Carbon budget of Canada's managed forest derived from a combined inventory and modelling approach

Werner A. Kurz, G. Stinson, E. Neilson, C. Dymond,
C. Boisvenue, J. Metsaranta, B. Simpson

Natural Resources Canada
Canadian Forest Service
Victoria, BC, Canada

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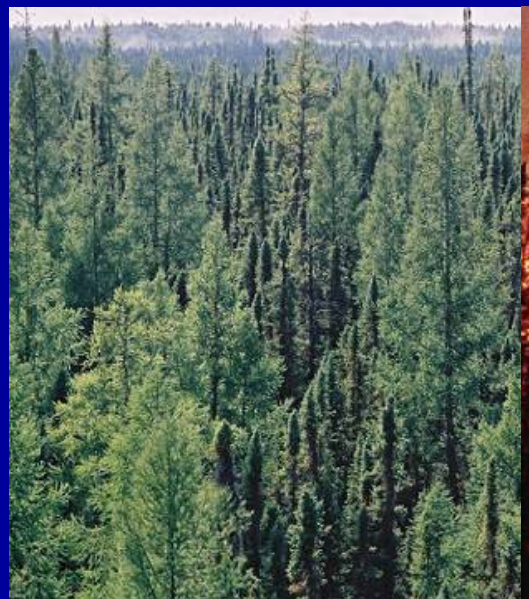
Outline

- Background and methods
- Carbon balance in Canada's managed forest
- Examples of policy decision support
  - Near term projections
  - Age-class effects
  - Mitigation Options
- Conclusions

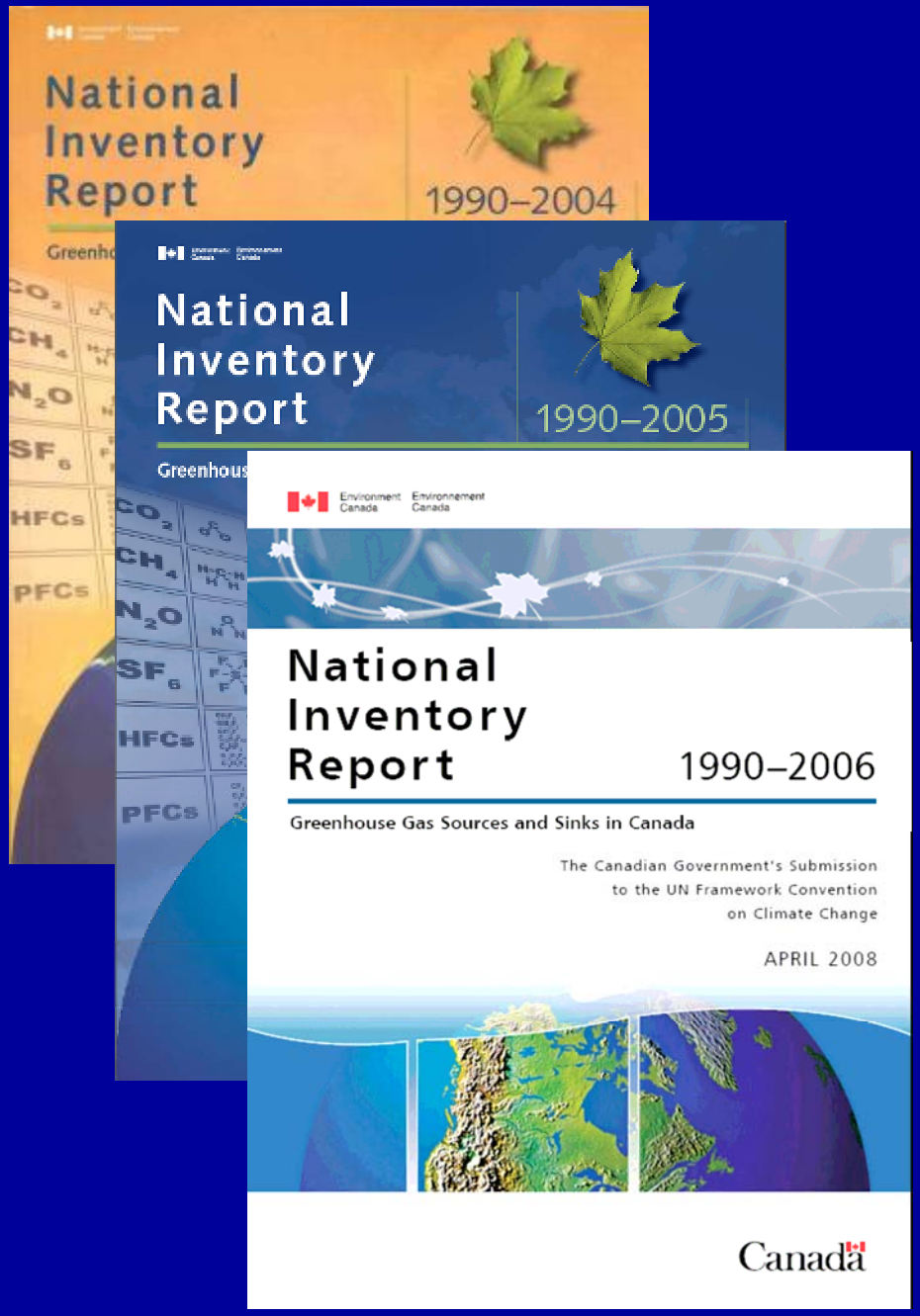


Forest Carbon Accounting in Canada

- Contribution of Canada's forests to the global C cycle
- Looking backward:
  - Monitoring and reporting of forest C stock changes (annually to UNFCCC, FAO, C&I etc).
- Looking forward:
  - Support policy analyses (projections):
    - Decision on forest management in Kyoto reporting,
    - Negotiations for post-2012 climate regime,
    - Assess implications of forest management options,
    - Develop climate mitigation and adaptation strategies.

Approaches to Developing Forest Carbon Budgets

- Choice of methods depends on national circumstances and intended use of the system
  - Difference between two inventories (e.g. USA)
  - One inventory plus change information (e.g. Canada)
  - No Inventory – process modelling (e.g. Australia)
  - Mixed approaches (?)
- Convergence of methods can be expected



Canada's National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS)

Estimation of greenhouse gas emissions and removals and reporting to EC for National GHG Inventory Reporting.

Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)

- An operational-scale model of forest C dynamics.
- Allows forest managers to assess carbon implications of forest management: increase sinks, reduce sources

- Builds on >19 years of CFS Science
- Available at: carbon.cfs.nrcan.gc.ca

CBM·CFS3

Operational Scale Carbon Budget Model of the Canadian Forest Sector
Release 1.0

Natural Resources Canada / Ressources naturelles Canada

MODEL FOREST NETWORK / RÉSEAU DE FORÊTS MODÈLES

Canada

Kurz et al. 2009, Ecol. Mod.

Carbon Budget Model of Canadian Forest Sector

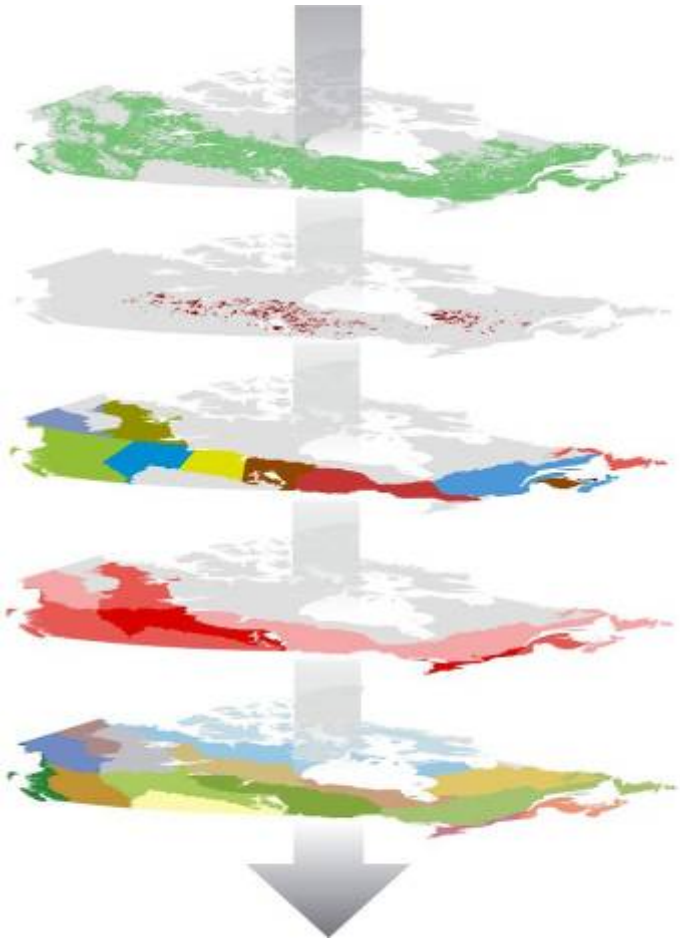
Forest inventory and growth & yield data

