Climate Change Resilience and Carbon Storage Silvicultural Prescriptions for the Wabanaki Forest Region

Appendix B - Supporting Information v.1.0

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2019

Contents

Introduction

This document provides context and background to the Climate Change Resilience and Carbon Storage Silvicultural Prescription Decision Tree (C&C Decision Tree). The purpose of this tool is to support the forestry practitioner in developing silvicultural systems to manage forest stands with the intended outcome of improving the stand's climate change resilience and carbon storage.

The C&C Decision Tree leads the practitioner towards individual recommended treatments. However, they also lead towards a management strategy, a silvicultural system to be used as a guide for the management of the stand in the long-term. This tool is designed to be used — to be tested and improved through use. This is a silvicultural tool, and as such is designed to be used for individual forest "stands" (i.e. distinct patches of forest at the operational level).

It is highly recommended that the user of this tool complete a thorough assessment and projection of the stand condition (i.e. composition and structure) and site quality (i.e. vegetation type, soil type, ecosite, site productivity, etc.) before using this tool. This tool is designed to work in a wide range of stand types/conditions and on a wide range of ecosites. This tool does not recommend a specific procedure for stand and site assessment

This tool was developed specifically for the forests of the Maritime Provinces of Canada (a.k.a. the Maritimes).This forest, as well as the forests of the the Gaspé region of Quebec and those of the New England states, form a unique forest type known as the Wabanaki forest (also known as the Acadian forest). The Maritimes, and indeed all of the Wabanaki Forest Region, has been historically located at the very northern limit of a temperate climate–a temperate-boreal (i.e. hemiboreal) transitional climate. Many of the temperate species found in the Maritimes are found at the northern limits of their historical ranges. Likewise, many of the boreal species found in the Maritimes are at the southern limits of their historical ranges. Unlike the more continental climates of hemiboreal forest regions/ecozones west of the Maritimes, the historical climate of the Maritimes has been relatively moderated by the North Atlantic, where precipitation has not been a limit to growth at the regional scale, and where summers have been cooler and winters milder, than more continental climates to the west. There is, however, considerable variability in local climates (i.e. ecoregions) within the Maritimes, due to proximity to the ocean and changes in elevation. For example, western New Brunswick has a significantly more continental climate than ecoregions closer to the coast, and the highest elevations in New Brunswick have historically had true boreal climates. Although this tool was developed for the specific geographical context of the Maritimes, this tool should work reasonably well for other cool, humid northern-temperate and hemiboreal forests.

Climate Change Context

Speaking very generally, climate scientists project that the climate of the Maritime provinces will continue to change and experience an overall increase in temperature and precipitation, with an increase in severe weather (storm) events. The increase in temperature is likely, however, to also increase evapotranspiration rates of plants across the landscape. This will, therefore, result in more intense and more prolonged droughts and consequently a net decrease of available water. The present —day trends for climate change correspond to Representative Concentration Pathway (RCP) 8.5-this RCP is one of four standard scenarios used by climate scientists to explore the depth and breadth of climate change by 2100. RCP 8.5 is considered the "worst-case" scenario and without significant decreases in humanity's greenhouse gas emissions worldwide, we will collectively continue to align with this scenario. Here is a brief snapshot of the projected changes from now to 2100 in temperature and precipitation under RCP 8.5:

Temperature

The number of days per year reaching more than 25° Celsius across the Maritime provinces is currently a median of 6 days in cooler, coastal areas to 66 days in the warmest parts of the region (Figure 1). In contrast, by 2100, those cooler and coastal regions will see a median of 86 days over 25° Celsius, and inland areas could see as many as 119 hot days per year.

