

# Risk Assessment of the Decision to Elect Article 3.4 “Forest Management” in Canada

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Land-use Related Choices under the Kyoto Protocol

Graz / Austria

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Natural Resources  
Canada

Ressources naturelles  
Canada

Canada 

# Acknowledgements

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- CFS Carbon Accounting Team:  
Graham Stinson, Greg Rampley, Caren Dymond, Kevin Belanger, Michael Magnan
- And many members of Provincial and Territorial Resource Management Agencies across Canada
- Climate Change Action Fund and Panel on Energy Research and Development (PERD) for partial funding of the study.

# Outline

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- The Age-Class Legacy
- Risk Assessment on Article 3.4
  - Methods
  - Preliminary Results
- Conclusions

## The age-class legacy

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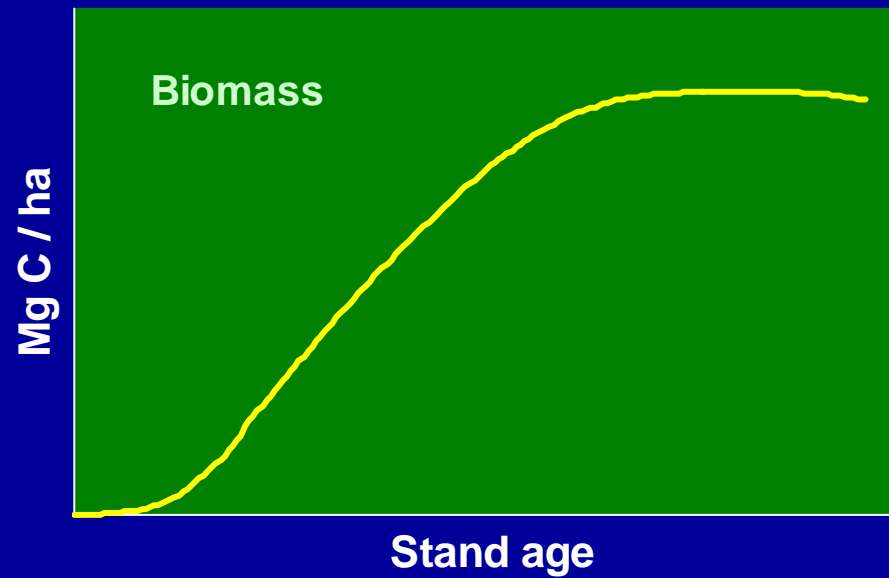
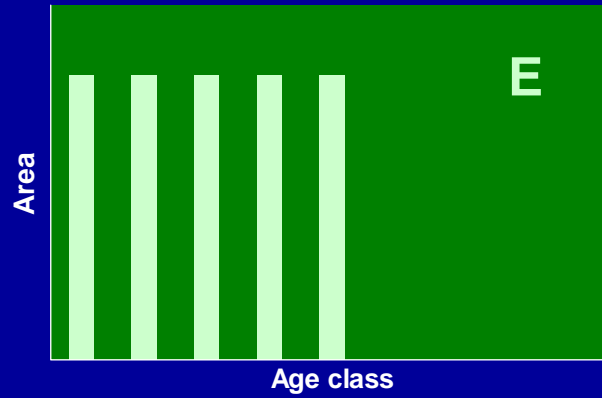
The future net C balance is affected by the current forest age-class structure which results from stand-replacing disturbances over the past decades.

# Hypothetical Landscape Example

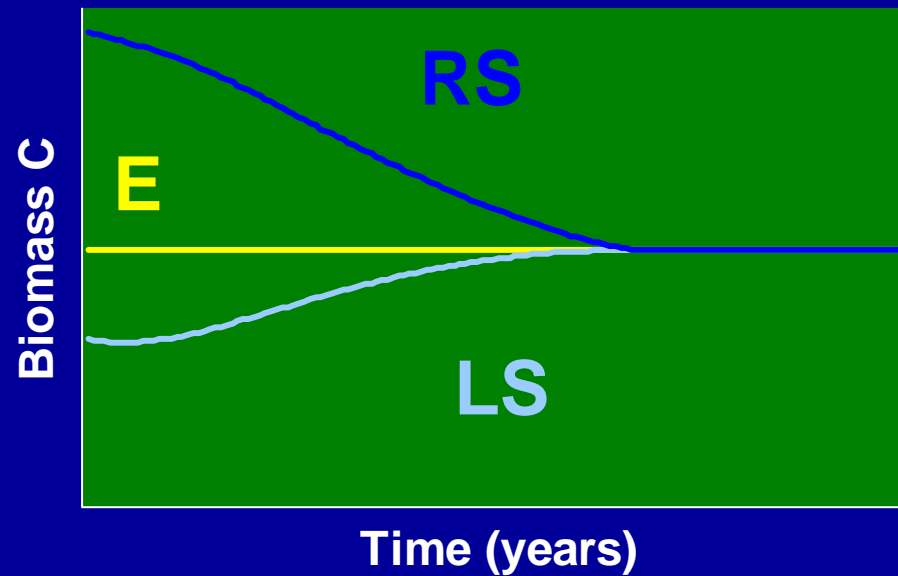
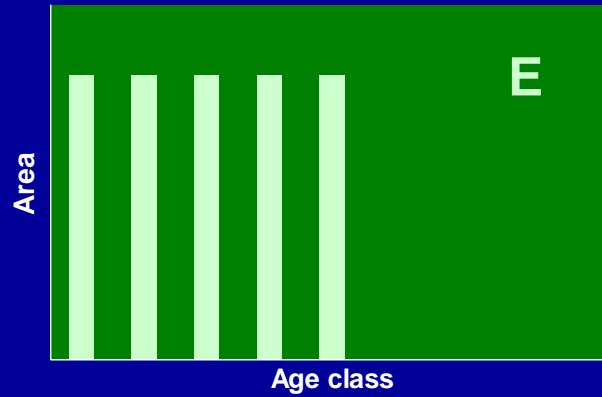
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- 100,000 ha landscape
- Single site type described by one growth curve
- Three initial age-class structures:
  - Even (1% of area in 100 one-year age classes)
  - Left shifted (e.g. created from increased disturbances)
  - Right shifted (e.g. created from decreased disturbances)
- Management regime: clearcut harvest 1 % of area / yr
- Simulations conducted with the CBM-CFS3

# The age-class legacy



# The age-class legacy



## Lessons Learned

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- Age-class structure affects the amount of C stored in the landscape: In this example, the right-shifted age-class structure contains 2.8 times more biomass than left-shifted age-class structure.
- Age-class structure affects future C dynamics. With the same management regime (harvest 1 % of area / yr):
  - the RS landscape loses biomass C,
  - the E landscape is “neutral” and
  - the LS landscape gains biomass C.

# International Reporting Requirements

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- Under Kyoto (and UNFCCC) we must report annual carbon stock changes in the area of the managed forest.
- In this example, the same management regime leads to three different reported stock changes.
- Important to assess the impacts of initial age-class structure of the managed area(s) when selecting management options.

## International Reporting Requirements

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- Information should also be provided which indicates whether or not anthropogenic greenhouse gas emissions by sources and removals by sinks from land use, land-use change and forestry activities under Article 3 paragraph 3 and elected activities under Article 3 paragraph 4 factor out removals from:
  - (a) Elevated CO<sub>2</sub> concentrations above pre-industrial levels;
  - (b) Indirect nitrogen deposition; and
  - (c) The dynamic effects of age structure resulting from activities prior to 1 January 1990;

Marrakesh Accords: FCCC/CP/2001/13/Add.3, English, Page 23.

