume of all managed stands (all ages); and,
- **operable growing stock** – hardwood and softwood volume from operable stands (restricted by operable ages – stand must be old enough to be harvested).

5.4.2.1 Total Residual Growing Stock

The amount of total growing stock on the land base was projected to be stable on the FML #3 land base (Figure 5.14) after the overabundance of overmature age class has been harvested 40 years in the future. The amount of total hardwood growing stock tends to increase slightly after that, since more volume in the young mixedwoods builds up and is not harvested. Adding a total growing stock constraint to the baseline scenario has little impact on both the amount of growing stock in the final planning periods and the volume harvested.

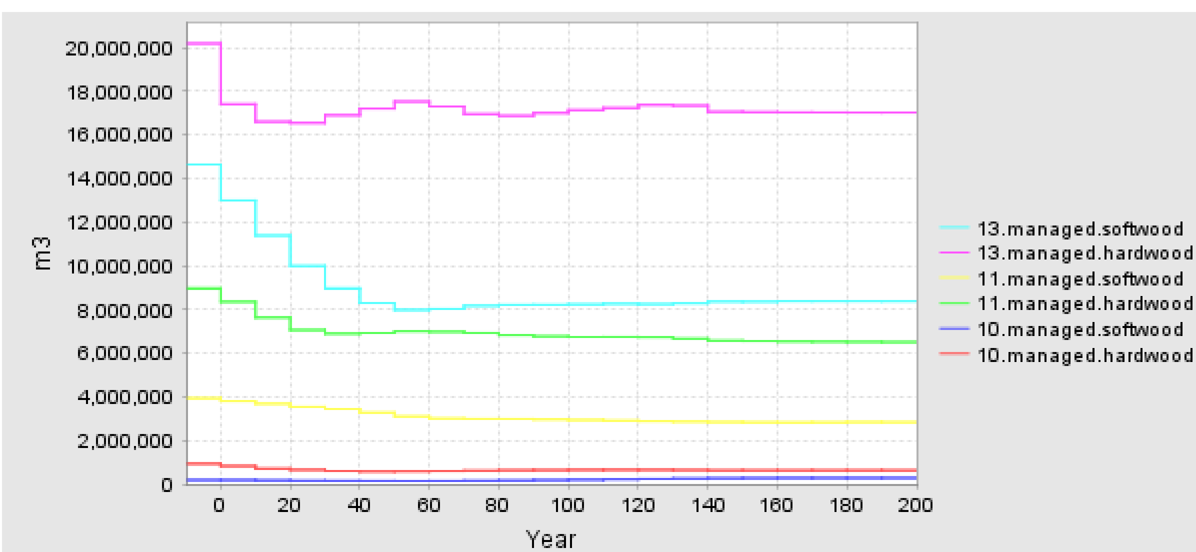


Figure 5.14 Total growing stock of wood for FML #3.

5.4.2.2 Operable Growing Stock

A constraint was applied to ensure a non-declining operable amount of operable growing stock in each Forest Management Unit for the remaining 50 years of the planning horizon (Figure 5.15). This did not impact the amount of volume harvested.

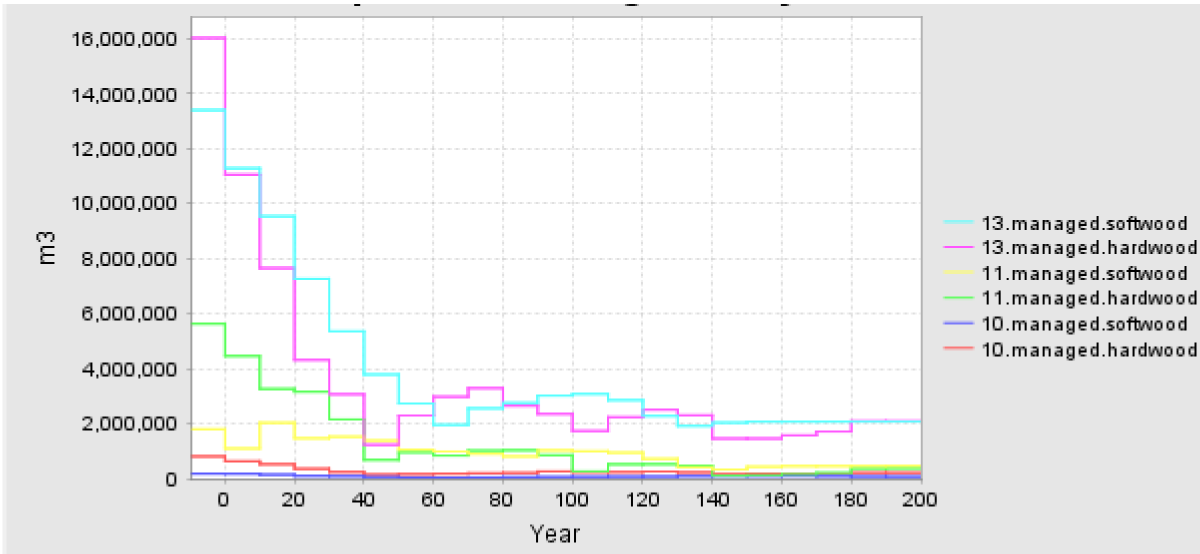


Figure 5.15 Operable growing stock of wood for FML #3.

The volume flow was restricted by the amount of operable wood on the land base. The restriction or 'pinch point' was projected to occur after 40 years in the planning horizon, but there is no pinch point in the final planning periods. The low point of the operable growing stock in most Forest Management Units and species groups was around 40-60 years in the future. The amount of growing stock for the remainder of the planning horizon was projected to remain stable.

In scenarios where the harvested volume can vary and increase over the planning horizon the closing growing stock objective (*i.e.* volume of growing in the last planning period 190-200 years from now) plays more of a role. However, it does not have a significant impact on volume harvested.

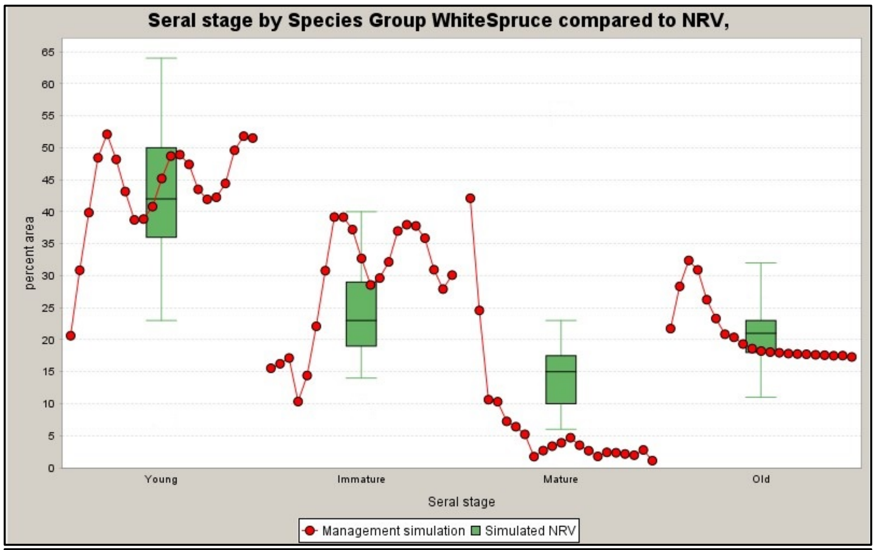
5.4.2.3 Growing Stock Decision

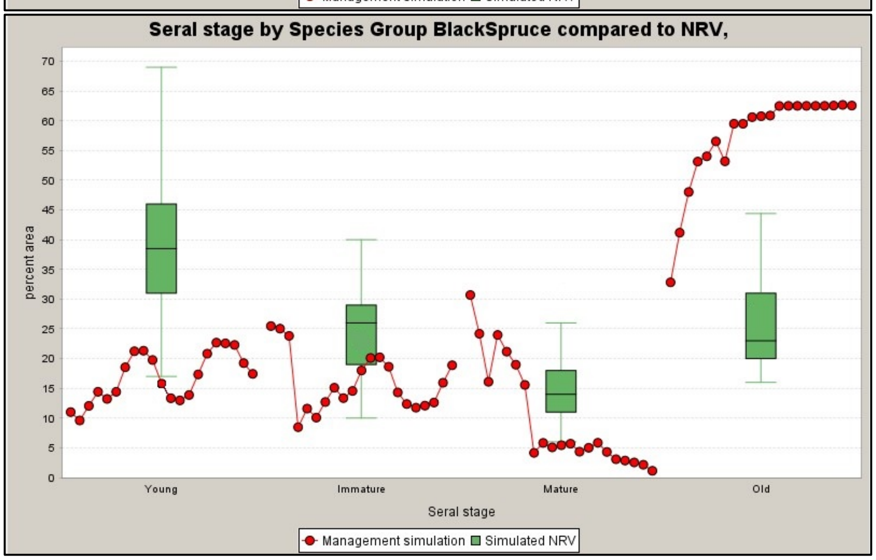
The Modeling Core Team decided to incorporate Operable Growing Stock for the Baseline Scenario. Further development of the Baseline scenario will be based on Operable Growing Stock, instead of Total Growing Stock.

5.4.3. NRV in the Baseline Scenario

The partially completed Baseline Scenario only had aspatial elements in it, when the Natural Range of Variation (NRV) analysis for FML #3 became available. Therefore, NRV ranges were incorporated as targets for mature and old seral stages, by broad species groups.

The red dots and red line on the graphs represent 10-year planning periods from time zero (year 2020) to 200 years in the future (year 2220). Initially, the future projections often missed the NRV range, which is represented by the green box in Figure 5.16. It was clear that simply adding NRV into the Baseline Scenario, without an NRV target, rarely met the simulated NRV range (*i.e.* green zone on graphs) for mature and old seral stages.





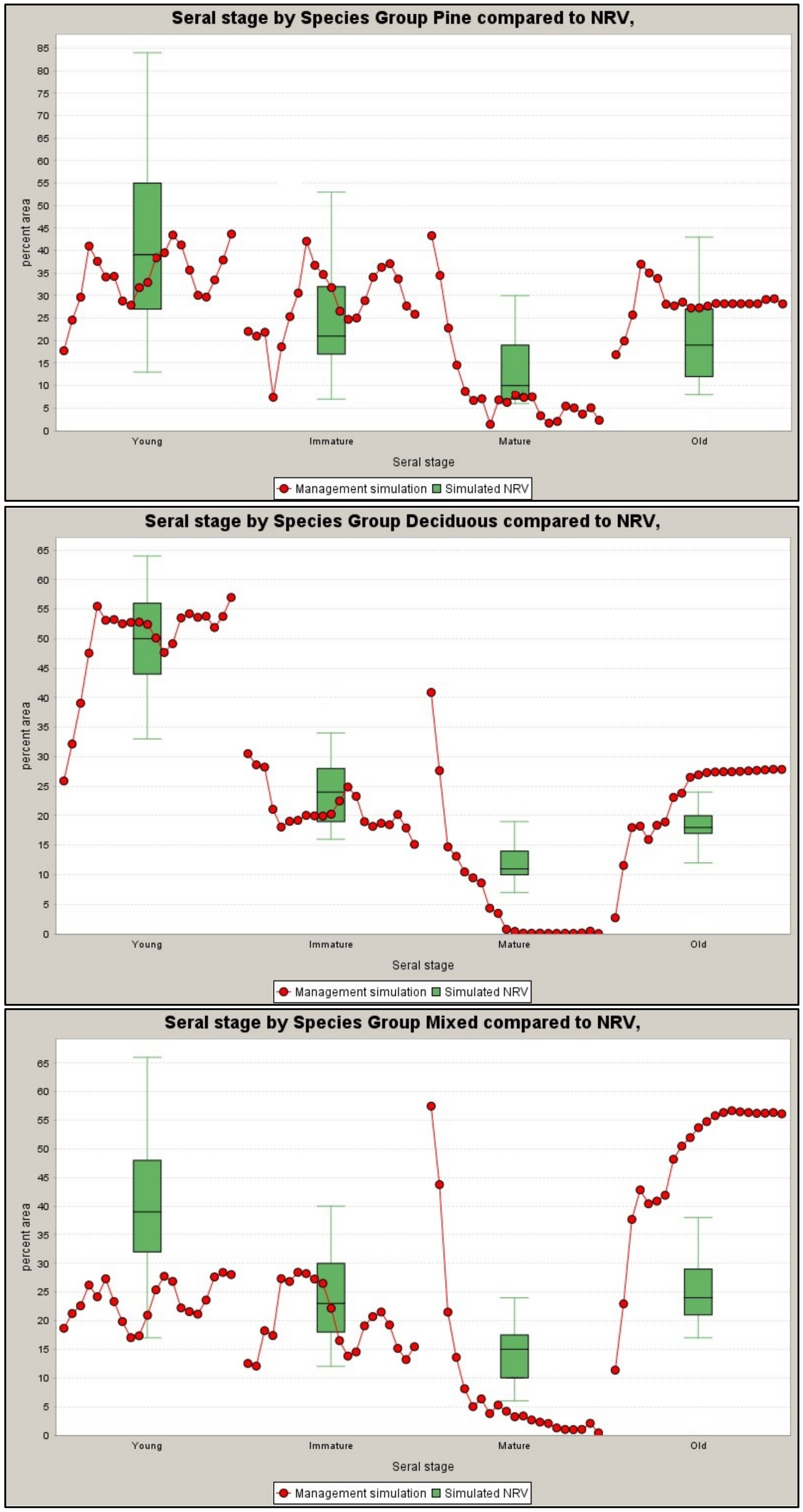


Figure 5.16 Initial simulated NRV seral stage ranges in FML #3 by broad species groups.

Natural Range of Variability targets (25th percentile by seral stage) were set for mature and old forest in the Baseline Scenario. For example, white spruce had a target of 18% of the old seral stage white spruce land base. This helped ensure that the landscape proportions of mature and old seral stages moved towards the target NRV ranges inside the green boxes and was a significant improvement.

5.4.4. Silviculture Treatments

There were two silviculture treatments used in the development of the Baseline Scenario for FML #3:

1) Planting of softwood seedlings to replace harvested softwood stands; and,
2) Natural regeneration (passive) of hardwood stands by root suckers.

These silviculture treatments were initially applied as a percent planted to the H, N, M, and S cover groups without a percent range. Later, the Modeling Core Team applied a range to the cover group percent planted treatment (Table 5.6). This allowed for more flexibility in the proportions and types of stands that can be planted.

Table 5.6 Initial percent planted silvicultural treatments applied by cover group.

Cover Group	% plant	Range %
H - hardwood	0%	0%
N – hardwood mixedwood	30%	+/- 10%
M – softwood mixedwood	80%	+/- 10%
S - softwood	90%	+ 10%

Later, in the H – hardwood cover groups, the proportion of planting in hardwood stands was increased from 0% to 2.5% allowing an additional pathway for creating mixedwood stands on the land base. The final planting proportions are in Table 5.7.

Table 5.7 Final percent planted silvicultural treatments applied by cover group.

Cover Group	% plant	Range %
H - hardwood	2.5%	-2.5%
N – hardwood mixedwood	30%	+/- 10%
M – softwood mixedwood	80%	+/- 10%
S - softwood	90%	+ 10%

There are real world circumstances where H – hardwood cover group stands get planted, including:

- Small portion(s) of a hardwood block that has concentrations of white spruce (*e.g.* 50 ha hardwood block with 4 ha of white spruce in a clump)

- Extra white spruce seedlings are sometimes available after all softwood cutovers have been planted. It is better to plant the spruce seedlings in a hardwood than to destroy the seedlings.

In FMU 10, there has been no planting of softwood, since almost all stands are hardwood, and almost no softwood stands get cut. Hardwood stands were targeted for harvest, as described in the volume flow section above. During the harvesting of hardwood stands, there is a small volume of residual softwood that could be harvested, or left in wildlife tree clumps. Renewal of softwood is accomplished by leaving softwood seed trees, combined with leaving small understory softwood trees unharvested, if present.

5.4.5. Cover Group Stability

The final step of completing the aspatial portion of the Baseline Scenario was to ensure stability of the cover groups S, M, N, and H at the landscape level. The goal was to create a realistic balance of cover types in conjunction with a reasonable ratio of planting to natural regeneration.

In the earlier cover group runs, it was apparent that maintaining 'N' on the landscape was a challenge, since there were many silviculture transitions that forced a net loss in the area of 'N' on the land base. In the cover scenarios, we investigated adding flexibility to the amount of cover for the model to retain over time. Two approaches were explored:

- The model was asked to retain +/- 15% of the starting area of each of H, N, M and S cover types over time, and;
- N and M were combined to create a 'mixedwood' group, and so the model was asked to retain +/- 15% of the starting area of each of H, (N + M) and S cover types.

The above targets were established in the model, forcing the proportions of the cover groups to remain stable throughout the 200-year time line (Figure 5.17). This required the model to consider how the treatment options it selects might impact the overall proportions on the land base each time a treatment decision is made. Maintaining cover groups received a very heavy target weight in the Baseline scenario.

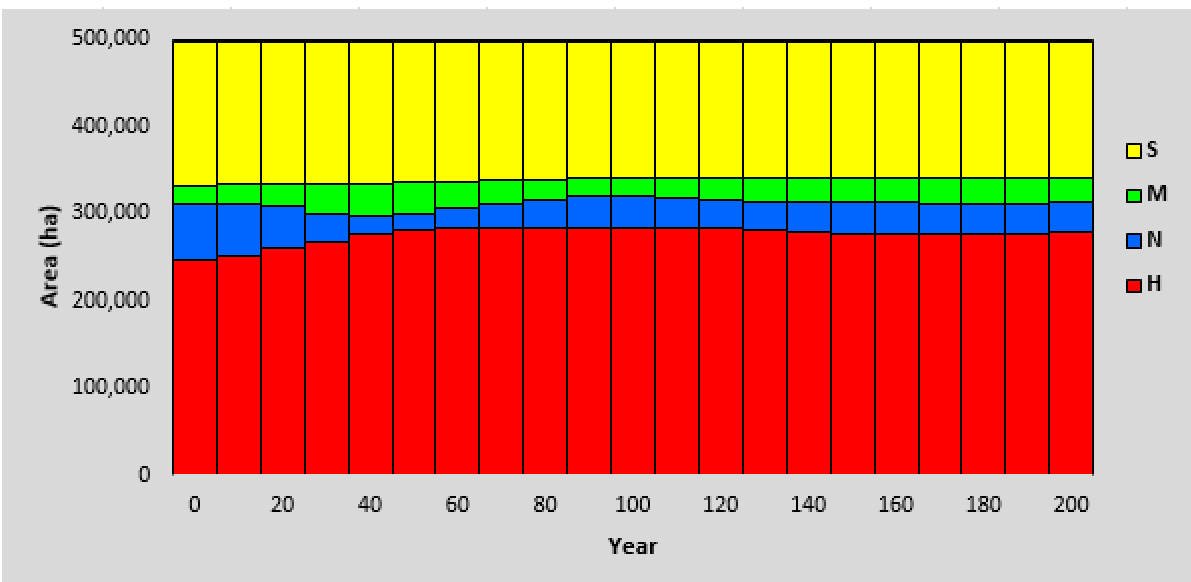


Figure 5.17 Stable proportions of cover groups over the 200-year planning horizon.

5.5. BASELINE SCENARIO DEVELOPMENT - SPATIAL CONTROLS

Spatial controls are things that have a specific location. Spatial controls are done after all the aspatial controls are completed. The spatial controls used to create the Baseline Scenario include:

- Previously manually planned cut blocks for the first two years (2020 and 2021)
- Deferral areas
- Harvest patches
- Roads that provide access to the harvest patches
- Watershed limits

The previous aspatial scenarios have explored the numerous aspatial factors that influence ecological and harvest objectives in FML #3. The spatial objectives in the scenarios can examine the influence of location, proximity, and economics on harvest patterns. In these scenarios, we used the road network to add economic feasibility to harvest decisions and examined patch sizes and their impact on economics and forest patterns.

5.5.1. Planned Blocks

The first two years of the 10-year harvest schedule was chosen by utilizing manually planned blocks. The approved Operating Plan (OP) proposed cut blocks for 2020 and 2021 will form the first two years of the 10-year Spatial Harvest Schedule for FML #3.

These two years of Operating Plan proposed cut blocks will have an influence or 'seed' the location of the year three to 10 spatial harvest schedule. Roads upgraded or built to access the 2020 and 2021 cut blocks and existing roads will be utilized where possible for future harvest (*i.e.* 2022 to 2030), thus reducing roads and resulting fragmentation across the landscape.

5.5.2. Wellman Lake Deferral Area

Telling the Patchworks model where you are going to go is as important as telling the model where not want to go. The Wellman Lake area (Figure 5.18) was identified and deferred for harvest from 2006 to 2026 in the 2006 20-year plan. This planned deferral (bounded in red) helps create a solution closer to operational reality known to be true for the first 20 years of the Forest Management Plan.

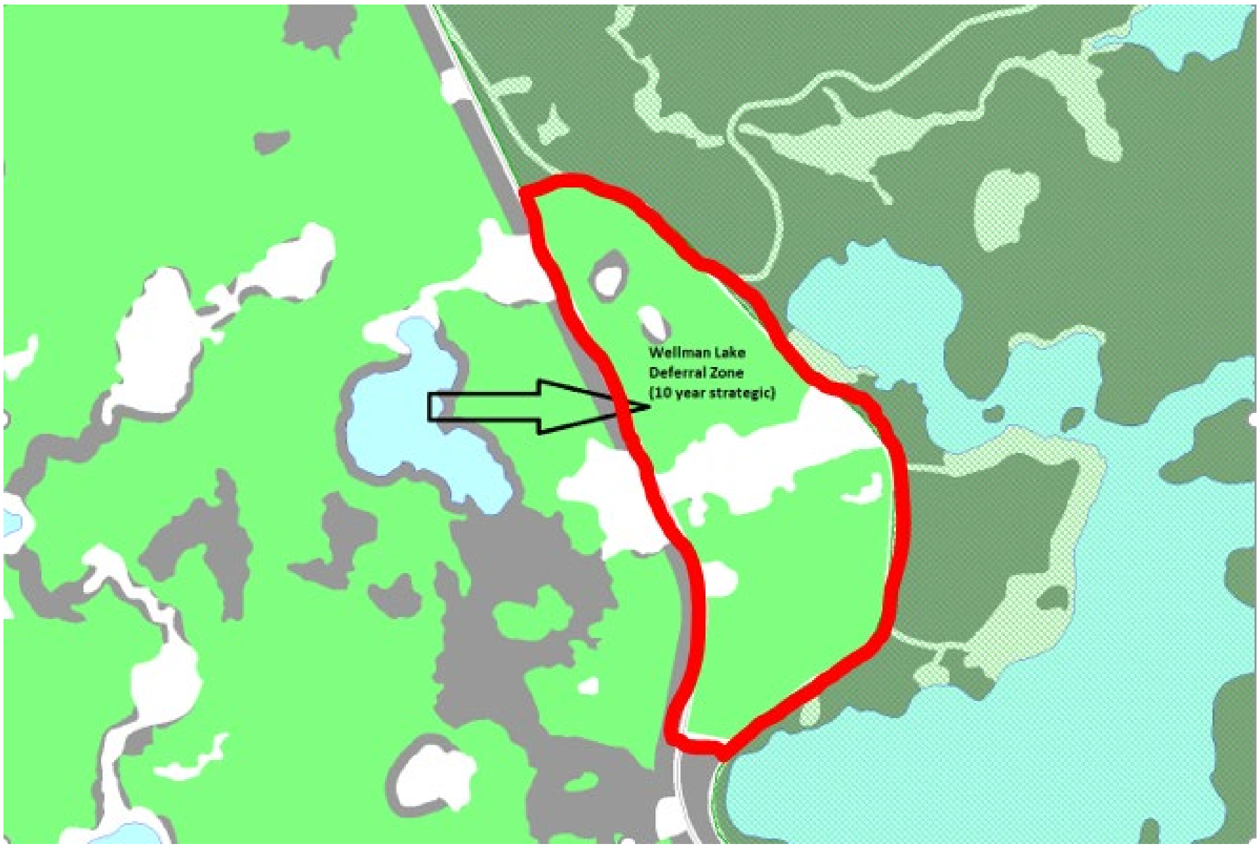


Figure 5.18 Wellman Lake deferral (2006 to 2026) area.

5.5.3. Road Controls

The roads, transportation controls, and wood flow is strategic in nature. The computer-generated roads provide an approximation of a very complex system. The transportation controls help communicate to the model that not all wood is available, all the time, everywhere.

The strategic road network also provides the opportunity for a relative comparison between scenarios to determine if different strategies have an impact on the road network and the resulting spatial pattern on the landscape. At the strategic level, only the relative comparison between management strategies (*i.e.* Baseline and Moose Emphasis Scenarios) is valid. At the operational level, the total road distance (km) or cost ($) is a valid comparison between scenarios.

5.5.3.1 Strategic Road Network

The existing road network is a starting point for the Patchworks model. However, roads need to be built in the future to access future harvest blocks. To accomplish this, candidate future roads are chosen from a 'lattice' where there are currently no roads. The lattice of future roads helps connect every block in the dataset to ensure a road can be built to every candidate harvest block over the 200-year planning horizon. The softwood is transported by road to the Spruce Products Ltd. sawmill north of Swan River, and the hardwood is transported by road to the LP siding mill east of Minitonas.

5.5.3.2 Destinations – Mills

In the FML #3 Forest Management Plan there are two strategic destinations in the model to accept the two product types harvested:

- Swan River – Spruce Products mill – softwood – strategic demand up to 400,000 m^3/year

- Minitonas – LP Siding mill – hardwood – strategic demand up to 800,000 m^3/year

Although these mills utilize wood from outside FML #3, we can only model the harvested wood flow from within FML #3 to the mills. We do not model wood from other sources, including the Porcupine Mountain Provincial Forest, FMU 12, Saskatchewan, and private land wood. In the strategic model, all wood harvested from FML #3 will be transported by road to either the LP siding mill or the Spruce Products sawmill.

5.5.3.3 Barriers for wood flow

Operating area road constraints were added at the request of the Modeling Core Team, since the model was simply choosing the mathematically shortest route and hauling almost all wood north on gravel highway #366.
A realistic wood flow was manually mapped by Operating Area (Figure 5.19), where wood is brought out of the Duck Mountain and onto a paved highway, even if the distance is slightly longer. Within Patchworks, barriers were created to force the model to adhere to the operational reality of a realistic wood flow.

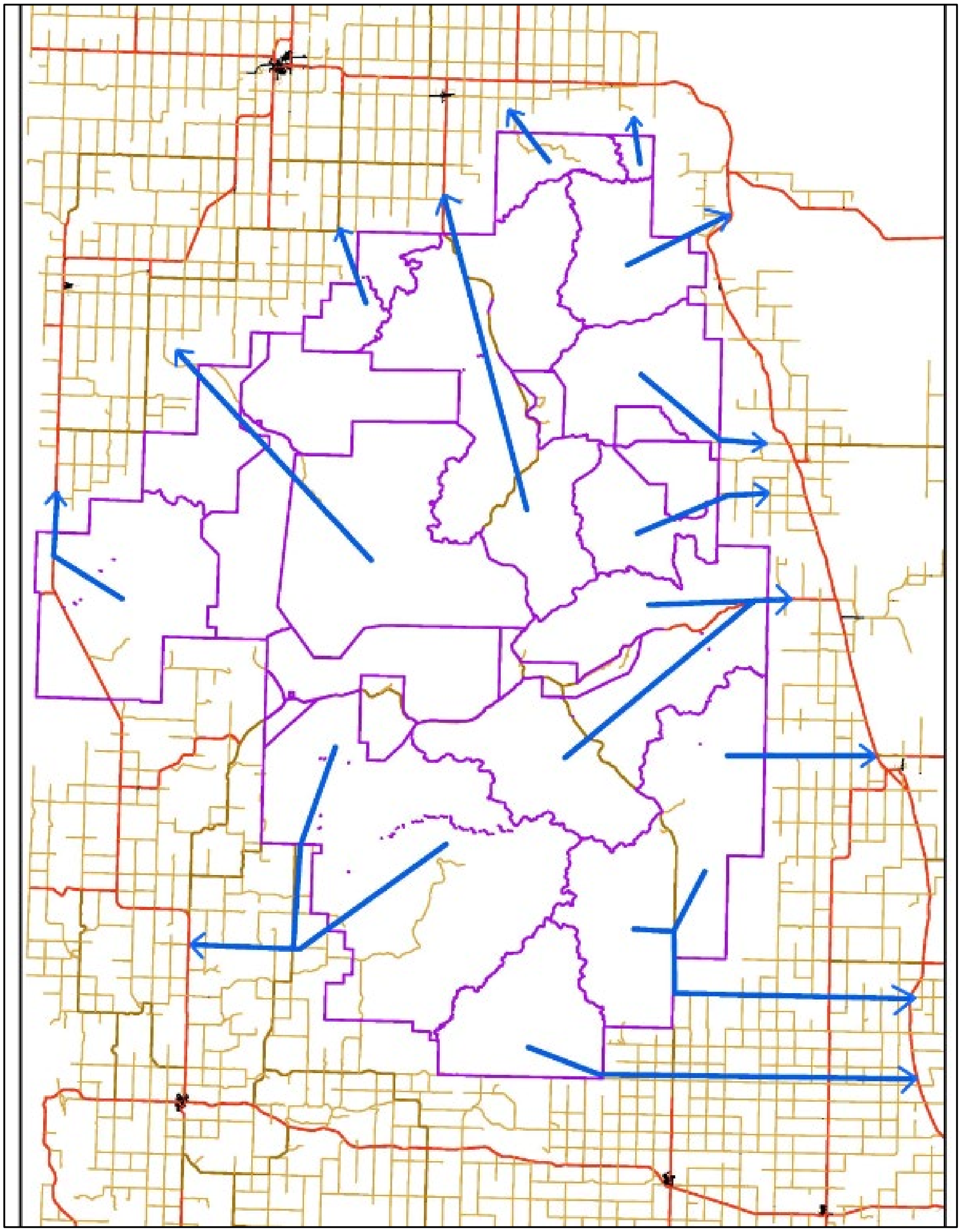


Figure 5.19 General wood flow out of the Duck Mountain Provincial Forest.

