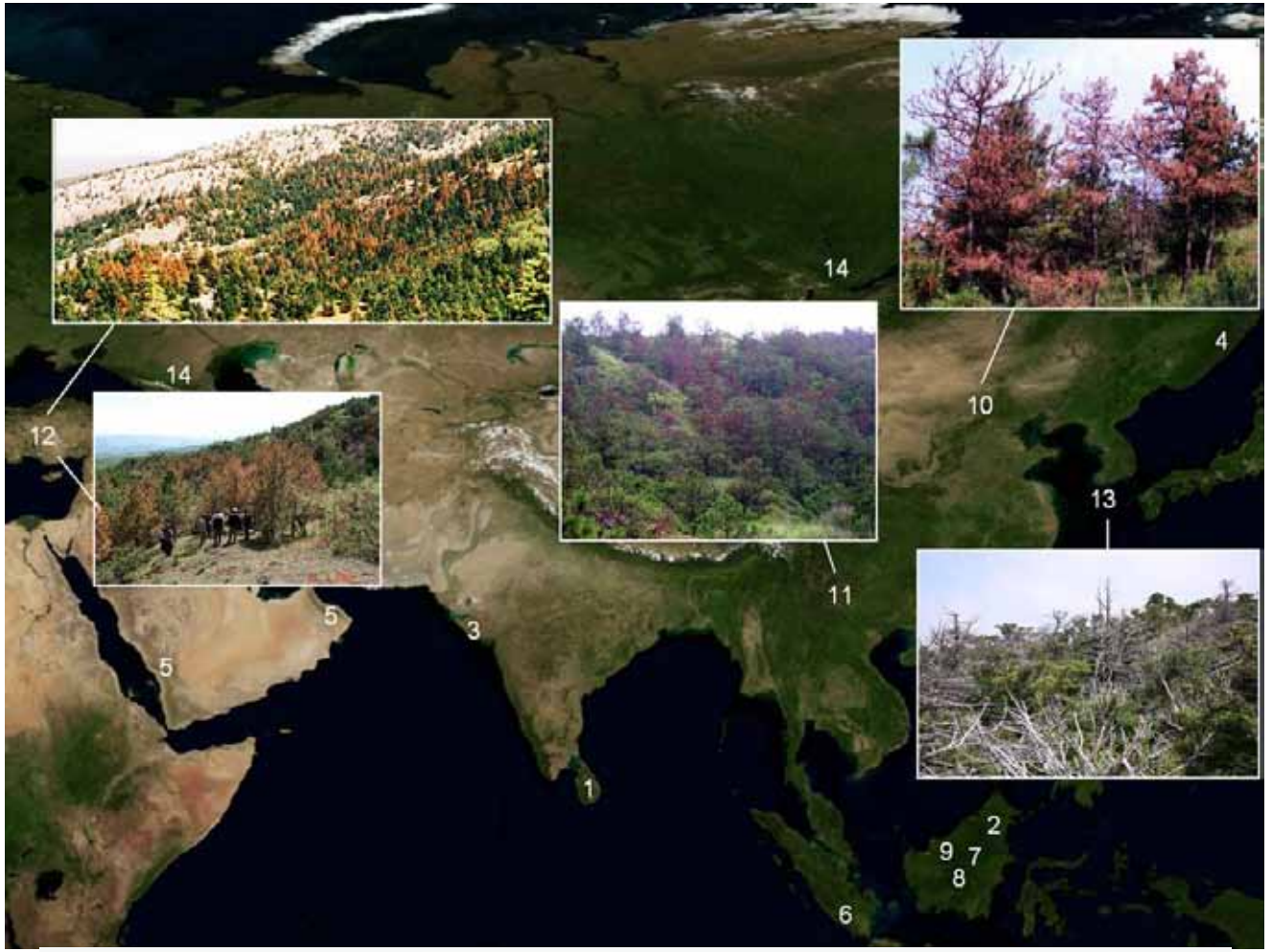
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

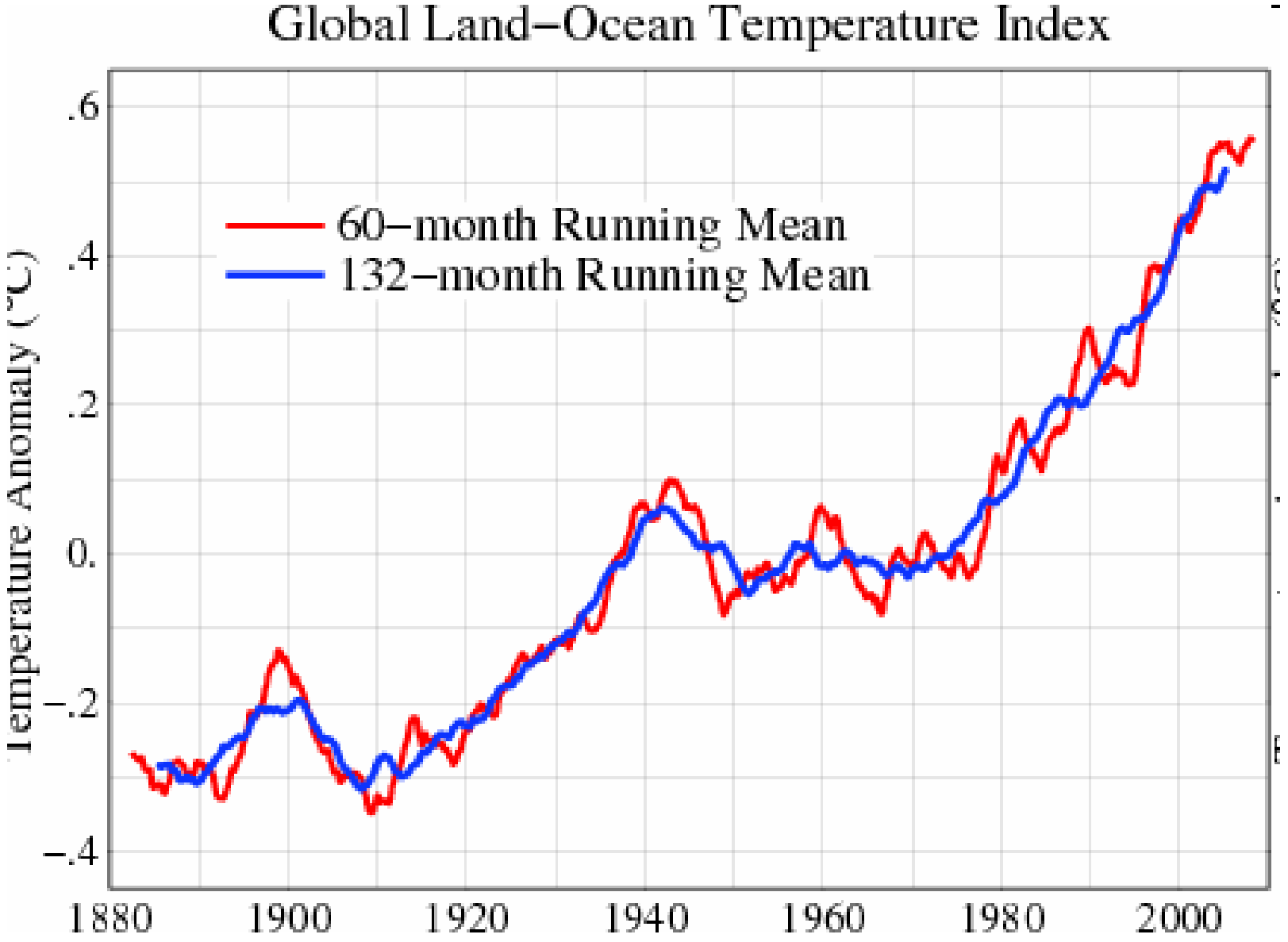
Tento projekt je spolufinancován Evropským sociálním fondem a Státním rozpočtem ČR InoBio – CZ.1.07/2.2.00/28.0018

Forest ecosystems and global climate change



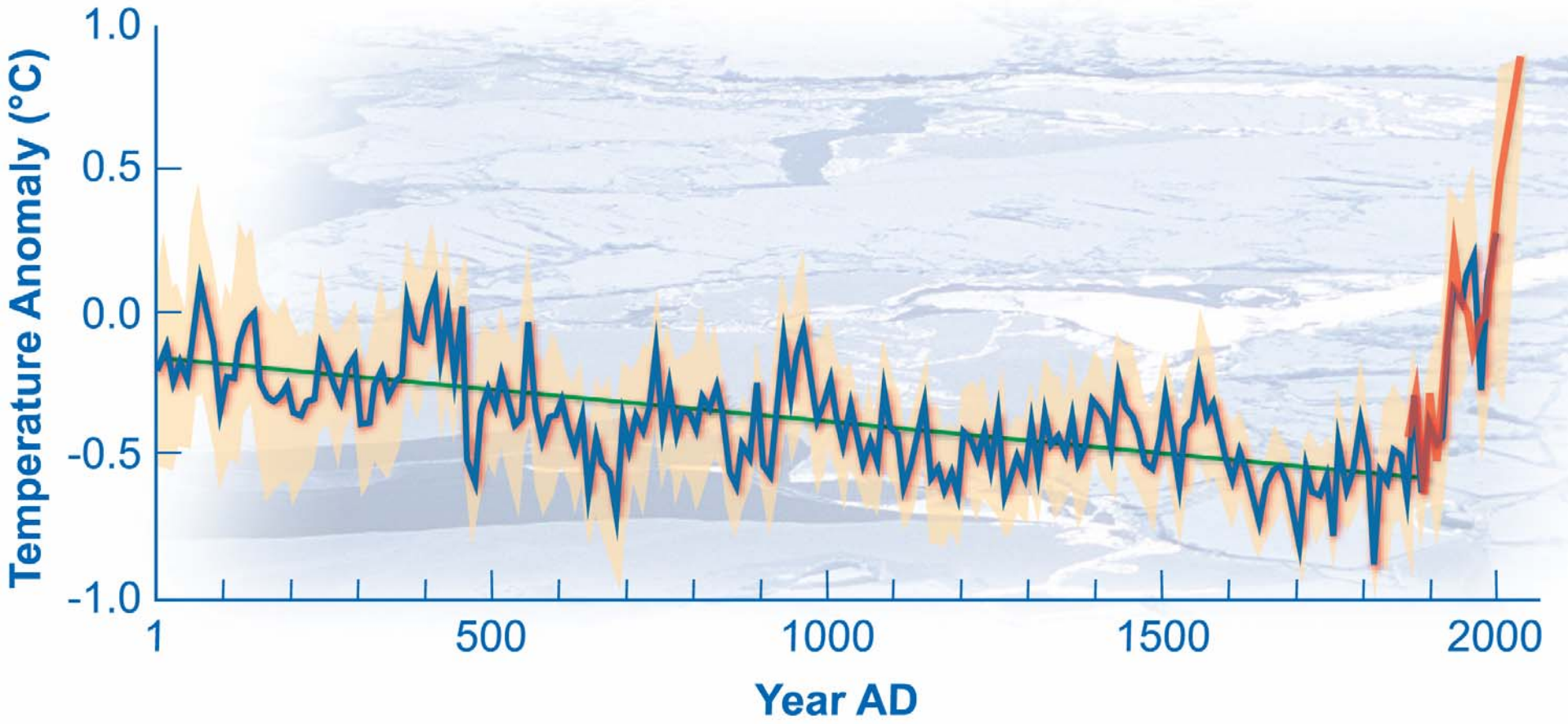
esf evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Year 2010 (january-september) was the warmest ever



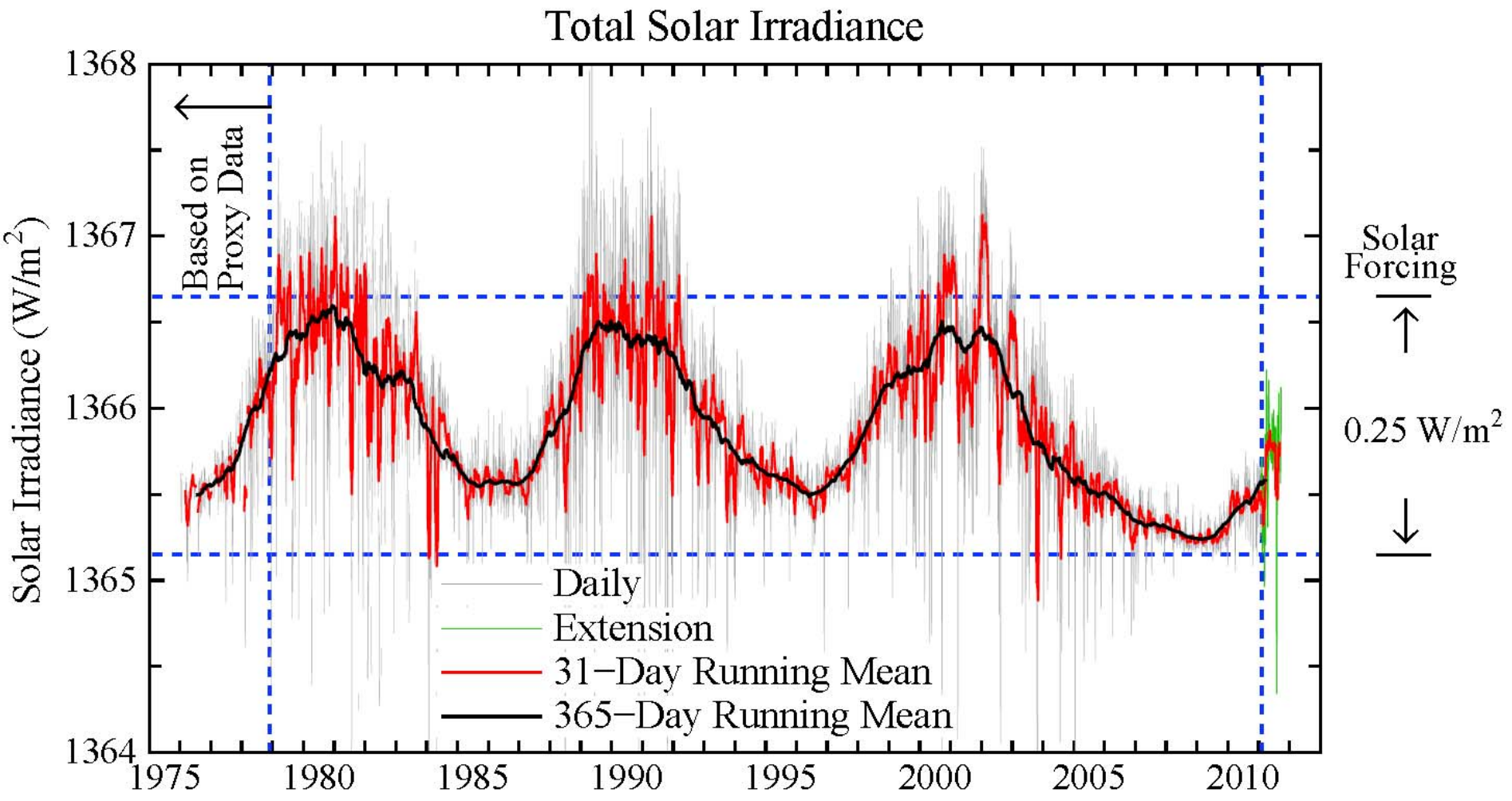
NASA, 2010

Natural climate change?

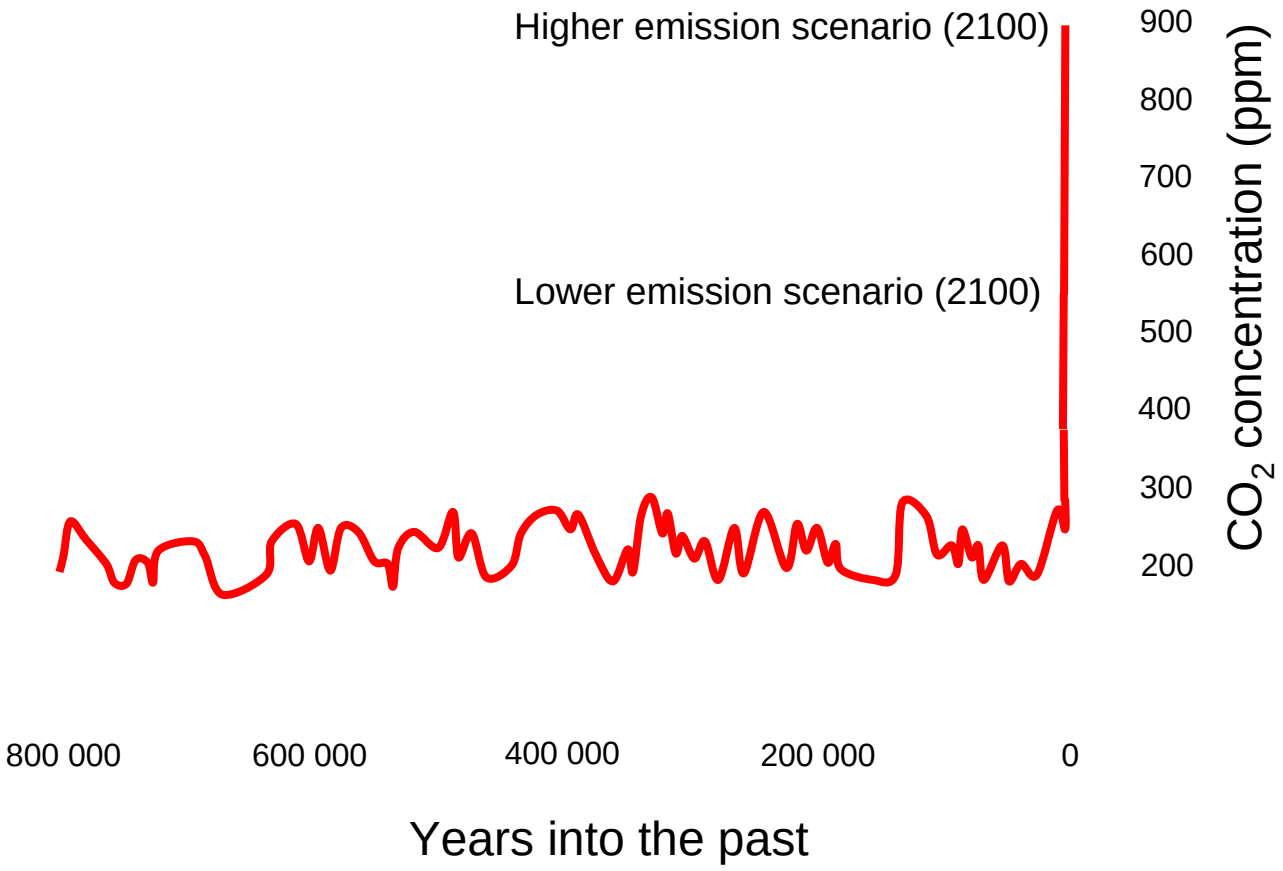


NCAR, 2009

While the sun activity is...



