2027-2046 FML 2 Forest Management Plan

PART 2 – ANALYSIS AND MODELLING

Forest Management Licence No. 2 20-Year Forest Management Plan

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Analysis and modelling of forest resources is used to improve forest management by creating a digital representation of the forest ecosystem to explore potential future forest conditions. Modelling improves forest management by helping us to understand the impacts that forest management activities have on long-term sustainability of ecological, social, and economic values. Using a model to explore potential outcomes, trade-offs between competing values, and opportunities to achieve goals is an accepted practice in determining a long-term sustainable management strategy for forest management plans.

In Part 1 of this plan, a detailed look at the current condition of the forest is reported (see section 4 Current Forest Description). This information is a key starting point for Part 2. The planning context outlined in Part 1 provides the information needed to understand the condition of the forest at the start of the 20-year forest management plan; resource analysis and modelling will help in planning into the future. Part 3 – Implementation and Monitoring will provide the details of how the plan will be implemented on the ground and what activities will take place to achieve the future objectives discussed here in Part 2.

> *A forest management plan is a specific statement of the objectives you have for your forest, followed by a series of activities that will take place in order to meet those objectives. The forest management plan* ***is a "road map" to guide you from where you are to where you want to be in the future.***

Forest management planning occurs at two core levels: strategic and operational.

Strategic planning is what occurs when forest managers consider the "big picture" of the forest system over an extended period of time—planning through a "coarse-filter". It emphasizes broad-scale components of forest management, such as forest age class and composition, and how these components may influence key forest values such as the amount and arrangement of habitat types. Strategic planning provides the framework of operating areas where forest management activities may occur to achieve the goals of the plan over the long-term, but it does not detail how these activities will be operationalized in the real world.

Operational planning is what occurs during the 20-year implementation of the forest management plan and focuses on the finer-filter components of forest management that need to be taken into consideration in order to apply the strategic framework on the ground (i.e., the actual harvest and forest renewal activities). Operational planning takes the strategic-level direction identified in a forest management plan and divides it into approachable, feasible, and focused 2-year forest management operating plans (FMOPs). If strategic planning (the forest management plan) provides the framework of operating areas, operational planning (forest management operating plans) provides the step-by-step instructions on how to make that framework reality in the short-term. Part 3 of the plan, Implementation and Monitoring, focuses on operational planning.

This chapter of the forest management plan, Part 2 – Analysis and Modelling, focuses on strategic planning and explains how a computer-based forest model can be used to predict how the forest may change over time under different management approaches. This forest model is used to explore "what-if" scenarios to better understand what management activities are needed on the ground to achieve the desired future forest objectives that will balance environmental, economic, and community needs.

When used in forest modelling, the term "strategic" refers to planning and decision-making that considers the "big picture" of the forest system over an extended period of time, often decades or even centuries. This involves setting overarching goals, such as maintaining a certain level of timber production, protecting biodiversity, or ensuring water quality, and then using the forest model to explore different scenarios to see how those goals can be achieved. Strategic decisions are usually made at landscape or regional scales, rather than focusing on individual stands or small areas of the forest.

For this forest management plan, these landscape or regional scales are captured when we consider the forest at the Forest Management Licence (FML) area, forest section, and/or forest management unit (FMU) scales (see Map 6.1 in Part 1 – Planning Context for FML strategic-level administrative boundaries) and longer time frames (10, 20, to 100+ years).

A forest management plan generally consists of:

1. A detailed accounting of the current conditions of the forest area (Part 1 – Planning Context);
2. A strategic long-term management direction and resulting potential harvest areas (Part 2 – Analysis and Modelling); and,
3. An implementation strategy that can guide management activities and monitor progress of operation-level management over the 20-year duration of the plan (Part 3 – Implementation and Monitoring).

This section of the plan will answer some key questions, such as:

- What are the values and objectives for the forest, and how can we track them?
  See Values, Objectives, Indicators, and Targets (VOITs).
- What information and assumptions were used to build the forest model?
  See Forest Modelling.
- How was the analysis designed to explore "what-if" scenarios, and what model controls were available?
  See Scenario Analysis.
- What is the Preferred Forest Management Scenario (PFMS) for this forest management plan, how was it selected, and what are the results?
  See Preferred Forest Management Scenario.
- What are the strategic values, objectives, indicators, and targets for this forest management plan and how were they addressed?
  See Values, Objectives, Indicators, and Targets (VOITs) and Appendix N – Values, Objectives, Indicators, and Targets (VOITs) for the Preferred Forest Management Scenario.
- How is this forest management plan and its associated operations vulnerable to climate change and what adaptations could be implemented to mitigate the impact?
  See Climate Change Adaptation.
- How does this forest management plan affect sensitive values when looking at the strategic- and operational-level outcomes as a whole?
  See Cumulative Effects.

9 Values, Objectives, Indicators, and Targets (VOITs)

Management objectives form the foundation of a forest management plan. These objectives are often developed through the Values, Objectives, Indicators, and Targets (VOITs) framework and provide the strategic direction for the plan and guide the strategic modelling and decision-making process.

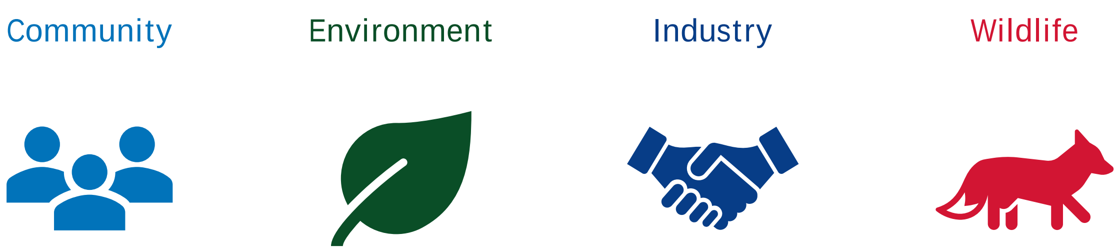
Where do objectives come from in a forest management plan?

The objectives, or goals, for the forest and the forest management plan are developed to protect or enhance things that people, communities, and governments identify as a value of forests, or where there is a concern around an important forest value. As part of the forest management planning process, an extensive development and engagement process was undertaken to collect values and concerns from various sources. NFMC worked to collect values and concerns from rightsholders, stakeholders, and government partners to develop objectives that would address as many concerns and values as possible, prior to completing the resource analysis and identifying potential harvest areas.

Values and objectives for FML 2 were derived from four primary sources:

1. Company internal regulation, policy, guidelines, and operational standards;
2. Known regulation, policy, and guidelines as dictated by the Provincial or Federal government.
3. Certification standards not already captured in the above from Canadian Standards Association (CSA) Sustainable Forest Management (SFM) certification, or from International Organization for Standardization (ISO) Environmental Management Systems (EMS) certification; and,
4. Values and concerns heard from engagement activities with local forest-based communities.

During discussions with rightsholders and stakeholders, values and concerns about forest values were shared that can be broadly categorized into four core themes:



Taking into consideration the values collected, the existing government policy and regulation, and the economic goals for NFMC and the region, values, objectives, indicators, and targets (VOITs) were developed for this forest management plan. VOITs are an accepted method for tracking sustainability criteria in forest management plans across Canada. VOITs for FML 2 are organized as they pertain to the six criteria identified in the Canadian Council of Forest Ministers (CCFM) *Framework of Criteria and Indicators of Sustainable Forest Management in Canada* (2005). The criteria are:

1. *Biological Diversity*
2. *Ecosystem Condition & Productivity*
3. *Soil & Water*
4. *Role in Global Ecological Cycles*
5. *Economic & Social Benefits*
6. ***Society's Responsibility***

Using these six criteria to talk about forest values and sustainability helps to ensure that the focus of a forest management plan goes beyond the forest, operations, and economics. A forest management plan, and the strategic objectives to guide future direction, must consider a wide variety of values. Figure 9.1illustrates the six sustainability criteria from CCFM that were used to lead discussions with rightsholders and stakeholders to gather and listen to concerns and values. More information about the engagement process with rightsholders and stakeholders can be found in Part 4 – Engagement with Rightsholders and Stakeholders.

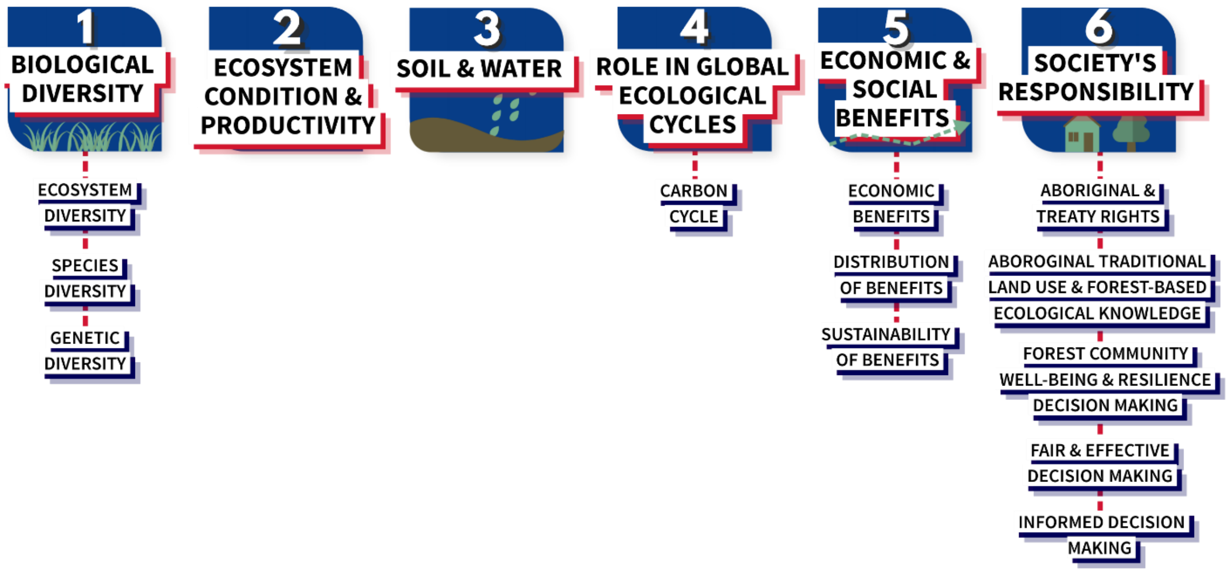


Figure 9.1. Canadian Council of Forest Ministers (CCFM) criteria and indicators for sustainable forest management in Canada graphic used to lead discussions with rightsholders and stakeholders during the process of gathering values and concerns.

VOITs provide an overview of the strategic goals of a forest management plan, how the achievement of those goals is measured, and the state of the VOITs at specific time periods during the implementation of this plan.

What are VOITs and how do they relate to forest management planning?

Value (V):

- Values are the things that people and communities care about in a forest. These could include things like the health of the forest, the wildlife it supports, the timber it produces, recreational opportunities, and cultural or spiritual significance.
  Example: A community might value clean water that comes from forested watersheds or the preservation of old forests for biodiversity.

Objective (O):

- Objectives are specific goals or outcomes that the forest management plan aims to achieve to protect or enhance these values. They translate broad values into actionable goals and provide a direction to move toward over time.
  Example: If the value is biodiversity, an objective might be to maintain a certain amount of forest types that would provide a variety of habitat for species that exist in the forest.

Indicator (I):

- Indicators are measurable signs or metrics that tell us whether the objectives are being met. They help in monitoring forest condition and management effectiveness.
  Example: An indicator for a value of water quality might be the area in hectares of disturbance in watersheds to mitigate the amount of sediment increasing in streams.

Target (T):

- Targets are specific, measurable thresholds or benchmarks for the indicators. They define the level of performance that needs to be achieved to meet the objectives. You can think of this as the result or the level that the forest management plan determined it needs to be at in the future to protect or enhance values and achieve the goals of the plan.
  Example: A target might be to keep disturbance area below 300 hectares in a specific watershed within the first 20 years of the plan.

VOITs guide the overall planning process. They ensure that the forest management plan aligns with what is important to rightsholders, stakeholders and the environment. Forest management plans are built around these values and objectives, with specific actions designed to achieve the targets set for each indicator. This helps ensure that the forest is managed sustainably, balancing ecological, social, and economic needs.

VOITs help translate broad societal values into specific, measurable goals and targets in forest management.

Section 13 Preferred Forest Management Scenario and Appendix N – Values, Objectives, Indicators, and Targets (VOITs) for the Preferred Forest Management Scenario provide detailed descriptions of the VOITs that were developed and included in this forest management plan. Many of the VOITs are strategic; however, some VOITs are addressed at the finer operational scale or during on-going engagement with rightsholders and stakeholders for the duration of the plan.

How do VOITs relate to strategic resource analysis and modelling?

VOITs provide the foundation for creating different scenarios in forest estate modelling. By identifying the key values and setting objectives, forest managers can model various strategies to see how well they can meet these goals over time, what the impact on other objectives may be, and how a balance can be achieved. For instance, if the objective is to increase carbon storage, the model might be used to explore different levels of harvesting to observe the impact on carbon levels, using indicators like tonnes C (carbon) of forest ecosystem carbon to measure changes.

Only strategic level objectives can be included or represented in the forest estate model. These objectives must be measurable, achievable and used for the longer term. These management objectives form the core of the forest management plan.

The following sections of Part 2 provide detailed information about how the forest model was built (section 10 Forest Modelling and subsection 10.1 Model Assumptions), and how the model was used to explore different scenarios (“what-ifs”) that could help achieve objectives for the forest (section 12 Scenario Analysis). The results of the work done to build the model and use it to explore trade-offs leads to the selection of the Preferred Forest Management Scenario. This is the strategic direction for the forest management plan and provides the management activities that are required to meet our objectives for the forest—the “road map” that will be followed for the next 20 years of the plan. The results of the Preferred Forest Management Scenario help fill in the strategic level VOITs and frame the operational details in Part 3 of this plan, the Implementation and Monitoring chapter.

10 Forest Modelling

One of the main challenges of forest management planning is the simple fact that trees grow slowly. It is not possible, or responsible, to decide to manage the forest a certain way and then wait to see if the right decision was made years from now. It would be much too late to go back and change things if it was not the right decision.

A forest management plan is not only about the individual trees themselves, but about entire forest ecosystems that are complex systems, growing and changing naturally over time. To meet these challenges, and responsibly understand the impacts of actions today on the future of the forest, forest managers use a forest model to represent the forest system.

Forest modelling in the context of forest management planning is an important tool used to look ahead and predict what the future forest may look like if different management activities were to take place. For example, what would the future forest look like if no harvest took place over the next 100 years? Or what would it look like if more wood was cut than has been cut historically over the next 100 years? Waiting 100 years to find out is infeasible. Using a model to simulate how the forest would grow, change, and respond to management activities is the best way to understand how values and objectives can be achieved, and where activities need to take place to achieve those objectives.

Forest modelling, sometimes also referred to as forest estate modelling or wood supply modelling, uses a computer simulation model to forecast future forest conditions as a result of management strategies and constraints being considered. The use of forest models helps to explore and understand impacts and trade-offs of management decisions within a large geographical area over long timeframes, also referred to as analysis horizons. The information derived from forest modelling provides decision support to select the Preferred Forest Management Scenario.

What type of forest model was used for the FML 2 20-year Forest Management Plan?

There are many forest models available for use to forecast future forest conditions. Like choosing a word processing software package to write a document, there are many tools to choose from. They each have their strengths and weaknesses, and one may be better suited for the type of document you are writing. For this forest management plan, NFMC chose to use the spatially explicit forest modelling software called Patchworks™. Patchworks™ is a type of simulation forest model that can mimic the complex, real-world processes happening in a forest. The Patchworks™ model can take into account many factors, such as tree growth and human management activities (like logging or planting), and can consider multiple objectives at the same time to find a balance, or trade-off, between competing objectives. Patchworks™ is also spatial, meaning that it can evaluate how the arrangement of activities may impact objectives or future forest condition. Considering the location of management activities within the FML at the strategic level allows for better connectivity of operations during plan implementation. Simulation forest models are great for exploring "what-if" scenarios and understanding how different factors interact over time. They are especially useful when you need to account for the complexity and unpredictability of natural ecosystems. Patchworks™ was used for the development process during Scenario Analysis and to generate the results presented in the Preferred Forest Management Scenario.

What information goes into a forest model?

Scientists, practitioners, and government agencies have been collecting information about how trees and forests grow for a long time. In FML 2, data has been collected in a variety of forest types that exist in the region, and for a variety of tree ages. This information can be pulled together to understand how fast different types of trees grow under different conditions – known as growth and yield curves. It is information like this that can be used to simulate what the future would look like in a model. A forest model needs three main inputs to get started:

1. An inventory of the location, species, and age of the current forest (the landbase or forest resource inventory);

2. Assumptions about how the trees grow, how they change through time (naturally or from forest management activities), and other information to represent how forestry is practiced in the area (model assumptions); and,
3. A way to represent the goals and objectives that are important to the forest management plan inside the model that can be summarized and tracked. These representations will be herein referred to as model controls. Each model control applied in the FML 2 forest model is described in section 12 Scenario Analysis.

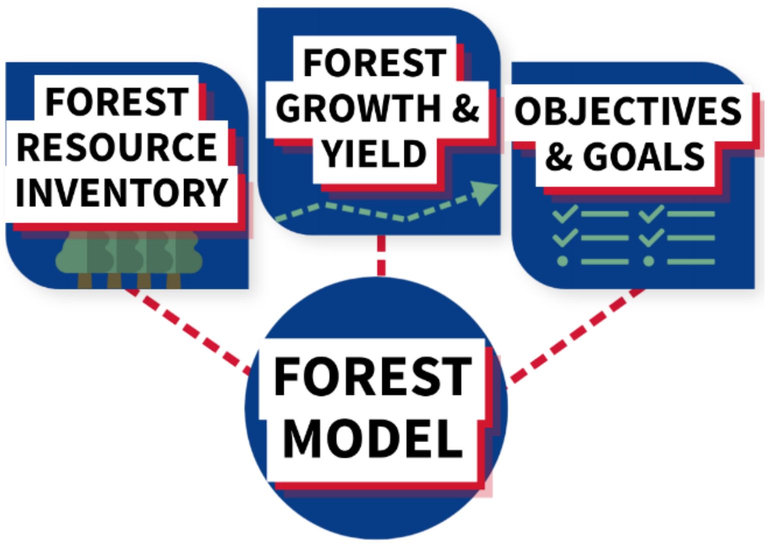


Figure 10.1. The main components of a forest model.

One overarching goal of a forest management plan is to inform on sustainable harvest levels of a particular forested region. However, a forest management plan is not always the only method used to determine what is sustainable. Across Canada, there is significant variability in how jurisdictions determine sustainable harvest levels, and there is no "gold standard" since each jurisdiction's method can have both strengths and weaknesses. For example, in Ontario, there is a very structured forest management planning process through which sustainable harvest levels are determined. Canada's largest forestry jurisdictions, British Columbia and Quebec, take a different approach relative to Ontario. The Quebec provincial government leads the determination of sustainable harvest levels and leads the development of forest management plans. The British Columbia provincial government leads the determination of sustainable harvest levels, and the proponents (operators), sometimes including the Province itself, develop the forest management plan within the bounds of those sustainable harvest levels. Manitoba's approach aligns more closely with British Columbia's approach.

The FML 2 forest modelling process detailed in this plan considers additional values and objectives as compared to the provincial base case. Sustainable harvest levels and inputs used in the provincial base case models have provided valuable inputs and reference levels for the development of the Preferred Forest Management Scenario detailed in the following section of this plan. In Manitoba, the sustainable harvest levels resulting from the Preferred Forest Management Scenario do not replace the sustainable harvest levels (annual allowable cut) determined by the provincial government.

Many of the model assumptions (or inputs) used to build the FML 2 forest model are the same as those used by the Province while exploring base case scenarios to determine sustainable harvest levels. All of the information input into the Patchworks™ model is documented in the following Model Assumptions subsection. The Scenario Analysis section explains the model controls and how they were used to build and explore the "what-if" scenarios. Results from the final Preferred Forest Management Scenario come directly from the Patchworks™ model.

Modelling and Analysis Subcommittee

To facilitate the collaborative development of the forest model and scenario analysis process, a Modelling and Analysis Subcommittee was established. The Modelling and Analysis Subcommittee was created from a subset of the greater Planning Team, and included Company staff, provincial representatives from both the Forestry and Wildlife branches, and consultants that facilitated the forest model development and analysis process.

10.1 MODEL ASSUMPTIONS

The following subsections detail the assumptions made within the FML 2 Patchworks™ forest model developed for the 20-year Forest Management Plan.

10.1.1 Strategic Modelling Period

The strategic modelling period began at year 2025 and continued over an analysis horizon of 200 years, subdivided into and reported on in 10-year periods. Using a 200-year analysis horizon allows the sustainability of the forest to be assessed well into the future.[1]

A 200-year analysis horizon is often used in forest modelling as it allows forest managers to consider the long-term impacts of their decisions on the forest ecosystem, timber supply, and other resources. This extended timeframe helps to ensure that the forest remains healthy, productive, and sustainable over multiple generations. Trees and forests take a long time to grow and mature. Some species may take more than a century to reach full maturity. A 200-year horizon captures multiple growth cycles, allowing managers to plan for the long-term sustainability of the forest, including the regeneration of harvested areas and the natural changes of the ecosystem.

The goal of forest management is often to balance current timber use with future availability. A 200-year horizon ensures that the forest management plan considers the needs of future generations, not just immediate outcomes. While this forest management plan provides direction for the next 20 years, the resulting forest management activities for those 20 years are a result of considerations of long-term sustainability and the trade-offs from seeking to achieve long-term objectives.

*A note on what is **referred to as the "end of the world" effect:***

> The "end of the world" effect refers to a common modelling issue where the behavior of the model near the end of the analysis horizon becomes unrealistic because the computer model does not know that time continues forever. A forest model has been set to maintain sustainability to the end of the analysis horizon—in this instance, 200 years. Beyond these 200 years, nothing is programmed. Therefore, as the end of the analysis horizon approaches, the model might prioritize short-term gains over long-term sustainability, since it "knows" that it doesn't have to account for anything beyond the end point. Forest management is generally concerned with the first 100 years of the predicted future in order to represent a rotation of growth, harvest, succession, and regeneration. Models use 200 years to ensure that these first 100 years are not influenced by the "end of the world" knowledge that the computer model has. However, results of this modelling exercise are reported strategically for the entire 200 years, and therefore goals have been put in place to prevent the distortion of these results (such as closing growing stock constraints). Replanning for updated forest management plans occurs every 10 to 20 years to incorporate updated information and model assumptions.

[1] Note that while this forest management plan is published as a 2027-2046 plan to accommodate an FMLA extension to increase engagement capacity, forest modelling had been completed prior to the extension being granted. Additional forest modelling considerations were made to consider known planned harvest activities for 2025 and 2026.

10.1.2 Spatial Data Preparation

10.1.2.1 Landbase

A digital landbase for FML 2 by forest section was prepared by the Province and was provided to NFMC as a starting point for creating an input inventory dataset for the Patchworks™ forest model with an effective date of December 31, 2020. These datasets were combined into a single FML 2 landbase dataset (i.e., each of the three forest section datasets were combined to create a single FML 2 dataset). Updates to depletions to consider most recent harvest activity and natural disturbances were then incorporated into the landbase to bring it up to a more current effective date of May 2022. A general description of the current condition of the forest based on this landbase can be found in section 4 Current Forest Condition of Part 1 – Planning Context. This information provides a complete forest "catalog" or forest inventory of forest types (i.e., broad species groups), ages, and other important forest establishment history. The individual pieces of a forest inventory are often referred to as polygons. These are the starting point for modelling and analysis.

Additional information is added to this landbase to incorporate some assumptions required for building a model. The following sections outline the steps taken to add these additional assumptions.

10.1.2.1.1 Net Down

A "net down" process was applied to the landbase dataset. A net down process reduces the initial landbase to only include polygons that are forested and have adequate stratification to assign a yield curve. This net landbase is key in forest modelling to establish where forest management activities may occur.

Recall Table 4.1 (below) from section 4 Current Forest Description from Part 1 – Planning Context. For the purposes of forest modelling, non-productive forest areas (wetlands and other low-productivity but high-value vegetated ecosystems), non-forested areas, and open water areas are net down from the landbase dataset. This results in only productive forest area and potentially productive forest area remaining in the landbase dataset for forest model input.

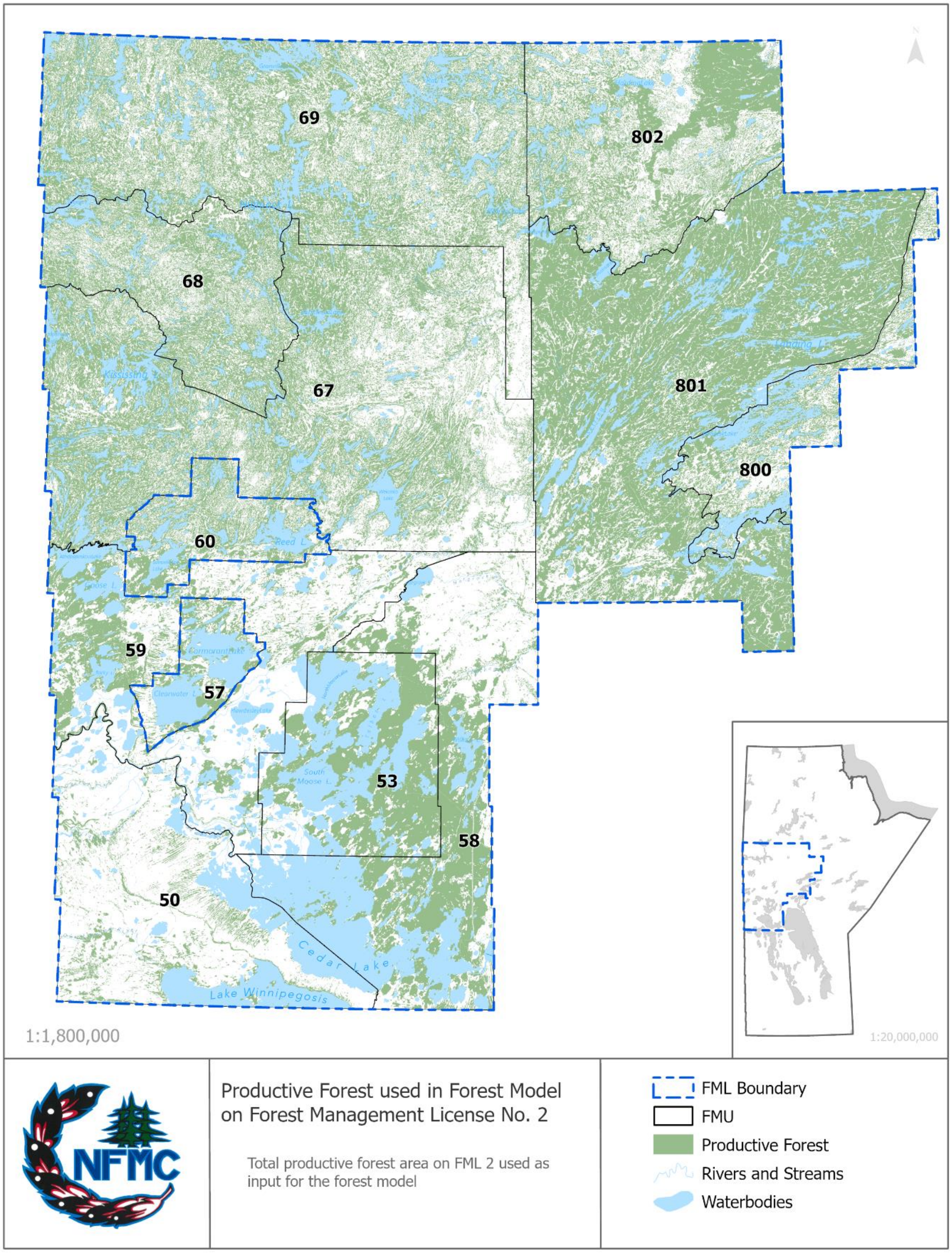
Table 4.1. FML 2 classified by hectares of cover type. Categories include productive forest, non-productive (NP) and potentially productive (PP) forest, non-forested (NF) area, and open bodies of water. Productive forests have been further classified as softwoods (S), mixed woods with softwoods leading (M), mixed woods with hardwoods leading (N), and hardwoods (H).

Forest Section	Productive (ha)					NP & PP (ha)	NF (ha)	Water (ha)	Total Area (ha)
	S	M	N	H	Total				
Sask. River	489,430	92,910	70,408	65,774	718,522	NP 961,266 PP 93,116	413,493	763,314	2,949,711
Highrock	1,300,156	196,156	143,706	82,420	1,722,436	NP 805,217 PP 127,321	487,537	529,384	3,671,895
Nelson River	1,187,857	143,847	102,106	71,309	1,505,118	NP 418,546 PP 64,100	202,915	342,861	2,533,540
Total	*2,977,442*	*432,912*	*316,220*	*219,502*	*3,946,077*	*NP 2,185,029* *PP 284,536*	*1,103,945*	*1,635,559*	*9,155,146*

Following net down, the landbase area totals to 4,230,613 hectares (Map 10.1); however, this does not mean forest management activities will occur in these areas, or are eligible to occur in these areas, by default. The current forest description defined in Table 4.1 is for the entire FML area and includes data from forest management units 57 and 60 (Grass River Provincial Park). While Canadian Kraft Paper Industries Ltd (CKP) is not licenced to operate within these units, they can be included within the forest model. The inclusion of these areas assists in providing a strategic-level overview of the FML and allows for management considerations to be made that consider the "full-picture" of the region.

10.1.2.1.2 Grouping Polygons

For the purposes of forest modelling, polygons can be grouped into larger polygons. This is an important step in the model preparation as it helps to eliminate small, unrealistic polygons, and simplifies the model by aggregating stands that are similar (e.g., forest type, age, and management status). Grouping helps to create a more efficient and more realistic forest model.



Map 10.1. Productive forest landbase input into the FML 2 forest model following net down.

Polygons were aggregated for the purposes of modelling to an average target size of 40 hectares. Grouping allowed polygons with similar harvest availability, age, forest management unit, strata, density, and site class to be merged if they were within 20 metres of each other. When grouping was complete, the average polygon size in the input landbase dataset had increased from 7.6 hectares to 10.2 hectares.

During the analysis process, these grouped polygons are often referred to as model blocks. Once input into the model, blocks cannot be split into smaller polygons but can be further aggregated during harvest simulation to create larger harvest features, or harvest patches.

10.1.2.1.3 Managed vs. Unmanaged Forest Areas

Following the input of the net landbase, the forest model is able to further categorize blocks into "managed" and "unmanaged" forest area:

- Managed indicates the productive forest area within the model that is available for harvest (i.e., the area is operable). Managed blocks can be directly influenced by forest management activities through harvest and forest renewal.
- Unmanaged indicates the productive and potentially productive forest area within the model that is not available for harvest now or in the future (i.e., the area is inoperable). Unmanaged blocks remain in the model to contribute to non-timber resource values such as ecological and habitat values.

The categorization of the managed versus unmanaged net landbase is based on finer-scale forest stratification attributes. In the case of FML 2, forest areas excluded from forest management activity and areas that do not meet a minimum timber volume yield to be considered operable were the primary source of areas labelled as "unmanaged". This generally occurred as a result of low density and/or low productivity sites. For more information, see sections 10.1.2.4 Forest Area Excluded from Forest Management Activity for Forest Modelling and 10.1.4 Yield Curves.

For the FML 2 Patchworks™ forest model, the managed (available for harvest) forest area is 2.3 million hectares. Table 10.1 summarizes the amount of managed and unmanaged area in each forest management unit (FMU) in the forest model.

Table 10.1. Productive forest area classified as either managed (operable) or unmanaged (inoperable) within the forest model for each forest management unit (FMU).

Forest Section	FMU	Managed Area (ha)	Unmanaged Area (ha)	Total Area (ha)
Saskatchewan River	50	40,698	53,298	93,996
	53	156,212	50,779	206,991
	57*	19,736	22,964	42,700
	58	154,454	122,798	277,252
	59	126,367	64,331	190,698
Highrock	60**	0	108,938	108,938
	67	484,167	284,990	769,157
	68	108,904	168,637	277,541
	69	329,494	364,628	694,122
Nelson River	800	27,625	93,612	121,237
	801	739,634	338,070	1,077,704
	802	181,197	189,081	370,278
	Total	*2,368,488*	*1,862,126*	*4,230,614*

FML 2 Forest Management Licence Agreement (FMLA) does not permit Canadian Kraft Paper Industries Ltd (CKP) to operate in FMU 57; however, there are operators that are permitted. The inclusion of FMU 57 captures this potential forest management activity.
***Grass River Provincial Park.*

10.1.2.2 Depletions – Harvest and Wildfire

Developing a forest management plan is an extensive process, and it can take multiple years to develop, select, and approve the strategic management direction derived from a forest model. In anticipation of this, the model development process needs to consider previous stand-replacing disturbances (i.e., completed harvest, wildfire) as well as predicted future stand-replacing disturbances (i.e., planned harvest) that are forecast to occur before the forest management plan is approved and ready to be implemented.

In the interest of modelling with a net landbase that was as current as possible, the forest model was programmed to update the landbase with the most recent harvest depletions (2022 to 2024), approved planned harvest depletions (2024 and up to 2025), and natural disturbance from fire up to mid-2024. This update adjusted the forest age for each affected block. For natural disturbance, forest age was adjusted to be age 0 at model start (2025). For harvested areas, block age was adjusted according to the appropriate post-harvest regeneration delay for that particular stratum at model start (2025; see section 10.1.7 Post-Harvest Regeneration Delay for more information).

10.1.2.3 Caribou Management Units

Caribou management units (CMUs) are geographical subregions identified by the Province within which one or more caribou ranges may be managed in combination for population sustainability, connectivity, and habitat goals (Manitoba Boreal Woodland Caribou Management Committee, 2015). There are seven CMUs that overlap FML 2: Interlake, Kamuchawie, Molson, Naosap, Partridge Crop, The Bog, and Wabowden Caribou Management Units (see Map 7.1 in section 2 Ecological and Physical Description of Part 1 – Planning Context). To assist in tracking the amount and spatial arrangement of boreal woodland caribou habitat at the strategic level, CMUs that overlap the FML were included in the forest model. Each polygon within the net productive forest landbase has been attributed with its respective CMU. There are some polygons that do not overlap any CMU.

10.1.2.4 Forest Area Excluded from Forest Management Activity for Forest Modelling

These are productive forest areas in which forest management activity is excluded but that remain in the forest model as part of the unmanaged landbase for the purposes of this forest management plan (i.e., these areas are available to contribute to ecological objectives but are not available for timber harvest). Approximately 722,000 hectares of modelled forest area fall within this category, including provincial parks, such as Clearwater Lake and Grass River Provincial Parks, Other Effective Area-Based Conservation Measures (OECMs), Areas of Special Interest (ASI), Wildlife Management Areas (WMAs), ecological reserves, riparian buffers, and any other protected areas in which timber harvest is specifically prohibited. Note that there are some WMAs in which harvest is permitted to occur. While some of these areas are part of Manitoba's network of protected and conserved areas and legally prohibit industrial logging and their management and development activities remain under the jurisdiction of the Province, they are included in forest modelling to help provide a more complete picture of the landscape. Others may be areas that have been deemed sensitive or of special interest that the Company has elected not to operate within, although definitive regulation preventing timber harvest may not be in place. For more information regarding these areas, see Part 1 – Planning Context, Forest Administration subsection 6.2.6 Protected Areas, Areas of Special Interest, OECMs and Wildlife Management Areas and Map 6.6 for reference.

Additionally, productive forest area on Aboriginal Reserve Land, Treaty Land Entitlement, and lands identified under the Grand Rapids Forebay and Northern Flood Agreements are unavailable for harvest and other forest management activities by NFMC and are categorized as unmanaged within the forest model for the purpose of this forest management plan. See Part 1 – Planning Context, Forest Administration subsection 6.2 Ownership and Status for maps and additional information regarding these areas.

10.1.2.5 Operating Areas

To assist in navigating the size of the FML, NFMC identified known operating areas within every forest management unit (FMU) except for FMU 802, the most remote of the units on the FML. These operating areas are strategic in size and assist in directing harvest to areas with known access, operability, and that are preferred by contractors, particularly for the start of the 20-year plan. In other words, including these areas can assist in deterring the model from creating new operating areas in not-yet-accessed parts of the FML that would require extensive development at plan start.

10.1.2.6 Watersheds and Watershed Disturbance

To assist in tracking watershed disturbance at the strategic level, watersheds that overlap the FML were included in the forest model (see Map 2.10 in section 2 Ecological and Physical Description of Part 1 – Planning Context). The advantage of this inclusion is the ability to track the amount of productive forest area within each watershed that has experienced recent stand-replacing disturbance(s). Stand-replacing disturbance is categorized as less than or equal to (≤) 10 years old for softwood forest types and as less than or equal to (≤) 5 years old for hardwood forest types.

The amount of disturbed area within each watershed is measured in hectares but is reported as a proportion of the total within-FML watershed area. The forest model itself is limited to reporting only on watershed area that is:

1. Within the FML boundary (i.e., watershed area outside of the FML boundaries is excluded from consideration); and,
2. Within the *productive forest* landbase that is input into the forest model (i.e., does not include non-productive forest area such as wetlands).

As such, it is only able to give an approximation of stand-replacing disturbance within a watershed in any given period caused by forest management activities. A more in-depth analysis of watershed disturbance occurs both in the Cumulative Effects section of this plan, and as a part of the annual reporting process for Canadian Standards Association (CSA) Sustainable Forest Management (SFM) standard certification.

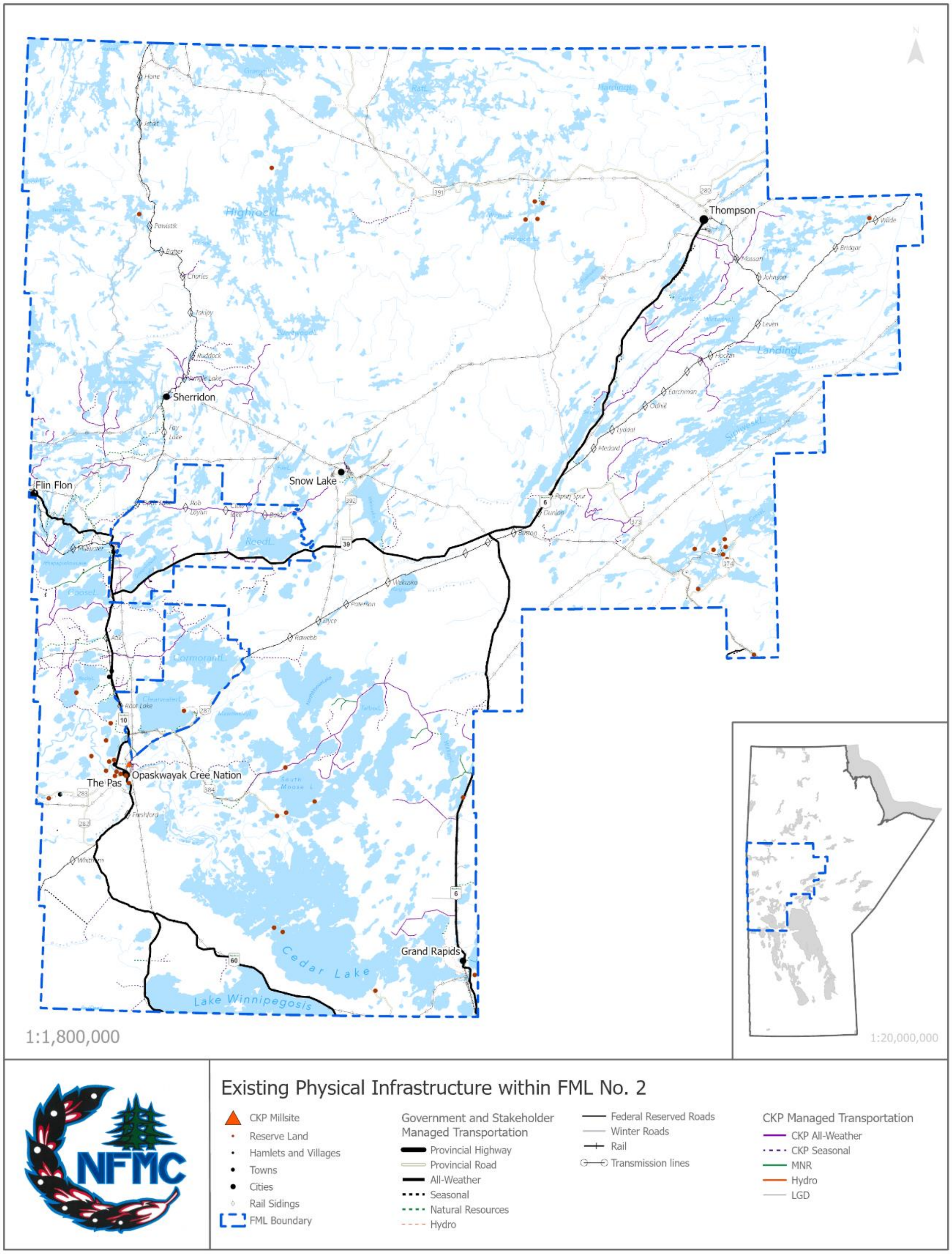
10.1.3 Access Network

Forest management activities on any landbase would not be possible without the means to *access* an area in which a company is interested in operating. Forest estate modelling can integrate this component of forest management planning through the use of an access network. Composed of transportation corridors such as road infrastructure and railway lines, an access network connects forested areas to a single mill or a set of mills.

The purpose of modelling with an access network is to strategically balance the indicators associated with transporting wood products to the Canadian Kraft Paper Industries Ltd (CKP) mill located in The Pas. The access network that was used in the model was built with the established existing road network for the area as a foundation, including highways, primary, branch, and operational roads managed by Canadian Kraft Paper Industries Ltd (CKP), combined with a triangular tessellation of 1-kilometre segments that were added to the network to simulate potential future access opportunities.

The access network also includes the use of existing railway lines on the FML, with several rail sidings activated for use in the model based on historic use. These are the Charles, Jungle Lake, Laurie River, Massan, Pipun Spur, Radar, and Thompson rail sidings. A maximum amount of wood that could be hauled from these rail sidings was set within the model based on current utilization levels for each siding, respectively. Maximum values were set at twice the current estimation of utilization to account for planning at the strategic level and allow for potential future use.

Map 10.2 details the access network applied in the FML 2 forest model.



References: Canadian Kraft Paper, MB Data Hub, MB Hydro, Inco, HBM&S

Map 10.2. Existing physical infrastructure used to develop the access network for the FML 2 forest model.

10.1.4 Yield Curves

Within the net landbase, each polygon is stratified by the Province based on the forest section it is in, stratum (i.e., dominant species – see Appendix A for a full definition of strata), site class, and density class. These attributes are combined to create a set of stratification keys that can be assigned to any productive forest polygon. There are nearly 100 unique keys in the landbase that have a range of dynamic attributes associated with them.

For example, for the key SK_JP_1_3:

SK	*JP*	*1*	*3*
Saskatchewan River Forest Section	*Jack pine stratum*	*Site class: 1*	*Density class: 3*

Yield curves were developed and provided by the Province for use in the forest model (Province of Manitoba, 2014 & 2015). The Province developed three sets of yield curve tables to best-fit the range of forest types found on the wide expanse of the FML. Yield curves tables were developed for forested stands in Saskatchewan River Forest Section, Highrock Forest Section, and FMU 69, with each forest management unit (FMU) assigned, respectively. See Table 10.2 for the breakdown of the FMUs that use each yield curve table. Differentiating forested stands between FMUs within a forest section allows for yield curve tables to capture the potentially variable nature of forested stands within forest sections.

Curve tables provided indicate the estimated merchantable volume (yield) for keys related to Saskatchewan River Forest Section, Highrock Forest Section, and FMU 69.

Table 10.2. Yield curve tables and source file names from which associated keys and merchantable volume curves were applied for each forest management unit (FMU) in the forest model.

Yield Table (File Name)	Forest Section(s)	FMU(s)
FMU 69 (FMU69_yield_tables)	Highrock	69
	Nelson River	800 & 802
Highrock Forest Section (Highrock Yield Tables_BaseCase)	Highrock	67 & 68
	Nelson River	801
Saskatchewan River Forest Section (Sask River Yield Tables_BaseCase)	Saskatchewan River	50 53 58 & 59

Each unique key has a yield value associated with 5-year age intervals, starting at 0 and ending at age 200 (Figure 10.2). There are yield curves associated with each key that are differentiated based on wood type (coniferous or deciduous) and whether harvesting by log length (8-foot, 16-foot, or 20-foot logs) or tree length. For FML 2, it is the model assumption that 8-foot length logs are being harvested.

Yield curves play a role in assigning whether a productive forest stand is to be managed or unmanaged in Patchworks™ over the 200-year analysis horizon. After the net down process has occurred, Patchworks™ adds an additional dynamic layer to the FML 2 productive forest landbase by assigning productivity to each stand.

Through this process, low productivity stands that will not reach the minimum harvest yield of 50 m^3/ha are identified and labelled as unmanaged to avoid the consideration of the stand as operable (manageable) area. This was a common occurrence, for example, in low-density lowland black spruce stands (i.e., SK_LBS_0_1, etc.).

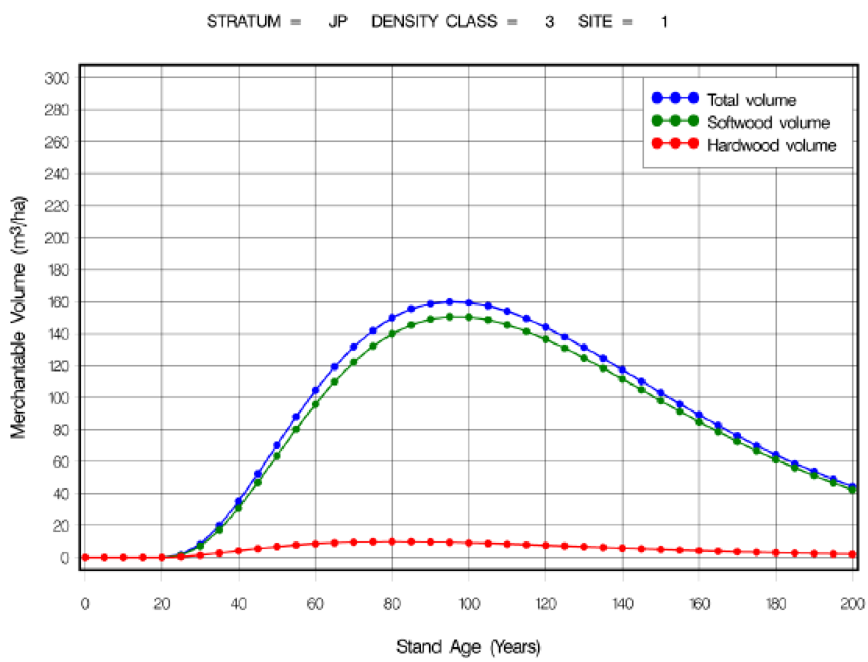


Figure 10.2. An example of merchantable volume (yield) by stand age for high-density jack pine site class 1 stands in Saskatchewan River Forest Section (Province of Manitoba, 2015).

10.1.4.1 Yield Reduction for Retention of Residual Vegetation

During on-the-ground harvest operations, not all volume present in the stand is removed. Depending on the strata type and volume, a proportion of the stand is left remaining as retention to meet biodiversity and wildlife requirements. Reduction factors to reflect this were developed and provided by the Province for use in forest modelling (seeTable 10.3). While the exact amount of vegetation retained will vary on a block-by-block basis, these factors make strategic-level assumptions that represent an average.

For more information, see Part 3 – Implementation and Monitoring, Implementation Strategies subsection 16.3.4.5 Retention of Residual Vegetation.

Table 10.3. Yield reduction factors by strata to reflect retention of residual vegetation developed and provided by the Province.

Strata		Softwood Volume Reduction	Hardwood Volume Reduction
JP	Jack pine	0%	3%
LBS MSPF OSFWD SFWD STL UBS	Lowland black spruce Softwood-leading mixedwood Other softwood mix Pure softwood mix Black spruce and tamarack Upland black spruce	1%	3%
CHDWD NSPF OHDWD TA	Pure hardwood mix Hardwood-leading mixedwood Other hardwood mix Trembling aspen	2%	3%

10.1.4.2 Yield Gains from Planting Forest Renewal

The planting of tree seedlings post-harvest is a forest renewal method commonly used to assist in returning a harvest block that may not regenerate naturally to its pre-harvest composition. Planting seedlings post-harvest can improve stand density and spacing.

The Province developed and provided a yield gain factor of 6% (Province of Manitoba, 2014 & 2015) for harvested stands that are modelled to be renewed via planting methods.

10.1.5 Operability

For a managed block to be considered eligible for harvest within any given period in the forest model, it must meet the criteria of achieving a minimum age and a minimum volume.

10.1.5.1 Minimum Harvest Ages

Minimum harvest ages represent the economically ideal time at which to harvest a stand, based on its rate of growth. The mean annual increment (MAI) and periodic annual increment (PAI) from the strata yield curves were analyzed to identify recommended minimum rotation ages. Minimum harvest ages were developed and provided by the Province (Province of Manitoba, 2014 & 2015) and are summarized in Appendix K – Model Assumptions by Key.

10.1.5.2 Minimum Harvestable Volume

A minimum harvestable volume is required for a block to be considered feasibly operable within the model. The minimum harvestable volume criteria developed and provided by the Province are in Table 10.4.

Table 10.4. Minimum harvest volume for a block to be considered operable for harvest, in cubic metres per hectare (m^3/ha), by stratum developed and provided by the Province.

<table>
<tr><th colspan="2">Strata</th><th>Minimum Volume (m^3/ha)</th></tr>
<tr><td>JP</td><td>Jack pine</td><td rowspan="7">50</td></tr>
<tr><td>LBS</td><td>Lowland black spruce</td></tr>
<tr><td>MSPF</td><td>Softwood-leading mixedwood</td></tr>
<tr><td>OSFWD</td><td>Other softwood mix</td></tr>
<tr><td>SFWD</td><td>Pure softwood mix</td></tr>
<tr><td>STL</td><td>Black spruce and tamarack</td></tr>
<tr><td>UBS</td><td>Upland black spruce</td></tr>
<tr><td>CHDWD</td><td>Pure hardwood mix</td><td rowspan="4">75</td></tr>
<tr><td>NSPF</td><td>Hardwood-leading mixedwood</td></tr>
<tr><td>OHDWD</td><td>Other hardwood mix</td></tr>
<tr><td>TA</td><td>Trembling aspen</td></tr>
</table>

10.1.6 Natural Succession

Natural succession of forest stands has been built into the forest model through the use of stand mortality ("death") ages. Mortality ages were developed and provided by the Province and indicate the age at which a forest stand will experience natural succession and renew as a young forest that is 0 years of age. The provided mortality ages can be found in Appendix K – Model Assumptions by Key.

Mortality ages represent the approximated age of a forested stand when the existing forest structure collapses due to the gradual aging and decline of the individual trees within it. When a stand reaches the mortality age in the model, natural succession is simulated by resetting the stand age and its associated attributes (e.g., yield) to 0.

The inclusion of natural succession in a forest model allows for the consideration of the fact that forest ecosystems are unable to exist indefinitely in the condition in which they are inventoried. Instead, they experience a natural cycle of growth and succession that has impacts on both timber and non-timber resources values.

10.1.7 Post-Harvest Regeneration Delay

Unlike natural succession, if a forested block is harvested in the forest model prior to reaching natural succession, the stand is once again renewed as a young forest but experiences a regeneration delay to account for the extended timeframe in which it may take an area to regenerate either naturally or through forest renewal methods post-harvest.

Regeneration delays were developed and provided by the Province and are summarized in Appendix K – Model Assumptions by Key. Softwood forest types have a regeneration delay of 5 to 10 years applied post-harvest, depending on forest stratum. Hardwood forest types do not experience a regeneration delay post-harvest.

10.1.8 Post-Harvest Transitions

The Province developed and provided post-harvest transitions based on data collected from forest renewal data, summarized in Table 10.5. Through a collaborative process between the Modelling and Analysis Subcommittee, some rules were updated based on the most up-to-date silvicultural information. Post-harvest transitions are an important model input that influence the future forest condition based on the forest renewal methods applied.

Historical records, current practices, and local operational knowledge were considered by the Modelling and Analysis Subcommittee when refining post-harvest transitions. Based on the data available, the Province assigned post-harvest transition rules for some strata to be differentiated based on silviculture treatment, limited to leave for natural and plant treatments.

In the model, leave for natural suggests that the harvested block is expected to have sufficient seed source and suitable ground conditions to allow natural regeneration to occur without the need for silvicultural intervention. Strictly for the purposes of modelling, leave for natural also captures scarification for jack pine harvest blocks. Planting suggests that the harvest block will benefit from tree planting as a forest renewal method post-harvest.

For more information on forest renewal methods and their application in the forest model, see section 12.2.2.4 Forest Renewal of Scenario Analysis. For more operational information on forest renewal, see Part 3 – Implementation and Monitoring, Implementation Strategies subsection 16.4 Forest Renewal.

Table 10.5. Post-harvest transition rules applied in the forest model by strata, forest renewal method, and forest management unit (FMU).

Pre-Harvest Strata		FMUs			Forest Renewal Methods	Post-Harvest Strata	Post-Harvest Proportion (%) of Transition
CHDWD	Pure hardwood mix	-	67 68 69	800 801 802	Leave for natural Planting	CHDWD	100%
JP	Jack pine	50	67	-	Leave for natural	MSPF	30.6%

Pre-Harvest Strata		FMUs			Forest Renewal Methods	Post-Harvest Strata	Post-Harvest Proportion (%) of Transition
		53 58 59	68		Planting	JP	23.7%
						SFWD	20.1%
						NSPF	17.8%
						UBS	7.8%
		-	69	800 801 802	Leave for natural Plant	JP	100%
LBS	Lowland black spruce	50 53 58 59	67 68 69	800 801 802	Leave for natural Plant	LBS	100%
MSPF	Softwood-leading mixedwood	50 53 58 59	-	-	Leave for natural Plant	MSPF	71.3%
						NSPF	23.5%
						SFWD	5.2%
		-	67 68	-	Leave for natural Plant	NSPF	42.9%
						SFWD	23.8%
						MSPF	23.7%
						UBS	9.6%
		-	69	800 801 802	Leave for natural Plant	MSPF	35.8%
						UBS	22.8%
						NSPF	17.4%
						SFWD	24.0%
NSPF	Hardwood-leading mixedwood	50 53 58 59	-	-	Leave for natural Plant	NSPF	100%
		-	67 68	-	Leave for natural Plant	NSPF	72.1%
						MSPF	18.8%
						SFWD	9.1%
		-	69	800 801 802	Leave for natural Plant	MSPF	38.1%
						NSPF	22.4%
						UBS	22.4%
						SFWD	12.2%
OHDWD	Other hardwood mix	50 53 58 59	-	801	Leave for natural Plant	OHDWD	100%
OHDWD	Other hardwood mix	-	67	800	Leave for natural	NSPF	79.1%

Pre-Harvest Strata		FMUs			Forest Renewal Methods	Post-Harvest Strata	Post-Harvest Proportion (%) of Transition
			68 69	802	Plant	MSPF	20.9%
OSFWD	Other softwood mix	-	67 68 69	800 801 802	Leave for natural Plant	OSFWD	100%
SFWD	Pure softwood mix	50 53 58 59	-	-	Leave for natural Plant	MSPF	61.6%
						NSPF	11.7%
						SFWD	11.3%
						UBS	9.7%
						OHDWD	5.7%
		-	67 68	-	Leave for natural Plant	UBS	45.2%
						SFWD	31.4%
						MSPF	16.7%
						NSPF	6.7%
		-	69	800 801 802	Leave for natural Plant	UBS	37.9%
						SFWD	30.7%
						MSPF	22.1%
						NSPF	9.2%
STL	Black spruce and tamarack	50 53 58 59	-	-	Leave for natural Plant	STL	53.5%
						MSPF	46.5%
		-	67 68 69	800 801 802	Leave for natural Plant	STL	100%
TLS	Black spruce and tamarack	50 53 58 59	-	-	Leave for natural Plant	TLS	100%
TA	Trembling aspen	50 53 58 59	67 68 69	800 801 802	Leave for natural Plant	TA	100%
UBS	Upland black spruce	50 53 58 59	-	-	Leave for natural Plant	UBS	100%
		-	67	-		UBS	50.3%

Pre-Harvest Strata		FMUs	Forest Renewal Methods	Post-Harvest Strata	Post-Harvest Proportion (%) of Transition
UBS	Upland black spruce	68	Leave for natural Plant	SFWD	28.0%
				MSPF	13.5%
				NSPF	8.2%
		- 69 800 801 802	Leave for natural Plant	UBS	60.7%
				MSPF	20.4%
				SFWD	14.1%
				NSPF	4.7%

Within the forest model, the post-harvest transition was pre-determined for each eligible harvest polygon of the productive forest landbase prior to scenario execution (i.e., the model is not actively randomly assigning the post-harvest transition for every polygon while it is solving for the optimized solution). The post-harvest transition rule for any polygon applies only to the first time a polygon is harvested. If the same polygon is then harvested a second (or third) time across the 200-year analysis horizon, the post-harvest transition defaults to the stratum that it is proportionally most likely to transition to (i.e., the majority stratum). This rule is applied to capture the strategic nature of the long-term projection of harvest and forest renewal beyond the short and mid-term of the forest management plan.

For example, if a pure softwood (SFWD) polygon is harvested and transitions to upland black spruce (UBS), if that polygon is harvested a second time, it will by default transition back to/remain upland black spruce as this is the majority transition listed for upland black spruce in the table above (50.3% and 60.7% post-harvest proportion of transition).

It is important to note that this methodology applies only to the forest modelling processes. On-the-ground silvicultural treatments are deliberately selected as part of operational planning during plan implementation. See Part 3 – Implementation and Monitoring, Implementation Strategies subsection 16.4 Forest Renewal for more information.

10.1.9 Harvest Methods

The primary harvest method used by Canadian Kraft Paper Industries Ltd (CKP) on the FML is variable retention harvesting, and extensive effort goes into the planning of on-the-ground harvest operations at the block level when implementing a forest management plan. However, to strategically capture harvest methods at the *polygon* level, the forest model applies a simplified clearcut method. This method is combined with applying a yield (volume) reduction to the harvested polygon to simulate variable retention of residual vegetation within the forest model (see section 10.1.4.1 Yield Reduction for Retention of Residual Vegetation).

For more detailed information on harvesting methods at the operational level, see section 16.3.4 Harvesting Methods of Part 3 – Implementation and Monitoring.

10.1.10 Forest Ecosystem Carbon

Carbon curves for the productive forest ecosystems on FML 2 were generated using the Carbon Budget Model of the Canadian Forest Service (CBM-CFS3) and included in the Patchworks™ forest model. The forest ecosystem carbon pools that CBM-CFS3 can estimate include aboveground biomass, belowground biomass, litter, deadwood, and soil organic carbon.

The CBM-CFS3 uses the keys applied to each block of productive forest (i.e., has identifiable strata, site class, and density) along with their associated yield curves to assign values to each of the carbon pools listed above. CBM also requires an ecozone be selected to accurately assign tree-specific carbon equations as well as climatic parameters such as precipitation, temperature, etc. The carbon curves output from the CBM are in tonnes of carbon per hectare (tC/ha) and can be translated to the CO_2 equivalent if needed. Because strata and yield cannot be identified for the non-productive forest areas on FML 2, they are not included in the carbon quantification within the FML 2 Patchworks™ model. Below is an example of the carbon values generated by the CBM-CFS3 for the SK_JP_2_3 key (Saskatchewan River, jack pine, site class 2, density class 3; Figure 10.3).

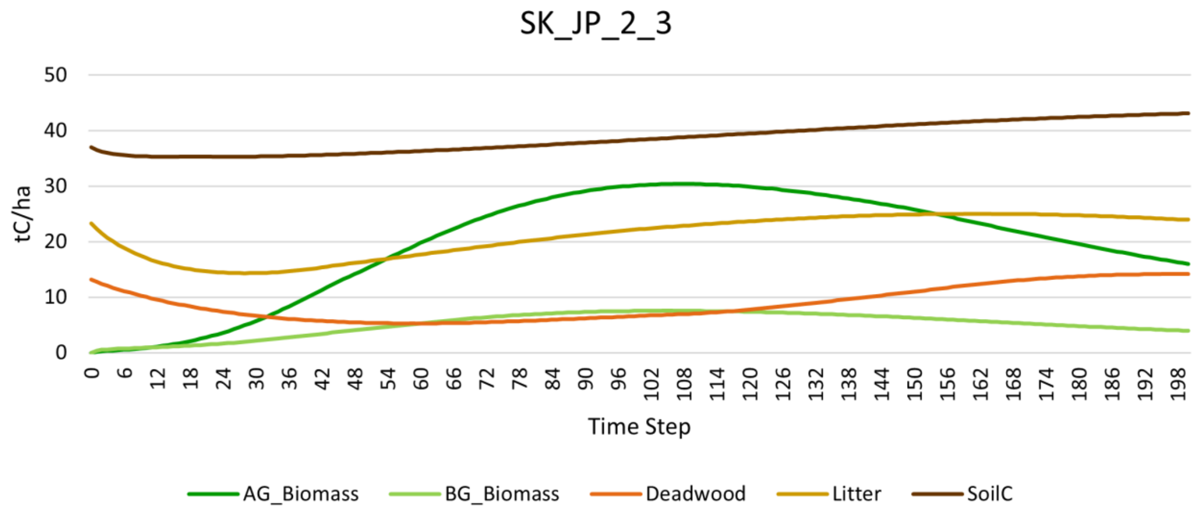


Figure 10.3. Carbon values generated by the Carbon Budget Model of the Canadian Forest Service (CBM-CFS3) for the aboveground biomass (AG_Biomass), belowground biomass (BG_Biomass), deadwood, litter, and soil organic carbon (SoilC) forest ecosystem carbon pools.

The average amount of forest ecosystem carbon stored on the managed, productive forests of FML 2 at any given time over the 200-year analysis horizon is approximately 400 million tonnes C, with the largest proportion being stored in forest soils. Harvesting activities on FML 2 are most likely to impact aboveground forest carbon, only the third largest of the five carbon pools. A great resource to learn more about carbon dynamics in Canadian forests is the *Parks Canada Carbon Atlas Series: Carbon Dynamics in the Forests of National Parks in Canada*[2] (Sharma, et al., 2023).

As the carbon values are only for the productive forest landbase, the forest ecosystem carbon values estimated by Patchworks™ are not to be considered as absolute, but rather to be considered with a relative lens when comparing scenarios in search of the Preferred Forest Management Scenario (PFMS). The carbon estimates included in the forest model are strategic and represent a relative amount at the landscape level. The inclusion of productive forest ecosystem carbon provides an additional indicator to be taken into account when layering in other values and objectives and doing the climate vulnerability assessment.

The forest ecosystem carbon values estimated by the CBM-CFS3 and Patchworks™ are mutually exclusive of the wetland carbon storage and sequestration values estimated by Ducks Unlimited Canada (Ducks Unlimited Canada, 2022) for FML 2. See section 2.7 Wetlands of Part 1 – Planning Context and section 15 Cumulative Effects for more information on the effects of operations on wetland carbon.

Including these curves within the forest model allowed for an estimation of the influence of the proposed forest management activities on the total amount of forest ecosystem carbon on the productive forest that could be compared between scenarios during scenario analysis.

[2] For more information on carbon dynamics in Canadian forests from the *Parks Canada Carbon Atlas*, see: https://publications.gc.ca/collections/collection_2024/pc/R62-581-2023-eng.pdf.

11 Modelling Wildlife Habitat and Habitat Elements

A major component of determining the strategic direction for a forest management plan is exploring trade-offs for not only the economic aspects of forestry, but also for the social and ecological values of the forest. A major component of the determination of the Preferred Forest Management Scenario was exploring wildlife habitat elements.

There are so many wildlife species that live on FML 2 – how can we represent them all?

Landscapes provide habitat for many wildlife species, each with its own preferences for combinations of vegetation types, development stages, and patch sizes and configurations. It would be difficult to manage wildlife habitat with a species-by-species approach within the context of a strategic-level forest management plan. To reduce this complexity, the forest can be classified into categories according to how forests function as habitat groupings of forest types and age classes (seral stages)—often referred to as habitat elements. Using these categories to represent habitat elements within the region covers many species habitat requirements. This is often referred to as the “coarse-filter and fine-filter” approach. At the strategic (coarse-filter) level, we can track and maintain these general habitat elements over the landscape and over long timeframes. This helps to ensure the general amount of habitat elements that occur now in the region remain in the region over time, even when forest management activities occur.

Focusing on landscape-level habitat elements in strategic forest modelling provides a broader, more flexible approach that supports multiple species, improves resilience to change, and aligns with long-term sustainability goals. This approach helps forest managers develop a comprehensive view of forest conditions that goes beyond individual species needs, fostering a well-rounded and adaptable ecosystem management strategy.

There are species-specific habitat assessment tools that assess the amount, arrangement, and quality of the habitat available within the current and future forest. These tools are usually applied outside of the forest model (often referred to as post-processing in resource analysis) because habitat models use other assumptions that are not included in the strategic forest model. Habitat Suitability Index (HSI) or Resource Selection Function (RSF) models are assessment tools used to understand habitat quality, relative carrying capacity, or the probability of occupancy of an area or forest type for a specific species. HSI models predict the suitability of habitat for a particular species based on an assessment of habitat attributes, with 0 being the lowest quality and 1 being the highest quality. Using these models, the forest can be categorized by these indices to observe changes in the amount and arrangement of suitable habitat from the start of the forest management plan to future time periods (e.g., 10 years, 20 years). An RSF-type model will categorize the area by a likelihood of selection or occupancy for a particular species. RSF-type models require actual location data of the animal to build. This means that these models are developed based on locations the animal has been confirmed to use, and then identifies the forest type and characteristics associated with those locations to try to find that unique combination in other places within the forest or in future time periods.

These models are different from the concept of a forest model that has been discussed so far and are often applied outside of the forest model to assess what type of habitat would be available considering other elements not available in a strategic forest model. Every tool has its strengths. A forest model is an excellent tool for exploring forest growth and changes over time and space based on actions, whereas habitat models are excellent tools to take the forest conditions predicted and assess what type of habitat exists, how it is arranged, and what the quality is for the species in question. This forest management plan includes both strategic-level, coarse-filter habitat elements within the forest model, as well as some species-specific, fine-filter habitat assessments that consider additional habitat elements and relationships outside of the forest model.

Some wildlife species have very specific needs – when are these addressed?

Following the coarse- and fine-filter approach, the forest management plan gives the opportunity to plan for the amount and changes of strategic-level habitat elements over time. There are additional opportunities to consider and plan for wildlife habitat elements at the operational (fine-filter) level during plan implementation. For more information on how wildlife can be considered at the operational level, see section Part 3 – Implementation and Monitoring, Implementation Strategies subsection 16.1 Planning.

One of the highly valued, culturally important focal species in the region that benefits from these two levels of planning is moose. Moose are a culturally significant species on the FML, and engagement activities for this forest management plan heard this from both rightsholders and stakeholders. Planning for moose habitat is a great example of a species that can be represented at both the strategic, coarse-filter level while also benefitting from more detailed, fine-filter operational planning. In the forest model, general habitat elements have been defined to identify preferred forest types in the region over time. However, how these habitat elements are arranged at the local level to provide fine-scale habitat needs are a key component to moose habitat planning. This level of detail is planned for and implemented at the operational scale. Because of these requirements and the cultural and social importance of this species you will find information about moose and moose habitat planning throughout this plan. See the following sections to get the full picture.

For more information related to planning for moose habitat, see subsection 11.3 Moose Habitat Elements of this section, subsection 12.2.2.3.3 Wildlife Habitat and Habitat Elements of Scenario Analysis, and section 15 Cumulative Effects.

Can the forest model consider species at risk habitat – like for boreal woodland caribou?

