PROJECT REPORT
2002-2
FINAL PROJECT REPORT

sustainable forest management network

réseau sur la gestion durable des forêts

A Framework For Determining The Ability Of The Forest Sector To Adapt To Climate Change

A Network of Centres of Excellence
Un réseau de centres d'excellence

Sheri A. O'Shaughnessy and Mark Johnston

For copies of this or other SFM publications contact:

Sustainable Forest Management Network
G208 Biological Sciences Building
University of Alberta
Edmonton, Alberta, T6G 2E9
Ph: (780) 492 6659
Fax: (780) 492 8160
http://www.ualberta.ca/sfm

ISBN 1-55261-151-5

A Framework For Determining The Ability Of The Forest Sector To Adapt To Climate Change

A Framework for Assessing Climate Change Adaptation Options for the Forestry Sector in the Prairie Provinces: A Case Study of LP Corp, Manitoba

by

Sheri A. O'Shaughnessy[1] and Mark Johnston[2]

[1] Department of Geography, University of Saskatchewan, Saskatoon, Saskatchewan
[2] Saskatchewan Research Council, Saskatoon, Saskatchewan

May 2002

ABSTRACT

The circumpolar boreal forest is expected to be significantly affected by climate changes due to its high latitudinal location and its inherent sensitivity to climate. In order to maintain and enhance the long-term health of the boreal forest, researchers across Canada have been investigating the effects that changing climate will have on the present and future ecological and economic sustainability of our forests. The task confronting forest managers is to develop a workable framework for management that recognizes changes in the climate. This framework will enable adaptive management of the forests and will incorporate economic needs with new and changing environmental and social demands being placed on forests. Implementation of adaptations to climate change impacts on forest management remain in a state of infancy. However, preliminary research suggests that adaptive strategies can be developed and implemented. Consultations with the forest industry in the Prairies suggest that there must be improved communication between scientific researchers and forest managers in order to identify adaptation options for the future. In particular, results of research must be presented at spatial and temporal scales that are relevant to forest management and operations.

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to my supervisors, Dr. Mark Johnston and Dr. Lawrence Martz, for their suggestions, and guidance throughout this project.

I am also indebted to the following: Dr. Ken Van Rees, one of my committee members; Elaine Wheaton from Saskatchewan Research Council for her expertise in climate change and her guidance and emotional support and the other staff in the Environmental Branch at Saskatchewan Research Council for their skills, expertise, and support that they offered continually throughout this project. I would also like to extend my thanks to the external examiner, Marie Boehm.

I would also like to express my thanks to my parents who have offered an endless supply of love and support. They have always encouraged me and helped me go on when I did not think I could.

Finally, I would like to thank the Prairie Adaptation Research Cooperative (PARC) and the Sustainable Forest Management Network for their financial support of this project.

INTRODUCTION

Background

Climate change has become a global concern (McCarthy et al., 2001). As the global environment changes and affects landscapes and ecosystems, there is a greater need to understand climate change and its impacts to enable human systems to adapt their management and usage of the natural environment. In order to maintain and enhance the long-term health of forest ecosystems, at a national as well as a regional level, government and scientific agencies have been investigating the effects that the changing climate will have on the present and future sustainability (ecologically and economically) of the boreal forests (Krankina et al., 1997). The task confronting the forest management community is to develop a workable set of guidelines that will assist managers to adapt to changes in the climate. These guidelines will enable the sustainable and adaptive management of forests and will incorporate economic needs with the new and changing environmental and social demands being placed on forests.

Past research has demonstrated that forest ecosystems have been responding to climate change (Shine and Forster, 1999) because biological systems constantly adapt to their environment. To further develop this understanding, studies dealing with impacts of climate change on forest ecosystems, anticipated impacts and sustainable management adaptations to climate change are required within the forest sector (Parker et al., 2000). To adapt forest management to the effects of climate change, it may be necessary to modify traditional forest management strategies (Lindner, 2000). Adaptation of forest management and planning strategies involves adjustments to be made within the strategies to actual or expected climatic impacts, which moderates harm or exploits beneficial opportunities (McCarthy et al., 2001).

