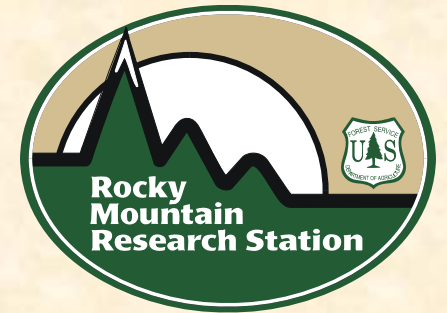
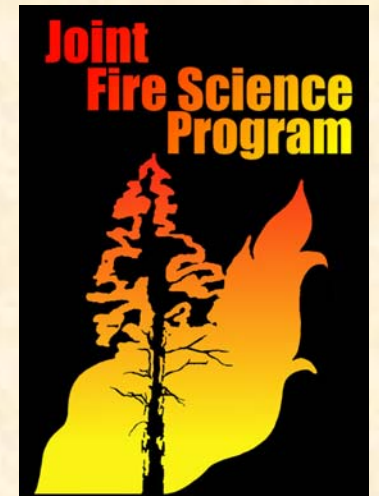


# Fire and carbon cycling for the Yellowstone National Park landscape

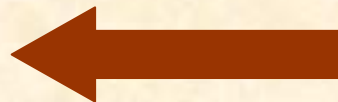
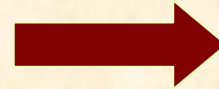
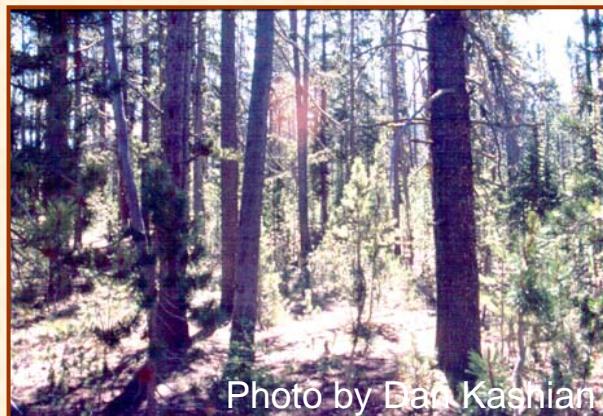


Michael G. Ryan, USDA Forest Service, RMRS  
Daniel M. Kashian, Wayne State University  
William H. Romme, Colorado State University  
Monica G. Turner, University of Wisconsin  
Erica A.H. Smithwick, Pennsylvania State University  
Daniel B. Tinker, University of Wyoming



For IAWF Meeting, The '88 Fires: Yellowstone and Beyond Sept. 22-27, 2008  
Google 'Michael G Ryan' for website for papers and more information

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

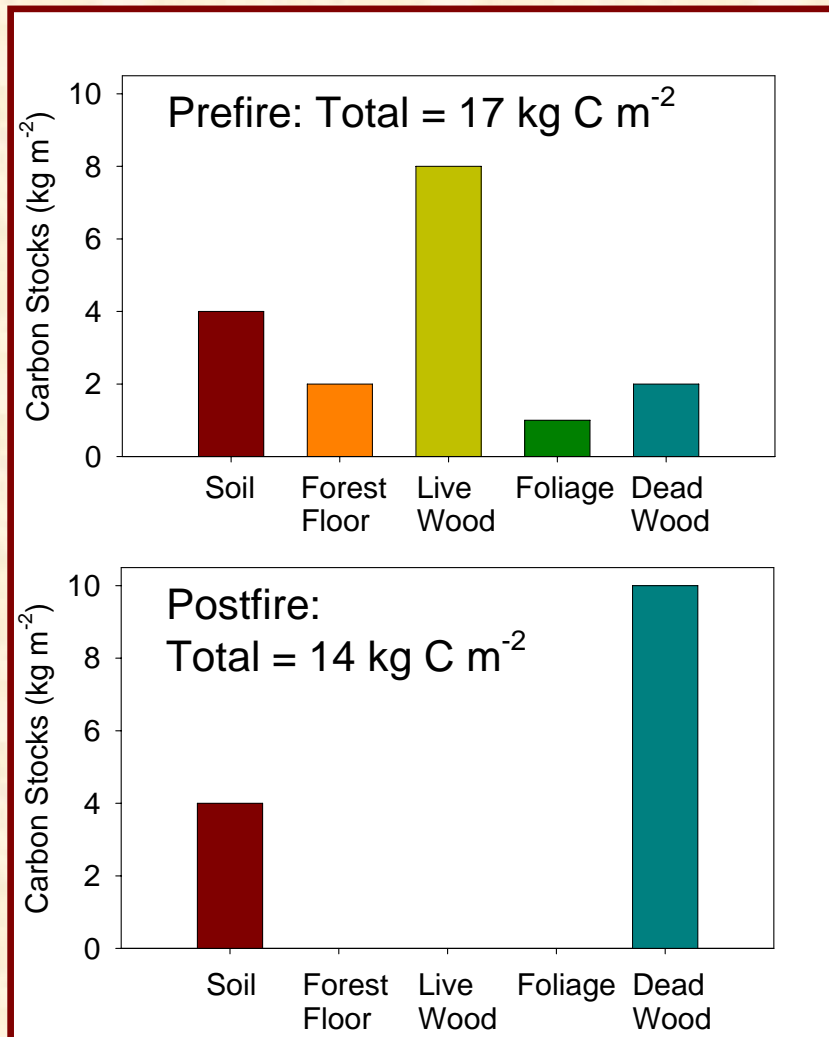


# Two Questions

- Long-term: How will carbon in the landscape vary if fire return interval changed from 200-300 years to 100-200 years or tree density changed?
- Short-term: What is the carbon balance of the YNP landscape after the fire? How long will it take to recover?

