

Forests and Climate What Next?

Jim Maclellan

NB Climate Change Research Collaborative

University of Maine, September 10, 2013



Your Environmental Trust Fund at Work
Votre Fonds en fiducie pour l'Environnement au travail



OUTLINE

- Knowledge Perspectives
- Accounting for the Local
- Problem Framing ...
- Structuring Decision Making ...
 - Top Down
 - Bottom Up
- What's Next?

Report of the National Systems in Changing Climate Task Force
 2008-2011-2012
 2012-2013-2014

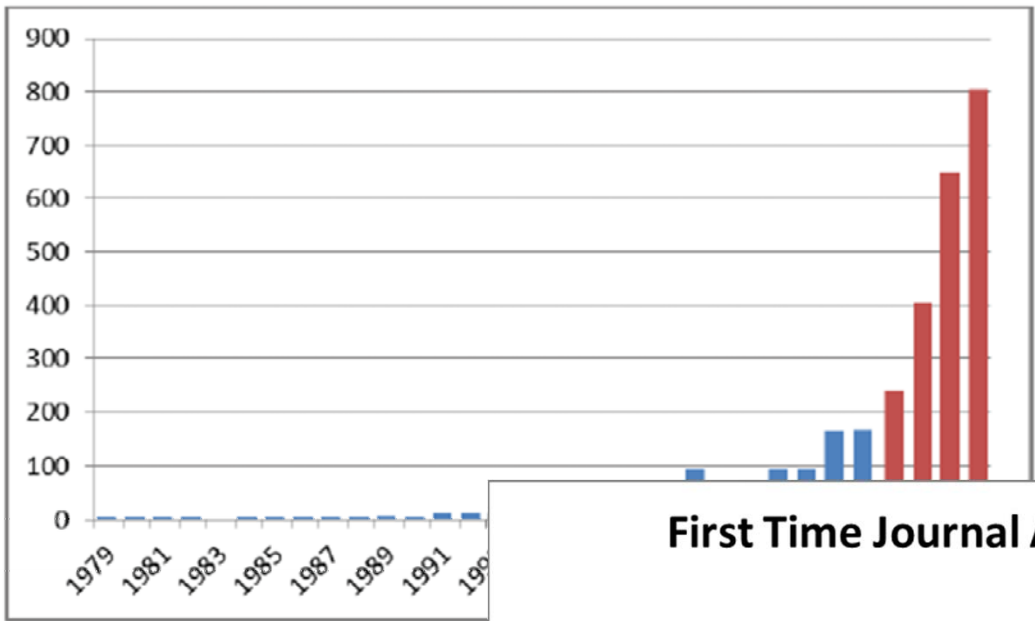
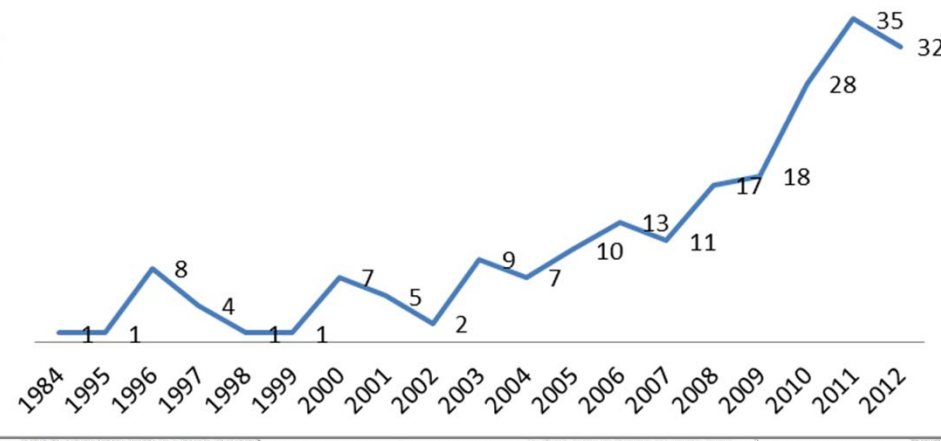


Figure 2: The number of climate change adaptation article the previous study of Figure 1 ("Climate Change Adaptation search as reduced by an estimate of the number of non-relevant articles")

First Time Journal Appearance





Natural Systems in Changing Climate

www.natural-systems-in-changing-climate.org

Vol. 1, 1 September 2012, Pages 4401-4402, doi:10.1038/nsc12012

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Climate Change and Infectious Diseases: From Evidence to a Predictive Framework

www.natural-systems-in-changing-climate.org

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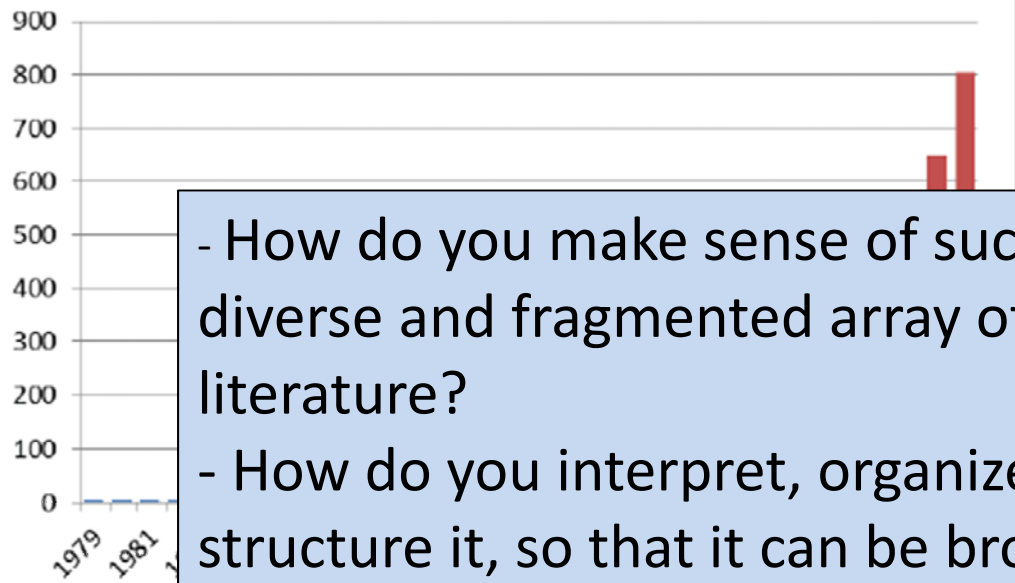
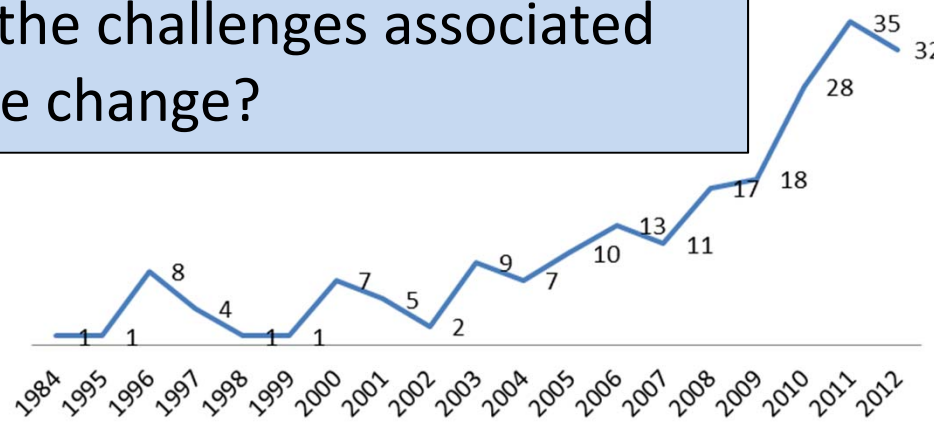


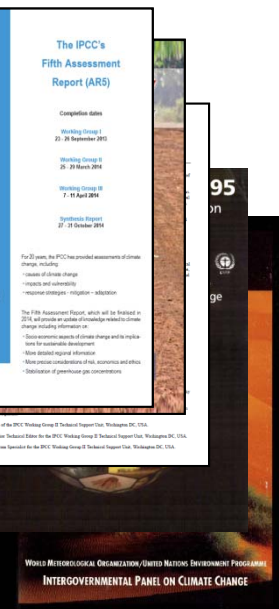
Figure 2: The number of studies published in the previous year of research as reduced by climate change.

- How do you make sense of such a diverse and fragmented array of literature?
- How do you interpret, organize and structure it, so that it can be brought to bear on the challenges associated with climate change?