Understanding of adaptation to climate change impacts on forest ecosystems remains in a state of infancy (Parker et al., 2000). However, there is preliminary research about climate change impacts and adaptation within the boreal forest that suggests that adaptive strategies must be developed and tested (Krankina et al., 1997). This type of research is essential to ensure the survival and sustainability of the boreal forest.

Problem

Management practices are not currently prepared to adapt to the impacts that climate change may have on the boreal forest (Parker et al., 2000) due to a gap between the research and management. By narrowing this gap, a link between the impacts of climate change on the boreal forest and on forest management would be established. The current management principles do not apply climate change science regarding the impacts of climate change on the boreal forest. Therefore, a framework that can be used to identify potential climatic impacts, management activities, and possible adaptation options for the forest sector must be developed. This framework would provide a starting point that would enable forest management to adapt to the potential impacts of climate change on the boreal forest. Forest management, in response to societal demands has recently undergone a shift from an emphasis on maximum timber productivity and sustained yield to an emphasis on (1) maintaining the forest and its associated diversity as an interconnected whole, using a holistic landscape view; (2) sustainable ecosystem management; and (3) identification of adaptation options for future changes within the boreal forest ecosystem (Alberta Pacific Forest Industries, 2000). This form of management is referred to as Sustainable Forest Management (SFM).

Need

It is becoming increasingly evident that in order to ensure the ecological and economic sustainability of the boreal forest, action must be taken to aid the forest sector in adapting to the changing global climate (Krankina et al., 1997). Practicing SFM involves managing forest ecosystems to maintain their integrity, biodiversity, and productive capacity (Alberta Pacific Forest Industries, 2000). The challenge is to manage forests as ecosystems. This form of management aids adapting management practices to the changing climate by providing integrated management of natural landscapes, ecological processes, wildlife species, and human activities. The task confronting forest managers is to develop a workable framework for management that actively recognizes changes in the climate. This framework will enable adaptive management of the forests and will incorporate economic needs with the new and changing environmental and social demands being placed on forests. The goal is to refine and develop SFM practices so that they are based on relevant information about the changing climate, encompassing all forest values while maintaining the integrity of the ecosystems.

Objectives

The objectives of this project are (1) to develop an analytical framework for the forest sector that will enable them to identify climate change impacts and their adaptation options and (2) to assess the framework in a case study with the forest company LP Canada Ltd. The case study will include an analysis of the ways in which climate change is likely to affect the ecosystems on LP's land base, the vulnerability of LP's operations to potential climate change impacts, and the adaptation options available to LP given these impacts, combined with current climate change research. The second objective of this study was funded by the Sustainable Forest Management Network. This framework and case study will set the stage in the future for assessing both site-specific adaptations options, and planning alternatives like harvesting methods and site preparation options in forest management. It will also provide a scientifically sound approach to help managers meet the overall goal of sustaining the boreal forest and maintaining ecological processes, further ensuring biodiversity for continued ecological and economic stability within the boreal forest (Lindner, 2000).

SUMMARY OF DATA ANALYSIS

General Methodology

The general methodology for this project was based on qualitative data collection. In climate change and adaptation research, there has been a move in the direction of assessing and gaining knowledge concerning likely impacts of climate change by soliciting judgements and opinions of experts in particular fields (Burton, 1995). In this project, the use of expert opinion and judgement was the methodology used to obtain an assessment of the state of knowledge regarding climate change impacts, management, and adaptation within the forest sector in the Prairie Provinces.

This methodology of expert and stakeholder judgement and participation has been used by decision support systems that combine dynamic simulation with expert judgement for tools of policy analysis (Burton, 1995). This methodology provides a way to assess the state of knowledge concerning issues surrounding climate change when empirical methods are lacking. Due to the lack of information available surrounding the issues that were addressed in this project, the use of this methodology was instrumental in the design of this project.

