What's a Tree Got to do With It?
U.S. Forests and Climate Change 101

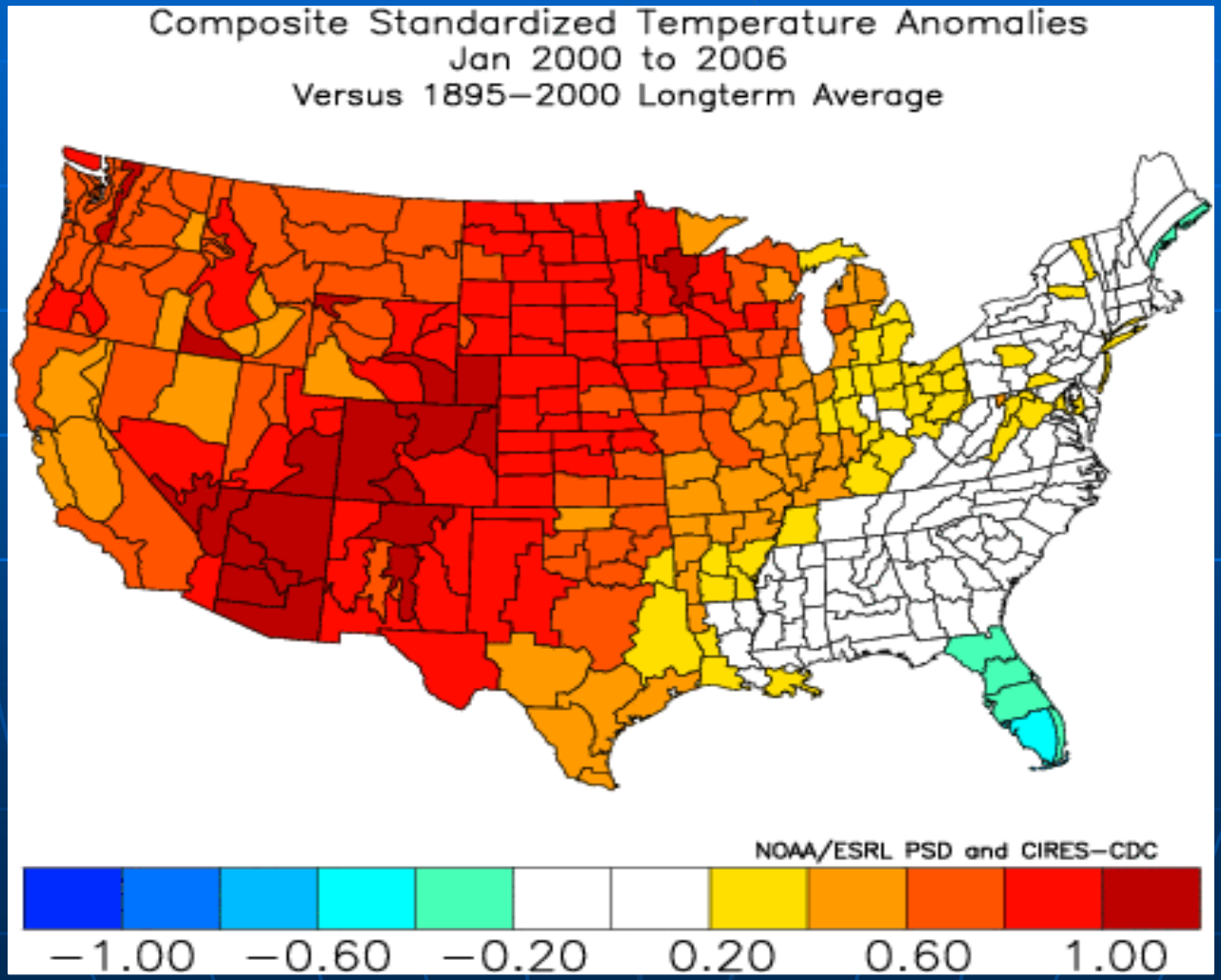
Sally Ride Science Educator Conference
July 23, 2008 - Silver Spring MD

Allen M. Solomon
National Program Leader for Global Change Research
US Forest Service

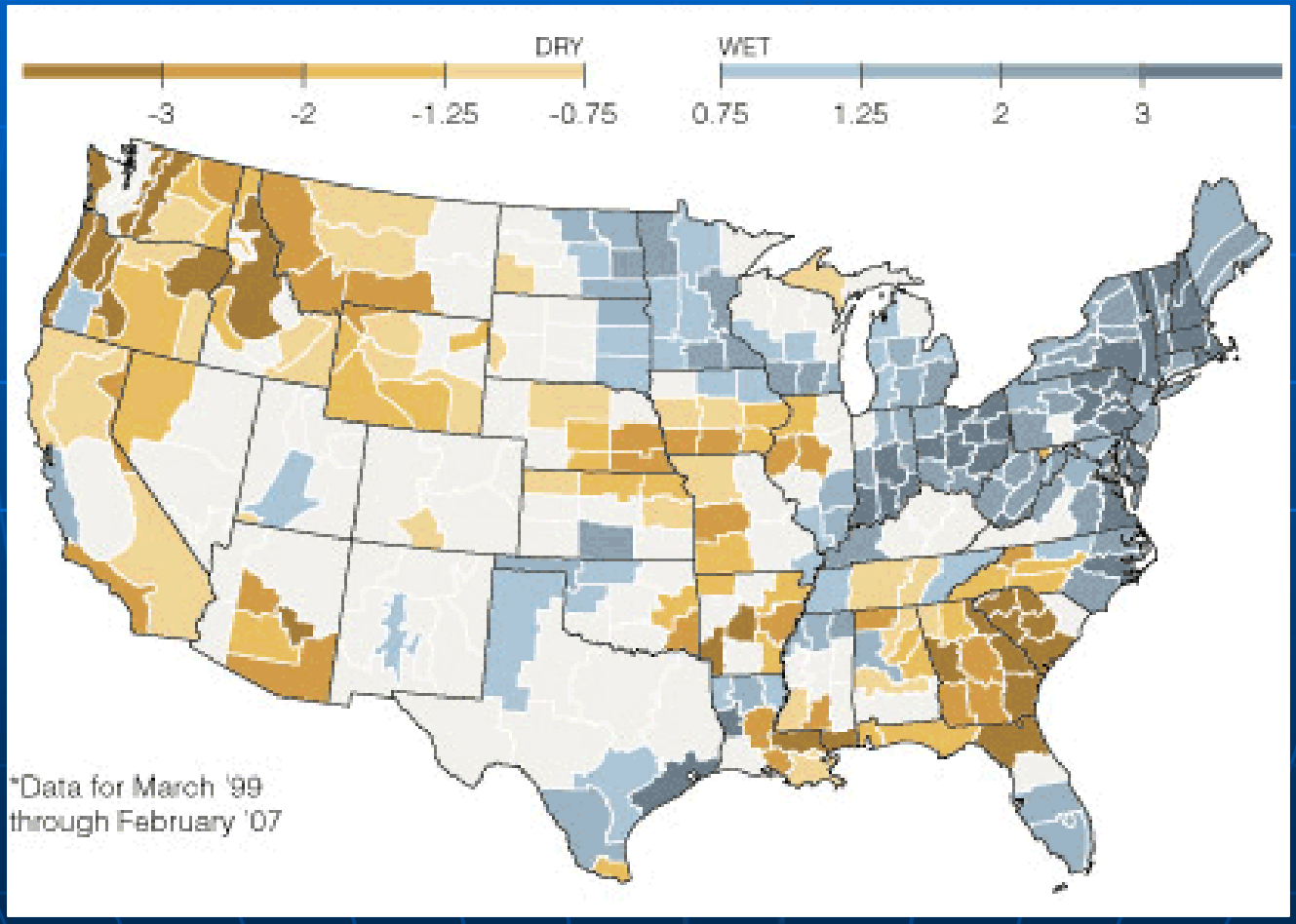
Roadmap of the Talk

- What is the pattern of US climate change so far and how much can we expect in this century?
- How do trees and forests regulate atmospheric greenhouse gases?
- What stresses on our forest ecosystems have we seen and what more should we expect?
- What can be done to help sustain and protect trees and forests from impacts of changing climate?

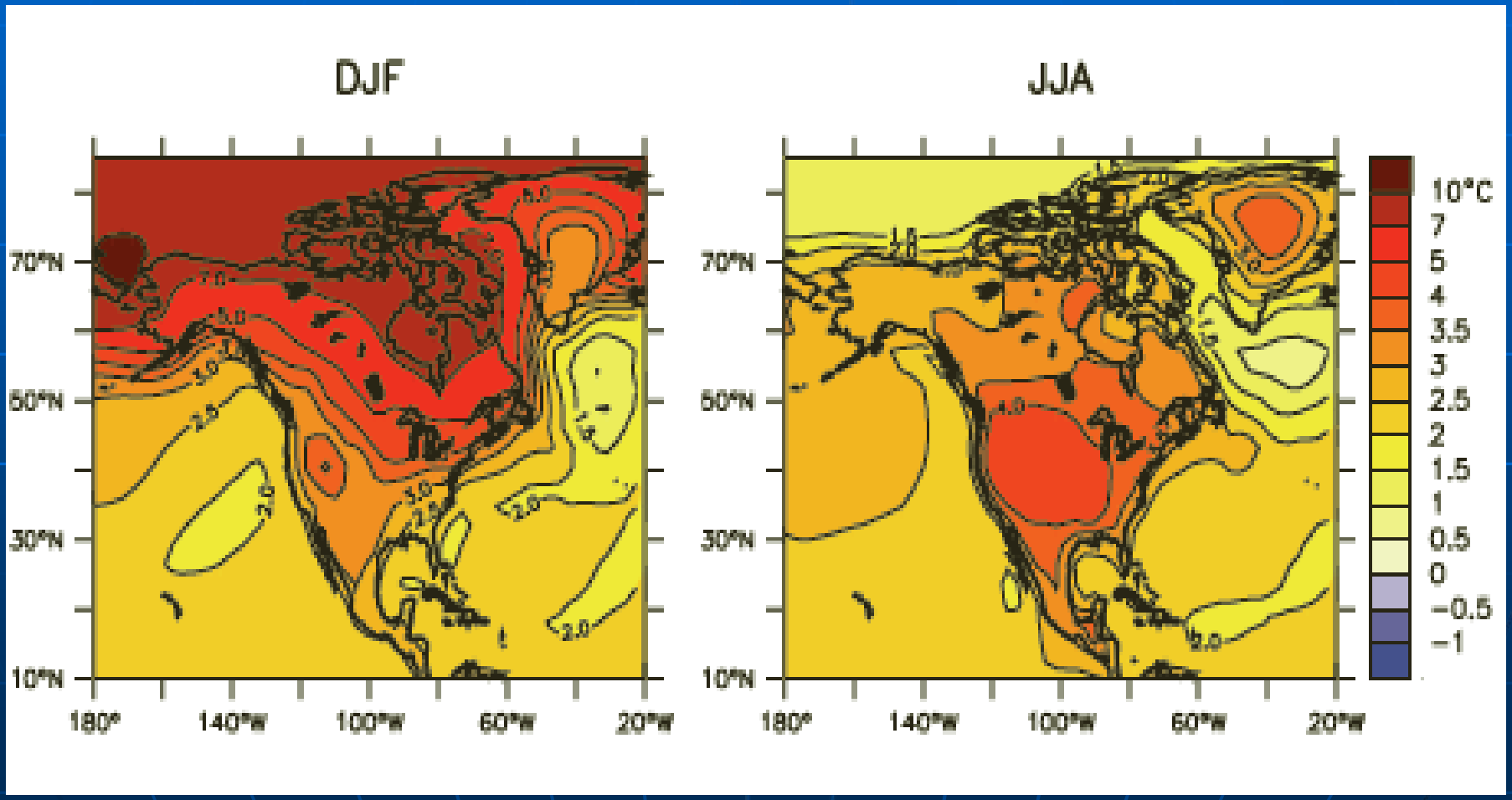
U.S. Temperature Anomalies: 2000-2006 versus 1895-2000