Natural disturbance monitoring data

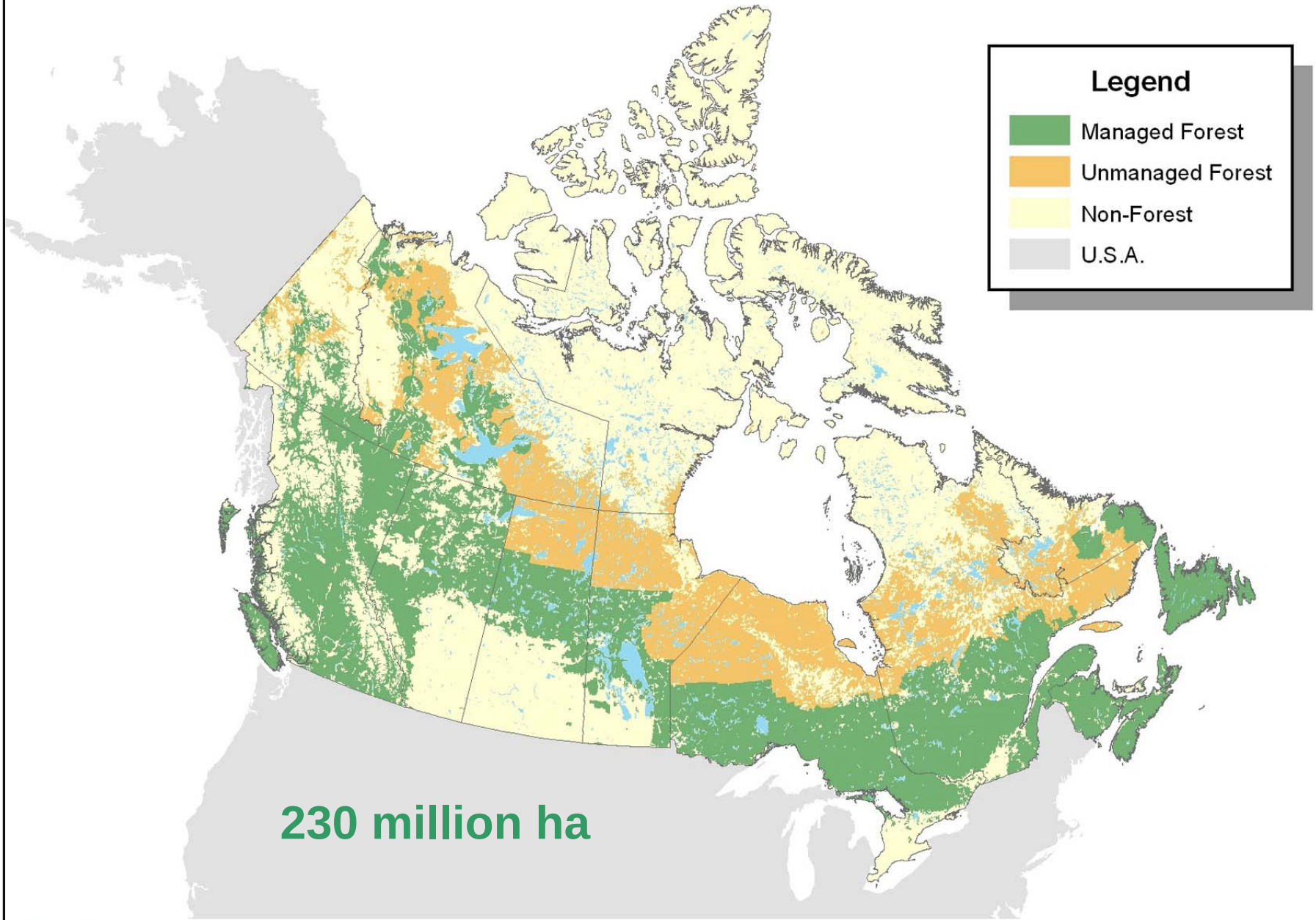
Forest management activity data

Land-use change data

Ecological modelling parameters



CBM-CFS3



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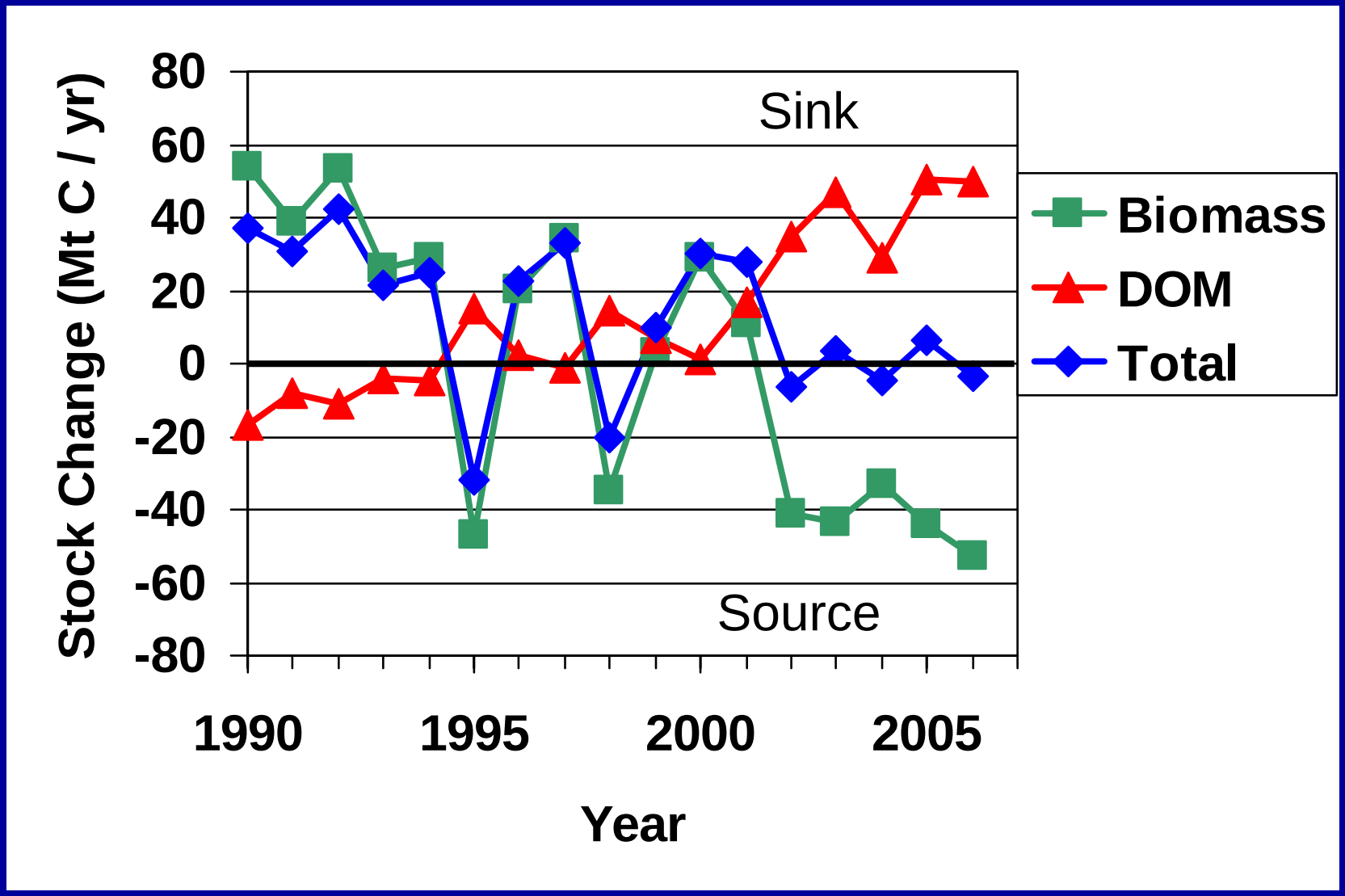
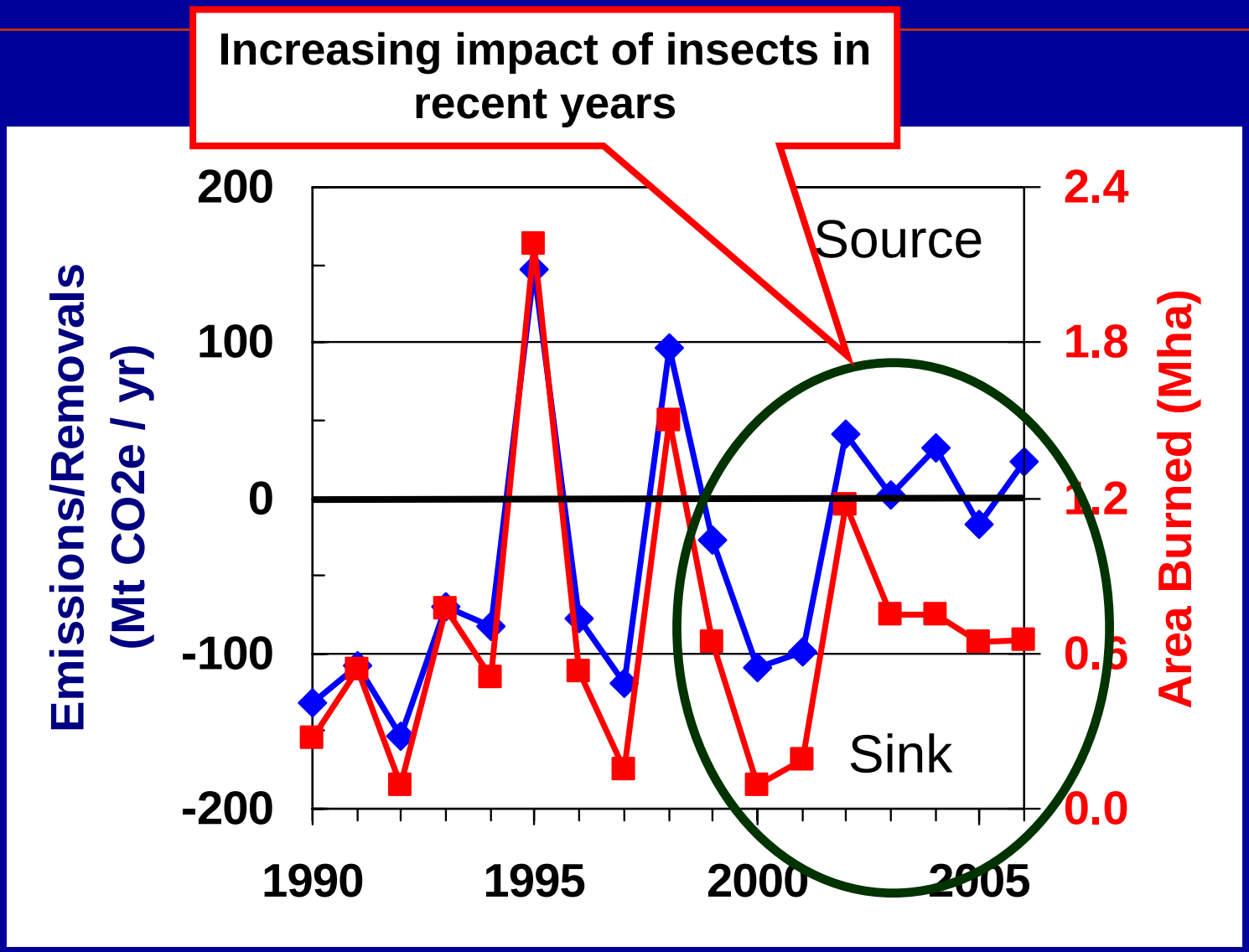
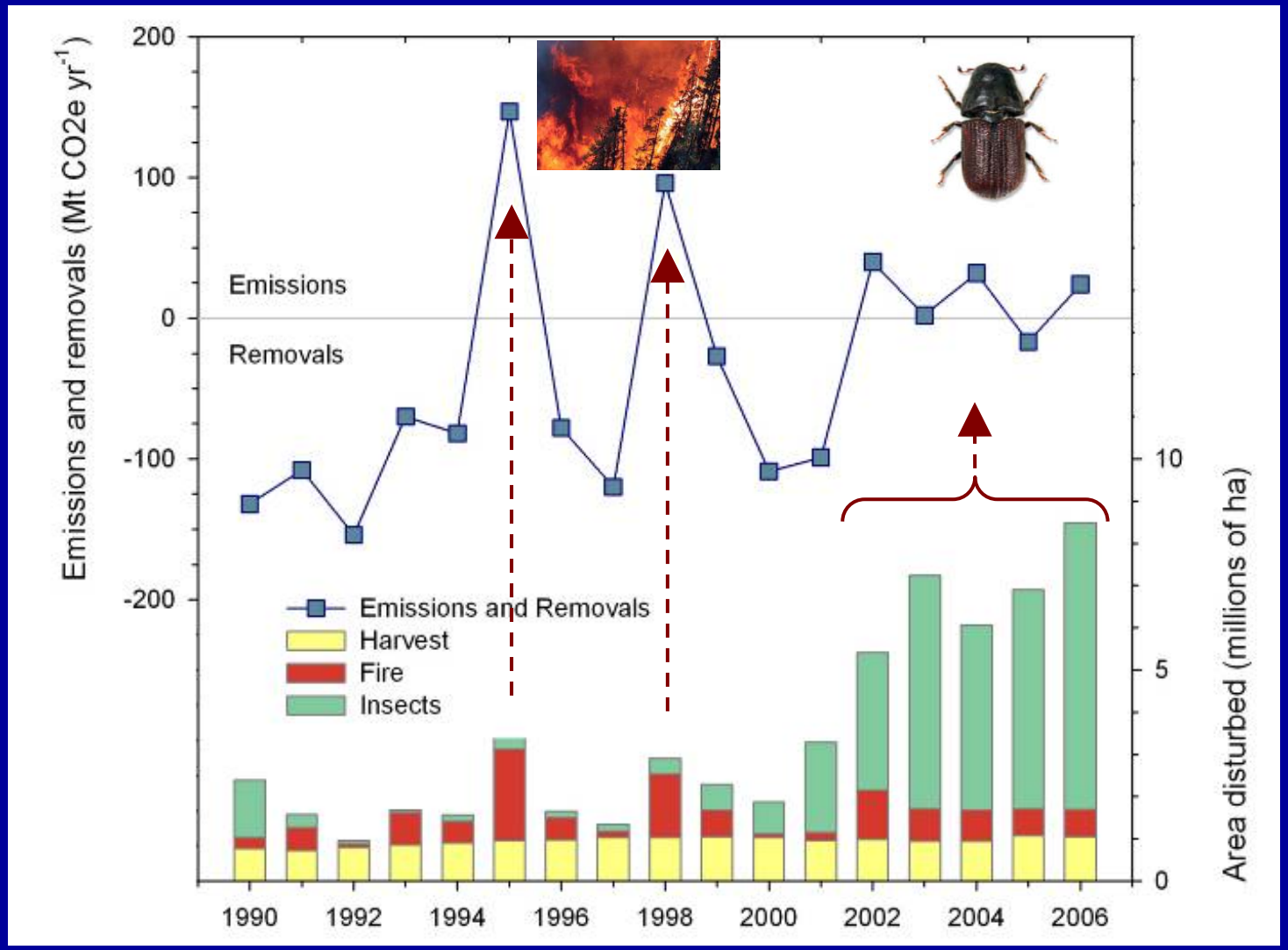
Managed Forest Ecosystem Stock Changes



The Area Burned Affects the Annual GHG Balance



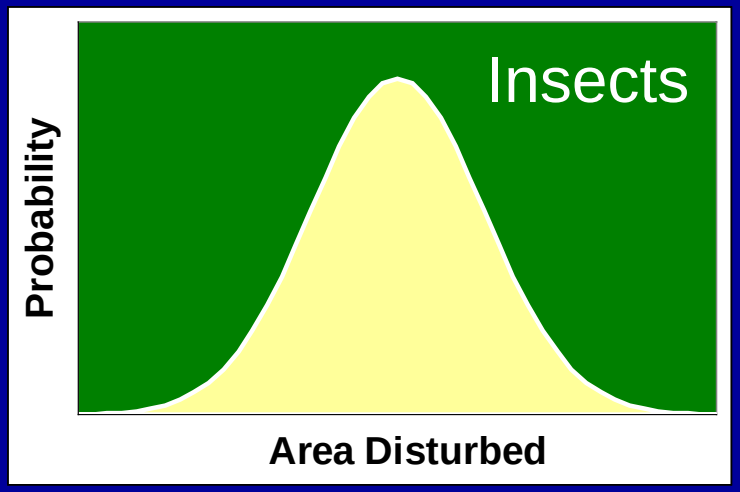
Managed forest GHG emissions and removals

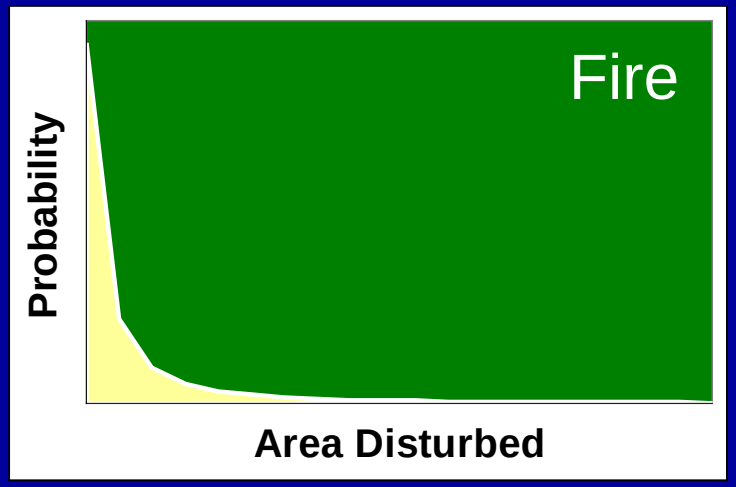


Policy Question: FM in Kyoto?

