A Climate Change Vulnerability Assessment for British Columbia's Managed Forests

ADAPTING TO
CLIMATE CHANGE

Editors: Don Morgan and Dave Daust

Table of Contents

BRITISH
COLUMBIA

Acknowledgements

We would like to thank the Province's Future Forest Ecosystem Initiative (FFEI) and Future Forest Ecosystems Scientific Council (FFESC) programs for providing funding and support. The report would not have been possible without earlier guidance from Evelyn Hamilton and continued support from Kristine Weese and Kathy Hopkins. We would like to acknowledge the founding Provincial Vulnerability Assessment working group, including Jenny Feick, Doug Lewis, Robin Pike, Leslie McAuley, Elizabeth Campbell, Jennifer Burleigh, Marty Kranabetter, Caron Dymond, Francis Njenga, Doug Fraser, Ed Korpela, Christine Fletcher, Mike Fenger, Dave Coates and Erin Hall. The content of the case study section is based on reported results from three vulnerability assessment projects and on workshop-based discussion with the leaders of those projects. In particular, we thank Rachel Holt, Greg Utzig, Ken Zielke and Harry Nelson for sharing their insight. We also thank the many people that participated in each project, volunteering their expertise to help define management challenges and identify possible solutions. Laurie Kremsater and Evelyn Hamilton reviewed the entire draft manuscript. Rachel Holt, Greg Utzig, Ken Zielke, Phil Burton and Karen Price reviewed one or more sections. Thanks also to Christina Melymick for editorial oversight and the Bulkley Valley Research Centre for administrative support.

Introduction

Dave Daust and Don Morgan

This report provides an assessment of the vulnerability of managed forests in British Columbia to climate change. The assessment was completed to support the Ministry of Forests, Lands and Natural Resource Operations (FLRNO) and the Ministry of Environment (MoE) in their efforts to adapt BC's forest and range management framework to climate change. Funding for this assessment was provided by the Province's Future Forest Ecosystems Scientific Council, a collaborative research program overseen by FLNRO, MoE, the University of BC, and the University of Northern BC. The strategies and actions recommended in this vulnerability assessment report are now being considered by the FLNRO and MOE, and many aspects are being addressed through the Forest Stewardship Action Plan for Climate Change Adaptation and other related initiatives.

A vulnerability assessment is an examination of the impacts, exposure and sensitivity of ecosystems and ecological processes to a changing climate. This vulnerability assessment is intended to be a high level view of the vulnerability of hydrology and aquatic biology, soils, forest ecosystems and wildlife in BC to climate change driven shifts in temperature, precipitation and natural disturbance processes. To provide a sense of how vulnerability varies across BC, a series of regional case studies have been collated that outline climate change, vulnerability and potential adaptation actions. The report concludes with a discussion of common regional adaptation strategies and recommends steps to increase adaptive capacity. This report focuses more on challenges associated with climate change than opportunities because challenges are many and will be more difficult to manage than opportunities. Many challenges will require a coordinated societal response.

Warning: The projected impacts of climate change that we describe in this report are uncertain because climate projections are uncertain and as are biophysical responses to climate and greenhouse gases. We have tried to portray a reasonable picture of possible impacts; however, actual impacts could be much better than described—or much worse.

Climate Change in BC

BC's climate has already changed and is predicted to continue to change (Chapter 2a). The future is expected to be warmer and wetter, with reduced snowpacks in most areas and increased drought in southern BC.

Hydrology and Aquatic Ecosystems

Hydrological regimes (Chapter 2b) are expected to shift due to a combination of climate-induced changes, including:

- increased evaporation,
- altered vegetation composition affecting water interception,

- increased frequency and magnitude of storms,
- decreased snow accumulation and accelerated snow melt, and
- accelerated melting of glaciers permafrost, lake ice and river ice.

Overall, these changes will affect the timing and magnitude of streamflow, with consequences for sediment delivery and the duration and volume of the low flow. Hybrid rain and snow dominated hydrological regimes may shift to rain dominated regimes.