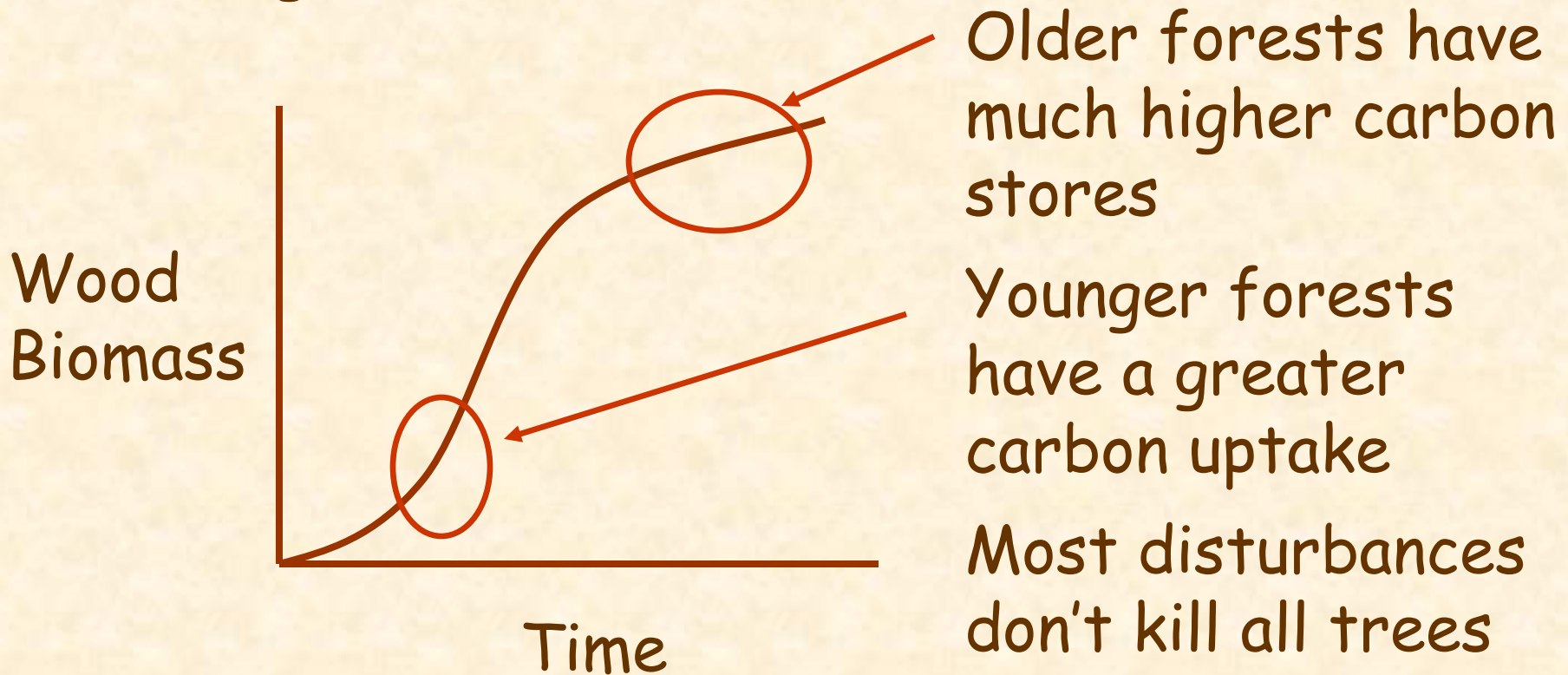
# How Does Fire Change Forest Carbon?

