Adaptation to Climate Change in Forestry

DAVID L. SPITTLEHOUSE

Research Branch, British Columbia Ministry of Forests, P.O. Box 9519, Stn Prov Govt, Victoria, BC, V8W 9C2, Canada, email dave.spittlehouse@gems4.gov.bc.ca

Abstract: Climate change adaptation strategies for the forest management sector should be based on the application of vulnerability assessment or risk management concepts. A planning framework for facilitating adaptation in forestry must address biophysical and socio-economic impacts, and will include policy and institutional considerations. The framework requires us to analyze the situation and assess current and future vulnerabilities of forests to climate change. We can then develop risk management strategies that include actions needed now and in the future to aid responses to climate changes. Adaptation needs to reduce current vulnerability to climate change and speed recovery after disturbance in a changed climate. The adaptation plan should include monitoring of the state of the forest to detect change. An example of using this framework to adapt to changing forest productivity is presented. Many forest ecosystems and species will have to adapt autonomously because management can only influence the timing and direction of forest adaptation at selected locations. In general, society will have to adjust to however forests adapt.

Key Words: climate change, adaptation, adaptive planning, vulnerability, forests, ecosystems, risk management

Introduction

By the end of the 21st century, the mean annual temperature for western North America could be 2–5ºC above the range of temperatures that occurred over the last 1000 years (Houghton et al. 2001). An increase in winter precipitation and a decrease in summer precipitation may also occur. These changes would significantly affect human society and ecosystems (McCarthy et al. 2001). Canada's natural resources and associated industries and communities are vulnerable to climate change, and there is a need for the forestry community to be proactive in adapting to climate change (Davidson et al. 2003; Spittlehouse and Stewart 2003; Standing Senate Committee on Agriculture and Forestry 2003).

Adaptation to climate changes refers to adjustments in ecological, social, and economic systems in response to the effects of changes in climate (Smit et al. 2000; Smit and Pilifosova 2001; Davidson et al. 2003). The development of adaptation measures for some time in the future, under an uncertain climate and in an unknown socio-economic context, is bound to be highly speculative (Burton et al. 2002). Some people may view responding as a greater risk than doing nothing, or that adaptation is not a feasible option. Although forest ecosystems will adapt

autonomously, their importance to society means that we may wish to influence the direction and timing of this adaptation at some locations. In other cases, society will have to adjust to whatever change brings.

This paper is based on Spittlehouse and Stewart (2003). My objective is to encourage the forestry community to begin assessing their vulnerability to climate change and developing adaptation strategies. An adaptive capability is a necessary component of sustainability (Holling 2001). Sustainable forest management already embodies many of the activities that will be required to respond to the effects of climate change on forests. Including adaptation to climate change as part of forest planning does not necessarily require a large financial investment now with an unknown future payback time.

Adaptation to Climate Change

The long-term responses of forests to climate change will be at the species level with species' ranges moving northward and upward in elevation. New assemblages of species will occur in space and time (Hebda 1997; Kirschbaum 2000; Hansen et al. 2001). In some areas, physical factors such as nutrient availability, soil depth, and permafrost will mediate responses (Stewart et al. 1998). However, forecasting impacts is difficult because of our limited knowledge about the vulnerability of ecosystems and species, and because of the poor spatial and temporal resolution of the future climate. Although we do not have a clear view of the future climate and forest, it is critical to begin developing adaptation strategies now because adaptation to climate change in forest management requires a planned response well in advance of climate change impacts. Spittlehouse and Stewart (2003) presented an extensive list of adaptive actions proposed in the literature for gene management, forest protection, forest regeneration, silvicultural management, forest operations, nontimber resources, and park and wilderness area management. Many of these activities are currently used in forest management.

Adaptation requires that the forestry community

- establish objectives for the future forest under climate change;
- increase awareness and education within the community about adaptation to climate change;
- determine the vulnerability of forest ecosystems, forest communities, and society;
- develop present and future cost-effective adaptive actions;
- manage the forest to reduce vulnerability and enhance recovery;
- monitor to determine the state of the forest and identify when critical thresholds are reached; and
- manage to reduce the impact when it occurs, speed recovery, and reduce vulnerability to further climate change (Dale et al. 2001; Spittlehouse and Stewart 2003).

I focus here on a framework for planning adaptive actions. First, we need to identify the issue of concern. Next comes the assessment of the vulnerability (sensitivity, adaptive capacity) of the forest, forest communities, and society to climate change. This assessment facilitates the development of adaptive actions to be taken now and those required for the future as change occurs. Current activities include those that facilitate future responses to reduce vulnerability. Adaptation options must include the ability to incorporate new knowledge about the future climate and forest vulnerability as they are developed. Until climate change has had sufficient impact to warrant intervention, it is likely that in many situations there is not much that is to be done 'on the ground, in the forest' for a few decades. However, we need to have a suite of options ready to go when we do wish to intervene; thus, there is work to do now. Essentially, the framework is a format for risk analysis, of which there are many examples in the literature (Kelly and Alger 2000; Davidson et al. 2003; Spittlehouse and Stewart 2003; Turner et al. 2003).

I present here an example of using the framework noted above on the effect of climate change on tree growth. This will obviously not be in the detail required for a full analysis but is presented to show how the risk analysis may take place. Other examples can be found in Spittlehouse and Stewart (2003) and at the Canadian Climate Impacts and Adaptation Research Network—Forest Sector web site (www.forest.c-ciarn.ca).

