LIMITED REPORT

Forest Ecosystem Vulnerability to Climate: Economic Aspects

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S. Kulshrehtha

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TABLE OF CONTENTS

page

LIST OF TABLES

page

LIST OF FIGURES

INTRODUCTION

Trees and forests of the Canadian Prairie Provinces are an important natural resource to the people of the region. They provide many economic opportunities, and much needed employment, particularly in areas where such opportunities are few and far in between. Production of lumber and related products, and eco-tourism are some examples of these activities. In addition, forests also provide ecosystem stability, carbon storage, wildlife habitats, recreational opportunities, watershed protection, erosion control, aesthetic values, spiritual and cultural values to the society. A changing climate may threaten some or all of these benefits that society derives from this important resource.

OBJECTIVES

The primary objective of this study is to briefly outline the economic aspects of climate change-induced impacts on forests in the Canadian Prairie provinces. This is accomplished through a review of the economics aspects of the sector, followed by a review of available studies related to the area. One of the inescapable conclusion from this review is that economic aspects of climate-induced impacts on forests is a relatively unstudied subject. Although a number of studies have been undertaken that show physical impacts on the Canadian Prairie Provinces (as well other regions), very few of them have progressed to show socio-economic significance of such changes.

REVIEW OF FOREST AND RELATED SECTOR IN THE CANADIAN PRAIRIE PROVINCES

Physical Characteristics of The Canadian Prairie Provinces Forests

Boreal forests are an important part of forest cover in the prairie provinces. For example, almost three quarter of the northern Saskatchewan is covered under the Boreal forests. Of the total Saskatchewan provincial land area of 652 km^2, forests occupy 288 km^2 or 44% of the total[1]. For other prairie provinces, the proportion is higher for Alberta at 58% of the total and slightly lower for Manitoba (Table 1). However, much of this forest resource is not commercial, partly due to its location (extreme north and isolated). It is estimated that currently there is 44.7 million ha of productive forests in the three prairie provinces, constituting 47.9% of the total forest area. Within the three prairie provinces, Alberta has a slightly higher relative proportion of productive forest land (at 55% of total forest lands) and Saskatchewan the lowest (at only 37% of total forest lands). The productivity of the forests also varies from province to province, being highest in Alberta (producing 77 $m^3\ ha^{-1}$ and lowest in Saskatchewan (only 29 $m^3\ ha^{-1}$), as shown in Table 1. Prairie boreal forests hold a prominent part in Canada. The region occupies 22.3% of Canadian forest lands, and 20.9% of the productive forest lands.

[1] Based on data provided in Samoil and Boughton (1987), which were based on estimates made by the Canadian Forestry Service and the Saskatchewan Parks, Recreation and Culture.

Table 1: Forest Area in the Prairie Provinces, with Comparison with Canada, 1991

Particulars	Manitoba	Saskatchewan	Alberta	Prairies	Canada	Prairies % of Canada
Forest land area (Mill. Ha)	26.3	28.8	38.2	93.3	417.6	22.3
Land area (Mill. Ha)	54.8	57.1	64.4	176.3	921.5	19.1
Area of water (Mill. Ha)	10.2	8.2	1.7	20.1	75.5	26.6
Total Area (Mill. Ha)	65	65.2	66.1	196.3	997.1	19.7
Forest Area % of Total	40.5	44.2	57.8	47.5	41.9	--
Productive Forest Area (Mill. Ha)	13.2	10.6	20.9	44.7	213.8	20.9
Wood Volume (Mill Cubic Meters)	903	826	2954	4683	24969	18.8
Productive forest area as % of forest land area	50.2	36.8	54.7	47.9	51.2	--
Wood volume per ha of forest area (Cubic Meters)	34	29	77	50	60	--

Source: Statistics Canada (# 25-202-XPB)

Majority of forest related activities in the province are on provincial crown lands. In fact, over 95% of these lands are under the jurisdiction of the province, with the federal government owning less than one percent, and the remaining under private and municipal jurisdictions. In terms of volume of forest growing stock, trembling aspen, jack pine, and white spruce are the predominant species.

Canadian and prairie forests have played, and would continue to play, an important role in the economic, social and environmental well-being over the next century. The economic significance of these resources is described in the next section. In addition, the social and environmental significance of the forests cannot be challenged, since forests provide a number of socio-cultural and ecosystem related functions to the society at large. Some of these functions, such as carbon sequestration are much too important to be ignored, particularly in light of global changes such as climate change, and global security.

Economic Significance of the Forestry Sector in The Canadian Prairie Provinces

Economic significance of a goods-producing sector can be measured in several alternative ways, although four of these are more commonly used: Value of shipment (equivalent to level of economic activity), Addition to the provincial wealth (measured as gross domestic product), Wages and salaries (Significant in the context of society), and Employment (a meaningful measure for the society's welfare).