The provincial *20-year Forest Management Plan Guideline* (Manitoba Agriculture and Resource Development, 2021) directs that*:*

> *Within Boreal Caribou ranges proponents would be expected to implement a management strategy using the best available information to mitigate effects of forest management activities on caribou habitat. This includes a Caribou Habitat Protection Plan to be incorporated into the forest management plan to provide guidance to the management plan. Manitoba will provide further details as the provincial caribou action plan for range plan development is finalized.*

This forest management plan has implemented many habitat modelling elements and assessments to help inform planning for boreal woodland caribou ranges that overlap the FML based on the best available information at the time. The Province has provided feedback and direction through the Modelling and Analysis Subcommittee to refine many of the habitat elements and factors used in the forest model that influence the simulation of the amount, arrangement, and quality of caribou habitat over time.

Caribou home ranges are very large, and habitat needs are focused on older conifer forest types (Manitoba Boreal Woodland Caribou Management Committee, 2015). Using a strategic-level forest model can be very useful to plan for and visualize where future habitat will develop as the forest ages over time. The development of the Preferred Forest Management Scenario explored ways to reduce fragmentation of future caribou habitat elements by aggregating harvest activities and reducing the amount of transportation and access required on the landscape. Due to the size of habitat element requirements of caribou, planning ahead at the landscape level over long timeframes becomes very important.

Combining the use of the forest model with the use of a Habitat Suitability Index (HSI) model provides a robust picture of boreal woodland caribou habitat elements and the forest management plan impact. More information about modelling and assessment of important habitat elements for caribou can be found in subsection 11.2 Boreal Woodland Caribou Habitat Elements.

FML 2 represents a unique region of Canada. Do habitat models exist that represent this area accurately?

While engaging with rightsholders and stakeholders during the development of this forest management plan, it was noted that some of the specific habitat models that existed historically for use in Manitoba were out of date, lacked regional validation, or might not apply to the northern boreal regions of Manitoba. Based on this feedback and additional research, NFMC explored alternatives such as updated wildlife habitat models that may be valid for use within the plan, as well as the possibility to enhance future habitat modelling with data collection and research initiatives on the FML during the 20-year implementation period of plan.

See subsection 11.4 Boreal Songbird Habitat Elements to learn more about the boreal songbird habitat modelling that was explored for this plan and the Research section of Part 3 – Implementation and Monitoring to read about the planned initiatives to collect local data to better represent the region for use in future planning.

11.1 MATRIX OF HABITAT ELEMENTS FOR WILDLIFE SPECIES

Landscapes provide habitat for many wildlife species, each with its own preferences for combinations of vegetation types, development stages, patch sizes and configurations. It would be difficult to manage wildlife habitat with a species-by-species approach within the context of a forest management plan. To reduce this complexity, the forest can be classified into categories according to how forests function as habitat groupings of forest types and age classes. Using these categories to represent habitat types within the region covers many species habitat requirements. These groupings or categories are often referred to as habitat elements.

A matrix (or it can be thought of as a box; Table 11.1) of habitat elements defined using broad forest cover types and seral stages (see Scenario Analysis subsection 12.2.2.3.2 Forest Seral Stages for detailed information about this important biodiversity indicator) was used to categorize habitat elements distributed across FML 2. These habitat elements can be represented directly in the forest model and are tracked over time as the forest ages and regenerates from disturbances. The matrix of habitat elements covers many representative species found within the region. The forest model can measure and report on the abundance of these general habitat elements within the FML and demonstrate relative changes as a result of the strategic direction identified in the Preferred Forest Management Scenario.

The matrix is developed by taking the broad forest cover types that occur in FML 2 (softwood, softwood-leading mixedwood, and hardwood-leading mixedwoods and hardwoods) and intersecting each type with age ranges that would represent different stages of forest development—young, immature, mature, old, and very old forest stands—also known as seral stages. The dimensions of the box represent general but unique habitat types that occur around the FML and maintaining the dimensions (or the corners of the box) is a way to model landscape level habitat elements over time in a forest model. Table 11.1 below has been populated with examples of species that would occupy or potentially use the habitat element represented by each broad forest habitat type.

Some species prefer older pure conifer (or softwood – pine, spruce) types of forest. Referring to the matrix in Table 11.1 , we can find this type of habitat element under the softwood column and mature and old seral stage row in the bottom left corner. The example species listed here are those animals that often occupy or prefer this type of forest, and include caribou, marten, olive-sided flycatcher, red-breasted nuthatch, and the great grey owl.

As discussed in Part 1 and in the Landbase Net Down section here in Part 2 (see section 10.1.2 Spatial Data Preparation), not all of the area within FML 2 is included in the forest model or is available for forest management activities. The non-productive land not included in the model is still important habitat for some species; however, it is not directly influenced by management and cannot be tied to the model assumptions necessary to build the forest model. This area has been noted in the far column of the habitat matrix as non-productive forest land. An example of some non-productive land that is important habitat but not included in the forest model directly are the bogs, wetlands or forested wetlands. Although these areas are not directly influenced by management, they can be indirectly influenced by management activities and are recognized as an important value that is planned for with tools such as riparian buffers or operational best management practices when building roads or operating in proximity to a wetland. In some species-specific assessment models, non-productive land can be included as an additional habitat element in post-processing assessments. These elements would be represented as static over time but provide a more cumulative view of useable habitat distributions over time for species with large range requirements such as caribou.

Table 11.1. Habitat elements matrix describing the broad forest habitat elements represented within FML 2 using seral stages and cover types. Examples of wildlife species that would utilize these general habitat elements have been listed inside the table.

Seral Stages	Softwood	Softwood-leading Mixedwood	Hardwood-leading Mixedwood & Hardwood	Non-Productive Forest
Young	Great grey owl Lynx Marten Red breasted nuthatch White-throated sparrow	Common yellowthroat Great grey owl Lynx Marten Moose (browse) Red-breasted nuthatch White-throated sparrow	Black and white warbler Common yellowthroat Great grey owl Lynx Moose (browse) Ruffed grouse	Beaver Caribou Common yellowthroat Greater yellowlegs Moose
Immature	Marten Red breasted nuthatch Great grey owl	Marten Moose (cover) Red breasted nuthatch Great grey owl	Black and white warbler Moose (cover) Great grey owl Ruffed grouse	
Mature, Old, & Very Old	Caribou Marten Olive-sided flycatcher Red breasted nuthatch Great grey owl	Marten Olive-sided flycatcher Red breasted nuthatch Hairy woodpecker Great grey owl	Black and white warbler Hairy woodpecker Great grey owl Ruffed grouse	

The matrix of habitat elements can be seen as representing the full spectrum of forest types in the region at a coarse scale. If all corners, or categories of the box, are represented and maintained at the landscape level the future forest condition would in theory represent all the required habitat elements (the amount of each habitat would be represented at the landscape level). See how these habitat elements were used in the forest modelling and analysis to help provide strategic direction for the Preferred Forest Management Scenario (see section 13).

It is important to remember, however, that each of the species examples represented within the cells of the matrix may have very specific habitat requirements at a finer scale that cannot be represented within the strategic forest model. As discussed earlier, these finer-scale habitat elements can be better addressed during other phases of the forest management plan such as harvest patch size distribution planning, 2-year forest management operating plan (FMOP) development, harvest block mitigation, road planning, and forest renewal activities. These other planning components can help address how the habitat elements are arranged, so that the elements are useable and of better quality. The matrix of habitat elements represents the strategic scale of planning (the amount of each habitat type), and more fine scale habitat elements would be planned for at the operational scale (the arrangement of habitat type and detailed elements within harvest block).

Representing habitat is not as simple as a two-dimensional box, however there are many reasons why this modelling tool would be used within a forest management plan and specifically during strategic-level forest modelling:

1. Capturing Ecosystem Complexity

- Forest ecosystems are complex, with many interconnected habitats, species, and ecological processes. Landscape-scale habitat elements—like forest age, canopy cover, water sources, and connectivity between patches—represent these broader ecosystem characteristics.
- By managing at the landscape scale, forest managers can strategically ensure that a range of habitats is maintained, which indirectly supports many species, including those with specific needs. This makes the model more holistic and adaptable to various ecosystem needs.

2. Supporting a Wide Range of Species

- When managers focus on individual species, they may be limiting themselves to accounting only for that specific species' needs. By managing for landscape-scale habitat elements instead, managers can help create diverse habitats that support a broader range of species and ecological functions.
- For example, maintaining a mix of old and young forest patches supports different species that require varying types of habitats, rather than only those that align with a single species' needs.

3. Adapting to Change

- Forests are dynamic and change over time due to natural processes (like aging, natural succession, fire, or disease) and human activities (like harvesting or conservation efforts). Landscape-scale habitat elements are better at accommodating this change since they encompass a variety of conditions across the forest.

4. Efficiency and Practicality

- Monitoring populations of individual species, which fluctuate naturally over time, can be resource-intensive and complex. Focusing on landscape-scale habitat allows managers to track broader characteristics in a way that is more straightforward and sustainable in the long-term.

5. Long-Term, Strategic Planning

- Landscape-scale modelling aligns well with the goals of strategic forest estate modelling, which aims for sustainable forest management over extended periods (often 100+ years). Broad habitat elements help provide a stable framework for achieving long-term ecological health, as they align more closely with the overall structure and function of the forest.
- Since strategic modelling needs to account for the forest as a whole rather than specific outcomes for individual species, focusing on landscape-scale habitat elements helps keep the model focused on sustainability at the ecosystem level.

11.2 BOREAL WOODLAND CARIBOU HABITAT ELEMENTS

Boreal woodland caribou habitat is a priority management objective for FML 2 to align with the federal and provincial designation of woodland caribou as a species at risk (Environment Canada, 2012). Woodland caribou conservation, planning, and management requires a landscape-level approach and considers both the relative abundance of habitat and the arrangement at the caribou management unit scale (CMU; see Map 7.1 in section 2 Ecological and Physical Description of Part 1 – Planning Context). Due to the strategic nature of the scale at which caribou habitat will need to be considered, and the scale that will be directly influenced by forestry and access, woodland caribou is addressed directly within management objectives and within the forest model. In addition to the below information, section 12.2.3.2 Young Forest Patches details an additional measure applied in the Habitat Scenario to provide direction to the Preferred Forest Management Scenario.

At the time that this 20-year forest management plan was developed, the Management Unit Range Plans mandated in *Manitoba's Boreal Woodland Caribou Recovery Strategy* (Manitoba Boreal Woodland Caribou Management Committee, 2015) were still being developed. However, collaboration with the Province has resulted in high-level strategies for this plan that will reflect the over-arching intent of the future Management Unit Range Plans.

11.2.1 Forest Model

To strategically consider boreal woodland caribou habitat features on the FML, three caribou habitat types were defined and included in the forest model to allow for the tracking of both the amount and arrangement on the landscape. These habitat types are refuge, useable, and preferred habitat for boreal woodland caribou. See Table 11.2 for a description of each habitat type definition provided by the Province. These are similar to the habitat elements discussed in the previous section; however, they further categorize specific forest types and age classes that represent general habitat types for caribou. Using forest strata and stand age allows for a finer classification but can still be identified within the forest model.

Table 11.2. Boreal woodland caribou habitat type definitions used to track the amount and arrangement of habitat features in the model provided by the Province.

Forest Cover Type	Strata		Onset Age for Habitat		
			Refuge	Useable	Preferred
Softwood	JP	Jack pine	Always	≥ 41 years old	≥ 60 years old
	LBS	Lowland black spruce	Always	≥ 41 years old	≥ 101 years old
	OSFWD SFWD STL UBS	Other softwood mix Pure softwood mix Black spruce and tamarack Upland black spruce	≥ 41 years old	≥ 60 years old	-
Mixedwood	MSPF	Softwood-leading mixedwood	≥ 70 years old	-	-

The amount of each type of boreal woodland caribou habitat can be measured in hectares, with reporting available at the FML, forest management unit (FMU), and caribou management unit (CMU) level. For more information, see 12 Scenario Analysis, Biodiversity subsection 12.2.2.3.3 Wildlife Habitat and Habitat Elements (Boreal Woodland Caribou Habitat).

11.2.2 Habitat Suitability Index (HSI) Model

HSI models predict the suitability of habitat for a particular species based on an assessment of habitat attributes, with 0 being the lowest quality and 1 being the highest quality. Arsenault and Hazell (2021) developed a caribou preference model that fits with Manitoba's available data and creates an assessment of habitat state for a caribou range. The HSI model was used as an assessment tool that could evaluate caribou habitat after each scenario for relative comparisons of changes to habitat through time and location (as a result of projected forestry activities). The habitat model incorporates key factors of forest and non-forest vegetation, land cover, stand age, and disturbance. The habitat model considers the following factors by applying suitability scores:

- Vegetation/land cover types;
  E.g. jack pine forest stands have higher scores than deciduous forest stands, which generally score low.
- Stand age; and,
  E.g., mature forest stands have higher scores than the youngest forests.
- Anthropogenic (human-created) and natural disturbances.
  Anthropogenic disturbances such as roads, settlements, and timber harvesting are buffered by 500 metres, and have the lowest scores. Natural disturbances also have low scores but are not buffered.

The HSI is calculated outside of the forest model using a Geographic Information System (GIS) and can be used to assess how each forest model scenario may change the amount and arrangement of caribou HSI through time using the equation below.

$$Annual\ Caribou\ HSI = \ Caribou\ Land\ Cover\ Preference\ x\ Stand\ Age\ x\ Disturbance$$

The HSI rating associated with each land cover type and forest stand age predicted by the technical memo (Arsenault & Hazell, 2021) are detailed in Table 11.3 and Table 11.4. Most of the upland land cover types in Table 11.3 can come directly from the forest model (e.g., pine, coniferous, mixedwood, deciduous). Other land cover types such as shrub, grassland, dunes, and lowland wetlands (e.g., bogs, fens, and swamps) are not included within the forest model input as they are generally considered non-productive vegetated areas (for the purposes of forest modelling for a forest management plan). Instead, information for these land cover types were assembled independently using the original FML 2 inventory into a non-productive landbase layer. This non-productive layer was reviewed by the Province before being used in this assessment. The non-productive layer was then used in combination with forest model output to calculate HSI for the FML.

For further information on this approach to HSI, refer directly to the Arsenault and Hazell 2021 documentation in Appendix S – Woodland Caribou Habitat State Analyses Technical Memo.

Table 11.3. Woodland caribou land cover type preference and habitat suitability index rating, from Arsenault and Hazell (2021). Preference ratings range from most preferred (+3) to most avoided (-3).

Land Cover Type		Caribou Preference	HSI Rating
Upland	Pine	3	1.0
	Coniferous	2	0.8
	Mixedwood (coniferous dominant)	1	0.6
	Mixedwood (deciduous dominant)	-1	0.2
	Deciduous	-1	0.0
	Sand Dune	0	0.0
	Bedrock / Rubble	1	0.6
	Upland Shrub	-1	0.2
	Native Grassland	-1	0.0
Lowland	Treed Bog	3	1.0
	Shrubby Bog	2	0.8
	Graminoid Bog	1	0.6
	Treed Fen (rich, poor)	2	0.8
	Shrubby Fen	1	0.6
	Graminoid Fen	0	0.4
	Treed (Conifer) Swamp	2	0.8
	Mixedwood Swamp	0	0.4
	Hardwood (Birch) Swamp	0	0.0
	Shrub Swamp/Riparian Shrub	-1	0.2
	Meadow March/Riparian Meadow	0	0.0
	Mudflats/Gravel Bar/Rocky Shore	0	0.0
	Emergent Marsh	0	0.0
	Aquatic Bed	0	0.0
Lowland	Open Water	0	0.0

Land Cover Type		Caribou Preference	HSI Rating
Disturbed	Burned (< 40 years)	-2	---
	Clearcut/Clearing (< 40 years)	-3	---
	Permanent Polygonal Disturbance (agriculture, settlements, infrastructure)	-3	---
	Linear Disturbance	-3	---

Table 11.4. Woodland caribou preference by forest stand age and habitat suitability index rating, from Arsenault and Hazell (2021). Rationale for differentiating forest stand age is to differentiate the likelihood of terrestrial lichen abundance.

Stand Age Range (years old)	HSI Rating
< 10	0.0
10-19	0.2
20-29	0.4
30-39	0.6
40-49	0.8
50-59	0.9
60-100	1.0
> 100	0.8

Results from the HSI model can be reported as both a chart (Figure 11.1as well as spatially to assess the distribution of suitable habitat (Figure 11.2). Within a chart, the amount of suitable habitat present over 40 years can be assessed and compared relative to plan start (2025; period 0). The blue bars indicate the total amount of habitat units, while the green and yellow lines provide a more refined representation of suitable habitat by only reporting area where habitat units are greater than either 0.5 (green line; good quality suitable habitat) or 0.75 (yellow line; best quality suitable habitat). For the purposes of this forest management plan, results will focus primarily on habitat units greater than 0.5, capturing suitable habitat that is of relatively good quality.

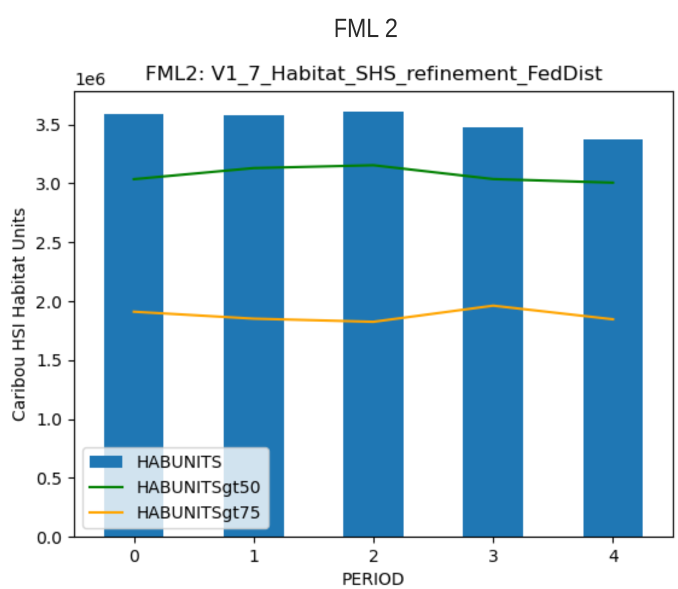


Figure 11.1. An example of area that has a caribou habitat suitability index (HSI) value greater than 0 (HABUNITS; blue), and of that area, the area that has an HSI value greater than 0.5 (HABUNITSgt50; green) and 0.75 (HABUNITSgt75; yellow) for the FML.

Reviewing the results of the HSI model spatially provides an opportunity to evaluate where suitable habitat may be concentrated across the FML and within certain Caribou Management Units (CMUs) with the Province and assess how this distribution may relate to known population patterns of boreal woodland caribou on the landscape.

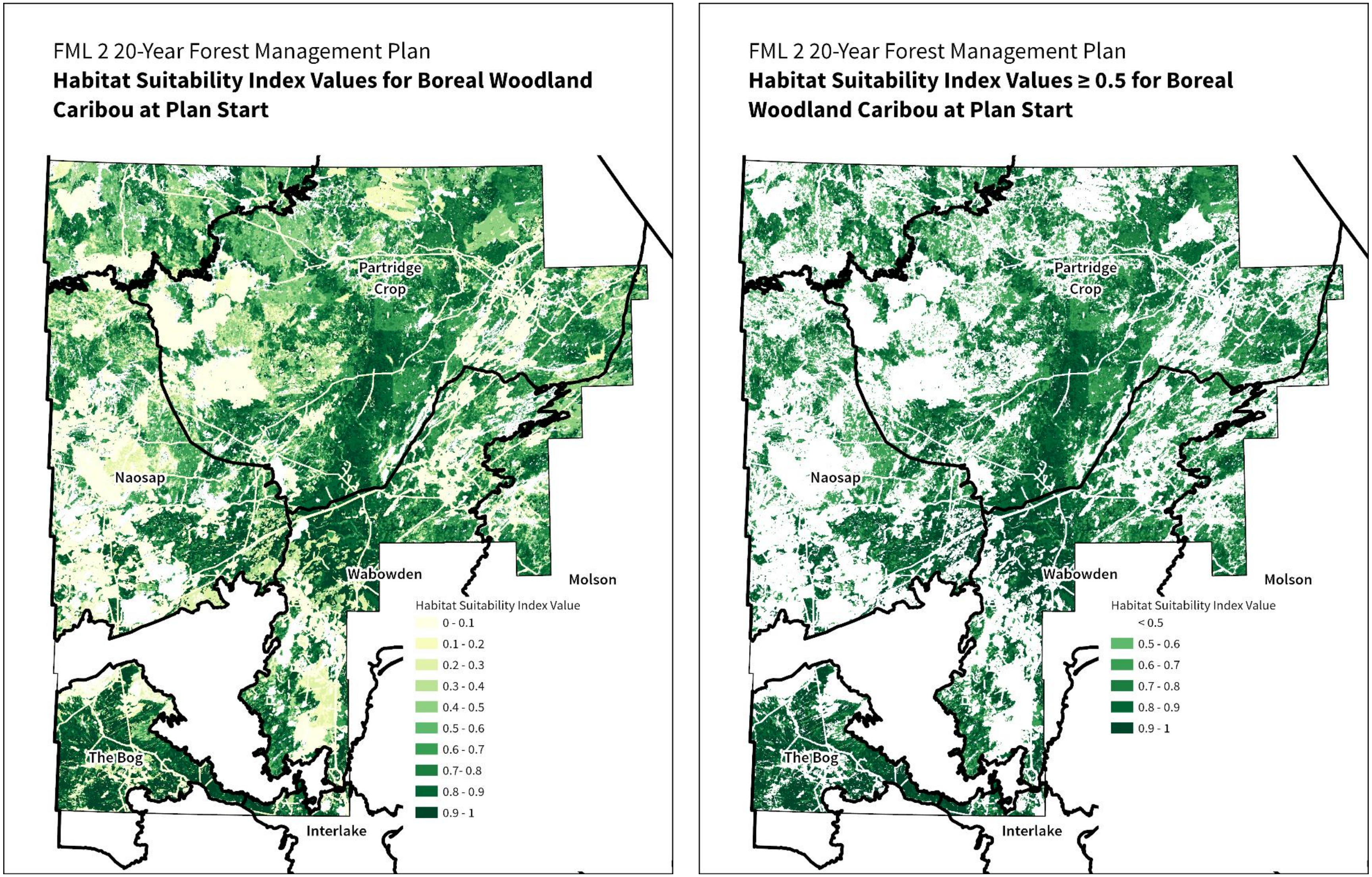


Figure 11.2. An example of the location of boreal woodland caribou habitat suitability output from the boreal woodland caribou habitat suitability index (HSI) model for plan start on FML 2. All HSI values are represented in the map on the left, while only habitat suitability index values greater than 0.5 are represented in the map on the right for comparison. Exclusing HSI values less than 0.5 focuses in on the spatial arrangement of higher quality suitable habitat.

11.2.3 Assessing Cumulative Habitat Disturbance for Caribou

An assessment of boreal woodland caribou habitat disturbance focuses on understanding how human activities and natural factors impact the potential habitat of boreal woodland caribou populations. Environment Canada has developed an assessment methodology that considers how disturbances, both natural and anthropogenic (human), can impact caribou recruitment and populations (Environment Canada, 2011). *Manitoba's Boreal Woodland Caribou Recovery Strategy* (Manitoba Boreal Woodland Caribou Management Committee, 2015) also references this methodology:

> *Based on the methodology developed by Environment Canada (2011), the national recovery strategy identifies a minimum of 65 per cent undisturbed habitat in a range as a disturbance management threshold, which provides a measurable probability (60 per cent) for a local population to be self-sustaining (Environment Canada 2012). Manitoba intends to protect and manage 65 to 80 per cent intact suitable boreal caribou habitat in management units. While there is general agreement on caribou populations being sustainable or not sustainable in the low and high ends of the habitat disturbance gradient, respectively, there is no discrete habitat disturbance threshold separating sustainable from unsustainable.*

This methodology uses mapped disturbances on the boreal forest to determine areas likely to be avoided by caribou, as well as areas more likely to support caribou population recruitment. In addition, the strategy recognizes that the precise location of the 65 per cent undisturbed habitats within a range will vary over time. Environment Canada states in the national strategy that habitat within ranges should exist in an appropriate spatial configuration such that boreal caribou can move throughout the range and access required habitat when needed. This 2011 assessment led to the development of the *Recovery Strategy for the Woodland Caribou* (Environment Canada, 2012).

Assessing cumulative disturbance primarily focuses on two categories:

1. Anthropogenic (Human) Disturbances: Industrial activities such as logging, mining, oil and gas extraction, and infrastructure development (settlements, roads, pipelines) are all notable sources of landscape disturbance. These activities fragment and/or permanently remove habitat from the landscape. Caribou not only avoid these disturbed areas, but also generally avoid the immediate vicinity of these disturbances. To capture this, anthropogenic disturbances are buffered by 500 metres. Disturbances from logging are no longer considered disturbed after 40 years post-harvest to capture forest renewal.
2. Natural Disturbances: Natural calamities such as wildfires also contribute to landscape and habitat disturbance, though the impact is often less severe in comparison to human disturbances. While wildfires can temporarily reduce the quality of habitat, the forest will eventually recover. Wildfires are not buffered and are considered undisturbed 40 years post-fire.

At the time this forest management plan was developed, *Manitoba's Boreal Woodland Caribou Recovery Strategy* (Manitoba Boreal Woodland Caribou Management Committee, 2015) was in place, but a province-wide assessment of cumulative disturbance and/or Management Unit Range Plans were still in development. A cumulative assessment of large boreal landscapes includes many data layers, and the ability to grow and age those data layers over time as areas recover from disturbance. Components of this analysis had been started (anthropogenic information was being gathered by the Province for use), however a complete assessment was not available at the time. This was identified as a knowledge gap in the development of the forest management plan, however, NFMC worked closely with the Province to include strategic-level objectives in the 20-year forest management plan that reflect the intent of the recovery strategy and Management Unit Plans in development at the time. This includes the development of a strategic direction for the forest management plan that focuses on minimizing habitat disturbance by localizing harvest into more contiguous patches and limiting the amount of new road required to access these harvest areas. By working with the Province and making a significant effort to move towards, over time, a forest landscape condition which provides an adequate amount and distribution of boreal woodland caribou habitat, NFMC has worked to consider and mitigate the potential effects of the forest management plan on cumulative disturbance within the Caribou Management Unit (CMUs) on the FML.

NFMC acknowledges that the Province is actively working towards completing and publishing a series of Management Unit Plans that would directly address the management of CMUs that overlap the FML. NFMC and the Province commit to continuing collaboration and mitigation regarding caribou habitat throughout forest management plan implementation as new information, policies, and plans become available.

11.3 MOOSE HABITAT ELEMENTS

Moose are a culturally significant species on FML 2 and NFMC heard this from both rightsholders and stakeholders during the plan engagement activities. Planning for moose habitat is a great example of a species that can be represented at both the strategic, coarse-filter level while also benefitting from more detailed, fine-filter operational planning. In the forest model, general habitat elements have been defined to identify preferred forest types in the region over time. However, how these habitat elements are arranged at the local level to provide fine-scale habitat needs are a key component to moose habitat planning. This level of detail is planned for and implemented at the operational scale. Because of these requirements and the cultural and social importance of this species, you will find information about moose and moose habitat planning throughout this plan.

The following information is a general description of moose habitat and habitat needs provided by the Province (for full resource, see Appendix P – Provincial Moose FAQ). Considering this information and the coarse and fine filter approach to planning, this section will outline some of the important habitat element components and planning tools considered for moose in this forest management plan.

The following description of moose habitat is an excerpt from a 2023 Provincial FAQ (Frequently Asked Questions) about moose:

> *Moose require a mix of forest cover types and ages throughout the year for browse and cover. Moose are typically found living near water sources, such as lakes, muskeg, and streams. A mix of both young and old forests are ideal. Young forests and bodies of water provide food while mature trees can provide shelter. During the winter, deep snow can make it difficult for moose to move around, making them vulnerable to predation. Therefore, moose tend to use softwood forests for cover in late winter, as they provide more shelter from heavy snow compared to younger forests. During the spring and summer, moose use softwood forests for shade and wetlands and other water sources for food and managing heat stress. There is limited information about their calving sites, except they are often near water and in areas that provide protection from predators.*
>
> *Moose consume at least 30 kilograms of browse per day to meet their nutritional needs. Moose forage on submerged aquatic plants in shallow wetlands as well as browse on shrubs and new tree growth in the summer. Food sources vary throughout the year dependent on palatability and availability, with more aquatic vegetation and new browse (e.g., leaves on deciduous trees such as aspen) consumed in the spring and summer and denser browse, such as twigs and understory shrubs such as dogwood and hazel consumed in the fall and winter when other foods are no longer available. Stands less than 20 years old provide more younger browse which can support greater densities of moose on the landscape.*
>
> *Moose populations can benefit from forestry and fire by returning forested stands to younger age classes, which provides more favourable browse habitat. Additionally, moose require patches of older forest stands for cover from predators, weather, and during calving. Planning human activity and forest operations to emulate natural disturbances such as wildfire will help manage the natural variation of habitat within a forest and create a dynamic mix of habitat necessary to support moose populations.*
>
> *Maintaining habitat is only one factor, however. There are other pressures affecting moose such as changes in predator dynamics or increased hunting pressures as a result of increased access into areas of moose habitat that previously had no access. Managing the access into forested areas will help protect moose and other wildlife. Roads can fragment habitat, result in increased vehicular collisions, increase hunting*

pressures into sensitive areas, and create travel corridors for predators such as wolves. Forestry companies that manage the net increase of roads within their FML will help protect habitat and moose populations. If access is not managed, areas with a mixture of habitat patches may become sinks to moose populations rather than sources of moose. Moose will travel to areas with a mixture of browse and cover, but if they have hunting and predation pressures then moose populations may also decline.

Moose distributions may change across the landscape based on the location of preferred habitat, which means that moose distributions and densities may fluctuate over time as habitat availability changes because of fire, forestry, and other human activities. There is no information to suggest that the distribution of moose has changed significantly across the FML 2 area. In addition to habitat alteration, other impacts that could affect the distribution of moose population could be either predation from wolves, or land use changes that have resulted in too much fragmentation and a loss of food and/or cover, or a loss of habitat. Moose distributions have changed some in the southeast region of Manitoba (e.g., the Whiteshell area), largely because of habitat overlap with white-tailed deer, which are known to carry brainworm parasites. The white-tailed deer range is expanding in a northern direction, which may result in the distributions of moose changing due to the impact of brainworm on moose populations. Moose distributions may also change in the future as a result of climate change, as climate change may affect vegetation distributions, altering forage, water and cover availability.

How do we know what types of forest moose are using as habitat?

The Province and other researchers with university partnerships in the province study moose habitat use and seasonal movements through aerial surveys, GPS collaring programs, wildlife cameras, hunter reports, and engaging with local communities to gather traditional ecological knowledge. New ways of tracking where moose are going on the landscape are being explored by researchers that will be more efficient and less disruptive to moose populations as on-going research. For this plan, NFMC collaborated with the Province to understand what type of information had been collected around the province that could be used in the strategic-level forest model, as well as to provide direction for operational planning.

Using the data collected from these research programs, biologists can identify the locations where moose are or have been seen. Once the location is known, the features in that area can be identified to start to build a picture of what forest types are used, in what season, and in what configuration. Figure 11.3 is an example of some of the work that was done in the province to refine habitat elements and use. The symbols on the map represent moose collar location points collected between February 2020 and August 2022 and have been categorized by season. This data demonstrates that moose may be using cut blocks (green outline; 2014 harvest) as habitat 8 to 10 years after the area was harvested.

When all this information is rolled up, biologists start to see patterns of use and general forest types can be classified at different scales. Figure 11.4 is an example of how some location information was summarized from a study to show what forest types and ages were being selected for in different seasons. This particular example highlights the use of aspen stands by season and age, and that moose prefer young aspen (0-20 age) in all seasons, as compared to immature or mature stands. Interestingly, we see another spike on the graph for very old aspen. This can be explained by the idea that very old aspen stands are starting to die and fall over at this point in their lifecycle. This can create openings that allow sunlight to reach the forest floor so new trees can take hold and grow, interspersing new understory of growth for moose to eat while still providing cover from the hot sun.

Although there is not specific moose collar data available for FML 2, general habitat elements for moose can be defined strategically based on research done in neighbouring regions that represent similar forest types, literature reviews, expert knowledge and engagement. The following section outlines what general habitat types were defined for moose in the forest model.

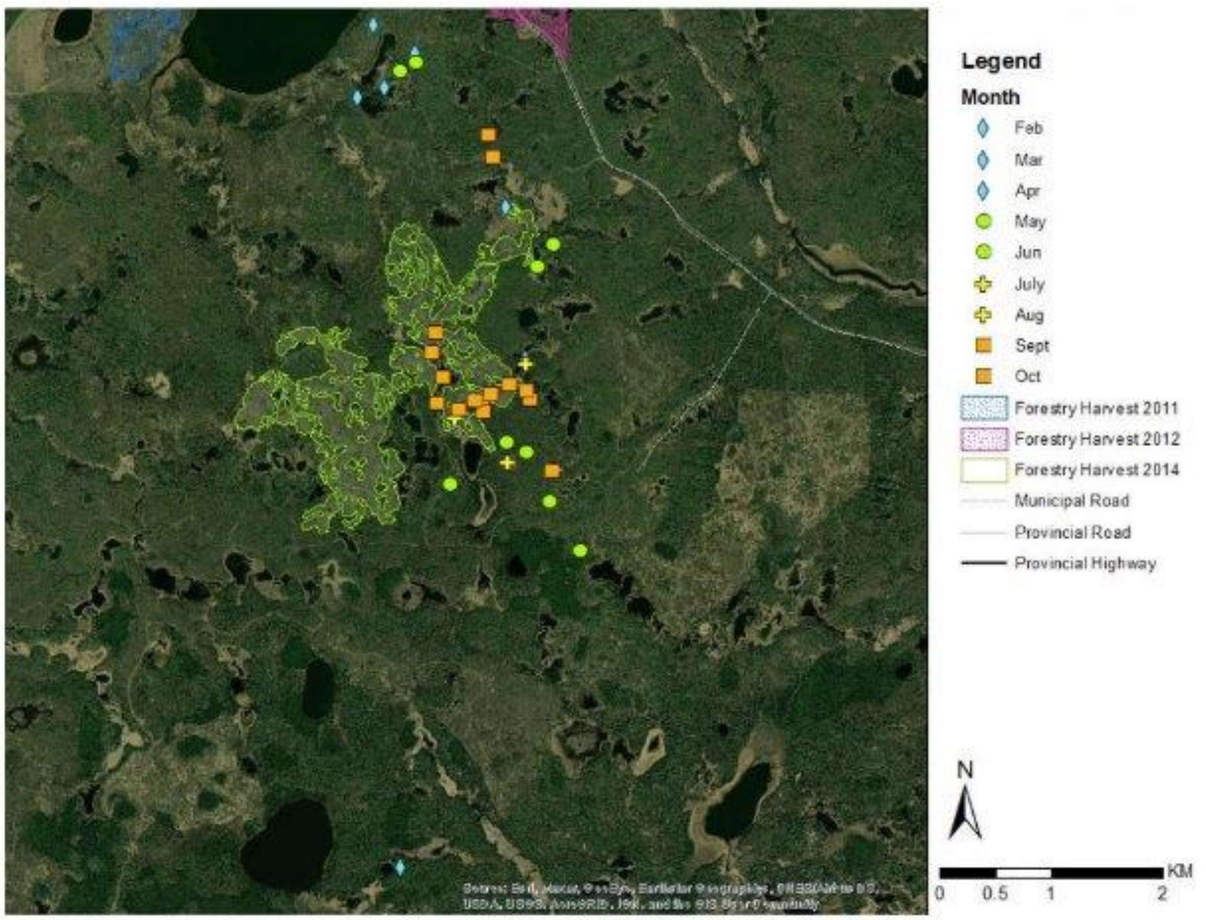


Figure 11.3. An example of location points for a single moose collected from February 2020 to August 2022 through a GPS collaring program by the Province. These points can be used to interpret habitat types that are frequently used by moose during varying seasons.

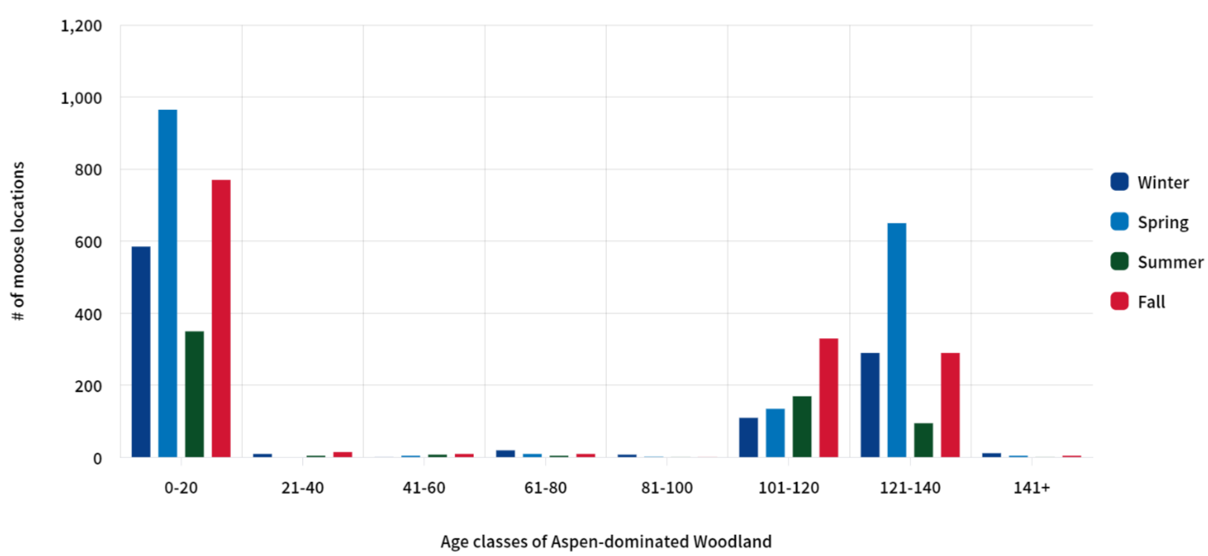


Figure 11.4. An example of how some moose location points collected through GPS collaring programs by the Province were summarized to show what aspen forest ages were being selected for in different seasons.

11.3.1 Forest Model

Similar to boreal woodland caribou discussed above, new habitat elements specific to moose were defined to categorize the forest into more refined features that would represent moose habitat types. These habitat elements are also tied to forest types and ages, that can then be identified as indicators within the forest model to strategically report at the landscape level over long periods of time, as well as be compared to what currently exists on the landscape.

To strategically consider moose habitat features on the FML, three moose habitat types were defined and incorporated into the forest model to allow for the monitoring of both their amount and arrangement on the landscape. These habitat types are:

- Thermal (winter) cover;
- General cover habitat; and,
- Browse (foraging) habitat.

Moose use all three of these habitat types within their range to provide necessary habitat elements and features. Having a single element does not necessarily benefit moose. For example, having an abundance of cover area is excellent but if there is no food nearby for the moose the overall quality of the area is reduced. In this way, it is important to consider strategically having the right amount of each habitat element on the landscape, but to also take steps to arrange these elements at the right scale and proximity to each other to be useful to moose. In the forest model, we can focus on the strategic level amounts of these habitat types. See Table 11.5 for habitat type definitions provided by the Province.

Table 11.5. Moose habitat type definitions applied within the forest model provided by the Province.

Forest Cover Type	Strata		Onset Age for Habitat		
			Thermal Cover	General Cover	Browse
Softwood	JP	Jack pine	Mature seral or older seral stage	-	-
	LBS	Lowland black spruce			
	OSFWD	Other softwood mix			
	SFWD	Pure softwood mix			
	STL	Black spruce and tamarack			
	UBS	Upland black spruce			
Mixedwood	MSPF	Softwood-leading mixedwood	-	> 35 years old	< 20 years old
	NSPF	Hardwood-leading mixedwood			
Hardwood	CHDWD	Pure hardwood mix	-	-	< 20 years old
	OHDWD	Other hardwood mix			
	TA	Trembling aspen			

Similar to the general matrix of habitat elements, these moose habitat types are refined to identify particular forest types and ages that represent habitat features. Once categorized, these habitat types can be mapped and summarized within the forest model to understand where habitat is located and how it may change as a result of management activities or disturbances. Figure 11.5 provides an example of how habitat types may be mapped within the forest model for Grass River Provincial Park. Grass River Provincial Park is an area in which no forest management activity by NFMC occurs but provides a good demonstration of how natural forest dynamics can change the amount and arrangement of different habitat types over time. These examples map the amount of thermal cover, general cover, and browse habitat at plan start (2025), mid- plan (2035), and at the end of the plan (2045). Browse habitat present in the park at plan start is a result of recent wildfire disturbance. The natural growth of these young hardwood forests causes these areas to no longer be considered browse habitat once they become older than 20 years old. Conversely, the thermal and general cover habitat types are able to remain relatively stable. It is important to note that the forest model, and therefore these maps, are not able to consider non-productive forests and vegetated areas such as wetlands and other generally open spaces. As a result, the amount of browse habitat present on the FML is not captured completely, but only as representation of what occurs on the productive forest landbase.

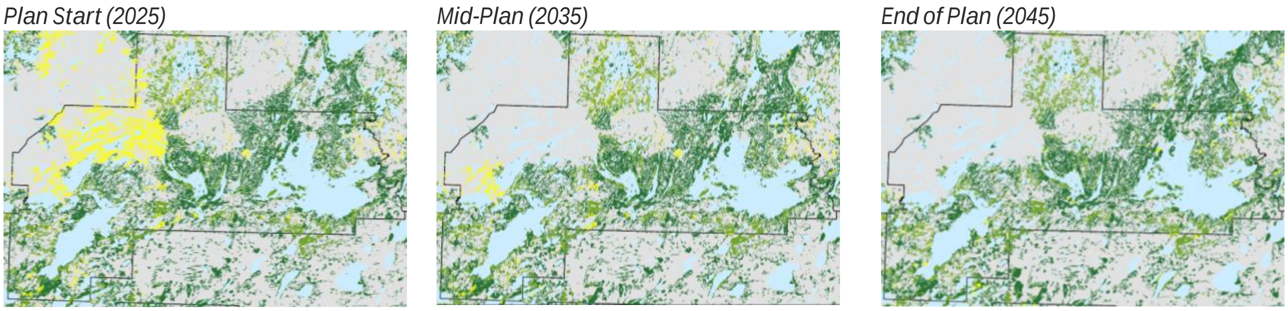


Figure 11.5. An example of the ability to map moose habitat using the forest model. This example focuses on Grass River Provincial Park, an area in which no forest management activity by NFMC occurs but provides a good demonstration of how natural forest dynamics can change the amount and arrangement of different habitat types over time.

For more information, see 12 Scenario Analysis, Biodiversity subsection 12.2.2.3.3 Wildlife Habitat and Habitat Elements (Moose Habitat).

In addition to these habitat elements, other indicators and objectives in the forest model contribute to the strategic-level planning for general moose habitat elements. Several forest management plan Values, Objectives, Indicators, and Targets (VOITs) exist that may not be specific to moose but contribute to the overall coarse filter amount and arrangement of habitat requirements. For example:

- Control size of harvest openings that create young forest across FML (young forest patch size);
  See section 12 Scenario Analysis subsection Harvest Patches.
- Maintain conifer forest types on the landscape (softwood forest cover);
  See section 12 Scenario Analysis subsection Forest Cover Type.
- Maintain forest types in old and very old seral stages (old seral stage forest representation); and,
  See section 12 Scenario Analysis subsection Forest Seral Stages.
- Minimize fragmentation and access development from roads (active roads).
  See section 12 Scenario Analysis subsection Access.

11.3.2 Operational Planning

Many moose habitat elements exist at the fine-filter scale and can't be adequately tracked or planned for with a strategic-level forest model. Unlike caribou, moose home ranges tend to be smaller and the interspersion of several features within a localized area is important. As discussed earlier in this section, forest modelling and analysis is done at the strategic, coarse-filter scale and looks at forest polygons, or groups of polygons, to make forest patches. Fine-filter planning is required to better address the arrangement of features that would exist within these polygons for moose habitat planning. Figure 11.6 illustrates an example of strategic-level (coarse-filter) proposed harvest area (green) and the more detailed operational-level planning (fine-filter; orange) that can be done during implementation. Figure 11.7 provides an example of what this local-level planning may look like on the ground following harvest operations.

Some of the local-level planning that is included in this plan is outlined in Table 11.6 and in the Provincial Moose FAQ found in Appendix P. Additional information about planning for moose at the operational scale is included in Part 3 – Implementation and Monitoring. Section 15 Cumulative Effects section of this chapter also includes an analysis of moose in subsection 15.5 Moose.

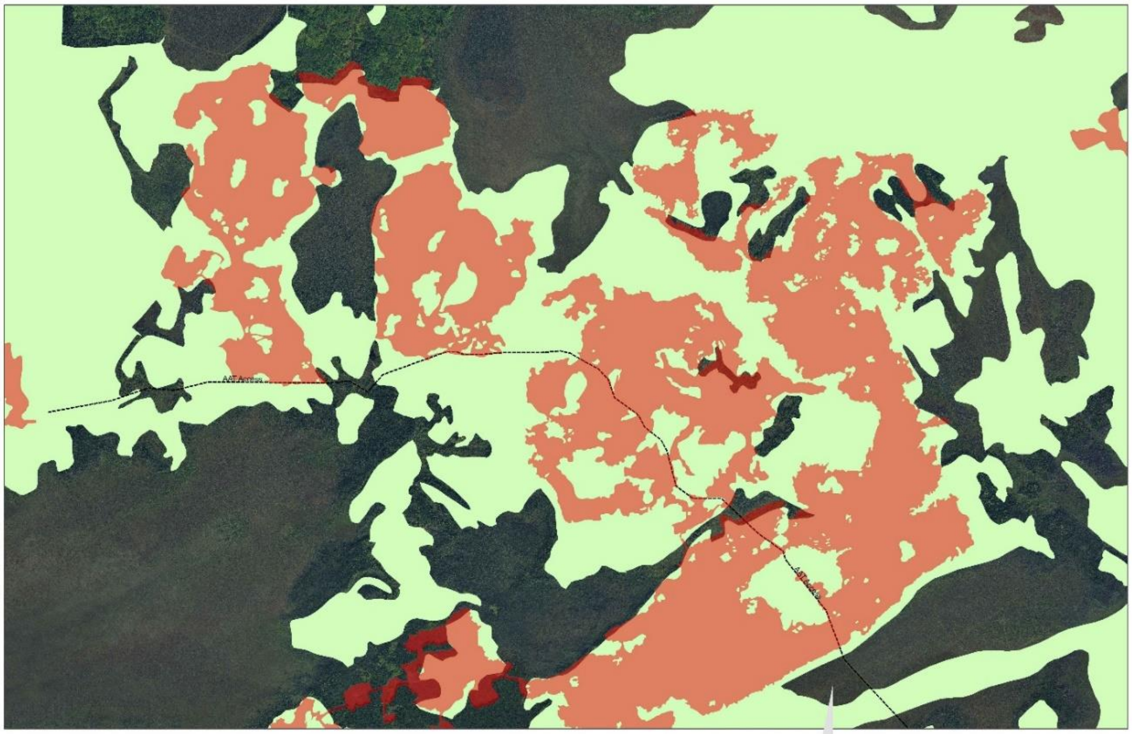


Figure 11.6. An example of strategic-level proposed harvest block selection (green) versus actual operational implementation of the harvest block (orange) with finer-scale management of in-block features which create significantly more interior edge.

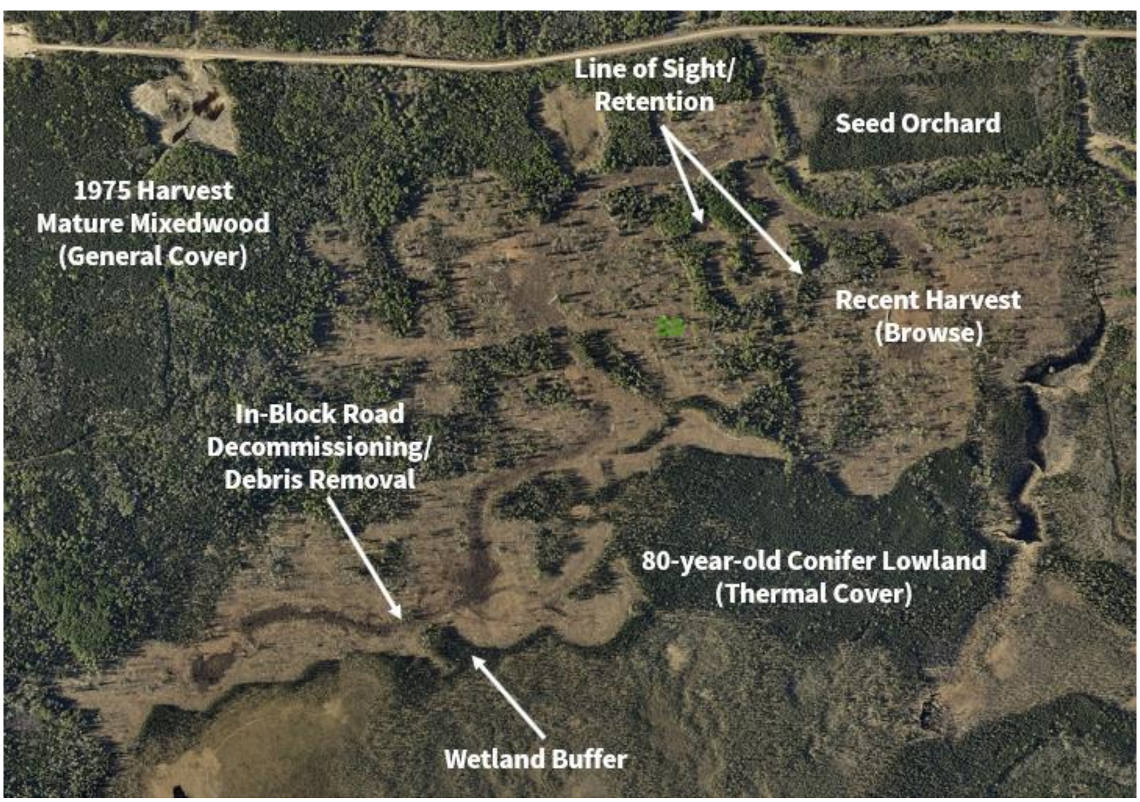


Figure 11.7. An example of what a harvested area may look like following operational, fine-filter planning for moose habitat elements.

Table 11.6. Information provided by the Province of Manitoba as examples of mitigation guidelines considered for moose during the mitigation process. These examples are not an exhaustive list, and their applicability for each block is dependent on site-specific factors. In Manitoba, there are currently guidelines in place to help determine appropriate mitigation, which have been included as reference in the Document column.

Factors to Consider	Condition	Reason for Consideration	Document
Providing thermal cover. (Winter and summer)	Minimum 20% cover should be maintained within operating areas. Maximum 200-metre distance to thermal cover within blocks.	Thermal cover is important in the summer to reduce heat stress potential, and in the winter for cover from cold winter and deep snow.	Manitoba Government - *Forest Management Guidelines for Wildlife in Manitoba* and *Consolidated Buffer Management Guidelines*
Reducing line of sight within the block	No more than 400-metre line of sight within blocks.	Line of sight breaks are important to minimize hunting pressure in areas previously not open, and to also minimize the likelihood of altered predator-prey dynamics in a newly cut block.	Manitoba Government - *Forest Management Guidelines for Wildlife in Manitoba* and *Consolidated Buffer Management Guidelines*
Riparian buffer to protect habitat areas around water sources. Note that buffer sizes may vary depending on the size/ classification of the waterbody and/or species use.	Need to ensure they maintain proper windfirm buffers around all waterbodies. Retain buffers of at least 100 metres on large waterbodies, 60 to 100 metres on medium waterbodies, and 30 to 60 metres on smaller waterbodies to provide habitat for some interior forest species.	Riparian buffers are important for sediment and erosion control, as an aesthetic buffer, and can also help with providing cover for moose adjacent to aquatic environments where they may forage in the summer. Moose feed on aquatic vegetation, and the buffers allow cover from weather as well as predators and harvesters.	*Forest Management Guidelines for Riparian Management Areas* https://www.gov.mb.ca/nrnd/forest/pubs/practices/riparian_mgmt_re_sept2009.pdf
Ensure all access is closed as operation is completed in each area.	Materials dragged across all in-block roads to ensure they are closed. If they have excess materials, they can leave some piles as per biomass guidelines.	Access management is very important as road networks can become pathways for disease introduction through facilitating ungulate movement, such as deer accessing areas mostly inhabited by moose, as well as pathways that allow predators and harvesters to access areas previously with limited access. Decommissioning plans are included as part of forestry road management, and biomass guidelines can be used to help determine access management, such as using excess materials to cover in-block roads.	*Forestry Road Management* forestry_road_mgmt_2012.pdf (gov.mb.ca) *Biomass Management* Microsoft Word - Biomass Management_Jan_2015_Ver13-fnl.doc (gov.mb.ca)
Mineral licks.	50- to 200-metre setback buffer from the outer perimeter of the feature.	Provides protection of the wildlife feature, plus cover for the animals that may be using the feature. Mineral licks are important for supporting ungulate health.	*Forest Management Guidelines for Terrestrial Buffers* https://www.gov.mb.ca/nrnd/forest/pubs/practices/terrestrial_final_jan2017.pdf

11.4 BOREAL SONGBIRD HABITAT ELEMENTS

At the early stages of the development of this forest management plan, preliminary indicator species were identified in the Terms of Reference that had existing habitat models that could be selected from. Preliminary indicator species were identified as having well-defined habitat models that can be included in the plan to quantify the relative abundance of habitat and the relative change in habitat amount as a result of the management strategy chosen. The Wildlife Subcommittee consulted both a report written to address the availability and selection process of wildlife species and models for forest management planning in Manitoba (Kuhnke & Watkins, 1999) as well as the associated Manitoba Model Forest Habitat Suitability Index reports for relevant species.

Many of the available Habitat Suitability Index (HSI) models historically available for use in Manitoba were derived with references and observations from southern ecoregions based on the knowledge and data available at the time. Many of these models have not been validated with observation data within the northern boreal regions where they would need to be applied for use within this forest management plan. For these reasons, as well as feedback from rightsholders and the public, NFMC implemented a new approach using boreal songbird habitat models to assess relative habitat measures in the forest management plan and for alternative management strategies.

The approach is documented in this section, and results are available in subsection 13.2.9 Assessing Wildlife Habitat and Habitat Elements of the Preferred Forest Management Scenario. The approach began by utilizing data-driven songbird models from a neighbouring jurisdiction within a similar ecoregion, but evolved into creating new songbird models using local Manitoba observation data. Developing this forest management plan and engaging with rightsholders and stakeholders has identified a need to collect additional habitat and wildlife species data to continually improve models that represent habitat needs and conditions within the FML. Ongoing research and data collection plans are included in the Research section of Part 3 – Implementation and Monitoring to assist in developing a rigorous monitoring program to validate and continuously refine the modelling approach.

What is an RSPF model?

There are species-specific habitat models that assess the amount, arrangement, and quality of the habitat available within the current and future forest. These models are usually applied outside of the forest model because they use other assumptions that are not included in the strategic forest model tools. A Resource Selection Probability Function (RSPF) model estimates the probability that a given resource or habitat will be selected by an organism, with values ranging from 0 to 1. A related model prescribed previously is the Resource Selection Function (RSF) model, with the difference being the type of data used to build the model. An RSPF is based on presence/absence data, as may be obtained in a bird point count study, whereas an RSF model is based on presence only data (use/availability), as may be obtained in a moose GPS collaring study, with random available habitat points selected in a GIS. This leads to statistical differences in interpretation, where the RSPF model estimates *absolute* probability of selection, an RSF model estimates only *relative* likelihood of selection. The likelihood of selecting an area is presented in a range from 0 to 100, 0 being a very low likelihood of selecting that area and 100 being a very high chance of selecting that area. This likelihood is also sometimes referred to as “probable habitat”. RSPF models use selection/occurrence thresholds that are developed by researchers to determine the minimum likelihood that a species would select an area as probable habitat.

Building RSPF models requires actual location data for an animal, meaning these models are developed around known locations and areas where the animals have been. This means that these models are developed based on locations the animal has been confirmed to use, and then researchers identify the forest type and characteristics associated with those locations to try to find that unique combination in other places within the forest or in future time periods.

You can think of an RSPF model as a way to ask questions such as: *This bird liked this specific location in the forest – what is special about this location? Are there other locations in the forest similar to this? Is the same bird over there as well?*

Why songbirds?

Songbirds are excellent indicators of forest ecosystem health and biodiversity. They have been well researched and widely used in conservation biology and landscape ecology in many regions. Their response to known environmental changes is well documented, which makes it easier to compare findings or apply research from other regions or ecosystems. A lot of research has been focused on songbirds over the years due to their wide distribution in many forest ecosystems. The distribution of boreal songbird species fills the "habitat element box" illustrated at the beginning of this section in Table 11.1. Some species prefer young softwood types, some prefer older hardwood types, and everything in between. In addition, the arrangement, size, structure, and connectivity of habitat elements is extremely diverse. One of the primary reasons there is so much research and data available for songbirds is the relative ease with which they can be monitored using either visual or auditory survey methods. Songbirds are much more accepting of someone listening to them at dawn than some larger mammals are to current survey methods.

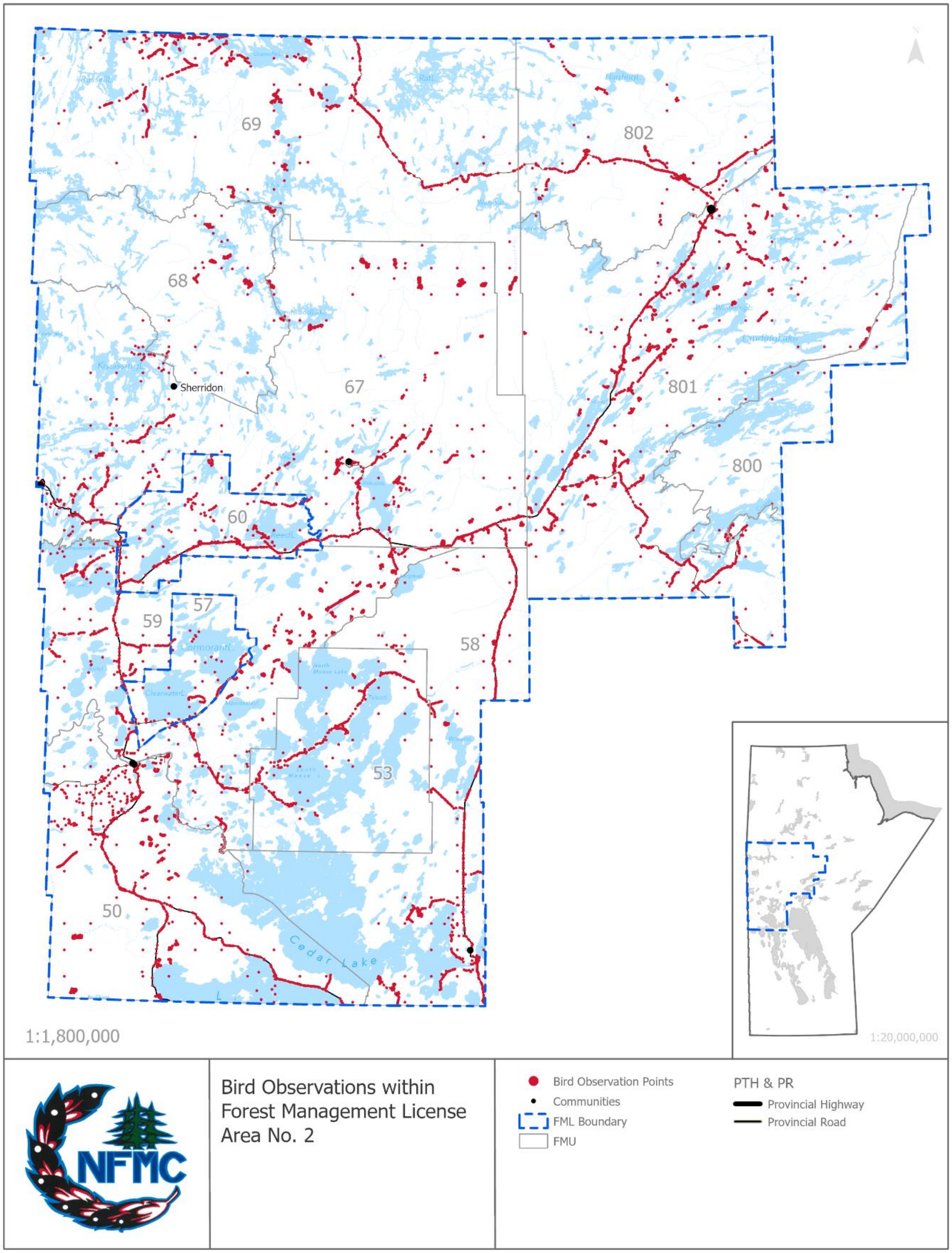
Do all Manitoba boreal songbirds prefer the same habitat elements?

This is a question that NFMC set out to start to answer with this forest management plan. In order to start to answer this question, data of known songbird locations in the FML was required. This information was found in the Atlas of the Breeding Birds of Manitoba (birdatlas.mb.ca and naturecounts.ca) and was a wealth of open-source, publicly available data describing the distribution, abundance, habitat, and conservation of 312 species of birds that bred or potentially bred in the province between 2010 and 2014. This data was extracted and narrowed down to include only the data that overlapped with FML 2 (Map 11.1), resulting in observation count information for 215 species.

The bird count information was leveraged and refined with the assistance of Dr. Rob Rempel[3]. The information was review and filtered to find overlapping species from the Manitoba data with FML, and to remove any points collected prior to when the forest inventory information was updated. This location data was a starting point to start to develop songbird habitat models for use in Manitoba, but also identified a gap in the available observation data for the region. This gap has been identified and a research plan developed for field data collection during implementation of the forest management plan to continually refine, validate and develop unique habitat models for the area, which will assist in monitoring changes and supporting management decisions (see Part 3 – Implementation and Monitoring section 18 Research for more information).

More information is available in the following sections on what habitat elements and forest characteristics were generated from the forest model, how the songbird models were applied to the results of the management scenarios, as well as some background information on how these models were evaluated for their application in the region.

[3] Dr. Rob Rempel is the Principal at Forest Ecosystem Research and Information Technologies (ferit.ca).



References: Nature Counts: A Program of Birds Canada. [https://naturecounts.ca/nc/default/main.jsp]. Last Visited 2024-11-28

Map 11.1. Bird observation point data retrieved from naturecounts.ca for FML 2.

11.4.1 Forest Model

Several habitat characteristics from the forest model can be used to help characterize boreal songbird habitat elements. These strategic-level forest characteristics help describe structure and composition of forested areas and how those characteristics may change over time in various management scenarios. The characteristics in Table 11.7 were output from the forest model and provided input for the boreal songbird models. This information is available from the forest model in all locations where there is productive forest that can grow, age, and be managed or regenerated.

Table 11.7. Forest characteristic parameters output from the FML 2 Patchworks™ forest model for use in boreal songbird models.

Songbird Model Parameter	Acronym	FML 2 Source	Processing Notes
Tree Height (Local-scale[4]/Stand-level)	HEIGHT	Generic height curves were generated by strata using FML 2 inventory data.	Area weighted by lead species (strata). Curves were generated where existing height attributes were inventoried.
Percent Hardwood (Local-scale/Stand-level)	PHV	Direct attribute from projected future productive forest condition spatial output from forest model.	Estimated proportion of hardwood by strata.
Percent Canopy Closure (Local-scale/Stand-level)	PCC	Generic crown closure curves were generated by strata using FML 2 inventory data.	Generic relationship of crown closure to age in the inventory was assumed (area weighted).
Average Stand Age (Local-scale/Stand-level)	AGE	Direct attribute from projected future productive forest condition spatial output from forest model.	Stand age is tracked by the forest model.
Percent Young (Local-scale/Stand-level)	PYF	Direct attribute from projected future productive forest condition spatial output from forest model.	Based on seral stage definitions for forest types in young stage.
Contrast Weighted Edge Density (Landscape-scale[5])	CWED	A measure of the amount of edge between adjacent stands at different seral stages.	Used raster tools to determine contrast weighted edge of density.
Percent Mature and Old Forest (Landscape-scale)	PMOF	Direct attribute from projected future productive forest condition spatial output from forest model.	Proportion of mature (or older) using seral stage definitions.

These are dynamic forest characteristics that can be output from one model (the forest model) and input into another (an RSPF boreal songbird model) to assess unique habitat relationships that cannot be directly evaluated within the forest model itself.

It is important to recognize the limitations of what information is available from a forest model to use within a habitat model. As discussed in the subsection 10.1.2 Spatial Data Preparation, only a certain proportion of the forest is considered productive, and a smaller subset available for management within a forest management plan. This portion of the landbase has information that can be used to classify the forest types and apply dynamic attributes that can grow, change, and transition the forest over time. Although there are other vegetated portions of the landbase that are important for habitat and ecological values, the information is not able to be used within a forest model, and therefore this area remains static (meaning it can not be projected to change over time). In section 10.1.2.1.1 Landbase Net Down, Map 10.1 illustrates the distribution of the productive forest area that is

[4] Local-scale is a 50-hectare proximity. Forest conditions are averaged across an area of 50 hectares.

[5] Landscape-scale is a 5,000-hectare proximity. Forest conditions are averaged across an area of 5,000 hectares.

included in the Patchworks™ forest model. The gaps, or holes, seen in the map still represent important areas and ecosystems in the region, but are not able to be included in the forest model.

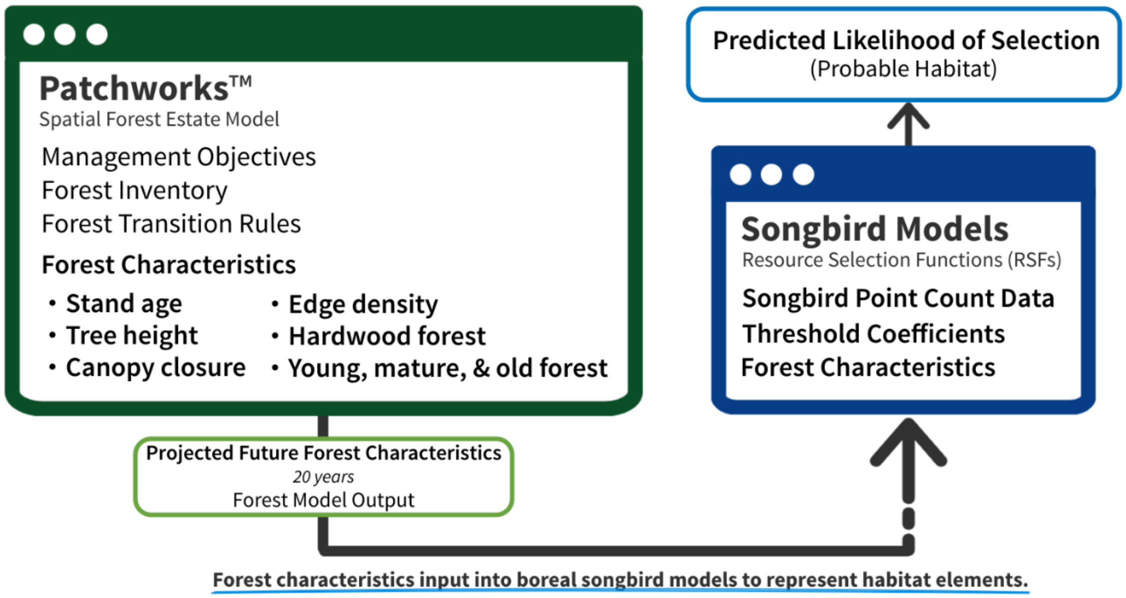


Figure 11.8. An example of the flow of forest characteristics output from the Patchworks™ forest model into the Resource Selection Probability Function boreal songbird models.