5.5.4. Harvest Blocks vs. Harvest Patches

Harvest blocks are individual cut blocks. After the first-pass cut blocks have reached the tree height requirement, second-pass cut blocks can be harvested adjacent to the original first-pass cut blocks. The combination of first and second-pass harvest blocks form a disturbance patch (Figure 5.20), which is significantly larger than individual cut blocks.

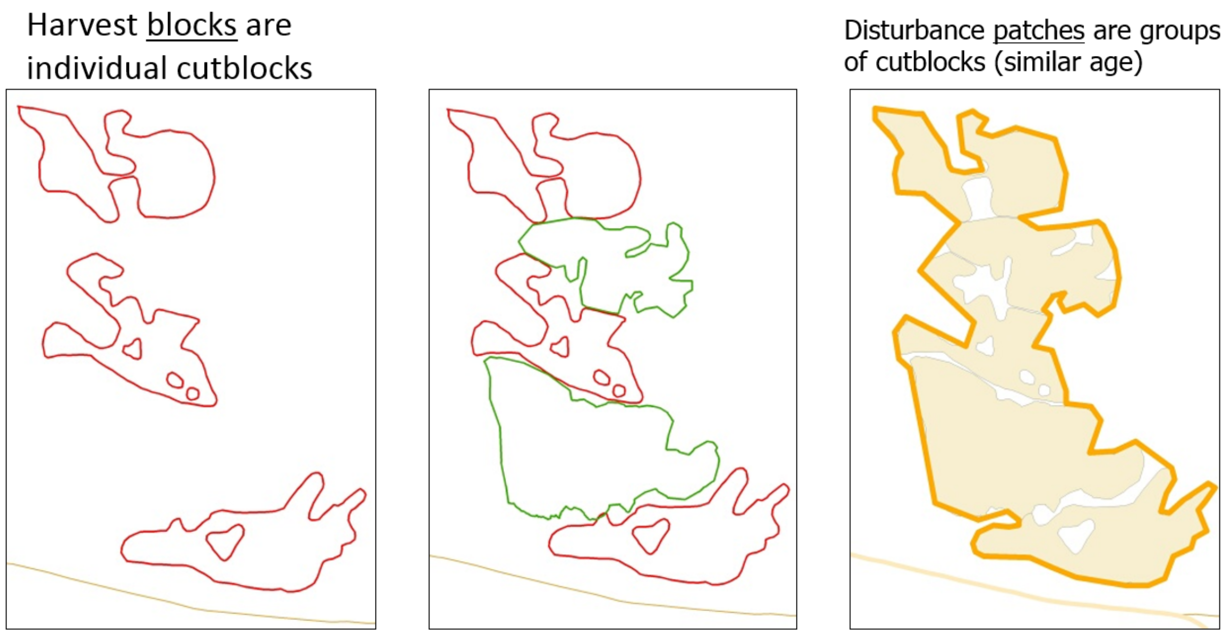


Figure 5.20 Harvest blocks and harvest patches.

5.5.5. Harvest Patch Model Controls

Harvest patches were modeled for 40 years to ensure sustainability of the wood supply when considering location in the short term. Years 41 to 200 of the modeling simulation do not have spatial harvest patch objectives.

5.5.5.1 Harvest Patch Sizes

The patch sizes used for the first four 10-year planning periods are:

- 0 – 5 ha (to eliminate small slivers and artifacts in dataset)
- 5 – 50 ha (to represent the small single stands that may be allocated)
- 50 – 250 ha (encouraged and prioritized to reduce fragmentation)
- 250 – 500 ha
- 500 -1000 ha
- 1000+ (small % area allowed – low frequency)

A priority was placed on the harvest within the 50 – 1000 ha classes. A small number of small blocks were modeled to reflect the reality of Quota Holders harvesting small blocks. The possibility of a few large blocks (1000 ha +) were allowed in the model.

NRV analysis (Andison 2019) for FML #3 showed significantly larger historical disturbance patches than 1000 ha. Historically, fire disturbances greater than 5,000 ha were common. The 1961 burn in the middle of the Duck Mountain Provincial Forest was approximately 21,000 ha. The nearby Porcupine Mountain had the 1980 Woody Fire, whose size (in Manitoba only, not including Saskatchewan) was 70,000 to 80,000 ha.

5.5.5.2 Deferral Zones in FMU 11

Deferral zones help reduce a potentially unrealistic harvest pattern. In Forest Management Unit (FMU) 11, two harvest deferral zones were delineated within the first 10 and 20 years, Kettle Hills area and the north east section of FMU 11.

5.5.6. Watershed Disturbance Control

A maximum cumulative harvest level of 30% is the permitted threshold in each watershed (Figure 5.21) of the Duck Mountain Provincial Forest or Forest Management Unit 13.

LP's Environment Act License (2191E) states in Section 17 (ii) that:

> *The Licensee shall: "limit the area in a watershed which is in a harvested and not sufficiently regenerated state, as determined by subsection 17(i) of this Licence"*

Section 17 (i) of the license requires LP to consult with the Department of Fisheries and Oceans (DFO) Canada to determine what percent of a forested watershed may be harvested without affecting stream flows. In 1996, LP and DFO mutually agreed that the cumulative harvest area could not exceed 30% of any watershed.

Disturbance was defined as:

> *Area Disturbed = stands <=5 years in hardwood and hardwood leading stands + stands<=10 years in softwood and softwood leading stands.*

The percentage of disturbance was calculated as:

> *(Area Disturbed in FMU 13 per watershed) / (productive area per watershed) * 100%.*

These calculations apply only to disturbances within FMU 13 and are used to track the 30% maximum disturbance over the 200-year planning horizon. If a watershed exceeded 30% disturbance in any 10-year period over the 200-year planning horizon, then harvesting would need to be reduced in that watershed and period to be below 30% disturbance.

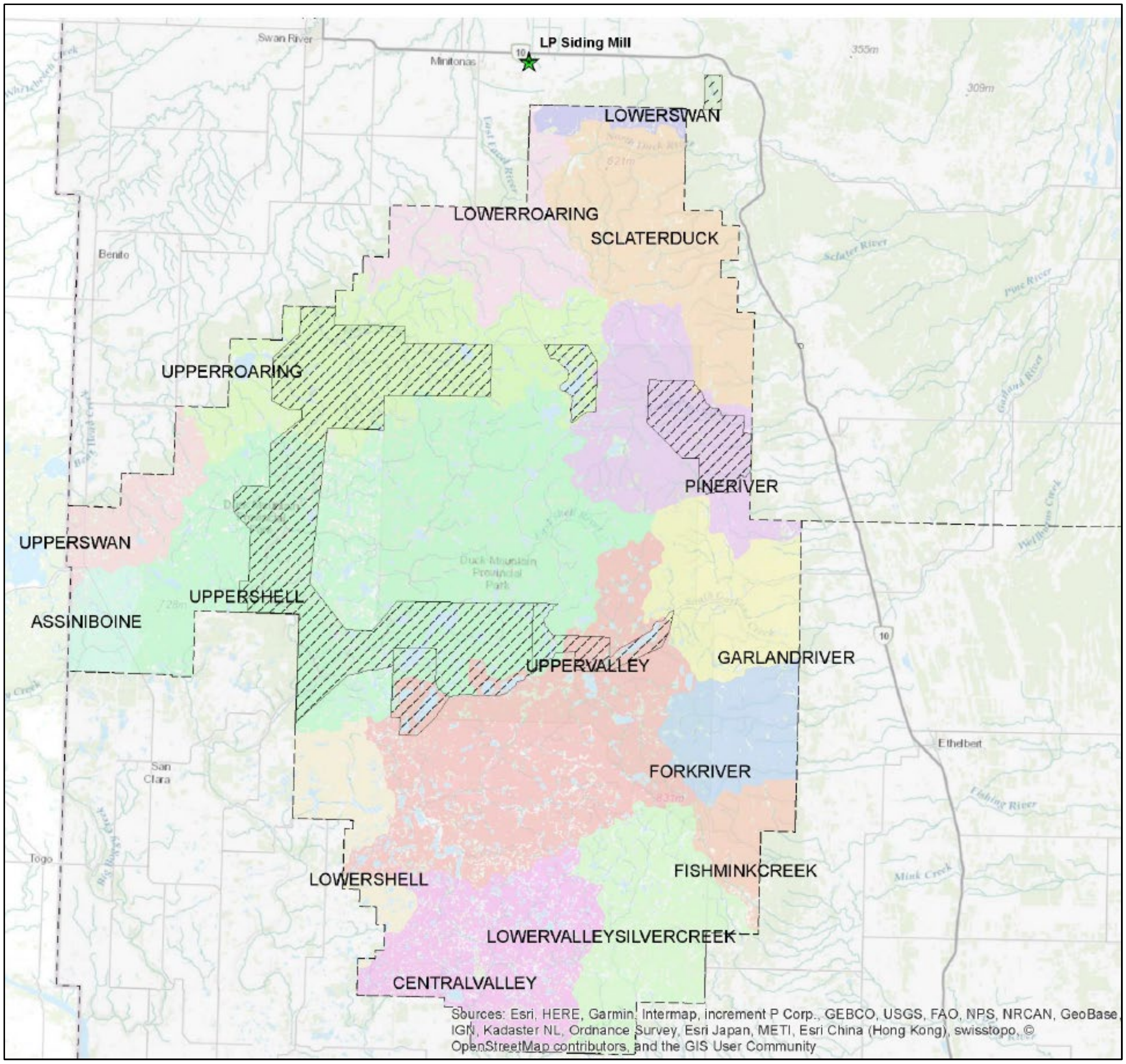


Figure 5.21 Watersheds in the Duck Mountain.

5.6. BASELINE SCENARIO OUTPUTS

The outputs to Baseline Scenario are described in this section, including:

- Ecological drivers and outcomes
- Economic drivers and outcomes
- Spatial and Operational drivers and outcomes

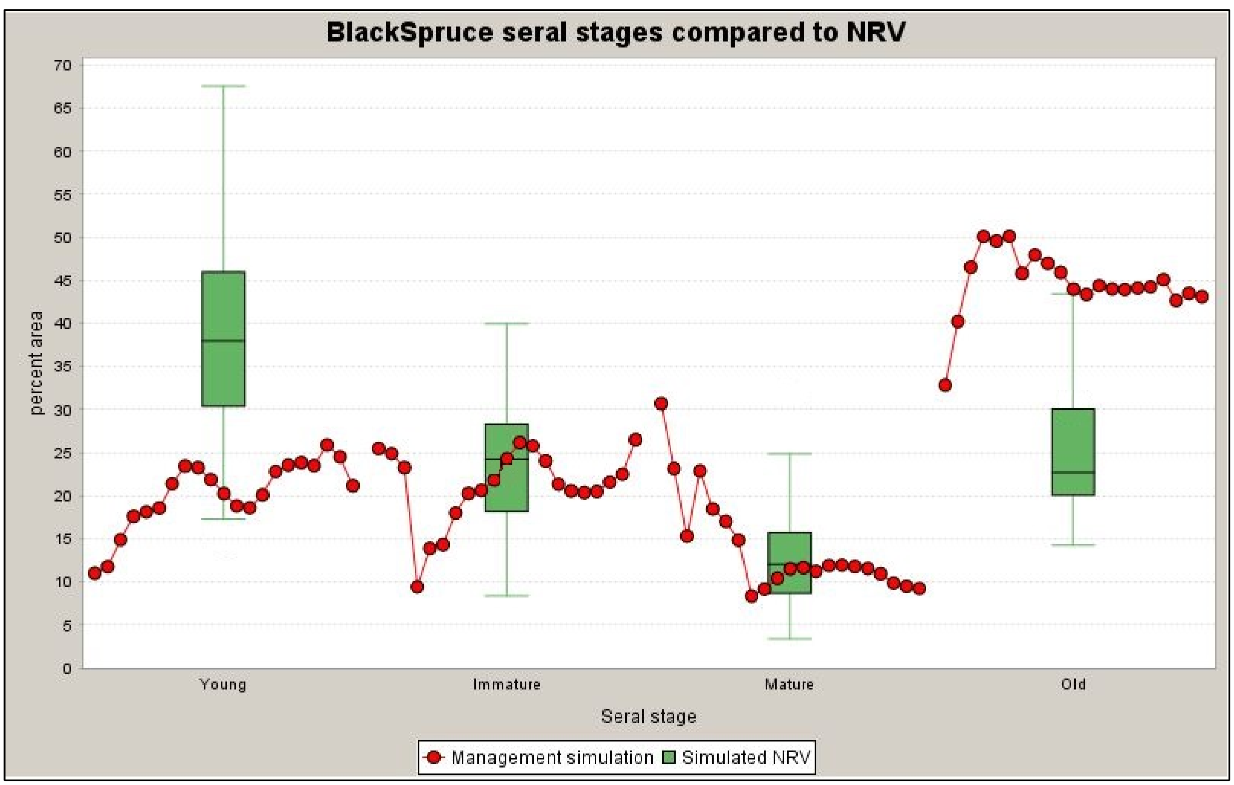
The scenario output is very comprehensive and has approximately 150 different modeling outputs, but only the significant drivers of output (ecological, economic, spatial, and operational) are shown in this section.

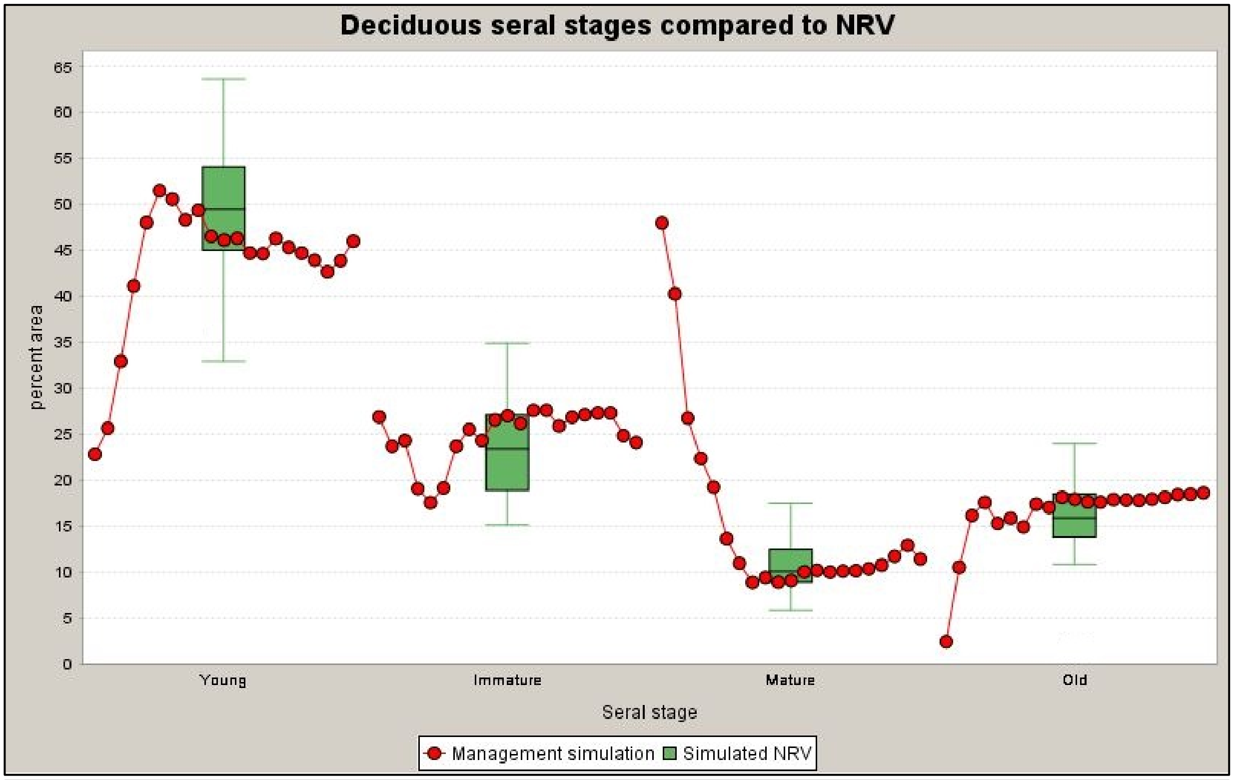
5.6.1. Ecological drivers and outcomes

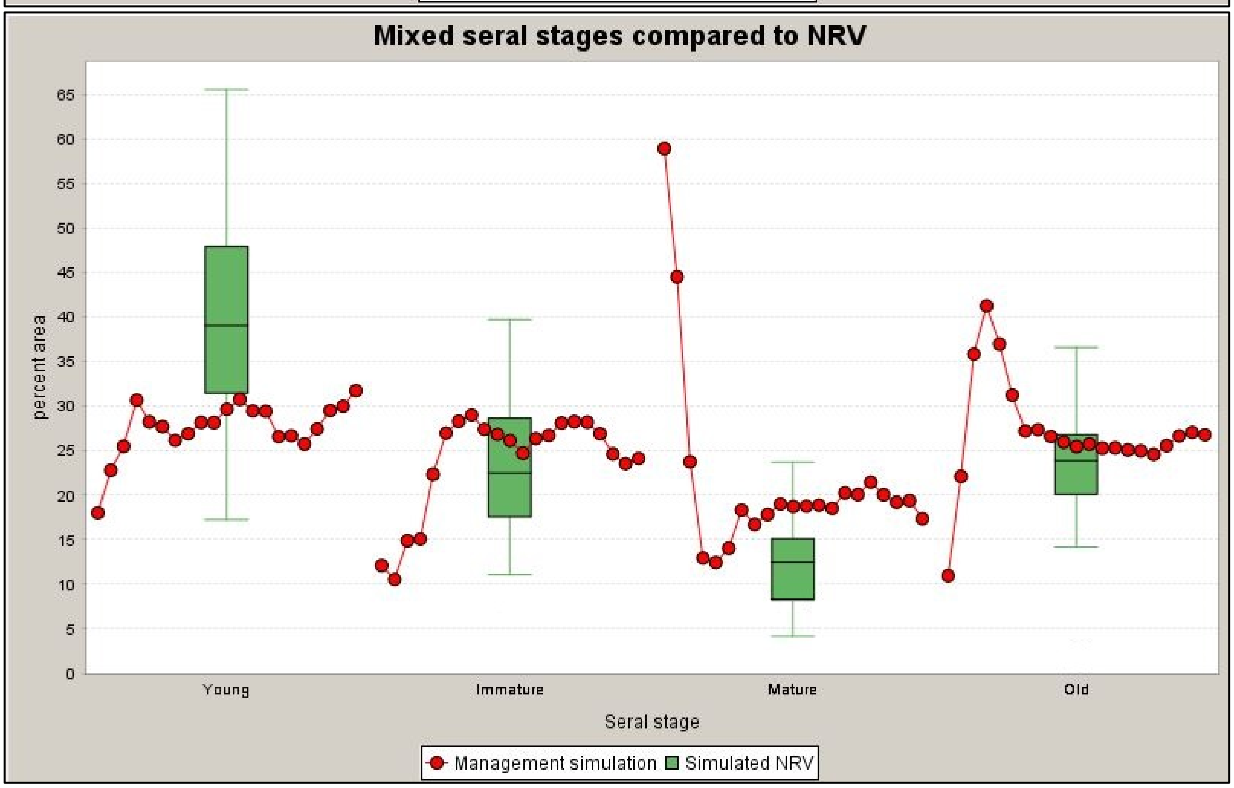
Modeling outputs for the ecological drivers of the Baseline Scenario are shown below by category. The ecological drivers include: Natural Range of Variation; cover groups; and, old forest retention across the landscape.

5.6.1.1 Natural Range of Variation

Natural Range of Variation (NRV) was a main ecological driver for the Baseline Scenario. NRV was used to model and control the amount of mature and old seral stages on the landscape over time to be within the 'inner quartile range' or green box (Figure 5.22).




Deciduous seral stages compared to NRV
percent area
65
60
55
50
45
40
35
30
25
20
15
10
5
0
Young
Immature
Mature
Old
Seral stage
Management simulation
Simulated NRV


Mixed seral stages compared to NRV
percent area
65
60
55
50
45
40
35
30
25
20
15
10
5
0
Young
Immature
Mature
Old
Seral stage
Management simulation
Simulated NRV

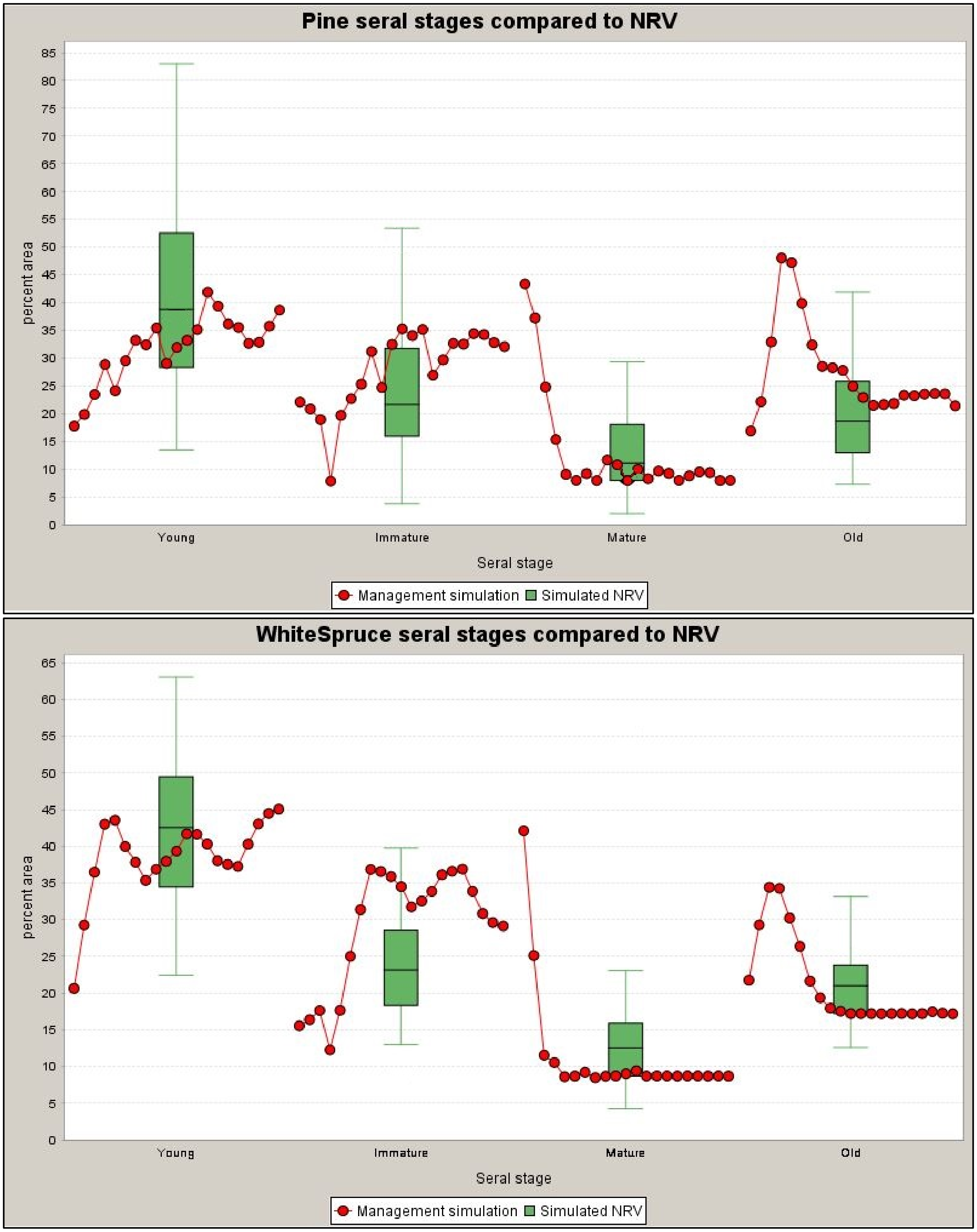


Figure 5.22 NRV sustainability by cover type and seral stage.

5.6.1.2 Cover group

The Baseline Scenario provides sustainability with regards to landscape-level cover groups (H-hardwood, N-hardwood mixedwood, M-softwood mixedwood, and S-softwood) over the entire 200-year planning period. Hardwood and softwood cover groups are very stable (Figure 5.23). Mixedwood cover groups vary slightly over time but are still stable.

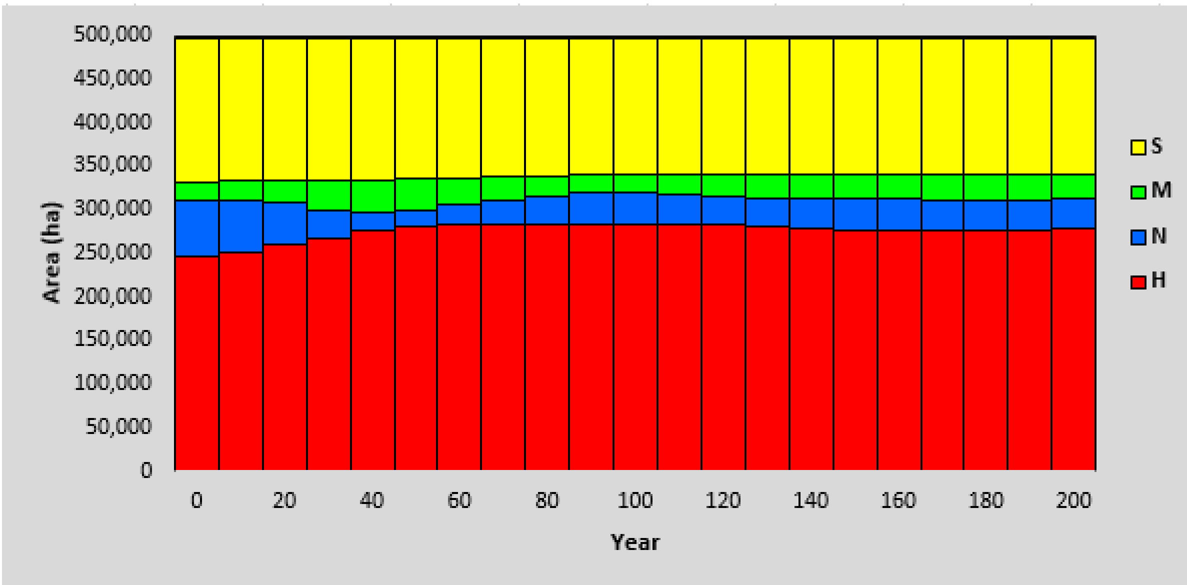


Figure 5.23 Cover type stability over 200 years in FML #3.

Natural forest succession changes some cover groups over long periods, mostly an increase in softwood. The silviculture controls of planting and Leave-For-Natural (LFN) provide a means of balancing cover groups.

Cover group stability is important to coarse-filter, landscape-level biodiversity since different species utilize different cover groups. Retaining a stable amount of each cover group across the entire landscape always in the 200-year planning period benefits biodiversity and habitat for wildlife species.

5.6.1.3 Old forest retention on the landscape

Retaining a stable amount of old forest across the entire landscape during the 200-year planning period (Figure 5.24) is an important coarse-filter, landscape-level objective that benefits biodiversity and wildlife habitat. Old forest is linked to NRV, and therefore uses the NRV species groups.

For context, the entire FML #3 forested land base is approximately 500,000 ha. Therefore, the maximum amount of old forest is in period 20-30 years (160,000 ha plus) is approximately 32% of the land base will be in the oldest seral stage. Later (50 years from now) there is a stable (26%) amount of old forest.

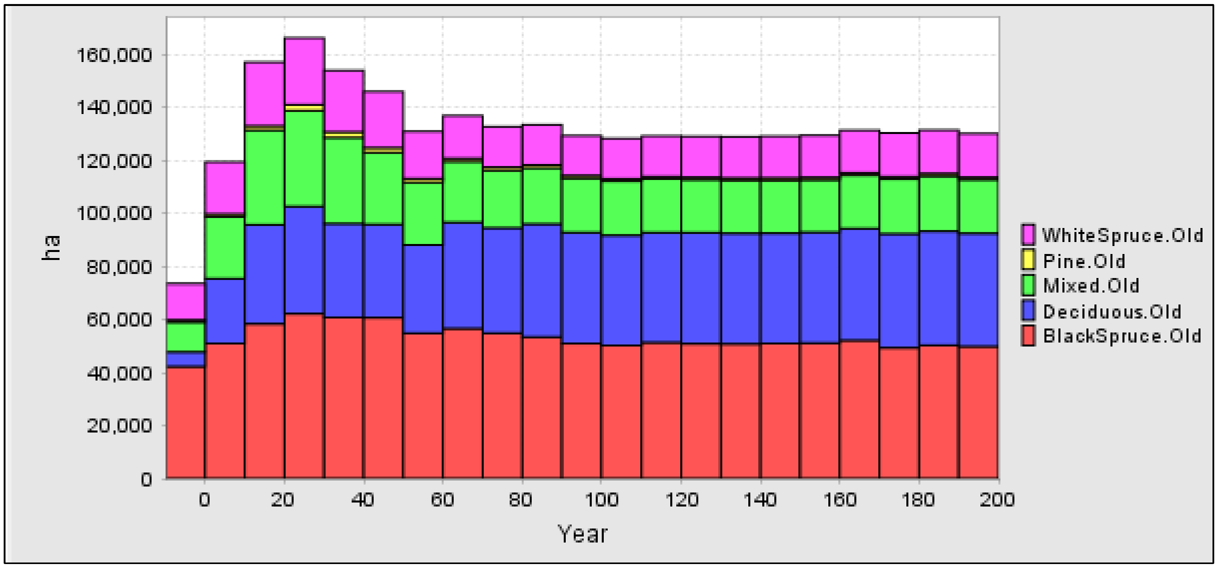


Figure 5.24 Total area of old seral stage NRV species groups over the 200 year planning period.