A complicating factor in the measurement of the economic significance is the scope of the forestry sector. Generally speaking, the sector is conceived in terms of primary production, as well as secondary production activities. Primary production refers to logging and related forestry operations. However, the logs so produced are further processed into lumber, and other wood products, including pulp and paper products. The latter are called secondary forest products. Furthermore, some of these wood products also find use in other value-added industries, such as furniture making, and could be labeled tertiary forest products. A further complicating factor in determining the economic significance of the sector is the fact that much of the information is not

routinely collected. Even when it is collected, for some regions information is not released, since it is considered confidential under the Statistics Canada's confidentiality rules.

Samoil and Boughton (1987) have estimated that in 1984-85, Saskatchewan forest industry (including wood industries and paper and allied products industries) has a level of shipments valued at $290 million. This led to a contribution to the gross domestic product of the province of $148 million, or 0.9% of the total. Lumber exports (foreign) have remained fairly stable during the pre-1990 period, have shown a steady increase. However, during the 1995-1999 period, these exports are estimated to have averaged $540 million (Saskatchewan Bureau of Statistics, 2000). A more recent account of the industry is provided by the Statistics Canada for the year 1995, and results are shown in Table 2.

The forest industry in the prairies is organized as 1,149 establishments, producing almost $6 billion worth of products, employing 23,462 workers, and adding a little over $3 billion to the regional gross domestic product. Relative to the Canada as a whole, its contributions are between 8 -10% of the total. Among the three prairie provinces, economic activities (as measured through value of shipments) of the sector are the largest in the province of Alberta (at $4.4 billion), followed by Manitoba (at $0.9 billion), and then Saskatchewan (at $0.7 billion). This pattern is reflected in all the economic indicators – employment, wages and salaries paid, and gross domestic product (valued added). The forest industry complex, as presented in Table 2, consists of three categories of industries – logging establishments, wood industries, and paper and allied product industries. One should note that some of the tertiary production industries are not included here. Details on these are shown in Table 3. In 1995, in the three prairie provinces, there were 771 logging establishments, 314 wood industry establishments, and 64 paper and allied product establishments. Alberta, as expected, had the largest share of these establishments.

Table 2: Summary of Forest Industries in the Prairies, by Province, 1995

Particulars	Manitoba	Saskatchewan*	Alberta	Total Prairies	Canada	Prairies % of Canada
No. of Establishments	209	258	682	1149	12508	9.2
Value of Shipment of Goods ($ Million)	$862	$665	$4,451	$5,978	$71,368	8.4
Employment						
Production and Related Workers	4390	2734	12690	19814	228713	8.7
Total Activity Workers	5183	3230	15049	23462	274214	8.6
Wages and Salaries ($ Million)						
Production and Related Activity	$123	$111	$484	$717	$8,654	8.3
Total Activity	$158	$135	$595	$888	$11,118	8
Value-added ($ Million)						
Production and Related Activity	$409	$257	$2,376	$3,042	$30,952	9.8
Total Activity	$408	$258	$2,385	$3,051	$31,475	9.7

* Saskatchewan data for the paper and allied industries is for 1993, obtained from Canadian Forest Service (1996)
Source: Compiled from Statistics Canada (Cat. No. 25-202-XPB)

Table 3: Number of Wood Industry Establishments in the Prairie Provinces, 1995

Particulars	Manitoba	Saskatchewan	Alberta	Prairies
Logging establishments	121	204	446	771
Sawmills and planing mills	11	7	51	69
Shingles and shake	0	0	1	1
Veneer and plywood	0	1	3	4
Other wood industry establishments	53	40	148	241
Total wood industries establishments[1]	**64**	**48**	**202**	**314**
Paper and allied industries establishments	24	6	34	64
Total number of establishments	209	258	682	1149

[1] Includes sawmills to other wood industries
Source: Compiled from Statistics Canada (Cat. # 25-202-XPB)

Relative contributions of various types of forest industries to the provincial economy is shown in Table 4, for the three provinces and for prairies as a whole. The paper and allied product industries are the ones that have the highest contribution to the provincial gross domestic products in all three provinces. This feature is consistent with rest of Canada, where these industries are the ones contributing the most to the total value-added of the forest industries. Wood industries are the next economically significant sub-sector of the forest industries.

Table 4: Value-added by Manufacturing Activity, by Type of Forest Industry, Prairies by Province, Million Dollars, 1995

Particulars	Manitoba	Saskatchewan	Alberta	Prairies	Canada	Prairies % of Canada
Logging	32	54	213	299	4054	7.4
Sawmills, planing mills	28	52	495	575	5231	11
Other wood industries	109	73	362	544	3116	17.5
Paper and allied industries	240	78*	1306	1624	18032	9
Total Forest Industries	409	257	2376	3042	30952	9.8

* Based on 1993 data, obtained from Canadian Forest Service (1996).
Source: Compiled from Statistics Canada (Cat. # 25-202-XPB).