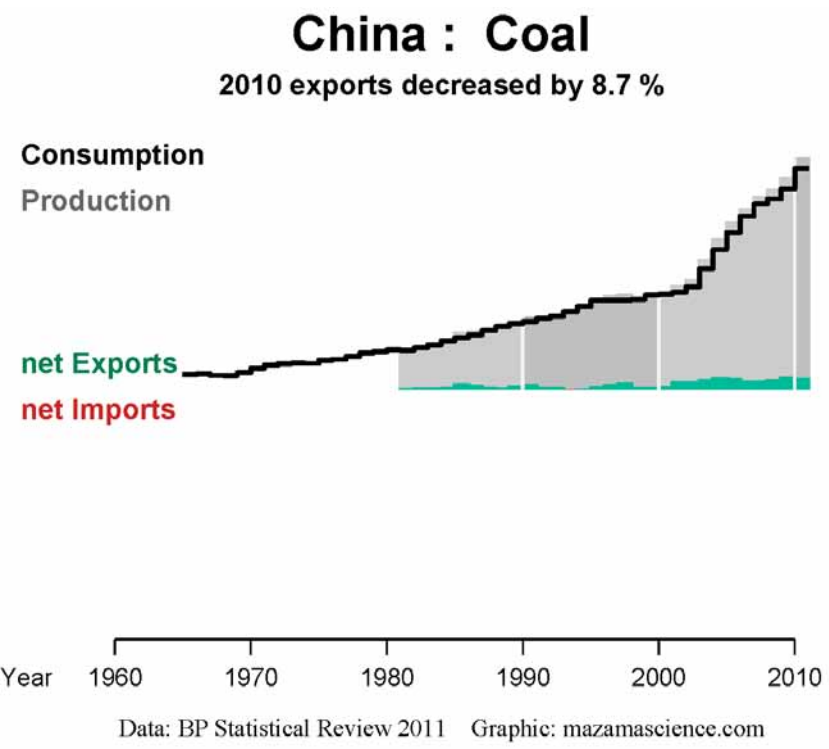
Frohlich and Lean, 2010

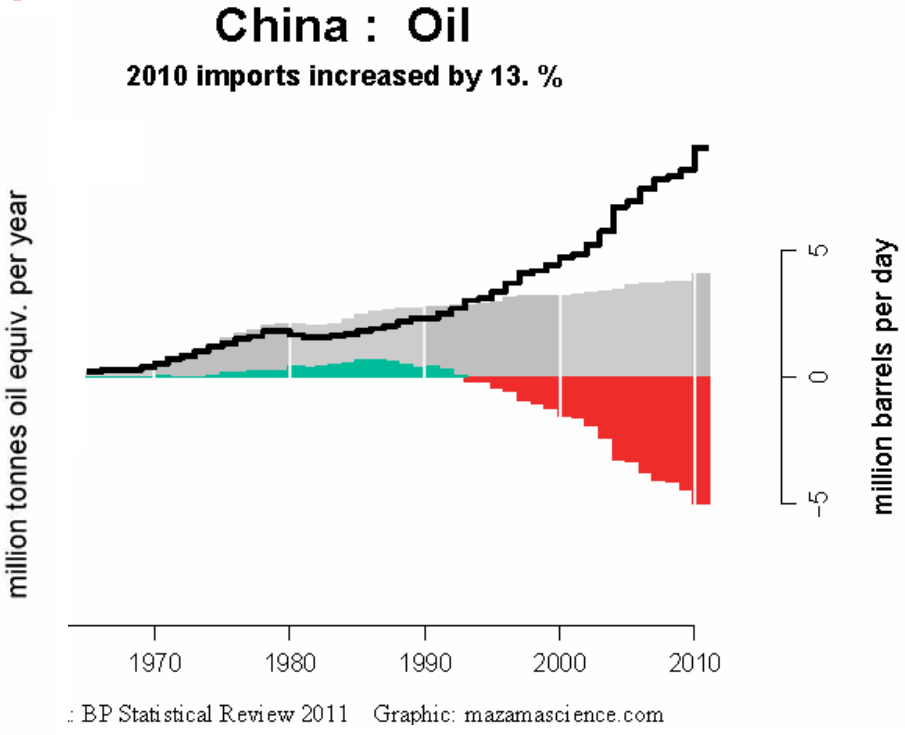


Luthi et al., 2008

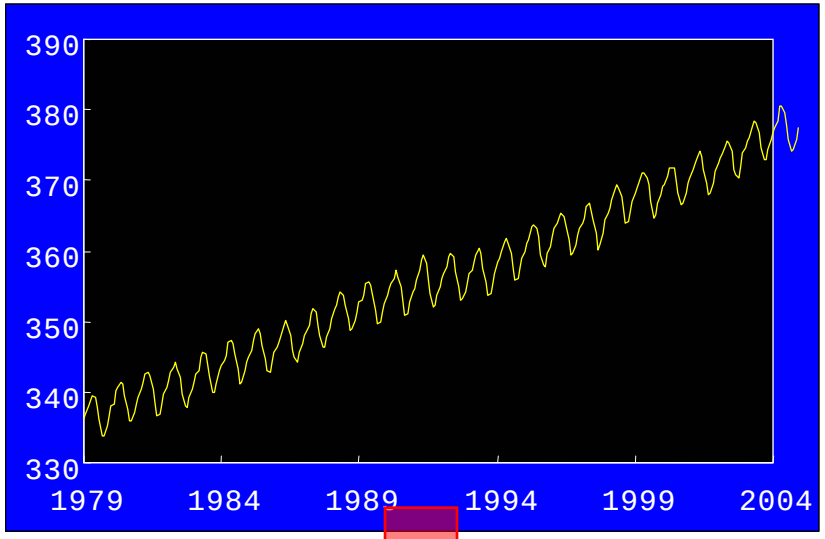
CO_2 emissions and concentration will increase

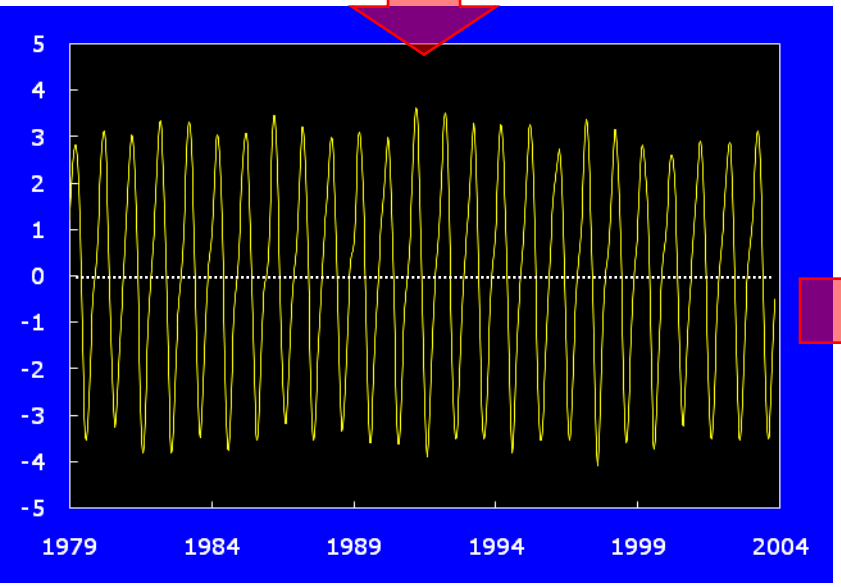
USA





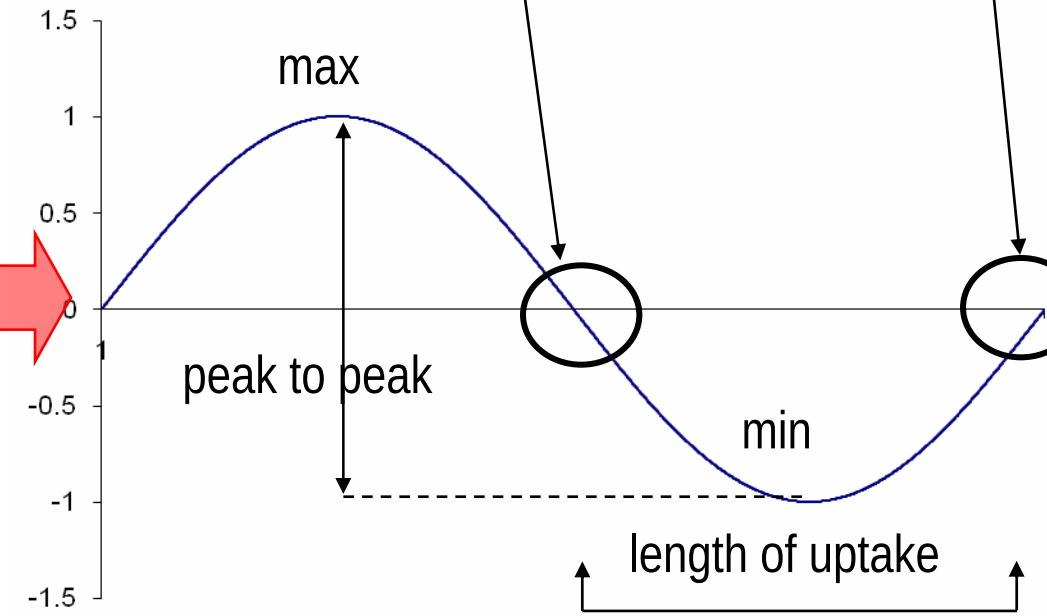
Atmospheric CO_2 long term records



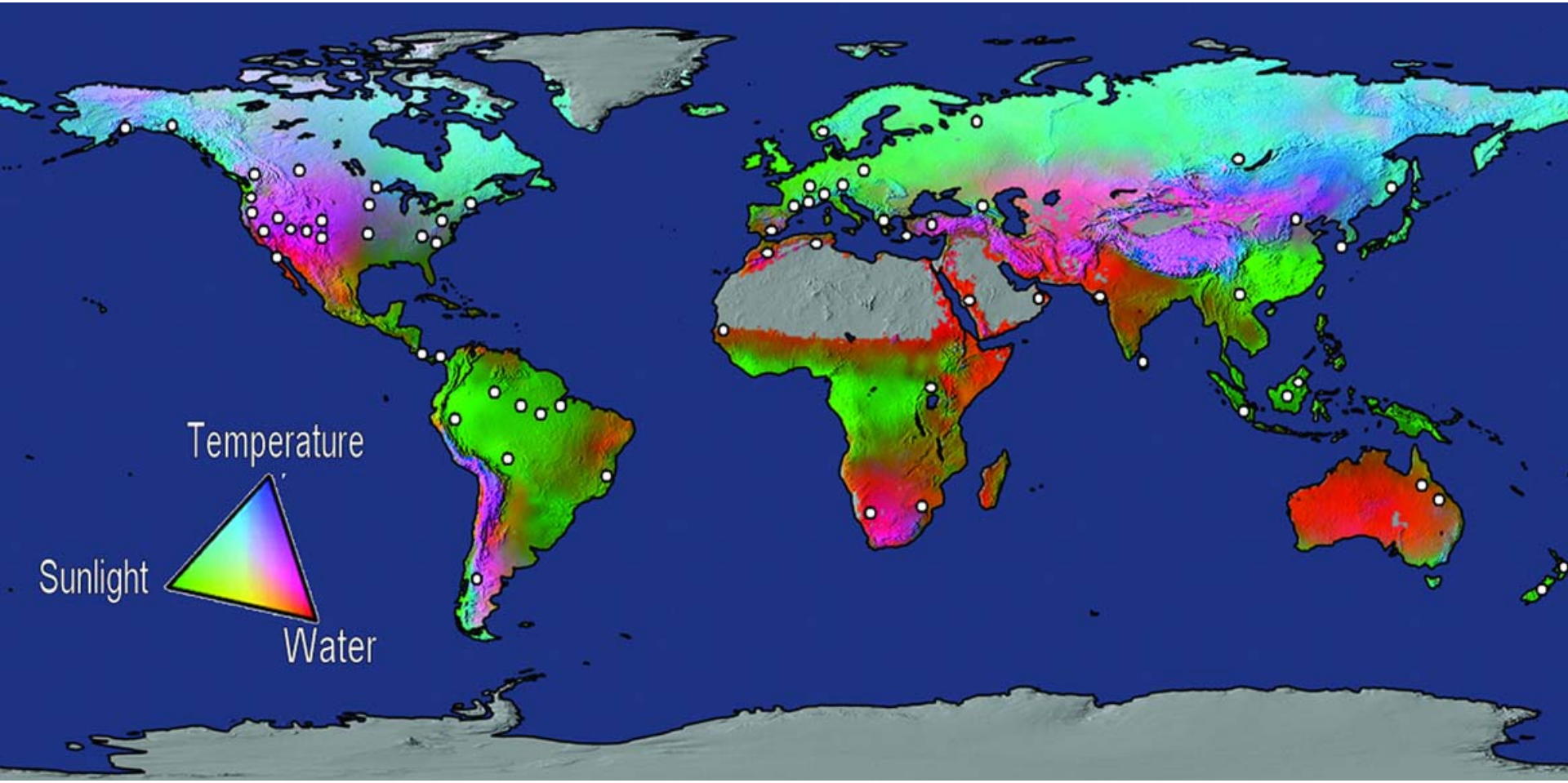


crossing down
Spring,
early summer

crossing up
Autum,
early winter



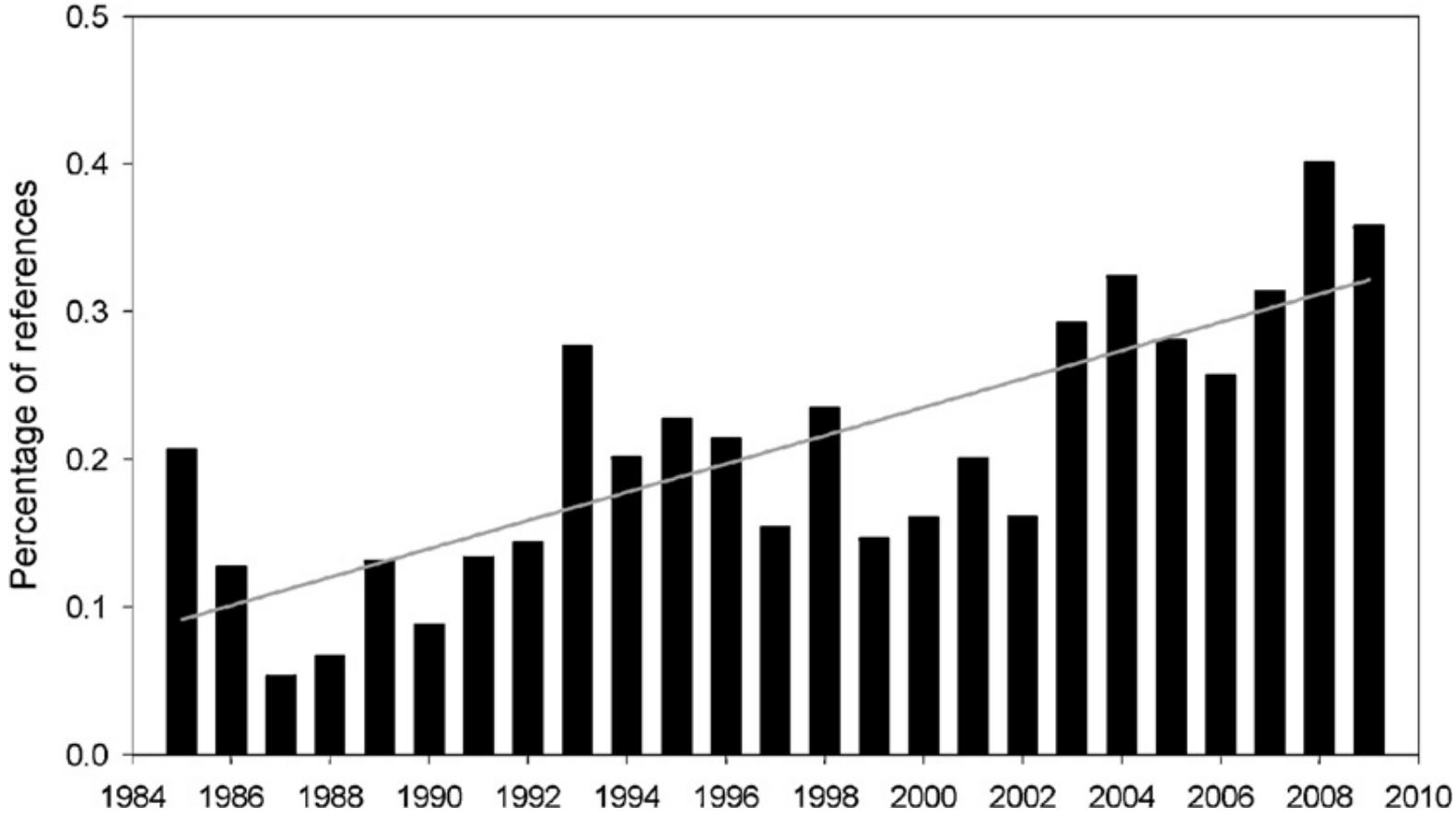
Environmental limits of forests – temperature, sunlight, water



- Climatic stress – drought, high temperatures

(Boisvenue and Running, 2006)

