



# Enhancing Forest Climate Change Mitigation And Adaptation in Canada

A Collaborative Research Agenda



CANADIAN FOREST SERVICE, NATURAL RESOURCES CANADA





Natural Resources  
Canada

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Canada

# **Enhancing Forest Climate Change Mitigation And Adaptation in Canada**

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# Enhancing Forest Climate Change Adaptation and Mitigation Strategies in Canada: A Collaborative Research Agenda

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## Executive Summary

In the past decade, Canada has witnessed an increasing frequency and severity of extreme natural disturbance events associated with climate change. This has led to heightened awareness of the importance of Canada's forested landscapes in sustaining resilient ecosystems, a strong economy and healthy communities. At the same time, the need for long-term action to reduce greenhouse gas (GHG) emissions has become ever more apparent, as has the necessity for the forest sector to play a role in GHG reductions. There is an urgent need for immediate and continued action, informed by research and scientific understanding, as well as Indigenous and local knowledge, to develop and implement climate change mitigation and adaptation strategies across Canada and the world.

The *Forest Climate Change Collaborative Research Agenda* will encourage and facilitate priority research and informed decision-making, science-policy integration and knowledge exchange, around topics that are of key economic and strategic importance to Canada. This agenda recognizes that climate change research and knowledge are critical to enabling sustainable forest management, the future bio- and circular economies, as well as healthy and resilient communities.

The agenda is ambitious and will not be realized without collaboration and partnerships to identify policy and priority research needs. Realizing the agenda also requires producing science and tools that are relevant, timely and useful. This agenda is intended to promote discussion and engagement, to help strengthen existing research efforts in Canada and strengthen collaborative relationships directed at forest climate change research.

## Acknowledgements

We extend thanks to the many organizations and individuals who have contributed to this *Forest Climate Change Collaborative Research Agenda*. There is considerable interest in advancing a collective response to the challenges brought on by climate change, exploring opportunities and developing solutions for Canada's forests, forest sector and forest communities. We look forward to continuing these partnerships and developing new ones as we work to implement the actions described in this agenda.

# Introduction

## Vision statement

Canada's forest ecosystems, communities and industries are resilient in the face of a changing climate, and contribute significantly to efforts to reduce future climate change

### Climate change and Canada's forests

Climate change presents one of the greatest challenges facing the world today. With its vast forested regions, Canada is already feeling the effects of the changing climate, and will face greater change with more significant challenges in the coming decades. Canada has some of the largest forested areas in the world (nearly 10% of the global forests and 30% of the boreal forest). How we manage forests and how we use wood must be part of efforts to reduce further global climate change.

Changing temperature and precipitation patterns are changing Canada's forests and increasing the risk and occurrence of disturbances such as fire, drought, flooding, wind throw and pest (insect and disease) outbreaks. Forestry operations increasingly contend with vast areas of disturbed forest, road wash-outs and narrower, less predictable windows of frozen ground for winter harvesting. Research utilizing integrated modeling approaches points to a likely future of increasingly severe disturbances, and maladaptation of some tree species in their current ranges.<sup>1,2</sup> As climate changes, managing for multiple values across Canada's forested landscapes is likely to become increasingly challenging.

At the same time, forest management in Canada is practised sustainably, informed by both ecosystem and socio-economic considerations. Canadians have a strong knowledge-base to draw from, with globally recognized scientific expertise, as well as Indigenous and local knowledge that can and does inform local and regional decision-making. Thus, we have an opportunity in Canada to lead globally by advancing and mobilizing our knowledge of forests as we respond to the challenges and opportunities presented by a changing climate.

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<sup>1</sup>Boulanger et al. 2017. Changes in mean forest age in Canada's forests could limit future increases in area burned but compromise potential harvestable conifer volumes. *Can J For Res*, 47(6): 755-764, <https://doi.org/10.1139/cjfr-2016-0445>

<sup>2</sup>Taylor et al. 2017. Rapid 21st century climate change projected to shift composition and growth of Canada's Acadian forest region. *For Ecol Man*, 405: 284-294 <https://doi.org/10.1016/j.foreco.2017.07.033>



## Forest ecosystems, communities and industries

Forests in Canada offer a wide range of values, from recreational, aesthetic, cultural, medicinal and spiritual values, to the provision of ecosystem services, natural infrastructure, and a wide array of forest products. The sustainable management of forests in Canada, through the leadership of private, public and non-profit organizations, involves considering the ways that Canadians value and benefit from their forests.

- **Ecosystems:** Forests provide many ecosystem services and benefits including those related to biodiversity, water, wildlife and global climate regulation;
- **Communities:** Forests and trees play a central role in the lives of many Canadian communities, socially, culturally, spiritually and economically; and,
- **Industries:** Forests are an important part of the Canadian economy, contributing to employment and local livelihoods and well-being, through the production of wood, pulp and paper, and non-timber forest products, such as hunting, fishing and recreation, tourism as well as growing components of the bioeconomy (e.g., bio-products and bioenergy).

