

# Climate Change and Forest Management: An Overview

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Einstein Agrees:

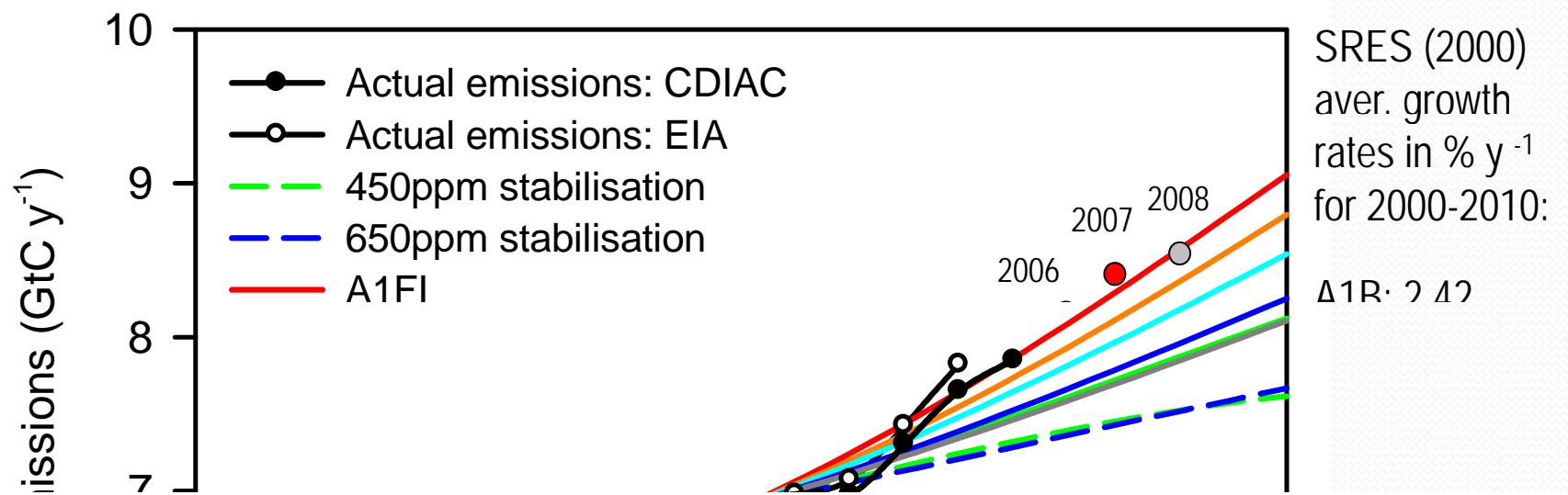
The climate change debate is over.

$$\begin{aligned} \text{oil + coal + gas} \\ = \text{CO}_2, \\ +\text{CO}_2 = +\text{temp} \end{aligned}$$



The 2007 IPCC  
Fourth Assessment  
Report is already  
out of date

# Fossil Fuel Emissions: Actual vs. IPCC Scenarios



# Conclusions

Since 2000:

- The growth of carbon emissions from fossil fuels has tripled compared to the 1990s and is exceeding the predictions of the highest IPCC emission scenarios.
- The efficiency of natural sinks (especially the ocean) has decreased by 10% over the last 50 years and will continue to do so in the future, implying that the longer we wait to reduce emissions, the larger the cuts needed to stabilize atmospheric CO<sub>2</sub>.
- All of these changes characterize a carbon cycle that is generating stronger climate forcing and sooner than expected.

Source: Global Carbon Project 2009 update available at: <http://www.globalcarbonproject.org>