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



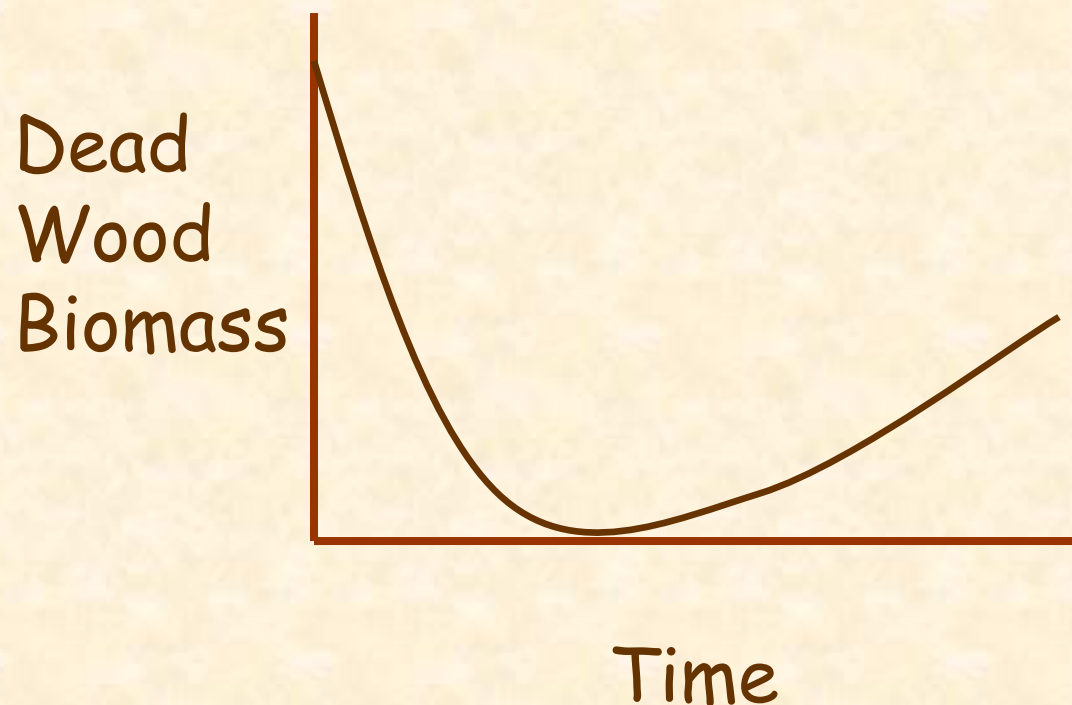
# Wood Biomass

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



# Dead Wood

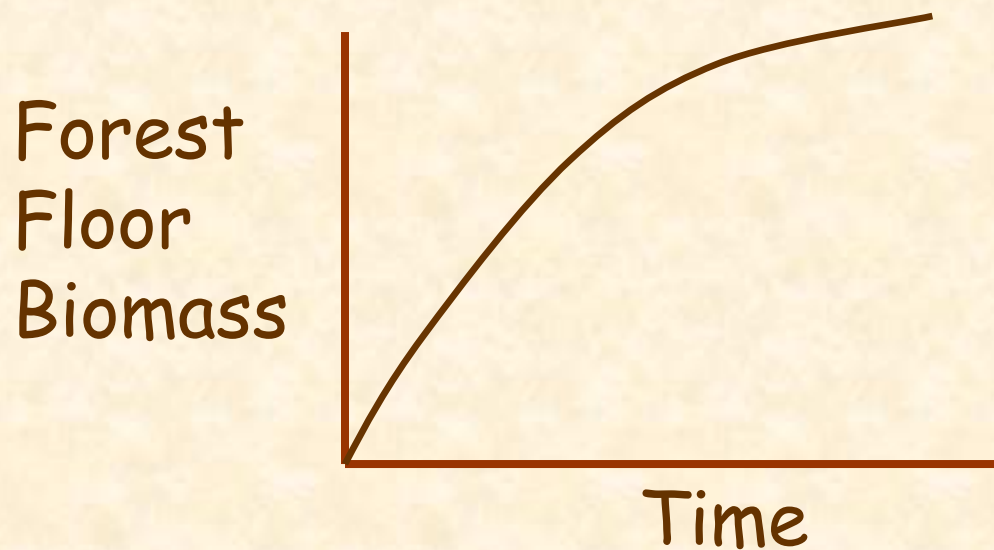
- It is high after a disturbance kills trees
- Lowest when the dead wood from the disturbance has decayed and before large trees start dying



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.