11.4.2 Boreal Songbird RSPF Models

Forest characteristics were output from the Patchworks™ forest model that represent plan start (2025), halfway through the plan (2035), and plan end (2045) to capture any changes in characteristics that may have resulted from the management activities proposed for the duration of the forest management plan.

Initial models applied in FML2 were originally derived from Dr. Rempel's work in Ontario for as part of the coarse filter application of the Forest Management Guide for Boreal Landscapes (Ontario Ministry of Natural Resources, 2014). The foundational work for the songbird models within the Ontario guidelines available to forest managers were developed by Dr. Rempel and are detailed in the published forest policy scenario analysis (Rempel, et al., 2007).

Initially, the Ontario songbird models were run, and model performance was tested using the observation data available for the region. The Ontario models performed poorly for all species and a plan to derive new models using Manitoba Bird Atlas data and Patchworks™ habitat layer output was put in place for the forest management plan. Information on the testing of original Ontario models and the modifications made are contained in Appendix Q -- Report on Testing and Developing Bird Models for FML 2 Forest Management Plan.

To develop new Manitoba bird models, Dr. Rempel used the habitat projections layer output from the Patchworks™ model to describe the forest characteristics for the current forest conditions (time 0) and 40 years into the future for the entire FML 2 landscape. A new training data set was derived from the Atlas data to use 75% of the observation points to train the new models and 25% of the observation points were retained for testing of the new models. Once the new RSPF models were developed and applied to the landscape, model performance on the initial thirty species was evaluated to select the strongest models. Boreal songbird species for which models were run and performed well are detailed in Table 11.8.

Table 11.8. Boreal songbird species selected for inclusion and application to the Preferred Management Scenario results, including common name, American Ornithologists' Union (AOU) alpha code, and Latin name.

Common Name	AOU Alpha Code	Latin Name
Alder flycatcher	ALFL	*Empidonax alnorum*
American redstart	AMRE	*Setophaga ruticilla*
Black-and-white warbler	BAWW	*Mniotilta varia*
Blackburnian warbler	BLBW	*Setophaga fusca*
Hermit thrush	HETH	*Catharus guttatus*
Least flycatcher	LEFL	*Empidonax minimus*
Mourning warbler	MOWA	*Geothlypis philadelphia*
Ovenbird	OVEN	*Seiurus aurocapilla*
Pileated woodpecker	PIWO	*Dryocopus pileatus*
Red-eyed vireo	REVI	*Vireo olivaceus*
Winter wren	WIWR	*Troglodytes troglodytes*

The songbird habitat models used to assess the output of the forest model scenarios consider both local-and landscape-level habitat elements (forest characteristics) and evaluates the arrangement of these elements at various scales. Individual species can have a unique relationship to each of these habitat elements, meaning that one species may have a positive association with young forest types, while another species may not be influenced at all by that forest characteristic. These positive, negative, or neutral relationships with the habitat elements are known as coefficients in an RSPF model.

Using the characteristics output from the forest model in combination with the coefficients and constants from the songbird models, a value for each location on the forest can be calculated for each of the species listed above. The values calculated represent the model value for a given bird species, using the equation form below. The model values can then be transformed into a likelihood (or probability) of an area representing habitat for the species; the higher the number (closer to 1), the more likely the area represents suitable (probable) habitat.

Bird Model Equation Form

$$
\begin{gathered}
Bird\ Model\ Value\ = \\
(coefficient\ x\ PCC\ +\ coefficient\ x\ PCC^2)\ + \\
(coefficient\ x\ PYF\ +\ coefficient\ x\ PYF^2)\ + \\
(coefficient\ x\ HEIGHT\ +\ coefficient\ x\ HEIGHT^2)\ + \\
(coefficient\ x\ CWED + coefficient\ x\ CWED^2) + \\
(coefficient\ x\ AGE\ +\ coefficient\ x\ AGE^2)\ + \\
(coefficient\ x\ PHV\ +\ coefficient\ x\ PHV^2)\ + \\
(coefficient\ x\ PMOF\ +\ coefficient\ x\ PMOF^2) + \\
intercept
\end{gathered}
$$

Refer back to Table 11.7 for equation acronym names and descriptions (e.g., PCC, PYF, CWED, etc.).

In addition to the predictions for likelihood of suitable (probable) habitat, for each songbird species, an occurrence threshold can be used to further refine the results into areas that could be categorized as "occupied" versus "unoccupied" for each species. The occurrence thresholds for each species were applied to generate predicted occurrence maps included in the results.

Model coefficients and threshold values for the selected species are included in Appendix Q – Report on Testing and Developing Bird Models for FML 2 Forest Management Plan.

Results from the bird models are relatively easy to interpret. Figure 11.9 provides an example of the occupied habitat for the ovenbird, from plan start to forty years into the future. The predicted amount of occupied habitat is stable for this species at approximately 30-40% of the forest for the 40 years shown (four 10-year periods). The trends in the Null scenario and the Preferred Forest Management Scenario (PFMS; “Preferred Scenario”) are similar, remaining steady across the 40 years, with the PFMS indicating a modest increase of about 2-3% in habitat by year 40, relative to the no harvest (“Null Scenario”) scenario.

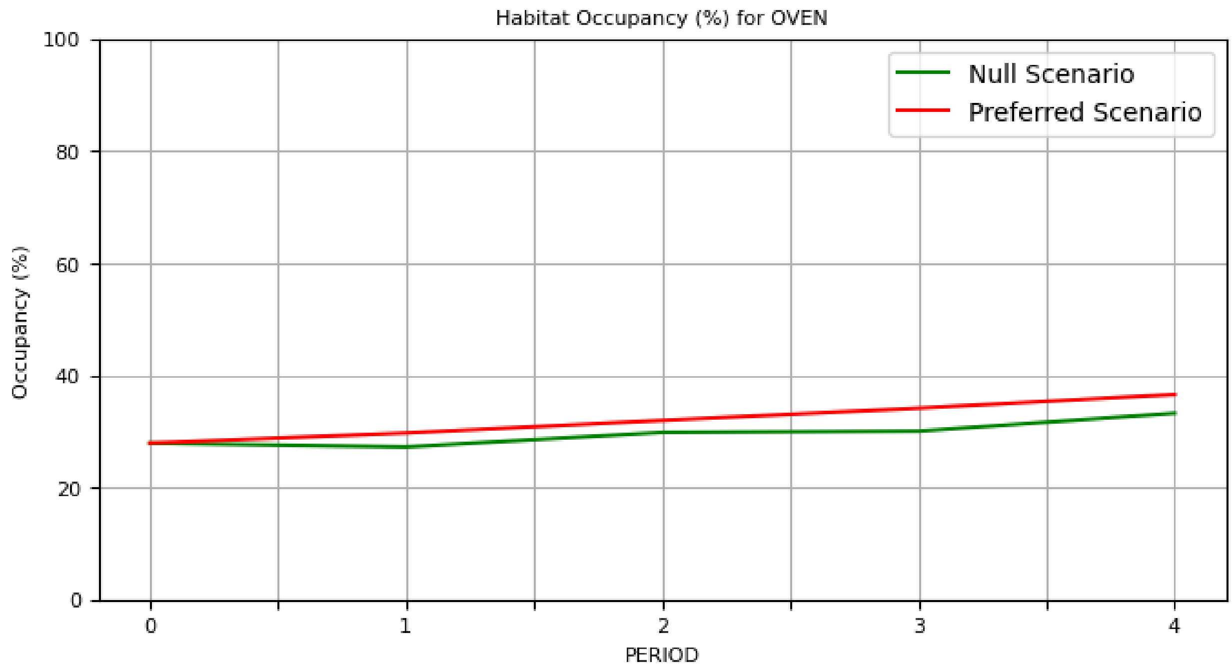
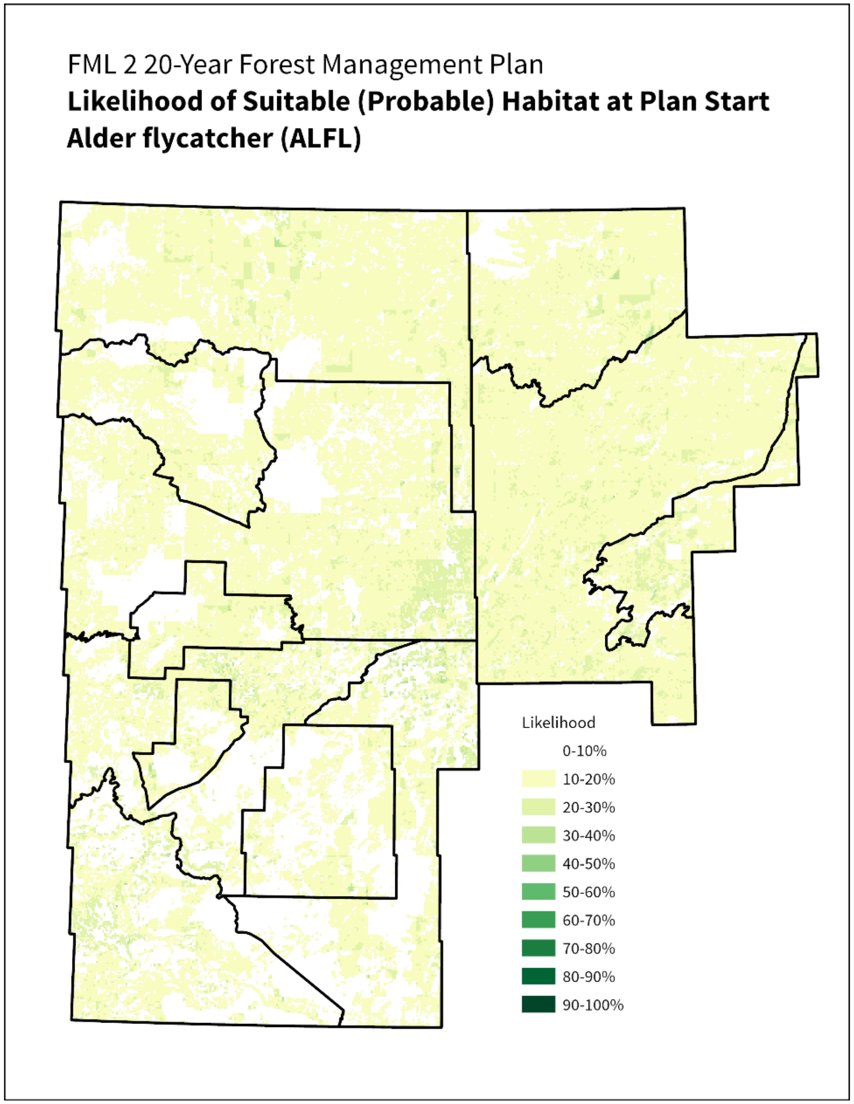


Figure 11.9. An example of the predicted percent habitat occupancy output from the boreal songbird model for the ovenbird (OVEN) compared between the no harvest scenario (“Null Scenario”) and the Preferred Forest Management Scenario (“Preferred Scenario”). The percent habitat occupancy is the percentage of the FML that is predicted to be occupied habitat over four decades (from plan start, period 0, to forty years into the future, at period 4).

The locations of predicted habitat at different timescales and for different scenarios and species can also be viewed as spatial information on a map. Figure 11.10 provides examples of the predicted spatial distributions of alder flycatcher (ALFL) habitat at plan start. These results can also be output as a chart, where the change in predicted habitat can be viewed across time compared between different scenarios.



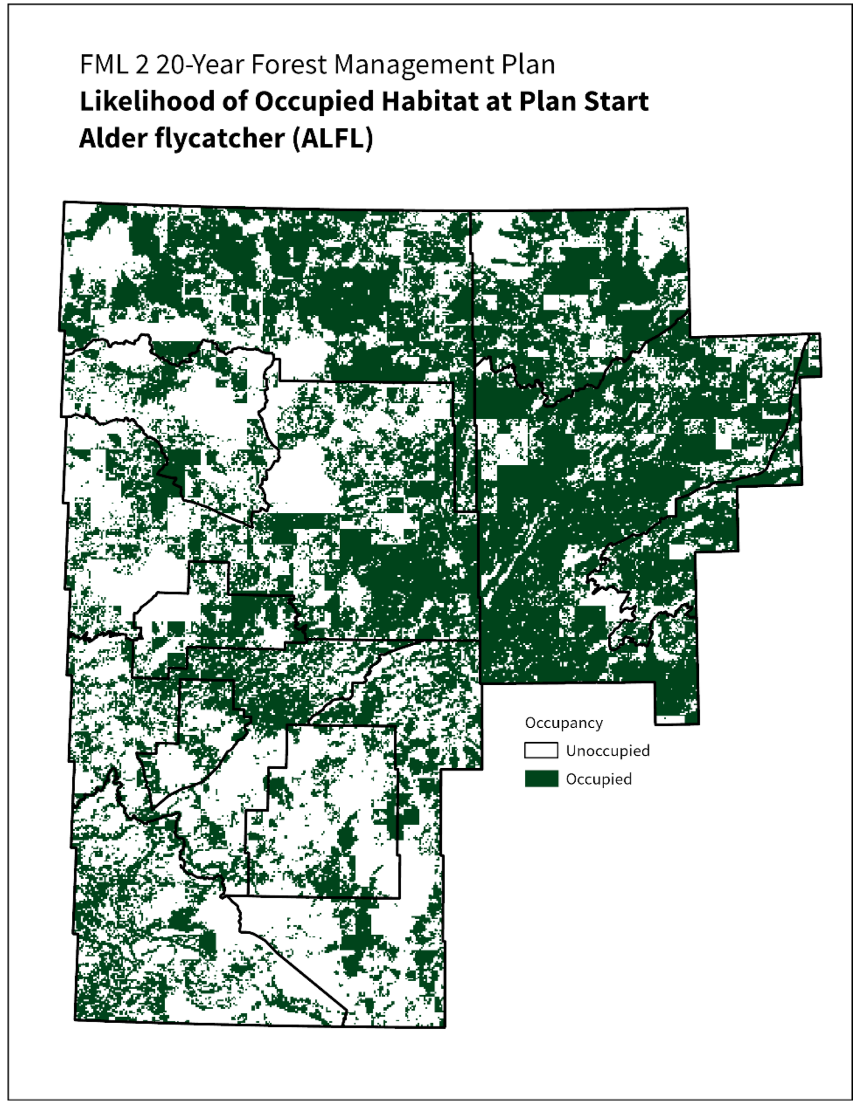


Figure 11.10. An example of the location of predicted suitable (probable) habitat (left) and likelihood of occupied habitat (right) output from the boreal songbird model for alder flycatcher (ALFL) at plan start on FML 2. For the alder flycatcher, the threshold for predicted occupancy of habitat is 12.69%. For more information, see Append Q – Report on Testing and Developing Bird Models for FML 2 Forest Management Plan.

11.4.3 Model Performance Evaluation

As a start, species observation data from within the FML was downloaded from the Atlas of the Breeding Birds of Manitoba (birdatlas.mb.ca). The observation data from the Atlas provides a starting point for songbird model validation. Observation point counts exist for many of the numerous boreal songbird species within the FML. The observation data was filtered to select only counts that align with interpreted inventory conditions within new FLI spatial data. If there was a disturbance event update (fire, harvest, etc.) since the observation count data was logged, the record was removed from the validation set. This initial observation data assists in understanding the general habitat conditions preferred by each species. The observation data was further refined to account for observation error, or detection bias using Quantitative Population Assessment for Detection (QPAD) statistical methods. This can help account for factors such as distances, observer skill, time of day or bird behaviour and can help ensure the observed data points more accurately reflect species abundance.

Of the remaining observation points the data was further subdivided into a training data set representing a majority of the observations (75%) and a validation data set representing 25% of the observations. Retaining a selection of the observation points from the development of the models is an important step. This data can be used to test the new models. It is like asking the question – *are the birds where the new models says will be habitat for them?* These other observation points can be used to test the models performance to validate whether the predicted habitat or occupancy aligns with where those types of birds have been observed on the ground.

The results of the performance evaluation are described in Appendix Q. Performance evaluations and led to the selection of the songbird models included within the forest management plan for FML 2. These new models using Manitoba observation data were used to evaluate the projected future forest condition.

The selected birds represent a broad array of habitat requirements, with some requiring coniferous forest, deciduous forest or either, and with age requirements of old, young or either. This distribution of forest types represents the habitat elements 'matrix' discussed earlier in this section. With the habitat elements (e.g., forest cover types and seral stages) forming a major component of the ecological management objectives within the forest model, the bird models represent a tool to evaluate or assess how the forest types are changing and how that may change the availability or location of habitat in the future. The birds selected for use in the forest management plan are considered common to abundant in Manitoba, representing a diversity of forest conditions and can be viewed as focal species.

Developing Manitoba boreal songbird models has addressed a gap in habitat assessment information available for the region, however additional data collection has been identified as a future research outcome during the implementation of the forest management plan to continually improve habitat modelling in the area. NFMC acknowledges that there is an information gap in observation data from the FML that can be used to refine and improve habitat models and has developed a research plan outlined in Part 3 – Implementation and Monitoring to supplement the science that is available for boreal songbirds.

12 Scenario Analysis

An important concept of resource analysis and forest modelling is the scenario—a specific set of assumptions and conditions used to explore how resources (like forests, water, or wildlife) might behave under different management strategies, environmental changes, or future events. Scenarios help predict and evaluate outcomes to inform decision making. In the context of a forest management plan, scenarios generated by the Patchworks™ forest model can answer important "what-if" questions about the future forest condition. Asking the right questions, in the right order, and comparing results from each scenario is referred to as a scenario analysis. Using a forest model and a well-defined scenario analysis does not predict the future but provides a range of possibilities over large areas and long timeframes. This can ultimately provide very useful information to help inform decision making in selecting a strategy to direct forest management.

The purpose of scenario analysis for this forest management plan was to develop a selection of viable and sustainable options for a Preferred Forest Management Scenario (PFMS). The PFMS is what provides the strategic direction for the 20-year duration of the forest management plan. The selection of a PFMS is a requirement under the Province's *20-Year Forest Management Plan Guideline* (Manitoba Agriculture and Resource Development, 2021). This section will describe the scenario analysis process undertaken to reach the two final scenarios that were developed for the purposes of the PFMS selection exercise: the Baseline scenario and the Habitat scenario.

The Baseline scenario was developed to feature an operationally feasible strategic direction that considered all aspects of scenario analysis to achieve long-term environmental and economic sustainability.

The Habitat scenario built upon the Baseline scenario with the inclusion of some additional analysis that strived to further minimize linear fragmentation and overall habitat disturbance.

How do you build a scenario in a forest model?

Building a scenario involves defining model controls based on what kinds of questions need to be asked. These model controls are mechanisms in the model that allow our objectives and goals for the forest to be translated into something a computer-based forest model can understand. Using these model controls, we can measure or quantify various indicators and provide some direction to the model. For example, we would like more of this in the future, we would like less of this in the future, or we would like to maintain this in the future.

Model controls can be used to translate some values, objectives, indicators, and targets (VOITs) into a forest model. Let's look at an example for a biodiversity objective to maintain a forest with an age class structure and composition that resembles that of a fire-driven boreal forest ecosystem. To translate this objective to the forest model we can summarize the area of various age classes on the forest, as well as the area of different forest types. These summarized features are referred to as indicators. Goals can then be set for each indicator based on the management objectives that reflect the desired future forest condition. They can be thought of as a way to tell the model what outcomes we want to see or what benchmarks we want to achieve, and how we are going to measure or quantify the associated indicators.

To provide direction while building a scenario in a forest model, model controls may be defined that:

- Maximize an indicator. This translates to encouraging the model to give us as much of that indicator as possible. A limit is not applied.
  E.g., if we set a goal to maximize harvest volume, we are encouraging the model to give us as much harvest volume as possible within the boundaries of all of the other model controls in place that ensure the harvested amount is sustainable.
- Minimize an indicator. This translates to encouraging the model to limit an indicator as much as possible. A limit may be applied to minimize to a certain level, or simply to 0.
  E.g., if we set a goal to minimize the amount of hardwood being harvested to 0 hectares, we are encouraging the model to limit hardwood harvest (without completely removing the choice to harvest hardwood from within the model) as best as it can within the boundaries of all of the other model controls in place.

- Maintain an indicator. This translates to encouraging the model to keep an indicator the same as much as possible. A goal may be set to maintain something within a certain threshold (± 5) of a known amount, or to maintain a minimum/maximum value or proportion of an indicator.
  E.g., if we set a goal to maintain the amount of softwood forest on the FML, we are encouraging the model to keep the amount present at the start of the analysis horizon as consistent as possible for all 200 years as best as it can within the boundaries of all of the other model controls in place.
- Track an indicator. This translates to not setting any goals within the forest model, but monitoring and assessing how the indicator may change throughout scenario analysis based on the influence of other model controls.
- Have a non-declining indicator. This translates to encouraging the model to keep an indicator from decreasing. This does not limit the indicator from increasing (i.e., the indicator can go up, but it cannot go down).
  E.g., if we set a goal to have the amount of growing stock be non-declining for a certain timeframe, we are encouraging the model to keep the amount the same or higher, but not lower, as best as it can within the boundaries of all of the other model controls in place.

These directional statements will be used in this section to describe the model controls that were set while building the Baseline and Habitat scenarios.

While scenario analysis is often focused on setting goals, there are also model controls that can be applied as constraints. Where a goal may *encourage* the model to make strategic decisions within the boundaries of all of the other model controls in place, a constraint is a hard limit the model must adhere to. Setting goals provides some flexibility within the model to explore trade-offs and find a balanced solution. Setting constraints enforces non-negotiable objectives that other model controls may be required to be more “flexible” around to achieve their own goals as best as possible.

Putting goals and constraints in place creates the framework for the forest model to generate an outcome for harvest levels that is sustainable. The consistent layering in and exploring “what-if” scenarios is what allows forest managers to understand the impacts of these goals on harvest levels. While the goals that are set may have some flexibility to trade off with other indicators, the overarching objective of applying sustainable goals is to trade off directly with harvest levels. In other words, the harvest levels that are ultimately produced from the Preferred Forest Management Scenario are the result of applying many indicator goals that reflect and ensure long-term sustainability. Indicator goals are set to be achieved, while harvest levels are the maximum result possible after trading-off the cumulative achievement of those indicator goals.

This section outlines the scenario design process and provides a step-by-step development of the Baseline scenario, highlighting the interim scenarios that were reviewed and analysed along the way. The Habitat scenario was developed by making some changes to the Baseline model controls to create an alternative management scenario that could be compared for the selection of the Preferred Forest Management Scenario.

While we have so far focused on strategic (long-term) and operational (short-term) planning, planning at the mid-term is sometimes referred to as tactical planning. Tactical planning is the bridge between strategic and operational planning (Figure 12.1). Integrating tactical planning into the forest model allows for some high-level operational planning aspects to be considered in the development of a strategic forest management plan direction.

The inclusion of tactical planning in the forest model focuses primarily on predicting *where* forest management activities will occur, and these tactical activities are applied as spatial model controls through access and patching. For more information, see Scenario Analysis sections 12.2.2.5 Access and 12.2.2.6 Harvest Patches.

Figure 12.1. Timeline of forest management planning levels as they relate to forest modelling. While most aspects of forest modelling are strategic, there are some mid-term, tactical-level aspects that are applied for only a limited duration in the model.

Why apply spatial model controls for only 40 years?

Model controls that have spatial implications, such as those related to access and harvest patches, are applied on a shorter (mid-term) strategic timeframe as opposed to aspatial model controls that are applied on a long-term timeframe. Using twice the forest management plan duration (40 years) to set the spatial controls allows for the forest management plan planning period to be spatially accounted for, with some degree of certainty, twice over within the 200-year analysis horizon. Due to the unpredictable nature of the boreal landscape (e.g., fire and other natural disturbances that will undoubtedly occur over the next 20 years) and other economic factors, applying spatial targets further than a mid-term period would challenge the model to make spatial considerations at an infeasible scale.

Why not just run one scenario?

Just like a recipe, ingredients need to be added one at a time, taste-tested, and potentially adjusted before more ingredients are added. Building scenarios in a forest model is similar. Adding all the model controls at once would make it difficult to understand what is influencing the outcomes of the model, what is having a positive effect, and what is having a negative effect on our future forest goals. Building a scenario that includes all the model controls required into a well understood baseline scenario provides a foundation to then explore alternative management scenarios or explore future uncertainty risks or potential consequences.

Who was involved in the scenario analysis and selection process?

Both the Planning Team and the Modelling and Analysis Subcommittee were involved at different stages of scenario development.

The Planning Team was composed of a selection of individuals, including representatives from Nisokapawino Forestry Management Corporation, Canadian Kraft Paper Industries Ltd , and Nekoté Limited Partnership, as well as representatives from within Nekoté communities, government personnel from the provincial Forestry and Peatlands, Fish and Wildlife, and Parks Branches, and consultants that assisted in the development of this plan. The Planning Team ultimately ranked and selected the Preferred Forest Management Scenario (PFMS).

From within the Planning Team, a subset of members were appointed to the Modelling and Analysis Subcommittee. The purpose of the Modelling and Analysis Subcommittee was to meet regularly throughout the scenario analysis process to remain up to date on progress and provide active and collaborative feedback throughout the development process as it occurred. It was the wider purpose of the Modelling and Analysis Subcommittee to also provide additional context to the broader Planning Team, when necessary, regarding the scenario analysis process during the selection of the PFMS.

12.1 SCENARIO DESIGN

The purpose of scenario design is to create a linear process of “layering in” model controls in a way that is clear, methodical, and repeatable—similar to following a recipe or replicating a science experiment. Model controls are added in one at a time to understand the effects and make adjustments (if necessary) to develop scenarios within which the cumulative impacts of each model control are known. The scenario analysis process is common practice during the development of a forest model for the purpose of a forest management plan.

The benefit of the scenario design step of the analysis is to create a plan ahead of time that can:

1. Test that model assumptions were translated properly to represent conditions in the forest (calibration);
2. Sort model controls and indicators that are general landscape level to more specific spatial or local level controls (balanced management and spatial scenarios);
3. Plan an analysis that will explore options and impacts to link to the desired future forest conditions (Habitat scenario);

The model controls applied in any given scenario analysis process – the scenario design – may vary depending on jurisdiction and the unique circumstances and needs of a particular forest landscape. The model controls applied, and scenarios explored in this forest management plan reflect values that were driven by legislation, a selection of criteria and indicators from the VOITs, and rights and stake holder involvement.

Table 12.1 summarizes the scenario design approach taken for scenario analysis. Categories of model controls are organized along the top of the table as columns, and further broken down as the specific indicator that can be controlled and measured in the model. The rows of the table indicate the unique scenario that is created by choosing the model controls that will be active (the checkmarks). The scenarios are grouped by the stage of the analysis (calibration, balanced, spatial, etc.). The scenarios were designed to move from very general and simple explorations of model assumptions (calibration) to more complex spatial and short-term controls. The process moved from the top of the table to the bottom of the table. Model controls were added one at a time to build balanced management scenarios that also considered spatial patterns on the landscape. Some of the initial scenarios do not represent valid management directions but were included in order to review model assumptions and understand impacts from each individual control to find a balance of trade-offs.

The process outlined in the scenario design was collaboratively developed and followed by the Modelling and Analysis Task Team during scenario analysis. The purpose of the Modelling and Analysis Task Team was to meet regularly throughout the scenario analysis process to remain up to date on progress and provide active and collaborative feedback throughout the development process as it occurred. The Modelling and Analysis Task Team was a subset of the broader FML 2 Forest Management Plan Planning Team. For more information regarding the Planning Team, see section 13 Preferred Forest Management Scenario.

Table 12.1. Scenario design checklist that outlines the scenario analysis process used in the calibration forest model and development of management scenarios.

			Model Controls														
			Harvest Volume			Closing Inventory	Biodiversity		Silviculture		Access				Patch Distribution		Operating Areas
Stage	Scenario Name	Scenario Description	Levels	Product Type	Flow		Cover Type	Seres	Treatments	Budget	Build	Haul	Maintain	Unutilized	Harvest	Young Forest	
Base Model Calibration	Maximize Harvest	Maximize harvest by forest management unit.	✓	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Limit Hardwood	Maximize harvest by forest management unit, limit harvest from hardwood-leading stands.	✓	✓	--	--	--	--	--	--	--	--	--	--	--	--	--
	Even Flow	Maximize harvest by forest management unit, limiting harvest from hardwood-leading stands, while supplying an even flow of product.	✓	✓	✓	--	--	--	--	--	--	--	--	--	--	--	--
	Non-Declining Closing Inventory	Maximize harvest by forest management unit, limiting harvest from hardwood-leading stands, while supplying an even flow of product. Maintain non-declining operable closing softwood forest inventory in the last 50 years of analysis.	✓	✓	✓	✓	--	--	--	--	--	--	--	--	--	--	--
Balanced Forest Management	Forest Cover Type	Base Model. Maintain softwood forest cover types by forest section.	✓	✓	✓	✓	✓	--	--	--	--	--	--	--	--	--	--
	Forest Seral Stages	Base Model. Maintain softwood forest cover types by forest section. Maintain old and very old forest seres by seral-specific species group by forest section.	✓	✓	✓	✓	✓	✓	--	--	--	--	--	--	--	--	--
	Silviculture (Forest Renewal)	Base Model. Maintain softwood forest cover types by forest section. Maintain old and very old forest seres by seral-specific species group by forest section. Limit silvicultural treatments to reflect operational realities and feasibility. Balance net silviculture budget.	✓	✓	✓	✓	✓	✓	✓	✓	--	--	--	--	--	--	--

			Model Controls														
			Harvest Volume			Closing Inventory	Biodiversity		Silviculture		Access				Patch Distribution		Operating Areas
Stage	Scenario Name	Scenario Description	Levels	Product Type	Flow		Cover Type	Seres	Treatments	Budget	Build	Haul	Maintain	Unutilized	Harvest	Young Forest	
Spatial Analysis	Access	Base Model with Balanced Forest Management. Apply access-related goals to influence the spatial arrangement of harvest. Minimize unutilized harvest volume not reaching the mill.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	--	--	--
Spatial Analysis	Harvest Patches	Base Model with Balanced Forest Management. Apply access-related goals to influence the spatial arrangement of harvest. Minimize unutilized harvest volume not reaching the mill. Apply goals to influence harvest patch size distribution within periods.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	--	--
Spatial Analysis	Operating Areas (Baseline Scenario)	Base Model with Balanced Forest Management. Apply access-related goals to influence the spatial arrangement of harvest. Minimize unutilized harvest volume not reaching the mill. Apply goals to influence harvest patch size distribution within periods. Incentivize the model to harvest within known and accessible operating areas.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	--	✓
Habitat Scenario		Base Model with Balanced Forest Management and Spatial Analysis. Add additional patch objectives to influence young forest pattern and distribution.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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12.2 SCENARIO DEVELOPMENT

Model controls were applied according to the scenario design set out for the FML (see Table 12.1). The "layering-in" process and the cumulative impacts of each control as it was applied are detailed in the following sections. This description of the scenario analysis process tells the story of the development of the two forest management scenarios put forward as the selection options for the PFMS: the Baseline scenario and the Habitat scenario.

12.2.1 No Harvest Scenario

Prior to beginning the formal scenario analysis process, a "no harvest" scenario was run. A no harvest scenario has no goals or constraints applied and provides a reference to understand the natural growth patterns and dynamics of the modelled forest in the absence of forest management. The no harvest scenario can be useful to compare indicators throughout scenario analysis as model controls are layered in. The no harvest scenario can also provide insight into the potential or limit of ecological indicators within the bounds of only the natural succession processes simulated within the forest model prior to introducing forest management.

While the no harvest scenario is a useful tool in the scenario analysis process to provide additional context and understanding of the modelled forest, it is not a viable long-term management option.

12.2.2 Baseline Scenario

12.2.2.1 Harvest Volume

Three primary model controls were used to track indicators and set management objectives, where necessary, regarding harvest volume: Softwood harvest levels, harvest product type, and harvest flow.

12.2.2.1.1 Harvest Levels

Harvest levels in the forest model are reported in cubic metres per year (m^3/yr). Harvest levels can be set on the FML or the forest management unit (FMU) level for softwood volume and hardwood volume.

Harvest levels within the model (Table 12.2) were set to attempt to maximize to at least the non-spatial sustainable softwood annual allowable cut (AAC) by forest management unit (FMU) as determined by the Province in their base case wood supply analyses for the Saskatchewan River and Highrock Forest Sections (Province of Manitoba, 2014 & 2015). For FMUs in Nelson River Forest Section, the most recent sustainable softwood AAC determined and provided by the Province was used (see Appendix V – Provincial Annual Allowable Cut Letter). Note that ongoing updates to AAC are determined by the Province, refer to Appendix V for more information.

Table 12.2. Annual allowable cut (AAC) sustainable harvest levels, in cubic metres per year (m^3/yr), as determined by the Province for each forest management unit (FMU) by forest section.

Forest Section	FMU	Softwood Annual Allowable Cut (AAC) (m^3/yr)
Saskatchewan River	50	27,959
	53	106,244
	58	133,946
	59	98,348
Highrock	67	403,587
	68	64,934
	69	238,210
Nelson River	800	19,712
	801	389,422
	802	142,649

This was applied at the forest management unit (FMU) level for the 200-year modelling horizon. If long-term sustainable harvest levels were found to be over that of the provincially-determined annual allowable cut (AAC), no penalty was applied at point in scenario analysis.

Indicator	Goal	Spatial Scale	Time Scale
Softwood harvest levels	Maximize	Forest management unit	200 years

Harvest "maximization" is an initial step in the forest modelling analysis and provides a similar but opposite calibration scenario to the "No Harvest" scenario. Prior to any additional model controls being applied, a "maximum harvest" scenario provides an indication of total operable wood products on the FML over the 200-year planning period (Figure 12.2). This scenario is not intended to provide a realistic management option as it is intrinsically unsustainable. The purpose of many of the calibration scenarios is to check that the model is working correctly and reflects the expected outcomes from model assumptions being used. Errors or omissions can be caught at these early stages of analysis when reviewing these initial calibration scenarios. The "maximize harvest" scenario is intended to serve only as an initial modelling exercise and contains no sustainability-related objectives.

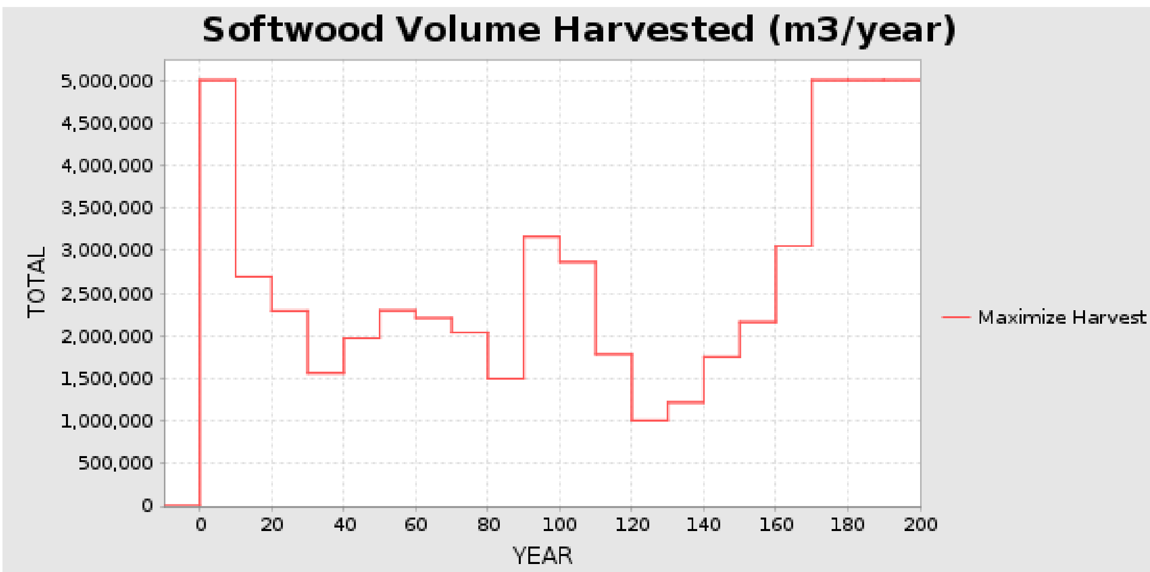


Figure 12.2. Patchworks™ report of softwood volume harvested from the FML, in cubic metres per year (m^3/yr), for the initial harvest calibration step of the scenario analysis process.

12.2.2.1.2 Harvest Product Type

Product types within the forest model are based on two product categories:

1. Volume from 8-foot softwood logs; or
2. Volume from 8-foot hardwood logs.

As such, it is possible to set management objectives for softwood products and hardwood products independently.

Under the Forest Management Licence Agreement (FMLA), NFMC is permitted to harvest only softwood products on the FML. To reflect this, a model control was applied to minimize the amount of harvested area from stands with hardwood-leading forest strata. The harvest of some hardwood-leading stands was permitted to strategically reflect that the harvest of hardwood products occurs on the FML by entities other than NFMC. Aside from minimizing the production of hardwood products, no additional goals were set regarding hardwood product types.

Indicator	Goal	Spatial Scale	Time Scale
Harvested hardwood area	Minimize	FML	200 years

Minimizing the harvest of hardwood-leading stands had an impact on overall softwood harvest volume (Figure 12.3). Softwood by-product harvest from within hardwood stands makes up a small proportion of total softwood volume being harvested on the FML.

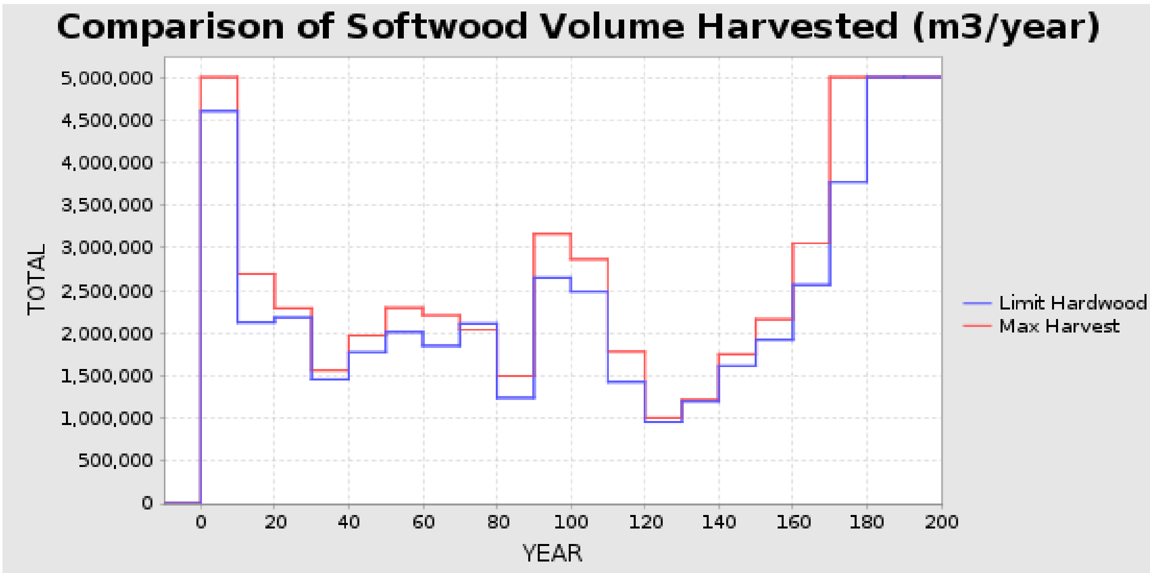


Figure 12.3. Patchworks™ report of softwood volume harvested from the FML, in cubic metres per year (m^3/yr), comparing the initial harvest maximization and the hardwood limiting steps of the scenario analysis process.

12.2.2.1.3 Harvest Flow

Harvest flow is defined as the change in volume harvested between specified periods, and can be set to ensure a long-term, sustainable flow of wood. Flow is measured as a proportionate change and controls are set as a plus or minus (±) threshold from a specific reference point, such as between successive periods or in relation to the last period of the analysis horizon. This ensures that the supply of wood products is predictable and consistent year-to-year.

To ensure long-term sustainability, an even-flow model control was applied. In other words, the model was encouraged to maintain an even amount of softwood being harvested between periods. Using the change in the volume of softwood harvested per period (m^3/P) as an indicator, a goal was set to maintain softwood harvest levels within plus or minus (±) 5% of the last period modelled (period 20). This was applied at the forest management unit (FMU) level across the entire 200-year analysis horizon.

Indicator	Goal	Spatial Scale	Time Scale
Softwood harvest flow	Maintain ± 5%	Forest management unit	200 years

Implementing an even harvest flow has an immediate impact on overall softwood harvest volume. This highlights the effects of prioritizing a long-term predictable and consistent flow of wood products (Figure 12.4).

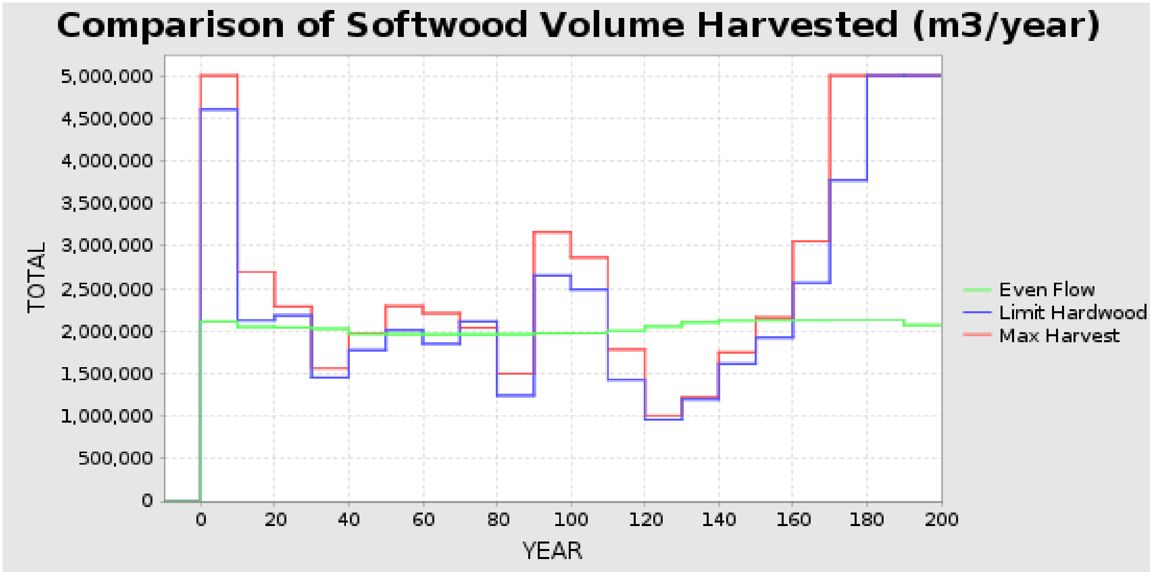


Figure 12.4. Patchworks™ report comparing softwood volume harvested from the FML, in cubic metres per year (m³/yr), between the initial harvest maximization, hardwood limiting, and the even harvest flow steps of the scenario analysis process.

12.2.2.2 Closing Forest Inventory

Closing forest inventory refers to the amount of growing stock on the productive forest landbase at the end of the analysis horizon. Total growing stock is measured as the total existing wood volume (both softwood and hardwood) on the productive forest landbase, including areas that fall within the unmanaged (non-harvestable) category. Growing stock can be further broken down to consider only *operable* growing stock. Operable growing stock considers only volume from within the productive forest landbase that is considered eligible for harvest (i.e., is on the managed forest landbase , has met the minimum volume requirement, and is above the minimum age for management), and does not include recently disturbed forest area, forest area excluded from harvest (as per 10.1.2.4 Forest Area Excluded from Forest Management Activity for Forest Modelling), or otherwise low-productivity areas ineligible for harvest. Operable growing stock can provide an estimation of the amount of volume on the landbase that is capable of supplying timber products at any given time on the modelling time horizon.

A note on what is referred to as the "end of the world" effect:

> The "end of the world" effect refers to a common modelling issue where the behavior of the model near the end of the analysis horizon becomes unrealistic because the computer model doesn't know that time continues forever. A forest model has been set to maintain sustainability to the end of the analysis horizon—in this instance, 200 years. Beyond these 200 years, nothing is programmed. Therefore, as the end of the analysis horizon approaches, the model might prioritize short-term gains over long-term sustainability, since it "knows" that it doesn't have to account for anything beyond the end point. Forest management is generally concerned with the first 100 years of the predicted future to represent a rotation of growth, harvest, succession, and regeneration. Models use 200 years to ensure that these first 100 years are not influenced by the "end of the world" knowledge that the computer model has. However, results of this modelling exercise are reported strategically for the entire 200 years, and therefore goals have been put in place to prevent the distortion of these results (such as closing growing stock constraints). Replanning for updated forest management plans occurs every 10 to 20 years to incorporate updated information and model assumptions.

To ensure long-term economic and environmental sustainability, a non-declining model control was applied to the closing softwood forest inventory (i.e., the operable softwood growing stock that remains at the end of the analysis horizon). Using the change in the volume of operable softwood growing stock available per period (m³/P) in the last 50 years of analysis as an indicator, a goal was set to have operable softwood growing stock be non-declining (i.e., volume of operable growing stock should not, on average, decrease between periods in the last 50 years of the 200-year analysis horizon to avoid the "end of the world" effect). This was applied at the forest management unit (FMU) level.

Indicator	Goal	Spatial Scale	Time Scale
Operable growing stock	Non-declining	Forest management unit	Last 50 years (150-200)

Implementing this goal did not greatly reduce harvest levels following the implementation of an even harvest flow (Figure 12.5). Combined, these form the foundation of ensuring long-term economic and environmental sustainability. Having both applied consistently throughout the scenario analysis process provides a two-fold assurance that the strategic direction of the plan is rooted in long-term sustainability.

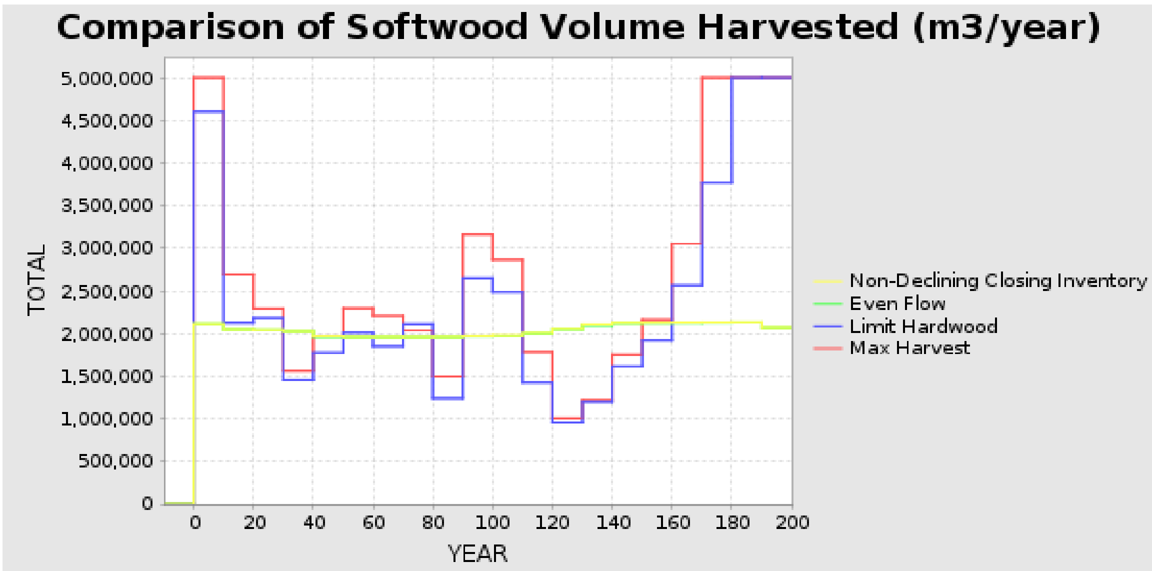


Figure 12.5. Patchworks™ report comparing softwood volume harvested from the FML, in cubic metres per year (m^3/yr), between the initial harvest maximization, hardwood limiting, even harvest flow, and non-declining closing forest inventory steps of the scenario analysis process. Note that if there is minimal change in volume between analyses, lines may begin to overlap.

12.2.2.3 Biodiversity

The biodiversity model control category includes ecological landscape-level forest features that can be influenced and monitored on a strategic level. These features result in model controls that consider forest cover type, forest seral stage, Wildlife Management Areas (WMAs), and wildlife habitat elements such as those specific to boreal woodland caribou. Identifying indicators and setting goals for these features assists in predicting a future forest condition that is consistent with a naturally occurring boreal forest landscape that is capable of supporting a broad range of wildlife species.

Using these model controls assists in influencing the future forest to achieve a number of value-based management objectives under Canadian Council of Forest Ministers (CCFM) Criterion 1: Biological Diversity.

12.2.2.3.1 Forest Cover Type

Forest cover type is strategically considered using four standard categories:

- Softwood forest (S);
- Softwood-leading mixedwood forest (M);
- Hardwood forest (H); and,
- Hardwood-leading mixedwood forest (N).

Forest strata that fall within the softwood forest (S) cover type include pure jack pine (JP), lowland black spruce (LBS), upland black spruce (UBS), black spruce and tamarack (STL), general softwood (SFWD), and other softwood

(OSFWD) stands. Forest strata that fall within the hardwood forest (H) cover type include pure commercial hardwoods (CHDWD), pure trembling aspen (TA), and other hardwood (OHDWD) stands. Softwood-leading mixedwood forest (M) includes only the mixedwood – softwood leading stratum (MSPF) and Hardwood-leading mixedwood forest (N) includes only mixedwood – hardwood leading stratum (NSPF). For a more robust definition of strata, refer to Appendix A – Definition of Strata.

The area of each forest cover type on the productive forest landbase can be measured in hectares and can be tracked on the FML, forest section, and forest management unit (FMU) levels. The predominant forest cover type across boreal forest ecosystems, and within all forest management units on FML 2, is softwood forest. Softwood forest cover type is a vital component of boreal forest habitat.

Using the proportion of the productive forest area that is softwood cover as an indicator, a goal was set to maintain the amount of softwood forest cover present at plan start within plus or minus (±) 5%. This was applied on the forest section level across the entire 200-year analysis horizon.

Indicator	Goal	Spatial Scale	Time Scale
Softwood forest area	Maintain ±5%	Forest section	200 years

Assessing these indicators at the forest section scale is meant to encompass the subtle differences in forest composition found between each forest section, as section boundaries closely follow those of the three ecodistricts overlapping the FML (see Maps 2.2 and 6.1 in Part 1 – Planning Context for ecozones and forest section administrative boundaries).

Setting a goal for softwood cover type assists in preventing the disproportionate conversion of softwood cover to mixedwood or hardwood cover types within each forest section, potentially resulting in a landscape that is not representative of a naturally occurring boreal forest. Specific model controls were not set for the three other categories as the softwood cover-type dominates for the forest landscape and indirectly influences the other forest types. In other words, by setting a target to influence the cover type most prevalent on the landscape (softwood forest cover greater than 70%), the remaining cover types are maintained as well. Due to limited harvest on hardwood leading types (harvest volume control) the hardwood cover type is also controlled indirectly. Layering in this control in the scenario analysis process resulted in minimal impacts to harvest volume following the implementation of the even harvest flow objective (Figure 12.6).

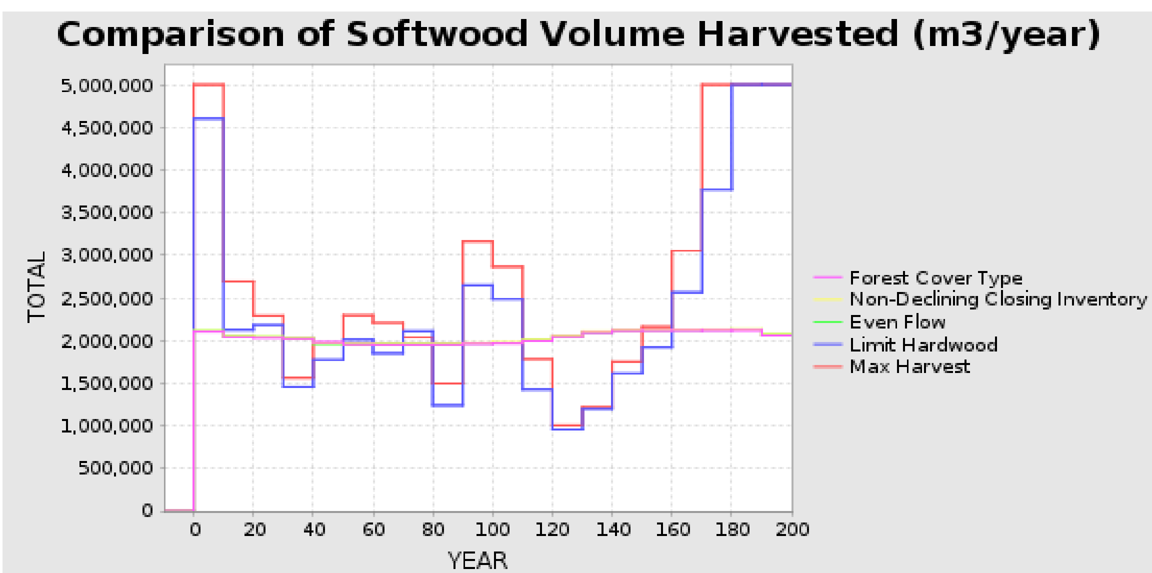


Figure 12.6. Patchworks™ report comparing softwood volume harvested from the FML, in cubic metres per year (m³/yr), between the initial harvest maximization, even harvest flow, hardwood limiting, non-declining closing forest inventory, and forest cover type steps of the scenario analysis process. Note that if there is minimal change in volume between analyses, lines may overlap.

12.2.2.3.2 Forest Seral Stages

Within secondary succession, seral stages can be defined according to the landscape's species composition and associated age class. Secondary forest succession typically begins after a disturbance event that has left the ecological basis for vegetative growth intact, i.e., soil, roots, and seeds remain. (Alaska Department of Fish and Game, 2018). The use of the term "seral stage" within this forest management plan is consistent with the seral stages typically identified within secondary boreal forest succession.

Seral stages for modelling were defined based on broad forest type categories, grouping softwood (S), softwood-leading mixedwood (M), and hardwood/hardwood-leading mixedwood (H, N) forest cover types together by age class. Softwood forest is further subcategorized within the model into jack-pine-leading and spruce-leading stands to account for differences in successional development stages, structure and composition between the species. There are five age classifications used: Young, Immature, Mature, Old, and Very Old. Within these descriptions, specific age classes vary based on cover type and softwood-leading species (Table 12.3). This definition is consistent with that used in the Government of Saskatchewan's *Forest Management Planning Standard* (2017). These definitions were reviewed for their applicability in a neighbouring jurisdiction by Forestry Branch and agreed to collaboratively by the Modelling and Analysis Subcommittee.

Table 12.3. Seral stage definitions used in the development of the FML 2 20-year forest management plan, based on forest type and age class.

Forest Cover Type	Seral Stage				
	Young	Immature	Mature	Old	Very Old
Softwood; Jack pine dominated	0 - 20 years	21 - 70 years	71 - 90 years	91 - 110 years	> 110 years
Softwood; Spruce dominated	0 - 20 years	21 - 80 years	81 - 100 years	101 - 120 years	> 120 years
Softwood-leading mixedwood	0 - 20 years	21 - 80 years	81 - 100 years	101 - 120 years	> 120 years
Hardwood & hardwood-leading mixedwood	0 - 20 years	21 - 70 years	71 - 90 years	91 - 110 years	> 110 years

In the forest model, these seral stages are used strategically to predict the condition of the future forest landscape and serve as a proxy for the presence of seral-specific habitat features (see section 11.1 Matrix of Habitat Elements for Wildlife Species). The area of each seral stage by forest type on the productive forest landbase can be measured in hectares and can be tracked on the FML, forest section, and forest management unit (FMU) levels.

Using the proportion of productive forest represented by each seral stage as an indicator, a goal was set to maintain a minimum of 15% of all seral forest types classified as old and very old forest combined, with a minimum of 5% of the 15% being very old forest. This was applied at the forest section level for the 200-year analysis horizon.

Indicator	Goal	Spatial Scale	Time Scale
Old and very old seral stage forest area by cover type	Maintain a minimum of 15% old or older seral stage for each cover type Maintain a minimum of 5% very old for each cover type	Forest section	200 years

Again, using forest sections as the spatial scale at which these indicators are assessed is meant to encompass the subtle differences in forest composition found within each forest section, as section boundaries closely follow those of the three ecodistricts overlapping the FML (see Maps 2.2 and 6.1 in Part 1 – Planning Context for ecozones and forest section administrative boundaries).

Similar to applying cover-type-based model controls, old and very old forest seral stages had minimal additional impact following even harvest flow (Figure 12.7).

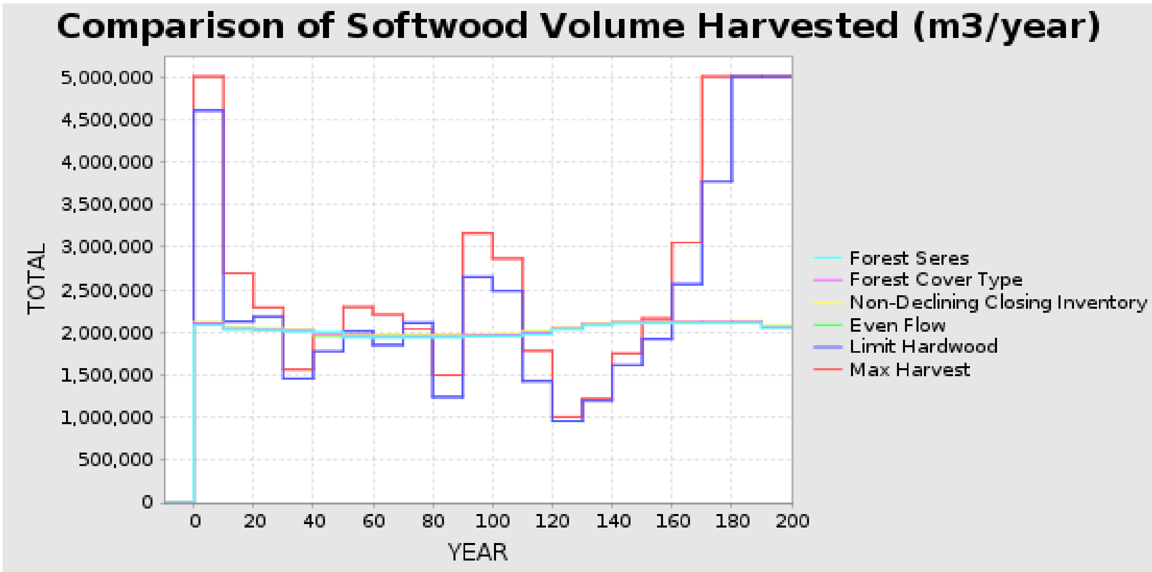


Figure 12.7. Patchworks™ report comparing softwood volume harvested from the FML, in cubic metres per year (m^3/yr), between the initial harvest maximization, hardwood limiting, even harvest flow, non-declining closing forest inventory, forest cover type, and forest sere steps of the scenario analysis process. Note that if there is minimal change in volume between analyses, lines may overlap.

Mature Forest Cover in Wildlife Management Areas

To preserve seral diversity specifically within Wildlife Management Areas (WMAs), a model control was set at the FML level to maintain at least 20% mature (or older) forest within WMAs in which harvesting is permitted to occur. This is consistent with the Province's Base Case wood supply analysis for Saskatchewan River Forest Section (Province of Manitoba, 2015).

12.2.2.3.3 Wildlife Habitat and Habitat Elements

The inclusion of habitat-specific features as controls within the model was a choice made to assist in developing a Preferred Forest Management Scenario that considers landscape-level habitat elements critical to species such as boreal woodland caribou and moose.

The initial approach to scenario analysis for wildlife habitat features was to track the changes in the habitat types described below to assess if applying a goal was necessary. If the amount of each habitat type was maintained and reflective of the natural fluctuations of the landscape (i.e. as compared to the no harvest scenario), then a specific model control goal would not provide any additional benefit. No specific amount for the specific habitat elements, or range of achievements, was available to set as a specific goal.

Additional model controls added during the spatial analysis of the habitat scenario helped to translate desired future forest conditions for some specific wildlife species. These include management of access and fragmentation or edge patterns on the landscape using model controls for transportation expenditures and harvest patch size configurations.

For more information, see section 11 Modelling Wildlife Habitat and Habitat Elements.

Boreal Woodland Caribou Habitat

An indicator was created to track the change in the amount of preferred boreal woodland caribou habitat (see Table 11.2) within the total productive forest over time. This was tracked at the caribou management unit level across the 200-year analysis horizon.

Indicator	Goal	Spatial Scale	Time Scale
Preferred caribou habitat area	Track	Caribou management unit	200 years

The scenario analysis process focused on tracking how the amount of preferred caribou habitat changed between scenarios as model controls were layered in. As seen in Figure 12.8, the amount of preferred caribou habitat on the total productive forest is projected to be less than would be present if no forest management activities occurred ("No Harvest"), highlighting a trade-off between active forest management and an absence of forest management.

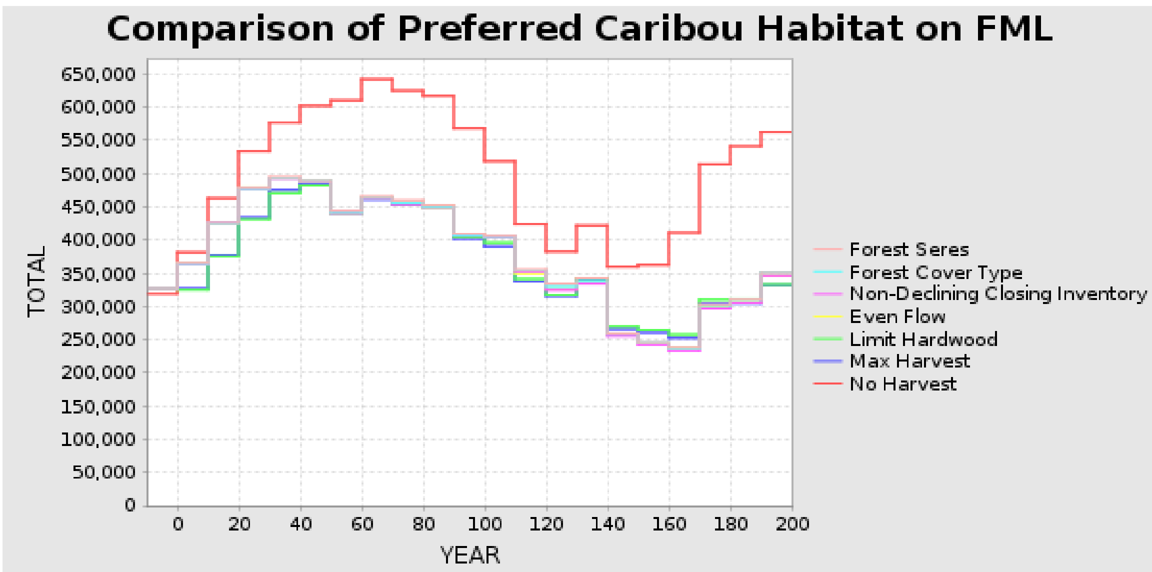


Figure 12.8. Patchworks™ report comparing the area of caribou preferred habitat on the FML between scenarios throughout the analysis process up to this point, reported in hectares (ha). Note that if there is minimal change in volume between analyses, lines may overlap.

Figure 12.8 also highlights that the amount of preferred caribou habitat on the FML is strongly linked to the pattern of natural succession. This pattern is what creates the "peaks"—when jack pine and lowland black spruce forests have naturally aged and accumulated on the landscape as preferred habitat—and "valleys"—when those same forests become old enough to reach "mortality" and naturally succeed into a forest that is young again (Figure 12.9). For more information, see Forest Modelling subsection 10.1.6 Natural Succession.

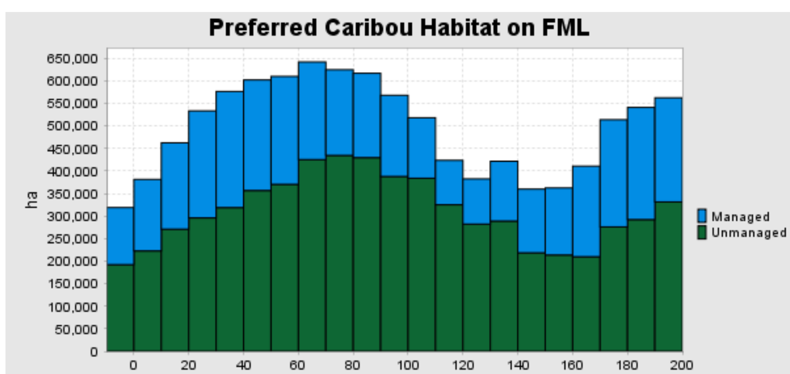


Figure 12.9. Patchworks™ report of preferred caribou habitat on the FML for the no harvest scenario illustrating the peaks and valleys of natural succession impact the amount of habitat present on the landscape. This report separates preferred caribou habitat into managed (eligible for forest management activities) and unmanaged (no forest management activities can occur) area.

Additional habitat assessments were completed to further consider the amount and arrangement of boreal woodland caribou habitat outside of the forest model. For more information, see Modelling Wildlife Habitat and Habitat Elements section 11.2 Boreal Woodland Caribou Habitat Elements.

Moose Habitat

An indicator was created to track the change in the amount of browse, general cover, and thermal (winter) cover habitat for moose (see Table 11.5) within the total productive forest over time. This was tracked at the FML level across the 200-year analysis horizon.

Indicator	Goal	Spatial Scale	Time Scale
Browse moose habitat area General cover moose habitat area Thermal cover moose habitat area	Track	FML	200 years

Similarly to caribou habitat, the analysis process focused on tracking how the amount of moose habitat changed between scenarios as model controls were layered in. The amount of moose browse habitat on the total productive forest was projected to be more than would be present if no forest management activities occurred (Figure 12.10; “No Harvest”). This is due to the creation of young forest mixedwood and hardwood forest as a result of harvesting. While young forest created through harvest rather than natural processes may vary in composition, moose have generally not been found to discriminate between foraging areas, regardless of origin (Johnson & Rea, 2024).

All types of moose habitat are strongly linked to the pattern of natural succession. This pattern is what creates the “peaks”—when mixedwood and hardwood forests that are young due to recent natural disturbance or succession have accumulated on the landscape as browse habitat—and “valleys”—when those same forests have aged and become old enough to no longer be considered suitable for supporting browse behaviours—in the figure below. For more information, see Forest Modelling subsection 10.1.6 Natural Succession.

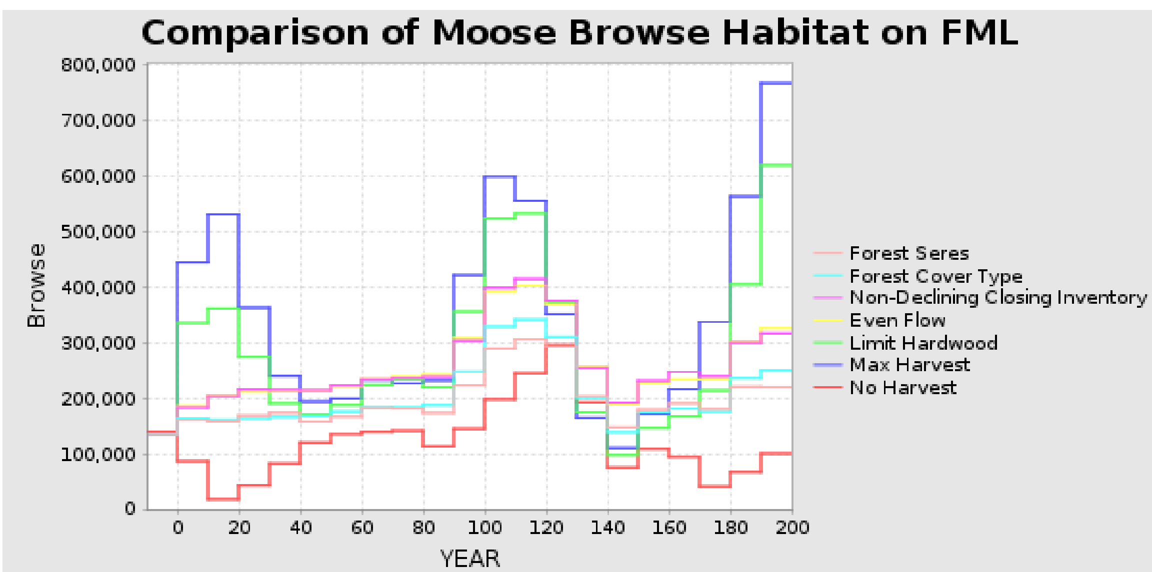


Figure 12.10. Patchworks™ report comparing the area of moose browse habitat on the FML between scenarios throughout the analysis process up to this point, reported in hectares (ha). Note that if there is minimal change in volume between analyses, lines may overlap.