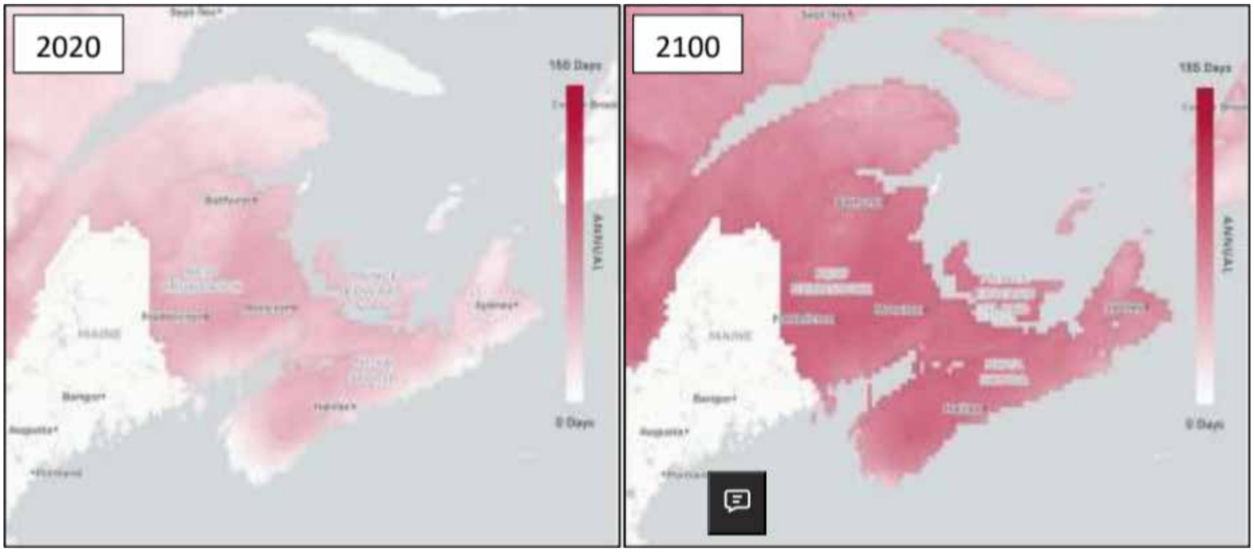

Figure 1. Number of days per year reaching 25° Celsius or above. (Images taken from the Government of Canada's Climate Atlas at https://climatedata.ca/).

Currently, the Maritime provinces experience very few "tropical nights"– that is, nights where the temperature remains over 20° Celsius (Figure 2). By 2100, only the high elevation areas and coolest coastal areas will experience only a few tropical nights; most of the Maritimes provinces will experience as many as 40-50 nights per year over 20° Celsius.

