21 paper

FOREST BIODIVERSITY:
ADAPTING TO A CHANGNING CLIMATE

DON C. MACIVER[1] and ELAINE WHEATON[2]

[1]Meteorological Service of Canada, 4905 Dufferin Street, Downsview, Ontario, Canada, M3H 5T4;
[2]Saskatchewan Research Council, 15 Innovation Blvd., Saskatoon, Saskatchewan, Canada, S7N 2X8.
*(*corresponding author Tel: 416-739-4391, email: don.maciver@ec.gc.ca)*

ABSTRACT. Atmospheric scientists, using global climate models, have developed scenarios of the future climate that far exceed the historical climate envelope and current forest management practices. Adaptation of forest biodiversity means taking into account a changing climate; improving our understanding of forest landscapes, ecosystems, species and genetics under climate change; adjusting the way we plan, plant, tend, protect and harvest our future forests; and conserving native forest biodiversity. Not all forests are alike, nor do they share the same multi-taxa, adaptive life-cycles, feedbacks and threats. Given the life cycle of most forest species, forest management systems will need to adjust their limits of knowledge and adaptive strategies radically to initiate, plan and enhance forest biodiversity in relative harmony with the future climate. Protected Areas (IUCN), Global Biosphere Reserves (UNESCO), Model Forests and Smithsonian Institution sites provide an effective community-based platform to monitor changes in forest species, ecosystems and biodiversity under changing climatic conditions.

Keywords: Forest biodiversity, forests, Smithsonian Institution, UNESCO, SI/MAB, Biosphere Reserves, adaptation, climate change, community-based monitoring

1. Introduction

Forest biodiversity is not single-species management but, instead, recognizes the functional ability or impairment of ecosystems to support many diverse species. Human population expansion, land-use conversions and atmospheric changes have dramatically altered ecosystems and species worldwide. For example, many northern latitude ecosystems are limited climatically and lack the species richness of more tropical climates. In particular, these countries can ill afford to lose even one species or ecosystem.

It was perhaps Sigmund Freud that provided some further insight into the scale and importance of emerging issues. Freud observed that "humanity has in the course of time had to endure from the hands of science two great outrages upon its naïve self love. The first when it realized that our earth was not the center of the universe but only a speck in a world system of magnitude barely conceivable and the second was when biological research robbed man of his particular privilege of having been specially created and relegated him to a descent from the animal world" (Gould, 1977). In hindcast, the degree of uncertainty, at the time, associated with each of these outrages might possibly be equated to the uncertainty of the climate change debate, today. But more importantly, what would be the consequences if climate change is, in fact, the "third outrage" on humanity?

The Intergovernmental Panel on Climate Change (Watson, 1996) concluded that "the balance of evidence… suggests a discernible human influence on global climate". The most recent IPCC assessment (2001) suggests "there is new and stronger evidence that most of the warming observed over the past 50 years is attributable to human activities". We know from past experiences that weather and climate have a powerful influence on biological and human environments and that today's forest biodiversity is the culmination of a long evolution within a climate envelope containing many natural fluctuations and extremes. The conclusion by the IPCC is alarming with the result that today's forests and their resident populations will be maladapted to future climate and its many variabilities and extremes. This projected magnitude of climate change, especially the anticipated rate of change because of human influences on the climate system, is beyond our current level of knowledge and adaptation mindset. This "outrage" imposed by humanity on the climate system will require a significant paradigm shift and new levels of knowledge for forest managers. However, knowing the anticipated future climate scenarios, continuing population demands, and emission increases, forest managers can begin an adaptation process to design the taxa targets to satisfy a multiplicity of needs, products and services.

Why should adaptation to climate change and variability be considered? Responses to global warming are considered mainly in terms of mitigation with the aim of reducing human generated greenhouse gas emissions. However, adaptation is also a main part of the response set. Pro-active adaptation actions, especially the many benefits, are needed for several reasons, principally because humaninduced climatic change appears unavoidable, regardless of the mitigation actions to slow the speed of global warming.

Characteristics of systems related to adaptation are identified in several literature streams, including disciplines in both the natural and socioeconomic sciences. These include concepts such as resilience, sensitivity, tolerance, thresholds, critical levels, susceptibility, vulnerability, adaptability, adaptive capacity, coping range, flexibility, size (individual or collective) and part of the forest ecosystem (e.g. human, plant, animal, water, soil, air). Several of these are described in Smithers and Smit (1997). Any new operative word will need to focus much more on enhancing the "resourcefulness" of the forest estate, especially through human management practices that build on the interlinkages among forest ecosystems, species and genetics and the changing atmosphere.

