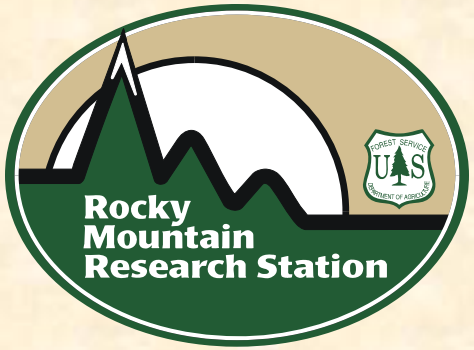
# What is the role of forests in the US carbon balance?

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For HJ Andrews Video Short Course, July 30- August 1, 2008

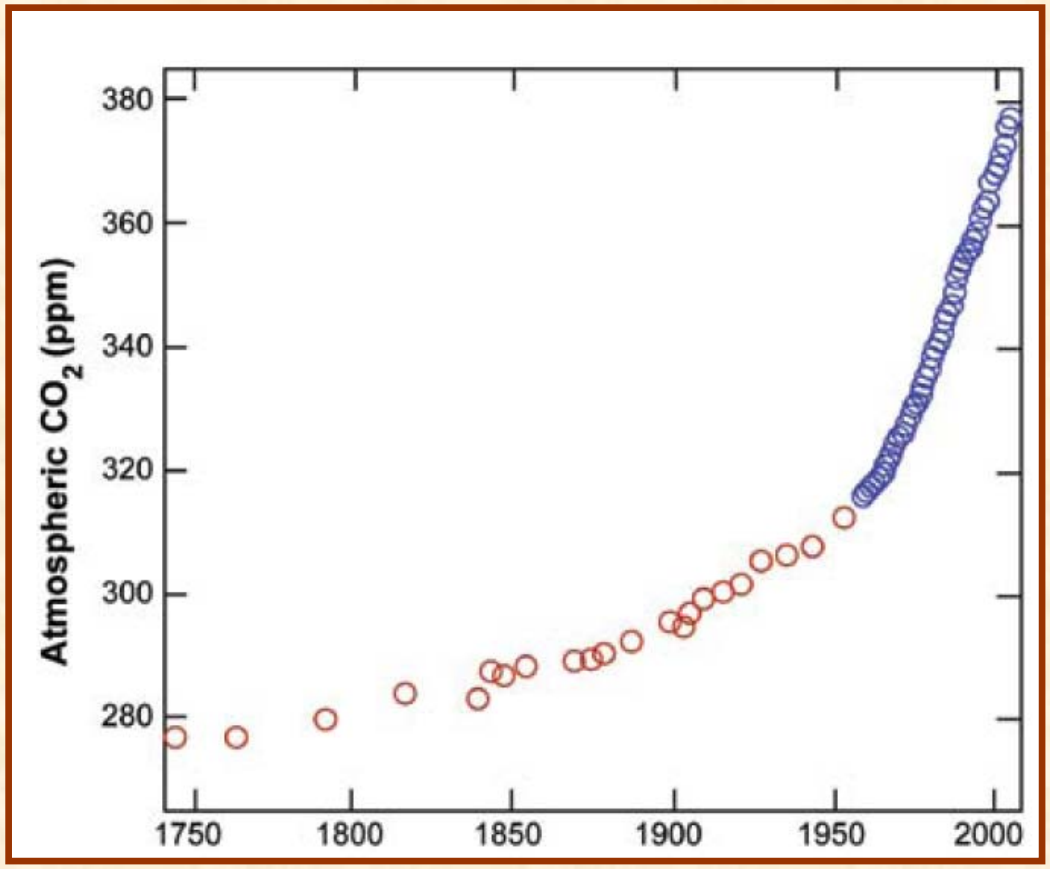
# Why does the carbon cycle matter?

$CO_2$ absorbs radiation from earth and warms it

Rising $CO_2$ increases ocean acidity

$CO_2$ was not higher than 280 ppm for > 400,000 years

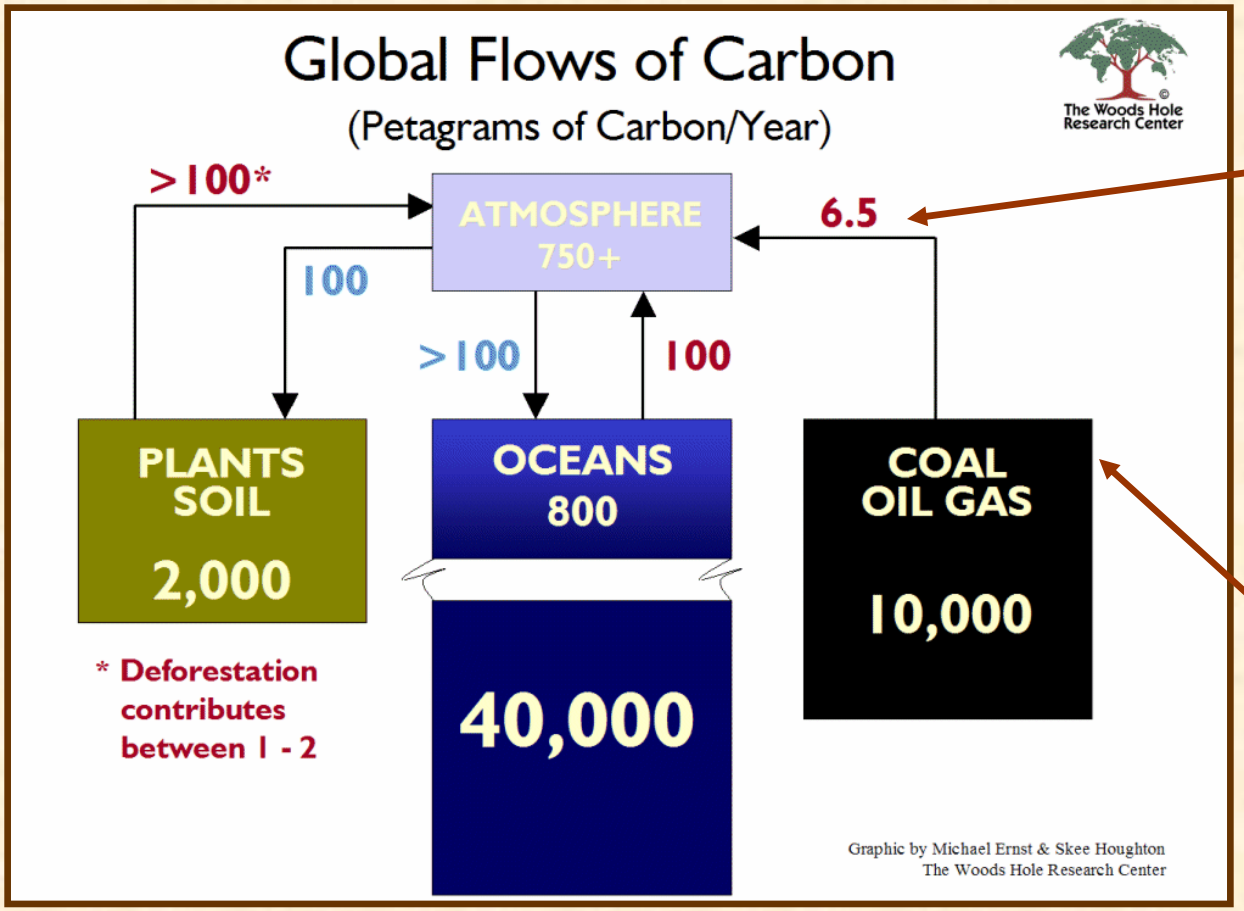
Rising $CO_2$ shows an imbalance between sources and sinks