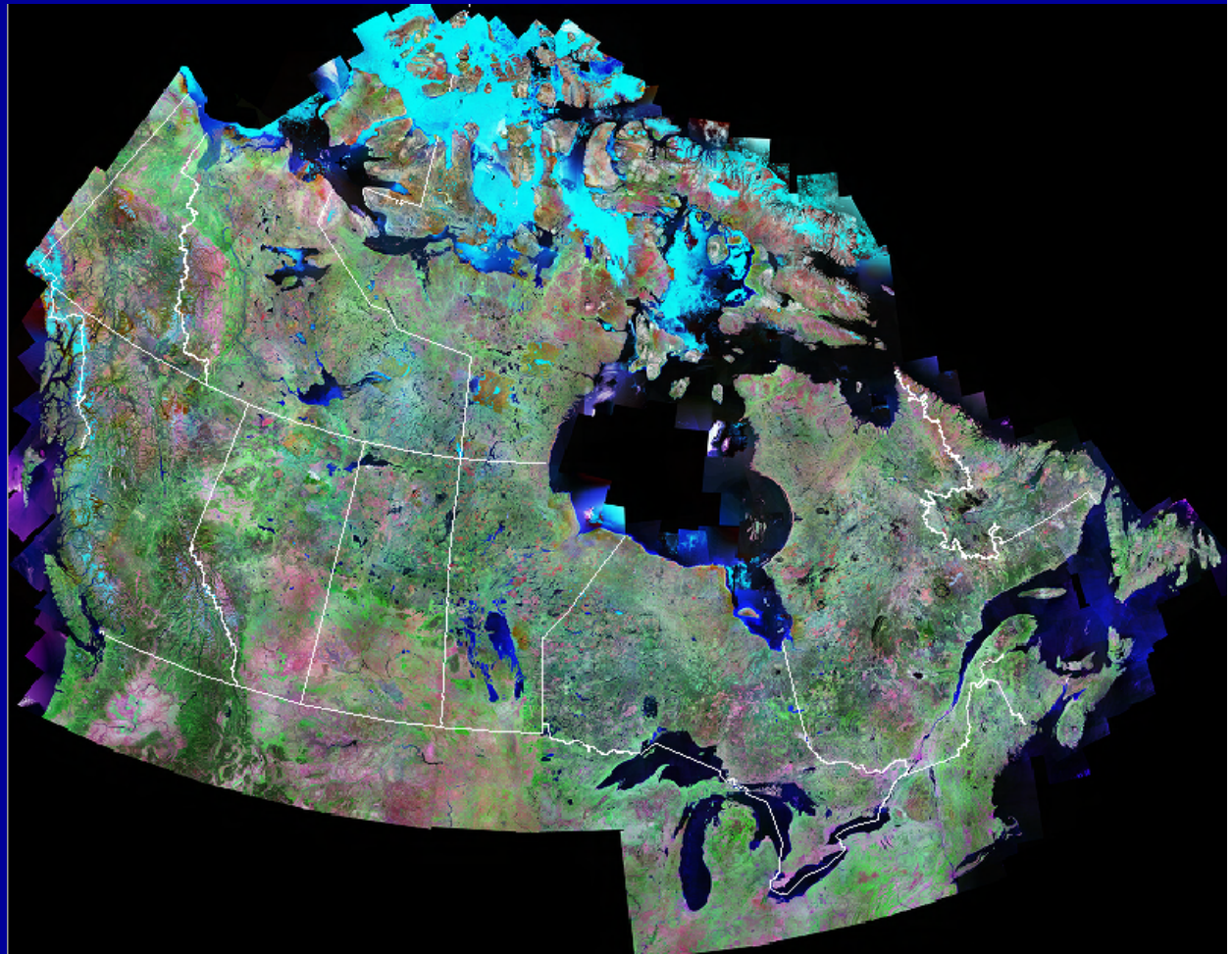
# Canada's Forest Carbon Stocks

~400 Mha forest  
and wooded land

Tree biomass:  
~ 15 Gt C

Woody debris,  
litter and soil:  
~ 70 Gt C

Annual Harvest:  
~ 50 million t C

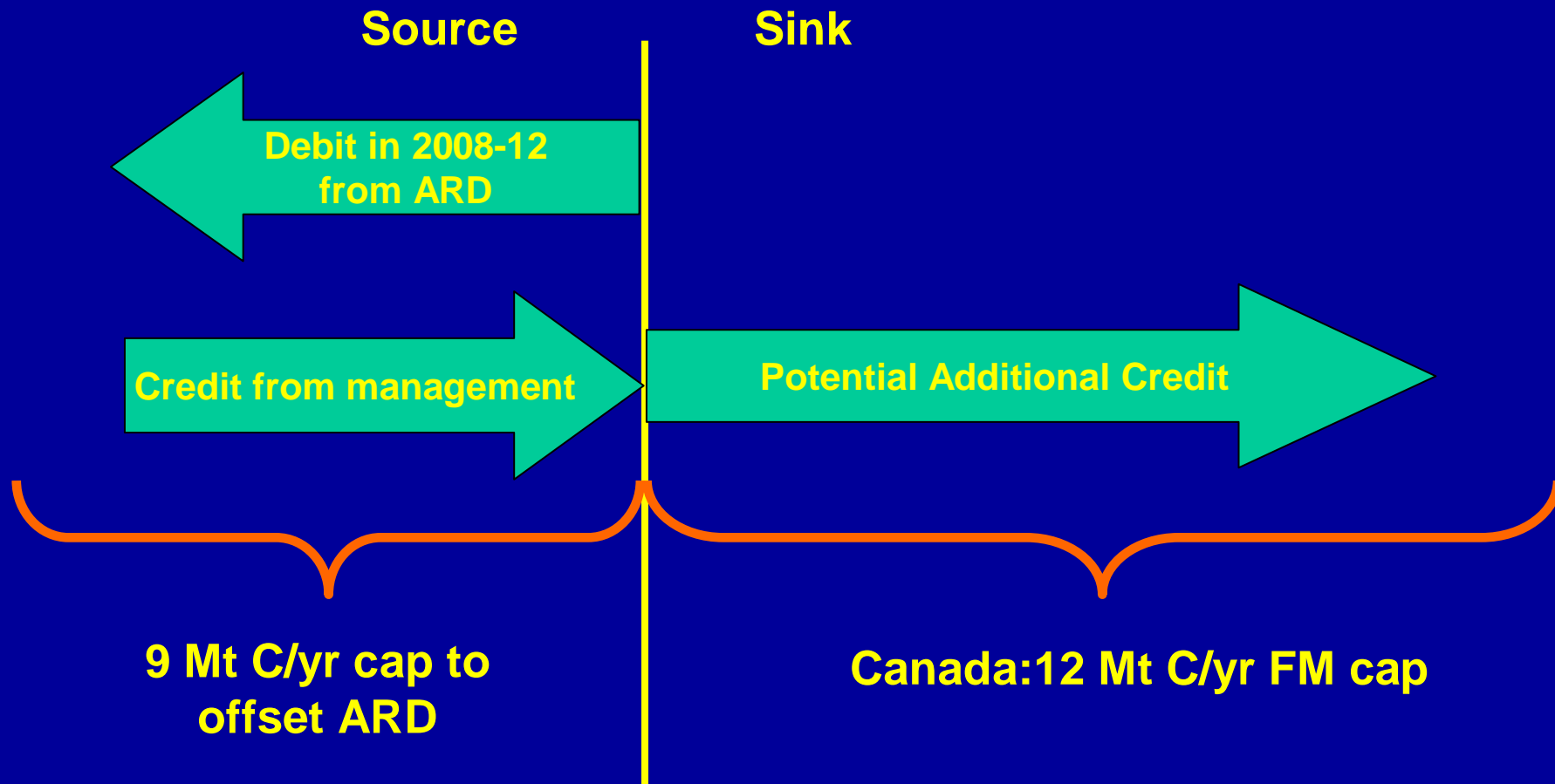


# Forest Management Carbon Accounting under the Kyoto Protocol

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- Countries that have ratified the Kyoto Protocol must decide by 2006 whether or not to elect forest management activities under Article 3.4.
- If yes, then account for annual C stock changes in area of forest subject to forest management during the first commitment period (2008 – 2012).
- All stock changes – human induced or natural causes.
- Absolute stock change – not relative to 1990 (as in cropland management). No baseline.
- Maximum sink capped but source may be unlimited.

