

Balancing Climate Change and Financial Objectives: Exploring Management Strategies  
for Small Woodlot Owners in the Maritime Provinces

by

Carley Jean Archibald

B. Sc. Environmental Science, Dalhousie University, 2020

A Report Submitted in Partial Fulfillment  
of the Requirements for the Degree of

Master of Forestry

in the Graduate Academic Unit of Forestry and Environmental Management

**Supervisor:** Anthony R. Taylor, Ph.D., Faculty of Forestry and  
Environmental Management

**Examining Board:** Jasen Golding, MFE., Faculty of Forestry and Environmental  
Management

Jae Ogilvie, MSc. F., Faculty of Forestry and Environmental  
Management

This report is accepted by the Dean of Graduate Studies

THE UNIVERSITY OF NEW BRUNSWICK

March 2026

© Carley Archibald, 2026

## Abstract

Climate change will impact forest dynamics in the Acadian (Wabanaki) Forest Region, necessitating adaptive strategies for sustainable forest management of small woodlots of the Maritime provinces. Using strategic forest management model Remsoft® Woodstock, this study explores the multifaceted impacts of climate change on forest dynamics, management regimes, and revenue in UNB's Taymouth Woodlot. A comparison of results between the 'baseline' and 'climate adjusted' scenarios found that climate informed forest management practices may allow small woodlot owners to maintain nearly equivalent annual revenues under conditions of RCP 8.5, with sustainable harvest levels within 5% of baseline conditions. Despite declining productivity in softwood-dominant stand types, harvest levels were maintained by balancing selection harvesting in mixedwood stands, and clearcutting in increasingly productive hardwood stands. However, the declining availability of spruce-fir forest products highlights the potential for supply constraints if local value chains are not adjusted to adapt to the changing climate.

**Keywords:** climate-sensitive optimization, dynamic transition rules, dynamic yield tables, species composition shift, strategic forest planning

## **Acknowledgements**

I'd like to sincerely thank my supervisor, Dr. Anthony Taylor, for his exceptional insight and enthusiasm for this project; as well as my committee, Jae Ogilvie and Jasen Golding, for providing guidance throughout the process. I'd also like to express my deepest gratitude to my parents for their unwavering support and encouragement, and my late grandmother, Karen Archibald, who inspired my pursuit of higher education.

# Table of Contents

|   |      |
|---|------|
| Abstract .....  | ii   |
| Acknowledgements.....   | iii  |
| Table of Contents.....  | iv   |
| List of Tables .....  | vi   |
| List of Figures.....  | vii  |
| List of Abbreviations .....   | viii |
| INTRODUCTION .....  | 1    |
| <i>Small woodlots in the Maritime provinces of Eastern Canada</i> .....       | 1    |
| <i>The effects of climate change on the Acadian Forest</i> .....              | 2    |
| <i>Accounting for climate change in small woodlot forest management</i> ..... | 4    |
| METHODS .....   | 6    |
| <i>Study area</i> .....   | 6    |
| <i>Forest Management Decision Support Systems (DSS)</i> .....                 | 8    |
| <i>Field data collection and preparation</i> .....                            | 8    |
| <i>Woodstock planning model parameters and management design</i> .....        | 10   |
| <i>Spatial set up, areas, landscape, and control</i> .....                    | 10   |
| <i>Actions, eligibility, and potential future stand types</i> .....           | 11   |
| <i>Baseline yields and transitions</i> .....                                  | 15   |

|  |    |
|--|----|
| <i>Climate-informed yields and transitions</i> .....                     | 18 |
| <i>Optimization</i> .....  | 19 |
| RESULTS .....  | 21 |
| <i>Forest inventory</i> .....  | 21 |
| <i>Harvesting and silviculture treatments</i> .....                      | 22 |
| <i>Sustainable harvest level, net revenue and end-product mix</i> .....  | 25 |
| DISCUSSION .....   | 28 |
| <i>Overall findings</i> .....  | 28 |
| <i>Forest inventory</i> .....  | 29 |
| <i>Harvesting and silviculture treatments</i> .....                      | 30 |
| <i>Sustainable harvest level, net revenue and end-product mix</i> .....  | 31 |
| <i>Limitations of results</i> .....                                      | 31 |
| <i>Management implications for small woodlots in the Maritimes</i> ..... | 32 |
| Bibliography .....   | 33 |
| Appendix A.....  | 38 |
| Appendix B.....  | 41 |
| Curriculum Vitae   |    |

## List of Tables

|   |    |
|---|----|
| Table 1 Existing stand types and attributes in the Taymouth Woodlot. ....   | 11 |
| Table 2 Stand level action (treatment) description and purpose. ....  | 11 |
| Table 3 Potential future stand types (resulting from natural succession or<br>harvest/silviculture actions) in the Taymouth Woodlot (Neily et al., 2023). ....  | 12 |
| Table 4 Treatment eligibility by stand type. ....   | 14 |
| Table 5 Wood product categories, species, specifications and stumpage price<br>(NBDNRED, 2024) used to calibrate Kershaw’s (2007) PRCalc. ....  | 16 |
| Table 6 Input parameters to the NSGNY 3.0 (Steenberg et al., 2023) for plantations and<br>thinned natural stands. ....  | 18 |
| Table 7 Predicted departure from baseline conditions under RCP 8.5 for the first 50 years<br>of model planning horizon (expressed as a ratio) derived from Taylor et al. (2017). ....   | 19 |
| Table 8 Costs associated with harvesting and silviculture actions. ....   | 20 |
| Table 9 Average age and area of individual harvest treatments under baseline and RCP<br>8.5 climate scenario. ....  | 24 |
| Table 10 Frequency of harvest (clearcut and selection) by stand type for baseline and<br>climate change scenarios. Gray shading reflects each stand type’s eligibility for harvest.<br>Key differences are indicated with bold font. .... | 24 |
| Table 11 The average annual harvest volume (m <sup>3</sup> ) and percent of total harvest volume<br>(%) by product category. ....   | 26 |

## List of Figures

|  |    |
|--|----|
| Figure 1 Location of the study area (Taymouth Woodlot) within the Maritime provinces.  | 7  |
| Figure 2 Stand types and sample points in the Taymouth Woodlot (NBDNRED, 2023).  | 10 |
| <i>Figure 3</i> The stand simulation parameters for balsam fir softwood stands as seen in OSM's Notepad++ user interface (Hennigar, 2013)..... | 15 |
| <i>Figure 4</i> Trends in mature canopy covered area and growing stock over time.....  | 22 |
| <i>Figure 5</i> The per-period (5 year) harvest area by treatment type over the 100-year planning horizon. ....                                | 23 |
| Figure 6 Costs, total and net revenue measured per-period for the 100-year planning horizon. ....  | 27 |
| Figure 7 The proportion of total revenue by product category between the baseline and climate change scenarios.....                            | 28 |

## **List of Abbreviations**

|               |  |
|---------------|--|
| <b>AAC</b>    | Annual Allowable Cut                               |
| <b>BGI</b>    | Biomass Growth Index                               |
| <b>DBH</b>    | Diameter at Breast Height                          |
| <b>GTV</b>    | Gross Total Volume                                 |
| <b>FEC</b>    | Forest Ecosystem Classification                    |
| <b>Ha</b>     | Hectare  |
| <b>HWA</b>    | Hemlock Wooley Adelgid                             |
| <b>NB</b>     | New Brunswick                                      |
| <b>NBFPC</b>  | New Brunswick Forest Products Commission           |
| <b>NBFWO</b>  | New Brunswick Federation of Woodlot Owners         |
| <b>NRCan</b>  | Natural Resources Canada                           |
| <b>NS</b>     | Nova Scotia  |
| <b>NSDNR</b>  | Nova Scotia Department of Natural Resources        |
| <b>NSWOOA</b> | Nova Scotia Woodlot Owners & Operators Association |
| <b>OSM</b>    | Open Stand Model                                   |
| <b>PCT</b>    | Pre-commercial thinning                            |
| <b>PEI</b>    | Prince Edward Island                               |
| <b>PRCalc</b> | Product Ratio Calculator                           |
| <b>RCP</b>    | Representative Concentration Pathway               |
| <b>WMO</b>    | World Meteorological Organization                  |
| <b>UNB</b>    | University of New Brunswick                        |

## INTRODUCTION

### *Small woodlots in the Maritime provinces of Eastern Canada*

The Acadian (also known as the Wabanaki) Forest Region includes the provinces of Nova Scotia (NS), New Brunswick (NB), and Prince Edward Island (PEI) (Rowe, 1972; Baldwin et al., 2020). It is part of an ecological transition zone that includes a unique and diverse assemblage of over 32 boreal and temperate tree species found nowhere else on the planet (Rowe, 1972; Basquill and Baldwin, 2020). This ecosystem is of high ecological and cultural value (Loo & Ives, 2003) and of significant socioeconomic importance as forestry, pulp and paper, and wood products manufacturing currently contribute approximately two percent of annual gross domestic product (GDP) of the Maritime provinces (NRCan, 2026). Relative to many other forest regions in Canada, it is an inhabited forest, surrounding and embracing communities, and dotted with tens of thousands of small, privately owned woodlots (“small woodlots”).

Small woodlots are a key part of the forest industry in the Maritime provinces. There is a uniquely high proportion of private ownership in this region, with 90,000 private landowners (owning between 10 and a few thousand acres) controlling roughly 40% of the forests (5 million hectares) (Allaby, 2023). There is also a long history of forest management, with small woodlots typically managed by rural families over many generations, for a wide range of ecological, social, and economic values (Nadeau et al., 2012). Although majority of the economic value is derived from softwood lumber, pulp, and paper (NBFPC, 2022; NSDNR, 2016) the extracted wood products include a variety of other timber and non-timber forest products (firewood, berries, maple syrup) (Nadeau et al., 2012). Despite their importance in the forest product supply chain, small, private

woodlots rarely have written management plans, and managers often rely on generalized historical trends to choose management regimes and estimate wood supply (Floyd et al., 2012). However, these trends may no longer be reliable due to the predicted effects of climate change on the Acadian Forest (Taylor et al., 2017; Albert et al., 2023).

### ***The effects of climate change on the Acadian Forest***

The Earth's global mean near-surface temperature has hit record highs for the second year in a row, surpassing the 1.5°C threshold set in the 2015 Paris Agreement for the first time in 2024 (WMO, 2024). Canada is warming at over twice the global rate, and the effects of widespread warming are projected to continue to intensify unless global carbon emissions are reduced to near-zero (Bush & Lemmen, 2019). It is expected that the mean annual temperature in the Maritime provinces will increase by 4-6°C by the end of the 21<sup>st</sup> century (relative to 1981-2010 baseline) under the business-as-usual Representative Concentration Pathway (RCP) 8.5 (Albert et al., 2023). A predicted moderate increase in annual precipitation will be counteracted by higher temperatures, leading to a reduction in summer available moisture (Albert et al., 2023). The cumulative impact will be more growing degree-days and atmospheric water deficits (Bush & Lemmen, 2019; Albert et al., 2023) impacting the many tree species in the Acadian Forest existing at their climatic limit (Heyder et al., 2011).

Climate is one of the most important drivers of stand succession in the Acadian Forest (Taylor et al., 2020) and an increase in temperature and decrease in available moisture would significantly impact its forest composition and growth (Boulanger et al., 2016; Taylor et al., 2017). If atmospheric carbon levels continue to rise, late-century conditions will support a higher abundance of warm-adapted temperate species (white

pine, red maple and American beech) compared to cold-adapted, commercially valuable boreal softwoods (spruce and balsam fir) (Taylor et al., 2017; Vaughn et al., 2021; Albert et al., 2023). This change is expected to be especially apparent in mixed-species stands, where regenerating shade-intolerant hardwoods can easily outcompete boreal conifers, especially following low-retention harvests (Taylor et al., 2017; Taylor et al., 2020). Although the growth rates of warm-adapted species are expected to initially increase, there will be a more significant reduction in conifer productivity, leading to eventual displacement (Simons-Legaard et al., 2025). The long-term result is an overall decrease in net productivity and gradual shift toward temperate hardwoods in the Acadian Forest (Steenberg et al., 2013; Albert et al., 2023).

A changing climate is also expected to increase the frequency and severity of natural disturbances in the Maritime provinces (Taylor et al., 2020; Brecka et al., 2020). Warmer summers will increase the likelihood of heatwaves (Bush & Lemmen, 2019) leading to more low-intensity droughts, and a predicted doubling of the annual area burned by wildfire (Boulanger et al., 2014; Hanes et al., 2019). Rising ocean temperatures will fuel tropical storms along the Atlantic coast (WMO, 2024) putting additional stress on wind-susceptible red spruce. There may also be a northward migration of new insects and diseases, including the Hemlock Woolly Adelgid (HWA) currently impacting Southwestern Nova Scotia (Paradis et al., 2008). The combined effects will lead to a significant reduction in regional softwood supply and quality by the end of the 21<sup>st</sup> century (Brecka et al., 2020; McMonagle et al., 2024) rendering many current management plans unsustainable (Albert et al., 2025).

