Putting Bugs into CLM

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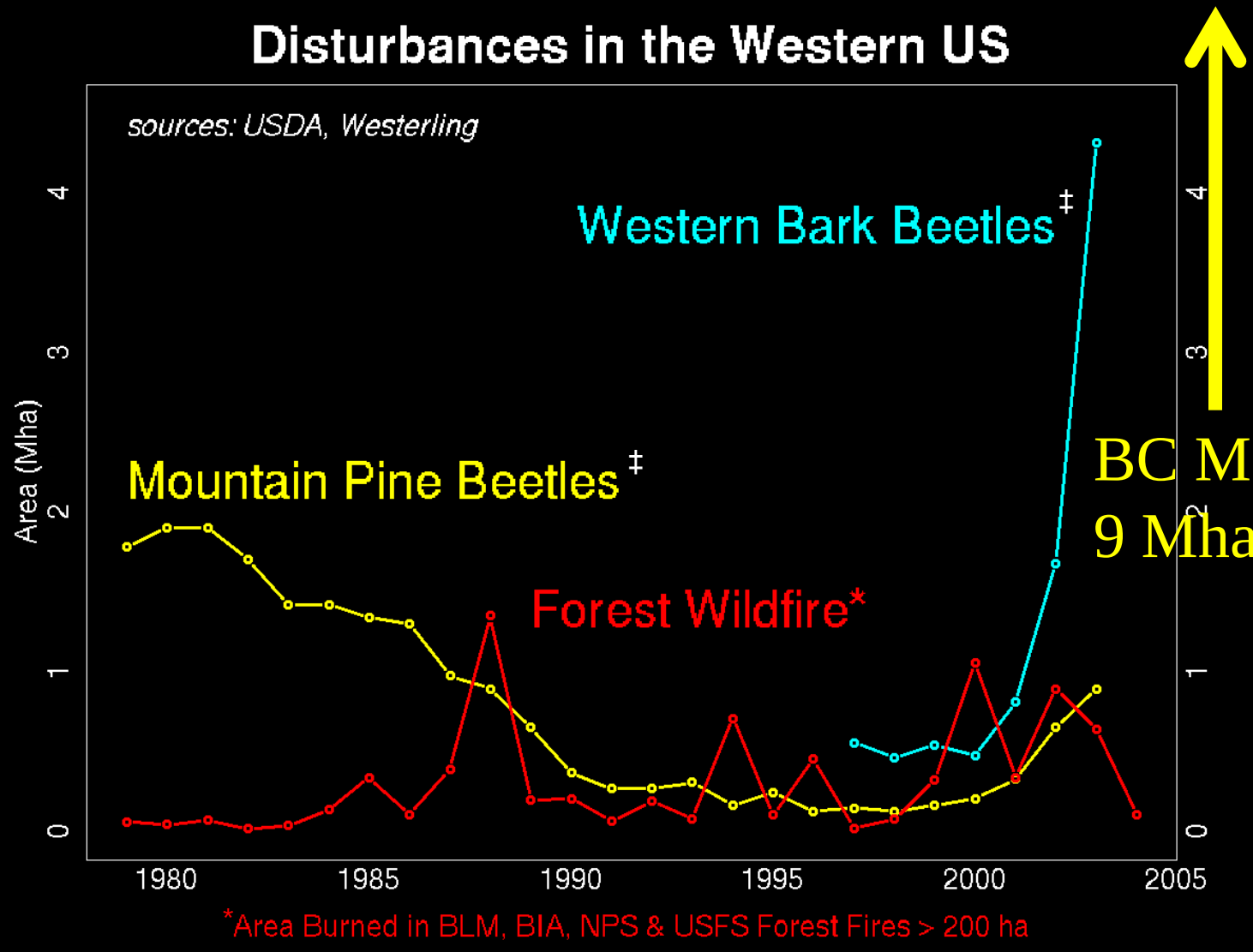
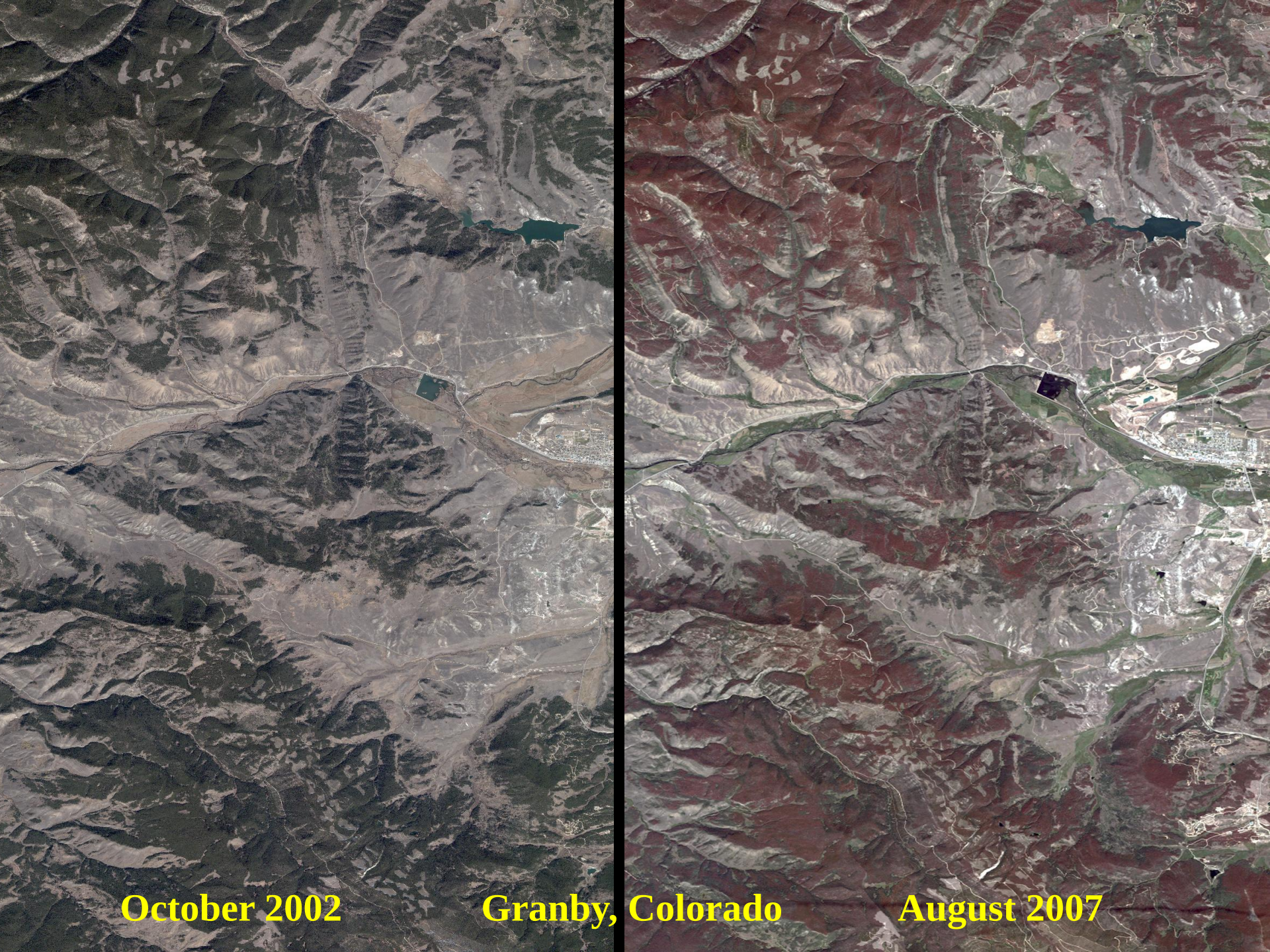
Sept 2005, Railroad Ridge, ID

