# EXECUTIVE SUMMARY

## CONTEXT

Over the next several decades, the climate in Canadian forests will shift northward at a rate that will likely exceed the ability of individual tree species to migrate. While most tree species can migrate naturally up to a few hundred metres per year via seed dispersal, the climatic conditions in which each species thrives may move north by several thousand metres per year. Canada's forests are home to well over 100 species of trees, of which 93 are commercially important. Canada's tree species are vulnerable to climate change because trees are sensitive to climate, and there is now little doubt that significant climate change will continue over the next century. In fact, the effects of climate change on tree species are already occurring. For example, drought has caused significant mortality of aspen trees in the southern boreal forest of Alberta and Saskatchewan, and warmer winters have contributed to a mountain pine beetle epidemic that is expected to kill more than three-quarters of the pine volume in British Columbia by 2015. Although it is expected that the overall net effect of climate change on commercially important tree species in Canada will be negative, a changing climate may also increase tree growth in some areas.

Adaptation to climate change by modifying forest management policies and practices has the potential to reduce the vulnerability of tree species to climate change. However, before the process of adaptation can begin, it is necessary to understand how and where tree species are vulnerable, and to identify viable adaptation options.

The purpose of this report is to provide a systematic national assessment of:

- tree species vulnerability to climatic change,
- management implications and options, and
- knowledge gaps in our understanding of both species vulnerability and adaptation.

### GENERAL EFFECTS OF CLIMATE CHANGE ON TREE SPECIES

Climate change effects on tree species will be ongoing, cumulative, and interactive. For example, trees that are stressed by changes in site conditions (such as the development of moisture limitations) will be more susceptible to insects and diseases that become more active due to changing climatic conditions. The many interactions and feedbacks in the life cycle of a tree add to the complexity of climate change effects. Ultimately, a comprehensive, integrated, systems approach that accounts for the full range of factors and the interactions between them is needed to understand what makes tree species vulnerable to climate change and how best to help them adapt.

Climate change will create changes in microclimates, local site conditions, disturbances (e.g., fire, insects, disease, drought, extreme storms), phenology (i.e., the timing of biological activity over a year in relation to climate), and the distribution, abundance, and ecosystem interactions of invasive species, all of which could lead to increased tree mortality and changes in competitive interrelationships (including the potential for the introduction of exotics). Tree species and genotypes will acclimatize, adapt, and migrate; however, in many cases, the rate and magnitude of future climate change may significantly exceed the ability of tree species to naturally adjust. Tree species may, therefore, become increasingly maladapted (i.e., the local environment to which species are adapted begins to change at a rate beyond that which they can accommodate).

The general effects of climate change on tree species include changes in:

- regeneration success
- forest health (e.g., reduced vigour, maladaptation, and increased mortality)
- productivity (positive in some places; negative in other places)
- amount of growing stock (as a result of increased frequency, intensity, duration, and location of disturbances)
- species ranges, species composition, age class distribution, and forest structure at any given location, over time.

#### VULNERABILITY OF CANADA'S TREE SPECIES

Commercial tree species in all regions are threatened by climate change, but some are more vulnerable than others. The greatest warming will occur in the central and northern parts of Canada, an area dominated by boreal forest. Species in the northern boreal forest are highly adapted to cold climates. Increased wildfire activity, permafrost melting, and maladapted trees pose significant threats to northern species such as white and black spruce. Northern forests are also sparsely populated and have relatively low commercial timber value. Therefore, investment in human-assisted adaptation will likely be low. The main threats to the southern boreal forest are drying (including periodic intense droughts) and increased wildfire activity. Concerns have been expressed about the potential for the mountain pine beetle to spread into jack pine forests and move across the boreal forest into eastern Canada. However, experts are sceptical about this scenario because jack pine stands may not occur in sufficient density to allow mountain pine beetle populations to develop to the point of creating a widespread outbreak, even if climates warm enough to allow overwintering survival of the beetle. While northern and southwestern boreal forests are highly vulnerable to climate change, forests in the central and eastern portions of the boreal forest region are less vulnerable because there is a lower likelihood of moisture deficits developing. However, there remains a need to incorporate climate change considerations into regeneration decisions across the boreal forest because of the potential for maladaptation and increased disturbance.

The Montane Cordilleran region of central British Columbia may experience a loss of alpine ecosystems as tree lines increase in elevation. Forest cover may decrease in dry areas of the southern interior of the region. Disturbance activity (i.e., fire, insects, drought, extreme weather) will increase throughout the Montane region, but there is the potential for

productivity gains—at least up to 2050—in the northern portions of the region because moisture is not expected to be limiting. The southern montane forest is highly vulnerable whereas the northern montane forest is moderately vulnerable to climate change.

The Pacific Maritime, Mixedwood Plains, and Atlantic Maritime regions face an increased threat from biotic disturbance and extreme weather events (increased frequency and intensity of severe windstorms). However, the overall vulnerability of forests in these regions is expected to be lower than that of western boreal forests—at least up to 2050.
There will be areas of high vulnerability within local populations of tree species in all the regions mentioned above. For example, transition zones between regions and between ecosystems within those regions will be more vulnerable to climate changes because environmental controls within those zones are close to species' tolerance limits, and the capacity for genetic adaptation is lowest (particularly at the southern edge of species' ranges).

One of the more significant concerns about climate change is the uncertainty about what will actually happen. Although changes in the composition, structure, and age of forests will occur, there is uncertainty about the magnitude, location, and timing of those changes at local scales. Due to this lack of predictability, forest managers will have to deal with completely unanticipated and novel events. Moreover, the lessons learned about forest ecosystem function, succession, regeneration, disturbance processes, and growth based on historical observation and plot measurements may not help forest managers to predict what will happen in the future and design and implement effective management responses.