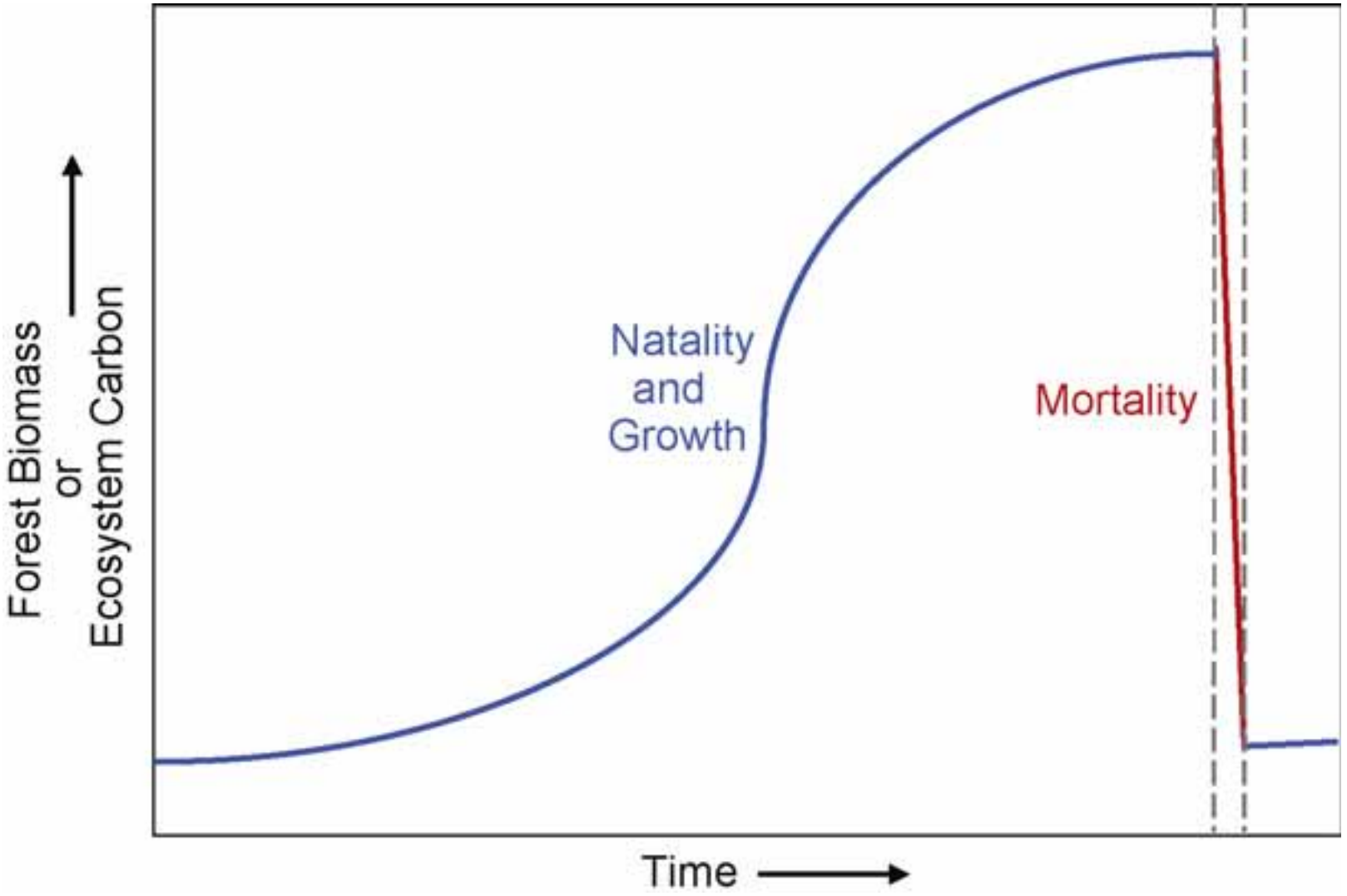
Fraction of drought related references



(forest+mortality+drought)/forest

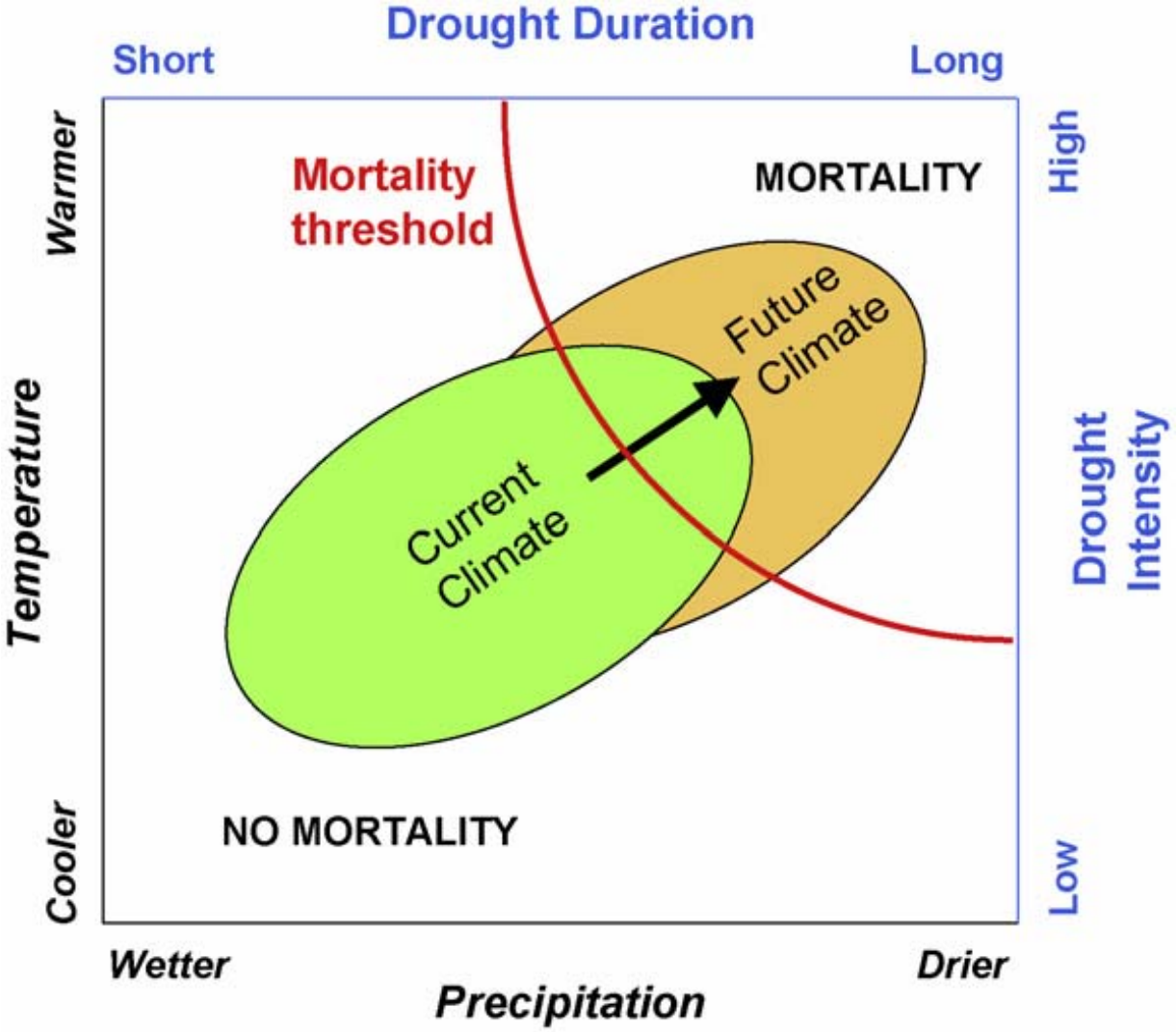
Allen et. al., 2009

Dynamics of biomass (carbon) in time

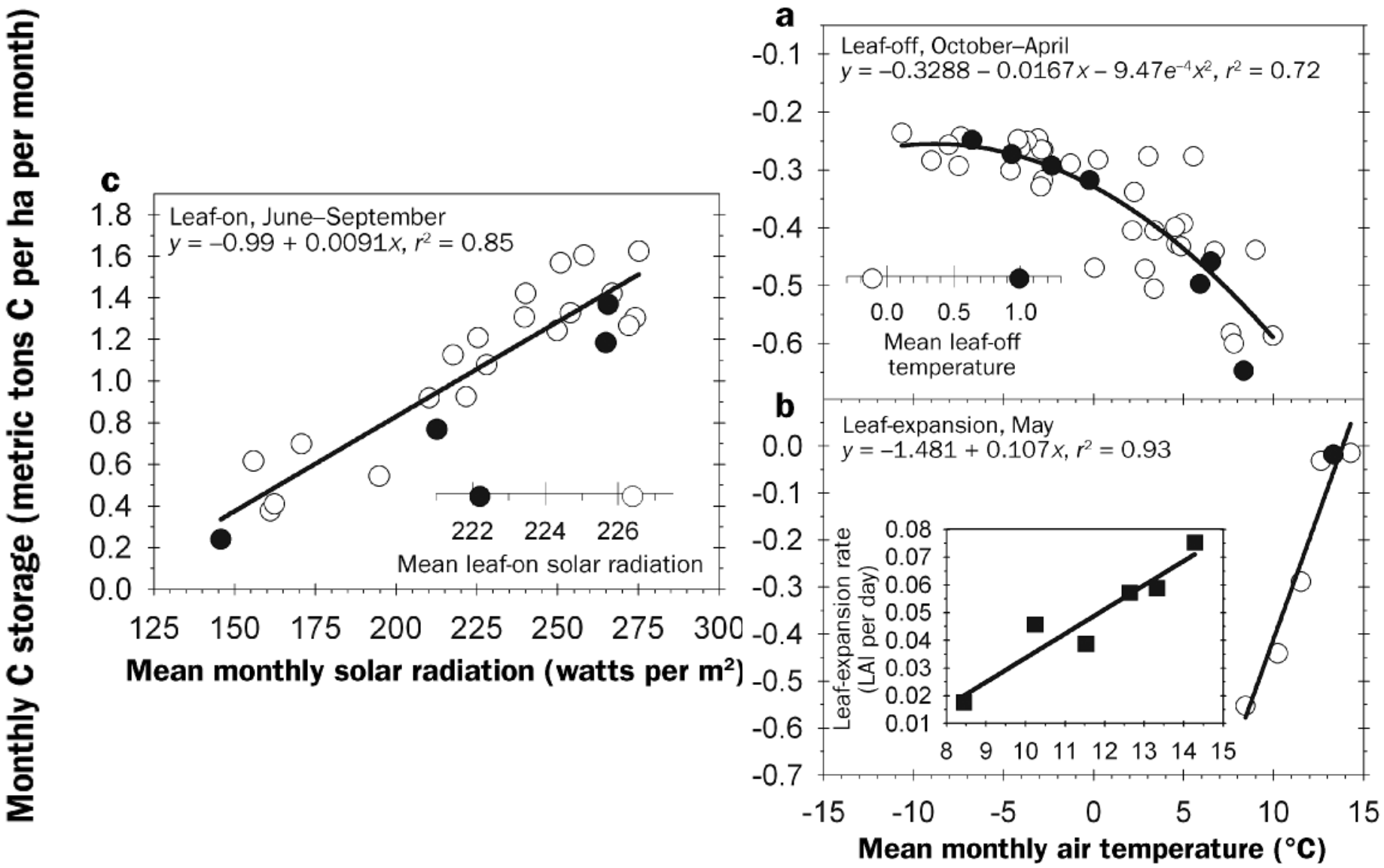


Allen et. al., 2009

Schematic effect of climate shifts on forest mortality

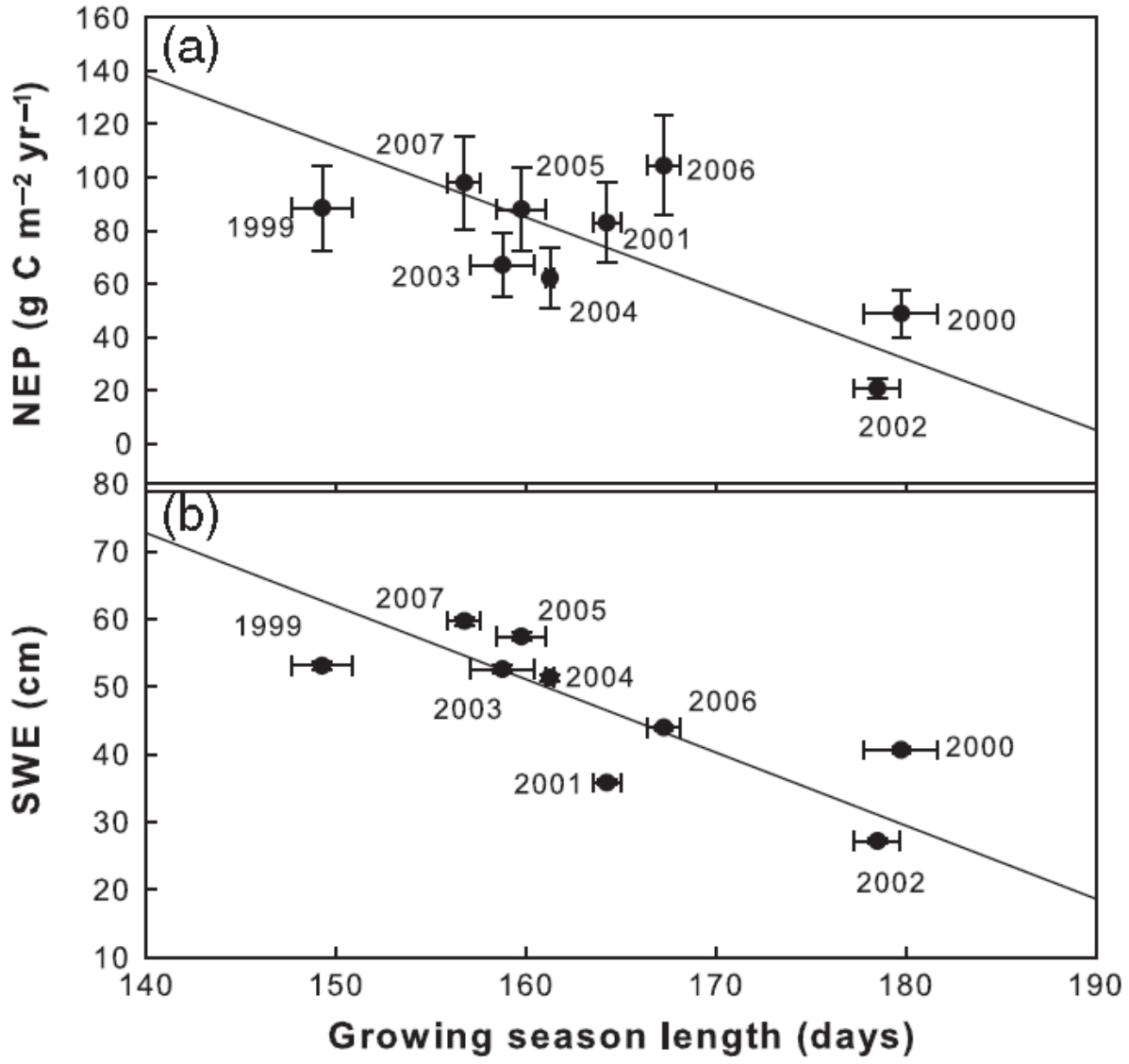


Effect of ecological factors in relation to carbon sink



Gough et. al., 2008

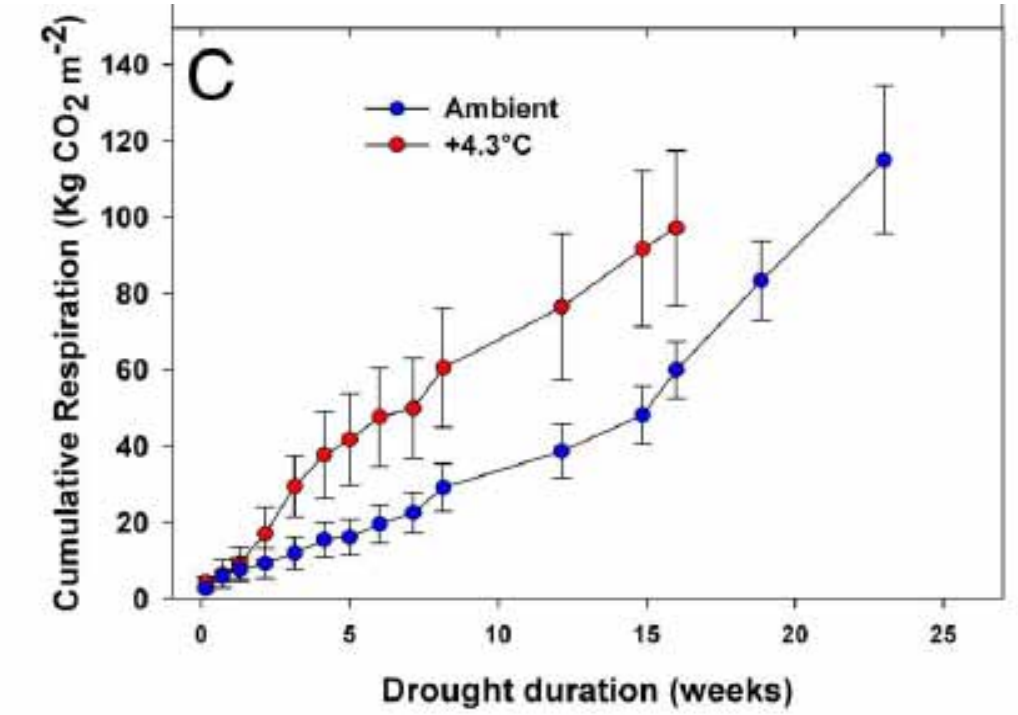
Longer growing season – larger carbon sink?

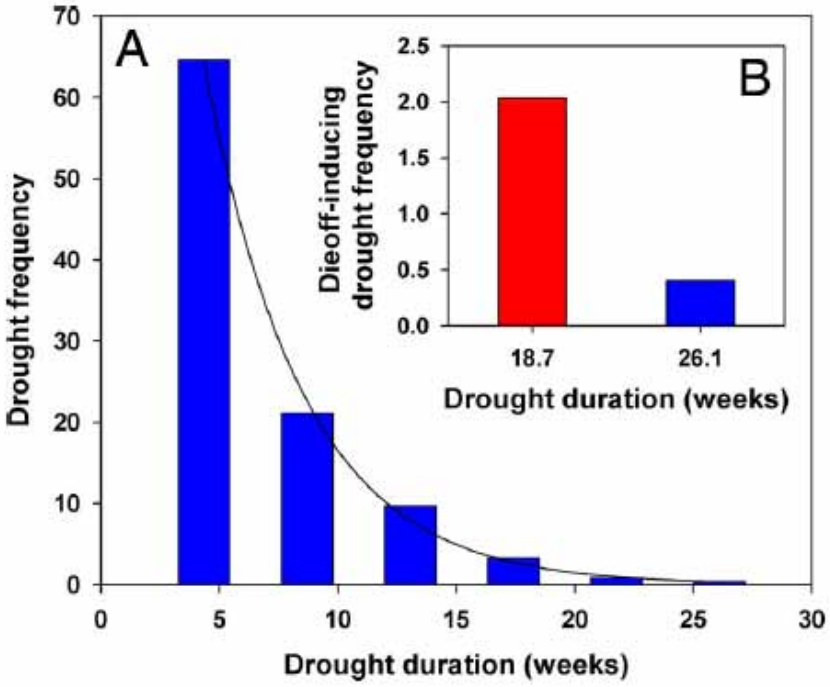


Sub-alpine forest in Rocky Mountains

Hu et al., 2010

Effect of higher temperatures during the drought on forest mortality (*Pinus edulis*)



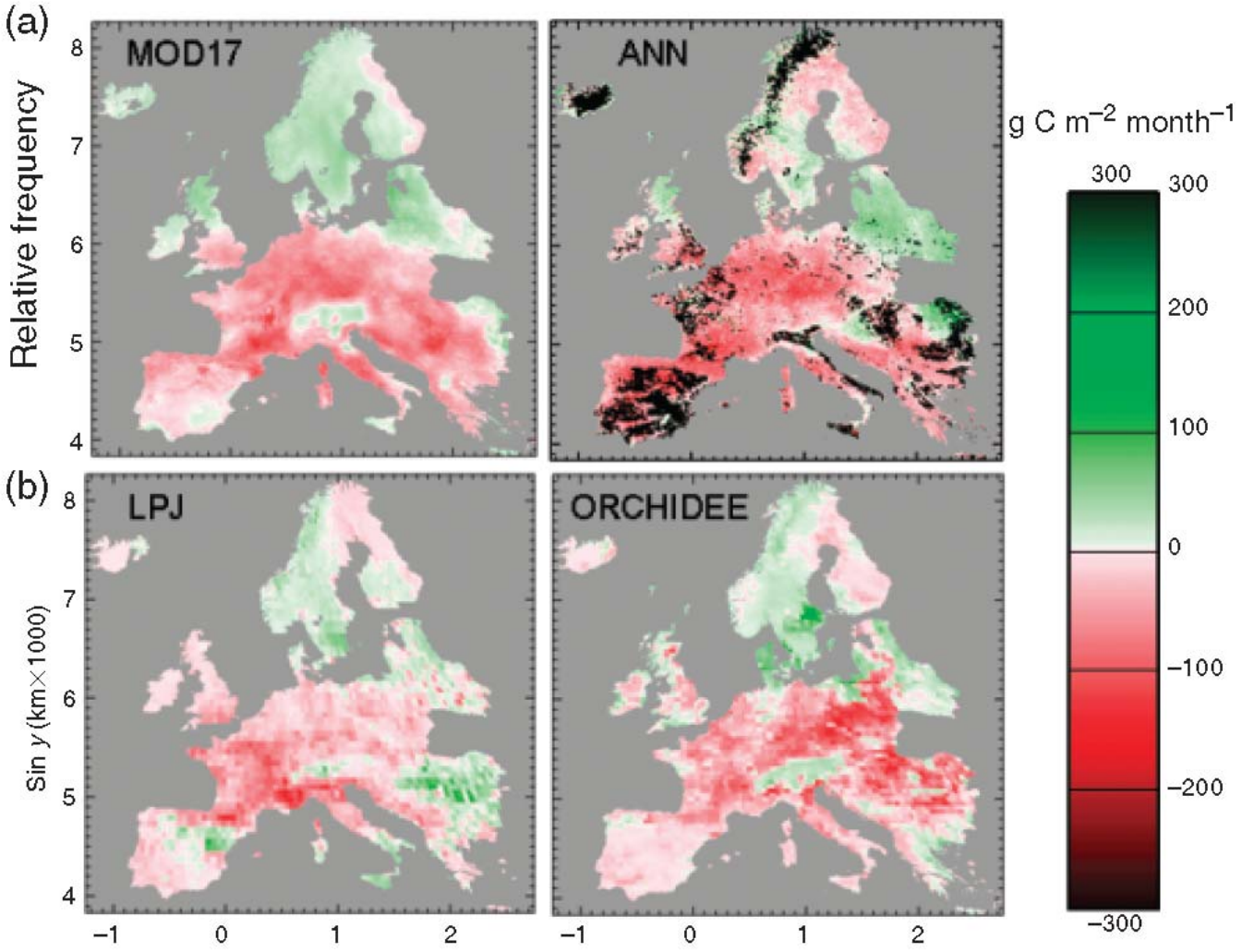


+ 4,3 °C during the drought shortened time needed for large-scale die-off by o 26 %

5-fold increase in the number of catastrophic drought

Adams et al., 2010

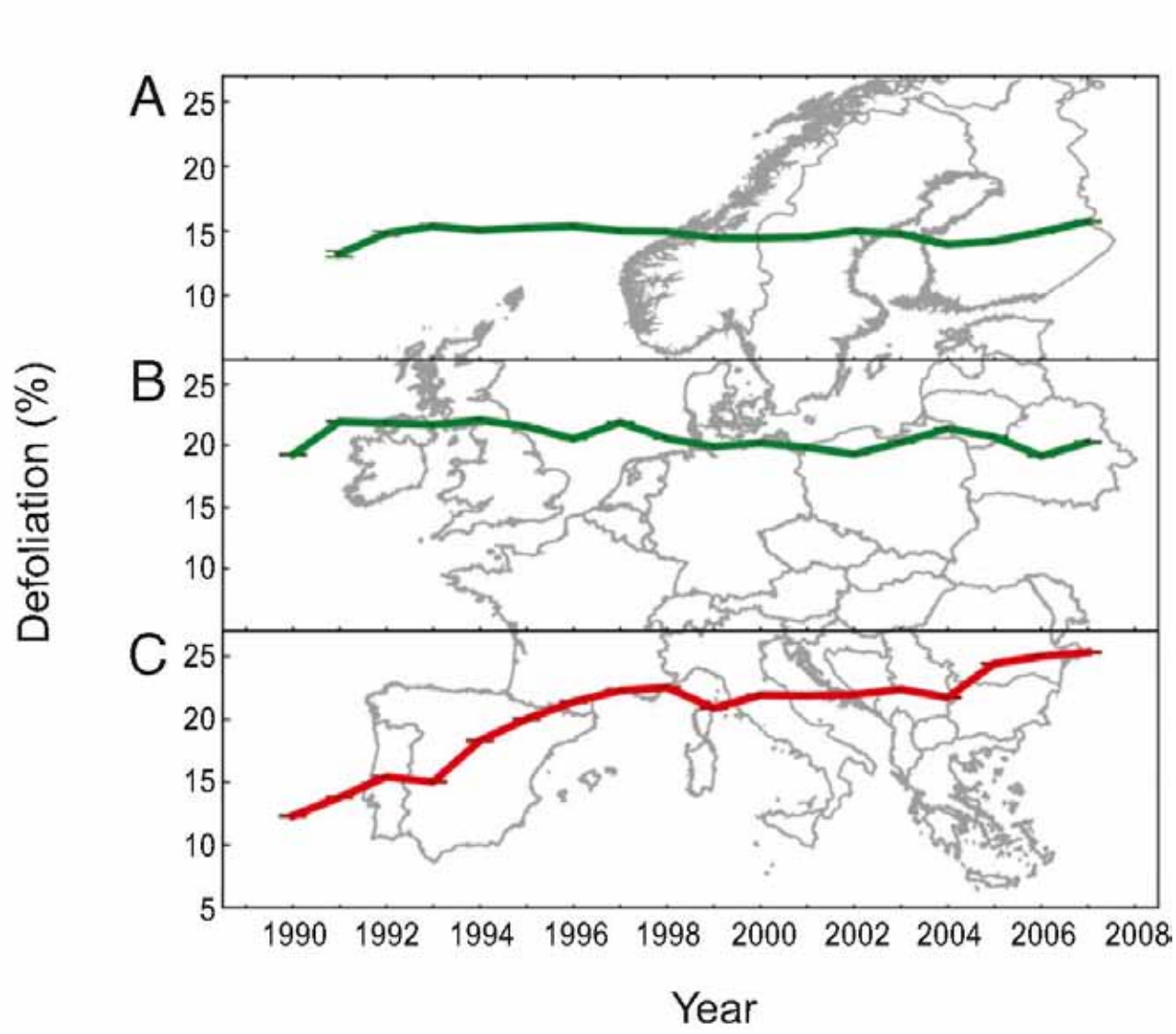
European heat wave of 2003 and carbon sink



Decrease in GPP and respiration!