Various prairie provinces have exhibited a different rate of growth in various industries comprising the forest industries. A comparison of employment in logging and wood industries in the three prairie provinces indicates that these industries are growing in the province of Alberta, where as in the other two province, they are either stagnant or have shown a very moderate growth. Details are shown in Figure 1. Employment in these industries in Alberta grew from almost 7,700 workers during the early eighties, dipping to almost 6,000 workers during the mid-eighties, and then rose to about 11,200 workers by the mid-nineties. Manitoba similarly, showed an increase from 2,500 workers in the early eighties to almost 3,300 workers by the mid-nineties. For Saskatchewan, however, the level of employment in the early eighties of 2,200 workers has declined over the last decade, with mid-nineties employment level still around 2,000 workers.

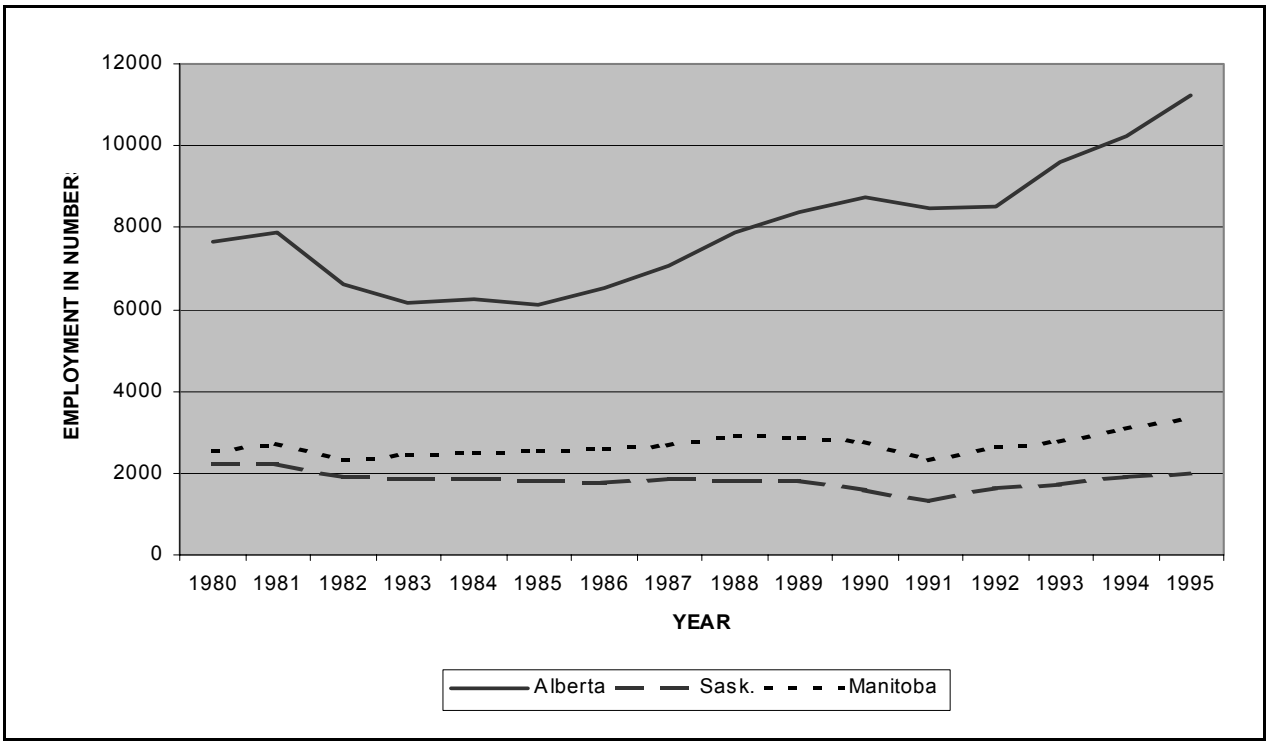

Figure 1: Trend in Employment in Logging and Wood Industries of Prairie Provinces, by Province, 1980-1995

A part of the lack of growth in Saskatchewan could be explained, at least partially, by productivity differences. Such a comparison for the year 1993 is shown in Table 5. The criterion used here was that of value-added level per unit of raw material – roundwood production. For Saskatchewan, the level of gross domestic product per unit of roundwood production is $48, as against $89 for Alberta and $178 for Manitoba. In fact, Manitoba level of value-added is higher than that for Canada as a whole, where for every cubic meter of roundwood, $120 is added as national value-added.

Table 5: Industrial Roundwood Production and Value-added, Prairies, by Province, 1993

Region	Industrial Roundwood Production (1 000 m^3)	Value-added in Total Activity (Million $)	Value-added in $ per 1 000 m^3 of production
Manitoba	1455	259	178
Saskatchewan	4357	210	48
Alberta	14180	1270	89
Prairies	19994	1739	87
Canada	169256	20332	120

Source: Compiled from Canadian Forest Service (1996)

In addition to wood products, the Prairie Provinces' forests also produce a multitude of non-timber products, including fish, wildlife, pelts and fur animals, outdoor recreation, and watershed benefits. Collection of products such as berries, and mushroom not only provides employment for local residents, but also is a source of income to many people.

