Chapter 7: MONITORING FRAMEWORK

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7. MONITORING FRAMEWORK

Monitoring serves to assess, verify as appropriate, and adapt as necessary to achieve Sustainable Forest Management (SFM), *i.e.,* the sustainable flow of ecosystem goods and services for the present and future. Through monitoring, we can determine how effective forest management activities are in producing results or meeting stated targets of the approved FMP. The end use of monitoring results is to continuously improve forest management direction using Adaptive Management.

After the FMP has been implemented for a minimum of five years, monitoring could contribute to refinement in both strategic and operational planning. Operational practices could also be refined, depending on the monitoring outcomes compared to the targets.

The Forest Management Licence #3 (FML #3) monitoring framework is divided into three main sections:

1. **Existing Monitoring** (*e.g.* pre-harvest surveys and silviculture surveys);
2. **Five-year Report Monitoring** on the approved Forest Management Plan goals and targets (*e.g.* balancing cover types); and,
3. **Future Monitoring** (*e.g*. joint projects such as moose).

Existing monitoring efforts in FML #3 continue by the FML #3 Licencee and Quota Holders. These monitoring efforts include bird monitoring, bird surveys, Pre-Harvest Surveys, silviculture surveys, harvest inspections, water crossing inspections, cutover imagery, and many different research projects.

Five years after FMP (Forest Management Plan) approval by the Province of Manitoba, an FML #3 Five-year FMP Report will be created, per the provincial 20-Year plan guidelines (Manitoba Conservation 2007). The Five-year FMP Report will provide a check to see if forest management operations and strategies being implemented are moving towards the stated FMP targets.

Future monitoring projects will be done within an Adaptive Management framework (Manitoba Conservation 2007). Ecosystems and all their interlinked ecosystem components are complex and numerous. Therefore, future monitoring will be actively pursued in partnerships with the province of Manitoba, Indigenous communities, conservation organizations, stakeholders, and educational institutions.

7.1 MONITORING CONTEXT

The framework and concepts for monitoring in FML #3 include:

1. An Adaptive Management framework will be used for monitoring;
2. Monitoring of Forest Management Plan (FMP) directions and targets will start once the FMP is approved in writing;
3. Coarse-Filter Biodiversity includes Natural Range of Variability and Indicator Bird Species;
4. Fine-Filter Biodiversity includes moose;
5. Indigenous involvement in monitoring is desirable;
6. Significant concerns brought forward during FMP development have been placed into Chapter 7 Monitoring (*e.g.* Forest Management Unit (FMU) 11 forest regeneration may be different than FMU 13 forest regeneration);
7. Citizen Science is encouraged;
8. Cost-sharing of monitoring efforts with The Province of Manitoba, conservation agencies, or academic agencies;
9. Research and monitoring grants can be sought from the Sustainable Forestry Initiative certification body, federal government, and the provincial government.
10. Mutually-beneficial partnerships are strongly encouraged; *e.g.* larger efforts such as Light Detection and Ranging (LiDAR) may only happen through a multi-agency partnership.

Science-led efforts will provide better monitoring and better conservation plans. Real-world data will be used instead of expert opinion. Active forest management activities can be a conservation tool, especially configuration of harvest that benefits wildlife habitat.

The nature of potential future monitoring projects involves both the Forest Management Licence holder and The Province of Manitoba. There are three kinds of monitoring projects regarding which agency leads the monitoring:

1. The Forest Management Licence holder only (*e.g.* tracking Natural Range of Variability, moose habitat in the FML #3 Five-year Report);
2. Joint projects which have monitoring efforts (monetary or in-kind) by both agencies (*e.g.* elk habitat and use; moose habitat use); and,
3. Projects peripheral to meeting FMP requirements, led by The Province of Manitoba but the Forest Management Licence holder may from time to time make in-kind contributions.

Joint monitoring projects are not limited to just two partners. A greater number of partners brings more expertise, ideas, experience, in-kind contributions, and sometimes financial contributions. Larger partnerships have a greater chance of obtaining grants, especially with the Sustainable Forestry Initiative forest certification body.

7.1.1 Adaptive Management

Adaptive Management (AM), also known as Adaptive Resource Management (ARM), is a structured, iterative process of robust decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring[1].

[1]https://en.wikipedia.org/wiki/Adaptive_management [accessed Sept. 24, 2019]

Essentially, Adaptive Management is "learning by doing", rather than "learning then doing" (Lancia *et al*. 1996; Nudds 1998; and Nudds 2018). A key to different types of adaptive management is presented in Table 7.1.

Table 7.1 Key to types of Adaptive Management (Nudds and Baker 2019).

1. Deliberate attempt to evaluate policy
   - **A.** Yes..........Adaptive management; go to **2**
   - **B.** No...........Reactive management.

2. Two or more alternate policies evaluated
   - **A.** Yes..........Active adaptive management (AAM); go to **3**
   - **B.** No...........Passive adaptive management (PAM); go to **6**

3. Evaluation is prospectively planned
   - **A.** Yes...........Manipulative AAM; go to **4**
   - **B.** No............Mensurative AAM; go to **5**

4. Evaluation uses spatial/temporal controls
   - **A.** Yes...........AAM by treatments with controls
   - **B.** No............AAM by treatments and model selection

5. Evaluation is retrospectively assembled
   - **A.** Yes ....AAM by treatments with controls

6. Evaluation is prospectively planned
   - **A.** Yes...........Manipulative PAM; go to **7**
   - **B**. No............Mensurative PAM; go to **8**

7. Evaluation uses spatial/temporal controls
   - **A.** Yes...........PAM by treatment with controls
   - **B.** No............PAM by treatment and model selection

8. Evaluation is retrospectively assembled
   - **A.** Yes ....PAM by treatment with controls

Karl Popper (1959) famously stated that policy is a hypothesis that needs to be revised in light of experience. Adaptive Management is a process of policy/hypothesis testing at the scale of whole ecosystems (Walters, 1997). In forestry, Adaptive Management is a means of attaining longer-term goals sooner, through shorter-term testing of policies/hypotheses accomplished by monitoring the outcomes of management practices on forest ecosystems (Lyons *et al.* 2010).

There are two critical elements in adaptive management – the first is the need to use modeling to predict the outcomes of management decisions. The second element is the requirement that learning become an integral and linked part of the planning and management cycle and not a separate process (Rempel *et al*. 2004). We could evaluate a policy by harvesting forest in a way that improves moose habitat and could improve the moose population in absence of other factors.

For example, adaptive management can be utilized to evaluate whether a harvest pattern intended to improve moose habitat does improve moose habitat. Observing whether the moose population improves, in turn, informs – through a process known as 'strong inference' – on the merits of alternate hypotheses about the effects of other factors on moose (*e.g.,* hunting, disease, ticks, *etc*.).

Some of the differentiating characteristics of Adaptive Management are:

- acknowledgement of uncertainty about what policy or practice is "best" for the management issue;
- thoughtful selection of the policies or practices to be applied (the assessment and design stages of the cycle);
- careful implementation of a plan of action designed to reveal the critical knowledge that is currently lacking;
- monitoring of key response indicators;
- analysis of the management outcomes in consideration of the original objectives; and,
- incorporation of the results into future decisions.

7.1.2 Predictive Modeling and Testing Assumptions

Another key element of an adaptive management approach to forest management is the use of predictive modeling to assist with the design of monitoring and research projects. Through scenario planning, we predict possible future forest conditions. This is based on a combination of different strategies that were designed to achieve different management objectives. These future landscapes are assessed for a suite of desired features, in terms of location and attributes, based on the expected outcomes of the management strategies. The monitoring program is designed to assess the outcomes in terms of data and new knowledge that can be used to assess the effectiveness of strategies, key assumptions, and uncertainties.

A Sustainable Forest Management (SFM) framework should involve several key elements (after Rempel *et al.* 2004):

1) establishing a clear set of values and goals;
2) planning actions that are most likely to meet those goals;
3) implementing appropriate management activities;
4) monitoring the outcomes of management to check on predictions (*e.g.* 5-year report);
5) evaluating monitoring outcomes and adjusting management if goals were not met; and
6) revisiting goals based on new knowledge gained about the system.

The elements of the SFM Framework are linked together using of a suite of indicators arranged within a hierarchical structure. A suite of indicators has been developed within the FMP to assess and evaluate the ability of the management scenarios tested to achieve the desired future forest condition in terms of ecological, social and economic values.

There are several criteria to consider when selecting indicators (Hannon and Macallum, 2004) including:

- effectiveness
- ability to measure during a specified time period
- relate to the issue
- responsive to management actions
- cost efficient

Indicator selection should be based on linking the indicators to important processes, structures and compositions in the forest that may be altered by forest management activities (Rempel *et al*. 2004).

7.1.2.1 Prescriptive Indicators

Compliance or management control indicators are used in scenario planning to describe the desired Future Forest Condition (*e.g*. a range of harvest patch sizes). Prescriptive indicators are chosen to represent structural, functional, or compositional forest elements that are likely to be different after harvesting, relative to after natural disturbances (*e.g*. different amounts of snags and coarse woody debris, patch size distribution, connectivity, and old seral stages).