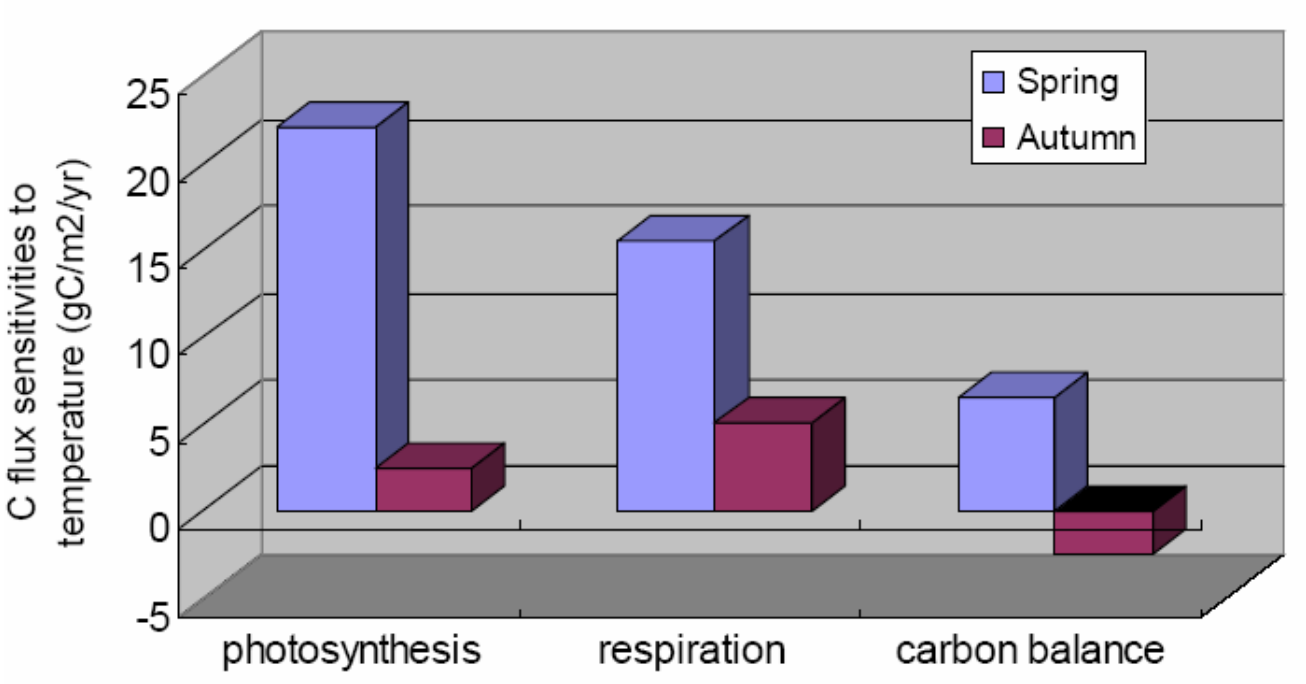
Reichstein et. al., 2006

Changes in precipitation and defoliation



Carnicer et al., 2011

Temperature vs. gross C Fluxes in NH (>25°N)

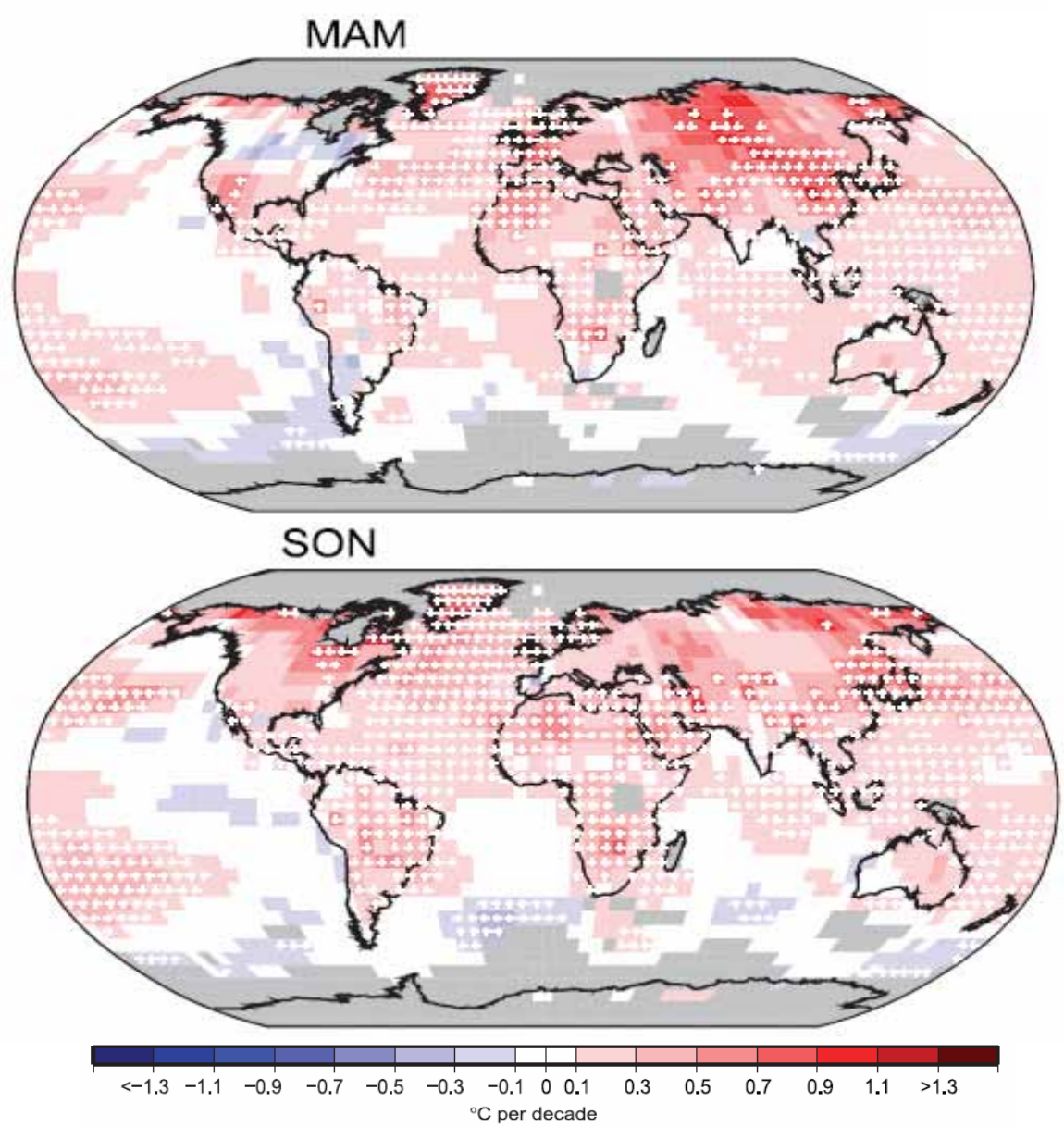


Spring: Warm temperatures accelerate growth more than soil decomposition. The annual relationship of NEP to temperature is positive
=> Warming enhances carbon uptake

Autumn: Warm autumn accelerate growth less than soil decomposition. The annual relationship of flux to temperature is negative.
=> Warming reduces carbon uptake

Piao et al. 2007, Nature

Carbon sink in Eurasia is > than in North America



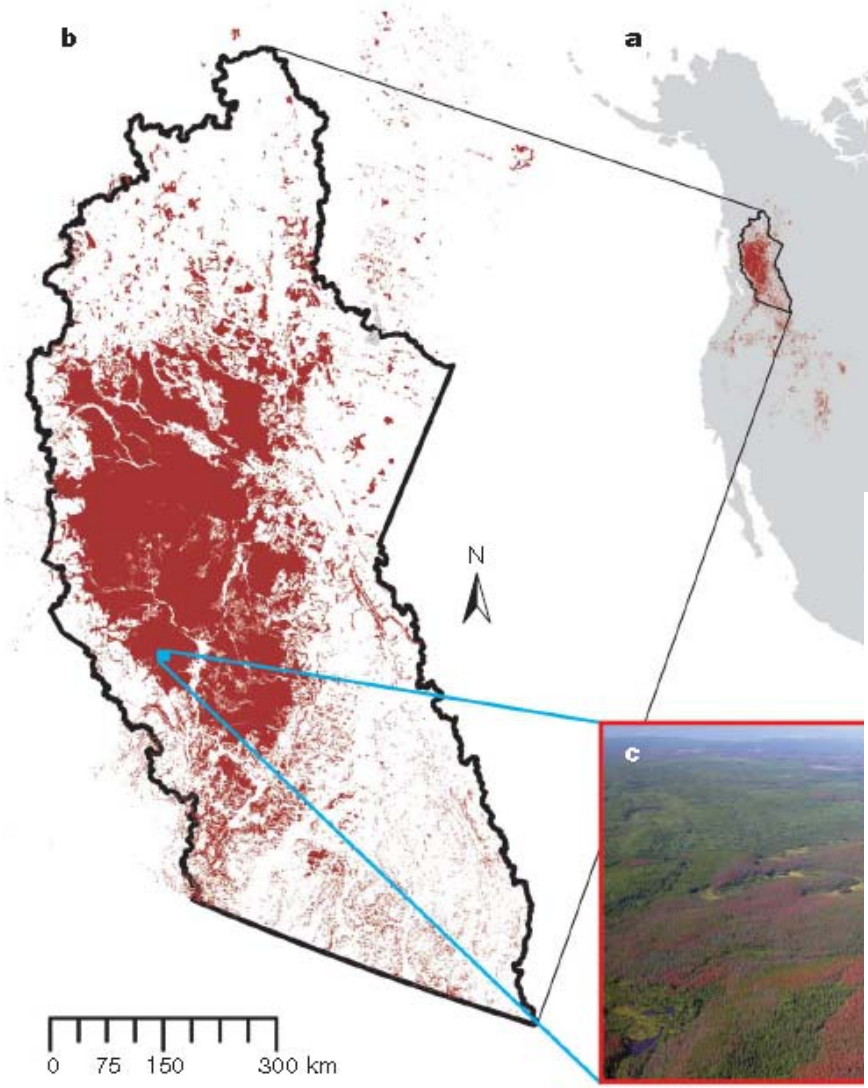
The warming trend is more pronounced in spring over Eurasia

The warming trend is more pronounced in autumn over North America

IPCC 2007

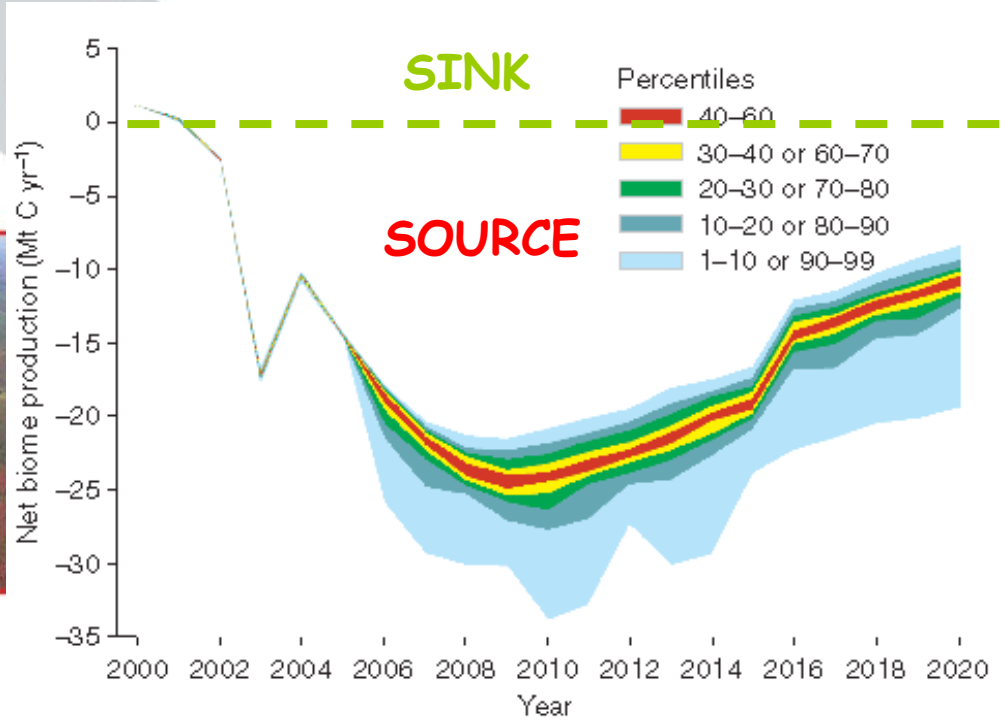
Forests in North America

Pinus ponderosa (pest *Dendroctonus ponderosae*)



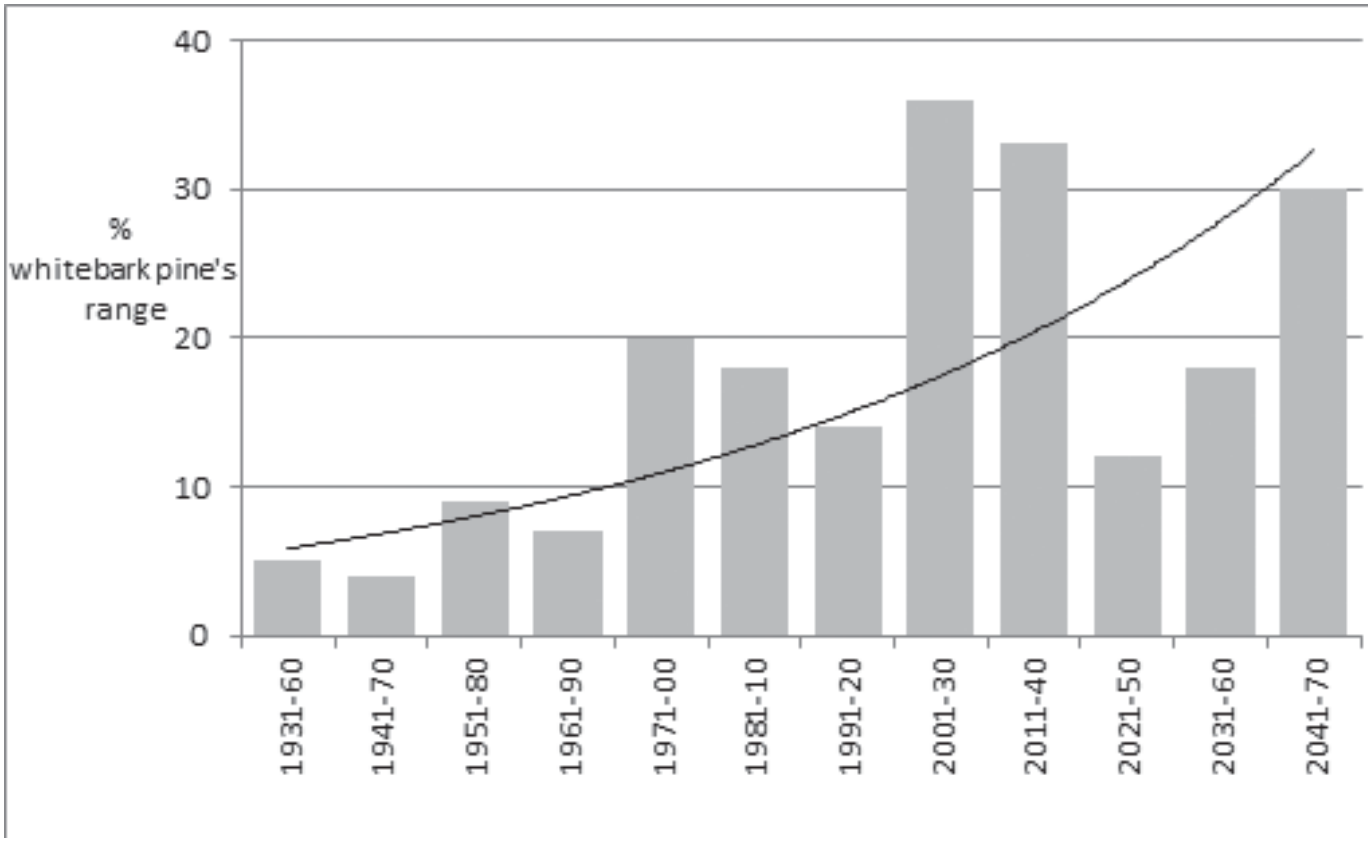
Current outbreak is 10-fold bigger than any other in history

Decrease in productivity si similar to increase in 80 to 90-ties as a result of global change



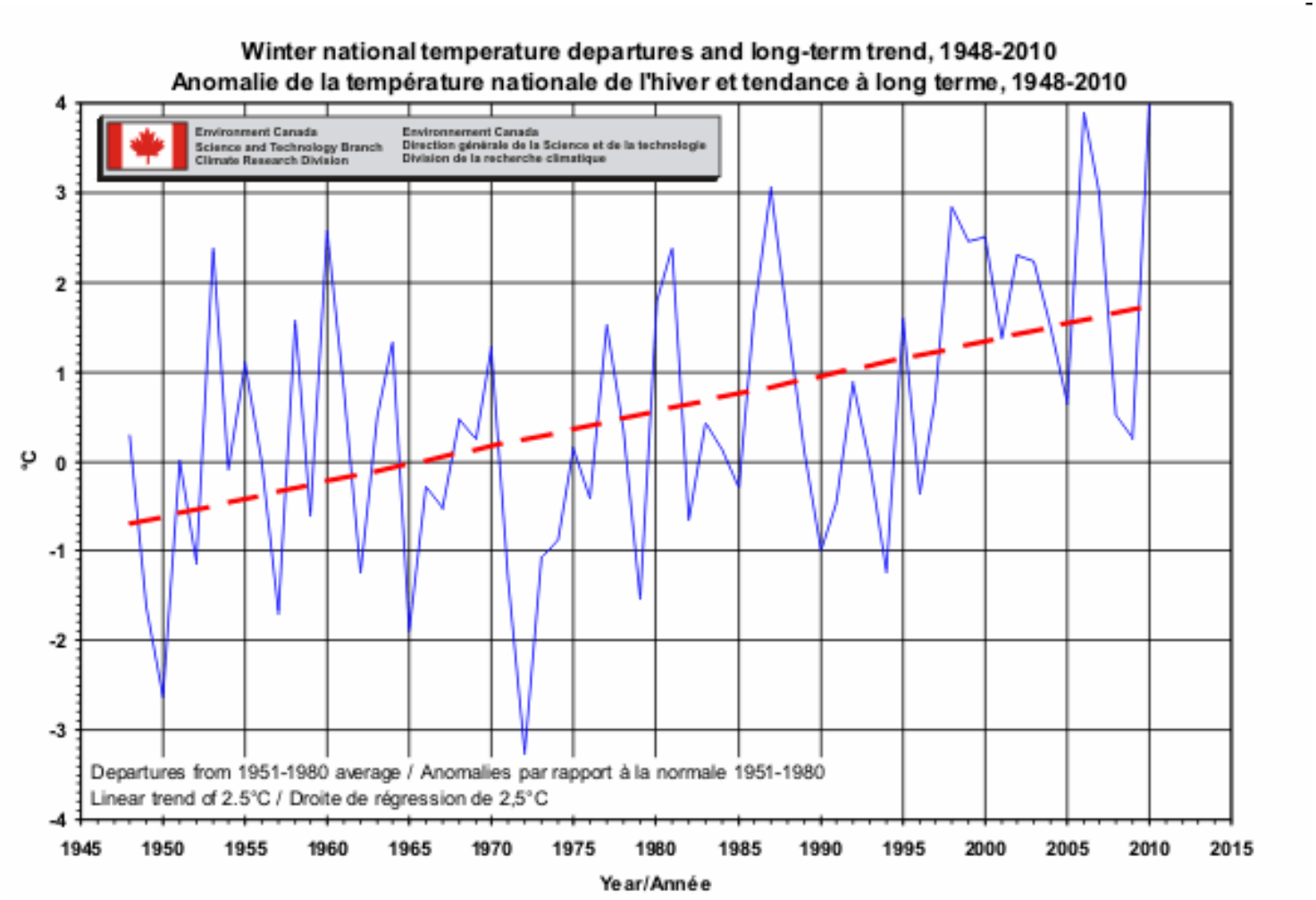
Kurz et al., Nature 2008

Whitebark pine's range in British Columbia that is climatically suitable habitat for mountain pine beetle.