12.2.2.4 Forest Renewal

Forest renewal is the practice of managing forests to cultivate the regeneration and reforestation of a disturbed area to meet specific objectives. In the case of this forest management plan, forest renewal pertains to renewal of blocks post-harvest. Forest renewal methods include leaving a harvest block to regenerate naturally, scarifying to enhance the success of natural regeneration, planting, and applying vegetation management strategies. These forest renewal methods are often more simply referred to as silviculture. A silvicultural prescription is a framework that describes the link between current forest condition, forest renewal methods, and the future forest condition.

In real life, forest renewal methods for each block are determined individually by a silviculture professional based on unique site conditions and known information. The forest renewal controls built into the model are a strategic generalization of what occurs on the ground but allow for a degree of realism and feasibility to be integrated into the development of the plan. This includes generalizing forest renewal methods and approximating costs based on known rules, regulations, practices, and budgets.

For a more in-depth description of forest renewal methods from an operational perspective, see Part 3 – Implementation and Planning, Implementation Strategies subsection 16.4 Forest Renewal.

Within the forest model, forest renewal considerations were broken down into two general categories for consideration:

- Silviculture Budget, a relative estimation of the balance between the cost of applying forest renewal methods and the amount of money that is available for spending. Modelling a relative approximation of a silviculture budget can assist in developing a strategic direction that is economically feasible and operationally realistic.
- Forest Renewal Methods, including leave for natural, scarification, planting, and vegetation management, often simply referred to as silviculture. Within the forest model, applying these methods determines what species a harvest block will be projected to regenerate (grow back) as and the associated future timber yield.

12.2.2.4.1 Silviculture Budget

A silviculture budget model control was developed to translate the idea of economic feasibility and operational reality to the forest model. This control assists in limiting the application of certain forest renewal methods over time. The purpose of this is to keep the budget relatively balanced to avoid forest renewal spending that may result in a disproportionate and/or unrealistic set of forest treatments over time. All harvested areas are renewed to meet the provincial renewal standards; however, planting and vegetation management are the most expensive type of renewal treatment. Without a budget in place, the forest model has no concept of “spending” and will apply more planting and vegetation management than is economical and create costly forest renewal strategies that generate an idealized but unrealistic future forest condition (i.e., a forest with increased yield from plantation gains and consistent maintenance of strata).

The silviculture budget is a calculation of the amount of silviculture liability accrued after harvest (or the expected maximum cost/ha) versus the actual cost of treatments. (i.e., silviculture budget = accrued liability – forest renewal spending). The amount of silvicultural liability accrued can vary by strata. Silvicultural spending accumulates when there is scarification, planting, and vegetation management forest renewal treatments, as well as the cost to conduct post-harvest silvicultural surveys.

The silviculture budget is managed in the model to not exceed liabilities (i.e., to spend responsibly) while also allowing the model to make more expensive treatment expenditures like planting when appropriate. Using the silviculture budget remaining in each period as an indicator, a goal was set to maintain the residual net silviculture budget to be consistently within a plus or minus a range that is predictable and realistic. This was applied at the FML level across the 200-year analysis horizon.

Indicator	Goal	Spatial Scale	Time Scale
Silviculture budget	Maintain spending within a plus or minus range that is predictable and realistic	FML	200 years

Figure 12.11 provides an example of what the impact of controlling this indicator looks like between steps of the scenario analysis process. Setting a goal to maintain spending within a range that is predictable and realistic causes the amount of residual net silviculture budget to be consistent over the entire 200-year analysis horizon, balancing forest renewal spending with accruing liability.

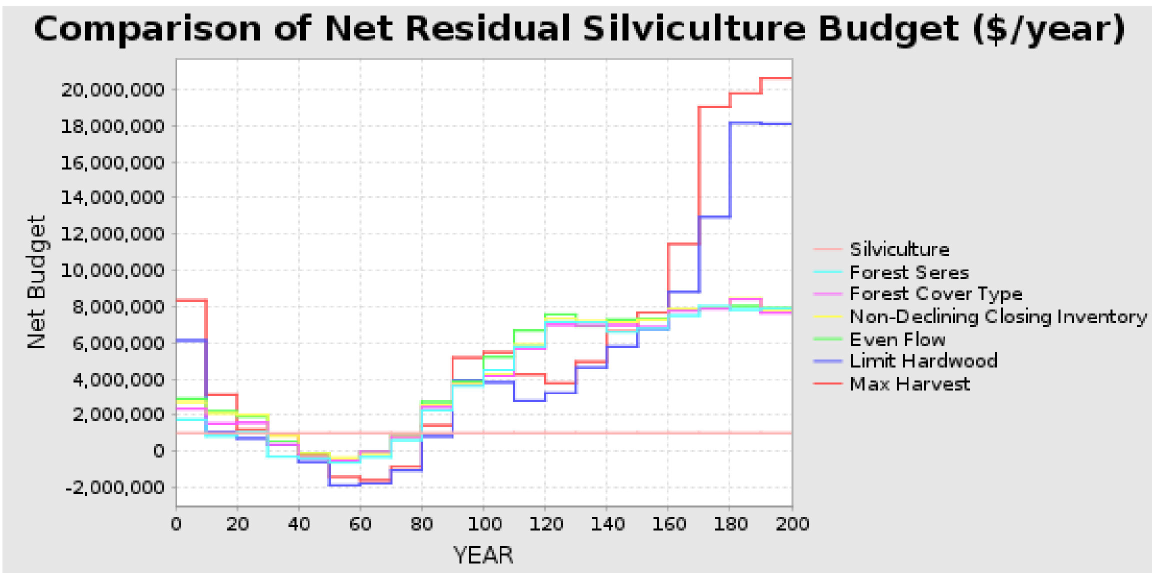


Figure 12.11. Patchworks™ report comparing the net residual silviculture budget between scenarios throughout the analysis process up to this point, reported in dollars per year ($/year). Note that if there is minimal change in volume between analyses, lines may overlap.

12.2.2.4.2 Forest Renewal Methods

The forest renewal methods available within the model were leave for natural and planting, with an option to apply a vegetation management (release) treatment to harvested softwood stands.

In the model, leave for natural suggests that the harvested block is expected to have sufficient seed source and suitable ground conditions to allow natural regeneration to occur without the need for silvicultural intervention. Strictly for the purposes of modelling, leave for natural also captures scarification for jack pine harvest blocks.

Planting suggests that the harvest block will benefit from tree planting as a forest renewal method post-harvest. Planting was limited to only operable areas with softwood-leading strata to reflect operational realities.

Vegetation management refers to the intentional control of competitive plant species within a forested area to achieve specific forest management objectives. This is also commonly referred to as "releasing" the softwood saplings from competition, or a release treatment. Release was represented in the model in combination with either leave for natural or planting (i.e., leave for natural with follow-up release, or planting with follow-up release). Applying release was set to be available only for polygons with softwood-leading strata to reflect operational realities. Leave for natural with vegetation management was additionally limited to only jack pine stands, implying the use of scarification and follow-up vegetation management, if necessary.

For both leave for natural and planting, forest strata follow the transition rules detailed in Model Assumptions section 10.1.8 Post-Harvest Transitions. The use of the release results in an exception to the transition rules, and instead the pre-harvest strata of the polygon is maintained post-harvest (i.e., no change in strata post-harvest when release occurs).

The full set of available post-harvest silvicultural treatment responses by stratum are detailed in Table 12.4.

The amount of each type of forest renewal applied within a period can be measured in hectares, with reporting available at the FML, forest section, and forest management unit (FMU) levels.

Table 12.4. Forest renewal methods available for use by strata in the FML 2 forest model.

Strata		Leave for Natural	Leave for Natural with Release	Plant	Plant with Release
CHDWD	Pure hardwood mix	✓	-	-	-
JP	Jack pine	✓	✓	✓	✓
LBS	Lowland black spruce	✓	-	✓	✓
MSPF	Softwood-leading mixedwood	✓	-	✓	✓
NSPF	Hardwood-leading mixedwood	✓	-	-	-
OHDWD	Other hardwood mix	✓	-	-	-
OSFWD	Other softwood mix	✓	-	✓	✓
SFWD	Pure softwood mix	✓	-	✓	✓
STL	Black spruce and tamarack	✓	-	✓	✓
TA	Trembling aspen	✓	-	-	-
UBS	Upland black spruce	✓	-	✓	✓

Model controls regarding forest renewal methods are based on the proportion of harvest area to which a treatment is applied. These controls ensure that the model does not unrealistically do too much of any treatment. For instance, it would be infeasible and very expensive to plant every stand after harvest. And this is not necessary since natural regeneration will achieve the goals of silviculture with less expense when the conditions are right. For instance, jack pine stands are good candidates for scarification following harvest, and then allowing natural seed to regenerate the stand. These jack pine stands often do not require planting as there is sufficient natural regeneration to achieve forest renewal goals.

Two goals were set to limit the application of specific forest renewal methods on the landscape to provide greater operational realism to the proposed scenarios. These goals are detailed in the following two sections.

Jack Pine Scarification

For jack pine blocks, the leave for natural treatment is synonymous with a scarification treatment, which is the primary forest renewal approach for jack pine post-harvest.

Using the proportions of harvested jack pine blocks that received either forest renewal method (leave for natural or planting), a goal was set to have a minimum 85% of harvest blocks renewed through scarification. This was applied at the FML level across the 200-year analysis horizon. The remaining 15% of harvested jack pine blocks may be eligible for either more leave for natural, or planting. This allows the model to capture any harvested jack pine blocks that may require additional silvicultural intervention with supplemental infill planting.

Indicator	Goal	Spatial Scale	Time Scale
Harvested jack pine forest area that is scarified (LFN)	Maintain a minimum of 85%	FML	200 years

Setting this goal resulted in a notable increase in the amount of harvested jack pine area that was scarified, as is consistent with the current operational norm. This concurrently minimized the number of jack pine stands being planted (Figure 12.12). Previous scenarios throughout the analysis process had jack pine harvest blocks being planted up to 45% of the time, an amount not typical of day-to-day operations as it is generally an as-needed, supplemental management practice.

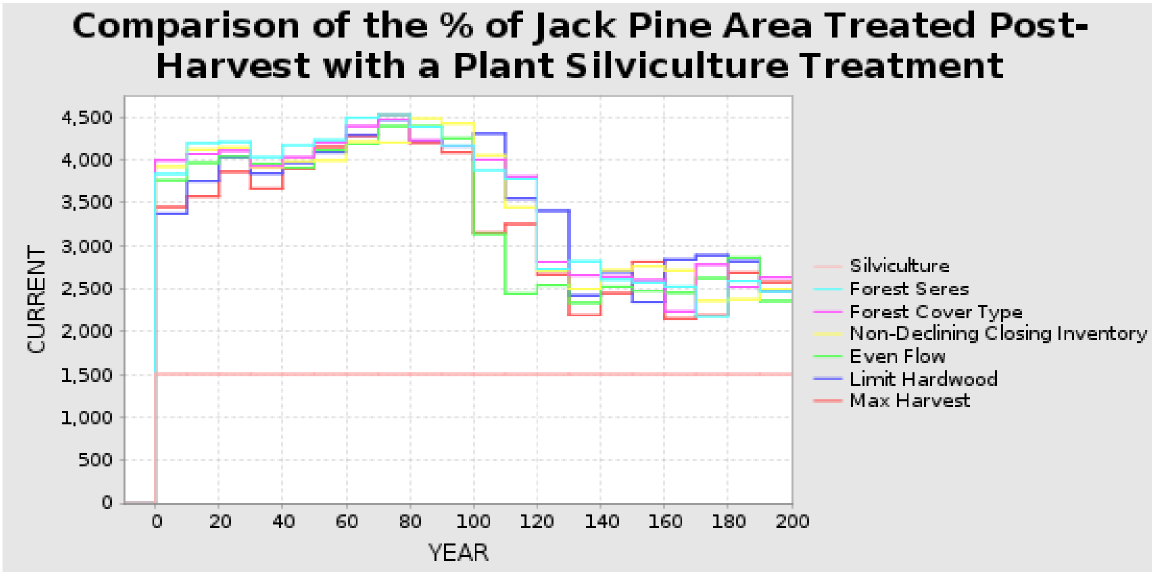


Figure 12.12. Patchworks™ report comparing the proportion of jack pine area planted post-harvest between scenarios throughout the analysis process up to this point, reported as the percentage multiplied by 100 (CURRENT). Reporting in this instance is of the inverse renewal method (i.e., goal was to have 85% of jack pine stands be scarified within the model, leaving only 15% of the area to be planted, should the model choose). The implemented goal resulted in a consistent 15% of harvested jack pine stands being planted post-harvest, and as such 85% being scarified (categorized under leave for natural). Note that if there is minimal change in volume between analyses, lines may overlap.

Vegetation Management

Note that for the intention of strategic forest modelling, the term "release" is used to represent both leave for natural with vegetation management (release) and planting with vegetation management (release). This is an option that the forest model may choose in order to achieve other future forest model controls. For example, applying a release treatment to a stand would ensure that stand would remain a softwood type and would therefore help contribute to achieving the total softwood cover type goal in the future or a softwood seral stage goal. As with the jack pine planting discussed above, the forest model doesn't know that it would be infeasible and expensive to do a release treatment to all harvested softwood stands. This can be translated to the model by creating a model control that limits the number of release treatments that can be applied to bring it more in line with what would be possible at a strategic level.

Using the proportion of all harvested softwood forest area that was released as an indicator, a goal was set to have a maximum of 45% of harvested softwood stands be released post-harvest. This was applied at the forest section level across the 200-year analysis horizon.

Indicator	Goal	Spatial Scale	Time Scale
Harvested forest area that is released	Maintain a maximum of 45%	Forest section	200 years

Setting this goal caused the amount of area that was released to decrease and become stable over the 200-year analysis horizon (Figure 12.13). This control helps to account for an aspect of operational feasibility that is more reflective of current practices, where previously the model had been averaging 65% of harvested areas released.

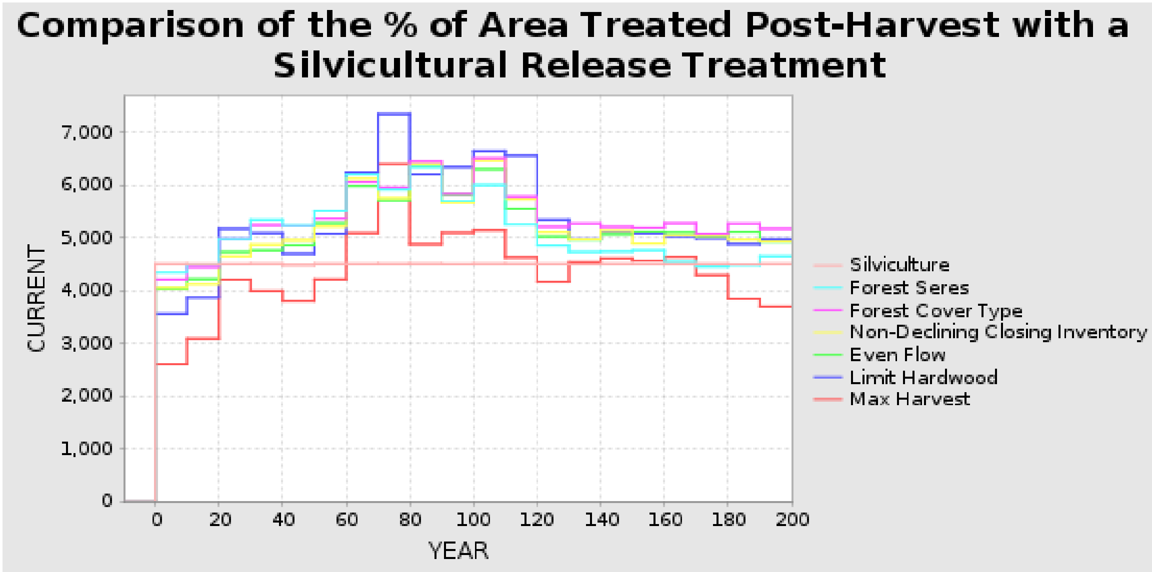


Figure 12.13. Patchworks™ report comparing the proportion of area treated post-harvest with a silvicultural release treatment between scenarios throughout the analysis process to this point, reported as the percentage multiplied by 100 (CURRENT).

12.2.2.4.3 Forest Renewal Impacts

Applying forest renewal controls within the model had minimal impact on softwood harvest levels (Figure 12.14). However, the amount of each type of forest renewal method applied changed considerably after controls were applied (see previous Figure 12.12 and Figure 12.13). This exemplifies the within-model capabilities to adjust the "choices" that are being made within the model to reach similar long-term sustainable outcomes.

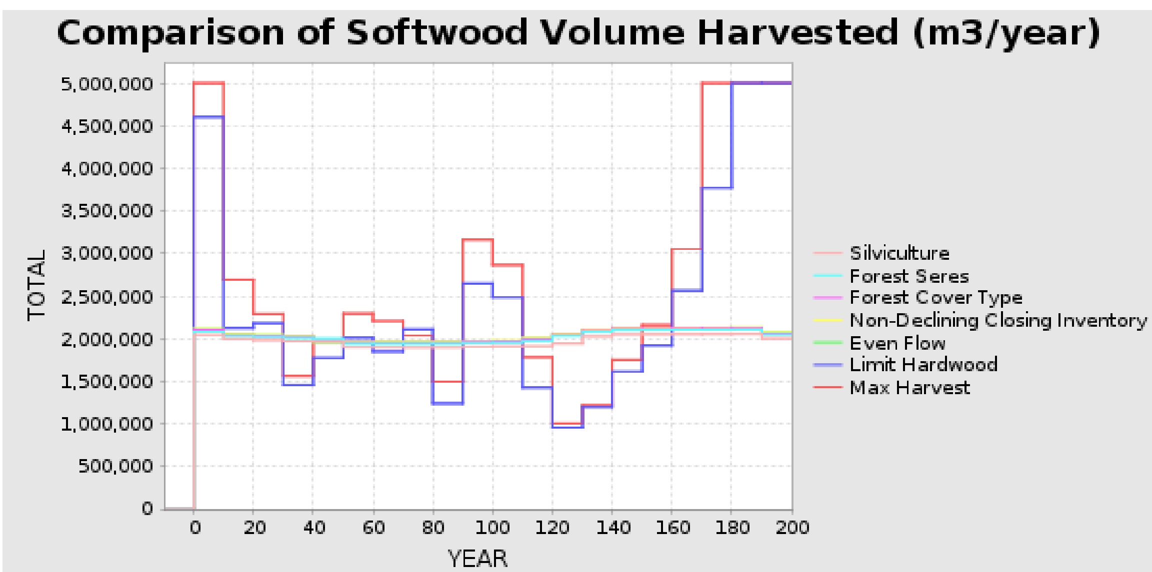


Figure 12.14. Patchworks™ report comparing softwood volume harvested, in cubic metres per year (m^3/yr), between the initial harvest maximization, hardwood limiting, even harvest flow, non-declining closing forest inventory, forest cover type, forest sere, and silviculture (forest renewal) steps of the scenario analysis process. Note that if there is minimal change in volume between analyses, lines may overlap.

12.2.2.5 Access

Access was the first spatial model control to be applied in the forest model. Prior to this, all other controls applied throughout the scenario analysis process were *aspatial* (i.e., they did not affect the spatial arrangement of harvest on the FML). Spatial model controls can influence the arrangement of activities on the landscape over time. An example of the impacts of controlling spatial features on the landscape will be shown below (Figure 12.16) in maps of the resulting activities suggested by the model. These model controls are another way to translate the idea to the forest model that all areas of the forest are not accessible everywhere, all the time. This is economically infeasible but also has a major impact on ecological indicators of the future forest. Using these spatial controls is a start to bring these known realities into a strategic landscape-level forest model.

Three transportation-related model controls were implemented for an additional layer of strategic-level operational realism and were applied through the use of the access network (see section 10.1.3 Access Network):

- Construction Cost: How much it would cost to build new roads to access previously inaccessible harvestable areas. While the “new” roads are physically present in the access network, their construction is a proposed/theoretical strategic concept. This is a way to tell the computer model to limit how it plans where harvest activities will be suggested based on a cost expenditure.
- Maintenance Cost: How much it would cost to keep Woodlands-owned roads in a useable condition; and,
- Hauling Cost: How much it would cost to use a truck and/or rail to transport wood from a harvest block to the mill.

Applying these three model controls ensures that each road in the access network has associated strategic costs. Construction costs tally the cost of each road segment when it is accessed for the first time, while existing roads have a cost of zero. Maintenance costs tally the cost of actively used forestry roads in each planning period, existing or proposed, and not including road maintained by third parties such as the government or other entities (e.g., for highways or municipal roads). Haul costs tally the cost of moving each cubic metre (m^3) of wood along the access network to the mill destination. For instance, it is most cost-effective to transport wood to the mill via existing and well-maintained highways (because you can drive faster than on forestry roads). Costs associated with hauling wood to the mill using the rail network are also applied, alongside the ability to control the volume of wood product travelling to the mill from each rail siding.

Note that the access network and related outputs associated with this model do not represent absolute cost values, the exact location and/or construction of roads on the FML, or an access plan to be adhered to. Access within a forest model is meant to provide a simple strategic-level representation of a very complex system. The controls are defined to be relative – it costs more to drive on bush roads than highways or it costs more to build a new road than use an existing one. These costs provide incentives for the model to make choices that consider the general cost of access. Adding a limit to the amount of money spent on these strategic access indicators starts to force the model to consolidate harvest activities on the landbase or make smarter choices to arrange harvest to reduce the length of road required to haul wood to the mill.

Using the length, in kilometres (km), of active road on the FML as an indicator, a goal was set to minimize the costs associated with the construction of new forestry roads, maintenance of roads, and hauling from harvested stands to the mill through road or rail access. This was applied at the FML level for the first 40 years of the 200-year analysis horizon.

Indicator	Goal	Spatial Scale	Time Scale
Lenth of active road	Minimize	FML	First 40 years

Why apply spatial model controls for only 40 years?

Model controls that have spatial implications, such as those related to access and harvest patches, are applied on a shorter (mid-term) strategic timeframe as opposed to aspatial model controls that are applied on a long-term timeframe. Using twice the forest management plan duration (40 years) to set the spatial controls allows for the forest management plan planning period to be spatially accounted for, with some degree of certainty, twice over within the 200-year analysis horizon. Due to the unpredictable nature of the boreal landscape (e.g., fire and other natural disturbances that will undoubtedly occur over the next 20 years) and other economic factors, applying spatial targets further than a mid-term period would challenge the model to make spatial considerations at an infeasible scale.

Controlling how effectively the forest model is accessing harvest blocks on the FML to achieve a more operationally feasible spatial arrangement of harvest in the short-term had a more notable impact on long-term harvest volume than the aspatial controls that preceded it (Figure 12.15).

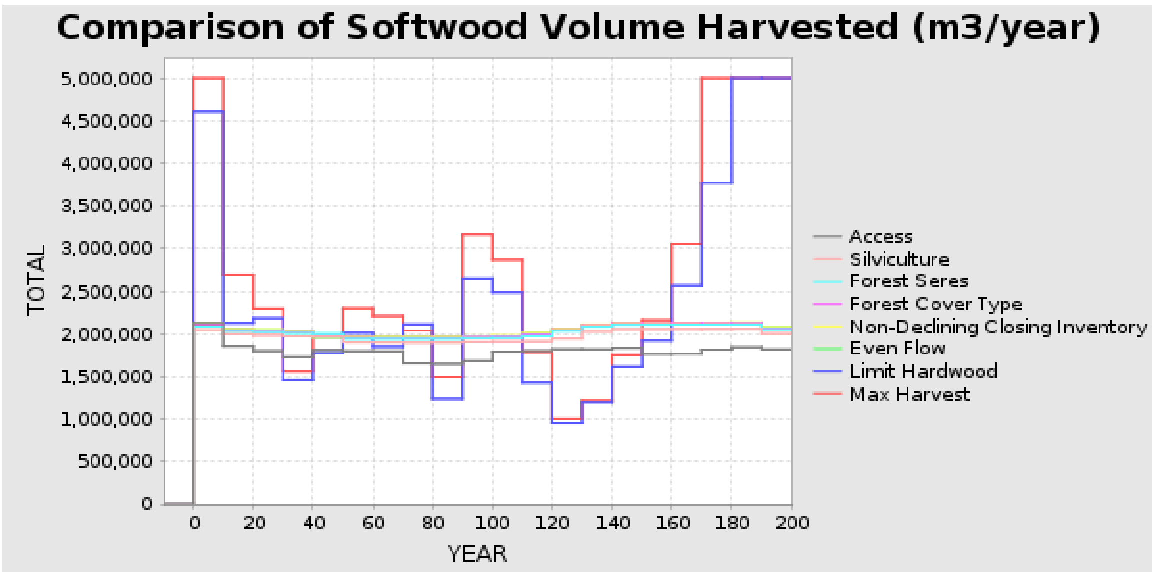


Figure 12.15. Patchworks™ report comparing softwood volume harvested, in cubic metres per year (m^3/yr), between the initial harvest maximization, hardwood limiting, even harvest flow, non-declining closing forest inventory, forest cover type, forest sere, silviculture, and access steps of the scenario analysis process. Note that if there is minimal change in volume between analyses, lines may overlap.

12.2.2.5.1 Unutilized Harvest Volume

Unutilized harvest volume is volume that has been harvested by the forest model but is not "delivered" to the mill via the access network. This may occur because the harvested polygon is not connected to the access network (within 1 kilometre), constructing new access to the harvested polygon is not economically feasible, or hauling the volume from the harvested polygon to the mill is not economically feasible. The access network is strategic in nature but does include general barriers to construction of new roads, such as water bodies, rivers, or any other areas designated as excluded from harvest. This may create areas on the FML that are "isolated" from the access network created for the forest model, even though they are productive forest and available for harvest.

Within the model, we want to reduce the amount of volume coming from these "isolated" or "unutilized" stands to minimize artificially inflating harvest volumes (i.e., the forest model reporting softwood harvest volume that is infeasible to access and/or transport to the mill in reality). Unutilized harvest volume is considered and controlled alongside the activation of the access network in the scenario analysis process (Figure 12.15).

Using the total amount (softwood and hardwood) of volume resulting from harvest that is unutilized (i.e., harvested volume that is not delivered to a destination), a goal was set to minimize unutilized volume overall. This was applied at the FML level across the entire 200-year analysis horizon.

Indicator	Goal	Spatial Scale	Time Scale
Unutilized volume	Minimize	FML	200 years

Figure 12.16 illustrates the spatial differences between scenarios at this step in the analysis process. Left (aspatial) highlights the infeasible pattern of harvest and access modelled before any spatial controls were implemented. Right highlights the point at which spatial, access-based goals were applied and a harvest pattern that is more accessibly feasible was modelled.

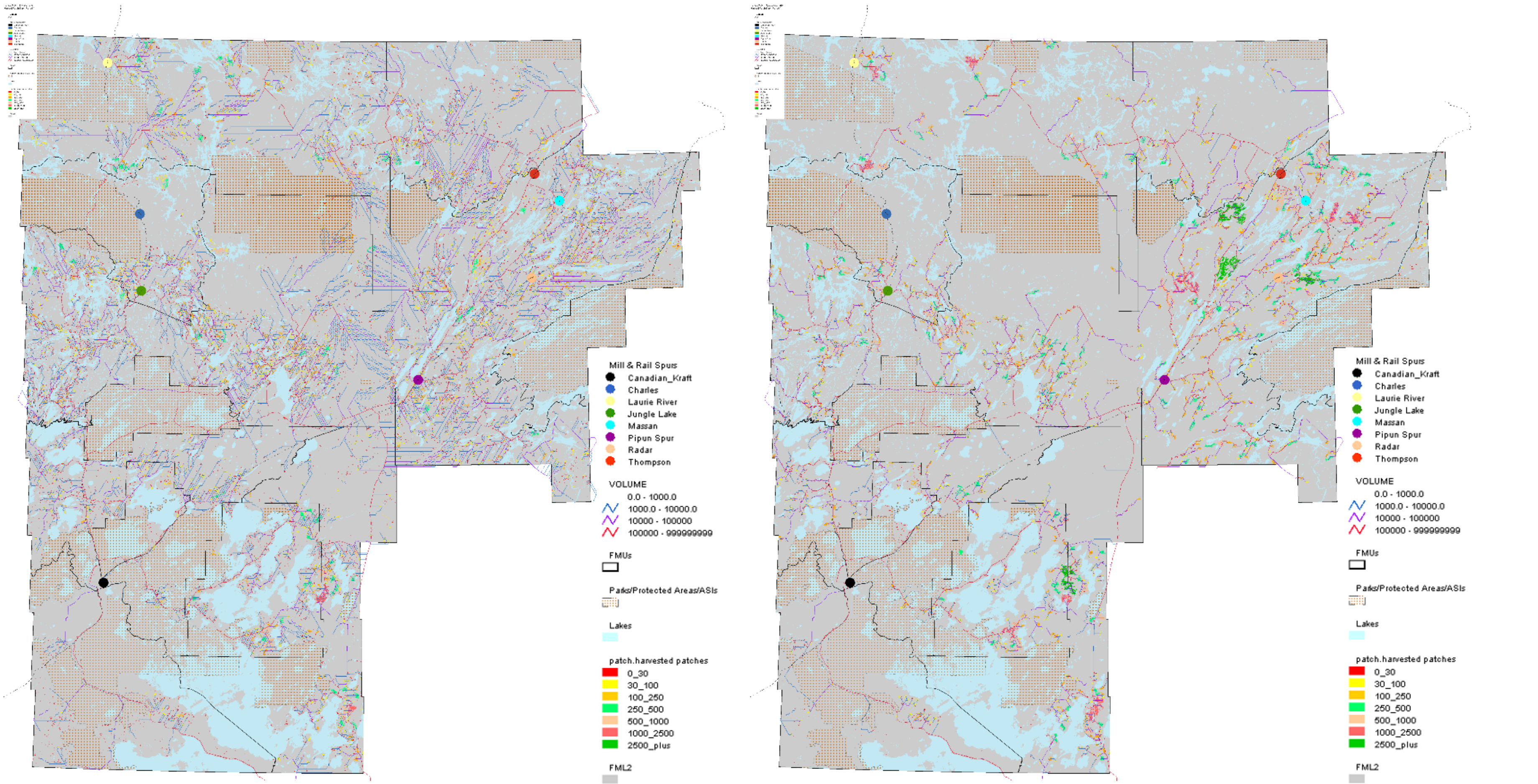


Figure 12.16. Patchworks™ map reports to compare the spatial distribution of harvest patches (patch.harvested patches, by size) and active road segments required to access those patches (VOLUME, by volume hauled) for period 1 (first 10 years of the 200-year analysis horizon) between the Silviculture (left) and Access (right) steps of the scenario analysis process.

12.2.2.6 Harvest Patches

Harvest patches are the second spatial model control to be applied in the forest model.

A harvest patch is a collection of harvested polygons that are grouped together based on their spatial proximity to one another within a 10-year modelling period. Proximity describes the distance between two or more polygons near to each other in a landbase (Figure 12.17). For the purposes of forest modelling on FML 2, separate proximities were applied based on north and south geography. This is sometimes referred to as neighbourhoods or neighbourhood relationships. The forest model can search through a defined neighbourhood to see if a polygon in that neighbourhood has the characteristics it is looking for. In this case, the forest model would be looking for other polygons that have been harvested within the same 10-year period. If this is true, the polygon becomes a member of the patch, and the size and shape of the patch can be tracked by the model.

In the southern extent of the FML (Saskatchewan River Forest Section), a 100-metre proximity threshold was applied to group harvested polygons near enough to each other to be considered a harvest patch. In the north, (Highrock and Nelson River Forest Sections), a wider proximity threshold of 200-metres was applied to capture the more varied topography of the region to account for the more variable, generally rocky and wet terrain in the region that increase the possibility of greater dispersion between forest stands. Proximity and the grouping of harvested polygons into harvest patches are discrete within each 10-year period (i.e., harvested polygons from period 1 cannot be grouped based on proximity with harvested polygons in period 2 to make a harvest patch).

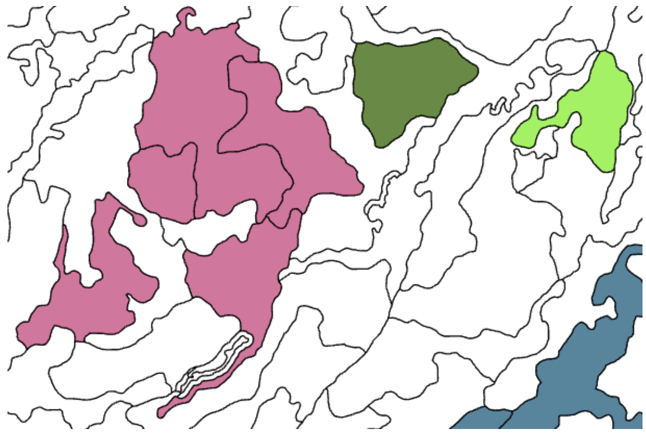


Figure 12.17. An example of harvested polygons within close proximity to each other (pink) that formed a harvest patch and harvested polygons that were outside of the proximity threshold (green and blue) that were not included in the harvest patch.

The advantage of a patch in the forest model is being able to track the size, shape, and location of the resulting group of polygons (the patch) as opposed to individual polygons. Harvest patches can be used in the forest model to influence the spatial arrangement of harvest to create a pattern that is operationally feasible, more closely resembles natural disturbance, and is as non-disruptive to the landscape as possible (Figure 12.18). This is often done by setting goals to *minimize* the amount of small harvest patches being created and to *maintain* a certain amount of larger harvest patches.

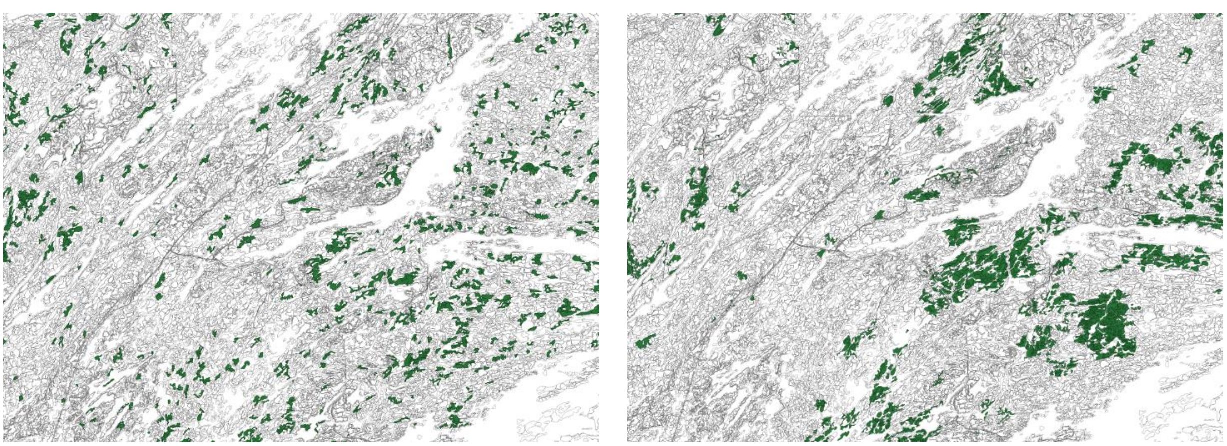


Figure 12.18. An example of before (left) and after (right) harvest patch goals are applied. Highlighted areas are harvested polygons. On the right, multiple harvest patches have been created by harvesting polygons that are within a close proximity to each other.

12.2.2.6.1 Examining Existing Openings on the Landscape

The current forest condition was examined for existing stand openings to create a starting approximation for harvest patch sizes for use in the forest model. Existing openings were categorized by aggregations of forest stands that were considered young, with the threshold age being 20 years, and were a result of natural succession (i.e., the natural aging, "dying", and renewing of the forest), natural disturbance (e.g., wildfires and insect infestations), or historical harvest. By examining existing openings, the forest management plan can set goals to create harvest patches of similar sizes that assist in maintaining the pattern of disturbance already present on the landscape.

The plan-start landbase inventory was organized into categories of existing openings of young forest through a Geographic Information Systems (GIS) raster analysis. For a polygon to be identified as part of an existing opening within the landbase, the adjacent polygons had to not only also be less than or equal to 20 years of age but be within plus-minus (±) 10 years of age of each other (i.e., two polygons aged 6 and 14 would be considered an existing opening, two polygons aged 6 and 18 would not) . Several ranges of size categories for existing openings were explored, however, all analyses led to the same conclusions. There is a large proportion of young forest (less than or equal to 20 years) on the FML that exist in large openings (greater than 2,500 hectares), and a generally even distribution of openings between the sizes of 30 and 2,500 hectares .

In Table 12.5 are the results of the analysis conducted on the current forest condition to identify existing stand openings on the FML. Very large openings (greater than 2,500 hectares) were the dominant size in both the north (Highrock and Nelson River Forest Sections) and the south (Saskatchewan River Forest Section) of the FML. Otherwise, the amount of forest in each opening size up to 2,500 hectares was relatively even, with the smallest openings of less than 30 hectares being slightly more common in the south.

Table 12.5. Existing stand opening size distributions of young forest (less than or equal to 20 years) found to occur on the landbase at plan start for the north (Highrock and Nelson River Forest Sections) and south (Saskatchewan Forest Section) of FML 2.

Existing Opening Size	Size Distribution	
	North	South
0 to 30 hectares	6%	10%
30 to 50 hectares	3%	5%
50 to 100 hectares	3%	9%
100 to 250 hectares	6%	10%
250 to 500 hectares	4%	6%
500 to 1,000 hectares	4%	6%
1,000 to 2,500 hectares	14%	5%
> 2,500 hectares	60%	49%

For the purposes of forest modelling, it was the existing openings identified within the 30 and 2,500-hectare range that became the focus of goal setting to create harvest patches of similar sizes to emulate the current distribution that reflects both natural and anthropogenic disturbances in the two regions. Of the categories that were identified through this analysis, there were two size categories that could generally be considered infeasible or unrealistic to be created in the future through harvesting:

- Less than (<) 30-hectare patches – Patches of this size are a very small area, and it is unlikely that there would be an effort put into operating for a small patch as a standalone area. While they may occur through plan implementation due to not-yet-identifiable operational reasons, patches of this size are not targeted at the strategic level; these small openings can occur naturally through succession and gaps in the canopy being created, or small insect outbreaks, blowdown, etc.; and,
- Greater than (>) 2,500-hectare patches – Patches of this size are generally caused by fires and are not operationally feasible within a single 10-year period at the FMU level.

Table 12.6 details the resulting harvest patch size goals (i.e., the proportion of the total harvested area that should occur within each patch size category) in the north and south of the FML. The largest patch size category (> 2,500 hectares) was deemed operationally infeasible and a had a goal set to minimize their occurrence within the forest model. Additionally, very small harvest patches (less than 30 hectares) also had a goal set to minimize their occurrence.

Table 12.6. Size distribution goals for harvest patches used in the forest model for target setting in the north (Highrock and Nelson River Forest Sections) and south (Saskatchewan River Forest Section). The percentages in this table are a reflection of the existing opening sizes greater than 30 hectares and less than 2,500 hectares identified in Table 12.5.

Harvest Patch Size	Goal Size Distribution	
	North	South
0 to 30 hectares	0%	0%
30 to 50 hectares	8%	11%
50 to 100 hectares	10%	22%
100 to 250 hectares	18%	24%
250 to 500 hectares	11%	16%
500 to 1,000 hectares	10%	14%
1,000 to 2,500 hectares	42%	14%
> 2,500 hectares	0%	0%

Using the size distribution of harvest patches as an indicator, a goal was set to harvest polygons in an arrangement that creates patches that are within plus or minus (±) 10% of the size distribution of existing openings found to be reflective of current forest conditions on the landscape (as described in Table 12.6). This was applied at the FML level, differentiated by northern and southern region, for the first 40 years of the 200-year analysis horizon.

Indicator	Goal	Spatial Scale	Time Scale
Harvest patch size distribution	Maintain within goal distributions currently present on the landscape	FML, divided into northern and southern regions	First 40 years

Applying this spatial control to further aggregate harvest had an additional but small impact on harvest levels (Figure 12.19). Encouraging harvest aggregation allowed for a more consistent harvest flow to be achieved in the long-term, with less consistency in the first four periods due to the more challenging nature of satisfying spatial goals in the short-term.

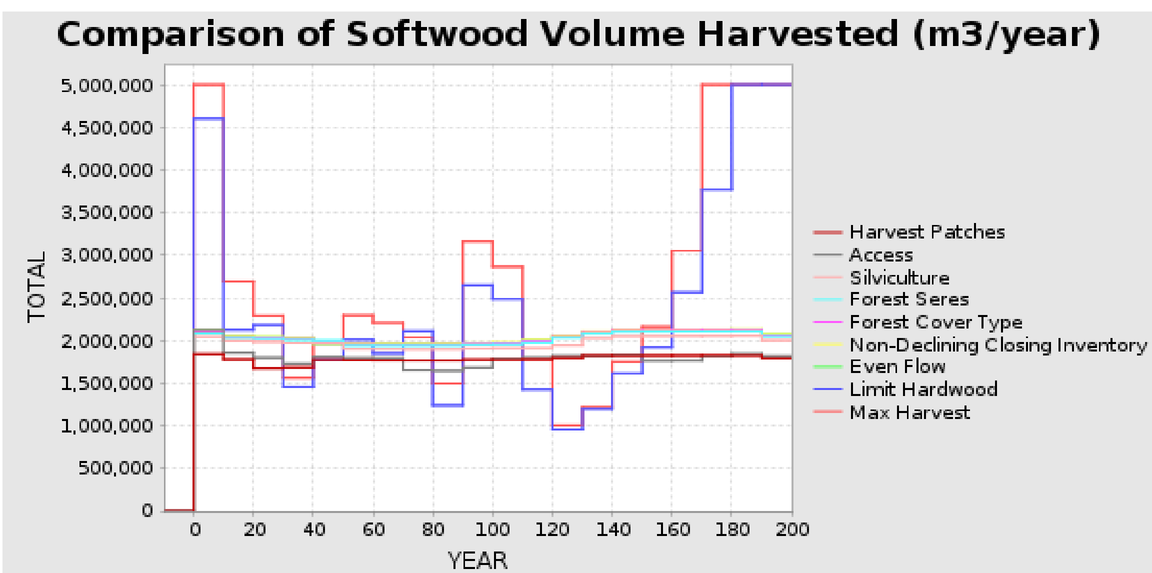


Figure 12.19. Patchworks™ report comparing softwood volume harvested, in cubic metres per year (m^3/yr), between the initial harvest maximization, hardwood limiting, even harvest flow, non-declining closing forest inventory, forest cover type, forest sere,

silviculture, access, and harvest patch steps of the scenario analysis process. Note that if there is minimal change in volume between analyses, lines may overlap.

12.2.2.7 Operating Areas

NFMC identified FML-wide preferred operating areas that were used to encourage the model to harvest within these areas, when and where possible. This was another spatial model control that did assist in creating a more operationally feasible spatial arrangement of strategic harvest in the first four periods of the 200-year analysis horizon. Forested stands within the operating areas were summarized into groups that could then be used to set a minimum area harvested model control to increase the area harvested (hectares).

Incentivizing the use of operating areas was the final model control added in the scenario analysis to represent the Baseline scenario (Figure 12.20) and had one last additional, although minimal (-1%), impact on harvest levels following the activation of within-period harvest patches.

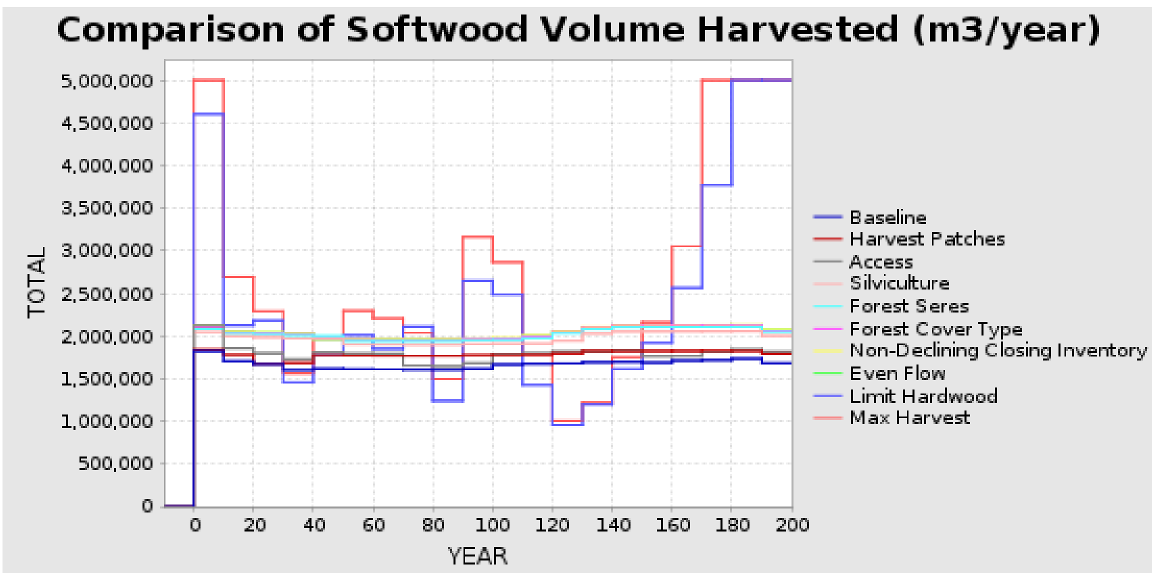


Figure 12.20. Patchworks™ report comparing softwood volume harvested, in cubic metres per year (m³/yr), between the initial harvest maximization, hardwood limiting, even harvest flow, non-declining closing forest inventory, forest cover type, forest sere, silviculture, access, harvest patch, and operating areas steps of the scenario analysis process. Incentivizing the forest model to harvest within preferred operating areas brought the scenario analysis process to the Baseline scenario.

12.2.2.8 Baseline Scenario as a Selection Option for the Preferred Forest Management Scenario

The Baseline scenario represented a scenario that included all of the management objectives that were necessary to develop a strategic direction for the forest management plan that was operationally, economically, and ecologically sustainable. The Baseline scenario demonstrates a future forest condition that would result from the forest management plan that considers a sustainable harvest levels across the FML while maintaining key ecological indicators such as maintaining forest cover types and old forest habitat on the landscape. Operational realities are considered with limits on the type and cost of forest renewal methods applied, and then economic factors such as building and maintaining roads, and minimizing haul costs, have an influence on the locations and patterns of proposed harvest in the Baseline scenario. Harvest patch sizes are organized into sizes that emulate patches of young forest that exist naturally on the landscape to help maintain coarse-filter ecological processes. The Baseline scenario represents a viable scenario that meets the key objectives of the forest management plan and that is able to be considered as a feasible option for the selection of the Preferred Forest Management Scenario.

12.2.3 Habitat Scenario

The Habitat scenario built upon the Baseline scenario, including all model controls described in the scenario analysis process. The development of the Habitat scenario was the result of collaborative discussions and exploring additional model controls that could achieve better outcomes for the desired future forest conditions for some habitat elements. The following key aspects of the forest model were further explored:

1. Applying a maximum softwood harvest level by forest management unit;
2. Emphasizing the importance of even harvest flow to encourage a more consistent and predictable flow of volume; and,
3. Activating young forest patches.

Further details regarding these items can be found in the following subsections.

12.2.3.1 Harvest Levels

Following the development of the Baseline scenario, harvest levels were assessed in comparison to the provincially-determined annual allowable cut (AAC; refer to Table 12.2 in the Harvest Levels section of the Baseline Scenario analysis). With some forest management units able to sustainably harvest above the AAC level set by the Province in the Baseline scenario, the Habitat scenario set goals to limit softwood harvest levels only up to a certain amount in the forest management units deemed necessary (i.e., where above provincial AAC in the Baseline scenario) to more closely align with the provincial AAC.

Using the amount of softwood volume harvested by forest management unit (FMU) as the indicator, the goal for softwood harvest levels was adjusted to be limited to +2.5% of the provincial annual allowable cut (AAC; Table 12.2). A range of +2.5% of the AAC was used to preserve within-model flexibility at the strategic level. This was applied on the forest management unit (FMU) level across the entire 200-year analysis horizon.

Indicator	Goal	Spatial Scale	Time Scale
Softwood harvest levels	Limit up to +2.5% of AAC where necessary	Forest management unit	200 years

12.2.3.2 Young Forest Patches

For the Habitat scenario, we introduced the concept of young forest patches—a type of feature patch.

How does a young forest patch differ from a harvest patch?

Recall that a harvest patch is a collection of polygons that are grouped together based on their spatial proximity to one another within a 10-year modelling period. A young forest patch is similar in that it groups polygons together based on proximity to one another, but with some key distinctions in criteria for patch membership, and proximity (neighbourhood distances):

- Young forest patches are not limited to considering only harvested polygons – young forest patches can consider any forest polygon less than or equal to 20 years old, including young forest from natural succession, existing natural disturbances, or harvest;
- Young forest patches are not limited to assessing proximity within a single, discrete 10-year period. Instead, young forest patches can assess proximity within discrete 20-year periods; and,
- Young forest patches used a uniform proximity threshold of 200-metres for grouping across the FML (where harvest patches used separate proximities based on north/south geography). Any polygon less than 20 years of age and within 200 metres of each other can become a part of a young patch across the FML.

The inherent goal of both types of patches are the same—to aggregate harvest in way that minimizes disturbance and habitat fragmentation on the landscape. The use of both types of patches has a cumulative effect within the forest model that takes harvest aggregation one step further, creating a harvest pattern that is less disruptive and further reduces the amount of road required to access operating areas (Figure 12.21).

Figure 12.21. An example of before (left; Baseline scenario) and after (right; Habitat scenario) young forest patch goals are applied. Highlighted areas are harvested polygons. Dark green polygons were harvested in period 1 (the first 10 years). Light green polygons were harvested in period 2 (the following 10 years). On the right, multiple harvest patches have been further aggregated.

Where the creation of a large harvest patch that best emulates natural disturbance may be infeasible to achieve within a single 10-year period, progressively 'growing' these patches across the full 20-year duration of the forest management plan is a considerably more approachable concept. This concept, in the modelling world, helps group disturbances between periods and encourage future harvest to use existing infrastructure.

Activating young forest patches within the model allows for the creation of a future forest condition that introduces new habitat features as well as maintains existing habitat features that are a more appropriate size and configuration for boreal woodland caribou. These larger patches of young forest further aggregate the harvest pattern into fewer active operating areas on the forest, reducing habitat disturbance and fragmentation. Over the 20-year duration of the forest management plan, the pattern of management activities across the FML is projected to be more similar to observed natural patterns, with more areas of young forest existing in patches greater than 5,000 hectares in size.

Using the size distribution of young forest patches as an indicator, a goal was set to create an arrangement of young forest patches that are within plus or minus (±) 10% of the size distribution specified in Table 12.7 to encourage an arrangement that is more representative of the spatial patterns of young forests created by natural disturbance. This was applied at the FML level for the first 40 years of the 200-year analysis horizon.

Indicator	Goal	Spatial Scale	Time Scale
Young forest patch sizes	Maintain within goal distributions	FML	First 40 years

Table 12.7. Size distribution goals for young forest patches used in the forest model for target setting on the FML.

Young Forest Patch Size	Goal Size Distribution
0 to 1,000 hectares	-
1,000 to 2,000 hectares	10%
2,000 to 5,000 hectares	40%
> 5,000 hectares	50%

12.2.3.3 Habitat Scenario Impacts

Figure 12.22 compares the softwood harvest levels for the Baseline and Habitat scenarios. Harvest levels saw a significant decrease when compared to the Baseline scenario. Aggregating the harvest pattern to create larger and more contiguous patches of young forest was restrictive on the overall harvest pattern and level that was possible.

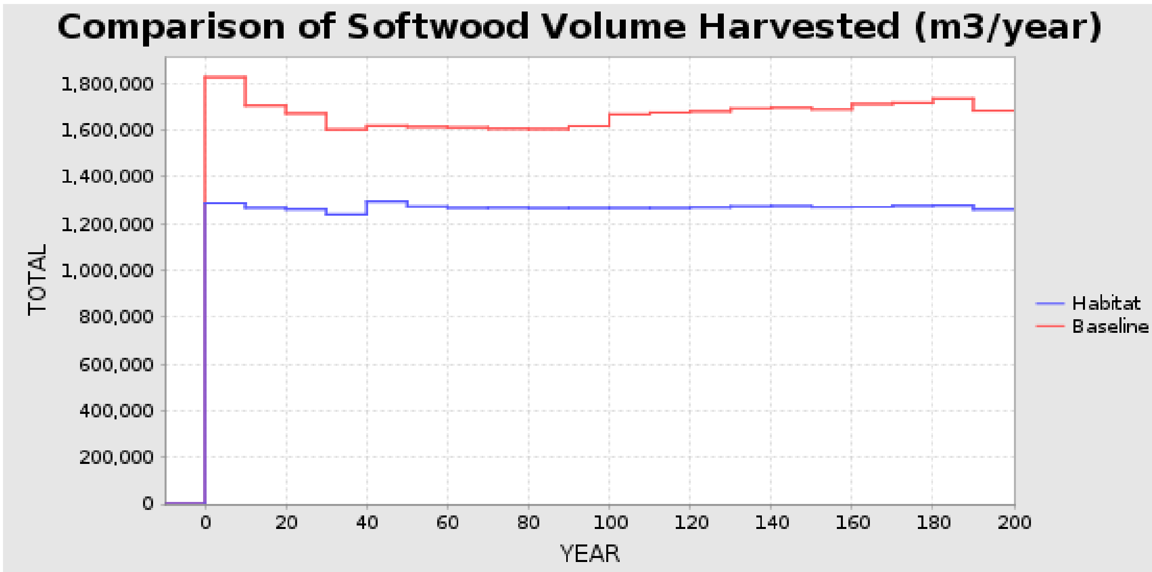


Figure 12.22. Patchworks™ report comparing softwood volume harvested, in cubic metres per year (m^3/yr), between the Baseline and Habitat scenarios.

With the overarching goal of the Habitat scenario being to reduce habitat disturbance on the landscape from harvesting and linear features like roads, assessing these indicators also provides insight into the impacts of the additional model controls applied. The following figures demonstrate that the Habitat scenario was successful in minimizing the total length of new roads required to access the proposed future harvest (Figure 12.23), maintaining suitable habitat across FML 2 (Figure 12.24), and further aggregating the spatial distribution of harvest on the landscape (Figure 12.25).

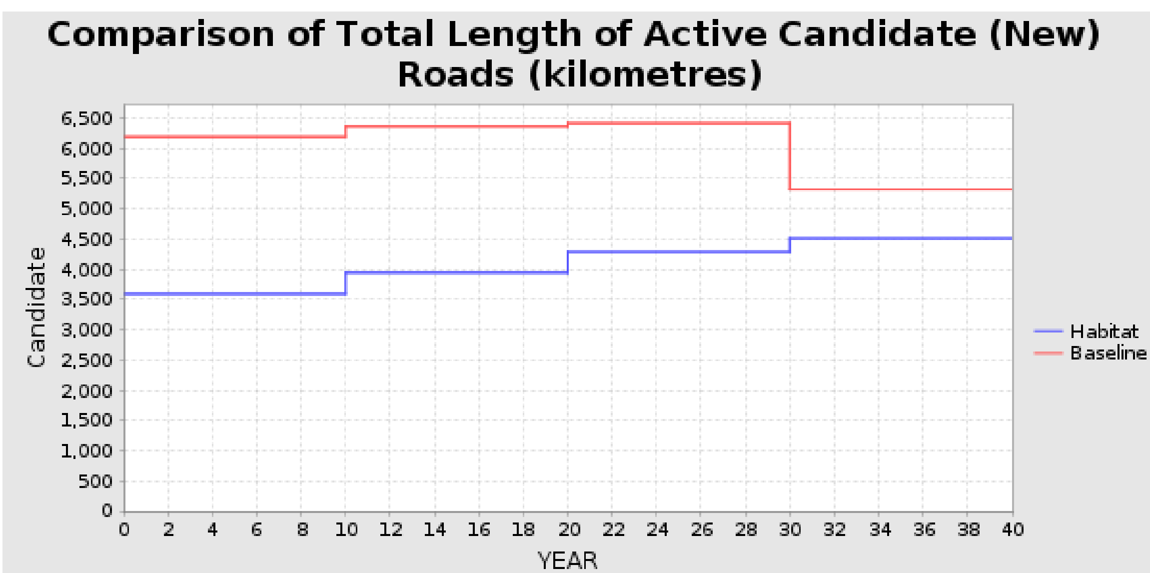


Figure 12.23. Patchworks™ report comparing the total kilometres of candidate (new) road required to access the proposed future harvest for the first 40 years of the analysis horizon between the Baseline and Habitat scenarios.

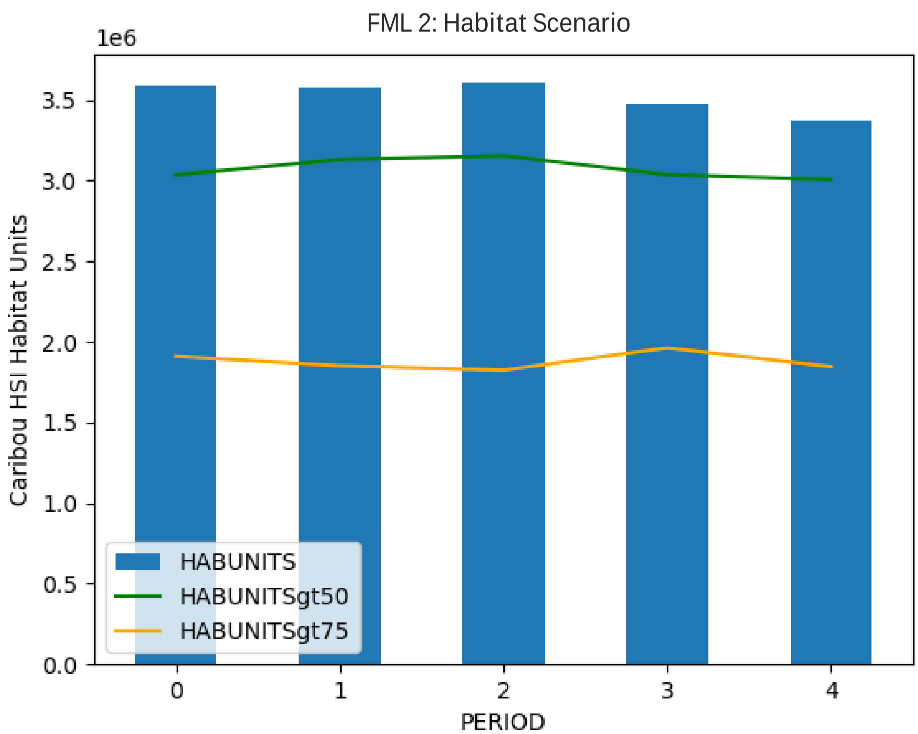


Figure 12.24. Area that has a caribou habitat suitability index (HSI) value greater than 0 (HABUNITS), and of that area, the area that has an HSI value greater than 0.5 (HABUNITSgt50) and 0.75 (HABUNITSgt75) for the entire FML area resulting from the Preferred Forest Management Scenario (PFMS).

Figure 12.25 illustrates the spatial differences between the Baseline (left) and Habitat (right) scenarios. Left (Baseline) represents a viable and sustainable option for strategic direction for the forest management plan. Right (Habitat) represents another viable and sustainable option for strategic direction but considers an additional layer of spatial aggregation to minimize habitat disturbance caused by management activities and access. This minimization of habitat disturbance results in a trade-off with harvest levels, as seen in Figure 12.22.

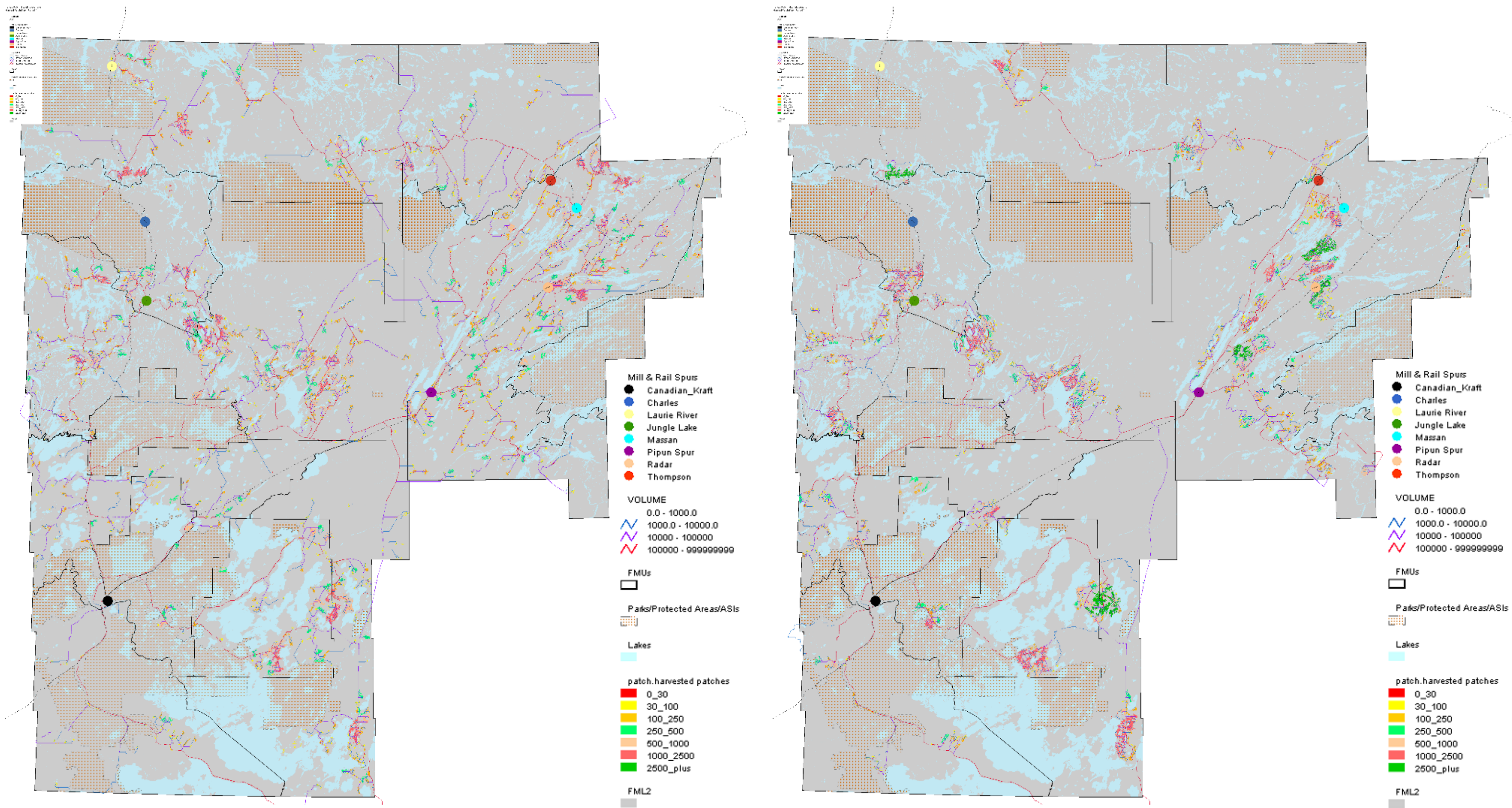


Figure 12.25. Patchworks™ map reports to compare the spatial distribution of harvest patches (patch.harvested patches, by size) and active road segments required to access those patches (VOLUME, by volume hauled) for period 1 (first 10 years of the 200-year analysis horizon) between the Baseline (left) and Habitat (right) scenarios.

13 Preferred Forest Management Scenario

13.1 SELECTION PROCESS

The selection of a Preferred Forest Management Scenario (PFMS) is a requirement under the Province's *20-Year Forest Management Plan Guideline* (Manitoba Agriculture and Resource Development, 2021) and was tasked to the FML 2 20-Year Forest Management Plan Planning Team.

The Planning Team evaluated and ranked scenarios based on how well they met key ecological and socio-economic strategic-level goals according to the method outlined in the Province's *20-Year Forest Management Plan Guideline* (Manitoba Agriculture and Resource Development, 2021). The goals evaluated had to be quantifiable (i.e., measurable). The scenario that scored that highest in these evaluations was selected as the PFMS.

As described through the scenario analysis process (see section 12 Scenario Analysis), two final scenarios were developed and used for the purposes of this exercise: the Baseline scenario and the Habitat scenario.

The Baseline scenario featured an operationally feasible strategic direction that considered all aspects of scenario analysis to achieve long-term environmental and economic sustainability.

The Habitat scenario built upon the Baseline scenario, with the key differentiator being the inclusion of an additional patch target to further aggregate disturbance. This cumulative aggregation better emulates natural disturbance patterns favoured by some wildlife species, such as boreal woodland caribou, while also requiring fewer active roads to access potential harvest areas, minimizing linear fragmentation and overall minimizing landscape disturbance.

The scenario chosen by the Planning Team as the PFMS was the Habitat scenario. Scoring objective achievement was done by individuals and groups of individuals from the Planning Team. For example, the provincial Wildlife Branch scored weights and objective achievement as a group of individuals from within that branch that were on the Planning Team.

The scoring exercise required each individual or group of individuals assign a perceived personal weight of value for each objective indicator. Weights options ranged from 1 (less valuable) to 3 (more valuable).

Respondents then identified which scenario (Baseline or Habitat) had the best level of objective achievement. Objective achievement could be scored as one scenario having better achieved the objective than the other *or* there being no perceivable significant difference in objective achievements. If one scenario was scored as the better achieving of the two scenarios, it received a score of 2, and the other scenario received a default score of 1. If a respondent felt that objective achievement had no perceivable significant difference between scenarios, a score of 0 was applied.

The weight and objective achievement were then combined for each respondent or group of respondents to calculate the weighted total score for objective achievement for each objective indicator. This was calculated by multiplying together the weight (1-3) and objective achievement score (0-2).

Weighted Total Score for Objective Achievement = Weight of Value Score x Objective Achievement Score

For example, if an objective indicator was weighted as more valuable (3) to an individual and that same individual determined that the Habitat scenario was found to be best-achieving (2) of that objective indicator, the Habitat scenario received a weighted total score for objective achievement of 6, and the Baseline scenario received a score of 3, for that specific objective indicator, for that specific individual's response.

6 = 3 x 2 (Habitat Scenario); 3 = 3 x 1 (Baseline Scenario)

The results of the ranking exercise to select a PFMS are summarized and reported in Table 13.1. The weighted total score for objective achievement reported in this table is the sum of all responses for that objective indicator.

Table 13.1. Preferred Forest Management Scenario selection process final ranking table of objective indicators and weighted total scores for objective achievement.