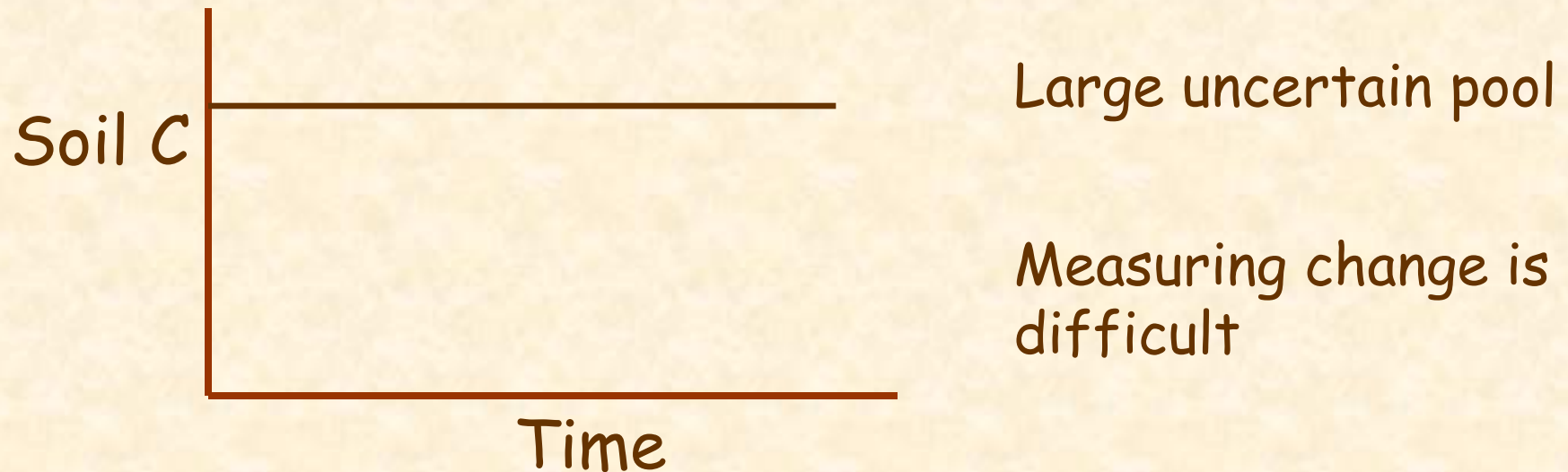


Usually  
consumed in fire

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



# Methods

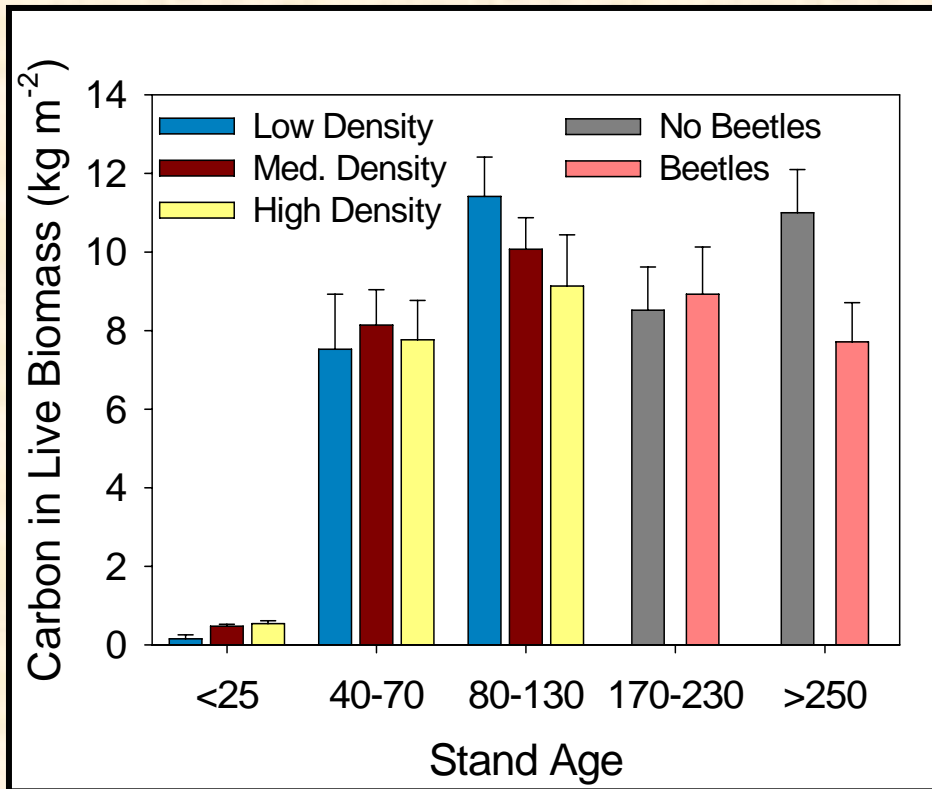
- Chronosequences replicated across age and tree density (77 independent stands)
- Carbon in: Live and dead wood (above and belowground), soil C (0-30 cm, litter, understory, seedlings and saplings)



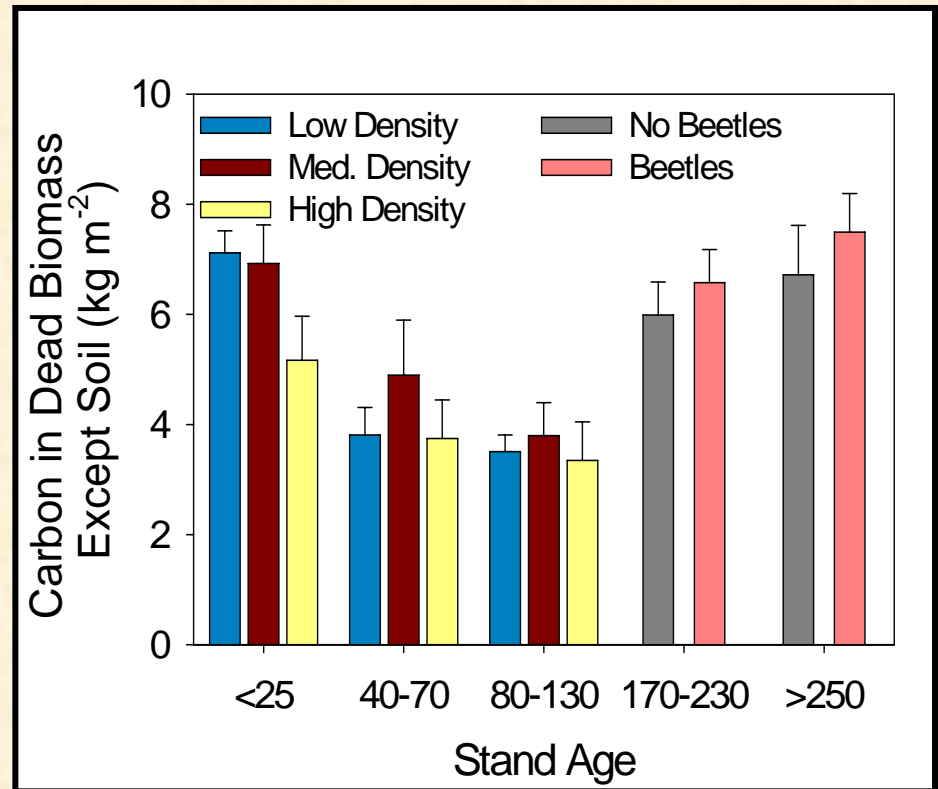
Carbon in different components follows theory, *except for soil.*

Surprises: Live biomass recovers quicker and stabilizes quicker than expected.