Conceptual Framework

A main component of the larger project was the development of a conceptual framework (Figure 1) that would aid forest managers in understanding the potential climate change impacts on their landbase and operations, and in identifying possible adaptation options for climate change impacts. This conceptual framework was designed at a generic level to assess climate change impacts on the biophysical resource as well as on management practices for adaptation to climate change, specifically in the forest sector.

The framework has been developed based on a framework designed by Carter et al. (1994) utilized for the development of an adaptation strategy (Parry and Carter, 1998). I modified the framework using information gathered in the literature review, interviews and discussions with various forest managers across the Prairie Provinces, and a workshop discussion session involving several key forest managers from government, independent agencies, and industry.

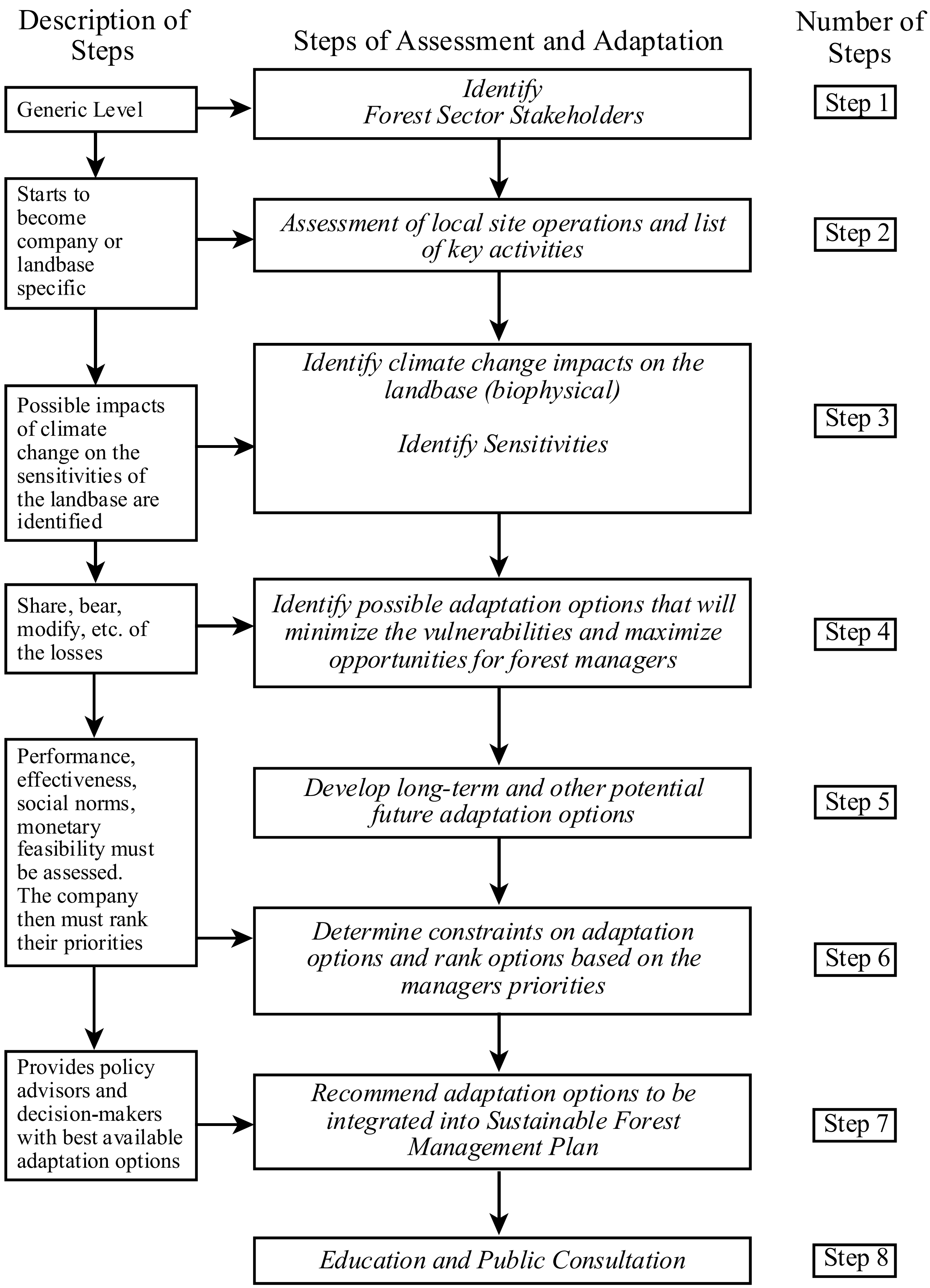

Figure 1: **Conceptual Framework for Adaptation to Climate Change for the Forest Sector** (modified from Carter et al., 1994)