### *Accounting for climate change in small woodlot forest management*

It is critical that small woodlot owners integrate climate change into long-term strategic management planning to better predict future wood supply and mitigate economic risk (Albert et al., 2025). With almost half of the region's forested area managed by small, private landowners (commonly referred to as "woodlot owners") (Allaby, 2022) there could be a tremendous cost associated with inaction on climate adaptation. Some studies predict a reduction in the value of the region's forest sector outputs by up to 50% by 2150 (McMonagle et al, 2024). However, the uncertainty in the magnitude and timing of climate change poses an enormous challenge to managers wishing to adapt, as does our limited knowledge of the forests' vulnerability to the changing conditions (Keenan, 2015; Spittlehouse, 2005). Incorporating climate change considerations into woodlot forest management is often informal and improvisational, increasingly applied by forest managers out of necessity, without strategic-level oversight (Ogden & Innes, 2007).

While forest managers in the Maritime provinces have been engaged in conversation about climate change, they are challenged to generate on-the-ground actions without adequate supports (Laatsch & Ma, 2015). There are few dedicated local resources within the various provincial agencies or territorial governments to provide ongoing support for vulnerability assessments (Halofsky et al., 2018), and even fewer for providing guidance on adaptive management to build resilience, apart from the occasional workshop or case study (NBFWO, 2022; NSWOOA, 2023). While woodlot owners are aware that climate-informed management must be considered, there are limited studies that utilize modern techniques to identify which strategies might better

capitalize on predicted future forest composition and growth trends. This research addresses this gap by presenting a case study in which a small private woodlot is used to develop a strategic forest management plan that integrates conventional financial woodlot objectives with considerations of climate change.

The purpose of this report is to identify financially feasible, climate informed management strategies for small, private woodlots using the Remsoft® Woodstock decision support system software. A strategic forest planning model was created based on a small woodlot in central New Brunswick, using baseline yields from the Open Stand Model (OSM) (Hennigar, 2013), an open-source tree-list modelling platform calibrated for the Acadian Forest Region, and the Nova Scotia Growth and Yield Model Version 3.0 (Steenberg et al., 2023). Climate informed yield tables and successional rules were adapted from Taylor et al. (2017) and based on the stand simulation model PICUS (Lexer and Hönninger, 2001). A comparison of the strategic management planning schedules for the ‘baseline’ and ‘climate informed’ scenarios will provide insight into the (1) impacts on species composition and growing stock over time, (2) optimal type and timing of harvesting and silviculture treatments for climate-informed forest management and (3) differences in sustainable harvest levels, net revenue and end-product mix under predicted climate change conditions.

## METHODS

### *Study area*

The study area was a 36-hectare (90 acre) woodlot north of Fredericton, New Brunswick (near the community of Taymouth, hereafter referred to as the “Taymouth Woodlot”) owned and managed by the University of New Brunswick’s (UNB) Office of Forest Lands (Figure 1). It was acquired by the university through a land trade with the Government of New Brunswick in 2020, and previously under private ownership. There has been minimal use of the woodlot in recent years, for academic or recreational purposes, apart from maintenance to the main access point and adjoining trails. The forest has not been managed for timber (except for light firewood harvesting by previous private owners) since the 1960’s, when field observations suggest that a large portion of the area was harvested. There is currently no management plan in place.

The Taymouth Woodlot is situated on a gradual, west-facing slope within the Nashwaak River valley, bordered by private residences to the west, a highway to the east, and public and privately owned woodlots to the north and south, respectively (Figure 1). The climate in this region is humid-continental, typical of inland areas within the Acadian Forest Region (Basquill and Baldwin, 2020) with average temperatures ranging from  $-6^{\circ}\text{C}$  in the winter to  $18^{\circ}\text{C}$  in the summer. The area receives substantial precipitation (approximately 1,100 mm annually) including significant snowfall, although the winter snowpack has been decreasing in recent years. The Maritime provinces are also susceptible to a range of extreme weather events, including thunderstorms, nor-easters and post-tropical storms, often bringing intense precipitation and strong winds (Taylor et

al. 2020). Despite this, the Taymouth Woodlot remains relatively intact, with very minimal damage caused by natural disturbance events in recent history.

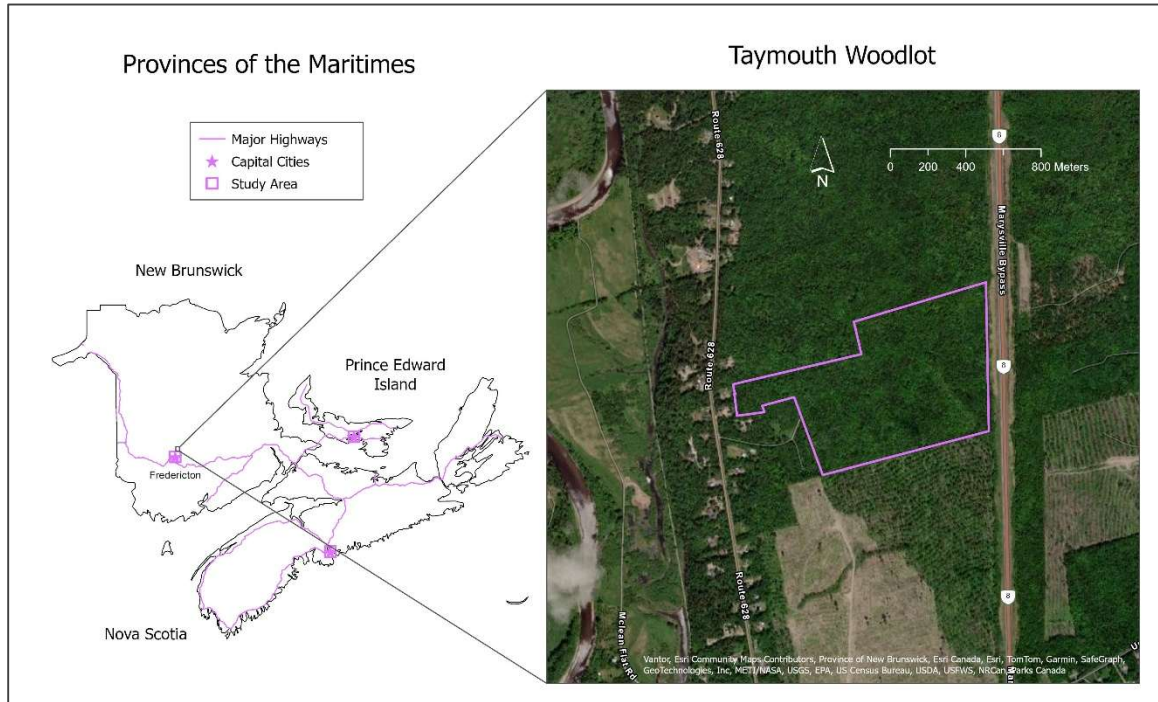


Figure 1 Location of the study area (Taymouth Woodlot) within the Maritime provinces.

The Taymouth Woodlot was selected as the study area based on its species composition and age structure, characteristic of many woodlots in the Acadian Forest Region (Rowe, 1972; Baldwin et al., 2020). There are a total of 12 stands on this property, as interpreted and mapped by the New Brunswick Department of Energy and Resource Development (2023). The trees are a combination of tolerant and intolerant hardwood and softwood species, dominated by balsam fir (*Abies balsamea*) (34%), red maple (*Acer rubrum*) (16%), yellow birch (*Betula alleghaniensis*) (11%), large-tooth and trembling aspen (*Populus grandidentata* and *Populus tremuloides*) (10%) and eastern hemlock (*Tsuga canadensis*) (9%). There is also white birch (*Betula papyrifera*) (6%), sugar maple (*Acer saccharum*) (4%) red spruce (*Picea rubens*) (4%) and American beech

(*Fagus grandifolia*) (4%) present to a lesser extent. Although much of the forest composition reflects an early-mid successional state, there are a significant number of super-canopy Eastern hemlock (*Tsuga canadensis*) trees remaining, with sampled ages ranging up to 125 years old. According to the local Biomass Growth Index (BGI) model (Hennigar et al. 2016), the soils are considered moderately productive, with minimal variation across the site (maximum growth of 3,264 – 3,923 kg/ha/yr) and moisture conditions ranging from well-drained slopes to imperfectly drained small depressions, creating seasonal wetlands along the southern boundary. The characteristics of this study area were used to form the basis of the strategic forest planning model in the Woodstock Optimization Studio decision support system software.

### ***Forest Management Decision Support Systems (DSS)***

Woodstock Optimization Studio (Remsoft<sup>®</sup>, 2024) is a forest planning and decision support system developed to provide analytical solutions to resource management planning questions. It provides a means for comparing multiple forest management planning outcomes based on user provided inputs and produces strategic planning schedules to help guide forestry decision making. The optimization module within Woodstock uses linear programming to identify the optimal combination of management actions to achieve an objective function, while also satisfying various potential management constraints, providing important insight into the trade-offs of alternative management scenarios.

### ***Field data collection and preparation***

A forest inventory was conducted by undergraduate students using a systematic, variable radius sampling method, following a 100-meter grid (one point per hectare)

across the woodlot (Figure 2). At each of the 41 sample points, a 2 basal area factor prism was used to identify sample trees, and a unique ID, species, and diameter at breast height (DBH) was recorded for each one. The crown height and total height of a random subset of sampled trees were measured using a clinometer, and the age of a stand-representative, canopy co-dominant tree was estimated using an increment borer. This inventory data was used to calculate the stand-level basal area (BA), stem density and average DBH by species, and combined with other field observations (presence of regeneration and/or tolerant species) to classify and estimate the average age of each stand.

Using the local Nova Scotia Forest Ecosystem Classification (FEC) (Neily et al., 2023), a hardwood-softwood and intolerant-tolerant matrix was employed to stratify all stands into unique stand types. A stand was classified as ‘hardwood’ or ‘softwood’ if it contained greater than 70% (by basal area) hardwood or softwood species, and was otherwise ‘mixedwood’. Similarly, a stand was classified as ‘tolerant’ if it contained greater than 50% long-lived, shade-tolerant species (such as eastern hemlock, red spruce, sugar maple, yellow birch, or American beech). A total of four stand types were identified, including Intolerant Hardwood, Intolerant Mixedwood, (Intolerant) Balsam Fir Softwood, and (Tolerant) Eastern Hemlock Mixedwood. The stand classification was mapped on to the stand boundary polygons mapped by NBDNRED (2023) (Figure 2).

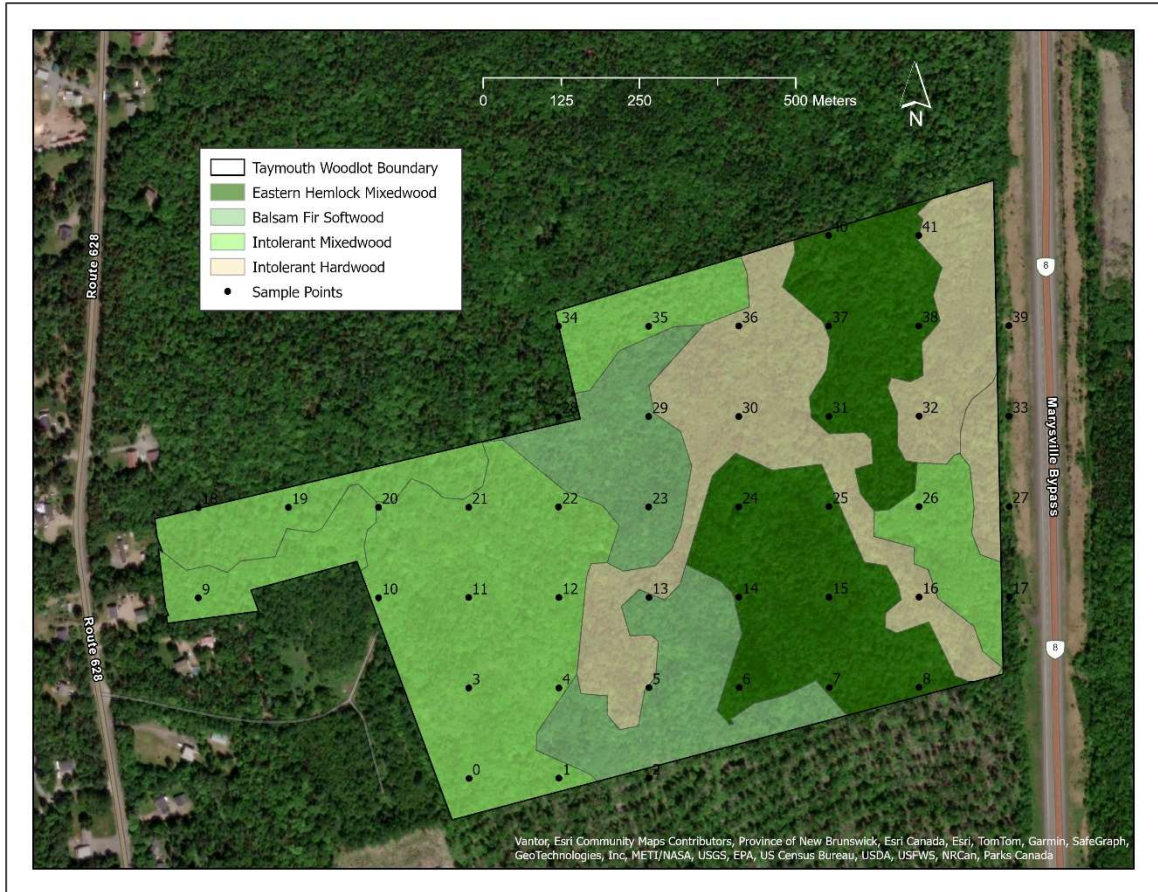


Figure 2 Stand types and sample points in the Taymouth Woodlot (NBDNRED, 2023).