7.1.2.2 Evaluative Indicators

Evaluative (passive) indicators are used to test whether the future forest condition achieves the desired values and management objectives (*e.g*. species richness), provide new knowledge, and promotes continued learning that feeds into the adaptive management process.

> *"Good evaluative indicators should be sufficiently abundant and widespread within specific habitats to monitor, be in the core of their range, and exhibit low temporal and spatial variability to enable ease of census"* (Dufrene & Legendre 1997 in Rempel *et al.* 2004).

Furthermore, evaluative indicators are closely related to the original objectives, but represent essentially unproven hypotheses that must be continually tested. For example, if we implement Variable Retention harvesting, we will have more cavity-nesting birds. We have hypothesized a 'cause and effect' linkage. The prescriptive indicator allows the plan to be compared directly to the outcome. The evaluative indicators allow the effectiveness of the prescription itself to be assessed (Rempel *et al.* 2004).

Future research and monitoring projects may be developed in collaboration with other provincial and national level partnerships. Additional input to research priorities or monitoring requirements can be obtained from consultation with stakeholders, public advisory committees, other resource managers, and the Province.

7.2 EXISTING MONITORING

The current and existing monitoring of actual activities for roads, crossings, harvest areas, volumes, and all renewal efforts will be continued. Forest operations will be monitored to ensure compliance with operational prescriptions. Monitoring will also identify the effect of forest management activities on forest cover and forest values.

The following monitoring programs are included in the existing monitoring section:

- Bird Species at Risk Surveys
- Pre-Harvest Surveys
- Growth and Yield studies
- Harvest Inspections
- Cutover Imagery
- Forest Renewal Assessments
- Stream Crossing Inspections
- Road Decommissioning
- Forest Certification (SFI Audits)
- Invasive Insects

The remainder of this section describes:

1. an overview of each active monitoring program;
2. Standards for data collection, forms or details as appropriate; and,
3. If the Provincial Government has a similar program (*e.g.* insect surveys), there is a description of how the monitoring program will be coordinated with similar programs.

7.2.1 Bird Species at Risk Surveys

Bird species at risk surveys are performed in proposed summer cutblocks listening for birds classified as species at risk. Surveys are done to avoid summer harvest in blocks that contain bird species at risk.

Proposed cutblocks that would have harvesting activity during the bird breeding season are screened for species at risk birds. Field staff digitally record bird calls in these proposed summer harvest blocks. The digital recordings are sent to bird experts who identify the bird calls. These data are put into a data base of summer bird observations. If any proposed summer cutblocks contain bird species at risk, harvest is deferred until after the bird breeding season is over.

The dates that bird species at risk sampling can occur is weather-dependent, but typically sampled between June 1st and June 21st of each year. Bird point samples are planned on a transect within the proposed summer harvest blocks. Transects are a minimum distance of 50 m from the block edge. The point samples along the transect are a minimum 250 m apart to avoid recording the same birds twice. Field staff arrive on site at 5 am with sensitive recording equipment. A 12-minute recording of the birds is taken at each point sample. Field sampling ceases at 9 am. Excessive wind or rain compromises the bird recordings, since the wind and raindrop noise mask any bird songs.

7.2.2 Growth and Yield studies

The growth portion of 'growth and yield' requires repeated measures data or dendrochronological destructive sampling. Permanent sample plots are the most common form of repeated measures data. Yield typically refers to a single measurement of the quantity of wood, measured from a temporary plot. Timber cruising or Pre-Harvest Survey (PHS) is the most common form of yield measurement. PHS measures many ecosystem components in addition to the wood (*e.g.* wildlife, soil, vegetation *etc.*).

7.2.2.1 Permanent Sample Plots

Permanent Sample Plots (PSPs) have been established and remeasured in different forest cover types. Mature, fire-origin stands were the earliest and largest PSP dataset. These plots were mostly established in aspen (H) and aspen-mixedwood (N) stands. Harvested and regenerated aspen PSPs exist in a mixedwood experiment, a grazing trial, and in regenerating aspen cutovers.

Mature Fire-Origin Plots
The Environment Act Licence 2191E required LP to establish Permanent Sample Plots (PSPs). PSPs were established in fire-origin hardwood and hardwood mixedwood stands. Some post-harvest regeneration PSPs were established in regenerating hardwood stands from 2011 to 2016. PSP remeasurements provide growth data by comparing the original PSP measurement metrics to current PSP measurements. Remeasurements provide valuable growth data that temporary sample plots cannot.

Standards for PSP data collection are outlined in the PSP manual (Appendix I). PSP data has previously been sent to the Province of Manitoba's Forest Inventory and Analysis section of Forestry and Peatlands Branch.

Young Harvested Aspen Stands
LP established a mixedwood (aspen and white spruce) density experiment in 1998 and continues to remeasurement the plots. The 20th year full remeasurement was completed in the fall of 2018. These measurements included pure spruce plots, various spruce-aspen and aspen-spruce mixedwood plots, and some pure aspen under various densities. The next scheduled remeasurement is fall 2021, when the experimental site will be 23 years old.

The Garland Grazing Trial was a combination of harvesting and controlled cattle grazing. Fenced enclosures with no grazing provided regeneration control plots. This trial was established in the spring of 2000. These permanent plots have been remeasured every five years, including the 20th year remeasurement in early summer 2020.

A third group of harvested and regenerated young aspen consists of plots re-established in hardwood cutovers in the spring of 2014. These plots, once remeasured, will assist in quantifying growth rates of regenerated aspen cutovers.

7.2.2.2 Pre-Harvest Surveys

Pre-Harvest Surveys (PHS) are a site-specific ecosystem assessment of mature forest, which is a proposed harvest area. PHS survey points are on a 150 m systematic grid with a random start. Pre-harvest surveys collect site-specific information which contributes to harvest prescriptions, silvicultural prescriptions, ecosystem classification, volume assessments, and benchmarking the pre-harvest forest condition. Pre-Harvest Surveys are conducted on all blocks allocated for harvest and provide information for the planner to determine the appropriate season of harvest and renewal prescription. Exceptional features such as unmapped streams or wildlife features are also field mapped.

Standards for data collection are outlined in the Pre-Harvest Survey manual (Appendix II). The PHS manual for the Mountain Forest Section meets or exceeds the standards described in provincial PHS guideline.

Bubble cards are scanned with a card reader, making the PHS data digital. These data are used to create PHS reports by cutblock. These PHS reports are used in mitigation with the local Integrated Regional Management Team. PHS reports data also appears on the Cutblock Prescriptions which form a significant part of the Operating Plans.

7.2.3 Harvest Inspections

Harvest inspections are performed on all harvest blocks to ensure the planned prescription is met, and that the Standard Operations Guidelines are being followed. Both LP operations staff and provincial Conservation Officers complete inspections on harvest blocks. Harvest inspections are performed to ensure work permit conditions are met during and following harvest operations. The inspection frequency is usually related to the speed at which operations are proceeding, meaning that if harvest activities are moving at a fast rate then the inspection frequency may be increased.

The province of Manitoba also performs harvest inspections to provide an additional check to ensure that proper forest management practices are being performed. A minimum of one final inspection from the Province of Manitoba was completed on each block to ensure that all harvest operations and road closures have been completed before final clearance is given to the Work Permit Holder.

The ‘Harvesting and Roads Monitoring/Inspection form’ is shown in Appendix III. Once completed, these forms are scanned. The paper and digital versions are filed by Forest Management Unit and by block number.

Copies of the Province of Manitoba cutblock inspections are also filed by Forest Management Unit and by block number. Both paper and digital versions exist for provincial inspections.

7.2.4 Cutover Imagery

In FML #3, airborne imagery or sometimes satellite imagery is obtained for all cutovers annually, for both LP and Quota Holder cutovers. The boundaries of the cutovers are delineated, digitized, and then mapped. All photos and imagery are archived, since the cutover records are important historically. Many other users, such as silviculture, planners, and researchers utilize the cutover information.

The imagery standard is a minimum resolution of 1 m pixels on the ground. The leaf-on summer imagery is collected with two separate cameras in the aircraft. A normal colour camera is used to capture imagery, as well as a near-infra red colour camera.

Once the imagery is received, the cutover boundaries are delineated by the field staff that harvested the block. These boundaries are reviewed and combined into a cutblock shape file for each year's harvest.

Copies of the cutover shape files are submitted to the provincial government. Typically, this occurs in conjunction with submission of the FML #3 Two-Year Report (formally Annual Reports).

7.2.5 Forest Renewal Assessments

Forest renewal assessments are required on all LP and Quota Holder harvest blocks. The primary reforestation goal is to regenerate all harvested stands to meet or exceed provincial forest renewal standards and acquire a 'Certificate of Reforestation' from the province of Manitoba. Forest renewal assessments are the mode of measurement to determine the silviculture success metrics (*i.e.* percent stocking, stems per ha, and second-growth tree heights).

The silviculture survey data collected provides numerous benefits, such as:

- reporting on the status of harvested areas;
- analysis of site-specific treatment responses;
- establishment of relationships; and
- development of trends.

Softwood 'S' and mixedwood 'M' harvest sites are monitored via forest renewal assessments 10 years after harvest. The Mountain Forest Section Renewal Company surveys Quota Holder softwood and softwood-mixedwood renewed stands.