# FM Credits in Canada's National Accounts

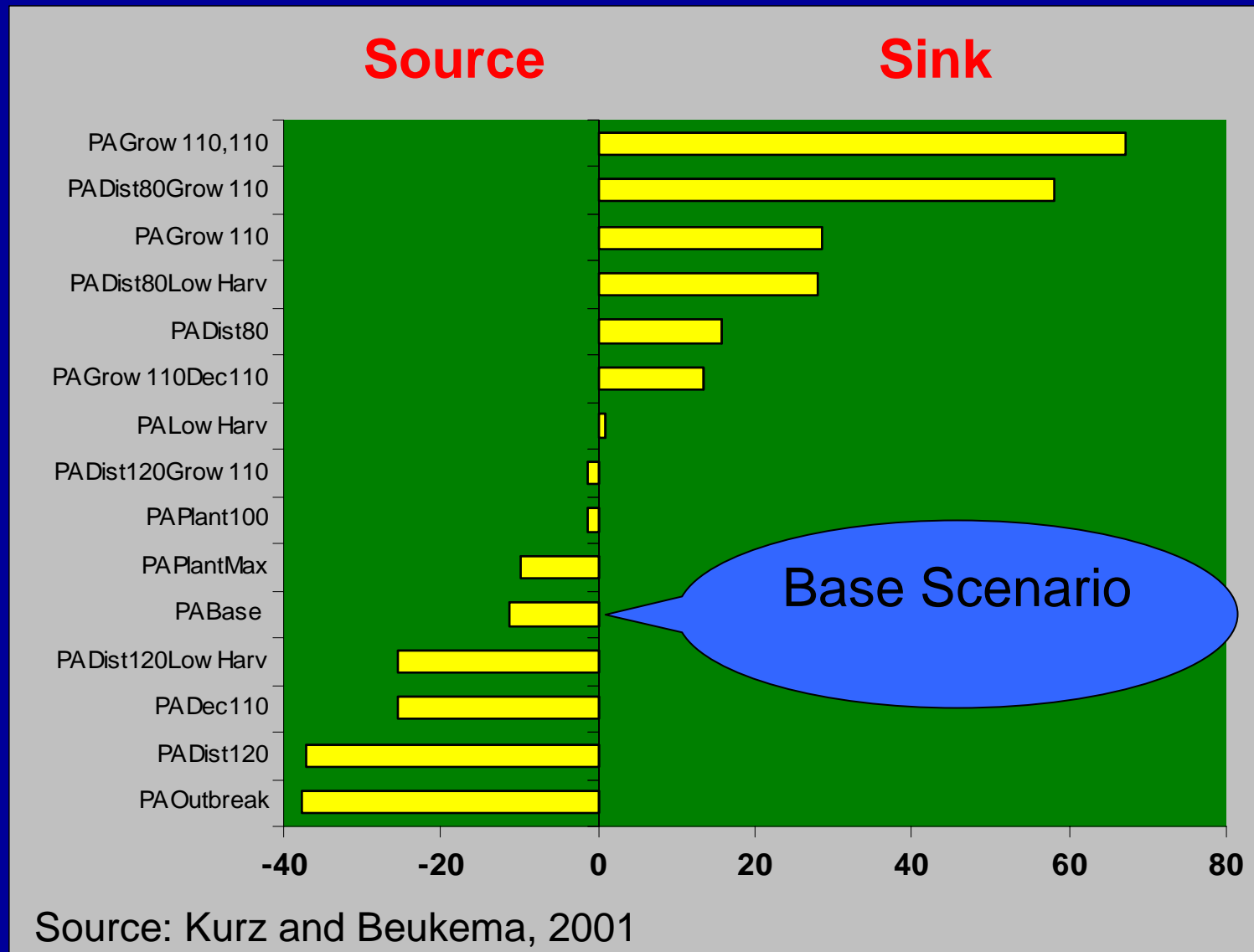


## Article 3.4 Risk Assessment

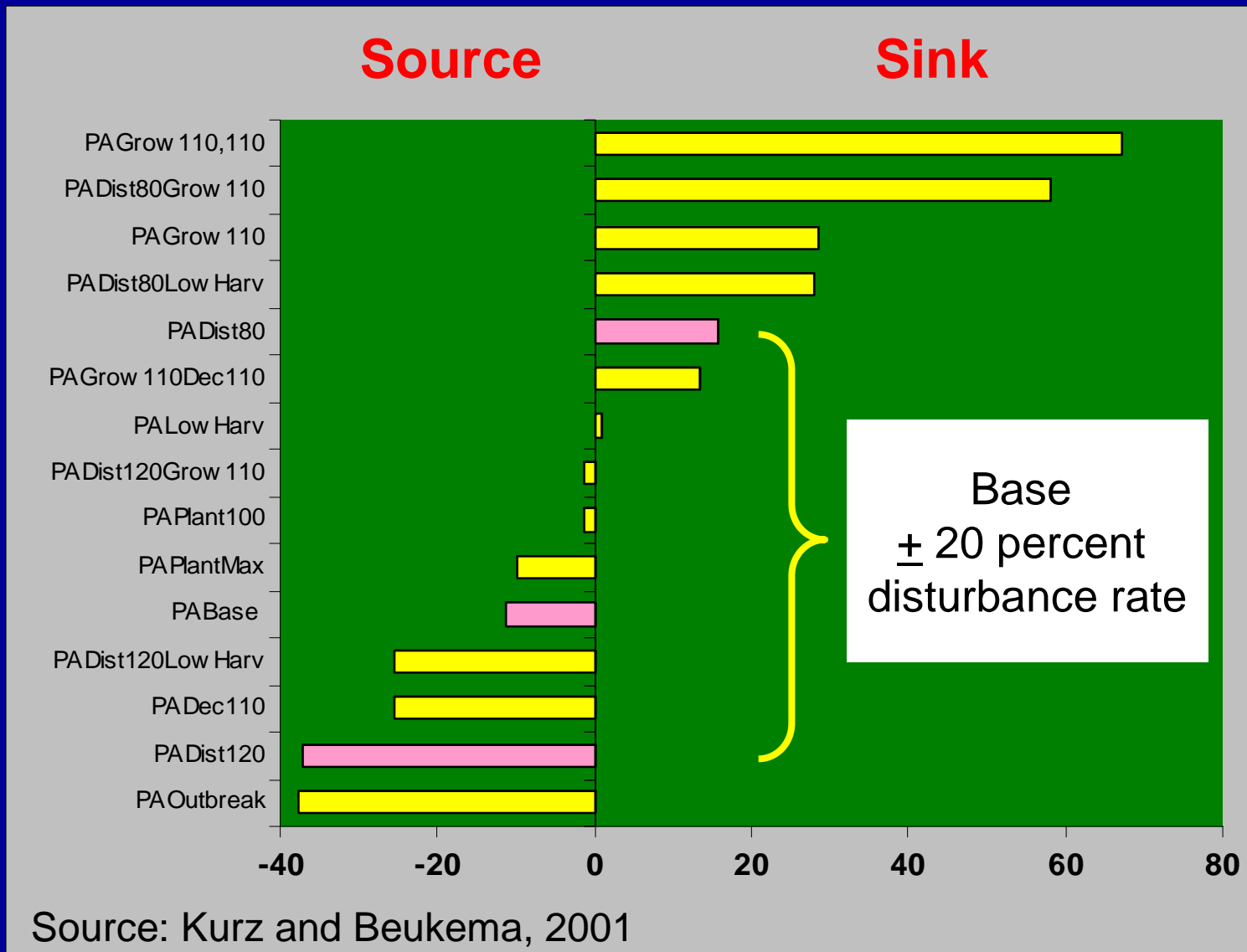
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- Potential to off-set emissions from ARD and from fossil fuels, but also a risk that FM will contribute a net source.
- Studies conducted in 1999 to develop preliminary scenarios (Kurz et al. 2000) and in 2000 to assess 32 scenarios (Kurz and Beukema 2001).

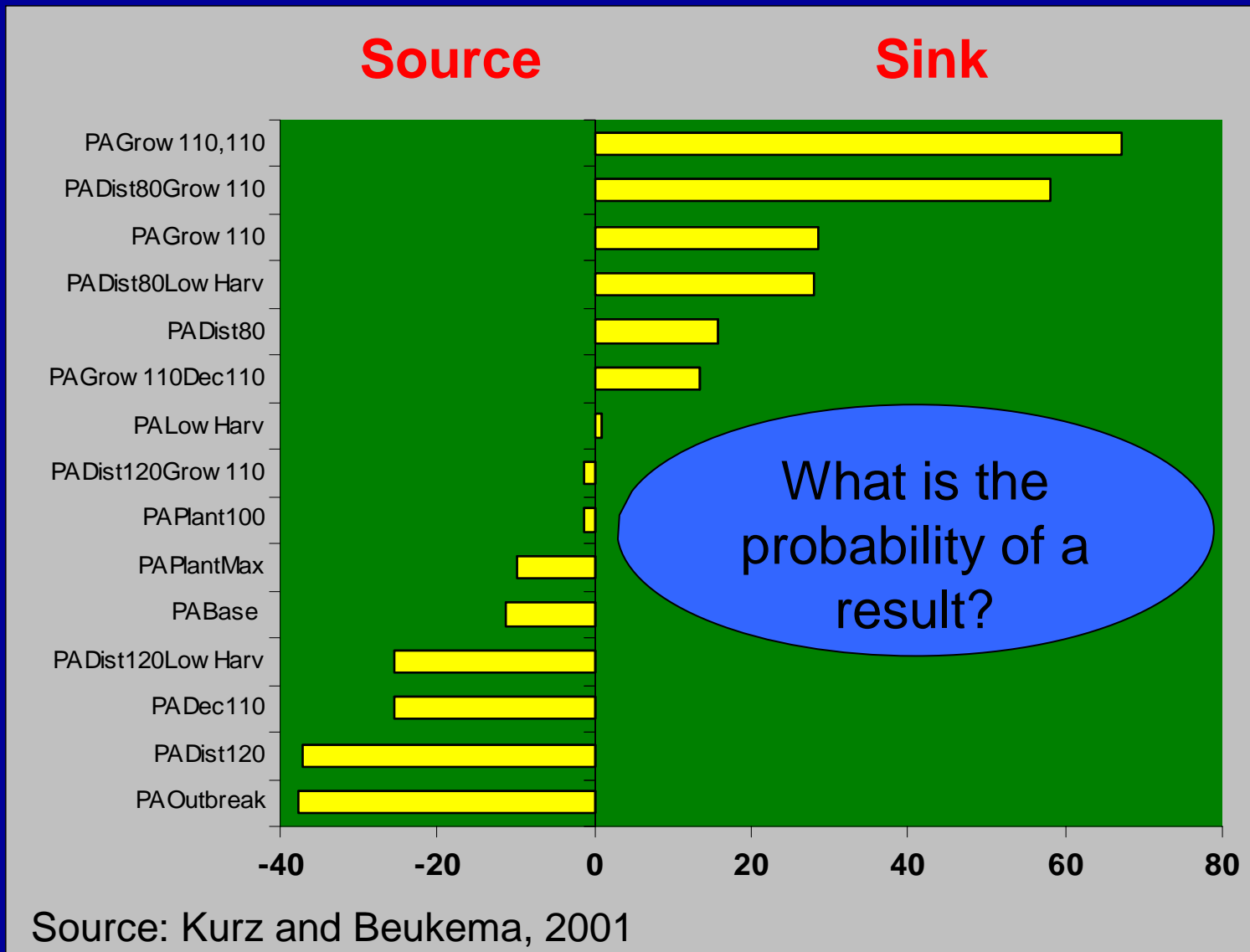
# Annual change in ecosystem carbon stock 2008-12



# Annual change in ecosystem carbon stock 2008-12



# Annual change in ecosystem carbon stock 2008-12



# Key Questions

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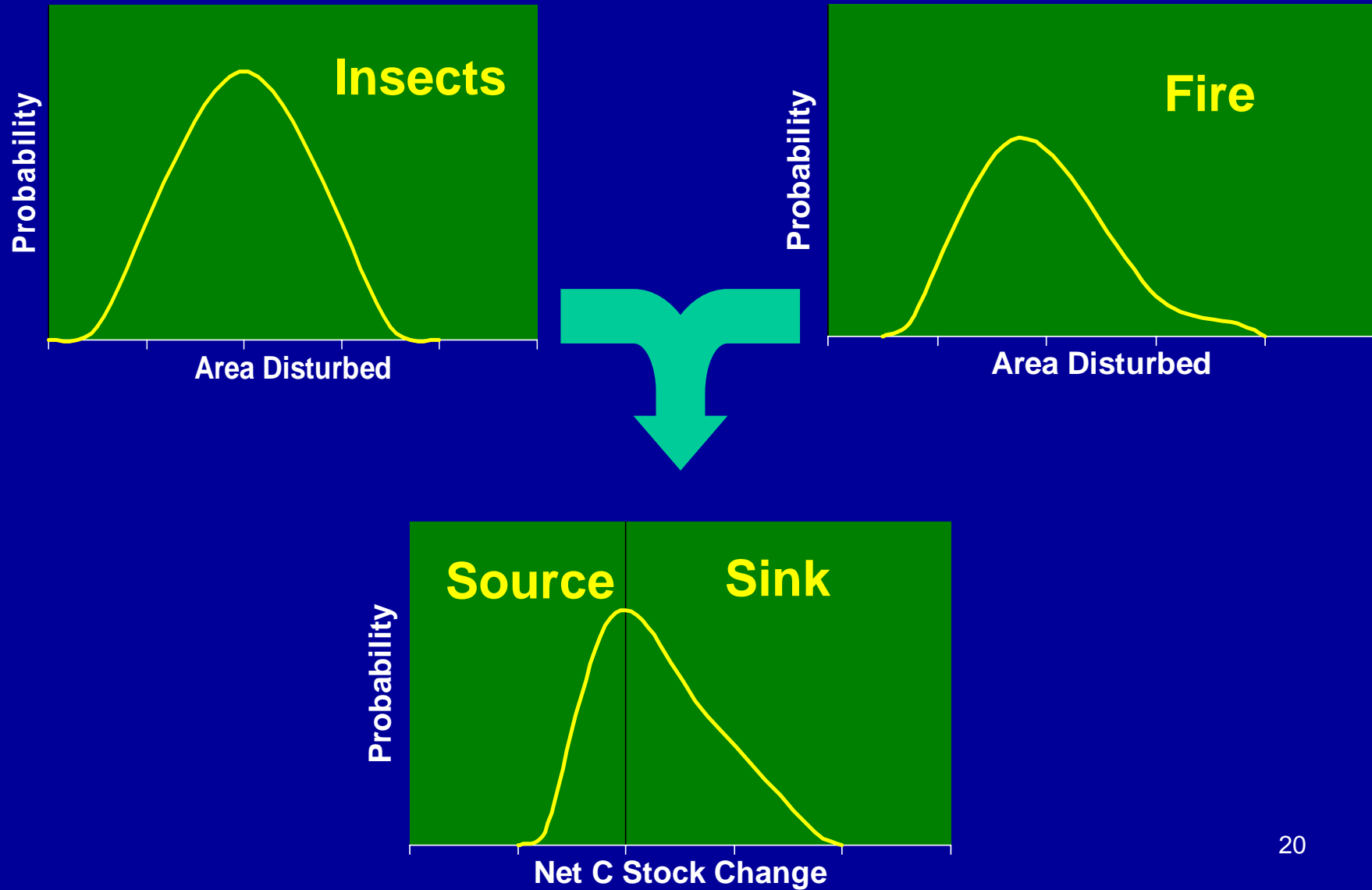
1. What is the probability distribution of the net C balance of the area subject to forest management in the first Kyoto commitment period (2008 – 2012)?
2. Does the choice of area subject to forest management affect the probability distribution?
3. To what extent can forest management activities influence the probability distribution?