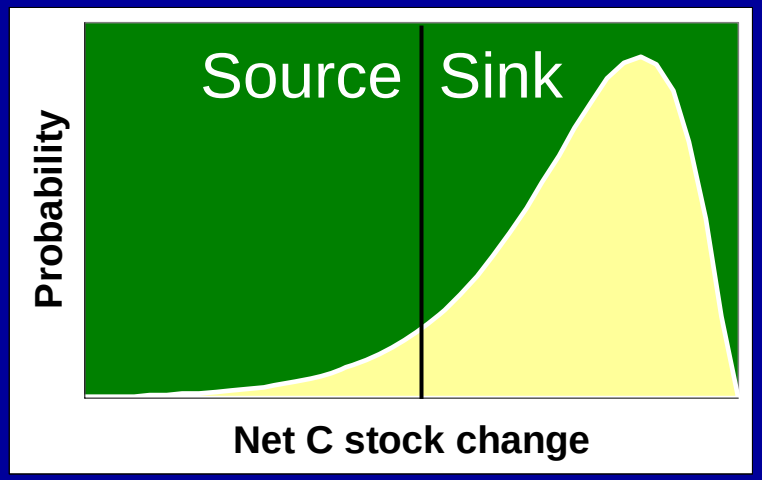
- Kyoto Protocol targets were set before rules were defined.
- Article 3.4 of the KP, provided the option to elect forest management to help meet emission reduction targets in the first commitment period (2008 – 2012).
- If elected, then account for annual C stock changes in area of forest subject to forest management.
- All stock changes in the managed forest – human induced or natural causes.
- How big will the sink be? ….
- But we cannot predict the future area disturbed.
- What is the probability distribution of the net C balance of the managed forest in the first commitment period?

Predicting future forest dynamics using a stochastic approach

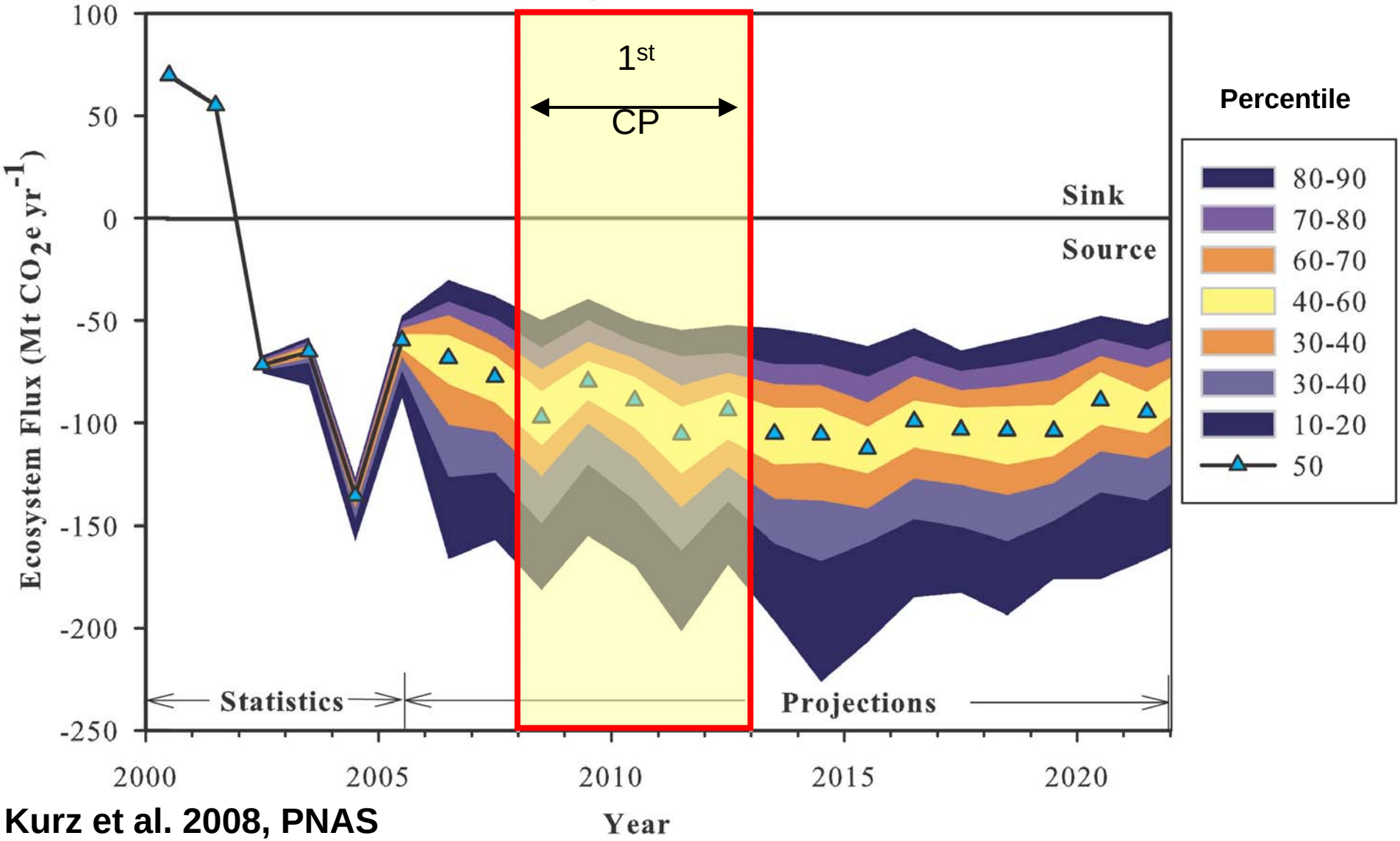




100 Monte Carlo Runs for all of Canada

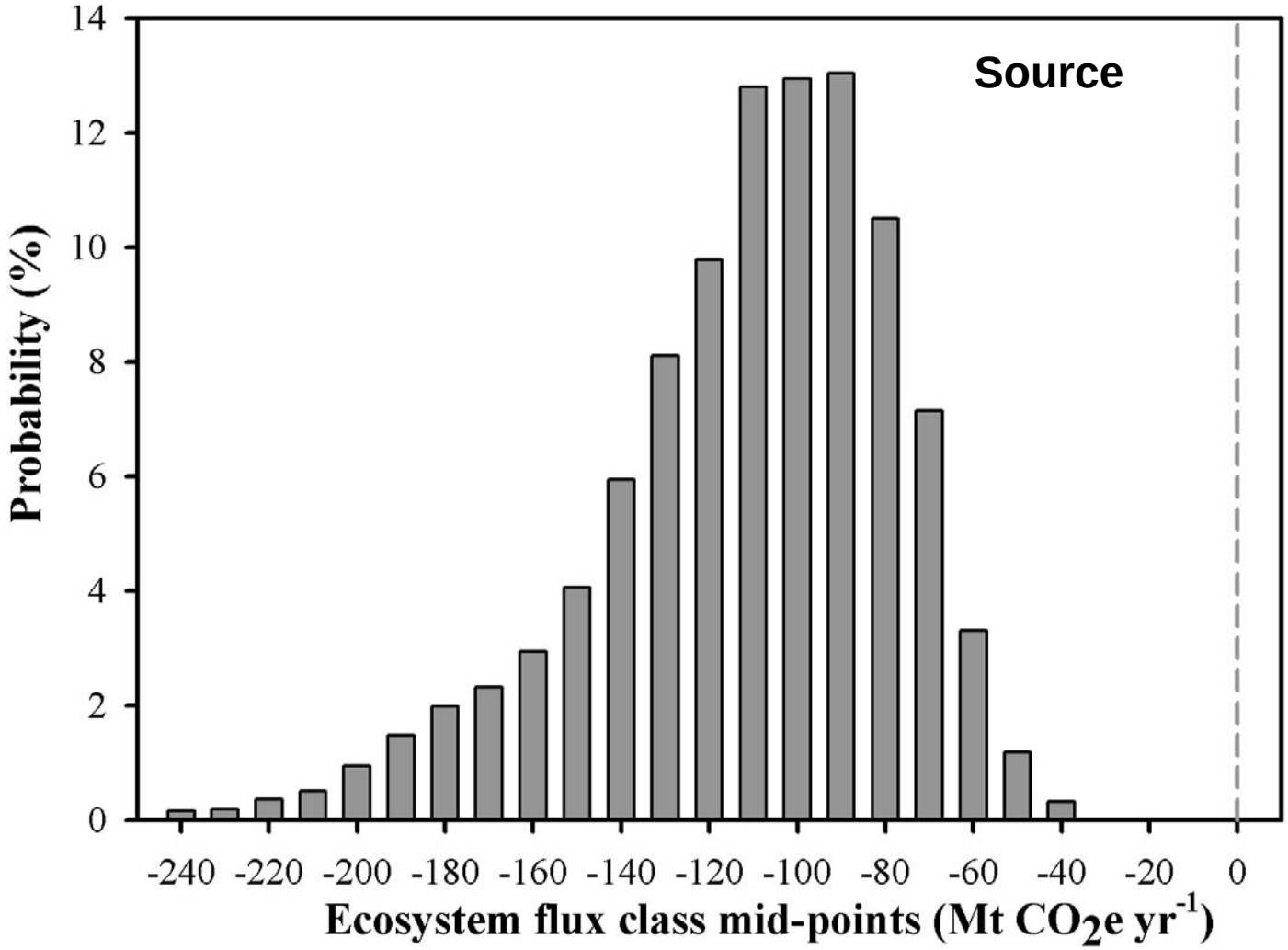


Canada's Managed Forest is Predicted to be a C Source in the Near Future



Kurz et al. 2008, PNAS

Probability Distribution of 5-yr average CO_2e Balance (2008 – 2012)