The standards for softwood forest renewal assessment data collection standards are outlined in the provincial forest renewal assessment manual (Manitoba Sustainable Development 2019). Digital survey data and maps are submitted to the Province of Manitoba annually in the 'ledger format' that facilitates provincial data consistency and ease of data import.

Hardwood 'H' and hardwood mixedwoods 'N' sites are surveyed for both LP and Quota Holder hardwood cutovers. Hardwood surveys are completed at ages three to five years after harvest.

The standards for forest renewal assessment data collection standards are outlined in the provincial forest renewal assessment manual (Manitoba Sustainable Development 2019). A survey package is annually submitted to the province of Manitoba that includes:

- summary table of each year's renewal assessments
- summary table of cutblock-level silviculture data;
- survey database (Microsoft Access);
- summary for each block;
- internal check cruise results;
- scans of completed field maps;
- maps of plot centers with colour orthophotography background; and
- GIS shape files.

The above-mentioned digital submission is in the 'ledger format' that facilitates provincial data consistency and ease of data import.

7.2.6 Stream Crossing Inspections

Road building and installation of stream crossings, such as culverts and bridges, are well-recognized as one of the forest management activities with the greatest potential to have adverse effects on aquatic systems. To avoid and minimize the potential for deleterious effects to aquatic systems, a tracking system and monitoring protocol was developed to monitor stream crossing installations, use and decommissioning. This system is consistently applied across FML #3 for all water crossings. The primary objective of this program is to ensure that effects from the construction and removal of water crossings will not impair water quality, fish or fish habitat within permanent or seasonal streams.

For all active water crossings (bridges and culverts), inspections and checklists are completed twice a year. The spring inspections are conducted between April 1st and June 1st, while the fall inspection is conducted between the dates of September 1st and November 1st before freeze-up occurs. These inspections ensure water crossing and erosion and sediment control techniques applied during the installation phase of the crossing are stable enough to withstand spring runoff and peak flow events.

For all deactivated water crossings such as bridges and culverts, inspections and checklists are completed twice a year, until vegetation has stabilized the exposed soil for two growing seasons. Digital photos are taken at the time of the inspection along with the completion of the Water Crossing Checklist form (Appendix IV).

7.2.7 Road Decommissioning

The length of existing and new roads constructed by both Quota Holders and LP in FML #3 is tracked in the FML #3 Two-Year Reports. Monitoring of roads has recently been expanded from existing and new road construction to include road decommissioning, which began in the 2017-2018 operating year (Appendix V). The standards for road decommissioning data collection use either aerial imagery or ground-based GPS data collection.

7.2.8 Forest Certification SFI Audits

Forest certification is not about collecting data, but instead requires evidence proving compliance with the certification standard. The Sustainable Forestry Initiative (SFI) Forest Certification Program https://www.sfiprogram.org/sfistandards/ is one of the world's most widely applied standards. SFI is also one of several voluntary systems that offers a means for companies and governments to demonstrate their commitment to responsible forest management. The SFI Program contains a comprehensive set of principles, objectives, and performance measures that were developed by foresters, conservationists and scientists. It combines the growing and harvesting of trees with the protection of wildlife, plants, soil, and water quality. An independent multi-stakeholder Sustainable Forestry Board governs the SFI Program and is the sole body responsible for the content of the SFI Standard and the Audit Procedures and Qualifications.

Adherence to the SFI certification standards is assured through the application of a series of operating guidelines and work instructions, supported by operator training and audits. These audits involve a review of documentation as well as field inspections, to provide evidence for the core indicators in the SFI forest certification program. SFI audit summaries for both LP and Spruce Products Ltd. are available on the web and in Appendix VI.

7.2.9 Invasive Insects

There is a potential for these invasive insects to become more prominent and be a problem in the future:

- Emerald Ash Borer – risk is greater to urban areas since there are no ash dominant stands within FML #3
- Mountain Pine Beetle – has the potential cross over to jack pine and red pine
- Gypsy Moth – a defoliator with a strong preference for hardwoods, but can also affect softwoods

Note that the Province of Manitoba monitors for these invasive species and will notify the Forest Management Licence holder if any invasive insect outbreaks occur near or within FML #3. If necessary, the Province of Manitoba will implement a management plan and communicate with the FML holder on potential mitigation strategies, such as salvage harvests.

7.3 FIVE-YEAR REPORT FMP MONITORING

This section outlines 20-year Forest Management Plan (FMP) monitoring elements that would be included in future five-year reports and two-year reports for FML #3 (Table 7.2). A five-year forest report summarizes five years of forestry actual activity and compares it to planned objectives in the Forest Management Plan, five years after FMP approval. The five-year forest report contains tables and text to describe forestry activities. The forest reports would discuss how the management objectives, targets, and strategies are being achieved during each five-year term. Reporting on results provides a way to measure progress on targets of FMP planned strategies.

Table 7.2. Two-year and five-year reports over the lifespan of the approved 20-year Forest Management Plan.

FMP Year	Planning	2-yr Reports
	submission of final revised FMP **Terms of Reference** (signed: July 29th, 2019) Submission of **new FMP** (Dec. 19th, 2019) **FMP approval** by provincial government – *expected date Dec. 2021*	2-year reports of actual roads, crossings, harvest, and renewal
1 2	1st year of approved FMP	2-year Report
3 4		2-year Report
5 6	5-yr Report (FMP Years 1- 5) – *due at the end of year 6*	2-year Report
7 8		2-year Report
9 10		2-year Report
11 12	5-yr Report (FMP Years 6 - 10) – *due at the end of year 11*	2-year Report
13 14		2-year Report
15 16	5-yr Report (FMP Years 11 - 15) – *due at the end of year 16*	2-year Report
17 18		2-year Report
19 20	5-yr Report (FMP Years 16 - 20) – *due at the end of year 21*	2-year Report

7.3.1 Land Base 5-Year Update

The spatial land base for FML #3 was a foundational piece of the 20-year Forest Management Plan (FMP). The 2020 land base was utilized by many different aspects of the plan, including:

- Natural Range of Variation – seral stages
- Bird modeling
- Moose modeling
- Marten winter cover modeling
- Cover type stability
- Carbon stocks, both upland and wetland
- Wood flows

Without updating the land base, none of the above-listed FMP aspects can be updated either. Therefore, the land base update is very significant. Five years after FMP approval, the spatial land base would be updated to allow five-year reporting of the above-listed FMP components. These components are also detailed in the following sections.

Data required would be all disturbances (*i.e*. fire, insect, disease, windthrow, and harvesting), as well as any administration boundary changes. The FML holder would supply all harvest disturbance boundaries and information. The Province of Manitoba would need to provide the fire, insect, disease, and windthrow spatial data. The Province of Manitoba would also provide spatial data on any administration boundary changes. All three of these updates would be required to accurately update the land base. The FML holder would retain a consultant to spatially incorporate these changes. The resulting updated land base would then be used for many different purposes, including updating aspects of the FML #3 Five-Year Report.

7.3.2 Natural Range of Variability

Natural Range of Variability (NRV) refers to the spectrum of ecosystem states and processes encountered over a long time period, typically dominated by wildfire disturbance. Two important metrics of NRV include seral stages and patch sizes.

0NRV Seral Stages

Seral stages are groups of forest ages. In general, the NRV seral stages have grouped seral stages for all species groups by 40-year age classes:

- **Young** Seral Stage (0 – 40 years old);
- **Immature** Seral Stage (40 – 80 years old, except immature hardwoods which are 40 – 60 years old);
- **Mature** Seral Stage (80 – 120 years old, except mature hardwoods which are 60 – 120 years old); and
- **Old** Seral Stage (120 years and older).

Natural Range of Variability (NRV) analysis for the Duck Mountain area (Andison 2019) has estimated the natural proportions of young, immature, mature, and old seral stages (Figure 7.1). The Forest Management Plan has an objective to move the mature and old seral stages closer to the natural proportions. Therefore, these seral stages would be monitored in the future.

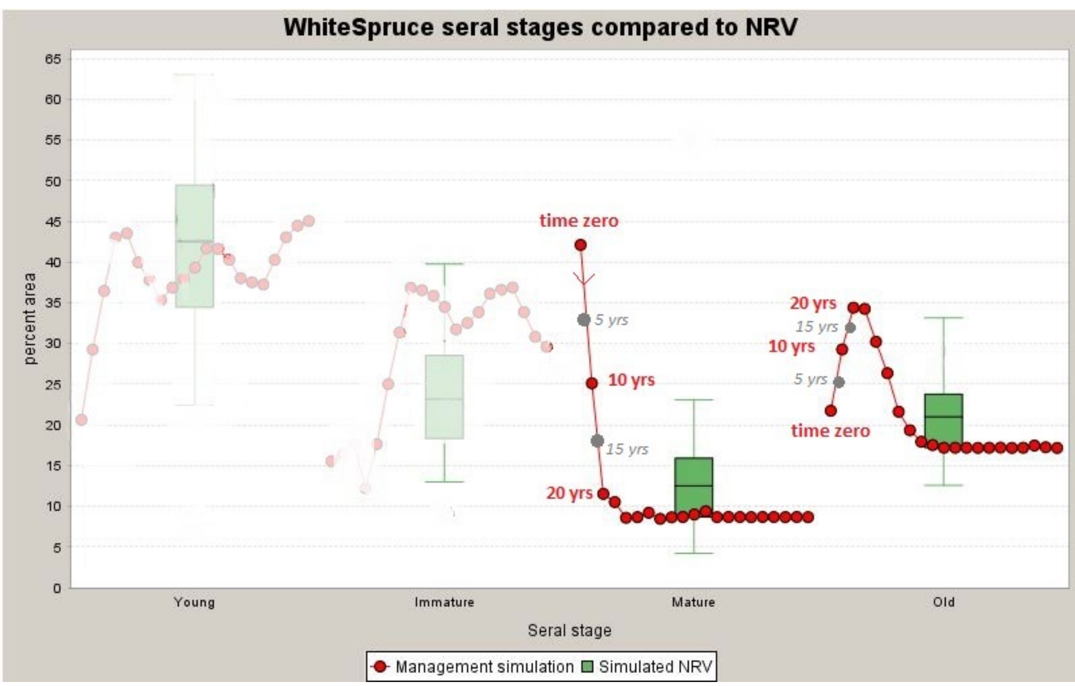

Figure 7.1 Example of tracking mature seral stage and old seral stage white spruce across FML #3.