In addition to direct employment, the forest sector also generate some employment in the local areas and in the province through purchase of goods and services from other industries, and from spending the income paid to workers of these industries. These are called indirect employment and could amount to another 9,680 jobs. One must be cognizant of the fact that forest industry is very localized in the norther half of the province. Its importance in terms of jobs generated (relative to the total) would be far more here that for the province as a whole. Many of the northern communities, as well as people of aboriginal ancestry, reliance on forestry-related activities is far greater than for other cultural groups of the Canadian Prairie provinces society.

REVIEW OF PAST STUDIES

Based on a review of past studies, it is very clear that since changes in the climatic pattern would be regional in nature, the physical impacts would be very location specific. Based on the available evidence, boreal forests would be much more affected by the climate change than temperate forests. One of the major factors affecting the temperate forests would be water shortages during the growing season. This would result in a decrease in the forest productivity – translated into lost wood production. A further dimension added to this impact is the occurrence of fires, particularly during the drier years. Such events may bring about economic hardships in the local region, and subject to flexibility on the part of economic agents on obtaining timber from other areas, may even result in serious hardships on the region as a whole. However, much of these predictions remain uncertain. Wheaton (1997) summarizing the literature for the Canada Country Studies concluded that "unmitigated global warming is estimated to have significant effects on the Western Canadian boreal forest" in the region. It is further predicted that warming is expected to reduce the biomass productivity in the agricultural zone of the Canadian Prairie provinces, but an increase is expected for the Canadian Shield areas (Williams and Wheaton, 1998).

Climate-induced changes on the forest industry could be brought about by both direct causes and indirect causes. The direct causes would include change in temperature and precipitation regimes in the boreal forest zone, accompanied by a CO_2 fertilization effect. The mean temperature increase and the CO_2 fertilization effect would yield an increase in the forest productivity. However, water shortages at critical periods of growth may modify such increases. Changing climate may affect the area under forest cover, resulting in a net loss in the area of boreal forest in the region (Wheaton, 1997, p.1 of Appendix B). This would in addition, have an effect on the recreational and other non-timber products, as well as on the biodiversity. These direct effects would be compounded by two types of indirect effects – impacts of fire regimes and insect infestations. These together would lead to a significant effect on the volume of forest products that can be harvested. The nature of impacts of climate change would vary depending on the nature of the forest. Binkley and Van Kooten (1994) have indicated that managed forests would be less susceptible to climate change than the natural or un-managed forests.

Very few studies encompassing economic analysis of the climate change-induced impacts for the Canadian Prairie provinces (and / or Canadian) forests have been reported. One such assessment is provided by Binkley (1988). The climate change scenario modeled in this study was GISS 2 x CO2. The study was multi-regional in nature with various countries linked through trade flows. The model was dynamic in nature, solved once every five year period. Measurement of economic impacts was undertaken using the concept of producer and consumer surplus. These results indicated that in Western Canada in the year 2030, income from timber sales would increase by 1.9% from the base results. In contrast, regions such as western and eastern USA, and European countries were forecasted to experience adverse effects from climate change. No attempt was made in this study to estimate the impact on the non-timber products, or to cast the results in terms of impacts on society or the regional economy in Western Canada.

As a part of the Canada Country Study, Saporta et al. (1998) recognized the existence of non-timber products as a part of the benefits from forest ecosystems. Based on studies in the Western USA, assumed to be applicable to Western Canadian forests, it was predicted that a climate change could have major implications for: high altitude wildlife species due to changes in the amount of snowfall and the timing of snow melt; habitat of salmonoid fish in the mountain streams; and on the large carnivores, such as wolverines and grizzly bears.

ADVANCES IN UNDERSTANDING SINCE THE CCS

Since the completion of the Canada Country Studies on climate change impacts, no studies were found that have examined economic impacts of climate change related phenomenon in the broader context of the society. However, a few studies have been reported for other jurisdictions, which have become the basis for the discussion in this section.

Climate change-induced impacts could be imparted both through adjustments in the wood supply as well as through non-wood functions of the forests. The latter would include both ecosystem functions and non-timber products of significance to the society. Climate change works through timber supply through changing the state of the forest. This would permeate to many other changes affecting the society and need to be considered. Ecosystem functions, such as biodiversity and carbon sequestration, to name a few, are more complex to model, yet hold a prominent place in the broader context of the society's welfare. To this date, this aspect of climate change and forests remains to be somewhat obscure. The effect of non-timber goods on the society has been typically ignored for forests in the Canadian Prairie provinces. In fact, very few studies have reported a good picture of the current situation in this region. In summary, non-timber forest goods are relatively unstudied subject in the Canadian Prairie provinces. Even those studies, that have been undertaken for other jurisdictions to examine the impacts of non-wood products on the macro-economy are, according to Solomon et al. (1996), limited in scope and uncertain.