	Weighted Total Score for Objective Achievement	
Objective Indicator	Scenario #1 Baseline	Scenario #2 Habitat
Softwood forest area within the Saskatchewan River (SK), Highrock (HR), and Nelson River (NR) forest sections, respectively.	5	10
Softwood (S), softwood mixedwood (M), and hardwood (H) species groups forest area by old (O) and very old (VO) seral stage the Saskatchewan River (SK), Highrock (HR), and Nelson River (NR) forest sections, respectively.	14	28
Mature forest area within identified harvestable Wildlife Management Areas (WMAs).	11	10
Young forest patches created by harvest represented within a suitable area distribution range indicative of the natural range of variation as a result of planned harvest activities.	13	26
Forest area that is considered preferred habitat for boreal woodland caribou within each Caribou Management Unit.	12	24
Gross FML area that is suitable boreal woodland caribou habitat as identified using a post-processing habitat suitability index (HSI) model.	12	24
Proportion of the landscape that is estimated to be undisturbed within each caribou management unit (CMU) on the FML.	12	24
Forest area defined as moose habitat.	26	13
Amount of operable softwood growing stock on the productive forest landbase per forest management unit (FMU) in the last 50 years of the 200-year planning horizon.	7	14
Length of active road required to access the projected future harvest.	17	34
Watershed area with recent stand-replacing disturbance.	3	6
Estimate of stored forest ecosystem carbon.	10	20
Projected softwood harvest level (m^3) per each forest management unit (FMU).	14	28
Change in softwood flow (%) between periods per each forest management unit (FMU).	9	18
Volume (m^3) of unutilized hardwood projected to be produced as a by-product of softwood harvest.	13	26
Net silviculture budget.	10	8
Forest area treated post-harvest with a silvicultural release treatment to ensure regeneration of condition within the Saskatchewan River (SK), Highrock (HR), and Nelson River (NR) forest sections, respectively.	3	6
Jack pine forest area treated post-harvest that is scarified.	13	26
Score	204	345
Preferred Forest Management Scenario	Habitat Scenario	

13.2 RESULTS

13.2.1 Harvest Volume

13.2.1.1 Harvest Levels

Projected strategic harvest levels for the 20-year duration of the forest management plan are reported in Table 13.2 on the following page, and reflected for the entirety of the 200-year analysis horizon at the FML-level in Figure 13.1.

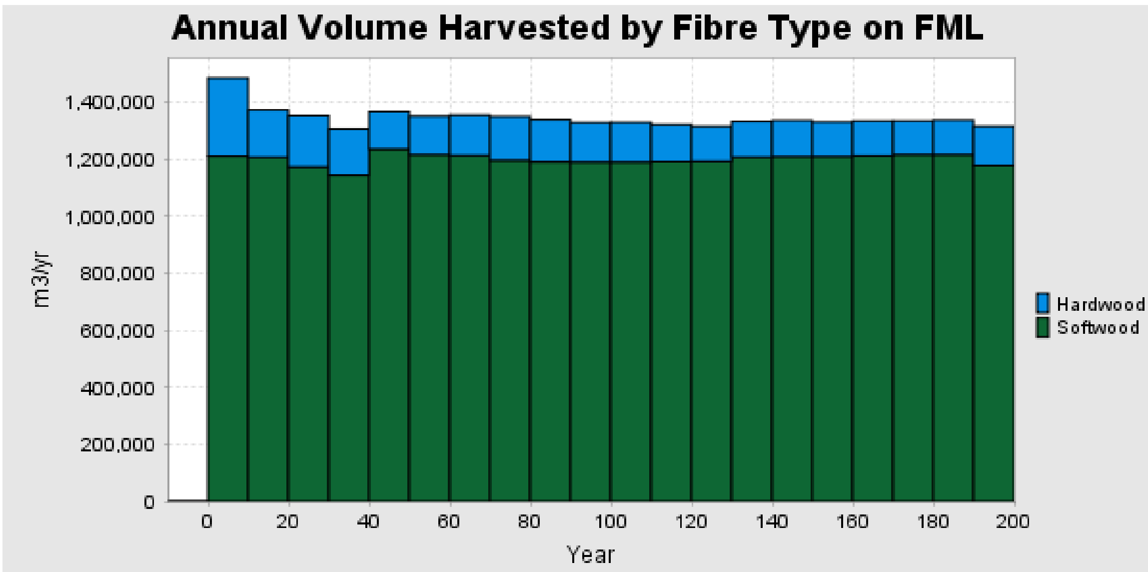


Figure 13.1. Patchworks™ report of the volume harvested, in cubic metres per year (m^3/yr), by fibre type on the FML resulting from the Preferred Forest Management Scenario (PFMS). See Figure 13.2 for reports by forest management unit (FMU).

While the intention of the forest model analysis is to determine a softwood harvest level that can be sustained in the long-term, some operational realism reflective of NFMC's current utilization levels and anticipated access were built into the forest model. For example, forest management units (FMUs) 69, 800, and 802 are the most remote locations relative to the location of the Canadian Kraft Paper Industries Ltd (CKP) mill in The Pas. These areas have not previously been accessed or operated in at their full annual allowable cut (AAC), and this is expected to remain consistent during the 20-year implementation of the plan. As such, harvest levels were permitted to be reduced to reflect this, providing a clearer projection of the ecological condition of the landscape in those areas.

FMUs in which operations have regularly occurred in the past have been strategically modelled at an average of 85% of the provincially-determined AAC in the short- and mid-term (Table 13.2; Figure 13.2). Prioritizing the spatial aggregation of harvest in an effort to minimize habitat disturbance and fragmentation was the most influential in reducing harvest levels to less than the AAC in many FMUs.

In FMU 801 of the Nelson River Forest Section, however, harvest levels were sustainably maintained at 102% of the AAC alongside spatial harvest aggregation. Contiguous, previously unharvested forest area is more common in the Nelson River Forest Section, and FMU 801 is the most accessible of the three Nelson-River-based FMUs, allowing for both economic, ecological, and spatial objectives to be maintained at the strategic level. Although above AAC by 2%, the forest model goal was set to be limited to +2.5% of AAC to allow for strategic flexibility. In this instance, should NFMC approach reaching strategic-level utilization in FMU 801 during plan implementation, NFMC will not harvest above the provincially-determined AAC.

Table 13.2. Softwood harvest volume, in cubic metres per year (m^3/yr), for each forest management unit (FMU) resulting from the Preferred Forest Management Scenario (PFMS). Volumes are reported for the first 10 years of the forest management plan (i.e., the short-term – 2025 to 2035), the second 10 years of the forest management plan (i.e., the mid-term – 2035 to 2045), and 100 years into the future (i.e., the long-term), and are compared as a proportion of the target AAC (see sections 12.2.2.1.1 and 12.2.3.1 Harvest Levels).

FMU	Softwood Harvest Volume (m^3/yr)			Target AAC (m^3/yr)	Proportion of AAC		
	Short-term 2025-2035	Mid-term 2035-2045	Long-term 2125		Short-term 2025-2035	Mid-term 2035-2045	Long-term 2125
50	23,639	23,702	21,290	27,959	85%	85%	76%
53	94,975	95,013	96,233	106,244	89%	89%	91%
58	96,470	96,343	84,083	133,946	72%	72%	63%
59	88,014	87,923	77,258	98,348	89%	89%	79%
67	308,392	308,258	306,545	403,587	76%	76%	76%
68	52,199	52,217	61,678	64,934	80%	80%	95%
69	77,851	78,012	90,103	238,210	33%	33%	38%
800	12,882	12,889	14,798	19,712	65%	65%	75%
801	399,157	399,157	379,688	389,422	102%	102%	98%
802	58,287	54,247	58,886	142,649	41%	38%	41%
Total	1,211,866	1,207,761	1,190,562	1,625,011	75%	74%	73%

13.2.1.2 Harvest Flow

The strategic direction of the forest management plan strives to achieve a flow of harvest volume at all temporal scales that is consistent, predictable, and sustainable both economically and environmentally.

The short- and mid-term harvest volumes remain consistent and predictable, while differences for some forest management units (FMUs) are predicted in the long term.

FMUs 68, 69, and 800 see an increase in strategic harvest levels in the long-term. These FMUs were purposefully operationally refined in the short-term to favour minimizing habitat disturbance, resulting in lower short-term harvest levels.

13.2.1.3 Harvest Product Type

Reflective of the objective to minimize hardwood harvest on the FML, hardwood harvest levels make up less than 20% of the total projected harvest levels for the Preferred Forest Management Scenario (PFMS) in the first 20 years of analysis (the duration of this forest management plan; Figure 13.1). These hardwood volumes serve to capture any hardwood harvest that may occur on the FML as a result of operators other than NFMC who may be licenced to harvest hardwood products from the area, as well as any hardwood by-product generated from within softwood and softwood-leading mixedwood stands harvested by NFMC.

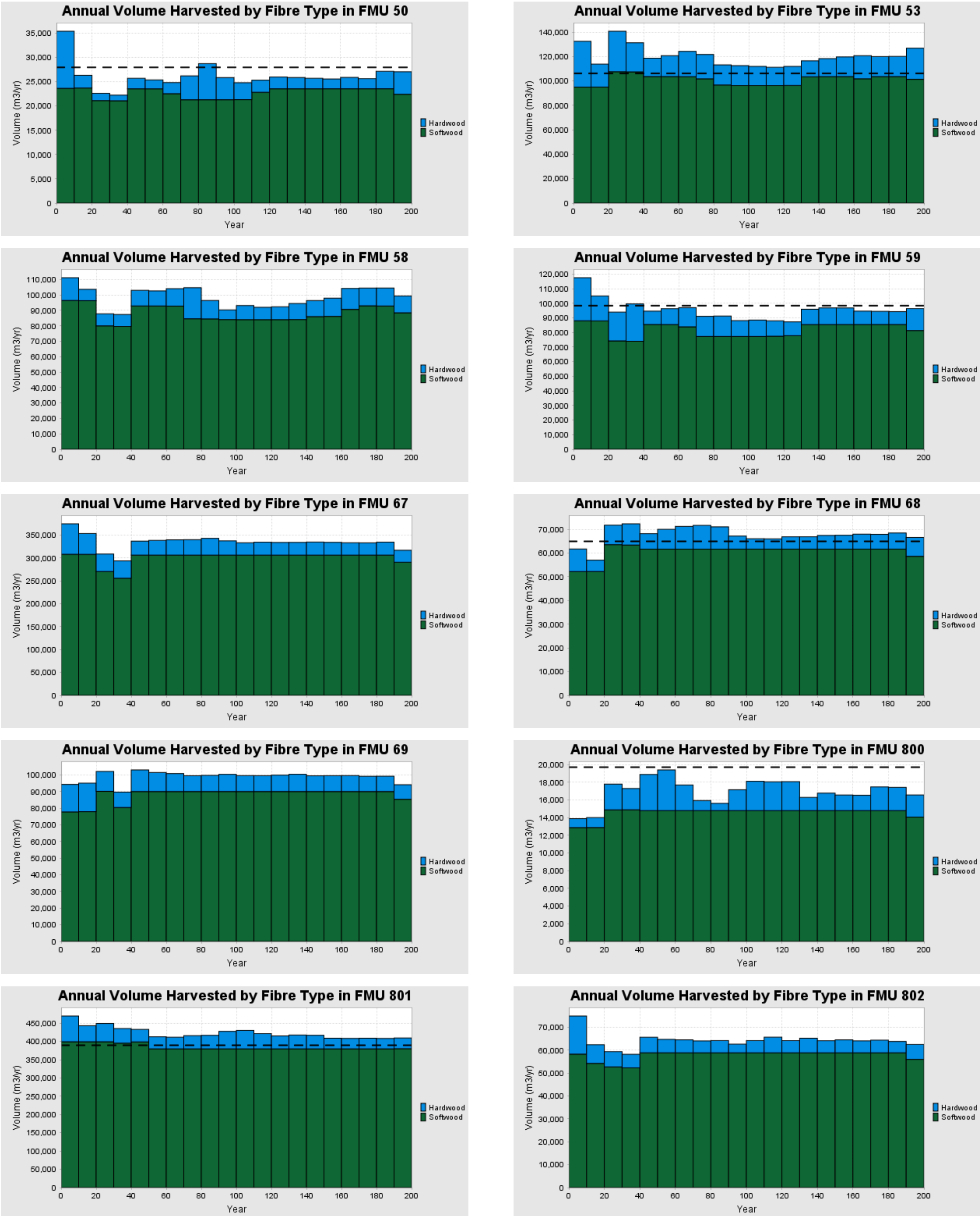


Figure 13.2. Patchworks™ reports by forest management unit (FMU) of the volume harvested, in cubic metres per year (m³/yr), by fibre type on the FML resulting from the Preferred Forest Management Scenario (PFMS). Black dashed lines indicate provincially-determined softwood annual allow cut (AAC) levels for each respective FMU. If the dashed line is not visible, projected harvest levels are below provincially-determined AAC.

13.2.2 Closing Forest Inventory

The non-declining closing softwood forest inventory is reported as the proportionate change in the volume of operable softwood growing stock within each forest management unit (FMU) in the last 50 years of the 200-year analysis horizon. A neutral (0%) change indicates that the amount of closing inventory is remaining consistent, while a positive change indicates that the amount of closing inventory is increasing. Both values indicate long-term sustainability.

In the Preferred Forest Management Scenario (PFMS), all FMUs were found to be maintaining or increasing closing softwood forest inventory in the last 50 years of the 200-year analysis horizon (Table 13.3;Figure 13.3).

Table 13.3. Closing softwood forest inventory (i.e., operable softwood growing stock) proportionate change in volume for each forest management unit (FMU) resulting from the Preferred Forest Management Scenario (PFMS). The proportionate change is measured based on the average change in the last 50 years of the 200-year analysis horizon.

FMU	Proportion of Change in Closing Softwood Forest Inventory (Operable Softwood Growing Stock)
50	+2%
53	0%
58	0%
59	+2%
67	+5%
68	+1%
69	+13%
800	+11%
801	+18%
802	+20%

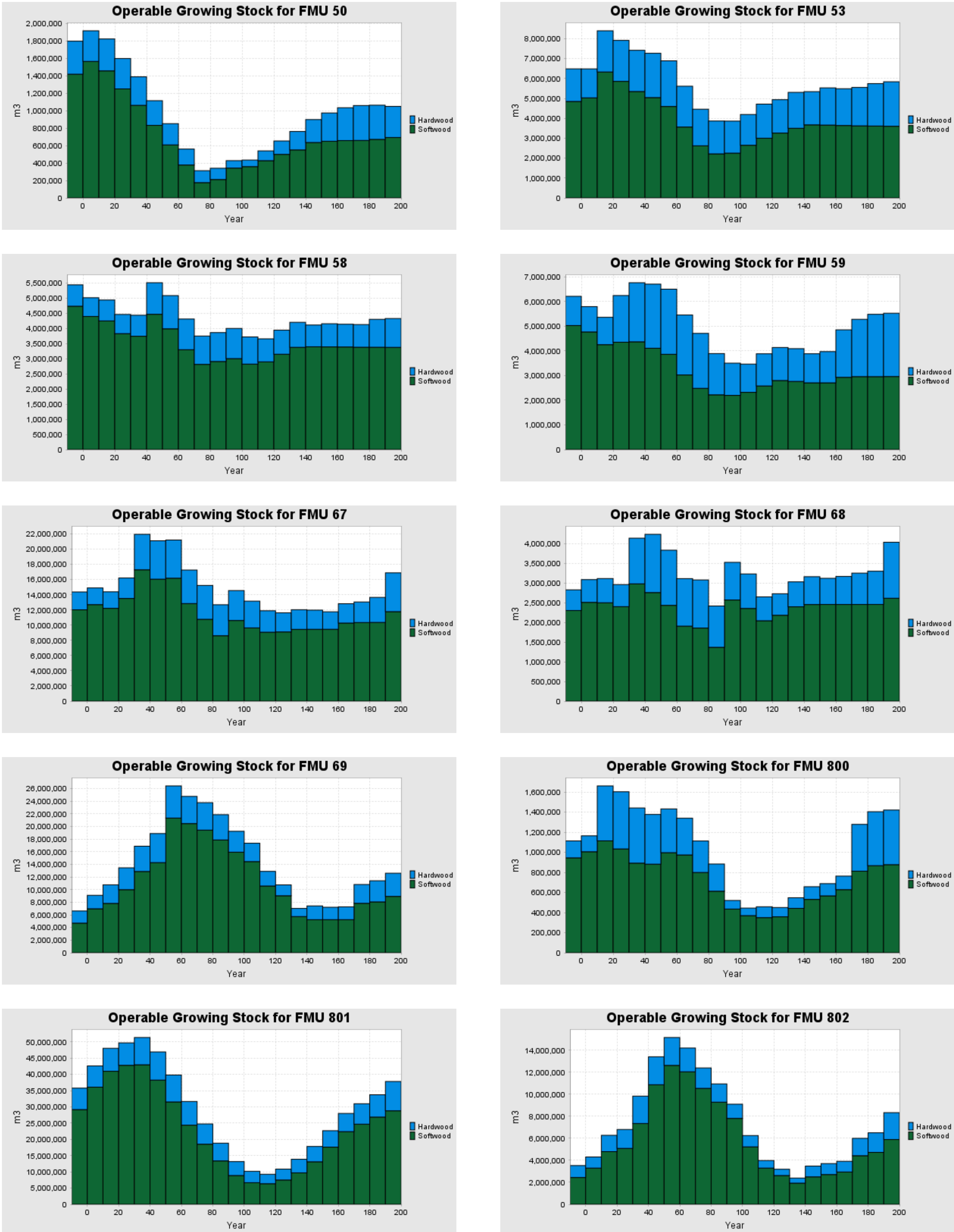


Figure 13.3. Patchworks™ reports by forest management unit (FMU) of the operable growing stock, in cubic metres per year (m^3/yr), by fibre type on the FML resulting from the Preferred Forest Management Scenario (PFMS).

13.2.3 Biodiversity

13.2.3.1 Forest Cover Type

Forest cover type is reported at the strategic level as the proportion of the productive forest area that is softwood cover type. The focus of this objective was to prevent landscape-level conversion of softwood cover types to mixedwood and/or hardwood-leading cover types as a result of forest management activities.

The desired target was to maintain the predominant forest cover type, softwood forest, within plus or minus of the amount present at plan start, which in turn assists in maintenance of mixedwood and hardwood forest cover on the FML as well. The desired target was maintained in all forest sections at all time scales, with almost no foreseeable conversion predicted to occur as far as 100 years in the future based on the proposed forest management activities of the PFMS.

Table 13.4 and Figure 13.4 report the proportion of productive forest area that is softwood cover type resulting from the Preferred Forest Management Scenario (PFMS). Actual forest area, in hectares, is reported in the Values, Objectives, Indicators, and Targets (VOITs) table in Appendix N.

Table 13.4. Proportion of and actual productive forest area that is softwood forest cover type for each forest section resulting from the Preferred Forest Management Scenario (PFMS). Softwood forest cover type is reported on for the end of the first 10 years of the forest management plan (i.e., the short-term – 2025 to 2035), the end of the second 10 years of the forest management plan (i.e., the mid-term – 2035 to 2045), and projected 100 years into the future (i.e., the long-term).

Forest Section	Proportion of Productive Softwood Forest Area			
	Plan Start – 2025	Short-term – 2035	Mid-term – 2045	Long-term – 2125
Saskatchewan River	69%	69%	69%	69%
Highrock	74%	74%	74%	73%
Nelson River	79%	79%	79%	79%

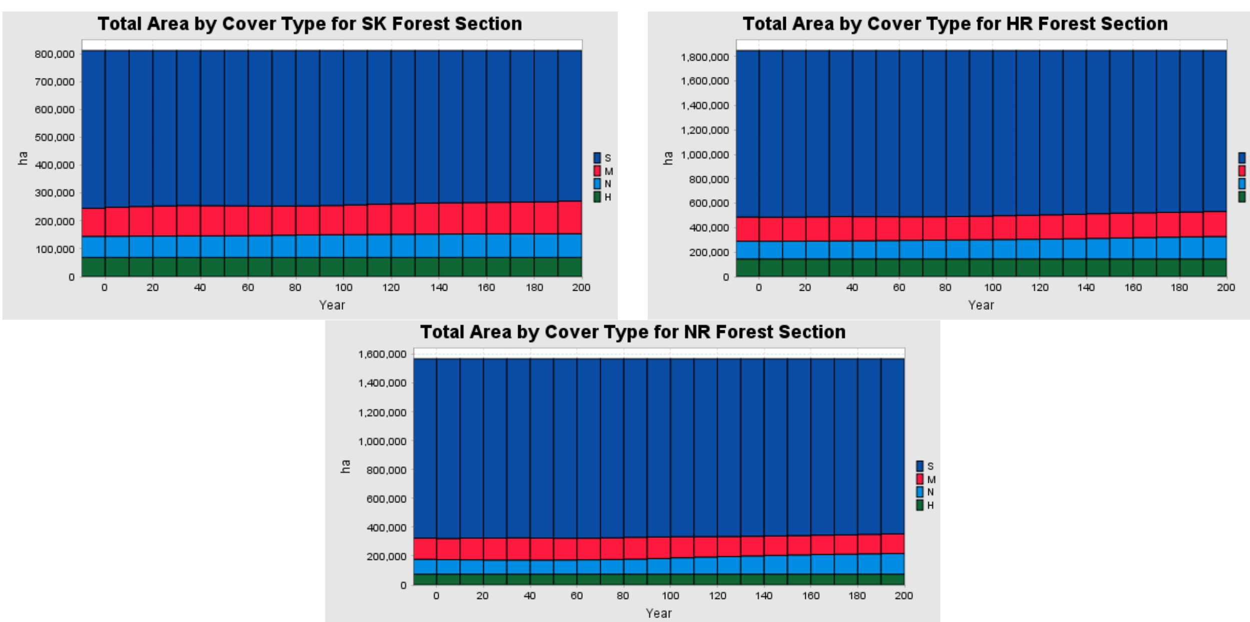


Figure 13.4. Patchworks™ reports by forest section of the area distribution, in hectares (ha), of each forest cover type on the FML resulting from the Preferred Forest Management Scenario (PFMS). Forest cover types are softwood (S), softwood-leading mixedwood (M), hardwood-leading mixedwood (N), and hardwood (H).

13.2.3.2 Forest Seral Stages

Forest seral stage targets are reported at the strategic level as the proportion of the productive forest area that fall within old and very old seral stages by seral-specific forest type – softwoods and softwood-leading mixedwoods (jack pine dominated), softwoods and softwood-leading mixedwoods (spruce dominated), and hardwoods and hardwood-leading mixedwoods. The desired target is to maintain a minimum of 15% of all seral forest types as old ("old" or older, i.e. old and very old forest), with at least 5% of this area maintained as very old forest within each forest section. The focus of this objective was to ensure adequate representation of sere-specific habitat types that may be at risk of becoming scarce on the landscape as a result of forest management activities and other disturbances. Old and very old seral representation on the landscape is projected to be well maintained at the desired target level at all time scales, with many overachieving the desired target level considerably in the long-term. While the short- and mid-term achievement levels will be targeted for the 20-year duration of the forest management plan, it should be noted that these values do not take into consideration young forest patches that will inevitably be created in the future as a result of natural disturbance. When layered in with harvest levels projected at the strategic level, the amount of old and very old sere area on the productive forest would likely be less than predicted by the Preferred Forest Management Scenario (PFMS).

Table 13.5 and Figure 13.5 report the proportion of productive forest area that is old (or older) and very old by seral-specific forest type resulting from the PFMS. Actual forest area, in hectares, is reported in the Values, Objectives, Indicators, and Targets (VOITs) table in Appendix N.

Table 13.5. Proportion of the productive forest area that is old (or older) and very old by seral-specific forest type for each forest section resulting from the Preferred Forest Management Scenario (PFMS). Seral proportion is reported on for the end of the first 10 years of the forest management plan (i.e., the short-term – 2025 to 2035), the end of the second 10 years of the forest management plan (i.e., the mid-term – 2035 to 2045), and projected 100 years into the future (i.e., the long-term).

Forest Section	Proportion of Productive Forest Area					
	Forest Type (Seral)	Seral Stage	Plan Start – 2025	Short-term – 2035	Mid-term – 2045	Long-term – 2125
Sask. River	Softwood	Old	26%	30%	33%	21%
		Very Old	12%	17%	19%	15%
	Softwood-leading mixedwood	Old	15%	18%	20%	15%
		Very Old	4%	7%	9%	9%
	Hardwood & hardwood-leading mixedwood	Old	25%	30%	33%	30%
		Very Old	7%	14%	19%	24%
Highrock	Softwood	Old	21%	25%	30%	43%
		Very Old	13%	15%	17%	31%
	Softwood-leading mixedwood	Old	13%	15%	19%	55%
		Very Old	7%	10%	10%	45%
	Hardwood & hardwood-leading mixedwood	Old	11%	17%	16%	66%
		Very Old	5%	5%	8%	46%
Nelson River	Softwood	Old	35%	46%	55%	28%
		Very Old	17%	23%	32%	25%
	Softwood-leading mixedwood	Old	32%	40%	44%	26%
		Very Old	13%	20%	27%	24%
	Hardwood & hardwood-leading mixedwood	Old	40%	43%	43%	41%
		Very Old	20%	29%	37%	38%

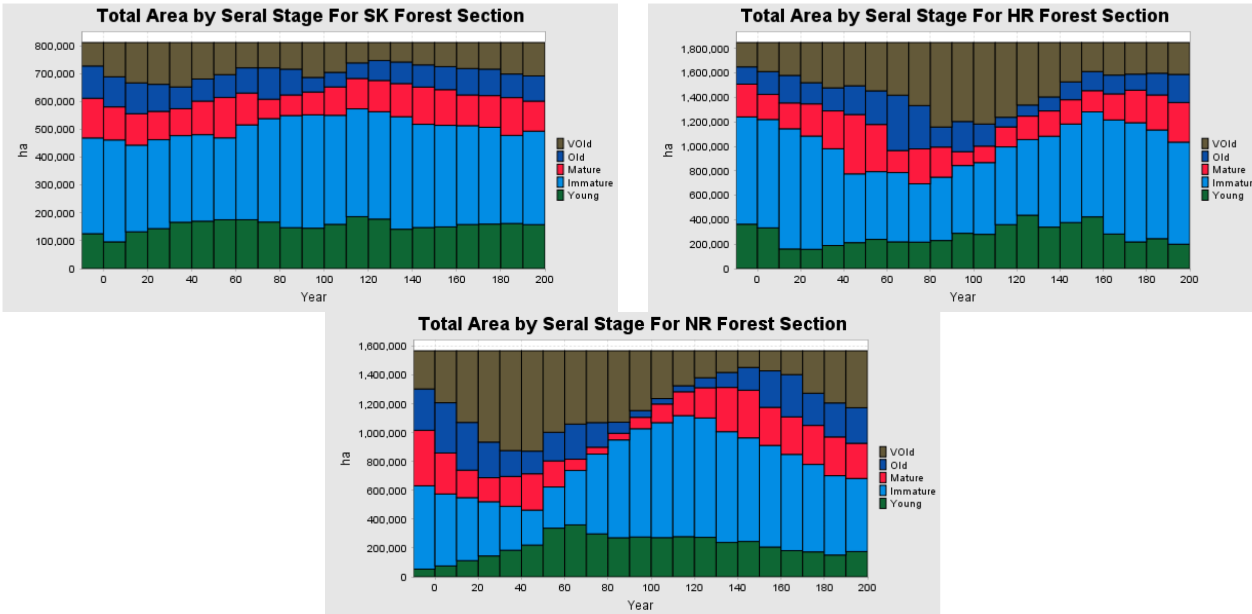


Figure 13.5. Patchworks™ reports by forest section of the area distribution, in hectares (ha), of each seral stage on the FML resulting from the Preferred Forest Management Scenario (PFMS).

13.2.3.2.1 Mature Forest Cover in Wildlife Management Areas

Mature (or older) forest cover was maintained within Wildlife Management Areas (WMAs) across the FML above the desired target of 20%. This assisted in specifically preserving seral-specific habitat types within WMAs.

Table 13.6 reports the proportion of productive forest area that is mature (or older) within WMAs resulting from the Preferred Forest Management Scenario (PFMS). Actual forest area, in hectares, is reported in the Values, Objectives, Indicators, and Targets (VOITs) table in Appendix N.

Table 13.6. Proportion of the productive forest area that is mature (or older) within Wildlife Management Areas (WMAs) on the FML resulting from the Preferred Forest Management Scenario (PFMS). Mature forest area is reported on for the end of the first 10 years of the forest management plan (i.e., the short-term – 2025 to 2035), the end of the second 10 years of the forest management plan (i.e., the mid-term – 2035 to 2045), and projected 100 years into the future (i.e., the long-term).

Proportion of Mature Productive Forest Area in Wildlife Management Areas (WMAs)			
Plan Start – 2025	Short-term – 2035	Mid-term – 2045	Long-term – 2125
53%	54%	61%	36%

13.2.3.3 Wildlife Habitat and Habitat Elements

13.2.3.3.1 Boreal Woodland Caribou Habitat

The focal goal of including boreal woodland caribou habitat in the forest model was to have the ability to follow the fluctuations in the amount and spatial arrangement of habitat throughout the scenario analysis process, and then set targets to maintain the amount of the most niche habitat type, preferred boreal woodland caribou habitat, on the landscape through the implementation of the strategic direction set out by the model.

Table 13.7 and Figure 13.6 report the area of each boreal woodland caribou habitat type (refuge, useable, and preferred habitat) by caribou management unit (CMU) predicted to be present on the FML by the projected future forest condition of the PFMS. The projected spatial arrangement of habitat can be found in Figure 13.8.

While this forest management plan will be striving to maintain the amount of preferred habitat over time in accordance with this strategic direction, at its maximum, only 20% of preferred caribou habitat on the productive forest is in the managed productive forest area (i.e., can be influenced through management activities in the forest model), limiting the degree to which forest management activities are able to affect the amount of preferred habitat present through time. The remaining 80% of preferred caribou habitat on the productive forest falls within the "unmanaged" category and is ineligible for management activity (for more information, see section 10.1.2.1.3 Managed vs. Unmanaged Forest Areas). Landscape-scale habitat is more widely influenced by the natural patterns of succession over time. The amount of area reported from the PFMS does not include any non-productive forest and/or non-forest area that may be boreal woodland caribou habitat, such as bogs, fen, and other wetland types, however, an assessment of these elements of boreal woodland habitat occurred through the use of a Habitat Suitability Index (HSI) model. See the following subsection 13.2.9 Assessing Wildlife Habitat and Habitat Elements for the results of this assessment.

Table 13.7. Area of each boreal woodland caribou habitat type for each caribou management unit (CMU) resulting from the Preferred Forest Management Scenario (PFMS). Habitat area is reported on for plan start (i.e., model time 0), the end of the first 10 years of the forest management plan (i.e., the short-term – 2025 to 2035), the end of the second 10 years of the forest management plan (i.e., the mid-term – 2035 to 2045), and projected 100 years into the future (i.e., the long-term).

CMU	Habitat Type	Area (ha)			
		Plan Start – 2025	Short-term – 2035	Mid-term – 2045	Long-term – 2125
Interlake	Refuge	21,776	22,073	23,300	21,696
	Useable	18,532	19,871	20,295	13,351
	Preferred	7,035	14,707	14,680	6,104
Kamuchawie	Refuge	210,290	273,386	276,517	300,158
	Useable	117,211	169,080	177,559	234,044
	Preferred	11,440	19,435	32,277	70,399
Molson	Refuge	123,300	150,025	146,611	117,911
	Useable	100,206	104,531	102,896	71,950
	Preferred	16,874	19,556	20,767	10,011
Naosap	Refuge	476,883	475,673	457,661	473,315
	Useable	328,374	360,659	351,532	313,795
	Preferred	64,926	69,728	90,844	86,480
Partridge Crop	Refuge	1,288,243	1,397,927	1,371,834	1,173,669
	Useable	999,316	1,066,951	1,088,884	797,190
	Preferred	102,081	114,351	149,711	186,781
The Bog	Refuge	57,450	56,195	55,073	47,461
	Useable	50,532	49,653	47,100	27,335
	Preferred	15,292	16,723	16,032	6,636
Wabowden	Refuge	551,698	537,227	528,502	421,937
	Useable	402,734	391,870	383,880	257,101
	Preferred	92,211	98,576	91,566	100,094

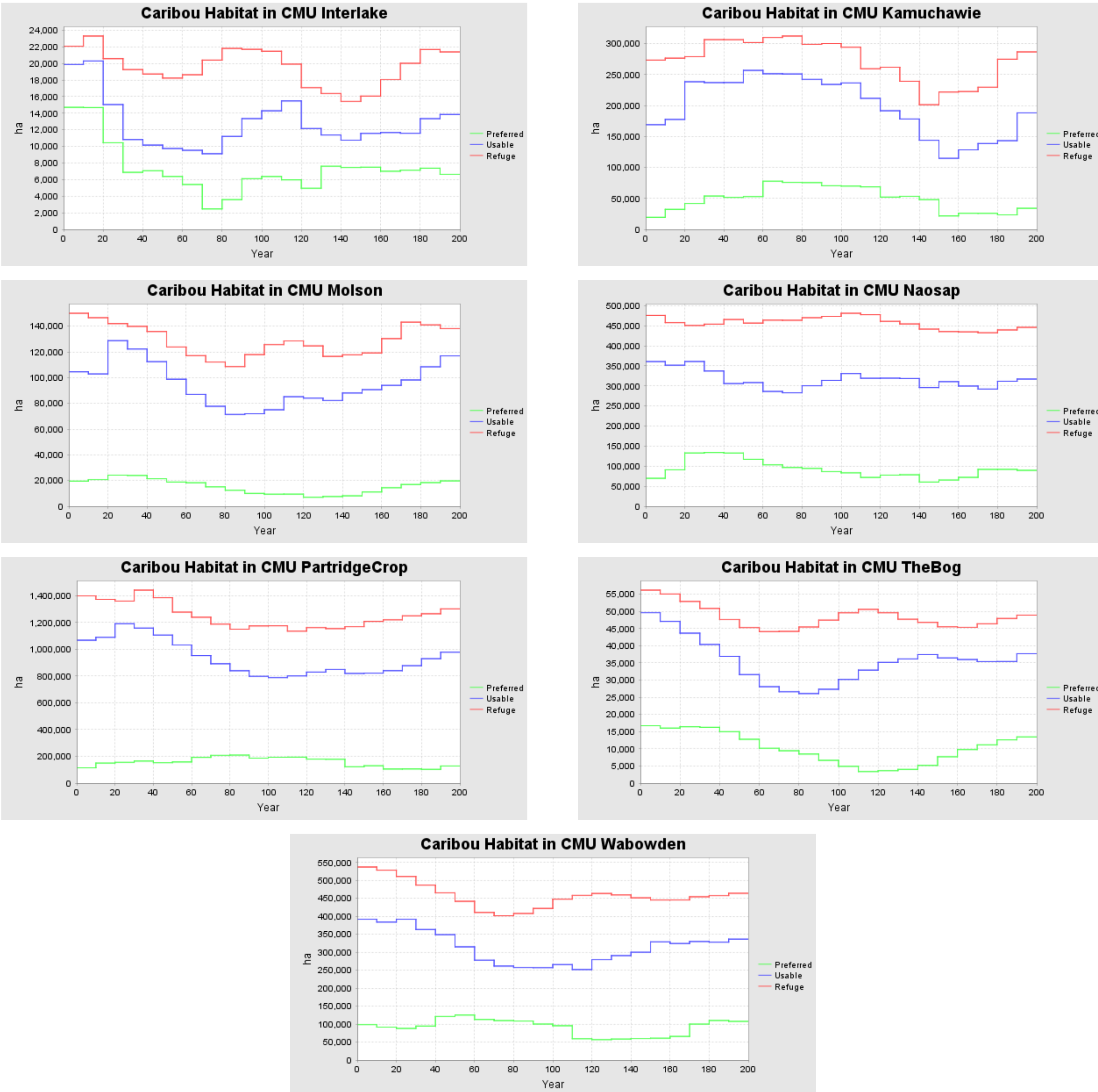
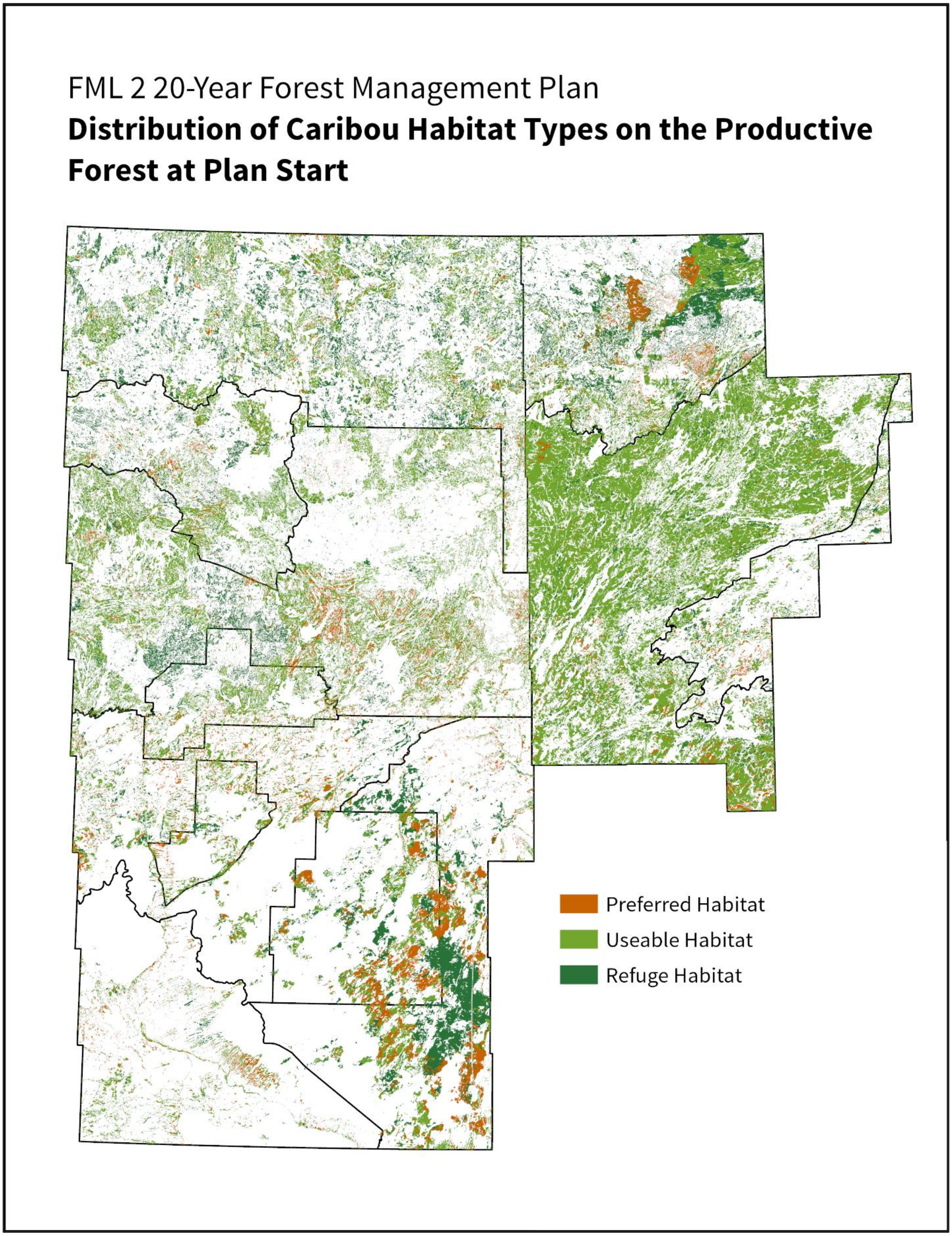


Figure 13.6. Patchworks™ reports by caribou management unit (CMU) of the area, in hectares (ha), by boreal woodland caribou habitat type resulting from the Preferred Forest Management Scenario (PFMS).



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2304 *Figure 13.7. The distribution of boreal woodland caribou habitat types on the productive forest of the FML projected to be present*
2305 *at plan start.*

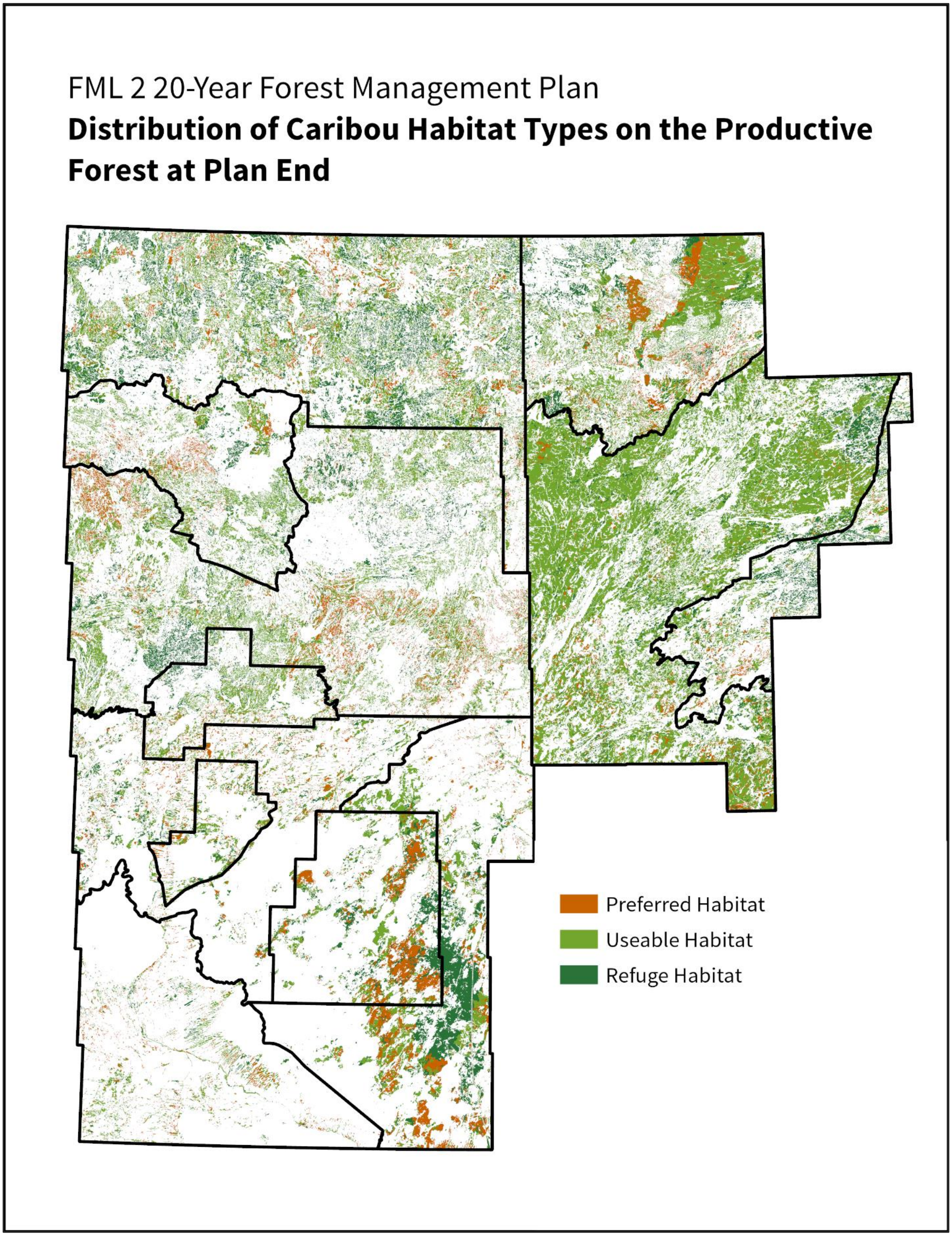


Figure 13.8. The distribution of boreal woodland caribou habitat types on the productive forest of the FML projected to be present at plan end as a result of the Preferred Forest Management Scenario (PFMS).

13.2.3.3.2 Moose Habitat

Moose habitat was included in the forest model in order to have the ability to follow the fluctuations in the amount and spatial arrangement of it throughout the scenario analysis process. This plan will target to maintain the amount of moose habitat on the landscape through the implementation of the strategic direction resulting from this scenario. Table 13.8 and Figure 13.9 report the area of each strategic moose habitat type included within the forest model for the FML. The projected spatial arrangement of habitat can be found in Figure 13.11.

While this forest management plan will be striving to maintain the amount of moose browse habitat over time in accordance with the strategic direction, the degree to which forest management activities undertaken by NFMC are able to directly influence the amount of browse habitat present on the landscape over time is limited due to the fact that the FMLA does not licence the company to harvest hardwood on the FML. Young hardwood constitutes a significant portion of browse habitat for moose—the other being young mixedwood forest, which NFMC *is* able to exhibit some influence over through management activities (see section 11.3 Moose Habitat Elements). Instead, browse habitat for moose is more widely influenced by the natural patterns of succession on the landscape over time. The amount of area reported through the forest model is also unable to consider any non-productive forest and/or non-forest area that may be moose habitat, such as wetlands.

Table 13.8. Area of each moose habitat type resulting from the Preferred Forest Management Scenario (PFMS). Habitat area is reported on for plan start (i.e., model time 0), the end of the first 10 years of the forest management plan (i.e., the short-term – 2025 to 2035), the end of the second 10 years of the forest management plan (i.e., the mid-term – 2035 to 2045), and projected 100 years into the future (i.e., the long-term).

Habitat Type	Area (ha)			
	Plan Start – 2025	Short-term – 2035	Mid-term – 2045	Long-term – 2125
Thermal cover	1,534,215	1,586,702	1,676,683	1,263,793
General cover	612,699	662,576	673,630	579,424
Browse	139,884	117,128	70,962	161,488

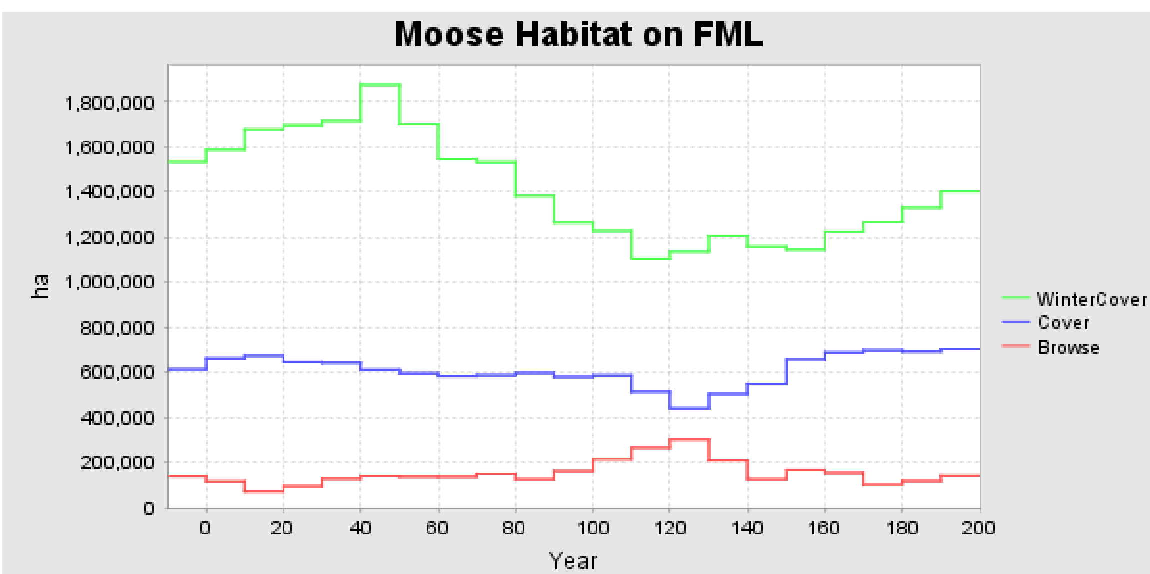


Figure 13.9. Patchworks™ report of the area, in hectares (ha), by moose habitat type resulting from the Preferred Forest Management Scenario (PFMS).

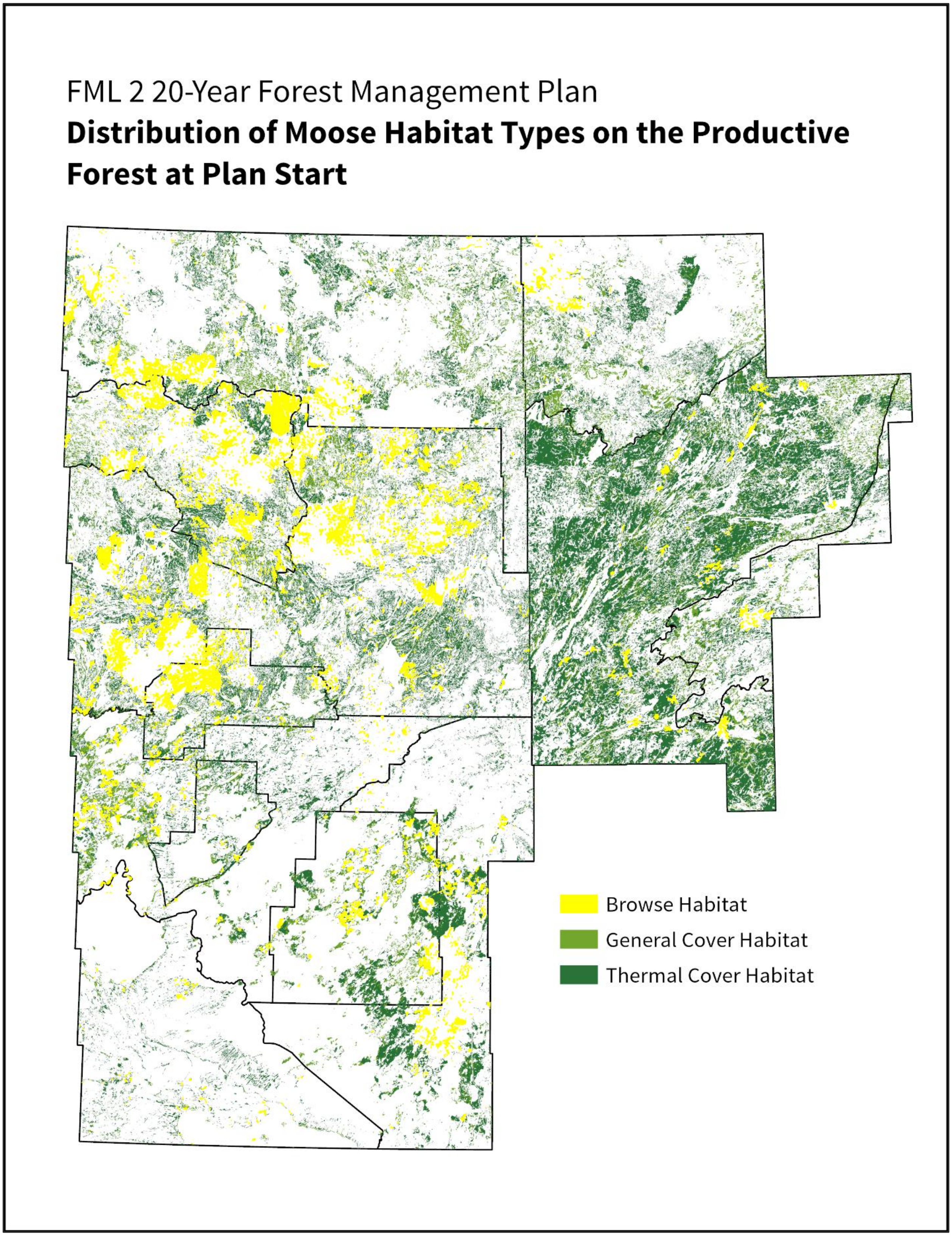


Figure 13.10. The distribution of moose habitat types on the productive forest of the FML projected to be present at plan start.

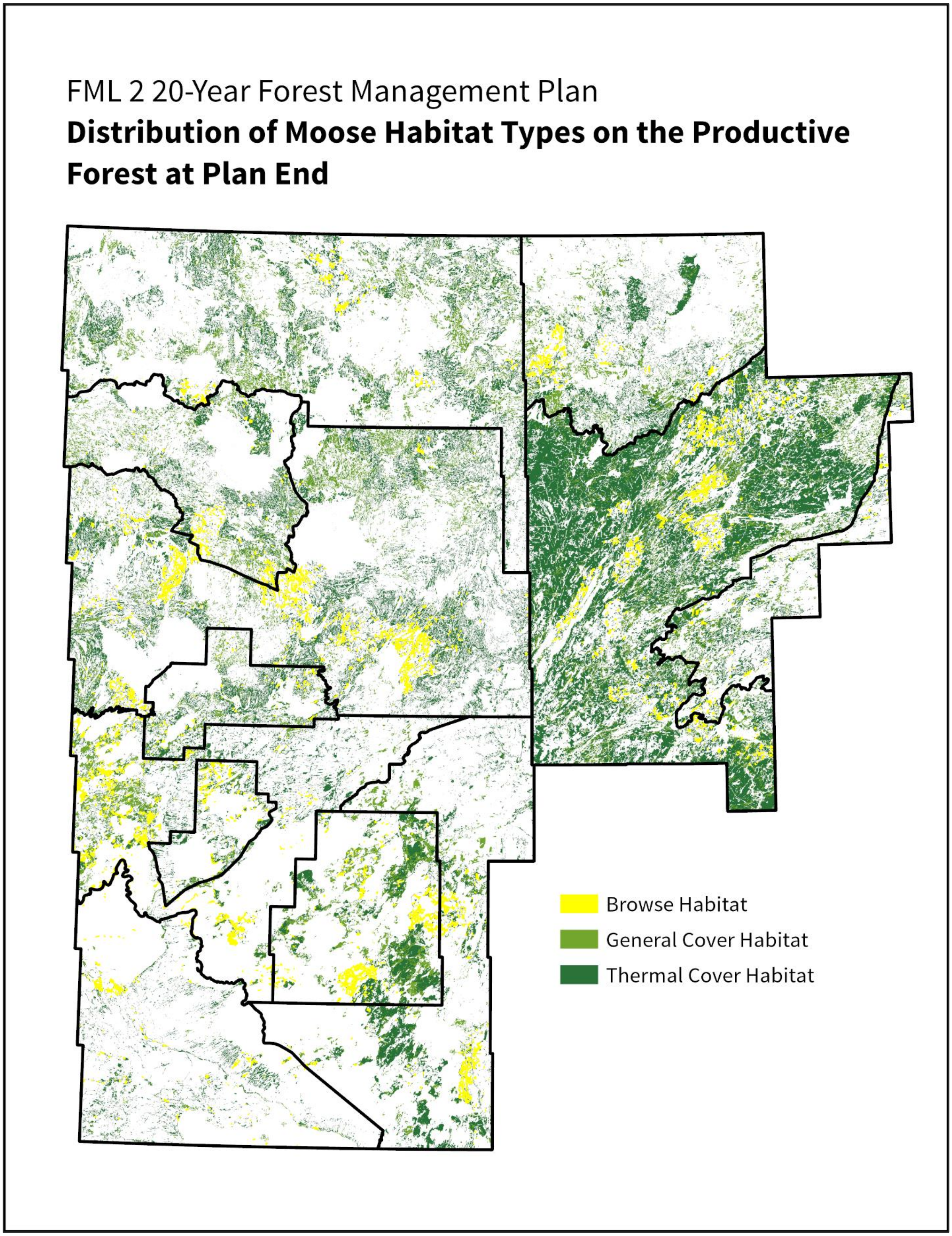


Figure 13.11. The distribution of moose habitat types on the productive forest of the FML projected to be present at plan end as a result of the Preferred Forest Management Scenario (PFMS).

13.2.4 Forest Renewal

13.2.4.1 Silviculture Budget

While the calculations used within the forest model to estimate silviculture budget are based roughly on actual costs and values, it is in no way reflective of the amount spent on part or future management activities projected to occur during the implementation of the forest management plan. The modelled silviculture budget is intended to translate the idea of economically feasible spending in relation to harvest activities as they occur.

The silviculture budget is managed in the model to not exceed liabilities (not spend too much) while also allowing the model to make more expensive treatment expenditures like planting when appropriate. Using the silviculture budget remaining in each period as an indicator, This was applied at the FML level across the 200-year analysis horizon.

A goal was set within the forest model to maintain a residual net silviculture budget that is consistently within a plus or minus a range to ensure a strategic direction with forest renewal considerations that are predictable and economically feasible. Figure 13.12 highlights that throughout the entire 200-year analysis horizon, the net silviculture budget is consistently less than $2,000,000 but remains positive of net zero, with the accumulation of liability being greater than silviculture spending. This ensures that the forest renewal activities proposed to achieve the strategic direction of the PFMS are unlikely to result in a budget deficit during implementation.

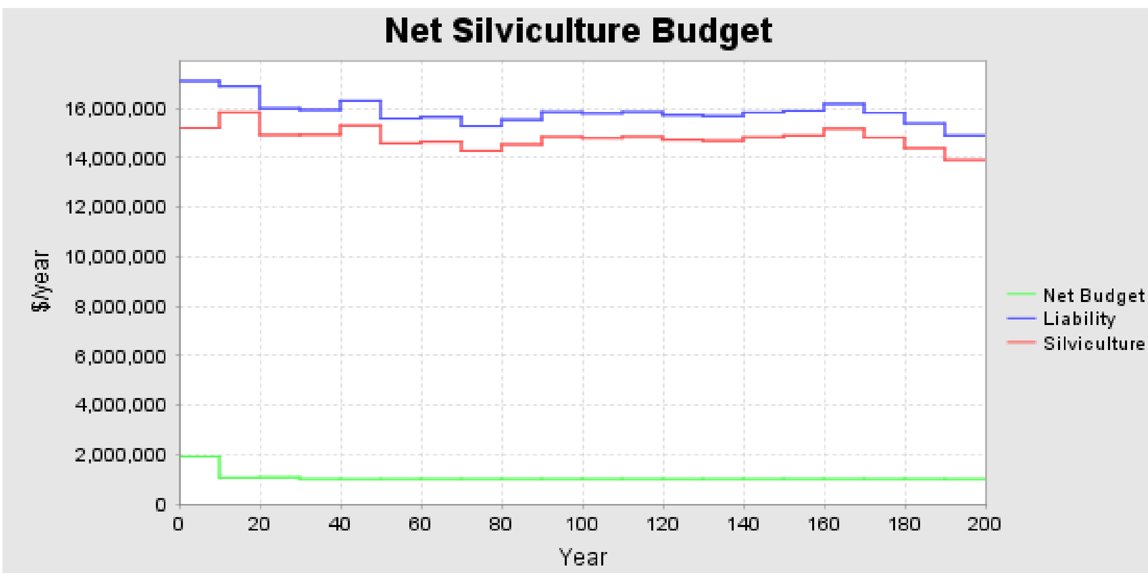


Figure 13.12. Patchworks™ report of the approximation of within-model annual silvicultural spending, liability accumulation, and net residual silviculture budget, in dollars per year ($/yr), resulting from the Preferred Forest Management Scenario (PFMS).

13.2.4.2 Forest Renewal Methods

Two strategic-level goals were applied for the Preferred Forest Management Scenario (PFMS) related to forest renewal methods:

- Maintain a minimum of 85% of harvested jack pine as being scarified (leave for natural) post-harvest; and,
- Minimize the amount of vegetation management (release) occurring post-harvest within each forest section to 45%.

Both goals were reasonably achieved within the PFMS, producing feasible targets for the duration of the forest management plan.

Table 13.9 and Figure 13.13 summarize projected forest renewal methods by leave for natural (LFN) and planting, and then by methods and strata in Table 13.10 and Figure 13.14, for the PFMS. Table values are reported as a treatment proportion based on total area harvested to capture the strategic achievement levels of the PFMS. This assists in clearly identifying a target to strive for when the strategic direction of the forest management plan is applied operationally at current utilization levels. In other words, while Woodlands does not anticipate harvesting at the modelled strategic harvest levels of the PFMS, they will aim to maintain the strategically modelled proportions of treatment on the landscape based on actual utilization levels during plan implementation. For more information, see Part 3 – Implementation and Monitoring, Implementation strategies subsection 16.3 Harvest Operations.

Note that in the reporting below, forest renewal methods results have only been reported in tables for the short- and mid-term to highlight the strategic direction for the duration of the forest management plan; however, figures report for the entire 200-year analysis horizon, highlighting the consistency of objective achievement.

Table 13.9. Proportion of area treated post-harvest with either a leave-for-natural (LFN) or plant treatment resulting from the Preferred Forest Management Scenario (PFMS). Post-harvest treatment proportion is reported on for the end of the first 10 years of the forest management plan (i.e., the short-term – 2025 to 2035) and the end of the second 10 years of the forest management plan (i.e., the mid-term – 2035 to 2045).

Treatment	Proportion of Treatment Post-Harvest	
	Short-term – 2035 (10-year)	Mid-term – 2045 (20-year)
LFN	30%	23%
PLANT	70%	77%

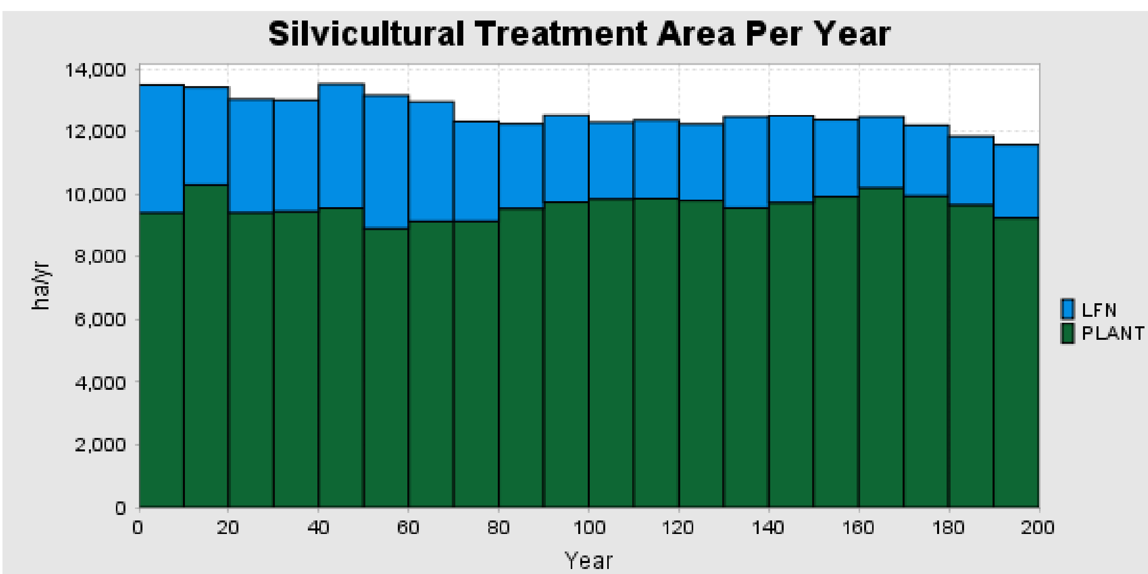


Figure 13.13. Patchworks™ report of the annual area distribution, in hectares per year (ha/yr), of leave for natural (LFN) and planting (PLANT) forest renewal methods applied across the FML resulting from the Preferred Forest Management Scenario (PFMS).

Consistent with the goal set, 85% of jack pine stands harvested in the PFMS are projected to be scarified (leave for natural; Table 13.10). Table 13.11 and Figure 13.15 summarize projected release by forest section. To create a strategic forest management direction that reflects operational practices, a goal to limit the proportion of vegetation management occurring within each forest section to 45% was applied. This is reflective of the proportion of area treated post-harvest at current utilization levels. Table 13.11 highlights that the PFMS was able to achieve a strategic direction that maintains an operationally feasible rate of vegetation management.

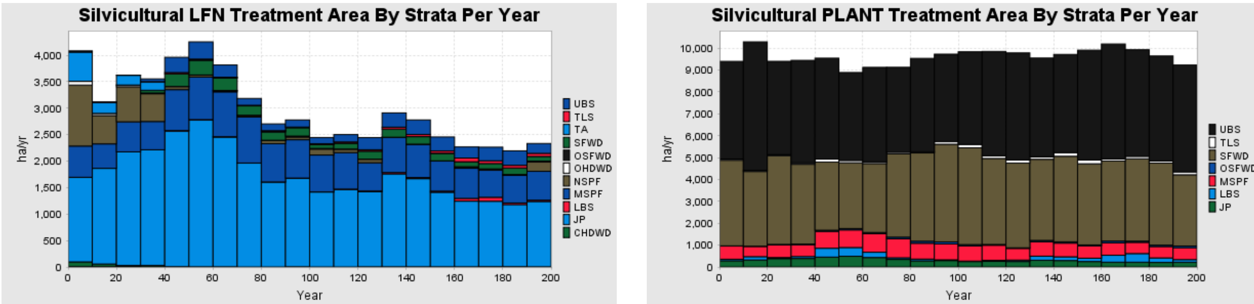


Figure 13.14. Patchworks™ reports by of the annual area distribution, in hectares per year (ha/yr), of the leave-for-natural (LFN) and plant treatments applied by strata on the FML resulting from the Preferred Forest Management Scenario (PFMS). See Appendix A for a full summary of strata definitions and consolidations within the forest model.

Table 13.10. Proportion of area by strata treated post-harvest with either a leave-for-natural (LFN) or plant treatment resulting from the Preferred Forest Management Scenario (PFMS). Post-harvest treatment proportion is reported on for the end of the first 10 years of the forest management plan (i.e., the short-term – 2025 to 2035) and the end of the second 10 years of the forest management plan (i.e., the mid-term – 2035 to 2045). See Appendix A for a full summary of strata definitions and consolidations within the forest model.

Strata		Proportion of Treatment Post-Harvest			
		LFN		PLANT	
		Short-term – 2035 (10-year)	Mid-term – 2045 (20-year)	Short-term – 2035 (10-year)	Mid-term – 2045 (20-year)
CHDWD	Pure hardwood mix	100%	100%	0%	0%
JP	Jack pine	85%	85%	15%	15%
LBS	Lowland black spruce	0%	0%	100%	100%
MSPF	Softwood- leading mixedwood	50%	50%	50%	50%
NSPF	Hardwood-leading mixedwood	100%	100%	0%	0%
OHDWD	Other hardwood mix	100%	100%	0%	0%
OSFWD	Other softwood mix	0%	0%	100%	100%
SFWD	Pure softwood mix	< 1%	< 1%	99%	99%
TA	Trembling aspen	100%	100%	0%	0%
TLS	Black spruce and tamarack	22%	10%	78%	90%
UBS	Upland black spruce	< 1%	< 1%	99%	99%

Table 13.11. Proportion of area by forest section within which vegetation management is projected to occur post-harvest resulting from the Preferred Forest Management Scenario (PFMS). Proportion of vegetation management area is reported on for the end of the first 10 years of the forest management plan (i.e., the short-term – 2025 to 2035) and the end of the second 10 years of the forest management plan (i.e., the mid-term – 2035 to 2045).

Forest Section	Proportion of Vegetation Management Post-Harvest	
	Short-term – 2035 (10-year)	Mid-term – 2045 (20-year)
Saskatchewan River	47%	47%
Highrock	47%	47%
Nelson River	47%	47%

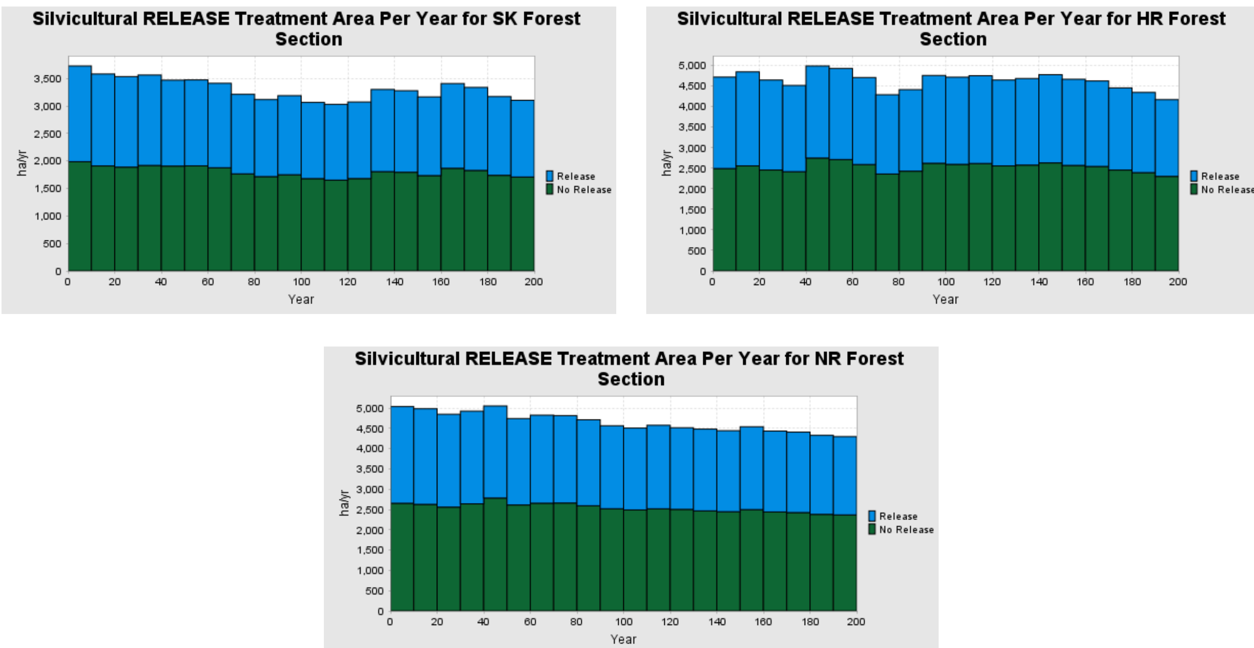


Figure 13.15. Patchworks™ reports by forest section of the annual area distribution, in hectares per year (ha/yr), of vegetation management (RELEASE) projected to occur post-harvest resulting from the Preferred Forest Management Scenario (PFMS).