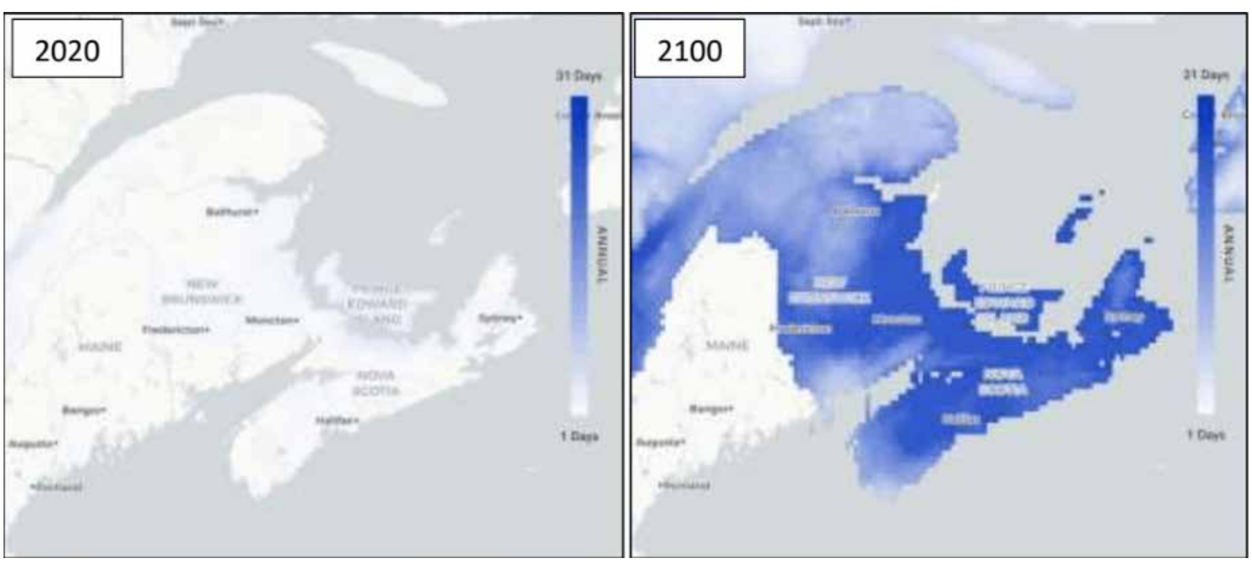

Figure 2. Number of days per year with "tropical nights" (i.e. nights that remain over 20° Celsius). (Images taken from the Government of Canada's Climate Atlas at https://climatedata.ca/).

Precipitation

The total annual precipitation is projected to increase (Figure 3). In the dryer parts of the Maritimes, the total annual precipitation is projected to increase from a median of 1112 mm in 2020 to 1294 mm in 2100. And in the wetter areas, total annual precipitation is projected to increase by nearly 20 cm from 2020 (1466 mm) to 2100 (1653 mm).

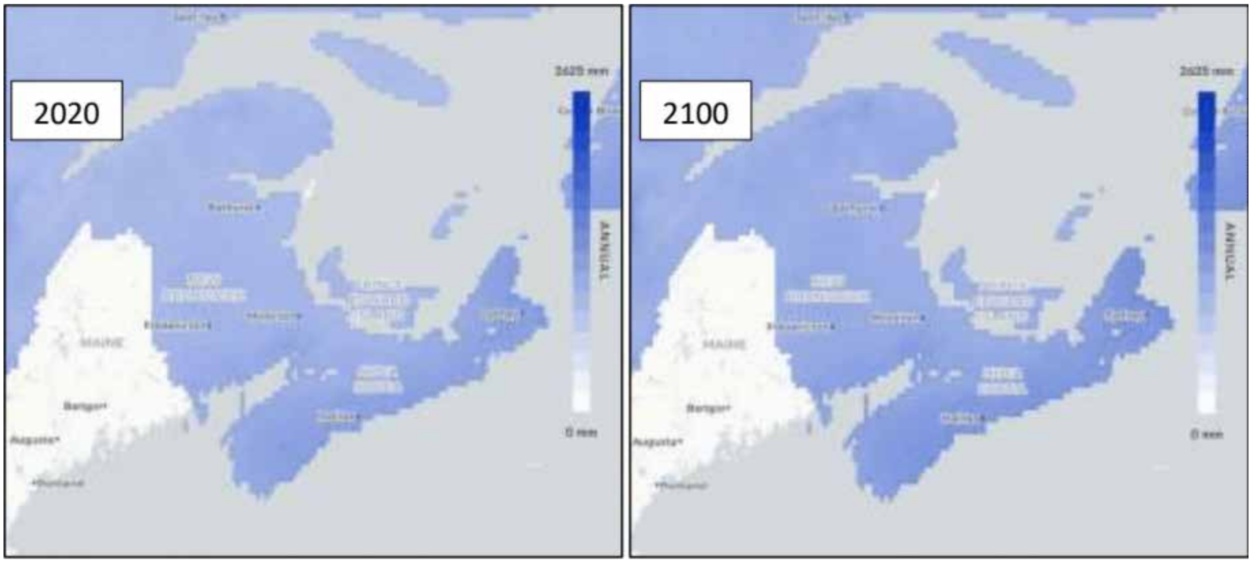

Figure 3. Total precipitation (in mm). (Images taken from the Government of Canada's Climate Atlas at https://climatedata.ca/).

The intensity and severity of storms is predicted to increase as well, which is likely to have significant impacts on everyone and everything —infrastructure, homes and businesses, forests, habitats and wildlife, and directly on people themselves. In the wettest areas of the Maritime provinces, such as the east and south of Nova Scotia, the largest precipitation total on a single day is currently a median of 64 mm, and could increase to 85 mm by 2100 (Figure 4). In the dryer areas, such as in northern New Brunswick, the current median of 41 mm is projected to increase to 46 mm.