### ***Woodstock planning model parameters and management design***

#### ***Spatial set up, areas, landscape, and control***

The first step of the model set-up was importing the forest stand classification map, including attributes on stand type, age, and area (Table 1). The ‘areas’ and ‘landscape’ model sections were built based on the spatial information, containing stand type descriptions and basic age and area statistics. In the ‘control’ section, the planning horizon was set to 100 years, divided into 5-year planning periods. The manual queue was turned off, allowing the model to utilize its optimization function to create a schedule of harvest treatments using the Mosek Solver. A ‘lifespan’ was set for each stand type,

indicating the age at which natural senescence would occur (95 years for intolerant forest types, 145 years for tolerant forest types).

Table 1 Existing stand types and attributes in the Taymouth Woodlot.

| Stand Type                | Age (Yrs) | Area (Ha) | Species Composition   |
|---------------------------|-----------|-----------|---|
| Intolerant Hardwood       | 70        | 8.7       | largetooth aspen (35%), red maple (30%), white birch (25%), yellow birch (10%)                      |
| Intolerant Mixedwood      | 70        | 13.4      | balsam fir (35%), red maple (25%), white birch (20%), largetooth aspen (20%)                        |
| Balsam Fir Softwood       | 70        | 5.8       | balsam fir (70%), red maple (20%), red spruce (10%)   |
| Eastern Hemlock Mixedwood | 100       | 8.3       | eastern hemlock (35%), sugar maple (25%), yellow birch (25%), balsam fir (10%), American beech (5%) |

*Actions, eligibility, and potential future stand types*

Next, the model was provided with a set of harvesting and silviculture treatment model ‘actions’ based on common practices in the Maritime provinces. Potential actions included clearcutting, selection, and shelterwood harvesting; as well as planting and per-commercial thinning. These treatments were selected to provide the model with enough options to achieve diverse woodlot management objectives, including even-aged management, un-even aged management, and natural or artificial regeneration (Table 2). An additional 12 potential future stand types were identified as likely to occur following the treatment actions, or as a result of natural succession from existing stand types (Neily et al., 2023). The origins and descriptions of all stand types are included in Table 3.

Table 2 Stand level action (treatment) description and purpose.

| Action           | Description                    | Management Objective  |
|------------------|--------------------------------|---|
| Clearcut Harvest | Harvest all merchantable stems | <ul style="list-style-type: none"> <li>• Produce maximum amount of merchantable wood fiber</li> <li>• Regenerate an even-aged forest</li> </ul> |

|  |  |  |
|--|--|--|
| Uniform Shelterwood Harvest                        | Harvest 30% on first entry (all species)<br><br>Return in 10 years (once shade-tolerant regeneration established) to clearcut harvest canopy | <ul style="list-style-type: none"> <li>• Produce merchantable timber in two stages</li> <li>• Naturally regenerate shade-tolerant understory (based on original composition)</li> <li>• Capture overstory mortality</li> </ul>     |
| Selection Harvest                                  | 30% volume removal (all species) at 15-year intervals, in perpetuity   | <ul style="list-style-type: none"> <li>• Produce continuous flow of merchantable timber</li> <li>• Maintain uneven-aged stand</li> <li>• Naturally regenerate shade-tolerant understory (based on original composition)</li> </ul> |
| Plant<br><br>Red spruce<br><b>OR</b><br>White pine | Planting at 1,800 stems/ha<br><br>Includes site preparation and early competition control (herbicide)  | <ul style="list-style-type: none"> <li>• Initiate even-aged, fully stocked stand of ideal density</li> <li>• Includes early competition control</li> <li>• Produce maximum amount of merchantable wood fiber</li> </ul>            |
| Pre-commercial Thinning (PCT)                      | Reduce density to 2000 stems/ha in 10–15-year-old natural stands   | <ul style="list-style-type: none"> <li>• Accelerate crop tree growth to increase individual piece size</li> <li>• Remove undesirable species</li> </ul>  |

Table 3 Potential future stand types (resulting from natural succession or harvest/silviculture actions) in the Taymouth Woodlot (Neily et al., 2023).

| Stand Type                | Origin   | Description   |
|---------------------------|--|---|
| Intolerant Hardwood       | Clearcutting (intolerant, tolerant or thinned hardwood)  | Naturally occurring. Existing. Large-tooth aspen, red maple, white birch, yellow birch                |
| Intolerant Mixedwood      | Clearcutting (any mixedwood, any planted or young balsam fir softwood)   | Naturally occurring. Existing. Balsam fir, red maple, white birch, large-tooth aspen                  |
| Balsam Fir Softwood       | Clearcutting (mature or thinned balsam fir softwood or planted spruce)   | Naturally occurring. Existing. Balsam fir, red maple, red spruce                                      |
| Eastern Hemlock Mixedwood | Natural succession (from intolerant mixedwood or balsam fir softwood) <b>or</b> clearcutting in mature (75+) eastern hemlock mixedwood | Naturally occurring. Existing. Eastern hemlock, sugar maple, yellow birch, balsam fir, American beech |
| Red Spruce Mixedwood      | Natural succession (from intolerant mixedwood or balsam fir softwood) <b>or</b>  | Naturally occurring. Potential. Red spruce, yellow birch, sugar maple, balsam fir                     |

|   |  |  |
|---|--|--|
|   | clearcutting in mature (75+) red spruce mixedwood  |  |
| Tolerant Hardwood                             | Natural succession (from intolerant hardwood) <b>or</b> clearcutting in mature (75+) tolerant hardwood | Naturally occurring. Potential. Sugar maple, yellow birch, American beech, red maple |
| Spruce Plantation                             | Plant (Spruce)   | red spruce planted at 1,800 stems/ha   |
| Pine Plantation                               | Plant (Pine)   | white pine planted at 1,800 stems/ha   |
| Thinned natural softwood                      | Pre-commercial thinning of balsam fir softwood   | 1,800 stems per ha (2.4m spacing) of balsam fir, red spruce                          |
| Thinned natural hardwood                      | Pre-commercial thinning of any hardwood  | 1,800 stems per ha (2.4m spacing) red maple, yellow birch                            |
| Uneven-aged tolerant hardwood                 | Selection harvest of tolerant hardwood   | Multi-age tolerant hardwood created by selection harvest                             |
| Uneven-aged hemlock mixedwood                 | Selection harvest of hemlock mixedwood   | Multi-age hemlock mixedwood created by selection harvest                             |
| Uneven-aged red spruce mixedwood              | Selection harvest of red spruce mixedwood  | Multi-age spruce mixedwood created by selection harvest                              |
| Post-regeneration cut in hemlock mixedwood    | Shelterwood harvest of hemlock mixedwood   | Residual overstory of hemlock and tolerant hardwood after 30% volume removal         |
| Post-regeneration cut in red spruce mixedwood | Shelterwood harvest of red spruce mixedwood  | Residual overstory of spruce and tolerant hardwood after 30% volume removal          |
| Non-sufficient regeneration                   | Clearcutting early-successional or young stands  | Poorly stocked stand of grey birch, pin cherry and speckled alder                    |

Eligibility for a specific treatment type was determined based on the suitability of the stand type to the objective of the treatment (Table 4). Almost all stand types were eligible to be clearcut at maturity (between 40-60 years old). However, only mature (60+ years old) tolerant softwood-dominant stand types (eastern hemlock and red spruce mixedwood) were eligible for shelterwood harvesting, to ensure a sufficient seed source for the natural regeneration of species present in the original overstory. Following a shelterwood harvest, stands were left for 10 years to establish shade-tolerant regeneration, then the overstory was clearcut (post-regeneration cut). Similarly, only

mature (80+ years old) tolerant stand types (both mixedwood and hardwood) were eligible for selection harvesting, as these stands had the potential to produce a continuous flow of merchantable timber while maintaining canopy cover and age-class diversity. Following a selection harvest, the uneven-aged stand was required to be selection managed in perpetuity, eligible for re-entry every 20 years. The plant action, for both red spruce and white pine, accounted for the effects of early competition control (herbicide) and was only available in intolerant stand types less than 5 years old. Natural softwood or hardwood stands were eligible for pre-commercial thinning between 10-15 years of age.

Table 4 Treatment eligibility by stand type.

| Stand Type                                    | Treatment |             |           |       |     |
|---|-----------|-------------|-----------|-------|-----|
|   | Clearcut  | Shelterwood | Selection | Plant | PCT |
| Intolerant Hardwood                           | ✓         |             |           | ✓     | ✓   |
| Intolerant Mixedwood                          | ✓         |             |           | ✓     |     |
| Balsam Fir Softwood                           | ✓         |             |           | ✓     | ✓   |
| Eastern Hemlock Mixedwood                     | ✓         | ✓           | ✓         |       |     |
| Red Spruce Mixedwood                          | ✓         | ✓           | ✓         |       |     |
| Tolerant Hardwood                             | ✓         |             | ✓         |       | ✓   |
| Spruce Plantation                             | ✓         |             |           |       |     |
| Pine Plantation                               | ✓         |             |           |       |     |
| Thinned natural softwood                      | ✓         |             |           |       |     |
| Thinned natural hardwood                      | ✓         |             |           |       |     |
| Uneven-aged tolerant hardwood                 |           |             | ✓         |       |     |
| Uneven-aged hemlock mixedwood                 |           |             | ✓         |       |     |
| Uneven-aged red spruce mixedwood              |           |             | ✓         |       |     |
| Post-regeneration cut in hemlock mixedwood    | ✓         |             |           |       |     |
| Post-regeneration cut in red spruce mixedwood | ✓         |             |           |       |     |
| Non-sufficient regeneration (NSR)             | ✓         |             |           | ✓     |     |

### *Baseline yields and transitions*

The OSM (Hennigar, 2013) was used to generate baseline yield tables for all naturally occurring stands (Table 3) based on the forest inventory (existing types) or generalized species compositions described in the FEC (potential types) (Neily et al., 2023). The tree- and stand-level forest inventory was loaded into a Microsoft database, including all sampled tree data, BGI, zone (NB) and management history of each stand. The simulation parameters were defined in OSM's Notepad++ user interface, identifying the input database, output file locations, and regionally calibrated tree height model (Figure 3). In order to produce yield tables starting from stand inception, the simulation needed to 'cut' the existing stand and 'recruit' a new stand using the 'plant' function. For each natural stand type, 5-year old saplings between 1-3cm DBH were planted at a density of 5,000 stems per hectare and grown for 150 years, using 5-year periods. The simulation generated tree- and stand-list projections into a .csv file.

```
SIMULATION
YEARS 150 # of years to simulate stand for
YPC 5 # of years per simulation cycle

INPUTS.SOURCE OSM_BFSW.mdb #Database location

#Turn on new beta height model:
#SIMULATION.Model.HeightModel.ModelType CRH2017 #Regional calibration (NB, ME, NS) based on Zone

OUTPUTS
StandSummary.ConsoleOn
StandSummary.FilePath BFSW_StandListProjections.csv
TreeList.FilePath BFSW_TreeListProjections.csv

Actions
def ClearcutNaturalRegeneration
OPERABLE 0
CUT
RECRUIT
PLANT 5000 DBH 1 3 Age 5
BF 70%
RM 20%
RS 10%

SIMULATION.Scenario BASE
SIMULATE
```

*Figure 3* The stand simulation parameters for balsam fir softwood stands as seen in OSM's Notepad++ user interface (Hennigar, 2013).

In each period, outputs from the OSM-generated tree list (including the species, DBH, and height) were inputted into the Kershaw et al. (2007) Product Ratio Calculator (PRCalc) which was calibrated based on averaged specifications for wood products from local mills (Table 6, Appendix B). Based on the minimum required diameter and length for each product, the PRCalc calculated the proportion of each individual tree’s gross total volume (GTV) that qualified as sawlogs and/or pulpwood for six unique product categories (spruce-fir sawlogs, eastern hemlock sawlogs, white pine sawlogs, hardwood sawlogs, mixed softwood pulp, and mixed hardwood pulp). The sawlog and pulpwood proportions were multiplied by OSM’s GTV (m<sup>3</sup>) for every tree, and then the number of stems per ha, to get the total volume (m<sup>3</sup>) of sawlogs and pulpwood per hectare represented by each sampled tree. These values were averaged across all plots in each stand type and inputted (by product category) into the final yield tables in Woodstock Optimization Studio.