### Climate change policy

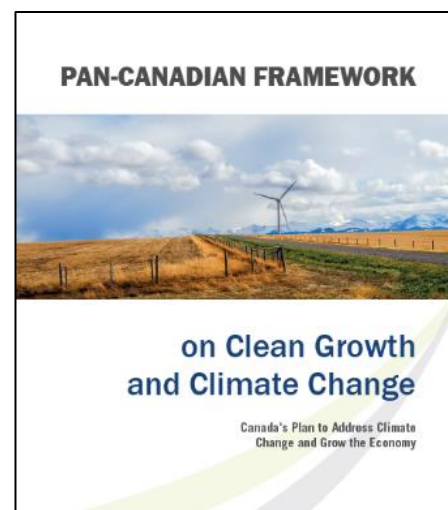
The objective of the 1992 United Nations Framework Convention on Climate Change ([UNFCCC](#)) is to stabilize greenhouse gas (GHG) concentrations “at a level that would prevent dangerous anthropogenic interference with the climate system.” Negotiations have taken place since 1994 and this objective has become the basis for emission reduction targets, mitigation policies and initiatives worldwide, including the 2015 [Paris Agreement](#). The Paris Agreement establishes the goal of limiting global temperature rise to well below 2°C compared to the pre-industrial era. Signatory countries are required to establish targets to limit emissions and to further reduce emissions thereafter. Like Canada, most signatory countries have set targets for 2030. The aim of the agreement is to achieve net-zero global emissions in the second half of the century. Canada, like most countries, recognizes that actions involving forests will be needed to help achieve these targets.

[The Pan-Canadian Framework on Clean Growth and Climate Change](#) (PCF) articulates priorities for federal, provincial and territorial governments taking action on climate change. The PCF is central to Canada’s strategy to meet its emission reduction targets under the Paris Agreement and for cooperative action on adaptation to climate change. Governments that adopted the PCF committed to take the following actions in support of climate change mitigation:

- Increase stored carbon by protecting and enhancing carbon sinks;
- Increase the use of wood for construction;
- Generate bioenergy and bio-products; and,
- Advance innovation in GHG-efficient forest management practices.

These governments also committed to the following actions to support adaptation and increase climate resilience:

- Translate scientific information and Indigenous Knowledge into action;
- Build climate resilience through infrastructure;
- Protect and improve human health and well-being;
- Support particularly vulnerable regions; and
- Reduce climate-related hazards and disaster risks.





The objectives and actions identified in the PCF provide a valuable compilation of cross-jurisdictional climate change priorities for forest management and forest ecosystems, communities and industries in Canada. The PCF also recognizes that respectful collaborations involving multiple levels of government, Indigenous Peoples and communities are critical for success.

Provinces and territories have jurisdictional authority over most forests in Canada. The federal government has a shared interest with provincial and territorial governments in many areas that touch forest ecosystems, communities and industries, many of which have broad implications for climate change, such as:

- Research and development;
- Indigenous rights;
- Regional and community economic development; and
- Health and safety.

For these reasons, forest climate change research requires a great deal of coordination, consultation and cooperation among those involved in forest management and stewardship.

The Canadian Forest Service of Natural Resources Canada (NRCan-CFS) provides science and policy expertise as well as advice on national forest sector issues. To do so, NRCan-CFS works closely with other federal departments and agencies as well as other partners, such as provincial, territorial and Indigenous governments, industry, non-governmental organizations and communities.

The [Canadian Council of Forest Ministers \(CCFM\)](#) provides an important forum for the federal, provincial and territorial governments responsible for forests to work cooperatively to address national issues. [A Vision for Canada's Forests: 2008 and Beyond](#), identified key priorities for CCFM, including climate change mitigation and adaptation.

*“A changing climate is one factor that will provide opportunities for and present major threats to Canada’s forests, their economic benefits, and the livelihoods of those who depend on them.”*

- Canadian Council of Forest Ministers<sup>3</sup>

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<sup>3</sup>CCFM. 2019. Climate Change. <http://www.ccfm.org/english/coreproducts-cc.asp> (accessed May 23, 2019).

## A Collaborative Research Agenda

### Mission statement

NRCan-CFS will mobilize efforts to address critical knowledge gaps, accelerate innovation and support decisions to enable effective management and stewardship of Canada's forests in response to climate change. This will be accomplished through the following three actions:

- **Collaborate:** Connect collaborators and build partnerships to identify the issues and questions that need to be addressed and develop cohesive efforts to research and implement solutions.
- **Generate new knowledge:** Advance and leverage science and technology to fill critical knowledge gaps, accelerate innovation, and inform decision-making.
- **Integrate and apply knowledge:** Deliver integrated knowledge, research, tools and information to understand and implement effective mitigation and adaptation actions, and to evaluate their long-term impacts.