5.6.2. Economic drivers and outcomes

Modeling output for the economic drivers of the Baseline Scenario are shown below by category. These economic drivers include: harvest levels; area harvested; and, wood products delivered to mills.

5.6.2.1 Harvest volume levels by FMU and product

A long term even-flow harvest volume of hardwood and softwood across Forest Management Licence #3 was the main economic driver. Projected future volumes are shown to be stable and sustainable over both the 20-year and the 200-year planning periods (Figure 5.25), for all Forest Management Units (*i.e.* FMUs 10, 11, and 13).

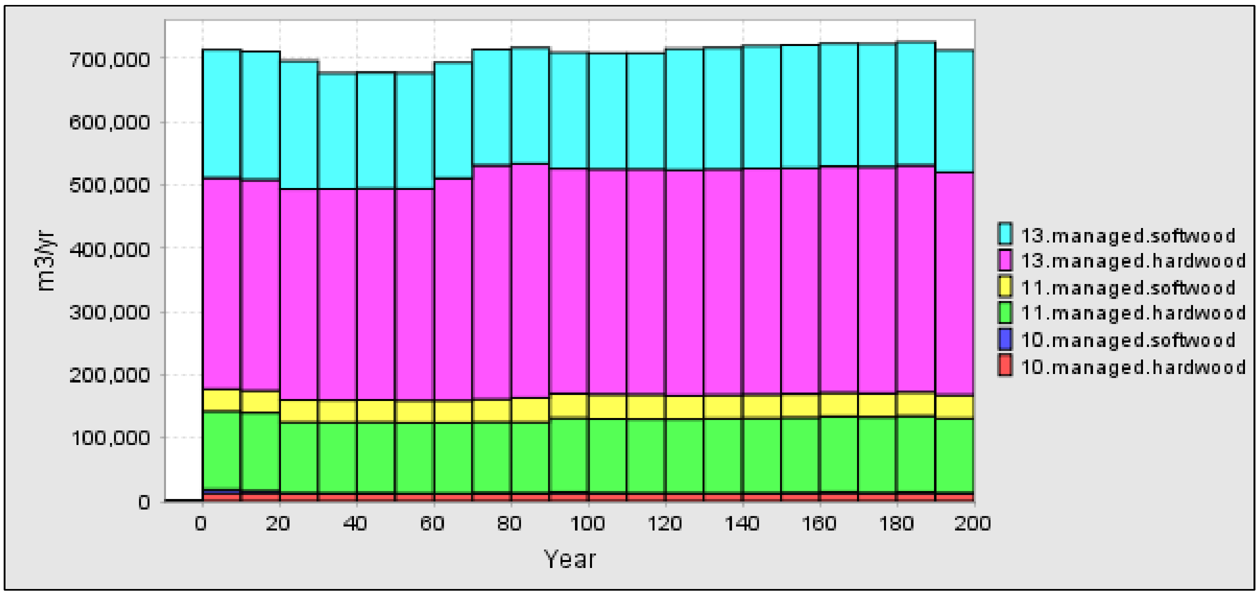


Figure 5.25 Annual harvest of softwood and hardwood is stable and sustainable across FML #3 for Forest Management Units 10, 11, and 13.

5.6.2.2 Area harvested by treatment type

All areas harvested will be regenerated by planting softwood seedlings (active treatment) or by leave-for-natural (LFN) regeneration (passive treatment). The amount of softwood seedlings planted in the future is both stable and consistent with current planting levels (Figure 5.26). 100% regeneration of all future harvest areas by natural regeneration or planting ensures forest sustainability.

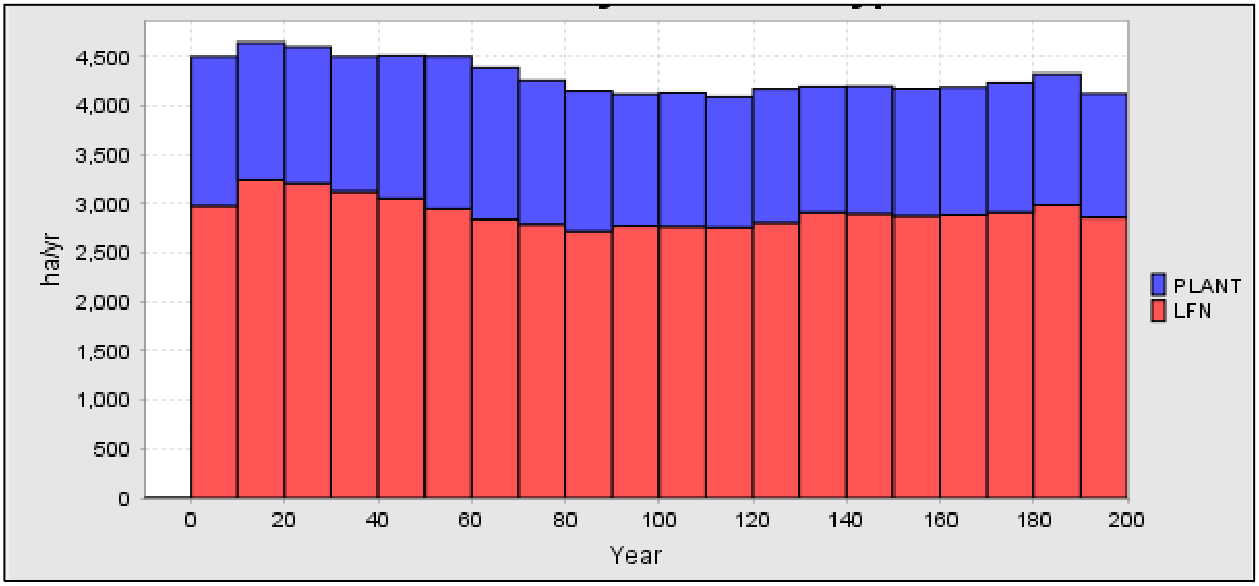


Figure 5.26 All area harvested is regenerated over the 200-year planning period.

5.6.2.3 Products delivered to Spruce Products and LP

The Baseline Scenario achieves a stable and sustainable flow of softwood to the Spruce Products Ltd. sawmill, and hardwood to the LP Siding mill (Figure 5.27). The full 200-year planning period is projected in the graph below.

Figure 5.27 Long term (200 year) product flows of softwood and hardwood to mills.

5.6.3. Spatial drivers and outcomes

Spatial drivers include future harvest blocks, roads, and watershed limits. Spatial outputs are shown in this section and include: harvest patch sizes; road reductions; and, watershed limits.

5.6.3.1 Harvest Patch Sizes

Forest fragmentation was reduced by having a wide range of harvest patch sizes (Figure 5.28). There was an option to have larger block sizes for habitat purposes (1,000 ha plus), but no larger size blocks occur in the Baseline Scenario over the 200-year planning horizon.

Note that there is a different patch size pattern from 0 to 40 years, the first four planning periods. This pattern difference is a result of strict spatial controls during the first 40 years. There are no spatial controls on patch size from years 41 to 200.

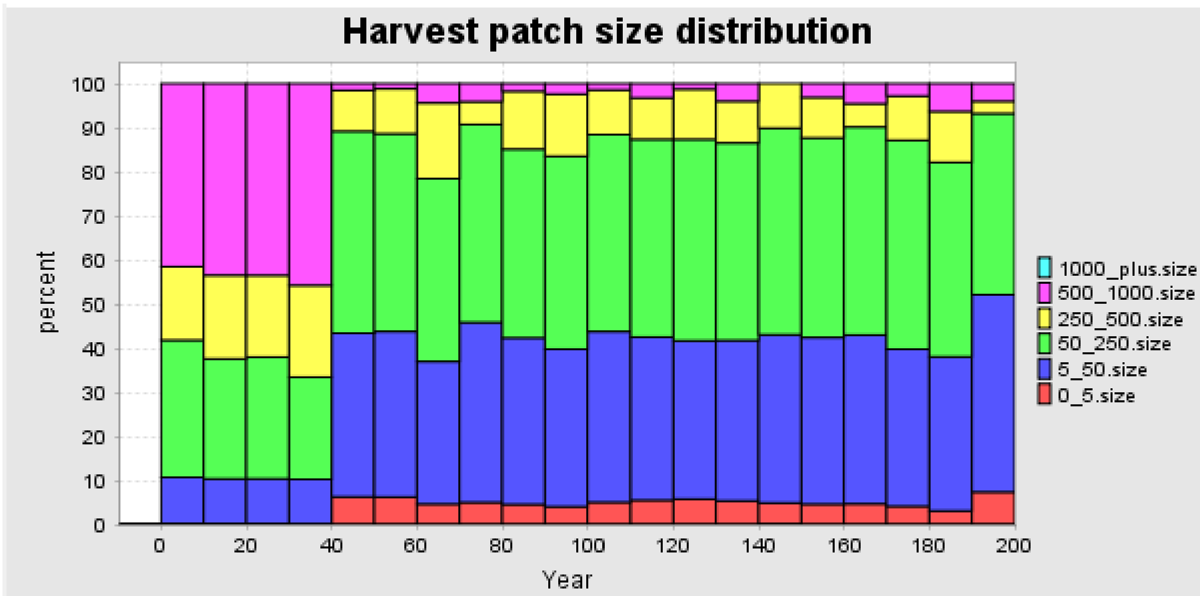


Figure 5.28 Harvest Patch sizes achieved in the Baseline Scenario.

5.6.3.2 Road Network - Active

The active road network has wood (softwood or hardwood) hauled on any road during a 10-year planning period (Figure 5.29) and (Table 5.8). This included many existing roads, including paved highway, gravel highway, Rural Municipality roads, and pre-existing dry-frozen forestry roads. Candidate roads are new roads that would need to be built in future planning periods to access future proposed harvest blocks.

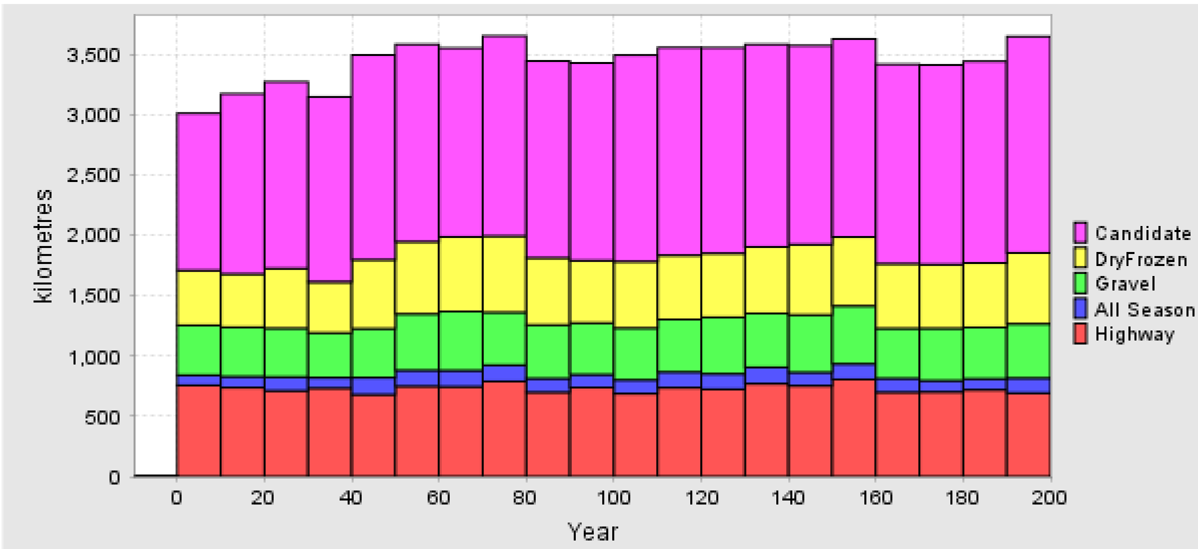


Figure 5.29 Total length of active roads by 10-year planning periods – Baseline scenario.

Table 5.8 Total length of active roads by category – Baseline scenario.

		existing	*existing*	*existing*	*existing*	***NEW***	
Planning Period	**Year**	**Highway**	**All Season**	**Gravel**	**DryFrozen**	**Candidate**	***Total***
		(km)	(km)	(km)	(km)	(km)	(km)
1	**10**	758	84	414	452	1,304	**3,013**
2	**20**	738	92	410	438	1,496	**3,175**
3	**30**	713	114	404	493	1,550	**3,275**
4	**40**	734	87	373	421	1,536	**3,150**

The active road network is not a complete road inventory of all roads that exist in FML #3. Roads that exist, but have no wood is hauled during a 10-year period, are not counted in the road statistics during that 10-year period.

The amount of active road network in the final Baseline Scenario was reduced from earlier iterations of the Baseline scenario. Reducing the active road network created more efficient access and reduced the total amount of roads, while still harvesting the same amount of softwood and hardwood volume.

5.6.3.3 Watershed Limits

Over the 200-year planning horizon, all the Duck Mountain watersheds are projected to be well within the 30% maximum disturbance threshold. When calculated as a percent disturbance (Table 5.9) the highest percent disturbance is 8.6% in the Upper Valley watershed in year 100, which is well below the 30% threshold.

Table 5.9 Projected watershed disturbance levels (%) are less than the 30% maximum.

	Years in future					
Watershed Name	**0**	**10**	**20**	**50**	**100**	**200**
ASSINIBOINE	0.3	0.1	0.1	0.7	0.3	0.3
CENTRAL VALLEY	1.5	0.8	1.1	2.7	3.5	1.6
CRANE	0	0	0	0	0	0
FISH MINK CREEK	0.7	0.2	0.3	0.1	1.0	0.7
FORK RIVER	0.5	0.2	0.5	1.2	1.1	1.0
GARLAND RIVER	1.9	1.8	1.3	1.6	3.0	3.3
HAMELIN DRAIN	0	0	0	0	0	0
KETTLE HILLS	0	0	0	0	0	0
LOWER ROARING	0.5	0.4	1.0	4.0	4.0	4.0
LOWER SHELL	0.3	0.2	0.4	1.1	0.8	0.7
LOWER SWAN	0.01	0.2	0.04	0.6	0.7	0.5
LOWER TURTLE	0	0	0	0	0	0
LOWER VALLEY SILVER CREEK	0.8	0.6	0.4	0.8	1.5	1.0
LOWER WOODY	0	0	0	0	0	0
PELICAN LAKE EAST	0	0	0	0	0	0
PINE RIVER	2.1	1.9	1.0	2.6	3.0	4.5
SCLATER DUCK	0.9	1.2	0.7	1.8	2.0	2.9
UPPER ROARING	1.2	2.3	2.1	3.9	4.1	4.9
UPPER SHELL	2.9	3.3	2.7	4.9	6.4	6.6
UPPER SWAN	0.4	0.2	0.5	1.6	1.2	1.0
UPPER TURTLE	0	0	0	0	0	0
UPPER VALLEY	4.4	3.9	2.5	8.3	8.6	8.6
UPPER WOODY	0	0	0	0	0	0

5.6.3.4 Baseline Spatial Harvest Schedule

The Patchworks model generated a strategic spatial harvest schedule by 10-year planning periods. This 20-year Forest Management Plan is covered by the first two 10-year planning periods. The Baseline scenario's strategic harvest schedule for planning periods 1 and 2 (years 1 to 10; and years 11 to 20) are shown in Appendix 1.

5.6.4. Baseline Scenario Post-Modeling Outputs

This section contains model output that is not generated within Patchworks. Instead, a land base file is exported from the Patchworks model to one of several external models. Each external model's output is described below, for the Baseline Scenario.

5.6.4.1 Bird Species at Risk Habitat

There is only one bird Species at Risk that has sufficient observations to create a habitat model in FML #3, the Canada Warbler (CAWA). Pattern analysis of the Canada Warbler within the Baseline Scenario shows that the estimates of probability of habitat occupancy increases over the next 40 years (Figure 5.30).

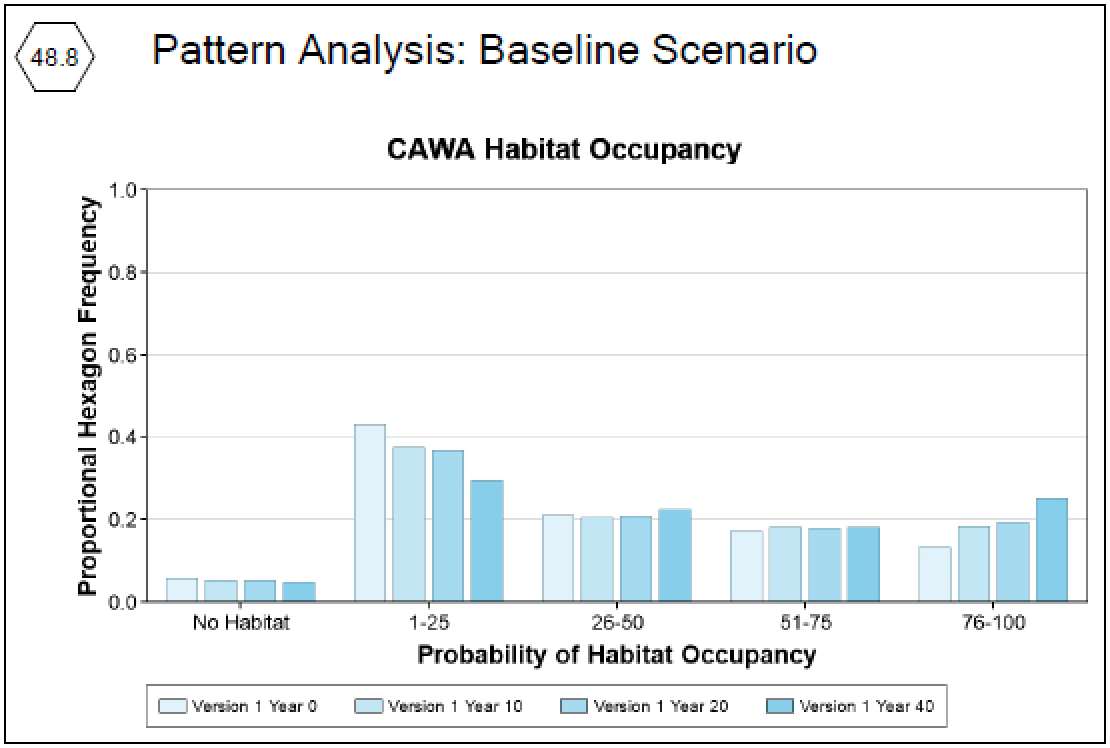


Figure 5.30 Canada Warbler estimates of probability of habitat occupancy under the Baseline Scenario.

Spatial estimates of Canada Warbler's habitat over the next 40 years are shown in Figure 5.31. A larger map of Canada Warbler habitat is shown in Appendix 2.

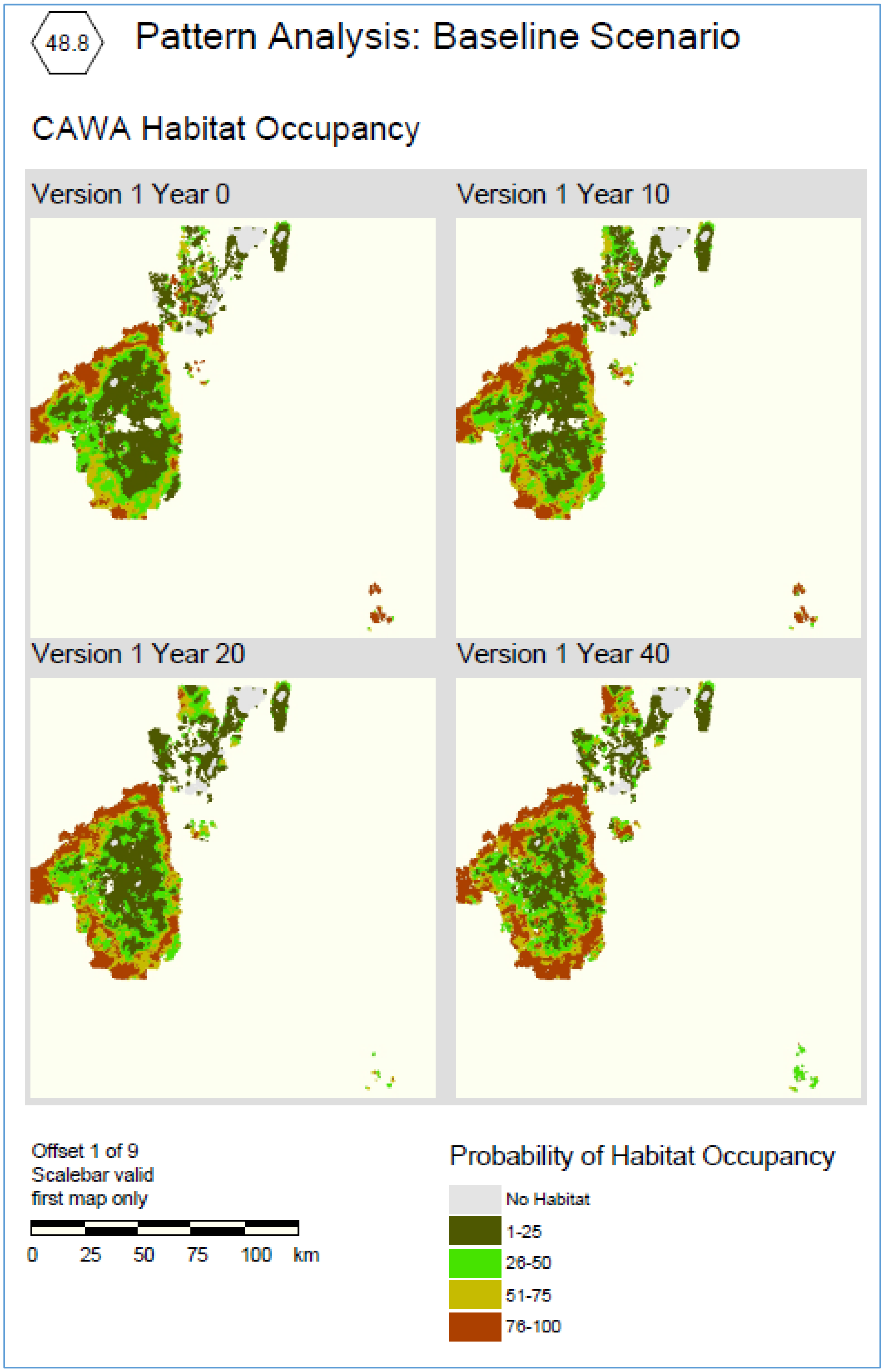


Figure 5.31 Canada Warbler habitat spatial estimates over 40 years.

5.6.4.2 Indicator Bird Species

Indicator bird species represent niches of the forest ecosystems. Some birds' habitat requirements are indicative of certain conditions (*e.g.* old conifer forest, young hardwood). A summary of the estimated change in indicator bird species habitat from time 0 to 40 years in the future is shown in Table 5.10, if the Baseline scenario were implemented.

The No Harvest response was estimated as positive, neutral, or negative based on the change in habitat quality over the 40-year modeling period, as estimated using change over time. If the amount of medium or high-quality habitat (Probability of occupancy > 50%) increased over time, or low-quality habitat decreased, then this was interpreted as a positive response. In contrast, if amount of low-quality habitat increased, then this was interpreted as a negative response. Note that the No Harvest scenario also excludes natural disturbance, so the forest is simply aging over time without any new regeneration.

The response to the Baseline and Moose Emphasis scenarios was estimated by comparing relative amounts of high- and low-quality habitat at year 40 with the No Harvest scenario, as reported in "Comparison of Birds under No Harvest versus Baseline and MEA – Year 40 for all Birds.pdf". If the amount of medium and high-quality habitat (probability of occupancy > 50%) was lower relative to No Harvest scenario, then this was interpreted as a negative response, and vice versa with the low-quality habitat.

Table 5.10. Summary of Indicator Bird Species with existing habitat models in FML #3.

American Ornithologist Union Code	Bird Common Name	*No Harvest* estimated response (positive, negative, or neutral)	BASELINE Estimated Response (positive, negative, or neutral)
*AMRE	American Redstart	*neutral*	neutral
BCCH	Black-Capped Chickadee	*Slightly positive*	neutral
BHCO	Brown-Headed Cowbird	*neutral*	neutral
BHVI	Blue-Headed Vireo	*positive*	negative
BOCH	Boreal Chickadee	*positive*	negative
BRCR	Brown Creeper	*positive*	negative
**COYE	Common Yellowthroat	*Slightly positive*	neutral

American Ornithologist Union Code	**Bird Common Name**	***No Harvest* estimated response** (positive, negative, or neutral)	**BASELINE Estimated Response** (positive, negative, or neutral)
CSWA	Chestnut-Sided Warbler	*negative*	positive
GCKI	Golden-Crowned Kinglet	*positive*	negative
HETH	Hermit Thrush	*Slightly negative*	positive
OVEN	Oven bird	*neutral*	slightly positive
REVI	Red-Eyed Vireo	*Slightly positive*	neutral
SWTH	Swainson's Thrush	*positive*	negative
***VEER	Veery	*negative*	positive
WIWR	Winter Wren	*positive*	negative
YBSA	Yellow-Bellied Sapsucker	*positive*	slightly negative
YWAR	Yellow Warbler	*positive*	Slightly negative

*AMRE is a surrogate for species at risk GWWA Golden-Winged Warbler

**COYE is a surrogate for species at risk OSFL Olive-Sided Flycatcher

***VEER is also a surrogate for species at risk GWWA Golden-Winged Warbler

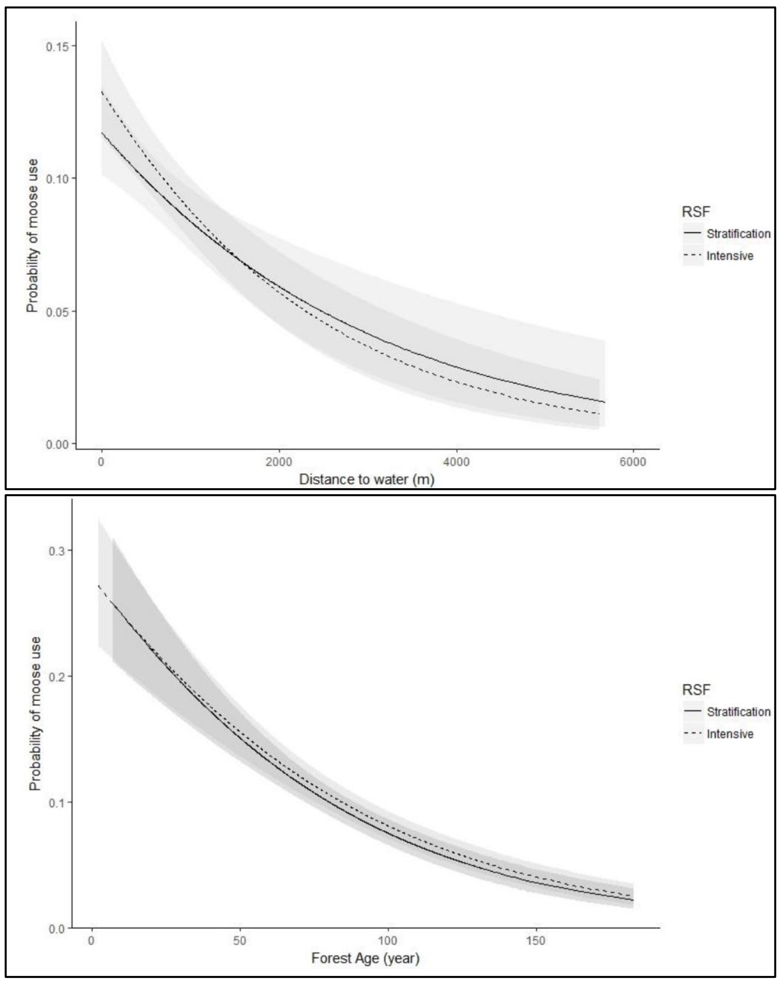
Indicator bird maps are displayed by scenario and species in Appendix 3.

5.6.4.3 *Winter Moose Habitat*

Winter moose aerial survey data from 2017 were used to quantify the relationship between winter locations of moose and habitat characteristics in the Duck Mountain (Zabihi-Seissan 2018a). A Resource Selection Function for winter moose was created.

Zabihi-Seissan (2018b) then validated the original Resource Selection Function (RSF) by including additional winter moose aerial survey data from the years 2010 and 2012. Three survey variables (Figure 5.32) were statistically significant across all surveys:

1. Distance to water (closer to water is better for moose);
2. Forest age (young forest is better, since it provides feeding or forage areas); and,
3. Distance to roads (further away from roads is better).