Strategic planning in the Forest Management Plan was done in 10-year increments. Therefore, 10 and 20-year reviews of land base seral stage actuals would be compared to planned seral stage proportions. However, it may be possible and desirable to interpolate 5-year increments of seral stages between the time zero (starting condition in the year 2020) and 10-years. This potential 5-year review of seral stage targets would necessitate updating the entire land base at five years in addition to a 10-year land base update. Note that all stand-replacing disturbances (harvesting, fires, insects, disease, and blow down) would need to be incorporated into the land base update. Also note that the Province of Manitoba is responsible to provide information on the natural disturbances, which includes fires, insects, disease, and blow down.

Natural Range of Variation (NRV) seral stage trends for mature and old seral stages are proposed to be compared (Table 7.3) in the first 5-year report, post-FMP approval. This will show if forest management activities are moving the forest towards the natural seral stage range target. Mature seral stages and old seral stages will be compared by species group (*i.e.* white spruce, black spruce, jack pine, deciduous, and mixedwood).

Table 7.3 Proposed comparison of planned and actual seral stage targets.

Species Group	Seral Stage	2020 Start Condition (%)*	5 Year Actual (%)	10 Year Planned (%)	10 Year Actual (%)
White Spruce	Mature	42%		26%	
	Old	21%		30%	
Black Spruce	Mature	31%		23%	
	Old	33%		41%	
Jack Pine	Mature	43%		34%	
	Old	17%		20%	
Mixedwood	Mature	59%		44%	
	Old	11%		22%	
Hardwood	Mature	48%		41%	
	Old	2%		10%	

*percent (%) of landbase by species group

NRV Patch Sizes

Fire has historically been the primary form of forest disturbance in the boreal forest. There have been very few fires in FML #3 in the recent past. Therefore, harvesting disturbance can emulate the natural fires, assuming the patch sizes of harvesting approximates natural fire patch sizes.

Public input showed some acceptance of incorporating larger disturbances into the landscape to better emulate fire patterns, but very large harvest blocks would have adverse effects on aesthetics and perhaps other values. A broader range of harvest block sizes (Table 7.4) is modestly proposed. This represents another coarse-filter strategy for biodiversity conservation.

Natural Range of Variation was modeled in 10-year planning periods. Five-year (post-FMP approval) patch size results can be generated from a summary of actual cutblock sizes. Maintaining a functional landscape pattern of forest cover and habitat types is achieved by scheduling the harvest of blocks to emulate natural disturbance patterns, such as patch size distribution.

Table 7.4 Proposed comparison of planned and actual harvest patch size distribution.

Patch Size (ha)	Proposed Patch Sizes (%)	5 Year Actual Patch Sizes (%)	10 Year Actual Patch Sizes (%)	15 Year Actual Patch Sizes (%)	20 Year Actual Patch Sizes (%)
0 to 5	0%				
5 to 50	10%				
50 to 250	10%				
250 to 500	25%				
500 to 1,000	50%				
1,000 plus	5%				

7.3.3 Bird Species at Risk

There were enough bird data (469 observations) to model probability of habitat occupancy for the bird species at risk Canada Warbler (CAWA). The model shows an increase in CAWA habitat under the Moose Emphasis forest management scenario (Figure 7.2).

If enough new Canada Warblers are observed, then the new data could be pooled with the existing 469 observations. The pooled data could be re-analyzed and examined for different trends to confirm or modify the original modeled Canada Warbler habitat future projections.

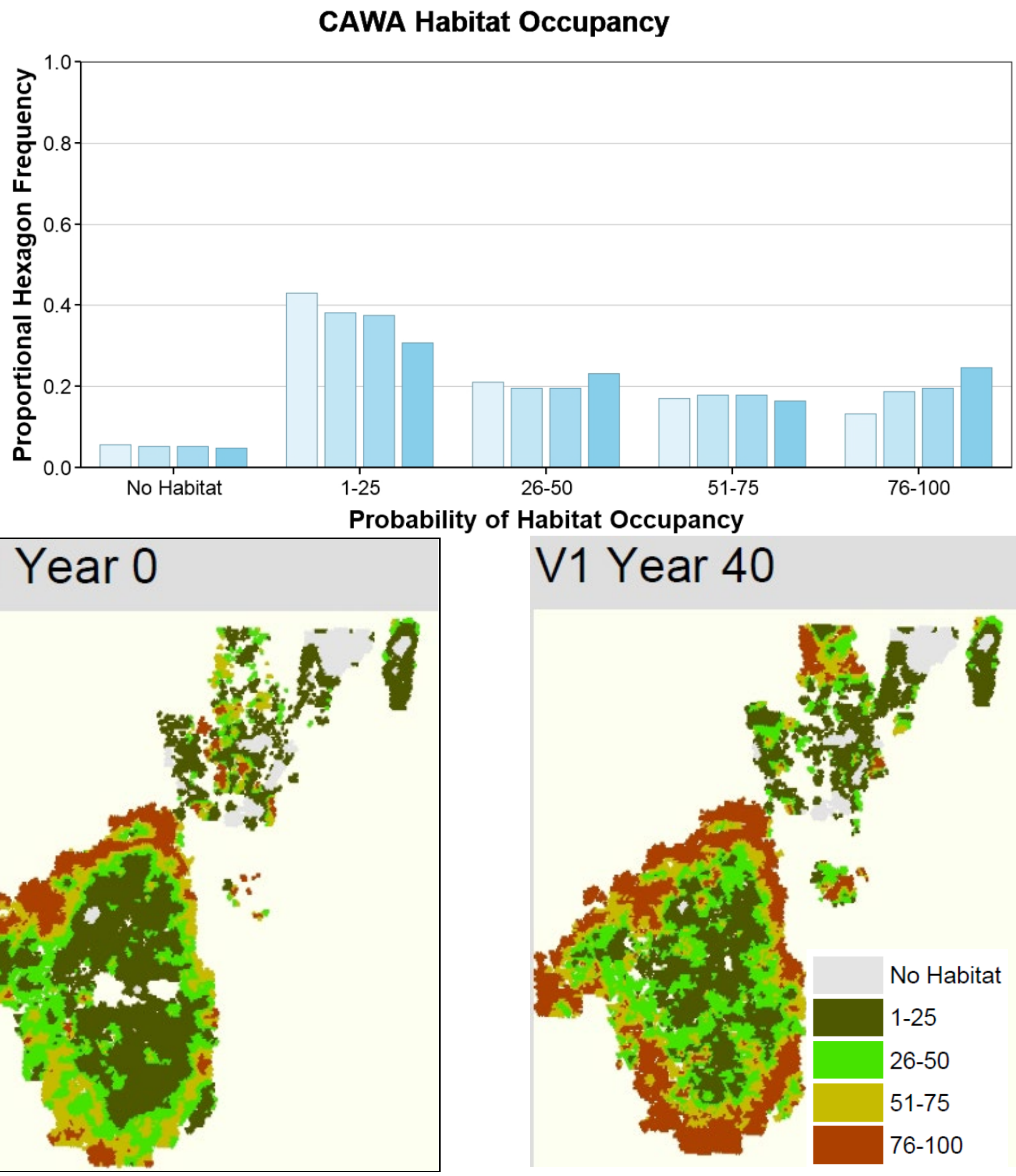

Figure 7.2 Canada Warbler projected habitat from time zero (left) to year 40 (right).

There is currently insufficient data to model the bird species at risk Golden Winged Warbler (GWWA). The GWWA only has 21 observations to date, which is far too little data to build a model. A habitat model could be built in the future if there are significantly more observations.

The Olive Sided Flycatcher (OSFL) does not have enough data to model OSFL probability of habitat occupancy. OSFL has only 45 observations to date. A habitat model could be built in the future if there are significantly more OSFL observations.

7.3.4 Indicator Bird Species

The Spatial Landscape Assessment Model (SLAM) output demonstrates the potential different habitat niches in the forest, represented by indicator bird species (Table 7.5). Indicator bird habitat occupancy projections can be confirmed or modified in the future if additional data become available.

Table 7.5. Linkages between indicator bird species, and FMP strata.