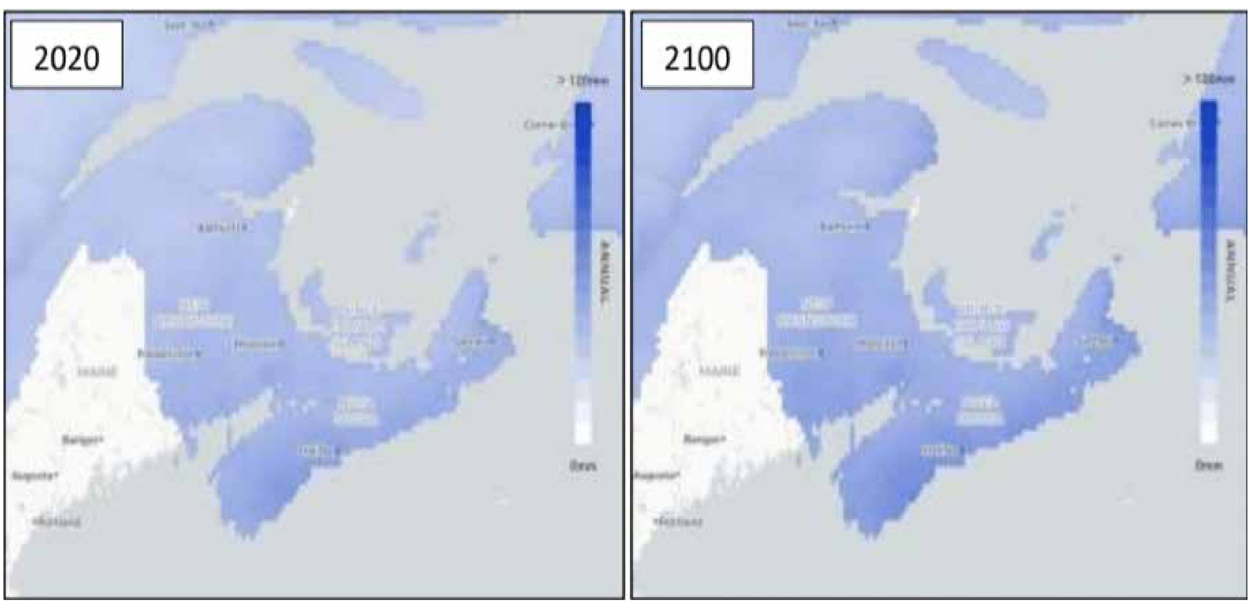

Figure 4. The largest precipitation total on a single day (in mm). (Images taken from the Government of Canada's Climate Atlas at https://climatedata.ca/).

Objectives and Intended Outcomes

This tool is designed to deliver on two silvicultural objectives:

1.Maintain or enhance the climate change resilience of a stand.
2.Maximize the carbon storage of a stand.

This tool does not treat these two objectives in isolation, thus there is a deliberate attempt for this tool not to marginalize one of these outcomes in order to achieve the other. The climate change resilience objective is most definitely of higher order priority to this tool. For example, the tool may recommend a treatment that may temporarily reduce the wood density of a stand with a resultant loss of carbon storage in order to steer the stand towards a more desirable condition of climate change resilience.

Silvicultural systems recommended by this tool exclude short rotation, even-age systems designed to maximize wood fiber production and minimize the risk of financial losses. A clear argument can be made that managing stands on very short rotations allows for the forest manager to more quickly respond to a changing climate (and a changing market). However, short rotation, even-aged silvicultural systems are incompatible with maximizing carbon storage, therefore they are not recommended by this tool.

Maintaining or Enhancing the Climate Change Resilience of a Stand: Tree Species Risk Assessment

One of the fundamental premises of this silvicultural tool is the notion of reducing the risks associated with climate change. The tree composition of a forest stand is a fundamental factor in the stand's capability to be resilient to climate change.