### Why develop a collaborative research agenda?

Over the past decade, there has been notable progress in our understanding of climate change impacts, adaptation needs and measures, and mitigation strategies. Research efforts in Canada have built a significant body of knowledge about forest carbon and how human activity and natural factors affect it. We know that how we manage Canada's forests and use wood products can contribute to mitigation efforts. Adaptation strategies and tools are available to reduce vulnerabilities and build resilient forest ecosystems, communities and industries. The long-term health of forest ecosystems, communities and industries depends on further developing this research to inform responses to climate change.

For Canada's forest ecosystems, communities and industries to respond to climate change, we need to mobilize our collective expertise, knowledge and capacity to develop targeted solutions. Further advances in scientific knowledge, integration of natural, social, economic and technological research, as well as Indigenous and local knowledge, are all essential ingredients for informed policy development and decision-making.

In 2012, a [Blueprint for Forest Carbon Science in Canada 2012-2020](#), with contributors from across the forest sector, established priority areas of work related to forest carbon and mitigation. This agenda provides an update to the 2012 blueprint as it reflects new policy developments, and expands the scope of science considered to address all forest climate change research needs.

Collaboration will be essential to achieving results. No single organization has the capacity to address the full spectrum of research, knowledge and extension services needed to enable climate change responses. Coordinated efforts and co-developed solutions will help identify and fill knowledge gaps and generate relevant and useful decision support tools. This agenda serves as a contribution to this effort from the NRCan-CFS, having conducted a series of engagement conversations with our own researchers and policy-makers and a variety of forest climate change collaborators and partners. While this agenda charts a course, it is one that will evolve as we engage further across Canada about the research needed to address forest climate change. This agenda will be revisited and updated over time as more is learned and as the socio-political context for climate change policy and practice changes.

## EXAMPLES OF WHAT WE HEARD: Forest Climate Change Research Needs



NRCan-CFS engaged with many individuals, agencies, governments and industry groups to identify the strategic priority issues and knowledge gaps reflected in this agenda. NRCan-CFS will continue to work with collaborators and partners to facilitate research that addresses these priorities, while providing support for the sharing of research findings and the application of research into practice and policy.

## Themes, Outcomes and Actions

### Theme 1:

#### The Role of Forests in Climate Change Mitigation

**Outcome 1.1:** Canada's forest carbon and greenhouse gas changes are accurately tracked and reported.

**Outcome 1.2:** Canada's forest management practices contribute significantly to medium- and long-term GHG emission reductions.

### Theme 2:

#### Climate Change Resilience and Adaptation

**Outcome 2.1:** Climate change impacts are understood in the context of likely future climate scenarios.

**Outcome 2.2:** Canada's forest ecosystems, communities and industries are resilient and adapt to climate change.

### Theme 3:

#### Integrated Solutions for Applied Climate Science and Knowledge

**Outcome 3.1:** Integrated solutions that optimize both mitigation and adaptation.

**Outcome 3.2:** Effective partnerships and applied climate science that enables mitigation and adaptation.

## Theme 1: The role of forests in climate change mitigation

### Outcome 1.1: Canada's forest carbon and greenhouse gas changes are accurately tracked and reported

Under the United Nations Framework Convention on Climate Change (UNFCCC), Canada must monitor, understand and report on how human activity is affecting its forest carbon and greenhouse gas (GHG) emissions and removals in the managed forest, from harvested wood products and from relevant land-use change (afforestation and deforestation). Estimates are included in Canada's GHG inventory report submitted annually to the UNFCCC. Estimates are also needed to show the impact of natural disturbances (e.g., wildfire or insect infestations) on managed forest emissions and removals. Federal reporting is done alongside that of provincial and territorial governments and others who also need to understand and report on their respective forest-related emissions and removals. Assessments of Canada's forest carbon are also required for other purposes, such as for national and provincial/territorial State of the Forest reports.

Research is needed to improve our knowledge and models of how management activities and natural processes affect forest carbon. Models can be applied to project scenarios of potential changes in forest carbon in the future, incorporating both anticipated rates of climate change and human activities that directly impact forest carbon. We also need research and modelling efforts to better understand what is happening to carbon across Canada's non-commercial forest ecosystems, including northern forests and forested peatlands. Improved understanding of how forest disturbances and human activity affect albedo and other aspects of the energy and hydrological cycles that influence climate is needed. Spatial and temporal detail in research and modelling will help improve our understanding, and can be especially important in exploring mitigation options (see *Outcome 1.2*).