# From Base Scenarios to Risk Analysis

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- Scenario analyses provide only a single estimate of C stock changes during the commitment period for each scenario of natural disturbance rates.
- The risk analysis uses probability distribution functions of the annual rates of natural disturbances to determine the probability distribution of the net C balance during the first and subsequent commitment periods.
- We use 100 Monte-Carlo runs of the model to simulate a range of possible futures.

# Calculate C Stock Changes during CP



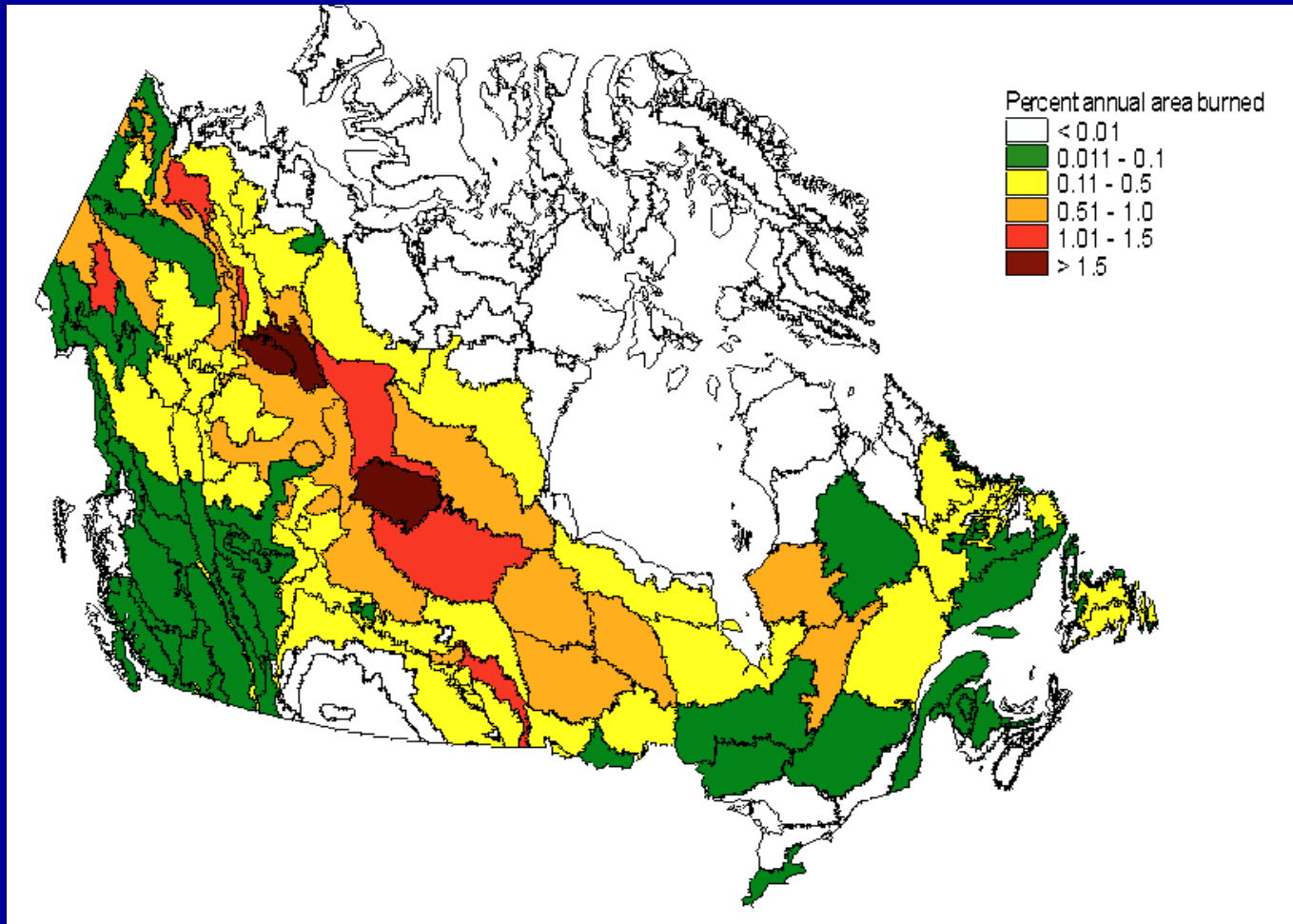
## Non-Cyclical Disturbances (Fire)

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- Assume no serial auto-correlation: area disturbed in year  $t$  does not depend on area disturbed in year  $t-1$
- Probability distribution for area disturbed annually

# CFS Large Fires Database

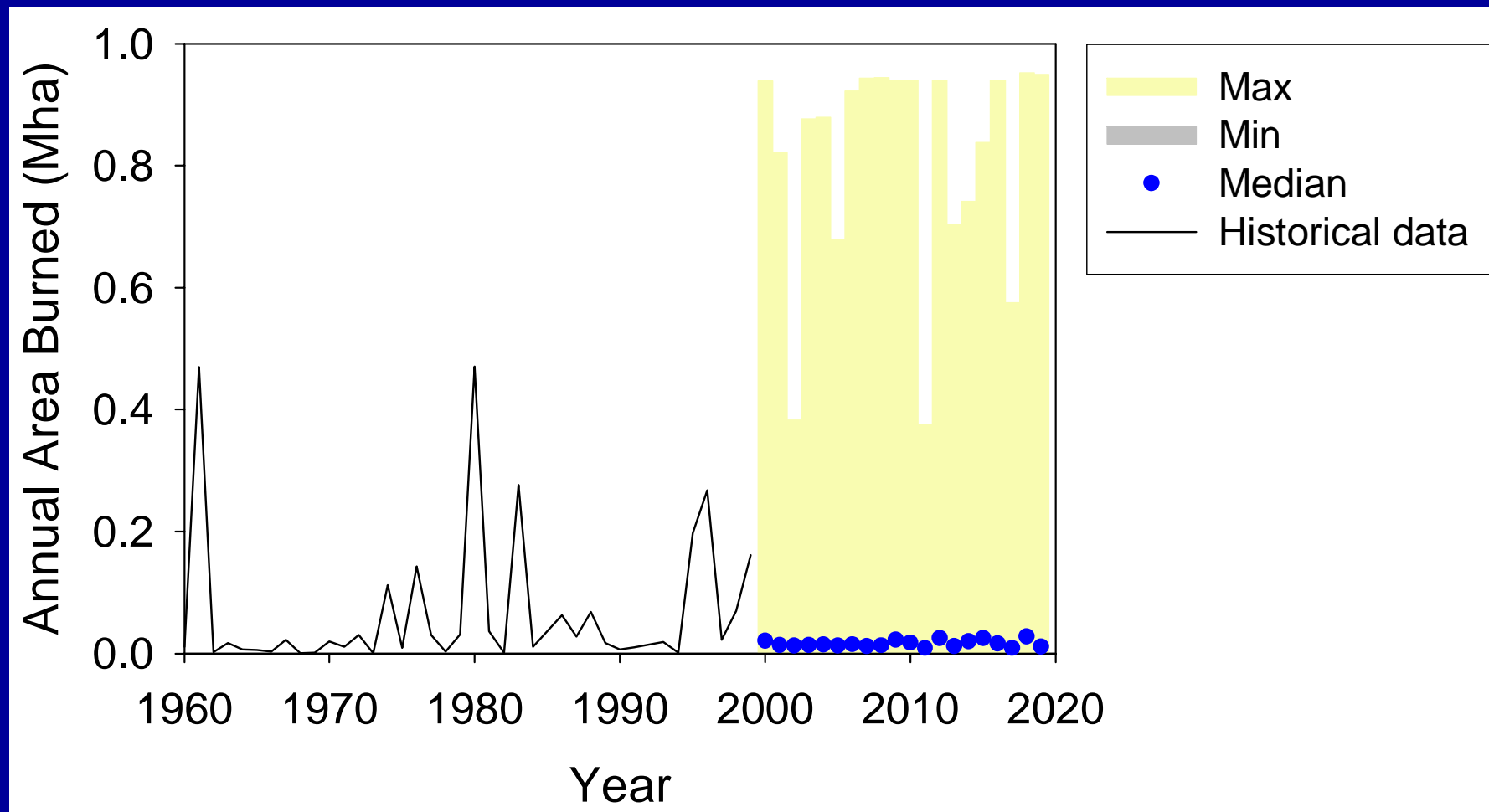
- Area burned in fires (> 200 ha) from 1959 - 1999.