Common Bird Name	Habitat Preference			Forest Management Plan Strata
	Age	Canopy	Forest Type	
American Redstart	Either	Open	Either	All HWD and MWD units only
Black-capped Chickadee	Either	Open	Either	All strata
Brown-headed Cowbird	Either	Open	Deciduous	All strata
Blue-headed Vireo	Old	Closed	Either	All strata (except HDW1 & HWD3)
Boreal Chickadee	Old	Closed	Either	All strata (except HDW1 & HWD3)
Brown Creeper	Old	Closed	Either	All strata
Common Yellowthroat	Young	N/A	Wetland	SWD4 only
Chestnut-sided Warbler	Either	Open	Deciduous	All HWD and MWD units only
Golden-crowned Kinglet	Old	Closed	Coniferous	All Strata (except HDW1 & HWD3)
Hermit Thrush	Old	Open	Either	All Strata (except HDW1 & HWD3)
Ovenbird	Old	Closed	Either	All Strata
Red-eyed Vireo	Old	Open	Deciduous	All Strata
Swainson's Thrush	Old	Open	Coniferous	All Strata (except SDW2 & SWD4)
Veery	Old	Closed	Deciduous	All HWD and MWD units only
Winter Wren	Either	Closed	Coniferous	All Strata (except HDW1 & HWD3)
Yellow-bellied Sapsucker	Old	Open	Either	All HWD and MWD units only
Yellow Warbler	Young	Open	Deciduous	All HWD and MWD units only

7.3.5 Cover Type Stability

The cover types (S-softwood, M-softwood mixedwood, N-hardwood mixedwood, and H-hardwood) are stable across the landscape (Figure 7.3). Cover type stability is important, since some wildlife species rely on specific cover types as part of their life requirements. Therefore, maintaining the landscape-level cover type balance is an important part of coarse-filter biodiversity.

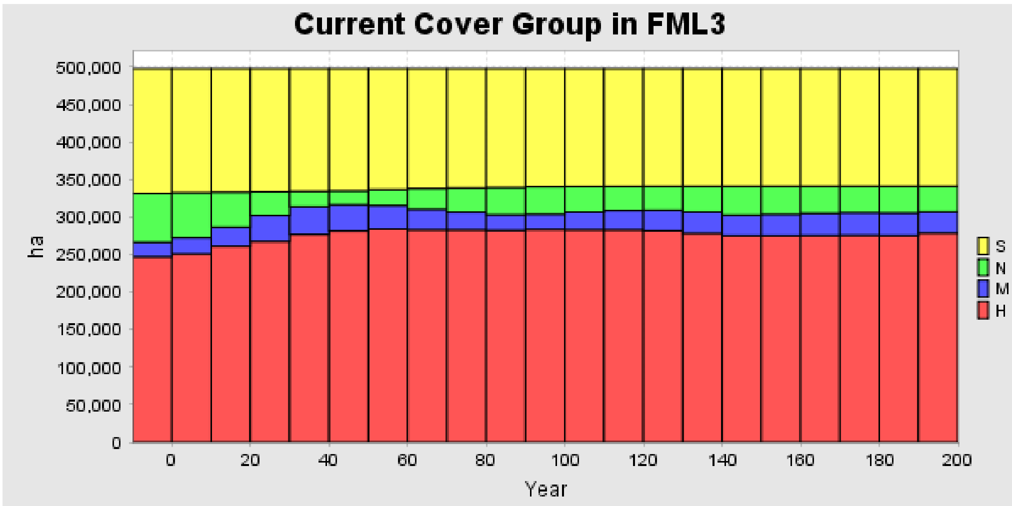

Figure 7.3 Cover type estimates from time zero to 200 years in the future across FML #3.

It is proposed to compare the 2020 existing (start condition) cover type distribution (Table 7.6) to five-year actual cover type distribution by percentage and area.

Table 7.6 Proposed cover type tracking in the five-year report.

Cover Group	**2020 Start Condition** (% and area of FML #3)	**5 Year Actual Cover Groups (%)**	**10 Year Actual Cover Groups (%)**	**15 Year Actual Cover Groups (%)**	**20 Year Actual Cover Groups (%)**
S - softwoods	33.4% 166,262 ha				
M – softwood mixedwoods	4.0% 19,677 ha				
N – hardwood mixedwoods	13.0% 64,842 ha				
H - hardwoods	49.6% 246,927 ha				
totals	**100% 497,708 ha**				

Potentially, we could explore maintaining cover types across environmental gradients. Cover type would be sub-divided by the ecological strata used all modeling of this Forest Management Plan (Table 7.7), in addition to cover type. Note that the 13 ecological strata (SWD1, SWD2, … HWD3) are fully compatible with the four cover types (*i.e.* S, M, N, H). Also note that the ecological strata are based on 24 ecosites, classified by Arnup *et al.* 2006 for the Duck Mountain Provincial Forest.

Table 7.7 Potential sub-division of cover types by ecological strata.

Cover Group	Ecological Strata	Ecosites
S - softwood 166,262 ha (33.4%)	**SWD1** – dry sandy	13, 24
	SWD2 – average moisture on clay	36
	SWD3 – wet sand or wet clay	43, 53
	SWD4 – organic soils	61
	SWD5 – organic soils, bogs and fens	62, 63, 64
M – softwood mixedwood 19,677 ha (4.0%)	**MWD1_M** – dry sandy	None sampled
	MWD2_M – average moisture on clay	34, 35
	MWD3_M – wet sand or wet clay	42
N – hardwood mixedwood 64,842 ha (13.0%)	**MWD1_N** – dry sandy	12, 23
	MWD2_N – average moisture on clay	31, 33
	MWD3_N – wet sand or wet clay	52
H - hardwood 246,927 ha (49.6%)	**HWD1** – dry sandy	11, 21, 22
	HWD2 – average moisture on clay	32
	HWD3 – wet sand or wet clay	41, 44, 51

7.3.6 Winter Moose

In the moose emphasis scenario described in chapter 5 of the Forest Management Plan (FMP), winter moose habitat is modeled over time (Figure 7.4).

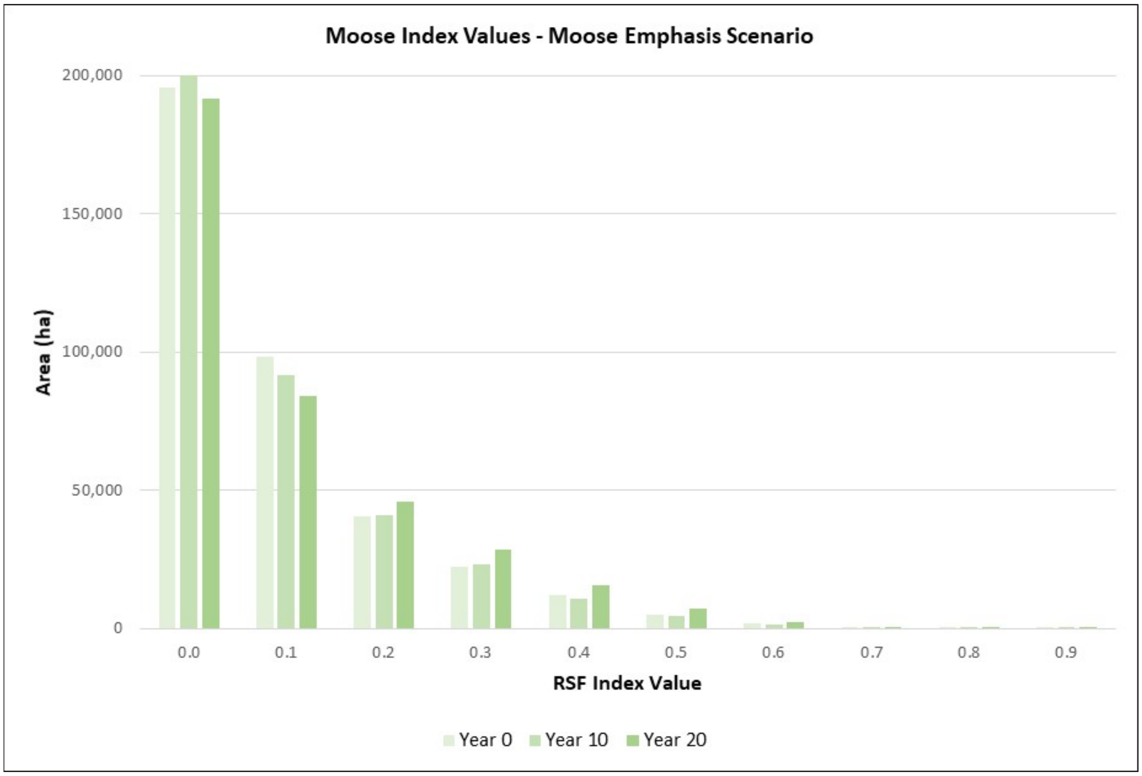

Figure 7.4. Winter moose habitat modeled estimates over the life of the 20-Year Forest Management Plan.

These winter moose habitat estimates are based on the spatial mixture of stand age, distance to water, and distance to roads. Note that young stands provide moose forage, while older stands provide moose cover. Moose habitat is classified on a scale of 0.0 to 1.0, with 1.0 being the best winter moose habitat (Table 7.8).

Table 7.8 Modeled winter moose habitat units from 2020 (time zero) to 20 years in the future.