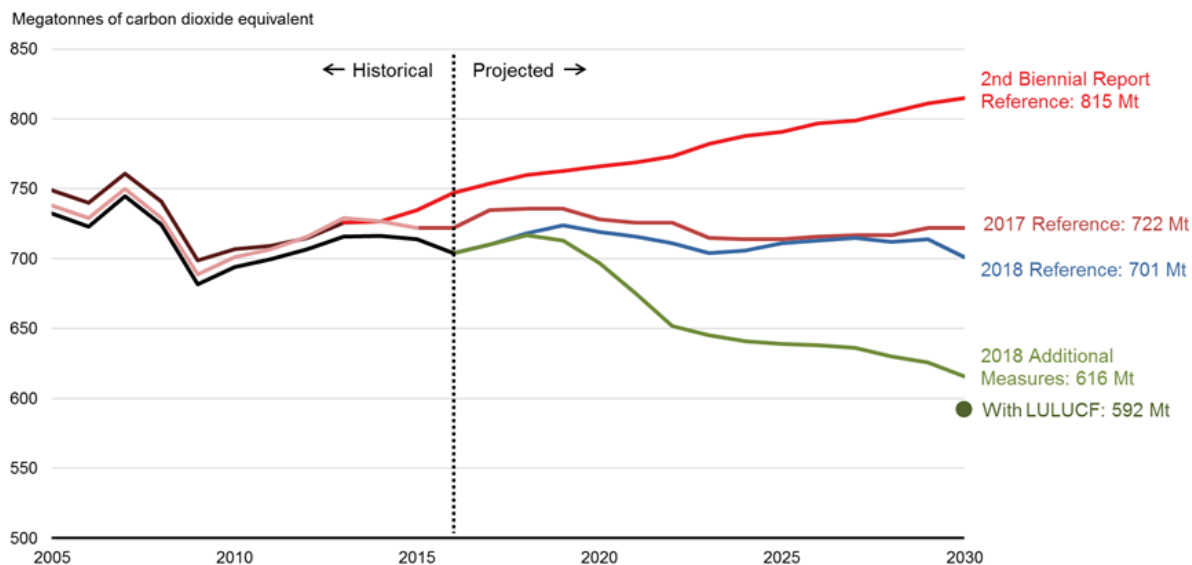
A spatially-explicit and authoritative carbon budget model, underpinned by research that calibrates its operations and validates its outputs, is necessary to meet on-going reporting requirements and to understand how forests can best contribute to climate change mitigation efforts. The Carbon Budget Model used by the Canadian Forest Service is the basis for a more flexible, spatially explicit Generic Carbon Budget Model that is currently under development.

#### **Knowledge gaps:**

- Improve understanding of major influences on forest carbon across time and space, including forest management activities, natural processes and climate feedback mechanisms, such as projections of the potential effects of a changing climate on forest carbon dynamics.
- Expand knowledge of carbon dynamics and develop spatially explicit carbon budget estimates for diverse forested landscapes across Canada, both managed and unmanaged, including forested peatlands and permafrost areas.
- Improve the representation of carbon pools and processes in the Generic Carbon Budget Model (GCBM) and other forest carbon modelling, reflecting available sources of monitoring data and developments in scientific knowledge.
- Fully develop the spatially explicit GCBM and use it to produce annual forest-related estimates and projections for reporting and policy assessment.
- Enhance spatially explicit carbon estimates and projections that can track ecosystem responses to management actions, including actions intended to address adaptation and mitigation objectives.
- Advance understanding of how forest disturbances and human activity affect albedo and other aspects of the energy and hydrological cycles that influence climate.

#### **Outcome 1.2: Canada's forest management practices contribute significantly to medium- and long-term greenhouse gas emission reductions**

Research indicates that to attain the Paris Agreement goal to limit global average temperature increases to well below 2°C will require removing more carbon dioxide from the atmosphere than is emitted or net-negative GHG emissions by the second half of the 21st century. Under the Paris Agreement, Canada has committed to reduce GHG emissions to 30% below the 2005 level by 2030 (less than 513 Mt), and we will need even greater reductions after 2030 (Figure 1). Enhancing GHG removals by way of terrestrial ecosystems, including forests, is an obvious mechanism to help achieve this goal.



**Figure 1:** Achieving Canada’s 2030 emission reduction goal will be challenging. The red line shows projected emissions based on policies in place as of September 2015, the brown line shows projected emissions based on policies in place as of September 2017, the blue line shows projected emissions based on policies in place as of September 2018, the green line shows projected emissions based on additional measures announced but not yet implemented as of September 2018, and the green dot shows the projected emissions for 2030 if land use, land use change and forestry (LULUCF) are considered. Based on these projections forests are expected to help Canada meet its Paris Agreement target. Source: <https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/progress-towards-canada-greenhouse-gas-emissions-reduction-target.html>

Through its mitigation actions, Canada’s forest management activities will help meet these targets. Collective efforts by governments and others will be needed to develop effective policies and practices, and to implement actions on the ground. British Columbia’s Forest Carbon Initiative is a good example of a substantial program designed to increase carbon storage and reduce emissions by regenerating areas burnt by forest fires, killed by Mountain Pine Beetle or otherwise degraded.