U.S. Precipitation Anomalies: 1999-2007 Palmer Drought Severity Index

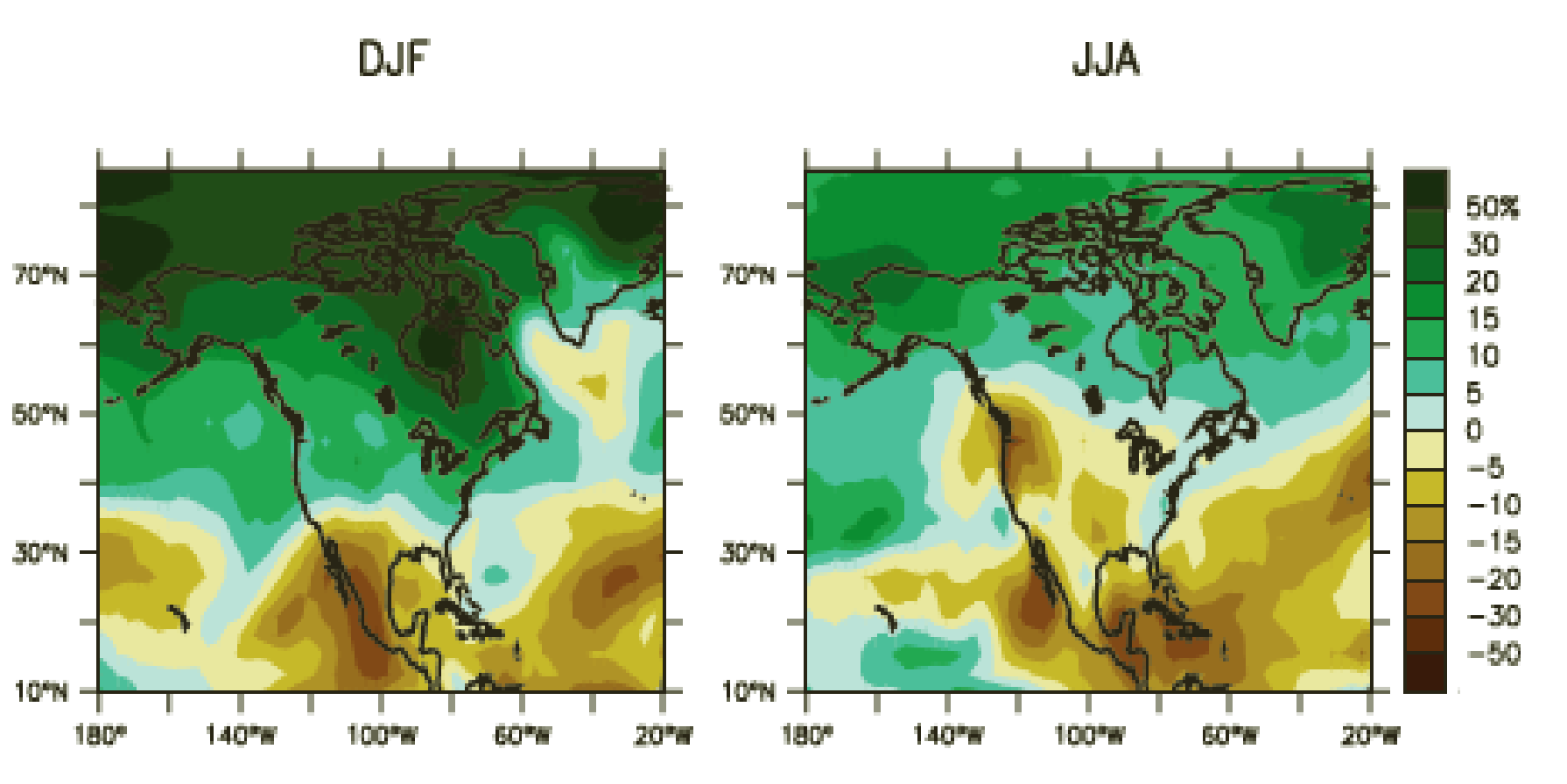


Temperatures at the end of the 21st Century: 2080-2099 compared to 1980-1999



IPCC Fourth Assessment Report, Working Group I, 2007

Precipitation at the end of the 21st Century 2080-2099 compared to 1980-1999

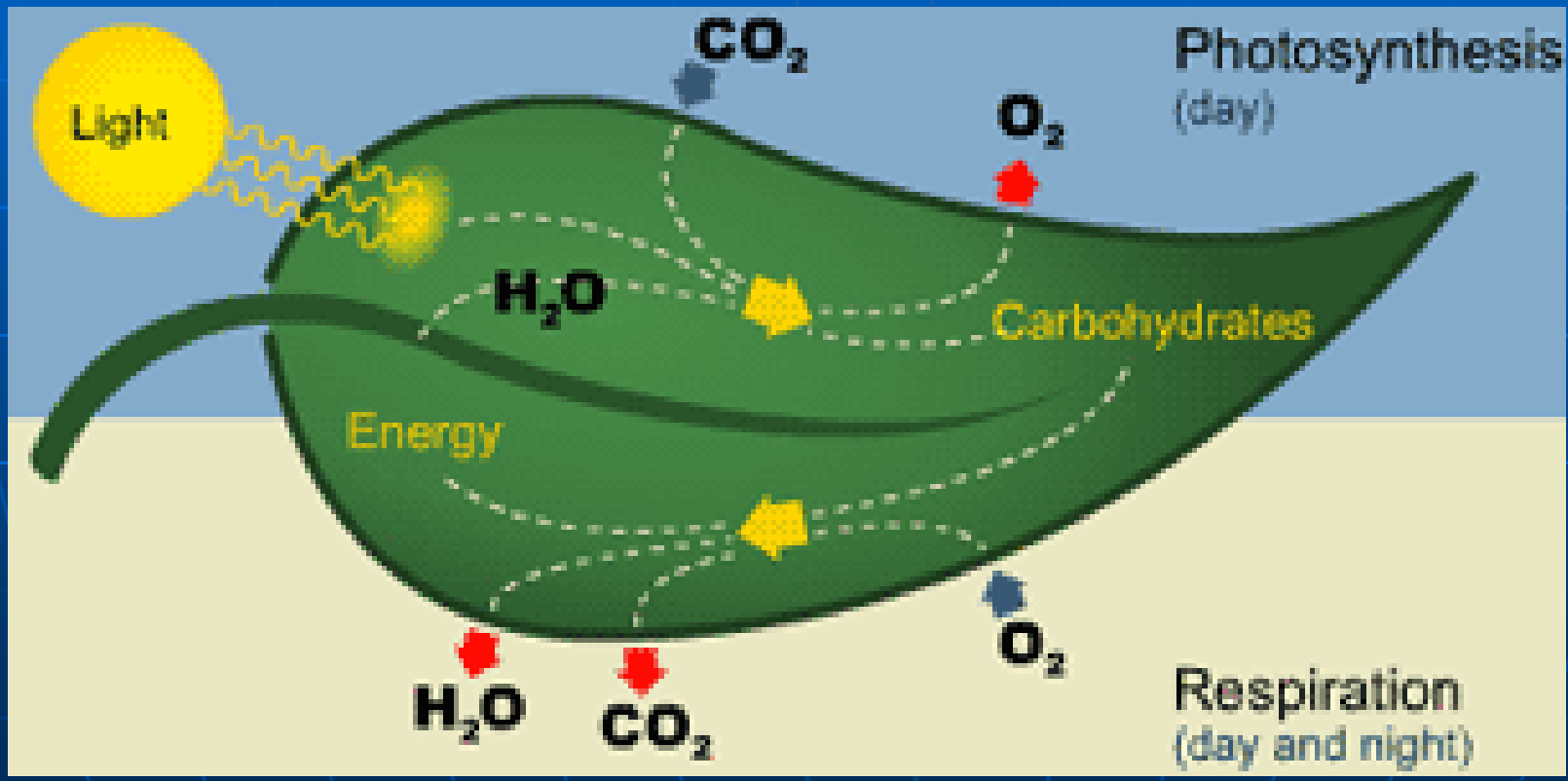


IPCC Fourth Assessment Report, Working Group I, 2007

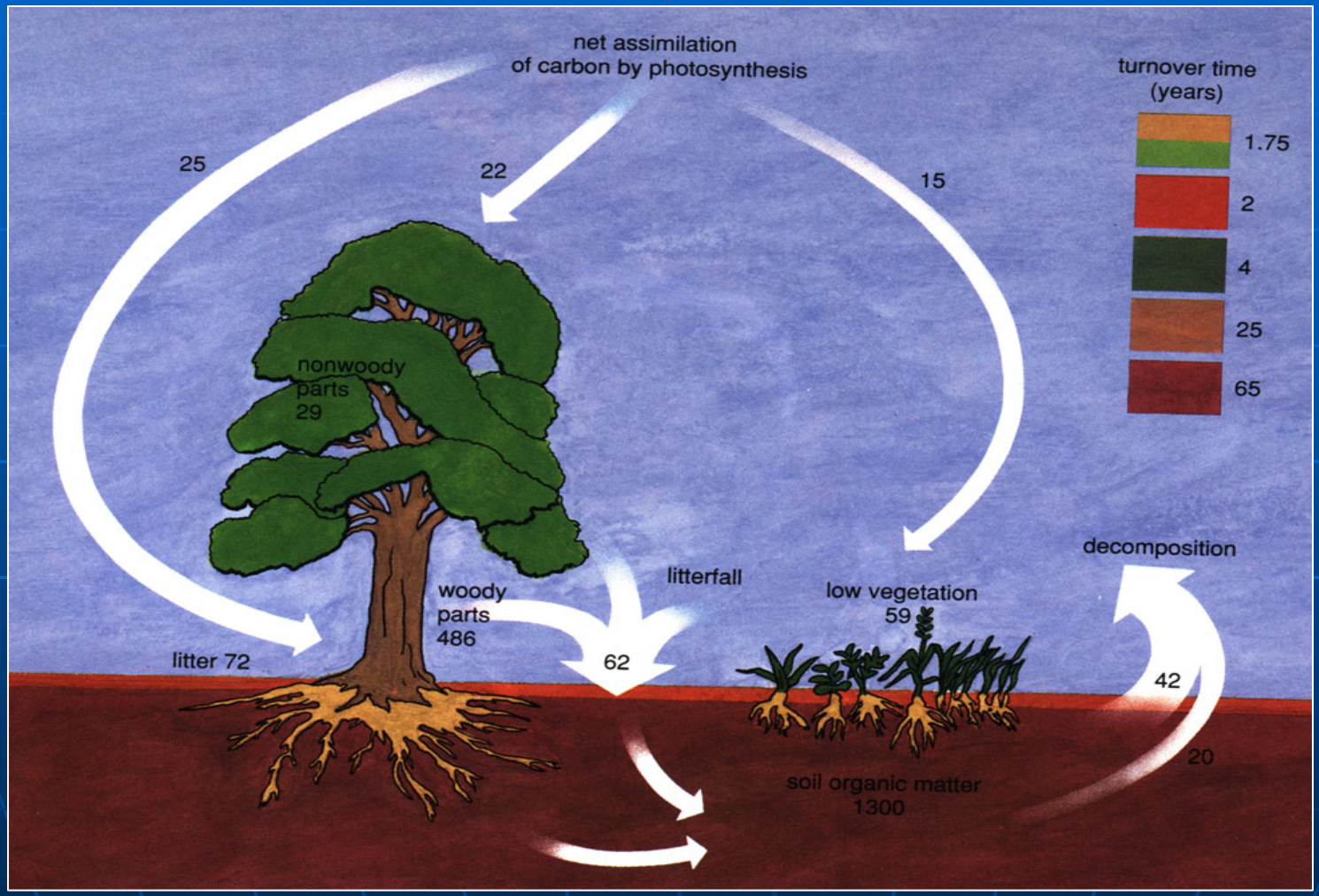
Roadmap of the Talk

- What is the pattern of US climate change so far and how much can we expect in this century?
- How do trees and forests regulate atmospheric greenhouse gases?
- What stresses on our forest ecosystems have we seen and what more should we expect?
- What can be done to help sustain and protect trees and forests from impacts of changing climate?

Capturing Carbon from the Atmosphere: What it takes



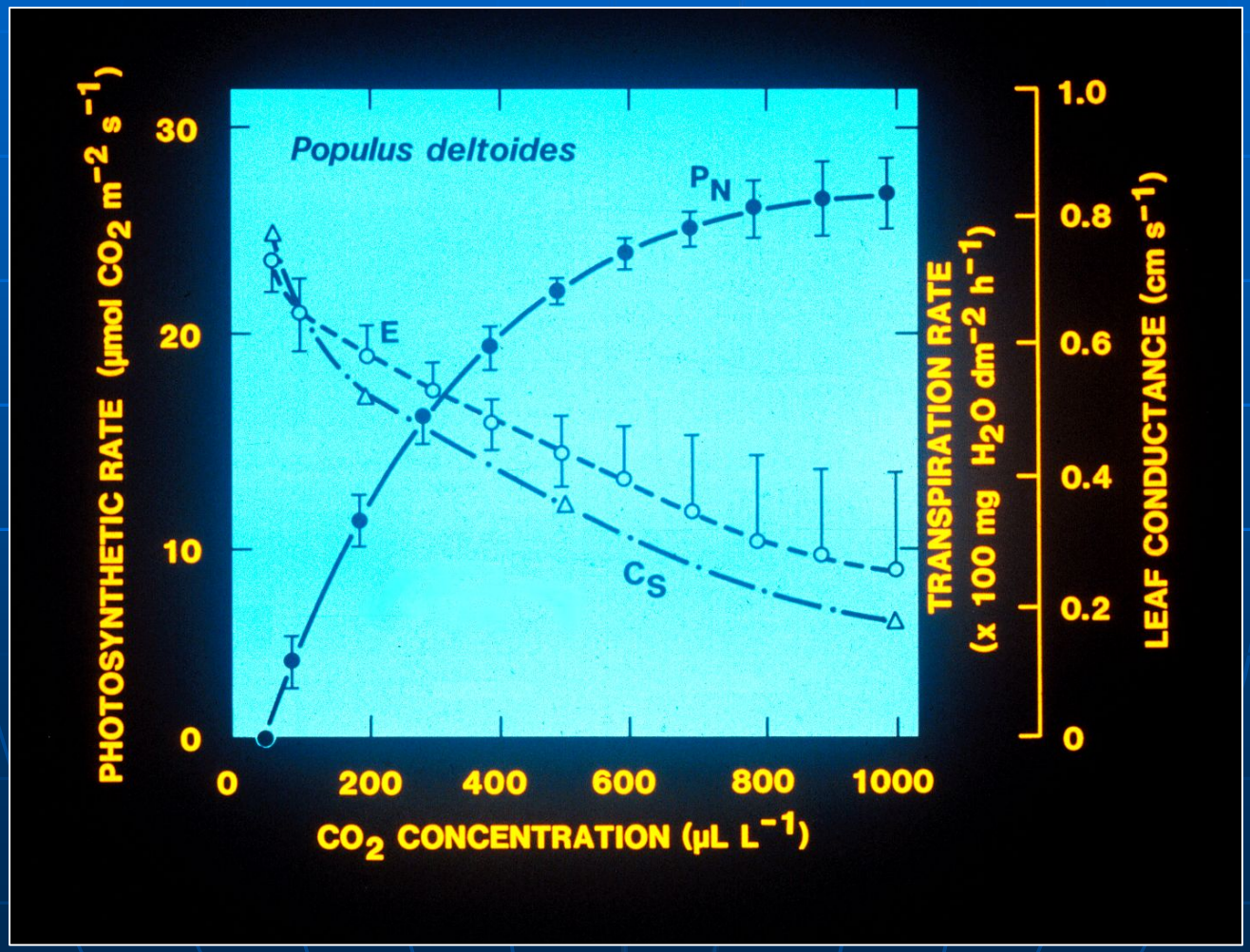