June 2005, Gore Range, CO

May 2007, Towgotee Pass, WY

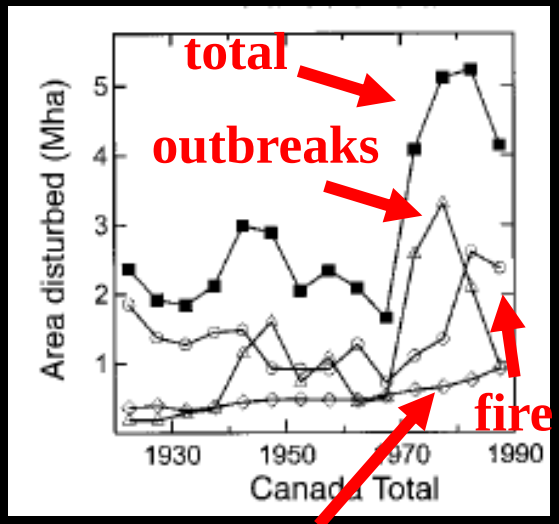
Infestations are widespread throughout US

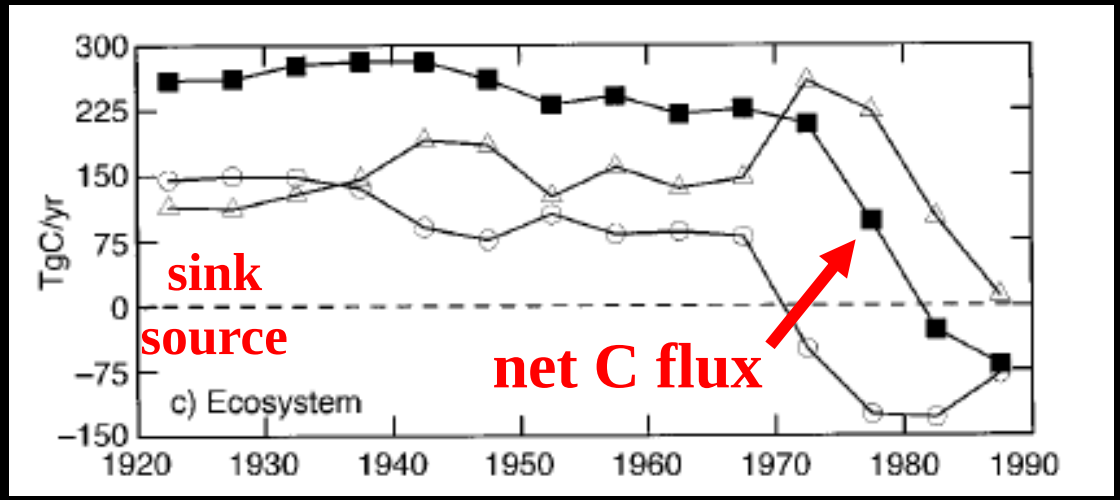



October 2002
Granby, Colorado
August 2007

Large-scale effects on carbon cycling

- Hicke et al. (2002): Locations of increase in satellite-derived net primary productivity correlated with insect outbreaks
- Kurz et al. (2008): Outbreak in British Columbia will cause persistent, strong carbon source
- Kurz and Apps (1999): Increased disturbance regimes (including infestations) in Canadian forests caused switch from sink to source





Kurz and Apps, Ecological Applications, 1999

Factors governing mountain pine beetle epidemics

Factors Related to Host Trees:

- presence of host species
- stem density
- stand age
- landscape connectivity of susceptible hosts
- drought stress on trees

Factors Related to Beetles:

- nearby beetle source
- temperature effects on
  - winter beetle mortality
  - population synchronization/ univoltinism ("adaptive seasonality")

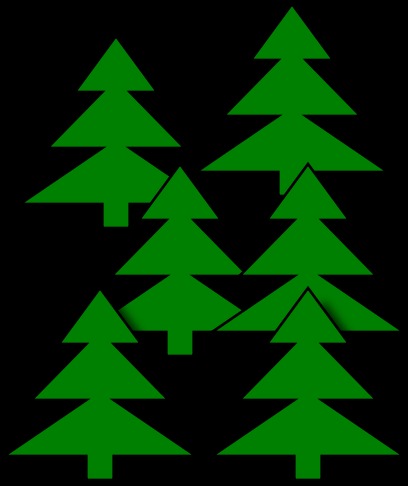
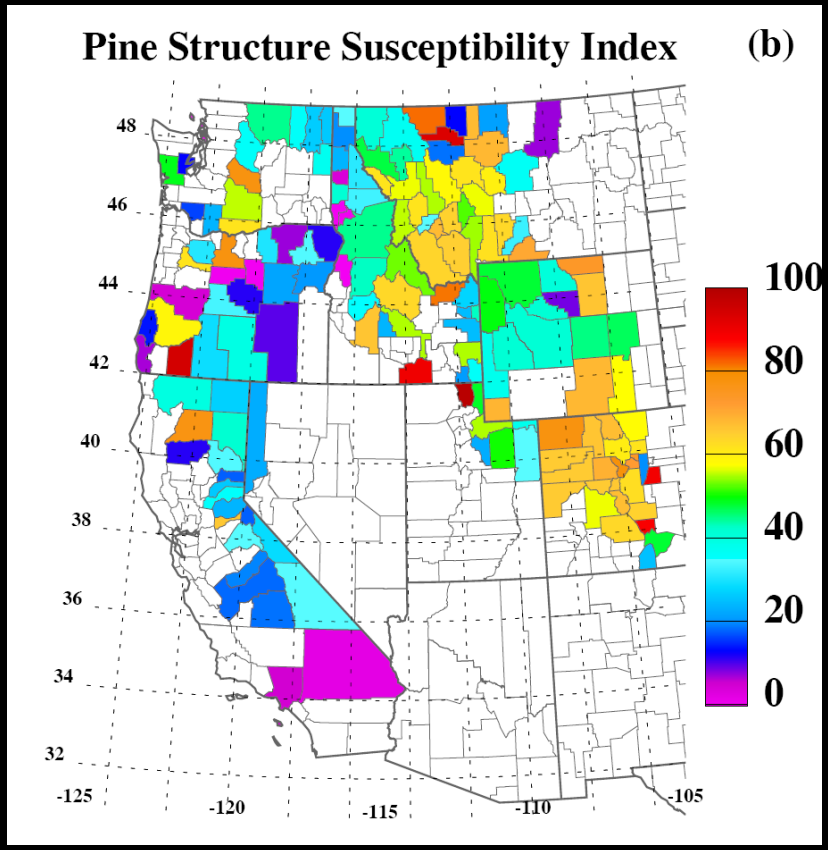


Photo courtesy USDA Forest Service, www.forestryimages.org

Safranyik et al. 1975; Shore and Safranyik 1992; Carroll et al. 2004; Logan and Powell 2001