Natural Disturbance

As a result of climate change, disturbance will increase (Chapter 2c). Fire and drought will likely increase in southern and coastal BC. Wind and rain storms will likely increase in coastal BC. Bark beetles will likely kill more trees across much of BC and will be particularly damaging in regions that have not experienced bark beetles outbreaks historically. Even-aged lodgepole pine plantations are especially vulnerable to a wide range of foliar diseases and stem rusts that are expected to expand over the coming decades. Future disease prevalence is uncertain because diseases correlate with patterns of seasonal precipitation, which are difficult to predict with climate models.

Soils

Climate affects carbon sequestration, nutrient availability and biotic communities within soils (Chapter 2d). Moisture and temperature regimes at a global scale play important roles in determining soil carbon stocks. In general, litter decomposition (and, consequently, the sequestration of carbon) is stimulated by warmer and wetter conditions and suppressed by cooler and drier conditions. Soil respiration rates are also typically stimulated by warmer temperatures, however, the increase is usually only temporary (i.e., one to three years). Altered rates of organic matter decay will also influence nutrient availability. Increased plant productivity (e.g., due to longer growing seasons) can only be sustained if sufficient nutrients are available. In general, warmer temperatures increase nutrient availability for plants and soil microbes, however, the influence of warmer temperatures on nutrient availability depends on soil properties, moisture and other factors. In general, the influence of climate change on ecosystem productivity and soil carbon storage will be difficult to accurately predict because of the numerous interacting factors that affect soil.

The activity and structure of the soil biotic community is strongly influenced by the composition of the plant community, therefore, shifts in plant species assemblages are expected to have cascading effects on the structure and function of the belowground biological community. Rapid migration of plants, animals and soil biota may uncouple complex relationships between species (e.g., mycorrhizal fungi), a particular concern for assisted migration. Rapid climate change may facilitate the movement and establishment of weedy and invasive species.

Forested Ecosystems

Changes in climate will affect forested ecosystems (Chapter 2e). The projected combination of warming, changed hydrology, decreased snowpacks (most areas), and increased disturbance intensity and frequency means that all present-day ecosystems will undergo ecological shifts, some to a larger extent than others. Several "climate-habitats" (reflecting combinations of climate variables associated with BEC zones) are expected to cover less than 20% of their current range by the 2080s (Montane Spruce, Sub-boreal Pine Spruce, Spruce Willow Birch, Boreal Altai Fescue Alpine, Interior Mountain-heather Alpine, Sub-boreal Spruce). Coastal Western Hemlock, Coastal Douglas-fir and Boreal White and Black Spruce may be only minimally affected.[1]

Some climate-habitats such as those for grasslands, dry forested ecosystems (Ponderosa Pine and Interior Douglas-fir) and Interior Cedar Hemlock are expected to expand their range, but the associated plant communities may not. Species faced with a changed environment can die out, move, or adapt to the new conditions. Most plant species, especially those with long inter-generational periods (e.g. trees) and poor dispersers will not be able to migrate quickly enough to keep pace with suitable climatic conditions. Even if migration is successful, altered species interactions will alter community structure.

The climate envelopes of tree species are shifting upslope and north (Chapter 2e). Predicted declines for conifers include loss of western red cedar in southern BC, continued loss of lodgepole pine (*Pinus contorta*) from sub-boreal ecosystems due to mountain pine beetles (*Dendroctonus ponderosae*) and Dothistroma needle blight (*Dothistroma septosporum*), and loss of interior spruce (*Picea engelmannii x glauca*) due to insects, pathogens and, potentially, regeneration difficulty. Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*) and western redcedar (Thuja plicata) may expand their range.

Wildlife

The impact of climate change on British Columbia's wildlife varies depending on species, their range, plasticity, adaptability, and ability to disperse (Chapter 2f). In general, wildlife species are adapted to a wide range of climatic conditions and have persisted under historic variability driven by climate oscillations. Despite their adaptability, wildlife species suffer periodic weather-related mortality due to extreme weather, and population recruitment reflects the weather-driven production of food crops.