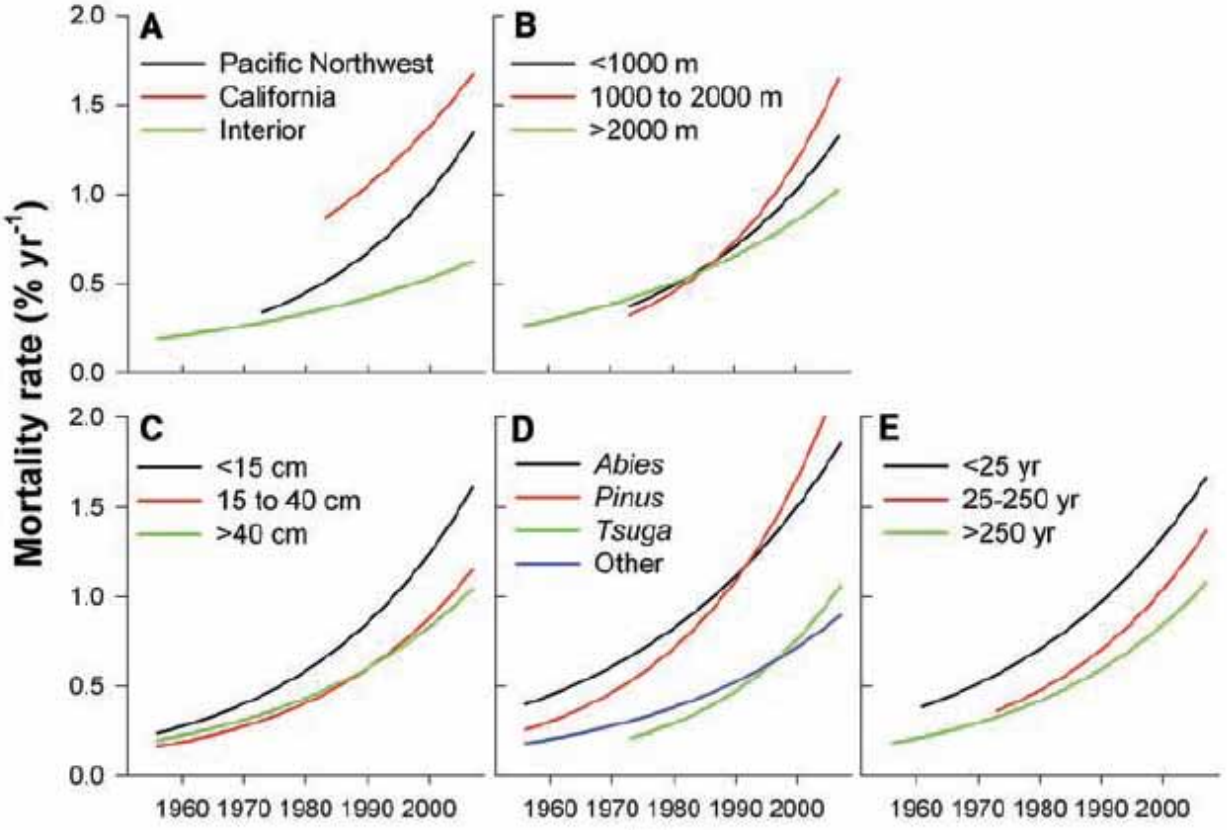
Campbell et al. 2010 Disturbance ecology and climate change, Conference

Winter temperature increase is crucial for insect survival



Average winter temperatures in Canada 1948-2010

Background mortality rate of natural forests is increasing

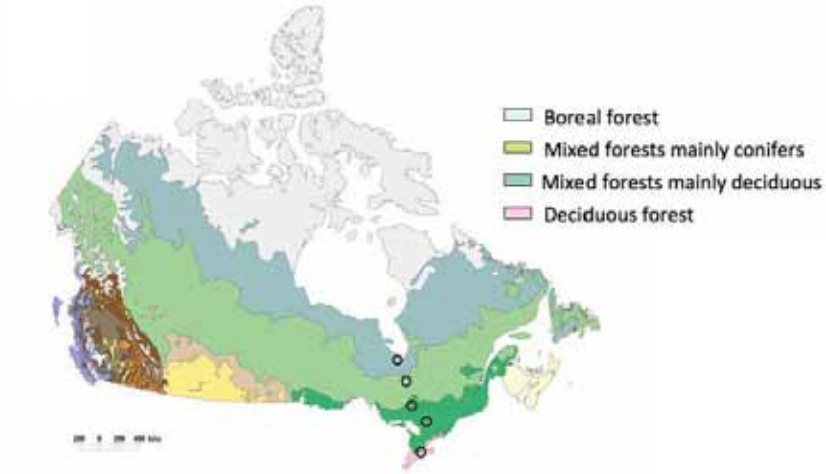


Widespread Increase of Tree Mortality Rates in the Western United States

Phillip J. van Mantgem,[1*†‡] Nathan L. Stephenson,[1*†] John C. Byrne,[2] Lori D. Daniels,[3]
Jerry F. Franklin,[4] Peter Z. Fulé,[5] Mark E. Harmon,[6] Andrew J. Larson,[4]
Jeremy M. Smith,[7] Alan H. Taylor,[8] Thomas T. Veblen[7]

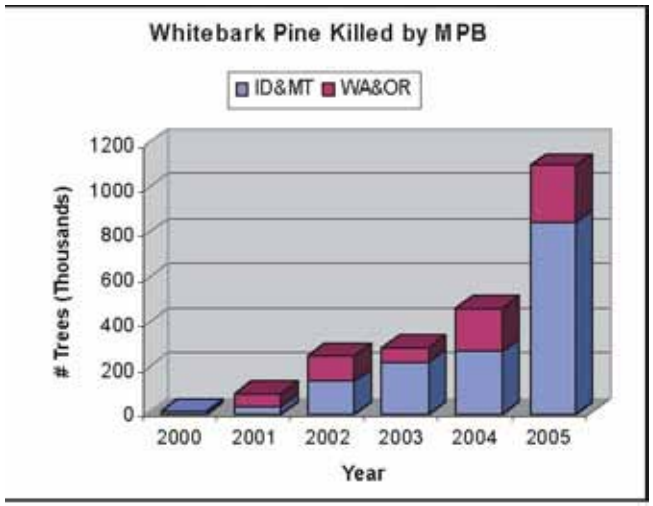
van Mangtem et al., Science, 2009

Growth of forests is slowing down



Silva et al., PlosOne, 2010

Suitable conditions in decline for Whitebark pine (*Pinus albicaulis*)

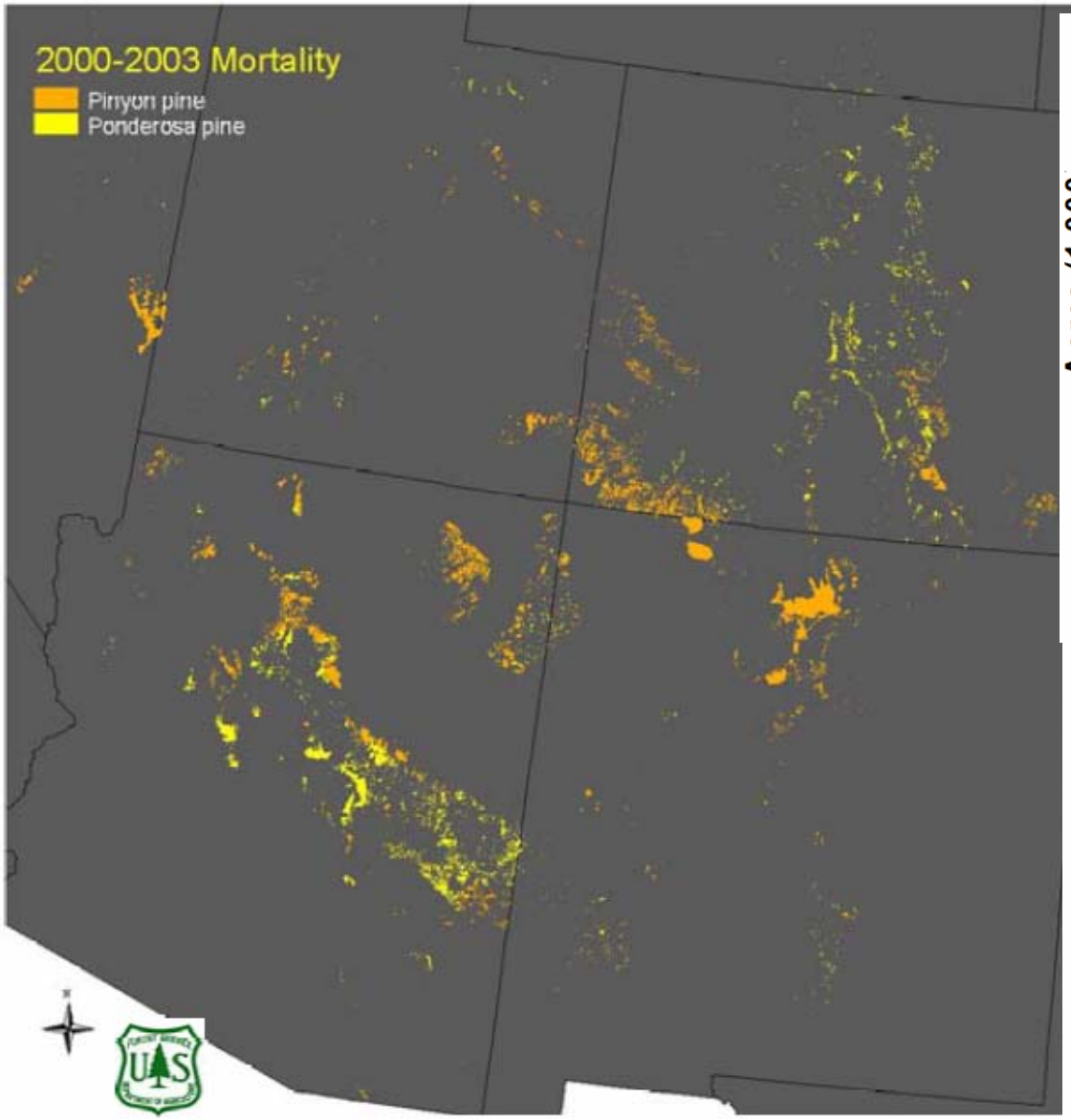


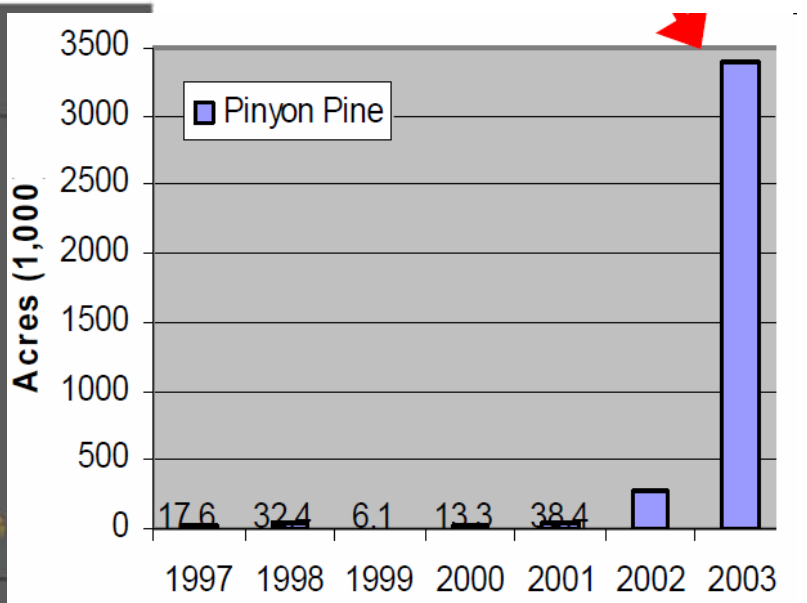
Today

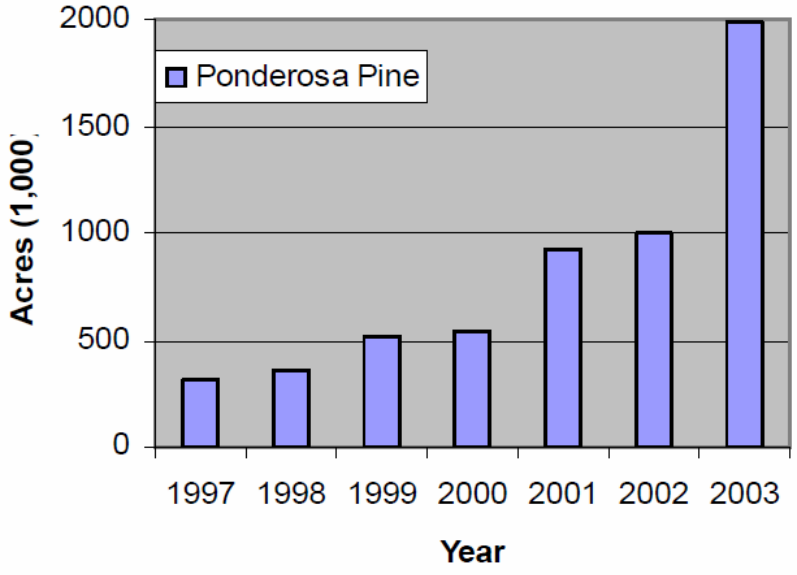
2080

Warwell et al., 2007, Proceedings Conference

And other species (*Pinyon pine, Ponderosa pine*)