Table 5 Wood product categories, species, specifications and provincial stumpage price (NBDNRED, 2024) used to calibrate Kershaw’s (2007) PRCalc.

| <b>Product Category</b> | <b>Species</b>   | <b>Min. Diameter (in)</b> | <b>Min. Length (ft)</b> | <b>Stumpage Price (\$/m<sup>3</sup>)</b> |
|-------------------------|--|---------------------------|-------------------------|--|
| Spruce-Fir Sawlogs      | R. Spruce, B. Fir  | 8”                        | 12’                     | \$29.54                                  |
| Hemlock Sawlogs         | E. Hemlock   | 8”                        | 12’                     | \$17.57                                  |
| Pine Sawlogs            | W. Pine  | 8”                        | 12’                     | \$24.87                                  |
| Hardwood Sawlogs        | S. Maple, R. Maple, Y. Birch, W. Birch                     | 10”                       | 12’                     | \$29.25                                  |
| Softwood Pulpwood       | R. Spruce, B. Fir, E. Hemlock, W. Pine                     | 4”                        | 8’                      | \$6.29                                   |
| Hardwood Pulpwood       | S. Maple, R. Maple, Y. Birch, W. Birch, L. Aspen, A. Beech | 4”                        | 8’                      | \$14.87                                  |

Following a shelterwood or selection harvest, a new set of yield tables were created based on the original stand yields, modified to reflect the volume removed during the harvest (Table 2) and resulting change in growth dynamics. In the case of selection harvesting, the resulting un-even-aged yield tables reduced volume according to product category (higher levels of pulp removed than sawlogs) by an average of 30% at each entry, for both hardwood and mixedwood stand types. The subsequent increase in merchantable volume allowed for re-entry every 15 years while maintaining the growing stock. The post-regeneration shelterwood yield tables were identical to the original stand yields, but used a growth modifier (\*P 70) to denote a 30% removal across all product categories (evenly) at the time of harvest.

In the case of plantations and pre-commercially thinned stands, the Nova Scotia Growth and Yield Model – Version 3.0 (Steenberg et al., 2023) was employed due to its increased level of applicability in even-aged, managed stands. The graphical user interface required general inputs for all stand types (including the dominant species, spacing, site index, rotation age) and additional treatment-specific values for thinned stand types (treatment age, thinned spacing) (Table 5). It outputted a simple table with the volume (m<sup>3</sup>) per product category (sawlogs, pulp) by stump age (in 5-year intervals). All simulations were run for 100 years, with site indices corresponding to averaged BGI values in existing stands. The PCT treatment was simulated at 15 years, increasing merchantable sawlog volume (relative to pulp) for both hardwood and softwood stand types. The resulting table of volumes by product category was imported into in Woodstock Optimization Studio. In some cases, yield curves were slightly modified based on expert opinion to improve accuracy under local conditions.

Table 6 Input parameters to the NSGNY 3.0 (Steenberg et al., 2023) for plantations and thinned natural stands.

| Stand Type               | Dominant species | Spacing (m) | Density (stems/ha) | Site Index | Thinned age (y) | Thinned spacing (m) |
|--------------------------|------------------|-------------|--------------------|------------|-----------------|---------------------|
| Spruce plantation        | Red spruce       | 2.4         | 1,800              | 13         |                 |                     |
| Pine plantation          | White pine       | 2.4         | 1,800              | 13         |                 |                     |
| Thinned natural softwood | Red spruce       | 1.4         | 5,000              | 13         | 15              | 2.4                 |
| Thinned natural hardwood | Red maple        | 1.4         | 5,000              | 16         | 15              | 2.4                 |

Following each action, a set of transition rules were defined to determine the future of that stand, depending on the species composition and age of the original stand. If the model elected to clearcut harvest a mature (75+ years) red spruce mixedwood stand, it would primarily regenerate red spruce mixedwood (90%) with small component of non-sufficient regeneration (10%). Similar rules applied to other mature, tolerant stand types, due to the age of the original stand creating a viable seed source (Table 3). However, in the case of a clearcut in an immature (<75 years) tolerant, or intolerant stand type, it was more likely to transition to intolerant mixedwood, or ‘non-sufficient regeneration’, and require artificial regeneration (planting). The transition rules for selection harvesting dictated a perpetual return to the uneven-aged version of stand type (Table 3) with re-entry allowed every 15 years, and a shelterwood harvest was followed by a clearcut of the remaining volume after regeneration establishment (10+ years).

#### *Climate-informed yields and transitions*

Once the standard actions, transitions, and yields were determined, a second scenario was created to compare the model’s recommended management actions between

‘baseline’ (volume yields and transitions based on historical climate conditions) and ‘climate change’ (volume yields and transitions adjusted based on predicted climate conditions). The two scenarios were exactly alike except for the ‘yields’ and ‘transition’ sections, which were modified based on predicted changes in forest growth and composition from Taylor et al. (2017) under RCP 8.5. This included implementing independent yield modifiers for each product category and adjusting transition rules to heavily favour intolerant hardwood (relative to both intolerant and tolerant mixedwood forest types) for natural regeneration following a clearcut harvest (Taylor et al., 2020). The independent growth modifiers were derived from the Taylor et al. (2017) predicted departure in relative abundance from baseline conditions (by species) based on the proportion of each species in each product category (Table 7).

Table 7 Predicted departure from baseline conditions under RCP 8.5 for the first 50 years of model planning horizon (expressed as a ratio) derived from Taylor et al. (2017).

|                    | 2030 | 2035 | 2040 | 2045 | 2050 | 2055 | 2060 | 2065 | 2070 | 2075 |
|--------------------|------|------|------|------|------|------|------|------|------|------|
| Spruce-Fir Sawlogs | 1    | 1    | 0.9  | 0.9  | 0.9  | 0.8  | 0.8  | 0.7  | 0.7  | 0.6  |
| Hemlock Sawlogs    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    |
| White Pine Sawlogs | 1    | 1    | 1    | 1    | 1    | 1.1  | 1.1  | 1.1  | 1.2  | 1.2  |
| Hardwood Sawlogs   | 1    | 1    | 1    | 1    | 1    | 1.1  | 1.1  | 1.1  | 1.1  | 1.2  |
| Softwood Pulpwood  | 1    | 1    | 1    | 1    | 0.9  | 0.9  | 0.9  | 0.9  | 0.9  | 0.8  |
| Hardwood Pulpwood  | 1    | 1    | 1    | 1    | 1    | 1.1  | 1.1  | 1.1  | 1.1  | 1.2  |

### *Optimization*

The primary objective of the optimization was to maximize non-declining net revenue throughout the 100-year planning horizon, while maintaining mature canopy cover on at least half the woodlot (18 hectares). The canopy cover constraint ensured that

ecological values (wildlife habitat, water and soil health, climate resilience) would be maintained alongside the primarily financial objective. Net revenue was calculated by summing the total stumpage revenue for all product categories (Table 5) and subtracting the associated costs (Table 8) in each period. The mature canopy cover was calculated by summing the total area with forest stands greater than 70 years old. Several additional outputs were calculated, including the total volume of growing stock, area and volume harvested by treatment, and stumpage value by product category.

Table 8 Costs associated with harvesting and silviculture actions (NBDRED, 2024; SENB Wood Marketing Board, 2024) and property cost allowance (for fixed costs such as road building, property taxes).

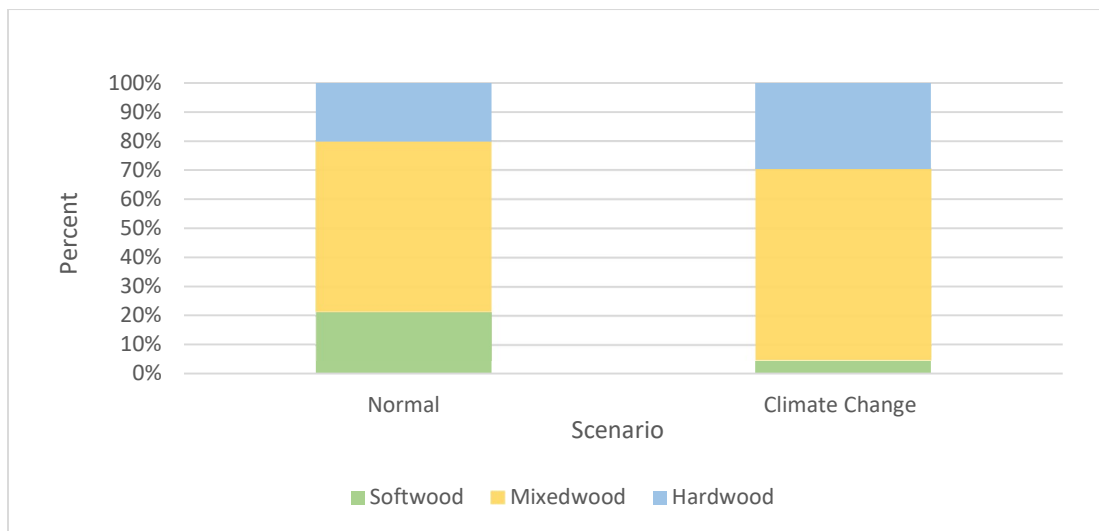
| <b>Description</b>            | <b>Cost (\$)</b>         |
|-------------------------------|--------------------------|
| Shelterwood harvesting        | \$385 per hectare        |
| Selection harvesting          | \$550 per hectare        |
| Planting                      | \$933 per hectare        |
| Pre-commercial thinning (PCT) | \$985 per hectare        |
| Property costs                | \$3000 per 5-year period |

The results, including key indicators related to forest stand composition over time, harvest area and volume (by treatment and species), sustainable harvest volume, and net revenue were analyzed using Microsoft Excel. The differences in the optimized harvesting and silviculture schedules were also explored. A trade off analysis of Woodstock’s recommended management regimes between the ‘baseline’ and ‘climate-informed’ scenarios was compared using summary graphs and tables of key indicators. In some cases, the “mid-point” (50 years) of the planning horizon was used to compare values due to the model’s tendency to limit actions in later stages (since the financial value won’t be realized during the 100-year planning horizon).

## RESULTS

### *Forest inventory*

Simulated differences in forest composition could be observed within 50 years under the RCP 8.5 climate change scenario, when compared with the baseline climate. The climate change scenario yielded less area of balsam fir softwood, planted red spruce, red spruce mixedwood, and un-even aged red spruce mixedwood than the baseline scenario. There was also a higher proportion of intolerant mixedwood, tolerant hardwood, un-even aged hardwood, planted white pine and non-sufficient regeneration. The resulting forest composition reflected these shifts, with a reduction in softwood-dominant stand area from 21% to 5% (7.6 ha to 1.8 ha) and increase in hardwood-dominant stand area from 20% to 30% (7.2 to 10.9 ha). (Figure 3).



*Figure 3* The proportion of softwood, mixedwood, and hardwood stand types (by area) at the mid-point of the planning horizon (50 years).

Despite differences in the forest composition, trends in overall growing stock and mature canopy-covered area were almost identical between the baseline and climate

change scenarios (Figure 4). In both cases, the starting growing stock steadily declined for the first 25 years from 10,425 m<sup>3</sup> (289 m<sup>3</sup> per ha) to approximately 7,500 m<sup>3</sup> (200 m<sup>3</sup> per ha) where it was maintained for the remainder of the 100-year planning horizon. The canopy-covered area (stand age of > 70 years) also steadily declined for the first nine periods (45 years) from 36 ha at the model inception, before stabilizing at 18 ha (as constrained by the model set-up).

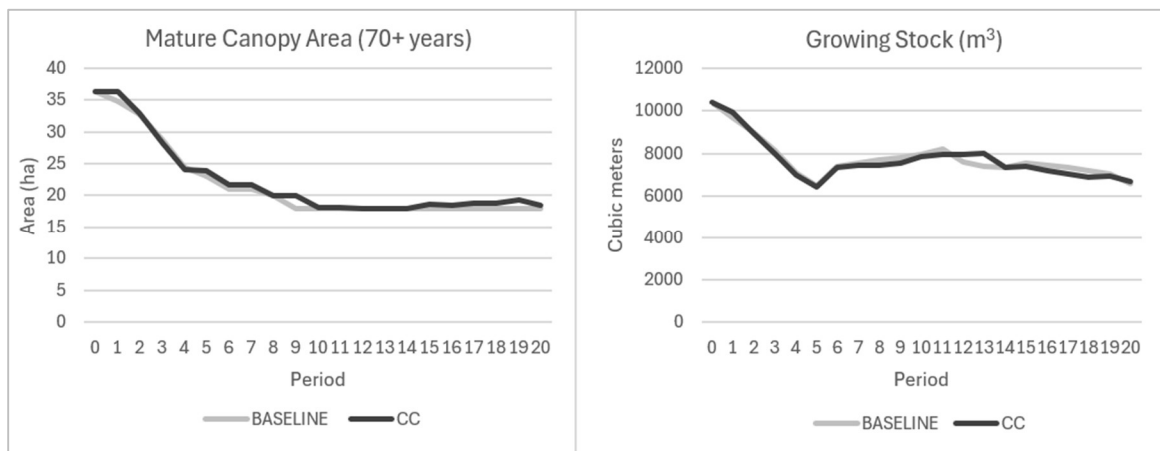
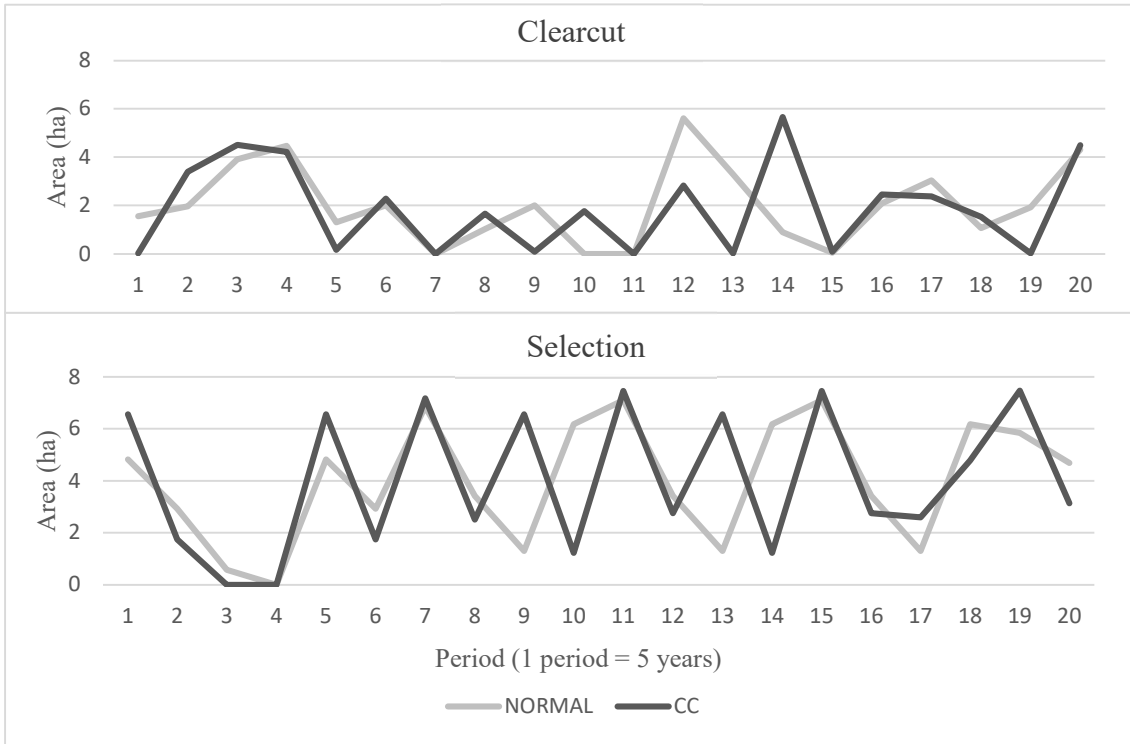


Figure 4 Trends in mature canopy covered area and growing stock over time.