From SOCCR Report: http://www.climatescience.gov

# Global C Cycle

- Fluxes to and from plants and soil are large




Fluxes – how much enters and how much leaves a pool per unit time

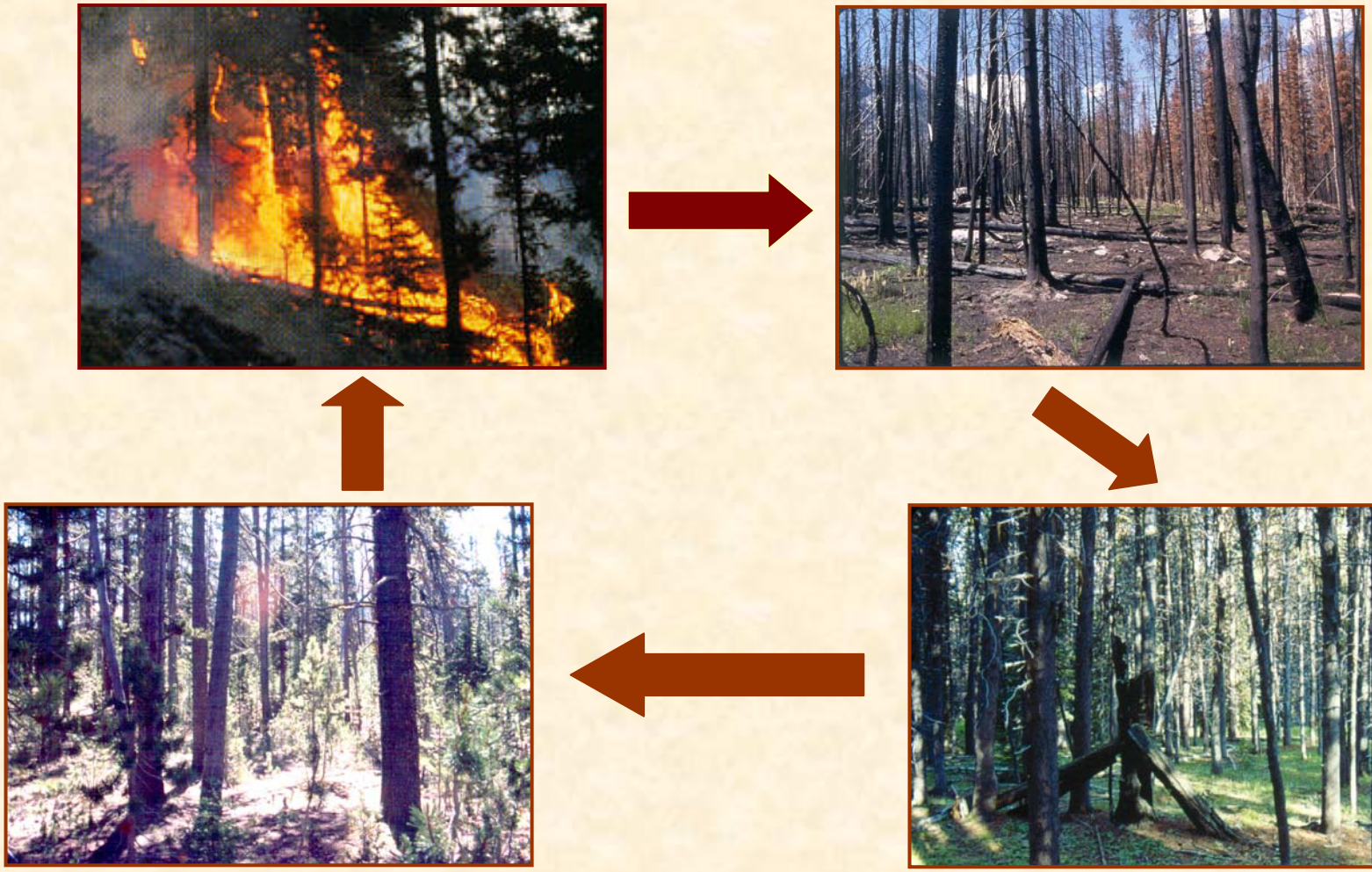
Pools – how much C is in a given location