Source: Stocks et al. 2003

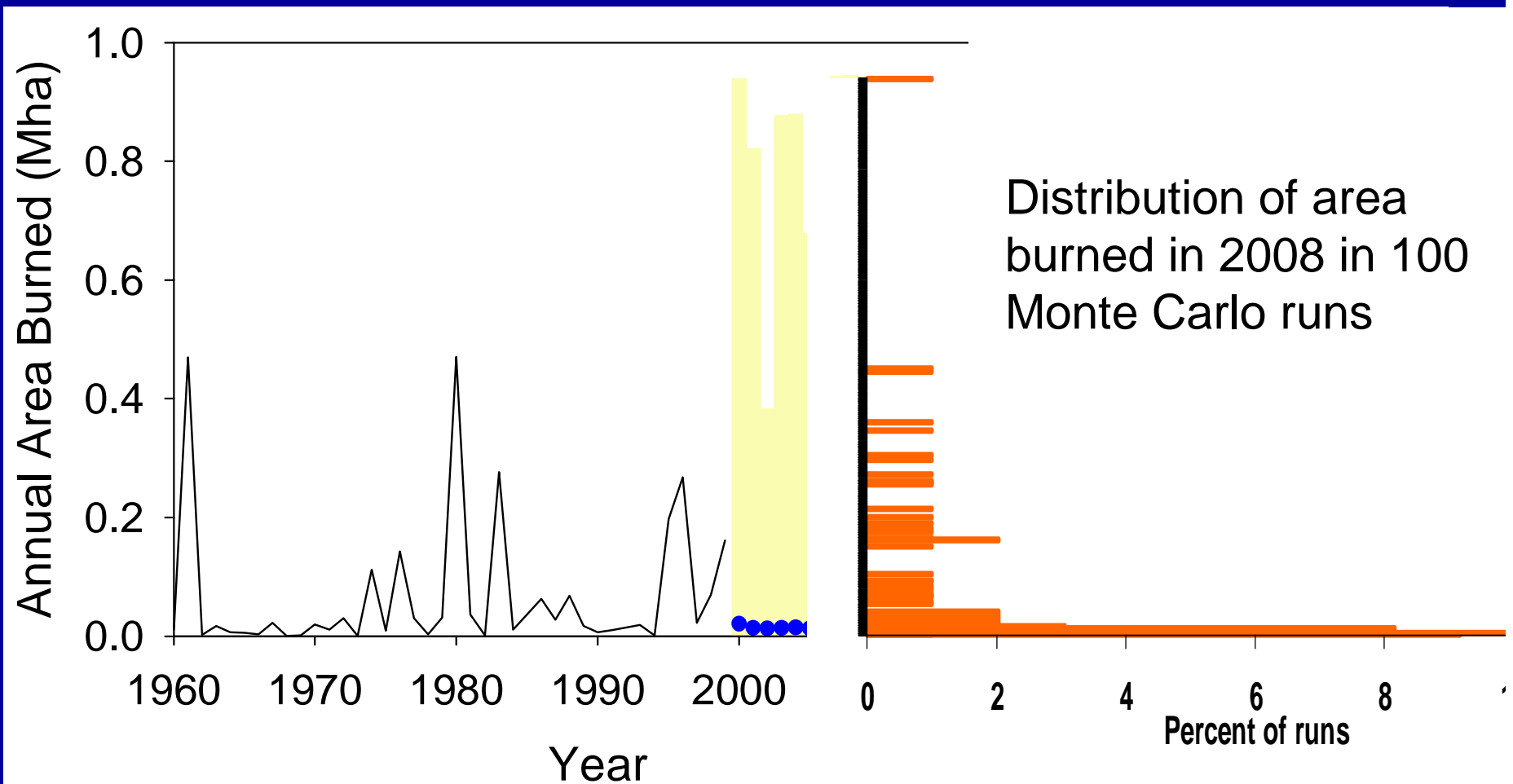
# Modelling fire

- Statistics represent the different Monte Carlo runs



# Modelling fire

- Statistics represent the different Monte Carlo runs



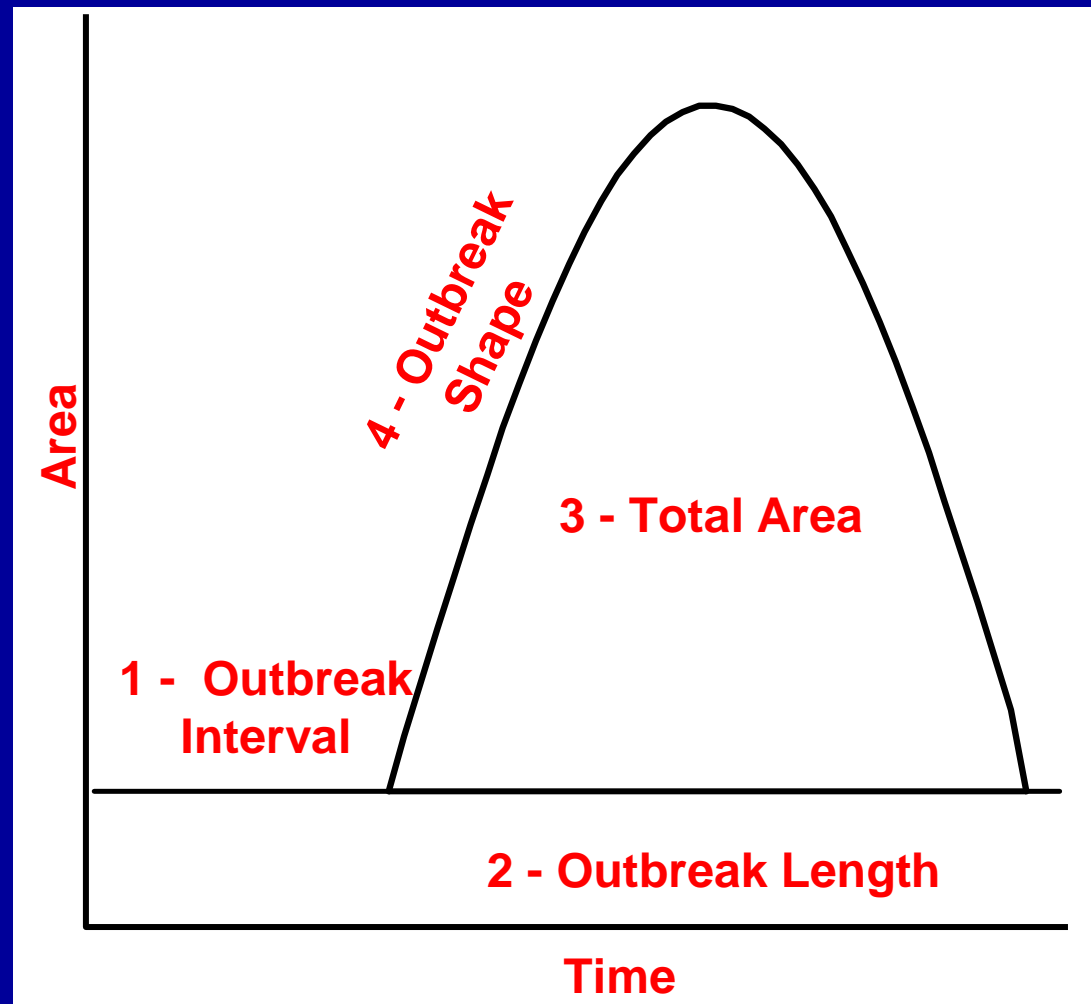
## Projected Cyclical Disturbances (Insects)

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- Assume that there is serial auto-correlation: area disturbed in year  $t$  depends on area disturbed in year  $t - 1$

# Stochastic Parameters used in Insect Outbreak Scenarios

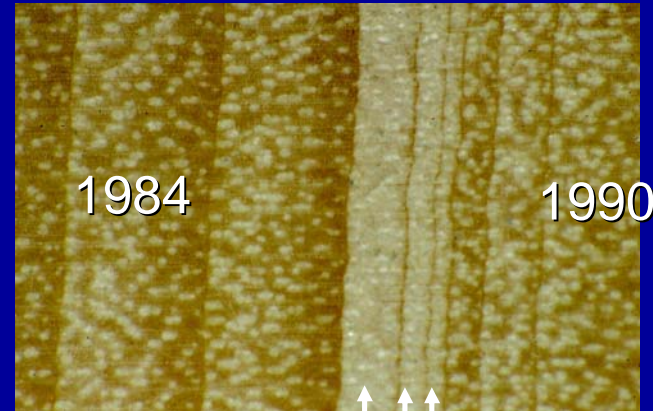
1. Interval between the end of one outbreak and the start of the next;
2. Outbreak Length;
3. Area of outbreak; and
4. Temporal dynamics of the outbreak (shape).



# Simulated Insect Impacts

## DEFOLIATORS

- Growth reduction
- Tree Mortality



Credit: T. Hogg

“White” tree rings formed during  
severe insect defoliation

## BARK BEETLES

- Tree Mortality



# Carbon Budget Model of Canadian Forest Sector

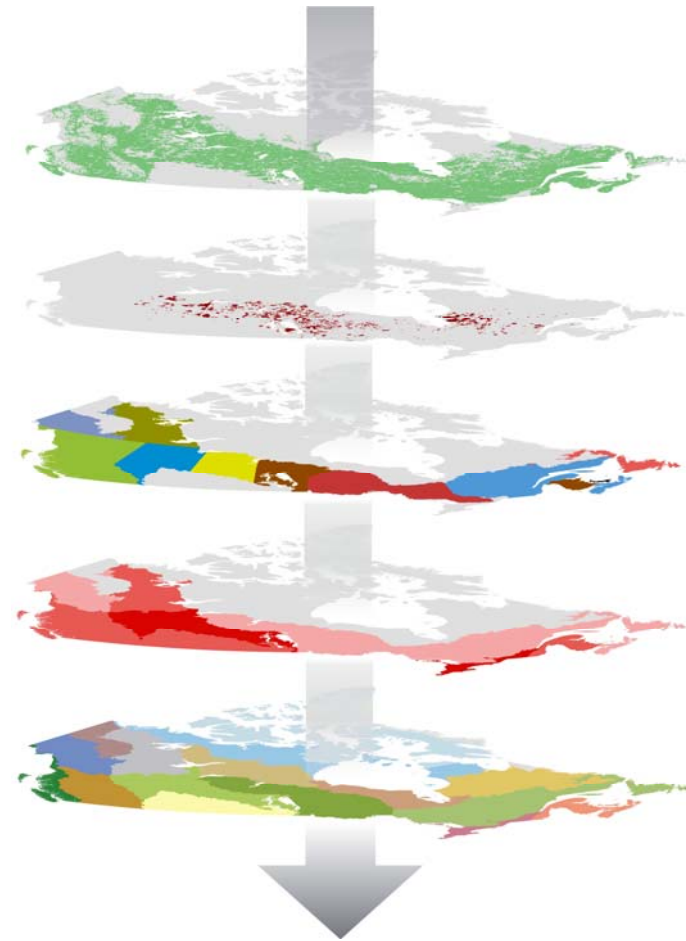
Forest inventory and growth & yield data