Wildlife species employ a variety of timing mechanisms to compensate for seasonal variation in the availability of food and climatic conditions - termed phenology. Recent shifts in phenology, including earlier frog breeding, bird nesting, and arrival of migrant birds and butterflies, match trends expected with climate change. Although these shifts may not compromise the viability of some wildlife populations, others already face lower reproductive success.

For many species, increased disturbance will result in loss of habitat and subsequent increases in mortality from disruptions in food supply and increased exposure to predators. Along with other drivers of environmental change – land use change, pollution and invasive species – climate change is a dominant agent shifting habitat occupancy. A poleward and altitudinal shift in a variety of taxa, observed in the 20th century, matches observed shifts in climate envelopes. Species are expected to follow future climate envelope changes depending upon their ability to disperse and resource availability.

---

[1] Tongli Wang, Elizabeth M. Campbell, Gregory A. O'Neill, Sally N. Aitken. 2012. Projecting future distributions of ecosystem climate niches: Uncertainties and management applications. Forest Ecology and Management 279 (2012)128-140

Regional Vulnerability Assessments

To better understand the impacts of the multiple climate-related changes described above on forest values and to develop appropriate management responses (adaptation), three regional climate change vulnerability assessments were conducted (Nadina, Kamloops and West Kootenay; Chapter 3a). Vulnerability assessments estimate the degree of climate change and the sensitivity of ecosystems in order to project potential impacts on forest values. They then develop a suite of potential management responses that reduce impacts and identify barriers to implementing these responses.

Climate is projected to become drier in summer in portions of all study areas. In Nadina, dry sites on the eastern plateau face increased drought risk. In Kamloops, higher ecological impacts are expected in relatively dry regions. In the West Kootenays, dry southern valleys may shift from forest to grassland, due to drought and fire. More importantly, northern valleys dominated by a gap-replacement disturbance regime could shift to a frequent fire disturbance regime and ecosystems could become simplified and dominated by invasive species.

Climatic-induced impacts interact. For example, trees stressed by a shifting climate are more susceptible to insects and disease (which may be increased in vigour due to warming). Tree mortality can increase fire hazard, and changes in temperature, coupled with increased disturbance can favour invasive species.

Regional biodiversity will decline. Climate change will affect plant community structure, with consequences for ecosystem function and resilience; it will likely lead to extirpation of some species in each region. Extirpation risk arises from loss of climatically-suitable site conditions and loss of old seral habitat, due to climate-induced disturbance. The biggest impact to biodiversity and ecosystem function comes from regime shifts. Potential ecosystem shifts in the study regions include old forest to young forest (due to disturbance), forest to weedy species, forest to grassland, alpine to forest, wetland to forest and forest to different forest (including conifer to deciduous). Many ecosystems will shift character, providing different levels or types of services, but more importantly, some ecosystems may become dysfunctional, trapped in a brushy, weedy phase that provides few desired services. Whether and how we choose to adapt our forest management to climate change will influence outcomes for many species.

Adaptation Strategies

In the regional vulnerability assessments, many strategies were identified to achieve management objectives under climate change (Chapter 3b), however, most, with the exception of assisted migration, are not novel, but rather are elements of ecosystem-based management that require broader application. Strategies can be grouped into two broad categories:

1. **Reduce risks to forest ecosystems:**
    a. limit cumulative effects:
        i. use a precautionary approach to development;
        ii. develop a regional cumulative effects assessment approach that limits total anthropogenic stress, accounting for climate change, in a region;

        iii. develop a BC-scale conservation strategy for adaptation and mitigation; and,
        iv. develop watershed-scale water conservation plans;
    b. promote resilience to change:
        i. promote stand-scale species diversity (e.g. retain broadleafs and plant more species);
        ii. promote landscape-scale ecosystem diversity (e.g., age-classes, leading tree species, structure); and,
        iii. maintain favourable microclimates and site conditions (e.g., partial cut, buffers);
    c. guide ecological transformation:
        i. retain connectivity among landscapes;
        ii. plant climatically-suited tree species (assisted migration);
        iii. develop a triage approach to deal with species at risk;
    d. combat detrimental change:
        i. monitor and control excessive disturbance (e.g., beetles, fire); and,
        ii. monitor and control invasive species.

