# Forest Pest Risk Management

## NATIONAL RESEARCH AGENDA (2019–2029)



CANADIAN FOREST SERVICE, NATURAL RESOURCES CANADA

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# Table of contents

# Executive Summary

This agenda aspires to set a long-term path for collaboration and partnership in scientific research, tackling Canada's most important socioeconomic and environmental challenges related to forest pests. Scientific solutions informed by complementary knowledge systems will help address current needs to safeguard access to wood fibre resources and international markets for Canada's forest products, and will maintain the integrity of forest ecosystems in the context of a changing climate and an expanding movement of goods and people.

This document defines critical research themes and priorities relevant to the various stages of pest risk management. Research results will generate knowledge and tools that support evidence-based policies and practices from the assessment of potential risks to actual interventions related to outbreaks. The Canadian Forest Service of Natural Resources Canada will lead proactive and continual engagement of the pest research community to ensure that the research remains relevant and responsive, and continues to minimize the negative effects of forest pests.

# Introduction

The world is becoming increasingly complex: expanding movement of goods and people, a changing climate, and an increased demand for responsible stewardship in Canada's forests. This complexity results in many direct and indirect impacts across the Canadian landscape affecting the ability of forests to withstand the emergence, evolution, and spread of pests. Forest pests include insects and pathogens that threaten the health and productivity of forests.

Addressing the many challenges caused by forest pests requires scientific research to better understand, forecast, mitigate, and adapt to these threats. In addition, as a signatory to the International Plant Protection Convention (IPPC) and the Convention on Biological Diversity, Canada has committed to addressing invasive alien species challenges and requires appropriate, science-based plant health programs.

Addressing current and emerging forest pest challenges of national significance calls for mobilizing people, infrastructure, and partnerships across Canada's research community around a shared vision and priorities. The Canadian Forest Service of Natural Resources Canada (NRCan) has proposed this National Research Agenda as a guide to coordinate efforts to tackle our most important socioeconomic and environmental challenges related to forest pests, across our domestic and international borders.

## Target Audiences

The target audiences for this agenda are forest pest practitioners across the country as well as forest pest research funders, providers, and users, many of whom helped develop this plan through consultations held in 2017 and 2018. These audiences include but are not limited to
- federal government departments and agencies (NRCan; Canadian Food Inspection Agency; National Research Council; Innovation, Science and Economic Development Canada; Environment and Climate Change Canada; Parks Canada Agency; Pest Management Regulatory Agency—Health Canada; Canada Border Services Agency);
- provincial and territorial governments (either directly or through intermediaries, such as the Canadian Council of Forest Ministers or SERG International);
- Indigenous peoples;
- municipal governments and associations;
- nonprofit organizations (e.g,., Forest Protection Limited; Société de protection des forêts contre les insectes et les maladies, (Québec, QC); Foothills Research Institute; Invasive Species Centre; Canadian Council on Invasive Species; Genome Canada and regional Genome Centres);
- other governments and international organizations (e.g., United States Forest Service, and Animal and Plant Health Inspection Service; IPPC; North American Plant Protection Organization; North American Forest Commission); and the private sector (e.g., industry, exporters, pest control firms, woodlot owners).

# Background

Canada has 9% of the world's forest area and is the fourth largest exporter of forest products globally. In 2017, forest products accounted for 7.2% ($35.7 billion) of Canada's total exports and the forest industry provided approximately 210 000 direct jobs across the country, particularly helping sustain many rural and Indigenous communities (NRCan 2018).

Insects and pathogens are part of the natural life cycle of forests. Their contribution has multiple benefits including renewing forests, recycling nutrients, and providing new habitat and food for wildlife. In some cases, damage caused by insects and pathogens negatively impacts economic, social, and ecological values. The latest national data available suggest that insects affected 15 489 117 ha of Canada's forests in 2016 (NRCan 2018). Although recent national estimates are not available for

diseases and wood decay, they are expected to cause significant losses and to present a significant threat to tree growth. Moreover, landscape-scale infestations as well as the introduction of invasive species in our environment can have severe and long-standing consequences for forests, industries, and communities. Other disturbances, such as drought, may exacerbate or mitigate this impact.