Natural disturbance monitoring data

Forest management activity data

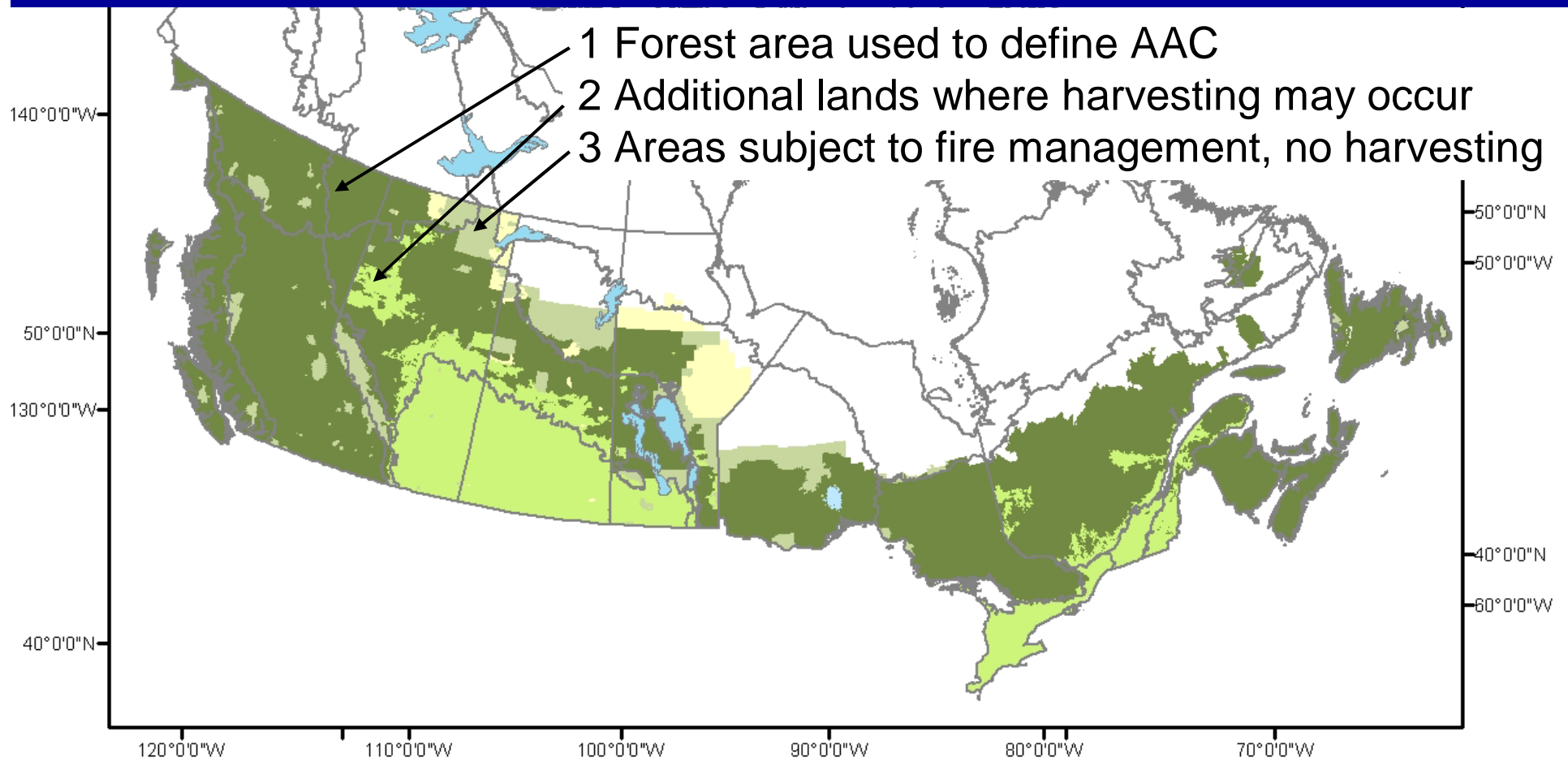
Land-use change data

Ecological modelling parameters



**CBM-CFS**

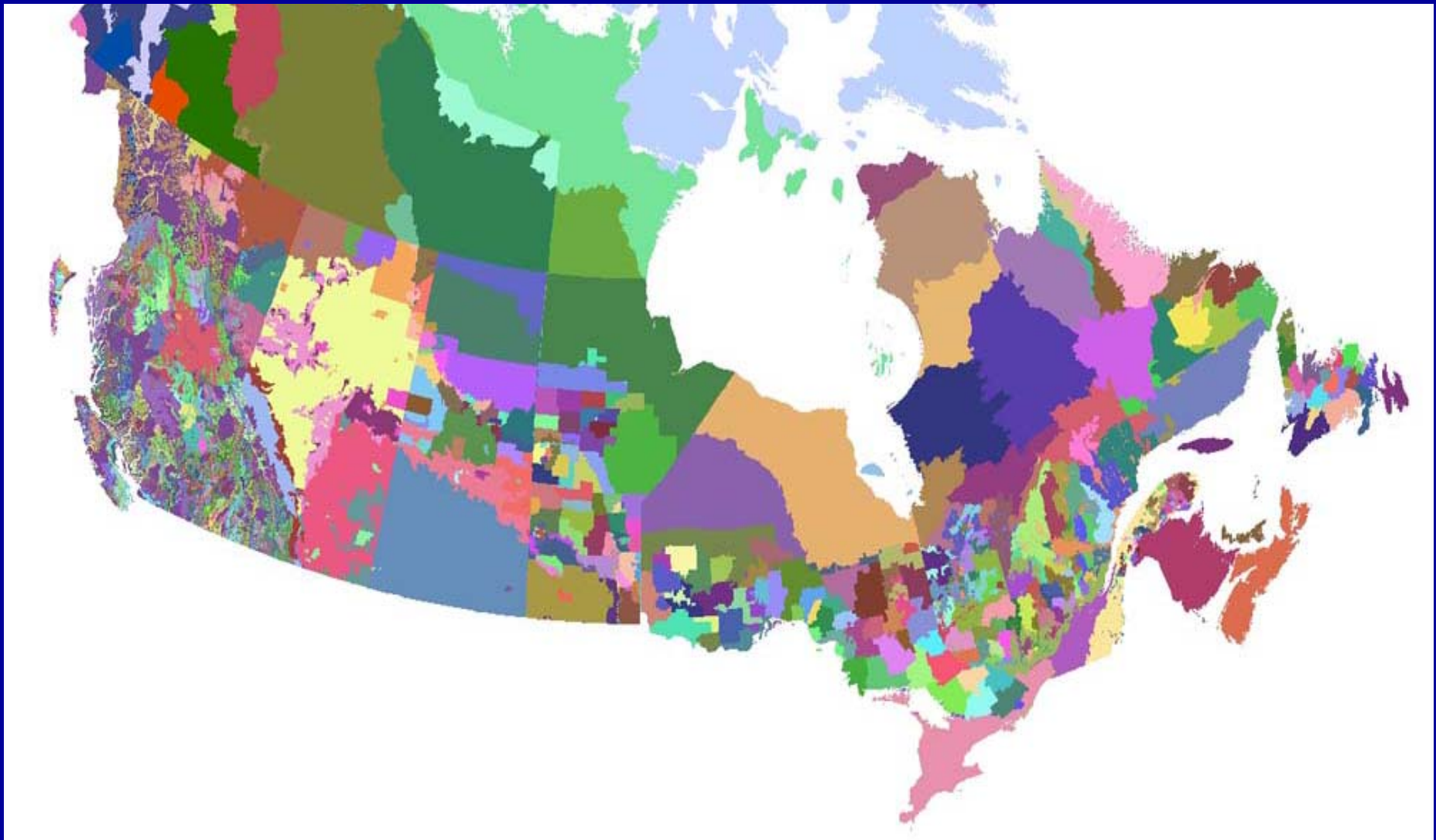
# Forest Management Definition Scenarios



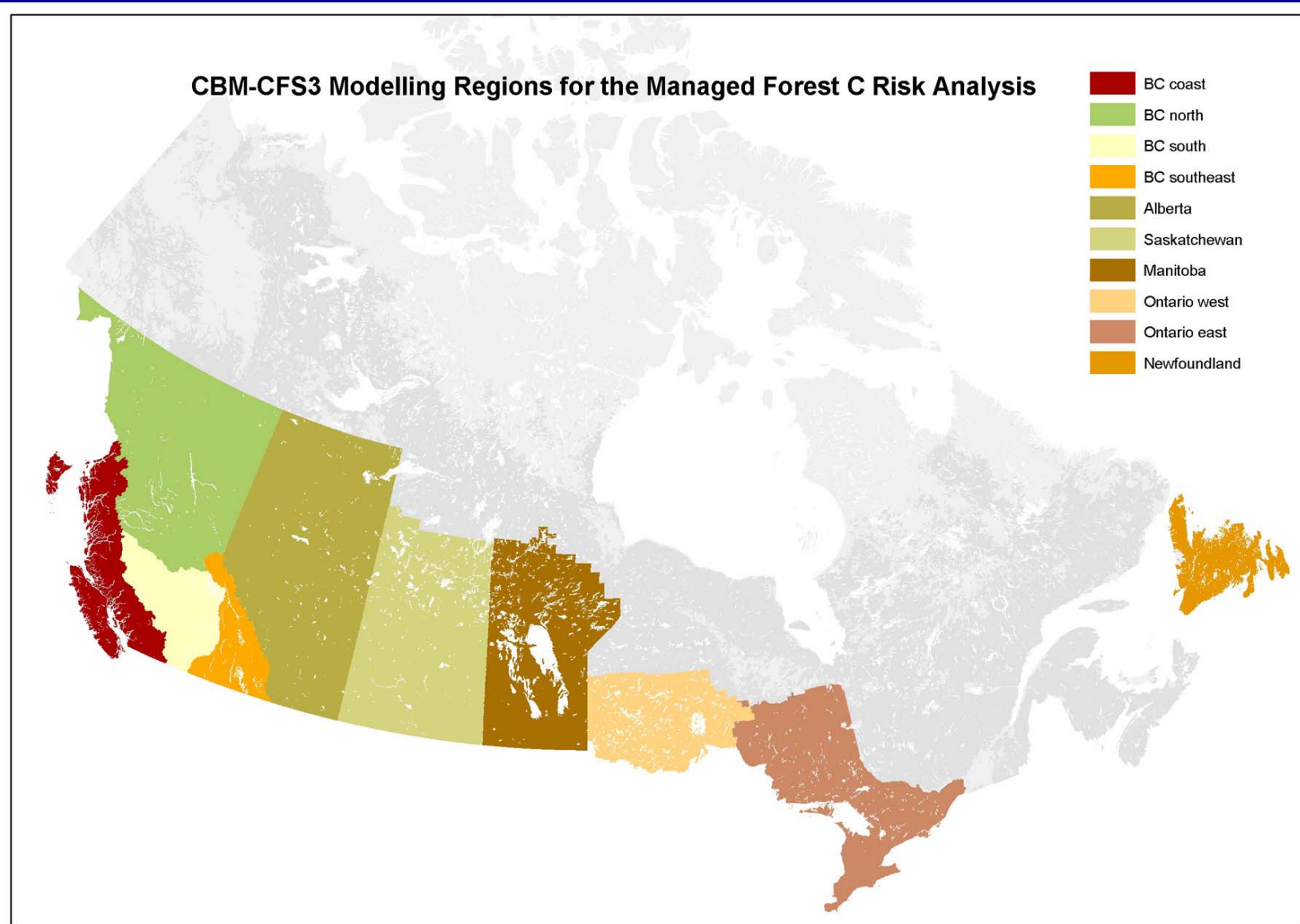
Note that FM scenario boundaries for Territories are yet to be defined...