Terrestrial Portion of the Global Carbon Cycle



Post, W.M., T.H. Peng, W. R. Emanuel, A.W. King, V.H. Dale and D.L. DeAngelis. The global carbon cycle. American Scientist 78:310-326, 1990.

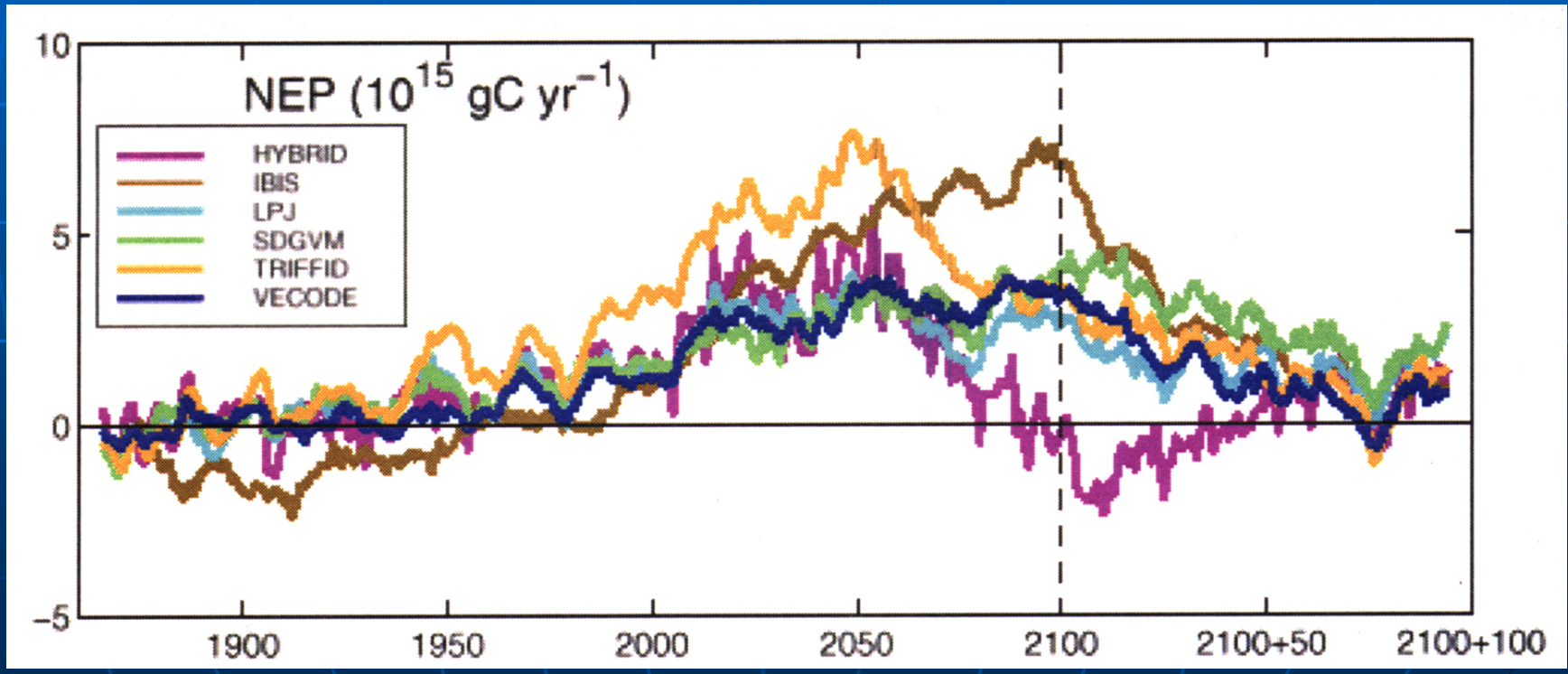
Yearly Carbon Uptake and Storage: Younger is Faster

Direct Effects of CO_2: Greater Growth, More Drought Resistance



D.L Regehr, FA Bazzaz, WR Boggess, 1975. Photosynthetica 9:52-61

Modeled Net Ecosystem Productivity from Year 1800 to 2200: Carbon Gain then Saturation



Cramer, W. and 16 others, 2001. Global Change Biology 7:357 - 373

Roadmap of the Talk

- What is the pattern of US climate change so far and how much can we expect in this century?
- How do trees and forests regulate atmospheric greenhouse gases?
- What stresses on our forest ecosystems have we seen and what more should we expect?
- What can be done to help sustain and protect trees and forests from impacts of changing climate?