In 2016, forest products totaling a value of approximately US$240 billion were exported worldwide (FAO 2017). This is a 57% increase since 2000 and more than a 300% increase since 1980. The increased volume of traded commodities and complexity of trade routes (Fig. 1) imply a higher likelihood of pest introduction into new environments. The emerald ash borer (*Agrilus planipennis* Fairmaire), a highly destructive invasive pest that accidentally arrived in North America from Asia, was most likely introduced by infested wood packaging material (NRCan 2010). White pine blister rust (*Cronartium ribicola* J. C. Fisch.) is an example of a forest disease introduced in Canada in the early 1900s. Economically, it is one of the most important forest diseases in North America as it has caused significant annual losses in eastern (*Pinus strobus* L.) and western (*P. monticola* Doug. ex D. Don) white pine (NRCan 2019). In addition, mortality caused by white pine blister rust in high elevation white pines (i.e., limber pine, *P. flexilis* James, and whitebark pine, *P. albicaulis* Engelm.) has ecological effects on wildlife and plants that depend on them for food and cover. Prevention and early detection are recognized as the most cost-effective ways to avoid long-term costs as well as some of the negative consequences of invasive forest pests, and, as such, are the priority strategic goals under *An Invasive Alien Species Strategy for Canada* (Environment Canada 2004).



**Figure 1.** Global commercial shipping routes in 2012 (© Shipmap.org by Kiln.digital).

# National Challenges

Canada's forest sector is emerging today as a leading actor in the developing bioeconomy (NRCan 2018). Scientific research and innovation play a key role in addressing challenges affecting the sector's ability to realize this potential while maintaining our forests' economic, environmental, and social sustaining roles.

## Secure Supply: Protecting Wood Fibre Resources Required by the Forest Industry

Reductions in wood fibre quality and quantity available to the forest industry resulting from tree growth losses and mortality following widespread, severe pest outbreaks and invasions may have significant consequences for the sustainability of the forest sector in Canada. Additional costs may also be incurred because of salvage harvesting in remote areas or the requirements associated with processing degraded wood. The impact on forest industry profitability may then be felt in communities that depend on forests for their livelihood. Scientific knowledge and tools support and help enhance forest health protection policies and programs to safeguard access to high-quality wood fibre supply.

## Barriers to Trade: Increasing Market Access for Canada's Forest Products

Globalization of trade and travel puts pressure on risk mitigation systems intended to stop exotic forest pests moving with commodities. The introduction of alien forest pests in Canada, such as the white pine blister rust, has killed thousands of high-value trees annually, and the introduction of others, such as the emerald ash borer, has also resulted in the adoption of wood movement, processing, and national and international trade restrictions. Development and adherence to science-based management practices and standards aimed at preventing or mitigating the risk of pest movement in trade activities globally reduce the likelihood of introducing alien forest pests into Canada. Science also supports our actions to meet international obligations under the World Trade Organization's *Agreement on the Application of Sanitary and Phytosanitary Measures*, which require that plant health decisions, particularly those with trade effects, such as import restrictions or commodity treatment requirements, are based on scientific evidence. Maintaining and increasing access to international markets is key to ensuring the competitiveness of Canada's forest industry.

## Climate Change: Mitigating Impacts and Fostering Adaptation

Interactions between forest insects and pathogens, trees, and climate are complex, almost certainly exacerbated by a changing global climate. The nature and magnitude of the effects of climate change are highly uncertain given that some changes will be beneficial while some will be detrimental to forest pests. For instance, the physiology of forest insects is sensitive to temperature, but a warmer climate could have variable effects on insect population dynamics, their range, and their impacts. Addressing these uncertainties will inform pest risk management decisions that are more adapted to this context of change.