2. **Reduce risks to forestry-dependent communities:**
    a. increase monitoring and detection of undesirable change;
    b. increase capacity of forestry communities to respond to change;
        i. increase emergency response capability (e.g., fire control, salvage harvesting);
        ii. increase diversity and flexibility of timber processing facilities;
    c. preferentially harvest susceptible timber (i.e., when facing imminent threat); and,
    d. increase capacity of infrastructure to withstand extreme events.

Applying all potential management actions can partially reduce impacts, but not in all cases. Limiting cumulative effects and promoting resilience may be more cost effective than directly combating all disturbance agents and resisting disturbance regime change within susceptible forests. Fire control will be necessary to protect important values.

Increasing Adaptive Capacity

While many strategies are available, few are being implemented. Barriers to adaptation include lack of knowledge or expertise (least important), lack of planning capacity, and lack of institutional support for change (most important; Chapter 3c). Recommendations for reducing each barrier, and hence increasing adaptive capacity (Chapter 3c) include:

1. Build institutional support:
    a. Increase awareness of provincial-scale forest managers of the need to support climate change adaptation;
    b. Strengthen governance to require adaptation, and allocate adequate resources;
    c. Remove economic disincentives for adaptation, and create incentives for companies to adapt;
    d. Strengthen planning capacity and provide government support for ongoing learning;
    e. Remove legislative and policy barriers:
        i. Increase flexibility for the purposes of research trials.
2. Improve planning capacity:
    a. Develop regional planning programs to review and revise forest management objectives and strategies;

    b. Shift to a structured decision-making approach that separates knowledge from values;
    c. Develop a regional cumulative effects assessment approach that considers climate change and uncertainty; and,
    d. Develop a triage approach to deal with the expected increase in species-at-risk.
3. Increase knowledge
    a. Develop regional learning programs to improve knowledge and support decision-making, including
        i. an enduring knowledge base; and,
        ii. permanent staff position(s) in each region.

Innovative approaches and creative negotiation may be instrumental in removing the most important barrier—limited government mandate and resources.

The adaptation strategies and recommendations to reduce barriers presented above are largely consistent with the findings of the Future Forest Ecosystem Science Council Research Synthesis[1]. In addition, we strongly agree with the FFESC recommendation to involve communities in climate change adaptation. Vulnerability assessment case studies benefited from the diversity of perspectives and knowledge brought by community participants.

Given the magnitude and importance of the recommendations presented above, we believe that the provincial government should use a provincial advisory committee to guide adaptation investment. This work should build upon current knowledge of climate related risks and of barriers to adaptation (e.g., this report; Haeussler and Hamilton 2012). Potential committee tasks follow:

- quantify economic risks and benefits of failure to adapt, and costs and benefits of adaptation;
- identify synergies with mitigation policy;
- secure an appropriate budget to support adaptation (a long-term stable funding mechanism is needed);
- guide implementation of adaptation recommendations;
- strengthen partnerships:
    - collaborate with the federal government, municipalities and First Nations;
    - consult ministries, industry and academia;
    - survey public opinion about the need to adapt to climate change;
    - develop an information-sharing strategy with the public.

By implementing the recommendations in this report, we can protect communities, reduce risks to BC's forest resources, and demonstrate responsible stewardship. These benefits are of major importance in improving ecosystem health and fostering public confidence in BC's resource management.

---

[1] Haeussler, S. and E. H. Hamilton. 2012. Informing Adaptation of British Columbia's Forest and Range Management Framework to Anticipated Effects of Climate Change: A Synthesis of Research and Policy Recommendations. Report prepared for the BC Future Forest Ecosystem Scientific Council; Online: http://www.for.gov.bc.ca/hfp/future_forests/council/.