### ***Harvesting and silviculture treatments***

Similar harvesting intensities were simulated in both scenarios, with a difference in average annual harvest area of only 2.5% (baseline, 1.21 ha vs. climate change, 1.18 ha). Over the 100-year planning horizon, the total area harvested (including multiple re-entries on the same area) was 121 ha in the baseline scenario, and 117 ha in the climate change scenario. However, there were significant fluctuations in harvest area by treatment type in both scenarios, where periods with less selection harvesting saw an increase in clearcutting, and vice versa (Figure 5). Despite these fluctuations, there were

no major positive or negative trends in harvested area over time, under either climate scenario. In both cases, selection harvesting accounted for about two-thirds of the average annual harvested area, with the remainder of the area being clearcut. Shelterwood harvesting was not employed in the optimized schedule for either climate scenario.



*Figure 5* The per-period (5 year) harvest area by treatment type over the 100-year planning horizon.

While no discernable difference was observed in the overall treated area, there was a notable difference in the timing and area of treatments employed. Clearcutting was typically scheduled later under the RCP 8.5 climate change scenario (79 years old) than the baseline scenario (65 years old) (Table 9). The average individual harvest area was also slightly smaller under predicted climate conditions, for both selection and clearcut

harvests (Table 9). The average stand age of selection harvest treatments was the same in both scenarios (as soon as they were eligible at 100 years old).

Table 9 Average age and area of individual harvest treatments under baseline and RCP 8.5 climate scenario.

| Harvest Treatment | Average Age (yrs) |                | Average Area (ha) |                |
|-------------------|-------------------|----------------|-------------------|----------------|
|                   | Baseline          | Climate Change | Baseline          | Climate Change |
| Selection         | 101               | 101            | 3.1               | 1.8            |
| Clearcut          | 65                | 79             | 1.2               | 1.0            |

The frequency of harvests by stand type also changed considerably under conditions of RCP 8.5. One key change was that tolerant hardwood stands were selected for both clearcut and selection harvests, which did not occur under baseline conditions (Table 10). Under the baseline scenario, clearcutting was employed in planted spruce and balsam fir softwood stands, replaced by tolerant hardwood and planted white pine stands under climate change conditions. In both climate scenarios, the most commonly clearcut stand type was intolerant hardwood. Overall, the frequency of selection harvests showed less variability between the two scenarios when compared to clearcut harvesting.

Table 10 Frequency of harvest (clearcut and selection) by stand type for baseline and climate change scenarios. Gray shading reflects each stand type's eligibility for harvest. Key differences are indicated with bold font.

| Stand Type | Selection |                | Clearcut |                |
|------------|-----------|----------------|----------|----------------|
|            | Baseline  | Climate Change | Baseline | Climate Change |
| BFSW       |           |                | <b>7</b> | <b>1</b>       |
| INTHW      |           |                | 10       | 14             |
| INTMX      |           |                | 4        | 4              |
| EHMIX      | 5         | 5              | 0        | 0              |
| RSMIX      | 1         | 1              | 4        | 2              |
| TOLHW      | <b>0</b>  | <b>1</b>       | <b>0</b> | <b>5</b>       |
| PSP        |           |                | <b>8</b> | <b>0</b>       |
| PWP        |           |                | <b>0</b> | <b>5</b>       |
| UNEHMIX    | 18        | 18             |          |                |
| UNRSMIX    | 3         | 3              |          |                |
| UNHW       | <b>0</b>  | <b>2</b>       |          |                |
| NSR        |           |                | 0        | 1              |

The planting of exclusively white pine under the RCP 8.5 climate scenario, as opposed to exclusively red spruce under baseline conditions, was the most prominent silvicultural change observed. However, the total area planted over the entire planning horizon was only 3.86 ha under the baseline scenario, and 1.63 ha under the climate change scenario. In both cases, all planting occurred within the first 35 years of the 100-year planning horizon, which could have been due to the model's inability to recognize the value if not harvested within the 100-year planning horizon. No pre-commercial thinning was conducted under either climate scenario. The full schedule of harvesting and silviculture actions is available in Appendix A.

### ***Sustainable harvest level, net revenue and end-product mix***

The maximum, sustainable annual allowable cut (AAC) was almost equal between scenarios. It averaged 195 m<sup>3</sup> under the baseline climate, and 192 m<sup>3</sup> under the RCP 8.5 climate, a difference of only 3 m<sup>3</sup> (2%) per year. However, the volume harvested by product category saw a significant change (Table 11). The average annual harvest volume of spruce-fir sawlogs exhibited the largest difference, from 25 m<sup>3</sup> under the baseline scenario to 8 m<sup>3</sup> under the climate change scenario – a reduction of 103%. A significant decrease (62%) was also observed in softwood pulp harvest volume, from 36 m<sup>3</sup> (baseline) to 19 m<sup>3</sup> (climate change). Conversely, the average annual harvest volume of hardwood sawlogs and pulp increased under the climate change scenario, from 15 m<sup>3</sup> to 21 m<sup>3</sup> (33%) and 31 m<sup>3</sup> to 50 m<sup>3</sup> (47%), respectively. There were no major changes observed in eastern hemlock or white pine sawlogs.

Table 11 The average annual harvest volume (m<sup>3</sup>) and percent of total harvest volume (%) by product category

| Product Category       | Baseline                 |             | Climate Change           |             |
|------------------------|--------------------------|-------------|--------------------------|-------------|
|                        | Volume (m <sup>3</sup> ) | Percent (%) | Volume (m <sup>3</sup> ) | Percent (%) |
| Spruce – Fir Sawlog    | 25                       | 12.8        | 8                        | 4.2         |
| Eastern Hemlock Sawlog | 88                       | 45.1        | 91                       | 47.4        |
| White Pine Sawlog      | 0                        | 0           | 3                        | 1.6         |
| Hardwood Sawlog        | 15                       | 7.7         | 21                       | 10.9        |
| Softwood Pulp          | 36                       | 18.5        | 19                       | 9.9         |
| Hardwood Pulp          | 31                       | 15.9        | 50                       | 26.0        |
| <b>Total</b>           | <b>195</b>               | <b>100</b>  | <b>192</b>               | <b>100</b>  |

The RCP 8.5 climate conditions had no significant effect on annual or overall net revenue. The maximum, non-declining annual net stumpage revenue was \$2,348 under the baseline scenario, and \$2,330 under the climate change scenario— a difference of only \$18 less per year. Over the course of the 100-year planning horizon, the total net revenue was \$234,846 under the baseline scenario, and \$232,981 under the climate change scenario (0.8% difference). The annual costs were also very similar, averaging \$1,078 under the baseline scenario and \$1,056 under the climate change scenario. The per-period trends for costs and revenues followed a similar pattern over time, with no major changes or trends identified under conditions of climate change (Figure 6).

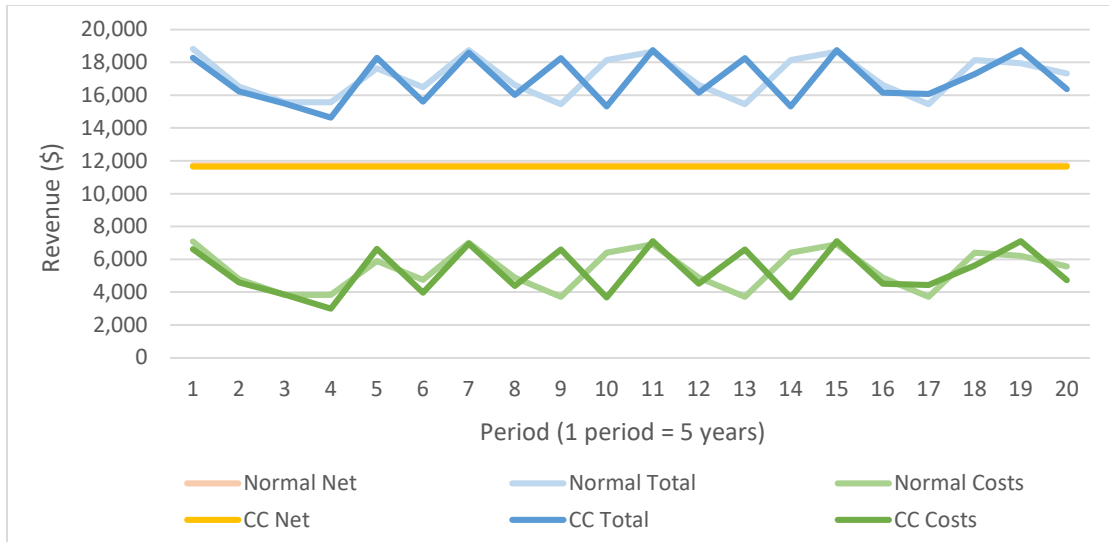


Figure 6 Costs, total and net revenue measured per-period for the 100-year planning horizon.

Despite minimal differences in total and annual revenue between the two climate scenarios, the proportion earned by product category did vary substantially (Figure 5). The largest change was observed in spruce-fir sawlogs, which went from comprising 22% of total revenue under the baseline scenario to only 7% under climate change scenario. Softwood pulp also saw a reduction from 7% to 3% of total revenue. Hardwood products increased in share from 27% (13% sawlogs, 14% pulp) to 40% (18% sawlogs, 22% pulp) under climate change scenario. Eastern hemlock saw little change (45% to 47%) and white pine grew from 0% to 2% of the proportion of total stumpage revenue under climate change.

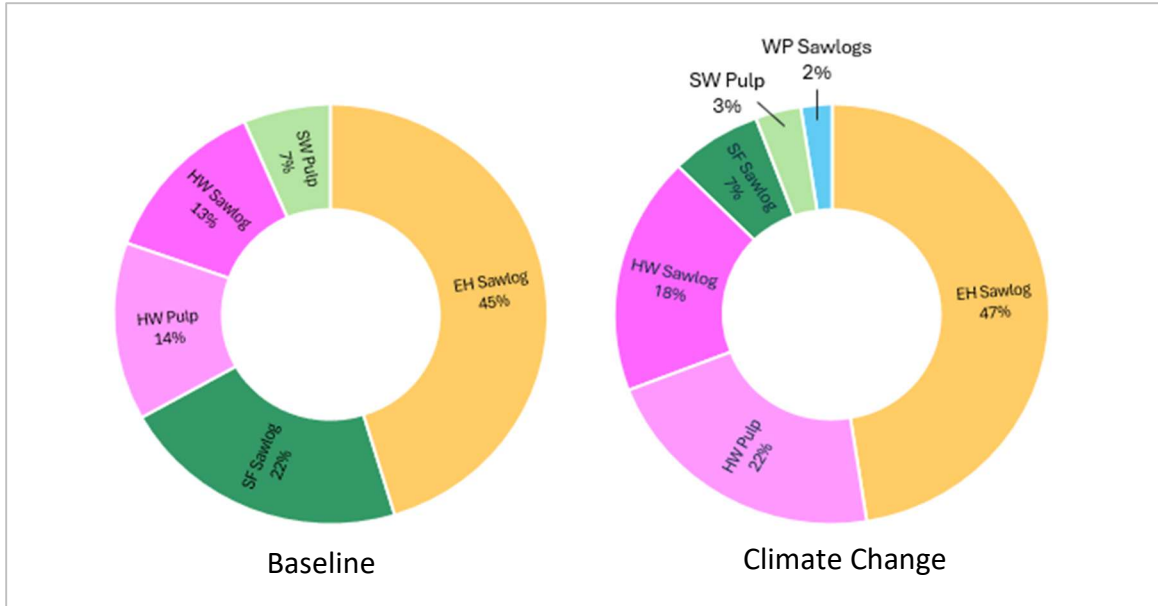


Figure 7 The proportion of total revenue by product category between the baseline and climate change scenarios

## DISCUSSION

### *Overall findings*

These findings suggest that climate-informed forest management strategies may permit small woodlot owners to achieve similar levels of annual revenue under future climate change, despite predicted changes in forest structure and composition. Indeed, even with changes in the productivity of key forest stand types, the Taymouth Woodlot maintained a sustainable harvest level (AAC) within 5% of baseline climate levels by leveraging the natural shift in forest composition away from cold-adapted boreal softwoods (e.g., red spruce and balsam fir) in favour of climate-adapted, temperate species (e.g white pine, hardwood).