13.2.5 Access

The goal of implementing spatial, access-based goals within the forest model was to create a strategic direction for the forest management plan that is economically feasible to access while also minimizing impacts at the landscape-scale to habitat from disturbance and linear fragmentation.

Table 13.12 and Figure 13.16 report the active length of each access road type for the Preferred Forest Management Scenario (PFMS). Active roads are identified as any road segment used to haul wood volume from a harvest block to the mill within a given 10-year period. While the forest model can use all roads within the access network, including highway, primary, branch, and operational roads, it does not have the capacity to decommission, move, or otherwise alter these roads. As such, the most telling indicator for scenario reporting is the kilometres of *candidate* (new) roads the forest model proposes to build to access previously unavailable harvest blocks. The PFMS strived to minimize the length of candidate roads proposed for harvest access.

Table 13.12. Length of active road, in kilometres (km), per period by road type resulting from the Preferred Forest Management Scenario (PFMS). Length of active road is reported on for the end of the first 10 years of the forest management plan (i.e., the short-term – 2025 to 2035) and the end of the second 10 years of the forest management plan (i.e., the mid-term – 2035 to 2045).

Road Type	Length of Active Road (km)	
	Short-term – 2035 (10-year)	Mid-term – 2045 (20-year)
Highway	1,532	1,503
Primary	957	980
Branch	226	251
Operational	153	168
Candidate	3,444	3,939

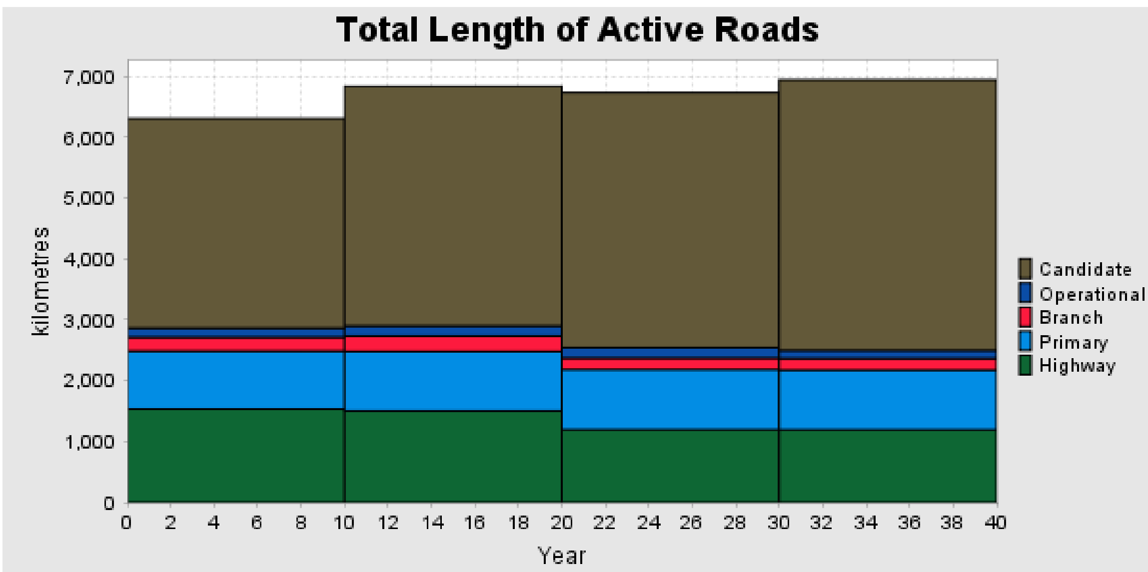


Figure 13.16. Patchworks™ report of the total length of active road, in kilometres, per period for the first four periods of analysis resulting from the Preferred Forest Management Scenario (PFMS).

13.2.5.1 Unutilized Harvest Volume

The amount of unutilized harvest volume (softwood and hardwood) was limited to approximately 34,600 cubic metres per year in the first modelling period (first 10 years of the forest management plan) and approximately 74,200 cubic metres per year in the second modelling period (second 10 years of the forest management plan). This amounts to less than 3% of total strategic volume harvested (softwood and hardwood) from the FML in the first period and less than 6% in the second period. These are considered acceptable amounts and are expected to be less than those projected by the forest model as the strategic direction of the plan is implemented at harvest levels more closely resembling those achieved historically (for more information, see section 16.2.1 Annual Wood Requirements of Part 3 – Implementation and Monitoring). The target of this plan will be to achieve minimize unutilized wood volumes less than or equal to those projected.

13.2.6 Harvest Patches

The goal of implementing harvest patches within the forest model was to create a strategic direction for the forest management plan that was economically feasible to access while also minimizing landscape-scale habitat disturbance by encouraging harvest patches that are more contiguous. Table 13.13 and Figure 13.17 report the patch size distribution of harvest patches in the northern (Highrock and Nelson River Forest Sections) and southern (Saskatchewan Forest Section) zones of the FML resulting from the Preferred Forest Management Scenario (PFMS). The PFMS strived to minimize the number of small, isolated harvest patches (less than 30 hectares) and encouraged the creation of larger harvest patches. The greater distribution of larger harvest patches on the landscape in the first two periods of the PFMS reflect a spatially aggregated harvest pattern to more closely emulate the pattern of young forest that occur naturally on the landscape and to minimize habitat disturbance.

Table 13.13. Patch size distribution of within-period harvest patches by northern and southern zone resulting from the Preferred Forest Management Scenario (PFMS). Within-period patch distribution is reported on for the end of the first 10 years of the forest management plan (i.e., the short-term – 2025 to 2035) and the end of the second 10 years of the forest management plan (i.e., the mid-term – 2035 to 2045).

Harvest Patch Size	Patch Size Distribution			
	North		South	
	Short-term – 2035 (10-year)	Mid-term – 2045 (20-year)	Short-term – 2035 (10-year)	Mid-term – 2045 (20-year)
0 – 30 hectares	6%	8%	5%	8%
30 – 50 hectares	5%	5%	4%	5%
50 – 100 hectares	7%	9%	9%	11%
100 – 250 hectares	16%	18%	14%	22%
250 – 500 hectares	11%	13%	8%	13%
500 – 1,000 hectares	13%	14%	16%	17%
1,000 – 2,500 hectares	16%	16%	23%	8%
2,500+ hectares	27%	17%	21%	16%

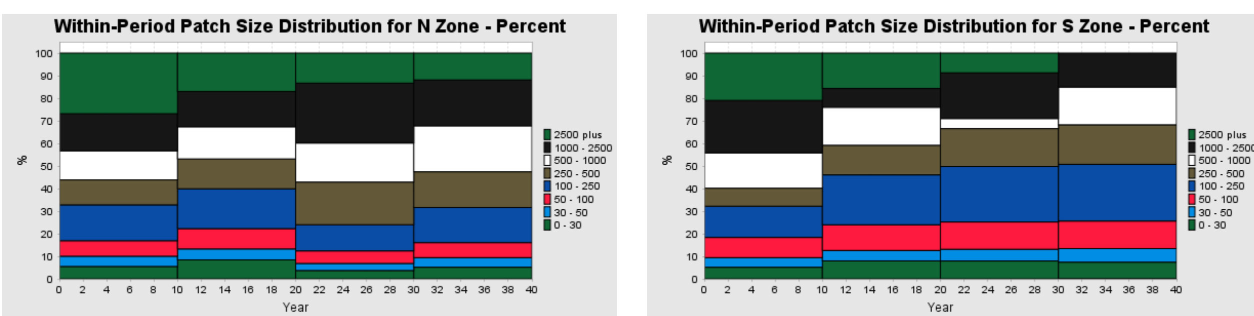


Figure 13.17. Patchworks™ reports of the within-period harvest patch size distribution by northern and southern zone for the first four periods of analysis resulting from the Preferred Forest Management Scenario (PFMS).

Table 13.14 and Figure 13.18 report the patch size distribution of 20-year patches of young forest area that were implemented specifically for the Habitat scenario. The strategic direction from the PFMS is able to consistently make patches greater than 5,000 hectares between periods for the duration of the forest management plan. This aggregation of disturbance will benefit the in the short-term by localizing disturbance, while creating contiguous patches of for future habitat to establish.

Table 13.14. Patch size distribution of 20-year young forest patch size distribution for the end of the forest management plan (year 20) resulting from the Preferred Forest Management Scenario (PFMS). Young forest patch distribution is reported on for the end of the forest management plan (i.e., the mid-term – 2045).

Young Forest Patch Size	Patch Size Distribution
	Mid-term – 2045 (20-year)
0 – 1,000 hectares	23%
1,000 – 2,000 hectares	11%
2,000 – 5,000 hectares	18%
5,000+ hectares	48%

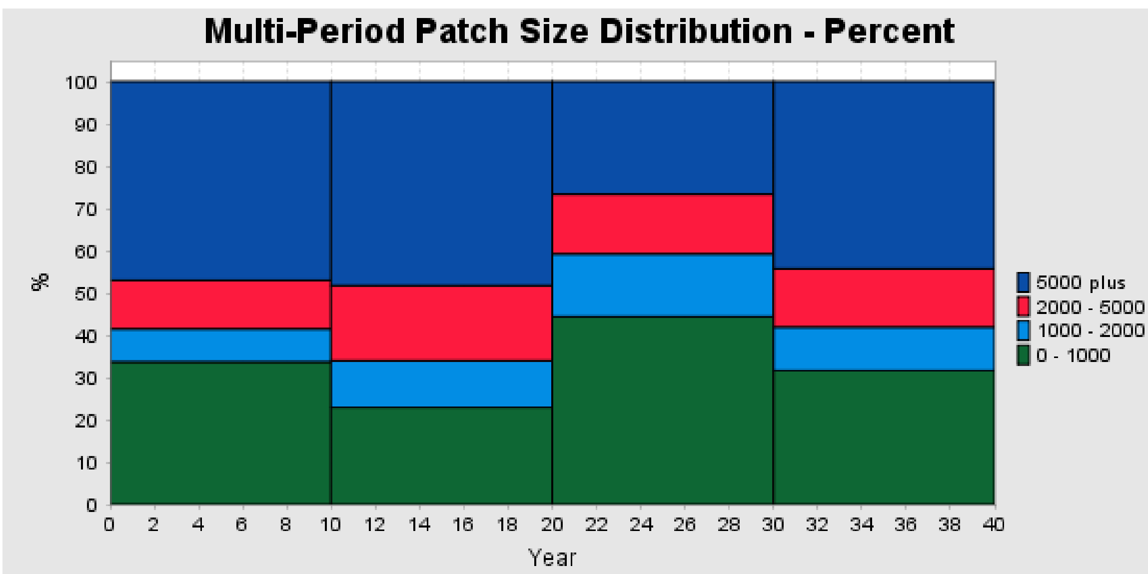


Figure 13.18. Patchworks™ reports of the 20-year young forest patch size distribution for the first four periods of analysis resulting from the Preferred Forest Management Scenario (PFMS).

13.2.7 Watershed Disturbance

The Preferred Forest Management Scenario saw none of the watersheds overlapping the FML approach the 30% disturbance threshold based on the area of productive forest disturbed versus both the gross and productive-forest-only areas of the watershed included within the model. The maximum disturbance value for a watershed at plan end (2045) was 10% in William River at The Mouth watershed, a watershed with a small proportion of FML overlap.

While the values reported from the model were not an absolute or comparable value to an in-depth Equivalent Clearcut Area (ECA) analysis, they provide a proxy for strategic direction. NFMC undertakes an assessment of watershed disturbance during implementation as part of satisfying Canadian Standards Association (CSA) requirements for forest certification. For an additional assessment of watershed disturbance, see the 15.2 Watersheds and Aquatic Ecosystems subsection of Cumulative Effects.

13.2.8 Forest Ecosystem Carbon

Forest ecosystem carbon in the forest model can only consider carbon stored within the productive forest and is meant to be a relative approximation of the fluctuations in forest ecosystem carbon stored on the productive forest of the FML over time. Similar to landscape-scale habitat types, forest ecosystem carbon is most impacted by the natural patterns of succession and disturbance on the landscape, with the impact of forest management activities being primarily limited to above ground forest ecosystem carbon.

The Preferred Forest Management Scenario (PFMS) sees an approximation of a 3% increase in total productive forest ecosystem carbon in the first period of the analysis, and a 6% increase in the second period (Figure 13.19).

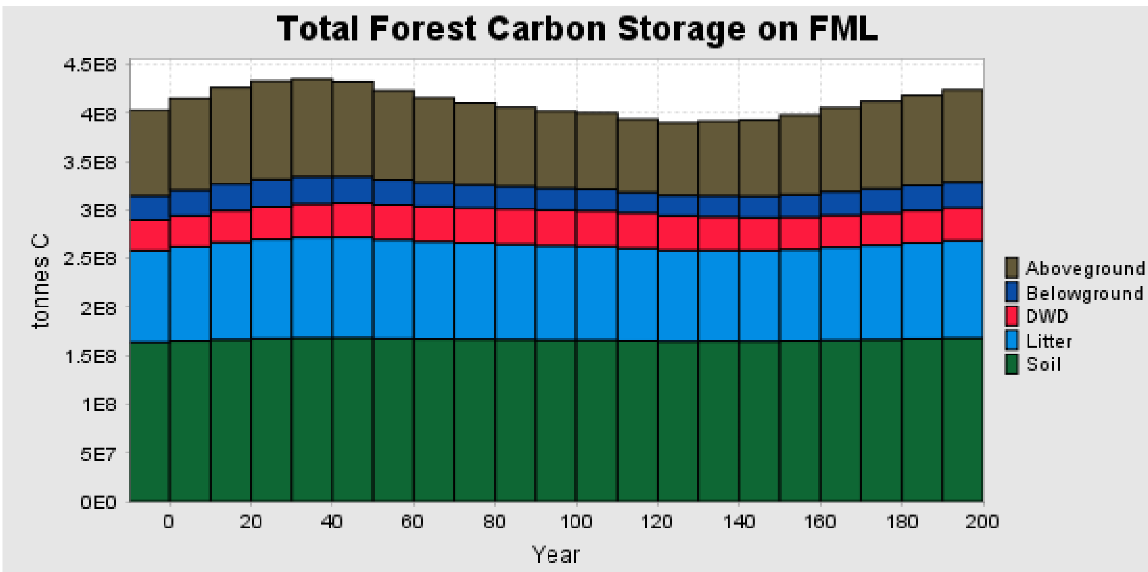


Figure 13.19. Patchworks™ report of productive-forest-only forest ecosystem carbon, in tonnes of carbon (C), on the FML resulting from the Preferred Forest Management Scenario (PFMS).

13.2.9 Assessing Wildlife Habitat and Habitat Elements

13.2.9.1 Boreal Woodland Caribou

The consideration of boreal woodland caribou habitat elements outside of the productive forest area considered in the strategic forest model was done through the caribou habitat suitability index (HSI) model, which allows for the assessment of habitat outside of the productive forest considered in the forest model, such as wetlands and other important habitat areas. For more information, see Modelling Wildlife Habitat and Habitat Elements, Boreal Woodland Caribou Habitat Elements subsection 11.2.2 Habitat Suitability Index (HSI) Model. The following metrics are calculated for each caribou management unit (CMU) in the context of the forest management plan and are therefore based on *the portion of that unit that overlaps the FML* (see Map 7.1 in section 2 Ecological and Physical Description of Part 1 – Planning Context). This causes some CMUs to have either very small (e.g., Interlake CMU) or only proportional overlap area with the FML itself and can cause results to appear disproportionally influenced by activity due to this small area of overlap. Keep this in mind when reviewing the following.

The area within each caribou management unit (CMU) with a caribou habitat suitability index (HSI) value greater than 0.5 is reported in Table 13.15 and Figure 13.20. The projected spatial arrangement of suitable habitat by the HSI model can be found in Figure 13.21 for plan start and Figure 13.22 for plan end. The patterns noted in the map in Figure 13.22 reflect where the habitat for caribou will be most suitable in the future. The most suitable are areas of mature spruce and pine away from disturbance. Areas that are young or disturbed within the last 40 years show the lowest suitability for caribou. Caribou habitat continues to shift around the landscape as stands mature and as previously disturbed or young areas of forest grow into mature stands. We see a trend towards increasing or stable amounts of suitable habitat in the Interlake, Naosap, Partridge Crop, Kamuchawie and Molson CMU's over the 20-year plan. Wabowden and The Bog CMU's are projected to trend to have less suitable habitat present throughout and following plan implementation, however, similarly to the preferred, refuge, and useable caribou habitat types caribou habitat types assessed through the forest model (Figure 13.6), suitable caribou habitat is strongly tied to the long-term, natural cycles of succession on the landscape (for more information, see Forest Modelling subsection 10.1.6 Natural Succession).

Note that spatially-dependent post-processing assessments such as HSI have been estimated only forty years into the future (twice the forest management plan duration) to avoid estimating past the point of spatial certainty on the landscape. They are reported for the short- and mid-term, i.e., the 20-year duration of the forest management plan.

Table 13.15. Area that has a caribou habitat suitability index (HSI) value of 0.5 or greater for each caribou management unit (CMU) resulting from the Preferred Forest Management Scenario (PFMS). Area is reported on for plan start (i.e., model time 0, 2025), the end of the first 10 years of the forest management plan (i.e., the short-term –2035,) and the end of the second 10 years of the forest management plan (i.e., the mid-term –2045).

CMU	Area (ha) With Caribou HSI > 0.5				
	Plan Start – 2025 (0-year)	Short-term – 2035 (10-year)		Plan End – Mid-term – 2045 (20-year)	
Interlake	32,754	34,241	5%	34,797	6%
Kamuchawie	238,746	303,769	27%	314,727	32%
Molson	131,232	144,237	10%	144,771	10%
Naosap	479,589	484,531	1%	494,548	3%
Partridge Crop	1,351,001	1,410,200	4%	1,413,342	5%
The Bog	283,588	276,013	-3%	269,894	-5%
Wabowden	519,180	477,237	-8%	482,233	-7%

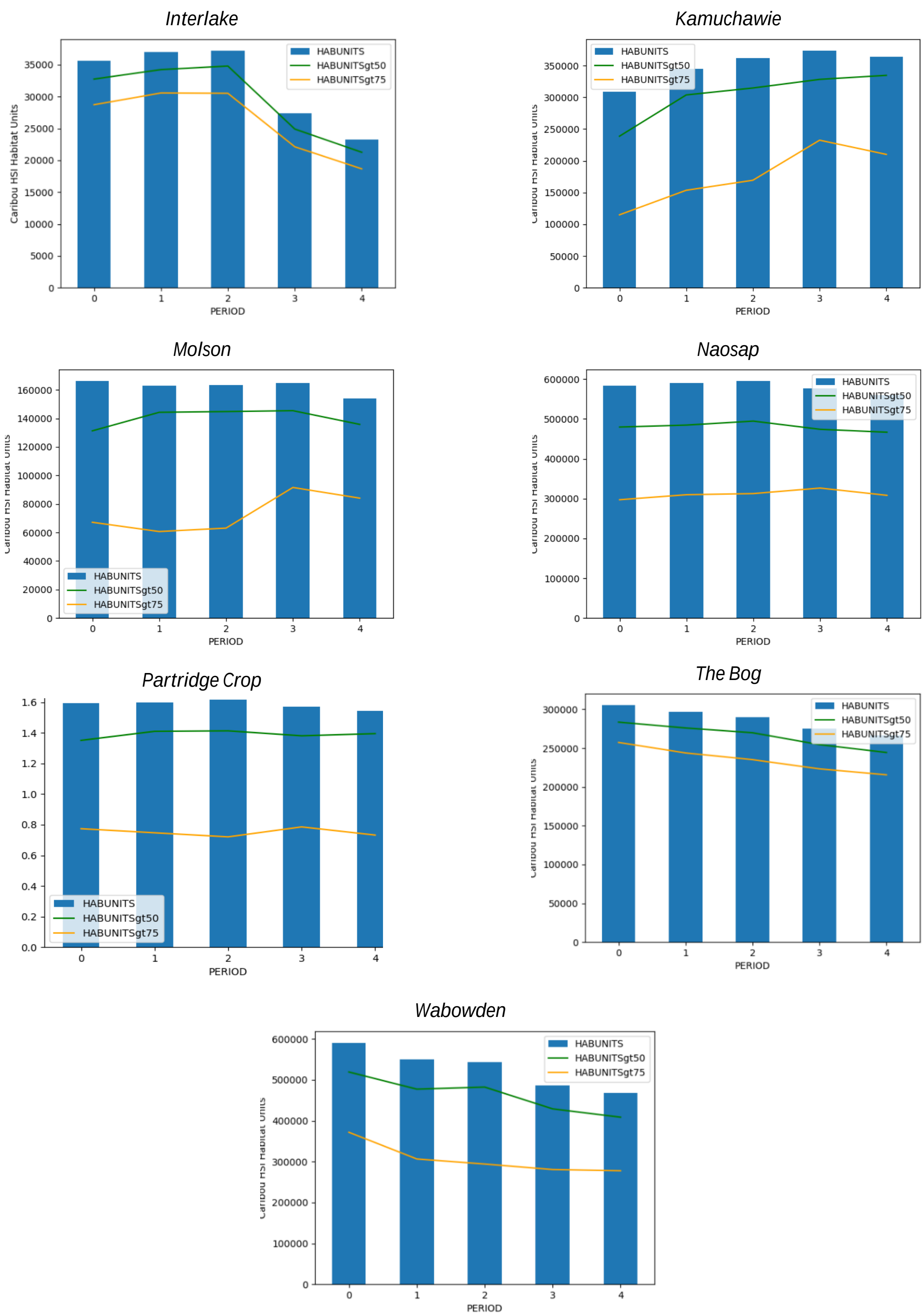


Figure 13.20. Area that has a caribou habitat suitability index (HSI) value greater than 0 (HABUNITS), and of that area, the area that has an HSI value greater than 0.5 (HABUNITSgt50) and 0.75 (HABUNITSgt75) for each caribou management unit (CMU) resulting from the Preferred Forest Management Scenario (PFMS).

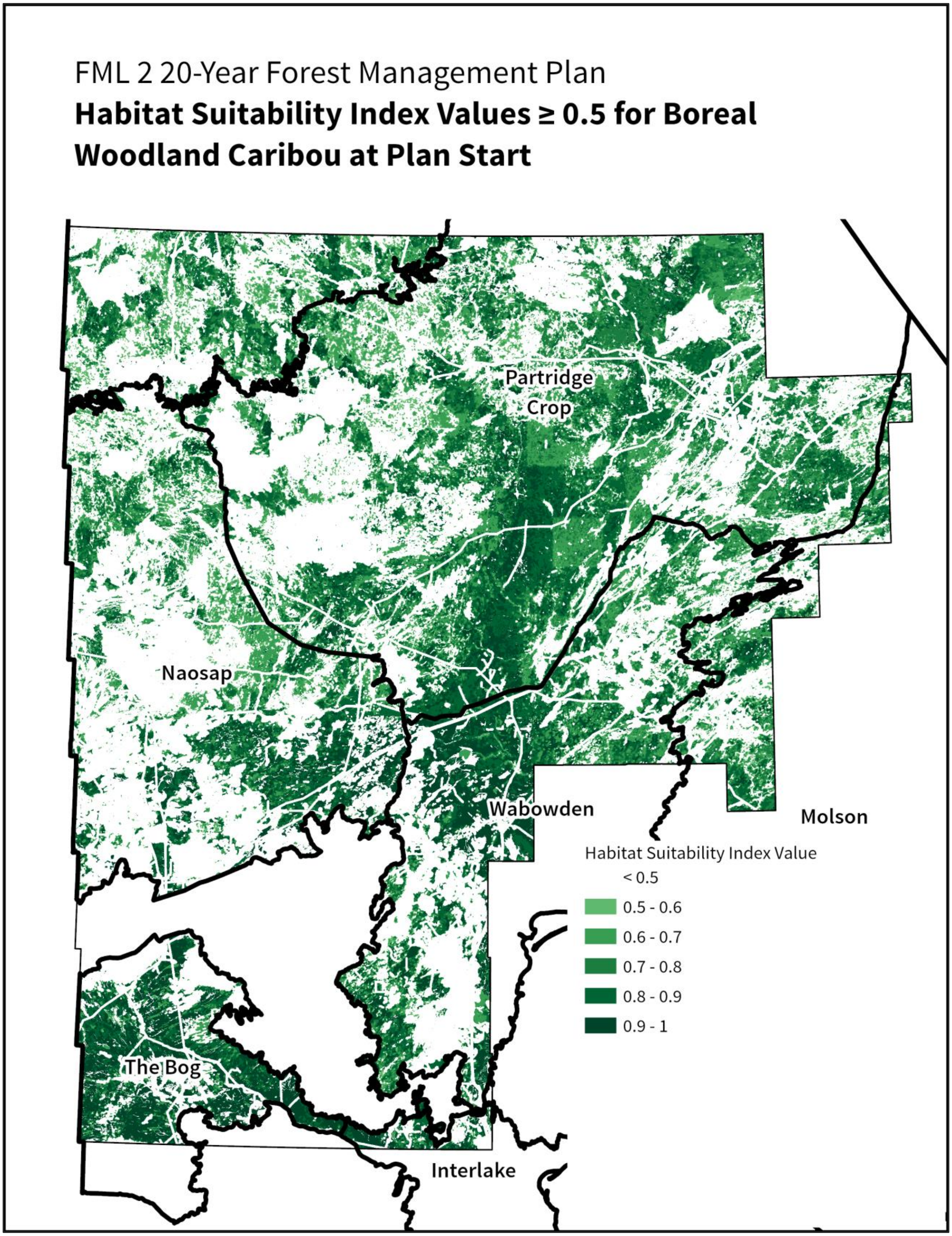


Figure 13.21. The distribution of area on the FML projected to have a habitat suitability index (HSI) value greater than 0.5 at plan start by the HSI model.

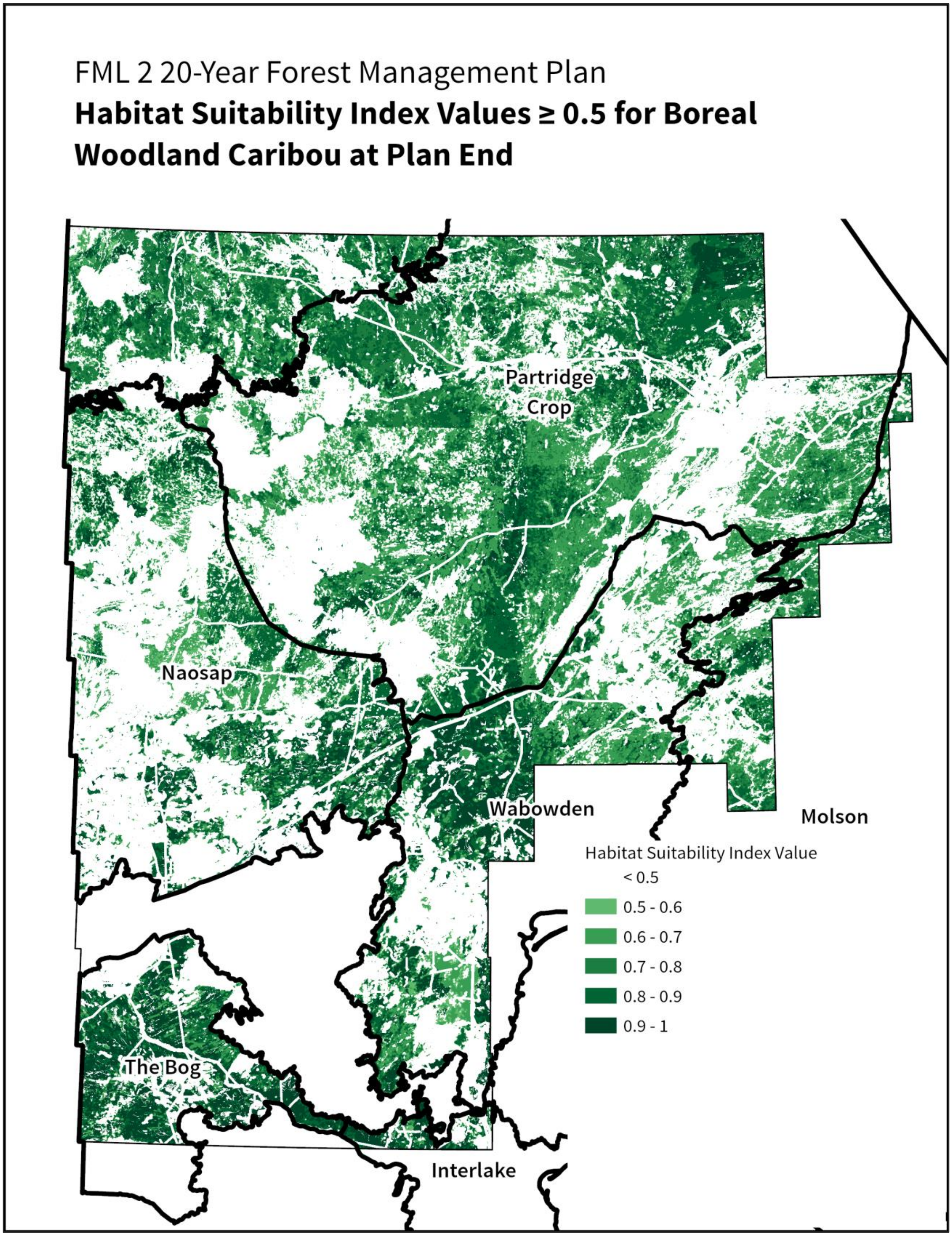


Figure 13.22. The distribution of area on the FML projected to have a habitat suitability index (HSI) value greater than 0.5 at plan end by the HSI model as a result of the Preferred Forest Management Scenario (PFMS).

13.2.9.2 Boreal Songbirds

The boreal songbird models were post-processed using geographic information system (GIS) software after the forest model completed a scenario. The future forest condition was output by the forest model, and the bird model could be calculated. This assessment approach allows us to view the potential future bird habitat that could be a result of a scenario. This type of assessment is another way to examine the outcomes of the Preferred Forest Management Scenario (PFMS). However, this type of assessment does not directly change or influence the PFMS since there are no bird habitat objectives as part of the forest model. Additional background information on boreal songbird models is available in Modelling Wildlife Habitat and Habitat Elements subsection 11.4 Boreal Songbird Habitat Elements.

For each of the eleven bird species that were assessed, some saw minimal to no impacts on habitat from the PFMS (Figure 13.23), while others experienced minor impacts but the general trend lines remain consistent between the PFMS and no harvest scenario (i.e., the trends in habitat remain the same, even if there is an absolute difference in the quantified amount of habitat between scenarios ; Figure 13.24).

In the following pages are the output results from the assessment organized into two groups of birds.

The first figure (see Figure 13.23) shows birds where the difference in results between the no harvest scenario (“Null Scenario”) and the PFMS (“Preferred Scenario”) was very small, or the amount of habitat remained stable. For these five species, it is predicated that the projected changes in the future forest condition through time will have minimal impact on the amount of suitable bird habitat across the FML.

The second set of charts (see Figure 13.24) shows six bird where the predicted amount of suitable habitat saw differences between the no harvest scenario and PFMS, or where the amount of notably habitat changed over time. Overall trends for these species remain relatively similar when comparing the two scenarios, with the influence of the proposed forest management activities not predicted to deviate dramatically from what is predicted in the no harvest scenario in the short-term.

The forest changes over time through the aging of stands (to younger and to older), to taller and shorter, to more open and less open, and also through how stands are arranged relative to each other. As the future forest condition evolved through forest management activities or natural processes, habitat for these species also evolved and changed. These eleven birds are generally abundant in the FML 2 area and none of the eleven bird species we used in the bird model showed large differences of notable concern between the no harvest scenario and the PFMS.

See Appendix R – Boreal Songbird Modelling Map Results to see result maps for all eleven songbird species.

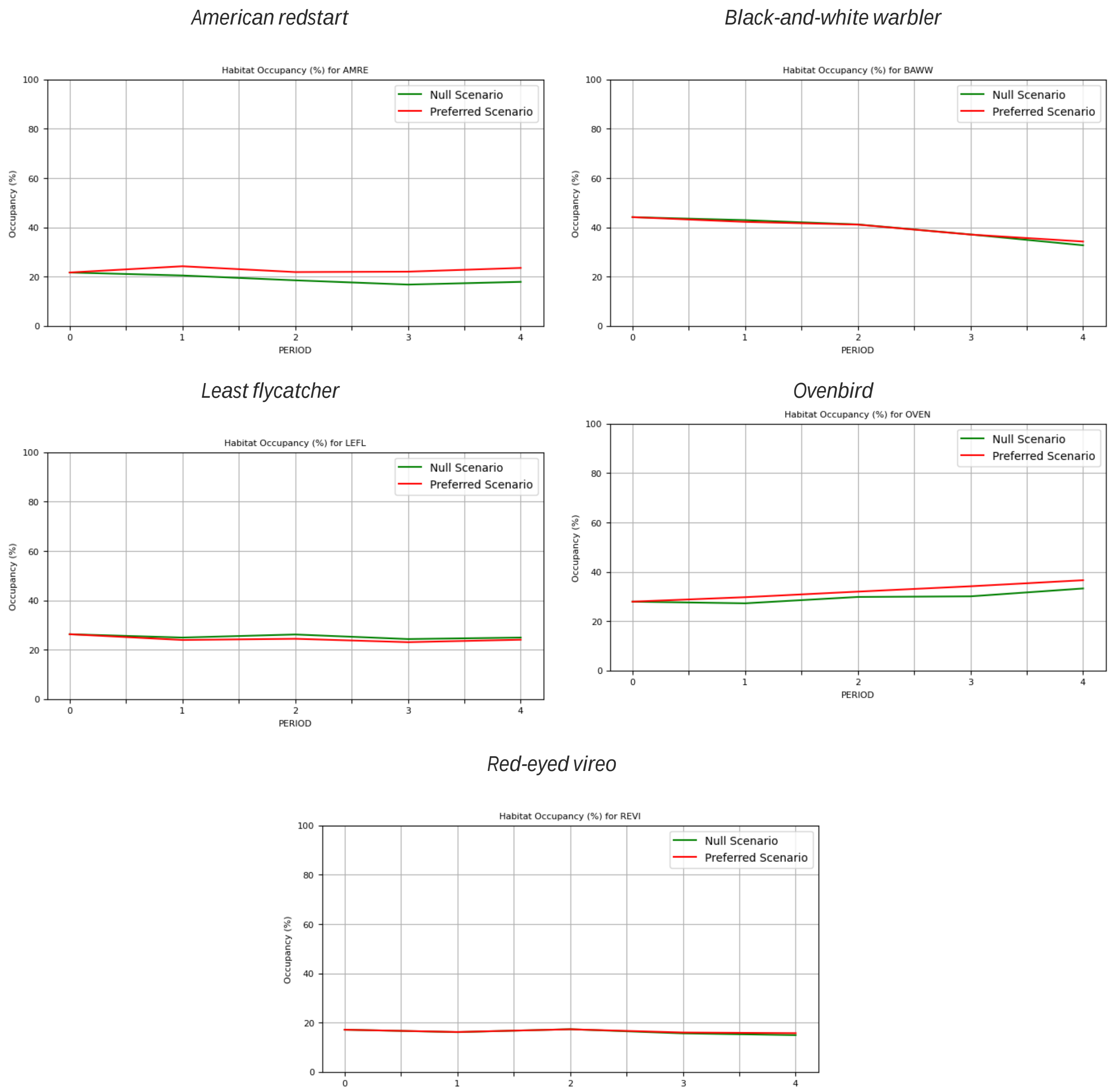


Figure 13.23. Boreal songbird model output for five of the eleven species modelled comparing likelihood of occupancy (%) between the No Harvest Scenario (Null Scenario; see Scenario Analysis subsection 12.2.1 No Harvest Scenario) and the Preferred Forest Management Scenario (PFMS; Preferred Scenario). Species shown are the American redstart (AMRE), the black-and-white warbler (BAWW), the ovenbird (OVEN), the least flycatcher (LEFL), and the red-eyed vireo (REVI).

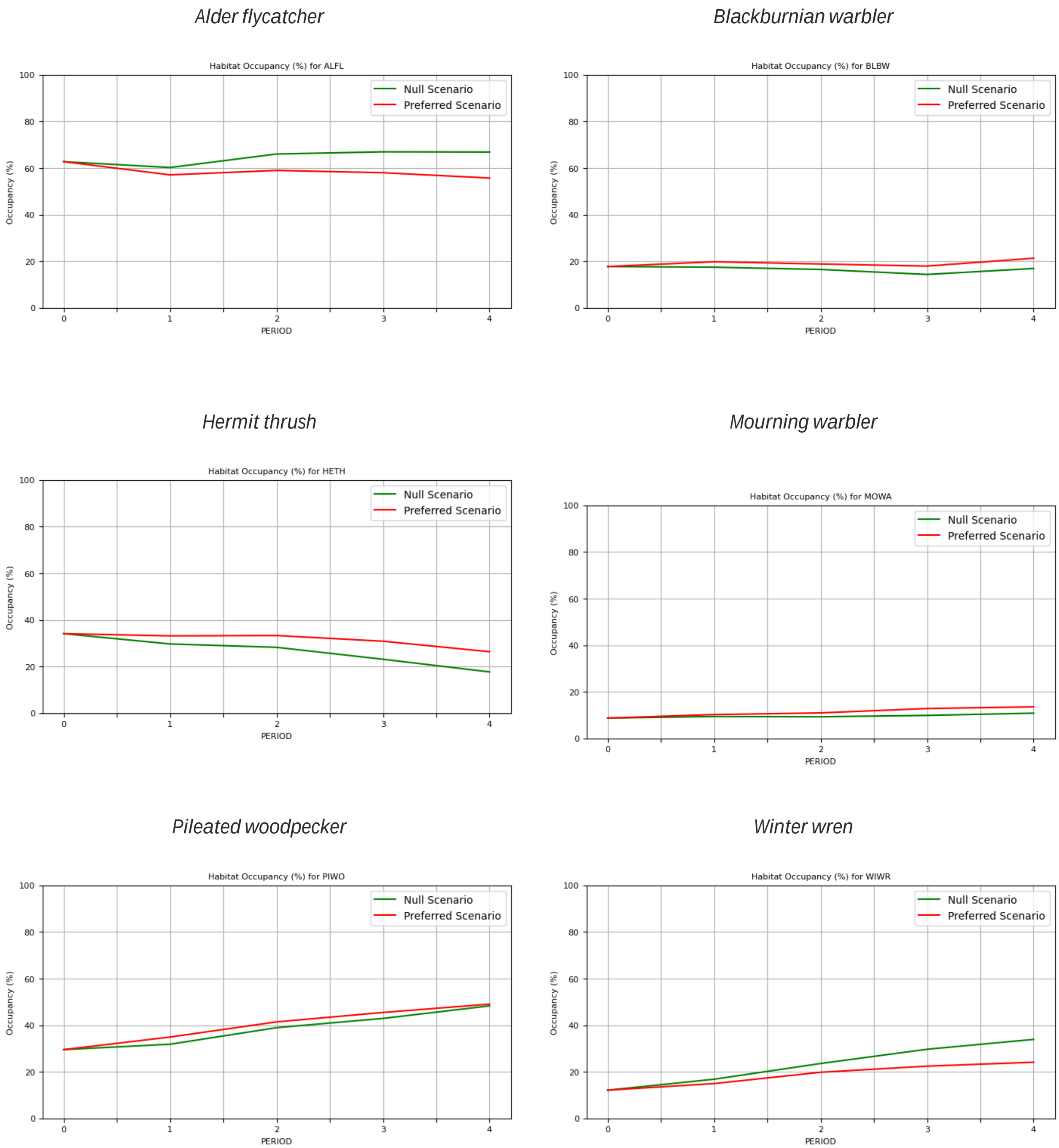


Figure 13.24. Boreal songbird model output for six of the eleven species modelled comparing likelihood of occupancy (%) between the no harvest scenario (Null Scenario; see Scenario Analysis subsection 12.2.1 No Harvest Scenario) and the Preferred Forest Management Scenario (PFMS; Preferred Scenario). Species shown are the alder flycatcher (ALFL), the blackburnian warbler (BLBW), the hermit thrush (HETH), the mourning warbler (MOWA), the pileated woodpecker (PIWO), and the winter wren (WIWR).

13.3 SPATIAL HARVEST SCHEDULE

Part of the output of the modelled Preferred Forest Management Scenario (PFMS) is a spatial harvest schedule (SHS). A spatial harvest schedule outlines the proposed operating areas and the projected harvest schedule resulting from the Preferred Forest Management Scenario (PFMS). The selected timber harvesting locations are identified by 10-year periods, outlining where forest operations should occur within the first 10 years of the plan (period 1), the second 10 years of the plan (period 2), plus two additional 10-year periods (periods 3 and 4) to achieve the strategic goals of the forest management plan.

These additional 20 years of spatial harvest schedule identified outside of the duration of the forest management plan are considered *contingency*. Contingency areas are identified as potential harvest areas in the event that an area in the initial 20-year spatial harvest schedule cannot be harvested or accessed as expected. Contingency areas may be explored if unforeseen circumstances, such as natural disturbances (e.g., wildfires, pest outbreaks), regulatory changes, or operational challenges make the planned harvest areas unavailable or less viable to help ensure that timber supply and forest management objectives can still be met.

Following the selection of the Preferred Forest Management Scenario (PFMS), engagement efforts with rights and stakeholders were undertaken to share and gather feedback for the spatial harvest schedule and contingency areas. Based on the feedback received through this process, some adjustments were made to the spatial harvest schedule for the duration of the plan. Adjustments did not impact overall strategic direction and were solidified within the PFMS.

PFMS results reported in the previous section and indicators reported in the Values, Objectives, Indicators, and Targets table for the PFMS reflect these refinements.

Maps of the spatial harvest schedule identified through the refinement of the Habitat Scenario can be found in Appendix M.

13.4 VALUES, OBJECTIVES, INDICATORS, AND TARGETS TABLE

See Appendix N – Values, Objectives, Indicators, And Targets Table. This Values, Objectives, Indicators, and Targets (VOITs) table provides a high-level overview of the forest management plan objectives, the targets of those objectives, and how these objectives will be reported on throughout plan implementation.

13.5 RISK ANALYSIS

Through the scenario analysis process, the Modelling and Analysis Subcommittee was able to identify a selection of potential “risks” to the strategic direction of the Preferred Forest Management Scenario (PFMS). Identifying “risks” is a core part of the scenario analysis process to ensure that forest managers are considering a broad range of possible future realities that may arise throughout plan implementation that may impact or threaten the forest management plan’s overall strategic direction. Risk analysis scenarios provide an opportunity to explore these potential impacts, and in combination with a Climate Vulnerability Assessment (CVA; see section 14 Climate Change Adaptation) and Cumulative Effects Assessment (CEA; see section 15 Cumulative Effects), can allow for the robust consideration of potential future threats and impacts to the forest management plan.

Three core areas around which potential risks were identified and could be explored through scenario analysis were:

1. Utilization Level – The risk that the forest model is predicting the future forest condition of the PFMS based on strategic utilization levels (i.e., harvest levels greater than those which Canadian Kraft Paper Industries Ltd currently operates at) and that key objective indicator targets may be infeasible to achieve at current utilization levels.

The primary concern regarding harvest levels less than the strategic levels projected in the forest model are the impacts to ecological indicators such as conserving softwood forest cover types and maintaining a minimum of old and very old seral forests on the landscape. To reflect current and recent past utilization levels, harvest volume objectives were reduced to 30% of provincially determined annual allowable cut (AAC) levels for forest management units (FMUs) 50, 53, 58, 59, 67, 68, and 801. The ability to harvest within FMUs 69, 800, and 802 was removed completely.

Under these conditions, ecological targets were not jeopardized. The amount of softwood forest cover within each forest section remained consistent, while old and very old sere representation increased on the landscape. This predicted an increase in preferred boreal woodland caribou habitat within the productive forest landbase as more old softwood forest was able to accumulate. At the same time, however, it was also predicted that moose browse on productive forest landbase would decrease as a result of fewer young forest patches being created as a result of timber harvesting. It should be noted, however, that the forest model is not able to predict or apply the creation of young forest patches on the productive forest landbase caused by natural disturbances that would inevitably occur as part of natural forest succession over time.

2. Hardwood Harvest – The risk that key objective indicator targets resulting from the PFMS are infeasible to achieve due to hardwood harvest being allowed to occur within the forest model.

The complete removal of the option to harvest hardwood stands (i.e., any polygon with a hardwood or hardwood-leading strata) proved to result in a less than 1% loss in softwood volume to the mill for the 20-year duration of the plan while maintaining all other objectives. This risk analysis also highlighted that the majority (52%) of the hardwood volume sourced in the PFMS came as a by-product of harvesting softwood-leading stands. This supports that the long-term strategic direction of the plan would be maintained should all hardwood operations cease on the FML.

3. Reduced Vegetation Management – Management of competition on regenerating sites is primarily addressed today through a planned application of herbicide in areas of high vegetative competition at an appropriate point in the sites' growth. The risk analysed is that a limitation in the ability to use herbicide as a means to achieve vegetation management in forestry may occur in the future.

Exploring the risk of not managing competitive vegetation using herbicide-based release treatments through the risk analysis process highlighted that in order to maintain the ecological objectives of the strategic direction of the landscape, the forest model reduced harvest to approximately 50% of the PFMS, while maintaining all other objectives. This supports that it would be possible to uphold the long-term ecological sustainability of the plan objectives in the face of factors that limit the use of herbicide, and that this would pose only an economic risk to the company. That impact would come in the form of reduced harvest levels or applying other vegetation management strategies that are less cost-effective in achieving the result of managed competitive vegetation.

14 Climate Change Adaptation

Climate change is defined as a significant change in either the average state of the climate or in its variability, measured over an extended period - usually at least 30 years. Climate change is having an impact on the boreal forest and is expected to continue to do so in the coming decades (D'Orangeville, et al., 2023; Prairie Climate Center, 2024; Gauthier, et al., 2014; Wang, et al., 2014). The forest industry is unique in that it can be both negatively affected by climate change impacts, while also being a good news story for climate change mitigation. Sustainable forest management (SFM), a guiding principle of forest management in Manitoba, helps mitigate climate change by maintaining healthy forests to sequester carbon (PEFC Canada, 2023; Environment and Climate Change Canada, 2020; Manitoba Sustainable Development, 2017). To address the impact of climate change, the Province requires the forest management plan to include identification and assessment of vulnerabilities, risks, and opportunities with respect to climate change, as related to the activities described in this plan.

Sustainable forest management is a management approach to maintain and enhance the long-term health of forest ecosystems, while providing ecological, economic, social and cultural opportunities for the benefit of present and future generations (Manitoba Agriculture and Resource Development, 2021).

14.1 CLIMATE VULNERABILITY ASSESSMENT

A Climate Vulnerability Assessment (CVA) was used to better understand the potential impacts of climate change on the forests and to support climate adaptation actions under increasing uncertainty. The goal of the CVA is to identify climate-change-related risks and potential adaptation measures to reduce forest vulnerability, take advantage of any positive opportunities that may be associated with climate change, and increase the likelihood that sustainable forest management objectives of this forest management plan will be achieved even in the face of an uncertain future climate. The CVA framework allows for evidence, science-based decision making, and informed judgements to address the complex challenges related to climate change.

Vulnerability is the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including variabilities and extremes (Edwards, et al., 2015).

The process that the CVA followed is based on the Canadian Council of Forest Ministers' (CCFM) adaptation framework approach, designed for forest managers to use in assessing the vulnerability of sustainable forest management systems to climate change (Edwards, et al., 2015). It is also guided by the learnings from the University of British Columbias's Micro-Certificate for Climate Vulnerability & Adaptation. Both CVA sources have been endorsed by the Federal and Provincial Governments (Environment and Climate Change Canada, 2023; Forestry and Peatlands Branch , 2022; Manitoba Sustainable Development, 2017). The adapted CVA framework used facilitated workshops and discussions with CKP harvesting staff and NFMC (outlined in Part 1 – Planning Context, Corporate Overview and Facility Description subsection 1.2 Woodlands Corporate Structure), referred to collectively in this section as the Woodlands department to complete five key steps:

1. Define the scope of assessment.
2. Understand current and future climate and forest conditions.
3. Complete a detailed vulnerability assessment.
4. Identify and prioritize adaptation options.
5. Implement and monitor adaptation efforts.

14.1.1 Assessment Scoping

The scope of the CVA was limited to the FML 2 landbase (Map 14.1), as described in Part 1 – Planning Context section 2 Ecological and Physical Description, and the Woodlands department was the main group contributing to the analysis. An extensive communications and engagement plan with rightsholders and stakeholders was implemented for this forest management plan.

The CVA steps and themed discussions were incorporated directly into the communication and engagement with rightsholders and shareholders. The goal of incorporating the CVA into engagement sessions was to gather as much feedback, knowledge, and experience as possible to inform the decisions made by the Woodlands department in the CVA. Presentations were made, recorded, and posted to the NFMC (niso.ca)[6] so that the Sustainable Forest Management Committee (SFMC), rightsholders, and stakeholders would understand the CVA process and for NFMC to reference while gathering climate and weather experiences during engagement meetings with the public.

14.1.2 Problem Statement

NFMC acknowledges that the extent of climate change in the future is uncertain, but that changes in weather patterns and local climate have already been occurring. Therefore, NFMC assessed how the forest management plan and associated operations are vulnerable to the effects of climate change and committed to determining and implementing adaptation options that will increase the resilience of forest operations over the next 20 years.

Resilience is the ability of a system and its component parts to anticipate, absorb, accommodate, recover, or reorganize from disturbances in a timely and efficient manner while retaining the same basic structure and ways of functioning. It is the capacity for self-organization and the capacity to adapt to stress and change (Edwards, et al., 2015).

14.2 CURRENT AND FUTURE CLIMATE AND FOREST

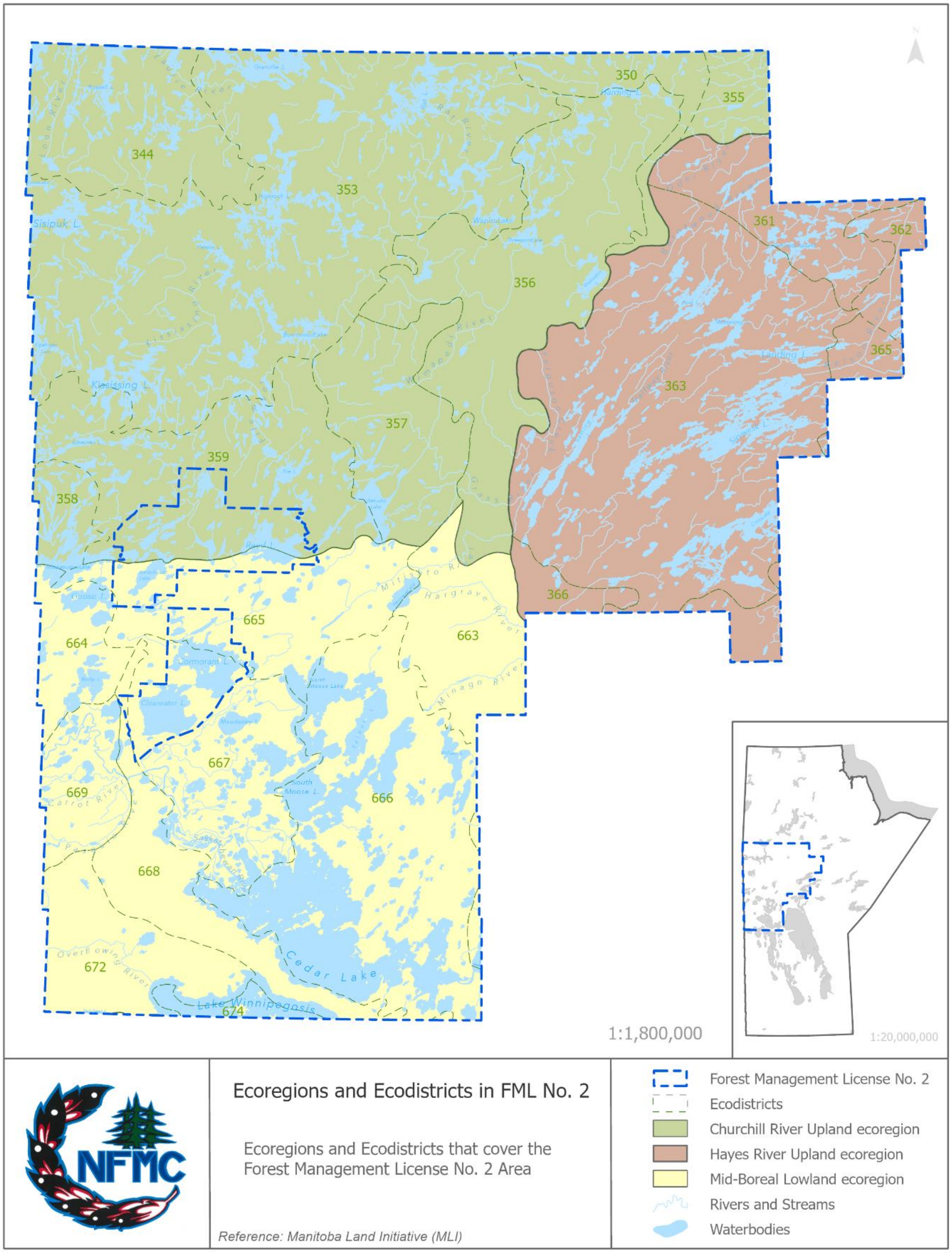
Climate is the “average weather” described in terms of the mean and variability of features such as temperature, precipitation and wind over a period ranging from months to thousands or millions of years. The usual period for describing climate in Canada is 30 years and referred to as a climate normal (Edwards, et al., 2015). Weather is the day-to-day and hour-to-hour atmospheric conditions at a given location.

Understanding the current and future climate for FML 2 is foundational to understanding and making science-based and informed decisions around the impacts of climate change on the forest, the forest management plan, and associated operations. There are two components to FML 2’s climate story:

1. Local experiences by the Woodlands department, rightsholders, and stakeholders who have been living, working, and recreating on the FML; and,
2. Predictions by scientists of what will occur in the future based on historic climate data and projected carbon emissions.

The first mostly pertains to the daily and seasonal effects of recent climate trends and the second is focused on how this could look in the next thirty to sixty years. The first can be generally classified as weather and the second as climate. Climate shapes the weather now and into the future, but it is the weather effects of climate that we experience, remember, and usually base our decisions upon.

[6] The presentation can be accessed directly here: https://www.youtube.com/watch?v=4f145Vpo1gA.



Map 14.1. Climate vulnerability assessment spatial scope of FML 2 and its ecoregions.

14.2.1 Current Climate and Weather

Current climate and weather fill in the gap between historical and future modelled data from 2006 to 2021. The current climate of FML 2 was described in detail in Part 1 – Planning Context (see section 2.2 Climate) of the forest management plan. This section is a summary of current climate indicators from Part 1 that are pertinent to the CVA. Recorded measurements from weather stations within FML 2 were extracted from Environment and Climate Change Canada Historical Climate Data website and utilized to summarize recent climatic averages for FML 2. The data available came in monthly and daily formats, depending on the station, and has some outliers and inconsistencies in collection; however, it is the best available current data at this time and the averages reflect the weather trends for the time period.

When the daily temperature and precipitation data from 2006 to 2021 was averaged and grouped by ecoregion (Churchill River Upland, Hayes River Upland, and Mid-Boreal Lowland) it corroborated that there are notable variances in climate across the FML (see Figure 14.1, Figure 14.2, and Figure 14.3):

- Hayes River Upland is the coldest ecoregion;
- Mid-Boreal Lowland receives a higher volume of precipitation in the months of May and June than the other two ecoregions; and,
- July is the hottest and wettest month, while February is the coldest and driest month. The remaining months are more variable in their temperatures and precipitation between the three ecoregions.

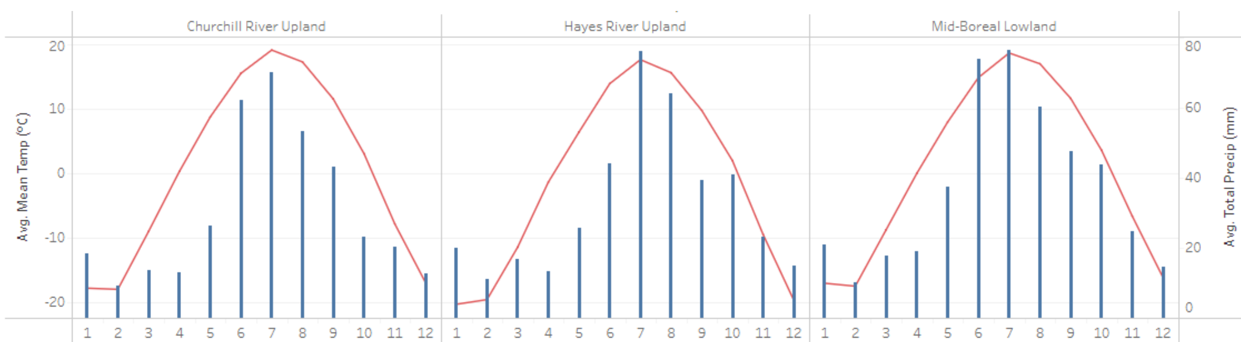


Figure 14.1. Climographs of the monthly average temperature (red lines) and total precipitation (blue bars) for the ecoregions within FML 2 between the years of 2006 and 2021. Extracted from the Environment and Climate Change Canada Historical Climate Data website.

The climographs in Figure 14.2, and Figure 14.3 depict the wider range of variability in weather experienced year-to-year across FML 2. When averaged across the entire FML the following trends are demonstrated from 2006 to 2021:

- Average annual temperature has increased slightly;
- Temperature minimums and maximums are relatively stable with both extremes increasing slightly; and,
- Total precipitation has been decreasing.

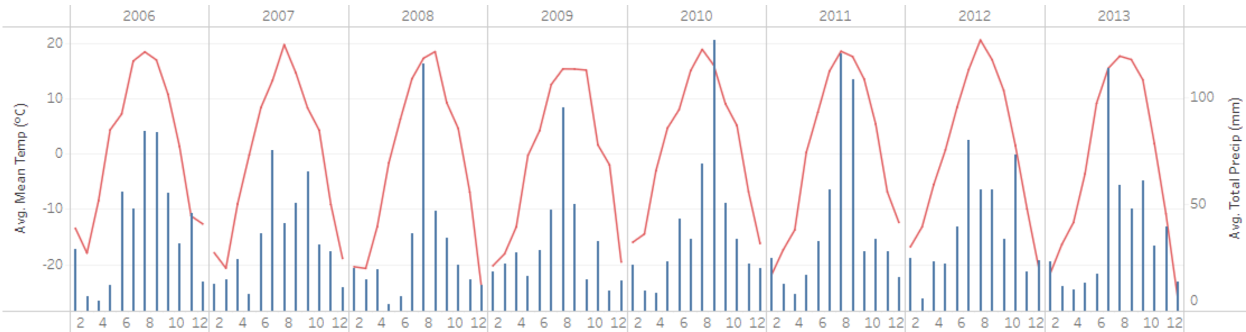


Figure 14.2. Climograph of the monthly average temperature (orange lines) and total precipitation (blue bars) for the entire FML 2 area between the years of 2006 and 2013. Extracted from the Environment and Climate Change Canada Historical Climate Data website (https://climate.weather.gc.ca/index_e.html) on July 7, 2022.

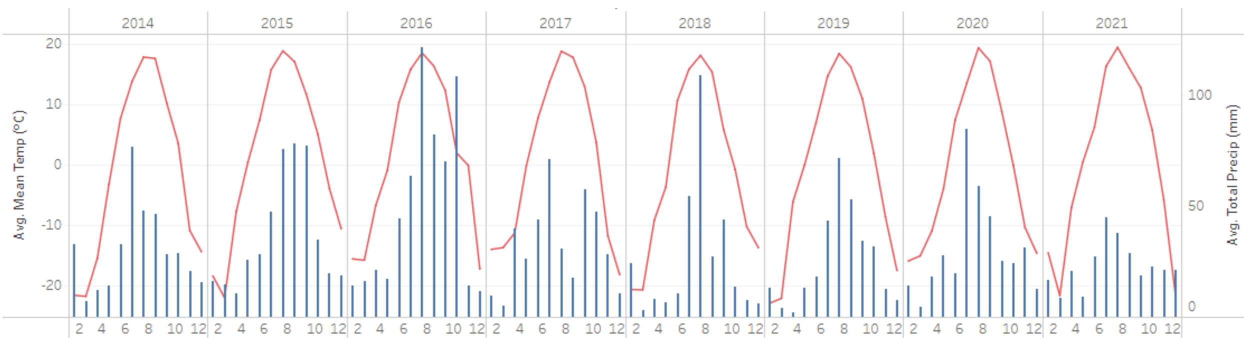


Figure 14.3. Climograph of the monthly average temperature (orange lines) and total precipitation (blue bars) for the entire FML 2 area between the years of 2014 and 2021. Extracted from the Environment and Climate Change Canada Historical Climate Data website (https://climate.weather.gc.ca/index_e.html) on July 7, 2022.

Frost-free days are defined as the number of consecutive days within a year in which the average daily temperature is above 0°C. Frost-free days can be utilized to understand how long the frozen-ground operational season is, as well as how many days are available for plant productivity. The number of frost-free days has been relatively stable, averaging at 166.4 days across the FML, with a slight decrease in recent years (Figure 14.4). There is a difference of 13 frost-free days between the ecoregions with the lowest average being in the Hayes River Upland and highest (Mid-Boreal Lowland) average number of frost-free days annually.

Figure 14.4. The number of frost-free days per weather station within FML 2 between 2006 and 2021.

14.2.1.1.1 Observed Climate and Weather Trends

Observed climate and weather trends were collected for FML 2 in two ways: during the first Woodlands Workshop and during engagement meetings with rightsholders and stakeholders and the Sustainable Forest Management Committee (SFMC). Local knowledge and observation are important for understanding what the current climate is like in FML 2 and what effects of climate change are already being felt. The following observations were voiced when discussing how current climate and weather is being experienced:

- Weather has become increasingly volatile seasonally and year to year (e.g., temperatures can fluctuate ± 20^{0}C, unpredictable changes like February rain are occurring);
- Seasonal trend of a pre-Christmas warm-up;
- Spring break-up shifting from April to mid-March typically;
- Temperatures have warmed, historically Halloween would be in snow, now it is in rain;
- Significant (10^{0}C) difference in temperatures between the north and south ends of the FML;
- Snowpack has decreased from historical levels, but extreme years can still be experienced;
- Summer variability is increasing with prolonged periods of drought and flooding;
- Extreme weather events (e.g. windstorms) are very localized and infrequent;
- 4PM thunderstorms in the summer are consistent, but shifting to drier lightning;
- Wildfire season has lengthened as well as wildfire intensity, severity, and frequency;
- Daily wildfire weather conditions conducive to crossover and ignition are lengthening; and,
- Extreme highs and lows for community water levels experienced in recent years.

Overall, the current climate from 2006 to 2021 has seen a slight increase in temperature, with a trend towards earlier spring break-up and pre-Christmas and mid-winter warm-ups. Year to year weather is quite variable and difficult to predict with extremes in temperature and precipitation occurring as well as a trend of increasing wildfire risk.

14.2.2 Future Climate and Weather

Future climate and weather address the second component of FML 2's climate story, which is based on the climate models and projections used by scientists to try and understand how the climate is changing and will be influenced by carbon emissions. Projections are model-derived estimates of future climate if assumed patterns of change were to occur based on historic data.

The future climate data was provided by the Prairie Climate Centre (PCC)[7] from the University of Winnipeg, who receive funding from the Province and are supported by the federal government (Environment and Climate Change Canada, 2023; Manitoba Sustainable Development, 2017). The PCC is a group of researchers and experts committed to making climate change meaningful and relevant to Canadians of all walks of life. They have developed the Climate Atlas of Canada[8] which provides climate data across Canada, associated reports, and stories of adaptation.

Future climate data is generated by climate models which use historical data combined with carbon emission levels to estimate how climate will be affected by different amounts of carbon introduced into the atmosphere.[9] The Intergovernmental Panel on Climate Change (IPCC) has developed Representative Concentration Pathways (RCPs) that represent different carbon emission levels (IPCC, 2023). To proactively consider a worst-case scenario

[7] Prairie Climate Center can be accessed here: https://prairieclimatecentre.ca/

[8] Climate Atlas of Canada can be accessed here: https://climateatlas.ca/

[9] For more information on how computers help us to understand climate see: https://climateatlas.ca/climate-change-projections

and better understand the full potential impacts of climate change, the future climate projection used for the CVA is RCP 8.5—a high carbon emission scenario, representing the top of predicted carbon emissions.

The PCC used an ensemble of twenty-four climate models approved for use by the IPCC downscaled to project future climate data for the three major ecoregions that exist within FML 2 and the FML as a whole.[10] Annual and seasonal variables were downloaded from the climate models to better address how future climate could affect sustainable forest management decisions and operations.