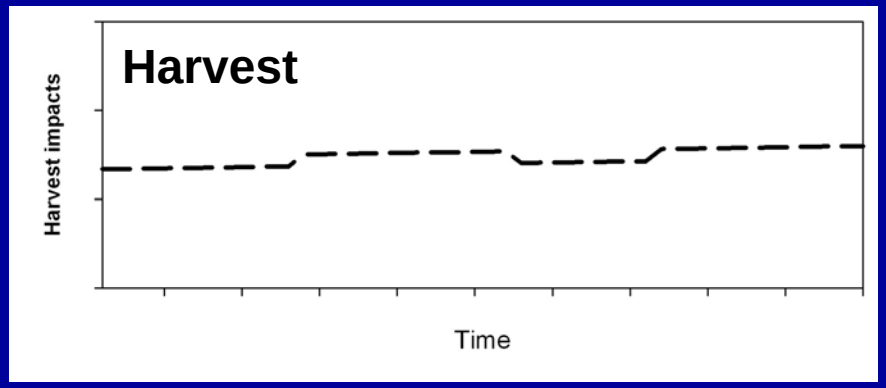


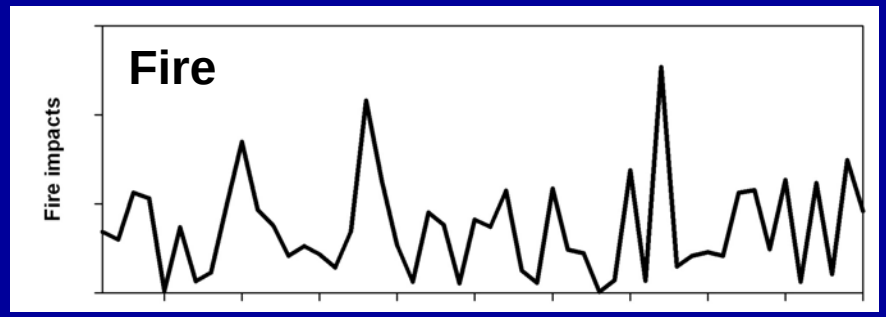
Kurz et al. 2008, PNAS

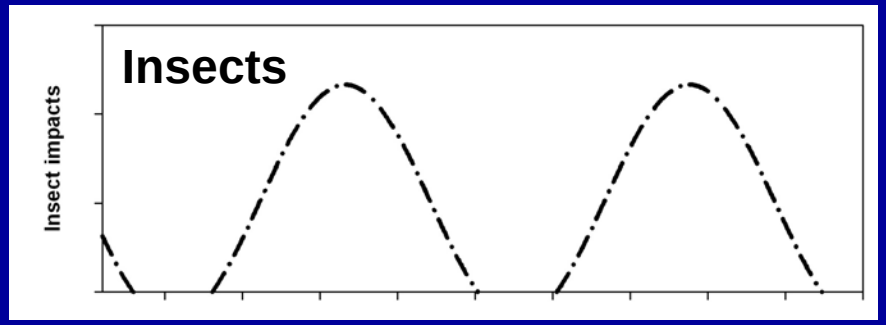
Why?

- Canada's managed forest was a net sink between 1990 and 2005 – why did we predict a net source for the first commitment period?

Why sink in past and source in future?



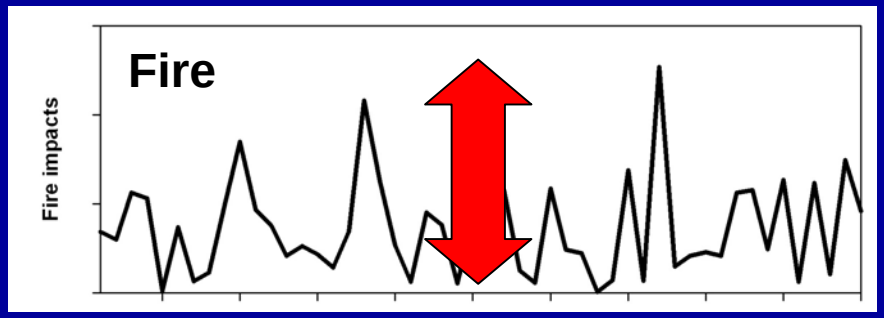


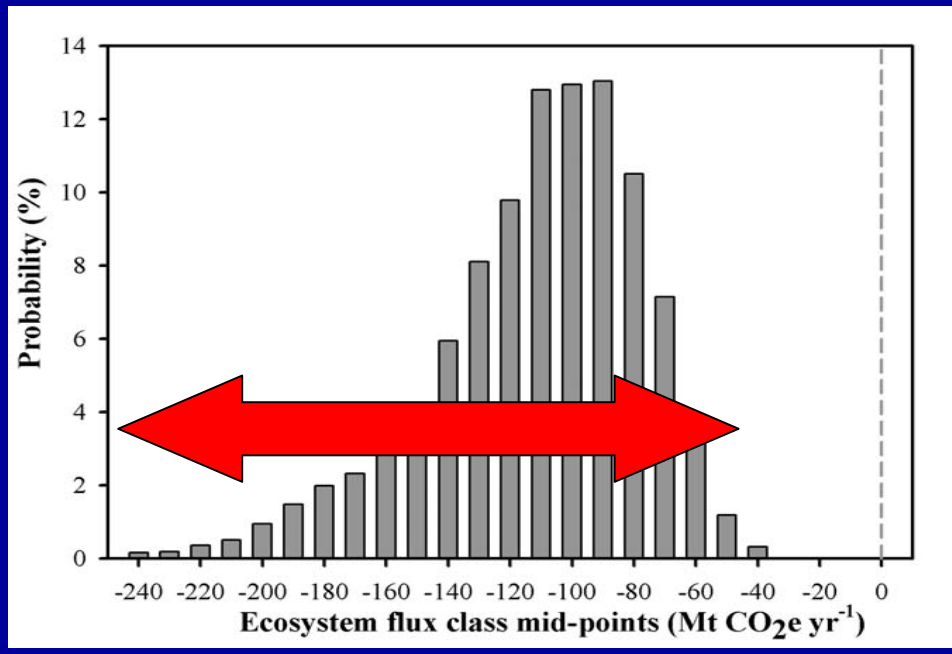


- Three major disturbance types
- Each disturbance has own temporal dynamics
- And each affects the probability distribution

Why sink in past and source in future?

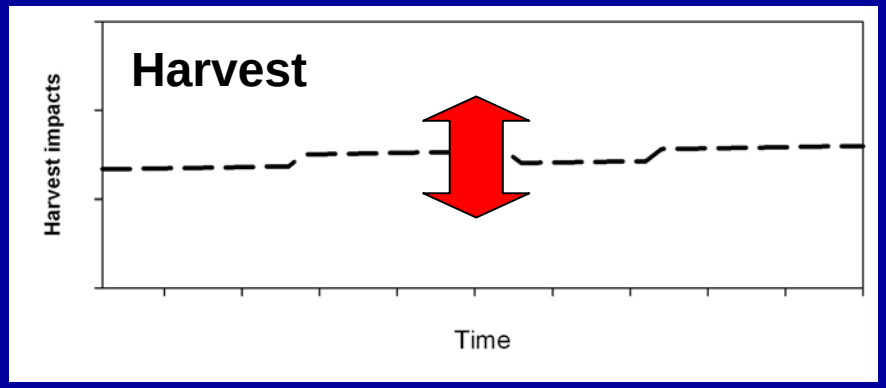
- Interannual variability in area burned determines range of probability distribution.
- Regions with low interannual variability in fires have narrow range of probability distribution.

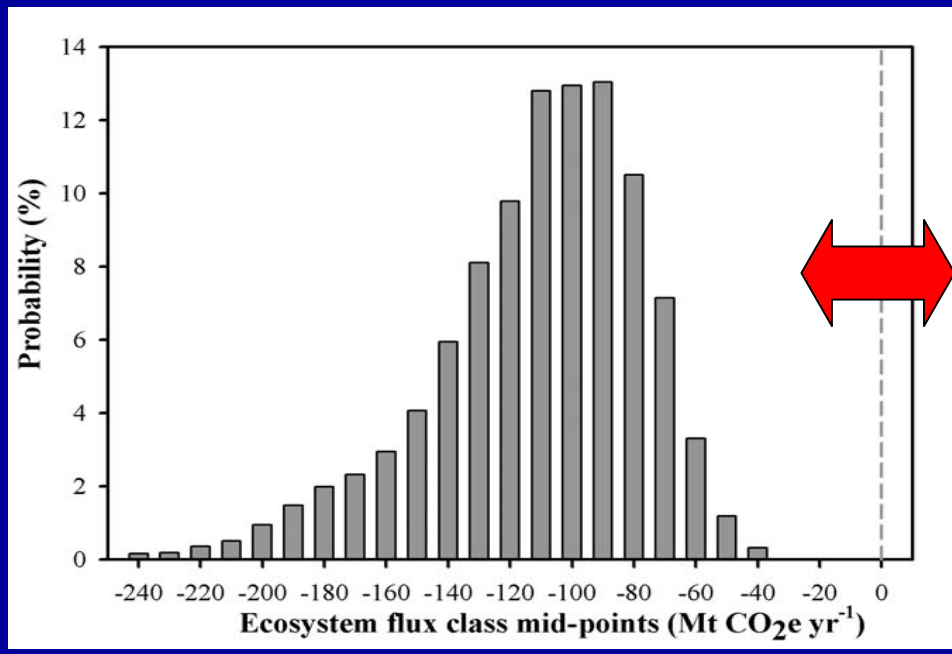




Why sink in past and source in future?

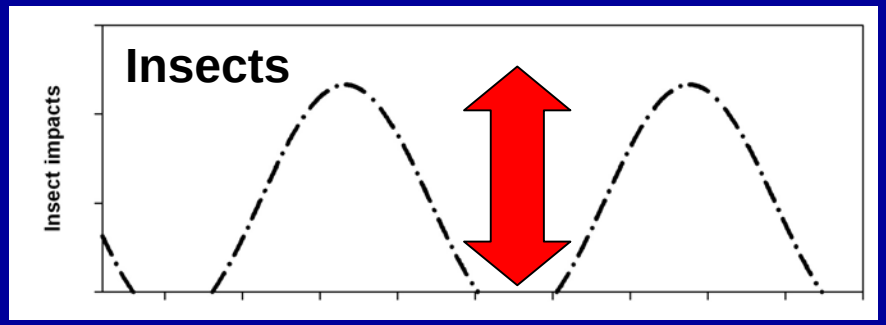
- Harvest rate determines location of distribution (relative to zero line).