2. Challenges of Adaptation Science: understanding the process

Adaptation means taking into account a changing climate; improving our understanding of forest landscapes, ecosystems, species and genetics under climate change; adjusting the way we plan, plant, tend, protect and harvest our future forests; and conserving native forest biodiversity. A main challenge facing adaptation science is to improve our theoretical understanding and predictive capacity. The purpose of this is to guide adaptive forest management. Adaptive management serves to reduce vulnerabilities to, and enhance opportunities of, climate variability and change. Responses can be nonlinear and may not occur until a certain threshold has been reached as suggested by paleo-forest evidence where changes have been step-wise and abrupt. Forests serve as an excellent example of this latter case when the rates of change of the future climate far exceed the historical rates of forest migrations and disturbance losses from forest fires and other insects, diseases and where population and land-use changes are expected to significantly change, as well. For example, a 1 degree Celsius increase in mean global temperature will have significant impacts on forest ecosystems and species, especially where forest climates have little or no buffering capacity (MacIver, 1998). The anticipated change in global climate of 3 to 5 degree Celsius or more could be devastating, leading to significant maladaptations over the next rotation cycle of most tree species.

The process of adaptation to a changing climate occurs in a wide variety of ways and under many circumstances. The process depends on many factors, including who or what adapts, what they adapt to, how they adapt, what resources are used and how, and the effects of adaptation within and across forest ecosystems, species and genetic levels. These related themes are part of a model of an adaptation cycle (see Figure 1) that changes through time and space. This framework is designed to organize concepts regarding adaptation, to stimulate ideas, and to explore the linkages among parts of the adaptation cycle.

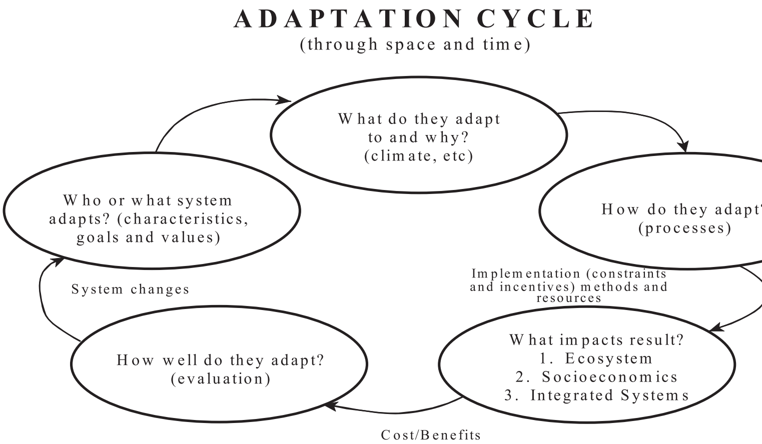

FIGURE 1

Adaptation cycle through space and time (Wheaton and MacIver, 1999)

The mainstreaming framework for the science of adaptation (see Figure 2) should address these questions with an overarching challenge to address: what is changing and why? Forest species have long rotation life cycles in the natural evolving world and species planted today are expected to thrive within the human induced climates of tomorrow. Hence, climate change adaptation should be a key part of today's decision making process, including the governance of the design and management of forests for the future. The design criteria for multi-taxa will be influenced by many factors, including lessons from past experiences, traditional forest knowledge in adaptation, adaptation technologies, risks, uncertainties, costs, benefits, social vulnerability and resilience, buffering capacities, impact assessments, data and information needs and knowledge of the forest climate.

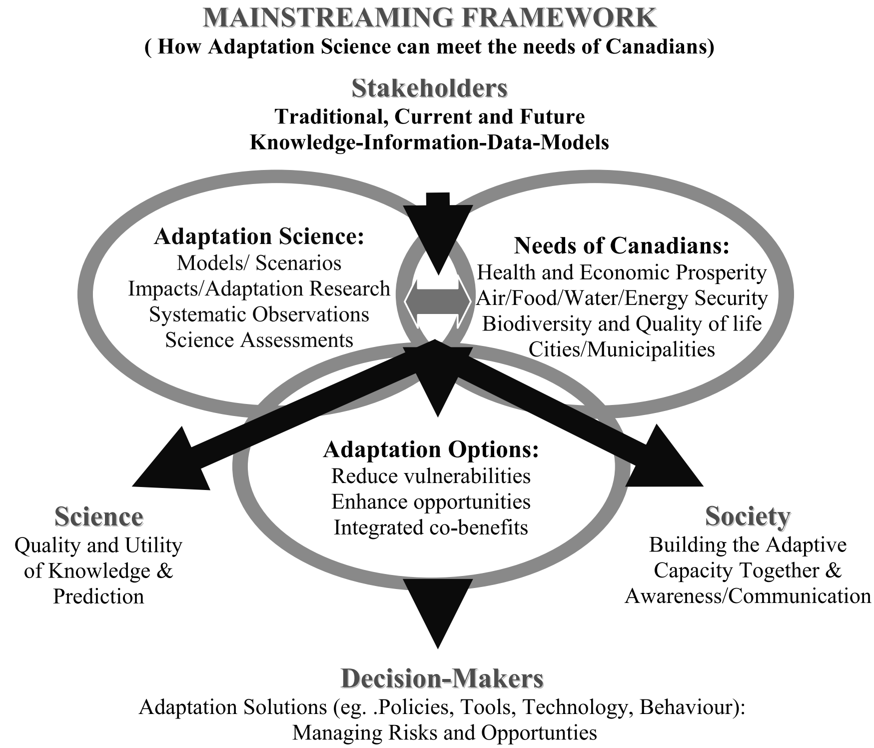

FIGURE 2

Adaptation Framework (Adapted from Wheaton and MacIver, 1999)

3. Challenges of Adaptive Management: reducing vulnerabilities through application of adaptation science

Adaptive management is the practice of adaptation science. There are many ways that adaptation processes can be managed. Figure 2 also depicts linkages of adaptation science with adaptive management and adaptation options.

When adaptive management first entered the vocabulary of forest management, it heralded a new way of thinking in which management policies were treated as experiments, learning from them and using them as a basis for changes and adjustments (Stankey, 2001). If we characterize current

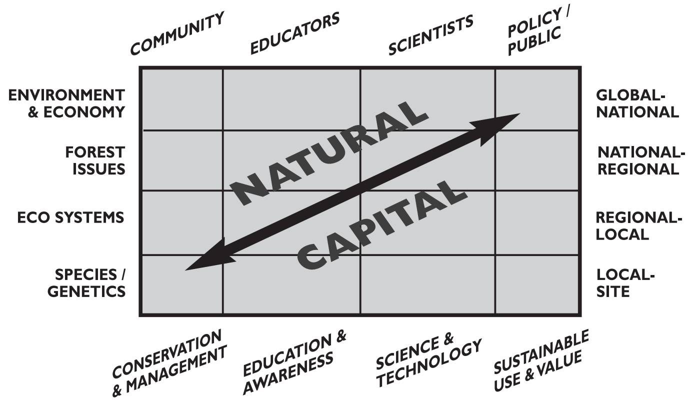

FIGURE 3

Natural Capital Framework

forest biodiversity management policies within the overarching theme of natural capital, then Figure 3 provides some insight into the multiplicity of goals, values and life services managed by many groups worldwide. Trees and forests are more than wood. In many communities they are the source of heat, food, shelter, and spiritual value. In others, they are the industrial forest, to others a habitat rich in biodiversity and to others a regulating influence on the atmosphere. The majority of forests worldwide continue to be natural and managed to varying degrees or not at all. But if we accept that humanity has created this third "outrage" on the world, then this graphical depiction quickly turns from a theme of viewing forests as natural capital to one of managed values for sustainability, by which all forests will be managed for a diversity of targets within the envelope of global climate change. This management of multi-taxa is the real challenge facing forest managers. Adaptive approaches offer hope for the successful management of natural-origin and planted forests for their multiplicity of values, but driven and defined at the local levels within a global climate change envelope.

4. Next Challenges: adaptation options

A preliminary framework to deal with adaptation options is presented in this paper and summarized in Figure 2. Adaptation options have been further subdivided into: reducing vulnerabilities; enhancing opportunities; and options assessments.