Under the climate change scenario, the Woodstock optimization software found a harvesting regime that balanced uneven aged, selection management with small, frequent clearcuts in its most productive stands, which may represent a viable climate adaptation pathway for small woodlot owners. The planting of white pine (as opposed to red spruce) generated a consistent supply of climate-adapted softwood, which helped fill the gap left by a reduction in spruce and fir productivity. However, the declining availability of spruce-fir forest products highlights the potential for supply constraints if local value chains are not adjusted to adapt to the changing climate.

### ***Forest inventory***

The combined effects of climate and management resulted in notable shift toward mixedwood and hardwood-dominant stand types. Balsam-fir softwood was no longer present in the stand type mixture, replaced by intolerant hardwood and mixedwood in regenerating clearcut harvests (Taylor et al., 2017). Subsequently, intolerant mixedwood forest types were less likely to succeed to red spruce or eastern hemlock mixedwood, leading to more hardwood-dominant stand area under climate change conditions (Figure 3). The resulting forest composition reflected these shifts, with a significant reduction in softwood-dominant stand area, and gradual increase in intolerant and tolerant hardwood species. This shift in forest composition is aligned with predictions from the literature (Steenberg et al., 2013; Taylor et al., 2020; Albert et al., 2023).

Despite changes to the composition of the forest, the non-declining trends in growing stock ( $m^3$ ) and mature canopy-covered area demonstrate the long-term ecological sustainability of the climate-adapted management regime. A strong component of selection harvesting in tolerant mixedwood stand types generates a consistent sawlog

supply, while partial canopy cover creates an ideal environment for natural regeneration of long-lived, shade tolerant species. A mature, multi-age forest also has higher levels of structural complexity, biodiversity, and overall resilience to natural disturbances associated with climate change (Albert et al., 2023). Further testing of the model's capability revealed that attempting to maintain additional mature forest area would result in an unsuccessful model run (impossible to reach any level of non-declining revenue).

### ***Harvesting and silviculture treatments***

The optimal type and timing of harvesting treatments saw a few key responses to climate-induced changes in stand productivity and growth. Selection harvesting continued to represent approximately two-thirds of the average annual harvest area, primarily performed in eastern hemlock mixedwood stands (Table 9). Approximately every period (five years), the primary harvest type alternated between clearcut and selection, with many periods seeing no clearcut harvesting at all (Figure 3). When they did occur, clearcut harvests were smaller in size on average (18%) and primarily performed in more mature stands (79 years old) of intolerant and tolerant hardwood (Table 8, Table 9). The combination of ongoing, un-even aged management in tolerant mixedwood stands, and even-aged management (clearcutting) in more productive hardwood stands may represent a viable adaptation strategy for small woodlot owners.

Following clearcut harvests, the likely natural regeneration of hardwood species (Taylor et al., 2020) was favourable and cost-effective for climate adaptive management. The absence of pre-commercial thinning naturally regenerated hardwood stands could be attributed to the heightened cost, or relatively strong stumpage price of hardwood pulp (Table 7). In the limited number of instances (a total of 1.63 ha) where artificial

regeneration was utilized, the planting of white pine was selected in every case, likely due to predictions that productivity will increase (rather than decrease, as predicted for red spruce) as climatic conditions change over time (Table 7). White pine is among the few softwood species that is expected to see steady increases in productivity with increasing temperatures and less moisture availability (Taylor et al., 2017). It is also currently a locally valuable species in the Maritime provinces, with many manufacturers of value-added products (such as panelling, moulding, and siding).

### ***Sustainable harvest level, net revenue and end-product mix***

There were no major changes observed in the 100-year AAC under climate change conditions, suggesting that adaptive management could help alleviate the predicted effects of climate change on overall wood supply (McMonagle et al., 2024; Albert et al., 2025). Similarly, a very similar level of non-declining annual revenue was achieved in the model, partly due to the strong stumpage price of increasingly productive hardwood sawlogs and pulpwood (Table 2). However, a drastic change in end-product mix highlights the need for significant changes in local supply chains and markets to realize the values found in this study. The significant decrease in production of commercially important spruce – fir sawlogs and softwood pulp was primarily replaced by hardwood sawlogs and pulp in the end-product revenue mix, which currently only make up a small fraction of market demand.

### ***Limitations of results***

The results of this study may help to guide climate-adaptive management decisions for small woodlot owners, but are limited by the availability of input information to the Remsoft Woodstock model. The key limitation of the model is the use

of static stumpage prices throughout the 100-year planning horizon. The changing abundance of both hardwood and softwood primary forest products is likely to have an impact on both wood supply and stumpage prices, and there was no mechanism used to account for this. Future research should aim to build upon this model with more detailed economic inputs. Despite these limitations, the results still apply to many small woodlots in the Maritime provinces, and implementation should be adjusted based on individual circumstances and future market conditions.

### ***Management implications for small woodlots in the Maritimes***

Climate change will have appreciable consequences for the Maritime province's traditionally spruce-fir dependant local industry if forest managers don't take steps to adapt to the new conditions (Taylor et al., 2017). The combined effects of changes in individual tree-species range, relative abundance and growth rates will lead to an overall shift in forest composition, requiring forest managers to consider climate-adaptive management strategies that favour temperate tree species (Taylor et al., 2017; Vaughn et al., 2021). The climate-adapted strategy identified in this study prioritized a balance of selection harvesting in tolerant mixedwood stands, and clearcutting in more productive hardwood-dominant stands, which may allow small woodlot owners to maintain annual revenues while preserving ecological value. Traditional silvicultural systems will also require adaptation (Vaughn et al., 2021) including the planting of white pine as the primary softwood species.

## Bibliography

Albert, C., Taylor, A.R., Logan, T., D'Orangeville, L. (2023). The Acadian Forest of New Brunswick in the 21st century: What shifting heat and water balance imply for future stand dynamics and management. *Environmental Reviews*, 31, 690–707.

<https://doi.org/10.1139/er-2022-0122>

Albert, C., Taylor, A. R., & D'Orangeville, L. (2025). Integrating the effects of climate change into long-term strategic forest management planning using a process-based stand model. *Canadian Journal of Forest Research*, 55, 1–17. <https://doi.org/10.1139/cjfr-2024-0238>

Allaby, M. (2023). The life of the land: the stewardship experiences of forest landowners in the Maritime provinces of Canada [Master of Science in Environmental Management]. Fredericton (NB): University of New Brunswick. Available from:

<https://unbscholar.dspace.lib.unb.ca/server/api/core/bitstreams/70d07f9a-5894-4591-80d2-b15af9212c92/content> [accessed 01 January 2026].

Basquill, S., and Baldwin, K. (2020). Acadian Temperate Forest. Canadian National Vegetation Classification. *Canadian Forest Service*. Ottawa, Ont. Available from <http://cnvc-cnvc.ca> [accessed 09 March 2026].

Boulanger, Y., Gauthier, S., and Burton, P.J. (2014). A refinement of models projecting future Canadian fire regimes using homogeneous fire regime zones. *Canadian Journal of Forestry Research*, 44, 365–376. <https://doi.org/10.1139/cjfr-2013-0372>.

Boulanger, Y., Taylor, A. R., Price, D. T., Cyr, D., McGarrigle, E., Rammer, W., Sainte-Marie, G., Beaudoin, A., Guindon, L., & Mansuy, N. (2017). Climate change impacts on forest landscapes along the Canadian southern boreal forest transition zone. *Landscape Ecology*, 32(7), 1415–1431. <https://doi.org/10.1007/s10980-016-0421-7>

Brecka, A. F. J., Boulanger, Y., Searle, E. B., Taylor, A. R., Price, D. T., Zhu, Y., Shahi, C., & Chen, H. Y. H. (2020). Sustainability of Canada's forestry sector may be compromised by impending climate change. *Forest Ecology and Management*, 474, 118352. <https://doi.org/10.1016/j.foreco.2020.118352>

Bush, E. & Lemmen, D.S. (2019). Canada's changing climate report. *Government of Canada*, Ottawa, Ontario. Available from: [https://changingclimate.ca/site/assets/uploads/sites/2/2020/06/CCCR\\_FULLREPORT-EN-FINAL.pdf](https://changingclimate.ca/site/assets/uploads/sites/2/2020/06/CCCR_FULLREPORT-EN-FINAL.pdf) [accessed 03 April 2025].

Floyd, D.W., Ritchie, R., & Rotherham, T. (2012). New approaches for private woodlots — Reframing the forest policy debate. *Province of New Brunswick*. Available from: <https://www2.gnb.ca/content/dam/gnb/Departments/nr->

rn/pdf/en/ForestsCrownLands/NewApproachesForPrivateWoodlots.pdf [accessed 07 July 2025].

Hanes, C.C., Wang, X., Jain, P., Parisien, M.A., Little, J.M., and Flannigan, M.D. (2019). Fire-regime changes in Canada over the last half century. *Canadian Journal of Forestry Research*, 49, 256–269. <https://doi.org/10.1139/cjfr-2018-0293>.

Hennigar, C.R. (2013). Open Stand Model Version 2.24.8.23: Help Documentation; FORUS Research: Fredericton, NB, Canada.

Hennigar, C. R., Weiskittel, A., Allen, H. L., & MacLean, D. (2016). Development and evaluation of a biomass increment based index for site productivity. *Canadian Journal of Forest Research*, 47(3), 400-410. <https://doi.org/10.1139/cjfr-2016-0330>

Keenan, R. J. (2015). Climate change impacts and adaptation in forest management: A review. *Annals of Forest Science*, 72(2), 145–167. <https://doi.org/10.1007/s13595-014-0446-5>

Kershaw, J. A., Richards, E., & Larusic, J. (2007). A Product Ratio Calculator for Northeastern Tree Species. *Northern Journal of Applied Forestry*, 24(4), 307–311. <https://doi.org/10.1093/njaf/24.4.307>

Laatsch, J. & Ma, Z. (2015). Strategies for Incorporating Climate Change into Public Forest Management. *Journal of Forestry* 113(3), 335-342. <https://doi.org/10.5849/jof.14-128>.

Lexer, M.J., and Hönninger, K. (2001). A modified 3D-patch model for spatially explicit simulation of vegetation composition in heterogeneous landscapes. *Forest Ecology and Management* 144(1), 43–65. [https://doi.org/10.1016/S0378-1127\(00\)00386-8](https://doi.org/10.1016/S0378-1127(00)00386-8)

Loo, J. & Ives, N. (2003) The Acadian forest: Historical condition and human impacts. *The Forestry Chronicle*, 79(3), 462–474. <https://doi.org/10.5558/tfc79462-3>

McMonagle, G., Lantz, V., Taylor, A. R., Boulanger, Y., Sharma, C., Withey, P., & Hennigar, C. (2024). Economic impacts of climate change on forests: A PICUS–LANDIS–CGE modeling approach. *Canadian Journal of Forest Research*, 54(10), 1057–1075. <https://doi.org/10.1139/cjfr-2024-0089>

Nadeau, S., Beckley, T., McKendy, M., and Keess, H. (2012). A snapshot of New Brunswick non-industrial forest owners in 2011: Attitudes, behaviour, stewardship and future prospects. Available from: New Brunswick Department of Natural Resources. <https://www2.gnb.ca/content/dam/gnb/Departments/nr-rn/pdf/en/ForestsCrownLands/2011SnapshotOfNB-NonIndustrialForestOwners.pdf> [accessed 09 September 2024]

Natural Resources Canada (NRCan). (2026). Forest statistical data: Contribution to national GDP. *Government of Canada*, Ottawa, Ontario. Available from: <https://cfs.cloud.nrcan.gc.ca/statsprofile/economy/contribution-to-national.html> [accessed 9 March 2026].

Neily, P., Basquill, S., Quigley, E., Keys, K., Maston, S., Stewart, B. (2023). Forest Ecosystem Classification for Nova Scotia (2022): Field Guide. *Nova Scotia Department of Natural Resources and Renewables*. Available from: <https://novascotia.ca/natr/wildlife/pdf/2023-002-biodiversity-tech-report.pdf> [accessed 24 November 2025].

New Brunswick Department of Energy and Resource Development. (2023). New Brunswick Private Woodlot Silviculture Program. Available from: [https://senb.ca/images/2023-24\\_Private\\_Woodlot\\_Silviculture\\_Manual\\_EN.pdf](https://senb.ca/images/2023-24_Private_Woodlot_Silviculture_Manual_EN.pdf) [accessed 30 March 2026].