## A NEW APPROACH: REDUCING VULNERABIITY THROUGH ADAPTATION

Climate change has important implications for the management of forest tree species in Canada. The vulnerability of commercially important tree species in Canada could be reduced by applying early adaptation measures. Early adaptation offers the potential to both minimize negative impacts and maximize benefits associated with climate change (e.g., timber management policies and controls could be modified to take advantage of any productivity gains). Several actions will facilitate adaptation, including:

- considering climate change during activities such as planning, reforestation, stand tending, and harvesting (i.e., mainstreaming climate change into forest management using a systems approach)
- developing capacity for ecological and genecological modelling to address questions related to shifts in species distributions, assisted migration of species and seedlots, and diversification of species and seed sources in reforestation
- reducing vulnerability to climate change by developing, sharing, and adopting climate-sensitive best management practices
- reducing the risk of losses to catastrophic disturbance through harvesting and "climate conscious" management (e.g., managing forest structures to reduce the risk of large fires or pest outbreaks)
- enhancing species-level monitoring (e.g., growth, mortality, dieback) to ensure the early detection of climate change impacts and effectiveness of adaptation measures
- incorporating vulnerability analysis, risk analysis, and adaptive management into forest management practices that are related to reforestation and species composition choices

- continually identifying key knowledge gaps, institutional arrangements, and policies that pose significant barriers to adaptation, and taking actions to rapidly address them

**OPTIONS AND OPPORTUNITIES**

Adaptation efforts that could reduce tree species vulnerability include:

- ensuring that the next generation of trees is better suited to the climatic environments within which they will be growing (i.e., facilitating migration, managing gene pools, and taking account of the potential range of future conditions when selecting species for stand regeneration)
- minimizing losses to the current inventory from climate change-induced disturbances
- modifying management of the current generation of trees such that the risks of maladaptation of some species are taken into account
- adopting climate-sensitive sustainable forest management best practices and implementing no-regret options (i.e., actions that are beneficial today and very likely to be beneficial in the future regardless of what form climate change takes)

Potential options for tree species management include:

- developing climate-based seed selection systems for reforestation
- accounting for changes in future site conditions in management decisions (e.g., anticipating where moisture may become limiting)
- examining the potential for establishing genetic outposts (small plantations of seed sources that are adapted to predicted future climates in remote locations) to hasten the adaptation of forests in unmanaged areas
- implementing long-term, multi-species provenance field trials to assess the climatic tolerance of seed sources in order to optimize assisted migration strategies. In these trials, researchers could include seed sources from the northern United States because they may be the best adapted to future Canadian climates, and they could include test sites in northern U.S. locations that have climates similar to those that will soon occur in Canada.
- examining opportunities to increase genetic and species diversity when planting forests as a means of increasing capacity to buffer climate uncertainty
- using large scale disturbances as windows of opportunity to re-establish forests that are less vulnerable to future climate change
- ensuring all disturbed or harvested forests are promptly reforested with species and seed sources that are adapted to predicted future climates (i.e., using assisted migration)
- reducing reliance on natural regeneration where naturally regenerated forests will be significantly maladapted to future climates
- increasing experimental plantings to test options for new species, and reviewing existing plantations of exotics across provinces and ecozones

- managing species for shorter rotations
- selecting and breeding to enhance traits that may be more suited to changed environmental conditions
- planting drought-resistant species in areas that are prone to increased drought
- re-evaluating seed orchard locations relative to potential future climate change
- identifying stands and forest structures that are susceptible to large scale disturbances, and using forest management to favour species and structures that are less vulnerable

An important caveat is that specific actions in specific regions will need to be implemented with care and caution. For example, adaptations pertaining to regeneration will need to take account of both the current and future climate. In some cases, knowledge gaps will need to be addressed before codes and standards for widespread implementation of adaptations are possible. In the interim, experimental testing, trials, and monitoring of new approaches may be needed. Also, greater flexibility in institutions to allow for local adaptation may be called for. What works in one location may not work in another. Diversified prescription portfolios, flexible codes and standards, and local adaptive management approaches will enhance the capacity of forest managers to adapt to climate change.

**NEXT STEPS: MOVING BEYOND TREES TO FORESTS AND THE FOREST SECTOR**

This report focuses on climate change and the vulnerability of commercially important tree species in Canada. This is a vitally important first step; however, the Canadian Council of Forest Ministers (CCFM) acknowledges that this provides only a partial picture. As has been implied in this study, and as is reflected in the current CCFM document *A Vision for Canada's Forests: 2008 and Beyond,* the impacts of climate change go beyond impacts on tree species. Climate change will also affect forest landscapes, the forest sector, the full array of forest management objectives that are part of sustainable forest management, and an array of constituencies (forest industry, forest-based communities, protected areas, First Nations populations, wildlife, water, public health and safety, timber supply, etc.). Therefore, a comprehensive approach that considers climate change in a broader context will be needed. It is the intention of the CCFM to follow up on this study with an assessment that focuses on these broader issues. This will include an evaluation of climate change impacts at a broader landscape scale and an assessment of how these changes will impact forest assets and values. Phase 2 will develop a better understanding of climate change vulnerabilities foreseeable for sustainable management of Canada's forests at the national level. It will also identify potential approaches to adaptation to reduce these vulnerabilities. A goal of the next phase is to develop a framework and guidance documents to assist jurisdictions and forest practitioners to incorporate climate change considerations into Sustainable Forest Management in Canada. This next phase will build upon earlier ecological and socio-economic assessments of the Canadian Council of Forest Ministers.