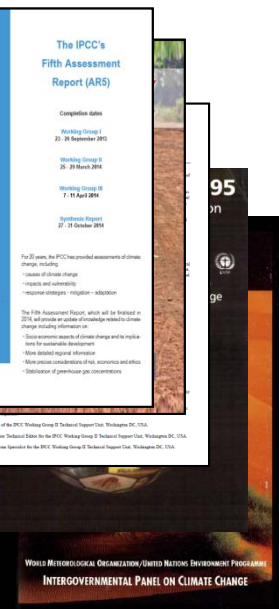
Knowledge Perspectives





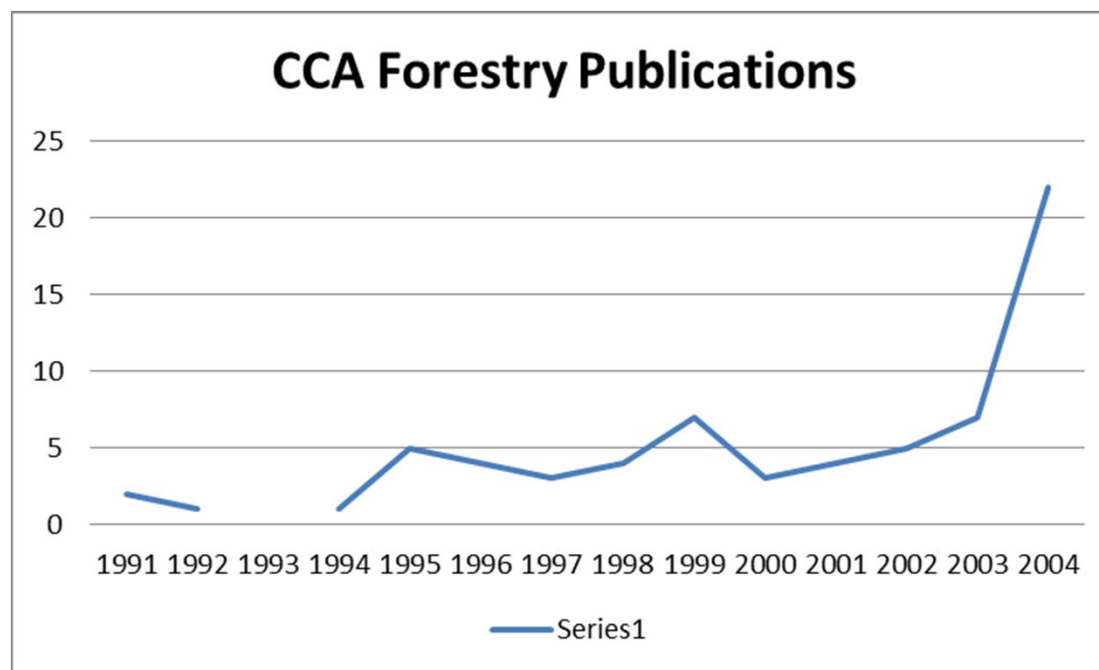
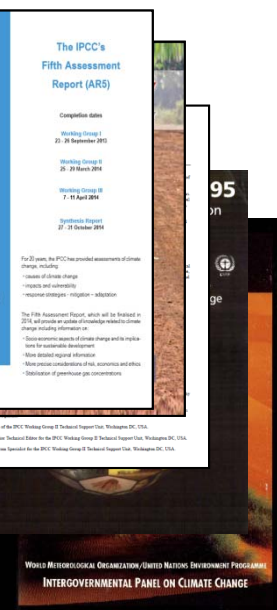
The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) as a response to the problems accompanying global climate change. Its mandate is **to collect and assess scientific, technical and socio-economic information relevant for the understanding of climate change, and its potential impacts and options for adaptation and mitigation.** It does not carry out research itself, but bases its assessments on peer reviewed and published scientific/technical literature.





What about forests?

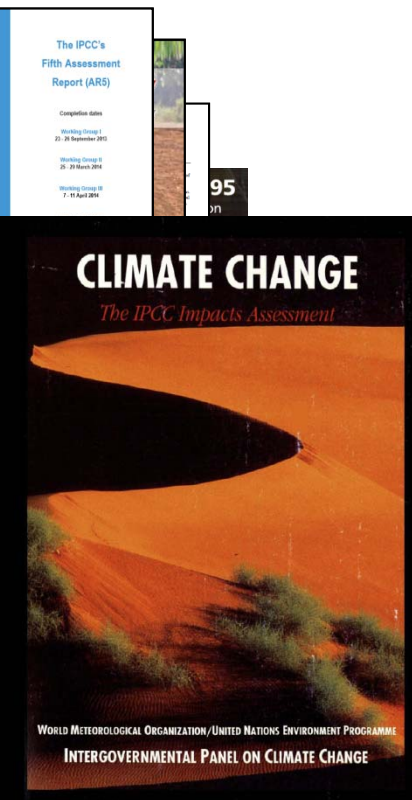




25

Year	Forest	Biodiversity
1990	0.0024	0.0000
1995	0.0032	0.0001
2001	0.0020	0.0004
2007	0.0020	0.0005
2013	0.0010	0.0003

Water\Marine
Agriculture
Forest Sector
Habitat
Conservation
Ecosystems
Subsistence
Tourism
Infrastructure
Fishing
Coastal
Energy
Transportation
Built Environment
Mining
Financial



The rotation period of forests is long and current *forests will mature and decline during a climate in which they are increasingly more poorly adapted*. Actual impacts depend on the physiological adaptability of trees and the *host-parasite* relationship. Large losses from both factors in the form of *forest declines can occur*. Losses from *wild-fire* will be increasingly extensive. The climate zones which control species distribution will move *poleward and to higher elevations*. Managed forests require large inputs in terms of *choice of seedlot and spacing, thinning and protection*. ... The most sensitive areas will be where species are close to their biological limits in terms of temperature and moisture. This is likely to be, for example, in semi-arid areas. *Social stresses* can be expected to increase and consequent anthropogenic damage to forests may occur. These increased and non-sustainable uses will place more pressure on *forest investments, forest conservation* and sound forest management.

(IPCC 1990)



What about Canada?

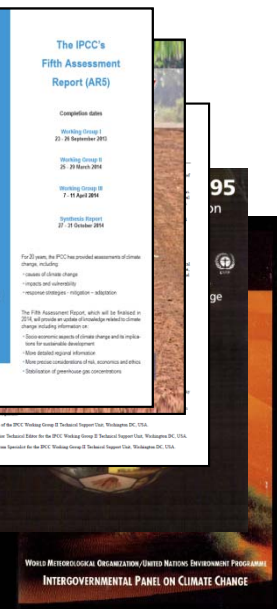
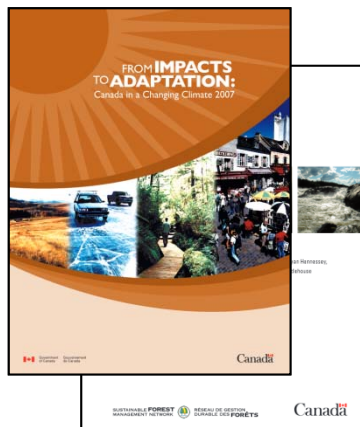


Table 1: Summary of the results of the analysis of the impact of climate change on the forest sector in Canada, 2007-2050	
Region	Impact (2007-2050)
Atlantic	1.2% decrease in forest area, 1.2% decrease in forest volume, 1.2% decrease in forest value
Quebec	1.2% decrease in forest area, 1.2% decrease in forest volume, 1.2% decrease in forest value
Ontario	1.2% decrease in forest area, 1.2% decrease in forest volume, 1.2% decrease in forest value
Manitoba	1.2% decrease in forest area, 1.2% decrease in forest volume, 1.2% decrease in forest value
Saskatchewan	1.2% decrease in forest area, 1.2% decrease in forest volume, 1.2% decrease in forest value
Alberta	1.2% decrease in forest area, 1.2% decrease in forest volume, 1.2% decrease in forest value
British Columbia	1.2% decrease in forest area, 1.2% decrease in forest volume, 1.2% decrease in forest value
Yukon	1.2% decrease in forest area, 1.2% decrease in forest volume, 1.2% decrease in forest value
Nunavut	1.2% decrease in forest area, 1.2% decrease in forest volume, 1.2% decrease in forest value
Canada	1.2% decrease in forest area, 1.2% decrease in forest volume, 1.2% decrease in forest value



FROM IMPACTS TO ADAPTATION




**SUSTAINABLE FOREST
MANAGEMENT NETWORK**



RÉSEAU DE GESTION
DURABLE DES FORÊTS

Canada



- 
- Current impacts on Canada's forests
 - Future impacts on Canada's forests
 - Extreme weather and climatic variability
 - Forest fire
 - Insect and disease disturbance
 - Effects on physiological processes
 - Productivity
 - Composition, distribution, and structure of Canada's forested ecosystems
 - Climate-sensitive zones
 - Regional forest vulnerabilities
 - Impacts on the Forest sector
 - Conclusion and recommendations



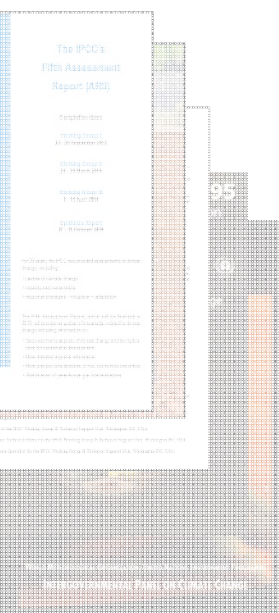
Regional Vulnerabilities: Atlantic Region

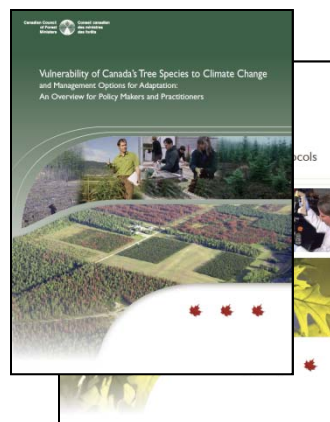
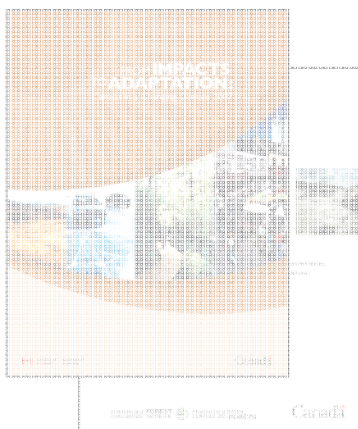
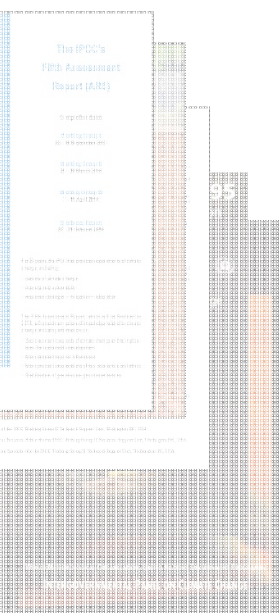
- Tree distribution of native species expected to shift
 - Some tree species may have difficulty persisting under a changing climate (e.g. balsam fir),
- Migration is such a slow process
 - influx of tree species common to Carolinian forest unlikely to occur during the 21st century unless assisted.
- Insects primary cause of disturbance to both Acadian and boreal forests of Atlantic Canada.
 - Spruce budworm is a significant source of forest disturbance. An opportunistic native species that takes advantage of windthrown
 - Other species include the spruce beetle
 - Hemlock woolly adelgid. Currently excluded from Atlantic Canada by winter temperatures, may capitalize on moderate winters
- Drought is considered a comparatively minor force of disturbance.
 - Less than 1% of the total forested area of the Atlantic Canadian provinces was burned in 2005.
 - Overall wetter conditions mean fire will not likely become a matter of increased concern.
- Acadian forests are subject to damage by wind damage which will likely increase in severity and frequency



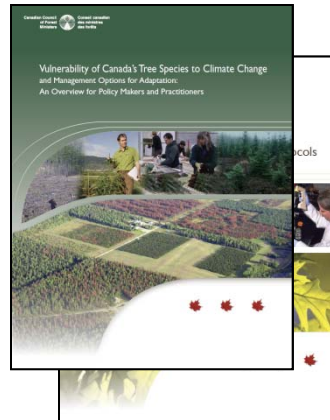
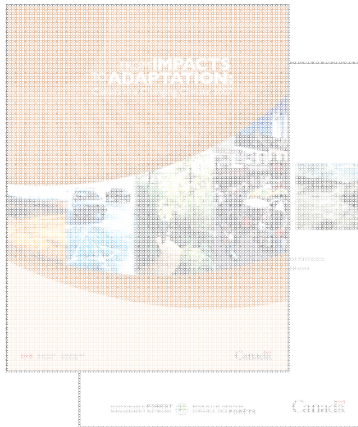
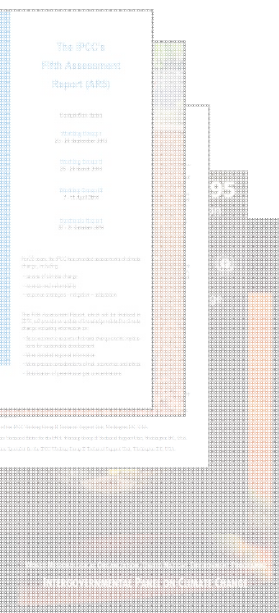
Regional Vulnerabilities: Atlantic Region

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 - Migration is such a slow process
 - influx of tree species during the
 - Insects primary of Atlantic Canada
 - Spruce budworm opportunistic
 - Other species
 - Hemlock winter by winter
 - Drought is considered
 - Less than 1 provinces vulnerable
 - Overall wet of increase
 - Acadian forests increase in severity and frequency
1. Enhance the capacity to undertake integrated assessment of vulnerabilities to climate change at various scales
 2. Increase resources for impacts and adaptation science and also increase resources to monitor the impacts of climate change.
 3. Review forest policies, forest planning, forest management approaches, and institutions to assess our ability to achieve social objectives under climate change
 4. Embed principles of risk management and adaptive management into forest management .
 5. maintain or improve the capacity for communications, networking, and information sharing with the Canadian public and within the forest sector.



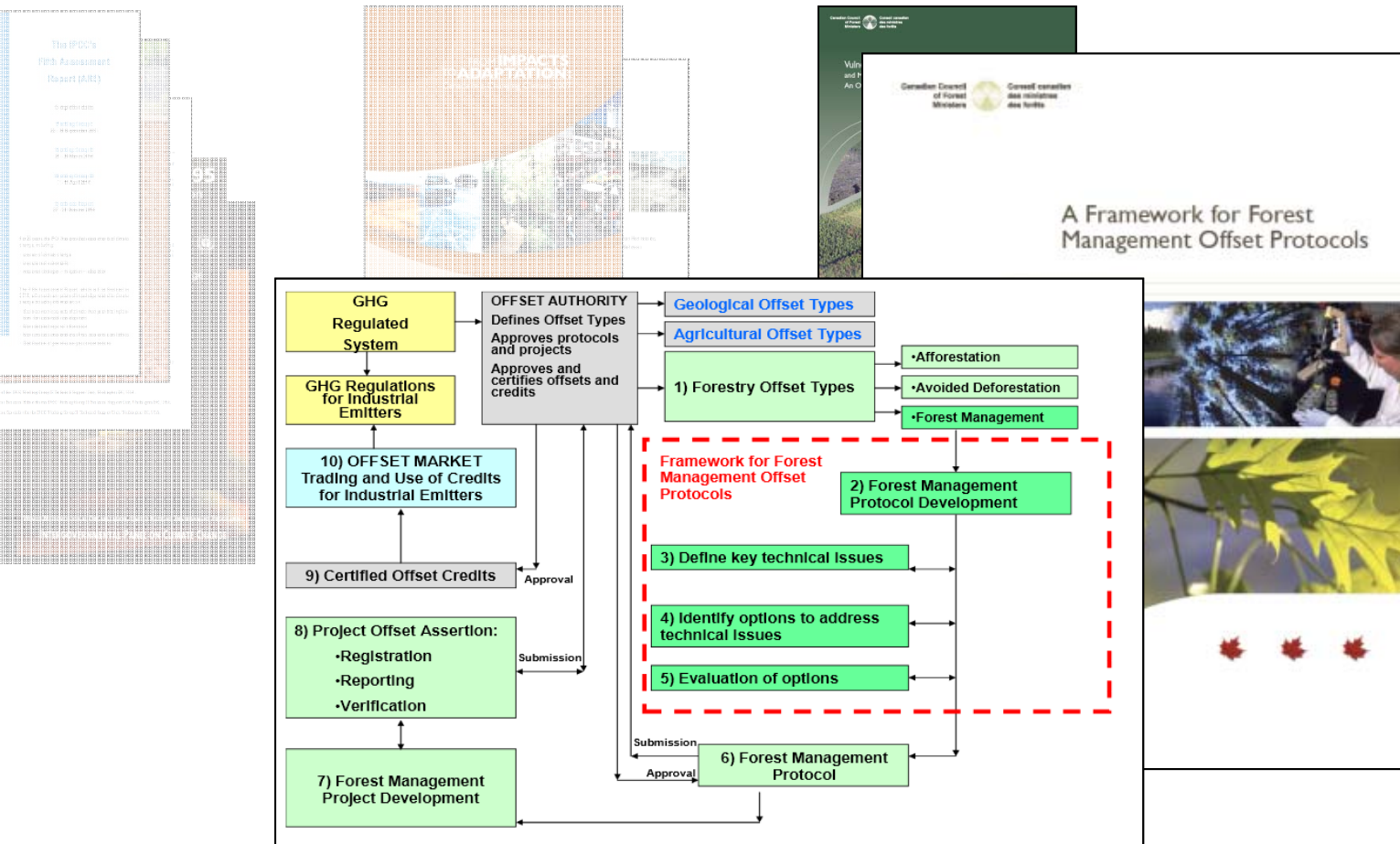


PHASE I



- FOREST CHANGE
 - Adaptation program occurs over 13 departments: Health, Energy, Agriculture, etc
 - 3rd year of a 5 year program
1. Develop a Set of Indicators,
 - climate signals, biophysical, etc.
 2. Tool Kit
 - What kind of data is needed, etc for Forest management
 - Scientific data and protocols
 - Vulnerability Assessment Tools
 3. Integration Assessment (internal)
 - S2 Climate Change Projects
 - S3 Disturbance and extreme weather
 - S4 Forest Composition and Productivity
 - S5 Timber Supply
 - S6 Forest Industry Competitiveness
 - S8 Policy Implications





Framework for Forest Management Offset Protocols



temperature gas (GPG) emissions, and carbon flux changes projected over 100 years were assessed by a regression model (Table 2). After 100 years, the GPG emissions of the 2005, 2025, and 2055 scenarios were 2.2, 2.6, and 2.8 Gg C yr⁻¹, respectively, which were 10% lower than the 2005 value. The carbon flux changes were also based on estimates of 2.1, 6, and 27%, respectively, of total emissions. Forest and product sinks were found to be crucial in decreasing carbon flux (GPG) (negative carbon emissions) and to 2027 (1.2 Gg C yr⁻¹ at year 50, but at forest loss, forest emissions, emissions exceeded vegetation by 0.8 Gg C yr⁻¹, resulting a GPG estimate of 3.4) (Table 3). After 100 years, the rate of forest product changes is of similar pace over 0.36, 0.24 of g dry weight per kg hydrolyzed, or 22.7 g adjusted net released by 100 years. Decreasing the GPG slightly, the ability of forest products requires reduction of wood, paper, biomass, and manufacturing emissions and consideration of natural disturbance, habitat, and recycled emissions.

Greenhouse gases (GHGs) emitted from human activities (*e.g.*, deforestation and fossil fuel use) and natural forest disturbances (*e.g.*, insects and fire) contribute to warming of the earth's climate. This warming could potentially have severe economic and social impacts around the globe. In 2007, forest products in the United States emitted up to 44 Tg of carbon (C), equivalent to 25% of US net forest C sequestration that year. This C stored in forest products was equivalent to 61% of industrial GHG emissions in the United States (Hogg 2009).

The present change in the net GPPG estimates due to altering C_{min} varied at both sources and across products but has been evaluated for varying abiotic conditions and for sources in northeastern North America (Hemmerle et al. 2008). However, few studies have evaluated the effect of changing C_{min} estimates from modifying abiotic conditions (e.g., temperature) and the effect of C_{min} on estimates with an exogenous reference fractionation. Evaluation of the effects of altering C_{min} on net primary production should include the contribution of nonrespirable material to the total GPPG, as well as the effect of C_{min} on the net primary production, which may occur in aquatic

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Journal of Finance • MARCH 2010 11

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E-mail address: madaxad@ub.edu (D.A. Madaxad).

2006). Scattered information regarding C dynamics for a limited number of wood types is insufficient to consider C

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doi:10.1016/j.jneuro.2007.07.017

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1. *Journal of Management Education*, 2000, 24(1), 10-19.

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Keywords: Moral identity, moral intensity, moral behavior, moral reasoning, moral climate, moral disengagement, moral identity theory, moral identity research, moral identity measurement, moral identity antecedents, moral identity consequences, moral identity moderators, moral identity mediators, moral identity outcomes, moral identity antecedents, moral identity consequences, moral identity moderators, moral identity mediators, moral identity outcomes

et al. 1984; Murray

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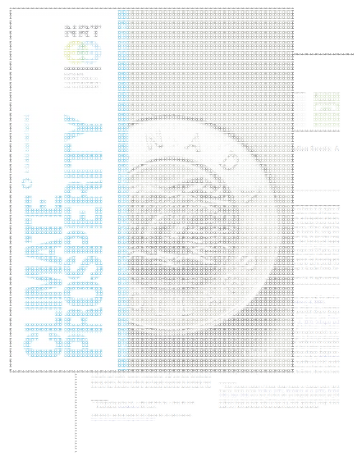
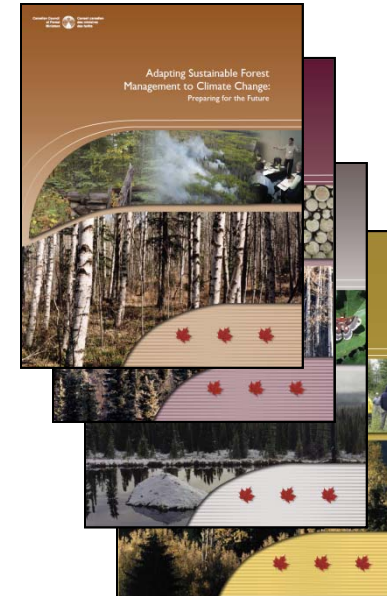
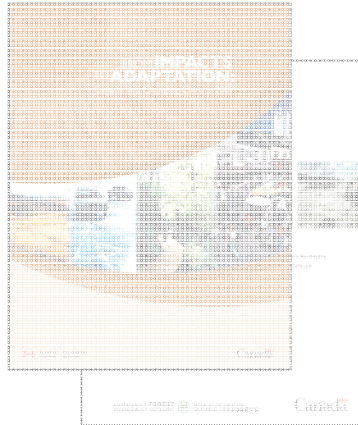
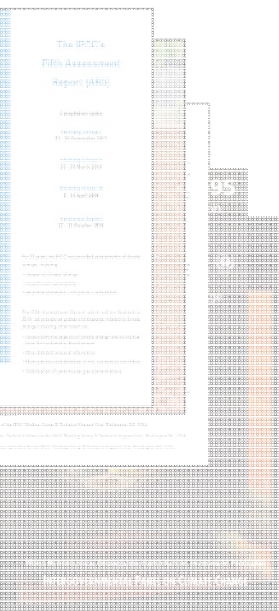
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Management Offset Protocols



PHASE II

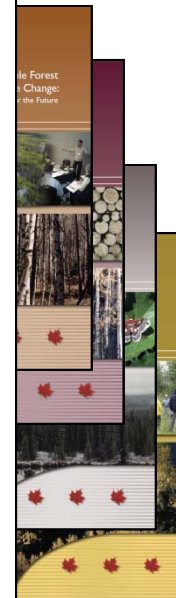


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- The background of the slide features a collage of various documents and images. On the left, there are several overlapping document covers, including one titled 'The IPCC's Fifth Assessment Report (AR5)' and another with 'IMPACTS ADAPTATION' in large letters. To the right, there is a prominent document titled 'Adapting Sustainable Forest Management to Climate Change: Preparing for the Future' which shows a forest scene. Below this document, there are several horizontal strips of images showing different forest landscapes, some with red maple leaves overlaid. The central text box is white with a black border and contains a bulleted list.
- Adapting sustainable forest management to climate change: preparing for the future
 - Adapting sustainable forest management to climate change: a systematic approach for exploring organizational readiness
 - **Adapting sustainable forest management to climate change: a framework for assessing vulnerability and mainstreaming adaptation into decision making**
 - Adapting sustainable forest management to climate change: scenarios for vulnerability assessment



Adapting sustainable forest management to climate change: a framework for assessing vulnerability and mainstreaming adaptation into decision making

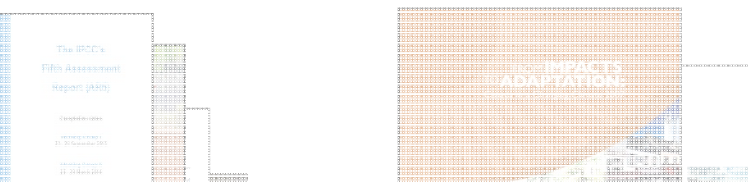
- This document presents a framework for assessing the vulnerability of sustainable forest management in Canada to climate change and linking the results of vulnerability assessment to an adaptation process that is integrated into forest management decision making.
- **VULNERABILITY ASSESSMENT FRAMEWORK**
 - Component 1: Provide Context
 - Component 2: Describe Current Climate and Forest Conditions
 - Component 3: Develop Scenarios of Future Climate and Forest Conditions
 - Component 4: Assess the Vulnerability of SFM to Current and Future Climate
 - Component 5: Develop and Refine Options for Adaptation
 - Component 6: Implement and Mainstream Options for Adaptation



counting
the Local





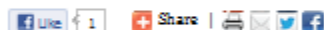


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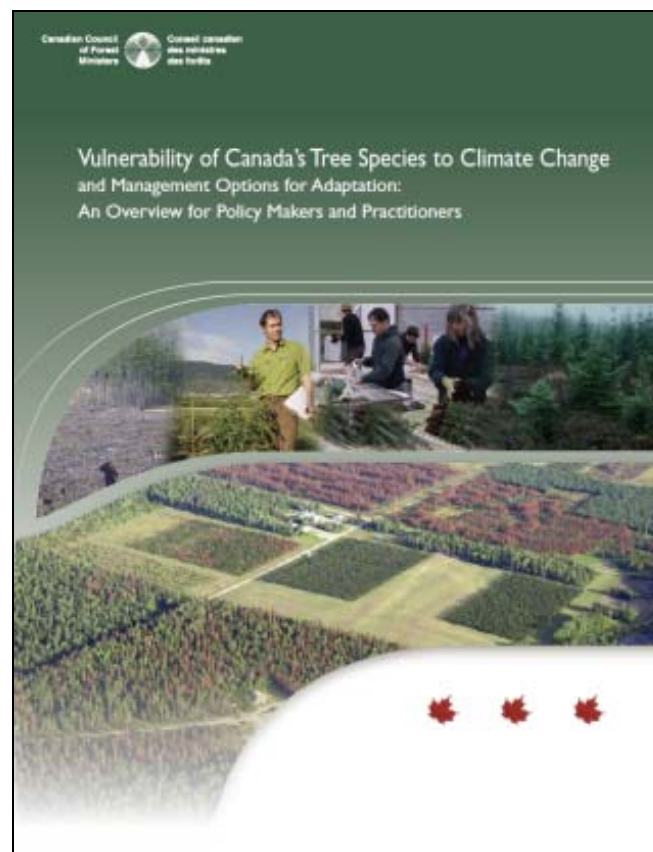
ERNMENT SERVICES CULTURE ACTIVITY

Balsam fir likely to disappear from New Brunswick's forest



FEBRUARY 27, 2012 - 5:14PM

Moncton - According to a new Canadian Council of Forest Ministers' report, balsam fir, New Brunswick's provincial tree, is likely to disappear from most of New Brunswick by the end of the century as a result of climate change. The report states: "Balsam fir is likely to disappear from Nova Scotia and most of New Brunswick, and move north into northeastern Quebec and Labrador." Balsam fir, New Brunswick's provincial tree, has historically fed the pulp and paper, and Christmas tree industries in this province.



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Simple Question

Will Bf disappear from New Brunswick forests?



Simple Question

Will Bf disappear from New Brunswick forests?

- The vulnerability assessment presumes a lot.
- What does it mean at the local level?



Simple Question

Will Bf disappear from New Brunswick forests?

- The vulnerability assessment presumes a lot.
- What does it mean at the local level?

Do simple questions lead to simple answers?



problem
aming ...



Problem Framing

“The initial representation of the problem may be the most crucial single factor governing the likelihood of problem solution” (Posner 1973)



Problem Framing

*The initial report
the most critical
likelihood of p*



*problem may
governing the
osner 1973)*



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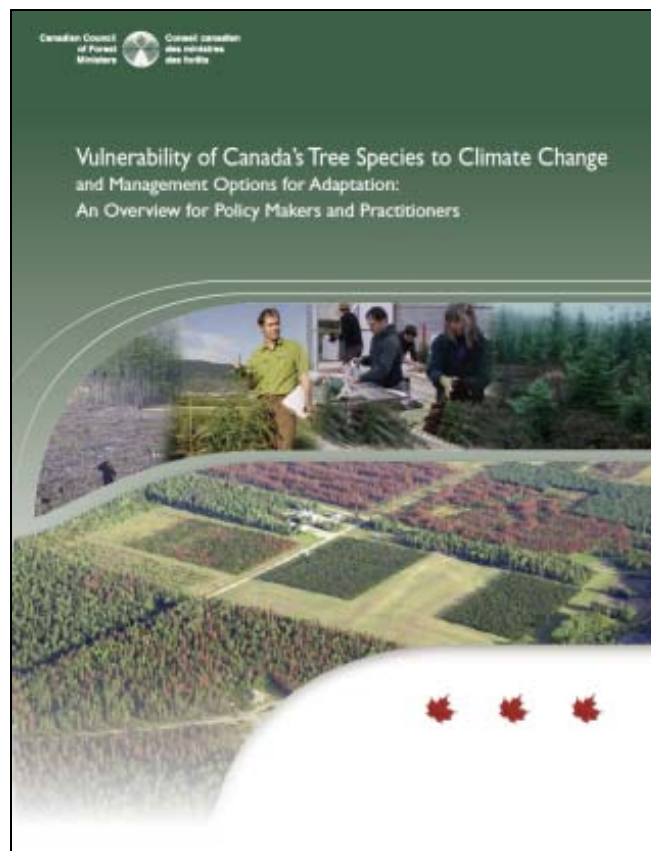
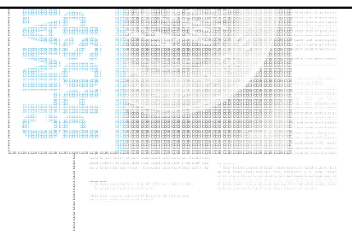
VERNMENT SERVICES CULTURE ACTIVITY

Balsam fir likely to disappear from New Brunswick's forest

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FEBRUARY 27, 2012 - 5:14PM

Moncton - According to a new Canadian Council of Forest Ministers' report, balsam fir, New Brunswick's provincial tree, is likely to disappear from most of New Brunswick by the end of the century as a result of climate change. The report states: "Balsam fir is likely to disappear from Nova Scotia and most of New Brunswick, and move north into northeastern Quebec and Labrador." Balsam fir, New Brunswick's most popular choice for Christmas trees, has historically fed the pulp and paper, and other industries in this province.



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VERNMENT SERVICES CULTU

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(Edward Burtynsky 2001)

background

The reality of human-induced climate change is now well established; dramatic changes are expected to our environment, our society and our economy. This is the first in a series of workshops that will examine expected climatic impacts for New Brunswick, sort out their implications, and identify adaptation options.

workshop overview

There is an apparent reluctance to include modelled projections of future forests in conservation strategies and forest management plans. Research clearly shows a dramatic decline for species such as Balsam fir in the Atlantic region, yet there is great uncertainty about how to practically apply this information.

speakers

To shed light on this issue, we have assembled a group of leading experts to discuss the fate of the eastern Canadian forest under a changing climate. Topics will not only reveal the intimate relationship between past/future climate and forests, but between climate and impact modeling.

who should attend?

This is the first of two workshops that seek to mobilise research knowledge. The audience for the first workshop should have an interest in long term forest dynamics and climate. The second workshop will seek to interpret and apply results from the first, towards adaptation planning in New Brunswick.

speakers

Dr. L. Cwynar, Palaeoecologist (UNB)
Dr. C. Laroque, Dendrochronologist (Mt.A)
Dr. P. Gachon, Climate Modeler (EC)
Dr. M. Wotton, Fire Ecologist, (NRCAN)
Dr. D. Quiring, Entomologist (UNB)
Dr. C. Bourque, Forest Modeler (UNB)
Dr. D. Bazely, Invasives Specialist (YorkU)

WHEN

February 21st, 2013,
Registration 7:45am; First Speaker 8:30am;
Panel Discussion 4:30-5:30pm.

WHERE

Wu Centre, UNB
6 Duffie Drive, Fredericton, NB

INFORMATION

For online links see below-left: OR
To register contact Lori: arpf@nbnet.nb.ca
For more info contact Jim: jmacell@unb.ca



UNB Art Centre Exhibit

EDWARD BURTYNSKY: Material Matters

Feb 15th to Apr 5th 2013



Modeling Ideal Species Distributions

Consistent weather patterns present common adaptive challenges, resulting in tightly related assemblages of species (Clements 1936).

VS

Species response to climatic change is based upon a set of individualistic life traits (Gleason 1926)



ecosystem movement”

- gross simplification, has the advantage of being based upon a “well-demonstrated” relationship between climate and ecosystem range.

ecosystem modification”

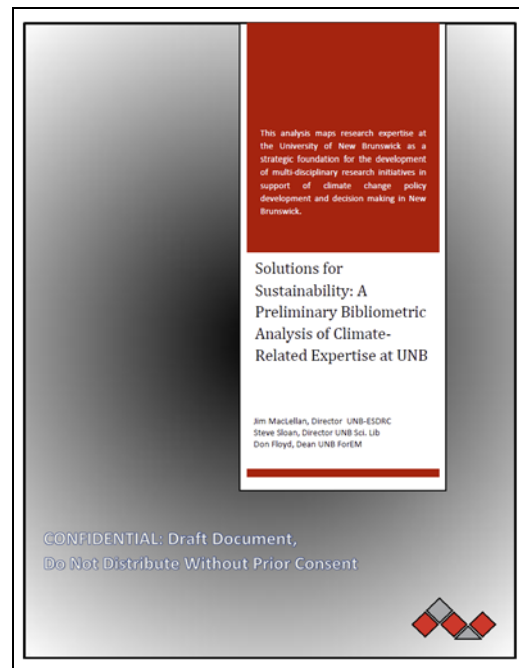
- assumes that regional responses will occur as a mix of species declines, and increases in abundance (Gitay et al 2002).



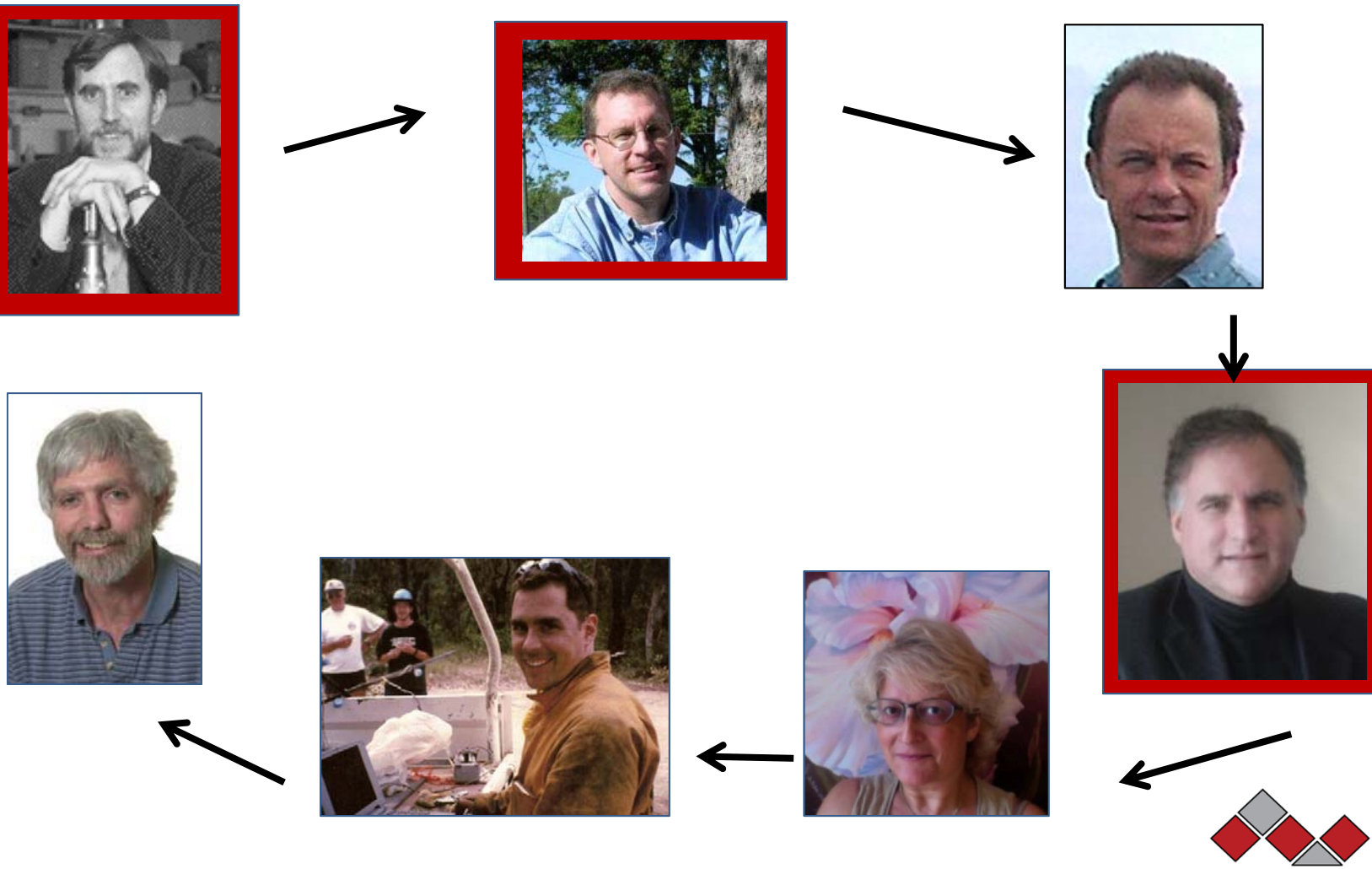
What factors do we consider?



What factors do we consider?



What factors do we consider?



habitat as a multiplication of response
function values of various attributes on the
landscape. In this case:

$$I = R(Q_s) \times R(SWC) \times R(GDD) \times R(SF)$$

ere

= available sunlight

C = soil water content

D = growing degree days

= soil fertility

→ Bf Disappears

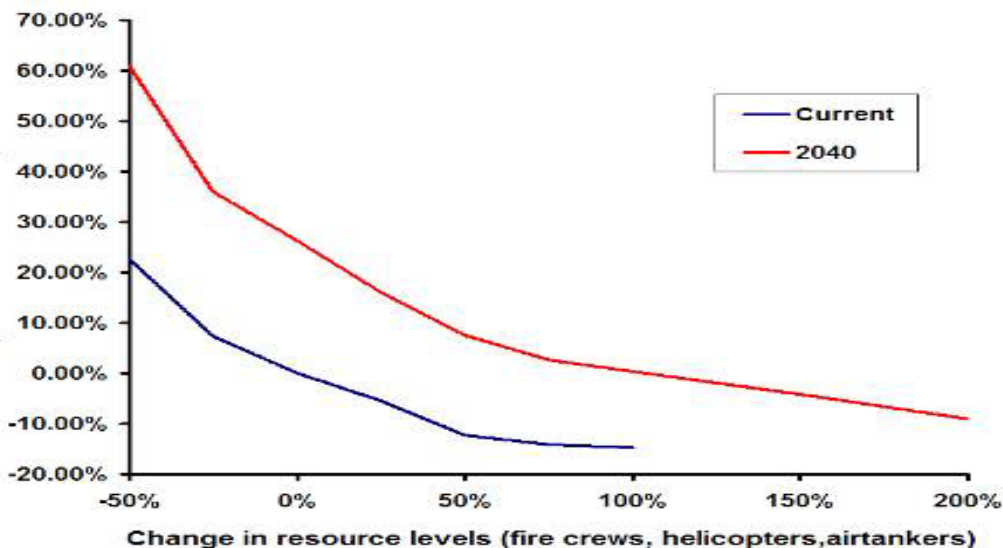


Increased temp generally leads to, increased fire occurrence

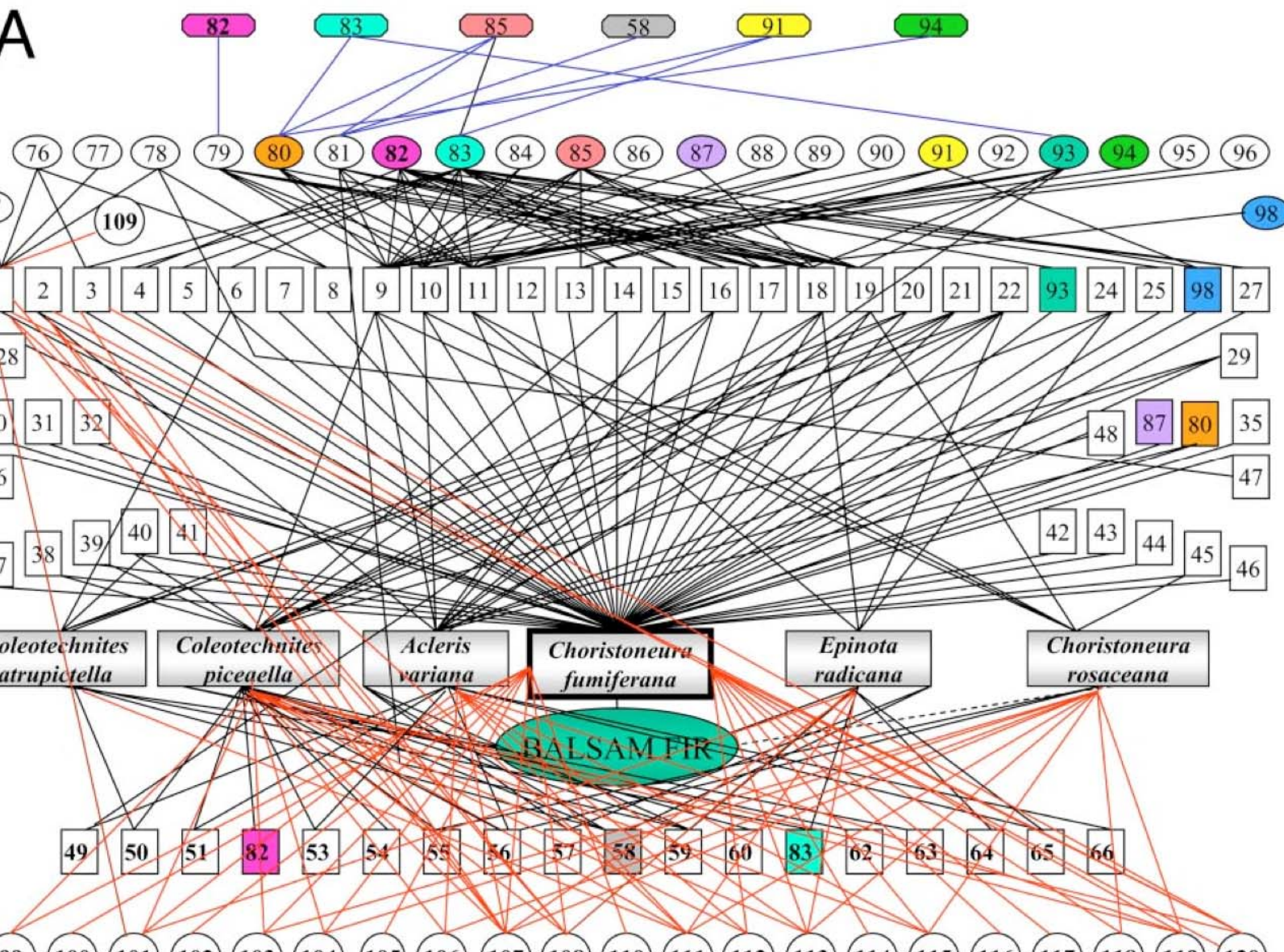
- increased fire escapes (a non-linear relationship)
- increased area burned