Our collective challenge, given the climate change scenarios, population increases, land-use changes and emissions, is a clear definition of our values, projected into the future and figuring out where we go from today. There is a need to reach agreement on a broad and descriptive vision of sustainable forests, woodlots and trees, shared by all. For example Figure 4, helps illustrate the many interlinkages that would allow for global and local target setting. In other words, a pro-active adaptation approach is needed to design future forests to survive and thrive in the future climate. Sounds simple, but the real challenge is taking the first step, tolerant of other competing values and yet managing tomorrow's forests and their many populations, now. For example, we know that forest migrations cannot keep pace with the expected rate of climate change. Forest ecosystems do not migrate en masse but species are resourceful in their continuing search for new development opportunities when the hospitality of the local landscape and environment are conducive for seed, pollen, habitat and growth processes. Without human intervention, it is expected that many forest reserves will become islands of declining habitat. Interconnecting corridors may help some forest populations but mass extinction of species is already underway. Humans have created this third great "outrage" and only humanity, not nature, can avoid expected maladaptations.

FIGURE 4

Sustainable Forests Framework

5. Global Adaptation Laboratories: Protected Areas, Biosphere Reserves and Smithsonian Biodiversity Sites

Knowing the future climate scenarios and increasing forest vulnerabilities, one of the key questions, simply stated, is how to we get from here to there? Convergence of major global efforts, such as Climate Change scenarios; Protected Areas (IUCN); the 400 World Biosphere Reserves (UNESCO), Smithsonian Biodiversity Sites and others (eg. ILTER sites and Model Forests) may provide some answers. The establishment of Smithsonian Forest Monitoring sites (SI/MAB), monitored by community groups using the same protocols and standards worldwide (Dallmeier, 1992), is particularly unique and noteworthy.

There are four general themes under which most forest biodiversity monitoring activities fall:

a. Monitoring based on species at risk
b. Monitoring based on population trends
c. Monitoring based on status and trends in habitat
d. Monitoring based on threats to biodiversity

It is important to remember that biodiversity monitoring is scale-dependent. For example, using these global protocols for forest biodiversity monitoring, there are now more than 80 SI/MAB sites in Canada, one-hectare in size, located across climate, chemical and ecological gradients (MacIver,1998). This also included the need for geo-spatial analysis based on Integrated Mapping Assessments (MacIver and Auld, 2000). In these ways, comparative biodiversity changes are assessed to better understand multi-taxa management approaches, especially in the managed versus the unmanaged forest. In addition, this includes the establishment of a climate change SI/MAB site within the urban heat island of Toronto, a city already experiencing equivalent climate change effects, to understand the performance of 23 forest species planted for today's and tomorrow's climate.

6. CONCLUSIONS

Tomorrow's forests and their many populations will need to be managed in a pro-active adaptive manner, given the anticipated threats of climate change. Lessons learned from past and current climate variabilities and extremes, future global climate scenarios and lessons derived from Protected Areas, Biospheres Reserves and Smithsonian Sites may help increase our collective understanding of adaptive forest biodiversity practices, especially human management options.

7. REFERENCES

Dallmeier, F. 1992. Long-Term Monitoring of Biological Diversity in Tropical Forest Areas. MAB Digest, UNESCO.

Gould. S.J. 1977. Ever Since Darwin. Norton Press.

IPCC (Intergovernmental Panel on Climate Change). 2001, *Climate Change 2001: The Scientific Basis-Summary for the Policymakers and Technical Summary of the Working Group I Report,* WMO and UNEP.

MacIver, D.C., 1998. Atmospheric Change and Biodiversity. Environmental Monitoring and Assessment 49:177-189.

MacIver D.C. and H. Auld. 2000. The Changing Atmosphere, Forest Biodiversity and Productivity in Ontario, Canada in Proceedings of the 14th AMS Conference on Biometeorology and Aerobiology, Davis California.

Smit, B. I. Burton and R.J.T. Klein. 1999. The Science of Adaptation: A Framework for Assessment. Mitigation and Adaptation Strategies to Global Change 4:

Smithers, J. and B. Smit. 1997. Human Adaptation to Climatic Variability and Change. Global Environmental Change 7 (2):129146.

Stankey, G.H. 2001. Too Early to Tell, or Too Late to Rescue? Adaptive management under Scrutiny. US Forest Service, PNW, Science Findings, April 2001.

Watson, R.T., M.C. Zinyowera and R.H. Moss (editors). 1996. Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: ScientificTechnical Analyses. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. +878 pp.

Wheaton E., D.C.MacIver. 1999. A Framework and Key Questions for Adapting to Climate Variability and Change. In Mitigation and Adaptation Strategies for Global Change 4: 215-225.