	Winter moose habitat quality (0.0 to 1.0)											
Year	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	Total Habitat Units across FML #3
Year 0	195,501	98,292	40,413	22,525	12,347	4,952	1,781	568	178	79	0	**15,852**
*Yr 5**	*199,154*	*94,989*	*40,809*	*22,835*	*11,686*	*4,836*	*1,682*	*454*	*135*	*53*	*0*	
Year 10	202,808	91,686	41,206	23,146	11,025	4,720	1,583	341	92	28	0	**15,001**
*Yr 15**	*197,253*	*87,819*	*43,656*	*25,972*	*13,330*	*6,064*	*1,981*	*423*	*107*	*32*	*0.5*	
Year 20	191,698	83,951	46,106	28,798	15,635	7,409	2,378	504	121	35	1.0	**20,506**

**years 5 and 15 are interpolated values between the 10-year modeling periods.*

In the 5-year FMP reports, winter moose habitat unit estimates could be compared to actual habitat units. An updated landbase would be necessary to update the winter moose habitat units.

7.3.7 Marten Winter Cover

Marten winter cover habitat estimates were based on modeling projections, from the opinion-based HSI model provided by the Province of Manitoba. A baseline of marten winter cover was estimated for the year 2020, which is the beginning of the Forest Management Plan (FMP). Future estimates, based on changes to the forest cover, were also estimated.

The 2020 marten habitat projections can be re-estimated post-FMP approval (Table 7.9) by using an updated land base that accounts for disturbances, growth, and succession. This land base would be updated to include actual changes in forest stands. For example, all forest stand ages can be increased by five years. Actual harvested areas age would be reset to zero, or the year the block was harvested.

Table 7.9 Marten Winter Cover Habitat Units across the landscape

Year	Planned MOOSE EMPHASIS scenario *(habitat units)*	5-Year Actual	10-Year Actual	15-Year Actual	20-Year Actual
0 *(baseline in 2020)*	50,667				
5*	45,842				
10	41,016				
*15**	*38,659*				
20	36,302				

**years 5 and 15 are interpolated values between the 10-year modeling periods.*

Marten winter cover habitat unit values are heavily benefitted by dense conifer stands. Natural stand aging and break-up changes these dense conifer stands (crown closure class 3 with a Suitability Index of 1.0) to older open stands (crown closure class 2 with a Suitability Index of 0.5). Reducing the Suitability Index of variable 3 by 50% (1.0 down to 0.5) has a significant landscape-level effect on future marten winter cover.

Mature seral stage conifer is highly beneficial to marten winter cover. However, undisturbed mature seral stage stands age and become old seral stage conifer stands with significantly less value to marten. Old seral stage stands are less dense and have a lower marten winter cover value.

The solution to maintaining mature seral stage conifer stands is follow the Natural Range of Variability targets and provide a steady supply of young and immature conifer stands over time, which will transition into mature conifer stands.

7.3.8 Limit disturbances within watersheds

Both the Baseline and Moose Emphasis Forest Management Scenarios ensure that never more than 30% of a watershed is planned to be in a harvested state. The values in Table 7.10 are planned projections based on the disturbance criteria of less than 5 years for hardwood types and 10 years for softwood types. This disturbance calculation applies only to disturbances within FMU 13 (Duck Mountain Provincial Forest) based on the total productive area of the entire watershed.

Table 7.10 Watershed limits (%) over time.

Watershed	Baseline 2020	Planned 5 yrs	Actual 5 yrs	Planned 20 yrs	Actual 20 yrs
ASSINIBOINE	0.31	0.09		0.08	
CENTRAL VALLEY	1.48	0.84		1.13	
CRANE	0.0	0.0		0	
FISH MINK CREEK	0.69	0.18		0.26	
FORK RIVER	0.51	0.16		0.46	
GARLAND RIVER	1.94	1.81		1.29	
HAMELIN DRAIN	0.0	0.0		0	
KETTLE HILLS	0.0	0.0		0	
LOWER ROARING	0.52	0.37		1.03	
LOWER SHELL	0.33	0.19		0.38	
LOWER SWAN	0.01	0.17		0.04	
LOWER TURTLE	0.0	0.0		0	
LOWER VALLEY SILVER CREEK	0.76	0.6		0.35	
LOWER WOODY	0.0	0.0		0	
PELICAN LAKE EAST	0.0	0.0		0	
PINE RIVER	2.14	1.87		0.95	
SCLATER DUCK	0.86	1.16		0.7	
UPPER ROARING	1.15	2.33		2.06	
UPPER SHELL	2.94	3.34		2.66	
UPPER SWAN	0.42	0.16		0.48	
UPPER TURTLE	0.0	0.0		0	
UPPER VALLEY	4.37	3.89		2.53	
UPPER WOODY	0.0	0.0		0	

7.3.9 Carbon Stocks

It is desirable to maintain sequestered carbon in the existing soil profile or in wetlands to reduce greenhouse gas carbon emissions. Atmospheric carbon is fixed into upland and wetland carbon during photosynthesis. Carbon is stored in peat, tree stems, branches, bark (non-stem biomass) and in significant amounts in root structures (soil biomass). When stands are harvested the carbon from the stem of the trees may be converted and locked in durable forest products for an average of 100 years.

Carbon stocks are maintained by maintaining levels of mature forest, but not converting to all overmature forest. The primary control on mature forest is the rate of harvest and the subsequent renewal of the forest. Harvesting removes carbon in the form of stem biomass and transforms carbon into building products. Non-stem biomass is either burned as hog fuel or decomposes on the forest floor. Soil biomass is reduced gradually after harvest, due to decomposition. All biomass categories are replenished as stands mature and decline as trees senesce. Intensive silvicultural treatments that promote better stand establishment increase the amount of carbon in trees as they grow. Silviculture can also improve stocking levels, although there is an upper limit due to site productivity.

Upland carbon stocks in FML #3 are projected to be stable over time. Specifically, carbon removals due to harvesting of softwood sawlogs and hardwood for both siding and firewood are balanced by the natural increases in carbon (Figure 7.5) in FML #3.

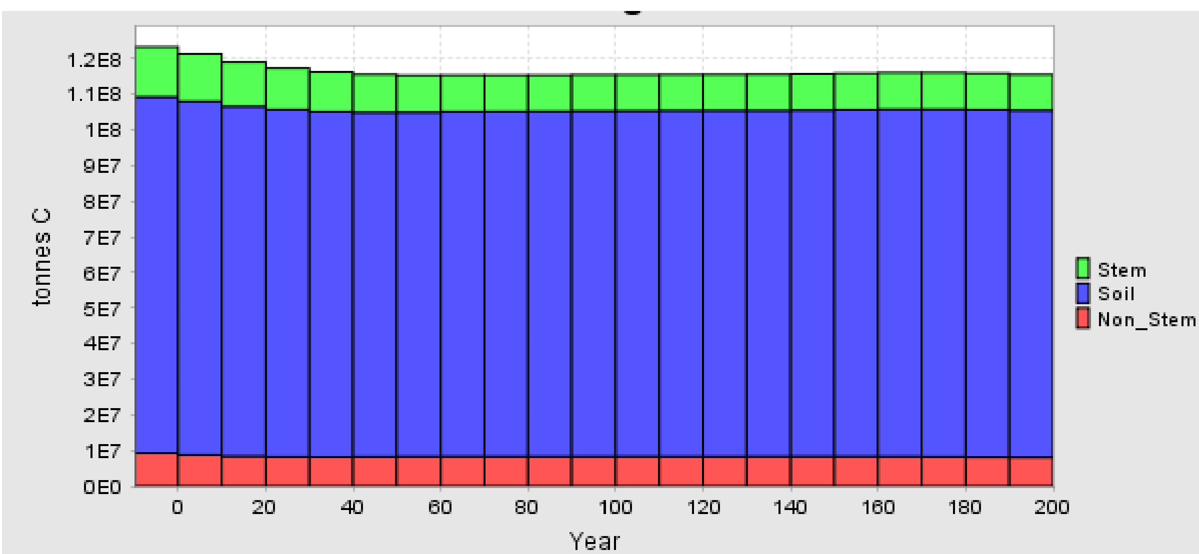

Figure 7.5 Upland carbon estimates over time are estimated to be stable.

The carbon estimates can be compared to actual carbon amounts in each FMP report. A sample of what this would look like is shown in Table 7.11.

Table 7.11 Upland carbon estimates from 2020 (time zero) to 20 years in the future.

Upland Carbon Type	0 (baseline year 2020)	baseline year 2020 (%)	Upland Carbon estimate at 10 yrs	Upland Carbon actual at 10 yrs	Upland Carbon estimate at 20 yrs	Upland Carbon actual at 20 yrs
Non-Stem Carbon*	9,242,584	7.5%	8,748,503		8,374,192	
Soil Carbon	100,034,944	81.1%	99,277,544		98,220,512	
Stem Carbon	14,022,850	11.4%	13,333,104		12,457,816	
Totals	**123,300,378**	**100.0%**	**121,359,151**		**119,052,520**	

**non-stem carbon includes tree roots, stumps, tops, and branches.*

Note that wetland carbon estimates are static, which prevents being able to calculate change in wetland carbon over time. Estimates of how wetland types change organic peat depths over time is needed to be able to calculate changes in wetland carbon.