## Ecological Integrity: Sustaining Ecological Values Derived from Forests

Canada's commitment to sustainable forest management requires that forest protection policies and practices have a sound scientific foundation to ensure forests remain healthy now and in the future. Forests in urban or rural areas provide a wide range of services that are not apparent, yet are very important for the environment and human well-being. Tree mortality resulting from the introduction of invasive pests can alter forest hydrology, which has implications for soil productivity, wildlife habitats, as well as human health and infrastructure. Although the ecological dimensions of forest pest infestations are difficult to quantify, they are nonetheless significant and must be addressed. Disruption in ecological services provided by forest ecosystems could be detrimental to forest-based communities, and particularly for Indigenous peoples, who have unique traditional, cultural, and spiritual needs related to forests. Science can help enhance the detection, identification, and management of those forest pests that pose significant risks to ecosystem integrity and resiliency, and, in turn, to overall forest health.

## Reconciliation with Indigenous Peoples: Bridging Knowledge Systems

As a full supporter of the *United Nations Declaration on the Rights of Indigenous Peoples* (UNGA 2007), Canada has set a path for a renewed relationship with Indigenous peoples, and cooperation and partnership are important enablers of this relationship. In the context of scientific research, this commitment highlights the need to consider various knowledge systems in recognition that multiple relevant and legitimate worldviews coexist. Bridging knowledge systems will aim to maintain the integrity of each system while allowing the creation of knowledge exchange mechanisms to facilitate mutual understanding (Rathwell et al. 2015) across cultures and to address specific concerns of communities pertaining to forest pests. Outlining similarities and differences of each system will help identify how they complement each other, but both systems must be considered equally (Rathwell et al. 2015).

# A National Research Agenda

Addressing national forest science challenges requires a concerted effort to provide the best available science-based solutions that build on the diverse capacity of Canada's research and stakeholder community. The extent and scope of the challenges require an agile, long-term approach to research to ensure that they are addressed comprehensively.

The purpose of this National Research Agenda is to set a high-level direction for research supporting forest pest risk management policies and practices for the next 10 years. This agenda provides the opportunity to create a nationally coordinated framework to identify, prevent, and manage the largest threats posed by pests to Canada's forests and trade activities at home and abroad.

This agenda aims to strike a balance between focusing on national challenges, regional requirements, long-term foundational research questions, and emerging short-term needs. A cohesive approach will maximize the value of existing research infrastructure and assets across Canada. This agenda aims to facilitate sustainable linkages among researchers across disciplines, forestry practitioners, and decision makers to ensure that science generates integrated solutions that are adapted to users' needs and connected to crosscutting, strategic objectives from an economic, social, and environmental standpoint. Finally, this agenda is an evergreen document that will be continually updated to reflect the evolving nature of the forest pest risk environment.

## Scope

This 10-year research agenda brings together forest pest science and technology (S&T) on native and alien forest pests (i.e., insects and pathogens) under a common framework that is consistent with Public Safety Canada's emergency management framework. Forest pest challenges are generally not considered emergencies as per the traditional definition, but the approach to managing infestations is, in principle, similar. This research agenda is structured to reflect S&T contributions across the stages of the emergency management continuum (Fig. 2).

The axiom "an ounce of prevention is worth a pound of cure" is relevant to forest pest risk management. Allocation of resources to prevention is widely recognized as more cost-effective than controlling or managing the consequences of an infestation. The proposed framework therefore strongly emphasizes science activities supporting prevention and risk mitigation. This research agenda also recognizes the need for science-based solutions supporting preparedness, response, and recovery. Structuring contributions to the system illustrated in Figure 2 will enable the research community to support evidence-based forest pest management policies and practices across a wide spectrum of situations. Such situations may range from the assessment of potential risks to actual interventions related to pest outbreaks.