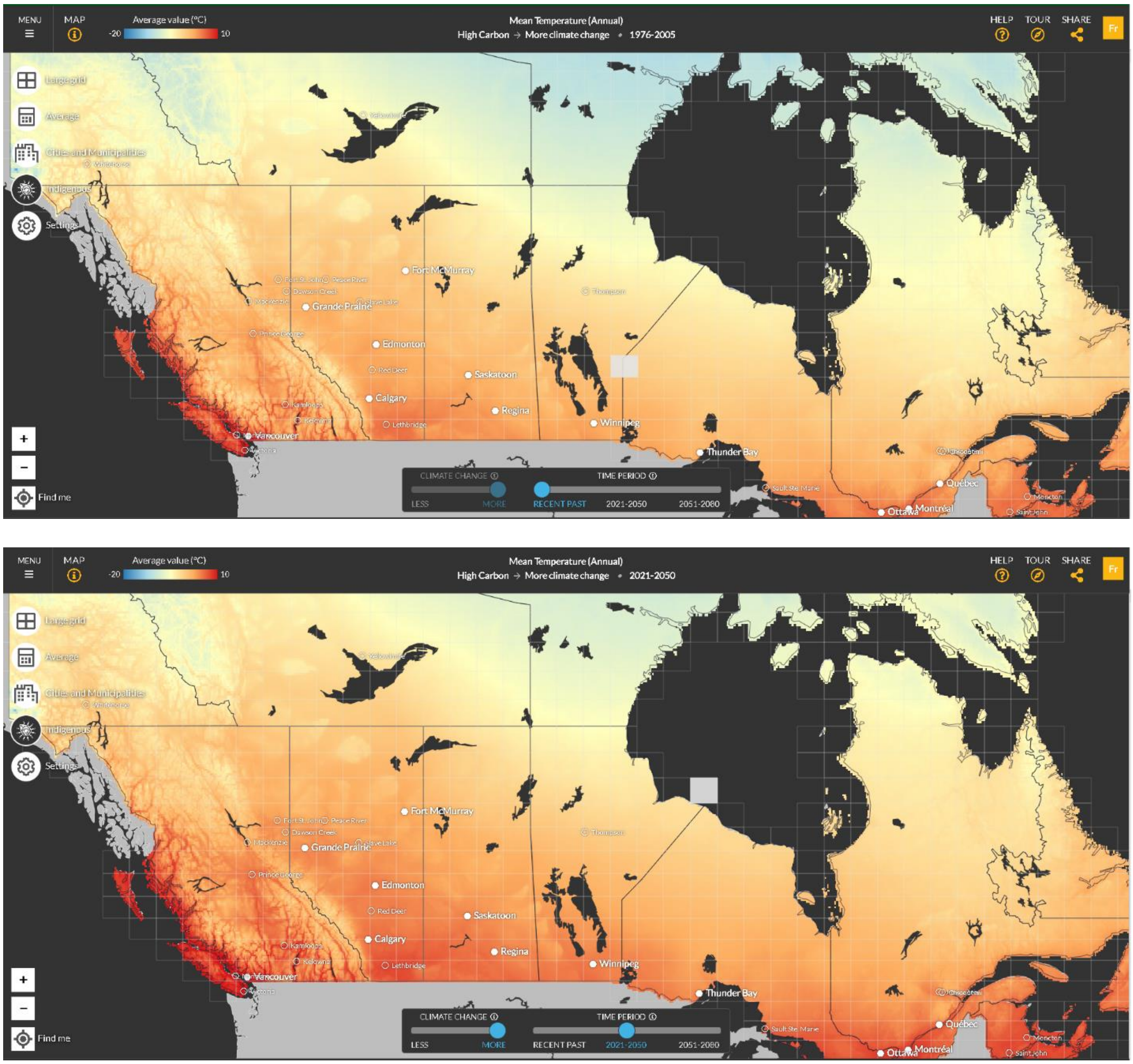


Figure 14.5. Screenshots of the Climate Atlas of Canada[11] displaying the mean annual temperature for the past and the short-term future under RCP 8.5.

[10] For more information on sources and uses of climate data see: https://climateatlas.ca/data-sources-and-methods

[11] The Climate Atlas of Canada map website can be accessed here: https://climateatlas.ca/map/canada/plus30_2030_85#

The PCC data is available in three different climate normals for comparison:

- Historical: 1976 to 2005;
- Future short-term: 2021 to 2050; and,
- Future long-term: 2051 to 2080.

According to information provided on the Climate Atlas of Canada website by the PCC, there are assumptions and limitations to using climate models that should be recognized by the users:

- The historical data is often not close to present now because of when the climate models were initially developed and the climate normals selected. This was identified when the data was initially provided to the Woodlands department as a gap in recent scientific climate knowledge. For this reason, current climate data (obtained after this was identified) and local experience discussed previously is important to bridge the gap (2006 to 2021) between the modelled data and what has occurred in the past 15 years;[12 13]
- Using an ensemble of models is the most common method to obtain climate projections because it averages out any single model extremes; [12]
- Downscaling involves adjusting the global climate models to address more localized areas of interest. The process of downscaling generalizes the data and makes it slightly less accurate, but is a standard practice. The overall trend remains accurate; and,
- PCC's climate data does not reflect changes in topography; however, FML 2 does not have significant topography (e.g., mountains), so it is not a significant factor.[14]

The PCC modelled data is a scientifically based estimate of what the climate will potentially be in the future. As such, it has been used as a tool to help address climate uncertainty but should not be considered the only future reality for climate.

14.2.2.1 Overall Trends in Future Climate

The projected future climate data is provided as averages for 30-year climate normals to show how climate is predicted to change over time based on the RCP 8.5. Similar to the current and historic climographs, the climograph in Figure 14.6 shows the change in average temperature over the year as lines, and total monthly precipitation as bars.

The model-project climograph illustrates that average monthly temperature is expected to increase consistently by 2 to 5^{0}C. The biggest increase is in the long-term future (2051 to 2080), especially in January which was modelled historically as the coldest month, and July which is typically the hottest month. Overall, there is projected to be a shift to warmer temperatures.

Monthly total precipitation sees similar increases from historical to future modelled climate normals as average temperature. In the short-term future (2021 to 2050) precipitation could potentially increase up to 6% annually. However, in the long-term future precipitation drops in August and returns to historical levels in July and September, indicating that when temperatures are hottest in thirty years, they could also have less precipitation and increase the chance of summer drought.

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[12] For more information on interpretation see: https://climateatlas.ca/atlas-guidebook/interpreting-climate-data

[13] For more information on the data sources and methods see: https://climateatlas.ca/data-sources-and-methods

[14] For more information on PCC's climate data see: https://climateatlas.ca/important-data-notes-and-limitations

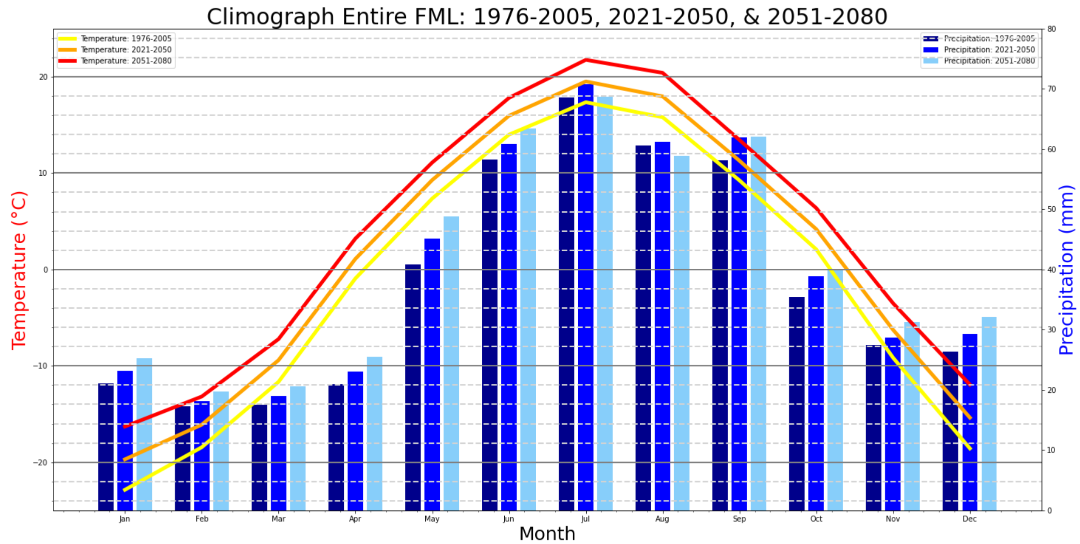


Figure 14.6. Model-projected climograph for FML 2 showing the changes between the three climate normals for average temperature (lines) and precipitation(bars) for each month. Climate normal colours shown above are: 1976-2005 yellow and dark blue, 2021-2050 orange.

Figure 14.7 below may be difficult to interpret, but it is valuable to see the graphs side by side. The graphs illustrate the projected seasonal differences in precipitation with winter (top left) and spring (top right) having the greatest increases in precipitation and summer (bottom left) having a minimal increase. The solid black lines represent the average of the twenty-four climate models used in the ensemble, if you track this line going into the future you can see the trend. The grey is the historical time period (1976 to 2005) represented by the model and red is the future projection (2006 onwards). The grey and red lines are showing the 90th and 10th percentiles (extreme ranges) projected by the ensemble of climate models; therefore, the variability in the twenty-four models is highlighted, but the overall trend can be seen.

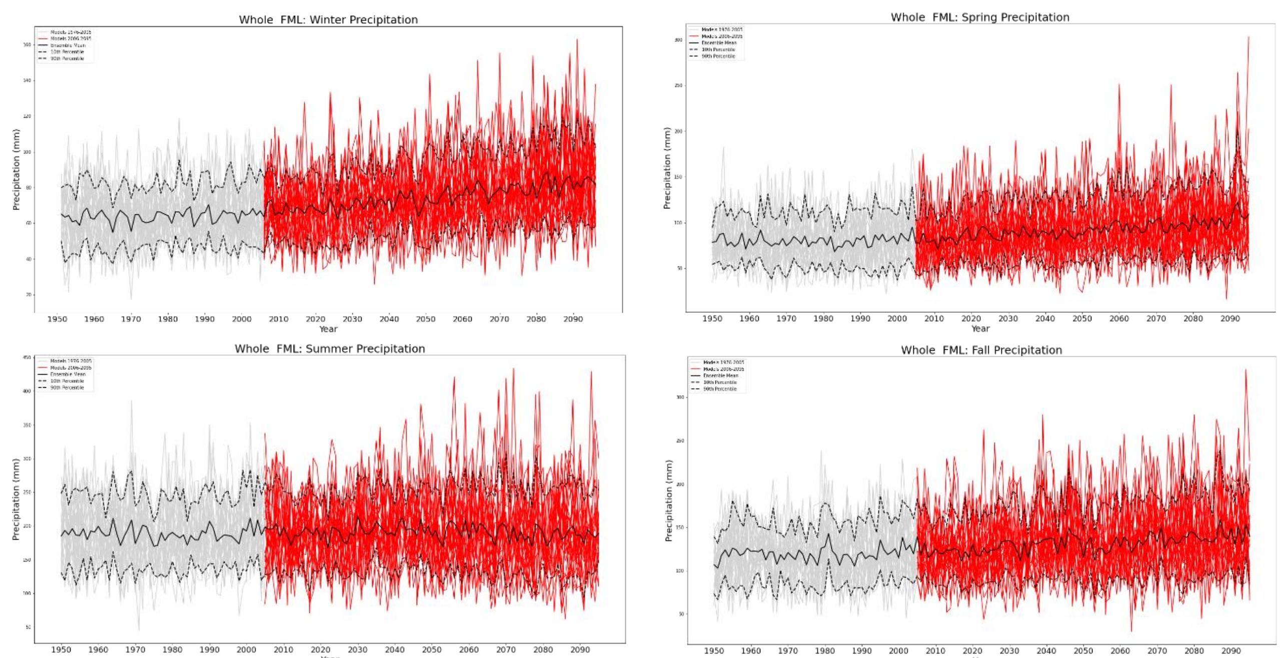


Figure 14.7. Time series of projected seasonal (winter, spring, summer, and fall) precipitation changes in the short and long-term future (red) for FML 2 under RCP 8.5.

The projected climate data for the three ecoregions (Figure 14.8) did show that Mid-Boreal Lowlands is warmer and has less precipitation (difference reflected mostly in the fall). As such, most climate change impacts will be felt more strongly in this southern ecoregion. Churchill River Uplands and Hayes River Uplands have minimal differences. Since the difference between Mid-Boreal Lowlands and the other two ecoregions would not change the type of climate impacts, the projected climate in this report shows FML 2 as a whole.

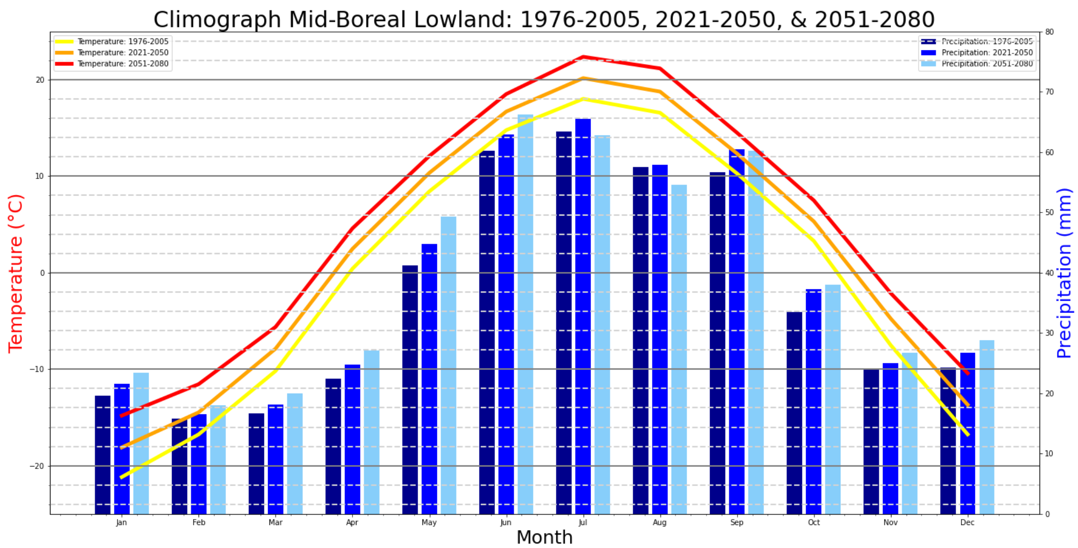


Figure 14.8. Model-projected climograph for Mid-Boreal Lowlands showing the changes between the three climate normals for average temperature (lines) and precipitation(bars) for each month. Climate normal colours shown above are: 1976-2005 yellow and dark blue, 2021-2050 orange.

14.2.2.2 Seasonal Trends in Future Climate

Seasonal variables for the whole FML have been prepared comparing the historic and future climate normals. The projected seasonal variables were chosen to provide a greater understanding of how the forest and operations will be affected by climate change. The low and high numbers for each climate normal represent the 10^{th} and 90^{th} percentiles (i.e., the range of climate projections from the models.)

Winter trends for the projected average short-term future (2021 to 2050) in Table 14.1:

- The number of very cold days is projected to drop by 15 days in the short-term future;
- The coldest temperature could increase by 3.6°C; and,
- Winter precipitation is expected to increase by 9%.

Table 14.1. Winter climate variables compared between historical, short-term, and long-term future. Averages (avg) are reported with brackets indicating change from historical, and low and high indicate 10^{th} and 90^{th} percentiles from the models.

Climate Variable	Description	1976-2005	2021-2050			2051-2080		
		Avg	Low	Avg	High	Low	Avg	High
Very Cold Days (Days)	Days when the temperature reaches -30°C.	34	9	19 (-15)	30	1	7 (-27)	16
Coldest Minimum **Temperature (°C)**	The coldest temperature of the year.	-40.6	-40.1	-37.0 (3.6)	-33.9	-36.6	-32.8 (7.8)	-29.0
Winter Precipitation (mm)	Average Total December, January, and February rain and snow.	64.8	50.4	70.80 (9%)	91.6	56	77.3 (19)	101.6

Summer trends for the projected average short-term future (2021 to 2050) in Table 14.2:

- The number of very hot days is projected to increase by 7 days in the short-term future;
- The highest temperature could increase by 2.2°C;
- FML 2 could start to experience nights that do not go below 20°C;
- Summer precipitation is expected to increase slightly by 2%; and,
- The number of days where temperatures reach 25°C is projected to increase by 17 days.

Table 14.2. Summer climate variables compared between historical, short-term, and long-term future. Averages (avg) are reported with brackets indicating change from historical, and low and high indicate 10th and 90th percentiles from the models.

Climate Variable	Description	1976-2005	2021-2050			2051-2080		
		Avg	Low	Avg	High	Low	Avg	High
Very Hot Days (Days)	Days when the temperature rises to 30°C.	3	2	10 (7)	19	7	23 (20)	39
Warmest Maximum **Temperature (°C)**	The highest temperature of the year.	31.2	30.8	33.4 (2.2)	36.2	32.5	35.8 (4.6)	39.1
Tropical Nights (Nights)	When the lowest temperature of the days does not go below 20°C.	0	0	1 (1)	3	1	7 (7)	16
Summer Precipitation (mm)	Average total June, July, and August rain.	187.5	136	192.8 (2%)	253.6	126.9	191 (1%)	261.1
Summer Days (Days)	Days when the temperature rises to 25 °C	26	26	43 (17)	60	41	63 (37)	83

Spring and fall trends for the projected average short-term future (2021 to 2050) in Table 14.3:

- Spring precipitation is expected to increase by 9%;
- Fall precipitation is expected to increase by 8%;
- The last day of spring frost is projected to occur 9 days earlier in mid-May; and,
- The first day of fall frost is projected to occur 9 days later at the end of September.

Table 14.3. Spring and Fall climate variables compared between historical, short-term, and long-term future. Averages (avg) are reported with brackets indicating change from historical, and low and high indicate 10th and 90th percentiles from the models.

Climate Variable	Description	1976-2005	2021-2050			2051-2080		
		Avg	Low	Avg	High	Low	Avg	High
Spring Precipitation (mm)	Average total March, April, and May rain and snow,	80.1	54.2	87.9 (9%)	125	60	95.7 (19%)	136.6
Fall Precipitation (mm)	Average total September, October, and November rain and snow.	121.1	89.2	129.4 (6%)	175.4	89.1	133.3 (10%)	182.1
Date of Last Spring Frost	Marks the approximate beginning of growing season.	26-May	8-May	17-May (-9)	26-May	29-Apr	10-May (-16)	20-May
Date of First Fall Frost	Marks the approximate end of growing season.	19-Sep	17-Sep	28-Sep (9)	9-Oct	27-Sep	9-Oct (21)	22-Oct

Annual trends for the projected average short-term future (2021 to 2050) in Table 14.4:

- The annual mean temperature is projected to increase by 2.3^{o}C;
- The annual mean precipitation is expected to increase by 6%;
- Heavy precipitation days are only expected to increase by 1 day; and,
- The frost-free season is expected to increase by up to 18 days.

Table 14.4. Annual climate variables compared between historical, current (2006-2021), short-term, and long-term future. Averages (avg) are reported with brackets indicating change from historical, and low and high indicate 10^{th} and 90^{th} percentiles from the models.

Climate Variable	Description	1976-2005	2006-2021*	2021-2050			2051-2080		
		Avg	Avg	Low	Avg	High	Low	Avg	High
Annual Mean **Temperature (^{o}C)**	The average annual mean temperature.	-1.2	-1.8	-0.2	1.1 (2.3)	2.5	1.8	3.6 (4.8)	5.4
Annual Mean Precipitation (mm)	The average annual precipitation (rain and snow).	453.6	404.7	391.5	480.8 (6%)	572.5	398.8	497.1 (9%)	596.7
Heavy Precipitation Days (Days)	A day on which at least a total of 10 mm of rain and/or liquid-equivalent frozen precipitation is deposited at the surface.	8	N/A	6	9 (1)	12	6	10 (2)	14
Frost Free Season (Days)	The approximate length of the growing season, during which there are no freezing temperatures to kill or damage plants.	115	166.4	118	133 (18)	149	133	151 (36)	170

**Collected from Environment and Climate Change Canada Weather Stations (Environment and Climate Change Canada, 2022).*

The 2006 to 2021 climate data in Table 14.4 indicates that the recent average for FML 2 has been colder with less precipitation and more frost-free days. It is important to remember that the data was obtained through different methods; there was a lot of variation in precipitation each year between 2006 and 2021 ranging from 278 to 585 millimetres, and the modelled data are averages for 30 years.

Figure 14.9 is a visual representation of some of the key seasonal and annual climate indicators from the tables above. You can see the overall projected trends for FML 2 from climate change.

The data provided by Prairie Climate Centre align with the predictions that national and provincial experts are using to guide policy development (Prairie Climate Center, 2024; Environment and Climate Change Canada, 2023; Lulham, et al., 2023; Sauchyn, et al., 2020; Bush & Lemmen, 2019; Manitoba Sustainable Development, 2017; Wang, et al., 2017; Flannigan, et al., 2013). [15]

These predictions include:

- Warming trends are predicted to be more pronounced in northern latitudes (Bush & Lemmen, 2019);
- Drier summers (precipitation increase not keeping up with temperature increase) and increased potential for prolonged droughts where conditions are already;
- Expanding wildfire season (starting earlier and ending later);[16]
- Increase in wildfire spread days (weather conducive to wildfire ignition and spread) by 50% in western Canada by the end of the century (Wang, et al., 2017);
- More precipitation in spring and fall potentially leading to more flood events (Lulham, et al., 2023);

[15] For more information on predicted climate: https://natural-resources.canada.ca/climate-change/climate-change-impacts-forests/impacts-climate-change-forests/13095

[16] For more information on climate change's influence on fire weather: https://natural-resources.canada.ca/climate-change/climate-change-impacts-forests/impacts-climate-change-forests/fire-weather/17776

- Increased frequency and intensity of extreme weather events (Lulham, et al., 2023);
- Sudden and unpredictable disturbances and weather fluctuations more common (Sauchyn, et al., 2020);
- More frequent lightning storms resulting in 80% more lightning strikes in Canada (Manitoba Sustainable Development, 2017); and,
- Increase in windy days that can further dry fuels and fan wildfire spread.[17]

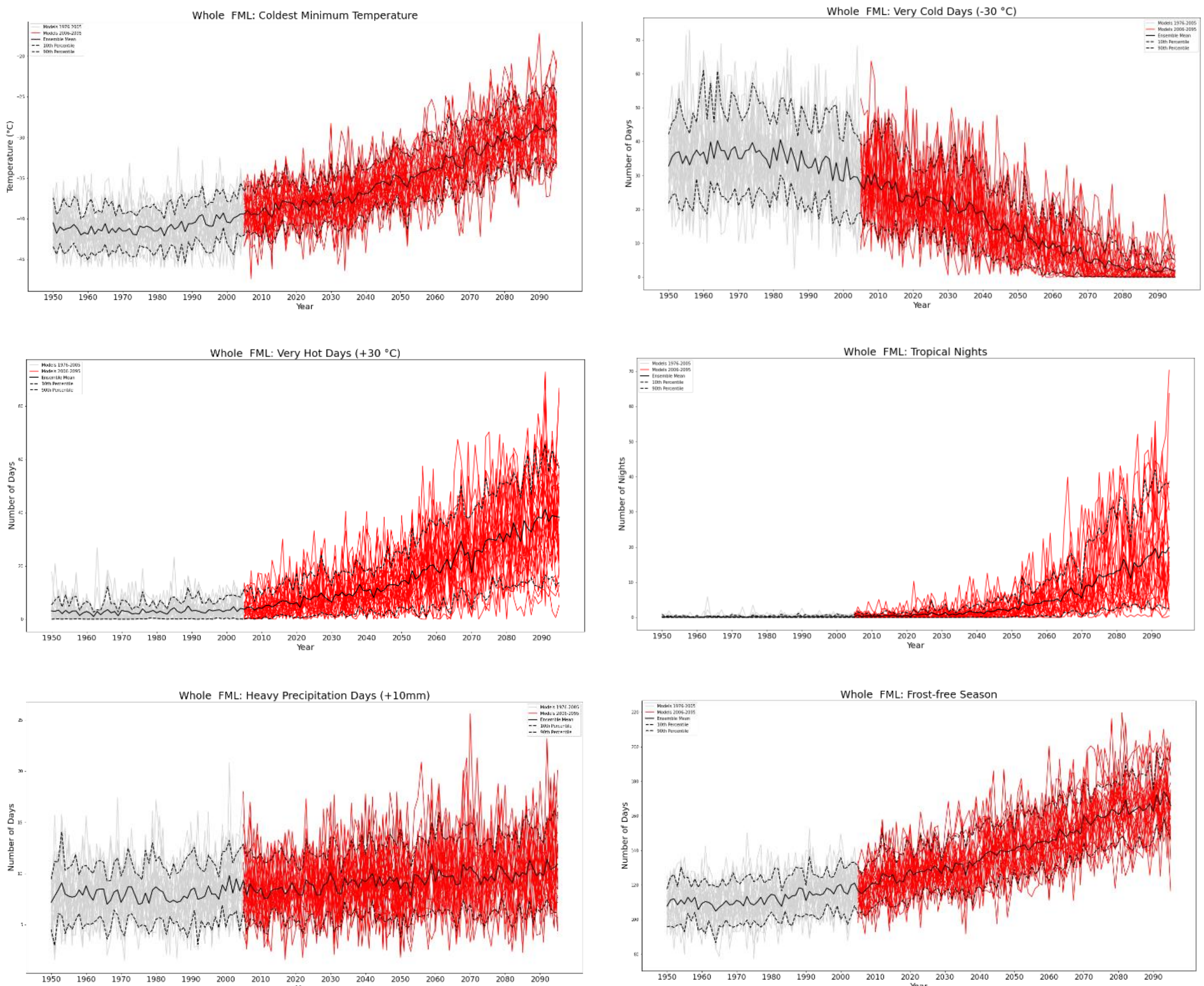


Figure 14.9. Time series of key climate indicators showing projected changes in the short and long-term future for FML 2 under RCP 8.5. Key climate indicators: Coldest Minimum Temperature, Very Cold Days, Very Hot Days, Tropical Nights, Heavy Precipitation Days, and Frost-Free Season. The coloured lines show the variability in the models: grey is historical (1976-2005), and the red is the projected future (2006 onwards). The dotted lines represent the 10th and 90th percentiles, and the solid line is the average of the model ensemble.

Overall, FML 2 is expected to get a little warmer and experience a precipitation increase in certain seasons. The growing period is expected to get longer and, inversely, the frozen operating period will likely get shorter. The

[17] For more information on how climate affects wildfires: https://climateatlas.ca/forest-fires-and-climate-change

data supports observations and expectations of Woodlands department that seasonal volatility will increase with extreme high and low temperatures, prolonged drought in the summer, and warming events in the winter.

Understanding the current and future climate is foundational for the CVA process. Having observed and scientific data available reduces the uncertainty around climate change and what could be experienced in the future. This information was used to frame the remainder of the CVA, including what the forest could look like based on the future climate projections.

14.2.3 Current and Future Forest Conditions

Global climate (average temperature, precipitation, and wind) drives the location of the world's terrestrial biomes (distribution and abundance of species), and local climate conditions and topography further refine species and ecosystems described as ecoregions (Hunter et al., 2018). Therefore, the current ecosystems on FML 2 have developed based on the historic climate conditions, and future ecosystems will change in response to future climate.

The current forest condition is described extensively in Part 1 – Planning Context, section 4 Current Forest Description. The Preferred Forest Management Scenario (PFMS) was based on the current and historic forest conditions, which was the information available at the time of modelling.

Future forest conditions are predictions of how the forest could change based on short and long-term future climate projections. Future forest condition changes and possibilities were discussed by the Woodlands department during a workshop held in July 2022 after reviewing future climate and weather predictions. The outcomes of that discussion (noted by an *) and future forest conditions compiled from scientific literature for Manitoba and the boreal forest are listed in Table 14.5 (Prairie Climate Center, 2024; D'Orangeville, et al., 2023; Forestry and Peatlands Branch , 2022; Lemmen, et al., 2021; Hennon, et al., 2020; Sauchyn, et al., 2020; Luo, et al., 2019; Gauthier, et al., 2014; Flannigan, et al., 2013; Price, et al., 2013).[18] No future forest condition predictions were volunteered during engagement.

Table 14.5. Predicted future forest conditions based on short- and long-term future climate projections from the Woodlands department (*) and scientific literature for Manitoba and the boreal forest.

Forest Criteria	Short-Term Future Condition (2021-2050)	Long-Term Future Condition (2051-2080)
Biological Diversity	Optimal seed zone changes. * Higher percent of forest in younger age classes. * Increase in early succession species.	Shift in climatic niches for forest species. Increase in hardwood species as ranges shift north. * Decrease in black spruce species as areas become drier.
Ecosystem Condition and Productivity	Productivity and biomass increase where limited by temperature in the northern range and decrease in the southern range. Increase growth where not moisture limited. * Potential increase in resilience for areas of the boreal benefitting from warmer temperatures. More destructive and unpredictable insect outbreaks. Jack pine bud worm a greater threat. *	Increased productivity declines as temperature increases, precipitation decreases, and drought stress occurs. * More tree growth where wetlands dry out. * Mountain pine beetle endemic to boreal and target jack pine as well. Increase in disease outbreaks.

[18] For more information on the impacts of climate change on forests: https://natural-resources.canada.ca/climate-change/climate-change-impacts-forests/impacts-climate-change-forests/13095 and https://climateatlas.ca/topic/forests

Forest Criteria	Short-Term Future Condition (2021-2050)	Long-Term Future Condition (2051-2080)
	Drier forests and wildfire fuels covering large areas. *	
Soil and Water	Decrease in soil moisture. Increased drought and flood risk.	Increased drought and flood risk.
Role in Global Ecological Cycles	More intense and frequent wildfires.	More intense and frequent wildfires.
Economic and Social Benefits	More salvage harvesting. * Wood access increasingly limited.	Increased uncertainty in timber projections.

The observed and scientific data and predictions gathered in this section for climate and forest change were extremely important and foundational for stimulating the discussions required in the following vulnerability assessment. The impacts and degree of vulnerability the forest management plan and associated operations have from climate change cannot be recognized without an understanding of the expected changes FML 2 could and have already experienced.

14.3 VULNERABILITY ASSESSMENT

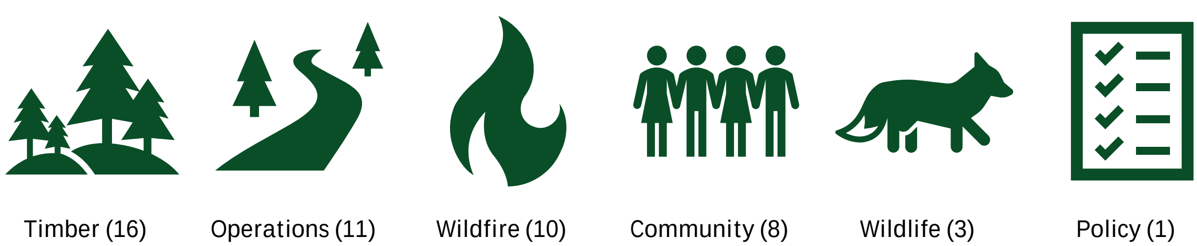
The purpose of the vulnerability assessment is to understand how the forest management plan and associated operations, referred to together as sustainable forest management (SFM) in this section, on FML 2 is impacted by and vulnerable to the changing climate and forest conditions identified in the previous section. This process will identify where adaptation is needed to reduce vulnerability, where positive impacts could be enhanced by adaptation, and is critical for meaningful climate change adaptation.

14.3.1 Climate Impacts

The first part of the vulnerability assessment is designed to answer the question: *How does the climate impact sustainable forest management on FML 2?*

During the first workshop, after reviewing the climate data and gathering insight on the potential future forest, the Woodlands department brainstormed potential positive and negative impacts to the forest, the forest management plan, and associated operations. Additional climate impacts were recorded during engagement with rightsholders, stakeholders and the SFMC and included along with the impacts raised by the Woodlands department.

Impacts are positive or negative effects on natural and human systems by physical events, disasters, and climate change (Edwards, et al., 2015). In total, forty-nine impacts were identified for the vulnerability assessment based on the knowledge, experience, and data we had at the time of this assessment. Each impact was organized into the CCFM Criteria for Sustainable Forest Management to allow the impacts, vulnerabilities, and adaptations to be directly linked to the forest management plan which uses the CCFM Criteria as guiding principles, as well as to associated certification standards that are evaluated based on the CCFM Criteria. Out of the forty-nine impacts, eleven were positive. Common themes that occurred in the impacts include, timber, operations, wildfire, community, wildlife, and policy.



14.3.2 Assessing Vulnerability

The second part of the vulnerability assessment is designed to answer the question: *How much does the climate impact affect sustainable forest management on FML 2?*

Vulnerability is the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change (including variabilities and extremes). It is a function of the character, magnitude and rate of climate change and the variation to which a system is exposed, its sensitivity, and its adaptive capacity (Edwards, et al., 2015).

Vulnerability = (Exposure + Sensitivity) + Adaptive Capacity

The vulnerability assessment is a relative ranking of how exposed and sensitive sustainable forest management on FML 2 is to the climate impacts (the effect), and the adaptive capacity of the system to the climate impact (the response).

- Exposure is the degree to which the system is exposed to significant climatic variations and the nature of that exposure, including physical climate changes (e.g. temperature, precipitation) and resulting climate conditions (Edwards, et al., 2015).
  Exposure answers the question: How common is this impact on FML 2?
- Sensitivity is the degree to which all elements of a system are affected, either adversely or beneficially, by climate-related stimuli. It may depend on innate physiological or biological variables, physical and ecological factors, or existence and extent of other stressors (Edwards, et al., 2015).
  Sensitivity answers the question: How many aspects of the forest or forest management plan and associated operations does the impact affect and how?
- Adaptive capacity is the ability of a human system to adjust to climate change (including variability and extremes) to reduce adverse impacts, moderate potential damages (moderate impacts to reduce vulnerability), take advantage of beneficial opportunities, or cope with the consequences. It includes the strengths, weaknesses, attributes and resources available to prepare and respond (Edwards, et al., 2015).
  Adaptive capacity answers the questions: How are NFMC, the government, or contractors able to respond to the impact? Are there barriers that make this more difficult?

All suggested impacts were reviewed by a group of the Woodlands department with planning and operational local knowledge. Through a series of meetings, each impact was discussed thoroughly to understand the scope of the impact exposure, sensitivity, adaptive capacity, and how they rank relative to one another (high, medium, or low). Any information that is considered business proprietary is not included in this document. The vulnerability rankings are subjective, based on sustainable forest management experience and the information and knowledge available (including engagement feedback) at that time. The vulnerability rankings and priorities will be re-visited through an adaptive management process; therefore, rankings are not static but adjust over time as information and conditions changes. Rankings are defined as follows:

Effect on System

- High: Really exposed and sensitive (i.e. the impact is FML wide and affected many aspects of the sustainable forest management system).
- Low: Not a major concern (i.e. the impact is localized and has minimal impact to accomplishing sustainable forest management).

Adaptive Capacity of System

- High: the current processes in place to respond and address the impact make NFMC resilient to the climate impact.
- Low: The current system is not sufficiently addressing the impact.
- Medium falls in between the rankings defined above.

When ranking adaptive capacity, the Woodlands department considered current awareness of the impact, what technology was being used and is available, economic resources available to address the impact, policy, human and social capital, knowledge, as well as short- and longer-term risk. Adaptive capacity is the human system: what forest managers and operators have the most control over, and where adaptation can mitigate or enhance the impact.

Once the impacts were ranked for effect and response, the Canadian Council of Forester Ministers (CCFM) vulnerability matrix (Table 14.6) was used to determine the overall vulnerability ranking. Overall, a majority of the impacts were ranked as medium; however, several were ranked as high and low.

Table 14.6. Vulnerability Matrix: high is red, medium is yellow, and green is low vulnerability (Edwards et al., 2015).

Effect on System (Exposure + Sensitivity)	Adaptive Capacity of System		
	High	Medium	Low
High			
Medium			
Low			

During the first Vulnerability Assessment Workshop with the Woodlands department, any knowledge gaps or uncertainties that came up were recorded. Uncertainty is a vulnerability — by acknowledging what we do not know we can include gaps as opportunities for adaptation to increase knowledge and understanding.

Uncertainty is the degree to which a value or relationship is unknown. It can result from a lack of information or disagreement about what is known or knowable, can originate from many sources (e.g. quantifiable data errors, ambiguously defined terms, uncertain projections of human behaviour), and can be quantitative or qualitative statements (Edwards, et al., 2015).

14.3.3 Prioritizing Vulnerability

The final part of the vulnerability assessment is designed to answer the question: *What impacts require adaptation as of forest management plan start?*

Not all impacts can be addressed at once. In order to prioritize, the High and Medium vulnerability impacts were reviewed and the question of whether proactive adaptation was required for the changing climate was considered, discussed, and agreed upon by members of the Woodlands department. If adaptation was not considered to be required, the impact was not prioritized. Impacts where the Province is already working on adaptation, i.e., that fall under government jurisdiction, and where current policy is a barrier for adaptation were not prioritized at this time (e.g., climate change influenced yield curves, species migration, changing forest management plan modelling parameters).

These prioritization discussions resulted in eight impacts that required adaptation: seven were negative and high vulnerability, and one was positive and medium vulnerability (Table 14.7). All other impacts and vulnerability rankings and priorities will be archived for future reassessment as new knowledge, learnings, or insights are gained as part of the CVA's adaptive management. Completing the vulnerability assessment, which required the most effort and thought in this CVA process, allowed the Woodlands department to focus on impacts where they can influence the most change.

Table 14.7 Priority impacts and vulnerability assessment rankings as of plan start (2025).

Priority Impact	Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Shortened frozen operating season.	High	High	Low	High
More saturated soils causing operation shutdowns.	Medium	High	Low	High
Decrease in snow depth affecting winter roads.	High	Medium	Low	High
Loss of fibre from increased wildfire frequency and severity.	High	High	Low	High
Increased reliance on residual fibre.	High	High	Medium	High
Forestry and climate change communication.	High	Medium	Medium	Medium
Forest management plans lack flexibility needed to deal with climate change.	High	High	Medium	High
Uncertainty.	High	High	Medium	High

14.4 ADAPTATION OPTIONS

A second Workshop was held with the Woodlands department to brainstorm adaptation options for the eight prioritized impacts identified through the vulnerability assessment steps. Each impact was summarized into a statement (Table 14.7), the exposure, sensitivity, and adaptive capacity were reviewed, then a timed brainstorm session was completed. The purpose of the adaptation options is to reduce vulnerability, increase resiliency and capacity to respond to impacts of climate change, address gaps and weaknesses, and promote positive adaptations already being completed. Below in Table 14.8 are examples of adaptation options that were devised during the Workshop for each impact and examples of the adaptations.

Adaptations are actions to manage the risks/reduce negative impacts of climate change, and to increase the magnitude and likelihood of positive impacts. It is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which in turn moderates harm or exploits beneficial opportunities (Edwards, et al., 2015).

Table 14.8. Prioritized impacts, number of options brainstormed and example of an option for each impact.

Prioritized Impact	#	Examples of Adaptation Options
Shortened frozen operating season	10	Plan for consistently available stockpile locations for even fibre flow.
More saturated soils causing operation shutdowns	7	Build in-block road networks to higher standards.
Decrease in Snow Depth Affecting Winter Roads	6	Utilize all weather roads so you are less dependent on winter roads.
Loss of fibre from increased wildfire frequency and severity	9	Utilize renewal strategies that promote fire resistance.
Increased reliance on residual fibre	5	Rely more on annual allowable cut than bringing in outside sources.
Forestry and climate change communication	8	Train the Woodlands department on climate change adaptation.

Prioritized Impact	#	Examples of Adaptation Options
Forest management plans lack flexibility needed to deal with climate change	5	Monitor and report for adaptive management at the 5-year Forest Report.
Uncertainty	4	Track operation shutdowns due to wildfire and analyze for long-term trends.

For the impact "uncertainty", the list of knowledge gaps and uncertainties recorded during the first Woodlands Workshop and the associated vulnerability assessment were reviewed and considered for adaptation. Seven of the uncertainties resulted in adaptation options to address the vulnerability. The rest were considered not important at the time, out of scope, or fell within government jurisdiction. The list of uncertainties will be maintained and added to as part of the CVA adaptive management, which is also an adaptation strategy to address uncertainty.

14.4.1 Existing Adaptations

Throughout the CVA process, adaptations that were already being introduced were identified and recorded. Some examples of these adaptations include:

- Identifying and protecting focal species that represent important ecosystems;
- Establishing landscape level targets for age and structure classes and habitat;
- Minimizing density of permanent road network and decommissioning and rehabilitating roads to maximize productive forest area;
- Employing vegetation control techniques to mitigate drought stress;
- Planting early in the season to reduce the effect of drought on seedlings;
- Monitoring forest health and pests during stand Pre-Harvest Forest Investigation surveys;
- Salvaging insect (jack pine budworm) disturbed stands and planting to reestablish forest;
- Rating culverts for 100-year storms;
- Weather data monitored daily for wildfire conditions;
- Supporting communities in developing FireSmart applications for funding; and,
- Pile burning to reduce fuel loads.

Additionally, there are adaptations that are being addressed by the Province already, including assisted migration trials for jack pine and creation of climate-sensitive forest growth models that were not available at the time of this forest management plan (Forestry and Peatlands Branch , 2022).

14.4.2 Prioritizing Adaptations

The second half of the workshop contributed to prioritizing the adaptation options for implementation by providing preliminary importance rankings and discussion of barriers to implementation and feasibility.

Barriers are impediments and capacity deficits that can stop, delay or divert development and implementation of comprehensive and integrated climate adaptation (and mitigation) efforts (Edwards, et al., 2015).

Feasibility is the degree to which climate goals and response options are considered possible and/or desirable (IPCC, 2018).

The final rankings and prioritization were completed by a group from the Woodlands department. Each adaptation option was evaluated and ranked High, Medium, or Low based on their importance in achieving sustainable forest management objectives and their feasibility in implementation. Those options considered important (High and some Mediums) were further identified based on the CCFM Guidebook as robust, no-regret, win-win, and must-do options shown and defined in Figure 14.10 (Edwards, et al., 2015).

The outcome of this evaluation was a prioritized list of adaptation options that was recommended for implementation. Adaptations that were not considered important at the time will be considered potential options in future assessments.

The ranking process stimulated valuable conversations about the current and future benefits and reality of putting the options into action. It helped focus the adaptations to what NFMC will implement as of forest management plan start (2025; Table 14.9).

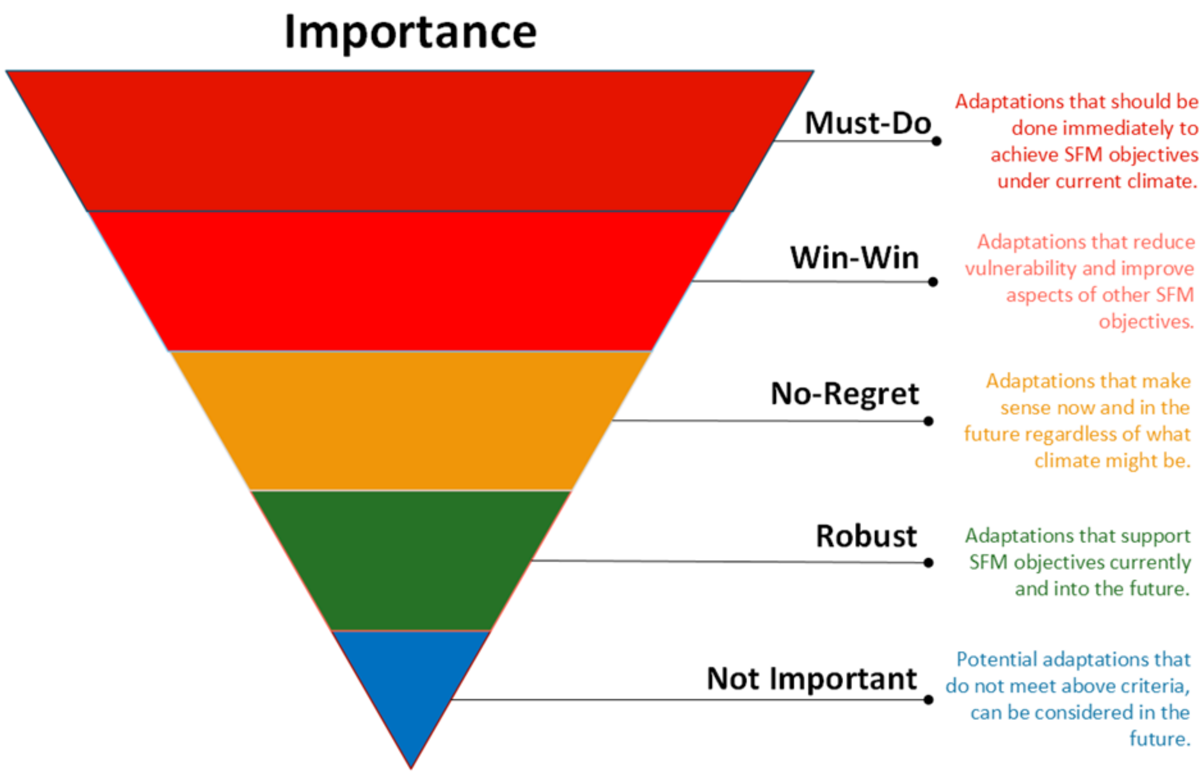


Figure 14.10. Ranking Importance of Adaptation Options (Edwards, et al., 2015).

14.5 IMPLEMENT AND MONITOR ADAPTATION

The final step in the CVA process is determining how adaptation options will be implemented and how adaptive management will be used to continuously improve climate adaptation. Key members of the Woodlands department collectively determined the implementation of the adaptation options. The adaptation options in Table 14.9 all have an implementation plan associated with them that incorporates them directly into existing Woodlands department systems and processes such as the forest management plan reporting schedule, Environmental Management System, and certification targets and reporting. These systems and processes are all outlined in forest management plan Part 3 – Implementation and Monitoring, but the specific details of the adaptation option implementation are considered proprietary by NFMC. The CVA will be reassessed as part of the forest management plan reporting process, which will ensure a formal review is completed and adaptive management—a core part of the CVA framework and forest management plan – is incorporated.

Adaptive Management describes an iterative process designed to improve the rate of learning about the management of complex systems. The process incorporates an explicit acknowledgement of uncertainties and knowledge gaps about the response of the system to management actions (Manitoba Agriculture and Resource Development, 2021). Should any of the prioritized adaptation options in Table 14.9 need to be implemented, they will be done so in the context of working within existing guidelines and legislation, while balancing trade-offs through the consideration of potential impacts to things like cumulative effects, ecological impacts, and societal benefits.

Table 14.9. Final prioritized adaptation options for the forest management plan.

Impact	Adaptation Option
Shortened frozen operating season	Review existing road systems strategically for opportunities to upgrade road classes for more dependable seasonal access.
	Utilize different tactics for building and maintaining winter roads so that they last longer by updating or developing best management practices guidelines.
Shortened frozen operating season	Plan for consistent availability of stockpile locations for even fibre flow by adding this to the best management practice guidelines.
	Track annual freeze up and melts to determine long-term pattern shifts.
More saturated soils causing operation shutdowns	Utilize different tactics for building and maintaining in-block roads so that they hold their structure by updating or developing best management practices guidelines.
Decrease in snow depth affecting winter roads	Consider winter road equipment to make ice and flood the road for better road maintenance and longevity.
	Utilize different tactics for maintaining winter roads and access routes at the end of the season so they are ready for future use if required by updating or developing best management practices guidelines.
Loss of fibre from increased wildfire frequency and severity	Initiate discussions with the Province regarding wildfire management.
Increased reliance on residual fibre	Stay abreast of new developments in the surrounding region that could strengthen or contribute to additional residual fibre supply.
	Run scenarios to understand potential outcomes if access to residual fiber is reduced and develop a contingency plan based on results if required.
Forestry and climate change communication	Provide climate change adaptation information to the public and include climate adaptation on agendas for engagement sessions.
	Include climate change adaptation in annual Woodlands Department training.
Forest management plan's lack flexibility needed to deal with climate change	Use the five-year monitoring and reporting requirement for the forest management plan to revisit the CVA, re-evaluate vulnerabilities and adaptation priorities, and make adjustments as required for adaptive management.
	Discuss with the Province the opportunity for contingency blocks in the forest management plan.
	Adjust the forest management plan model to account for major changes that occur during the 20-year implementation as required.
Uncertainty	Track operation shutdowns due to wildfire and wildfire risk for analysis of long-term trends.

14.6 CONCLUSION

Through the Climate Vulnerability Assessment (CVA) process, the uncertainty around climate change and how it influences the forest management plan and associated operations was reduced. The current and future climate data provided a baseline and foundation for evidence and science-based decision making. The step-by-step process allowed the Woodlands department to focus on tangible impacts, really understand how and to what degree their forest management plan and operations are affected, and choose meaningful, important, and feasible adaptations to implement. The implementation plan for the CVA focuses on incorporating the adaptations and their monitoring and reporting directly into existing systems, which will make putting them into action that much easier. Incorporating the CVA into the forest management planning process has made this forest management plan and associated operations for the next twenty years more resilient to climate change.

15 Cumulative Effects

The purpose of the Cumulative Effects Assessment (CEA) and chapter in this forest management plan is to address the question: *How does this forest management plan affect sensitive values when looking at the strategic- and operational-level outcomes as a whole?*

The CEA section can be considered a summary of the forest management plan, bringing together Part 1 – Planning Context, Part 2 – Analysis and Modelling, and Part 3 – Implementation and Monitoring in a format that holistically relates it to values that are sensitive to cumulative effects. The summary identifies how risks to these values are addressed throughout the plan.

What are cumulative effects?

There are many definitions of cumulative effects across and within different sectors and jurisdictions. The main objective is to understand how multiple interactions among human activities and natural processes accumulate over time and space. The definition of cumulative effects often referenced for forestry is:

Cumulative effects are changes to environmental, social, and economic values caused by the combined effect of past, present and potential future human activities and natural processes (Government of British Columbia, 2016).

What are human activities and natural processes in this cumulative effects assessment?

The scope of the CEA is limited to the FML 2 landbase (Map 15.1), and the forest management plan and its associated operations are the activities. Natural and human disturbances (sourced from the federal government as part of a disturbance layer) were included in additional analyses that contributed to the CEA as past activities, the rest of the activities are limited to those that NFMC can control. Unlike governments, NFMC does not have the data, capacity, or the influence to include any other activities outside of their jurisdiction. Therefore, this is not a comprehensive analysis covering all activities on the landbase.

The cumulative effects of the forest management plan and its associated operations are reviewed through the various forest management plan analyses for the current conditions (plan start), near future (20 years out at plan end), and the long-term future (200 years out) where available.

The forest management plan and associated operations activities can be divided into the two levels of planning and implementation described below.

Strategic planning is what occurs when forest managers consider the “big picture” of the forest system over an extended period of time—planning through a “coarse-filter”. It emphasizes broad-scale components of forest management, such as forest age class and composition, and how these components may influence key forest values such as the amount and arrangement of habitat types. Strategic planning provides the framework of operating areas where forest management activities may occur to achieve the goals of the plan over the long-term, but it does not detail how these activities will be operationalized in the real world. Part 2 of the plan, Analysis and Modelling, focuses on strategic planning.

Operational planning is what occurs during the 20-year implementation of the plan and focuses on the finer-filter components of forest management that need to be taken into consideration in order to apply the strategic framework on the ground (i.e., the actual harvest and forest renewal activities). Operational planning takes the strategic-level direction identified in a forest management plan and divides it into approachable, feasible, and focused 2-year forest management operating plans (FMOPs). If strategic planning (the forest management plan) provides the framework of operating areas, operational planning (the forest management operating plan) provides the step-by-step instructions on how to make that framework reality in the short-term. Part 3 of the plan, Implementation and Monitoring, focuses on operational planning and implementation.

What are environmental, social, and economic values in this cumulative effects assessment?

For this forest management plan, we are using the term sensitive values as defined by the 2022 Manitoba Draft Cumulative Effects Assessment Guidelines (Forestry and Peatlands Branch, 2022). Sensitive values are values that can be vulnerable to cumulative effects, are important to rightsholders and stakeholders, can be affected by the forest management plan and its associated operations, and can be spatially and temporally bounded (i.e., are restricted to existing within certain areas and timeframes). This new term also distinguishes values discussed for the purposes of the CEA from the broader forest management plan values, objectives, indicators, and targets (VOITS).

Sensitive values assessed by this CEA are:

- Watersheds and aquatic ecosystems;
- Carbon balance;
- Biodiversity;
- Moose; and,
- Boreal woodland caribou.

The assessment of cumulative effects on these sensitive values was completed using the bow-tie risk assessment method with guidance from Dr. Rob Rempel[19]. Engagement with rightsholders and shareholders was used to help identify the sensitive values and components of the bow-ties. Although each sensitive value is addressed specifically in the forest management plan there is value in bringing all the strategic and operational efforts together to assess cumulative effects.

15.1 BOW-TIE ANALYSIS TO ASSESS EFFECTS AND MITIGATION

For this forest management plan, the cumulative effects assessment (CEA) was completed using a bow-tie risk assessment analysis.

What is a bow-tie analysis?

A bow-tie analysis is a visual representation of the world that evaluates risk and demonstrates causal relationships. The bow-tie, a key framework diagram for the analysis (Figure 15.1), illustrates the cumulative effect in the centre (also referred to as the “top event”), the connections between the causes or threats to a sensitive value (left-hand side of the bow-tie), the consequences of the effect (right-hand side of the bow-tie), and all the different management tools available to prevent and respond to the threats. The accumulation of these individual threats represents potential cumulative effects, and the collection of preventative barriers represent the response to reduce the threats caused by cumulative effects.

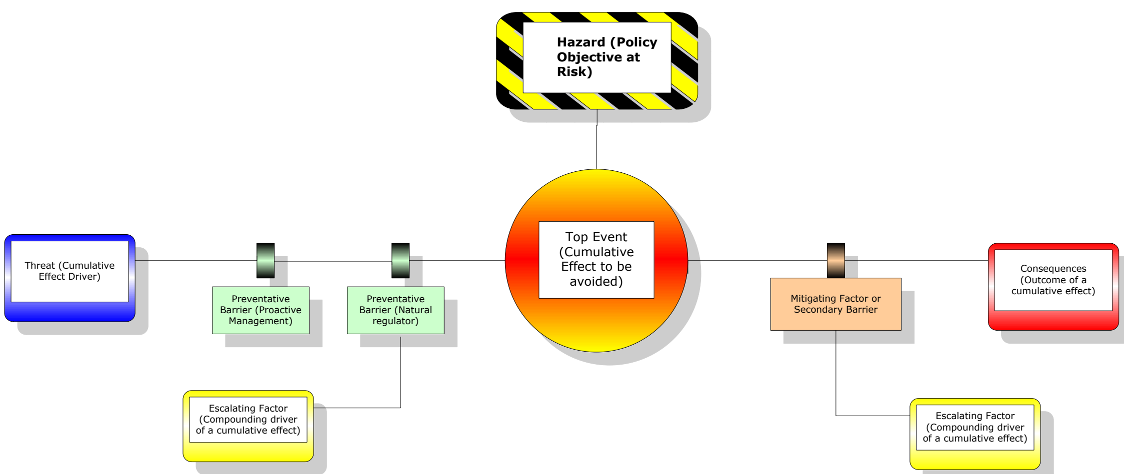
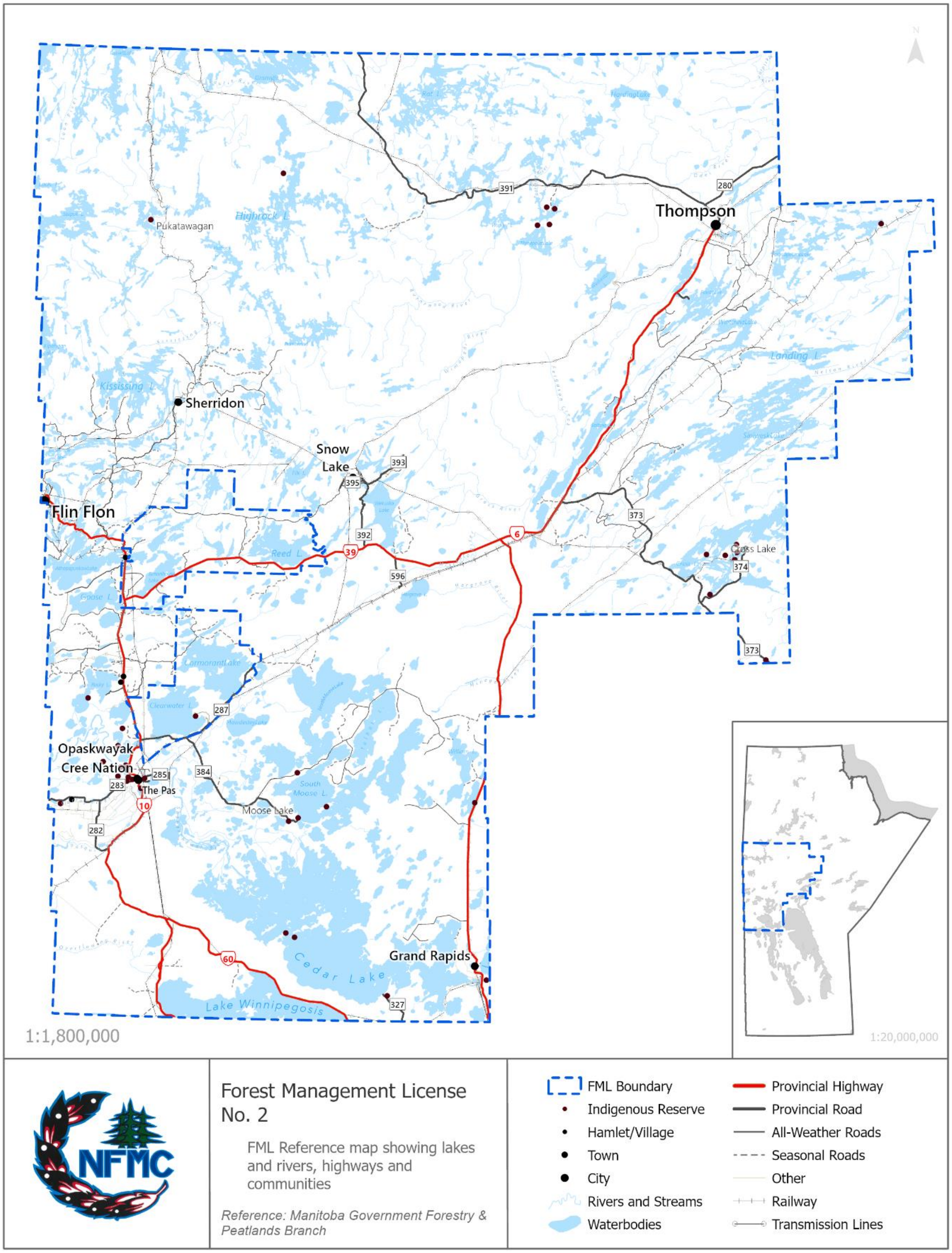


Figure 15.1. Example bow-tie analysis diagram and its components from Dr. Rob Rempel.

[19] Dr. Rob Rempel is the Principal at Forest Ecosystem Research and Information Technologies (ferit.ca) and a leader in cumulative effects assessment using the bow-tie risk assessment methodology.



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3243 *Map 15.1. Cumulative effects assessment scope boundary.*

A recent example of the bow-tie analysis being used for a CEA was for boreal caribou by the Canadian Forest Service (Winder, et al., 2021). Another example of its use was for an analysis of ecological sustainability of a forest management system in boreal Canada (Kishchuk, et al., 2018). The bow-tie analysis method is listed as a risk assessment technique by the International Organization for Standardization who provide standards for global challenge solutions. The use of the bow-tie analysis for this forest management plan CEA is logical considering the precedents and the analysis' validation as a risk assessment method.

How is the bow-tie used to assess cumulative effects?

The most important part of the bow-tie analysis is building the bow-tie diagram itself. Building the bow-tie requires an in-depth evaluation of what elements of the forest management plan and its associated operations influence the overall cumulative effect for each sensitive value. Going through this evaluation is the process of reviewing all available strategic- and operational-level management decision and tools, discussing their outcomes, and realizing their causal relationship with each sensitive value and cumulative effect. The process of building the bow-tie inherently identifies where there may not be enough strategies to mitigate and prevent a cumulative effect from occurring and is an opportunity for NFMC to fill in any gaps or identify them for discussion.

Once the bow-tie has been built, it becomes possible to visualize all of the individual threats that contribute cumulatively (or individually) to reaching a negative threshold (i.e., the top event/cumulative effect) for that sensitive value that is difficult to recover from, the consequences of that top event, and all the preventative barriers that exist to proactively and reactively reduce the risk of each threat and consequence. The bow-tie diagram itself and the additional analyses that were included in it will be used to visualize and understand whether the forest management plan and its associated operations are at risk of contributing towards a cumulative effect for each sensitive value.

How is risk being evaluated in this cumulative effects assessment?

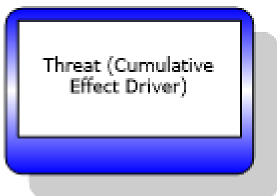
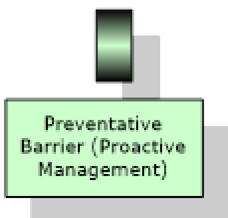
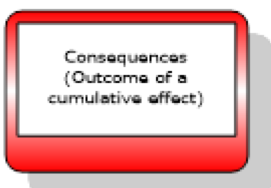
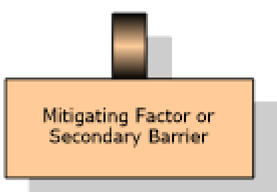
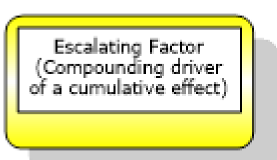
The forest management plan CEA bow-tie analysis is a qualitative risk assessment method, with the assessment of risk based on the knowledge and informed judgements of subject matter specialists–in this case Dr. Rob Rempel, who has published papers on the use of bow-tie analysis and worked closely with NFMC to ensure the method, and terminology was understood and being applied appropriately. Other subject matter specialists in forestry, wildlife, and FML 2 were included through rightsholders, shareholders, the Sustainable Forest Management Committee, and the public during forest management plan engagement sessions which helped identify risks and threats. Risk is being assessed in a general sense through the evaluation of significance for each sensitive value. For this CEA, there is no process of ranking the impact and likelihood of each threat and entering them into a risk matrix or assigning a risk value. Instead, it is a comprehensive discussion of risk and how the forest management plan and its associated operations affect the risk of a threat, consequence, or cumulative effect. The CEA uses informed judgements to determine if there is a gap in preventative barriers and mitigation factors, and will discuss opportunities for improvement, if recommended.

15.1.1 Bow-tie Analysis Components

The bow-tie analysis comes with its own set of terminology for its components (Table 15.1). The bow-tie diagram is read from left (proactive) to right (reactive), with the center knot representing the cumulative effect (top event).

Table 15.1. Bow-tie component descriptions and sources.

Component	Description
	The hazard is the policy objective at risk or overall goal for the management of the sensitive value. The hazard was developed for this CEA based on the sensitive value and strategic-level policies. Policy objective is used to describe this component in this section.

Component	Description
	The top event (i.e., the cumulative effect) is the negative outcome for the sensitive value from which it is difficult to recover. Cumulative effect is used to describe this component in this section. The top event is the cumulative effect that occurs when the hazard has failed and the management strategies (e.g., the barriers and factors in place) are not sufficient to avoid the cumulative effect occurring. The top of event can be triggered by individual threats or a combination of multiple threats.
	The threats are the drivers that can individually or in combination trigger the cumulative effect to occur. The initial threats for this CEA were primarily developed by Dr. Rob Rempel with an informed understanding of the threats to each of the sensitive values. These were reviewed, and in some cases revised, based on the values, concerns, and feedback heard during engagement with rightsholders and stakeholders throughout the forest management plan development process.
	The preventative barriers are proactive actions that are in place to prevent the threat from occurring, and thus contribute to reducing the risk of the cumulative effect. Preventative barriers are mostly human management activities at the strategic (coarse-filter) and operational (fine-filter) levels. They are the most important controls NFMC has on preventing cumulative effects. These were obtained from the forest management plan Parts 2 and 3: strategic management objectives, forest modelling, the Preferred Forest Management Scenario (PFMS), implementation guidelines, and best management practices for associated operations.
	The consequences are the outcome of policy failure and from the cumulative effect occurring. They are specific conditions that should be avoided for the sensitive value. The initial consequences for this CEA were developed by Dr. Rob Rempel with an informed understanding of the outcomes of the cumulative effects to each of the sensitive values. These were reviewed and, in some cases, revised based on the values, concerns, and feedback heard during engagement with rightsholders and stakeholders throughout the forest management plan development process.
	The mitigative factors are the reactive actions that can be taken to reduce the cumulative effect should it occur or to slow the progression towards the consequences. Mitigative factors can be human interactions or natural regulators. In this CEA they are crisis and adaptive management strategies that NFMC and the Province can use to respond to the negative outcomes of policy failure. These were sourced from a policy review and adaptive management strategies of the forest management plan.
	The escalating or de-escalating factors are influences that limit or increase the effectiveness of the barriers or prevent the barriers and factors from working as they would normally. They are compounding drivers or inhibitors of the cumulative effects that are outside of management's ability to control. These factors were developed by Dr. Rob Rempel and NFMC. They tend to be related to climate change which is an exacerbating challenge for all sensitive values.

15.2 WATERSHEDS AND AQUATIC ECOSYSTEMS

Water was a common value and concern identified by rightsholders and shareholders during engagement. Its degradation in quantity and quality has many downstream effects which is why watersheds and aquatic ecosystems were chosen as a sensitive value and is one of the most often cited values regarding cumulative effects. Map 15.2 shows the watersheds (twenty-six total) that intersect with FML 2. For more information on watersheds and water resources on the FML, see Part 1 – Planning Context Ecological and Physical Description subsection 2.6 Water Resources.

For the watersheds and aquatic ecosystem bow-tie, the policy objective is the protection of watershed and aquatic ecosystems, and the cumulative effect is degradation of water quality. The watersheds and aquatic ecosystems bow-tie is in Figure 15.2 and illustrates the four identified threats, thirteen barriers to the threats, and other mitigations and consequences regarding the forest management plan and its associated operations, as well as any provincial policy in place around the sensitive value of watersheds and aquatic ecosystems.

15.2.1 Additional Analysis: Watershed Disturbance Assessment

Disturbance assessments are a common indicator of hydrologic change based on the relationship between vegetation cover and water yields in forested watersheds and can provide an understanding of the effects forest management activities may have on the watershed. Thirty-percent (30%) disturbance is the threshold that has been commonly identified within peer-reviewed studies, and is the threshold assumed by the Governments of British Columbia and Saskatchewan, where disturbance below this threshold can be assumed to not affect stream flow in spring run-off (Buttle & Metcalfe, 2000; Haslam Lanf Community, 2015; Winkler & Boon, 2017; Government of Saskatchewan, 2019; Government of British Columbia, 1996).

Maintaining water resources by minimizing the impact of forestry-related disturbance on a watershed scale is an objective of this forest management plan, and was integrated at the strategic level through the inclusion of an estimation of disturbance by watershed within the forest model (for more information, see section 10.1.2.6 Watersheds and Watershed Disturbance). However, the forest model is only able to include the productive forest landbase and the planned harvest (i.e., cannot consider anthropogenic disturbances or disturbances within non-productive vegetative areas such as wetlands). Therefore, a more in-depth assessment of watershed disturbance was included as part of the forest management plan CEA to obtain a broader picture of forestry's influence on watersheds intersecting the FML.