Stronger action requires advancing our collective understanding of mitigation activities involving both how we manage the forest and how we use wood. This means understanding which forest management activities at a regional or local level can best contribute to mitigation goals, while considering costs, social acceptability, and trade-offs or synergies with other objectives of sustainable forest management. It means being able to quantify and assess the impacts on GHG emissions when wood is substituted for other materials or fossil fuels. We also must develop a broader, shared understanding of the potential mitigation impacts of bioenergy.

#### Knowledge gaps:

- Assess biophysical and socio-economic outcomes of a range of mitigation strategies and implementation options (e.g., forest management practices, afforestation, reducing deforestation, use of harvested wood products and substitution effects).
- Improve understanding of the use of forest biomass in lieu of fossil fuels and other products, in terms of the sustainability of forest biomass harvesting, competing uses for biomass and its availability, the economics of use and the quantification of GHG impacts.
- Research policy implications and options for implementation of mitigation strategies, such as changes in forest practices or offset project crediting involving forests or the use of wood.
- Integrate forest carbon considerations into research and modelling of landscape-scale cumulative effects.
- Monitor and quantify the early impacts of mitigation actions, including assessment of policy mechanisms and effects on carbon, albedo, water balance and other climate influencing factors.
- Quantify and compare actual and projected future GHG balances that reflect implementation of mitigation actions to better understand the impact of those actions.

- Increase understanding of how biogeophysical mechanisms that influence regional climate, including albedo and water balance, can be managed for the purpose of mitigation, and develop combined GHG and non-GHG impact assessments of these integrated strategies.

*“As Canada faces the challenge of reducing greenhouse gas emissions (GHGs), healthy Canadian forests and forest products obtained from them will have a vital role to play in the transition to a greener low carbon economy.”*

- Forest Products Association of Canada<sup>4</sup>

## **Theme 2: Climate change resilience and adaptation**

*“Changes in climate can potentially have widespread direct and indirect effects on people's physical, social and mental health and well-being.... The burden of these health issues is anticipated to increase as the changes in climate advance in the absence of further adaptations.”*

- Public Health Agency of Canada (PHAC)<sup>5</sup>

### **Outcome 2.1: Climate change impacts are understood in the context of likely future climate scenarios**

Unprecedented levels of greenhouse gases (GHG) are already in the earth’s atmosphere and will drive further warming and increase the occurrence of extreme events. Consequently, even successful and dramatic mitigation efforts will not diminish the need for adaptation. The effects of climate change on forest ecosystems, communities and industries are proving to be multi-faceted and complex. Changes in temperature and precipitation patterns are affecting seasonal dynamics, with effects on soil and water processes, productivity and biodiversity. Disturbance regimes (e.g., fire, insect and disease outbreaks, droughts and flooding) are also affected by a changing climate. These biophysical changes are accompanied by socio-economic changes as the forest sector and others are forced to adjust their behaviours in response to changing and less predictable ecosystems.

To inform responses to climate change, we need to improve how we track the ongoing changes that occur in our forests as well as our ability to forecast the effects of these changes. Developing projections of both trends and uncertainties requires functional knowledge of both ecosystems and socio-economic systems to develop and refine integrated models of future landscape change. Improved understanding of current and future changes to Canada’s forests, at the spatial scales needed by decision-makers, will inform and enable agile responses to change.

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<sup>4</sup> FPAC. 2016. 30 by 30 climate change challenge. <http://www.fpac.ca/sustainable-forestry/30by30/> (accessed May 23, 2019).

<sup>5</sup> PHAC. 2014. The Chief Public Health Officer’s report on the state of public health in Canada 2014 – public health in a changing climate. <https://www.canada.ca/en/public-health/corporate/publications/chief-public-health-officer-reports-state-public-health-canada/chief-public-health-officer-report-on-state-public-health-canada-2014-public-health-future/public-health-in-a-changing-climate.html> (accessed May 23, 2019).



Understanding and monitoring climate change impacts can take many forms, including targeted experimentation, combined empirical and modeling initiatives, and systematic monitoring and tracking systems for key indicators of change. Projections of important variables such as drought, annual area burned by wildland fires or growing season length are needed to better inform decision-making. Tracking both biophysical and socio-economic indicators will provide a baseline for assessing adaptation results, help increase awareness of the need for developing adaptation strategies and help guide investments to create the capacity for adaptation.

[The Canadian Centre for Climate Modelling and Analysis](#) in Environment and Climate Change Canada develops climate models that are used to predict changes globally and regionally over different timescales. Climate models support broader climate change adaptation and mitigation research in Canada. They also help improve overall understanding of the climate system.