Petagram = $10^{15}$ g

# Tropical Deforestation

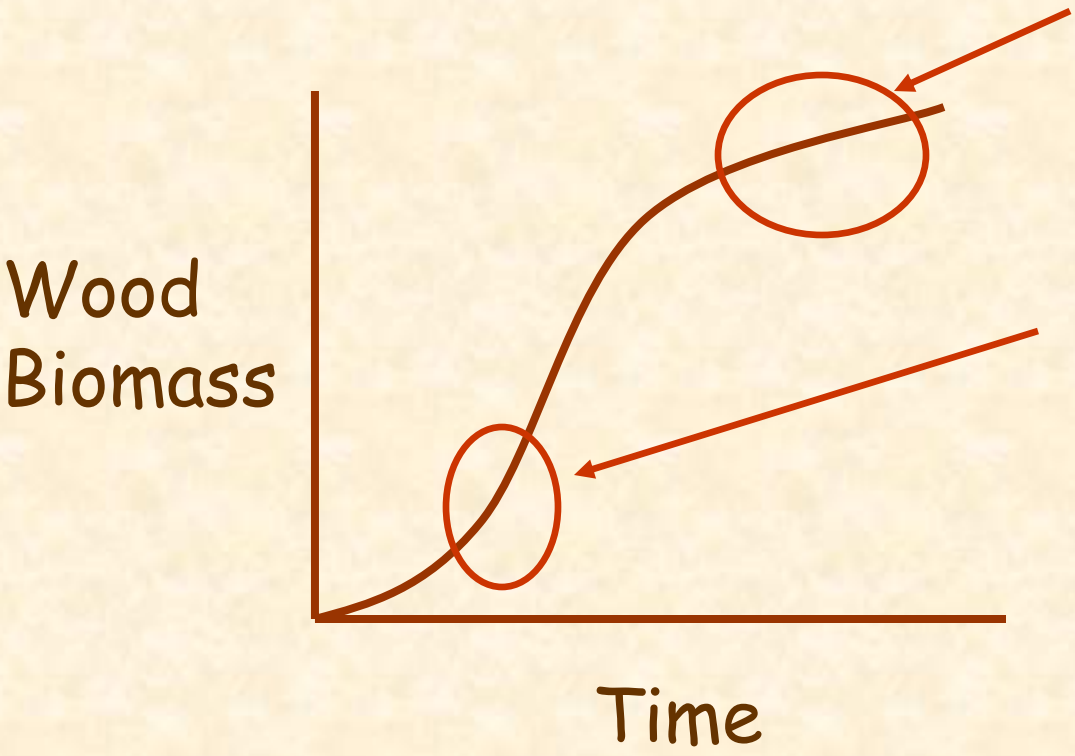
- Emissions for Tropical Deforestation: 1-2 Petagrams (10^15 g/year) – about the same as US fossil fuel emissions

# Forest carbon cycle after disturbance changes over the life-cycle of a stand



# Wood Biomass

- Wood growth is rapid early in life cycle
- Later, growth slows and trees die. Carbon accumulation slows or stops (storage is large)



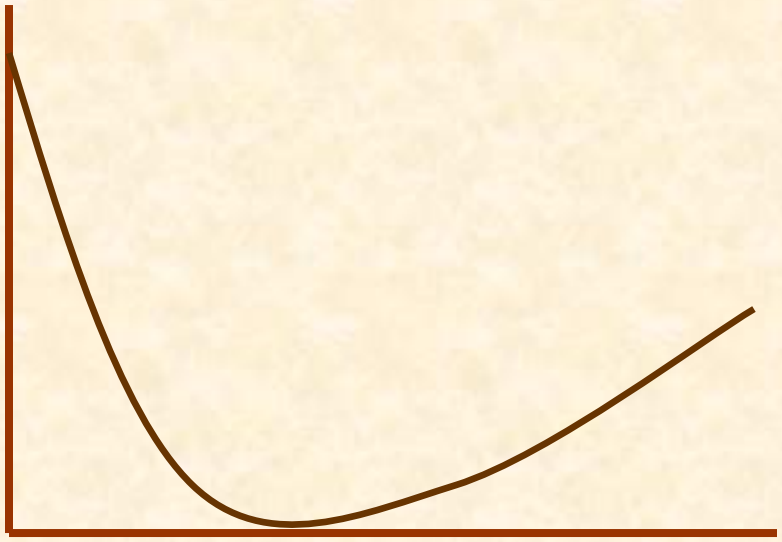

Older forests have much higher carbon stores

Younger forests have a greater carbon uptake

Most disturbances don't kill all trees

# Dead Wood

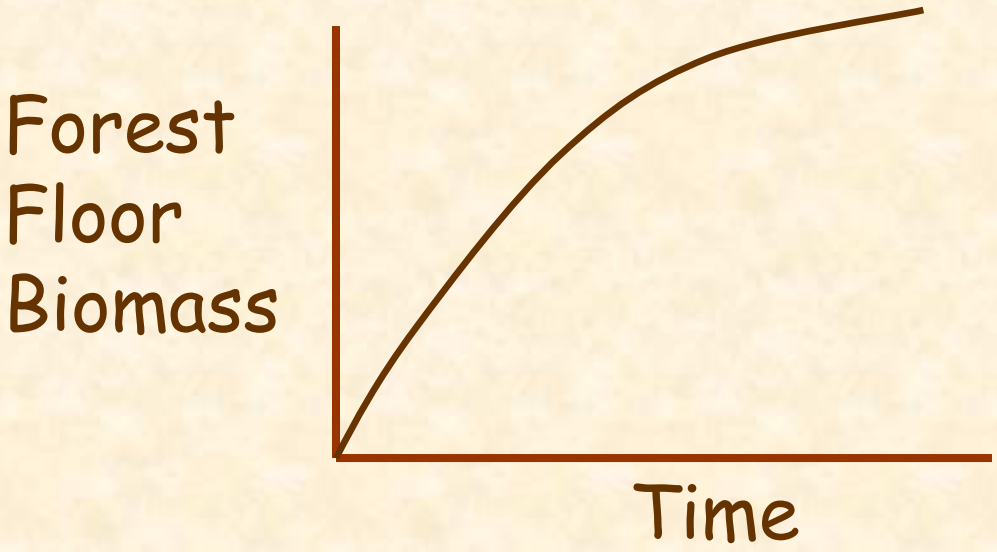
- It is high after a disturbance kills trees
- Lowest when the dead wood from the disturbance has decayed and before large trees start dying




Young forests have high dead wood and high decomposition

# Forest Floor

- After a fire, carbon in forest floor ('duff' or 'litter') increases over 50-60 years then stabilizes.