Facing climate change, some tree species in the Maritimes are projected to become more and more stressed (e.g. balsam fir, white spruce, white birch), while other tree species with more southern affinities are likely better adapted to the warming climate (e.g. eastern white pine, red oak, red maple). This tool classifies tree species that are projected to become more stressed by climate change as "high-risk. "Tree species that are projected to be resilient in a warming climate are classified as "low-risk".

As an extension of this premise, stands that are dominated by tree species that are "high-risk" are inherently high-risk stands and not projected to be resilient in the face of a warming climate. Therefore, one of the fundamental premises of this tool is to silviculturally manipulate stands towards compositions that are dominated by "low-risk" tree species.

This tool makes no attempt to prescribe which tree species should be classified as "low-risk", versus "high-risk". Risk assessment and tree classification must be done within a specific ecological and potentially economic context. Tree species risk assessment is fundamentally dependent on ecological land classification. For example, balsam fir is clearly a high-risk species in the southern ecoregions of the Maritimes, but significantly less of a risk in northern NB and at high elevations. Similarly, red spruce is at relatively lower risk in very cool, perhumid ecoregions-such as the Fundy ecoregions, but at a much higher risk in ecoregions with a more continental climate. Ultimately, tree species risk assessment is a moving target that needs to be managed within a context that acknowledges and accounts for the specific dynamics of the local ecological context.

Stand-Level Carbon Storage: Density and Age Structure Management

From the perspective of tree management in a stand (i.e. silviculture), maximizing carbon storage amounts to maximizing the density of a stand, over the longest period of time possible.

Stand Density Management and Thinning

Stand density is defined here by the total amount of tree vegetation in a stand. Basal area per unit area (e.g. m2/ha; ft2/ac) has a direct correlation with total tree biomass and can be efficiently measured and managed in an operational context. Therefore, stands with higher basal areas are generally storing more carbon than stands with lower basal areas.

Silvicultural systems that are designed to maximize wood fiber production deliberately maintain stands at relatively low densities (i.e. low basal area) in order to maximize growth rate. The cornerstone of managing stand density for maximum stand-level growth rates is thinning. Intensive thinning regimes can maintain a stand density that is incompatible with the carbon storage objective.

This tool is intentionally very cautious with its recommendation to thin a stand. Intensively thinned stands are artificially maintained at low densities in order to maximize growth rates. High density stands store more carbon. Therefore, one needs to be very cautious with thinning regimes if an objective is to maximize carbon storage.

Age Structure Management

Conceptually, the ideal carbon-storage stand is one with a high density, and with a structurally balanced mix of many distinct ages of trees (i.e. the balanced uneven-aged stand). In a perfectly balanced uneven-aged stand, the density and structure of a stand is stable over time. Therefore, by maintaining a balanced uneven-aged stand, one could theoretically store a defined amount of carbon in a stand indefinitely.

In practice, maintaining a balanced uneven-aged stand is easier said than done. Fundamentally, the maintenance of a balanced uneven-aged stand is dependent on continuous regeneration and ingrowth of desirable trees, and in this context, “desirable” would mean “low-risk” with respect to climate change resilience. There are few stands in the landscape where continuous recruitment of “low-risk” species is a reasonable expectation.

In practice, long-rotation irregular silvicultural systems are often more feasible than uneven-age systems. In general, to deliver on the carbon storage objective, this tool attempts to steer as many stands as possible towards either irregular or uneven-age silvicultural systems.

There are many climate change-resilient tree species that are not tolerant of shade. Many of these trees are also ideal for storing carbon, especially if they are long-lived and grow to great sizes (e.g. eastern white pine). In certain contexts it may be desirable to grow a stand dominated by these species. Stands that are dominated by species that are not shade-tolerant can be difficult, if not impossible, to manage using irregular or uneven-age silvicultural systems. Growing stands dominated by these species may require growing the stand to maturity and then regenerating the entire stand over a relatively short period of time, with a resultant temporary loss in carbon storage. In these situations, it is recommended that long-lived species are favored and that the stand is grown for as long a rotation as possible (at least 100 years), thus maintaining carbon storage over as long a period as possible.