Inputs

The inputs into the conceptual framework will come from the forest sector stakeholder. For Step One, the first input would be 'who' is the forest sector stakeholder. Step Two starts to become company or landbase specific where the forest manger would do an assessment of local site operations and list the key activities that are important in their management. Step Three assesses the possible magnitude and impacts of climate change from a biophysical perspective and then identifies the activities that may be sensitive or vulnerable on the forest stake holder's landbase. This would most likely be from an operational perspective.

Step Four examines the inputs of Step Three and identifies possible adaptation options for the most important impacts and sensitive or vulnerable activities. The purpose of the adaptation options identified in this step is to minimize the vulnerabilities and to maximize opportunities for SFM. When the forest manager is completing step Four, they will also determine if the adaptation option will share the loss of the impact, bear the loss of the impact, modify the impact, prevent the impact, or avoid the impact.

In Step Five, alternative adaptation options would be developed and added to the ones designed in Step Four. Step Six would provide a numeric input by assigning a ranking that would determine the priorities of the forest manager using the framework. Step Seven involves the input of new recommendation into SFM for adaptation. Step Eight involves having the public provide input on the results of the conceptual framework for that specific forest sector stakeholder. The comments from the public would be used to determine where societal concerns are and what recommendations that public may have for possible adaptation options for management of the forest.

Outputs

The outputs of each step in the conceptual framework will vary according to who is using the framework, because each of their inputs for Steps One through Eight will vary depending on management goals, ownership, operations, etc. The outputs from each step will determine the direction the forest stakeholder may go and what types of adaptation recommendations may be incorporated into SFM.

CASE STUDY

Case Study

The case study in this project was carried out with LP Canada Ltd., a forest company located in Swan River, Manitoba. The goal of the case study was to test the conceptual framework. The case study allowed me to determine if the conceptual framework was an efficient tool for the development of adaptation options for forest management. The case study was carried out in the second year of the project from March through June of 2001.

Purpose of Case Study

The purpose of this case study was to assess the conceptual framework to determine if it will be a useful tool to aid forest managers in identifying key activities within their operations and management that may be vulnerable or sensitive to climate change and the potential biophysical impacts of climate change on their landbase. By identifying the vulnerable and sensitive areas for LP, the development of possible adaptation options that may be implemented into their SFM can be carried out. The case study also demonstrates the usefulness of the conceptual framework with a 'real-life' working situation with a forest sector stakeholder from industry.

Discussion and Assessment Process

The first part of the case study involved a discussion of the eight steps of the conceptual framework with the Regional Biologist and the District Forester from LP.. We discussed each step in detail to determine if these steps were understood and answerable by the managers and whether they felt that other forest sector managers within government, independent agencies, and industry would be able to address each step of the framework. I facilitated and directed the discussion through the framework, but I did not give any of my own opinions or explanations of the steps. This was to determine how well this would work with a forest manager using this as a tool on their own for identifying impacts, sensitivities and vulnerabilities, and developing adaptation options for implementation into their SFM.