In many regions of Canada, where forest products industry is a major employer, socio-economic impacts of climate change would be transmitted through the macro economy to the many forest-dependent communities (Morrison, 1997). Community level socio-economic impact analysis still is in its infancy stage.

ECONOMIC MODELS SUITABLE FOR THE FOREST CONCEPTUAL MODELING APPROACH

The economic impacts on society of a changing climate through forests can be a complex subject. A number of difficulties can be envisaged:

- A part of the difficulty arises from the fact that much of these impacts are based on the perception of the members of the society, which are very culture-specific.

- A second complexity is added by the fact that Canadian forest sector, and for that reason, the forest sector in the Canadian Prairie provinces as well, operate within an international arena, where economic activities are not only affected by the local conditions, but also by the external forces. For these reasons, it is felt that no analysis of the forest sector in the Canadian Prairie Provinces facing climate change would be accurate without due consideration of the international situation.

- A third level of complexity is from the fact that forests produce a multitude of products.

A simple taxonomy of various forest products is presented in Figure 2. Climate change would likely affect both timber and non-timber goods and services. A comprehensive account of climate-induced economic impacts must address all three aspects of the forest complex – timber products, non-timber goods, and ecosystem services.

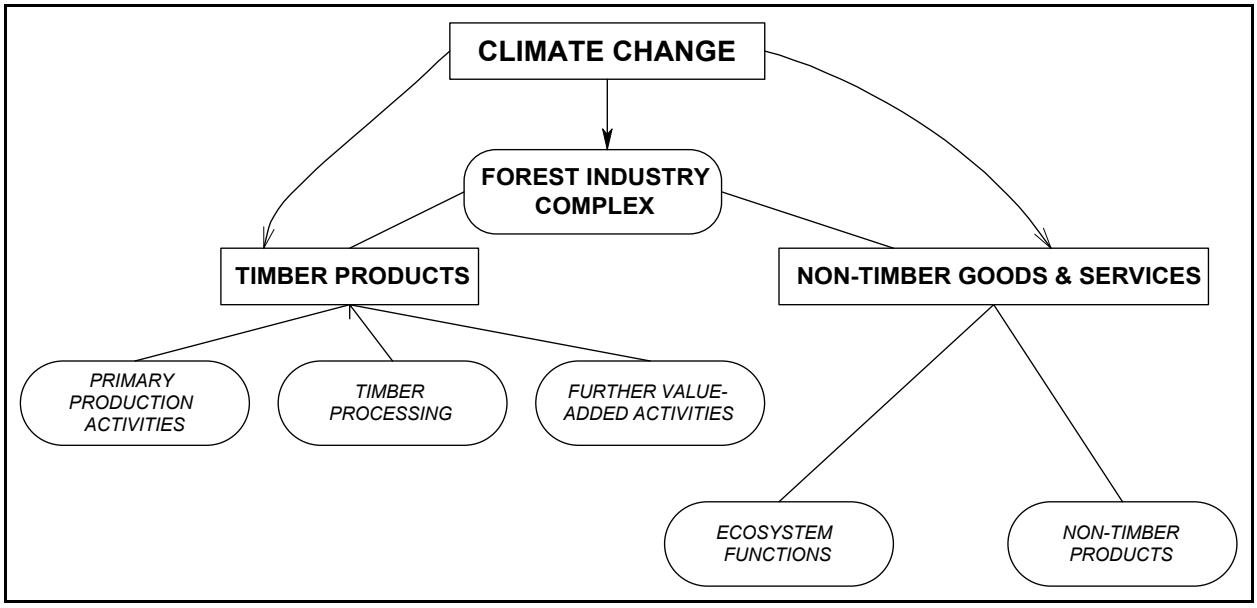

Figure 2: Effect of Climate Change on the Output of Forest Sector

In the wake of climate change impact assessment, two types of modeling processes have emerged in the literature. One of these is called economic modeling, whereas the other types are called integrated models. Using an economic modeling approach, conceptual economic impacts of a changing climate can be visualized at five levels of spatial scales:

1. International market place, with impacts on trade patterns, and pricing for wood and its derived products;

2. Macro economy (national) level, with cross-sectoral impacts included, resulting in implications for land use and for international competitiveness of the sector;

3. Meso economy level, with regional level impacts, and implications for regional competitiveness of the sector;

4. Meso-micro level including economic impacts on communities that depend on forest products, and,

5. Micro level, with implications for individual firms.

Global and National Models

Development of the global models of forest sector economics has been an important topic over the last 20 years. Models have been built for global forest industry by Randers (1977), Adams and Haynes (1980), Nilsson (1981), Buongiorno and Gilless (1984), Zhang et al. (1997). Many of these models tend to be large, with only limited details for each country of interest. Major emphasis here is on the determination of the prices and world trade. Although these models have yet to be applied for assessing the impact of climate change, their applicability remains unchallenged. One aspect of these models that requires special attention under this type of analysis is the supply side, as the assumptions of timber supply are critical (Tromborg et al., 2000).