This research agenda strives to position the forest pest risk management community across Canada to anticipate, respond, and adapt to new realities and emerging challenges. The specific activities needed to address priorities under the framework may change as challenges evolve and scientific understanding matures. Ongoing engagement and reviews will be central to ensuring the research agenda addresses the most important knowledge gaps for policy decision making.
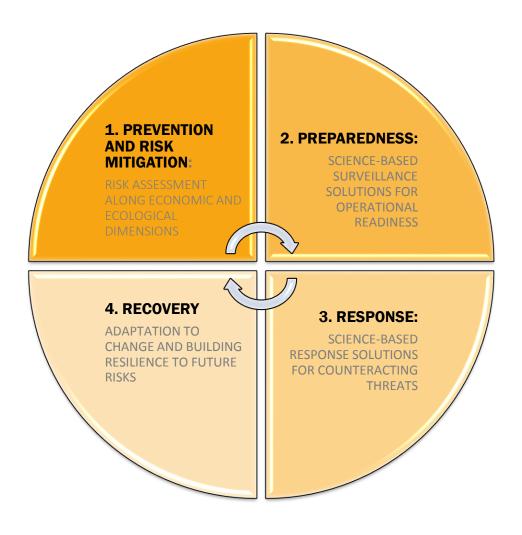
**Figure 2.** The research agenda's framework consists of four main components representing elements of the emergency management continuum.

## Research Themes and Priorities

This section identifies a series of research themes and priorities to address the suite of national challenges highlighted in this agenda. It is intended to provide high-level science direction for the coming decade under each pillar of the proposed framework, from prevention to recovery. It brings together components from science strategies being delivered by multiple organizations across the country. It is also expected to support engagement of Canada's research capacity, and investments into more effective, interdisciplinary research partnerships and infrastructures. Contributions from traditional ecological knowledge will be important as the agenda progresses. This latter knowledge has helped maintain healthy ecosystems through conservation, development, management, and use of environmental resources for millennia (UNPFII 2019). The holistic nature and place-based perspectives of Indigenous knowledge provide insights on various nuances of environmental changes (Rathwell et al. 2015). Where appropriate, interdisciplinary and mutually complementary approaches will be sought to address questions pertaining to forest pest activity. NRCan contributions to the relevant themes and priorities are outlined in the Annex.

### Theme 1. Prevention and Risk Mitigation: Risk Assessments along Economic and Ecological Dimensions

Understanding pest risks and reducing associated uncertainties are important to predict implications for, and to increase confidence in, policy and program decisions made in both forest resource management and international trade.

Scientific research under this theme will provide information, knowledge, and advanced modeling tools that will increase awareness of pest challenges posing the greatest threats to Canada's forest ecosystems, society, and the economy. This information will help anticipate and manage forest pest risk, understand potential impacts on resource and nonresource values, and address vulnerabilities of forest and human systems to a changing threat environment.

**Increase biological and ecological understanding of forest pest activity**
- Understanding the life history and biology of high-risk pest species (i.e., those pests that are likely to reach high numbers and have severe economic and ecological consequences).
- Understanding and modeling the population dynamics or epidemiology of economically or environmentally damaging forest pests and their natural enemies (e.g., parasites, pathogens, predators).

**Increase ability to anticipate future and emerging risks in a changing threat environment**
- Developing spatially explicit models and tools to project climate change effects on forest disturbance patterns, including pest dynamics, and outbreak frequency and intensity. This includes predicting incidence of forest pests that are not currently important but may become so as a result of a changing environment or interactions with other disturbances including fire, drought, wind-damage, and human activities.
- Assessing risk of known (e.g., timber products, live plants, soil, commercial transportation, recreational travel) and emerging pathways (i.e., those for which a risk assessment has not yet been performed, such as new commodities or changed processing techniques) of human-mediated pest entries as well as interception data to assist with pre- and postborder commodity inspections and regulatory standards development.
- Conducting proactive assessments to identify emerging biosecurity challenges threatening Canada. This includes assessing implications of current actions and possible future events.

**Generate credible information about the multidimensional impacts of forest pests under current and future environmental conditions**
- Understanding and modeling actual or potential impacts of forest pest activity on forest growth and yield, and timber values in natural forests and plantations (harvest levels, timber supply cost, wood quality, nonrecoverable losses).
- Conducting economic impact assessments to evaluate direct and indirect (e.g., economy-wide) effects of pest infestations and introductions.