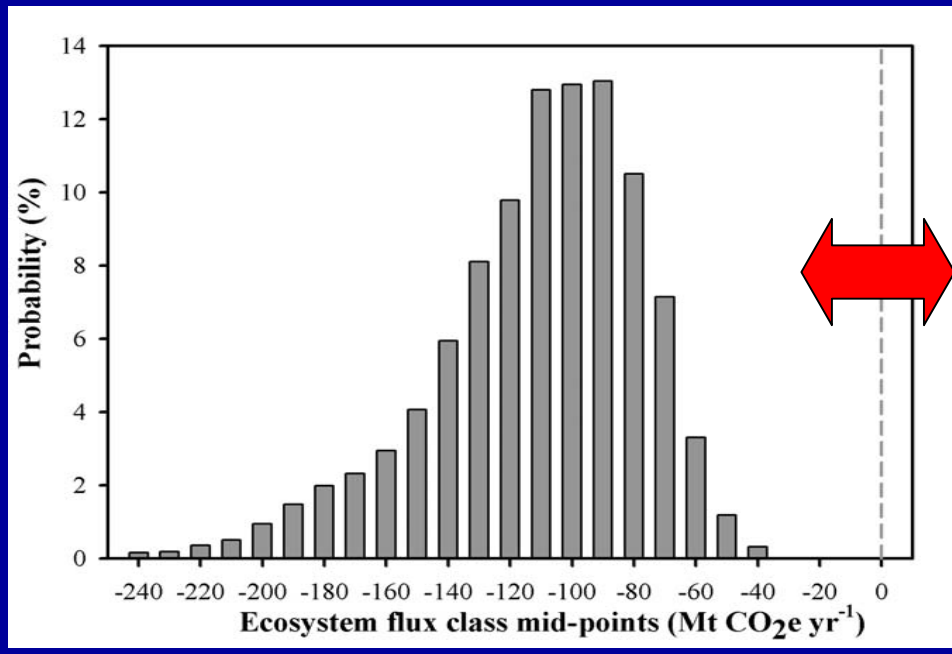




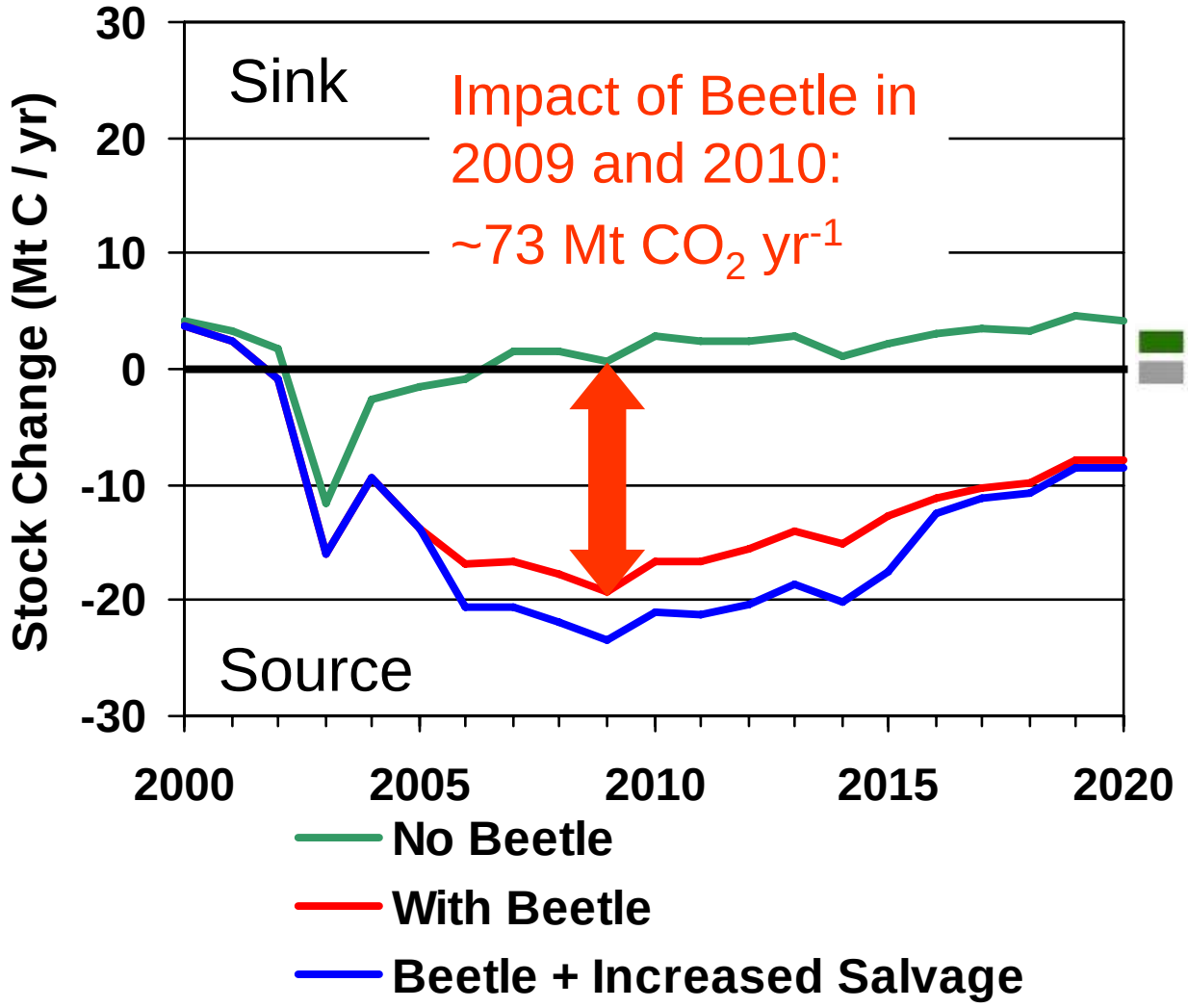
Why sink in past and source in future?

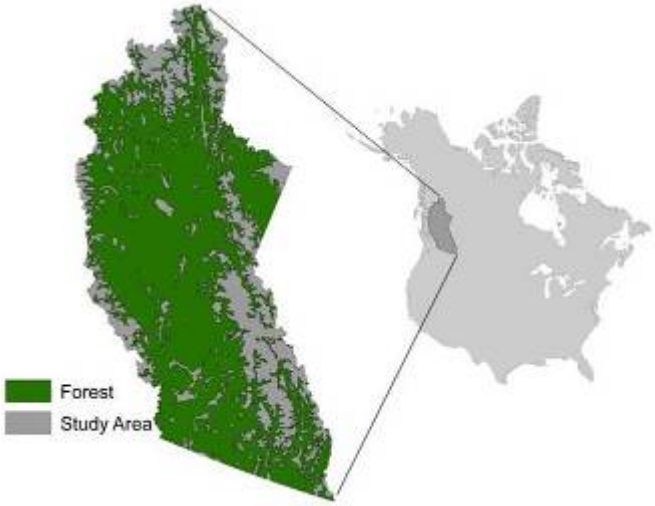
- Stage in insect outbreak cycle determines location of distribution (relative to zero line).
- 1990's were period of low insect activity → sink
- 2008 – 2012 period of high insect activity → source





Impacts of MPB in Western Canada





Source: Kurz et al. 2008, Nature

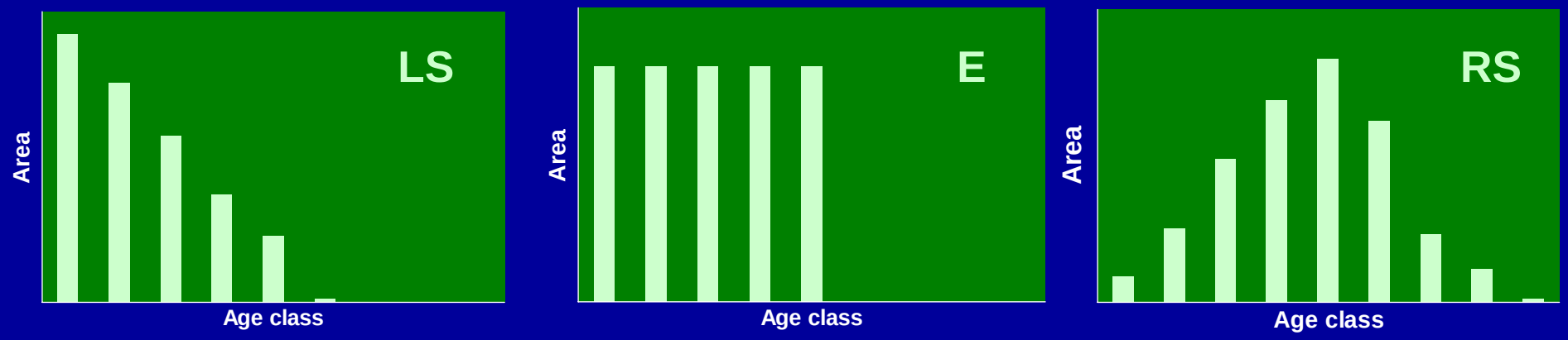
Canada did not elect Forest Management Reporting under Kyoto Rules

- Kyoto rules contribute to the risk that FM efforts are completely "swamped" by natural processes – thus Article 3.4 provides few incentives to change FM
  - Account for all carbon and non-CO_2 emissions within the managed forest: includes all wildfires and insects
  - No factoring out of pre-1990 age-class effects
  - Reporting of absolute changes (gross-net accounting) not against a baseline (net-net)
  - No accounting of harvested wood products
- These issues are discussed in the post-2012 negotiations

Policy Question: Effects of Age-Class Legacy

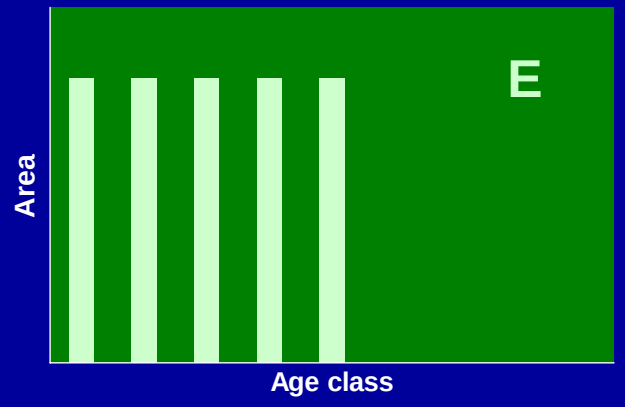
- The future GHG balance of the area subject to forest management is affected by today's age-class structure, which is the result of past disturbances (natural and human).
- Measuring the absolute stock changes over a specified (commitment) period confounds impacts of management (change) with effects of age-class legacy.
- Forest management areas with a "left-shifted" (young) age-class structure are more likely to be sinks, while those with a "right-shifted" age-class structure are more likely to be sources, even with the same management regime.

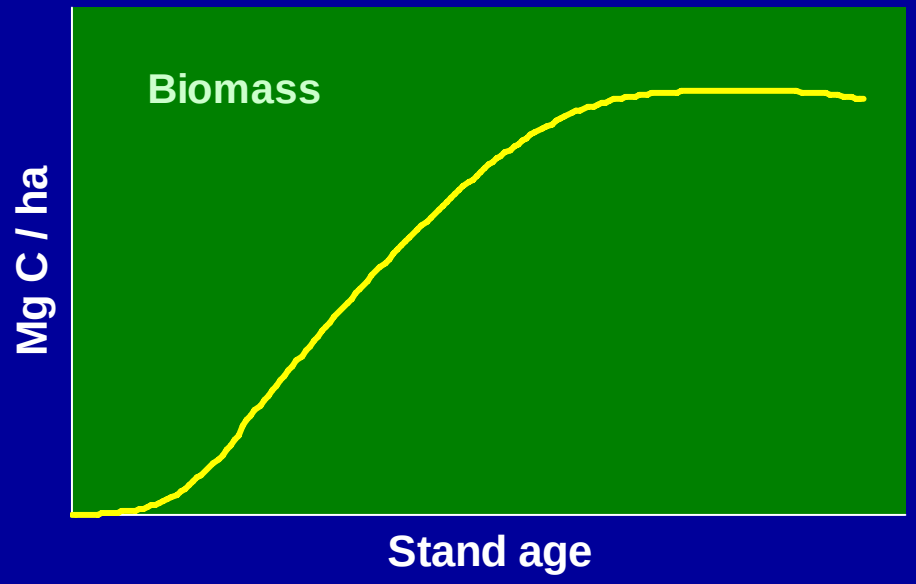
The age-class legacy



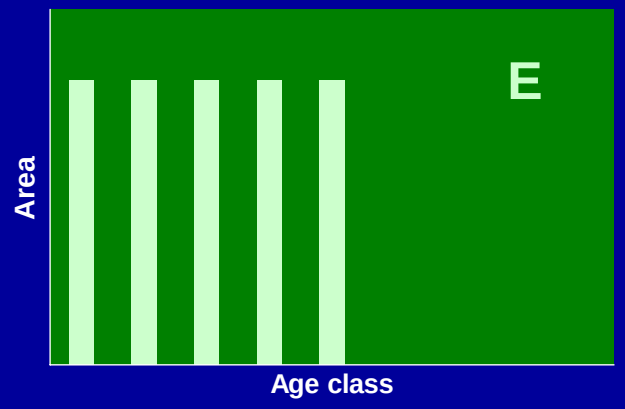
- Three initial age-class structures:
  - Even (1% of area in each 1 to 100 year)
  - Left shifted (e.g. created from increased disturbances)
  - Right shifted (e.g. created from decreased disturbances)
- Single site type described by one growth curve