Direct Effects of Climate Change: Gradually Increasing Temperatures

Growth slows, mortality increases

- Trees on poorest sites die first
- Large old trees and seedlings and saplings die more quickly

Direct Effects of Climate Change on Forests: Black and White Spruce Dieback in Alaska

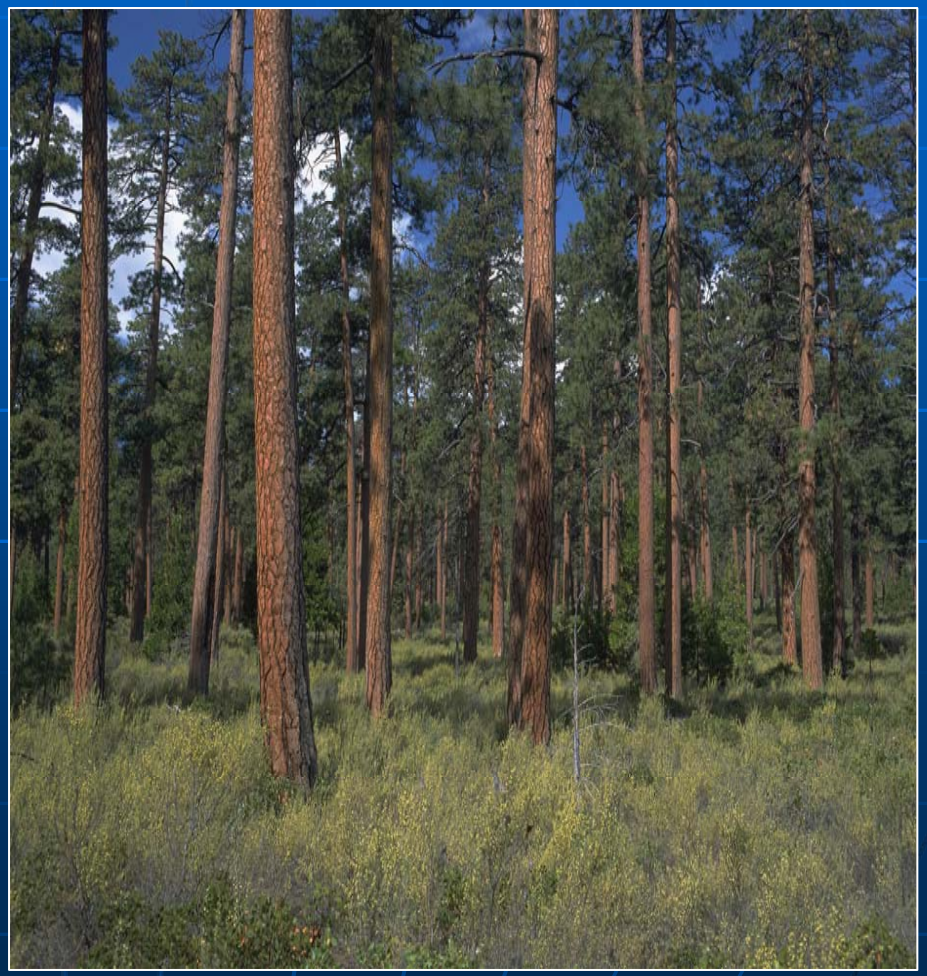
Direct Effects of Climate Change on Forests: Increasing Hurricane Intensity

Katrina damaged or destroyed 19 billion board feet of timber up to 100 miles inland

Along with higher sea levels, hurricanes are likely further north on the Atlantic Coast.

Direct Effects of Atmospheric CO_2 and Management on Forests: Enhanced Tree Density at All Vertical Levels

- Grazing consumed fine fuels for the past 100+ years
- Fire suppressed for the past 50 years
- Logging reduced for the past 20 years



Direct Effects of Atmospheric CO_2 and Management on Forests: Enhanced Tree Density at All Vertical Levels

- Grazing consumed fine fuels for the past 100+ years
- Fire suppressed for the past 50 years
- Logging reduced for the past 20 years

Indirect Effects of Climate Change on Forests: Drought and Pests

Warmth and drought enhance epidemics in forests.

Insect and disease epidemics are increasing in number and spreading rapidly.

Photos by Craig Allen, US Geological Survey

Indirect Effects of Climate Change on Forests: Drought and Pests

Warmth and drought enhance epidemics in forests.

Insect and disease epidemics are increasing in number and spreading rapidly.

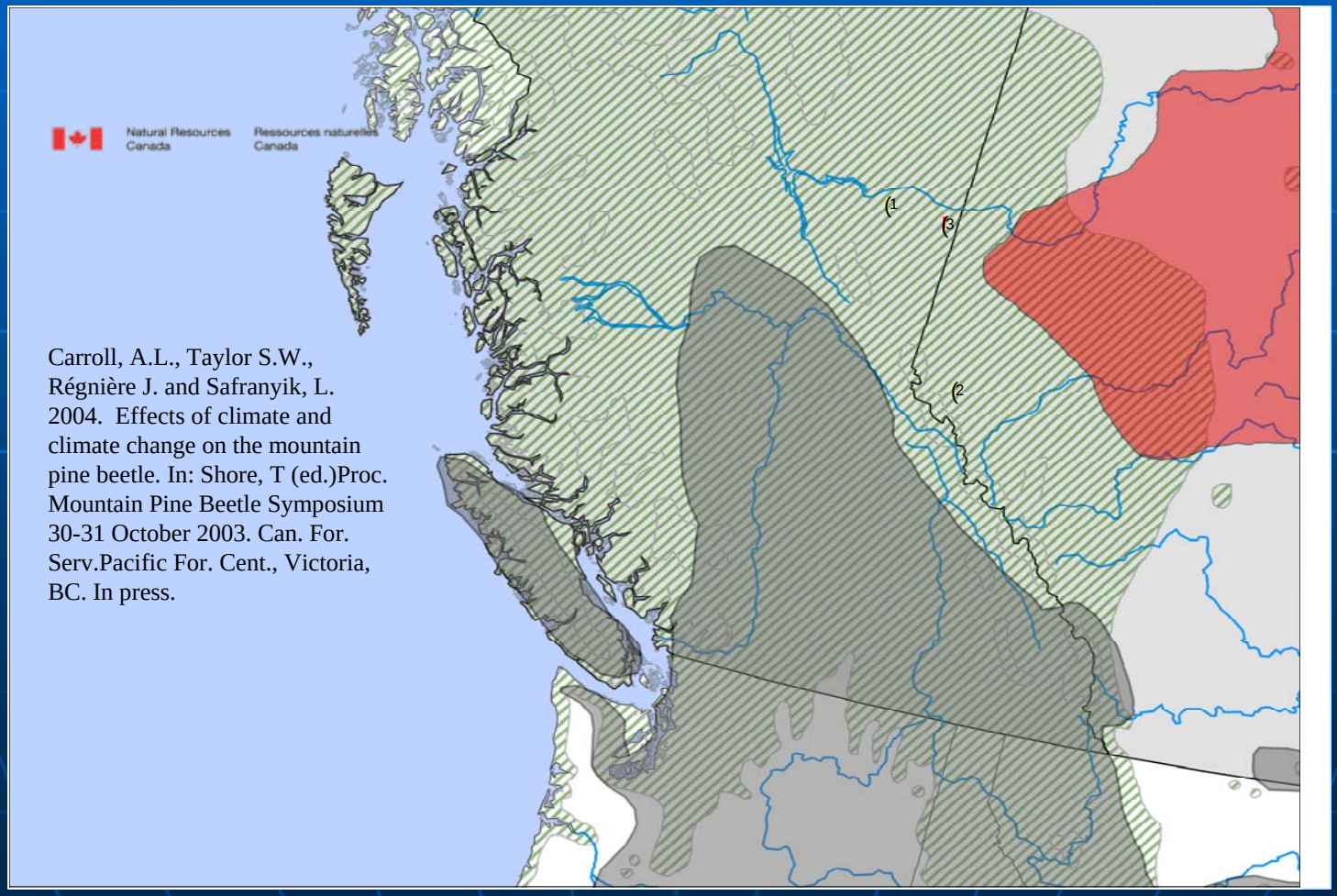
Photos by Craig Allen, US Geological Survey

Indirect Effects of Climate Change on Forests: Warmth and Pests

Winter Warming at higher latitudes Permits:

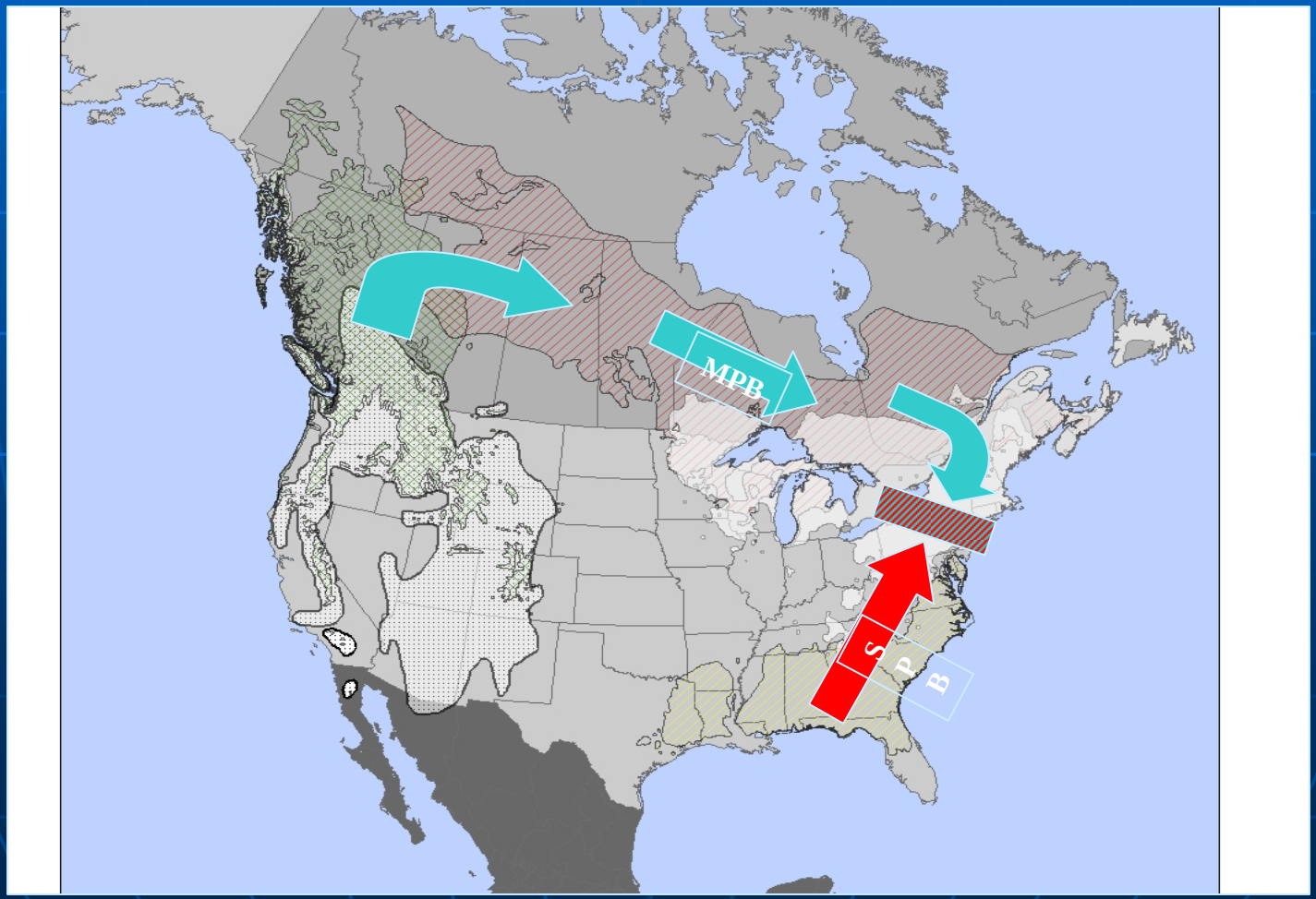
- More insect generations each year
- Insect survival over winter
- Rapid insect migration north