#### Knowledge gaps:

- Advance understanding of the drivers of forest ecosystem functions and services, and the effects of climate-related change, including effects on productivity, biodiversity, hydrological and biogeochemical cycles (*see also Outcome 1.1*).
- Improve the accuracy and use of both climate change and adaptation indicators and other tracking and monitoring approaches through the integration of existing data, research and modeling efforts and assessment of utility for end-users.
- Further develop modelled projections of forest landscapes across Canada under plausible climate change scenarios, providing increased understanding of trends, thresholds and uncertainties.
- Employ integrated modeling, earth observation technologies and geo-spatial visualization to produce maps and other tools for decision-makers to represent the projected effects of climate change on forests at different temporal and spatial scales.

*“The impacts of climate change are already being felt by the forest industry as winters become shorter and the operable time for winter blocks is reduced. For harvest operations, excessive rutting poses the greatest risk, and frequently forces operations to move to another block or shut down altogether.”*

- FPInnovations <sup>6</sup>

#### **Outcome 2.2: Canada’s forest ecosystems, communities and industries are resilient and adapt to climate change**

Current and future climate-driven changes to forest landscapes pose both risks and opportunities. As we increase our understanding of biophysical and socio-economic changes in Canada’s forest ecosystems, communities and industries as a result of climate change, extension services and programs are needed to bridge the gap between research, policy and practice. Adapting to a changing climate is essential for mitigating the potential risks to the forest sector, and also for realizing the potential benefits from opportunities that may arise from changing landscapes, economies or behaviours.

Tools, such as vulnerability and risk assessments, are important for communities wanting to invest limited resources to address their priority risks and increase their resilience to climate change. Such adaptation measures require awareness and knowledge, human and financial capacity, expertise and long-term commitment. Securing this commitment can be supported by improving awareness and understanding of trade-offs, including the costs of inaction. The translation of research and knowledge into action can often encounter competing priorities and policy limitations, and work is needed to understand and eliminate these barriers to action. Additionally, new and innovative adaptation strategies that enable the forest sector to capitalize on

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<sup>6</sup> FPInnovations. 2018. Adapting forest operations to climate change. <http://blog.fpinnovations.ca/blog/2018/05/07/adapting-forest-operations-to-climate-change/> (accessed May 23, 2019).

opportunities in the face of climate change are needed. The development and evaluation of alternative strategies will be an important focus for researchers, policy analysts and practitioners in the coming decade.

Genomics tools will play a critical role in responding to climate change. Forest genomics research will help ensure that the right trees get planted in the right climatic areas, improving the long-term health of forests and generating economic benefits valued at hundreds of millions of dollars every year.<sup>7</sup> Moreover, genomics will be critical to the bioeconomy, introducing new biological green technologies to replace chemically- or energy-intensive ones.

Effective development and implementation of adaptation measures require collaboration and co-creation between researchers and end-users. Tools often need to be developed or adapted with the help of local experts and end-users to be both relevant and practical for specific circumstances. Integrating biophysical and social science research is a key element of this process. We need to improve our collective understanding of the social dynamics that shape decisions and actions related to forest and forest management adaptation, and improve meaningful knowledge exchange with end-users and communities (*see Outcome 3.2*). Engaging broadly on adaptation strategies will ensure varied and unique insights that promote innovation and social acceptance of climate change responses.

#### **Knowledge gaps:**

- Generate new knowledge to facilitate the development of adaptation strategies for sustainable forest management under a changing climate, including the use of silviculture practices, changing species, rotation length, genomics and climate-modified wood supply modelling.
- Undertake collaborative, regionally-based projects to better understand the effects of climate change and bring together diverse perspectives and expertise to develop, implement and evaluate adaptation strategies.
- Engage with end-users to improve existing adaptation tools, increase their utility and establish needs for the development of new adaptation tools and resources.
- Explore opportunities and priorities with end-users to partner on adaptation efforts within vulnerable regions, such as northern and remote communities.
- Assess and learn from previous and existing adaptation efforts, evaluating results, sharing knowledge, best practices and lessons learned.

### **Theme 3: Integrated solutions for applied climate science and knowledge**

*“The complex and protracted nature of some issues such as eutrophication, the global scope and scale of issues such as air pollution, climate change and loss of biodiversity and the increasing need for multidisciplinary approaches require new ways of thinking and doing.”*

- Environment and Climate Change Canada<sup>8</sup>

#### **Outcome 3.1: Create integrated solutions that optimize both mitigation and adaptation**

Adaptation and mitigation strategies are typically designed to independently address their respective objectives. However, the most effective forest sector response to climate change considers both simultaneously. Identifying and implementing activities that address both priorities in tandem will take advantage of synergies and address trade-offs. Integration of adaptation and mitigation research is required to bridge the gap and to ensure that policies and practices are efficient.