New Brunswick Department of Energy and Resource Development. (2023). Forest R3 4 5/Forestières R3 4 5. *GeoNB*. Available from: [https://hub.arcgis.com/datasets/49e6aeb4f0914acfbe9ce36381dfba96\\_0/about?locale=en](https://hub.arcgis.com/datasets/49e6aeb4f0914acfbe9ce36381dfba96_0/about?locale=en) [accessed 24 October 2024]

New Brunswick Department of Natural Resources and Energy Development. (2024). Timber royalty rates. Available from: <https://www.gnb.ca/en/topic/environment-resources/forestry-conservation/forest-products/timber-royalty-rates-24-25.html> [accessed 8 November, 2024].

New Brunswick Federation of Woodlot Owners (NBFWO). (2022). A case study of New Brunswick woodlot owners adapting to climate change. *Natural Resources Canada*. Available from: [https://www.nbwoodlotowners.ca/\\_files/ugd/c144cd\\_31c6079b867c49658f7b0406ac5c782f.pdf](https://www.nbwoodlotowners.ca/_files/ugd/c144cd_31c6079b867c49658f7b0406ac5c782f.pdf) [accessed 17 March 2025].

New Brunswick Forest Products Commission. (2022). Forest Sector Review. Available from: <https://www2.gnb.ca/content/dam/gnb/Departments/nr-rn/pdf/en/Publications/forest-sector-review-2022.pdf> [accessed 30 July 2025].

Nova Scotia Department of Natural Resources (NSDNR). (2016). State of the forest report. *Government of Nova Scotia*, Halifax, NS. Available from: [https://novascotia.ca/natr/forestry/reports/State\\_of\\_the\\_Forest\\_2016.pdf](https://novascotia.ca/natr/forestry/reports/State_of_the_Forest_2016.pdf) [accessed 30 July 2025]

Nova Scotia Woodlot Owners & Operators Association. (2023). Ecological Forest Management in a Changing Climate. Available from: <https://www.nswooa.ca/foreststewardworkshops.html> [accessed 08 August 2025].

- Ogden, A. E., & Innes, J. (2007). Incorporating climate change adaptation considerations into forest management planning in the boreal forest. *International Forestry Review*, 9(3), 713–733. <https://doi.org/10.1505/ifor.9.3.713>
- Paradis, A., Elkinton, J., Hayhoe, K., and Buonaccorsi, J. (2008). Role of winter temperature and climate change on the survival and future range expansion of the hemlock woolly adelgid (*Adelges tsugae*) in eastern North America. *Mitigation and Adaptation Strategies for Global Change* 13, 541–554. <https://doi.org/10.1007/s11027-007-9127-0>.
- Remsoft. (2024). Woodstock Optimization Studio. Available from: <https://remsoft.com/woodstock-optimization-studio/> [accessed 04 August 2025].
- Rowe, J.S. (1972). Forest regions of Canada. *Canadian Forestry Service, No. 1300*.
- Simons-Legaard, E., Legaard, K., Weiskittel, A. (2025). Declining conifer productivity will drive future forest dynamics as climate changes in northern New England. *Ecological Applications* 35(3) e70028. <https://doi.org/10.1002/eap.70028>
- South East New Brunswick Wood Marketing Board. (2024). SENB Forest Management Fund 2023-2024. Available from: [https://senb.ca/images/2023\\_FOREST\\_MANAGEMENT\\_FUND\\_English.pdf](https://senb.ca/images/2023_FOREST_MANAGEMENT_FUND_English.pdf) [accessed 30 March 2026].
- Spittlehouse, D. L. (2005). Integrating climate change adaptation into forest management. *The Forestry Chronicle*, 81(5), 691–695. <https://doi.org/10.5558/tfc81691-5>
- Steenberg, J. W. N., Duinker, P. N., & Bush, P. G. (2013). Modelling the effects of climate change and timber harvest on the forests of central Nova Scotia, Canada. *Annals of Forest Science*, 70(1), 61–73. <https://doi.org/10.1007/s13595-012-0235-y>
- Steenberg, J.W., O’Keefe, R. N., Ring, J., Rushton, T., McGrath, T. P. (2023). Updated functions for the Nova Scotia Growth and Yield Model for Softwood Plantations. *Nova Scotia Department of Natural Resources and Renewables*, Truro, Nova Scotia, Canada. Available from: [https://www.researchgate.net/publication/370124338\\_Updated\\_Functions\\_for\\_the\\_Nova\\_Scotia\\_Growth\\_and\\_Yield\\_Model\\_for\\_Softwood\\_Plantations#fullTextFileContent](https://www.researchgate.net/publication/370124338_Updated_Functions_for_the_Nova_Scotia_Growth_and_Yield_Model_for_Softwood_Plantations#fullTextFileContent) [accessed 19 October 2025].
- Taylor, A. R., Boulanger, Y., Price, D. T., Cyr, D., McGarrigle, E., Rammer, W., & Kershaw, J. A. (2017). Rapid 21st century climate change projected to shift composition and growth of Canada’s Acadian Forest Region. *Forest Ecology and Management*, 405, 284–294. <https://doi.org/10.1016/j.foreco.2017.07.033>

Taylor, A. R., MacLean, D. A., Neily, P. D., Stewart, B., Quigley, E., Basquill, S. P., Boone, C. K., Gilby, D., & Pulsifer, M. (2020). A review of natural disturbances to inform implementation of ecological forestry in Nova Scotia, Canada. *Environmental Reviews*, 28(4), 387–414. <https://doi.org/10.1139/er-2020-0015>

Taylor, A. R., Endicott, S., & Hennigar, C. (2020). Disentangling mechanisms of early succession following harvest: Implications for climate change adaptation in Canada's boreal-temperate forests. *Forest Ecology and Management*, 461, 117926. <https://doi.org/10.1016/j.foreco.2020.117926>

Vaughn, W. R., Taylor, A. R., MacLean, D. A., D'Orangeville, L., & Lavigne, M. B. (2021). Climate change experiment suggests divergent responses of tree seedlings in eastern North America's Acadian Forest Region over the 21st century. *Canadian Journal of Forest Research*, 51(12), 1888–1902. <https://doi.org/10.1139/cjfr-2021-0047>

World Meteorological Organization (WMO). (2024). State of the global climate. Geneva, Switzerland. Available from [https://wmo.int/sites/default/files/2025-03/WMO-1368-2024\\_en.pdf](https://wmo.int/sites/default/files/2025-03/WMO-1368-2024_en.pdf) [accessed 05 February 2026].

# Appendix A

## Schedule

| PERIOD | FORTYPE | BASELINE |      | TREATMENT    |
|--------|---------|----------|------|--------------|
|        |         | AGE      | AREA |              |
| 1      | BFSW    | 14       | 1.55 | aCC          |
| 1      | EHMIX   | 20       | 4.82 | aSelect      |
| 1      | NSR     | 0        | 0.16 | aPlantSpruce |
| 1      | BFSW    | 0        | 1.4  | aPlantSpruce |
| 2      | BFSW    | 15       | 1.97 | aCC          |
| 2      | EHMIX   | 21       | 2.92 | aSelect      |
| 2      | NSR     | 0        | 0.2  | aPlantSpruce |
| 3      | INTHW   | 16       | 1.6  | aCC          |
| 3      | BFSW    | 16       | 2.31 | aCC          |
| 3      | EHMIX   | 22       | 0.57 | aSelect      |
| 3      | NSR     | 0        | 0.55 | aPlantSpruce |
| 4      | INTMX   | 17       | 0.66 | aCC          |
| 4      | INTHW   | 17       | 3.81 | aCC          |
| 4      | NSR     | 0        | 0.89 | aPlantSpruce |
| 5      | INTHW   | 18       | 1.3  | aCC          |
| 5      | UNEHMW  | 20       | 4.82 | aSelect      |
| 5      | NSR     | 0        | 0.26 | aPlantSpruce |
| 6      | INTHW   | 19       | 2.01 | aCC          |
| 6      | UNEHMW  | 20       | 2.92 | aSelect      |
| 6      | NSR     | 0        | 0.16 | aPlantSpruce |
| 7      | RSMIX   | 20       | 3.33 | aSelect      |
| 7      | EHMIX   | 20       | 3.53 | aSelect      |
| 7      | NSR     | 0        | 0.25 | aPlantSpruce |
| 8      | RSMIX   | 21       | 1.03 | aCC          |
| 8      | UNEHMW  | 21       | 0.57 | aSelect      |
| 8      | EHMIX   | 21       | 2.84 | aSelect      |
| 9      | RSMIX   | 22       | 2.01 | aCC          |
| 9      | UNEHMW  | 20       | 1.29 | aSelect      |
| 10     | UNEHMW  | 21       | 3.52 | aSelect      |
| 10     | UNEHMW  | 20       | 2.66 | aSelect      |
| 11     | UNRSMW  | 20       | 3.33 | aSelect      |
| 11     | UHEHMW  | 21       | 0.25 | aSelect      |
| 11     | UHEHMW  | 20       | 3.52 | aSelect      |
| 12     | INTMX   | 8        | 0.39 | aCC          |
| 12     | INTHW   | 9        | 1.27 | aCC          |
| 12     | INTHW   | 8        | 2.15 | aCC          |
| 12     | BFSW    | 10       | 1.7  | aCC          |
| 12     | UHEHMW  | 20       | 3.4  | aSelect      |
| 13     | PSP     | 12       | 1.55 | aCC          |
| 13     | PSP     | 11       | 0.19 | aCC          |
| 13     | BFSW    | 10       | 1.53 | aCC          |
| 13     | UHEHMW  | 20       | 1.29 | aSelect      |


|    |        |    |      |         |
|----|--------|----|------|---------|
| 14 | INTHW  | 10 | 0.89 | aCC     |
| 14 | UHEHMW | 20 | 6.18 | aSelect |
| 15 | BFSW   | 12 | 0.04 | aCC     |
| 15 | UNRSMW | 20 | 3.32 | aSelect |
| 15 | UHEHMW | 20 | 3.78 | aSelect |
| 16 | PSP    | 13 | 0.55 | aCC     |
| 16 | INTHW  | 11 | 1.03 | aCC     |
| 16 | BFSW   | 13 | 0.49 | aCC     |
| 16 | UHEHMW | 20 | 3.4  | aSelect |
| 17 | PSP    | 13 | 0.89 | aCC     |
| 17 | PSP    | 12 | 0.25 | aCC     |
| 17 | PSP    | 11 | 0.15 | aCC     |
| 17 | INTMX  | 13 | 0.12 | aCC     |
| 17 | INTHW  | 11 | 1.6  | aCC     |
| 17 | UHEHMW | 20 | 1.29 | aSelect |
| 18 | PSP    | 11 | 0.13 | aCC     |
| 18 | RSMIX  | 10 | 0.92 | aCC     |
| 18 | UHEHMW | 20 | 6.18 | aSelect |
| 19 | PSP    | 12 | 0.1  | aCC     |
| 19 | RSMIX  | 10 | 1.81 | aCC     |
| 19 | UNRSMW | 20 | 3.32 | aSelect |
| 19 | UHEHMW | 20 | 2.51 | aSelect |
| 20 | INTMX  | 8  | 1.55 | aCC     |
| 20 | INTHW  | 8  | 2.7  | aCC     |
| 20 | UHEHMW | 21 | 1.2  | aSelect |
| 20 | UHEHMW | 20 | 3.4  | aSelect |

| CLIMATE CHANGE |         |     |      |            |
|----------------|---------|-----|------|------------|
| PERIOD         | FORTYPE | AGE | AREA | TREATMENT  |
| 1              | BFSW    | 14  | 0.01 | aCC        |
| 1              | EHMIX   | 20  | 6.55 | aSelect    |
| 1              | NSR     | 0   | 0.01 | aPlantPine |
| 1              | BFSW    | 0   | 0.01 | aPlantPine |
| 2              | INTHW   | 15  | 3.38 | aCC        |
| 2              | EHMIX   | 21  | 1.74 | aSelect    |
| 2              | NSR     | 0   | 0.67 | aPlantPine |
| 3              | INTMX   | 16  | 4.51 | aCC        |
| 3              | NSR     | 0   | 0.9  | aPlantPine |
| 4              | INTMX   | 17  | 1.34 | aCC        |
| 4              | INTHW   | 17  | 2.87 | aCC        |
| 5              | INTHW   | 18  | 0.17 | aCC        |
| 5              | UNEHMIX | 20  | 6.55 | aSelect    |
| 5              | NSR     | 0   | 0.03 | aPlantPine |
| 6              | INTHW   | 19  | 2.28 | aCC        |
| 6              | UNEHMIX | 20  | 1.74 | aSelect    |
| 6              | INTMX   | 19  | 7.54 | _Death     |
| 6              | BFSW    | 19  | 5.81 | _Death     |
| 7              | TOLHW   | 20  | 0.25 | aSelect    |
| 7              | RSMIX   | 20  | 2.34 | aSelect    |
| 7              | EHMIX   | 20  | 4.58 | aSelect    |