# Vulnerability to Climate Change

$$V = f(E, S, A)$$

V = Vulnerability

E = Exposure: climate variability & change } impacts

S = Sensitivity: system characteristics }

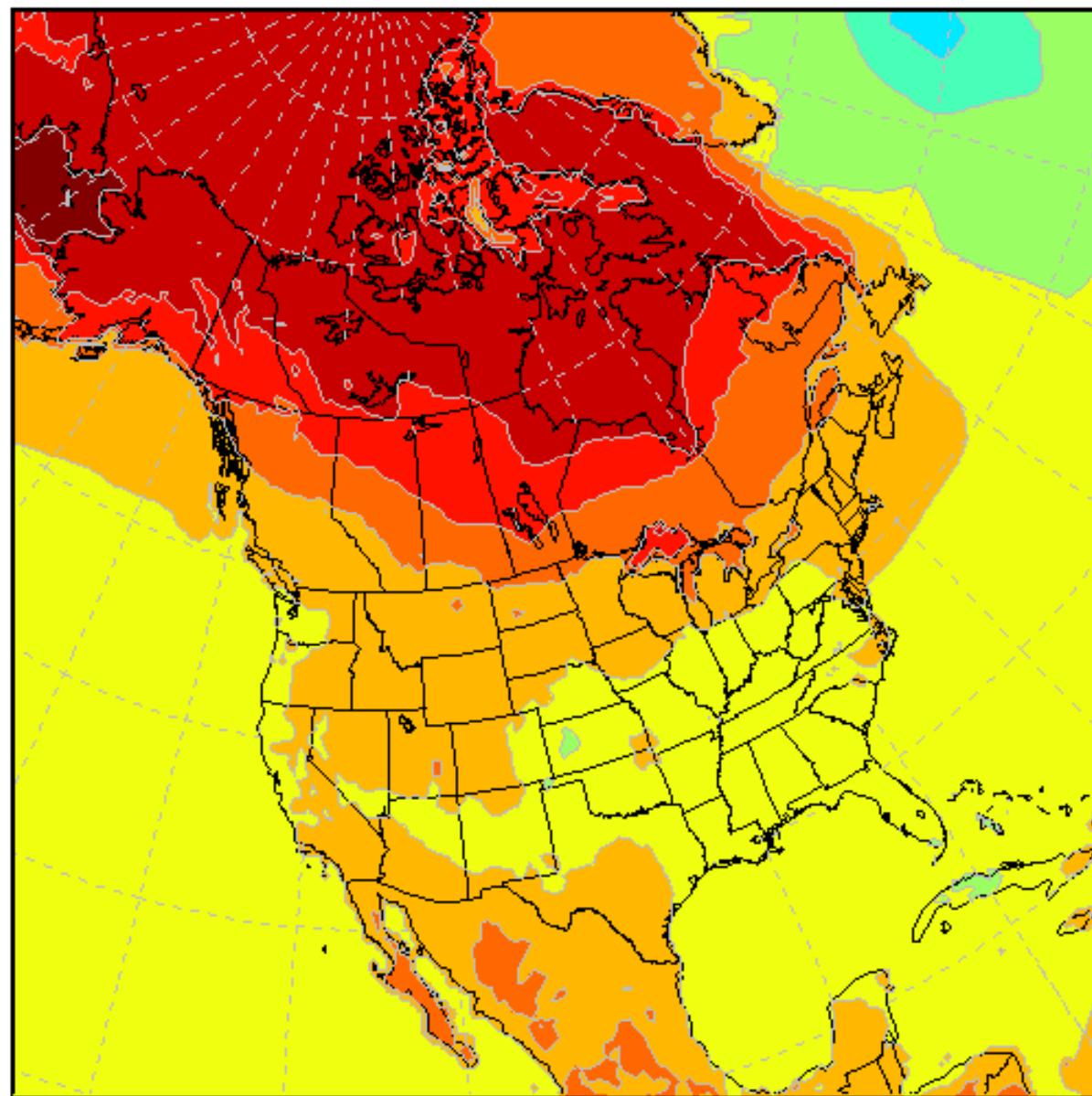
A = Adaptive Capacity: ability to implement adaptation

Can be for current or future climate

# Exposure

- Variability of current climate, or
- Data on future temperature and precipitation change
  - Global Climate Models, e.g. CGCM3 (IPCC AR4)
  - Canadian Regional Climate Model
- Available from the Canadian Climate Change Scenarios Network, <http://www.cccsn.ca/index-e.html>

Difference in Mean TMAX for the period DJF (1970s – 2050s)



$\Delta T$  (°C)

10
5
4
3
2
1
0
-1
-2
-3
-4
-5

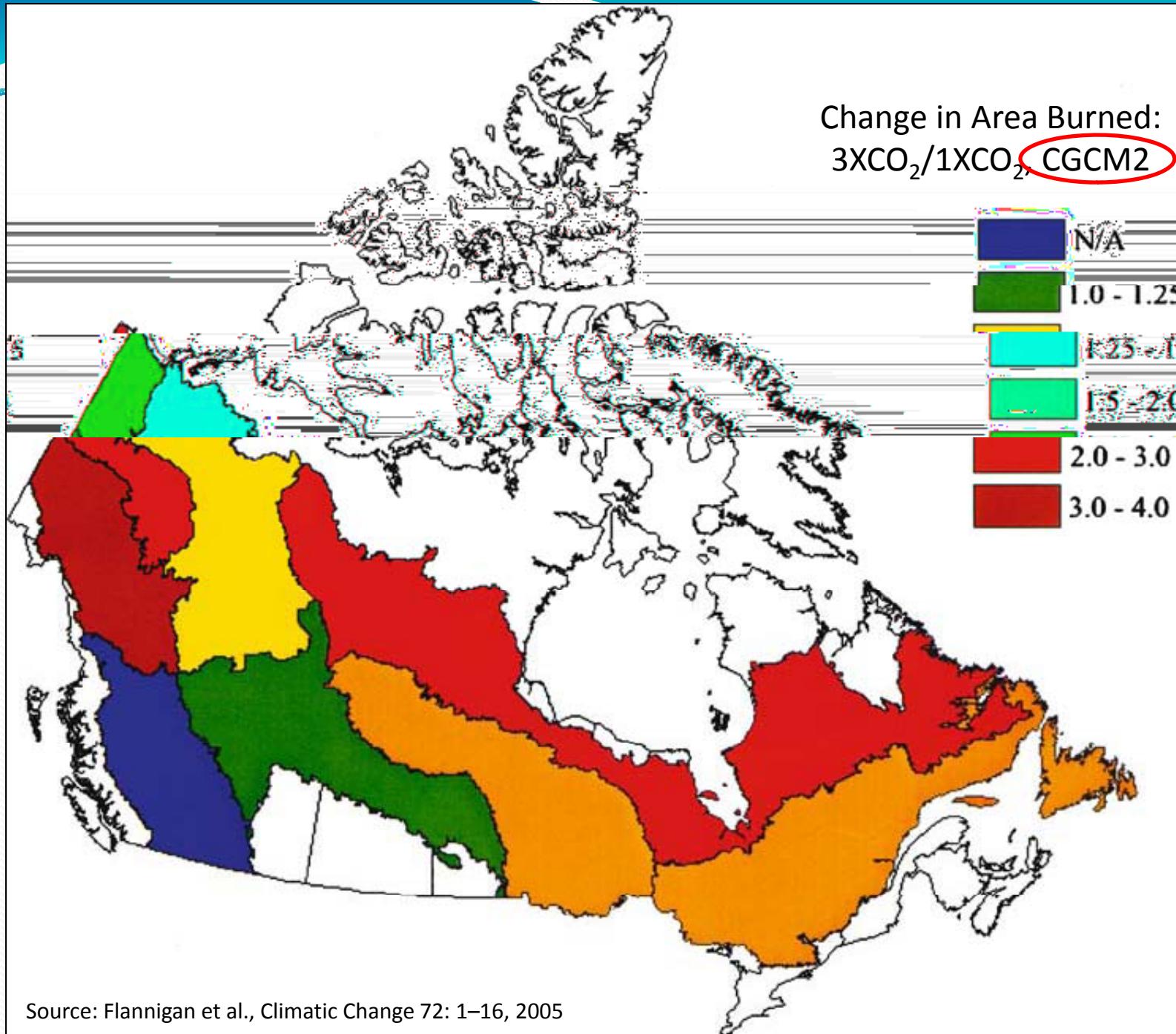
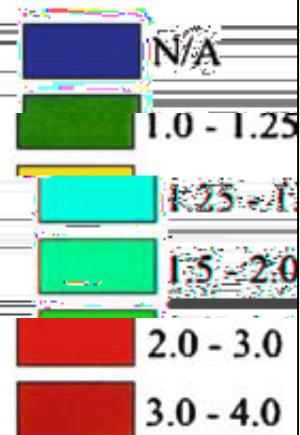
Canadian Regional Climate Model V4.2, SRES A2



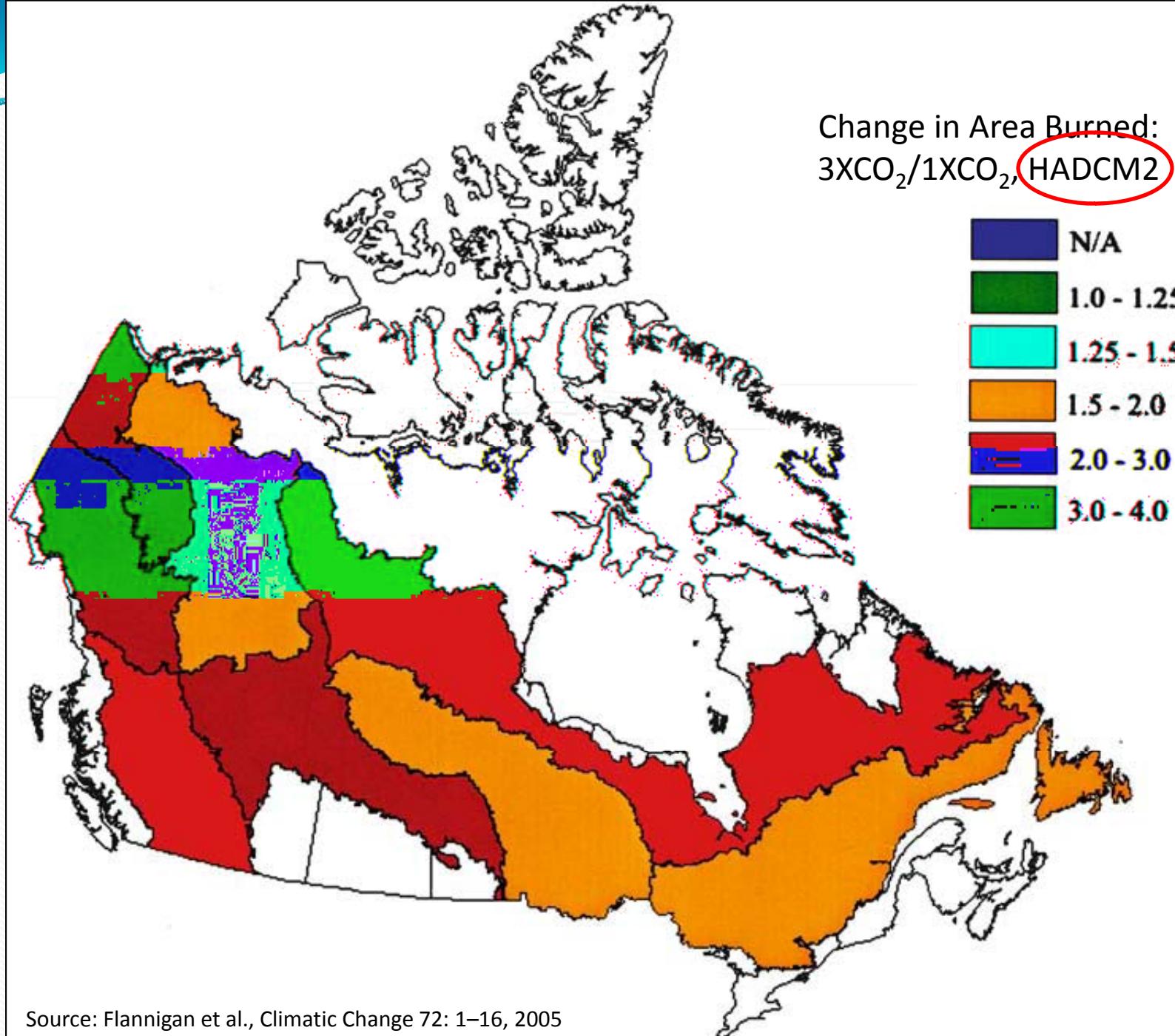
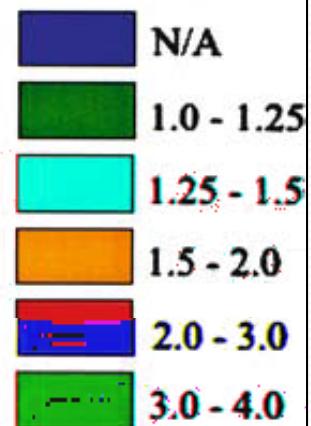
# Impacts (Exposure + Sensitivity)

- Fire
- Insects, disease
- Forest productivity
- Species distribution
- Storminess
- Operational impacts

Change in Area Burned:  
 $3\text{XCO}_2/1\text{XCO}_2$  CGCM2

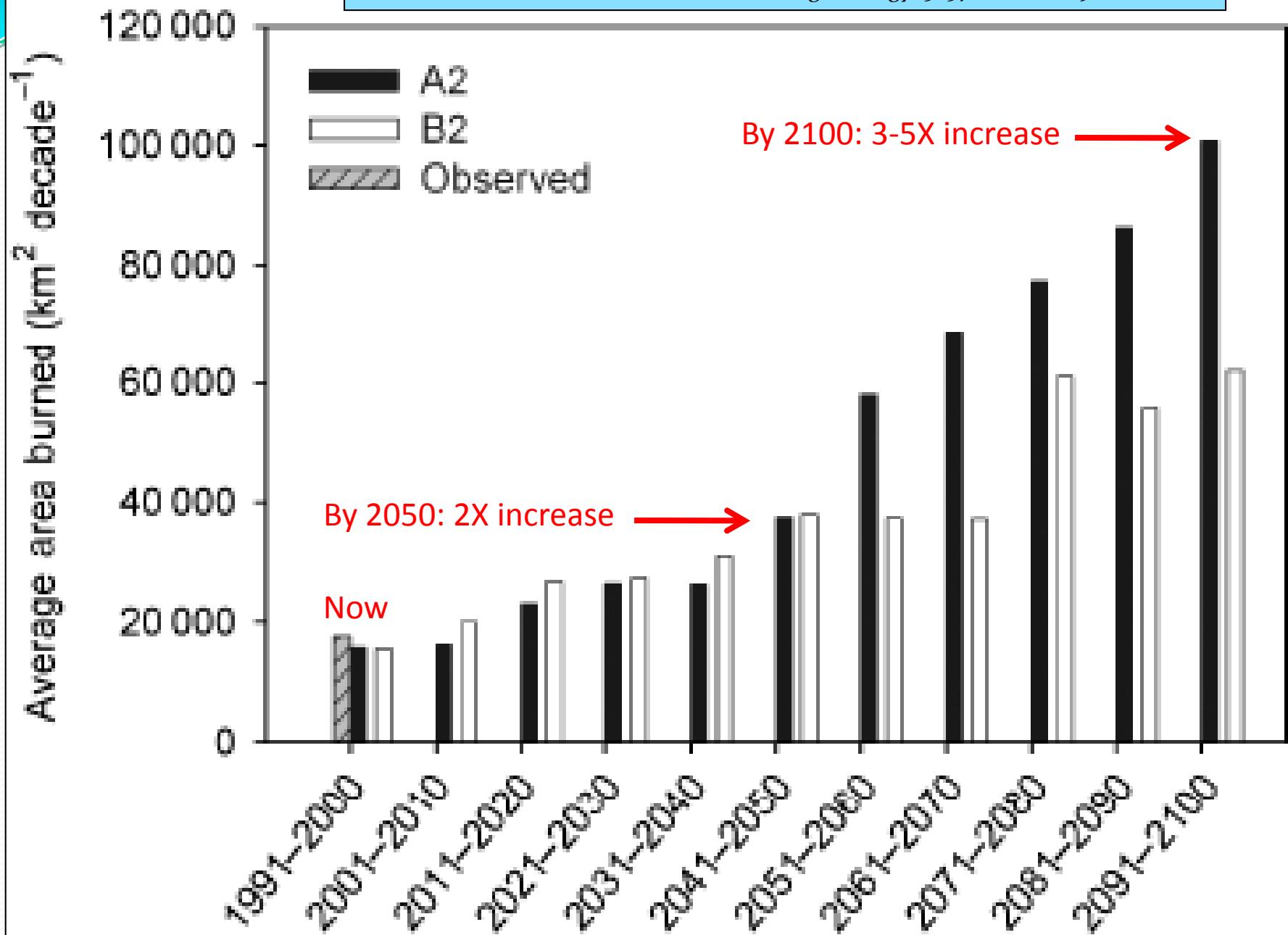


Change in Area Burned:  
 $3\text{XCO}_2/1\text{XCO}_2$ , HADCM2



## Area Burned for Western Canada (BC to MB)

Source: Balshi et al., Global Change Biology 15: 578–600, 2009





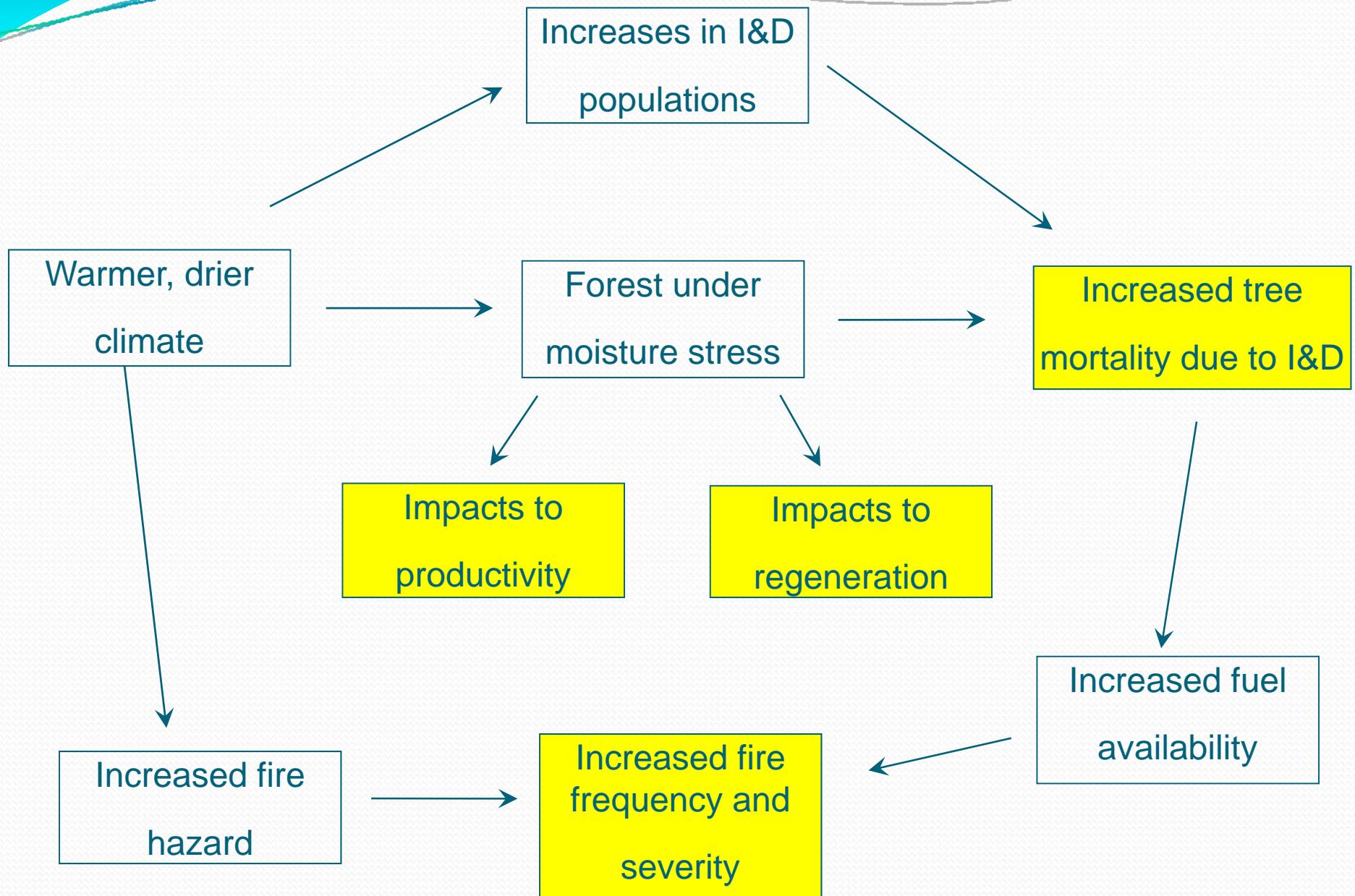
# Insects

- Higher temperatures generally beneficial to insects:
  - Overwinter survival, reproduction, growth etc.
- Hosts may be stressed by e.g. drought, = increased susceptibility
- Decoupling of phenological development in host vs. pest
- Introduction of new pests

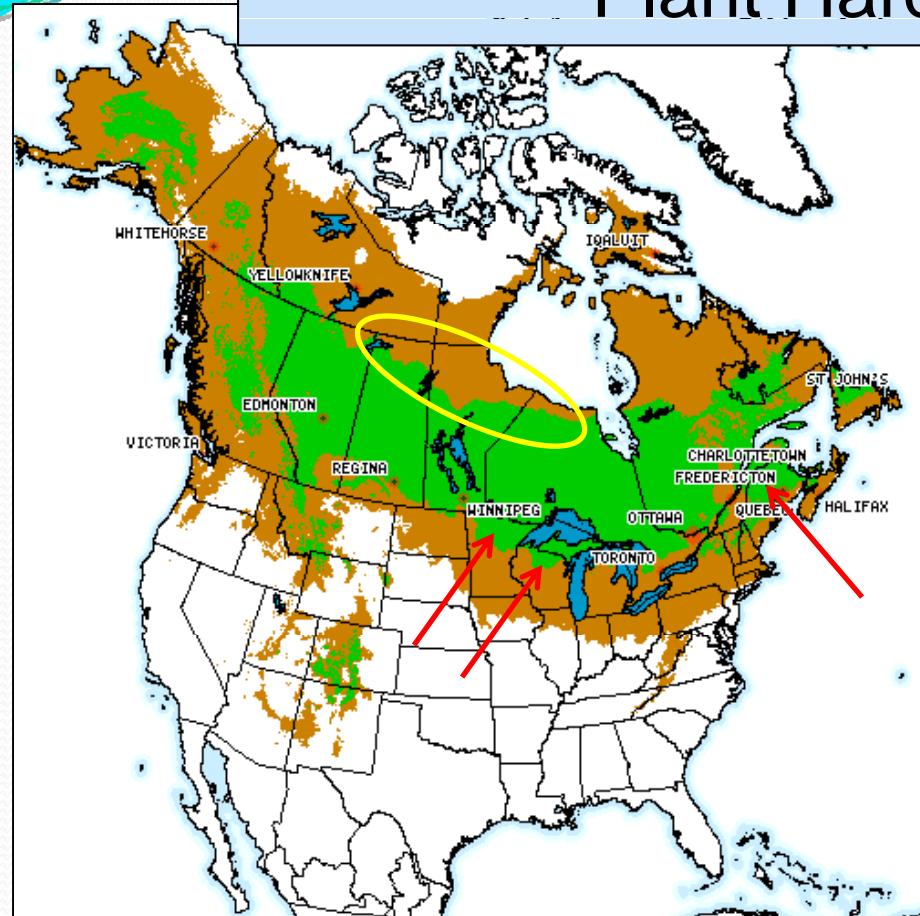
# Disease

- Warmer drier conditions may encourage some species, discourage others
- Stressed trees more susceptible
- Interaction between host, insect vectors and disease organisms = complexity!
- Increased overwinter survival of inoculum, mistletoe

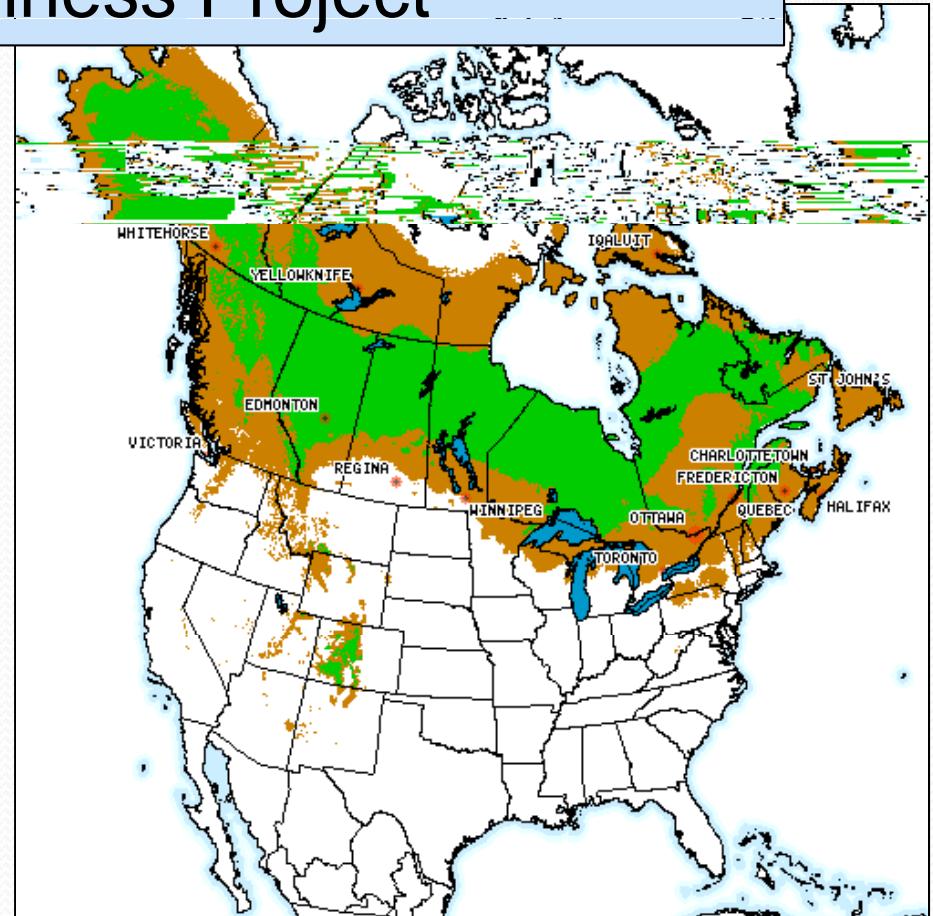
# Forest Ecosystem Vulnerability to Climate Change



# Canadian Forest Service Plant Hardiness Project



White spruce now (1971-2000 Normals)



White spruce 2050 (CGCM2-A2)

Source: [http://planthardiness.gc.ca/ph\\_futurehabitat.pl?lang=en](http://planthardiness.gc.ca/ph_futurehabitat.pl?lang=en)

# Tree growth

- Trees will be responding to changes in temperature, moisture and nutrient availability, and CO<sub>2</sub>
- Lab studies show growth increases with higher temperatures and CO<sub>2</sub>
- But this potential is not realized if other resources are limiting
- May be reasonable to conclude that good sites will get better and bad sites worse

# Shorter operating season on frozen ground





# CCFM Tree Species Study

# Genetics: migration

- Natural migration will not keep up with the pace of climate change
  - Historical rates - ~100 – 500 m/yr
  - Will require 3,000 – 5,000 m/yr to keep up with climate change
- Intervening habitat is not suitable
- Competition from current residents
- Assisted migration is a likely option
- But – which populations, and where?