Step One was self- explanatory and did not require a discussion. It was clearly understood that this was a step which involved identifying the stakeholder who was using the conceptual framework. Step Two and three were originally in reverse order and it was here in the discussion with LP forest managers, that it was decided that these two steps must be changed with the assessment of local site operations and listing of key activities moving to step two and identifying of biophysical climate change impacts on the landbase and their magnitude and identifying of activities (listed in Step Two) that are most vulnerable to the biophysical climate change impacts on the forest stakeholders landbase move to step three. Steps Four and Five were briefly discussed and we went through some possible examples of how this could be displayed. It was determined that any of the activities and biophysical impacts with a ranking of five or higher would be the focus of the rest of the steps and that adaptation options would be developed only for these. Steps Four, Five, and Six would be displayed in a table format because we determined that the results of these steps would be understood and displayed best in this fashion. Step Seven would be at the discretion of the forest stakeholder using the conceptual framework and would be based mainly on the results from Steps Four, Five, and Six. Step Eight was added to the conceptual framework as a result of the discussion had with the forest managers from LP Canada Ltd. I was not aware until the discussion session with LP that public consultation was such a large part of their management practices.

Once the discussion of the conceptual framework was complete, I made some revisions based on the input from the forest mangers from LP Canada Ltd. When the revisions were done, we went through them again to make sure that each step in the framework was logical in thought and progression. With this completed, I gave the final version of the framework to the forest managers at LP and instructed them to go through the conceptual framework and complete each step to assess their key activities and operations, identify biophysical climate change impacts and activities that are sensitive to these impacts on their landbase, and then to develop and recommend adaptation options that could be integrated into their SFM. I was only a guide in this process because I did not want to influence the results in any way. The goal of the test was to determine if the conceptual framework would be useful to forest managers as a tool for developing adaptation options to integrate into their SFM in order to adapt to climate change impacts on their landbase.

Results

The following tables show the results of applying the framework to LP's SFM system on their landbase (Tables 1 and 2).

Table 1 Results of the case study with LP for Steps Two and Three of the Conceptual Framework.
Steps 2 and 3: Rank the magnitude of impact that the biophysical impacts of climate change will have on the landbase and activities of your management area using a scale of 1-10 with 1 being the least severe and 10 being the most severe

Forest Sector Sensitivities of Climate Change	Activities	Biophysical Impacts of Climate Change					
		Fire	Insects	Disease	Soil Moisture	Temperature	Precipitation
Planning	Harvest Scheduling (season of harvest)	1	1	1	10	4	9
	Harvest Scheduling (influence of disturbance events)	8	6	6	1	1	1
	Harvest Scheduling (equipment)	1	1	1	10	3	7
	Access Development/Road Layout	3	1	1	10	3	7
	Block Layout (site considerations)	4	1	1	1	1	1
	Endangered Species (habitat change)	10	1	1	1	1	1
	Water quality/aquatic resources	8	1	1	6	1	6
Road Construction	Ballasting/Surfacing	2	1	1	7	1	7
	Stream Crossing installation (bridge/culvert)	1	1	1	6	1	6
	Deactivation/rehabilitation (re-vegetate)	1	1	1	9	3	9
Harvesting	Falling (Hand falling and bucking)	6	1	1	2	1	1
	Falling (Mechanical)	5	1	1	10	2	9
	Log forwarding	5	1	1	10	2	9
	Skidding	5	1	1	10	2	9
Reforestation	Access	3	1	1	5	1	4
	Mechanical site preparation	5	1	1	10	2	9
	Seedling snow cache	1	1	1	2	7	10
	Seeding	1	1	1	8	1	9
	Planting (timing)	1	1	1	10	3	10
	Planting (success)	1	1	1	10	3	10
	Planting (competition)	1	1	1	10	3	10
	Growth and yield response	9	8	8	3	1	6
Protection	Fire protection	10	8	8	10	3	10
	Fire suppression	10	8	8	10	3	10
	Forest Health	10	8	8	10	3	10

The results displayed in Table 1 address Steps Two and Three in the conceptual framework. These results identify potential activities that may be sensitive to climate change and local site operations that are involved in each activity. They then listed biophysical factors including fire, insects, disease, soil moisture, temperature, and precipitation that had the potential to be affected by climate change. A ranking system of one to ten (one being the least severe and ten being the most severe) was used to rank the magnitude of affect that the biophysical factors may have on the activities and local site operations given the potential impacts of climate change.