Reserves Trees and Forest Soil Carbon

Large dead trees play keystone roles in forest ecosystems at the stand level. They are critical structures with respect to wildlife habitat, and as deadwood is eventually incorporated into the soil ecosystem it provides key structure and function to soil, as well as being a source of carbon storage.

Conventional intensive silvicultural systems, which are designed to maximize wood fiber production, are carefully regulated so that the trees are harvested long before they grow old and die. The intensive thinning regimes associated with intensive silviculture also prevent stands from entering natural stem exclusion stages where trees die due to stress and competition for growing space.

To manage for carbon storage, it is recommended that all silvicultural systems incorporate permanent "reserves" that are intentionally retained and allowed to complete their life cycles (i.e. "full-cycle trees"), which eventually decompose into the soil ecosystem. Even classical even-age silvicultural systems can be modified into two-age systems by simply selecting individual large trees at the end of the rotation to serve as permanent reserves (i.e. "full-cycle trees").

Old Stands with Unique Old Forest Conservation Value

In the Maritimes, there are stands that have unique old forest conservation value. The forests of the Maritimes have a history of more than 200 years of extensive, and increasingly intensive, timber harvesting. Over the past 40-50 years the predominant form of timber harvesting has produced stands that are dominated by a single age of trees. These young stands are typically grown to 40-80 years of age and then harvested and regenerated into another cycle of even-age growth. Increasingly (outside of protected natural areas), very few stands are allowed to continue growing into very old development stages. In some cases, these very old forest stands can only exist free of silvicultural treatment for long periods of time.

If a specific stand has unique old forest conservation value, which can only be maintained free of silvicultural treatment, it is recommended that the landowner consider managing the stand as a protected natural area and free of treatment.

Partnerships

In 2018, with support from the New Brunswick Environmental Trust Fund, Community Forests International contracted Gareth Davies to develop climate-adaptive silviculture prescriptions for the Wabanaki Forest Region and build a decision tree tool for forest professionals. In 2019, with a first draft of this supporting document and the prescriptions decision key both complete, Community Forests International partnered with the New Brunswick Federation of Woodlot Owners to continue refining these materials and to deliver capacity-building activities to forestry professionals. Additional support for this project was provided through Natural Resources Canada's Building Regional Adaptation Capacity and Expertise (BRACE) Program in 2019-2021.

Suggested Citation

Community Forests International. 2019. Climate Change Resilience and Carbon Storage Silvi cultural Prescriptions for the Wabanaki Forest Region v. 1.0.

Resource List

These publications informed the key concepts of the Climate Change Resilience and Carbon Storage Silvicultural Prescription Decision Tree and this Supporting Document:

Aubin I., Boisvert-Marsh L., Kebli H., McKenney D., Pedlar J., Lawrence K., Hogg E. H., Boulanger Y., Gauthier S., & Ste-Marie C. 2018. Tree vulnerability to climate change: improving exposure-based assessments using traits as indicators of sensitivity. Ecosphere 9(2):e02108. 10.1002/ecs2.2108

Janowiak M. K., D'Amato A. W., Swanston C. W., Iverson L., Thompson F. R. III, Dijak W. D., Matthews S., Peters M. P., Prasad A., Fraser J. S., Brandt L. A., et al. 2018. New England and Northern New York Forest Ecosystem Vulnerability Assessment and Synthesis: A Report from the New England Climate Change Response Framework Project. Newtown Square (PA): United States Department of Agriculture Forest Service.

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Janowiak M. K., Swanston C. W., Nagel L. M., Brandt L. A., Butler P. R., Handler S. D., Shannon P. D., Iverson L. R., Matthews S. N., Prasad A., & Peters M. P. 2014. A Practical Approach for Translating Climate Change Adaptation Principles into Forest Management Actions. Journal of Forestry, 112 (5), 424-433.

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Swanston C. W., Janowiak M. K., Brandt L. A., Butler P. R., Handler S. D., Shannon P. D., Lewis A. D., Hall K., Fahey R. T., Scott L., et al. 2016. Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers. 2nd ed. Newtown Square (PA): United States Department of Agriculture Forest Service.

Created as part of the Building Capacity of NB Woodlot Owners to Adapt to Climate Change project

A partnership among: