

A framework for assessing climate change vulnerability of the Canadian forest sector

by Mark Johnston¹ and Tim Williamson²

ABSTRACT

We present a framework for assessing the vulnerability of the Canadian forest sector to climate variability and change. The framework includes factors of exposure, system sensitivity and adaptive capacity, which are applied to the Canadian forest sector. We summarize sources of exposure and sensitivities of the Canadian forest sector and then address the adaptive capacity of forest management and forest-based communities. We suggest that the adaptive capacity of the forest sector is likely to be high, but needs to be rigorously tested. We conclude by advocating a national forest sector vulnerability assessment, and emphasize that this needs to be an inclusive, stakeholder-driven process.

Key words: climate change, adaptation, vulnerability, forest sector, forest communities

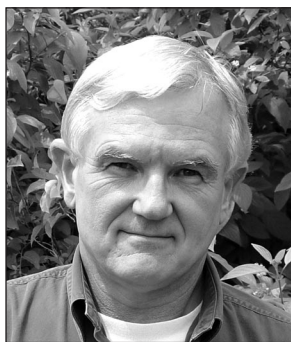
RÉSUMÉ

Nous présentons un cadre de travail pour l'évaluation de la vulnérabilité du secteur forestier canadien face à la variabilité et aux changements climatiques. Le cadre de travail comprend les facteurs d'exposition, la sensibilité du système ainsi que sa capacité d'adaptation, le tout au niveau du secteur forestier canadien. Nous résumons les sources d'exposition et de sensibilité du secteur forestier canadien et nous traitons de la capacité d'adaptation de l'aménagement forestier et des communautés dépendantes des forêts. Nous suggérons que la capacité d'adaptation du secteur forestier est vraisemblablement élevée, mais qu'elle doit être testée à fond. Nous concluons en plaidant pour une évaluation nationale de la vulnérabilité du secteur forestier et soulignons que ce besoin doit être un processus inclusif initié par les intervenants du milieu.

Mots clés : changements climatiques, adaptation, vulnérabilité, secteur forestier, communautés forestières



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Introduction

Canadian forests are expected to experience high levels of climate change impacts relative to forests in other regions (IPCC 2001, Flannigan *et al.* 2005, Scholze *et al.* 2006). Within Canada, the boreal forest may face more dramatic climate change because of its northern continental interior location. Climate change has already been documented for most of Canada, including temperature and precipitation increases, lengthening frost-free season, glacial melting and others (Barrow *et al.* 2004). While the general nature of these changes is becoming clearer, we lack a conceptual framework

for determining the vulnerability of the forest sector to climate change. Such a framework would assist forest managers in incorporating climate and climate change considerations into management plans (Spittlehouse 2005).

A Model of Vulnerability

Here we present an approach to vulnerability assessment tailored to forest management, based on a model developed by Smit and Pilifosova (2001) and applied to Arctic communities by Ford and Smit (2004). These authors characterize vulnerability with the following relationship:

$$[1] \quad V = f(E, S, A)$$

where V is vulnerability of the system of interest, E is exposure, S is system sensitivity and A is adaptive capacity. The relationship between E , S and A is not specified, as it will vary depending on local circumstances. However, it is understood that V is a positive function of the system's exposure and sensitivity and a negative function of the system's adaptive capacity (Ford and Smit 2004). Fig. 1 presents this model in the context of forests and forest management. Turner *et al.* (2003) used a modified version of this framework to describe an approach to the sustainability of human-ecological systems. They emphasize that this framework needs to be applied using a "place-based" approach, in which the unique charac-

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Table 1. Summary of main sources of exposure to climate change for Canadian forests

Exposure or Sensitivity	Impact	Reference
Increase in winter temperatures	Shorter season of winter operations	Spittlehouse and Stewart 2003
Increases in extreme events	Flooding; droughts	Hogg and Bernier 2005
Increases in forest fire activity	Reduction in wood supply; threats to infrastructure	Flannigan <i>et al.</i> 2005
Increase in insect outbreaks	Reduction in wood supply	Logan <i>et al.</i> 2003, Volney and Hirsch 2005
Changes in forest productivity	Changes to wood supply and carbon sequestration	Johnston and Williamson 2005, Volney and Hirsch 2005
Shifts in species composition	Changes to technology and markets; changes to recreational values	Scott and Lemieux 2005, Johnston <i>et al.</i> 2006

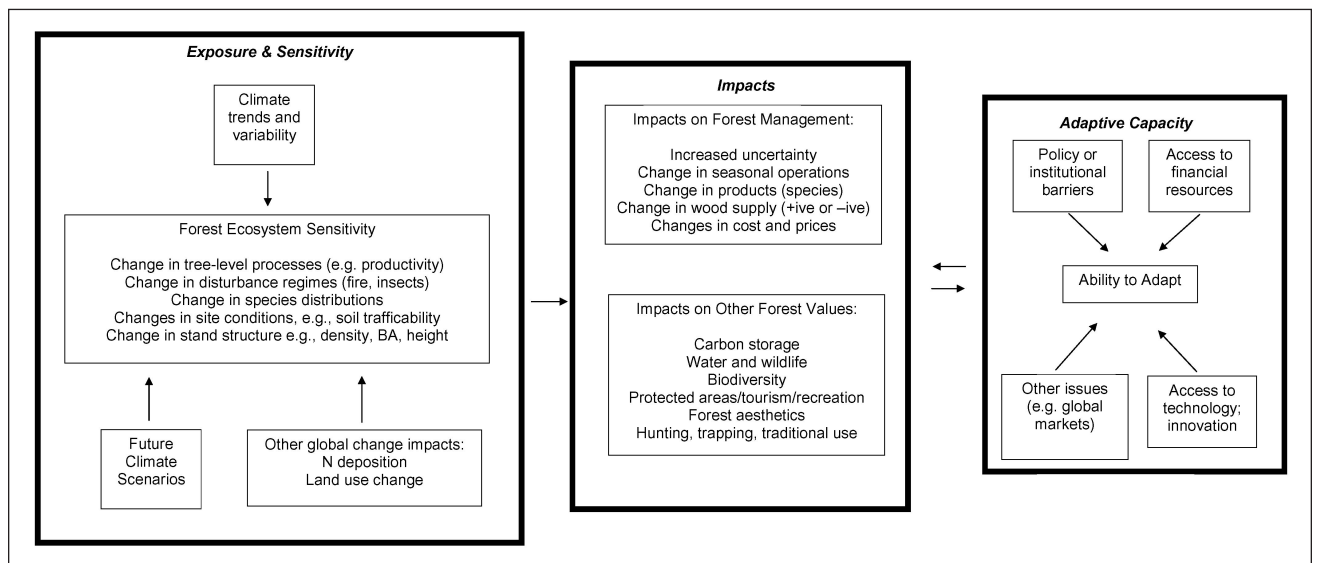


Fig. 1. Framework for assessing the vulnerability of the Canadian forest sector to climate change.

teristics of the system at a given location are explicitly recognized. The advantages of this approach are (i) it provides a unifying framework to contrast and compare impacts of climate change across jurisdictions, and (ii) it allows the simultaneous consideration of several unique sources of exposure and sensitivity along with adaptive capacities for particular social, economic and natural environments. In a country like Canada with widely varying biophysical and social conditions, a regionally based multidisciplinary approach is essential. Schröter *et al.* (2005) also adopted this framework in estimating the effects of climate change on the provision of ecosystem services for countries in the European Union.

Exposure and Sensitivity

The left-hand portion of Fig. 1 comprises two components. The first is the nature of the climate, e.g., temperature, precipitation, wind patterns and the variability in these factors (i.e.,

the magnitude of climate and climate change stimuli or exposure). These can be represented by either current climate or future climate scenarios. The second is the sensitivity of the system (i.e., the degree to which it is affected by climatic stimuli). This is a property of the forest ecosystem, and will vary by forest type depending on species composition, regeneration mechanisms, disturbance regimes etc. Table 1 summarizes several of the most important sources of exposure and sensitivity to Canadian forest ecosystems. More detailed reviews are given in Colombo *et al.* (1998), Spittlehouse and Stewart (2003) and Johnston *et al.* (2006).