Mitigation and adaptation not only need to be integrated, but also mainstreamed into existing policies, plans, practices and standards of sustainable forest management across Canada’s forested landscapes. The outcomes of such an approach can be far-reaching and profound. Forest-based, rural and northern communities can build

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<sup>7</sup> <https://www.genomecanada.ca/en/why-genomics/genomics-sector/forestry/tomorrows-trees>

<sup>8</sup> Environment Canada. 2014. Environment Canada’s Science Strategy 2014-2019. <https://www.canada.ca/en/environment-climate-change/services/science-technology/publications/strategy-2014-2019.html> (accessed May 23, 2019).

resilience through the smart design of urban and natural infrastructure, specifically engineered for climate change, while reducing insurance losses and financial risk. An innovative forest sector can realize clean growth through new bioeconomy initiatives and opportunities. Multi-disciplinary research, Indigenous science and knowledge, citizen science and local knowledge can work collectively to build trusted, credible and practical solutions for mitigation and adaptation action. For example, enhanced FireSmart fuel treatments could help communities reduce fire risks, prevent fire greenhouse gas (GHG) emissions and could feed new bioeconomy initiatives that would also reduce GHG emissions.

In addition to integrating mitigation and adaptation actions, other values associated with sustainable forest management and forest landscape stewardship must also be considered. Forest managers seek to balance the provision of a range of goods and services for society, including economic, ecological, spiritual and cultural benefits. Better understanding how management priorities and trade-offs may change will require an increased understanding of how different forest management practices and interventions would address climate change objectives, and the effects that these actions may have on other environmental, social and economic values.

#### **Knowledge gaps:**

- Increase knowledge and understanding of joint mitigation and adaptation actions, including synergies and trade-offs between them and interactions with other sustainable forest management goals.
- Develop integrated mitigation and adaptation strategies that can be tailored to account for regionally-scaled scenarios of future climate change and forest disturbance dynamics.
- Improve research management and policy approaches to incentivise collaborative and integrated research.
- Update decision support tools, including web-apps and multi-criteria visualization tools, to provide decision-makers with informed options around integrated mitigation and adaptation strategies in the context of sustainable forest management.
- Advance research and understanding of the barriers to implementation of joint mitigation and adaptation strategies in sustainable forest management, and how to overcome them.
- Support efforts to integrate joint mitigation and adaptation measures into multi-sector landscape planning, including incorporation into certification standards.

*“Knowledge of climate change impacts can be incorporated throughout the planning cycle; early adaptation offers the potential to both minimize negative impacts, as well as maximize opportunities associated with a changing climate.”*

- The Ontario Centre for Climate Impacts and Adaptation Resources<sup>9</sup>

### **Outcome 3.2: Effective partnerships and applied climate science that enables mitigation and adaptation**

Partnerships and collaboration will help to ensure that knowledge production is informed by the needs of its users and is made available to those who can use it. Many organizations conduct monitoring, collect data or engage in research and knowledge exchange concerning forests and climate change. Using a systems approach to building stronger partnerships across multiple levels of government, economic sectors and research institutions will help to build upon existing science and technology applications to address current and emerging needs in a practical and impactful way. More extensive and deeper collaboration will improve the exchange of information and knowledge from a diversity of perspectives, and ultimately strengthen our collective capacity to meet the challenges of climate change.

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<sup>9</sup> OCCIAR. 2017. Climate Change Impacts and Adaptation in Ontario’s Forestry Sector. [http://www.climateontario.ca/doc/RACIII/Forestry\\_Final.pdf](http://www.climateontario.ca/doc/RACIII/Forestry_Final.pdf) (accessed May 23, 2019).

This strengthening of relationships, co-creation of research, collaboration and knowledge exchange are prerequisites to achieving the other outcomes outlined in this research agenda. Addressing science and knowledge gaps, developing common data standards and better coordinating monitoring efforts and communications will help research translation and technology transfer. To improve efficiency, accommodate multiple users and ensure access, a multifaceted approach will be required to effectively share data, tools and information and to provide extension services to advance mitigation and adaptation efforts.

The application of climate change science into practise requires extension services, enabling consortia of knowledge producers and users to work together to adopt climate solutions. Tools that can be tailored to suit local needs must be coupled with a service model that facilitates their use and effectiveness, and creates the necessary conditions for actions across Canadian communities.

[The Canadian Centre for Climate Services](#) (CCCS) is a resource offered by Environment and Climate Change Canada that provides the public with access to climate change information. They collaborate - with other government departments and regional climate organizations in order to provide locally-relevant information.

### Knowledge gaps:

- Explore existing knowledge exchange network approaches that could be expanded to increase sharing of forest and climate change-related data, tools and information with a diverse audience of users and citizens.
- Find avenues for communication and knowledge exchange with education partners including public schools and community colleges, and with the general public including through citizen science activities.
- Participate in knowledge exchange activities and partnerships with Indigenous governments, organizations and communities, recognizing Indigenous rights to territories, resources and knowledge.
- Develop research management and policy approaches that embed the practices and evaluation of co-creation, learning, knowledge exchange and capacity-building.
- Build a forest climate change extension services model that supports the production of critical knowledge and decision-support tools and facilitates their use across the Canadian forest sector and forest communities.