7.3.10 Regenerating Cover Types

LP will use silviculture survey data to provide an approximation of post-harvest transitions at year five for hardwood and year 10 for softwood. Data from 1996 harvest blocks to present will be used.

Stands proposed for harvest receive a Pre-Harvest Survey before harvest. After harvest (time 0 years) a hardwood survey is performed by age 3 to 5 years. The example below (Figure 7.6) shows a Pre-Harvest Survey measurement of 20% softwood pre-harvest, and 20% at age five years, as measured from the silviculture survey.

Post-harvest transitions from age 5 or 10 years to 100 years old across all strata are needed.

This significant stand dynamics gap can be filled using a growth model. Two growth models are currently available:

1. Mixedwood Growth Model (MGM 2018) https://mgm.ualberta.ca/ which includes climate-sensitive survival functions; or
2. Province of Manitoba's in-progress version of GYPSY (Growth and Yield Projection System).

A growth model can estimates stand parameters using the silviculture survey data as the starting condition. The growth model then projects stand parameters out to rotation (60 to 100 years in the future). These growth estimates, based on local data, are exceptionally valuable.

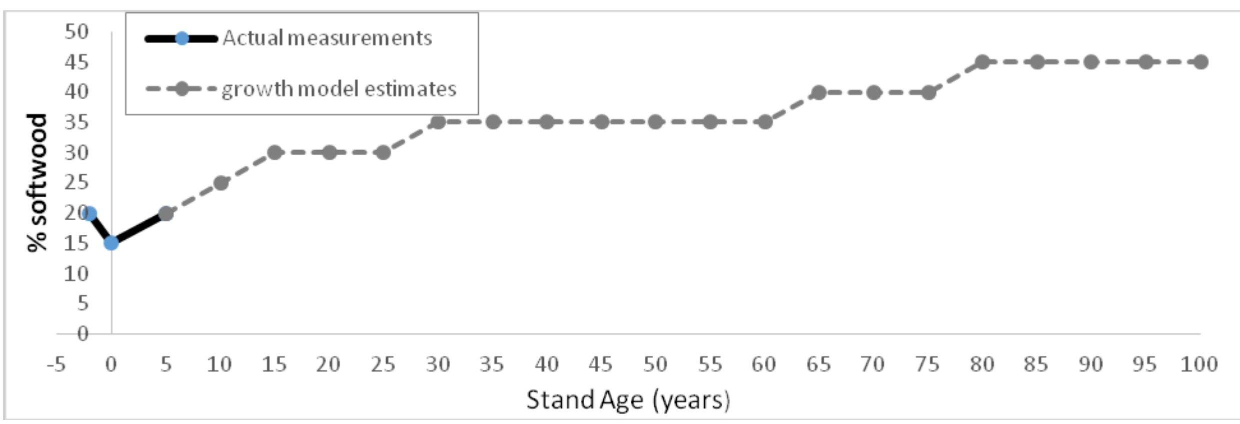

Figure 7.6 Actual measurements pre-harvest and 5 years post-harvest (solid line), then growth model estimates are needed (dashed line).

7.3.11 Regeneration Differences between FMU 11 and FMU 13

Regeneration or treatment and response differences between Forest Management Unit (FMU) 13 (Duck Mountain Provincial Forest) and FMU 11 (Swan-Pelican Provincial Forest) will be monitored. The mutually agreed upon treatment and responses were previously calculated from FML #3 (*i.e.* FMUs 13, 11, and 10), silviculture surveys. The format in the tables below (Table 7.12) will be used to compare FMU 13 and FMU 11 silviculture survey results in the Five-year reports (*i.e.* years 5, 10, 15, and 20 years post-FMP approval).

Table 7.12 Regeneration treatment and response tables for FML #3 (planted and leave-for-natural).

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

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

7.3.12 Yield Curves in FMU 11

The five-year average volumes of all harvested blocks in Forest Management Unit 11 will be compared to the FMU 11 yield curves (*i.e.* volume per hectare over stand age). Delineated cutover imagery will be used to determine actual area. Scale information by block will be used to determine actual volume. Actual volume per hectare in FMU 11 will be determined from actual volume and actual area.

All blocks harvested in FMU 11, five years after approval of the Forest Management Plan, will be compared as planned volume per hectare compared to actual volume per hectare. This comparison will be reported in the Forest Management Plan 5-year report.

Note that stand volume is <u>not</u> the driver of the FML #3 sustainability modeling in the Forest Management Plan. Volume is simply an output with a maximum sustainable volume not to be exceeded. Drivers of the FML #3 sustainable modeling are moose habitat, watersheds, Natural Range of Variability seral stages, *etc*. In contrast, volume is the driver in the Province of Manitoba sustainable volume calculations.

7.4 FUTURE MONITORING

Future monitoring projects need to be addressed in an Adaptive Management framework, as described in previous section 7.1.1. Monitoring would be accomplished in cooperative, cost-shared effort with the provincial government, conservation groups, or academic agencies. In addition, research grants can be jointly applied for from the Sustainable Forestry Initiative certification body, federal, or provincial governments. Indigenous involvement in monitoring is desirable.

Monitoring as a system helps structure our thinking about how the pieces might fit together to form a unified planning and monitoring system. Lack of a systems approach to monitoring such as 'just go collect data' typically ends up with an unimplemented and shelved monitoring report.

The future monitoring projects chosen to explore and pursue (ranked in order of importance) are:

1. Seasonal moose and elk habitat models
2. Climate Change Vulnerability and Adaptation
3. Bird Species at Risk habitat
4. Forest Growth Model Implementation

7.4.1 Seasonal Moose and Elk Habitat Models

Both the FML #3 holder and the Province of Manitoba have been exploring and pursuing collaborative options for modeling both moose and elk habitat. Habitat modeling would only be built with wildlife data, not expert opinion. Ideally, the wildlife data would be stratified by season, such as winter versus summer.

Resource Selection Probability Function (RSPF) models have been proposed (Appendix I) to be applied to all relevant moose and elk survey data. RSPF models are used in spatial ecology to assess which habitat characteristics are important to a species of animal.

Scale is important in wildlife habitat analyses. Therefore, a multi-scale analysis of the moose and elk data will be completed at three scales simultaneously:

1. Local scale (50 ha);
2. Meso scale (500 ha); and
3. Landscape scale (5000 ha).

Quantifying and assessing current moose and elk habitat (by season) will be beneficial in configuring operational and landscape-level harvest to benefit moose and elk, while not exceeding other ecosystem targets (*e.g.* watershed limits, fire emulation (NRV) targets, sustainable harvest levels, *etc*.).

7.4.2 Climate Change Vulnerability and Adaptation

The health and sustainability of Canada's boreal forests are vulnerable, to varying degrees, to climate change. Climate-related impacts that lead to vulnerabilities within Sustainable Forest Management, include:

- Increased frequency and intensity of extreme weather events,
- Increased frequency and severity of insect/disease outbreaks, along with the introduction of non-indigenous organisms,
- Forest growth/productivity/mortality changes (either positive or negative),
- Regeneration success challenges,
- Land and access conditions are changing (length of winter road season decreasing due to extreme temperature fluctuations, earlier spring thaws); road structures (including bridges and culverts); length of season when ground and water bodies are frozen – decreasing due to increase winter temperature fluctuations, late fall freeze up and earlier spring thaw)
- Changes in seasonality and precipitation events,
- Increased periods of drought (could lead to increased risk of fire).

With these vulnerabilities, SFM objectives may become more challenging to achieve. It is important to identify these vulnerabilities within the LP SFM system and develop tools and strategies that will help manage these changes. Using existing and developing additional tools in LP's SFM system to develop adaptation options, mainstream, and monitor at both a strategic and operational level to account for climate change through technology, government policy and collaboration among academia, government and other stakeholders, is a priority for LP.

LP is participating in a collaborative climate change vulnerability and adaptation project funded by Natural Resources Canada which is facilitated by the Saskatchewan Research Council and the University of British Columbia. Four industrial partners include Spruce Products Ltd., LP Swan River, Weyerhaeuser Saskatchewan (Hudson Bay, SK) and Edgewood (Carrot River, SK).

The objectives of the project are:

- To assess and manage Sustainable Forest Management vulnerabilities
- To mainstream adaptation options into LP planning and operations

This project is focused on assessing the climate-related impacts and vulnerabilities on sustainable forest management on the LP FMP area. The project applies the conceptual framework developed by the Canadian Council of Forest Ministers (CCFM) and involves:

- describing the current climate and forest condition on the LP FMP area;
- developing scenarios of future climate and forest conditions;
- assessing the vulnerability of SFM to current and future climate;
- developing and refining options for adaptation;
- mainstreaming and monitoring climate change and adaption at both strategic and operational scales.