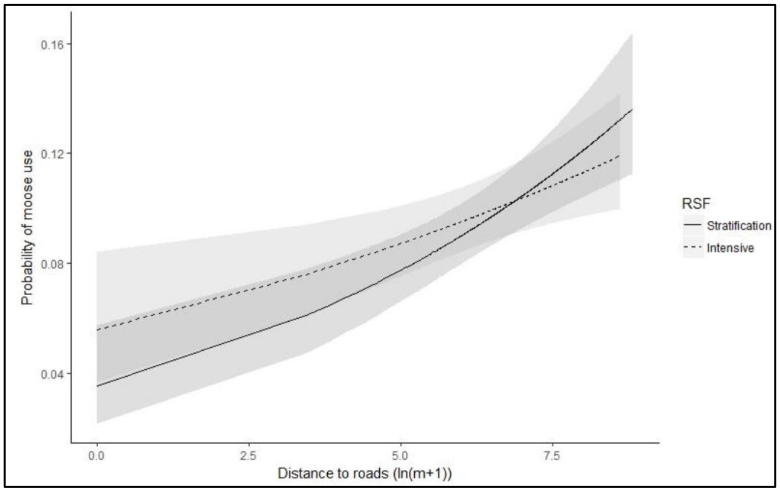


Figure 5.32 Winter moose habitat resource selection function significant variables. Shaded area consists of 95% confidence intervals.

The validated Resource Selection Function (RSF) was then used to assess winter moose habitat values for forest management scenarios. Time periods 0 (current condition), 10, 20, 30, and 40 years were evaluated for the Baseline scenario.

The RSF quantifies winter moose habitat from 0.0 (low) to 0.9 (high). The RSF histogram shows an increase of winter moose habitat over time (Figure 5.33), under the Baseline Scenario.

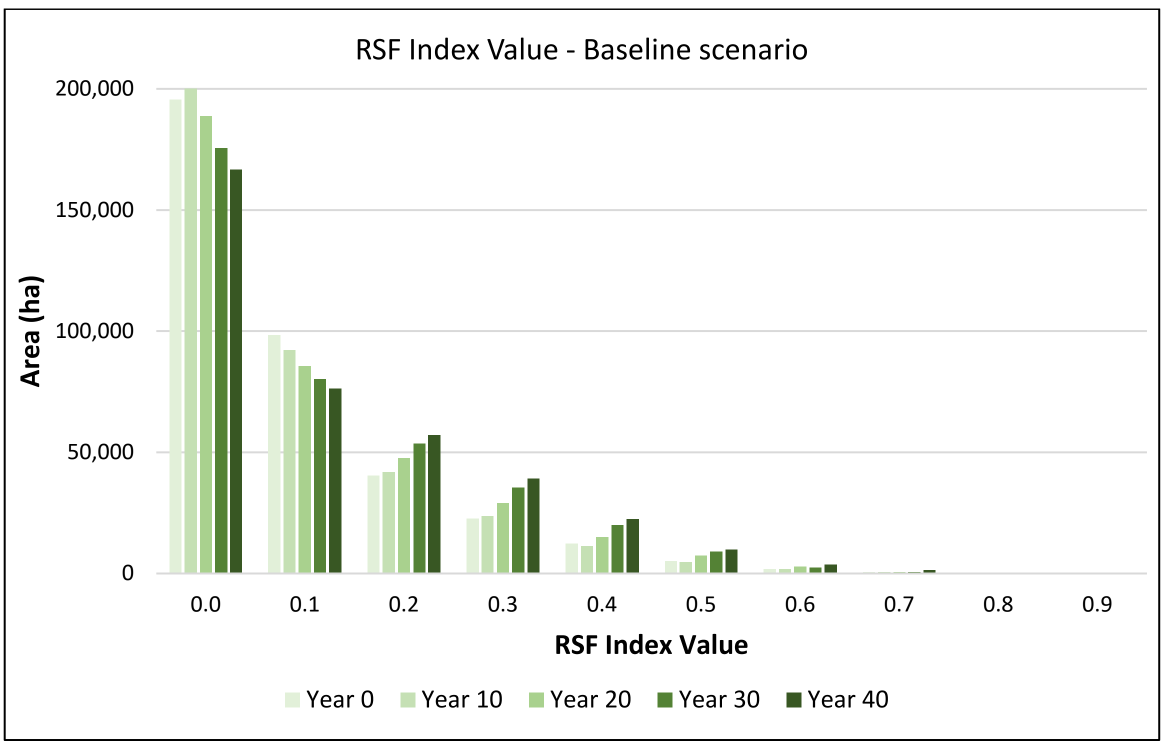


Figure 5.33 Baseline scenario winter moose habitat is estimated to increase.

Winter moose habitat maps for FML #3 are displayed in Appendix 4.

5.6.4.4 *Summer Moose Habitat*

A spatial Habitat Supply Model (HSM) was developed for summer moose habitat (KBM 2006), as part of the Manitoba Model Forest. This model was based on both expert opinion and literature review. Implementation of this model to evaluate habitat suitability for moose under different forest management scenarios was completed by Rudy and Honsberger (2019).

Aspatially, the histogram in Figure 5.34 shows the stability of summer moose habitat in FMU 13, under the Baseline Scenario. Summer moose habitat suitability, on a scale of 1 to 9, is shown in four 10-year planning periods (*i.e.* 0 to 40 years).

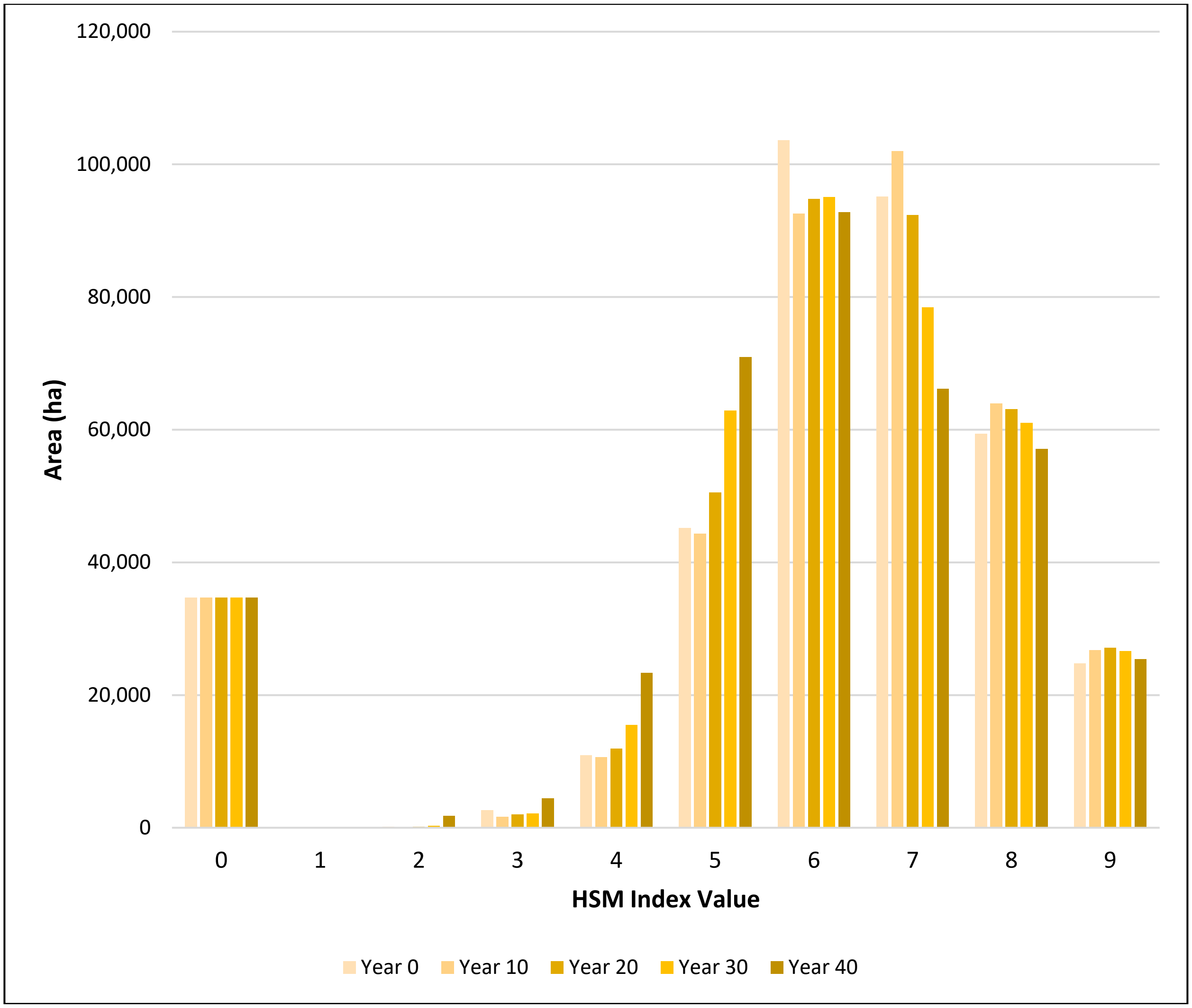


Figure 5.34 Histogram of summer moose habitat suitability in FMU 13 over 40 years.

Summer moose habitat maps for FML #3 are displayed in Appendix 5.

5.6.4.5 Marten Winter Cover Habitat

An aspatial winter cover Habitat Suitability Index (HSI) model for marten (*Martes americana*) was developed by Manitoba Forestry Wildlife Management Project (1994a). This model was based on both expert opinion and marten literature from other provinces. The HSI model numerically described (*i.e.* 0.0, 0.1, … 1.0) winter cover habitat quality for marten.

The marten winter cover HSI model was then validated and modified, based on additional expert review and interviewing marten trappers across Manitoba (Manitoba Forestry Wildlife Management Project (1994b). This validated model was used to assign HSI values to forested stands in FML #3. The individual stand HSI values were multiplied by the total area, resulting in Habitat Units. This was repeated for each 10-year planning period, from 0 to 200 years (Figure 5.35).

Both the No Harvest and the Baseline scenario are estimated to initially decline in marten winter cover habitat units. As mature conifer stands age and decline in crown closure, the marten HSI model considers old conifer stands with lower crown closure as lower marten habitat quality. This decline in marten habitat was verified by an Indigenous elder and experienced trapper. Simple aging of the forest and natural processes reduce marten winter cover over the landscape. Later, both scenarios are projected to stabilize with minor fluctuations over time.

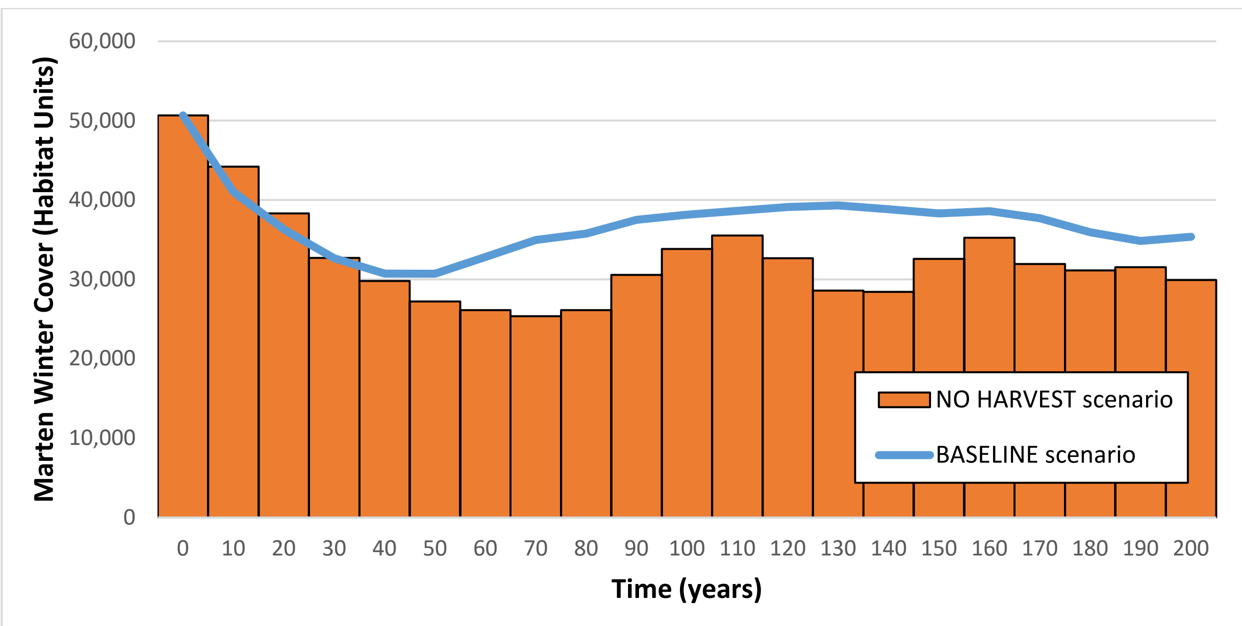


Figure 5.35 Marten winter cover over 200 years, of the Baseline Scenario, compared to the no harvest modeling.

5.7. MOOSE EMPHASIS SCENARIO

The Moose Emphasis Scenario builds upon the existing and approved Baseline Scenario. The Baseline Scenario harvest pattern was modified to benefit moose habitat, while still meeting many other ecological and economic sustainability objectives.

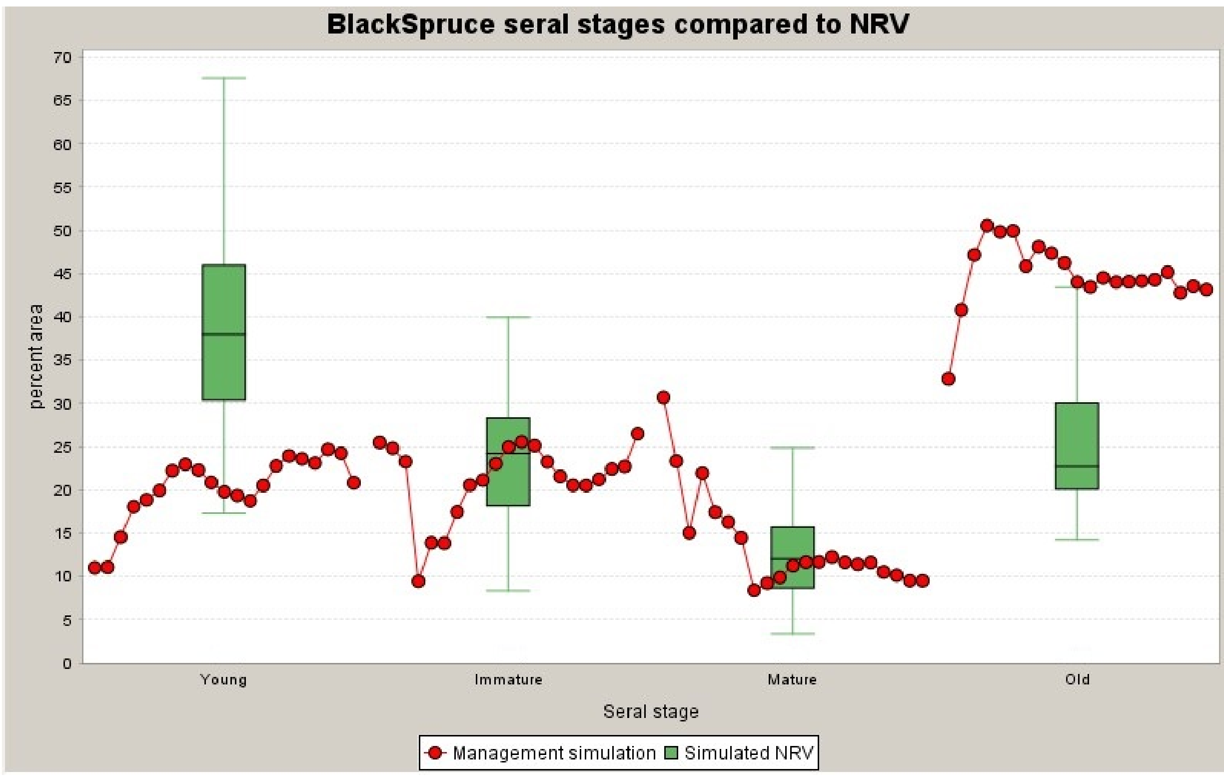
The FMP planning team made a choice at the July 23, 2019 meeting to include Moose Emphasis Areas (MEAs) instead of attempting to improve moose habitat everywhere across FML #3. A follow up meeting on July 24th, 2019 with a smaller group chose moose emphasis areas. Eight MEAs were chosen, based on previous moose winter aerial survey summarized maps (high, medium, low moose population areas), in addition to local knowledge from the regional wildlife biologist and planner. MEAs were later dropped on Sept. 13th, 2019, due to the high amount of harvest proposed within these eight areas to improve moose habitat.

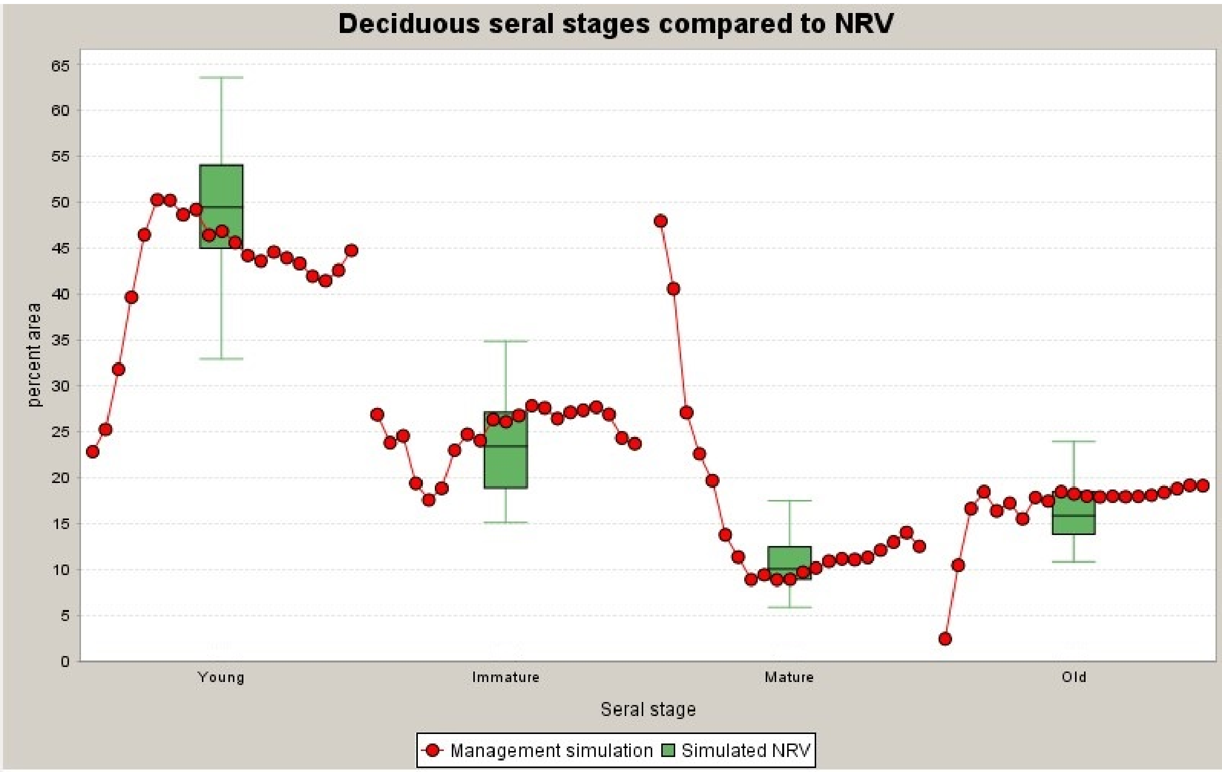
5.7.1. Ecological Drivers and Outcomes

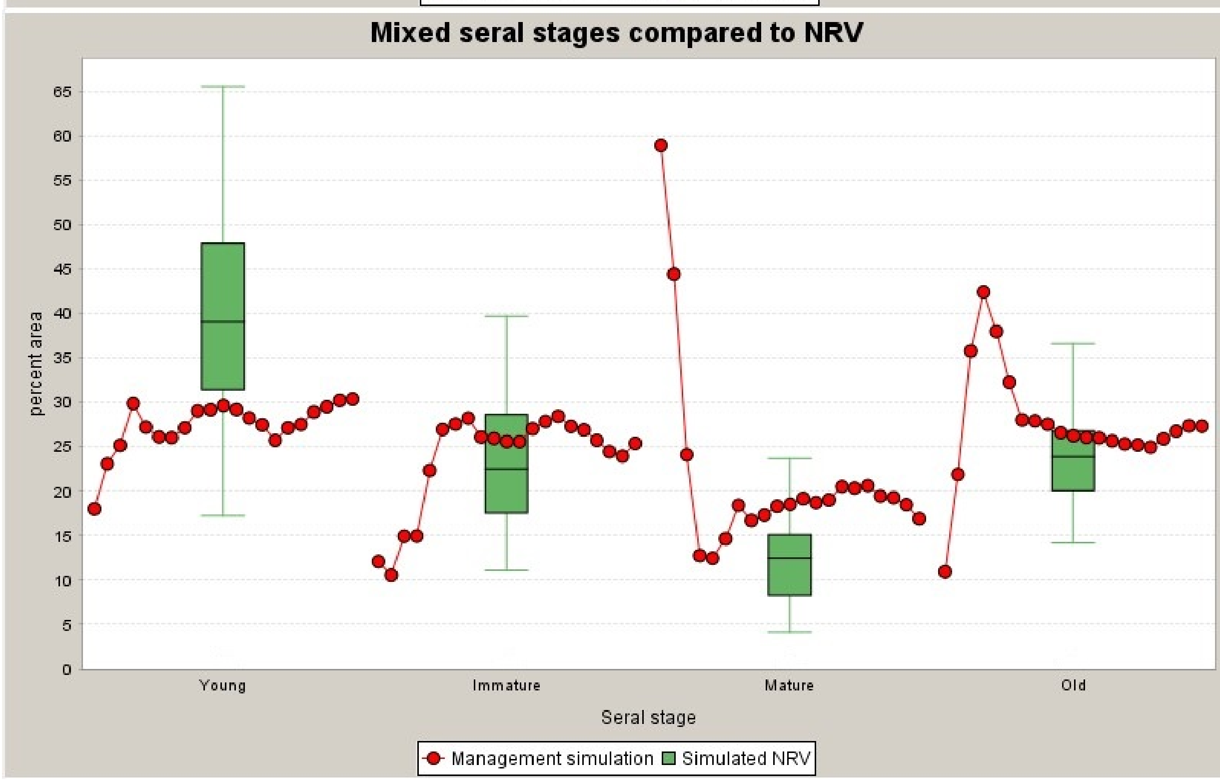
Modeling outputs for the ecological drivers of the Moose Emphasis Scenario are shown below by category. The ecological drivers include: Natural Range of Variation; cover groups; and, old forest retention across the landscape.

5.7.1.1 Natural Range of Variation

Natural Range of Variation (NRV) was a main ecological driver for the Moose Emphasis Scenario. NRV was used to model and control the amount of mature and old seral stages on the landscape over time to be within the 'inner quartile range' or green box (Figure 5.36).




Deciduous seral stages compared to NRV
percent area
0
5
10
15
20
25
30
35
40
45
50
55
60
65
Young
Immature
Mature
Old
Seral stage
Management simulation
Simulated NRV


Mixed seral stages compared to NRV
percent area
0
5
10
15
20
25
30
35
40
45
50
55
60
65
Young
Immature
Mature
Old
Seral stage
Management simulation
Simulated NRV

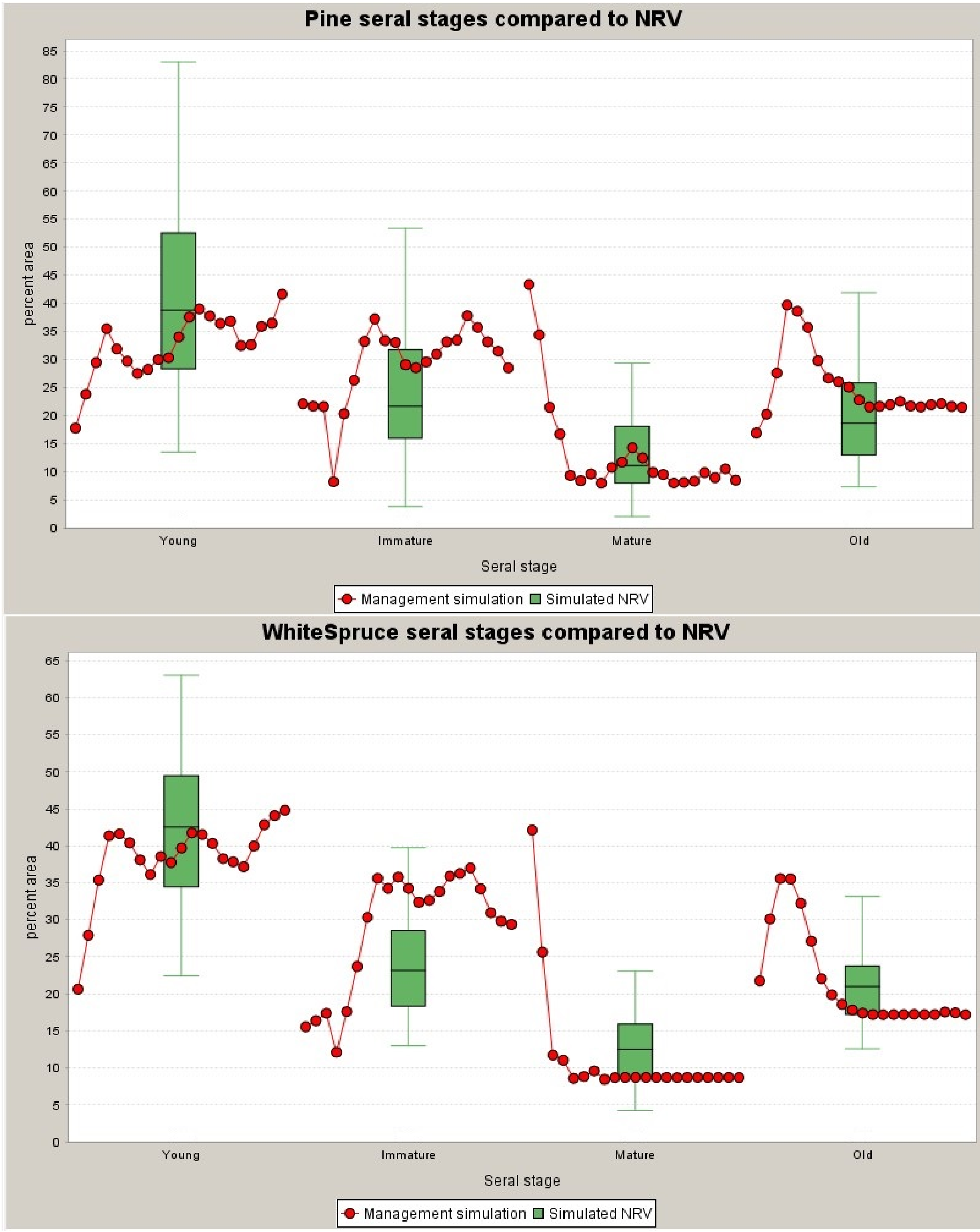


Figure 5.36 NRV sustainability by cover type and seral stage Moose Emphasis Scenario.

5.7.1.2 Cover Group

The Moose Emphasis Scenario provides sustainability with regards to landscape-level cover groups (H-hardwood, N-hardwood mixedwood, M-softwood mixedwood, and S-softwood) over the entire 200-year planning period. Hardwood and softwood cover groups are very stable (Figure 5.37). Mixedwood cover groups vary slightly over time but are still stable.

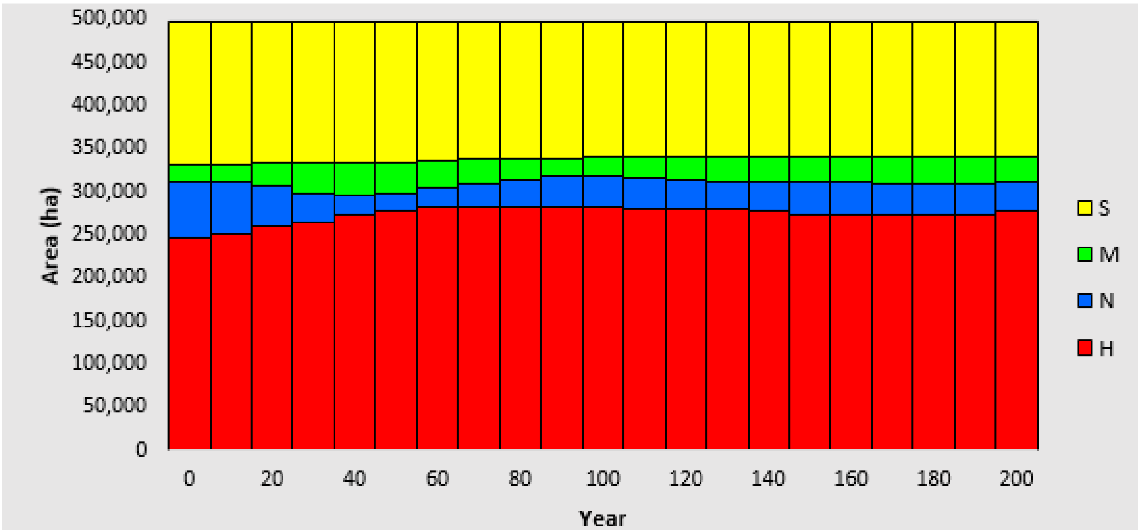


Figure 5.37 Cover type stability over 200 years in FML #3.

5.7.1.3 Old Forest Retention on the landscape

Retaining a stable amount of old forest across the entire landscape always during the 200-year planning period (Figure 5.38) is an important coarse-filter, landscape-level objective that benefits biodiversity and wildlife habitat for species that require old forest. Old forest is linked to Natural Range of Variability, and therefore uses the NRV species groups.