No differences between tree density classes.

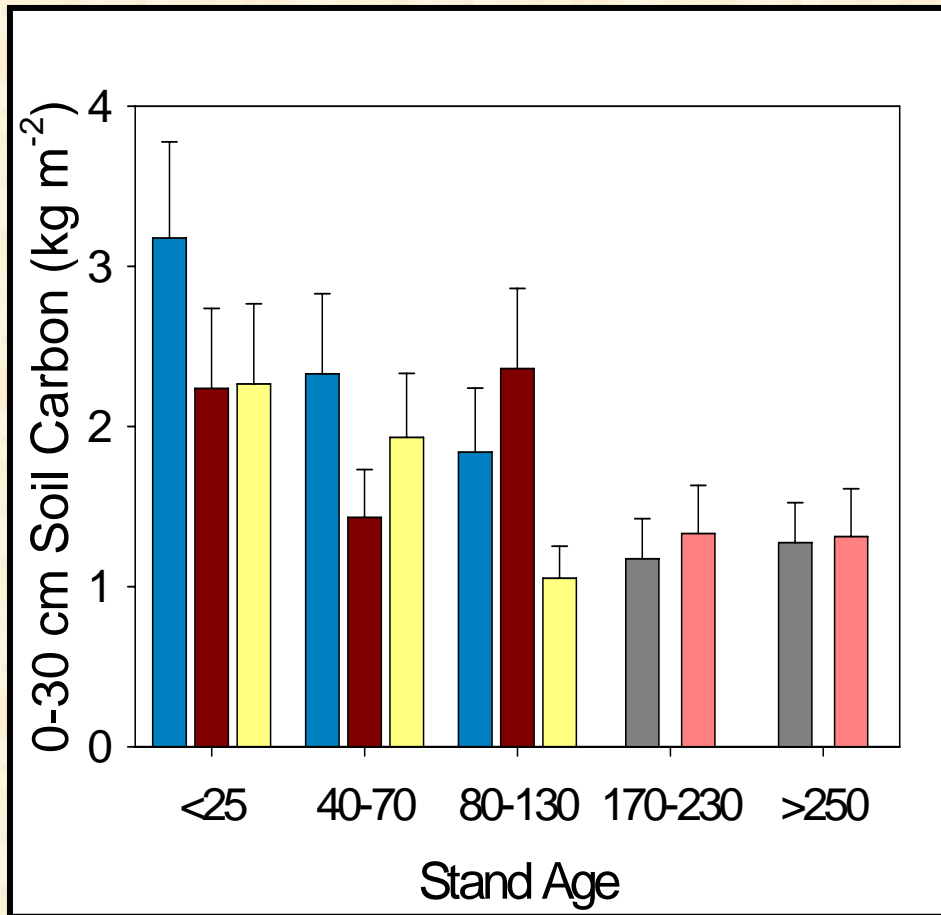


Live Biomass

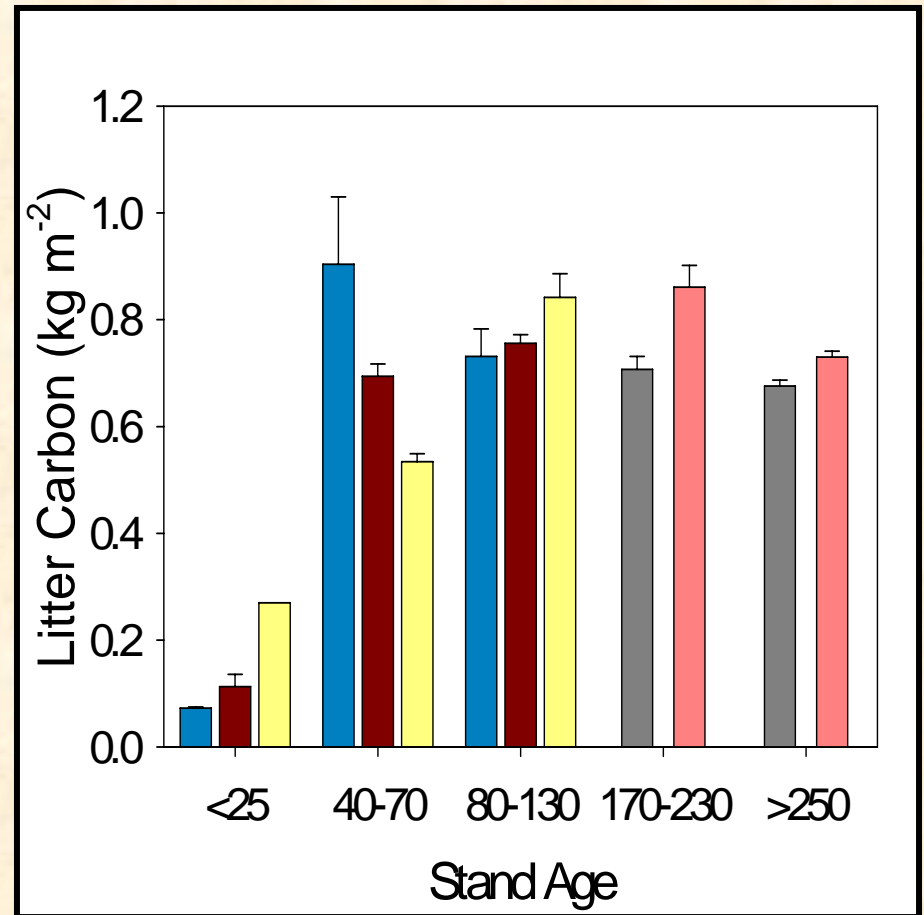


Dead Biomass

Soil carbon declines with stand age, perhaps because of lower inputs; Litter carbon recovers and stabilizes quickly