Usually consumed in fire

Not consumed in logging or beetle outbreak

# Mineral Soil

- Carbon in mineral soil is generally stable, unless large erosion or land-use or vegetation change


Large uncertain pool

Measuring change is difficult

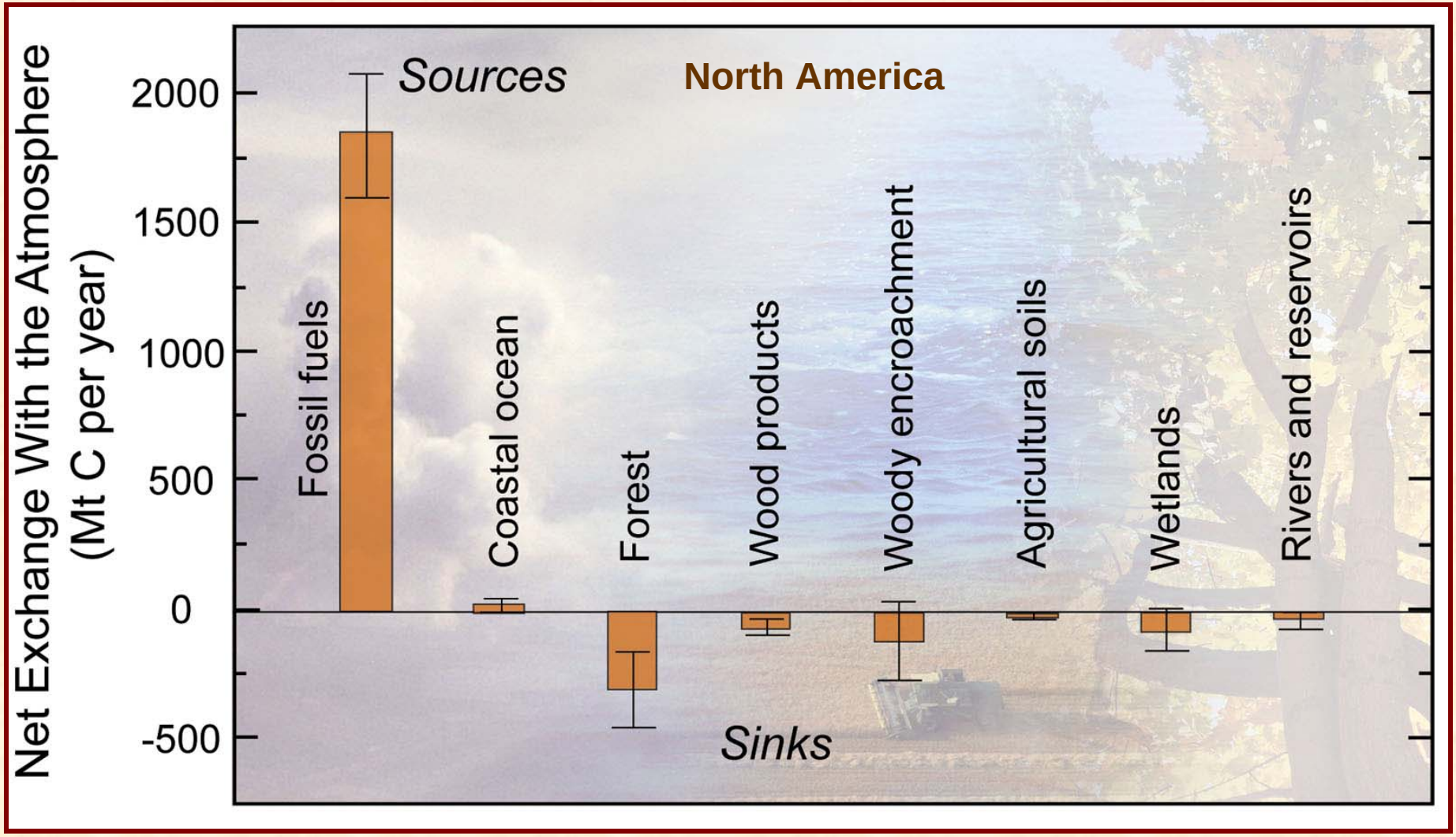
# Measuring Changes

- Identifying change usually done with repeat inventories (FIA for US):
  - US EPA Greenhouse Gas Inventory

# Products versus Forests

- Intact forests generally store C longer than forest products
- Particularly true for oldest forests
- Forests can generate a sustainable stream of biomass

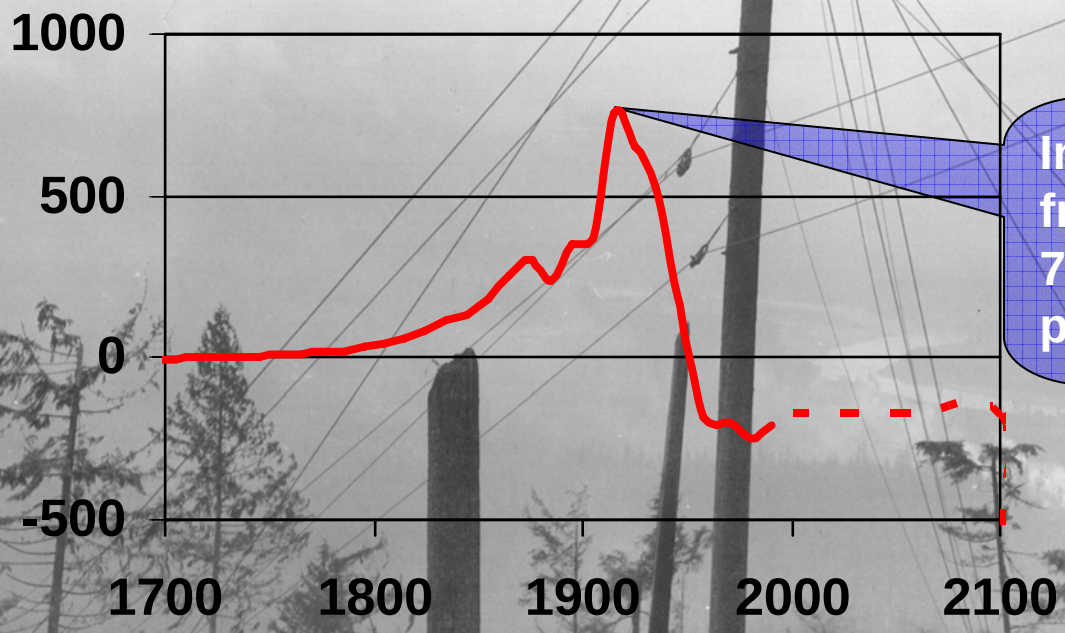
# In US, forests and long-lived wood products offset about 20% of fossil-fuel emissions




Mt = ($10^{12}$ g)