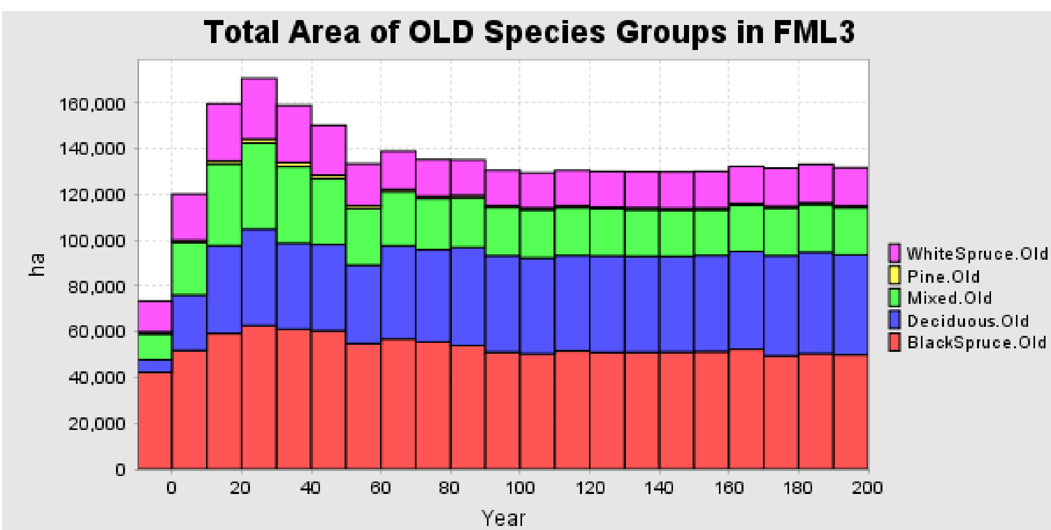


Figure 5.38 Total area of old seral stage NRV species groups over the 200-year planning period.

5.7.2. Economic Drivers and Outcomes

Modeling output for the economic drivers of the Moose Emphasis Scenario are shown below by category. These economic drivers include: harvest levels; area harvested; and, wood products delivered to mills.

5.7.2.1 Harvest volume levels by FMU and product

A long term even-flow harvest volume of hardwood and softwood across Forest Management Licence #3 was the main economic driver. Projected future volumes are shown to be stable and sustainable over both the 20-year and the 200-year planning periods (Figure 5.39), for all Forest Management Units (*i.e.* FMUs 10, 11, and 13).

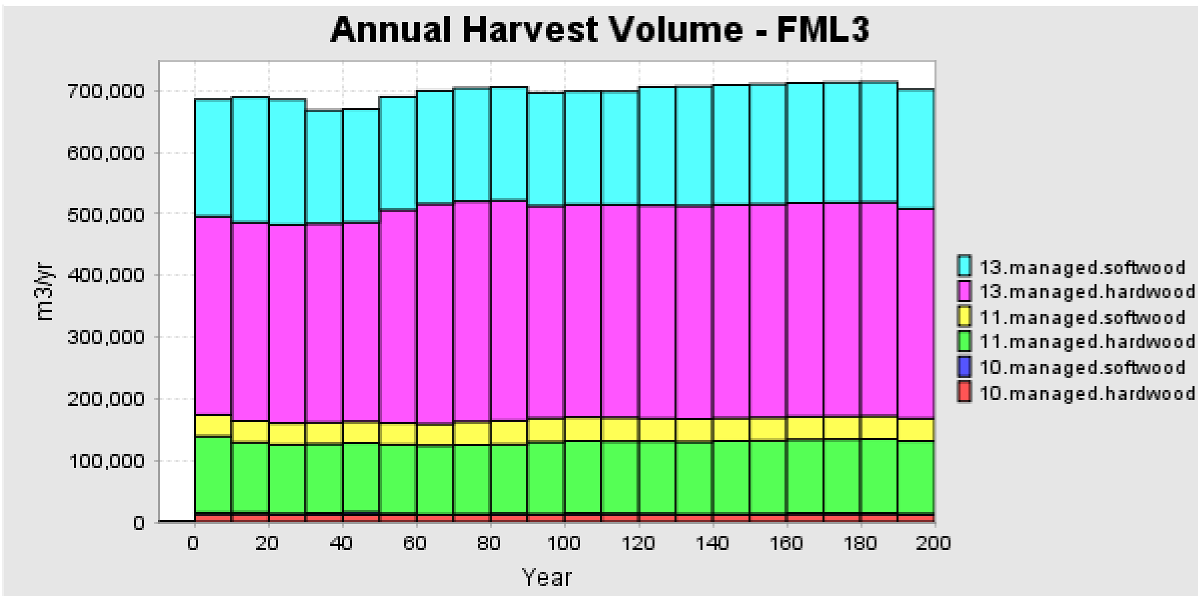


Figure 5.39 Annual harvest of softwood and hardwood is stable and sustainable.

The Moose Emphasis Scenario has about 1% less wood volume available than the Baseline Scenario. However, this was considered a worthwhile trade off.

5.7.2.2 *Area harvested by treatment type*

All areas harvested will be regenerated by planting softwood seedlings (active treatment) or by leave-for-natural (LFN) regeneration (passive treatment). The amount of softwood seedlings planted in the future is both stable and consistent with current planting levels (Figure 5.40). 100% regeneration of all future harvest areas by natural or planting ensures forest sustainability.

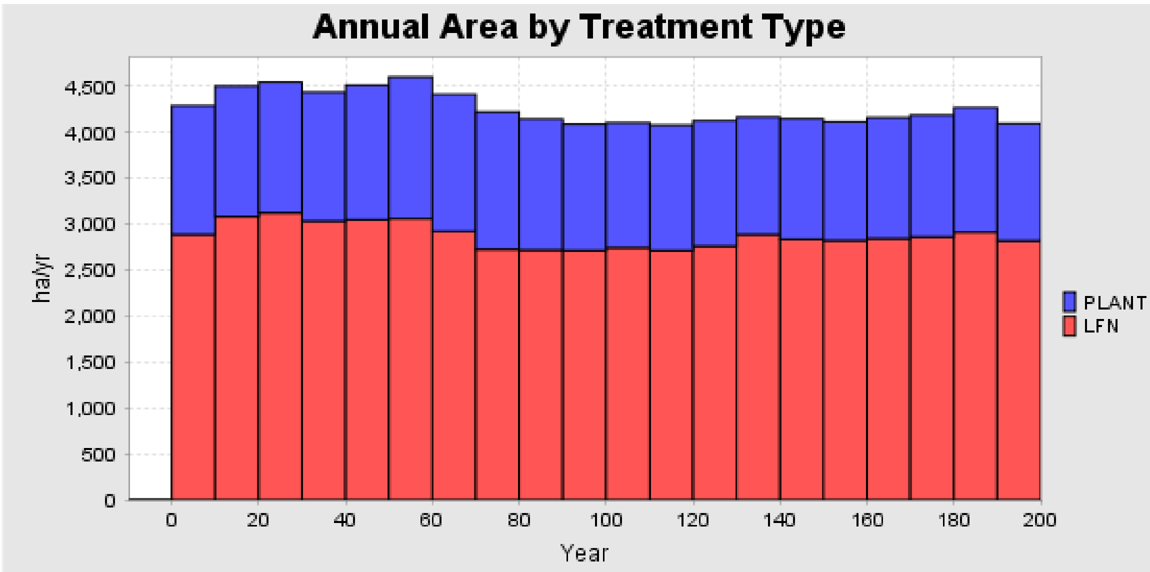


Figure 5.40 All area harvested is silviculturally treated over the 200-year planning period.

5.7.2.3 *Products delivered to Spruce Products and LP*

The Moose Emphasis Scenario achieves a stable and sustainable flow of softwood to the Spruce Products Ltd. sawmill, and hardwood to the LP Siding mill (Figure 5.41). The full 200-year planning period is projected in the graph below.

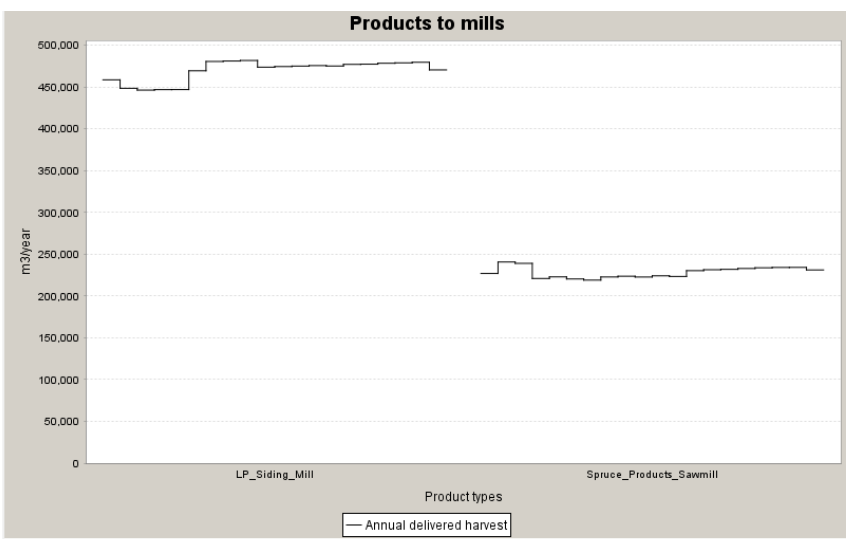


Figure 5.41 Long term (200 year) product flows of softwood and hardwood to mills.

5.7.3. Spatial Drivers and Outcomes

Spatial drivers of the Moose Emphasis Scenario include future harvest blocks, roads, and watershed limits. Spatial outputs are shown in this section and include: harvest patch sizes; road reductions; and, watershed limits.

5.7.3.1 Harvest Patch Sizes

Forest fragmentation was reduced by having larger harvest patches in the first and second 10-year planning periods (Figure 5.42). Larger block sizes for habitat purposes (1,000 ha plus) did occur in the Moose Emphasis Scenario.

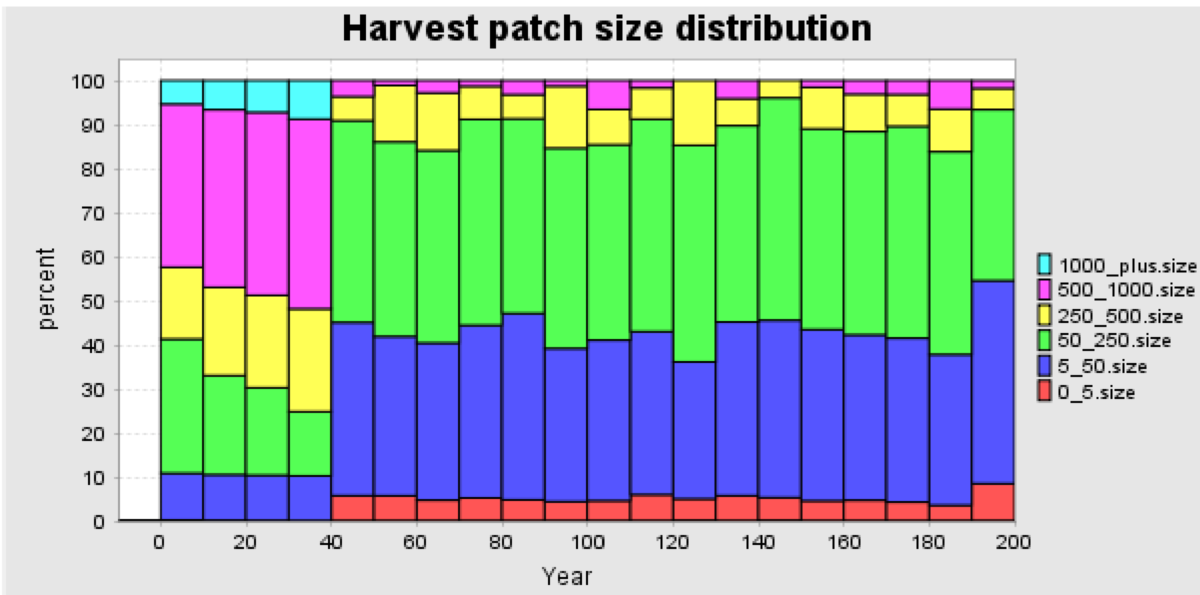


Figure 5.42 Harvest Patch sizes achieved in the Moose Emphasis Scenario.

5.7.3.2 *Road Network - Active*

Active road network are roads that have wood (softwood or hardwood) hauled on any road during a 10-year planning period. This includes many existing roads, including paved highway, gravel highway, Rural Municipality roads, and existing dry-frozen forestry roads. Candidate roads are new roads that would need to be built in future planning periods to access future proposed harvest blocks. The length of roads needed to access the proposed future harvest in the Moose Emphasis Scenario (Figure 5.43) was tracked (Table 5.11).

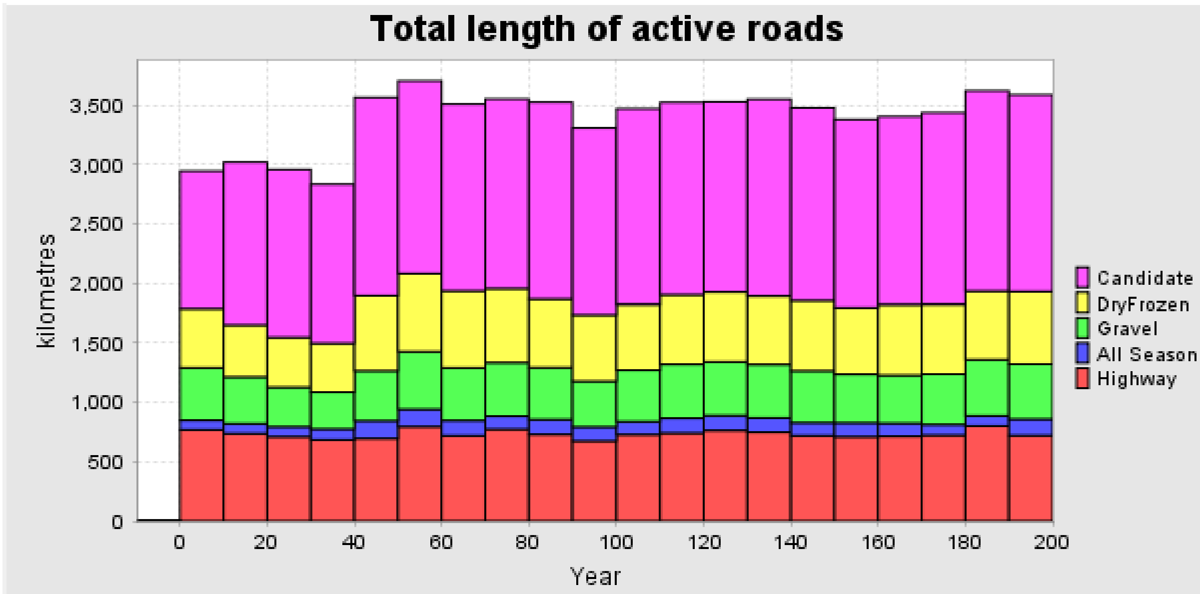


Figure 5.43 Length of active roads by 10-year planning periods for the Moose Emphasis Scenario.

Table 5.11 Length of active roads by category.

		existing	*existing*	*existing*	*existing*	***NEW***	
Planning Period	**Year**	**Highway**	**All Season**	**Gravel**	**Dry.Frozen**	**Candidate**	***Total***
		(km)	(km)	(km)	(km)	(km)	**(km)**
1	10	769	80	442	497	1,156	**2,944**
2	20	737	83	393	437	1,368	**3,018**
3	30	710	84	333	419	1,410	**2,957**
4	40	684	91	310	411	1,336	**2,832**

The active road network is <u>not</u> a complete road inventory of all roads that exist in FML #3. Roads that exist, but have no wood hauled during a 10-year period, are not counted in the road statistics during that 10-year period.

5.7.3.3 Watershed Limits

Over the 200-year planning horizon, all the Duck Mountain (FMU 13) watersheds are projected to be well within the 30% maximum disturbance threshold. When calculated as a percent disturbance (Table 5.12) the highest percent disturbance is 9.5% in the Upper Valley watershed in year 100, which is well below the 30% threshold.

Table 5.12. Projected watershed disturbance levels (%) are less than the 30% maximum.

Watershed Name	Year					
	0	10	20	50	100	200
ASSINIBOINE	0.3	0.03	0.1	0.7	0.9	0.3
CENTRAL VALLEY	1.5	1.5	1.7	2.5	3.2	1.7
CRANE	0	0	0	0	0	0
FISHMINK CREEK	0.7	0.3	0.4	0.4	0.8	0.8
FORK RIVER	0.5	0.3	0.5	0.7	1.5	0.9
GARLAND RIVER	1.9	1.4	1.0	2.2	2.7	3.4
HAMELIN DRAIN	0	0	0	0	0	0
KETTLE HILLS	0	0	0	0	0	0
LOWER ROARING	0.5	1.0	1.0	3.2	2.9	3.4
LOWER SHELL	0.3	0.2	0.4	0.7	1.0	0.9
LOWER SWAN	0.01	0.5	0.02	0.7	0.1	0.5
LOWER TURTLE	0	0	0	0	0	0
LOWER VALLEY SILVER CREEK	0.8	0.6	0.6	1.1	0.8	1.2
LOWER WOODY	0	0	0	0	0	0
PELICAN LAKE EAST	0	0	0	0	0	0
PINE RIVER	2.1	1.5	0.8	2.7	2.6	3.2
SCLATER DUCK	0.9	1. 6	0.8	1.8	2.1	2.1
UPPER ROARING	1.2	1.9	1.7	4.2	3.95	4.98
UPPER SHELL	2.9	2	2.3	5.7	5.96	6.81
UPPER SWAN	0.4	0.06	0.1	1.4	1.44	0.94
UPPER TURTLE	0	0	0	0	0	0
UPPER VALLEY	4.4	3.0	3.9	7.7	9.5	8.6
UPPER WOODY	0	0	0	0	0	0

5.7.3.4 Moose Emphasis Spatial Harvest Schedule

The Patchworks model generated a strategic spatial harvest schedule by 10-year planning periods. This 20-year forest management plan is covered by the first two 10-year planning periods.

The Moose Emphasis Scenario's Strategic Harvest Schedule for planning periods 1 and 2 (years 1 to 10; and years 11 to 20) is shown in Appendix 6.

5.7.4. Moose Emphasis Scenario Post-Modeling Outputs

This section contains model output that is not generated within Patchworks. Instead, a land base file is exported from the Patchworks model to one of several external models. Each external model's output is described below, for the Moose Emphasis Scenario.

5.7.4.1 Bird Species at Risk Habitat

There is only one bird species at risk that has sufficient observations to create a habitat model in FML #3 – Canada Warbler (CAWA). Pattern analysis of the Canada Warbler within the Baseline Scenario shows that the estimates of probability of habitat occupancy increases over the next 40 years (Figure 5.44), under the Moose Emphasis Scenario.

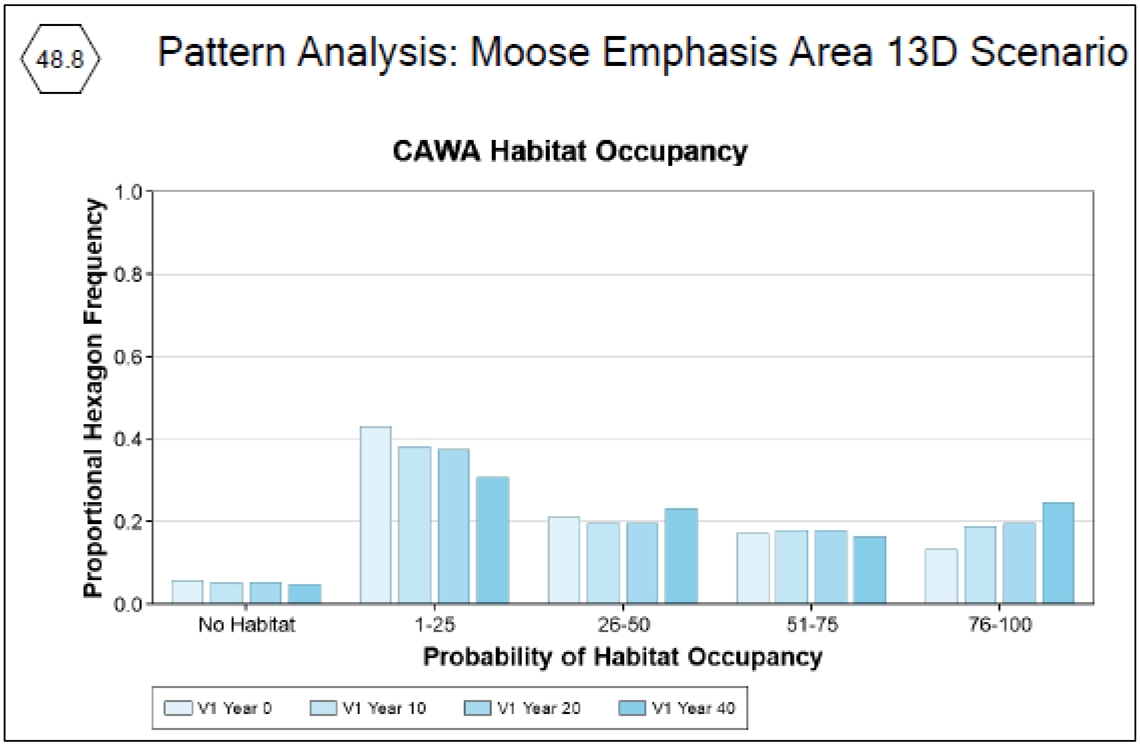


Figure 5.44 Canada Warbler estimates of probability of habitat occupancy under the Moose Emphasis Scenario.

Spatial estimates of Canada Warbler's habitat over the next 40 years is shown in Figure 5.45

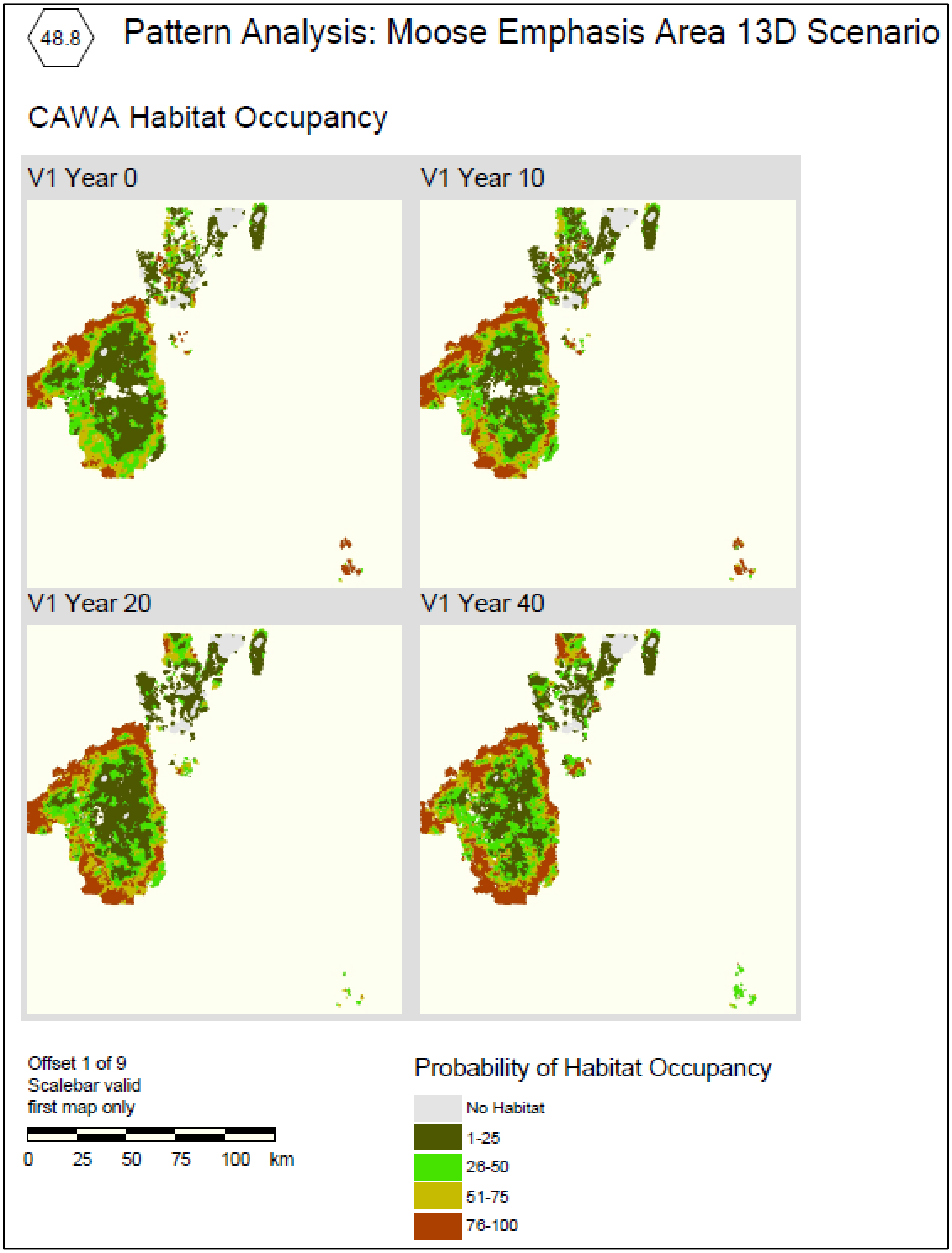


Figure 5.45 Canada Warbler habitat spatial estimates over 40 years.

A larger map of Canada Warbler habitat estimates is shown in Appendix 7.

5.7.4.2 Indicator Bird Species

Indicator bird species represent a niche in the forest ecosystems. Some birds' habitat requirements are indicative of certain conditions (e.g. old conifer forest). A summary of the estimated change in indicator bird species habitat from time 0 to 40 years in the future is shown in Table 5.13, if the Moose Emphasis Scenario were implemented.

The No Harvest response was estimated as positive, neutral, or negative based on the change in habitat quality over the 40-year modeling period, as estimated using change over time. If the amount of medium or high-quality habitat (Probability of occupancy > 50%) increased over time, or low-quality habitat decreased, then this was interpreted as a positive response. In contrast, if amount of low-quality habitat increased, then this was interpreted as a negative response. Note that the No Harvest scenario also excludes natural disturbance, so the forest is simply aging over time without any new regeneration.

The response to the Baseline and Moose Emphasis scenarios was estimated by comparing relative amounts of high- and low-quality habitat at year 40 with the No Harvest scenario, as reported in "Comparison of Birds under No Harvest versus Baseline and MEA – Year 40 for all Birds.pdf". If the amount of medium and high-quality habitat (probability of occupancy > 50%) was lower relative to No Harvest scenario, then this was interpreted as a negative response, and vice versa with the low-quality habitat.

Table 5.13. Summary of Indicator Bird Species with existing habitat models in FML #3.

American Ornithologist Union Code	Bird Common Name	*No Harvest* estimated response (positive, negative, or neutral)	MOOSE EMPHASIS Estimated Response (positive, negative, or neutral)
*AMRE	American Redstart	*neutral*	neutral
BCCH	Black-Capped Chickadee	*Slightly positive*	Slightly positive
BHCO	Brown-Headed Cowbird	*neutral*	positive
BHVI	Blue-Headed Vireo	*positive*	negative
BOCH	Boreal Chickadee	*positive*	negative
BRCR	Brown Creeper	*positive*	negative
**COYE	Common Yellowthroat	*Slightly positive*	neutral

American Ornithologist Union Code	Bird Common Name	*No Harvest* **estimated response** (positive, negative, or neutral)	**MOOSE EMPHASIS Estimated Response** (positive, negative, or neutral)
CSWA	Chestnut-Sided Warbler	*negative*	positive
GCKI	Golden-Crowned Kinglet	*positive*	negative
HETH	Hermit Thrush	*Slightly negative*	positive
OVEN	Oven bird	*neutral*	slightly positive
REVI	Red-Eyed Vireo	*Slightly positive*	neutral
SWTH	Swainson's Thrush	*positive*	negative
***VEER	Veery	*negative*	positive
WIWR	Winter Wren	*positive*	negative
YBSA	Yellow-Bellied Sapsucker	*positive*	slightly negative
YWAR	Yellow Warbler	*positive*	Slightly negative

*AMRE is a surrogate for species at risk GWWA Golden-Winged Warbler

**COYE is a surrogate for species at risk OSFL Olive-Sided Flycatcher

***VEER is a surrogate for species at risk GWWA Golden-Winged Warbler

Maps of indicator bird's habitat by species and scenario are shown in Appendix 3.

5.7.4.3 Winter Moose Habitat

The validated RSF (Resource Selection Function) was used to assess winter moose habitat values for the Moose Emphasis Scenario. Time periods 0 (current condition), 10, 20, 30, and 40 years were evaluated.

The RSF quantifies winter moose habitat from 0.0 (low) to 0.9 (high). The RSF histogram shows an increase of winter moose habitat over time (Figure 5.46), under the Moose Emphasis Scenario.