# Analyses of Forest C Stock Changes for over 2000 Spatial Entities

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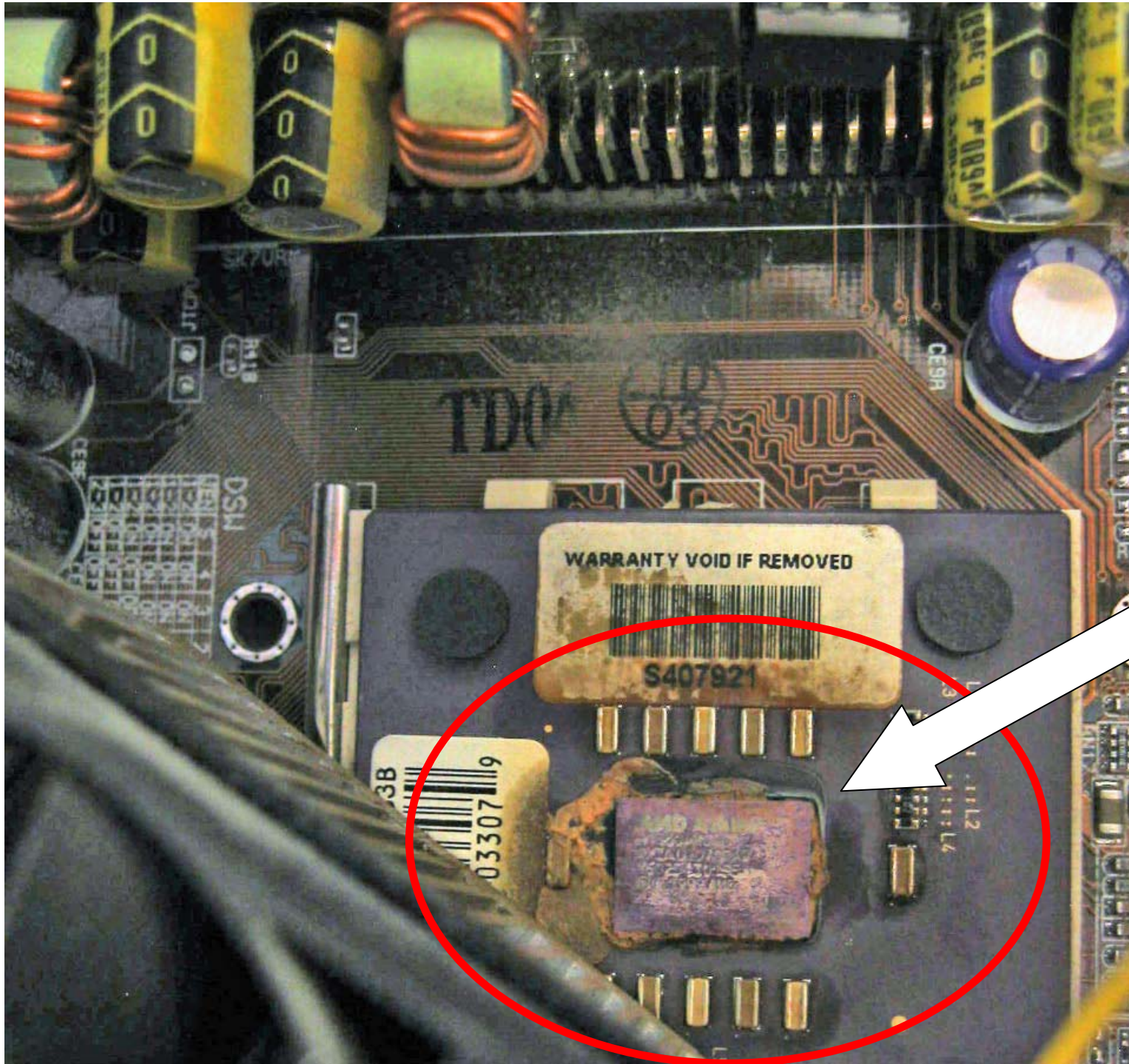
# Spatial Units combined into Modelling Regions



## Progress to Date

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Provinces	Regions	Spatial Units	Forest Area (Mha)	Records (x1000)
6	10	1,215	165.1	2,199



CPU after  
meltdown

## National Summary: Resampling

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- Each MC run for each region is independent of others
- The results of Run1 in one region can be combined with any other run from any other region.

Region	Run 1	Run 2
A	2	4
B	3	6
Total	5	10

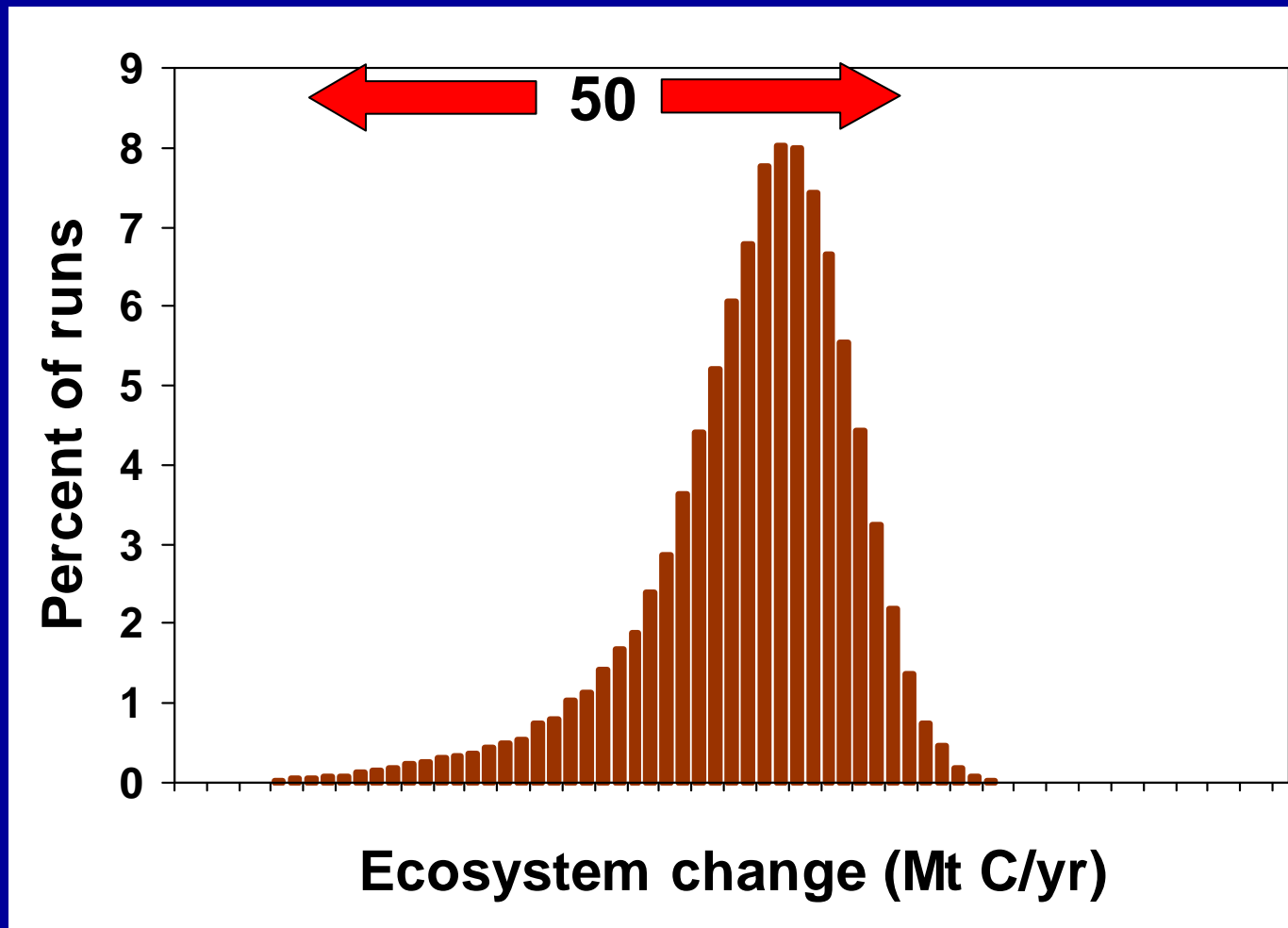
## National Summary: Resampling

- Each MC run for each region is independent of others
- The results of Run1 in one region can be combined with any other run from any other region.

Region	Run 1	Run 2	Sample 1	Sample 2
A	2	4	2	4
B	3	6	6	3
Total	5	10	8	7

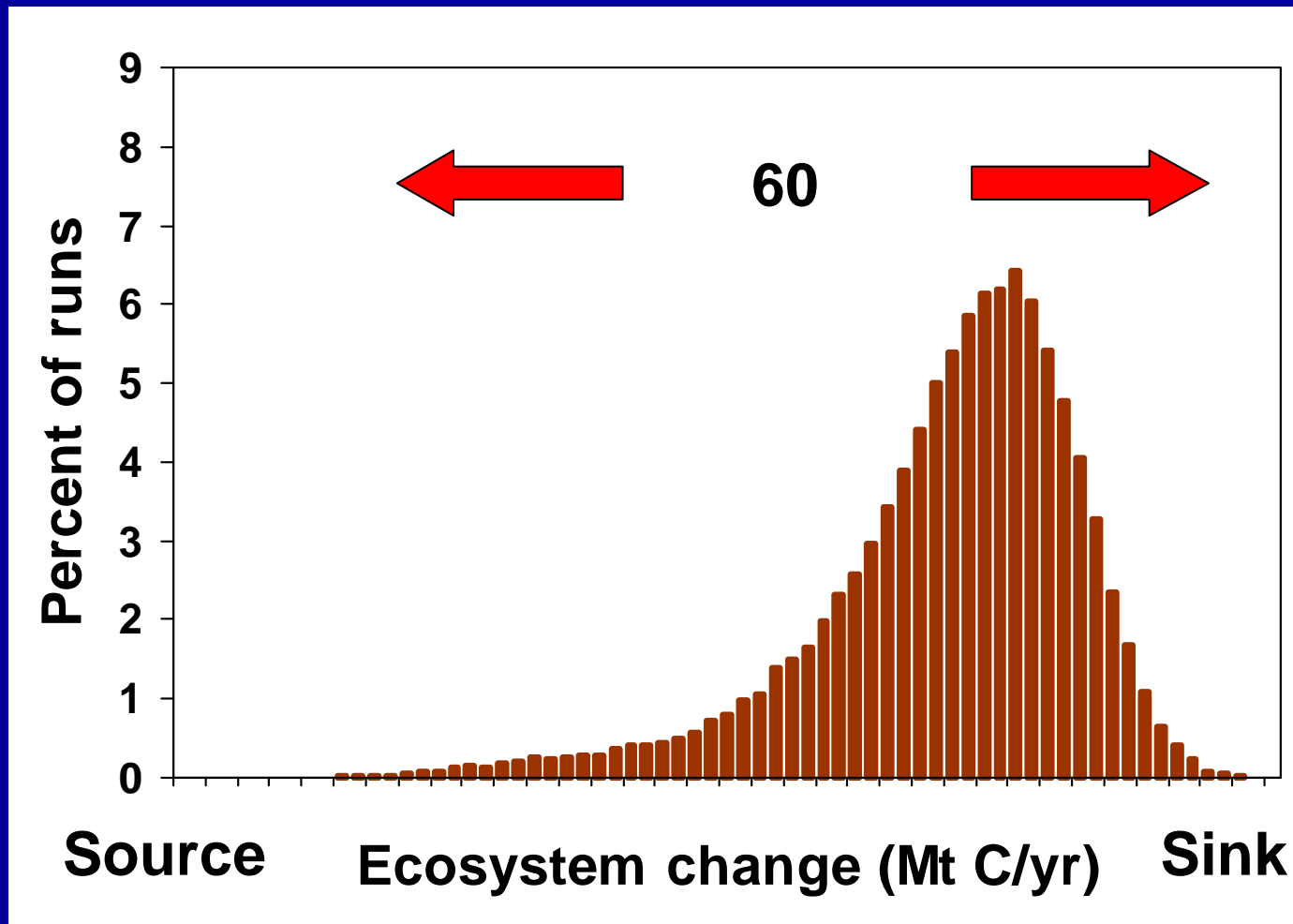
# C Stock Change in First Commitment Period