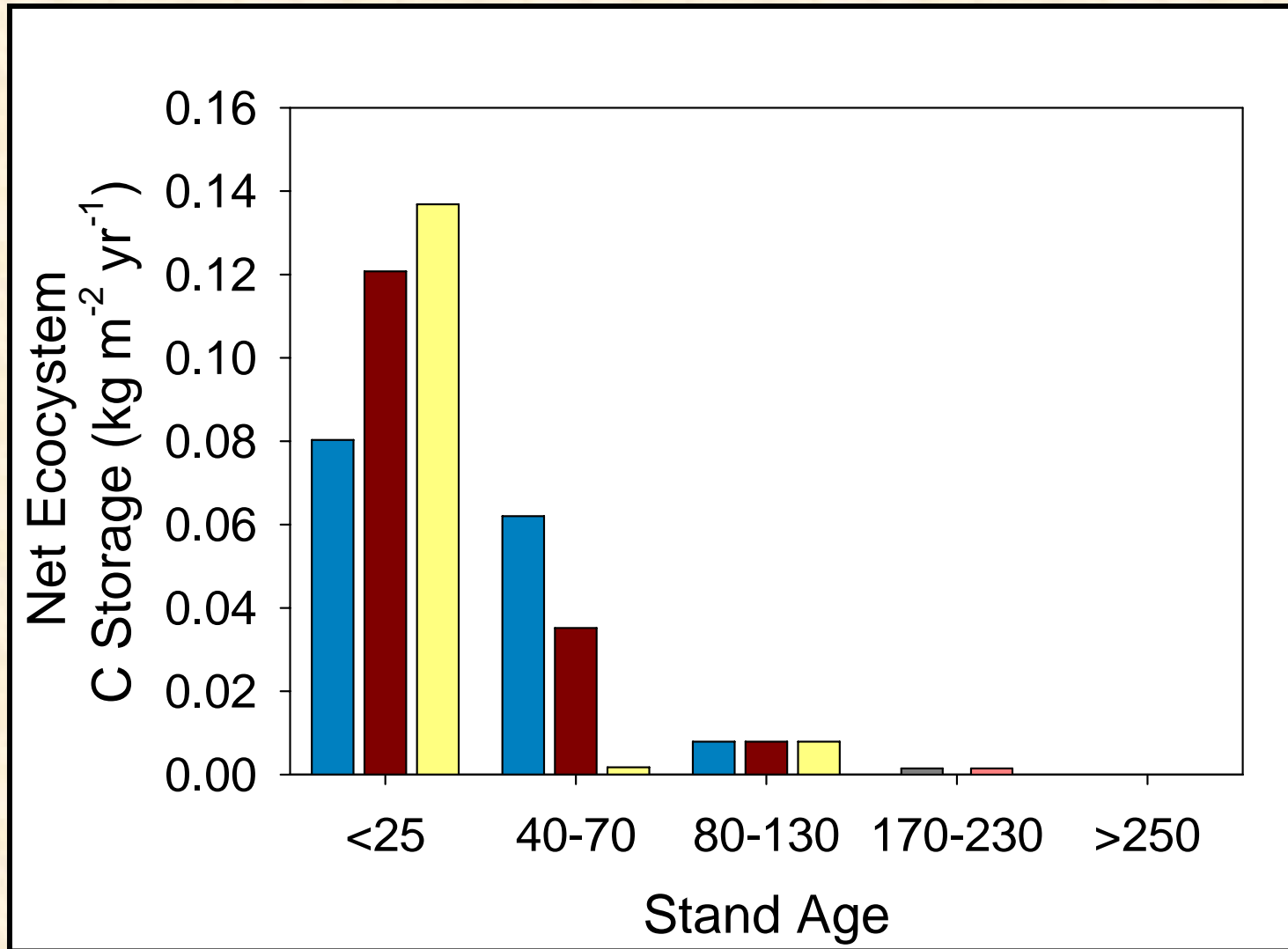


Soil Carbon



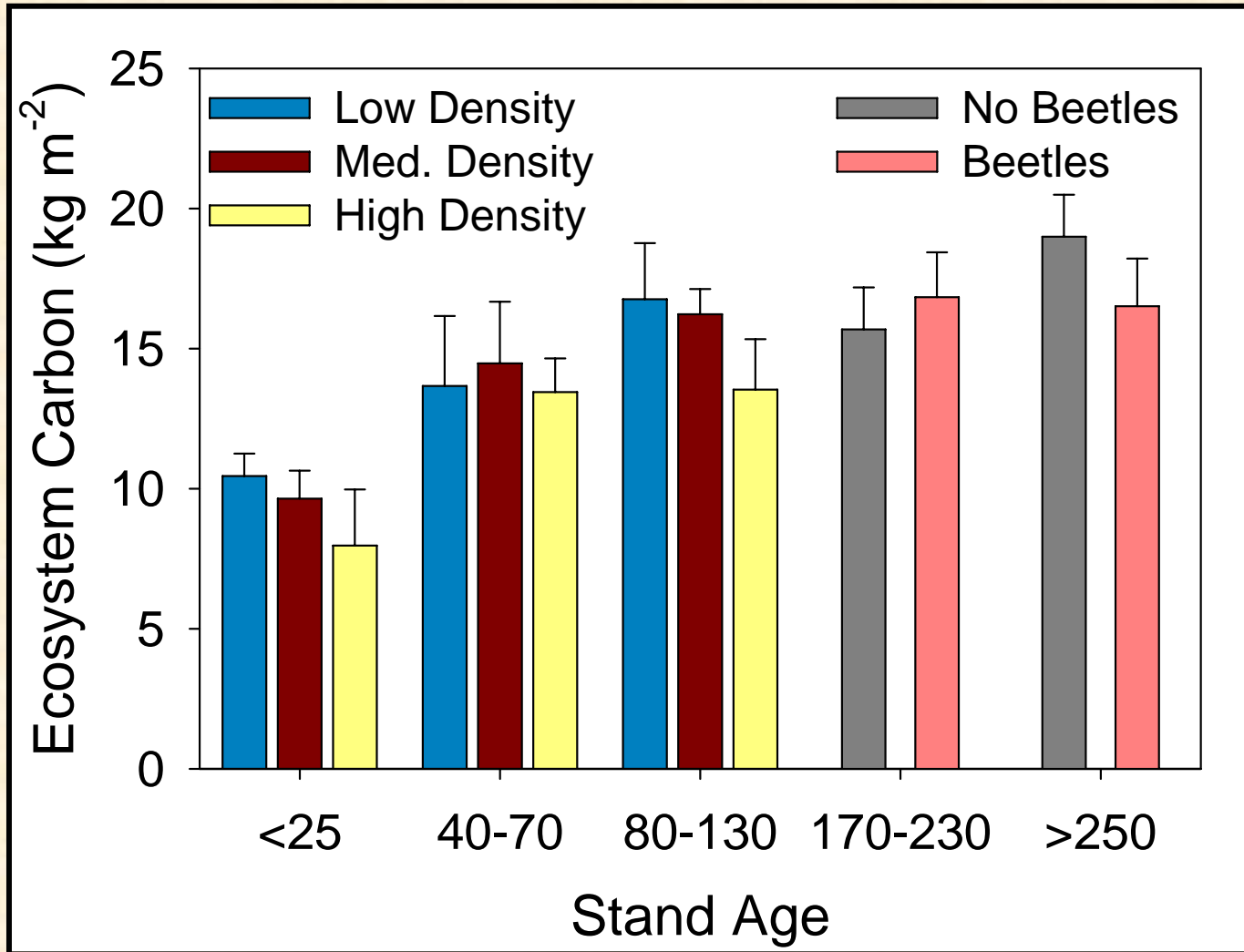
Litter Carbon (Forest Floor)

The *rate* of ecosystem carbon storage declines rapidly with time since disturbance