National and Regional Models

At the national level, economic impact analyses of forestry complex have been undertaken using four types of models:

1. Partial equilibrium econometric models,

2. Input-output models,

3. Hybrid econometric/input-output models suggested by Sullivan and Gilless (1990), and,
4. Computable general equilibrium models.

Partial equilibrium econometric models are typically models of timber supply and demand. A condition of market equilibrium is assumed and model is solved for prices, and level of output. Input-output models take the entire economy of a region into account and trace through the production and disposition of various products within the economy. External trade patterns are also incorporated here. Such models have been reported for the Saskatchewan forest sector by Kulshreshtha (1998). Econometric models and input-output models have the capability of conducting policy analysis through further extensions. Two such extensions have been reported. In one extension, econometric model solutions are passed through an input-output model for impact assessment. These are called Hybrid econometric/input-output models. The second type of extension is more formal and is developed using the logic of general equilibrium analysis. The

resulting models are called computable general equilibrium models. Assumptions are made with respect to not only the forestry production sector, but for other economic sectors as well. In addition, factor markets are also modeled here. Percy et al. (1989) provides an example of this type of equilibrium model of the Alberta forest sector – ALTIM 1.0. One of the constraints in computable general equilibrium models is the size, since the number of sectors that can be represented need to be small, in order to preserve manageability. However, these models are better suited to perform policy analysis. Alavalapati et al. (1998) have shown that results of the general equilibrium and input-out models can be biased, subject to the nature of scenario and adjustments made in the structure of the model.

Dynamic simulation model is another avenue for estimating economic impacts of climate change. Such a model has been reported by Maki et al. (1986), although its application for climate change impacts has not been reported. Under the general simulation approach, a variety of methods can be assembled, including logical relationships, econometric relationships, and input-output based results.

The integrated modeling attempts to deal with biophysical as well as socio-economic processes and their interactions, simultaneously. Integration may be modeled for various economic activities requiring the same set of resources, such as land. It may also be extended to include socio-economic changes along with interactions with biological, climate, and ocean systems. One of the major limitations of this type of models is that these, by necessity have to be global in scope. Thus, the details for any single country are somewhat limited (Scholes et al., 1998).

Community Level Models

As noted earlier, community level impact analysis is in somewhat of an infancy stage. Many studies conducted have been concerned with baseline data collection, and using them in an qualitative manner, impacts on communities. Kubursi et al. (1996) have developed a model for Ontario communities to analyze such impacts. In this attempt, methodology was based on a combination of input-output models translated into specific community's dependence on the forest sector using location quotient. This type of modeling, although does show the local level impacts, does not address the nature of changes that undergo at the community level.

Multiple Accounts Framework

In addition to the quantitative models, another technique that has been used for displaying results of economic impact analysis is the Multiple Account Analysis (MAA). It should be noted that this is not a method or model for estimation but simply the manner in which results can be presented. Depending upon the nature of economic impacts, and the interest of the decision-maker, several accounts can be identified to be included in MAA. These may include, nonetheless, the following accounts:

1. Economic impact analysis account, which can be further subdivided into sub-accounts, such as:
   a. National economic development
   b. Regional economic development
   c. Local economic development

2. Community level economic development account

3. Aboriginal People account

4. Environmental Quality account, and

5. Other social effects accounts.

The above list of accounts is tentative and can be modified for a site-specific situation. Data to be entered into any of these accounts can be estimated using various economic models and/or other sources of information available to the analyst. More recently, there are MAA tools linked with Geographical Information Systems, as suggested by Brown et al. (1994).

LINKAGES OF THE ECONOMIC MODELS WITH THE CONCEPTUAL MODEL

Although many different types of economic analysis models have been developed for a variety of purposes (policy analysis, resource use prioritization, research and investment funding, among others), not many have been developed exclusively for the examination of climate change-induced socio-economic impacts. In developing a methodology for estimating such impacts, the following considerations are important:

1. Since socio-economic impacts emanate both from timber and non-timber goods and services, both of these must be included in any comprehensive assessment of climate change-induced impacts.

2. International influences (through pricing and trade considerations) on the forest economy of the Canadian Prairie provinces can play a significant role and therefore, must be taken into account.

3. Although all major economic activities related to the forestry operations should be included, much of the tertiary production activities may not be totally dependent on the local production of raw material. For this reason, these activities could be excluded from the initial analysis.