The age-class legacy

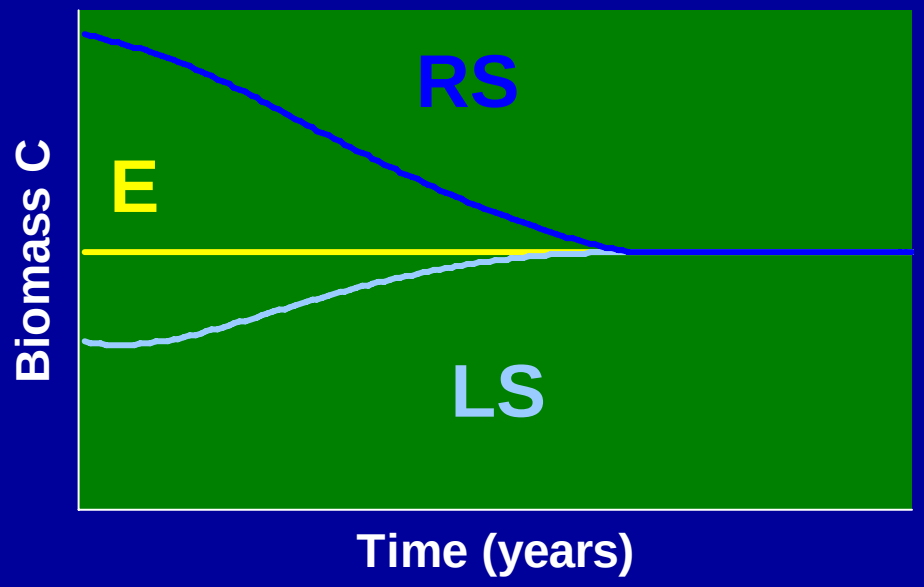




The age-class legacy

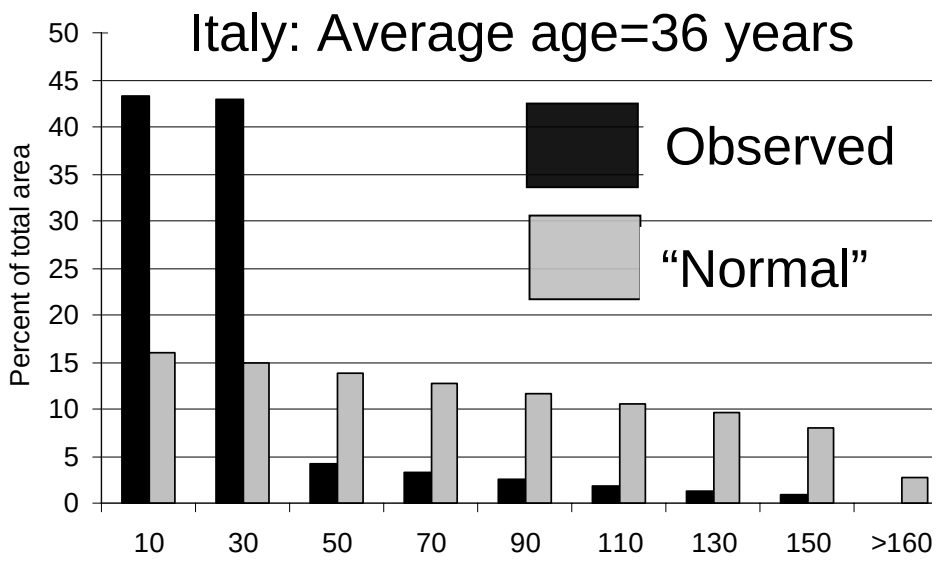


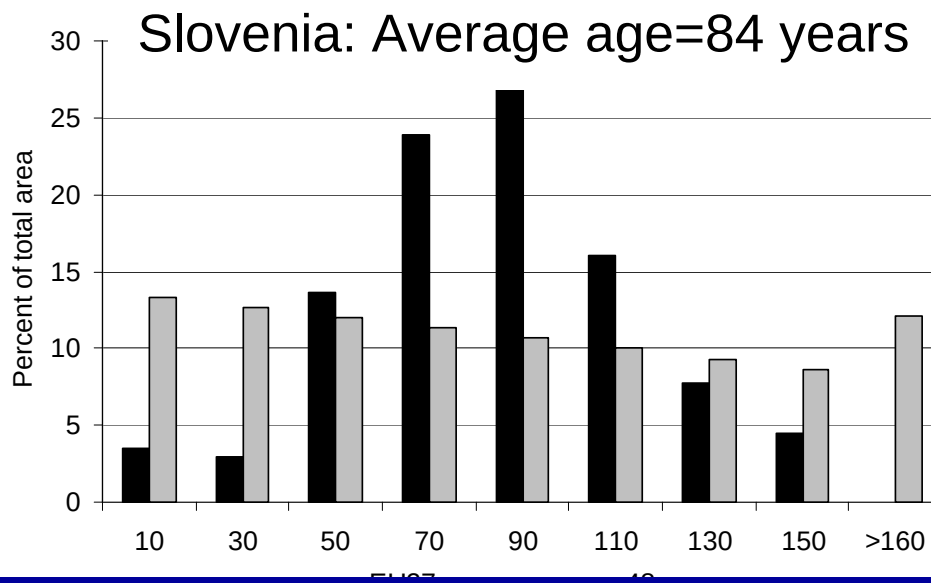
Management regime: harvest 1 % of area / yr



Effects of Age-Class Legacy

- Large differences in forest age-class structure among European Countries …

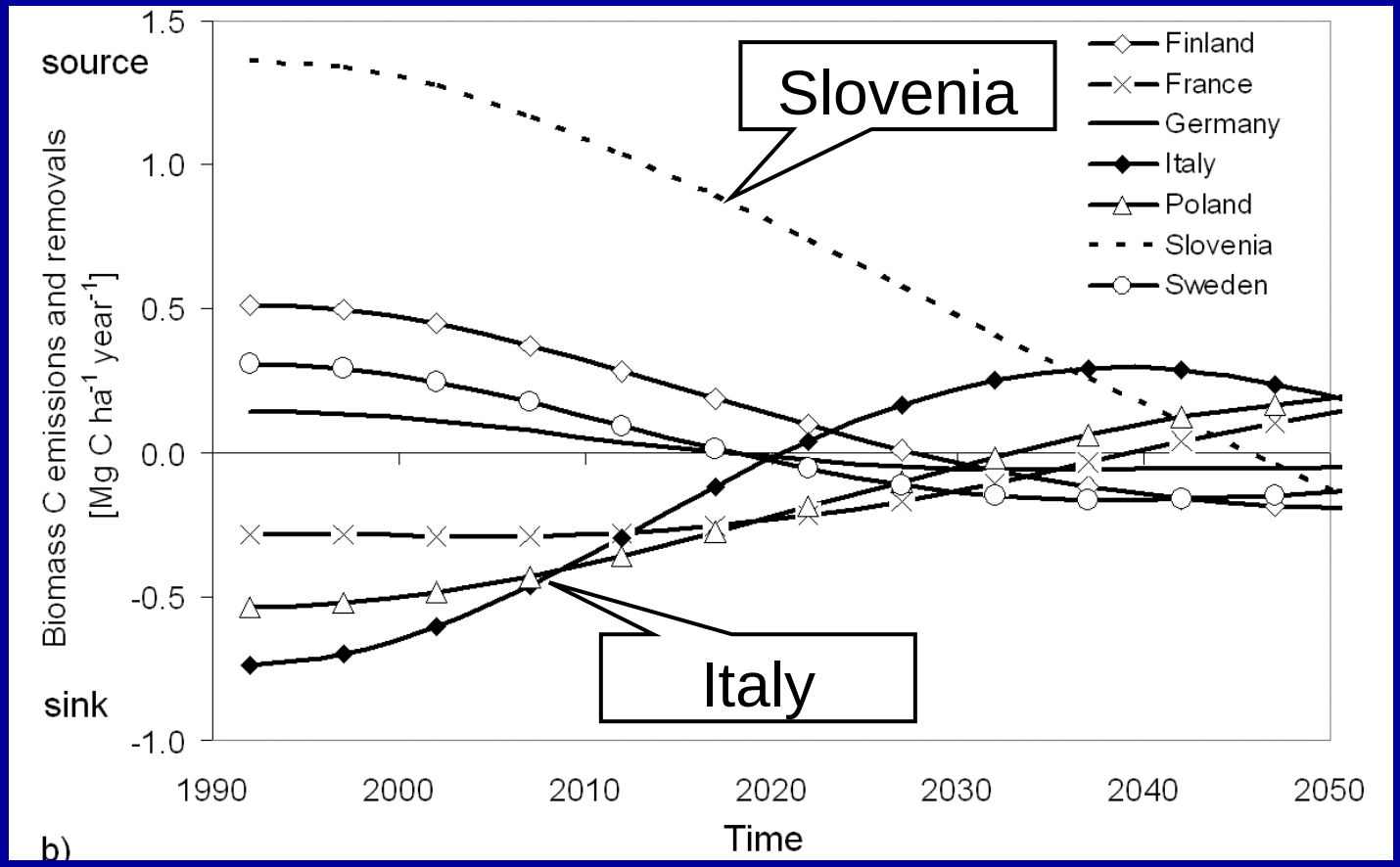




Source: Böttcher et al. 2008

Effects of Age-Class Legacy

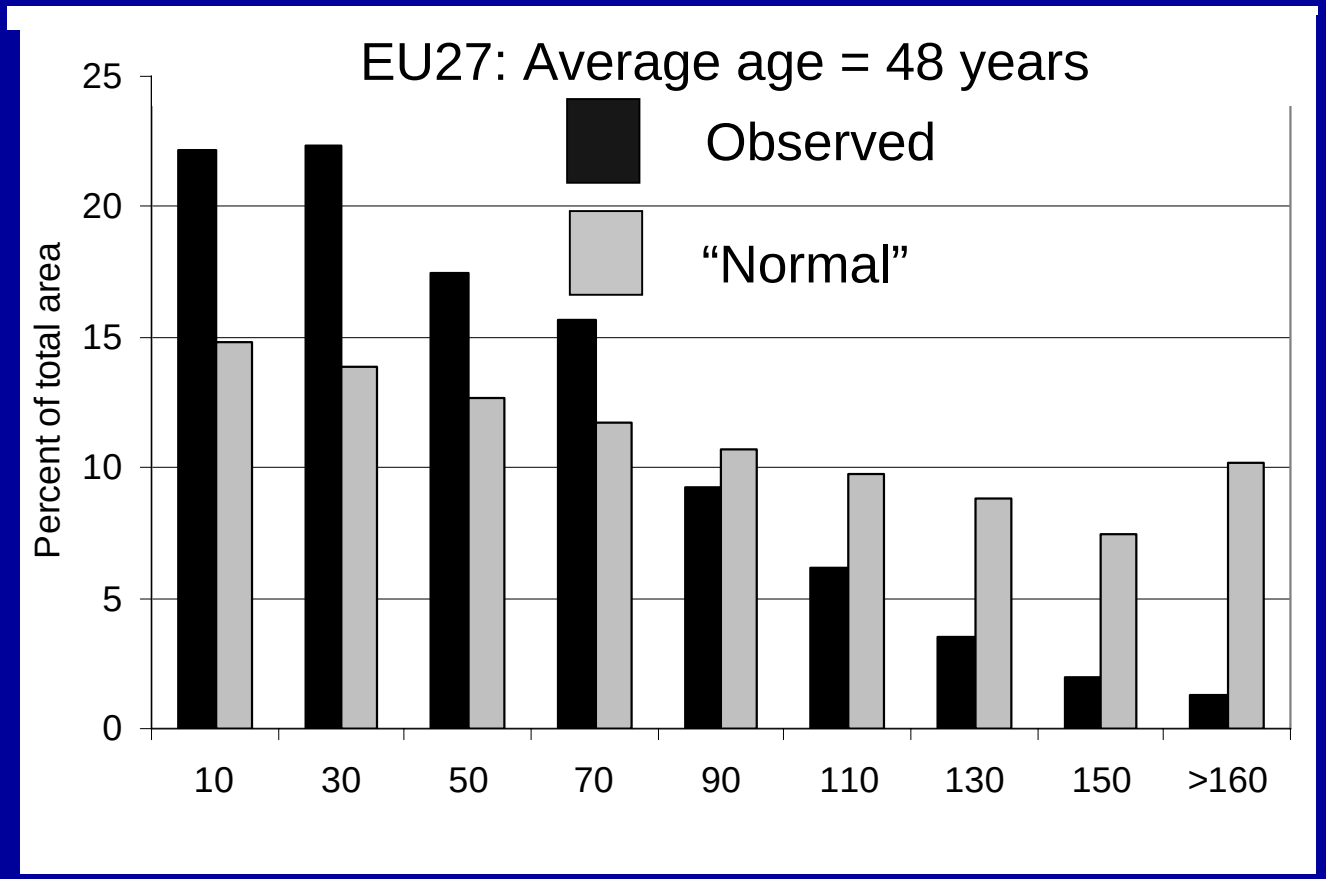
- … lead to very different BAU scenarios for biomass carbon.



Source: Böttcher et al. 2008

Effects of Age-Class Legacy

- Forest age-class structure of 27 EU countries is left-shifted.



Source: Böttcher et al. 2008

Effects of Age-Class Legacy

- The impacts on the carbon balance of changes in forest management (mitigation actions) can be separated from the impacts of age-class legacy through the use of a forward looking baseline.

Source: Böttcher et al. 2008

Policy Questions: Does the Forest Sector have a Role in a Mitigation Portfolio?

- Mitigation objectives are supported when changes in human activities result in
  - a reduction of emissions or
  - an increase in removals of GHG from the atmosphere relative to a projected business-as-usual baseline.
- Climate change will increase the area annually affected by fires, drought, and insects and could have negative impacts on forest carbon stocks.
- Nevertheless, forest management options are available to improve the net GHG balance of the forest sector.

