Canadian Council of Forest Ministers
Conseil canadien des ministres des forêts

A Canadian Council of Forest Ministers Climate Change Working Group Report

A Strategic Plan for the Advancement of National Climate-Sensitive Growth and Yield Modelling in Canada

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A Strategic Plan for the Advancement of National Climate-Sensitive Growth and Yield Modelling in Canada[1]

[1] Québec does not adhere to the objectives and actions contained in the Strategic Plan for Climate-Sensitive Growth and Yield Modelling, which aims to implement a national climate-sensitive growth and yield modeling initiative coordinated by the federal government. Québec assumes full responsibility for forest management on its territory, including adaptation to climate change and forest fire prevention. Québec is accountable to its citizens in its exclusive areas of jurisdiction and does not participate in pan-Canadian initiatives that limit its autonomy in this area.

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Photo credit: Pages 8 and 11, Michael Hoepting and page 9, Jeff Fera.

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EXECUTIVE SUMMARY

Growth and yield models, which are used to project the characteristics of individual trees or stands of trees over time and inform decisions about forest management and sustainability, are integral to a wide range of forest sector activities in Canada. These models are important for predicting and managing the wood supply, biomass supply, and other ecosystem services that forests provide. They help to inform decisions about harvest levels, silvicultural interventions, and other management actions that are needed to sustainably meet the demand for forest products and services. Growth and yield models are also critical for understanding and predicting the role of forests in sequestering carbon and mitigating climate change, as well as for assessing the impacts of climate change on forest ecosystems and the services they provide, such as wildlife habitat and other ecosystem functions.

Growth and yield models are currently unable to fully account for changes in climate and other environmental factors that are having significant impacts on tree growth, mortality, and recruitment. Climate-sensitive growth and yield models are needed to address this problem and increase the reliability of these models in a changing climate.

The Canadian Council of Forest Ministers (CCFM) is pursuing a collaborative, national level initiative to develop climate-sensitive growth and yield models. CCFM jurisdictions, namely the Canadian Forest Service (CFS) and the provincial and territorial forest management agencies, will each have specific roles in this initiative. The ultimate outcome is envisioned to be a national-level open-source approach, applicable in both managed and unmanaged forests, drawing from a diversity of approaches and models and having characteristics of interoperability, modularity, scalability, and complementarity with models developed by provincial and territorial forest management agencies. The initiative recognizes that open collaboration will be a key to success, given that one agency or research group working in isolation cannot solve this problem.

Achieving these goals will require activities such as research and development, data collection and analysis, model testing and validation, and capacity building. To ensure the success of this initiative, it will be important to consider adopting open-source code and open-source data philosophies. Making the data and the code openly available encourages collaboration and transparency, while ensuring that the results of this initiative are widely accessible and can be built upon by others. The use of open-source data and open-source code can also help increase the credibility and transparency of the work and can support the replication and testing of results by independent researchers.

The climate-sensitive growth and yield modelling initiative will help advance the understanding of how climate change is affecting forest growth or mortality in the present and how future forests will be affected by these changes. Developing more accurate and reliable growth and yield models will support the sustainable management of forest resources.

1. INTRODUCTION, MOTIVATION, AND BACKGROUND

Growth and yield models conceptualize complex relationships among tree growth, mortality, and recruitment. These models are critical to Canada's forest sector because they are used to project forest characteristics over time, and the resulting projections underlie all assessments of sustainability within the forest sector. Growth and yield models are integral to forest management planning (e.g., determining harvest levels) and are essential for exploring silvicultural options. They also fulfill a wider role in numerous other science and policy analyses, including climate change planning, carbon accounting, assessment of wildlife habitat, and economic analyses.

The growth and yield models that have to date received regulatory approval for use in forest management in Canada are unable to fully account for changes in climate and other environmental factors. Climate-sensitive growth and yield models are required if this situation is to be rectified. Forest responses to climate change are uncertain and may be negative, positive, or neutral, depending on the region and species of interest (Marchand et al., 2018). Increasing the capacity of growth and yield models to generate reasonable and defensible projections under various climate change scenarios will increase their utility. New growth and yield models should have the ability to alter rates of tree growth, mortality, and recruitment in response to changes in climate, atmospheric carbon dioxide (CO_2) concentrations, rates of atmospheric nitrogen deposition, and other factors.