Lodgepole Pine Range, Jack Pine Range and the Mountain Pine Beetle: A Climate-driven Catastrophe Ready to Happen



Carroll, A.L., Taylor S.W., Régnière J. and Safranyik, L. 2004. Effects of climate and climate change on the mountain pine beetle. In: Shore, T (ed.)Proc. Mountain Pine Beetle Symposium 30-31 October 2003. Can. For. Serv.Pacific For. Cent., Victoria, BC. In press.

Lodgepole Pine Range, Jack Pine Range and the Mountain Pine Beetle: A Climate-driven Catastrophe Ready to Happen



Indirect Effects of Climate Change on Forests: Increasing Crown Fires

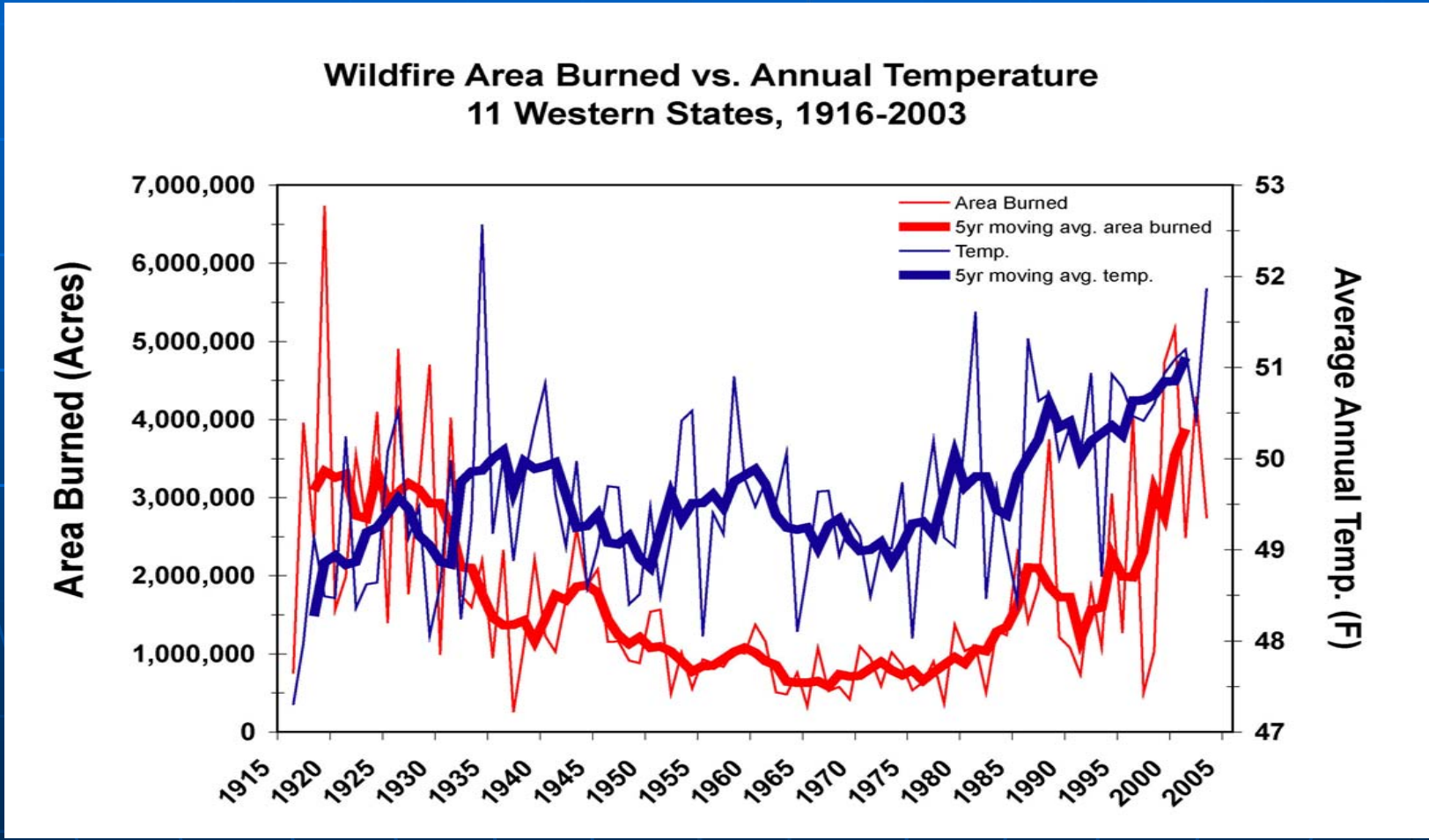
- Warming increases the frequency of intense stand-replacing fires
- Many large fires are in diseased and drought stressed forests

Following intense fire, different tree species will dominate

Soil organics and nutrients are oxidized and surfaces eroded

Changing climate makes recovery slow, uncertain

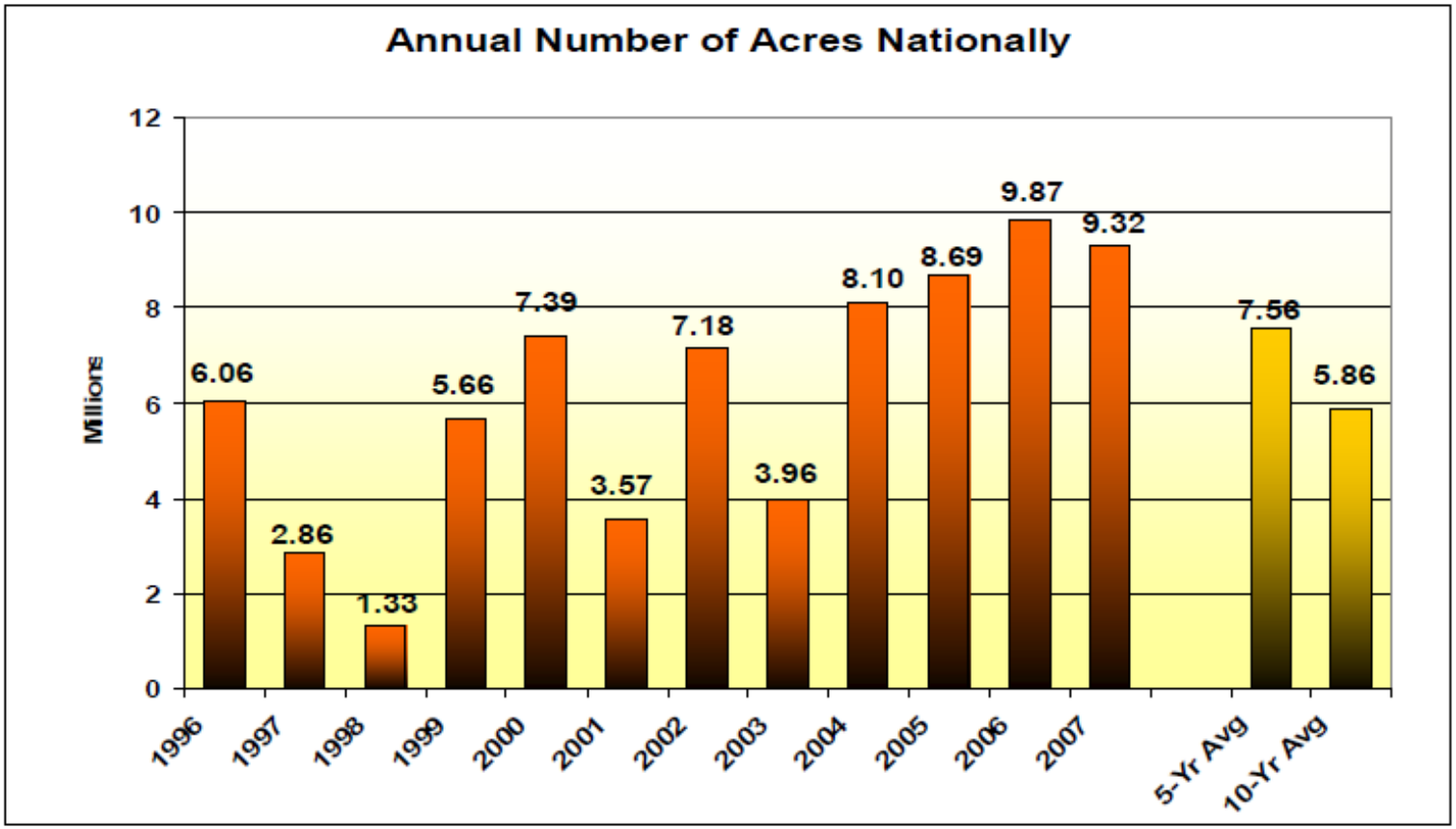
U.S. Forest Acres Burned Each Year 1910-2005