- Sum of 6 Provinces: Smaller Area Subject to FM



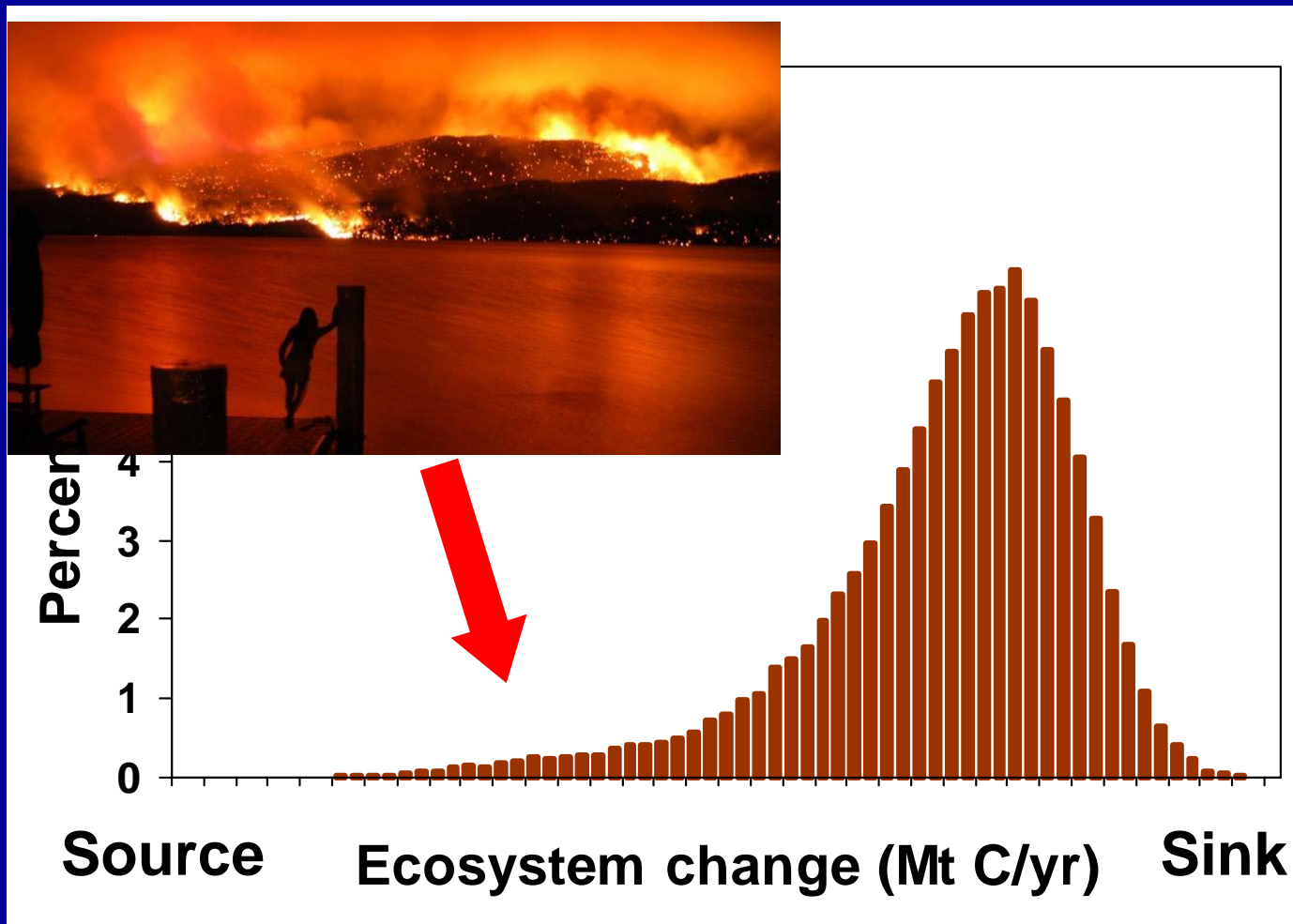
# C Stock Change in First Commitment Period

- Sum of 5 Provinces: Larger Area subject to FM



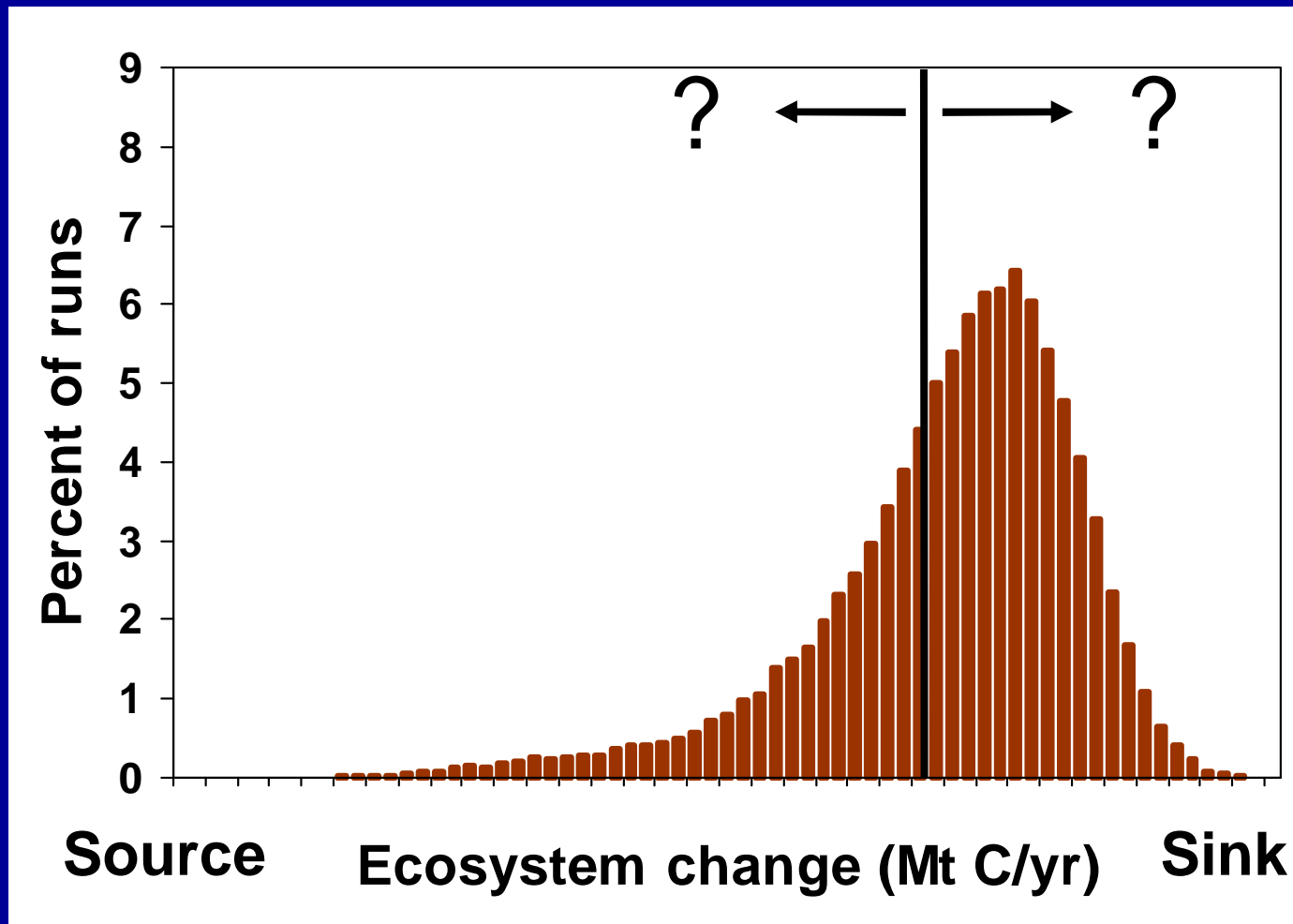
# C Stock Change in First Commitment Period

The distribution is asymmetrical: longer tail at source side!



# C Stock Change in First Commitment Period

- The location of the zero line is still unknown



## Conclusions from Risk Assessment

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- Remaining provinces and territories will be analysed prior to the decision.
- The probability distribution of the net C balance is asymmetrical with a risk of some large source years.
- Including forest lands with fire suppression and no harvest increases the probability of a sink.
- Legacy of age-class structure has big impact on future C balance in Canada.
- Article 3.4 carries considerable risk – in particular in forested landscapes that are dominated by natural disturbances: what will be an acceptable risk?



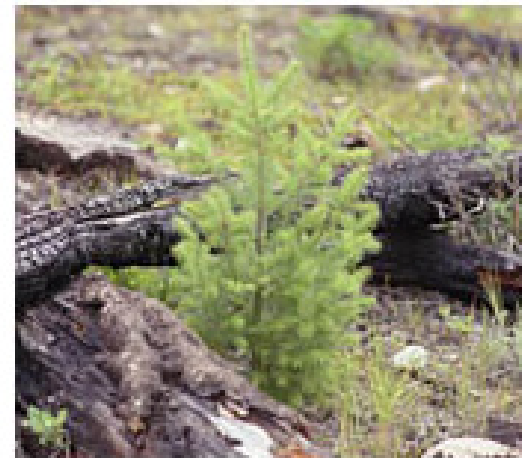
Natural Resources  
Canada

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Canada



# Forest Carbon Accounting Comptabilisation du Carbone Forestier

Canadian Forest Service  
Service canadien des forêts



<http://carbon.cfs.nrcan.gc.ca>

Canada