A conceptual methodology for climate change-induced socio-economic assessment is presented in Figure 3. The proposed framework for analysis recognized the above noted three considerations for impact estimation. It links such analyses with the bio-physical models, which generate a set of physical impacts in terms of forest productivity and composition. These changes could be further broken down into two groups: (1) those for timber harvest and volume, and (2) those for non-timber

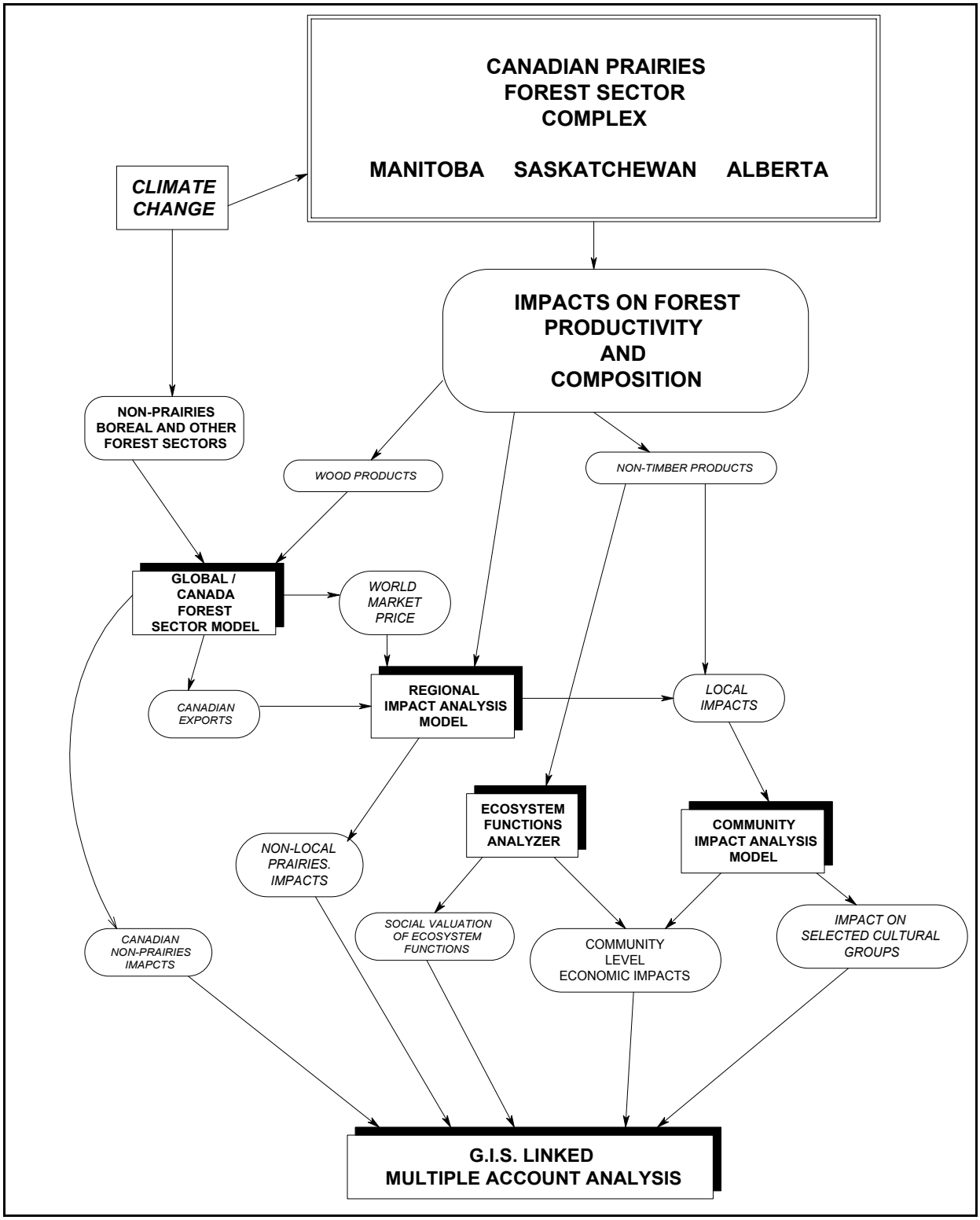

Figure 3: A Suggested Conceptual Framework for Estimating Economic Impacts of Climate Change on Forest Sector

goods and services. The first category of changes would be further specified in terms of timber volume and through specified relationships to other timber products (lumber, pulp, paper, among others). Volume of production and their monetary value would be estimated here. This would require another set of information related to economic changes – price of the product, and trade flows. Some of this information could be provided by external sources (such as a global / world forest sector model). The same type of information would be needed for the changes categorized under the non-timber goods and services.

The aggregated results for the timber and non-timber products would be used for estimating the indirect and induced impacts of the economic changes induced by global climate changes. Here, an input-output model of the regional economy (to estimate the local area impacts) and of the provincial economy could be used. The local area level impacts can then be translated into effect on communities using tools such as Economic Base Analysis or Income-Expenditures Analysis[2]. Alternatively a full-blown community impact simulator could be developed.