From J. Littell, data on file, University of Washington

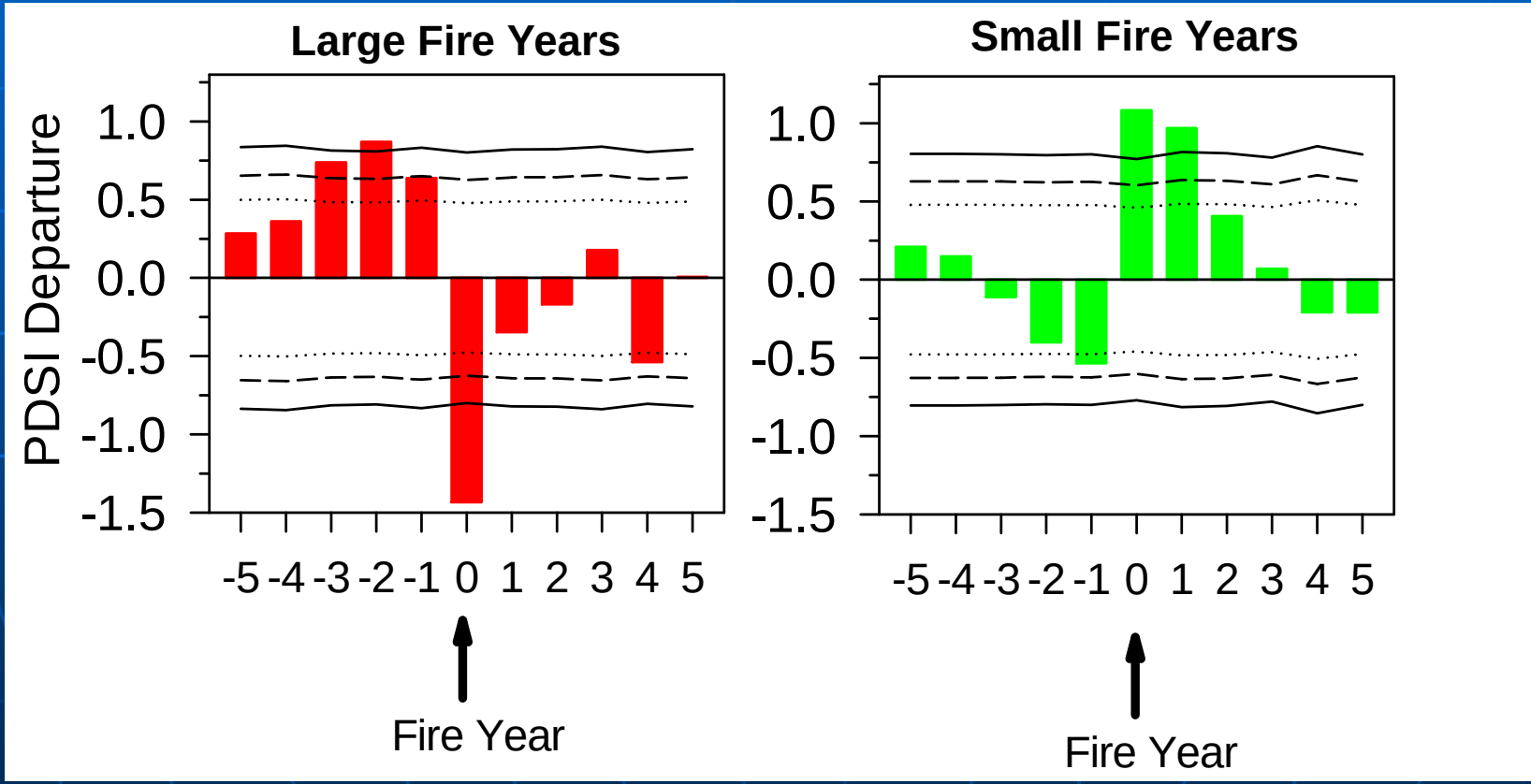
The Last Decade Has Seen the Most Intense Increase in Areas Burned

Wildfire Acres Reported to NICC



From the 2007 fire report on the NICC website.
http://www.nifc.gov/nicc/predictive/intelligence/2007_statssumm/2007Stats&Summ.html

Wildfire May Also Depend on Pattern of Drought Conditions in Previous Years



Swetnam TW, Baisan CH (2003)Tree-ring reconstructions of fire and climate history in the Sierra Nevada and south-western United States. In 'Fire and climatic change in temperate ecosystems of the Western Americas'. (Eds TTVeblen,WL Baker, B Montenegro,TW Swetnam) pp. 158–195.(Springer Verlag: NewYork)

Direct Effects of Climate Change on Forests: Synergy with Atmospheric Pollutants

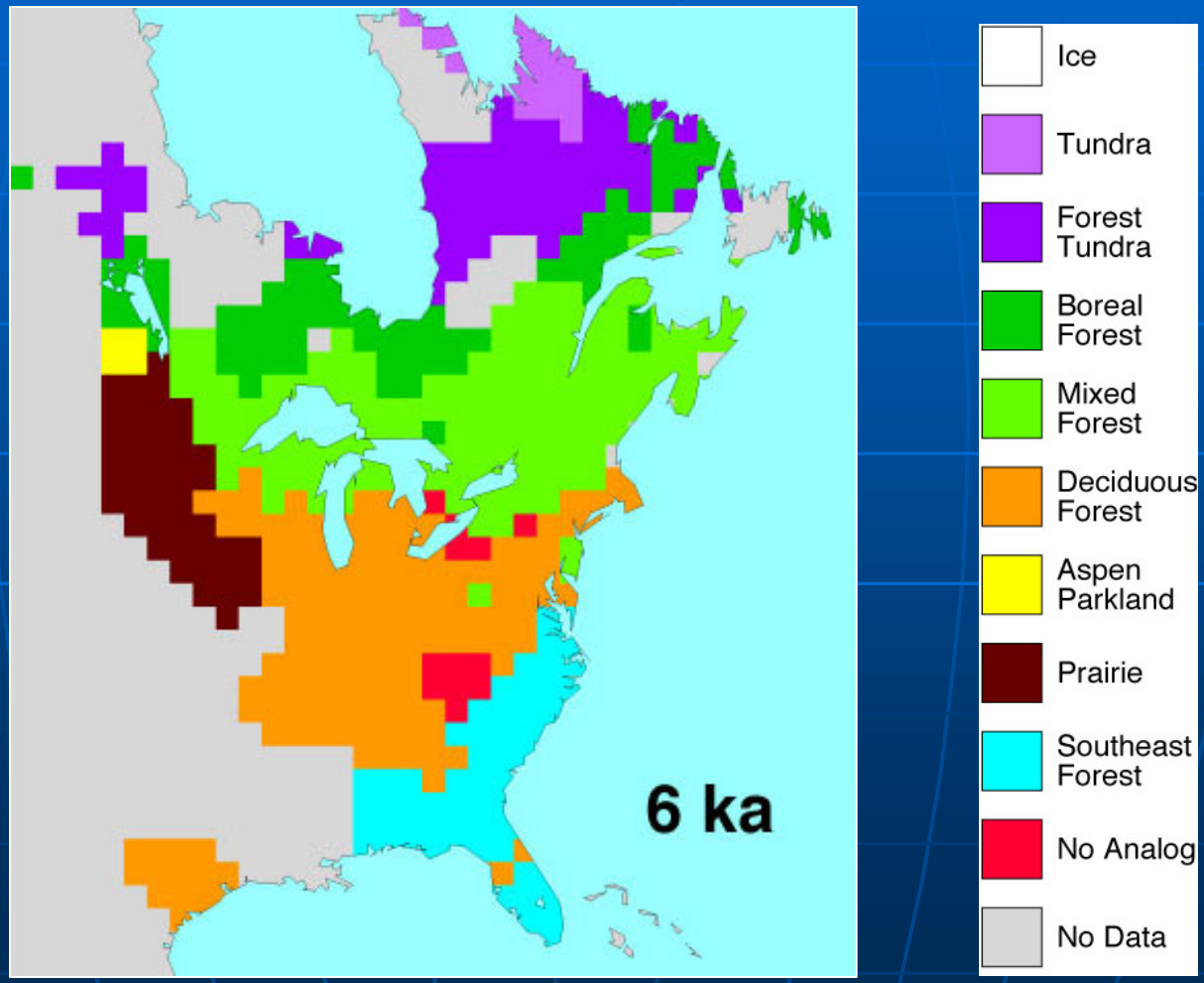
Growth Decreases:

- Tropospheric ozone
- Acid rains and fogs

Growth Increases:

- Nitrogen deposition
- Atmospheric CO_2

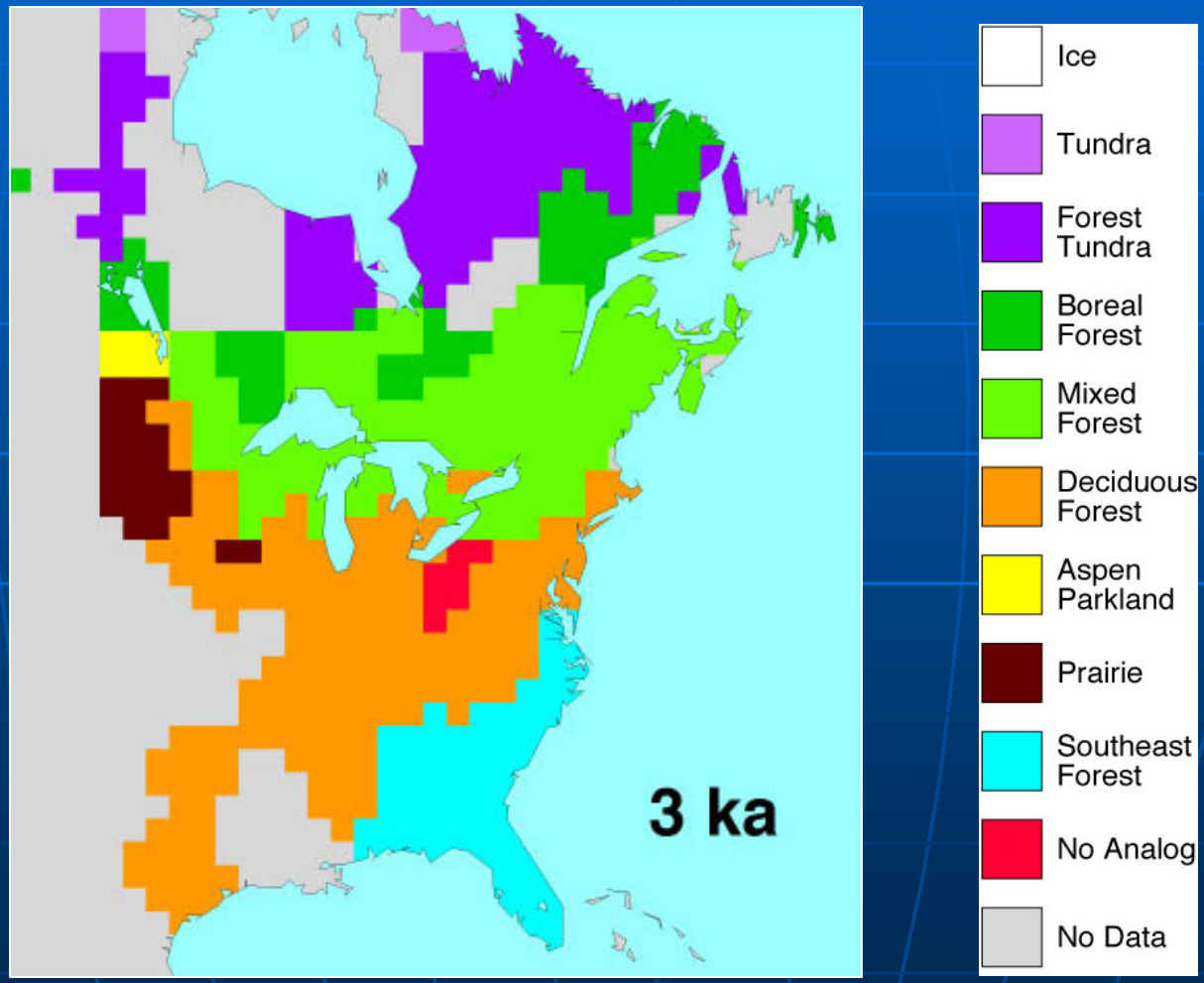
Direct Effects of Climate Change on Forests: Slow Migration of Species and Biomes