The concepts of growth and yield refer to predictions of growth, mortality, and recruitment of individual trees or stands of trees using input data and a series of component equations (i.e., models). The models generate various outputs including, but not necessarily limited to, wood volume, biomass, ecosystem production, and harvested wood products. The models may express these results at the tree, plot, stand, or other aggregate level, and they may account for silvicultural interventions or natural disturbances related to forest health, such as defoliation or drought. In this context, the term "climate-sensitive" refers to the ability of a growth and yield model to adjust its projections based on changes in climate (e.g., temperature and precipitation), other environmental conditions (e.g., water balance, atmospheric CO_2 concentration, and nitrogen deposition), and/or other topographic or edaphic factors (e.g., slope, aspect, elevation, soil nutrients, and soil depth).

Provincial and territorial forest management agencies and the Canadian Forest Service (CFS) have undertaken research to advance climate-sensitive growth and yield modelling capacity regionally and nationally, but these efforts have not yet resulted in national-scale coverage. It is recognized that the magnitude of the problem is such that individuals or groups working in isolation will not succeed in addressing it. To accelerate the solution, the CCFM is pursuing a national-level growth and yield modelling initiative. This initiative will be complementary to and collaborative with modelling efforts already underway within provincial and territorial forest management agencies.

The current document presents a strategic plan that outlines a path to achieving this goal. It builds upon the input of the CFS, provincial and territorial forest management agency experts, who have universally supported the need for such an initiative. The plan first outlines the respective roles of the jurisdictional forest management agencies and the CFS and then sets out five relevant goals and the actions required to achieve them.

2. THE ROLE OF PROVINCIAL AND TERRITORIAL AGENCIES

The provinces and territories have constitutional jurisdiction for the regulation and management of forests on public (Crown) lands in Canada. Sustainable forest management is the primary driver of provincial and territorial growth and yield modelling programs. Operational growth and yield models approved for jurisdictional use are varied in construct, and they differ in terms of their input data, state variables, and scale (related to both time and space). In addition, models are more sophisticated in jurisdictions where forestry is of greater economic importance. Some jurisdictional agencies have started to develop components of a climate-sensitive growth and yield model, whereas others have only begun to think about this challenge. Some, but not all, will be capable of developing a jurisdictional climate-sensitive growth and yield model that concurrently fulfills the needs of national-level initiatives. Human and financial resources represent major constraints. The success of a national climate-sensitive growth and yield initiative will depend on collaboration with, cooperation of, and feedback from all provincial and territorial forest management agencies. The following points outline the anticipated roles of the provincial and territorial growth and yield modelling programs.

1. Continue maintaining and developing operational growth and yield models for use in forest and other natural resource planning, as required to meet legal and operational needs in the respective jurisdictions.

2. Continue open and cooperative dialogue with each other and with CFS researchers concerning CSGYM development.

3. When feasible, participate in workshops, discussions, and meetings of the CCFM jurisdictions, providing updates about jurisdictional programs relevant to national-level climate-sensitive growth and yield modelling.

4. Contribute data and/or model code to databases or archives to assist the national climate-sensitive growth and yield modelling initiative. Current examples include the Multi-Agency Ground Plot database for permanent sample plot data, the Canadian Forest Service Tree-Ring Data repository for tree-ring measurements (Girardin et al. 2021), and remotely sensed data such as airborne lidar, digital aerial photogrammetry, and high-resolution satellite imagery.

5. When possible, assist in the testing and assessment of future national models or models from other sources (e.g., academia) against provincial and territorial data and field observations, and provide feedback.

3. THE ROLE OF THE CANADIAN FOREST SERVICE

Multiple CFS programs require projections of tree and stand growth, mortality, and recruitment for Canada's forested regions. Examples include Canada's National Forest Carbon Monitoring, Accounting and Reporting System (Stinson et al. 2011; Metsaranta et al. 2017; Kurz et al. 2018), the National Forest Inventory, and the Fibre Solutions Program (delivered by the Canadian Wood Fibre Centre).

To date, the development of climate-sensitive growth and yield models within the CFS has been regional in scope or not fully implemented at the national scale. A strategic plan for climate-sensitive modelling of growth and yield will also help coordinate research and model development within the CFS, with the benefit of accelerating the development of the modelling tools required to support federally mandated projects. The CFS will have the following roles within a national climate-sensitive growth and yield modelling initiative:

1. To respond to the general needs of the broader forest sector for national-level climate-sensitive growth and yield projections.