Table 2 Results of Steps Four, Five, and Six of the Case Study with LP for the Conceptual Framework.

Steps 4, 5 & 6: List the operational activity, followed by a hypothetical climate change scenario for the landbase. Then list the operational and biophysical impact that may occur on the activity given the scenario. Develop possible adaptation options (Step 4) for each activity listed, followed by long-term and potential future adaptation options (Step 5), then list the effect of each adaptation option on the activity. In this step, refer to the adaptation diagram with share, bare, modify, prevent, etc. Then list an increase, decrease, or no change in the cost of these adaptation options to the manager. For the last stage, step 6, evaluate and rank the priorities of these activities and adaptation options to determine where the manager's priorities are. Use a scale of 1-10 with 1 being low priority and 10 being high priority

Activity	Scenario	Impacts: Operations	Impacts: Biophysical	Adaptation Options	Effect of Adaptation	Cost	Priority Ranking	Comments
harvest scheduling (season of harvest)	increased winter temperature & average precipitation	access problems & potential for site disturbance (harvest in non- frozen conditions)	increased soil rutting & compaction, loss of site productivity	use equipment with minimum impact technology	modify/prevent	increase	3	
				build all weather roads instead of winter roads to ensure access	prevent	increase	9	
				don't harvest in winter	avoid	increase	6	increased costs due to inventory storage to ensure year round wood supply
			inability to use ice bridges for stream crossings	install timber or other types of bridges	prevent	increase	9	
	increased spring temperature & 25% increase in precipitation	access problems & potential for site disturbance	increased soil rutting & compaction, loss of site productivity	use equipment with minimum impact technology	modify/prevent	increase	3	
				build all weather roads	prevent	increase	6	
				don't harvest in spring	avoid	increase	9	increased costs due to inventory storage to ensure year round wood supply
harvest scheduling (disturbance events influence)	increase in winter temperature, decrease in winter precipitation	access problems with winter roads & crossings	rutting & erosion on roads, water quality issues due to erosion & sediments	build all weather roads (class 3)	prevent effects	increase	6	

Activity	Scenario	Impacts: Operations	Impacts: Biophysical	Adaptation Options	Effect of Adaptation	Cost	Priority Ranking	Comments
				delay operations until	avoid the impacts	increase	9	
				frozen conditions/ snow available				increased costs due to inventory storage to ensure year round wood supply
				use minimum impact technology on haul trucks	prevent effects	increase	3	
harvest scheduling (equipment)	increase in winter temperature, decrease in winter precipitation	shut down operations due to potential site disturbance	rutting, compaction, erosion, loss of longterm site productivity	use minimum impact technology on feller bunchers, skidders	prevent effects	increase	3	
				delay operations until frozen conditions/snow available	avoid the impacts	increase	9	increased costs due to inventory storage to ensure year round wood supply
				select sites with different soil types less susceptible to site impacts	avoid the impacts	no change	6	
access development/ road layout	increase in spring temperature & increase spring precipitation	shut down operations due to erosion & water quality issues	sediment transport into streams at road crossings, water quality issues	delay operations until spring rains cease or drier conditions available	avoid the impacts	increase	6	
				develop access during frozen periods	prevent effects	increase	9	
				ensure adequate erosion control measures installed along crossings	modify events	increase	9	

The results in Table 2 are based on Steps Four, Five, and Six of the conceptual framework. The input for these steps came from the results in Table 1. Any activity, local site operation, and biophysical factor that had a ranking of five or greater was then focused on for the following steps in the conceptual framework. In the results for Steps Four, Five, and Six, the management activity was listed, followed by a possible climate scenario that may have an effect on the activity, followed by the operational and biophysical impacts that may result due to the listed scenario. Then adaptation options were listed for each activity, scenario, and impact. The effect of the adaptation option was then considered, followed by the estimated increase or decrease in cost of the adaptation to the company. Once this was complete, Step Six was completed by assigning a ranking (of one to ten, with one being the lowest priority and ten being the highest) to the activity and adaptation options based on the priorities of the company. Some comments were made by the company regarding certain activities and adaptations in the last column.