From SOCCR Report: http://www.climatescience.gov

# US Forest Carbon Balance 1800-1950: Forest Disturbance on a Massive Scale-the Industrial Revolution

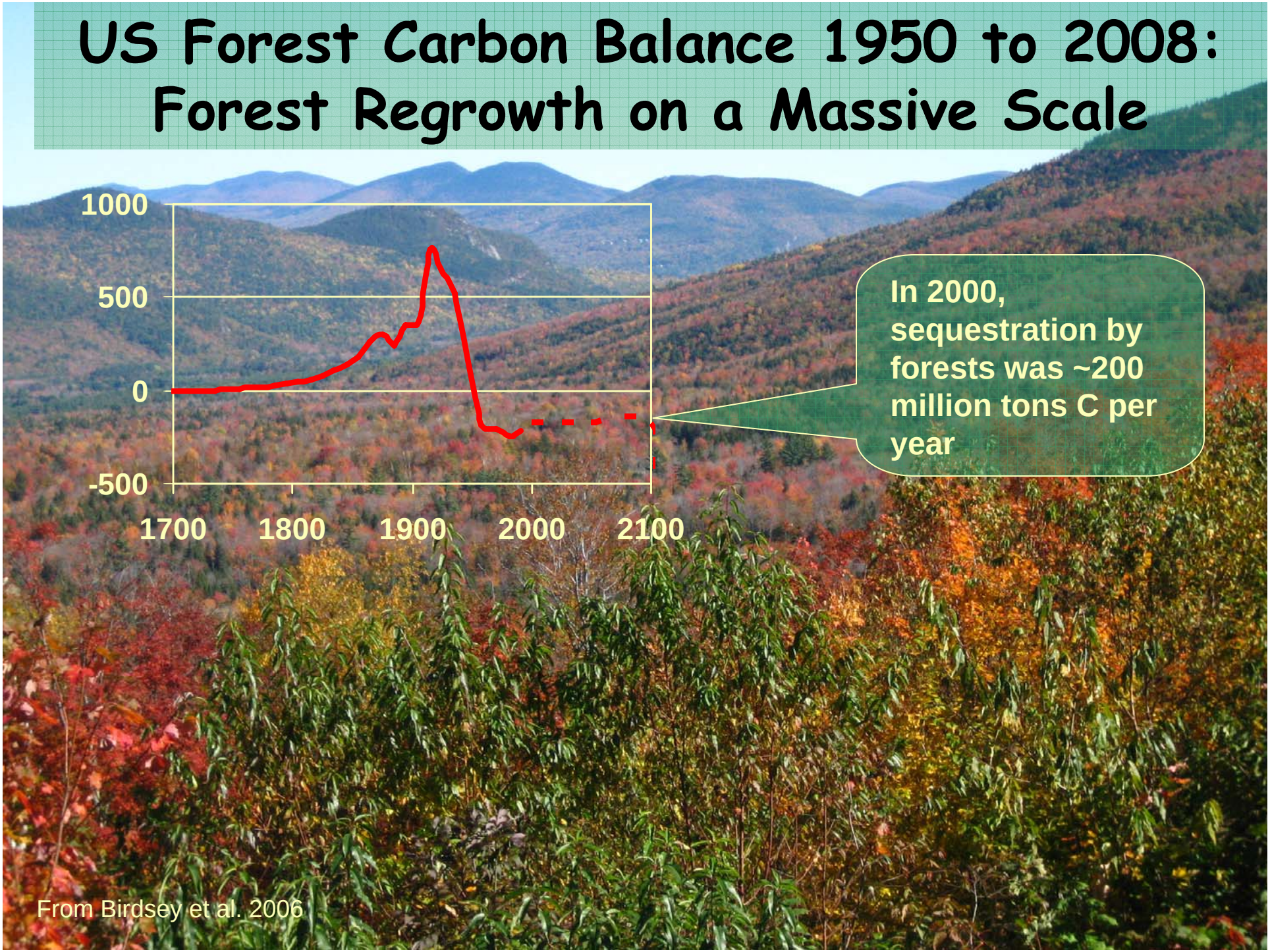



In 1915, emissions from forests were 760 million tons C per year

From Birdsey et al. 2006

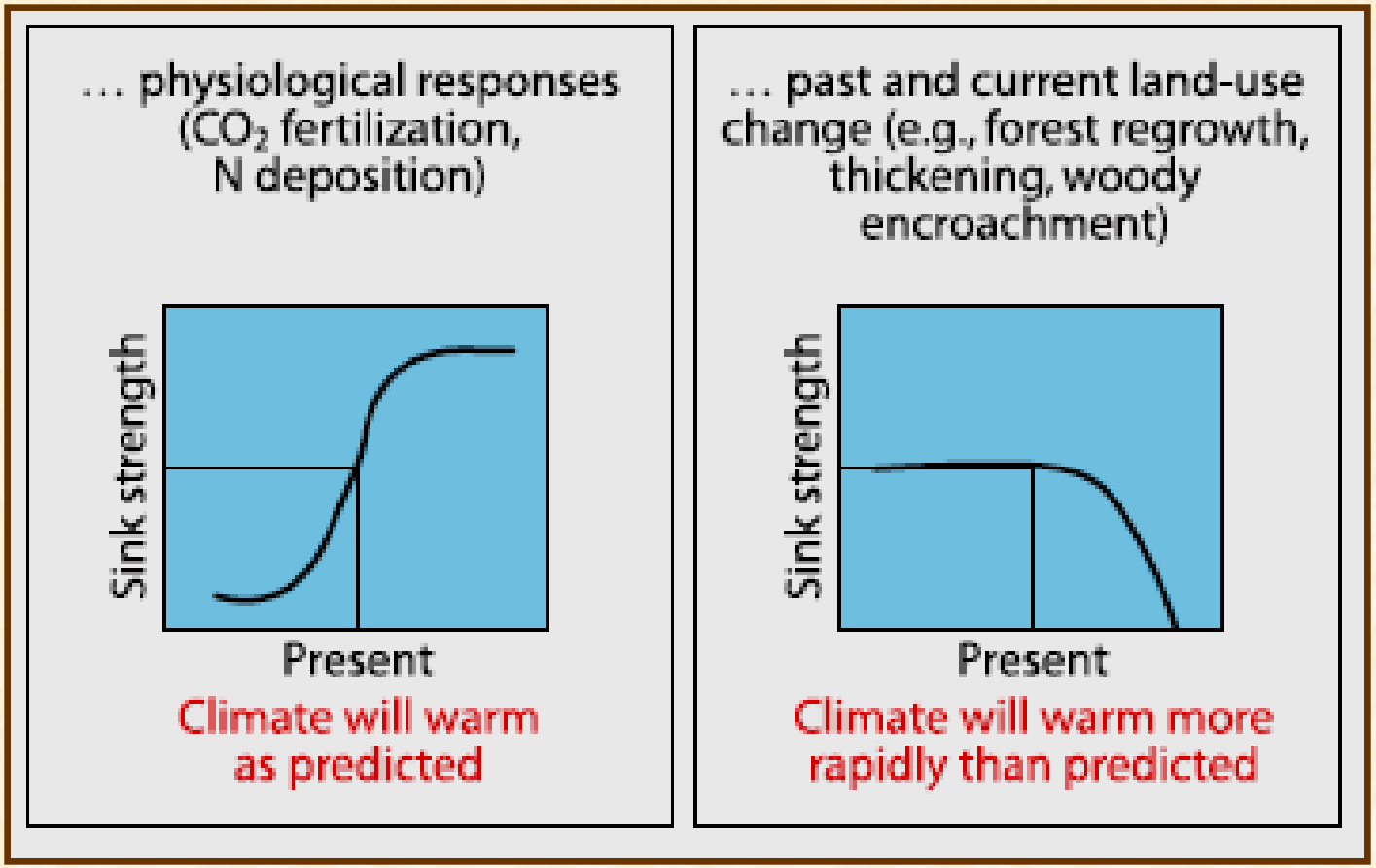
Photo by Kinsey