# Genetics: adaptation

- Large amount of genetic variation within species provides potential for adaptation
- But pace of change is the main concern
- Likely that species with high fecundity, long distance pollen flow and short generation times may be successful
- Describes pioneer species - which may be enhanced by higher disturbance rates

# Vulnerability index

- CFS Index of Vulnerability based on:
  - Ability to adapt in place
  - Ability to migrate
  - Phenotypic plasticity
- Ranked 9 species
  - 0 = low vulnerability, 1 = high vulnerability

# Vulnerability index

Species	Vulnerability Score	Ranking
Trembling aspen	0.00	low
Sugar maple	0.20	low
White pine	0.35	low-medium
Western larch	0.40	medium
Red oak	0.40	medium
Beech	0.40	medium
Red spruce	0.55	medium
Butternut	0.60	medium-high
Red pine	0.75	medium-high

Modified from J. Loo and K. O'Leary, unpublished manuscript



# Seed Transfer Zones

- Jurisdictions moving toward climate-based STZs (BC, AB, ON, QC?)
- BC altered elevation limits this year; other changes being contemplated
- Maybe single biggest management option at the species level
- But – how much of the forest landscape can we really affect?

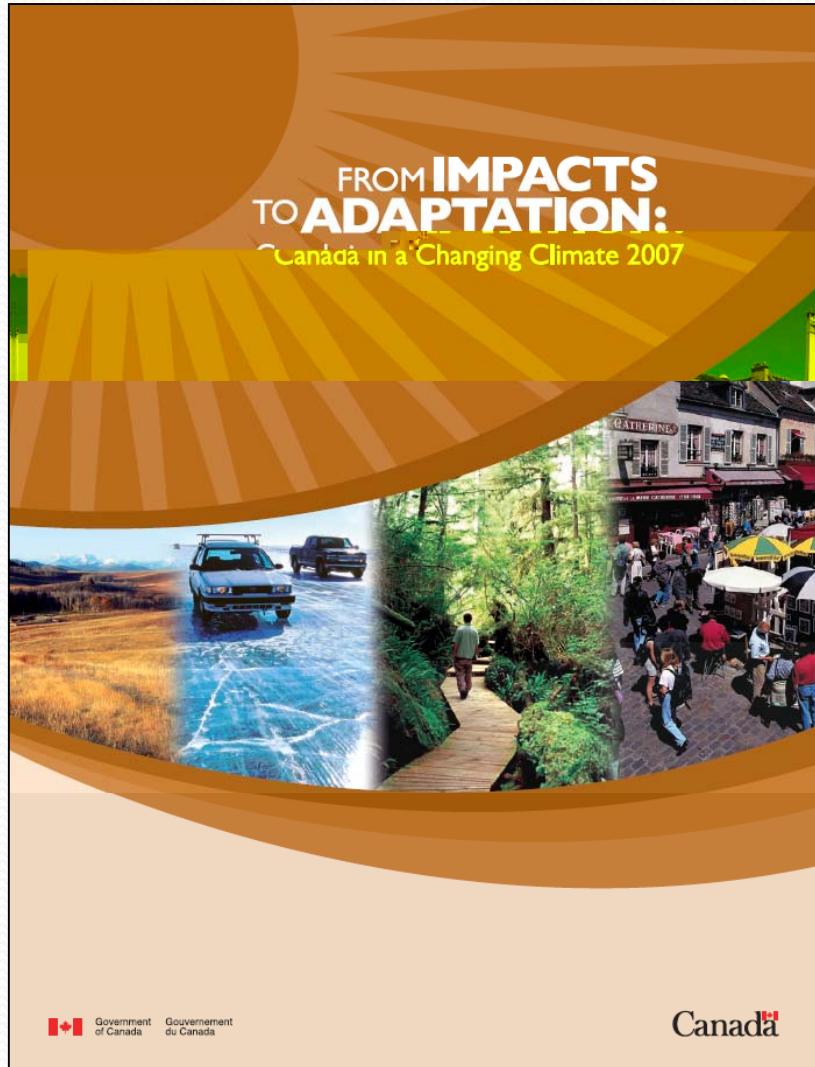
# Adaptive Capacity

- Ability to Implement Adaptation
- Determined by
  - Awareness
  - Technology availability
  - Resources
  - Institutions
  - Human capital
  - Social capital
  - Risk management
  - Information management

# Acknowledgements

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  - Canadian Council of Forest Ministers and the Climate Change Task Force
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  - Biocap Canada Foundation

# Canada's National Climate Change Assessment 2008



[http://adaptation.nrcan.gc.ca/assess/2007/index\\_e.php](http://adaptation.nrcan.gc.ca/assess/2007/index_e.php)