- Understanding the impact of forest pest risk management on urban, rural, and Indigenous communities, including human health, aesthetic and spiritual values, public perception and support of forestry, employment and community stability, etc.
- Understanding the impact of forest pests on ecosystem integrity, including ecological factors, such as species at risk, wildlife and habitat, hydrology, and soils.
- Assessing the costs and benefits of existing and proposed pest risk management policies and programs.

## Theme 2. Preparedness: Science-based Surveillance Solutions for Operational Readiness

Early detection and surveillance of damaging invasive alien species and native pests support forest health protection, all of which are integral to sustainable forest management and ecological resiliency. Landscape-scale monitoring contributes to a better understanding of forest pest hazard and risk to help inform forest health management decisions. Similarly, early detections help limit the potential economic losses from disruptions in international trade of forest products resulting from phytosanitary concerns among Canada's trading partners. The timely detection and identification of pests that are inadvertently introduced into Canada through trade and transportation are critical requirements for effective and rapid responses, before these introductions generate negative economic and environmental impacts.

Research under this theme will help strengthen preparedness by providing early signals of emerging threats and diagnosing them with accuracy. It will provide enhanced tools and approaches for detecting, identifying, delimiting, and monitoring high-risk pests in forests, including both managed and unmanaged forests, urban environments, and other high-traffic sites where human activities may result in introductions.

**Enable early warnings for emerging threats and advanced surveillance**
- Assessing, developing, and enhancing early detection tools (e.g., traps, lures), protocols, and cost-effective strategies.
- Implementing citizen science initiatives to augment surveillance capacity in urban, rural, and Indigenous communities.
- Integrating new technologies (e.g., remote sensing) and enhanced techniques for landscape-scale monitoring of forest pest activity (e.g., digital mobile sketch mapping).

**Ensure accurate and reliable forest pest identification enabling rapid response**
- Assessing, developing, and enhancing tools for rapid identification of forest pests (e.g., diagnostic keys, molecular tools, etc.), tracing back pathways, or certification of pest-free wood commodities.
- Maintaining physical and virtual reference collections of specimens and databasing specimen information and profiles.

## Theme 3. Response: Science-based Response Solutions for Counteracting Threats

Forest pest control is costly and requires effective tools and approaches to make the best use of limited resources. Proactive and rapid response to outbreak and infestation risks and impacts allows agencies to protect high-value resources and to address potential wood supply disruptions more effectively. Successful risk mitigation also helps demonstrate that our forest product exports have a low risk of carrying pests, which increases the likelihood of maintaining access to foreign markets.

Scientific research under this theme will facilitate developing and enhancing a range of response options, from early intervention, to biological control, to silvicultural treatments, for pests representing the highest risks to forest and trade values. It will assess the viability, efficacy, and cost-benefits of response solutions and risk mitigation measures required to comply with international trade requirements.

**Enable proactive responses to mitigate forest pest risks**
- Developing intervention strategies for proactive management of forest pest risks.
- Assessing, developing, and enhancing phytosanitary risk mitigation measures (e.g., commodity treatments, systems approach) and regulatory standards supporting safe trade and transportation.

**Increase efficacy and effectiveness of direct control and long-term management of forest pests to reduce impacts to an acceptable level**
- Developing and enhancing decision support tools for appropriate response to pest disturbances and mitigation of their impacts.
- Assessing and improving the efficacy and cost-effectiveness of control methods and strategies, including mechanical, chemical, and biological control.
- Understanding impacts of pest control agents on target and nontarget organisms and their effects on ecosystems and ecological interactions.

## Theme 4. Recovery: Adaptation to Change and Building Resilience to Future Risks

Recovery includes actions taken after a pest infestation or related challenges to help rebuild acceptable conditions for the forest sector and ecosystems. As a first step, optimizing use of affected wood to recover value supports an industry facing wood supply challenges. Second, assessing postdisturbance forest landscapes is essential to understand the long-term consequences of forest pests and to help adapt forest management approaches to reduce future vulnerabilities. For example, important investments could be made to improve the quality of fibre from plantations, including breeding resistance to forest pests.

Research under this theme will help address these challenges and seize opportunities to develop, assess, and increase ways to make forest ecosystems more resilient.