Mountain pine beetle epidemics

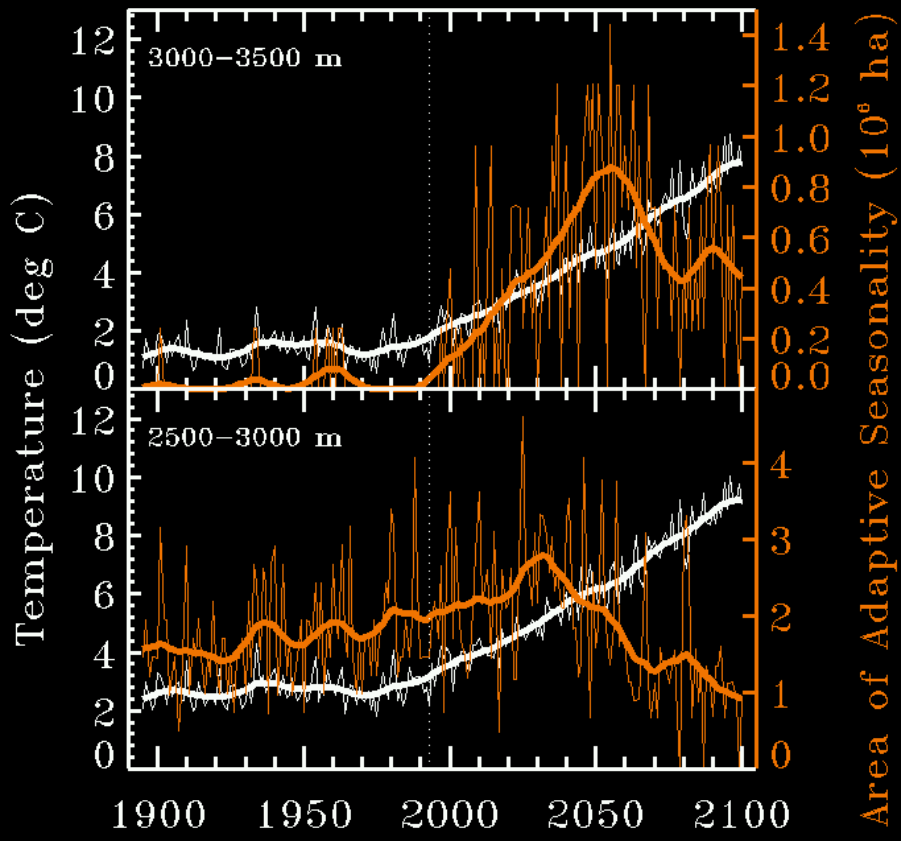
- Susceptibility based on stand structure
  - f(host presence, stand age, stem density, %large LPP) (Shore and Safranyik, 1992)



Hicke and Jenkins, FEM, 2008

Mountain pine beetle epidemics

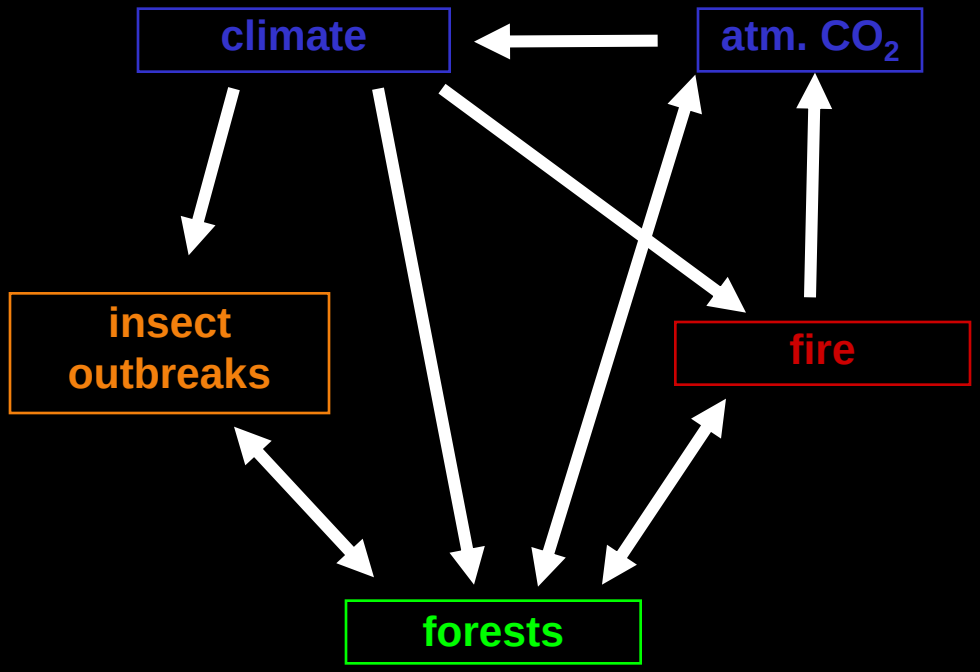
- Susceptibility based on stand structure
  - f(host presence, stand age, stem density, %large LPP) (Shore and Safranyik, 1992)
- Temperature suitability
  - mechanistic model of adaptive seasonality (Logan and Powell 2001)