High levels of fire activity take place during extremes (both in terms of low humidity air masses AND wind events)

- In an intensively protected forest a situation of **highly receptive fuels** can lead to high number of daily ignitions which can overwhelm even a well-prepared fire management agency
- **15% increase in occurrence means you must double your resources to contain fires**



SBW food web (low & high density)



2D1 Dilemma: What's Important?

Macro Scale modeling gets us in the door, but ...

- Must be augmented by micro scale modeling exercises, and expert interpretation.
- Critical not only to project ideal species distributions, but to contextualize this information for conservation and management plans in New Brunswick.

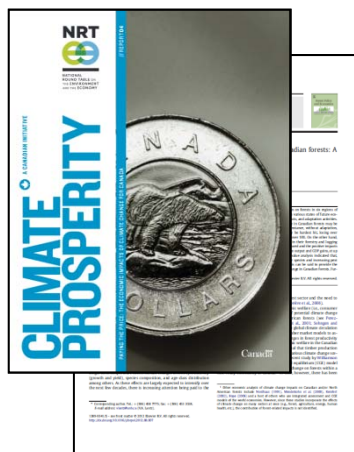
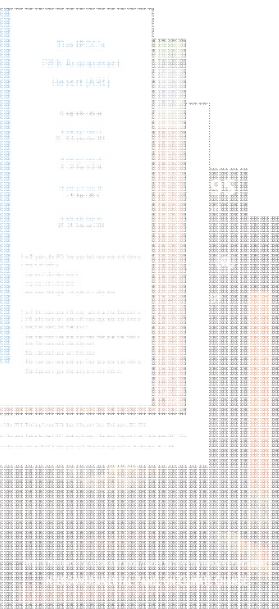
Focus efforts:

- Discussion seemed to diverge along *analogue*, *zero analogue* conceptual interpretations.
- In conversations with key members of the audience, fire was clearly not considered as important an issue as insects pest for instance. But ...
- Some factors were more quantified than others ...



structured
decision-
making ...
Down

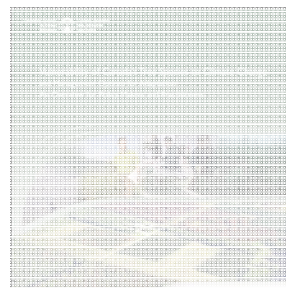






PRESENTATION 04

NATIONAL
ROUND TABLE ON
THE ENVIRONMENT
AND THE ECONOMY



TIMBER QUANTITY REDUCTIONS DUE TO CLIMATE CHANGE

	BRITISH COLUMBIA	ALBERTA	MANITOBA, SASKATCHEWAN, TERRITORIES	ONTARIO	QUÉBEC	ATLANTIC CANADA
2020s	3 to 4%	3 to 5%	4 to 5%	2%	1%	1%
2050s	5 to 8%	9 to 14%	7 to 11%	2 to 4%	1 to 2%	2 to 4%
2080s	8 to 14%	13 to 22%	13 to 23%	4 to 8%	2 to 4%	2 to 5%

CE

PRESENTATION 04

Canada

Information presented here is for informational purposes only and does not constitute an offer of insurance or any other financial product. For more information, please contact your insurance broker or the relevant regulatory authority. The information presented here is not intended to be used as a basis for investment decisions. The information presented here is not intended to be used as a basis for investment decisions. The information presented here is not intended to be used as a basis for investment decisions.



CUMULATIVE COSTS DUE TO CLIMATE CHANGE, 2010-2080

	- LOW CLIMATE CHANGE	+ HIGH CLIMATE CHANGE
REGION	SLOW GROWTH	RAPID GROWTH
BRITISH COLUMBIA	\$5B	\$32B
ALBERTA	\$2B	\$10B
MANITOBA, SASKATCHEWAN AND TERRITORIES	\$5B	\$33B
ONTARIO	\$10B	\$75B
QUÉBEC	\$3B	\$21B
ATLANTIC CANADA	\$1B	\$6B
CANADA	\$25B	\$176B

\$(2008), 3% DISCOUNT RATE

SUMMARY OF TIMBER ADAPTATION STRATEGY

	ADAPTATION STRATEGY			
STRATEGY	<ul style="list-style-type: none"> Enhance forest fire prevention, control, and suppression Enhance pest control Plant tree species suitable to future climate 			
OBJECTIVE	Reduce the impacts of climate change on timber supply			
COSTS OF IMPLEMENTING STRATEGY (PRESENT VALUE, 2010-2080)	-		+	
	\$2.3B		\$3.6B	
BENEFITS OF IMPLEMENTING STRATEGY (PRESENT VALUE, 2010-2080)	-		+	
	SLOW	RAPID	SLOW	RAPID
	\$19.9B	\$77.2B	\$34.4B	\$137.9B
BENEFIT-COST RATIO	-		+	
	SLOW	RAPID	SLOW	RAPID
	9:1	34:1	10:1	38:1
REMAINING COSTS OF CLIMATE CHANGE AFTER ADAPTATION (PRESENT VALUE, 2010-2080)	-		+	
	SLOW	RAPID	SLOW	RAPID
	\$4.6B	\$24.4B	\$8.1B	\$37.1B
POTENTIAL CO-BENEFITS	<ul style="list-style-type: none"> Enhanced greenhouse gas sequestration Health benefits from reduced forest fires Enhanced ability to achieve sustainable forest management objectives 			
IMPLEMENTATION CHALLENGES	<ul style="list-style-type: none"> Uncertainty on effectiveness Ecological risks to planting alternative tree species 			

■ Slow Canadian economic and population growth

■ Rapid Canadian economic and population growth

■ Low climate change

■ High climate change

2010-2080

CLIMATE CHANGE

WOOD GROWTH

\$32B

\$10B

\$33B

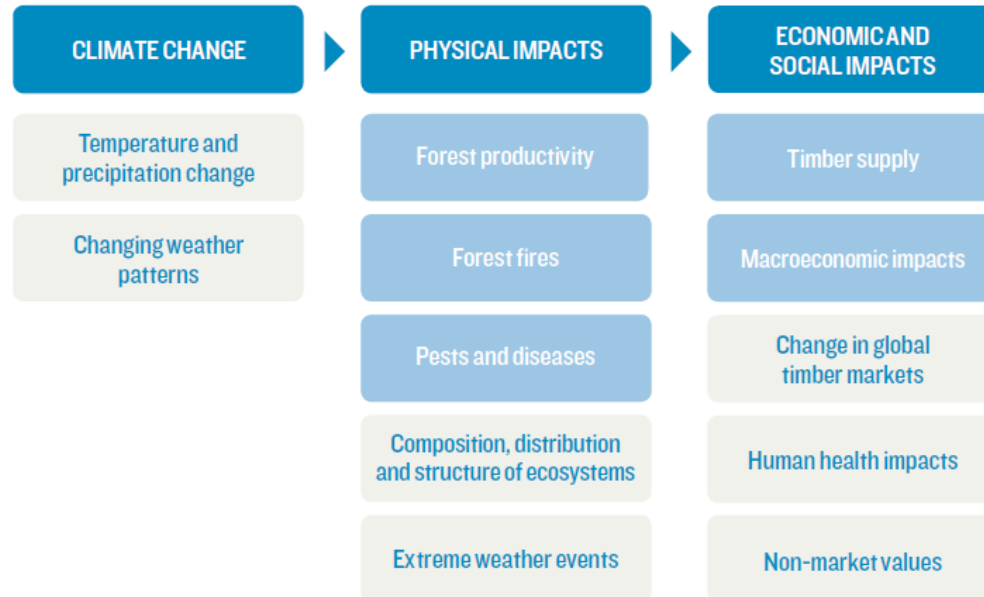
\$75B

\$21B

\$6B

\$176B

IMPACTS OF CLIMATE CHANGE ON CANADA'S FORESTS



Impacts quantified in our analysis

SOURCE: ADAPTED FROM WILLIAMSON ET AL. (2009)

larger forest temperature effects include changes in forest productivity (growth and yield), species composition, and age-class distribution among others. As these effects are largely expected to intensify over the next few decades, there is increasing attention being paid to the

coniferous community in Canada.¹ To date, however, there has been

¹ Other economic analysis of climate change impacts on Canadian and North American forests include: Williamson (2009), Williamson et al. (2009), Bontekamp (2003), Pope (2006) and a host of others who use integrated assessment and CGE models of the world economy. However, since these studies incorporate the effects of climate change on many sectors (e.g., forest, agriculture, energy, human health, etc.), the contribution of forest-related impacts is not identified.