**Advance adaptation to increase resiliency to future forest pest challenges**
- Understanding forest ecology and succession after pest disturbances, such as vegetation recovery, dynamics of other natural disturbances, and wildlife responses.
- Assessing landscape-level and stand-level silvicultural treatments (e.g., planned replacement of susceptible stands, species conversion, shorter rotations, density-management, etc.) and tree breeding options (i.e., for pest resistance) to reduce forest susceptibility to pest disturbances and increase ecosystem resilience, considering operational, ecological, social, and economic factors.
- Understanding rural, Indigenous, and urban communities' perceptions and attitudes relative to forest pest infestations and their management to inform socially acceptable pest management policy decisions.

**Optimize management and fibre use following pest disturbances**
- Assessing salvage harvesting scenarios following pest disturbances including ecological (e.g., vegetation composition and structure, forest biodiversity, water quality, etc.) and economic (e.g., timber markets, fibre cost, etc.) impacts.
- Developing and enhancing management practices in a postdisturbance context including salvage harvesting and ecosystem restoration.
- Assessing economic value recovery options through wood manufacturing operations, and alternate uses for salvaged wood.

# Governance and Implementation

## Governance

Currently, the Forest Pest Working Group of the Canadian Council of Forest Ministers (CCFM) offers an opportunity to provide governance for this research agenda because of the connections of its members to the scientific community in all regions of Canada. Academia and other target audiences have an important role to play in developing and delivering the research agenda and therefore must feature in this process, where interests intersect. NRCan is committed to playing a leadership role in bringing CCFM partners together in advancing this agenda, and to continue engagement with others to ensure that a wide spectrum of views are reflected.

## Capacity

A critical mass of expertise with diverse and flexible skills is required to address research needs expressed in this agenda. Finding the right balance between disciplines and knowledge systems to address current and future needs will be important. "Integrators" who can bridge disciplines and challenges will be instrumental in achieving this. Regular scans of the forest pest risk environment and ongoing connections across relevant research advisory bodies will help identify emerging pest challenges and associated research and capacity needs.

Fostering partnerships that seek complementarity among the research community in Canada and abroad will help identify and address eventual vulnerabilities. It will also help pool data and information, which represent an opportunity to expand analytical possibilities. Implementing the National Research Agenda will also promote engagement with citizens. Recent examples of successful citizen science projects (http://science.gc.ca/eic/site/063.nsf/eng/h_97169.html) show that involvement of citizens can be instrumental in achieving research objectives by helping monitor insect populations, collect samples, report damage to trees, etc.

## Implementation

Proactive and continual engagement of researchers will help ensure content remains relevant and responsive. This engagement will have multiple dimensions and objectives, including high-quality communication of priorities outlined in this agenda, guiding researchers, and building research capacity to tackle complex challenges. Clarifying the information needs of research end users and their capacity to absorb information will also help adapt engagement at appropriate stages. Building and enhancing relationships with Indigenous groups will help understand their concerns and needs as well as promote a synergistic and holistic approach to understanding the environmental challenge posed by forest pests and their interactions with other factors, such as climate change and wildland fire. Another key next step for collaborators is to develop an evaluation framework to assess progress toward achieving the priorities set out in this agenda and appropriately inform a change in direction based on evaluation results.

# Bibliography

Environment Canada. 2004. *An invasive alien species strategy for Canada*. September 2004. Ottawa. CW66-394-2004-eng.pdf (PDF, 570 KB) (accessed Jan. 31, 2020).

[FAO] Food and Agriculture Organization. 2017. 2016 Global forest products facts and figures. FAO Forestry Department, Rome, Italy.

Gouvernement du Québec. 2017. Besoins de recherche forestière 2017–2019, Synthèse des propositions recueillies par la Direction de la recherche forestière auprès du ministère des Forêts, de la Faune et des Parcs et de certains partenaires au Québec. Ministère des Forêts, de la Faune et des Parcs, Direction de la recherche forestière, Octobre 2017, Québec (Québec).

Government of British Columbia. 2015. Ecosystem health and disturbance intended outcome strategic plan. Ministry of Forests, Lands, Natural Resource Operations & Rural Development, Victoria, BC.