Hicke et al., JGR, 2006

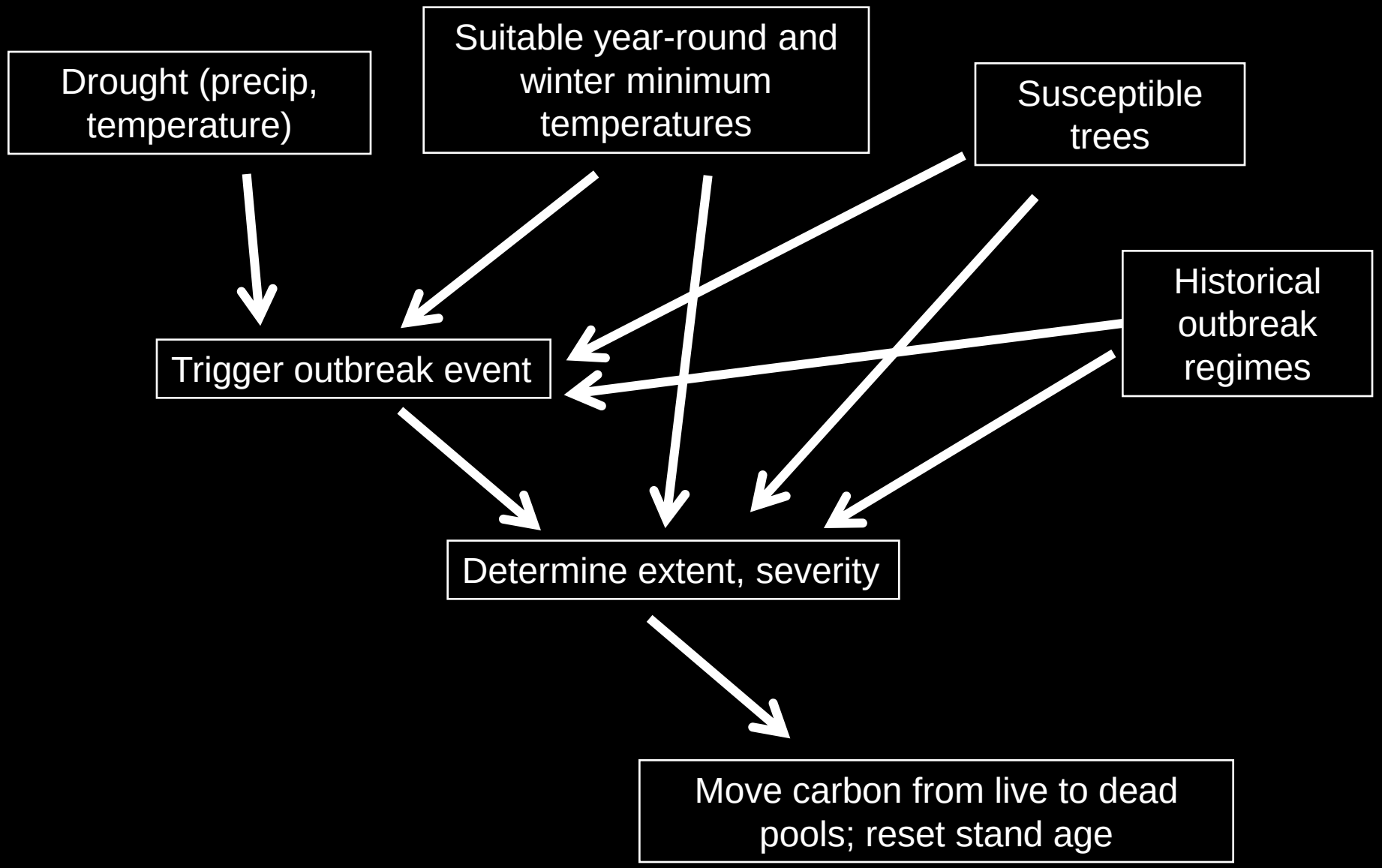
Overall goals of research

1. Incorporate a missing ecological process (insect outbreaks) into the NCAR climate (earth system?) model
2. Quantify impacts of past and future insect infestations on carbon cycle and future climate change
3. Investigate interactions among climate, forest ecosystems, and disturbances