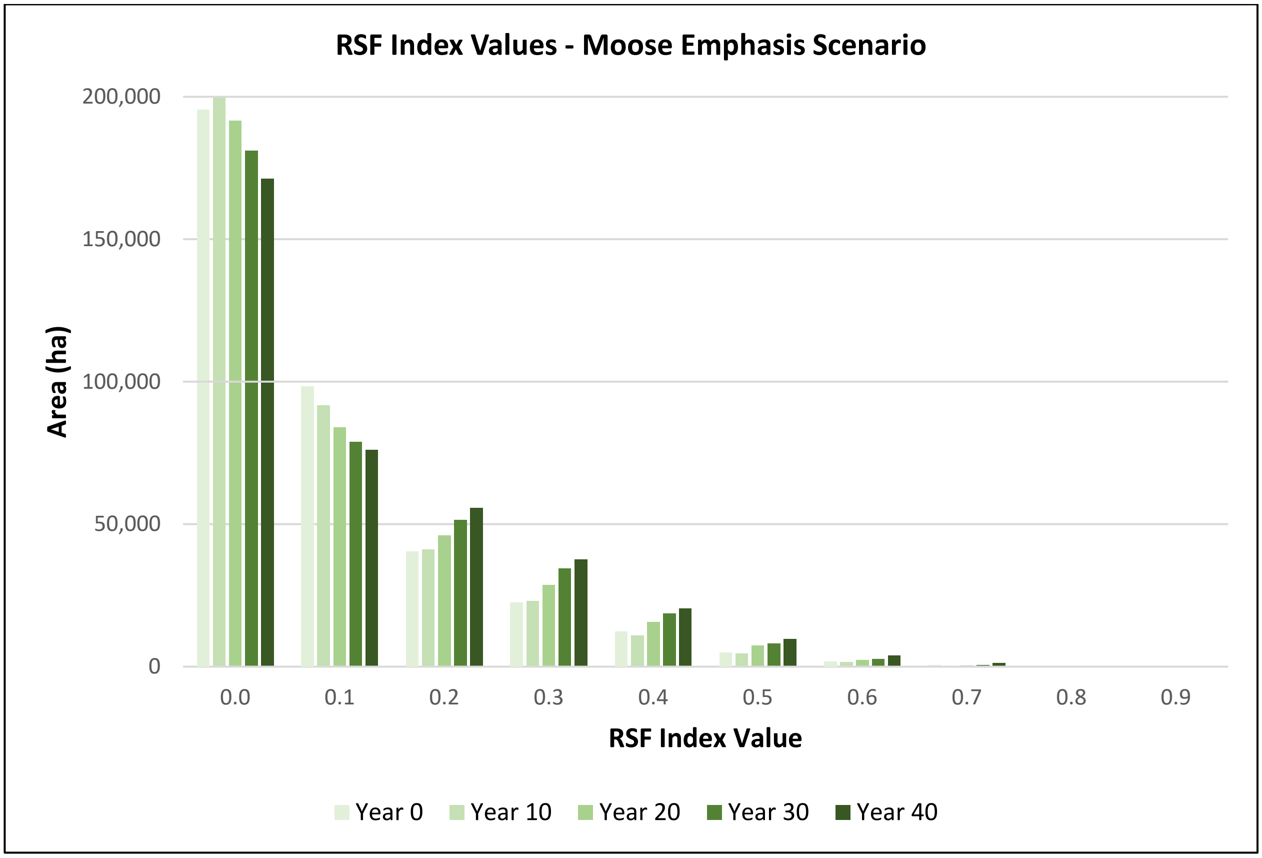


Figure 5.46 Winter moose habitat histogram for the Moose Emphasis Scenario.

Maps of winter moose habitat under the Moose Emphasis Scenario are shown in Appendix 9.

5.7.4.4 Summer Moose Habitat

Summer moose habitat was evaluated with the Habitat Supply Model. Summer moose habitat is ranked on a scale of 1 (low) to 9 (high). The Moose Emphasis Scenario keeps moose summer in FMU 13 habitat relatively stable over time (Figure 5.47).

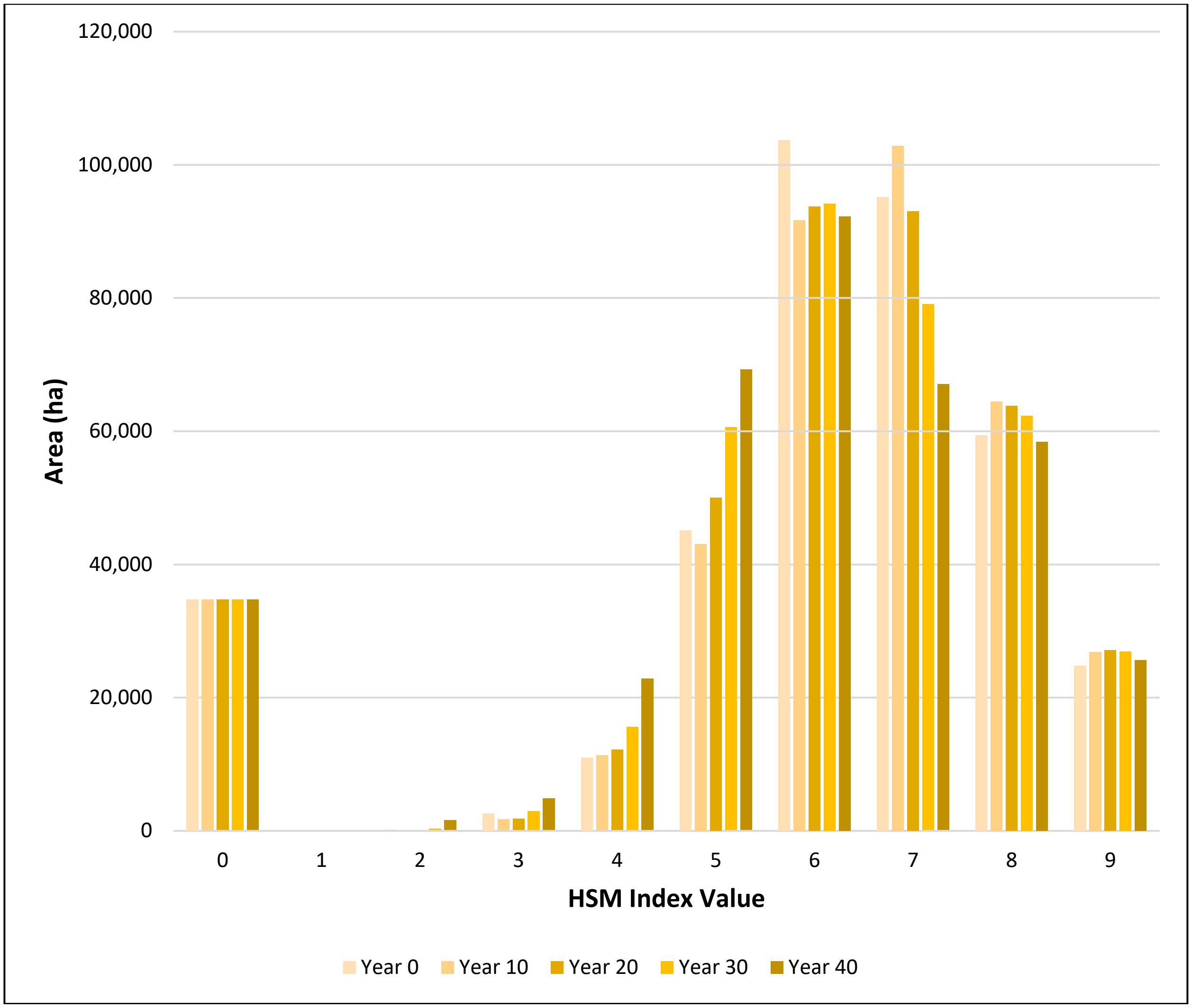


Figure 5.47 Moose Emphasis Scenario summer habitat is stable over time.

Maps of summer moose habitat estimated over time is shown in Appendix 10.

5.7.4.5 *Marten Winter Cover Habitat*

An aspatial winter cover Habitat Suitability Index (HSI) model for marten (*Martes americana*) was developed by Manitoba Forestry Wildlife Management Project (1994a). This model was based on both expert opinion and marten literature from other provinces. HSI models numerically (i.e. 0.0, 0.1, … 1.0) describe habitat quality and quantity for wildlife species.

The marten winter cover HSI model was then validated and modified, based on additional expert review and interviewing marten trappers across Manitoba (Manitoba Forestry Wildlife Management Project (1994b). This validated model was used to assign HSI values to forested stands in FML #3. The individual stand HSI values were multiplied by the total area, resulting in Habitat Units. This was repeated for each 10-year planning period, from 0 to 200 years (Figure 5.48).

Both the no harvest scenario and the Moose Emphasis Scenario initially decline in marten winter cover habitat units. As mature conifer stands age and decline in crown closure, the marten HSI model considers old conifer stands with lower crown closure as lower marten habitat quality. This decline in marten habitat was verified by an Indigenous elder and experienced trapper. Simple aging of the forest and natural processes reduce marten winter cover over the landscape. Later marten winter cover stabilizes with minor fluctuations over time.

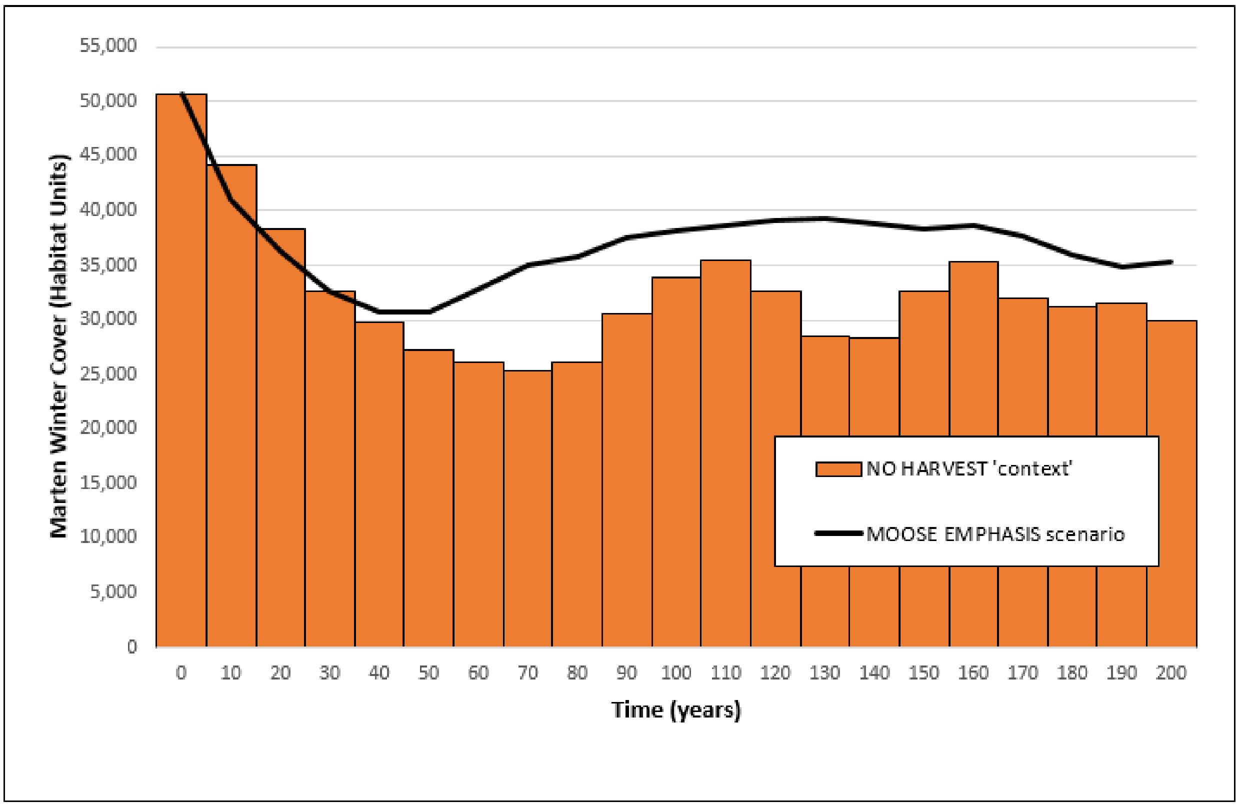


Figure 5.48 Marten winter cover over 200 years, of the Moose Emphasis Scenario, compared to the no harvest modeling.

5.8. COMPARISON OF BASELINE AND MOOSE EMPHASIS SCENARIOS

Both the Baseline Scenario and the Moose Emphasis Scenario are viable, sustainable, and stable scenarios. Either scenario is beneficial for the forest and meets the goals of providing both ecological and socio-economic benefits both now and in the future. However, there is a requirement to choose one scenario. The chosen scenario should have the greatest overall benefits to multiple parts of ecosystems in Forest Management Licence #3. The description of the process of scenario ranking, scoring, and choice of the Preferred Forest Management Scenario that will be implemented over the next 20 years is described in the sections below.

5.8.1. Scenario Ranking Process

The ranking of scenarios is a methodology to compare multiple objectives for each scenario, then weigh value of each scenario, thus comparing the scenarios to each other. The provincial 20-year forest management plan guideline (2007) has a template for scenario ranking (Table 5.14).

Table 5.14 Ranking scenarios by objectives (Manitoba Conservation 2007).

				Level of Achievement of Scenarios		
				1	2	3
Objectives	Target	Weight	Unit of Measure			
Quantifiable Objectives Non-Quantifiable Objectives						
			Score			
			Prefered Management Approach			

Rationale for FMP-5

This table ranks the scenarios in acheiving targets of the overriding objectives.

Instructions FMP-5

- List the scenarios in the columns under the heading Level of Achievements of Scenarios.
- List the objectives and their corresponding targets and unit of measure in the appropriate columns.
- Insert for each measurable target the level of achievement for each scenario.The plan author will develop a scoring system to evaluate the scenarios.
- List the non-quantifiable objectives.
- Rank the likelihood of the different scenarios in attaining the non-quantifiable objectives.

An important note is that the Province of Manitoba and LP mutually agreed not to put the provincial Base Case into the scenario ranking table, even though the 2007 FMP guidelines suggest the Base Case be included. The reasons for not including the Base Case include:

- The Base Case is an aspatial wood supply analysis, and not a spatial forest management scenario
- The Base Case is completed long before FMP objectives are chosen, and therefore is unfairly ranked against objectives that were not part of the Base Case formation

5.8.2. Choosing Objectives

There were approximately 150 different objectives to choose from in the modeling outputs for each scenario (*i.e.* Baseline and Moose Emphasis Scenarios). Obviously, these objectives needed to be scoped down to a much more manageable number.

The Forest Management Plan team and the Stakeholder's Advisory Committee were each asked to provide meaningful forest management indicators, based on each person's expertise and opinion. Indigenous communities were also encouraged to engage on forest management indicators and provide input.

An Excel worksheet was created to track all submitted responses on objectives (Appendix 11). Modeling Core Team reviewed the input and process for the summarized mutually selected indicator list. Quantifiable forest management objectives were mutually agreed upon (Table 5.15) from a possible list of 150 different indicators. These objectives were used to compare the two forest management scenarios (*i.e.* Baseline and Moose Emphasis).

Table 5.15 Mutually agreed upon forest management objectives in FML #3.

Objective % chosen	Objective	Comments
17.9%	**Moose**	Moose habitat consistently scored high from Indigenous communities, Stakeholders, and the FMP planning team.
12.2%	**Roads**	Most said to reduce or minimize roads; a few said to maximize roads and keep all access open
9.0%	**Natural Range of Variation (NRV)**	Emulating fire at the landscape level. Move towards Natural Range of Variation targets for mature and old forest seral stages by species groups (black spruce, white spruce, pine, deciduous, and mixedwoods).
8.3%	**Watershed Limits**	30% watershed in a 'harvested state' maximum not to be exceeded
7.1%	**Patch Size Distribution**	Wider range of Patch sizes better, since it benefits coarse-filter biodiversity, aligns with NRV, and benefits wildlife species
5.1%	**Cover Group**	Maintain area of S-softwood, M-softwood-mixedwood, N-Hardwood-mixedwood, and H-Hardwood
4.5%	**Species At Risk - bird**	Canada Warbler is the only SAR bird we have sufficient observations to link to habitat
3.8%	**17 Indicator Bird Species**	Indicator bird species each represent a different niche in the forest ecosystems (e.g. old conifer forest, young hardwood, *etc.*).
3.8%	**Marten Winter Cover**	Aspatial winter cover for marten – uses Habitat Supply Index model
71% TOTAL		**These mutually agreed upon objectives account for 71% of all responses from all communities and individuals.**

The purpose of ranking scenario objectives is to choose the forest management scenario that most benefits ecological, social, and economic factors. The initial objective ranking was based on the highest percentage responses from Table 5.15.

Non-quantifiable objectives are valid objectives that are difficult to attach a number to. For example, visual quality is somewhat subjective, and hard to attach a number to. Non-quantifiable objectives identified included (in alphabetical order):

- Access to firewood
- Aesthetics or visual quality
- Artifacts and Cultural
- Cumulative effects
- Effects to watershed
- Fragmentation
- Harvest near Treaty Land Entitlement
- Harvesting (boom or bust)
- Large wildlife
- Leaving buffer areas
- Parks
- Protecting traplines
- Water levels

5.8.3. Objective Comparison by Scenario

This section compares the mutually agreed upon quantifiable forest management objectives between the Baseline and Moose Emphasis Scenarios.

5.8.3.1 Amount of winter moose habitat

Winter moose habitat across FML #3 was determined for a 40-year period by utilizing the newly created Resource Selection Function (RSF) habitat tool. The 'No Harvest' modeling was compared to the Baseline and Moose Emphasis Scenarios, using preferred (*i.e.* 0.5, 0.6…1.0) winter habitat values.

All scenarios are the same at time zero (Figure 5.49). The 'No Harvest' modeling drops rapidly, due to lack of disturbance which creates important moose forage. Most of the 'No Harvest' future winter habitat values are below 0.4, and do not appear on the histogram of preferred winter habitat values.

Both the Baseline and Moose Emphasis Scenarios show significant improvement in winter moose habitat over time.

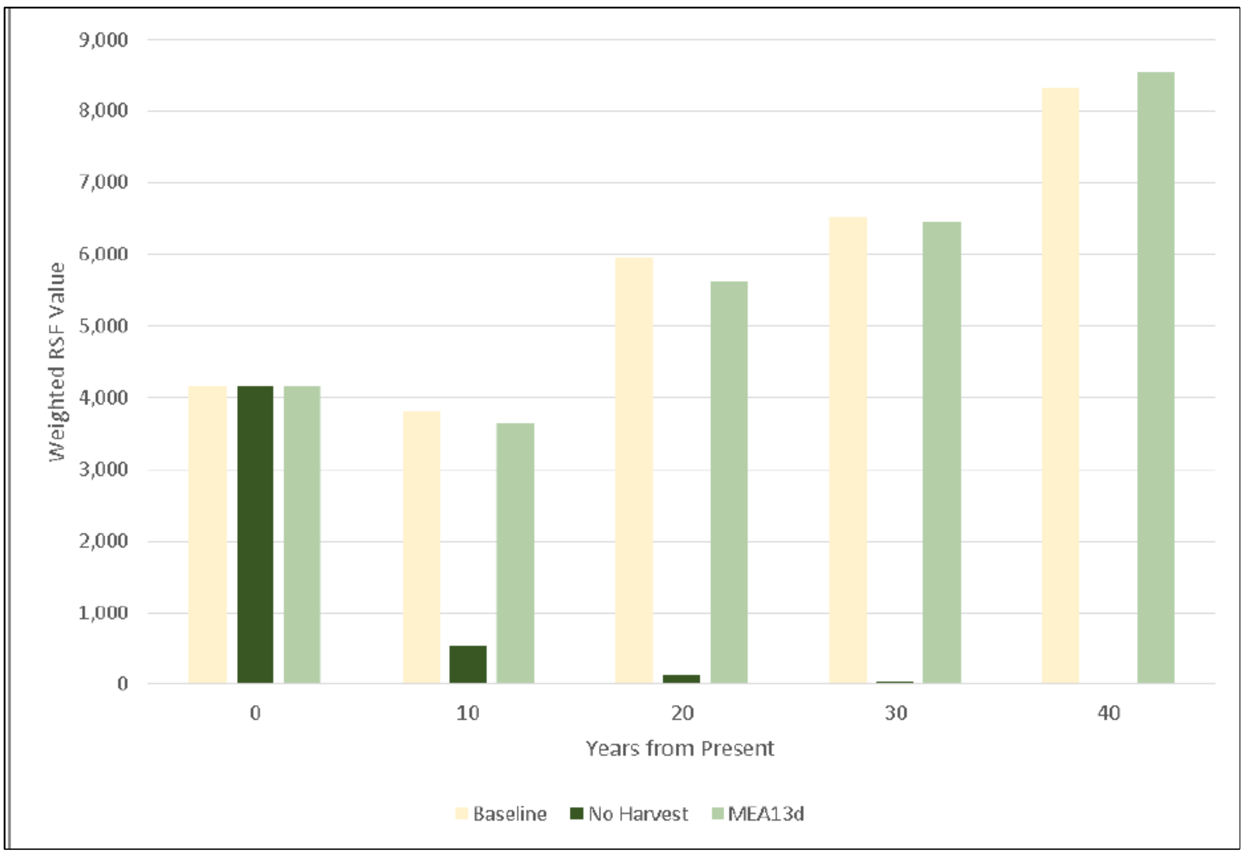


Figure 5.49 Winter moose habitat comparison by scenario.

5.8.3.2 Roads

The length of roads needed to be built to access future cut blocks is different between scenarios. The Moose Emphasis Scenario has 15% less existing and candidate roads. Candidate roads alone are 25% lower (Table 5.16) in the Moose Emphasis Scenario (Figure 5.51) compared to the Baseline scenario (Figure 5.50 and Figure 5.51).

The Moose Emphasis scenario's 25% reduction in roads is attributable to:

- Larger patch size distribution than the Baseline scenario;
- Re-using existing roads more often, thus reducing the length of new roads needed; and,
- A very small potential amount of volume (above the existing provincial AAC) was not scheduled for harvest.

Table 5.16 Length of roads needed by scenario and planning period.

	Period 1 (1 10 yrs)		Period 2 (11 20 yrs)		Period 3 (21 30 yrs)		Period 4 (31 40 yrs)		Cumulative	
Road Type	Baseline (km)	Moose Emphasis (km)	Baseline (km)	Moose Emphasis (km)	Baseline (km)	Moose Emphasis (km)	Baseline (km)	Moose Emphasis (km)	Baseline (km)	Moose Emphasis (km)
Candidate Future Roads	343.2	288.4	397.4	322.8	486.9	356.5	392.0	324.5	**1,619.5**	**1,292.1**
Existing All-Season	50.0	45.2	53.1	50.2	73.0	47.4	52.4	50.0	**228.4**	**192.8**
Existing Dry-Frozen	253.7	285.3	242.5	256.6	294.4	250.6	247.0	232.8	**1,037.5**	**1,025.2**
Totals	**646.9**	**618.8**	**692.9**	**629.6**	**854.2**	**654.4**	**691.4**	**607.3**	**2,885.4**	**2,510.1**
existing & candidate roads		-4.5%		-10.1%		-30.5%		-13.9%		-15.0%
candidate roads		**-19.0%**		**-23.1%**		**-36.6%**		**-20.8%**		**-25.3%**

In the table above, the cumulative sum column is a geographic sum. Each amount of active road in each period is the correct amount for that period. However, the last column (cumulative) excludes any overlap between the four periods, so each road is only counted once. The last column is the sum of any roads that were open over the 40 years, but the overlaps were excluded to ensure that roads were counted only once.

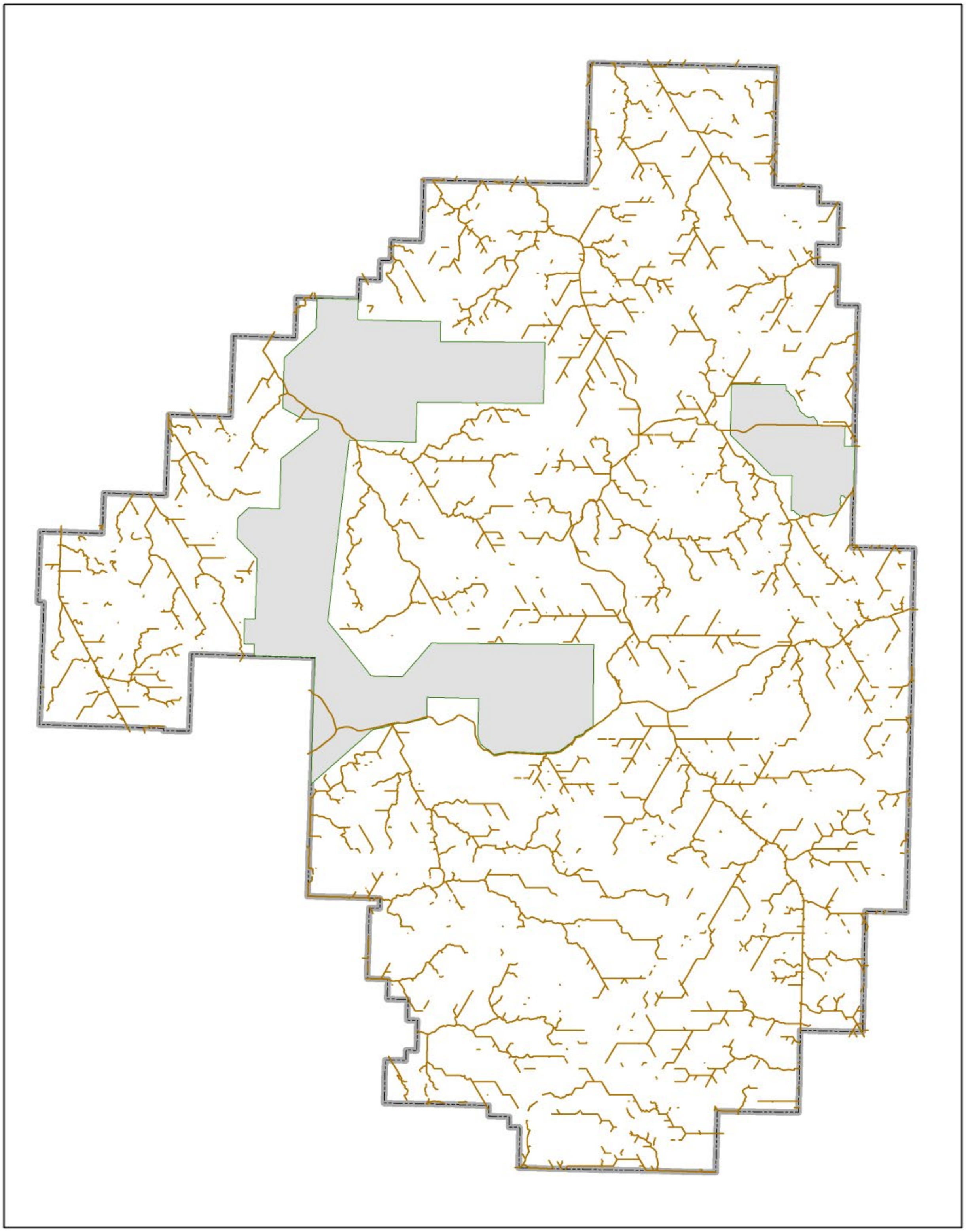


Figure 5.50   Baseline scenario roads.

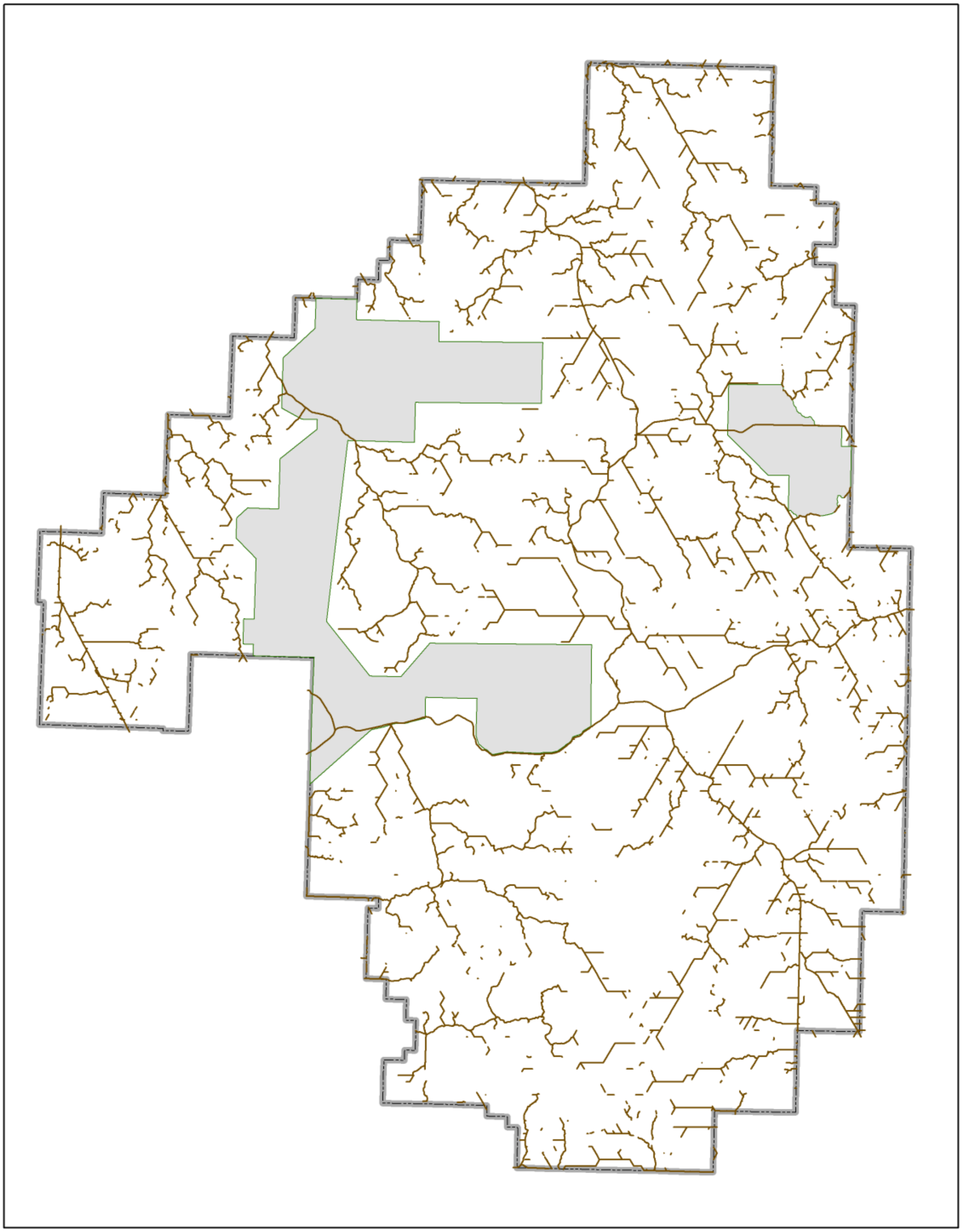


Figure 5.51 Moose Emphasis Scenario has less roads.