|    |         |    |      |         |
|----|---------|----|------|---------|
| 8  | RSMIX   | 21 | 1.66 | aCC     |
| 8  | EHMIX   | 21 | 2.49 | aSelect |
| 9  | TOLMX   | 22 | 0.08 | aCC     |
| 9  | UNEHMIX | 20 | 6.55 | aSelect |
| 10 | TOLHW   | 23 | 1.77 | aCC     |
| 10 | UNEHMIX | 20 | 1.21 | aSelect |
| 11 | UNRSMW  | 20 | 2.34 | aSelect |
| 11 | UNEHMIX | 21 | 0.52 | aSelect |
| 11 | UNEHMIX | 20 | 4.58 | aSelect |
| 12 | TOLHW   | 25 | 0.14 | aCC     |
| 12 | INTHW   | 10 | 2.68 | aCC     |
| 12 | UNEHMIX | 20 | 2.49 | aSelect |
| 12 | INTHW   | 21 | 0.25 | aSelect |
| 13 | INTHW   | 11 | 0.02 | aCC     |
| 13 | UNEHMIX | 20 | 6.55 | aSelect |
| 14 | TOLHW   | 27 | 0.01 | aCC     |
| 14 | INTMX   | 11 | 3.61 | aCC     |
| 14 | INTHW   | 10 | 2.02 | aCC     |
| 14 | UNEHMIX | 20 | 1.21 | aSelect |
| 15 | PWP     | 14 | 0.01 | aCC     |
| 15 | INTHW   | 11 | 0.06 | aCC     |
| 15 | UNRSMW  | 20 | 2.34 | aSelect |
| 15 | UNEHMIX | 20 | 5.11 | aSelect |
| 16 | PWP     | 14 | 0.67 | aCC     |
| 16 | PWP     | 13 | 0.35 | aCC     |
| 16 | INTMX   | 12 | 1.07 | aCC     |
| 16 | INTHW   | 12 | 0.2  | aCC     |
| 16 | INTHW   | 12 | 0.13 | aCC     |
| 16 | UNEHMIX | 11 | 2.49 | aSelect |
| 16 | UNHW    | 20 | 0.25 | aSelect |
| 17 | PWP     | 14 | 0.54 | aCC     |
| 17 | INTHW   | 11 | 1.82 | aCC     |
| 17 | UNEHMIX | 20 | 2.59 | aSelect |
| 18 | PWP     | 13 | 0.03 | aCC     |
| 18 | RSMIX   | 10 | 1.49 | aCC     |
| 18 | UNEHMIX | 21 | 3.96 | aSelect |
| 18 | UNEHMIX | 20 | 0.81 | aSelect |
| 19 | INTHW   | 10 | 0.02 | aCC     |
| 19 | UNRSMW  | 20 | 2.34 | aSelect |
| 19 | UNEHMIX | 21 | 0.4  | aSelect |
| 19 | UNEHMIX | 20 | 4.73 | aSelect |
| 20 | NSR     | 16 | 0.84 | aCC     |
| 20 | TOLHW   | 11 | 0.04 | aCC     |
| 20 | TOLHW   | 10 | 0.88 | aCC     |
| 20 | INTHW   | 10 | 0.53 | aCC     |
| 20 | INTHW   | 8  | 2.19 | aCC     |
| 20 | UNEHMIX | 21 | 0.37 | aSelect |
| 20 | UNEHMIX | 20 | 2.49 | aSelect |
| 20 | UNHW    | 20 | 0.25 | aSelect |

# Appendix B

## Wood product specifications

|   |  |
|---|--|
|  | <b>J.D. Irving, Limited</b><br><b>PURCHASE WOOD SPECIFICATIONS</b> |
|---|--|

### GRAND LAKE TIMBER SAWMILL - SAWLOGS

EFFECTIVE DATE: May 14<sup>th</sup>, 2017 weight scale

| GRADE 1 Note: Diameters are measured inside bark (ISB) |  |
|--|--|
| SPECIES  | Spruce/fir only; minimum 75% spruce, maximum 25% fir (white-wood only)   |
| AGE  | Delivered within 3 months of date cut (live trees at time of cut)  |
| LENGTH   | 12' and 16' plus 3" to 7" trim; loads must contain <u>greater than 50%</u> 16' logs.   |
| DIAMETER   | 16' logs = 6" minimum to 20" maximum (with excess butt flare trimmed)<br>12' logs = 8" minimum to 20" maximum (with excess butt flare trimmed)   |
| QUALITY DEFECTS  | Not more than 25% diameter rot or 1/3 of gross log volume in defects from damage, sweep, porcupine chews, or other non-merchantable defect.<br>Excessive knots: not more than 12 knots 1" – 3" in diameter OR not more than 8 knots greater than 3" diameter in any 4-foot section of a log. |
| GRADE 2 As above except for the following:             |  |
| SPECIES  | As for Grade 1 except:<br>Loads may contain less than 75% Spruce.<br>Jack Pine is acceptable but must be separated for unloading.  |
| LENGTH   | As for Grade 1 except there may be less than 50% 16' logs in the load.   |

**NOTE:** Loads may be rejected by JDI scale staff prior to unloading if they do not meet minimum specifications. Grade shall be determined by JDI, based on a 20+ log sample extracted randomly from each load and measured using the above specifications. Quality (% acceptable pieces) shall be measured using the above specifications. Loads assessed as 90% or higher shall be eligible for QUALITY BONUS where applicable under contract terms or as determined by J.D. Irving, Limited. Any supplier whose quality sample results fall below 60% for any one (1) load, or fall below 85% for any three (3) loads delivered within a 4 –week period, shall be placed on QUALITY SUSPENSION and deliveries immediately suspended. Suppliers placed on quality suspension shall not be allowed to resume delivery to GLT until approved by the Regional Wood Buyer.

The trucker or producer must notify the JDI scale staff or Chief Scaler of any disputes regarding scale or sample selection at the time of delivery. JDI will make best efforts to hold quality samples for 24 hours when results fall below 85% to allow time for inspection. These specifications are subject to change by JDI with minimum notice.

Signed:   
Brent Thompson

Date: April 20<sup>th</sup>, 2017



DEVON LUMBER CO. LTD.  
200 GIBSON STREET,  
FREDERICTON, NEW BRUNSWICK E3A 4E3  
TELEPHONE (506) 457-7120  
FAX: (506) 457-7122

Effective: July 11 2022

**Spruce & Fir Pulpwood**

**\$41.00/Tonne**

Minimum Top Size: 3 ½" outside bark

Maximum Butt Size: 9"

Length: 8' 4" - 8' 6"

**NO Soft Rot**

Price includes any Marketing Board Levies.

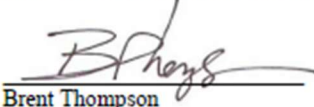
## VENEER SAWMILL – HARDWOOD SAWLOGS

**EFFECTIVE DATE: July 28<sup>th</sup>, 2019 fbm scale (international rule)**

| HARD MAPLE (HM) GRADES             | Length                          | Diameter   | Rot                                      | Sweep                                    | Splits            | # of Clear Faces | Heart        |
|------------------------------------|---------------------------------|------------|--|--|-------------------|------------------|--------------|
| 1 (veneer log)                     | 9', 10', 11' (plus 6" trim)     | 10"        | None                                     | None                                     | None              | 4                | 1/3 diameter |
|                                    |                                 | 11"        | 2" medium (centered)                     | up to 1"                                 | up to 2" - closed | 3                | 1/3 diameter |
|                                    |                                 | 12" - 13"  |  |  | None              | 4                | 1/2 diameter |
|                                    |                                 | 14" and up |  |  | up to 2" - closed | 2                | 1/3 diameter |
| 2                                  | 8' to 12' (plus 3" trim)        | 12" and up | up to 1/3 small end diameter             | up to 1/3 small end diameter             | one - straight    | 3                | 1/3 diameter |
| 3                                  | 8' to 12' (plus 3" trim)        | 9" - 10"   | None                                     | None                                     | None              | 4                | 1/2 diameter |
|                                    |                                 | 11" and up | up to 1/3 small end diameter             | up to 1/3 small end diameter             | one - straight    | 2                | 1/2 diameter |
| 4                                  | 6' to 8' (plus 3" trim)         | 10" - 11"  | up to 1/3 small end diameter             | up to 1/3 small end diameter             | one - straight    | 3                | Any size     |
|                                    |                                 | 12" and up | up to 1/3 small end diameter             | up to 1/3 small end diameter             | one - straight    | 2                | Any size     |
|                                    | 8' to 12' (plus 3" trim)        | 11" and up | None                                     | up to 1/3 small end diameter             | None              | 0                | Any size     |
| 5                                  | 8' to 12' (plus 3" trim)        | 8" - 10"   | None                                     | None                                     | None              | 2                | Any size     |
|                                    |                                 | 11" and up | up to 1/3 small end diameter             | up to 1/3 small end diameter             | one - straight    | 0                | Any size     |
| RED MAPLE (RM) GRADES              | Length                          | Diameter   | Rot                                      | Sweep                                    | Splits            | # of Clear Faces | Heart        |
| 2                                  | 9' or 10' (plus 3" trim)        | 12" and up | None                                     | <math>\leq 1/3</math> small end diameter | None              | 0                | Any size     |
| 3                                  | 9' or 10' (plus 3" trim)        | 11" and up | None                                     | None                                     | None              | 0                | Any size     |
| WHITE/YELLOW BIRCH (WB, YB) GRADES | Length                          | Diameter   | Rot                                      | Sweep                                    | Splits            | # of Clear Faces | Heart        |
| 1 (veneer log)                     | 8', 9', 10', 11' (plus 6" trim) | 10"        | None                                     | None                                     | None              | 4                | Any size     |
|                                    |                                 | 11"        | 2" medium (centered)                     | up to 1"                                 | up to 2" - closed | 3                |              |
|                                    |                                 | 12" - 13"  |  |  | None              | 4                |              |
|                                    |                                 | 14" and up |  |  | up to 2"          | 2                |              |
| 2                                  | 8' to 12' (plus 3" trim)        | 12" and up | <math>\leq 1/3</math> small end diameter | <math>\leq 1/3</math> small end diameter | one - straight    | 3                | Any size     |
| 3                                  | 8' to 12' (plus 3" trim)        | 9" - 10"   | None                                     | None                                     | None              | 4                | Any size     |
|                                    |                                 | 11" and up | <math>\leq 1/3</math> small end diameter | <math>\leq 1/3</math> small end diameter | one - straight    | 2                | Any size     |
| 4                                  | 6' to 8' (plus 3" trim)         | 10" - 11"  | <math>\leq 1/3</math> small end diameter | <math>\leq 1/3</math> small end diameter | one - straight    | 3                | Any size     |
|                                    |                                 | 12" and up | <math>\leq 1/3</math> small end diameter | <math>\leq 1/3</math> small end diameter | one - straight    | 2                | Any size     |
|                                    | 8' to 12' (plus 3" trim)        | 11" and up | None                                     | <math>\leq 1/3</math> small end diameter | None              | 0                | Any size     |
| 5                                  | 8' to 12' (plus 3" trim)        | 8" - 10"   | None                                     | None                                     | None              | 2                | Any size     |
|                                    |                                 | 11" and up | <math>\leq 1/3</math> small end diameter | <math>\leq 1/3</math> small end diameter | one - straight    | 0                | Any size     |
| 6 (pallet)                         | 8' to 12' (plus 3" trim)        | 6" and up  | None                                     | <math>\leq 1/4</math> small end diameter | None              | 0                | Any size     |

**GENERAL SPECIFICATIONS: Loads containing Ash logs shall be rejected entirely. Species must be sorted/separated on each load. No forked pieces. No stained logs. Limbs trimmed flush. Loads may be rejected by JDI staff prior to unloading if they do not meet minimum specifications.**

The trucker or producer must notify the JDI scale staff or Chief Scaler of any disputes regarding scale or grade at the time of delivery. JDI will make best efforts to hold disputed loads for 24 hours to allow time for inspection. These specifications are subject to change by JDI with minimum notice.

Signed:   
 Brent Thompson

Date: July 23, 2019.

## **A.V. Nackawic**

### **WOOD SPECIFICATION**

- Lengths of bolts shall be a minimum length of 2.44 meters (8 ft.) with a greater or lesser variance not to exceed 0.2 meters (plus or minus 8 inches).
- Random tree length mixed species (Hardwood & Birch) not to exceed 6.70 meters in length (22 feet)
- The bolt must have been cut from live and standing trees preferably less than sixty days prior to the day of delivery;
- The minimum diameter of a bolt shall be eight centimetres (3 inches measured inside the bark and the maximum diameter shall be fifty-nine centimetres (24 inches) measured outside the bark;
- The bolts shall not be burnt, crotched, or so knotty as to make it unsuitable for making bleached hardwood kraft pulp.
- Crotched bolts will not be accepted.
- Species must be sorted.

B. The Buyer has the right to have culled from the loads of Wood delivered, those bolts containing more than two-thirds rot by area on any one end and to adjust the scale of that load accordingly.

### **SPECIES**

A. For the purpose of this Agreement, the species of Wood shall be designed as:

1. 2.4 meters (8 foot)
  - Mixed hardwood (which includes all hardwood species excluding Poplar, White Birch and Yellow Birch);
  - Poplar;
  - White or Yellow Birch
2. 16 foot lengths preferred but tree length up to 22 feet is acceptable
  - Mixed Hardwood (which includes all hardwood species excluding Poplar, White Birch and Yellow Birch);
  - Poplar
  - White or Yellow Birch

## **Curriculum Vitae**

Candidate's Full Name: Carley Jean Archibald

Universities Attended (with dates and degrees obtained):

B. Sc. Environmental Science, Dalhousie University, 2020

Publications: N/A

Conference Presentations: N/A