Outline of near-term research

Methods of integration



Outline of near-term research

Model runs

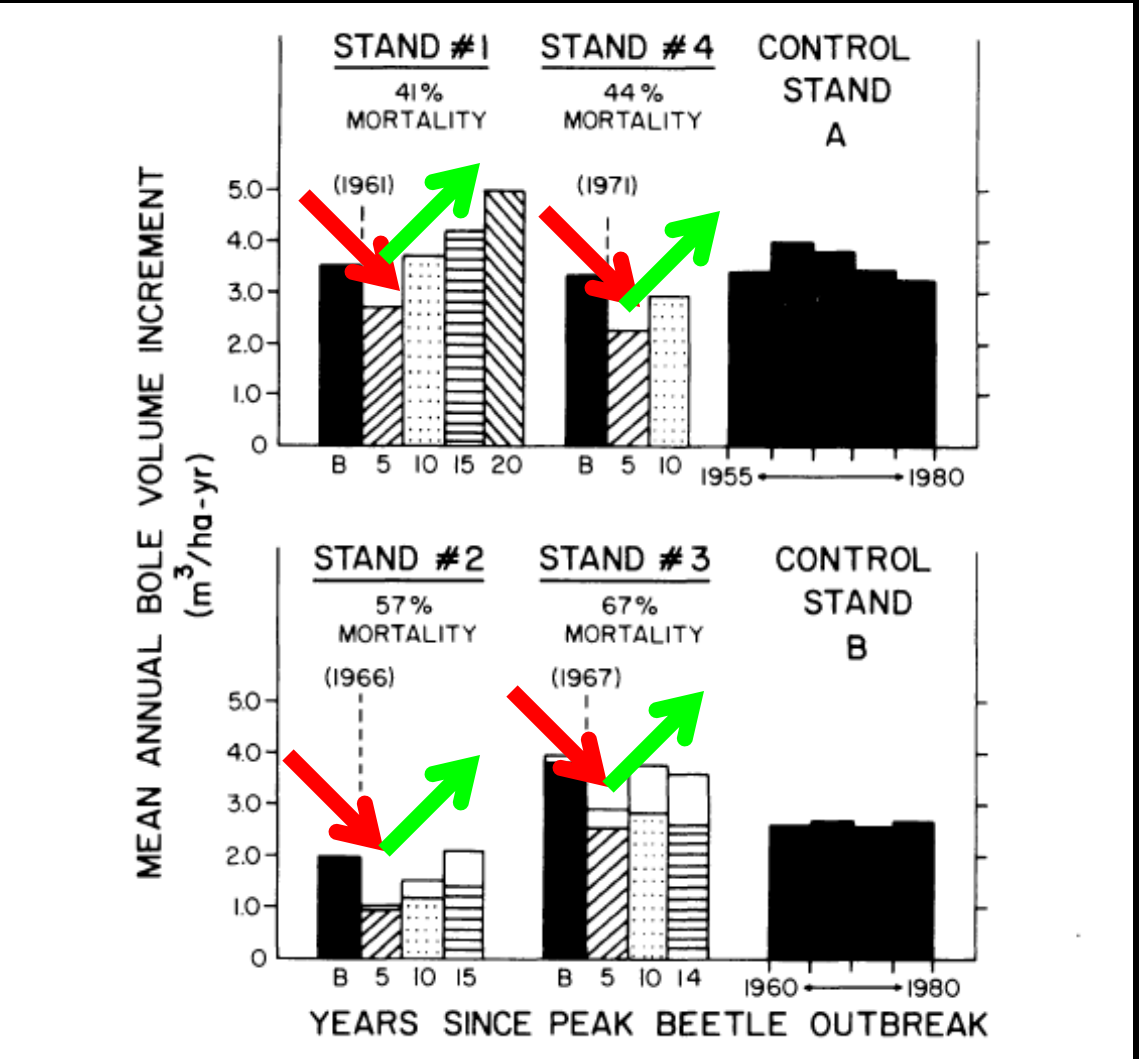
Run updated CLM-CN at high spatial resolution (1-10 km), offline to investigate carbon cycle effects

a) historical time periods (driven by observed outbreaks)

b) future time periods (prognostic mode)

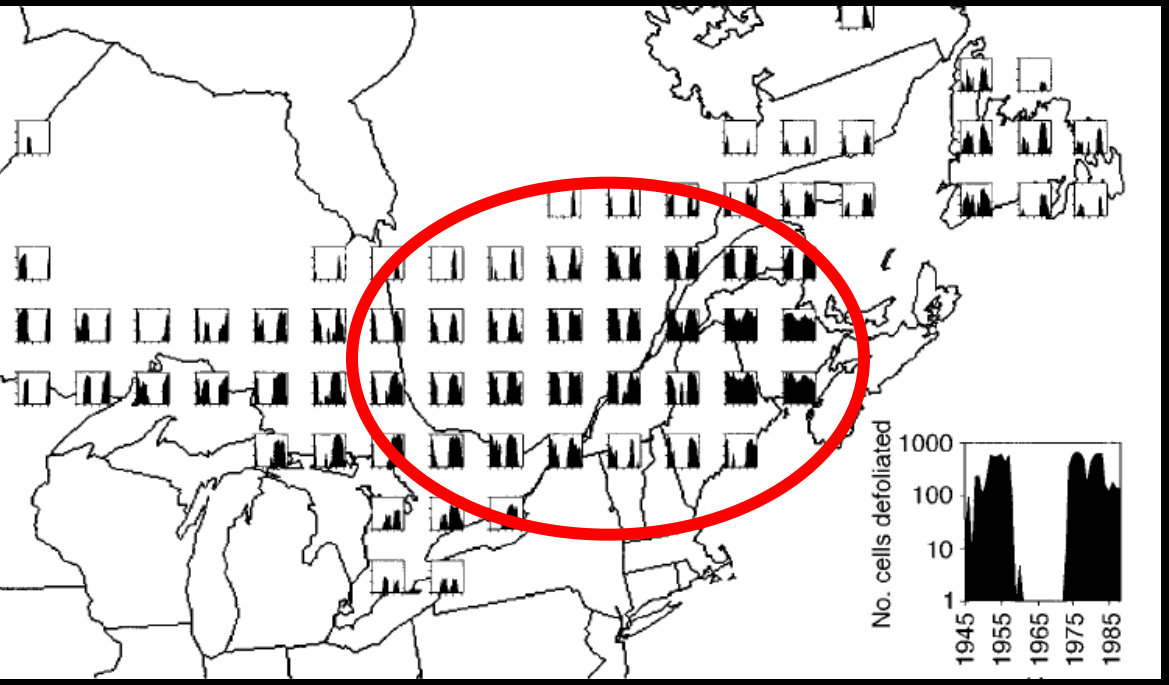
Stand-level NPP Response Following an Outbreak (Romme et al., 1986)