# US Forest Carbon Balance 1950 to 2008: Forest Regrowth on a Massive Scale



# Consequences of Sink Saturation

## If the Sink is a Result of



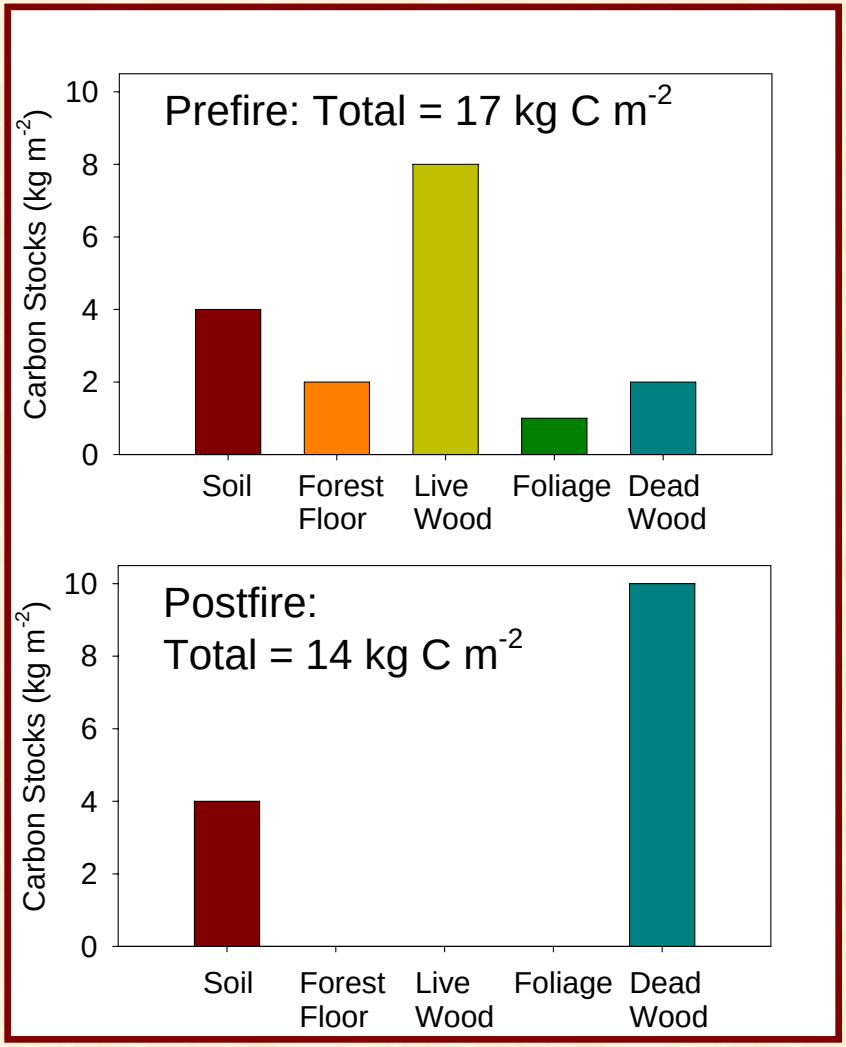

Canadell et al. 2007

# Bottom Line

- Forests play a large role in offsetting emissions
- We know *how* to measure it – but many pools not measured *well*
- Sink may not last