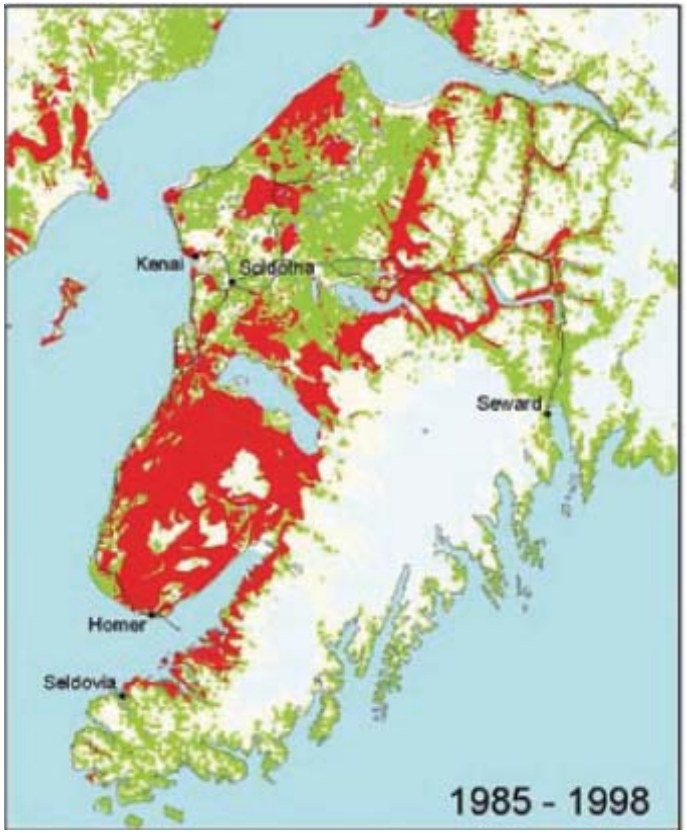




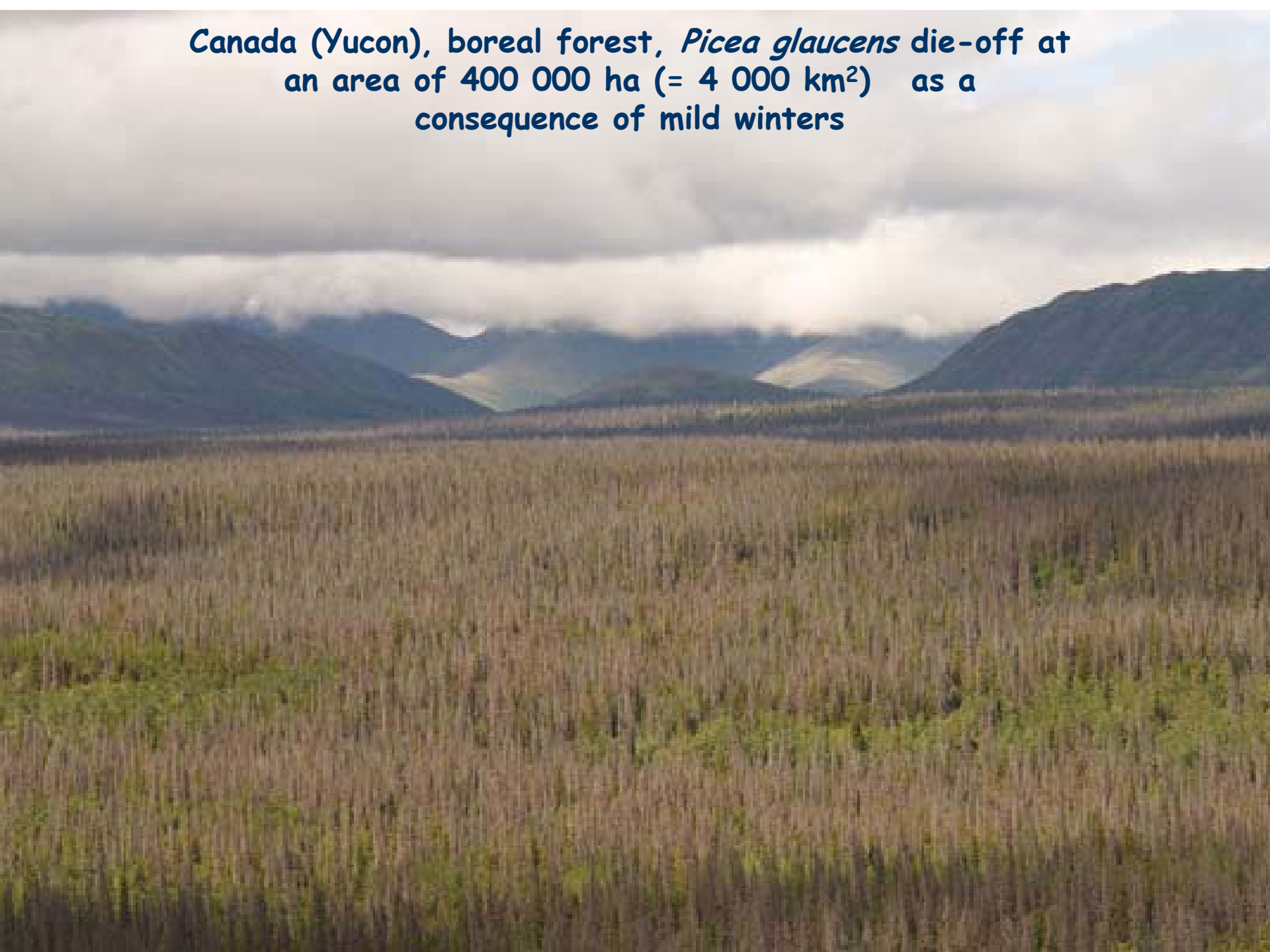


US Climate Change Science Program, 2009

And other species - *Alaskan Spruce (pest Dendroctonus rufipennis)*

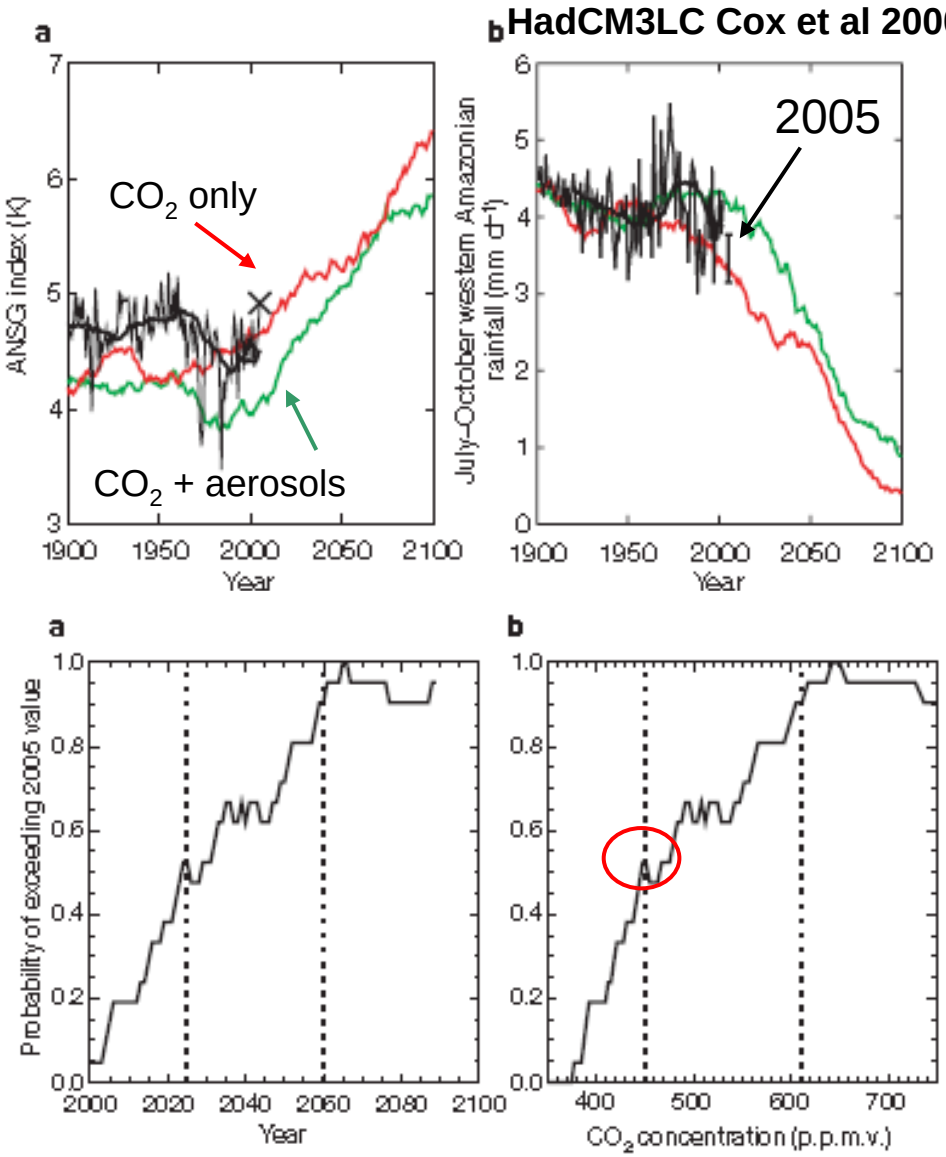


Global Climate Change Impacts In the United States, 2009



Canada (Yucon), boreal forest, *Picea glaucens* die-off at an area of 400 000 ha (= 4 000 km^2) as a consequence of mild winters

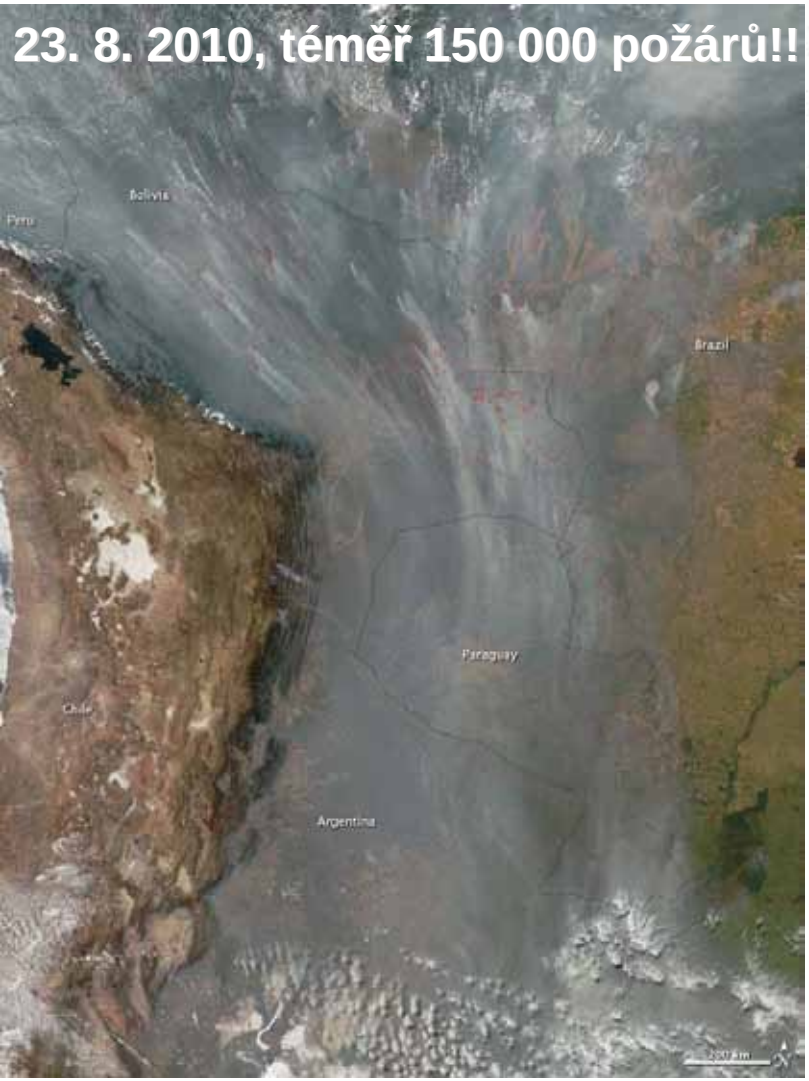
Amazon forest



At 450 ppm the 2005 drought will occur every 2 years!

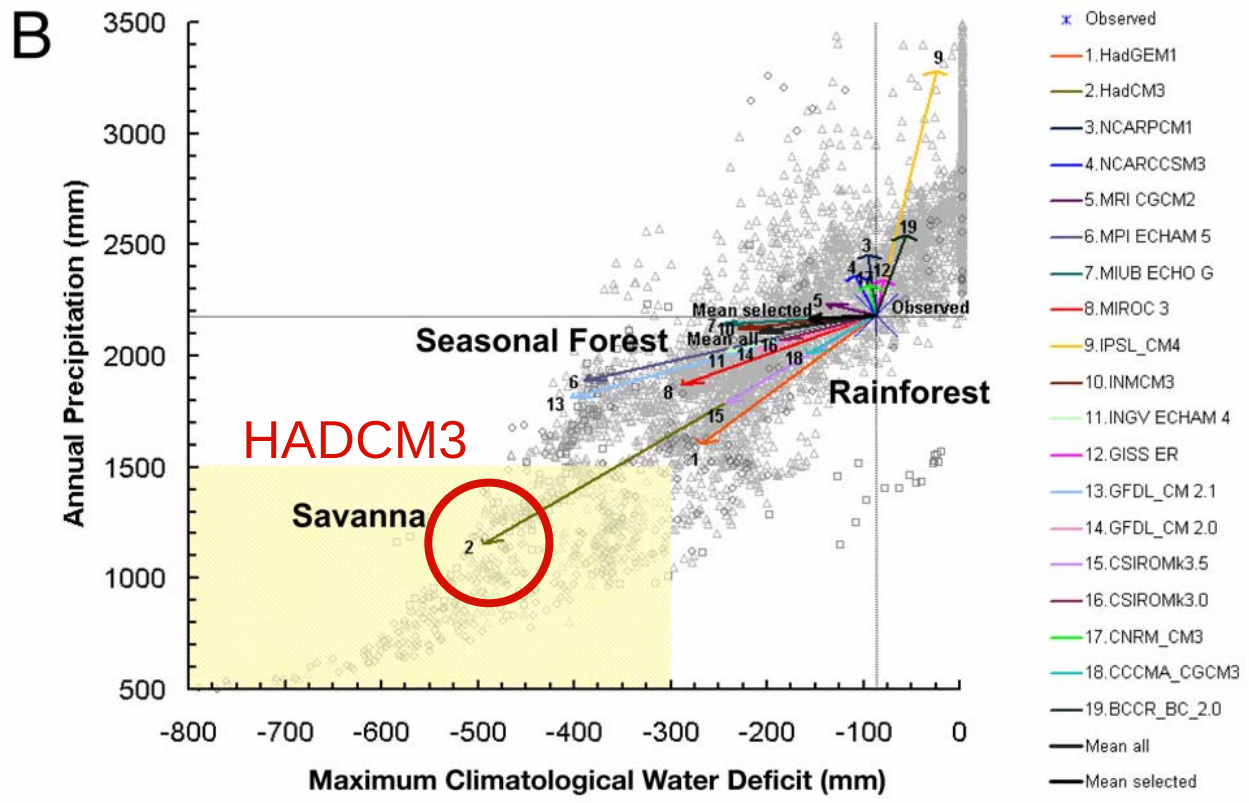
Cox et al., Nature, 2008

Fires in Amazon will increase



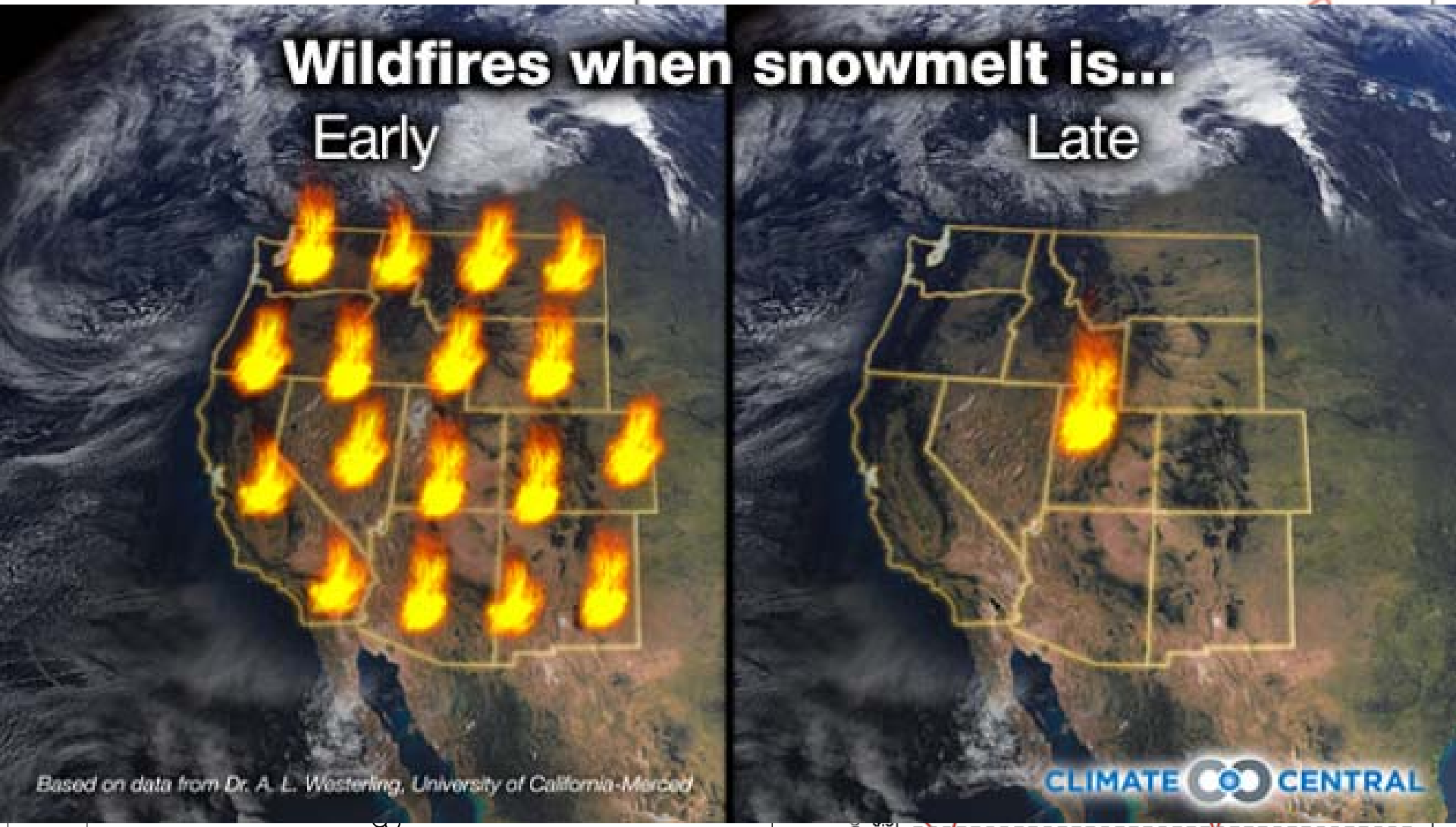
Mongabay, 2010

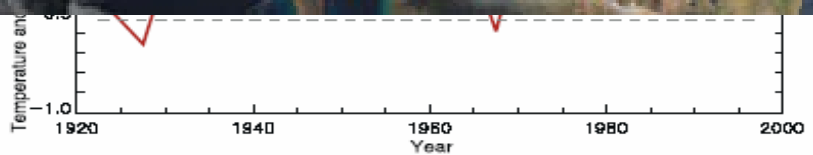
Amazon forest and climate models



Malhi et al., PNAS, 2009

Wildfires are bigger and more frequent





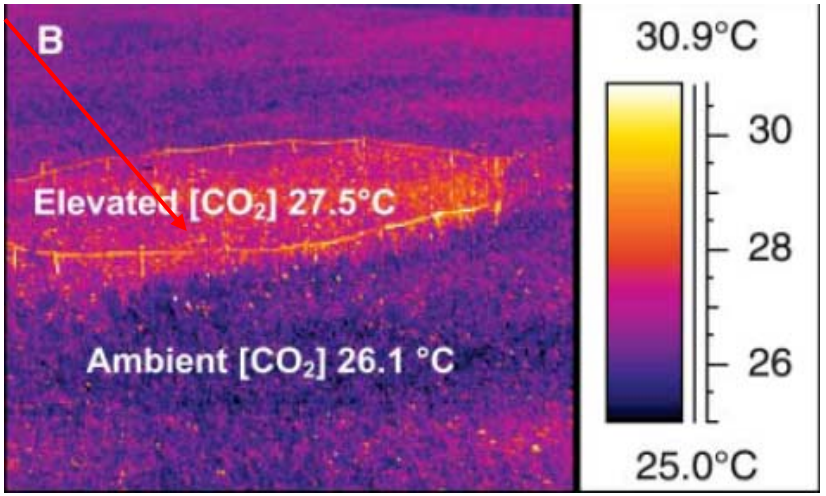
Increased CO_2 and leaf temperature

Lower stomatal conductance,
Lower transpiration

→

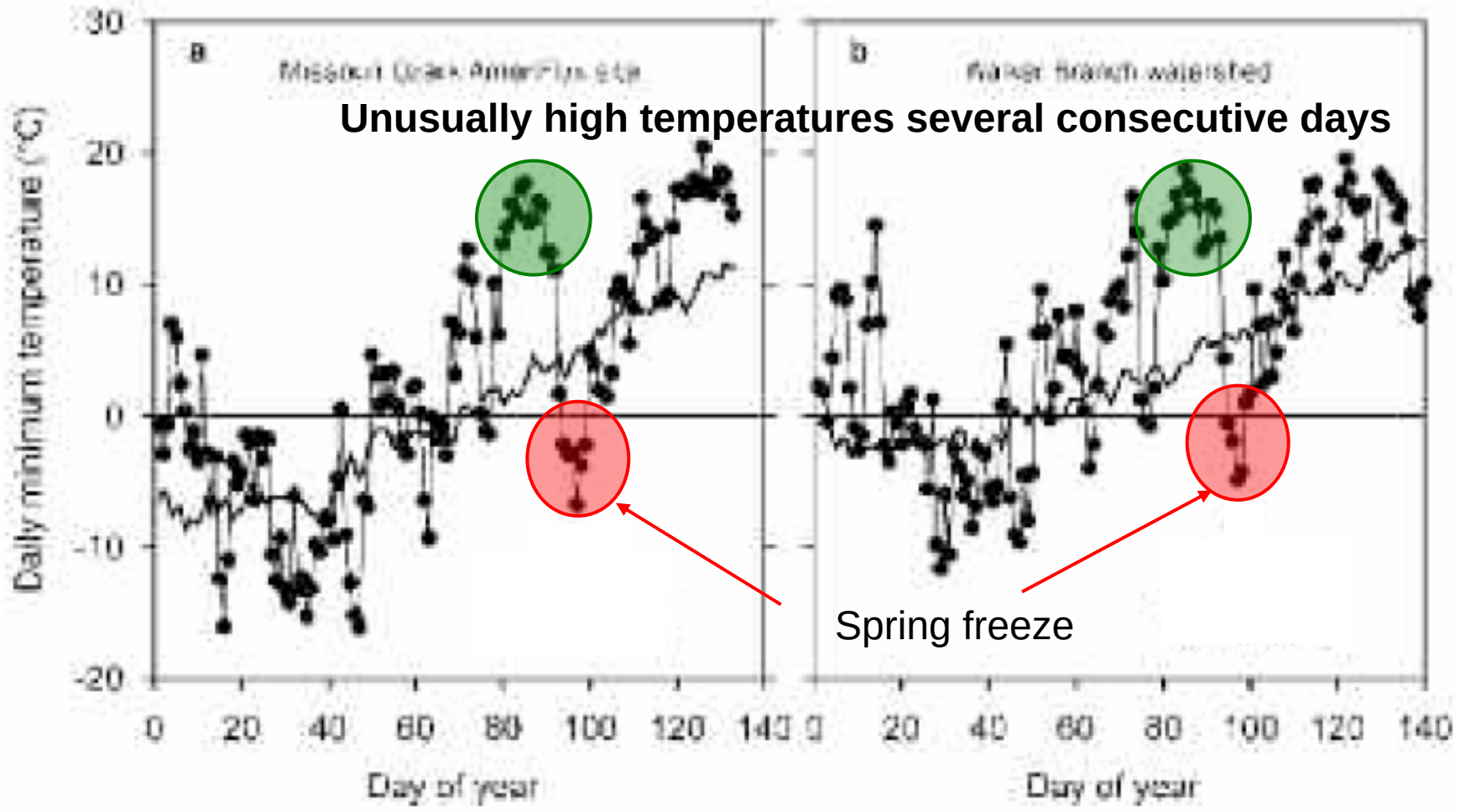
Lower freeze tolerance (as a result of slower acclimation)