J. T. Overpeck, R. S. Webb, and T. Webb III, 1992, *Geology* 20:1071-1074

NOTE: “ka” is a thousand years
“UKMO” is a future climate scenario by the U.K. Meteorology Office

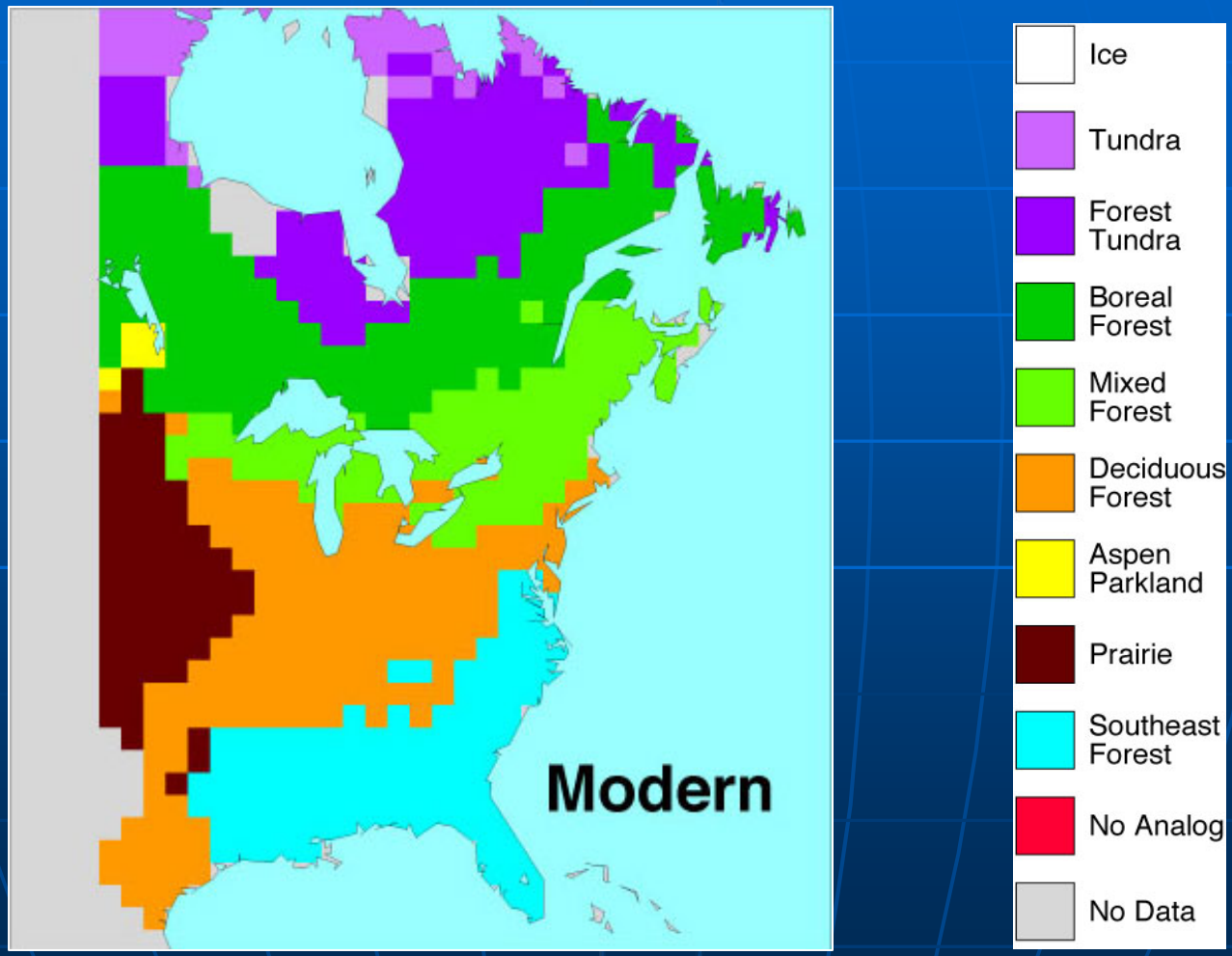
Direct Effects of Climate Change on Forests: Slow Migration of Species and Biomes



J. T. Overpeck, R. S. Webb, and T. Webb III, 1992, *Geology* 20:1071-1074

NOTE: “ka” is a thousand years
“UKMO” is a future climate scenario by the U.K. Meteorology Office

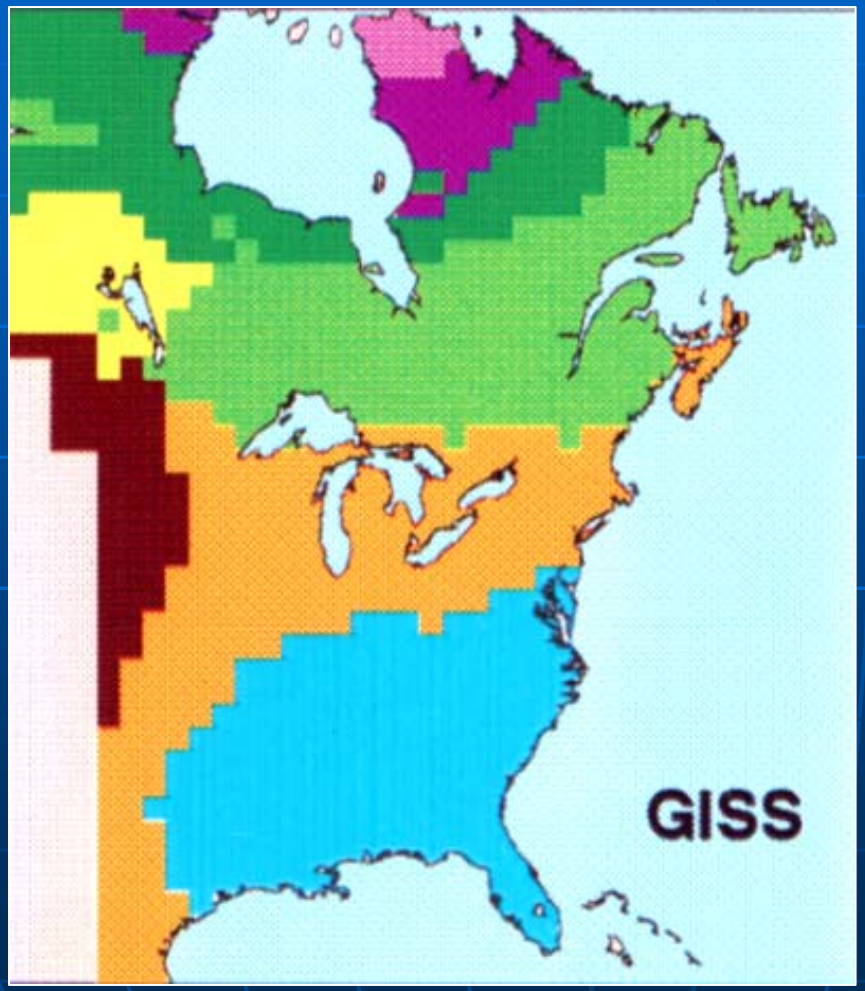
Direct Effects of Climate Change on Forests: Slow Migration of Species and Biomes



J. T. Overpeck, R. S. Webb, and T. Webb III, 1992, *Geology* 20:1071-1074

NOTE: “ka” is a thousand years
“UKMO” is a future climate scenario by the U.K. Meteorology Office

Direct Effects of Climate Change on Forests: Slow Migration of Species and Biomes



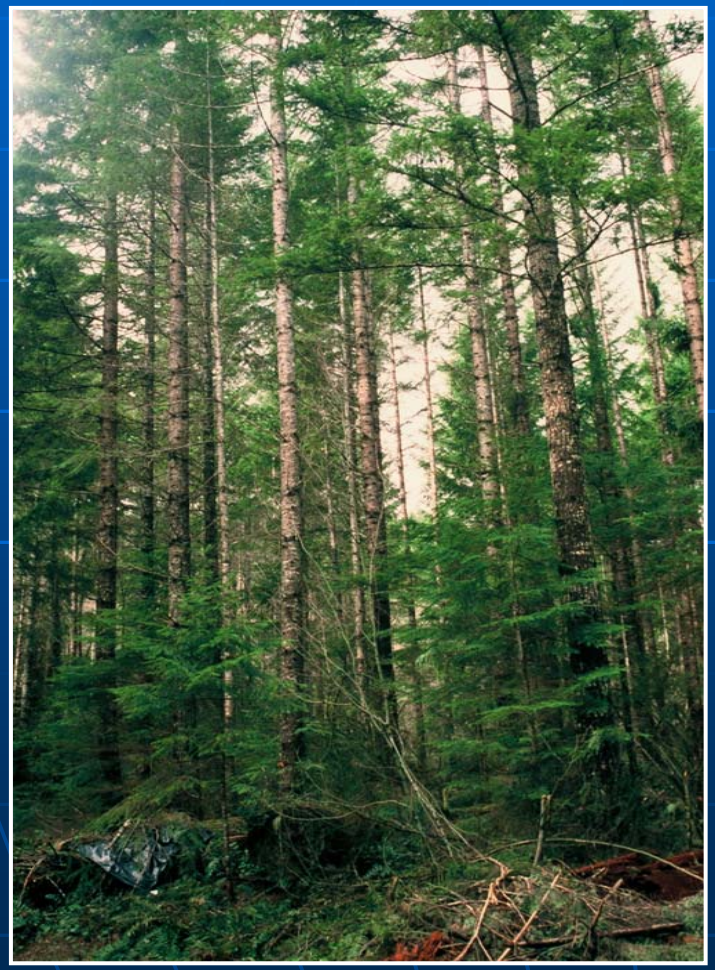
J. T. Overpeck, R. S. Webb, and T. Webb III, 1992, *Geology* 20:1071-1074

NOTE: “ka” is a thousand years
“UKMO” is a future climate scenario by the U.K. Meteorology Office

Roadmap of the Talk

- What is the pattern of US climate change so far and how much can we expect in this century?
- How do trees and forests regulate atmospheric greenhouse gases?
- What stresses on our forest ecosystems have we seen and what more should we expect?
- What can be done to help sustain and protect trees and forests from impacts of changing climate?