Using the results from Table 2, the company then identified which areas they would focus on and it aided them in determining possible adaptation options that could be integrated into their SFM plan. The results of the case study also allowed the company to identify areas that were more of a priority for future research regarding climate change and potential impacts on their landbase and management practices. Step Eight was not completed during this case study.

MANAGEMENT APPLICATIONS

LP Canada Ltd. Case Study

The Conceptual Framework for Adaptation to Climate Change was assessed in a case study with LP Canada Ltd., in Swan River, Manitoba. The forest managers at LP Canada Ltd. are interested in the issues surrounding climate change, potential climate change impacts, and adaptation for their landbase. Therefore they agreed to participate in the case study. They will also be using the results of the conceptual framework as part of their climate change section in their 20-year forest management plan and will be the first forest company to do so.

The purpose of the case study was to assess the conceptual framework in a situation that involved a forest sector stakeholder from one of the Prairie Provinces in order to determine if the conceptual framework would be a useful tool to address the concerns of climate change, potential impacts, and adaptations for forest managers. In the case study, the conceptual framework itself was analysed and discussed with forest managers from LP Canada Ltd. Steps Two and Three of the conceptual framework were reversed as a result of the discussions and Step Eight, education and public consultation were added to the framework. The analysis and discussion of the conceptual framework was very useful because it provided an opportunity for me to learn about issues that were more important than others within the forest sector and operations that would help make the framework more useful. I was also made aware of certain guidelines and policies that forest managers must adhere to and this was instrumental in making the conceptual framework more “user-friendly” for forest sector stakeholders.

The conceptual framework aids the forest stakeholder in determining where potential problems may arise and what they can do to deal with these problems. It allows the forest manager to see where the priorities may need to be placed and highlights areas that may require more study and research due to their sensitivity to potential climate change impacts. The managers that I was working with from LP Canada Ltd. were relatively knowledgeable concerning issues of climate change and the potential biophysical impacts that may affect their operational activities. When the forest managers from LP first began the second stage of the case study, they were under the impression that this would involve a very in-depth analysis of climate change impacts on their landbase and detailed scenario building in order to develop adaptation options for the future. I then explained to them that the conceptual framework was a very general model that would allow them to do a less detailed overall assessment and identification of their landbase, operational activities, climate change impacts, and adaptations in order to determine where more research and focus may need to be. Once this misunderstanding was cleared up, the rest of the case study went very smoothly and I received some excellent results from the forest managers at LP Canada Ltd. (Tables 1 and 2).

The results from Table 1 and 2 were very comprehensive. They addressed all aspects of management and planning that were instrumental in the operation of the company, ranging from long to short term. I was surprised at how detailed the responses were because I had not expected managers of a forest company to be as knowledgeable about climate change and potential impacts. They were able to address the questions in the conceptual framework and answer them by relating their operations to the biophysical aspects on their landbase. The results of the case study in tables four and five provide a direction for focus for LP Canada Ltd. with regard to future research and assessment of possible adaptation options that may be integrated into their management and planning process.

By analysing the results of the case study, I concluded that the case study demonstrates the usefulness of the Conceptual Framework. The forest managers from LP Canada Ltd. completed the framework from steps one through to seven and will complete step eight during the public consultation portion of their 20-year management plan. By using this framework, the forest managers at LP Canada Ltd. have a better understanding of where possible sensitivities or vulnerabilities may lie within their operations and on their landbase. This will enable LP to be better prepared for potential impacts in the future and will allow them to implement studies and monitoring to address possible areas of concern.

CONCLUSIONS

The forest sector must be able to adapt SFM to the potential impacts of climate change on the boreal forest ecosystem in order to be sustainable in the long term. It is becoming increasingly evident that in order to ensure the sustainability of the boreal forest ecosystem, action must be taken to aid the forest sector in adapting its current management framework to climate change. Practicing SFM involves managing the boreal forest ecosystem to maintain its integrity, biodiversity, and productive capacity over the long-term. With this in mind, it is apparent that a conceptual framework needs to be developed that would enable the forest sector to adapt SFM to climate change and the potential impacts on the boreal forest ecosystem. The Conceptual Framework for Adaptation to Climate Change for the forest sector developed through this project meets those needs. The framework was designed based on research involving a literature review, consultation with various forest managers across the Prairie Provinces, the workshop on determining the forest sector's ability to adapt to climate change, and the case study completed with LP Canada Ltd.