(Loveys et al. 2006)

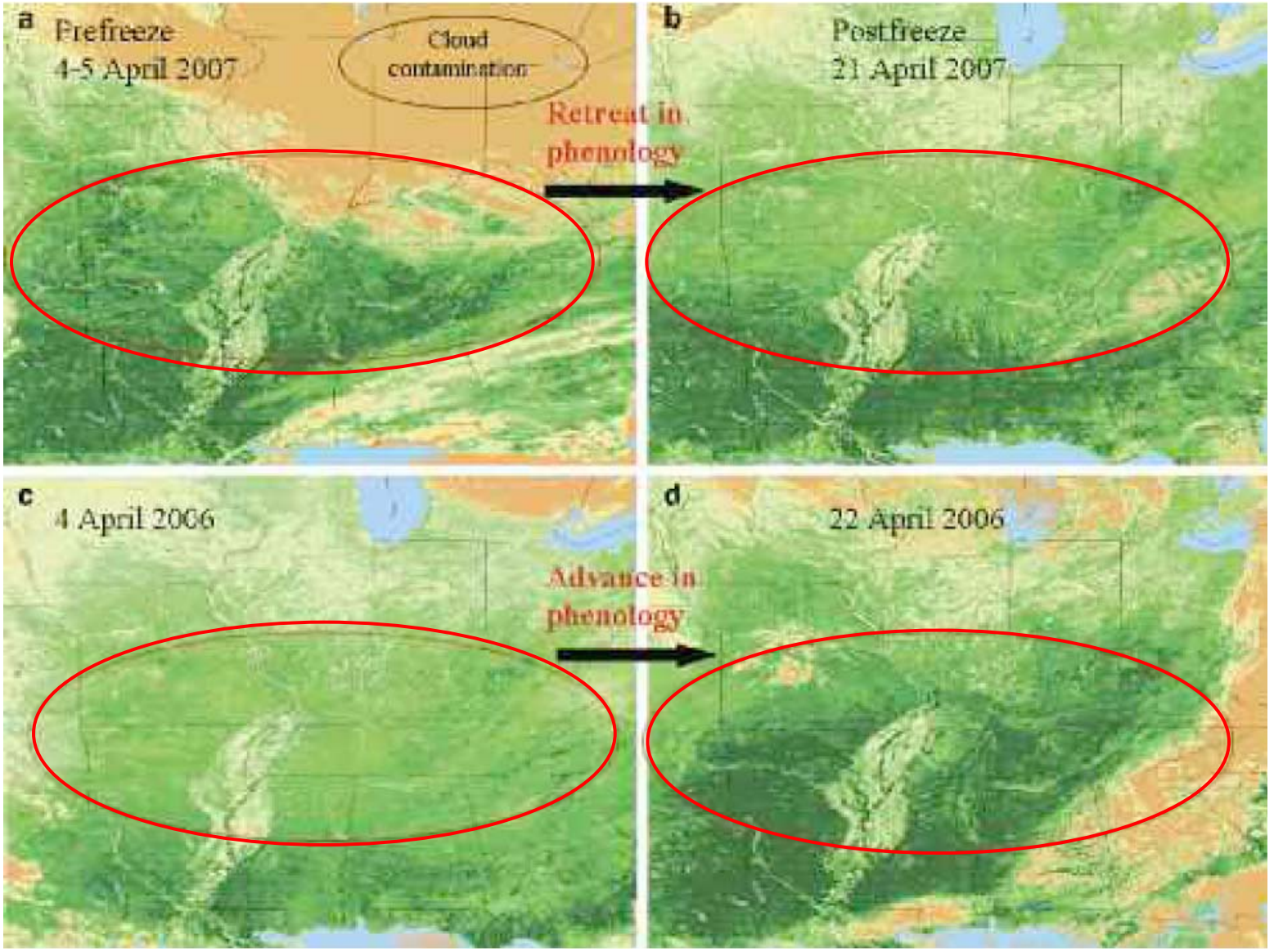


Long et al. 2006 Science

Effect of increased weather variability on ecosystems



Effect of increased weather variability on ecosystems



Gu et al. 2008 BioScience

Effect of CO_2 and temperature on plant-pest interactions

Anthropogenic increase in carbon dioxide compromises plant defense against invasive insects

Jorge A. Zavala*†, Clare L. Casteel*‡, Evan H. DeLucia*‡, and May R. Berenbaum*§¶

Sharply increased insect herbivory during the Paleocene–Eocene Thermal Maximum

Ellen D. Currano*††, Peter Wilf*, Scott L. Wing†, Conrad C. Labandeira†§, Elizabeth C. Lovelock¶, and Dana L. Royer‖

Review

New Phytologist

Tansley review

Insect-damaged fossil leaves record food web response to ancient climate change and extinction

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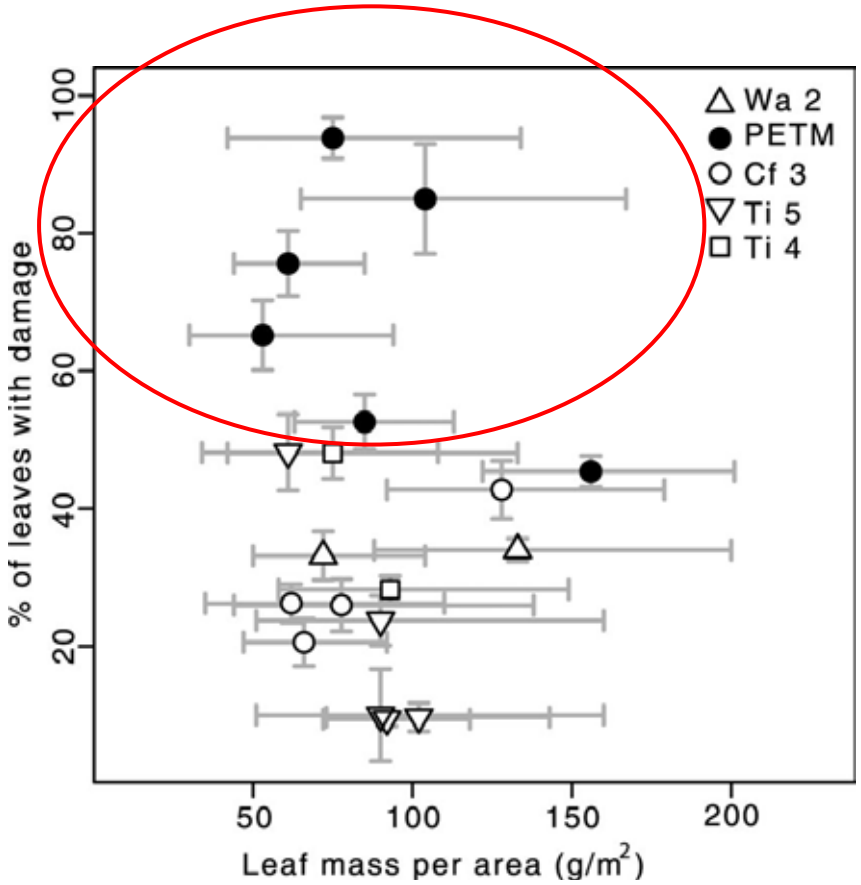
P. Wilf
Department of Geosciences, Pennsylvania State University, University Park, PA 16802, USA

Rising temperature is associated with increased herbivory in multiple studies, a result with major predictive importance for current global warming. Diverse floras are usually associated with diverse insect damage; however, recovery from the end-Cretaceous extinction reveals uncorrelated plant and insect diversity as food webs rebuilt chaotically from a drastically simplified state. Calibration studies from living forests are needed to improve interpretation of the fossil data.

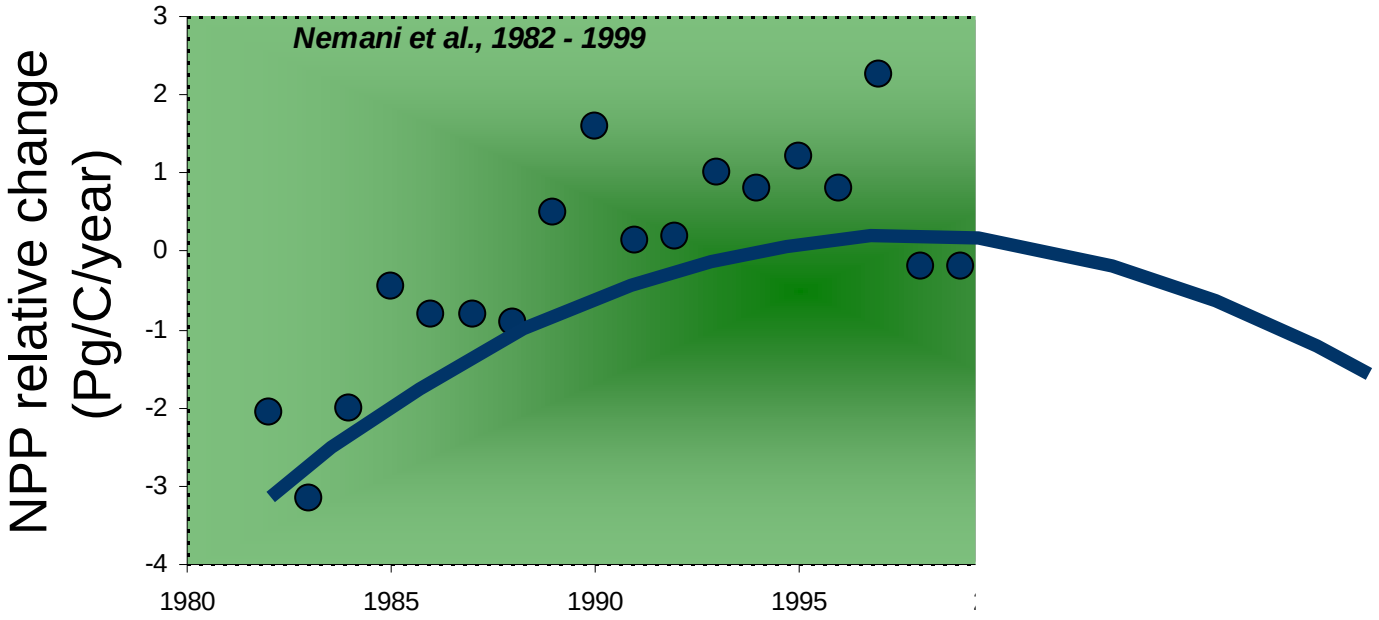
Paleocen-Eocen Thermal Maximum (PETM)

55.8 milions year ago:

- 3-fold increase of atm. CO_2
- Global temp. Increas by ≈ 5°C in 10 000 years
- Increased insect damage in angiosperm plant is probably the result of combined CO_2 and temperature effects

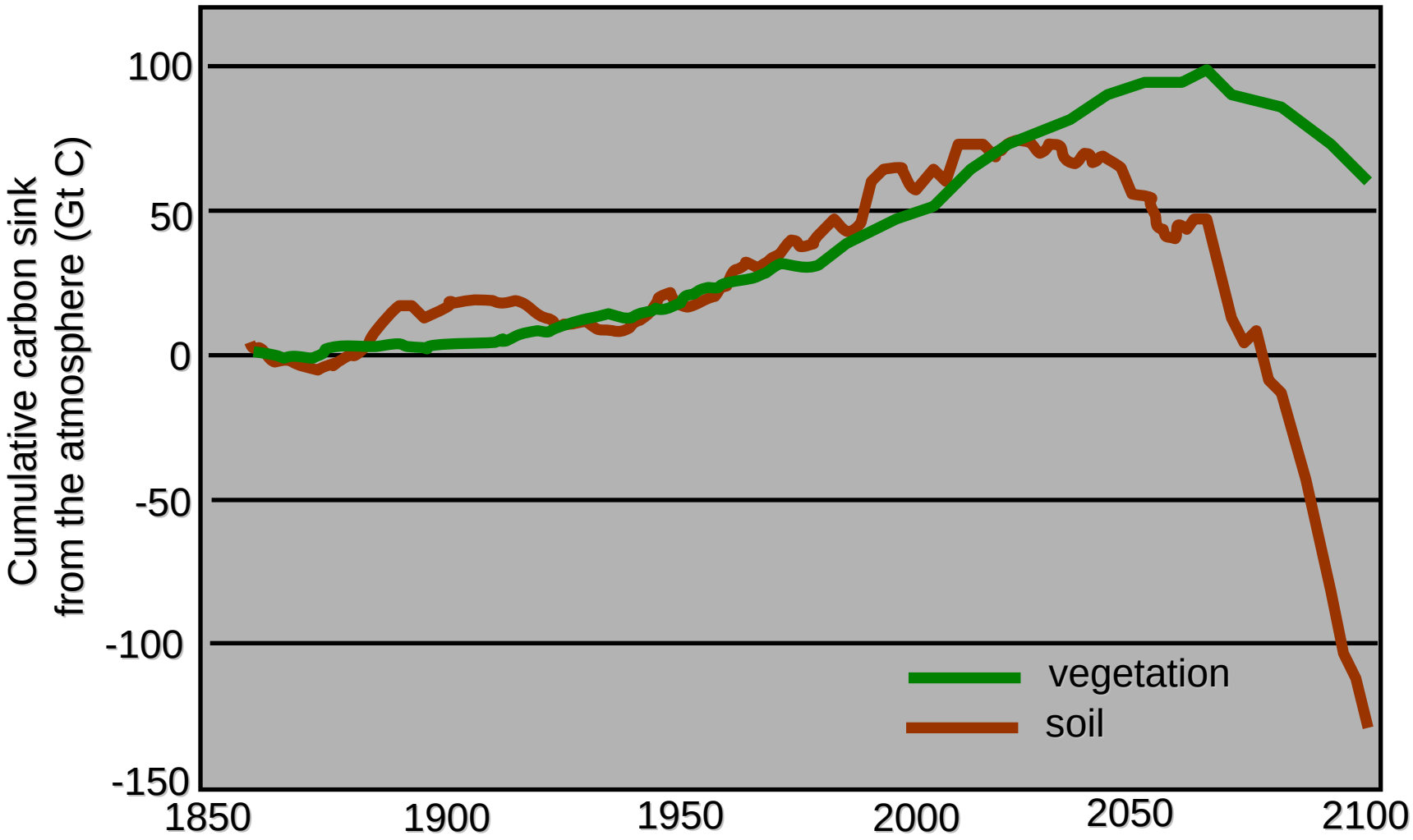


Observations of global NPP



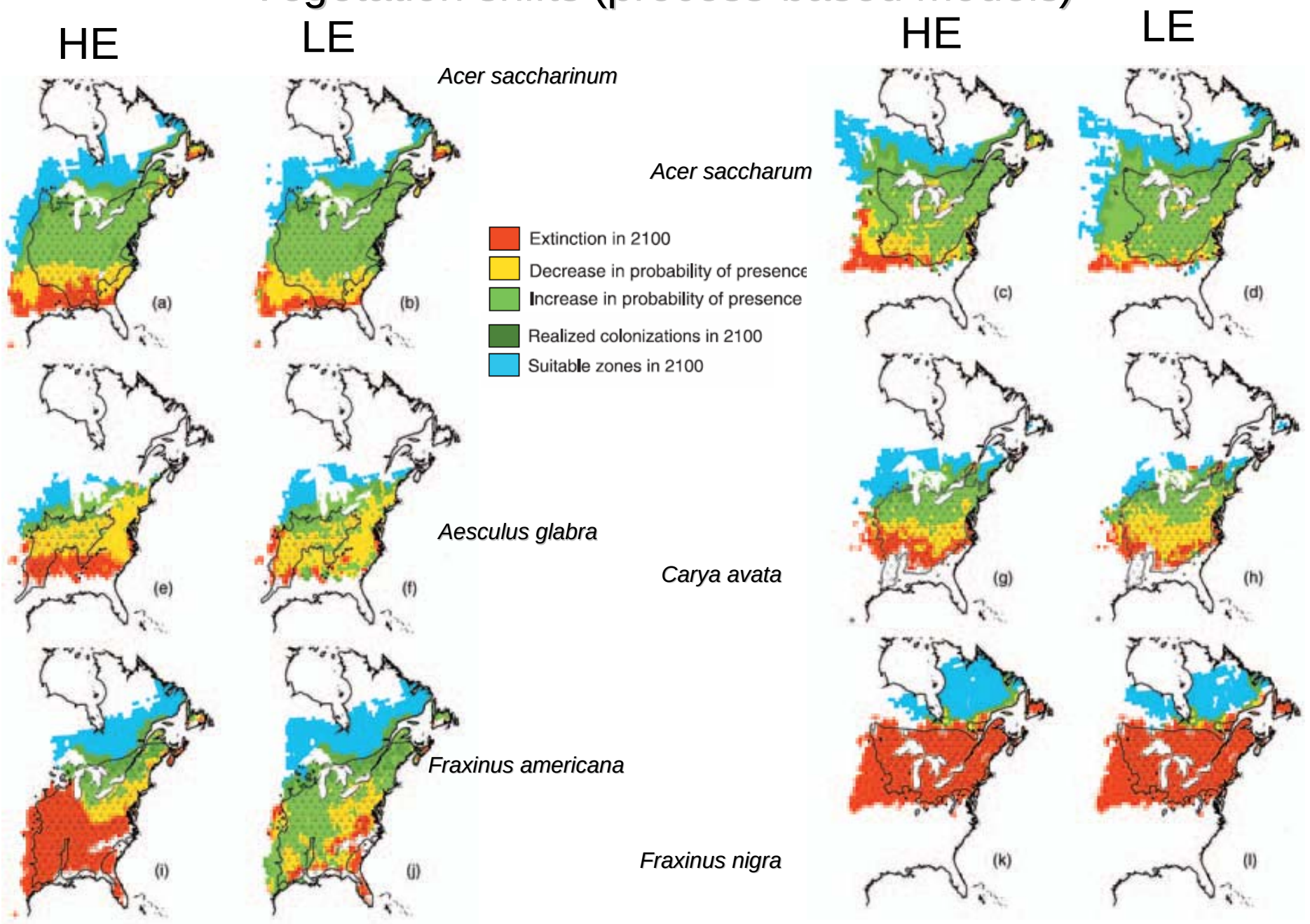
Running et. al., 2010

What do climate models expect?



Cox et al., Nature 2000

Vegetation shifts (process-based models)



Morin et al., Journal of Ecology 2008

Vegetation shifts (process-based models)

Climate change has already caused distribution shifts in many species, and climate predictions strongly suggest that these will accelerate in the future.