*“There is a need for federal departments to work with First Nations as full partners and to redouble efforts to address the climate crisis in a holistic, multi-dimensional, and interconnected way.”*

- First Nations-Canada Joint Committee on Climate Action<sup>10</sup>

*“International Collaboration is critical to share knowledge about a changing climate. Canada should increase scientific outreach and knowledge exchange with other northern temperate forest countries around the world.”*

- Forest Products Association of Canada<sup>11</sup>

## Enablers of the Agenda

The successful execution of our forest climate change research agenda requires good planning and governance. Governance is needed to enable the research and knowledge-sharing, facilitate information dissemination and translate research into policy, practices and actions.

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<sup>10</sup> First Nations-Canada Joint Committee on Climate Action. 2019. First Nations-Canada Joint Committee on Climate Action Annual Report to the National Chief and Prime Minister.

<sup>11</sup> FPAC. 2016. Forest Industry submission to the public consultation about the pan-Canadian framework on clean growth and climate change.

The National Forest Sinks Committee (NFSC), and the Forestry Adaptation Working Group (FAWG), established under [Canada's Climate Change Adaptation Platform](#) (Adaptation Platform), provide existing mechanisms for knowledge-sharing and partnership development that can be leveraged and expanded to support the outcomes described in this research agenda. Periodic review of issues and priorities of the NFSC, the FAWG, the Canadian Council of Forest Ministers (CCFM) and other forest-focused fora, will be used to inform and update this evergreen agenda. Such reviews could to ensure that the use of this agenda remains current and responsive to our collective needs and priorities. We will also continue to engage with international partners and organizations to position our work within a global context.

Beyond the forest community in Canada, many others play important roles in enabling the achievement of the outcomes described in this agenda. We will work to continually align our priorities and find collective solutions across federal departments, other governments and the many agencies and organizations that can support landscape-based, integrated climate change solutions in Canada. Working in close partnership with Environment and Climate Change Canada, the lead federal department on climate change policy and science, will be critical.

The federal government, provincial and territorial governments, Indigenous governments and organizations and municipalities all have leadership roles in addressing climate change in Canada. Engaging with research granting agencies, universities, non-governmental organizations and industries will contribute to integrated landscape management and climate change solutions, and to an adaptive and integrated systems approach to achieving our climate change goals.

#### **Governance actions:**

- Find common interests and organizational strengths, develop new collaborations and enhance existing ones.
- Identify and prioritize key issues to be addressed.
- Accelerate the uptake of research results through effective communication and knowledge exchange.
- Periodically update and expand on this national research agenda to reflect advances in science and technology, evolution of forest sector needs and the building and strengthening of new and existing partnerships.

## **Conclusions**

The Canadian Forest Service of Natural Resources Canada (NRCan-CFS) will pursue and convene others to address the science and knowledge gaps described in this research agenda with our partners and collaborators. Also, NRCan-CFS will continue to build and adapt the agenda to ensure it remains relevant and impactful. In this way, we will strive to benefit all Canadians, and to help position Canada as a world leader in addressing climate change.

We hope to have impact well beyond forests and forestry to integrate multiple resources management and values at multiple scales. Given the reality that climate change touches every one of us, working together will lead to rewarding and lasting outcomes that are felt across sectors, landscapes and communities. By encouraging a collaborative systems approach, we envision producing impactful results, including:

- Improved integration of environmental, economic, legal and social considerations in shaping climate change research, deliverables and knowledge transfer;
- Increased investment in research, knowledge exchange and technology transfer on climate change mitigation and adaptation at multiple scales;
- Heightened local awareness of climate change risks, community capacity and informed mitigation and adaptation responses in urban and rural environments across Canada;
- Strengthened climate-informed standards for urban and forest landscape planning, forest certification, professional practices, building codes and infrastructure design and engineering;
- Enhanced regional economic development through bioeconomy innovations, mitigation and adaptation responses;

- Established societal benefits including in areas of public safety and disaster risk reduction, human health and well-being and food, fuel and fibre security;
- Demonstrated economic benefits across sectors, including insurance rate and financial risk reduction, a diversified bioeconomy and climate-responsible resource development at the landscape scale.

Climate change is having significant effects on resource sectors, landscapes and communities across Canada, and around the world. Strategic investment paired with effective coordination and collaboration will ensure that the capacity and expertise of multiple organizations are leveraged to advance mitigation and adaptation efforts. Ultimately, we will achieve significant positive impacts for Canadian forests, forest communities and the forestry sector, to the benefit of all Canadians, by addressing critical knowledge gaps, and developing and implementing informed policies and practices.