- *Issue:* Impact of climate change on tree growth.
- *Vulnerability:* Lower summer precipitation and increased temperature could result in increased moisture stress. This in turn could reduce growth rates, change wood quality, increase the risk of disturbance by fire, insects, and disease, and could require a change in provenances or even species for reforestation. The expected climate change by 2020 will have only a minor effect on the trees to be harvested up to this date; however, by 2050, there may be significant impacts—e.g., a 10–20% reduction in volume at harvest—and current provenances may not be suitable for reforestation.
- *Options for the future:* Maintain status quo until 2030. Conduct sanitation thinning. Adjust rotation age for plantations after this date when planning the timber supply. Expect to have small logs and more fire salvage wood as part of the timber supply by 2050. Modify seed transfer zones for 2030.
- *Actions to do now:* Conduct provenance trials to determine climate limits of commercial tree species. Replace geographically defined seed transfer zones with zones defined by climate.

Climate change adaptation strategies can be viewed as the risk management component of sustainable forest management plans. Actions can be taken that are useful now, but would also reduce the risk of unacceptable losses in the future. As can be seen in the above example, many actions required in adapting to climate change benefit the present as well as the future. Spittlehouse and Stewart (2003) proposed a number of questions that need to be addressed to facilitate adaptation planning. These included the following:

- What are the research and educational needs?
- What are barriers to the implementation of adaptation in forest management?
- What forest policies need to be in place to facilitate adaptation?
- Are current monitoring systems adequate to spot problems induced by climate change soon enough to allow implementation of an acceptable response?

Conclusions

Current forest utilization and preservation is based on how forests developed under past climatic conditions. Policy makers and forest managers must accept that climate change is probable and that forests and forest communities will face significant impacts. Planned adaptation will reduce vulnerability for commercial tree species at selected sites; however, many forest species will have to adapt autonomously, and society will have to adjust to the result. Until climate change has had sufficient impact to warrant intervention, it is likely that in many situations there is not much that can be done 'on the ground, in the forest' for a few decades. However, it is necessary to start now in assessing forest vulnerability to climate change and developing adaptation strategies.

Acknowledgments

Support of this work is provided by the British Columbia Ministry of Forests and the Canadian Climate Impacts and Adaptation Research Network—Forest Sector (www.forest.c-ciarn.ca).

References

Burton, I., S. Huq, B. Lim, O. Pilifosova, and E.L. Schipper. 2002. From impacts assessment to adaptation priorities: the shaping of adaptation policy. Climate Policy **2**:145–159.

Dale, V.H, L.A. Joyce, S. McNulty, R.P. Neilson, M.P. Ayres, M.D. Flannigan, P.J. Hanson, L.C. Irland, A.E. Lugo, C.J. Peterson, D. Simberloff, F.J. Swanson, B.J. Stocks, and B.M. Wotton. 2001. Climate change and forest disturbances. BioScience **51**:723–734.

Davidson, D.J., T. Williamson, and J.R. Parkins. 2003. Understanding climate change risk and vulnerability in northern forest-based communities. Canadian Journal of Forest Research **33**:2252–2261.

Hansen, A.J., R.P. Neilson, V.H. Dale, C.H. Flather, L.R. Iverson, D.J. Currie, S. Shafer, R. Cook, and P.J. Bartlein. 2001. Global change in forests: response of species, communities, and biomes. BioScience **51**:765–779.

Hebda, R.J. 1997. Impact of climate change on biogeoclimatic zones of British Columbia and Yukon. Pages 13-1–13-15 in E. Taylor and B. Taylor, editors. Responding to global climate change in British Columbia and Yukon. Environment Canada, Vancouver, British Columbia.

Holling, C.S. 2001. Understanding the complexity of economic, ecological, and social systems. Ecosystems **4**:390–405.

Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, and D. Xiaosu, editors. 2001. Climate change 2001: the scientific basis. Intergovernmental Panel on Climate Change, Cambridge University Press, New York, New York.

Kelly, P.M., and W.N. Adger. 2000. Theory and practice in assessing vulnerability to climate change and facilitating adaptation. Climatic Change **47**:325–352.

Kirschbaum, M.U.F. 2000. Forest growth and species distribution in a changing climate. Tree Physiology **20**:309–322.

McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White, editors. 2001. Climate change 2001: impacts, adaptation and vulnerability. Intergovernmental Panel on Climate Change, Cambridge University Press, New York, New York.

Smit, B., and O. Pilifosova. 2001. Adaptation to climate change in the context of sustainable development and equity. Pages 876–912 in J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White, editors. Climate change 2001: impacts, adaptation and vulnerability. Intergovernmental Panel on Climate Change. Cambridge University Press, New York, New York.

Smit, B., I. Burton, R.J.T. Klien, and J. Wandel. 2000. An anatomy of adaptation to climate change and variability. Climatic Change **45**:223–251.

Spittlehouse, D.L., and R.B. Stewart. 2003. Adapting to climate change in forest management. Available from http://www.forrex.org/jem/2003/vol4/no1/art1.pdf. Print version available from BC Journal of Ecosystems and Management (2004) **4**(1):7–17.

Standing Senate Committee on Agriculture and Forestry. 2003. Climate change: we are at risk. Final report. Government of Canada, Ottawa, Ontario.

Stewart, R.B., E. Wheaton, and D.L. Spittlehouse. 1998. Climate change: implications for the boreal forest. Pages 86–101 in A.H. Legge and L.L. Jones, editors. Emerging air issues for the 21st century: the need for multidisciplinary management. Air and Waste Management Association, Pittsburgh, Pennsylvania.

Turner, B.L., R.E. Kasperson, P.A. Matson, J.J. McCarthy, R.W. Corell, L. Christensen, N. Eckley, J.X. Kasperson, A. Luers, M.L. Martello, C. Polsky, A. Pulsipher, and A. Schiller. 2003. A framework for vulnerability analysis in sustainability science. Proceedings of the National Academy of Sciences **100**:8074–8079.