1. An initial decline
2. Recovery with 10-15 years



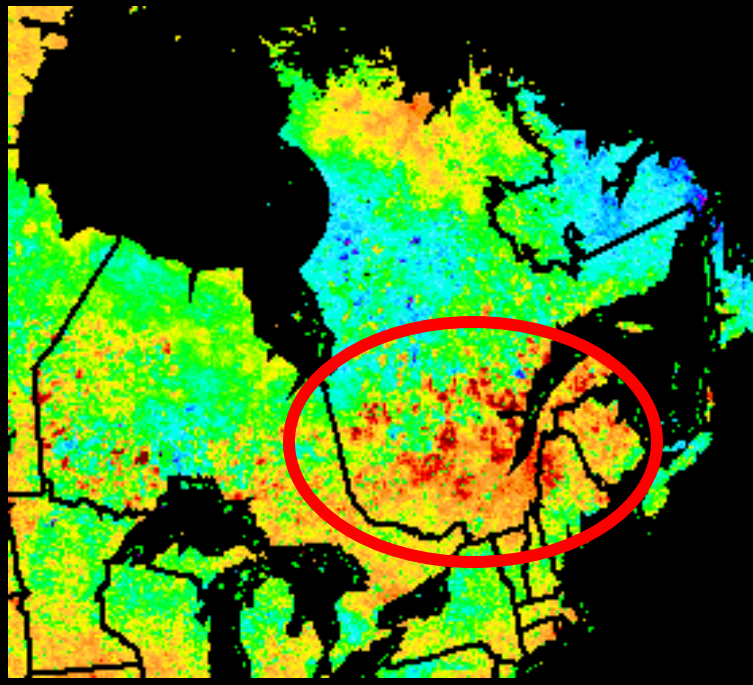
Regional-level NPP Response Following an Outbreak