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Regional economic impacts of climate change and adaptation in Canadian forests: A CGE modeling analysis

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Timber supply

Global economic impact

Canada

ABSTRACT

We analyzed the potential economic impacts of climate change and adaptation on forests in six regions of Canada over the 2010–40 period. We considered 15 impact scenarios, based on various states of future economic growth conditions, global climate change conditions, timber supply impacts, and adaptation activities. Our findings reveal that the physical and economic impacts of climate change in Canadian forests may be substantial and will not be distributed equally across Canada's regions. The timber, without adaptation, Manitoba, Saskatchewan and the Territories' forestry and logging sector may be hardest hit, losing over 30% of its output value, thereby reducing output and GDP in other sectors by over 10%. On the other hand, provinces such as Quebec and to a lesser extent Ontario could gain up to 2% in their forestry and logging and other service output and GDP. With adaptation, the negative impacts are reduced and the positive impacts are increased in all regions. In this case, Atlantic Canada in particular could realize output and GDP gains, as up to 2% compared to a no climate change, no adaptation scenario. Not present value analysis indicated that, under all scenarios considered, such adaptation activities as planting new tree species and increasing pest and fire control could be supported on economic grounds. Overall, this analysis can be used to provide the first (and preliminary) estimates of regional economic impacts from climate change in Canadian forests. Further analysis is needed to accurately quantify and model the impacts.

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1. Introduction

The forests of Canada have provided its citizens with a source of subsistence and economic growth for many centuries. Today, the forest sector directly employs approximately 240,000 people, contributes \$40 billion to national GDP (or 3% of total GDP), and is the country's largest net exporter with a balance of trade of over \$14 billion (NRCan, 2010).

The relatively heavy dependence that the Canadian forest sector has on Canadian forests for its supply of timber leaves it highly susceptible to natural and man-made disturbances such as climate change. Indeed, Canada's forests are already experiencing the effects of climate change. Some of the most visible effects include changes in the frequency and severity of fire, droughts, severe storms, and damaging insect and disease attacks (Williamson et al., 2008). Other, longer term (perhaps more subtle) effects include changes in forest productivity (growth and yield), species composition, and age class distribution among others. As these effects are largely expected to intensify over the next few decades, there is increasing attention being paid to the

potential impacts this will have on the forest sector and the need to adapt (Lantz, 2005; Seitzinger, 2006; Lempiere et al., 2008).

A few studies exist that provide economic welfare (i.e., consumer and producer surplus change) estimates of potential climate change impacts on Canadian and/or North American forests (see Perez-Garcia et al., 1997, 2002; and Seligson et al., 2001; Seligson and Sedjo, 2005). These studies typically couple global climate circulation models with partial-equilibrium, global timber market models to assess the impacts that climate-induced changes in forest productivity will have on timber production and economic welfare in the Canadian forest sector as a whole. Results often reveal that timber production and welfare losses occur in Canada under various climate change scenarios. Similar results have emerged in a recent study by Williamson et al. (2008) who use a computable general equilibrium (CGE) model to assess the economic impacts of climate change on forests within a case-study community in Canada.¹ To date, however, there has been

¹ Other economic analysis of climate change impacts on Canadian and/or North American forests include Neufuss (1996), Monckton et al. (2000), Nordst (2002), Hope (2006) and a host of others who use integrated assessment and CGE models of the world economy. However, since these studies incorporate the effects of climate change on many sectors (e.g., forest, agriculture, energy, human health, etc.), the contribution of forest related impacts is not identified.

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CGE Modeling Requires
Assumptions about:
← Climate Scenarios
← Socio-Economic
Scenarios
← International Markets





Regional economic impacts of climate change and adaptation in Canadian forests: A CGE modeling analysis

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CGE Modeling Requires Assumptions about:

- ← Climate Scenarios
- ← Socio-Economic Scenarios
- ← International Markets
- ← Pests
- ← Fire
- ← Growth
- ← Timber supply
- ← Species composition
- ← Adaptation options



structured
decision-
making ...
bottom Up





Resistance: protecting high-value resources

Resilience: maximize short term value and maintain diversity at landscape scale

Response: reduce rotation length and facilitate changing species diversity at landscape scale

Mitigation: enhance carbon storage, reduce emissions, forest product innovation using less desirable species



Recommendations: Climate change measures broadly related to forest landscape management	Strategy 1= Resist 2= Resilience 3= Response 4= Mitigation	Level 1= Strategic 2= Tactical 3= Operational
Maintain connectivity in a varied, dynamic landscape	2, 3	2
Realign management targets to recognize significantly altered conditions, rather than continuing to manage for return to a reference condition that is no longer realistic given climate change	3	1
Diversify risk by spreading habitats or plantations over a range of environments rather than strictly within the historic distribution	3	1
Use landscape-scale planning and partnerships to reduce fragmentation and enhance connectivity	2, 3	1
Manage for refugia (e.g., identify and manage refugia for species that may otherwise be lost, try uneven-aged management to increase landscape heterogeneity and "lifeboat" residual species, protect potential refugial habitats, retain biological legacies)	1	1
Avoid planting new forests in area likely to be subject to natural disturbance (e.g., flood)	2, 3	3
Minimize amount of edge created by human disturbances	2, 3	3

Recommendations: climate change measures broadly related to preparing for disturbance in forest management	Strategy 1= Resist 2= Resilience 3= Response 4= Mitigation	Level 1= Strategic 2= Tactical 3= Operational
Monitor to determine when and what changes are occurring	1, 2, 3	1
Adopt risk assessment and adaptive management principles	1, 2, 3	1
Agree on standardized climate scenarios for analysis	1, 2, 3	2
Include climate variables in growth and yield models	1, 2, 3	2
Incorporate climate change effects into long term resource supply analysis and forest management plans		
Anticipate surprises and threshold effects	2, 3	1
Anticipate variability and change and conduct vulnerability assessment	2, 3	1
Foster learning and innovation	1, 2, 3	1
Prepare for changes in disturbance regimes (e.g., increased wildfire activity, higher-elevation insect outbreaks, species mortality events, altered fire regimes)	2, 3	2
Minimize or mitigate other threats or stresses (e.g., spread of insects and diseases, herbivory, alter forest structure or composition to reduce risk or severity of fire, establish fuelbreaks to slow the spread of catastrophic fires, alter forest structure to reduce severity or extent of	1, 2, 3	2

Recommendations: climate change measures closely related to forest composition

	Strategy 1= Resist 2= Resilience 3= Response 4= Mitigation	Level 1= Strategic 2= Tactical 3= Operational
Adjust species composition (e.g., plant alternative genotype or species in anticipation of future climate, planting less sensitive species, diversify species mix on lower quality sites, favor current elements that do not decrease under projections, but don't eliminate against species projected to decrease, maintain elements across all sites, especially mesic sites, ...)	3	3
Rather than focusing only on historic distributions, spread species over a range of environments according to modeled future projections	3	1
Anticipate and respond to species decline	3	2
Expand genetic diversity guidelines (e.g., move germplasm in the predicted adaptive direction; expand seed zones in all directions; expand transfer guidelines to accommodate multiple habitat types; introduce long distance germplasm into seed mixes)	3	1
Increase species and genetic diversity in plantations	3	1
Maintain diverse gene pools	1, 2, 3	1
Prioritize and protect existing populations on unique sites (may require active management for conifer species lowlands)	1	2
Continue managing invasive species	1, 2, 3	1

What's Next?

Why has the consideration of “forests” been going down in IPCC assessment reports?

My answer:

- We can easily pose simple questions re climate change, but solutions are complex.

What then, constitutes an effective response?

- Approach issue at multiple scales in an adaptive manner that questions assumptions and facilitates the development of new, locally oriented knowledge.
- Engage locally embedded researchers as well as local communities through a series of mechanisms ...





THANK YOU

For more Information:

Jim MacLellan

jmaclell@unb.ca