Government of Ontario. 2015. *Integrated science action plan. Guiding and aligning future MNRF science.* Ministry of Natural Resources and Forestry, February 2015, Peterborough, ON.

[NRCan] Natural Resources Canada. 2010. Emerald ash borer. *In* Frontline, Forestry Research Applications, Technical Note No. 110, Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste. Marie, ON.

[NRCan] Natural Resources Canada. 2018. The State of Canada's forests. Annual Report 2018. Natural Resources Canada, Canadian Forest Service, Ottawa. 76 p.

[NRCan] Natural Resources Canada. 2019. White pine blister rust. Trees, insects and diseases of Canada's forests, Canadian Forest Service. https://tidcf.nrcan.gc.ca/en/diseases/factsheet/24 (accessed Jan. 31, 2020).

Rathwell, K.; Armitage, D.R.; Berkes, F. 2015. Bridging knowledge systems to enhance governance of environmental commons: a typology of settings. International Journal of the Commons 9(2):851–880. Doi: http://doi.org/10.18352/ijc.584.

[UNGA] United Nations General Assembly. 2007. United Nations Declaration on the Rights of Indigenous Peoples. https://www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html (accessed Jan. 31, 2020).

[UNPFII] United Nations Permanent Forum on Indigenous Issues. 2019. Traditional knowledge: generation, transmission and protection. Note by the Secretariat. United National Economic and Social Council. Eighteenth session, New York, 22 April–3 May 2019. https://www.un.org/development/desa/indigenouspeoples/unpfii-sessions-2/18-2.html (accessed Jan. 31, 2020).

## Annex. Natural Resources Canada, Canadian Forest Service Contribution to the National Research Agenda

### 1. PREVENTION AND RISK MITIGATION

PRIORITY AREA:

**RISK ASSESSMENTS OF FOREST PEST DISTURBANCES ALONG ECONOMIC AND ECOLOGICAL DIMENSIONS**

NRCan will generate the required knowledge and tools supporting assessments of the economic and ecological risks posed by forest pest challenges important to the Canadian Food Inspection Agency, provinces, territories, communities, and forest industry. These assessments will focus on high-risk pest challenges. Work on emerging invasive species will be included to allow for required flexibility to address biosecurity challenges as they arise. The assessments will improve understanding of where, when, and how significant pest disturbances will occur and the extent of potential consequences in forests, including urban environments, and with respect to human activities, such as international trade. Thus, the assessments will inform risk management decisions made by the relevant jurisdictions and policy decisions made by the Government of Canada.

### 2. PREPAREDNESS

PRIORITY AREA:

**SCIENCE-BASED FOREST PEST SURVEILLANCE SOLUTIONS FOR OPERATIONAL PREPAREDNESS**

NRCan will produce and evaluate science-based surveillance solutions to increase the ability of pest managers in provinces and territories, the Canadian Food Inspection Agency, and communities to detect, identify, and monitor high-risk forest insects and diseases. Their application by clients will support early detection and reliable identification of invasive alien species and pests of quarantine significance in forests, including urban environments, and other locations where human activities are prevalent. These surveillance solutions will also allow accurate delimitation of expanding populations of native and established alien pests across borders.

## 3. RESPONSE

**PRIORITY AREA:**

**SCIENCE-BASED RESPONSE SOLUTIONS TO FOREST PEST DISTURBANCES**

NRCan will identify, develop, and/or evaluate response solutions to support eradication, containment, or suppression efforts by lead agencies for high-risk forest insects and diseases in forests, including urban environments, and in other locations where human activities are prevalent, including international trade. Forest pest control is costly and requires effective tools and approaches to make the best use of limited resources. In partnership with clients and collaborators from academia and other research organizations, NRCan will assess the viability, efficacy, and cost-benefits of a range of response options, from biological control to silvicultural treatments, for species representing the highest risks to forest values and trade across Canada. This work will also include phytosanitary risk mitigation measures and management practices for application in the forest products sector to comply with national and international trade requirements