Time series of eastern spruce budworm defoliation, 1945-1988



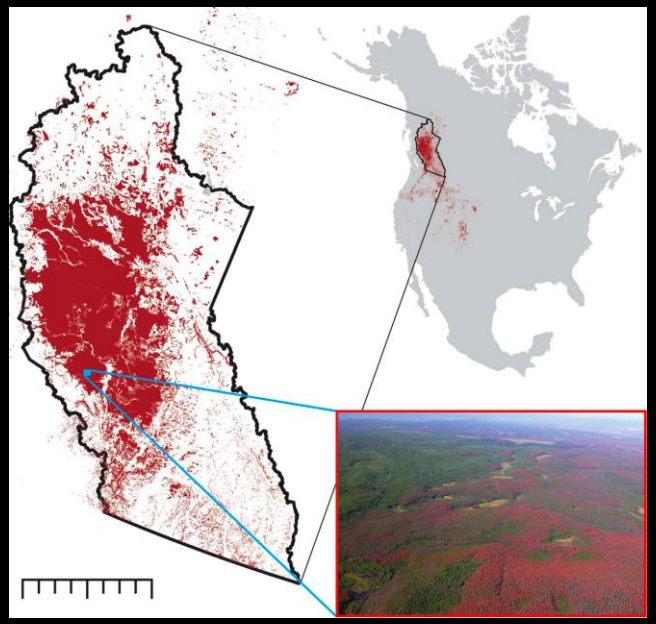
Williams and Liebhold, Ecology, 2000

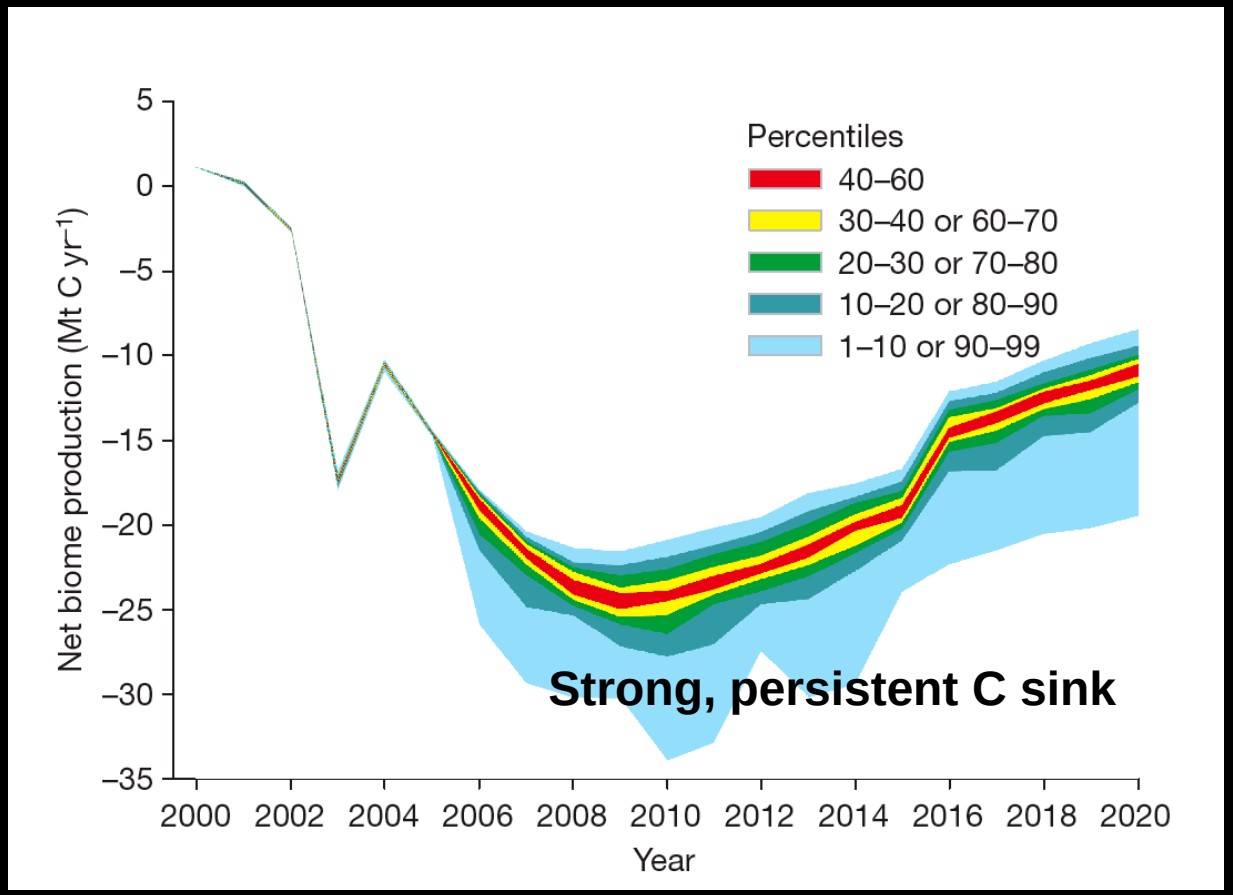
Trend in NPP, 1982-1998



Hicke et al., GBC, 2002

Regional-level NBP Response Following an Outbreak

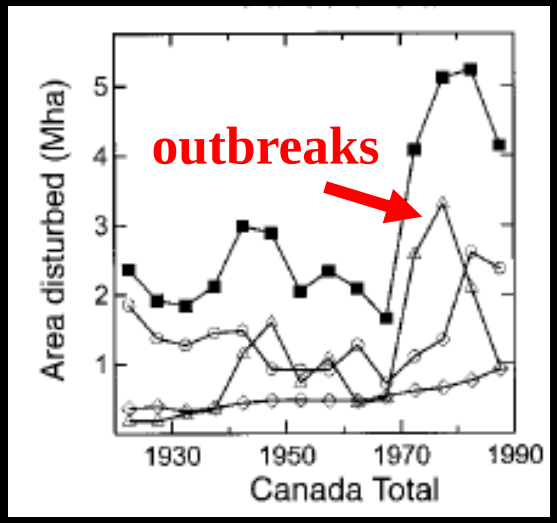


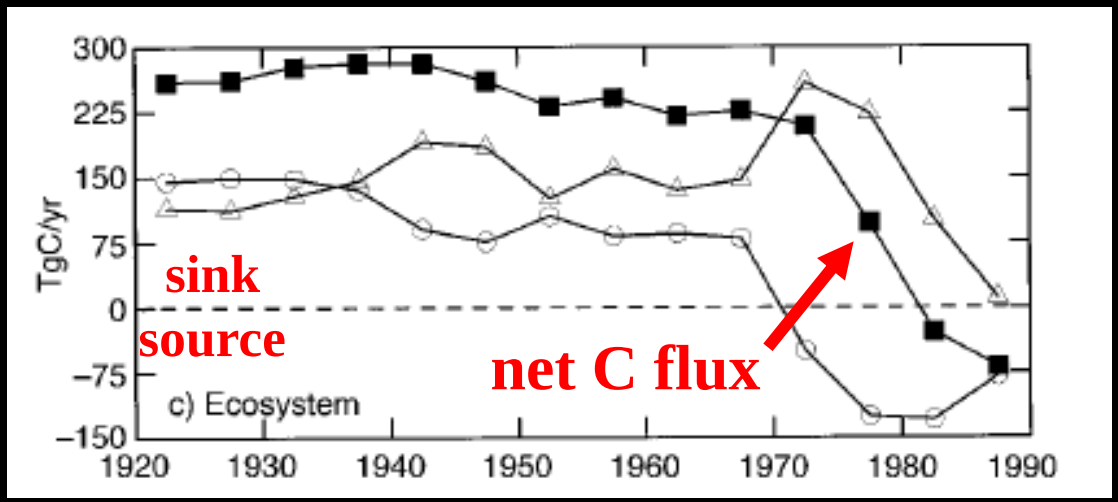


Kurz et al., Nature, 2008

Continental-scale effects of outbreaks on net carbon fluxes

- Kurz and Apps (1999) incorporated outbreaks into a carbon budget model for Canada
- they found that as a result of recent changes in disturbance (insects and fire), Canadian forests switch from a sink to a source





Kurz and Apps, Ecological Applications, 1999