5.8.3.3 Watershed Limits

The future watershed disturbance was compared between the Baseline and Moose Emphasis Scenarios. There were minor, but not significant differences in percent disturbance by watershed (Table 5.17). In all time periods and both scenarios, the percent disturbance is far lower than the 30% maximum.

Table 5.17 Percent disturbance by watershed, scenario, and time period.

	BASELINE scenario (years in the future)							Moose Emphasis Scenario (years in the future)					
	0	10	20	50	100	200		0	10	20	50	100	200
WATERSHED NAME	(%)	(%)	(%)	(%)	(%)	(%)		(%)	(%)	(%)	(%)	(%)	(%)
ASSINIBOINE	0.3	0.1	0.1	0.7	0.3	0.3		0.3	0.0	0.1	0.7	0.9	0.3
CENTRAL VALLEY	1.5	0.8	1.1	2.7	3.5	1.6		1.5	1.5	1.7	2.5	3.2	1.7
CRANE	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
FISH MINK CREEK	0.7	0.2	0.3	0.1	1.0	0.8		0.7	0.3	0.4	0.4	0.8	0.8
FORK RIVER	0.5	0.2	0.5	1.2	1.1	1.0		0.5	0.3	0.5	0.7	1.5	0.9
GARLAND RIVER	1.9	1.8	1.3	1.6	3.0	3.3		1.9	1.4	1.0	2.2	2.7	3.4
HAMELIN DRAIN	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
KETTLE HILLS	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
LOWER ROARING	0.5	0.4	1.0	4.0	4.0	4.0		0.5	1.1	1.0	3.2	2.9	3.4
LOWER SHELL	0.3	0.2	0.4	1.1	0.8	0.7		0.3	0.2	0.4	0.7	1.0	0.9
LOWER SWAN	0.0	0.2	0.0	0.6	0.7	0.5		0.0	0.5	0.0	0.7	0.1	0.5
LOWER TURTLE	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
LOWER VALLEY SILVER CREEK	0.8	0.6	0.4	0.8	1.5	1.0		0.8	0.6	0.6	1.1	0.8	1.2
LOWER WOODY	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
PELICAN LAKE EAST	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
PINE RIVER	2.1	1.9	1.0	2.6	3.0	4.5		2.1	1.5	0.8	2.7	2.6	3.2
SCLATER DUCK	0.9	1.2	0.7	1.8	2.0	2.9		0.9	1.6	0.8	1.8	2.1	2.1
UPPER ROARING	1.2	2.3	2.1	3.9	4.1	4.9		1.2	1.9	1.7	4.2	4.0	5.0
UPPER SHELL	2.9	3.3	2.7	4.9	6.4	6.6		2.9	2.0	2.3	5.7	6.0	6.8
UPPER SWAN	0.4	0.2	0.5	1.6	1.2	1.0		0.4	0.1	0.1	1.4	1.4	0.9
UPPER TURTLE	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
UPPER VALLEY	4.4	3.9	2.5	8.3	8.6	8.7		4.4	3.0	3.9	7.7	9.5	8.6
UPPER WOODY	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0

5.8.3.4 Patch Size Distribution

A wider patch size distribution is better, since it provides better coarse-filter biodiversity and better benefits to a variety of wildlife species. The Moose Emphasis Scenario has a wider patch size distribution than the Baseline scenario (Figure 5.52).

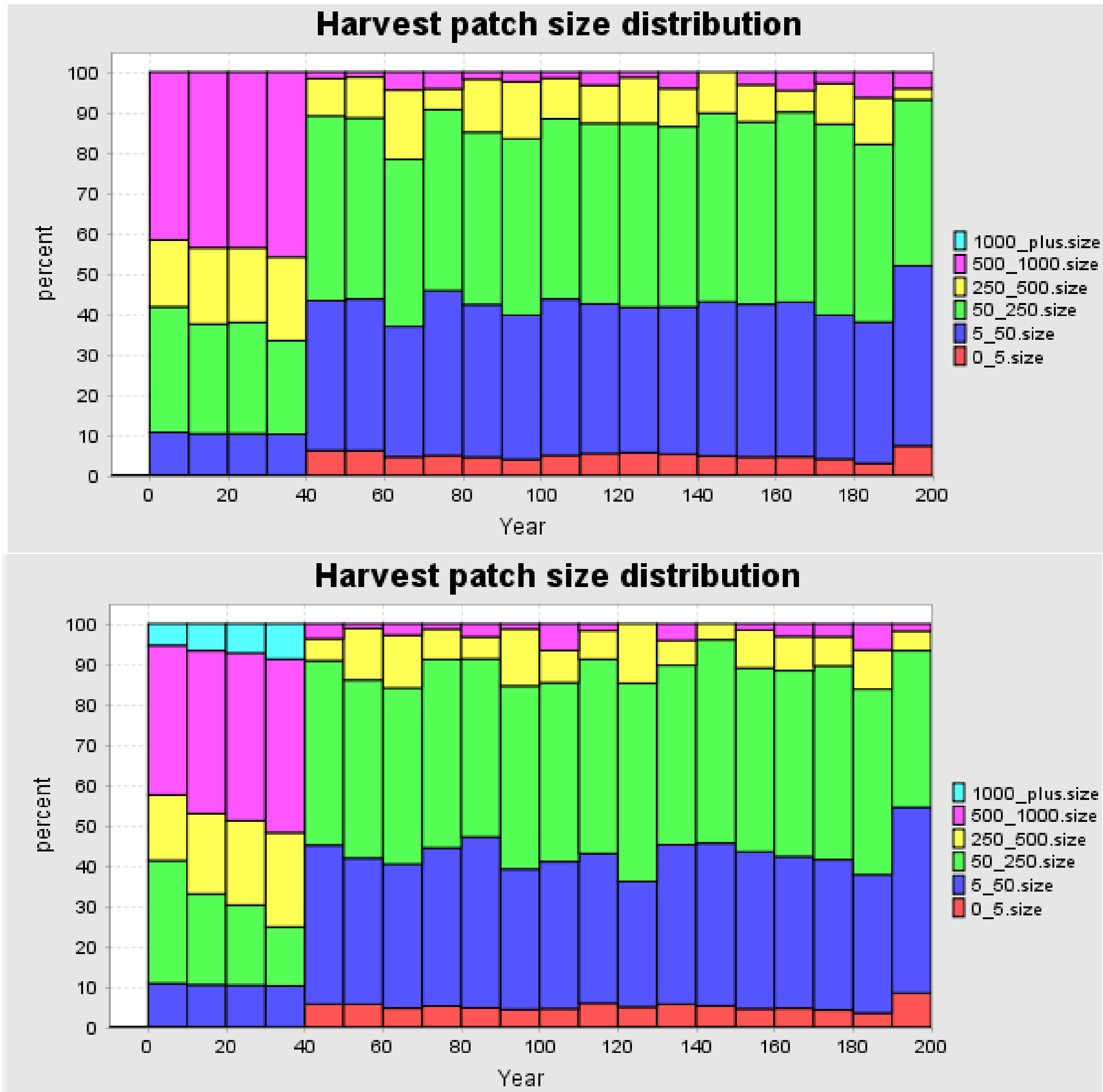
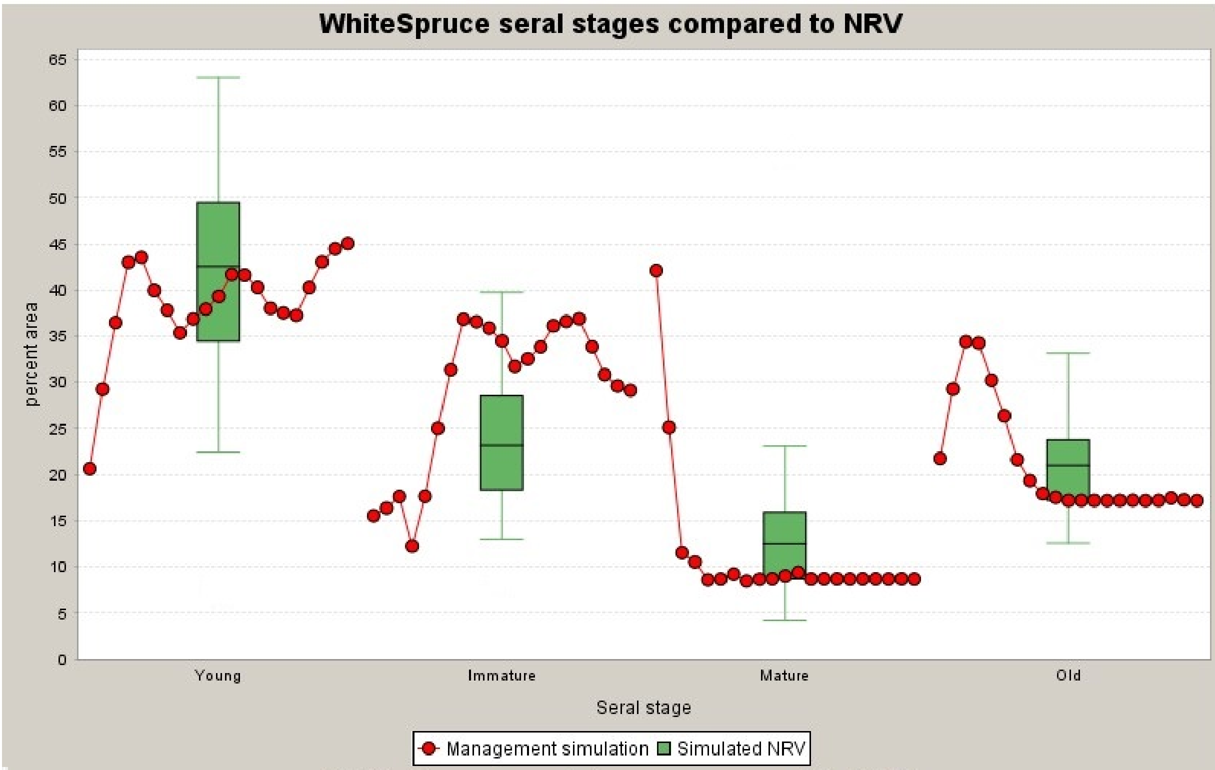


Figure 5.52 Harvest patch size distribution for the Baseline scenario (top) and the Moose Emphasis Scenario (bottom).

5.8.3.5 Natural Range of Variation (NRV)

Natural Range of Variation (NRV) is very similar, if not identical, between the Baseline and Moose Emphasis Scenarios (Figure 5.53 through Figure 5.57).



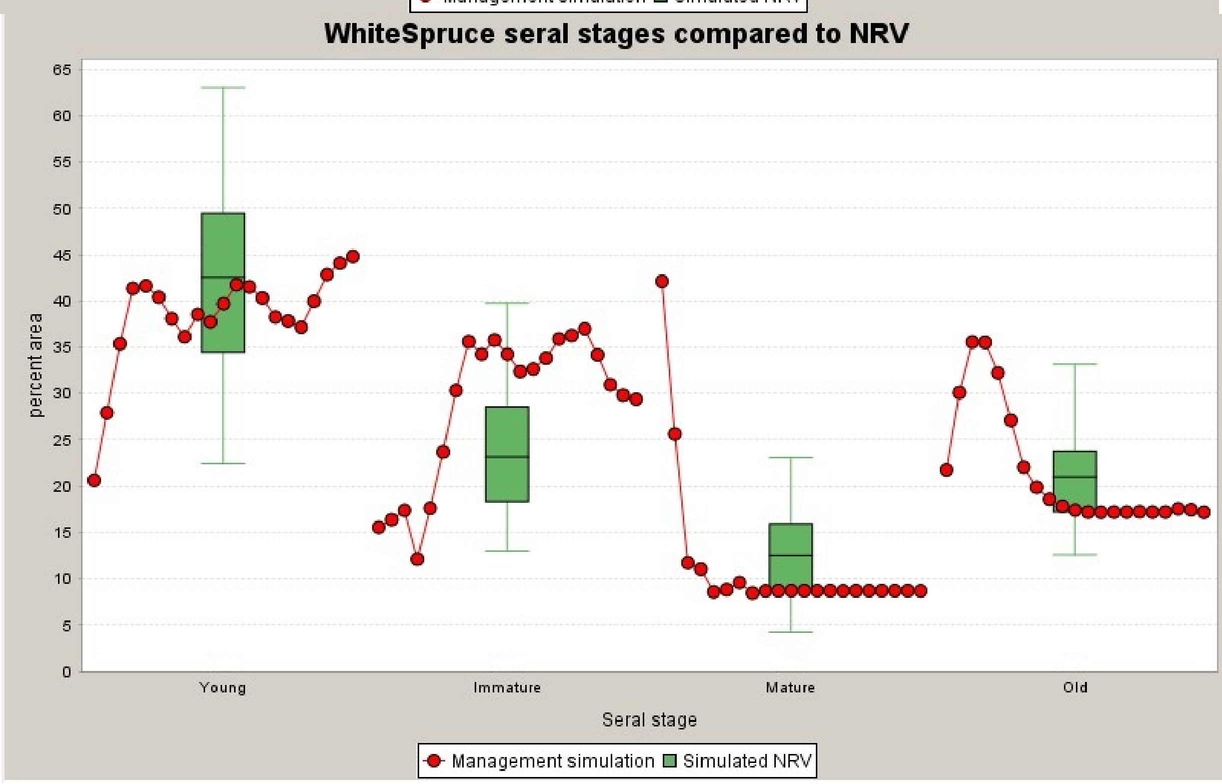
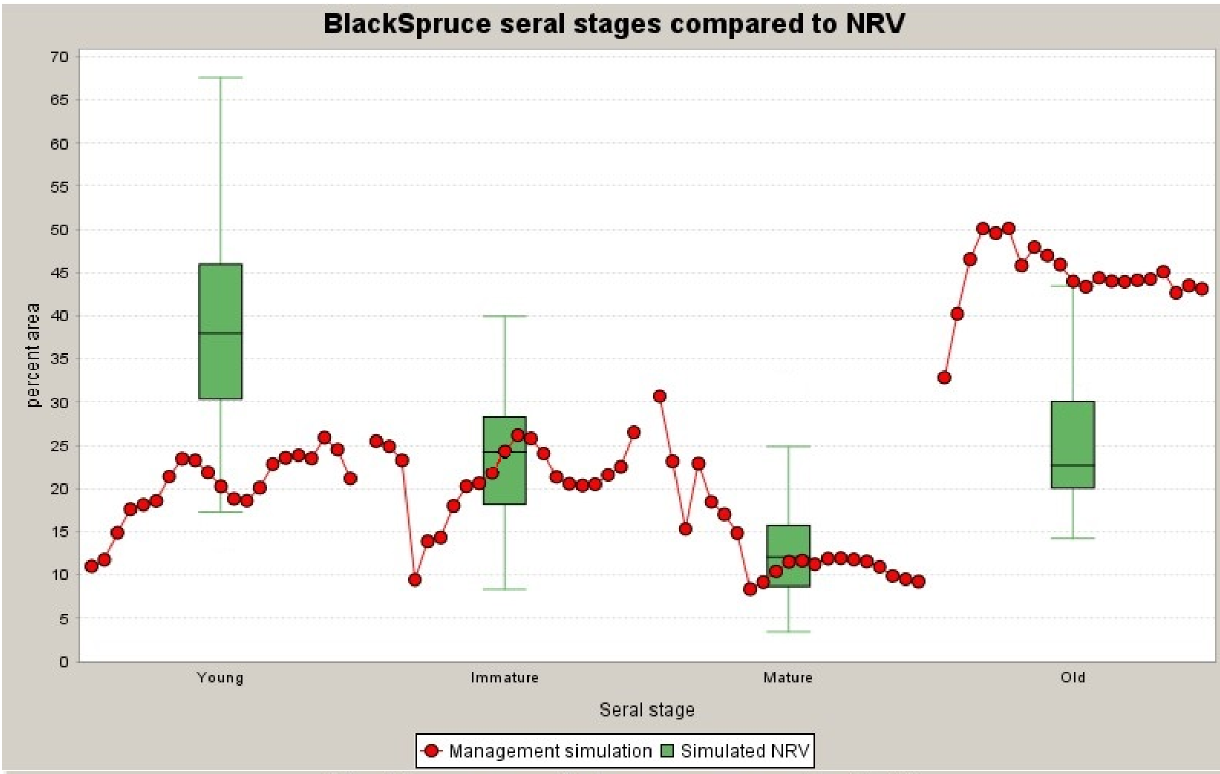


Figure 5.53 White spruce Natural Range of Variability seral stages for the Baseline (top) and Moose Emphasis Scenarios (bottom).



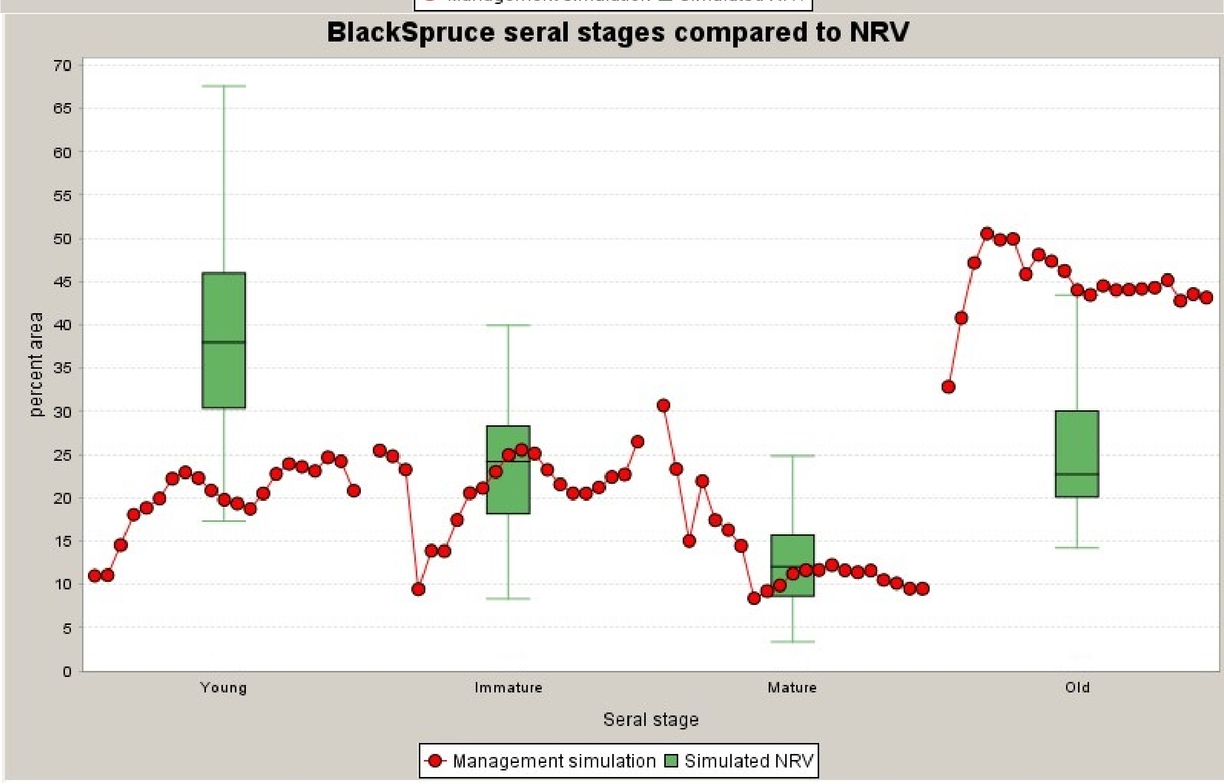


Figure 5.54 Black spruce Natural Range of Variability seral stages for the Baseline (top) and Moose Emphasis Scenarios (bottom).

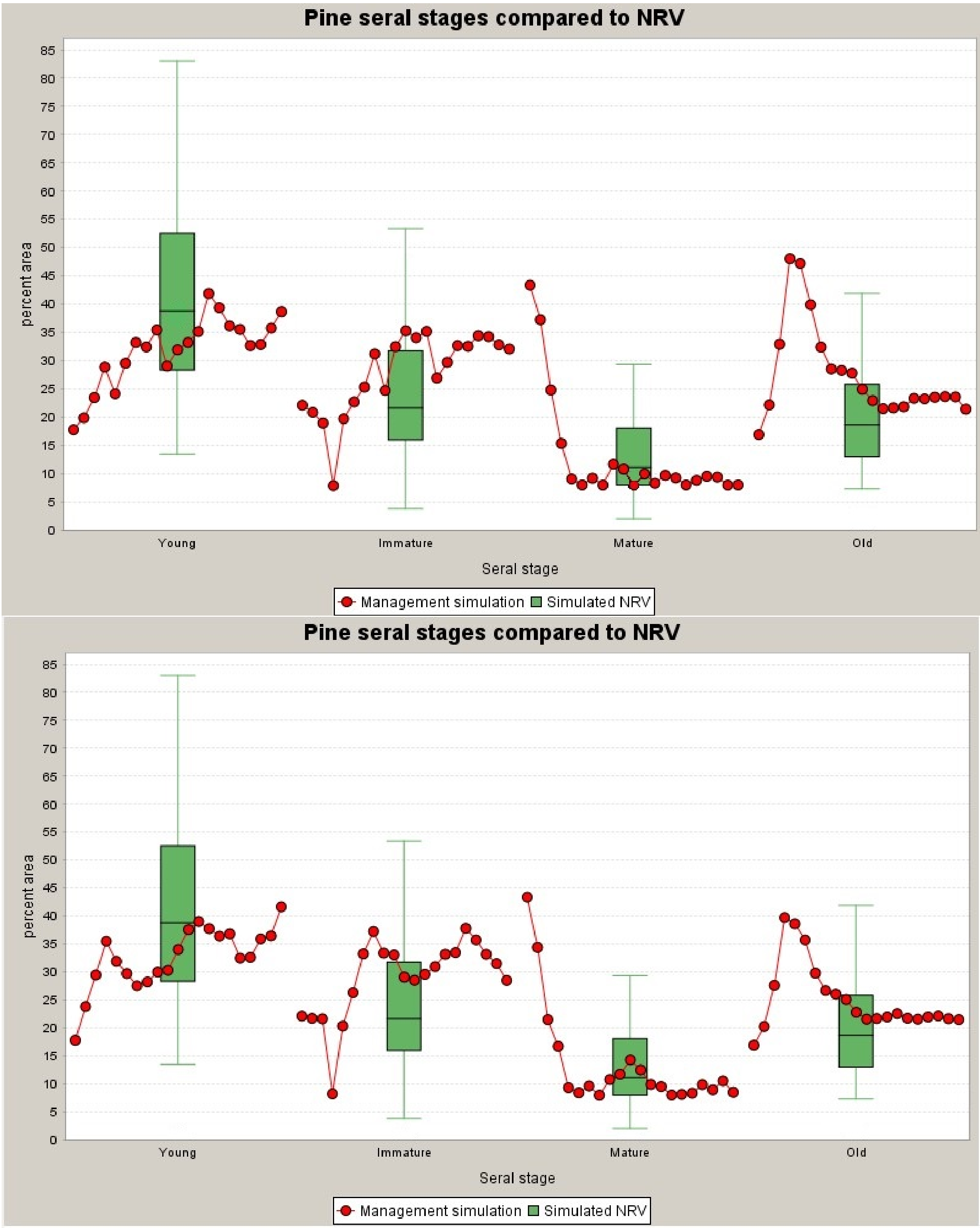


Figure 5.55 Pine Natural Range of Variability seral stages for the Baseline (top) and Moose Emphasis Scenarios (bottom).

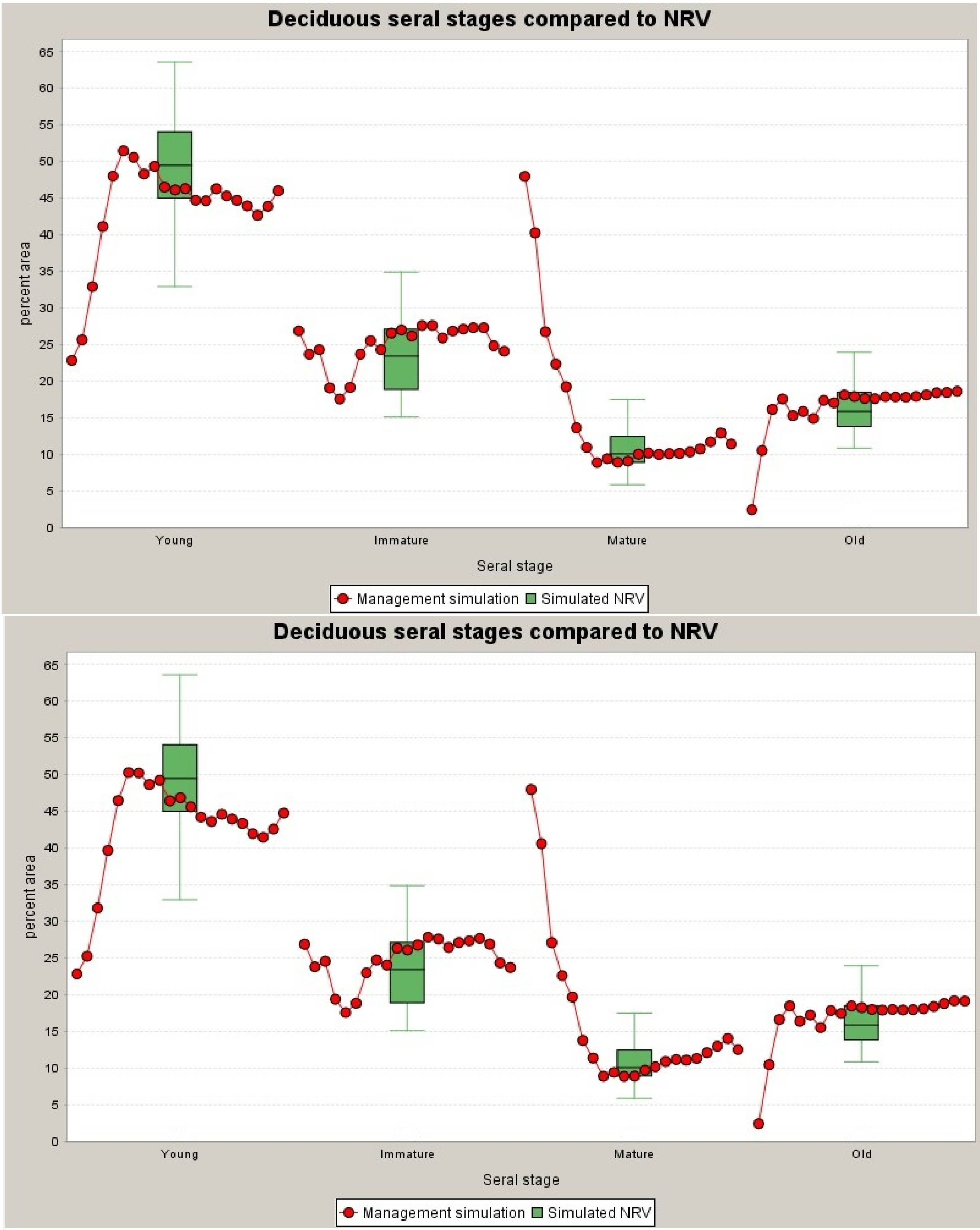
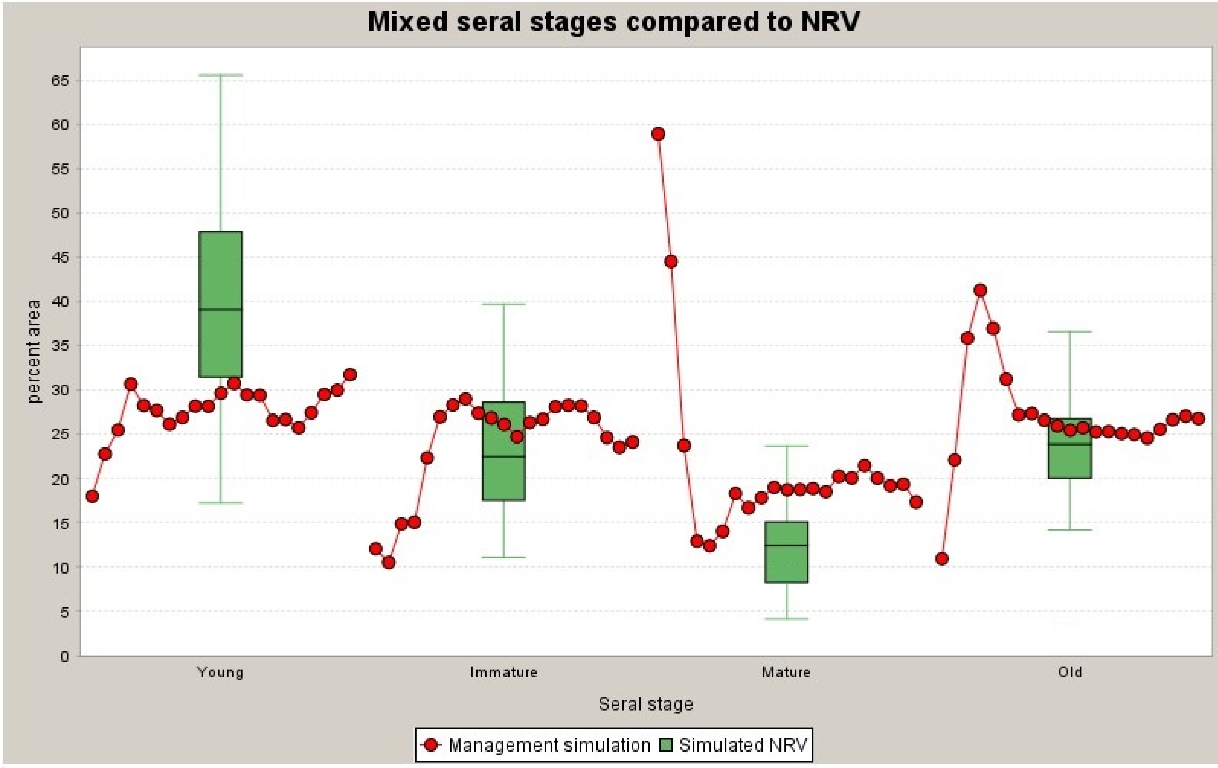


Figure 5.56 Deciduous Natural Range of Variability seral stages for the Baseline (top) and Moose Emphasis Scenarios (bottom).