Reduce Carbon Densities While Maintaining Forest Structure



Reduce Carbon Densities While Maintaining Forest Structure

Increase Forest Ecosystem Diversity

- reduce intensity of pest infestations
- increase probability that needed future species will be present

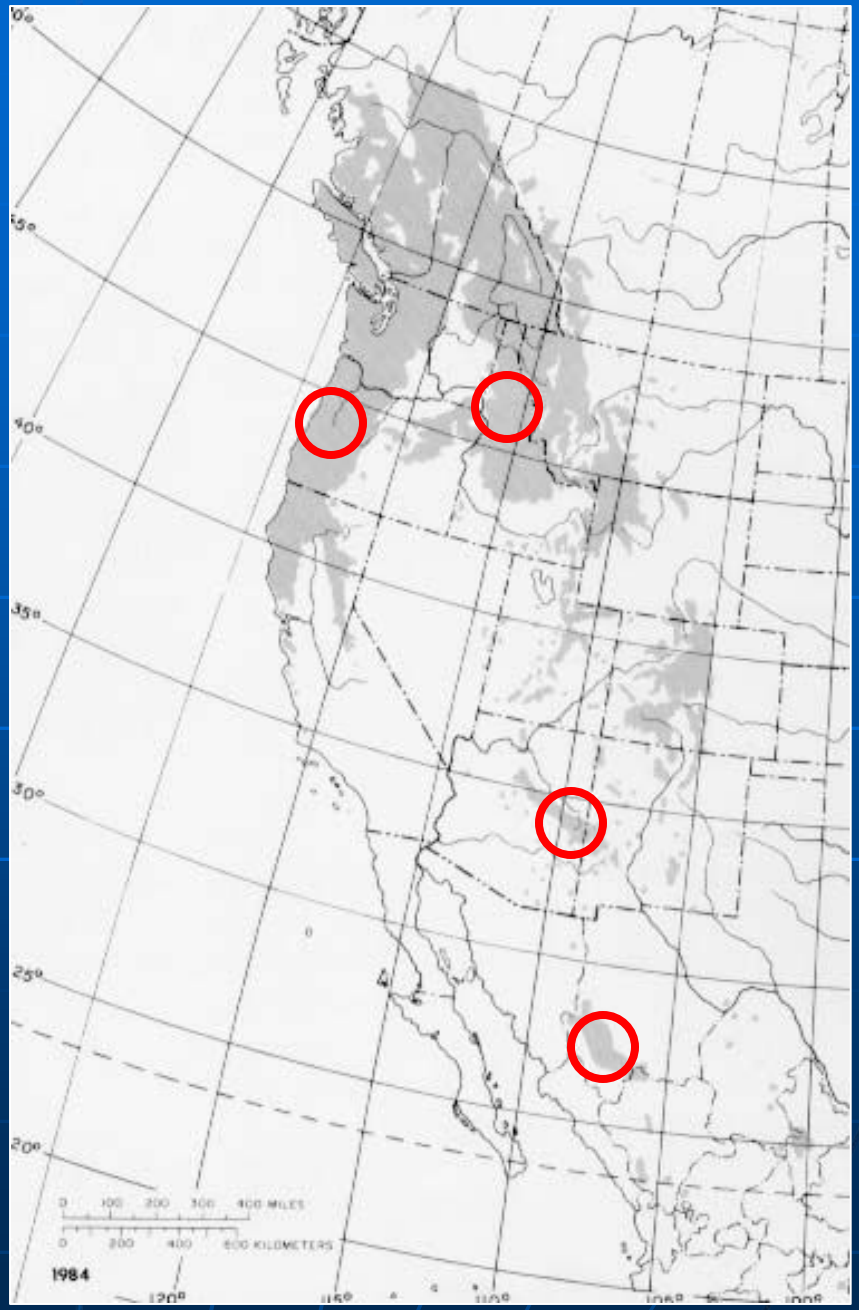
Assisting the Migration of Tree Varieties and Species

- Established trees thrive beyond their natural boundaries
- Seedlings rarely survive outside their boundaries
- Establish future species in today's forests now

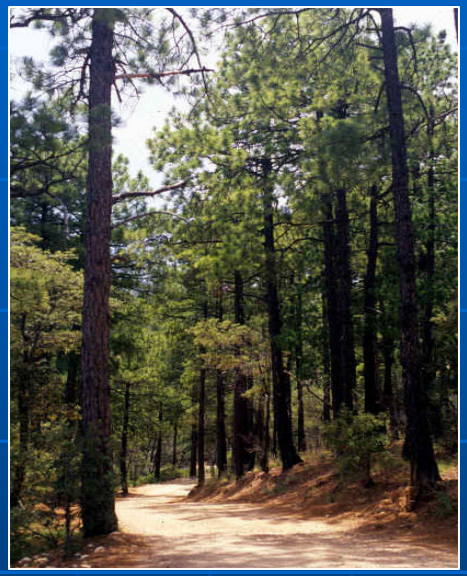
Reforestation must follow disturbance but what species to plant for maturity 50 yrs into the future?

From J. Zhang et al, 2009, Journal of Forestry 106:425-430

Forest Recovery from Major Disturbances: Choosing the Future's Trees



Forest Carbon Cycle: Normally a Process Taking Hundreds of Years

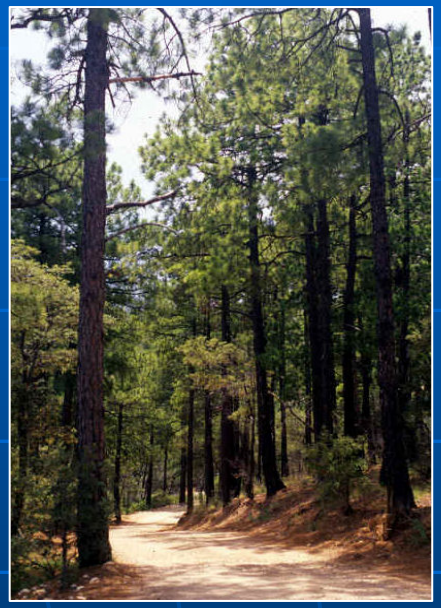


decades, centuries

years, decades

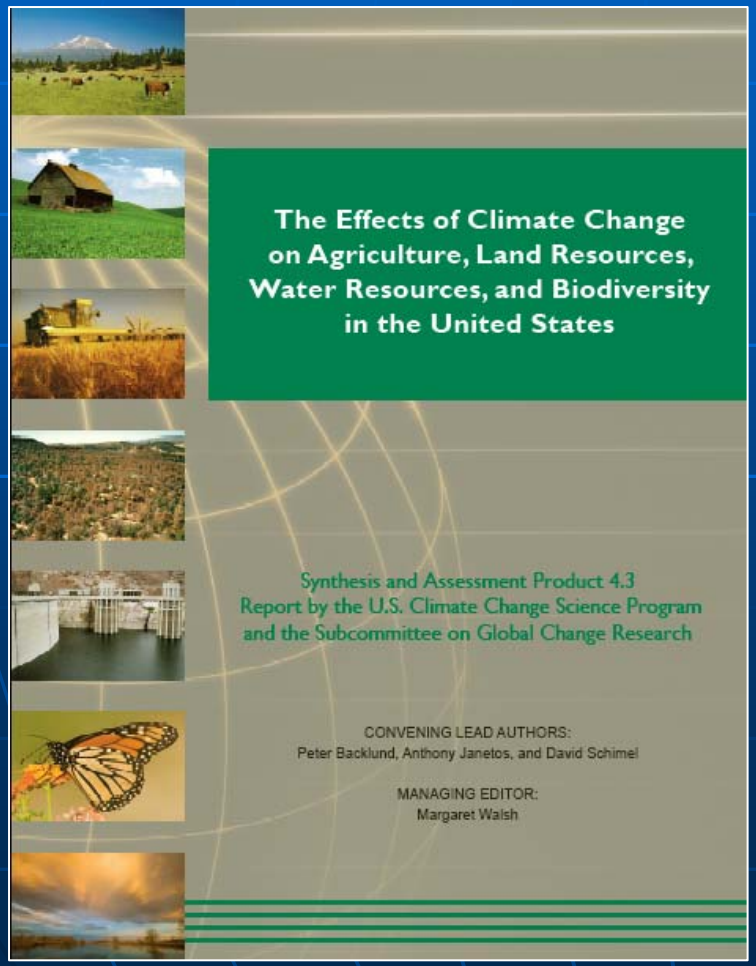
days, years

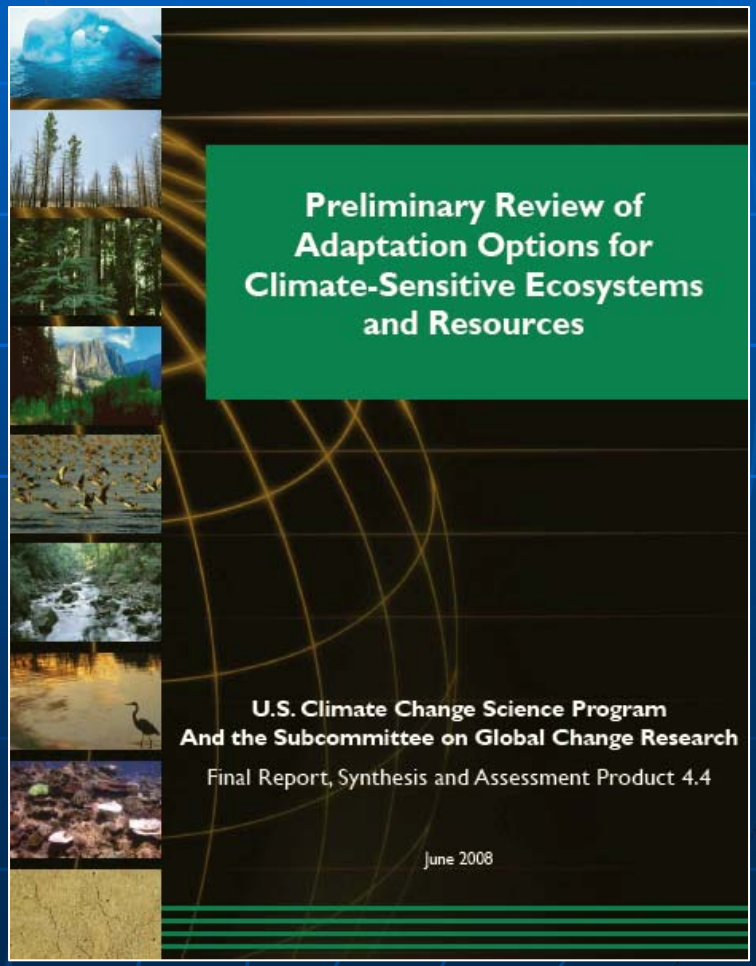
Forest Carbon Cycle: Now We Must Increase Cycling Rates



+

Two New and Important Sources of Information on Climate Impacts and Adaptation in the U.S.





Thank you.