2. To develop and maintain component modules for a climate-sensitive growth and yield projection system applicable to all forested regions in Canada in an open, transparent, and reusable format. This includes, but is not limited to, databases of field and remote sensing observations for model development and evaluation, and repositories of computer code for model development and implementation.

3. To coordinate research conducted by CFS staff that is relevant to the advancement of climate-sensitive growth and yield models in Canada.

4. To assist in coordinating federal research with research that is being done by the provinces and territories, academics, and other research groups and that is relevant to the advancement of climate-sensitive growth and yield models in Canada.

5. To openly share related knowledge and technologies with the provincial and territorial agencies, as well as with other federal government departments, and to work collaboratively with the researchers in those agencies and departments who are developing climate-sensitive growth and yield models for operational use. This includes sharing aggregated national-level data that complies all related data-sharing agreements.

4. GOALS AND RELATED ACTIONS

To further define the national climate-sensitive growth and yield initiative, a series of goals and related actions have been formulated.

Goal 1:

Develop and disseminate a clear definition of the national climate-sensitive growth and yield modelling initiative.

Related actions:

1. Agree upon a common mandate, vision, goals, and objectives, and update these elements as needed.

2. Develop a description of the management and organizational structure of the national climate-sensitive growth and yield modelling initiative. This description should specify where the initiative fits in relation to other national CFS programs and in relation to programs within the provinces and territories.

3. Obtain organizational approval and secure financial commitments from CFS and more broadly from the Government of Canada. Assist jurisdictional agencies, where desired and appropriate, in obtaining similar commitments from their organizations.

4. Actively communicate the mandate, vision, goals, and objectives of the initiative to a wider audience.

Goal 2:

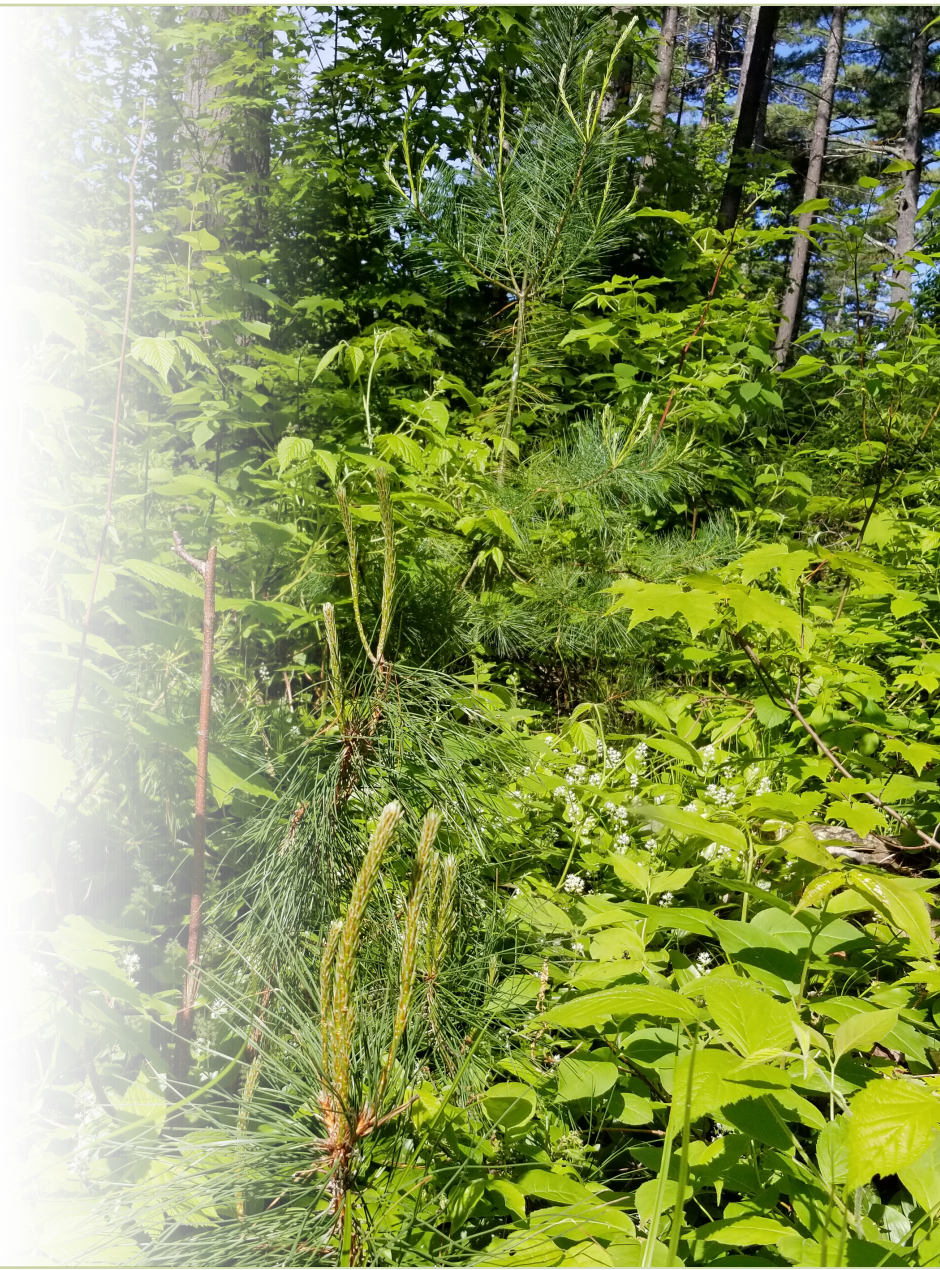
Formulate a list of objectives and develop a research strategy to achieve those objectives.