Mitigation Options in the Forest Sector

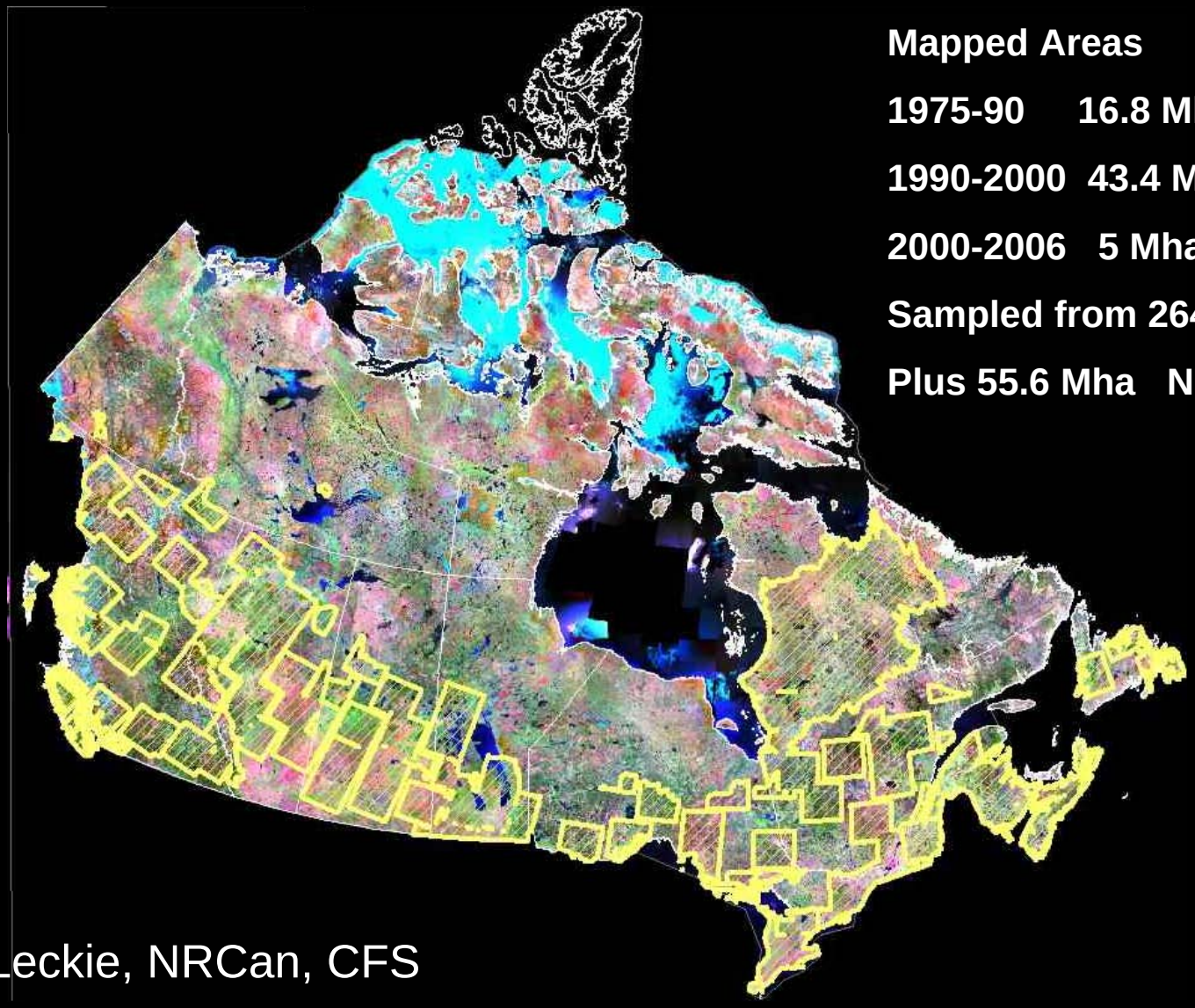
1. Increase (or maintain) forest area
2. Increase stand-level carbon density
3. Increase landscape-level carbon density
4. Increase C stored in products, reduce fossil emissions through product substitution and through bioenergy use

Source: IPCC 2007, AR4 WG III, Forestry

Reducing Emissions from Deforestation

- Global emissions from deforestation (i.e. land-use change) are larger than global emissions from the transportation sector (Stern Review, 2006).

CFS Deforestation Monitoring Program



Mapped Areas

1975-90 16.8 Mha

1990-2000 43.4 Mha

2000-2006 5 Mha to date

Sampled from 264 Mha

Plus 55.6 Mha N. Quebec

Source: D. Leckie, NRCan, CFS

Deforestation

Definition: the direct human-induced [non-temporary] conversion of forested land to non-forested land (UNFCCC)

2005 deforestation in developed countries

	Mt CO2e	%*
Australia	74.1	14
Canada	19.9	3
EU15	7.3	0.2
Japan	-0.6	0
New Zealand	0.8	1
Russia	?	
United States	?	

* % of total emissions excl. LULUCF

Source: UNFCCC

Reducing Deforestation

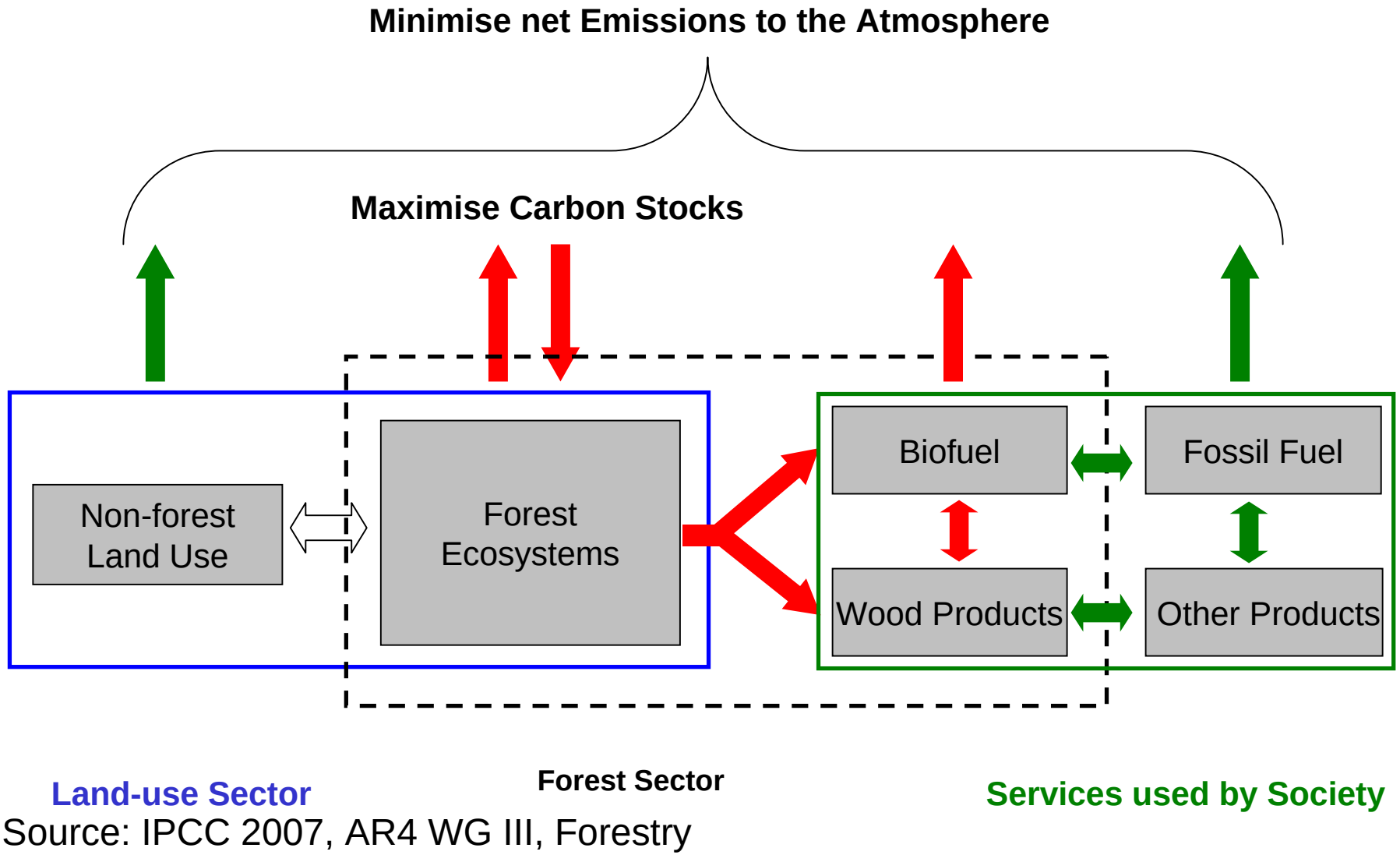
- Government of BC has declared intent to introduce legislation in 2010 to achieve zero net deforestation by 2015.
- Where does deforestation occur, in what sectors, and at what rates?
- Where are areas for future afforestation to off-set unavoidable deforestation?

Policy Question: Design of a Mitigation Portfolio

- Do we have tools in place that help us design a mitigation portfolio based on agriculture, forestry and other land use (AFOLU) activities?

- Analyses should take (global) system's perspective for mitigation portfolio design.

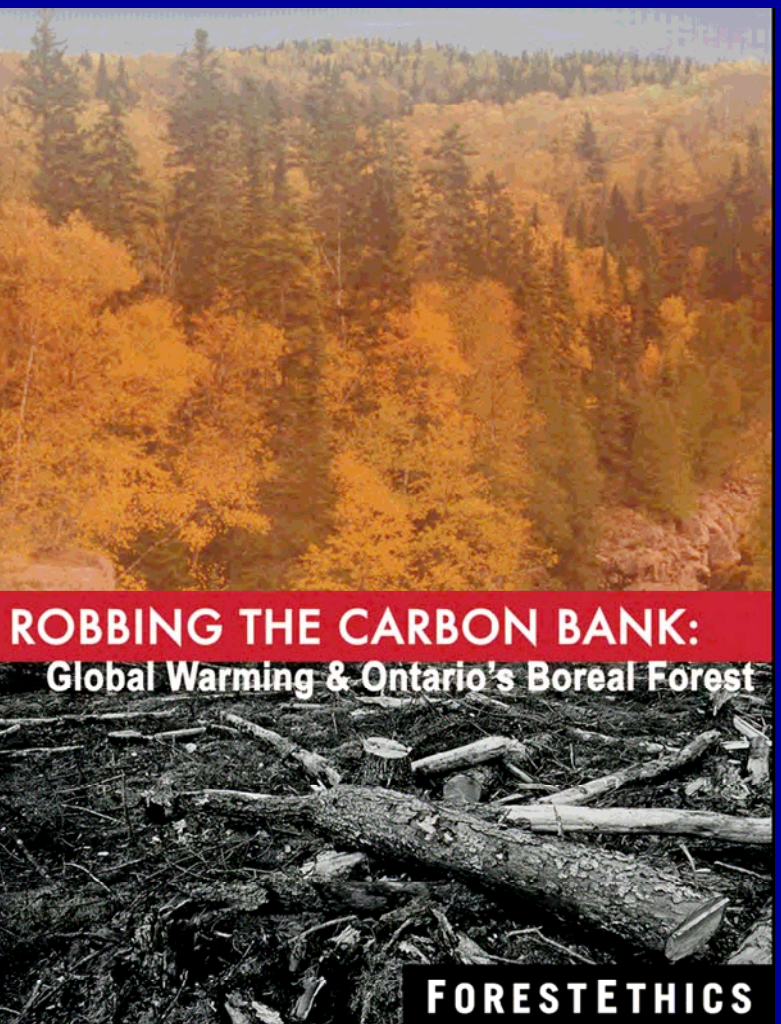
Forest Mitigation Strategies: What to Optimise?