Impacts on Forest Management

The centre of Fig. 1 shows how the effects of climate exposure and ecosystem sensitivity result in impacts to forest management. This is the link between biophysical and human systems and raises a number of important points. First, climate

variability and change will affect the full range of forest-based values. Therefore, levels of vulnerability and its assessment will vary according to specific contexts (e.g., forest management agreement areas, forest-based communities, protected areas). Second, climate change implies a significant increase in risk and uncertainty associated with forest management. This is an area that forest science and forest management have not historically addressed but is an aspect of the climate change issue with significant socioeconomic consequences. Third, other global change factors (e.g., nitrogen deposition, socioeconomic and market trends, land use change) will occur at the same time that climate change is affecting forest management. Therefore, information regarding these other factors are an important complement to climate scenarios when investigating vulnerability. Fourth, the impacts of climate change on forest management may be negative or positive, and thus it is important to understand where opportunities might exist in addition to attempting to reduce the negative impacts of climate change. Finally, impacts to other forest values are often less well understood than are impacts to forest management for wood production. For example, relationships among forest ecosystem sensitivities, wildlife habitat and resulting changes in biodiversity are only beginning to be addressed (Tin 2005).

Adaptive Capacity

The section on the right of Fig. 1 focuses on adaptive capacity in the forest sector. Adaptive capacity is shown to be linked to forest management impacts, indicating that impacts are determined by exposure and sensitivity as well as a system's capacity to adapt. Adaptive capacity is defined by factors that determine the ability and likelihood that forest managers will adapt in order to reduce current and potential future impacts. Some examples include the flexibility and efficiency of institutions and policy, distribution and availability of financial resources, technological capacity and human capital (e.g., workforce education) (Smit and Pilifosova 2001, Ford and Smit 2004). Additional factors include knowledge and awareness of potential impacts, social networks, trust, isolation, infrastructure quality and perception of climate risk (Adger *et al.* 2004, Williamson *et al.* 2005). It is also important to recognize that other issues outside of climate change will be occurring at the same time, so the role of adaptive capacity should be considered from the point of view of a broader suite of changes that may affect the forest sector (Johnston *et al.* 2006).

In addition to the general indicators of adaptive capacity given above, there are aspects of sustainable forest management in Canada that may contribute to adaptive capacity in the forest sector. Most provincial forest management agencies in Canada require the forest industry to periodically submit long-term forest management plans. Recent examples of forest plans in which climate change considerations have been included are Louisiana-Pacific (2006), Millar Western (2007) and Mistik Management (2007). Each of these plans was an individual effort without a common framework or objectives, but these examples show that long-term forest management plans provide a useful vehicle for considering the effects of climate change. In addition, most forest companies in Canada are undergoing one or more certification procedures that indicate that their products are produced from a sustainably managed forest landbase. Certification could support adap-

tive capacity in the forest sector by providing a tool that would guide forest managers on how to incorporate climate change considerations into forest management. However, current certification systems do not consider the implications of climate change and therefore more work would be needed to redesign certification protocols.

Conclusions

While research has shown that Canadian forests are sensitive to climate change, systematic assessments of the vulnerability of Canada's forest sector that consider exposure, sensitivity and adaptive capacity of forest management have not been conducted. A lack of understanding and knowledge of how Canada's forest sector is vulnerable to climate change may itself be a barrier to beginning the process of adaptation. Thus, it is important that vulnerability assessments for forest management systems begin to be undertaken across Canada. The general framework presented here may assist in designing such assessments. Once that has been completed, adaptation options can be identified for dealing with the identified vulnerabilities. We emphasize that identifying vulnerabilities and adaptation options must be an inclusive process, with stakeholders fully engaged from the outset. Our expectation is that the ability of the Canadian forest sector to cope with climate change is high, but before investing in adaptation, we require some understanding of where the forest sector is most vulnerable. We have the tools, and the time is now.

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