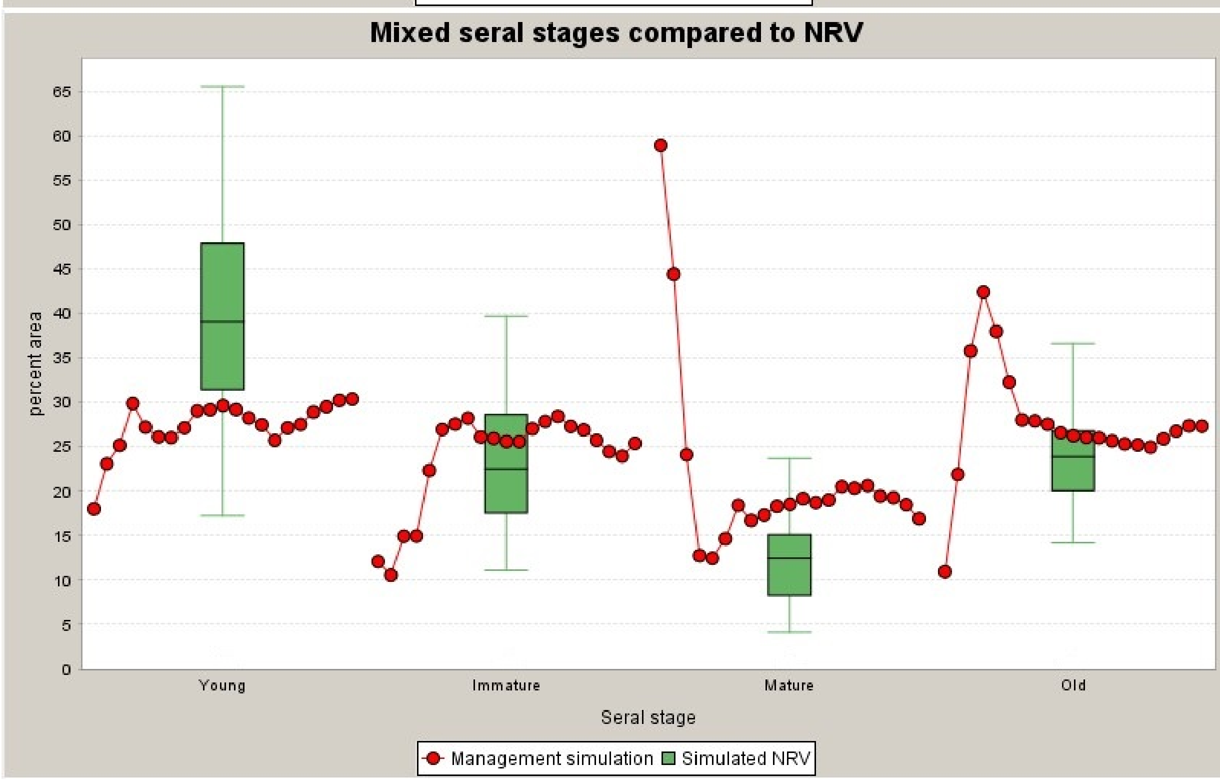
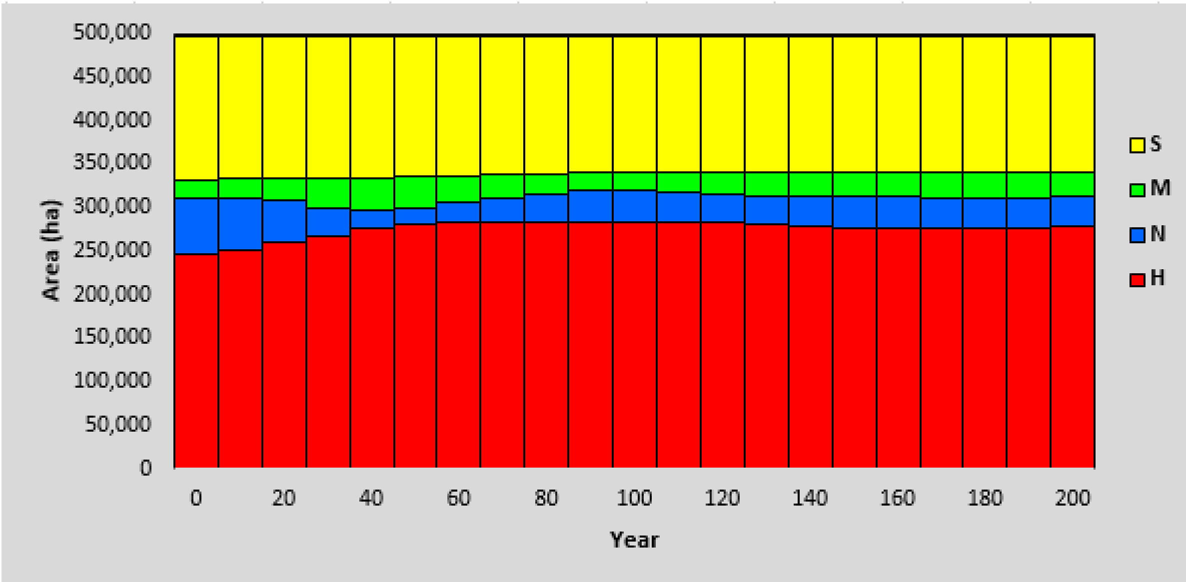


Figure 5.57 Mixedwoods Natural Range of Variability seral stages for the Baseline (top) and Moose Emphasis Scenarios (bottom).

5.8.3.6 Cover Group

Cover group (S-softwood, M-softwood mixedwood, N-hardwood mixedwood, and H-hardwood) is very similar between the Baseline and Moose Emphasis Scenarios (Figure 5.58). Both scenarios show stability of cover type.



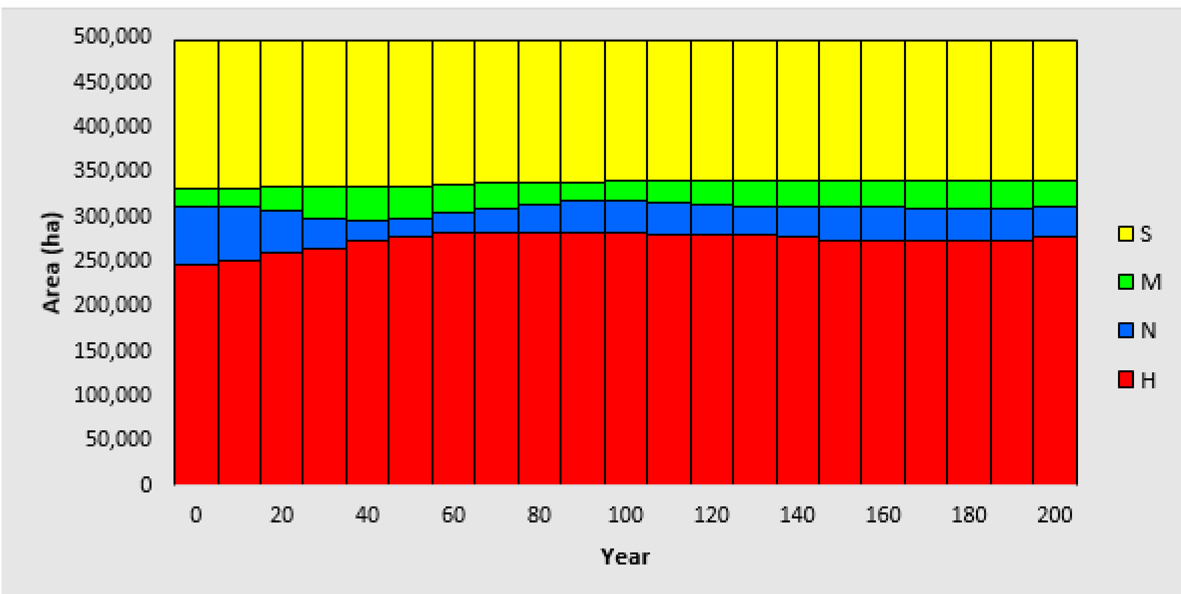


Figure 5.58 Cover type by Baseline scenario (top) and the Moose Emphasis Scenario (bottom).

5.8.3.7 Species At Risk – Canada Warbler

The Canada Warbler is the only bird species at risk that has sufficient data for a habitat relationship. Both the Baseline and Moose Emphasis Scenarios benefit Canada Warbler habitat in the future (Figure 5.59). The amount of low (1-25% habitat occupancy) Canada Warbler habitat decreases and is turned into better habitat (76-100% habitat occupancy).

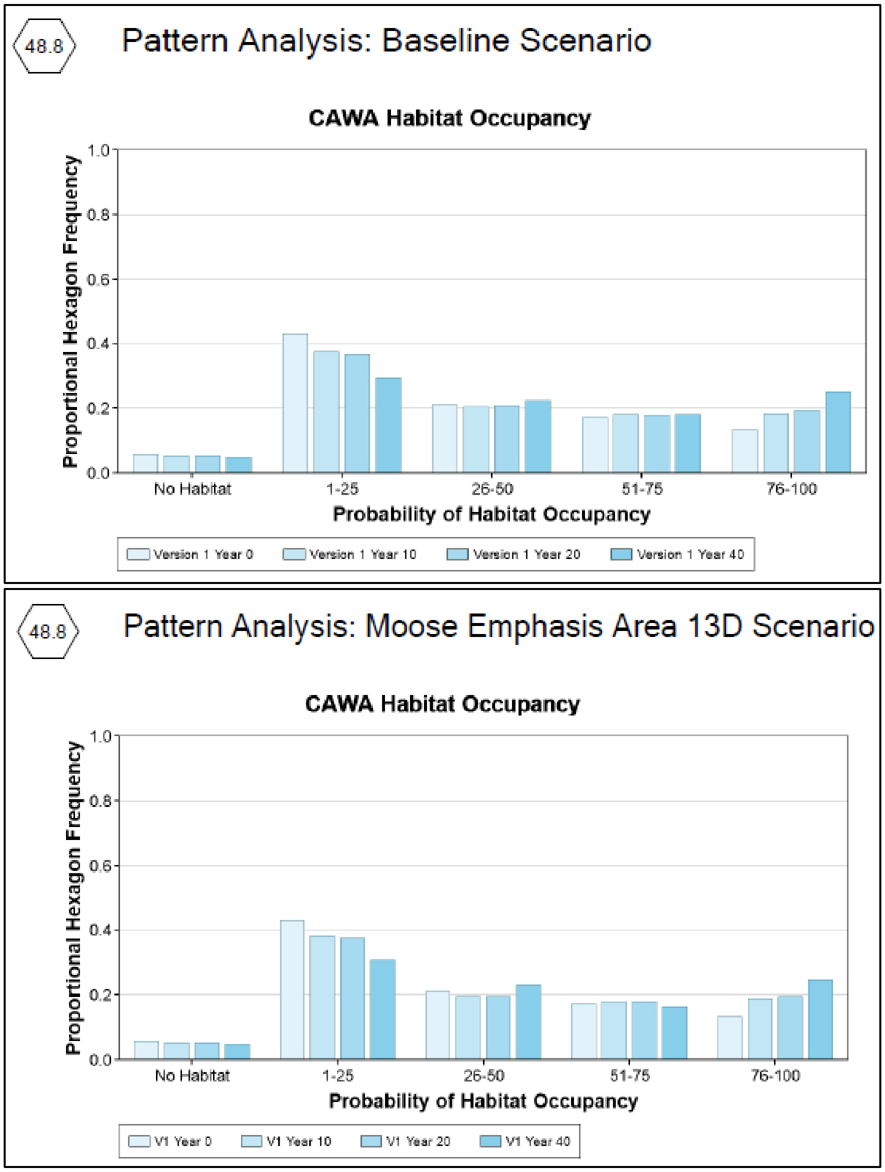


Figure 5.59 Canada Warbler habitat improvement by the Baseline scenario (top) and Moose Emphasis Scenario (bottom).

5.8.3.8 Indicator Bird Species

Indicator bird species represent a niche in the forest ecosystems. Some birds' habitat requirements are indicative of certain conditions (*e.g.* old conifer forest, unmixed hardwood *etc*.). The list of indicator birds covers the range of forest conditions (ages, cover types, and interspersion). A summary of the indicator bird species future estimates by scenario are shown in Table 5.18.

The Baseline and Moose Emphasis Scenarios have similar yet slightly different responses by indicator bird species. Maps comparing scenarios for each bird species are in Appendix 3. There is no clear pattern that one scenario is better, since the results are mixed as follows:

- sometimes the Baseline and Moose Emphasis have the same response (*e.g.* AMRE is
- sometimes the Baseline has a better response than the Moose Emphasis (*e.g.* BHCO is positive for Baseline, but neutral for Moose Emphasis);
- sometimes the Baseline has a worse response than the Moose Emphasis (*e.g.* BCCH is neutral for Baseline, but slightly positive for Moose Emphasis).

Table 5.18 Summary of estimated responses to indicator bird habitat by scenario.

American Ornithologist Union Code	**Bird Common Name**	***No Harvest* estimated response** (positive, negative, or neutral)	**BASELINE Estimated Response** (positive, negative, or neutral)	**MOOSE EMPHASIS Estimated Response** (positive, negative, or neutral)
*AMRE	American Redstart	*neutral*	neutral	neutral
BCCH	Black-Capped Chickadee	*Slightly positive*	neutral	Slightly positive
BHCO	Brown-Headed Cowbird	*neutral*	positive	neutral
BHVI	Blue-Headed Vireo	*positive*	negative	negative
BOCH	Boreal Chickadee	*positive*	negative	negative
BRCR	Brown Creeper	*positive*	negative	negative
**COYE	Common Yellowthroat	*Slightly positive*	neutral	neutral
CSWA	Chestnut-Sided Warbler	*negative*	positive	positive

American Ornithologist Union Code	**Bird Common Name**	***No Harvest* estimated response** (positive, negative, or neutral)	**BASELINE Estimated Response** (positive, negative, or neutral)	**MOOSE EMPHASIS Estimated Response** (positive, negative, or neutral)
GCKI	Golden-Crowned Kinglet	*positive*	neutral	negative
HETH	Hermit Thrush	*Slightly negative*	positive	positive
OVEN	Oven bird	*neutral*	Slightly positive	Slightly positive
REVI	Red-Eyed Vireo	*Slightly positive*	neutral	neutral
SWTH	Swainson's Thrush	*positive*	negative	negative
***VEER	Veery	*negative*	positive	positive
WIWR	Winter Wren	*positive*	negative	negative
YBSA	Yellow-Bellied Sapsucker	*positive*	Slightly negative	Slightly negative
YWAR	Yellow Warbler	*positive*	Slightly negative	Slightly negative

*AMRE is a surrogate for species at risk GWWA Golden-Winged Warbler

**COYE is a surrogate for species at risk OSFL Olive-Sided Flycatcher

***VEER is a surrogate for species at risk GWWA Golden-Winged Warbler

5.8.3.9 Marten Winter Cover

Marten winter cover is almost identical between the Baseline and Moose Emphasis Scenarios (Figure 5.60). It is also identical to the 'no harvest' modeling for the first 40 years.

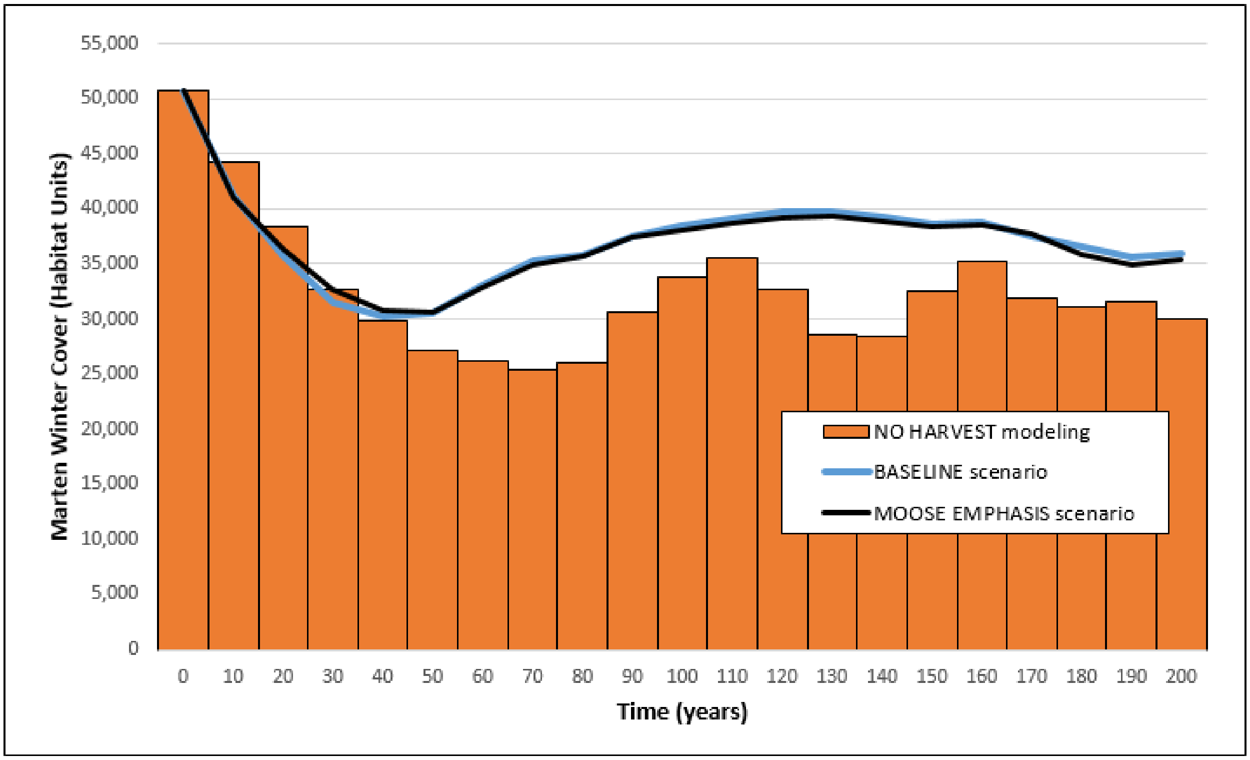


Figure 5.60 Marten winter cover over 200 years by scenario.

5.8.4. Scenario Scores

The Modeling Core Team reviewed the quantifiable objectives and assigned weights to each objective. The Modeling Core Team then scored the Baseline and Moose Emphasis for level of achievement of each objective (Table 5.20). For each objective, the objective's weight (1 to 3) was multiplied by the level of achievement score (1 to 5). These numbers were multiplied to obtain a weighted score. The weighted scores were summed for each scenario.

Often, the Baseline and Moose Emphasis scored the same. This was likely due to the Moose Emphasis Scenario being built upon the Baseline scenario and simply changing the spatial harvest pattern to increase benefits to moose.

The two largest differences between the two scenarios occurred in the roads objective and the patch size objective. The Moose Emphasis Scenario had a 25% reduction in candidate roads, which would need to be built in the future to access future harvest blocks and patches. Furthermore, the Moose Emphasis Scenario had a wider range of patch sizes than the Baseline scenario.

5.8.5. Preferred Management Scenario

The Baseline scenario is a very sustainable forest management scenario, that benefits moose and other wildlife. The Baseline scenario scored 69 points (Table 5.20). However, the Moose Emphasis Scenario scored higher (77 points), due to less roads and a wider patch size distribution. Therefore, the Moose Emphasis Scenario was chosen as the PMS (Preferred Management Scenario).

The Moose Emphasis Scenario has previously identified sustainable harvest levels that can be achieved. However, the province of Manitoba's Annual Allowable Cut volumes previously calculated are different (Table 5.19). In FML #3, the provincial Annual Allowable Cut will be utilized, even if the Moose Emphasis Scenario can sustainably harvest a higher volume.

Table 5.19 Potential volumes of softwood and hardwood.

	Province of Manitoba Annual Allowable Cut		**Moose Emphasis -**Preferred Management Scenario	
Forest Management Unit	**Softwood** Potential harvest volume (m^3 per year)	**Hardwood** Potential harvest volume (m^3 per year)	**Softwood** Potential harvest volume (m^3 per year)	**Hardwood** Potential harvest volume (m^3 per year)
10	210	7,850	2,605	12,627
11	26,819	92,004	34,775	118,840
13	234,022	311,934	196,428	322,119

Softwood in FMU 13 (Duck Mountain Provincial Forest) is the one exception to following the AAC, since the provincial AAC of softwood is significantly higher that what the Moose Emphasis Scenario can sustainably achieve. Therefore, the Forest Management Plan will use the lower softwood volume for FMU 13.

The ratio of hardwood to softwood volume in FMU 13 (Duck Mountain) is 70% hardwood and 30% softwood. The new provincial AAC has a hardwood to softwood ratio of 57% to 43% respectively. The higher softwood ratio prevents the Patchworks model from achieving the full softwood AAC. Softwood harvested from mixedwood and softwood stands generate residual hardwood volume, but the model quickly hits the hardwood AAC maximum, and cannot cut more area.

The FMP will be implemented in Operating Plans. Typically, the full AAC is planned for, but not always fully harvested. Due to typically harvesting less at the operation level, resource indicators from the Preferred Management Scenario will be monitored for adaptive management, as described in Ch 9-Monitoring Framework. Some monitoring will be part of the 5-year forest management report, and the resource indicators may be affected by factors such as natural disturbance or climate change.

Table 5.20 Ranking scenarios by objectives.

Quantifiable Objectives	# times chosen (n=156)	% of times chosen	Target	Weight (1-avg; 2-medium; 3-high)	Units of Measure	No Harvest modeling (context)	Level of Objective Achievement: Scenario #1 BASELINE FOREST MANAGEMENT – Achievement Score (1-5)	Scenario #1 – Weighted Score	Scenario #2 MOOSE EMPHASIS – Achievement Score (1-5)	Scenario #2 – Weighted Score	comments
MOOSE	27	17.3%	maintain or improve existing moose habitat	3	habitat units	poor for winter moose habitat	4	**12**	4	**12**	scenarios have identical scores
ROADS	19	12.2%	reduce roads, while accessing the same amount of wood	3	length (km)	n/a	3	**9**	5	**15**	Moose Emphasis has 25% less candidate rds
NRV	14	9.0%	move towards Natural Range of Variation targets for mature and old forest (by species)	3	% of landbase by seral stage	too much old seral stage	4	**12**	4	**12**	combined with OLD seral stage - same as NRV
WATERSHED	13	8.3%	30% watershed limit in a 'harvested state'	2	% of watershed in a harvested state	low % in a harvested state	4	**8**	4	**8**	some 3`s; scenarios have identical scores
PATCH SIZE	11	7.1%	Patch Size distribution (wider distribution better and more natural)	2	area classes (ha)	n/a	3	**6**	4	**8**	little bit of room for improvement (NRV)
COVER GROUP	8	5.1%	maintain proportion of Softwood, Softwood-mixedwood, Hardwood-mixedwood, and Hardwood	2	area (ha)	more conifer, less hardwood over time	4	**8**	4	**8**	scenarios have identical scores
SPECIES AT RISK - Bird	7	4.5%	Canada Warbler (CAWA) habitat	2	probablity of occupancy	slight decline	4	**8**	4	**8**	scenarios have identical scores
17 INDICATOR BIRDS	6	3.8%	17 indicator bird species representing different forest types (cover groups, age classes, interspersion)	1	probablity of occupancy	mixed results of positive, negative, and neutral	3	**3**	3	**3**	scenarios have identical scores
MARTEN	6	3.8%	winter cover for marten	1	aspatial habitat units	declines first 40 years, then stabilizes	3	**3**	3	**3**	scenarios have identical scores
						TOTALS		**69**		**77**	

MOOSE EMPHASIS CHOSEN AS THE PMS (PREFERRED MANAGEMENT SCENARIO)

5.9. CONCLUSIONS

Two forest management scenarios were created as viable options to manage Forest Management Licence #3:

1) Baseline Scenario; and,
2) Moose Emphasis Scenario.

Both scenarios were evaluated for their ability to sustain ecological goods and services, now and in the future. Both scenarios had very good sustainability across a wide variety of metrics. The Moose Emphasis Scenario utilized the Baseline scenario and changed the spatial harvest pattern to increase benefits to moose. Therefore, there were many similarities between the two scenarios.

The two largest differences between the two scenarios occurred in the roads objective and the patch size objective. The Moose Emphasis Scenario had a 25% reduction in candidate roads, which would need to be built in the future to access future harvest blocks and patches. Furthermore, the Moose Emphasis Scenario had a wider range of patch sizes than the Baseline scenario.

The Baseline Scenario is a sustainable forest management scenario, that benefits moose and other wildlife. However, the Moose Emphasis Scenario is an improvement, due to less access and a wider patch size distribution. Therefore, the Moose Emphasis Scenario was chosen as the PMS (Preferred Management Scenario). The next chapter of this Forest Management Plan is Chapter 6 Future Forest Condition and will be based on indicator output of the Moose Emphasis Scenario.

5.10. LITERATURE CITED

Andison, D.W. 2019. Synthesis Report. Pre-Industrial Fires Regimes of the Western Boreal Forest. fRI Research Healthy Landscapes Program, Hinton, AB. 49 pp.

Manitoba Conservation. 2007. Manitoba's Submission Guidelines for Twenty Year Forest Management Plans. Manitoba Conservation. Edited by Forestry Branch. 200 Saulteaux Crescent, Winnipeg, MB. 24 pp.

Manitoba Forestry/Wildlife Management Project. 1994a. Habitat Suitability Index Model for the Marten (*Martes Americana*). Version 3 revised June 1994. The Manitoba Forestry/Wildlife Management Project. Box 24, 200 Saulteaux Crescent. Winnipeg, MB. 15 pp.

Manitoba Forestry/Wildlife Management Project. 1994b. Validation and Modification of a Marten Habitat Suitability Index Model for Manitoba. The Manitoba Forestry/Wildlife Management Project. Box 24, 200 Saulteaux Crescent. Winnipeg, MB. 23 pp.

KBM Forestry Consultants. 2005. Habitat Element Curves – creation and validation. 31 pp. plus appendices.

KBM Forestry Consultants. 2006. A pilot moose habitat model for the Mid Boreal Uplands Ecoregion of the Manitoba Model Forest. Manitoba Model Forest publication. 23 pp. plus appendices.

Rudy, A. and T. Honsberger. 2019. Habitat supply model for moose. In progress.

Zabihi-Seissan, S. 2018a. Development of a Resource Selection Function to Identify Moose Habitat Selection using Forest Management Data in the Duck Mountain Area. Prepared for the Government of Manitoba. March 29, 2018. 15 pp.

Zabihi-Seissan, S. 2018b. Validation of the Moose Habitat Resource Selection Function using Forest Management Data in the Duck Mountain Area. Prepared for the Government of Manitoba. October 31, 2018. 37 pp.

5.11. APPENDICES

APPENDIX 1: **Baseline Scenario - Spatial Harvest Schedule map– planning period 1 (1 to 10 years) and planning period 2 (11 to 20 years)**

APPENDIX 2: **Bird Species-at-Risk Habitat Map – Canada warbler – all scenarios**

APPENDIX 3: **Indicator Bird maps – all Scenarios**

APPENDIX 4: **Baseline Scenario – Winter moose habitat maps** time 0, 10, 20, 30, and 40 years. D-size 24" X 36" portrait. Scale 1:350,000

APPENDIX 5: **Baseline Scenario – Summer moose habitat maps** time 0, 10, 20, 30, and 40 years. C-size 18" X 24" portrait. Scale 1:500,000

APPENDIX 6: **Moose Emphasis Scenario - Spatial Harvest Schedule – planning period 1 (1 to 10 years) and planning period 2 (11 to 20 years)**

APPENDIX 7: **Moose Emphasis Scenario – Winter moose habitat maps** time 0, 10, 20, 30, and 40 years. D-size 24" X 36" portrait. Scale 1:350,000

APPENDIX 8: **Moose Emphasis Scenario – Summer moose habitat maps** time 0, 10, 20, 30, and 40 years. C-size 18" X 24" portrait. Scale 1:500,000

APPENDIX 9: **Objectives mutually chosen to rank the two scenarios.**