# How Does Fire Change Forest Carbon?

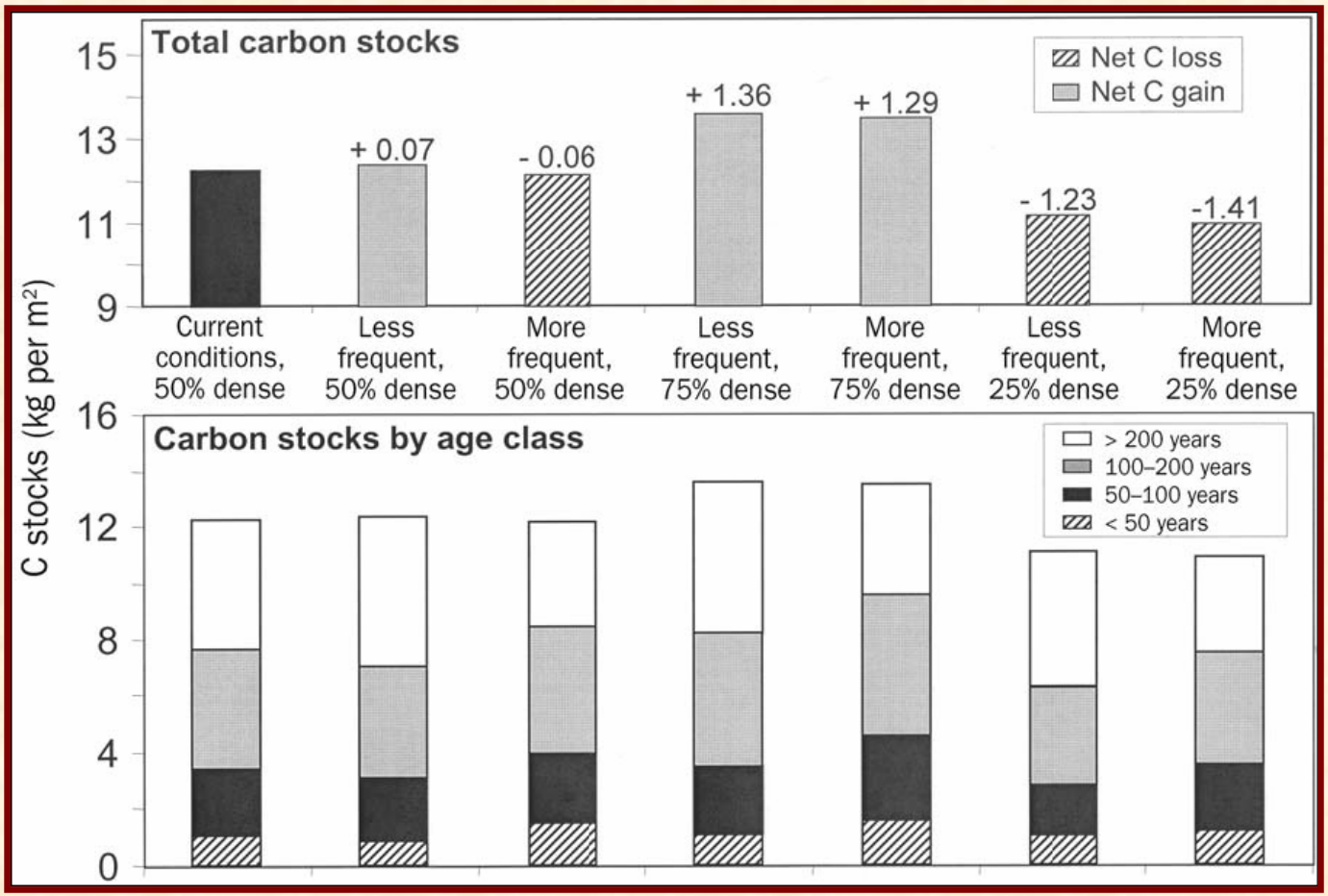
Fire kills trees, it doesn't consume them; Fire losses of foliage and forest floor are only ~10-20% of the site carbon




# Two Scenarios

- Long-term: What would happen to carbon stored on the landscape if you changed fire return interval (from 200-300 years to 100-200 years) and tree density.
- Short-term: What is the carbon balance of the YNP landscape after the fire? How long will it take to recover?

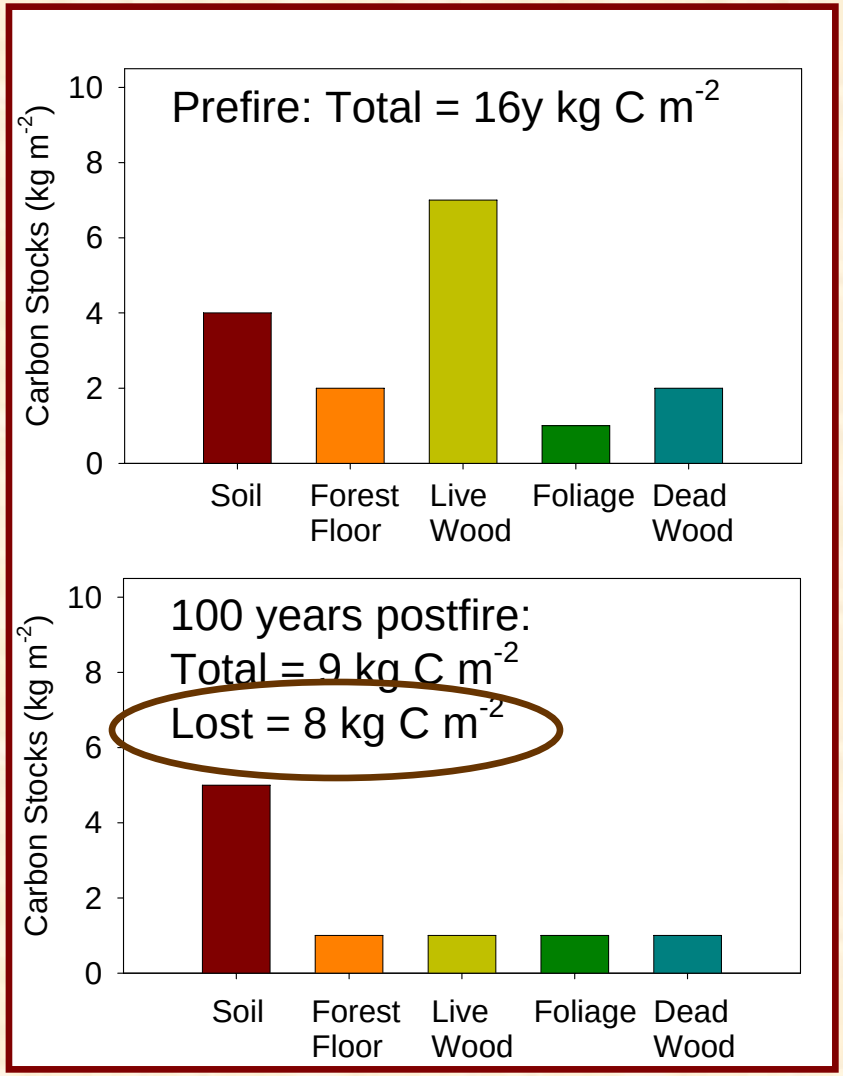
We simulated large changes in fire frequency and stand density.
Over the long-term, fire won't change carbon stored in forests much (~10%) *unless* fire converts forests to meadow