16 North american tree species, local extinctions in the south of species ranges (21% of the present distribution, on average)

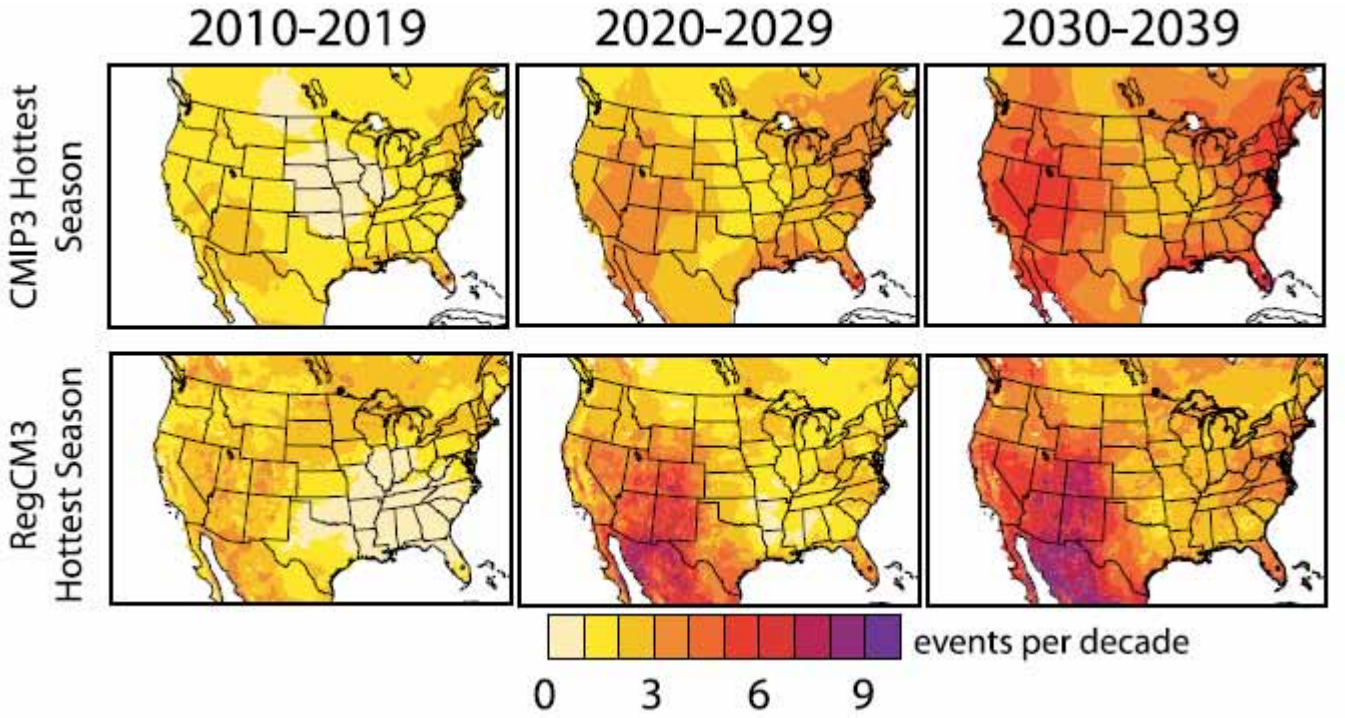
colonizations of new habitats in the north, though these are limited by dispersal ability for most species.

Distribution shifts are very species-specific, however the loss of habitats southward will be mostly due to **increased drought mortality and decreased reproductive success**

northward colonizations will be primarily promoted by **increased probability of fruit ripening and flower frost survival**

Morin et al., Journal of Ecology 2008

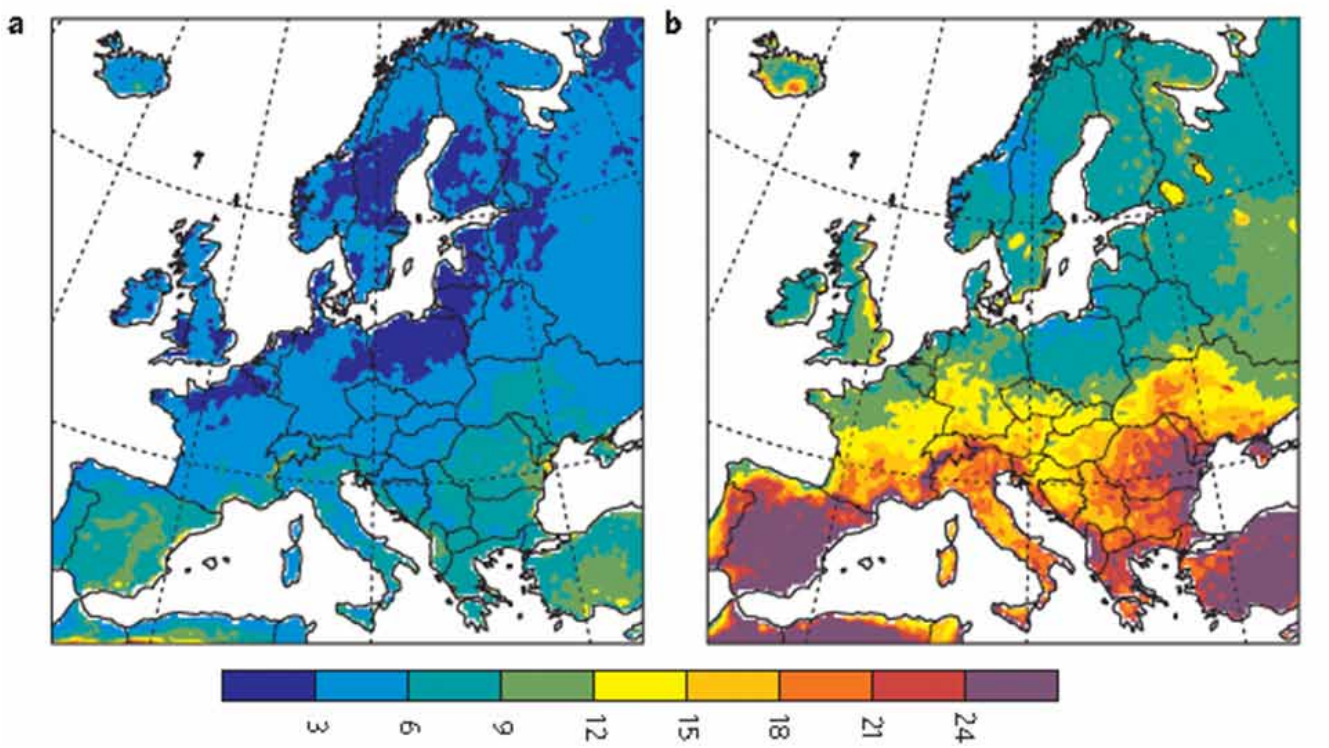
Occurence of extreme heat waves will increase



Diffenbaugh a Ashfaq, Geophys. Res. Lett., 2010

… also in Europe

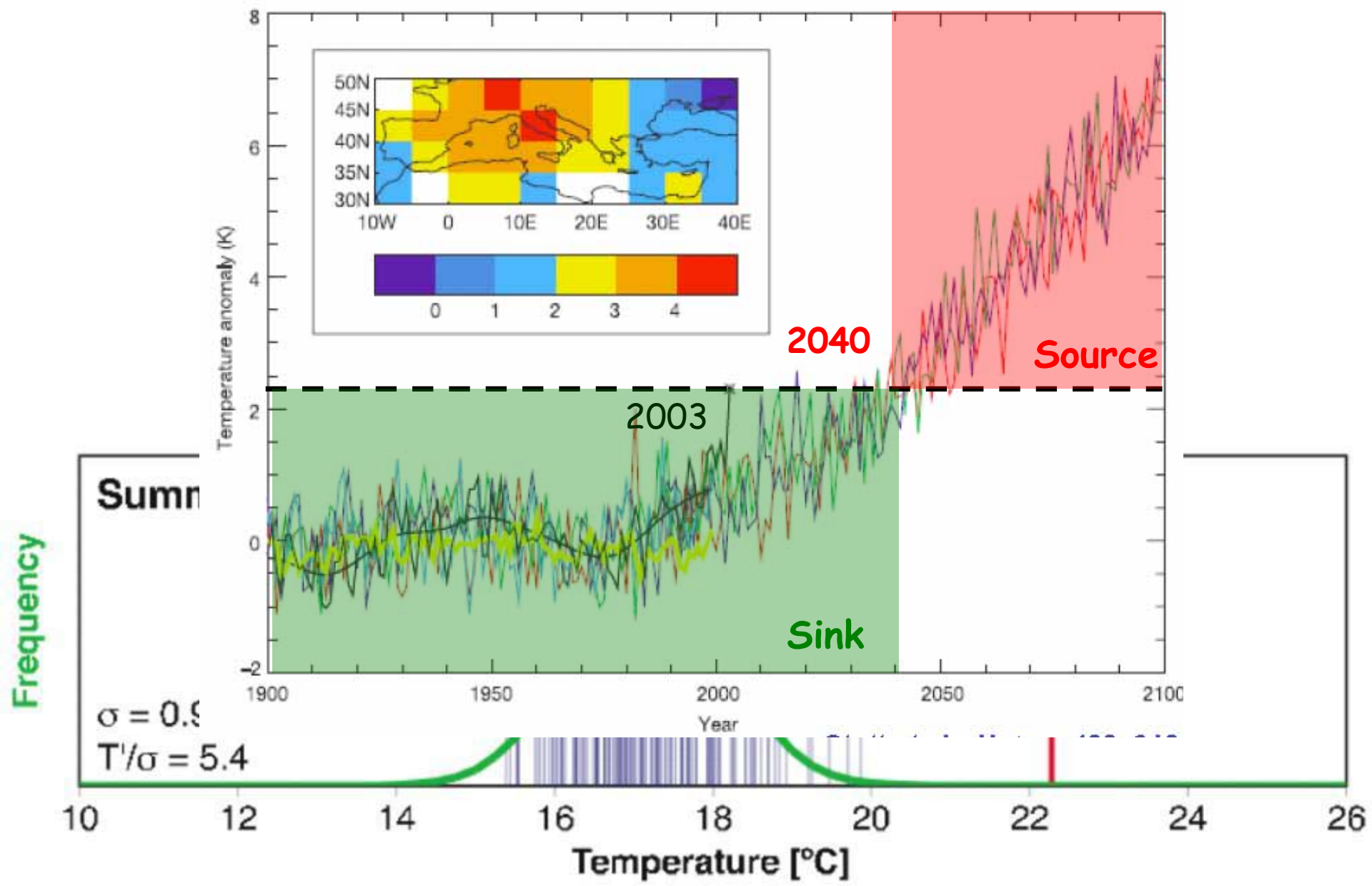
Increased heat wave frequency as compared to normal (1961-1990)



2021-2050 2071-2100

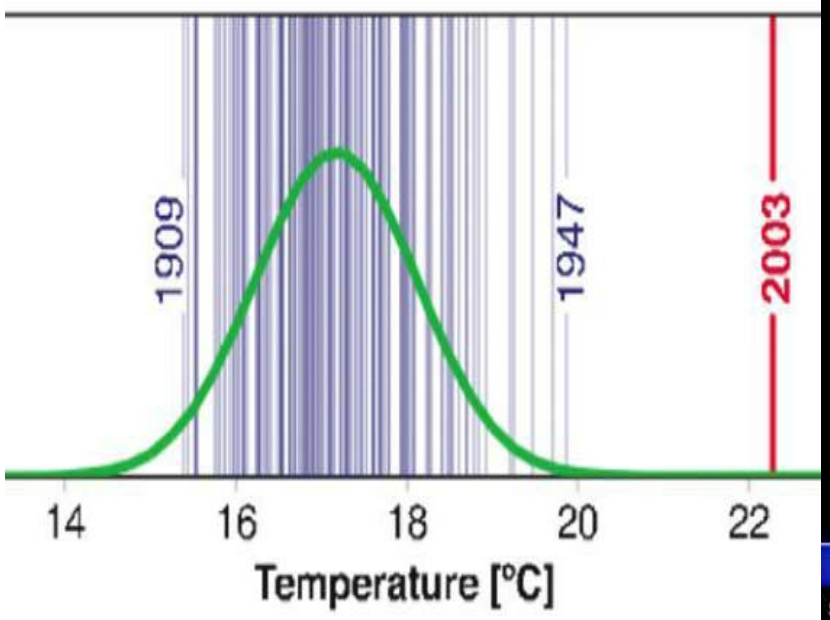
Fischer and Schaer, Nature Geoscience, 2010

Probability of heatwaves has already doubled in Europe

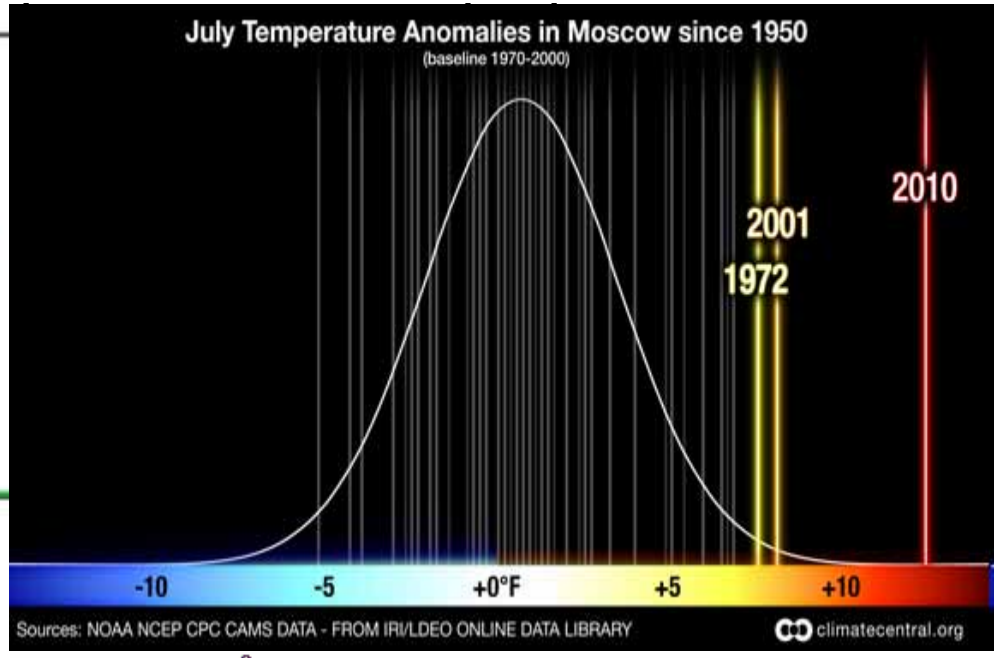


Stott et al., Nature, 2004

Heat wave in Russia



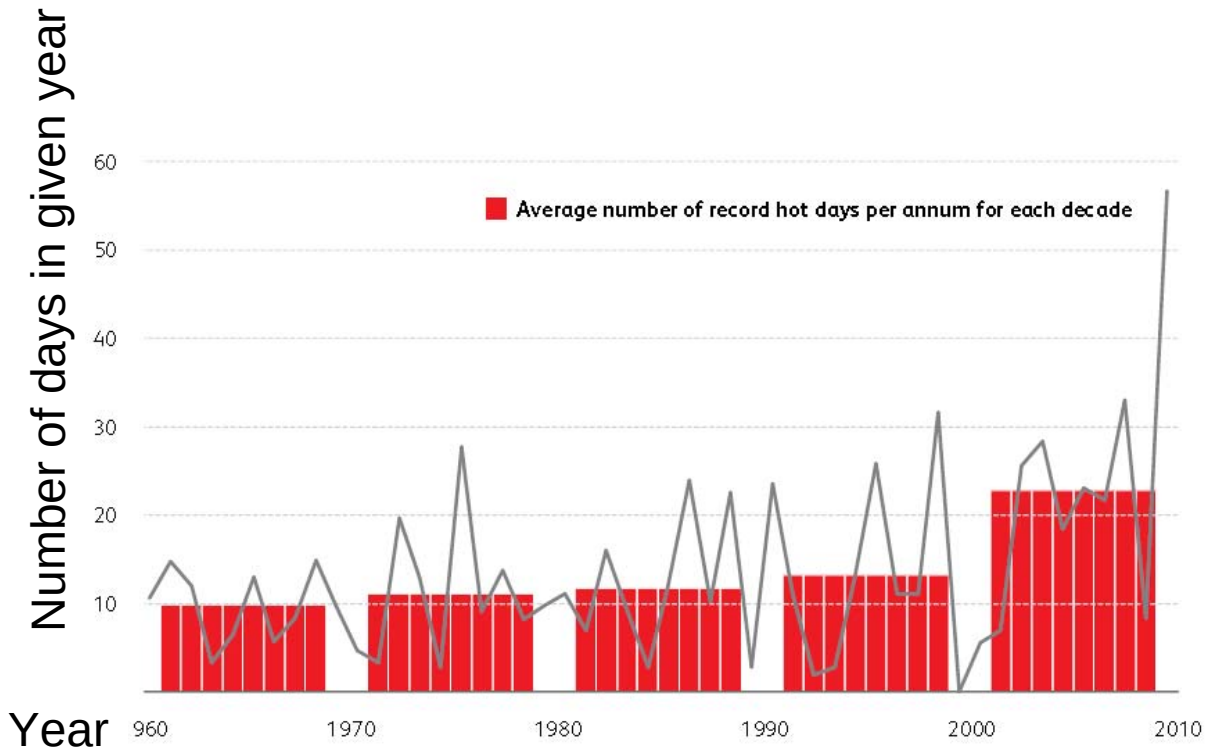
Once in 500 years



Once in 1000 years

NOAA/ESRL, 2010

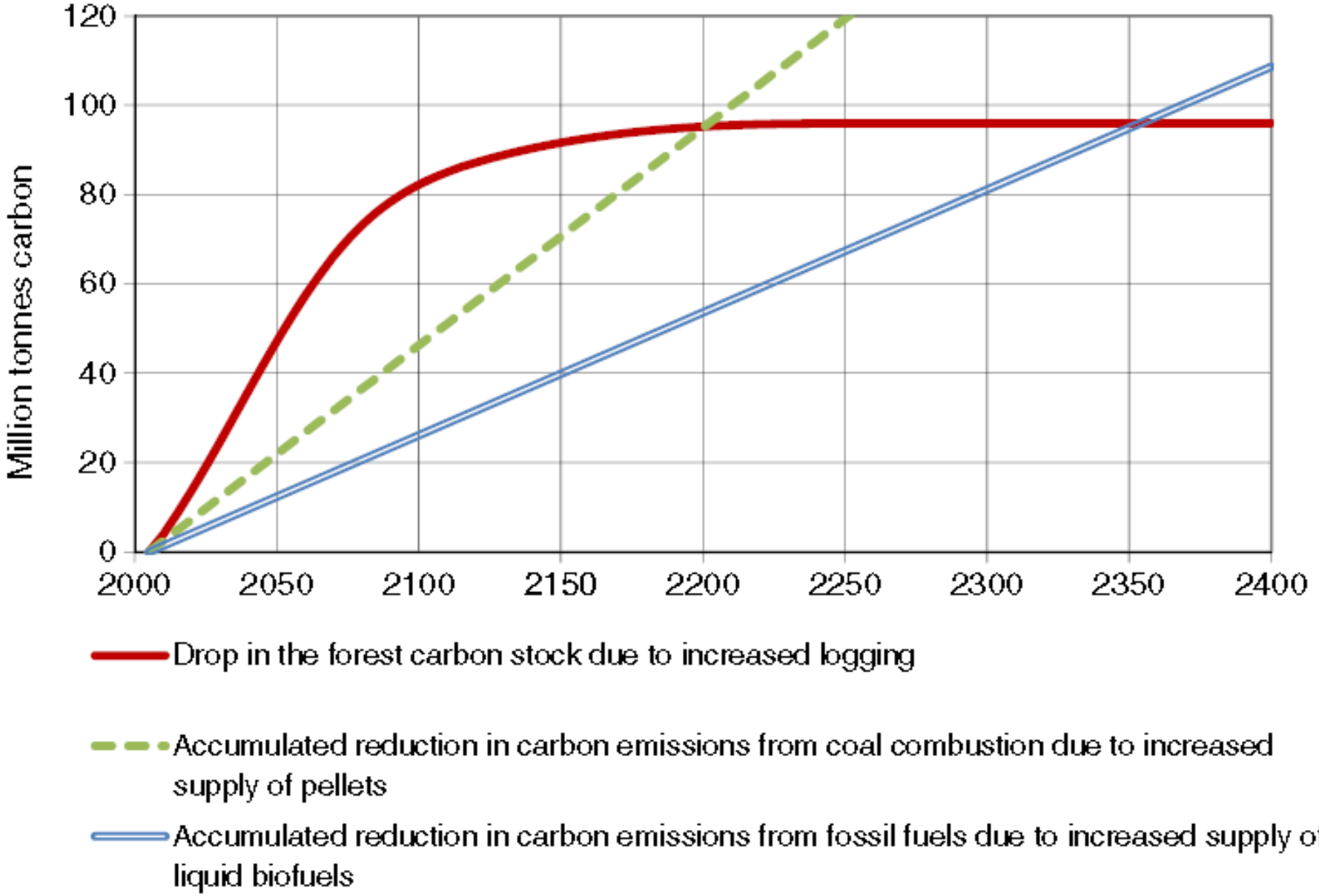
Average number of reacord hot temperatures in Australia



Bureau of Meteorology, Australia, 2010

Temperatures and wildfires in australia

Biomass as an renewable energy source?



Holtsmark, 2011

Conclusions

- Climatic extremes (droughts and floods) will be more frequent and larger
- Ability of the forest ecosystems to absorb carbon will decline in the future
- Climate change poses increasingly difficult challenge for long-term forest management

Thank You for attention