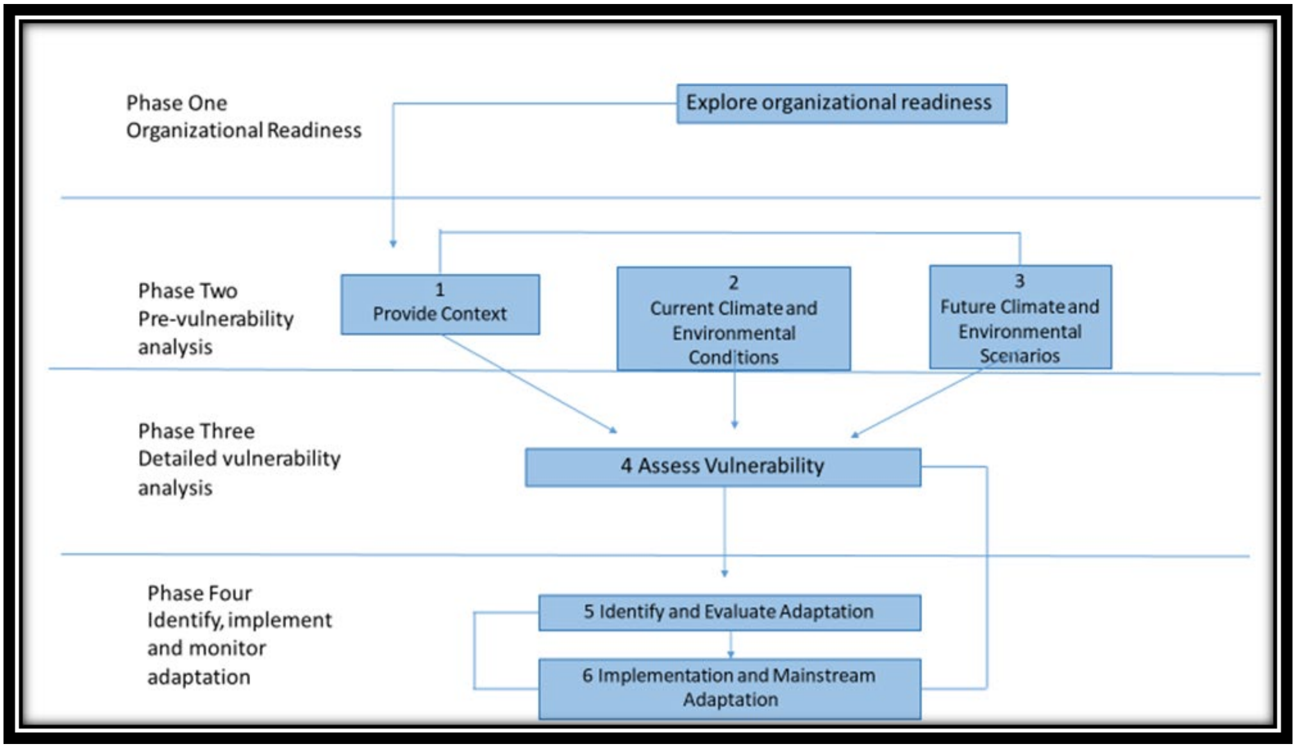

Figure 7.7 The four stages and six components of adaptation to climate change for Sustainable Forest Management (adapted from Edwards et al., 2015).

Phases one, two, and three are completed. Phase four is not yet completed and will happen after FMP submission. Possible monitoring and adaptations may include:

- Operation days lost (Mistik Management Ltd. case study) and local adaptations to reduce operational days lost; pre-approved and pre-permitted contingency winter stockpiles and,
- Weyerhaeuser Saskatchewan example of more bridges and less culverts to increase reliability and security of priority wood haul areas
- Adaption to assist mitigation – Explore and pursue increased haul weights on lower class roads, reducing fuel consumption and reducing $C0_2$ emissions.

The results of Phases one, two, and three demonstrate that LP's Sustainable Forest Management system is vulnerable to climate change and extreme weather events now and into the future, to varying degrees. It is also expected that vulnerabilities will change and may increase going forward. Moving into Phase four of the assessment process, LP will develop and identify potential adaption options to address vulnerabilities and establish a plan for implementation and mainstreaming of adaptation and monitoring for strategic and operational scales on FML #3 to ensure best practices and sustainability.

7.4.3 Bird Species at Risk

Bird species at risk could be monitored using a variety of techniques. Current bird monitoring options include:

- Continue to survey proposed summer hardwood cutblocks as part of the regular bird species at risk monitoring (mature hardwood ecosystems only)
- additional bird survey field work in targeted habitat (*e.g.* softwoods, young hardwood, bogs, and fens) where species at risk birds are more likely to be observed. Multiple years of field data could be analyzed, linking birds to habitat.
- wait for the Federal government to deliver habitat information in the future
- scan relevant bird habitat literature as it becomes available
- maintain our connection with BAM (Boreal Avian Modeling) at the University of Alberta https://borealbirds.ualberta.ca/

It is also important to maintain awareness of new bird monitoring equipment and techniques. Future improvements to the existing bird monitoring equipment and techniques would be evaluated and implemented if feasible. For example, automated bird sound recording stations have been established by the Canadian Wildlife Service in the Mountain Forest Section to record winter owls.

7.4.4 Forest Growth Model Implementation

Maintaining the cover type (hardwood, mixedwoods, and softwood) balance at the landscape-level is important to maintaining both coarse-filter biodiversity and the natural range of variability.

From stand ages five years (hardwood) to 10 years (softwood) forest renewal assessment data is collected. These data give a single point of a stand's species trajectory. After years 5 to 10 we assume future regenerating cover types of harvest blocks out to ages 50 to 150 years old. We could explore and pursue the use of a growth model to use data to interpolate:

- species composition and cover type;
- mortality (live trees, snags, coarse woody debris);
- tree heights by species;
- stand densities;
- diameters;
- volume; and,
- crown heights and crown widths.

We can begin by utilizing MGM (Mixedwood Growth Model). MGM 2018 https://mgm.ualberta.ca/ has been completed, tested, and now includes climate-sensitive survival functions. Previous versions of the MGM model have been available since the 1990's, attesting to the validity and longevity of the MGM model.

The Province of Manitoba has been developing a version of Alberta's GYPSY (2009) growth model https://www.alberta.ca/growth-and-yield-projection-system.aspx.

7.5 LITERATURE CITED

Andison, D.W. 2019. Synthesis Report. Pre-Industrial Fires Regimes of the Western Boreal Forest. fRI Research Healthy Landscapes Program, Hinton, AB. 49 pp.
Hannon, S.J. and C. Macallum, 2004. Using the focal species approach for conserving biodiversity in landscapes managed for forestry. Sustainable Forest Management Network Synthesis Paper. 57 pp.

Lancia, R. A., Braun, C. E., Collopy, M. W., Dueser, R. D. Kie, J. G., Martinka, C. J., Nichols, J. D. Nudds, T. D., Porath, W. R. and N. G. Tilghman. 1996. ARM! for the future: Adaptive resource management in the wildlife profession. Wildlife Society Bulletin 24:436–442.

Lyons, J.E., Runge, M.C., Laskowski, H.P., and W.L. Kendall. 2010. Monitoring in the context of structured decision-making and adaptive management. J. Wildlife Manage., 72 (2010), pp. 1683-1692.

Manitoba Conservation. 2007. Manitoba's Submission Guidelines for Twenty Year Forest Management Plans. Manitoba Conservation. Edited by Forestry Branch. 200 Saulteaux Crescent, Winnipeg, MB. 24 pp.
Manitoba Environment Act. 2009. Chapter E125, C.C.S.M.
http://web2.gov.mb.ca/laws/statutes/ccsm/e125e.php

Manitoba Sustainable Development. 2019. Manitoba Forest Renewal Assessment Ground Methodology Supplementary Manual. Forestry and Peatlands Branch. 200 Saulteaux Crescent, Winnipeg, MB. 13 pp. plus appendices.

Nudds, T.D. 1998. Adaptive management and the conservation of biodiversity. Pages 179-193 *in:* R.K. Baydack, H. Campa III, J.B. Haufler (eds.) Practical Approaches to the Conservation of Biodiversity. Island Press, Covelo, CA. 313 pp.

Nudds, T.D. 2018. Adaptive Management: Unifying Concept for Science, Policy and Management. Presentation to Forest Management Plan Planning Team. Nov. 27, 2018. Winnipeg, MB.

Nudds, T.D. and J. Baker. 2019. Key to Types of Adaptive Management. Unpubl. Modified after key produced for 1998 workshop preceding report by MacDonald, G.B., Fraser, J., and P. Gray (Eds.) 1999 Adaptive management forum: linking management and science to achieve ecological sustainability. Ontario Ministry of Natural Resources, Peterborough, Ontario.

Popper, K. (1959). The Logic of Scientific Discovery (2002 pbk; 2005 ebook ed.). Routledge. ISBN 978-0-415-27844-7.

Rempel, R.S., Andison, D.W. and S.J. Hannon. 2004. Guiding principles for developing an indicator and monitoring framework. The Forestry Chronicle. Vol. 80, No. 1. pages 82-90.

Walters, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology [online]1(2):1. Available from the Internet. URL: http://www.consecol.org/vol1/iss2/art1/

7.6 APPENDICES

APPENDIX 1: Permanent Sample Plot Procedures Manual

APPENDIX 2: Pre-Harvest Survey Manual

APPENDIX 3: Harvesting and Roads Monitoring/Inspection form

APPENDIX 4: Water Crossing Checklist form

APPENDIX 5: Road decommissioning table

APPENDIX 6: SFI Certification audit summary

APPENDIX 7: Development of Seasonal Moose and Elk Habitat RSPF Models