From Kashian et al. 2006, BioScience

# What happens with no regeneration?

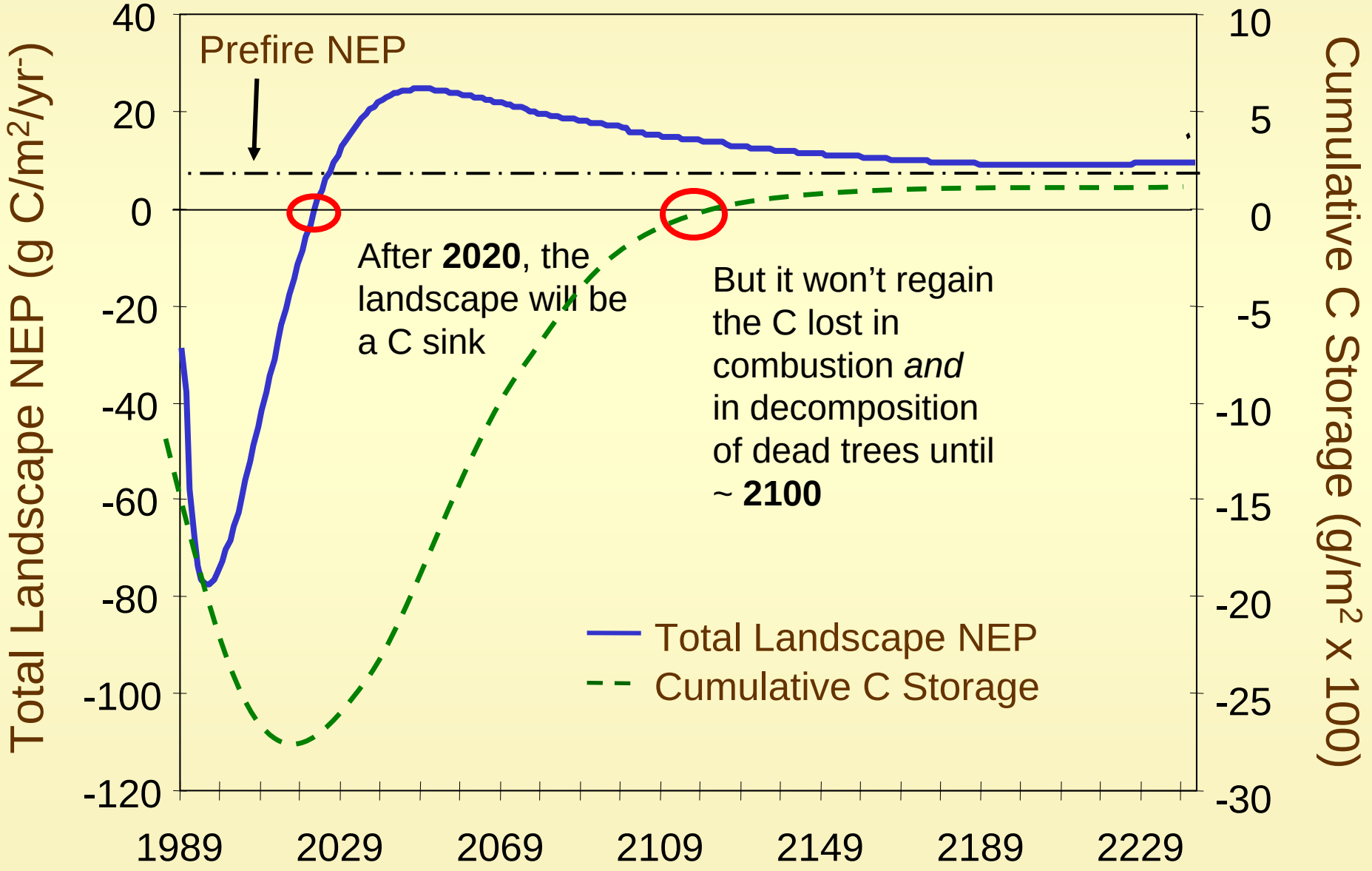
## Example: Hayman Fire, Colorado, 2002




After a fire, if a forest replaces itself, there is little change in carbon over a cycle

If fire turns forest into meadow or shrublands, carbon is lost to the atmosphere (for example, Hayman fire, Colorado)

# Short-term changes in C storage for Yellowstone Landscape

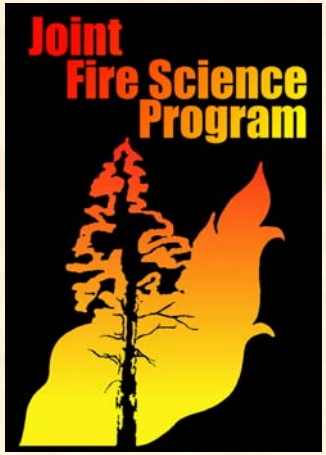


# Fire emissions are not a large part of the national carbon budget

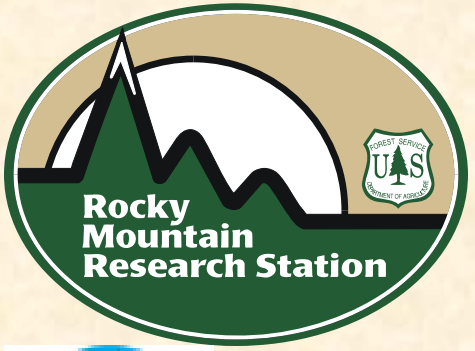
- Average acres burned per year, last 10 years: 6.5 million (0.9% of US forest area)
- Largest acres burned per year (2006): 9.9 million (1.3% of US forest area)
- Average annual emissions from combustion (EPA Greenhouse Gas Inventory): 35 Mt/yr
- US **Net** forest growth (RPA 2002): 170 Mt/yr
- US Forest removals (RPA 2002): 110 Mt/yr
- US Fossil fuel emissions (SOCCR): 1580 Mt/yr

# Take Home

- Good understanding of C cycle
- Reasonable Forest C from FIA and other inventories (but CWD and soil a problem)
- If a forest replaces itself after disturbance there is no long-term loss of carbon.
- Fire does cause short-term losses of carbon that can persist if the forest does not regenerate







NRS Global Change

- Effects of climate change on agriculture, land resources, water resources and biodiversity
  http://www.climatescience.gov/Library/sap/sap4-3/final-report/default.htm
- Forests and Carbon Storage
- State of the Carbon Cycle Report http://cdiac.ornl.gov/SOCCR/
- Yellowstone fires:

  http://lamar.colostate.edu/~mryan/Publications/Kashian_Romme_Tinker_Turner_Ryan_2006_Bioscience_56_598-606.pdf
- US Greenhouse Gas Inventory: http://www.epa.gov/climatechange/emissions/usinventoryreport.html