The conceptual framework for the forest sector was an important contribution produced in this project. This framework will be useful to various managers within the forest sector to aid in the assessment of their landbase and activities, identify potential biophysical impacts of climate change and determine what activities may be most sensitive to these impacts, and to identity possible adaptation options that may be integrated into their SFM practices in order to minimize the potential negative impacts of climate change and maximize the results of SFM.

This project has started to integrate science/research and planning and management within the forest sector in order to promote adaptation of SFM to climate change's potential impacts on the boreal forest. The results of this project should aid in bridging the gap that exists between technology and information transfer between research and the forestry sector. The research carried out in this project also demonstrates a relationship between the changing climate and climatic impacts on the boreal forest ecosystem across the Prairies. This research examined how climatic impacts may relate to SFM and potential adaptation options. This project has also identified many possible adaptation options at a generic level that may be utilized by various managers within the forest sector in the prairies. These adaptation strategies available for integration into SFM practices promote long-term planning and management from a biological as well as an economic standpoint.

The forest sector has been provided with a direct link between the changing climate and forest management within the Prairie Provinces. The forest sector and its managers in the Prairies can demonstrate wise stewardship of its forests with the adaptation of present SFM practices, which will lead to healthier, sustainable boreal forest ecosystems.

The forest sector does have many of the tools present within current SFM practices to adapt to the potential impacts of climate change. This project has provided a foundation for further research for developing adaptation options that can be utilized within management practices and plans that address the potential negative impacts of climate change on the boreal forest, within managed areas. It is important to realize however, that adaptation will not solve all the potential problems of climate change. Adaptation will provide a method and a starting point for preparing forest managers for possible future changes and associated impacts. Adaptation will allow managers to take a more proactive approach instead of waiting to see what will happen. This project has formed a link between climate change research and management within the forest sector and has provided tools that will enable further research.

REFERENCES

Alberta Pacific Forest Industries (ALPAC). 2000. *Alberta-Pacific's Detailed Forest Management Plan.* ALPAC, Boyle, Alberta.

Burton, I. 1995. *Impacts and Adaptations to Climate Change: Suggestions for a New Methodology.* Presentation. 22 pp.

Carter, T.R., M.L. Parry, H. Harasawa, and S. Nishioka. 1994. *IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations*. Department of Geography, University College London and Centre for Global Environmental Research , Tsukuba, Japan.

Krankina, O.N., R.K. Dixon, A.P. Kirilenko, and K.I. Kobak. 1997. Global Climate Change Adaptation: Examples From Russian Boreal Forests. *Climate Change*, **36**:197-215.

Lindner, M. 2000. Developing Adaptive Forest Management Strategies to Cope With Climate Change. *Tree Physiology*, **20**:299-307.

McCarthy, J.J.; O.F. Canziani; N.A. Leary; D.J. Dokken, and K.S. White. 2001. *Climate Change 2001: Impacts, Adaptation, and Vulnerability*. Cambridge University Press, Cambridge, United Kingdom.

Parker, W.C., S.J. Colombo, M.L. Cherry, M.D. Flannigan, S. Greifenhagen, R.S. McAlpine, C. Papadopol, and T. Scarr. 2000. Third Millennium Forestry: What Climate Change Might Mean to Forests and Forest Management in Ontario. *The Forestry Chronicle*, **76**:445-463.

Parry, M. and T. Carter. 1998. *Climate Impact and Adaptation Assessment*. Earthscan Publications Ltd., London, England.

Shine, K.P. and P.M. Forster. 1999. The Effect of Human Activity on Radiative Forcing of Climate Change: a Review of Recent Developments. *Global and Planetary Change*, **20**:205-225.