Related actions:

1. List and prioritize the needs of national-level programs in CFS, other government departments, jurisdictional forest management agencies, and potentially other partners that need climate-sensitive projections of forest growth. Update these priorities regularly and revise the specific objectives accordingly.

2. Formulate research strategies and work plans to achieve the stated objectives. This activity will include, but is not limited to, identifying the individuals or groups who will be responsible for advancing specific objectives, sharing, and reviewing work plans among groups, developing a reporting schedule, and identifying sources of funding.

3. Identify and communicate with groups or individuals who may not actively participate in model development but who nevertheless have an interest in climate-sensitive growth and yield modelling, for example, in establishing priorities for their own activities or tracking their progress through knowledge exchange activities.



Goal 3:

Develop and maintain the modular components needed to generate climate-sensitive projections of growth and yield at regional and national scales.

Related actions:

1. Identify candidate model and/or modular components needed to formulate a national-level growth and yield modelling system and undertake pilot projects upon which a national-level model can be built. This activity might include a suite of regional projects which, together, will inform national level modelling.

2. Identify the existing computing platforms through which users and developers access and run the modules, create new modules, or combine modules, favouring open-source code philosophies to facilitate effective collaboration and transparency.

3. Identify existing data sources that could be used in building, testing, and/or initializing models, and support efforts to standardize, compile, and make these data sources available, favouring open-source data philosophies to facilitate effective collaboration and transparency.

4. Seek out and/or establish best practice procedures for evaluating and validating models. Develop and implement upscaling and downscaling techniques (e.g., Fortin and Lavoie, 2022).

Goal 4:

Transfer knowledge and technologies.

Related actions:

1. Publish and transfer peer-reviewed and technical documents, including, wherever possible, relevant data sets and computer code used in the analysis.

2. Provide workshops and training sessions related to model use and development.

3. Develop and maintain the computing infrastructure required to develop, use, and maintain the national climate-sensitive growth and yield modelling system.

4. Provide timely technical support, if resources are available, to users of the national climate-sensitive growth and yield modelling system.

Goal 5:

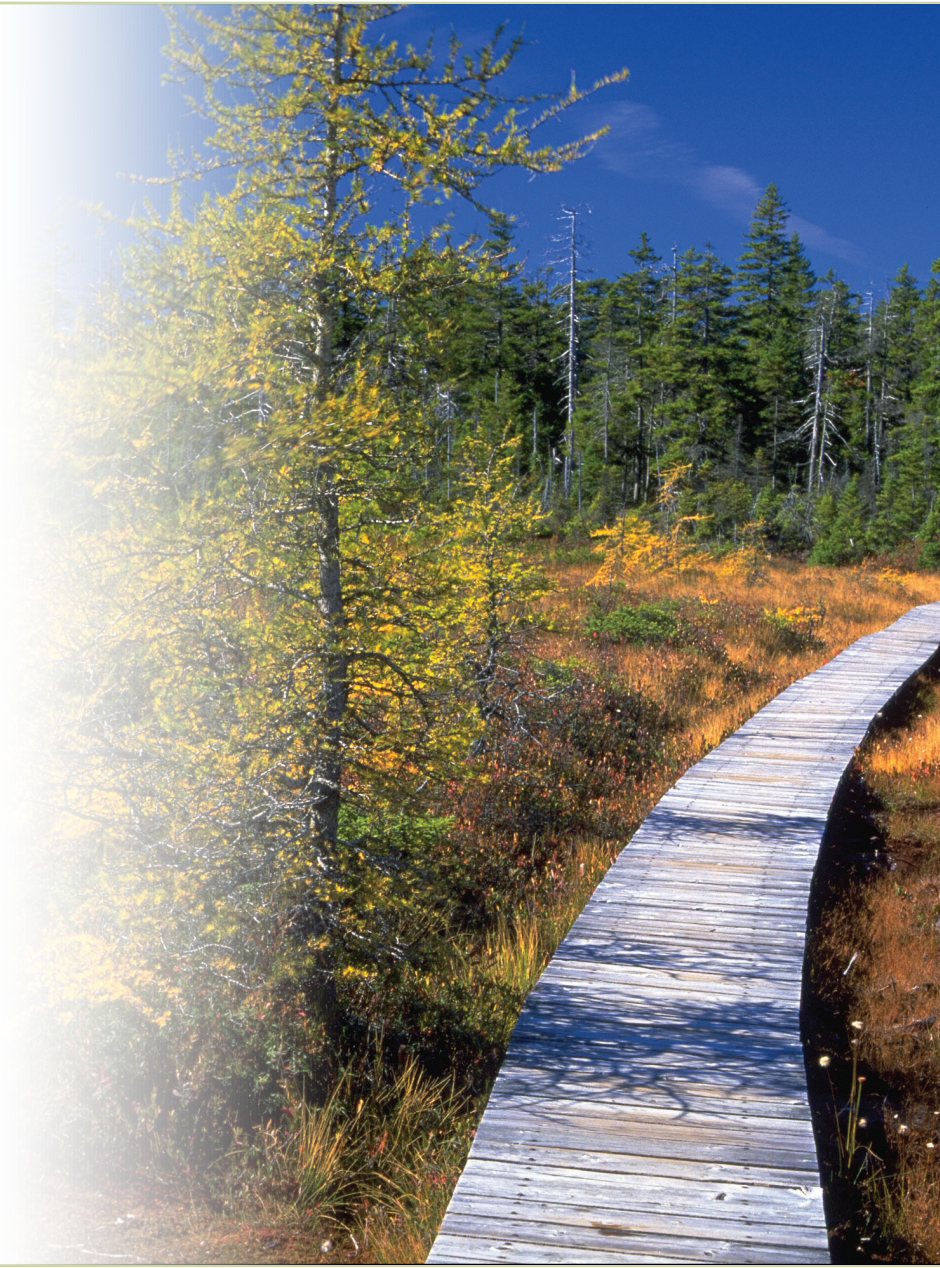
Engage among provinces, territories and the Federal Government with the broader science and resource management community.

Related actions:

1. Establish and maintain a working group of CFS, provincial and territorial growth and yield representatives for the purposes of sharing information and coordinating joint activities (as required and as appropriate).

2. Convene semi-annual group meetings, with other relevant parties as appropriate, to share information or for other specific purposes.

3. Develop and maintain the ability to market the initiative and share information with the broader science and resource management community through the most effective current communication channels (including traditional or social media).



5. SUMMARY

The following summary highlights the issues that must be addressed as well as the key contributions of the national climate-sensitive growth and yield modelling initiative:

- Projected changes in climate are likely to have a profound effect on forest productivity in Canada. It is therefore imperative that the growth and yield models forming the basis of forest management plans be able to account for the potential effects of climate and other environmental factors on forest growth.

- The main goal of the initiative will be to develop and maintain a national framework that accommodates and integrates the components of a climate-sensitive growth and yield model. Care will be taken to ensure that the outputs from the component models satisfy the needs of the various federal, provincial, and territorial programs that require projections of growth and yield.

- Researchers from national, provincial, territorial, and academic institutions have already made important advances with respect to the component models that are needed to generate climate-sensitive projections of growth and yield. Therefore, the scientists who will be a part of the climate-sensitive growth and yield modelling initiative will seek to form synergies and collaborate with those willing to contribute the knowledge and technologies needed to advance this national-level initiative.

- The products and knowledge produced through this national-level initiative are intended to be of benefit to all provincial, territorial, and academic institutions with an interest in climate-sensitive growth and yield projections. For this reason, a fundamental guiding principle of this initiative is that the knowledge and products developed should be accessible and freely available to all interested parties. This goal will be achieved through scientific publications, presentation forums, and the use of open-source code and data repositories.

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