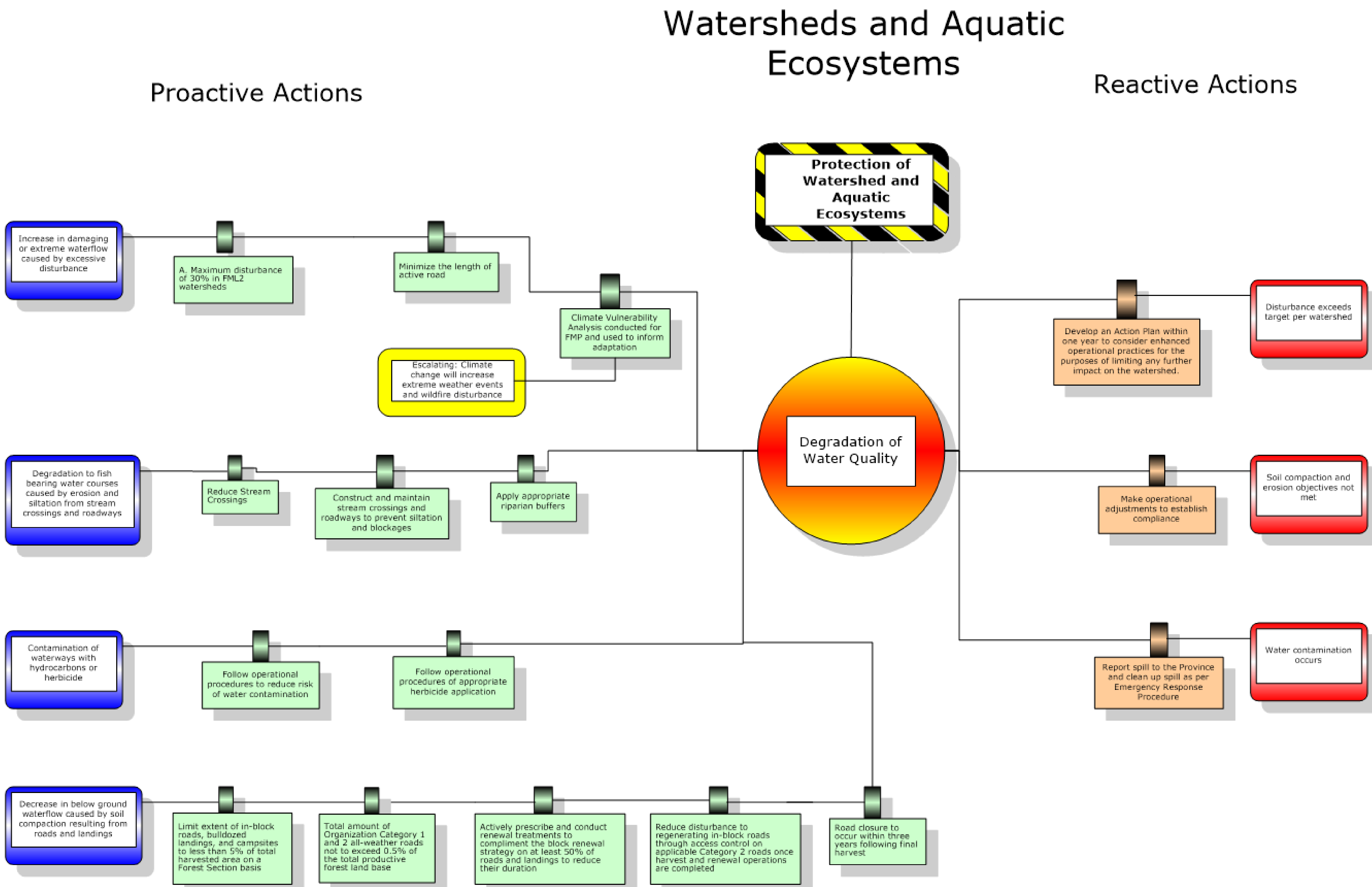
A disturbance layer was developed specifically for use in the watershed disturbance assessment. Assessing cumulative watershed disturbance primarily focuses on two categories:

1. Anthropogenic (Human) Disturbances: Industrial activities such as logging, mining, oil and gas extraction, and infrastructure development (settlements, roads, pipelines) are all notable sources of landscape disturbance. These activities fragment and/or permanently remove habitat from the landscape.
2. Natural Disturbances: Natural calamities such as wildfires also contribute to landscape disturbance, though the impact is often less severe in comparison to human disturbances. While wildfires can temporarily disturb a forest stand, the forest will eventually recover.

In 2024, Environment and Climate Change Canada (ECCC) made a new disturbance layer publicly available based on 2020 satellite imagery that characterizes anthropogenic disturbance across FML 2. The federal anthropogenic disturbance layer was created to provide a nationally consistent, reliable and repeatable geospatial dataset that follows a common methodology. For more information on how it was created please refer to the associated webpage[20].

[20] https://open.canada.ca/data/en/dataset/63e1cda6-debe-4b9b-b075-3666443e30b4

Map 15.2. Basins and watersheds within FML 2.



3326
3327 *Figure 15.2. Watersheds and aquatic ecosystems bow-tie diagram.*

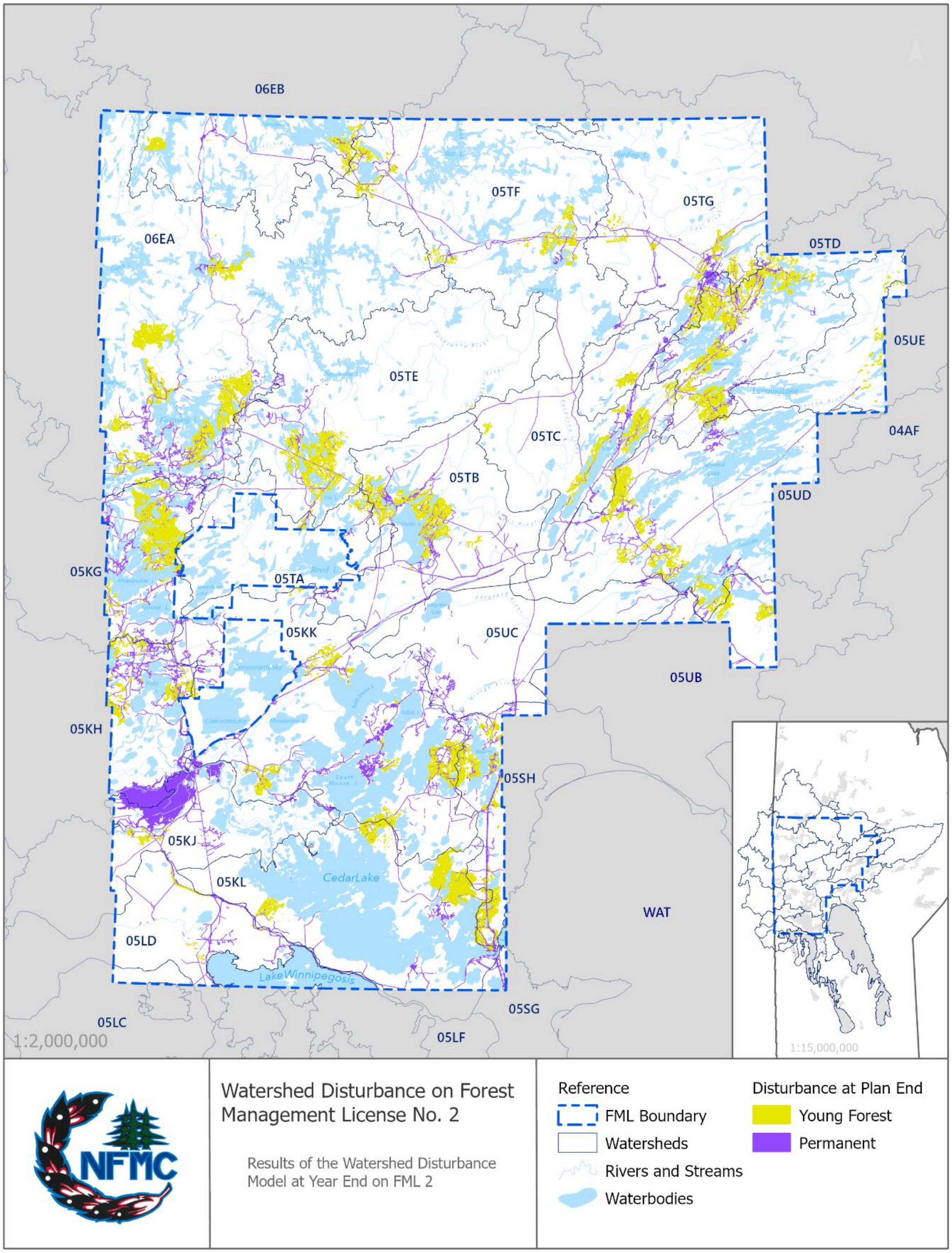
This layer was used in combination with spatial data for access (road networks) that may not have been captured within the federal layer, harvest, and natural disturbances that occurred after 2020 to estimate cumulative disturbance at plan start. Spatial data for wildfires originated from the Province. Projected disturbance from future harvest (5 years old or less for hardwoods and 20 years or less for softwood forest types) and access (road network) outputs from the forest model were then used to estimate disturbance into the future based on the proposed forest management activities.

No additional disturbance by industries other than forestry was included in the watershed disturbance layer beyond what may have already been captured and included in the 2020 federal anthropogenic disturbance layer. This information was not readily available at the time of modelling and is outside the scope of the CEA for this forest management plan. The resulting watershed disturbance projected for plan-end (2045) developed for this assessment based is in Map 15.3.

The watershed disturbance calculation was based on the total watershed area. This CEA watershed disturbance assessment saw none of the watersheds overlapping the FML approach the 30% disturbance threshold at plan end based on the area of disturbance within FML 2 (Table 15.2). The maximum disturbance value for a watershed was 11% in Grass River at the Mouth watershed. The average watershed disturbance value for FML 2 is 3% at plan-end.

Table 15.2. Watershed disturbance based on total watershed area and disturbance within FML2 for plan-start 2025) and plan-end (2045).

Watersheds	Area (ha)		Disturbance Area (ha)			
			Plan Start (2025)		Plan End (2045)	
	Total	FML 2	Total	% Total	Total	% Total
Apeganau Lake	692,094	691,363	87,702	13%	22,907	3%
Cowan River	919,409	759,942	75,780	8%	41,665	5%
Cumberland Lake Near Cumberland House	1,125,759	210,815	36,656	3%	30,815	3%
Devil Brook	904,100	606,847	41,340	5%	27,476	3%
Elbow Lake	325,607	120,718	18,398	6%	4,665	1%
Fox River at the Mouth	1,665,356	5,284	-	0%	149	0%
Grass River at the Mouth	450,987	370,564	34,368	8%	47,939	11%
Grass River Below Halfway River	352,396	352,396	12,551	4%	18,155	5%
Hughes River Upper Region	1,864,239	320,341	16,690	1%	8,582	0%
Issett Lake	979,347	781,957	31,274	3%	17,272	2%
Kamuchawie Lake	2,052,850	1,215,125	194,636	9%	50,072	2%
Lake Winnipeg Shoreline	307,292	12,227	645	0%	519	0%
Lake Winnipegosis at Dawson Bay	1,043,991	67,558	0	0%	0	0%
Lake Winnipegosis Shoreline	515,968	3,881	402	0%	379	0%
Meridian River	925,259	629,511	14,608	2%	20,362	2%
Minago River at the Mouth	385,566	348,564	11,904	3%	2,728	1%
Nelson River at Inlet to Cross Lake	699,632	104,579	3,706	1%	5,434	1%
Nelson River at Kelsey Generating Station	452,872	212,219	5,879	1%	2,552	1%
Nelson River at Warren Landing	2,471,101	3,577	0	0%	0	0%
Overflowing River at Overflowing River	408,764	233,789	7,380	2%	4,662	1%
Red Deer Lake Near Barrows	340,312	21,468	114	0%	32	0%
Saskatchewan River at Grand Rapids	610,751	577,261	39,338	6%	34,882	6%
Saskatchewan River at The Pas	433,174	268,124	37,091	9%	33,627	8%
Sturgeon-Weir River at Pelican Narrows	952,326	218,593	55,783	6%	37,549	4%
William River at the Mouth	334,555	149,362	35,236	11%	28,320	8%
Wuskatasko River	492,969	491,205	23,858	5%	26,464	5%
Total	*21,706,676*	*8,777,273*	*785,341*	*4%*	*467,209*	*2%*
Average				*4%*		*3%*



Map 15.3. Cumulative watershed disturbance projected for plan end (2045) based on the Preferred Forest Management Scenario (PFMS).

The watershed disturbance assessment completed is not a comprehensive equivalent clearcut analysis; however, it does provide an understanding of forestry's influence on the watersheds in FML 2 and whether forestry alone is at risk of meeting the watershed disturbance threshold of 30%. The results of this watershed disturbance assessment demonstrate that the strategic-level target of less than 30% watershed disturbance is met and will inform decisions for the implementation of the forest management plan.

15.2.2 Evaluation of Significance

Protecting watersheds and aquatic ecosystems is fundamental to practicing sustainable and environmentally friendly forest management. As the bow-tie illustrates, there are very direct ways (e.g., access roads causing siltation) forestry could threaten water quality. It also demonstrates that there are a number of strategic (e.g., minimizing the length of active road needed to access harvest) and operational barriers (e.g., construct and maintain watercourse crossings and roadways in a manner that prevents siltation and blockages) in place in the forest management plan and the implementation of its associated operations to proactively manage for each threat. The strategic barriers are established within the strategic-level direction of the forest management plan identified through the plan's values, objectives, indicators, and targets (VOITs) and the development of the Preferred Forest Management Scenario. The operational barriers mainly come in the form of operational best management practices associated with NFMC's Canadian Standards Association (CSA) Sustainable Forest Management (SFM) standard and the International Organization for Standardization's (ISO) Environmental Management System (EMS) standard certifications' operational best management practices (BMP) that will be employed during the implementation of the forest management plan. A number of the BMPs in place directly address water and soil protection. For more information on certification see Part 1 – Planning Context, Forest Administration subsection 6.4 Forest Certification Systems and Part 3 – Implementation and Monitoring, Monitoring and Assessment subsection 17.3 Standard Certification Monitoring and Assessment. For more information on best management practices, see Appendix O – Operational Best Management Practices.

During the forest management plan's Climate Vulnerability Assessment (CVA), the escalating factor of extreme weather events and wildfire disturbance was a major component (especially around water, soil, and associated operations) of the climate impacts that were assessed for vulnerability and there were adaptation options that will be implemented to address them. For more information, see section 14 Climate Change Adaptation.

Assessing watershed disturbance in both the forest model and through the additional cumulative analysis undertaken as part of this CEA are included in the bow-tie as preventative barriers. The additional CEA watershed disturbance assessment was created to evaluate for cumulative effects on the local FML 2 watersheds and aquatic ecosystems. The results demonstrate that all watersheds overlapping FML 2 are below the disturbance threshold of 30% and that it is unlikely that the management activities proposed in this forest management plan would potentially result in the cumulative effect of degradation of water quality by plan end.

Forestry is not the only activity on the FML 2 landbase. However, by understanding the disturbance caused by forestry and the full picture of the proactive barriers in place during the development and implementation of this forest management plan, the risk of triggering the cumulative effect of degradation of water quality is lowered.

15.3 CARBON BALANCE

Forests are a vital part of the carbon cycle. They store and release carbon in an ever-changing process of growth, decay, disturbance, and renewal. Carbon balance is the difference between carbon emission (or release) and carbon storage (or removal). Forests help maintain Earth's carbon balance by capturing carbon dioxide (CO_2) from the atmosphere when they grow and releasing CO_2 and other greenhouse gases (GHGs) when they decay or burn.[21] Manitoba's 2017 *Climate and Green Plan* makes it clear that forests and wetlands are essential ecosystems for Manitoba for multiple reasons, one of which is their ecosystem service of storing carbon, acting as a carbon sink, and mitigating climate change (Manitoba Sustainable Development, 2017). Understanding the sensitive value of carbon balance on FML 2 and how the forest management plan and its associated operations influence it is important.

For the carbon balance bow-tie risk assessment the policy objective is to maintain natural carbon cycles, and the cumulative effect is loss of carbon uptake and storage. The bow-tie itself is in Figure 15.3 and illustrates the five identified threats, twenty barriers, and other mitigations and consequences regarding the forest management plan and its associated operations as well as provincial policy in place around the sensitive value of carbon balance.

15.3.1 Additional Analysis: Wetland Carbon

As part of the forest model and the development of the Preferred Forest Management Scenario (PFMS), carbon balance for the productive forest landbase was calculated (for more information see Forest Modelling subsection 10.1.10 Forest Ecosystem Carbon and Preferred Forest Management Scenario Results subsection 13.2.8 Forest Ecosystem Carbon); however, as productive forest land is only part of the carbon on the FML (i.e., does not include non-productive vegetated areas like wetlands) , for the CEA we turned to Ducks Unlimited Canada (DUC) to understand the carbon storage potential of the wetlands that make up a significant portion of the FML 2 landbase as a whole. DUC has done extensive work mapping and classifying wetlands by building on the Canadian Wetland Classification System. In 2022 DUC identified the area of wetlands by class in FML 2 and based on their classification, an Enhanced Wetland Classification System (EWC) Carbon Project and Hybrid Carbon Layer (HCL) data sets estimated the soil organic carbon these areas store (Ducks Unlimited Canada, 2022). For more information on this report and wetlands on the FML, see Part 1 – Planning Context, Ecological and Physical Description subsection 2.7 Wetlands. Table 15.3 details the area by wetland class in FML 2 and the estimated calculation of carbon and carbon equivalents.

According to Ducks Unlimited Canada, the wetlands (excluding uplands, which is tracked by the forest model as part of the productive forest ecosystem) on FML 2 are estimated to contain over 3.5 billion tonnes of soil organic carbon, equivalent to 13 billion tonnes of carbon dioxide (CO_2) or the annual emissions of over 2.8 billion cars (DUC, 2022). In summary, there is a lot of carbon stored in FML 2 wetlands, and these carbon sinks are important to protect.

[21] More information on forest carbon can be accessed here: https://natural-resources.canada.ca/climate-change/climate-change-impacts-forests/forest-carbon/13085.

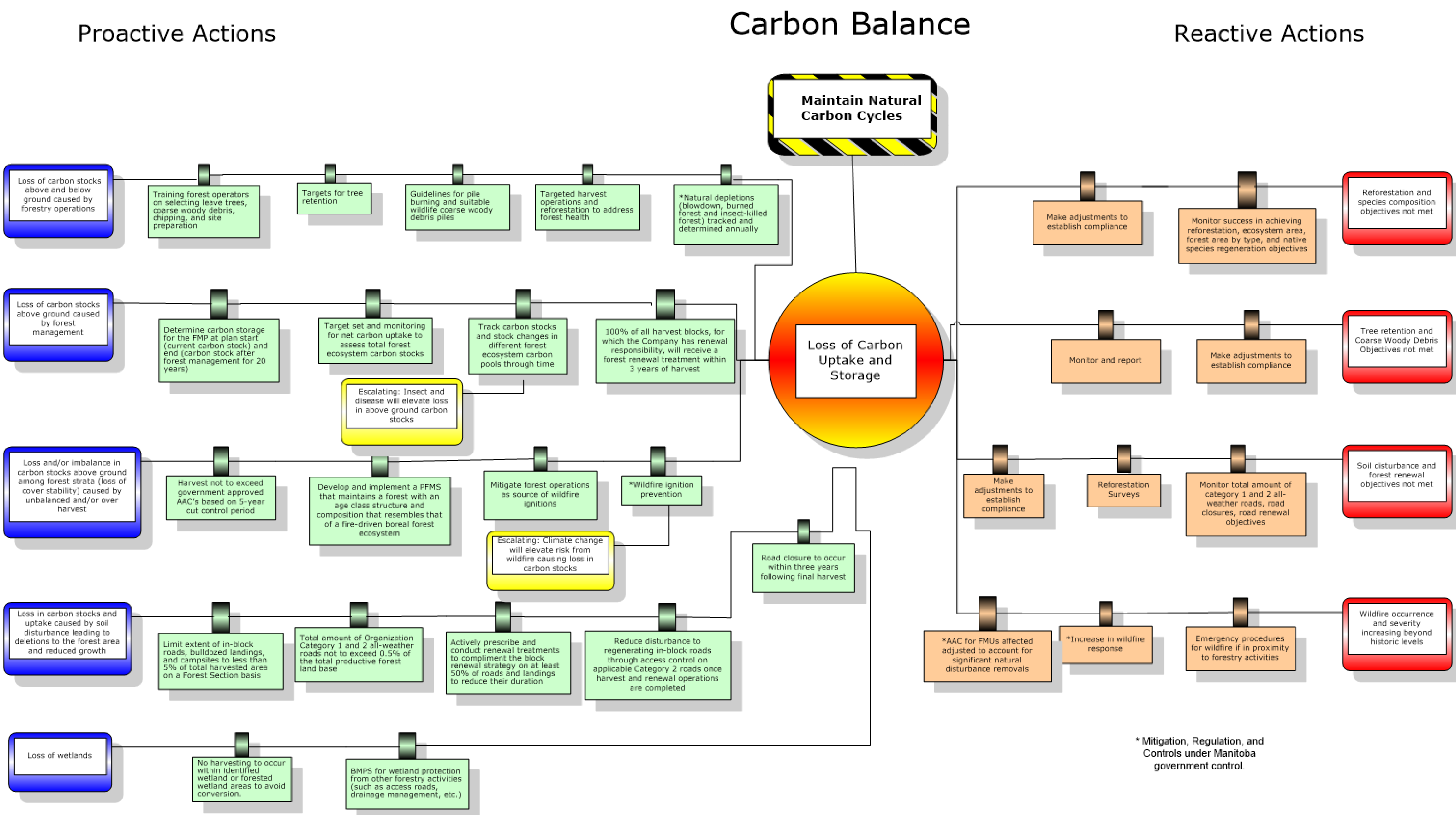


Figure 15.3. Carbon balance bow-tie diagram.

Table 15.3. Soil organic carbon and carbon equivalence values for wetlands by forest section and cover class on FML 2, provided by Ducks Unlimited Canada and up to date as of August 2022 (DUC, 2022).

		Combined HCL and EWC Analysis		Combined Carbon Equivalence		
Forest Section	Cover Class	Area (ha)	Soil Organic Carbon (tonnes)	CO_2 (tonnes)	# of Cars Annual Emissions	20-year Cars Annual Emissions
Highrock	Bog	734,922	561,654,137	734,922	561,654,137	734,922
	Fen	242,901	388,119,731	242,901	388,119,731	242,901
	General Peatland	0	0	0	0	0
	Open Water	523,230	151,213,555	523,230	151,213,555	523,230
	Mineral Wetland	51,261	14,814,405	51,261	14,814,405	51,261
	Upland	1,148,905	181,354,601	1,148,905	181,354,601	1,148,905
	Rock/Unclassified	740,807	0	740,807	0	740,807
	Subtotal	*3,442,027*	*1,297,156,429*	*3,442,027*	*1,297,156,429*	*3,442,027*
Nelson River	Bog	447,890	438,496,194	1,607,527,046	349,462,401	17,473,120
	Fen	307,743	545,374,464	1,999,342,784	434,639,736	21,731,987
	General Peatland	0	0	0	0	0
	Open Water	400,433	115,725,162	424,248,442	92,227,922	4,611,396
	Mineral Wetland	38,580	11,149,476	40,873,980	8,885,648	444,282
	Upland	1,193,705	188,426,352	690,771,005	150,167,610	7,508,380
	Rock/Unclassified	145,618	0	0	0	0
	Subtotal	*2,533,969*	*1,299,171,647*	*4,762,763,257*	*1,035,383,317*	*51,769,166*
Sask. River	Bog	160,846	279,315,044	1,023,968,952	222,601,946	11,130,097
	Fen	659,711	684,436,843	2,509,145,465	545,466,405	27,273,320
	General Peatland	888	1,162,910	4,263,229	926,789	46,339
	Open Water	687,854	198,789,721	728,763,117	158,426,765	7,921,338
	Mineral Wetland	402,198	175,094,845	641,897,703	139,542,979	6,977,149
	Upland	706,990	111,598,377	409,119,649	88,939,054	4,446,953
	Rock/Unclassified	181,589	0	0	0	0
	Subtotal	*2,800,075*	*1,450,397,740*	*5,317,158,116*	*1,155,903,938*	*57,795,197*
All Forest Sections	Bog	1,343,658	1,279,465,375	4,690,520,065	1,019,678,275	50,983,914
	Fen	1,210,645	1,618,252,192	5,932,512,534	1,289,676,638	64,483,832
	General Peatland	888	1,162,911	4,263,233	926,790	46,339
	Open Water	1,611,821	465,816,250	1,707,682,374	371,235,299	18,561,765
	Mineral Wetland	492,105	201,086,287	737,182,329	160,257,028	8,012,851
	Upland	3,050,324	481,493,715	1,765,155,960	383,729,557	19,186,478
	Rock/Unclassified	1,068,282	0	0	0	0
	Total	*8,777,724*	*4,047,276,731*	*14,837,316,496*	*3,225,503,586*	*161,275,179*

15.3.2 Evaluation of Significance

The carbon balance bow-tie illustrates strategic- and operational-level threats to aboveground and belowground carbon stocks, as well as direct threats to wetlands. Each threat has multiple preventative barriers identified by the bow-tie analysis to contribute to lowering the risk of that threat resulting in the loss of carbon uptake and storage. Adaptive management guides the mitigative factors identified to reduce the risk of the consequences of loss of carbon uptake and storage occurring. Escalating factors are natural disasters such as insects, disease, and wildfires that cause loss in carbon stocks when they occur. Although these occurrences are out of the control of NFMC, their impact is tracked (e.g., natural forest depletions from blowdown, wildfire, and insect-affected forests are determined annually), and adaptative management is used to adjust when required. The Province also plays a significant role in proactive and reactive actions regarding wildfire. The combined actions of NFMC and the Province work to maintain natural carbon cycles.

Estimating the amount of carbon storage by the productive forest at plan-start and plan-end is a strategic preventative barrier that aligns with the forest management plan objective to support a forest landscape condition that maintains its role in global ecological cycles through forest carbon storage and sequestration. This objective was integrated into the forest model and scenario analysis process to development the PFMS (for more information see Forest Modelling subsection 10.1.10 Forest Ecosystem Carbon and Preferred Forest Management Scenario Results subsection 13.2.8 Forest Ecosystem Carbon). The PFMS approximates a 3% increase in total productive forest ecosystem carbon in the first 10 years of the forest management plan implementation, a 6% increase in 20 years at plan-end, and a 5% increase in the long-term future at 200 years from plan start. Understanding the current and predicted carbon balance provides metrics to measure against when monitoring to evaluate if the objective of maintaining carbon cycles is being achieved. A PFMS that results in an increase in carbon storage in both the short- and long-term future contributes significantly to lowering the risk of loss of carbon uptake and storage.

Wetland conversation is considered strategically (e.g., they were not included as part of the productive forest landbase that was used to develop the spatial harvest schedule for the PFMS) and operationally (e.g., best management practices are followed to preserve hydrological flow from forestry activities such as roads) as shown by the bow-tie and outlined in Part 3 – Monitoring and Implementation, Implementation Strategies subsection 16.2 Road Development, Access Management, and Other Infrastructure. Therefore, the risk of wetland soil organic carbon storage uptake ceasing or losing the vast carbon storage in FML 2 wetlands due to forestry is lowered. The proactive and reactive actions illustrated by the bow-tie risk assessment provide multiple layers of protection for the sensitive value of carbon balance on FML 2.

15.4 BIODIVERSITY

Biodiversity is defined as the variety of living things, including genes, species, and ecosystems.[22] Manitoba's biodiversity provides many benefits to humans and supports ecological goods and services.[23] Protecting biodiversity and species of importance (e.g., ungulates, furbearers, raptors, songbirds, berries, medicinal plants, etc.) was a major value and concern heard from rightsholders and stakeholders during engagement sessions throughout the forest management plan development process. Therefore, understanding the risk of cumulative effects on biodiversity as a sensitive value is important. However, biodiversity is a broad concept, and for the purposes of the forest management plan the CEA focused on what NFMC and forest management can influence. For more information cumulative effects for moose or boreal woodland caribou specifically, please refer to their individual bow-tie assessments in the following subsections.

For the biodiversity bow-tie analysis, the policy objective is the conservation of biodiversity, and the cumulative effect is to avoid deviation from natural forest conditions. The cumulative effect addresses the top two reasons for biodiversity loss in Canada as outlined by the Office of the Governor General of Canada: habitat loss and degradation of ecosystems, and invasive species (Commissioner of the Environment and Sustainable Development, 2022). The biodiversity bow-tie in Figure 15.4 and illustrates the seven identified threats, twenty-two barriers, and other mitigations and consequences regarding the forest management plan and its associated operations as well as Provincial policy in place around the sensitive value of biodiversity.

[22] For more information on biodiversity: https://www.oag-bvg.gc.ca/internet/English/oth_202210_e_44128.html

[23] For more information on biodiversity in Manitoba, why it is important, and current initiatives: https://www.gov.mb.ca/sd/environment_and_biodiversity/biodiversity/index.html

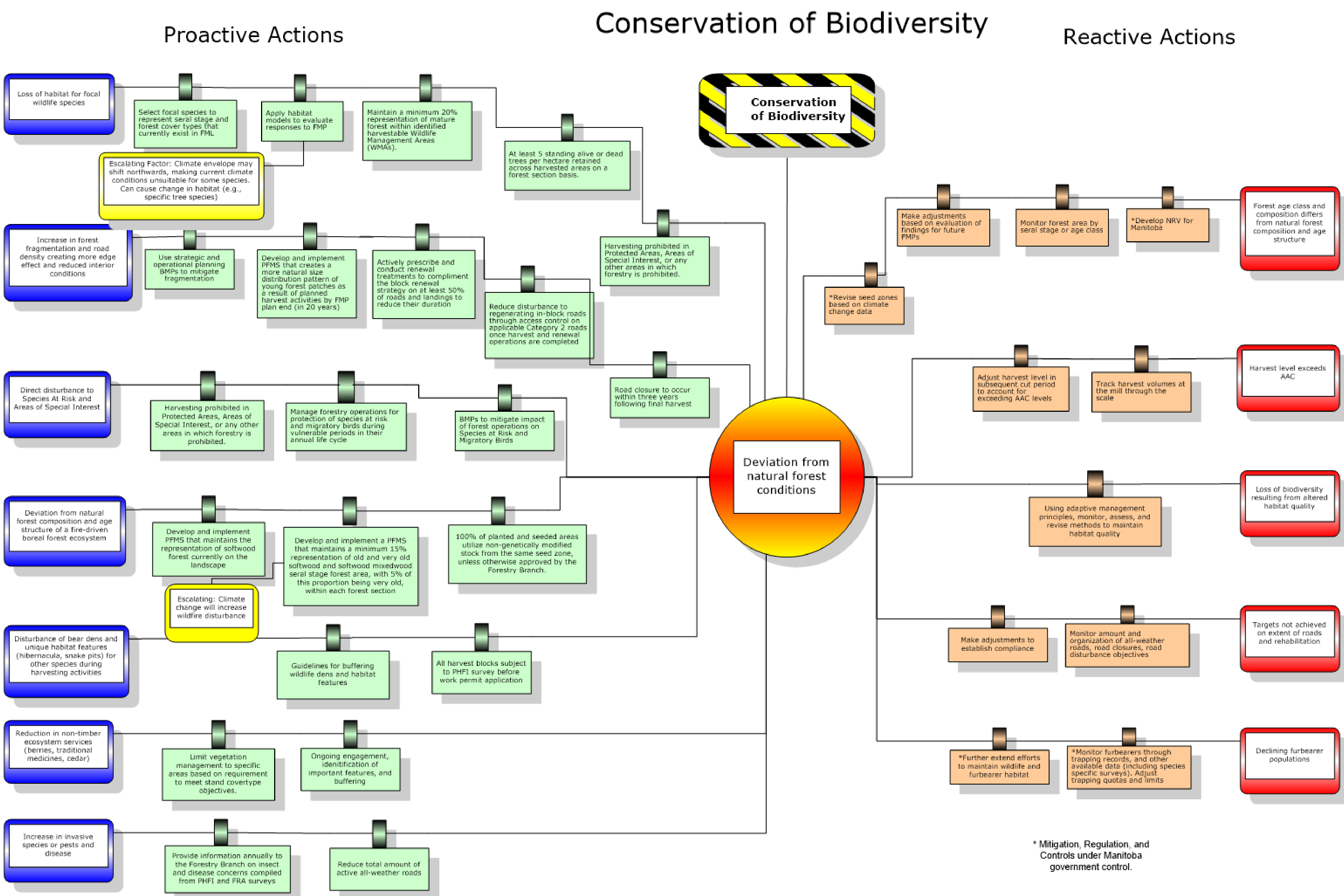


Figure 15.4. Biodiversity bow-tie diagram.

15.4.1 Evaluation of Significance

The threats, preventative barriers, consequences, and mitigative factors of the biodiversity bow-tie risk assessment can be separated into two levels: strategic and operational. Both of these relate to habitat loss and degradation (e.g., there not being the same type, amount, or quality of habitat available as there may be under natural forest conditions) or direct disturbance to certain species or services (e.g., damaging active nests or dens).

Strategically, there are a number of preventative barriers that stem from the forest management plan objectives and associated VOITs used to guide the development of PFMS and overall forest management plan that collectively contribute to reducing the risk of deviation from natural forest conditions at the landscape scale. Implementing the PFMS contributes to ensuring adequate available habitat for focal species and limits deviation from the natural forest condition with the exception of wildfire natural disturbances beyond the influence of NFMC.

Worth highlighting in the context of biodiversity is the forest management plan objective to consider the provision of forest area and structures that provide habitat requirements for selected boreal songbird species. Specific boreal songbirds were selected as focal species for the forest management plan because each species has a habitat considered important by numerous other species, and their ranges vary in forest types on the FML. By understanding where boreal songbird habitat is located and how this habitat is projected to change over time through the PFMS, we can understand where other species will also find suitable habitat. For more information on the boreal songbird model and associated proposed research and monitoring, see Modelling Wildlife Habitat and Habitat Elements subsection 11.4 Boreal Songbird Habitat Elements and Preferred Forest Management Scenario Results subsection 13.2.9.2 Boreal Songbirds.

At the operational-level, there are four important opportunities for preventative barriers to occur when implementing the strategic direction of the plan through the spatial harvest schedule: the pre-harvest forest investigation survey (PHFI) survey; engagement with rightsholders, stakeholders, and the public; the harvest block mitigation procedure; and harvesting and forest renewal methods. For more detailed information refer to Part 3 – Implementation and Monitoring section 16 Implementation Strategies.

1. The pre-harvest forest investigation (PHFI) survey is all about walking the potential harvest area, understanding what is there, and adapting the spatial harvest schedule (SHS) to address what is actually on the ground. All field information collected is used to make block level adjustments that mitigate potential negative impacts to the environment and reduce the risk of deviating from natural forest conditions.
2. Engagement with rightsholders, stakeholders, and the public occurs at Community information Sessions as part of the development of each 2-year forest management operating plan (FMOP). During these sessions, rightsholders, stakeholders, and the public are encouraged to provide feedback on planned operations that may impact resources of interest or share knowledge of the area to conserve biodiversity. Therefore, engagement is an important preventative barrier for certain threats and deviating from natural forest conditions.
3. The Province is engaged at multiple times throughout the operational planning process and during the harvest block mitigation procedure NFMC works closely with regional staff to review all planned harvest blocks and incorporate wildlife and other resource values on a case-by-case basis. This procedure ensures strategic management objectives and new information are implemented at the block level to conserve biodiversity.
4. Operational-level preventative barriers are a critical component of addressing quality of habitat and direct disturbance to certain species. NFMC’s Canadian Standards Association (CSA) Sustainable Forest Management (SFM) standard and International Organization for Standardization (ISO) Environment Management Systems (EMS) standard certifications use guidelines, operating procedures, and best management practices (BMPs) for operational processes and training to lower the risk of a threat and cumulative effect from occurring during planning, harvest, and forest renewal operations.

There have been gaps identified through the bow-tie risk assessment for biodiversity. These gaps are recommended to be minimized with the provincial reactive actions included in the bow-tie diagram. The first is that a natural range of variation (NRV) study has not been completed for FML 2. Having NRV guidelines for Manitoba that outline what pre-industrial forest conditions were would provide a consistent baseline to compare against for adaptive management and use for setting forest model goals and parameters. While this forest management plan uses the best data and information available at the time to guide forest modelling and Preferred Forest Management Scenario (PFMS) development, having a provincial standard of the natural range of variation would contribute to reducing the risk of deviating broadly from natural forest conditions. The second is revising the seed zones for forest renewal to account for possible species shifts due to climate change. At the time of this forest management plan the Province was working on these new guidelines; therefore, using them in the future will help respond to the escalating factor of climate change. The third is monitoring furbearer populations and extending efforts to maintain furbearer habitat. There is a lack of data available to guide strategic forest management decisions regarding furbearers at this time. Putting more resources towards understanding their populations would be a significant step towards reducing the risk of declining furbearer populations. Addressing these gaps would contribute significantly towards the policy objective of conserving biodiversity for FML 2.

15.5 MOOSE

Moose are a culturally significant species on FML 2 and NFMC heard this emphasized from both rightsholders and stakeholders during the plan engagement activities. Therefore, understanding the risk of cumulative effects on moose as a sensitive value is important.

For the moose bow-tie analysis, the policy objective is to conserve the moose population, and the cumulative effect is declining moose population. The bow-tie itself is below in Figure 15.5 and illustrates the five identified threats, seventeen barriers, and other mitigations and consequences regarding the forest management plan and its associated operations as well as Provincial policy in place around the sensitive value of moose.

15.5.1 Additional Analysis: Edge

Moose require a mix of forest cover types (e.g., mixedwood, hardwood) and seral stages (e.g., a combination of young and old forest ages is ideal) throughout the year for forage and thermal (winter) cover in a relatively small range (for more information on moose habitat, see Modelling Wildlife Habitat and Habitat Elements subsection 11.3 Moose Habitat Elements). For this reason, an understanding of how this mix of forest types and seral stages occurs on the landscape for moose is important. We can measure this mix at two scales: the landscape (strategic) and the block (operational) scale.

For the landscape scale, a metric called contrast weighted edge density was generated as output from the forest model for the Preferred Forest Management Scenario (PFMS). Contrast weighted edge density is a measure of the amount and quality of edge between adjacent stands of different seral stages (ages). The quality of edge is determined by the seral stages of adjacent stands; therefore, since moose prefer a mix of young and old seral stages, the quality of the edge increases as the age difference between adjacent stands becomes greater, with the goal being to not only create edge between the variety of cover types needed for moose, but also the combination of young and old forest ages. Understanding the quality of identified edge is important for determining and providing good moose habitat on the landscape.

The amount of contrast weighted edge was summed for the FML 2 productive forest landbase. This metric contributed to the boreal songbird modelling but is also broadly informative for moose habitat. The contrast weighted edge is expressed as metres of edge per hectare (m/ha) across the total productive forest landbase area and provides an insight into the quantity of edge across FML 2. Overall, the edge density represents the proximity of different forest habitat types on the landscape that would be beneficial for moose.

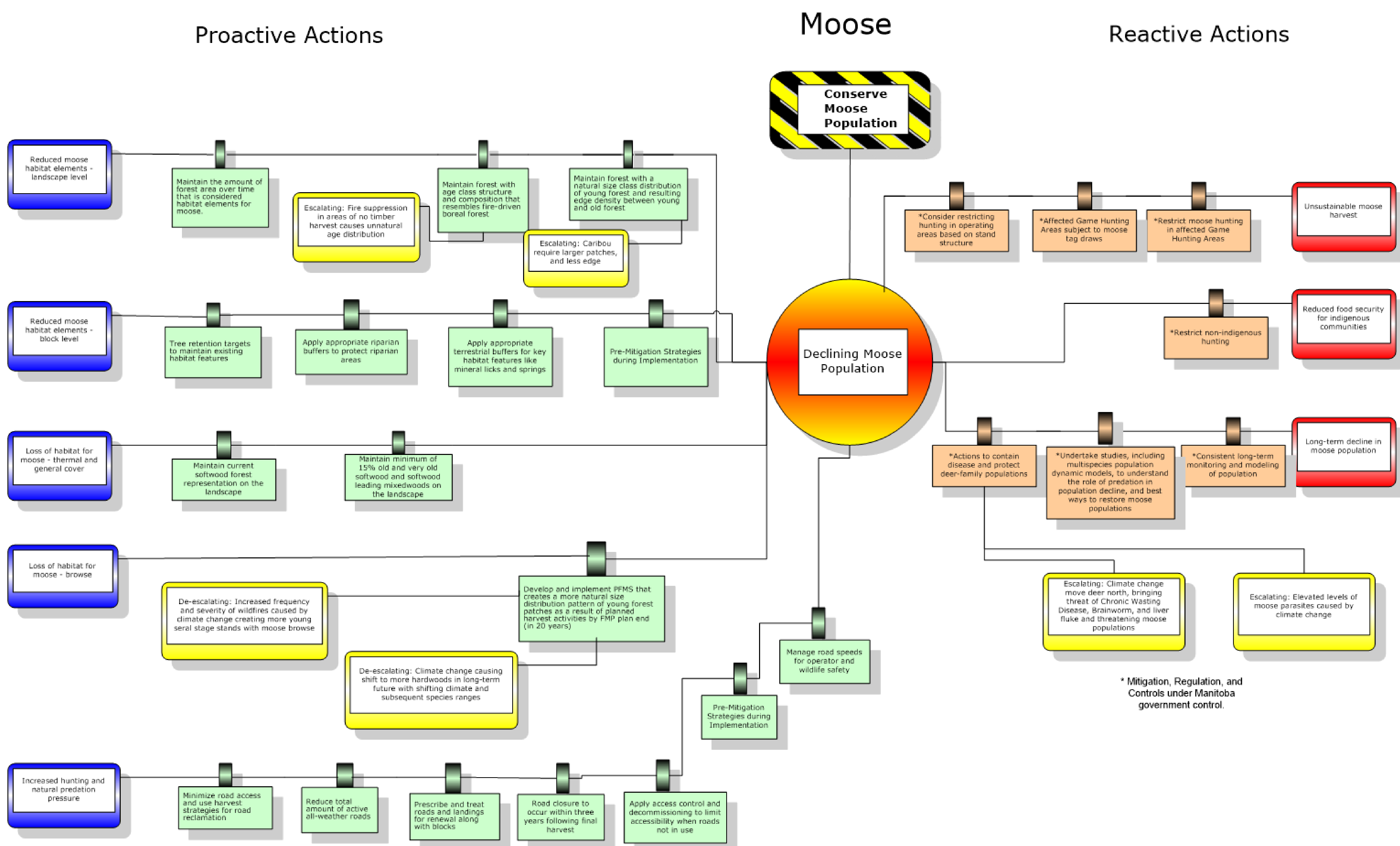


Figure 15.5. Moose bow-tie diagram.

The chart in Figure 15.6 compares the edge density for the PFMS (Preferred Scenario; green) and the no harvest scenario (Null Scenario; red), a model scenario in which no forest management occurs on FML 2 (for more information see Scenario Analysis subsection 12.2.1 No Harvest Scenario). The green trendline illustrates that the amount and quality of edge on the FML is projected to increase from plan start (period 0) to plan end (period 2) and increases even more forty years after plan start (period 4). Whereas the red trendline shows that the edge density would decrease from plan start (period 0) to plan end (period 2) and only increase slightly over forty years if no forest management occurred on the FML within the same timeframe. These results indicate the forest management activities planned for the forest management plan are projected to increase the total amount of edge across FML 2, and that it could be inferred that quality moose habitat should also increase accordingly on the landscape during forest management plan implementation.

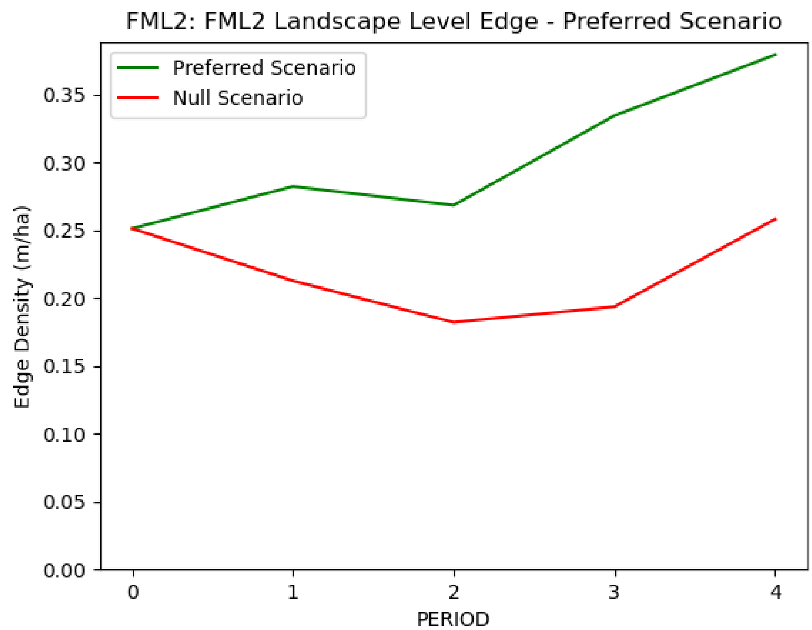


Figure 15.6. Mean edge density, in metres per hectare (m/ha), calculated from contrast weighted edge forest model outputs, compared between the Preferred Forest Management Scenario (PFMS; green) and the no harvest scenario (Null Scenario; red).

At the block scale, interior edge within harvest area designs is how the mix of forest habitat is achieved. Interior edge can be considered the perimeter of a harvest area within the block itself. The spatial harvest schedule (SHS) contains generalized polygons of productive forest stands that are suitable to achieve the objectives of the forest management plan. It is then up to NFMC to make those polygons operable and adhere to management objectives at the block-level through operational planning during implementation. Examples of guidelines for implementation for moose include:

- Providing thermal cover: Maximum 200-metre distance to thermal cover within blocks;
- Reducing line of sight within blocks: Maximum 400-metre of line of sight within blocks;
- Riparian areas: Retain windfirm buffers as required based on waterbody classification; and,
- Mineral licks: 50 to 200-metre setback buffer from outer perimeter of feature.

Incorporating these guidelines and other best management practices and processes will result in harvest blocks that has been refined from those originally identified in the spatial harvest schedule polygons. An example of this refinement is illustrated in Figure 15.7, where you can see the amount of edge (internal block perimeter) within the planned block (orange overlay) is significantly more than is present in the original spatial harvest schedule polygons (light green polygon). More interior edge at the block level provides moose with browse as well as general and thermal cover habitat requirements in close proximity, and results in harvest areas maintaining quality moose habitat candidates on the landscape.

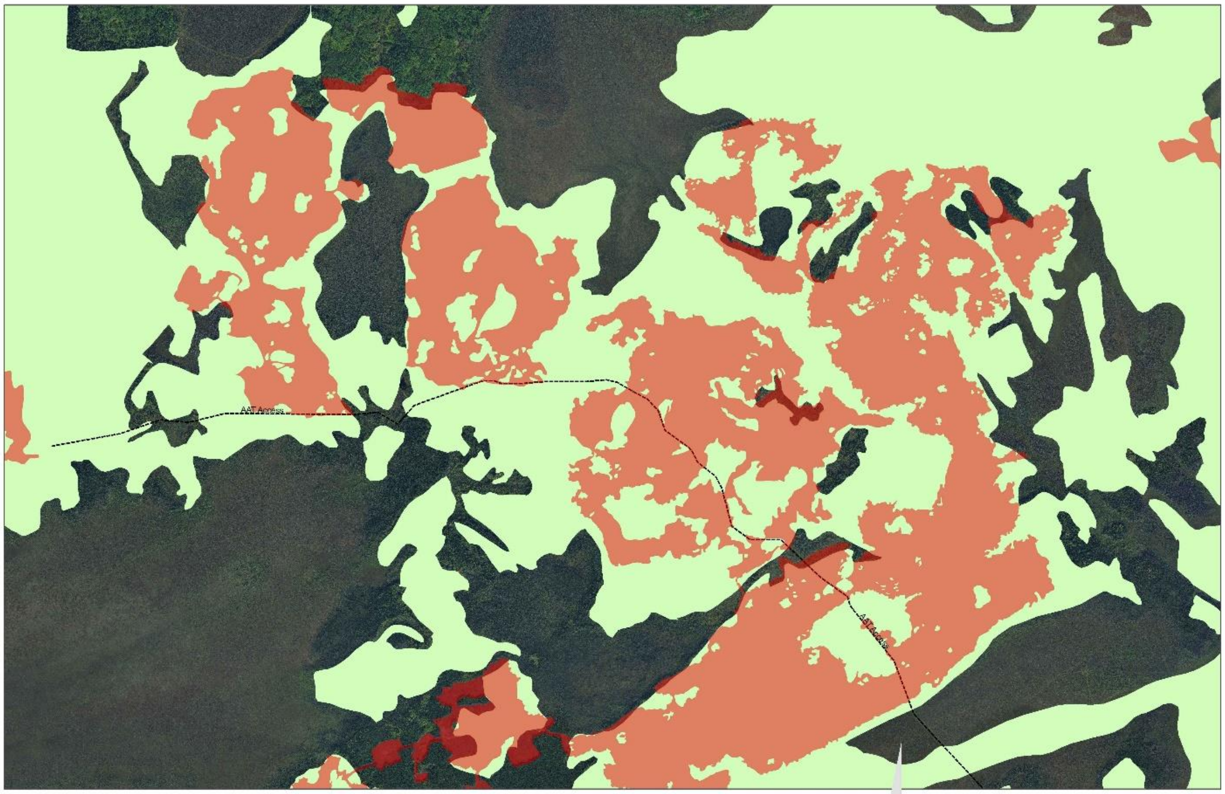


Figure 15.7. An example of strategic-level proposed harvest block selection (green) versus actual operational implementation of the harvest block (orange) with finer-scale management of in-block features which create significantly more interior edge.

15.5.2 Evaluation of Significance

The moose bow-tie revolves around ensuring there is sufficient habitat in order for moose populations to be conserved as well as hunting and predation pressures. Similar to biodiversity, the threats, preventative barriers, consequences, and mitigative factors of the moose bow-tie can be broken down into two levels: strategic and operational. At the strategic-level, three types of moose habitat were tracked and measured on the landscape to ensure that a sufficient representation of what moose need (browse, thermal cover, and general cover) are available and sustainable. More information on the strategic approach for the consideration of moose can be found in Modelling Wildlife Habitat and Habitat Elements section 11.3 Moose Habitat Elements. While the strategic consideration of moose is important, preventative barriers at the operational level a significant role to play in reducing the risk of declining moose populations. Operational-level mitigation measures are applied during forest management plan implementation.

Similar to biodiversity, at the operational-level there are four important opportunities for preventative barriers to occur when implementing the forest management plan: the Pre-Harvest Forest Investigation (PHFI) survey; engagement with rightsholders, stakeholders, and the public; the harvest block mitigation procedure; and harvesting and forest renewal operations. For more detailed information refer to Part 3 – Implementation and Monitoring section 16 Implementation Strategies.

As the additional edge analysis undertaken as part of this CEA outlines, creating quality moose habitat revolves around operational (block) level implementation. NFMC follows the provincial guidelines in place for wildlife, habitat element and feature buffers, and many other forest management applications, maintains Canadian Standard's Association (CSA) Sustainable Forest Management (SFM) standard certification through the maintenance of a sustainable forest management plan and annual reporting, and maintains International Organization for Standardization (ISO) Environmental Management Systems (EMS) standard certification best management practices (BMPs). All of these items are cumulative approaches to management and contribute to creating interior edge and quality moose habitat. Providing moose habitat at the strategic and operational level lowers the risk of declining moose populations.

A key preventative barrier at the operational level that occurs during implementation is harvest block mitigation. This process is an important connection point for NFMC to discuss block and operating area specific direction around wildlife and moose management with the Province. Additionally, this is the point where all information gathered from the PHFI and engagement is considered and final block and operating area decisions are made. Every harvest block must undergo mitigation prior to Work Plan approval being given by the Province. This process ensures that any new information and operational-level management objectives are considered and applied during implementation, and continue to lower the risk of declining moose populations through provision of moose habitat and managing access to address hunting and predation pressures. For more information, see Part 3 – Implementation and Monitoring, Implementation Strategies subsection 16.1.1.4.2 Wildlife Habitat and Habitat Elements.

There have been gaps identified through the bow-tie analysis for moose. These gaps are recommended to be minimized with the Provincial reactive actions included in the bow-tie. The first is around moose harvest and considering different options in managing hunting to mitigate unsustainable moose hunt levels and food security concerns for indigenous communities. The second is around a need for consistent, long-term monitoring for moose populations as well as studies that consider multispecies population dynamics to assist in understanding the role of predation in moose population decline and identify the best ways to restore moose populations, if necessary. Putting more resources towards understanding their populations would be a significant step towards reducing the risk of declining moose populations. This data could then be used to create science-based strategic and operational management objectives and procedures for future forest management plans. Addressing these gaps would contribute significantly towards the policy objective of conserving moose populations for FML 2.

15.6 BOREAL WOODLAND CARIBOU

Boreal woodland caribou are a federal and provincial species at risk and their habitat is a priority management objective for FML 2; therefore, caribou are an important sensitive value. The bow-tie diagram for caribou is a summary of all the management strategies that have been put in place strategically and operationally for the forest management plan to achieve the policy objective of conserving caribou populations and prevent the cumulative effect of a declining caribou population from occurring. The bow-tie for caribou is below in Figure 15.8 and illustrates the five identified threats, sixteen barriers, and other mitigations, and consequences regarding the forest management plan and its associated operations as well as Provincial policy in place around the sensitive value of caribou.

15.6.1 Additional Analysis: Caribou Habitat

The strategic-level description of the modelling done for caribou habitat and habitat elements can be found in detail in Modelling Wildlife Habitat and Habitat Elements section 11.2 Boreal Woodland Caribou Habitat Elements, with results found in Preferred Forest Management Scenario Results subsections 13.2.3 Biodiversity and 13.2.9 Assessing Wildlife Habitat and Habitat Elements.

. Caribou habitat and habitat elements were considered strategically in two ways:

1. The forest model tracked each type of boreal caribou habitat, with a forest management plan objective put in place to maintain the amount of preferred caribou habitat projected to be present within each Caribou Management Unit (CMU) that would result from implementing the spatial harvest schedule resulting from the Preferred Forest Management Scenario (PFMS). The PFMS results show that the amount of productive forest area considered preferred habitat for caribou increased or remained relatively consistent for all CMUs from plan start to plan end.

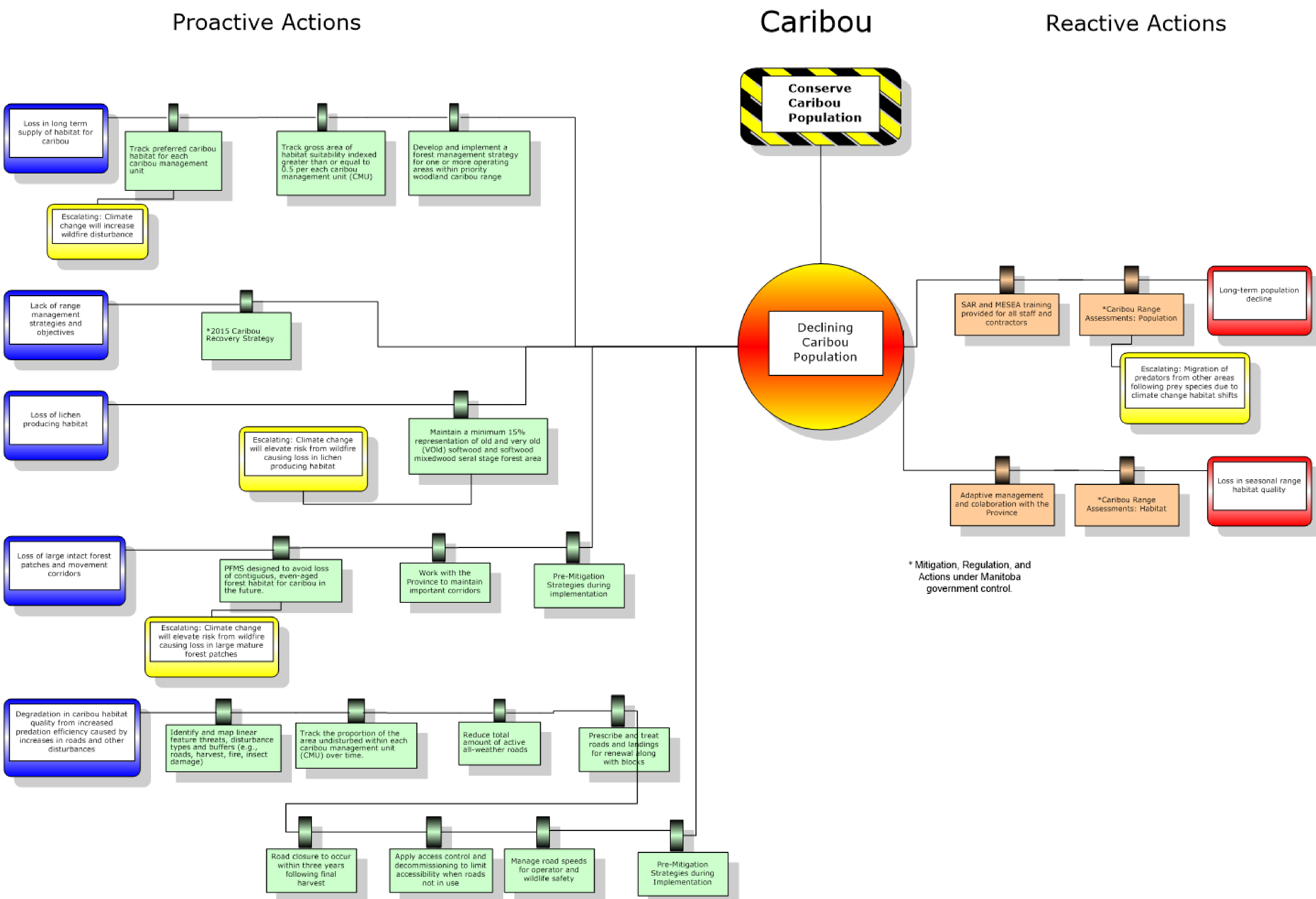


Figure 15.8. Caribou bow-tie diagram.

2. A habitat suitability index (HSI) model was used to assess the change in the arrangement and amount of suitable caribou habitat over time based on the strategic direction identified in the PFMS. The HSI results show that the area considered suitable habitat for caribou increased or remained relatively consistent for all CMUs from plan start to end based on the influence of both the PFMS and the natural cycles of the forest.

These analyses are incorporated directly into the forest management plan and assisted in guiding the selection of the PFMS.

15.6.2 Evaluation of Significance

Similar to moose, the caribou bow-tie analysis revolves around ensuring there is sufficient habitat in order for caribou populations to be conserved. An additional key threat identified for caribou, however, is the absence of management-unit-specific provincial policy and guidelines. At the time this forest management plan was developed, *Manitoba's Boreal Woodland Caribou Recovery Strategy* (Manitoba Boreal Woodland Caribou Management Committee, 2015) was in place, but no Management Unit Range Plans had been approved. Addressing this threat is a significant gap in the bow-tie, but it was identified early in the forest management plan process and NFMC has worked closely with the Province to include strategic-level objectives in the 20-year forest management plan that reflect the intent of the recovery strategy and Management Unit Plans in development. By working with the Province and making a significant effort to move towards, over time, a forest landscape condition which provides an adequate amount and distribution of boreal woodland caribou habitat, NFMC has lowered the risk of this threat resulting in the cumulative effect of declining caribou population. The Province is also actively working to address this gap by developing Management Unit Plans that will be able to be considered in future forest management planning opportunities. In summary, NFMC has minimized this policy gap as much as possible with strategic-level management strategies incorporated directly into forest management plan development.

The majority of the preventative barriers in the caribou bow-tie diagram are strategic and link directly to forest management plan objectives and the associated values, objectives, indicators, and targets (VOITs). The outcome of this is the habitat model results outlined in the additional caribou habitat analysis. The PFMS projections indicate that the strategic-level preventative barriers contribute to lowering the risk of declining caribou populations as a result of forest management activity.

Preventative measures at the operational level address road management to minimize disturbance and caribou habitat degradation, and using mitigation strategies during implementation. Like moose, a key preventative barrier is the harvest block mitigation procedure. For more information, see Part 3 – Implementation and Monitoring Planning, Implementation Strategies subsection 16.1.1.4.2 Wildlife Habitat and Habitat Elements. This process is an important connection point for NFMC to discuss block and operating area specific direction around wildlife and caribou management with the Province. It is through mitigation that features such as important caribou movement corridors or calving habitat elements are identified and integrated into the management strategy for a harvest block or operating area as part of 2-year forest management operating plan (FMOP) development. Additionally, this is the point at which all information gathered from the Pre-Harvest Forest Investigation (PHFI) survey and engagement is considered, and final block and operating area decisions are made. This process ensures that any new information and objectives are incorporated into the forest management plan implementation and continue to lower the risk of declining caribou populations through provision of caribou habitat and managing access to address predation pressures.

15.7 MONITORING AND FOLLOW-UP

Adaptive management is a guiding principle for the forest management plan that is powerful for addressing uncertainty, and in this case, we recognize the uncertainty associated with the effectiveness of the defined barriers for reducing cumulative effects. Monitoring the strategic- and operational-level strategies is essential to the implementation of the forest management plan. With the exception of those under the jurisdiction of the

Province, each preventative barrier listed in the bow-tie diagrams can be categorized into the two levels of planning outlined below and their associated monitoring and reporting processes. Additionally, adaptive management based on the monitoring and reporting completed in those processes represents the mitigative factors in the bow-tie analyses.

1. A forest management plan strategic planning value, objective, indicator, and target (VOIT) or planning and reporting requirement. More details can be found including monitoring and reporting in:

- Part 2 – Analysis and Modelling section 9 Values, Objectives, Indicators, and Targets.
- Part 3 – Implementation and Monitoring subsections 17.1.1 Forest Report (5-year), 17.1.2 Forest Management Report (2-year), and Appendix N – Values, Objectives, Indicators, and Targets Table.

2. A forest management plan operational planning and implementation best management practices (BMP) associated with federal and provincial guidelines or NFMC's Canadian Standards Association (CSA) Sustainable Forest Management (SFM) standard and the International Organization for Standardization's (ISO) Environmental Management System (EMS) standard certifications. To maintain these certifications operations are audited each year by an independent third party. More details can be found including monitoring and reporting in:

- Part 1 – Planning Context subsections 6.4.1 Canadian Standards Association Sustainable Forest Management Standard Certification and 6.4.2 International Organization for Standardization Environmental Management System Standard Certification.
- Part 3 – Implementation and Monitoring subsections 16.1.1 Forest Management Operating Plans, 16.1.2 Road Development, Access Management, and Other Infrastructure, 16.2 Harvest Operations, 17.3 Standard Certification Monitoring and Assessment, and Appendix O – Operational Best Management Practices.

Examples of monitoring and follow-up for each planning level and bow-tie analysis are provided in Table 15.4.

Table 15.4. Examples of monitoring and reporting for each bow-tie analysis.

Watersheds and Aquatic Ecosystems		
Level of Planning	Preventative Barrier	Monitoring and Follow-Up Summary
Strategic	Maximum disturbance of 30% in FML 2 watersheds	The productive forest area watershed disturbance assessment will be updated for the 5-year Forest Report. The cumulative watershed disturbance assessment will be re-run for the 20-year Forest Report.
Strategic	Climate Vulnerability Analysis conducted and used to inform adaptation	An evaluation of how adaptation options have been applied and a review of vulnerabilities will occur as part of the 5-year Forest Report.
Operational	Apply appropriate riparian buffers	Harvested riparian area calculated and reported in 5-year Forest Report. Operations and Final Inspections for implementation activities required to maintain International Organization for Standardization (ISO) Environmental Management System (EMS) certification identify if certification standards and government policies are not met.
Carbon Balance		
Level of Planning	Preventative Barrier	Monitoring and Follow-Up Summary
Strategic	Determine carbon storage for the forest management plan at plan	Carbon storage for the productive forest landbase is reported in the forest management plan and will be assessed and reported in the final 5-year Forest Report (at plan-end, forest management plan year 20).

Carbon Balance		
Level of Planning	Preventative Barrier	Monitoring and Follow-Up Summary
	start (current carbon stock) and end (carbon stock after forest management for 20 years)	
Strategic	Harvest not to exceed government approved annual allow cut (AAC) based on 5-year cut control period	Harvest is tracked at the mill as timber is scaled and volumes are reported to the government by a third party. Annual harvest volumes are tracked and reported in the Forest Management Report (2-year) and compared to the annual allowable cut for each forest management unit (FMU).
Operational	BMPS for wetland protection from forestry activities	Operations and Final Inspections for implementation activities required to maintain International Organization for Standardization (ISO) Environmental Management System (EMS) certification identify if certification standards and government policies are not met. Road develop strategies are developed through Forestry Road Development Plans (FRDPs) and require Work Permit application approval before construction can occur. Road and access updates are reported in the Forest Management Report (2-year).

Biodiversity		
Level of Planning	Preventative Barrier	Monitoring and Follow-Up Summary
Strategic	Apply habitat models to evaluate responses	The boreal song-bird models used to represent focal species in the forest management plan will be re-assessed and re-evaluated in the 5-year Forest Report. The 5-year Forest Report will also report on the progress of the boreal songbird monitoring program to be established during implementation.
Operational	Provide information annually to the Forestry Branch on insect and disease concerns compiled from Pre-Harvest Forest Investigation (PHFI) and Forest Renewal Assessment (FRA) surveys	Each harvest block undergoes a Pre-Harvest Forest Investigation (PHFI) survey as well as a Forest Renewal Assessment survey as per the provincial *Pre-Harvest Survey Guidelines* (Manitoba Conservation and Water Stewardship, 2014). PHFI data is reviewed during harvest block mitigation and any forest health guidance based on survey data is recommended to NFMC by the Province for implementation, as well as the consideration of forest health best management practices.
Operational	Best management practices (BMPs) to mitigate impact of forest operations on Species at Risk and Migratory Birds	The International Organization for Standardization (ISO) Environmental Management System (EMS) standard and best management practices (BMPs) provide training on Species at Risk (SAR) and guide nesting bird protection that adhere to federal and provincial legislation. If SAR or their habitat are identified during Pre-Harvest Forest Investigation (PHFI) surveys NFMC works with the Province to determine mitigation measures. The ISO EMS standard is audited annually by a third party to validate NFMC compliance.

Moose		
Level of Planning	Preventative Barrier	Monitoring and Follow-Up Summary
Strategic	Maintain the amount of forest area over time that	Assess adherence to the spatial harvest schedule at the 5-year Forest Report.

Moose		
Level of Planning	Preventative Barrier	Monitoring and Follow-Up Summary
	is considered habitat elements for moose	
Strategic and Operational	Tree retention targets to maintain existing habitat features	2% reduction in productive forest area volume to account for retention in the forest model. *Selecting Leave Trees and Coarse Woody Debris* guideline guides retention of residual vegetation during harvest block mitigation and operations. NFMC works with the Province on implementation of 20% residual retention for moose for identified operating areas during block mitigation. A standing tree survey is used to report success of retention post-harvest. The International Organization for Standardization (ISO) Environmental Management System (EMS)standard is audited annually by a third party to validate NFMC compliance with these guideline and best management practices (BMPs).
Operational	Road closure to occur within three years following final harvest	Standards for road decommissioning are set in the annual Forestry Road Development Plan (FRDP). Roads chosen for decommissioning based on age, effective elimination of vehicular traffic and prevention of potential issues that could cause environmental impacts and/or a public safety hazard are reported in the forest management operating plan (FMOP). Decommissioning is monitored for a 2-year period after completion and the Province issues a letter stating decommissioning obligations have been met when successful.

Boreal Woodland Caribou		
Level of Planning	Preventative Barrier	Monitoring and Follow-Up Summary
Strategic	Track gross area of suitable habitat indexed greater than or equal to 0.5 per each Caribou Management Unit (CMU)	Assess adherence to the spatial harvest schedule at the 5-year Forest Report.
Strategic	Preferred Forest Management Scenario (PFMS) designed to minimize loss of contiguous, even-aged forest habitat for caribou in the future	Aggregated distribution pattern of young forest patches assessed at 20-year Forest Report.
Operational	Block mitigation strategies identified during implementation	NFMC works with Provincial representatives from the Wildlife Branch to mitigate forestry impact on wildlife during block mitigation.
Operational	Road closure to occur within three years following final harvest	Standards for road decommissioning are set in the annual Forestry Road Development Plan (FRDP). Roads chosen for decommissioning based on age, effective elimination of vehicular traffic and prevention of potential issues that could cause environmental impacts and/or a public safety hazard are reported in the forest management operating plan (FMOP). Decommissioning is monitored for a 2-year period after completion and the Province issues a letter stating decommissioning obligations have been met when successful.

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Climate change is an escalating factor in every bow-tie and is a good example of how tracking changes in the forest and disturbances can be used to adjust the implementation of the forest management plan and guide the development of future forest management plans to reduce the risk of cumulative effects. Overall, the CEA will be reviewed and completed again for the subsequent forest management plan.

15.8 CONCLUSION

Through the bow-tie analysis, NFMC was able to view the strategic- and operational-level outcomes of the forest management plan, and associated operations as a whole and understand how they influence each sensitive value. Developing each bow-tie diagram helped identify connections between sensitive values and preventative barriers and mitigation factors that are part of the forest management plan and its implementation. It was an in-depth enough assessment to link strategic and operational strategies that were not necessarily designed to address those specific threats but do preform a proactive or reactive action that contributes to their management. Bringing together the planning context, modelling, analysis, implementation, and monitoring elements of the forest management plan in the bow-ties visually demonstrated NFMC's thorough management for sensitive values. Although this is not a comprehensive CEA accounting for all other industrial activities on FML 2, it provides an assessment on forestry and what NFMC can influence.

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