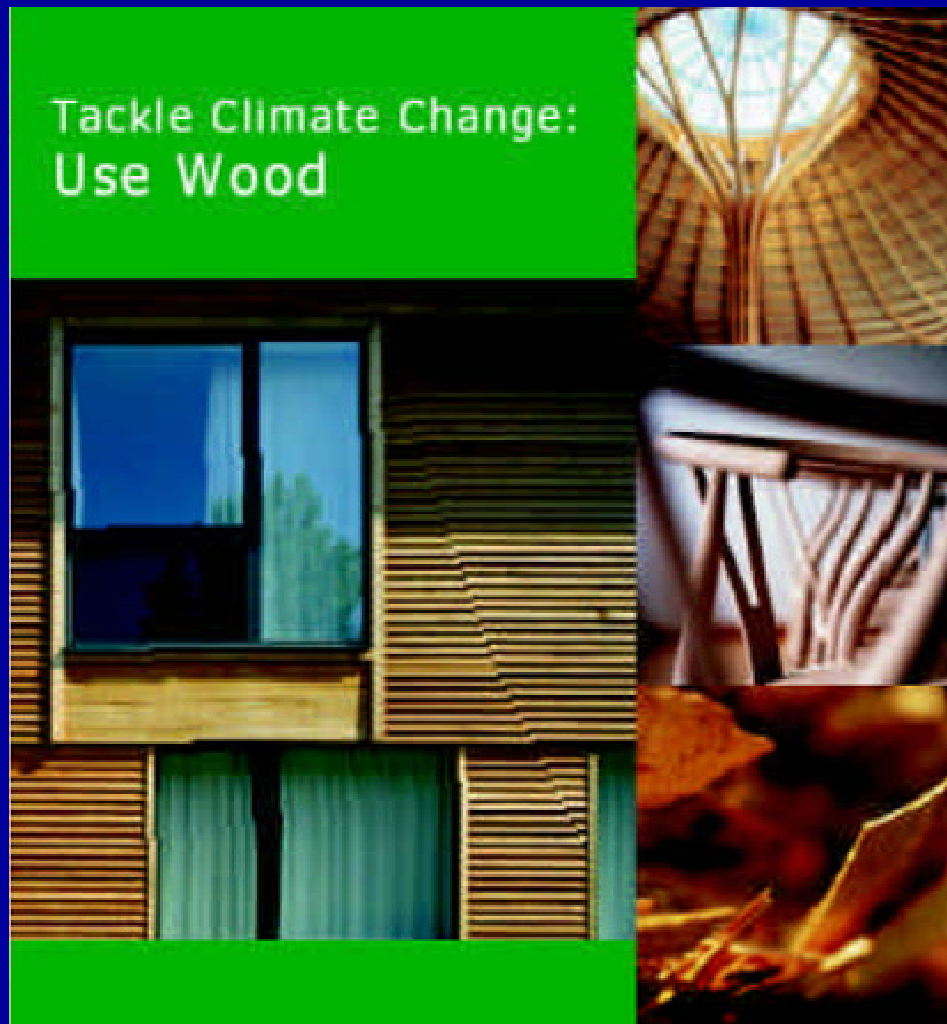
Source: IPCC 2007, AR4 WG III, Forestry

Forest Mitigation Strategies: Two competing positions

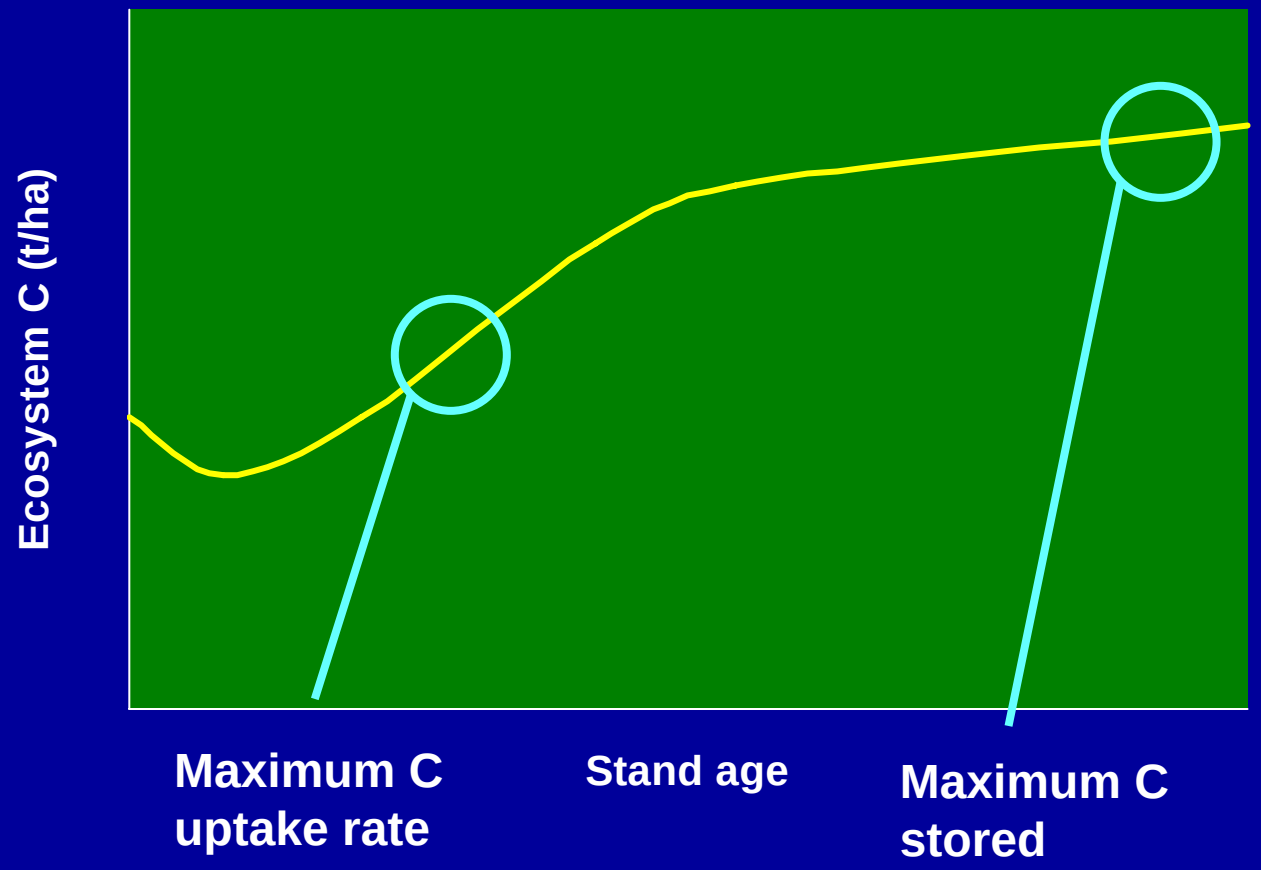
Stop logging …..



… or use wood?

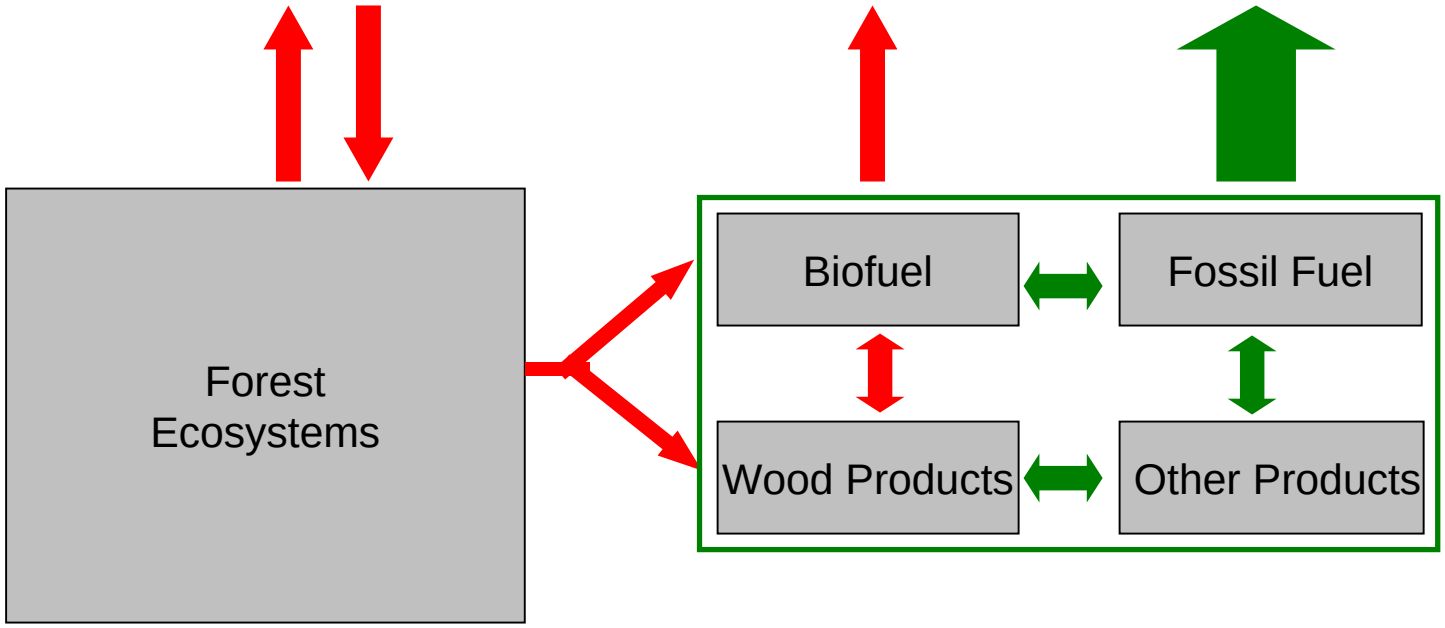


Stand-level C dynamics



Forest Mitigation Strategies: Two competing positions

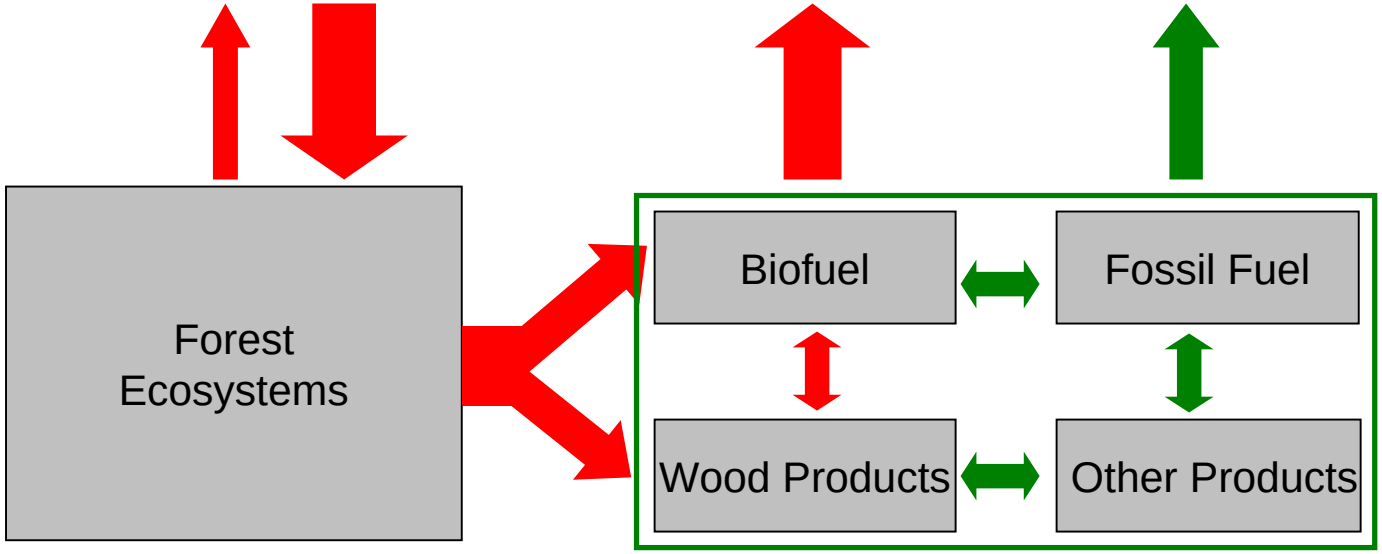
Maximise Carbon stocks ….



Services used by Society

Forest Mitigation Strategies: Two competing positions

… or maximise Carbon uptake?



Services used by Society

Analysing Carbon Management Strategies

- Developed carbon yield curves with CBM-CFS3.
- Used LP (Woodstock) to develop management plans with different carbon maximisation objectives, over 200 year analysis.
- Important to include forest product and substitution effects in design of management plan with carbon objectives.

	Forest	Products	F+P	F+P+S	Harvest
Maximise C in:	C/ha/yr	C/ha/yr	C/ha/yr	C/ha/yr	m3/ha/yr
Forest	0.164	0.064	0.228	0.277	0.98
Products	-0.035	0.183	0.148	0.287	3.13
Forest+Products	0.155	0.110	0.265	0.351	1.71
F+P+substitution	0.114	0.138	0.252	0.361	2.15

Source: Hennigar et al. 2008, For. Ecol. Mgmt.

Conclusions

- Canada's managed forest was C sink from 1990 – 2006 but sink strength is decreasing.
- Forests have become a source because of increasing natural disturbances (fires, insects)
- Forests and forest sector can contribute to a mitigation strategy by improving GHG balance relative to baseline.
- A sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fibre or energy from the forest, will generate the largest sustained mitigation benefit (IPCC AR4).

Conclusions

- The ongoing interaction between policy makers, negotiators, other stakeholders and scientists enhances the likelihood that scientific results will influence policy.
- In a carbon-constrained future the demand for policy relevant (but not policy prescriptive) carbon cycle science will increase.

Thank you very much!

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