Community level impacts can then be extended to special interest groups, such as aboriginals. However, this type of assessment would require a baseline survey of the communities with data collected on various socio-economic characteristics, with emphasis on its dependence on forest related activities.

The third major area of impact assessment would be the effect of climate change on ecosystem functions. Included here would be major functions, such as carbon sequestration, hydrological cycle, erosion prevention, and biodiversity. Each of these functions would need to be valued, and or monetized.

Once all the impacts have been estimated, their presentation could be in the form of a Multiple Accounts Analysis, which could have the potential of being linked with a GIS.

KNOWLEDGE GAPS AND RESEARCH CHALLENGES

One of the most serious knowledge gaps in developing the above noted methodology for the Canadian Prairie provinces' boreal forests is the lack of baseline information on many non-timber products, including ecosystem functions. Biodiversity, wildlife habitats, use of the forests for collection of non-timber products such as mushrooms, wildcrafting, berry picking, among others, are commonly sited examples. This type of information is not collected systematically. Furthermore, the relationship between forest cover and resulting non-timber products production is less understood.

If one were to include ecosystem function as a part of this impact analysis, another challenge faced is the knowledge of their social values, and the appropriate method of valuation of these services. The first and foremost problem here is that of scope – are these values necessarily local, or should these be national or global? Global values are associated with carbon sequestration and biodiversity, and are not easy to estimate. Other related issues that may arise include: Carbon storage in the peat-

[2] A good description of these methods is provided in Davis (1993).

forming wetlands, implications of shift in the biodiversity northwards, and consumptive and non-consumptive recreation values. For the biodiversity issues, one of the problems has been that most studies are limited and focused on a few important species. With respect to recreation, the issue would be the desirability of forests as recreation areas. This issue would be complicated by two sets of factors: One, climate change would bring forth a different spatial distribution of population in the region, and changes in the recreational opportunities (as an example, demand for recreation may increase due to longer summers); and Two, the preferences of future generations for recreational activities are very hard to predict .

In any future assessment of socio-economic impacts, role of technology is very important and cannot be ignored. Yet it is one of the most difficult trend to predict. Such trends would affect forest industry demand for products, through substitution of wood for non-wood products (steel or concrete), and through discoveries of new uses for wood products? These factors could significantly modify the magnitude of impacts of climate change on the Canadian Prairie Provinces society.

In the future, society may experience increasing conflict among various objectives. According to Solomon et al. (1996), these may include, but not limited to: (1) between traditional forestry and requirements for wilderness areas; (2) between timber production and biodiversity; and (3) between applied forest technology and landscape development. In addition, conflict could also arise from simultaneously meeting the sustained yield target and maintaining or improving the growth of economic activities related to the sector (Lonnstedt, 1984). Climatic changes would likely enhance these conflicts.

In addition to the above listed issues, many of the gaps in our knowledge remain unchanged, whether or not climate change continues. Phillips et al. (1986) have identified a number of research issues that need particular attention, and become even more pertinent in the context of climate change. These include: forest industry impact (regional and economic), economics of non-timber forest uses, and stumpage valuation, among others.

CONCLUSION

Socio-economic impact assessment of changes in the boreal forest of the Canadian Prairie provinces induced by climate change is an area of high social significance. Forestry is an important primary goods producing industry in the region. Many of the communities and businesses in the northern half of the prairies provinces region depend more heavily on various types of forest related activities.

Socio-economic impacts would be felt through changes in both timber (wood) products harvest and their use, as well as through production of non-timber products. Included in the latter category are the ecosystem services provided by these forests.

A comprehensive economic analysis of climate change-induced impacts requires at least five level of analyses:

- International level analysis to include changes in economic activities of the sector that may have implications for Canada;
- National analysis to indicate factors affecting forest sector in the Canadian Prairie Provinces;

- Regional level coupled with a local region analysis;
- Community level analysis for the forest-dependent communities; and,
- An analysis encompassing firm level impacts.

Presentation of results of these analyses may proceed on line of Multiple Account Analysis, with input-output model and community level models playing an important role. Furthermore, valuation of non-timber goods and ecosystems deserves a special mention.

Based on the proposed framework, a number of recommendations can be made:

- Complete a survey of various international models with two objectives: One, to examine their structure and their suitability for estimating climate change-induced impacts; and Two, to examine the specification of the Canadian forest sector for use in national impact analysis.
- Feasibility of developing a forest sector computable general equilibrium model with provincial and sectoral disaggregation be examined.
- Community level impact analysis be reviewed further, perhaps in conjunction with the methodologies developed for social impact assessments.
- Since the nature of data available in public arena is limited, attempts should be made to collect needed data from primary surveys.
- The above surveys should also address the nature of non-timber values provided by forests, in the context of community's dependence on such values.
- Appropriate method of valuation of ecosystem functions should be developed through a meta-analysis of the literature.

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