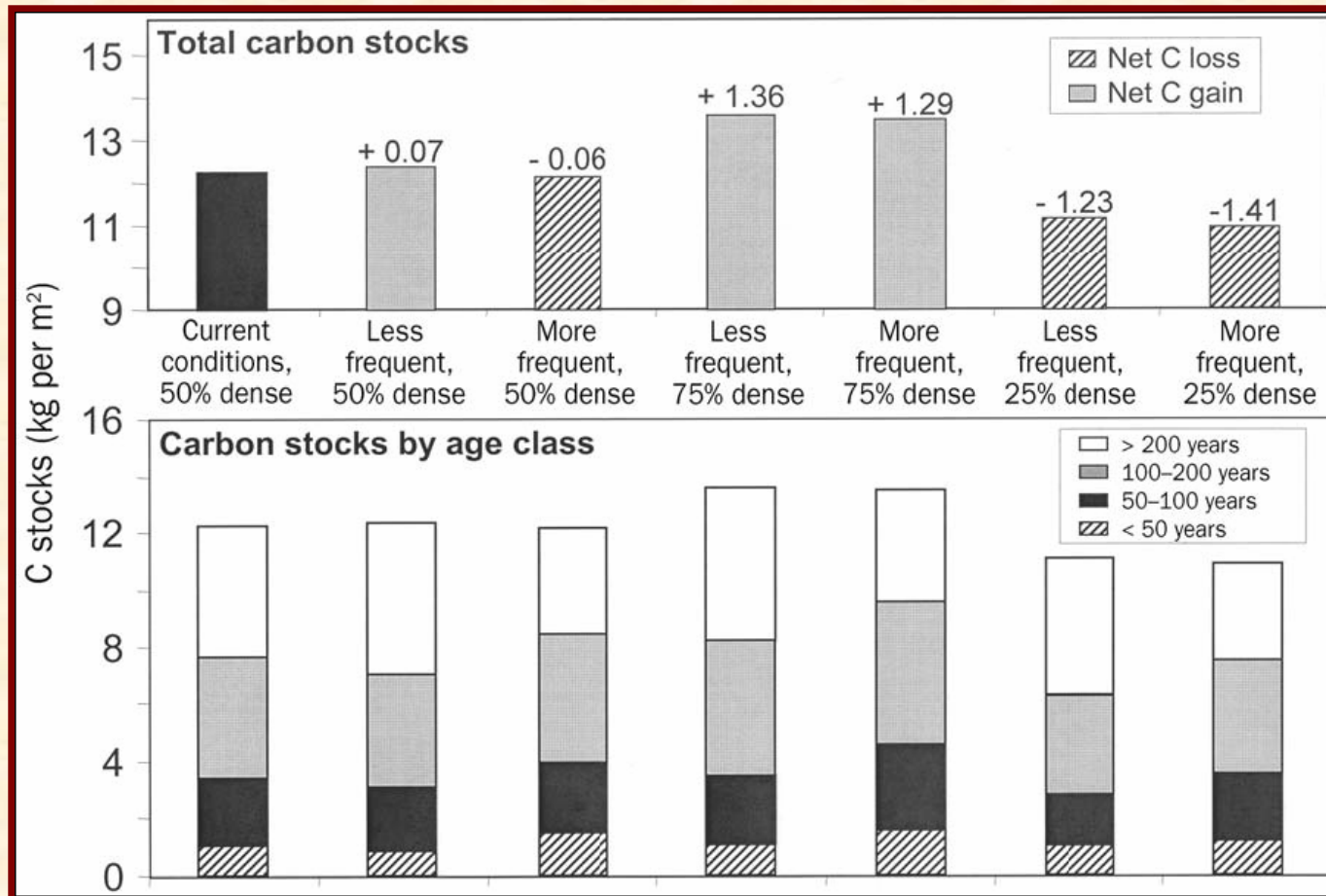
Annual Ecosystem Carbon Storage

The carbon lost in the 1988 fire and in the decomposition of the trees killed in the fire will be recovered quickly



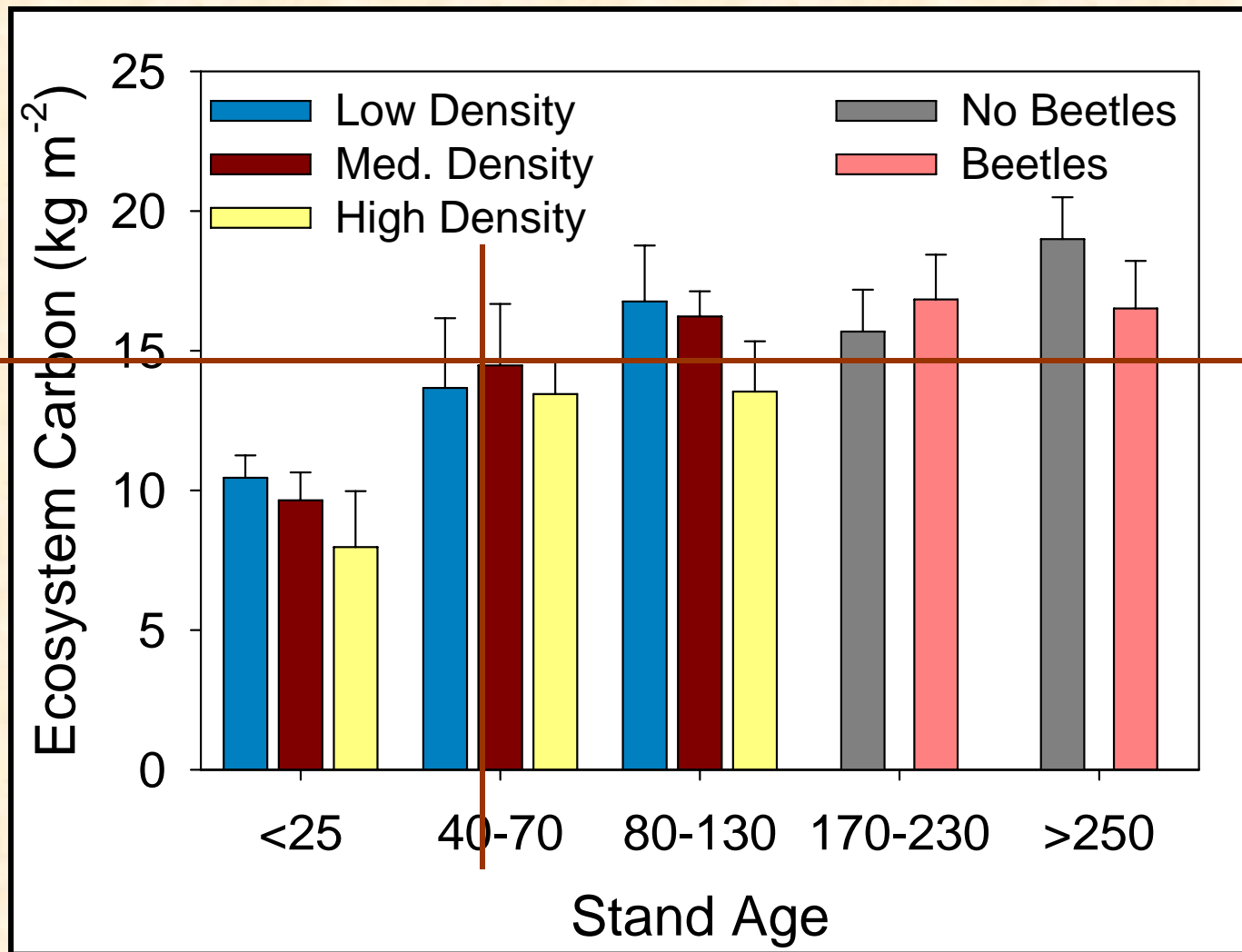
Total Ecosystem Carbon

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

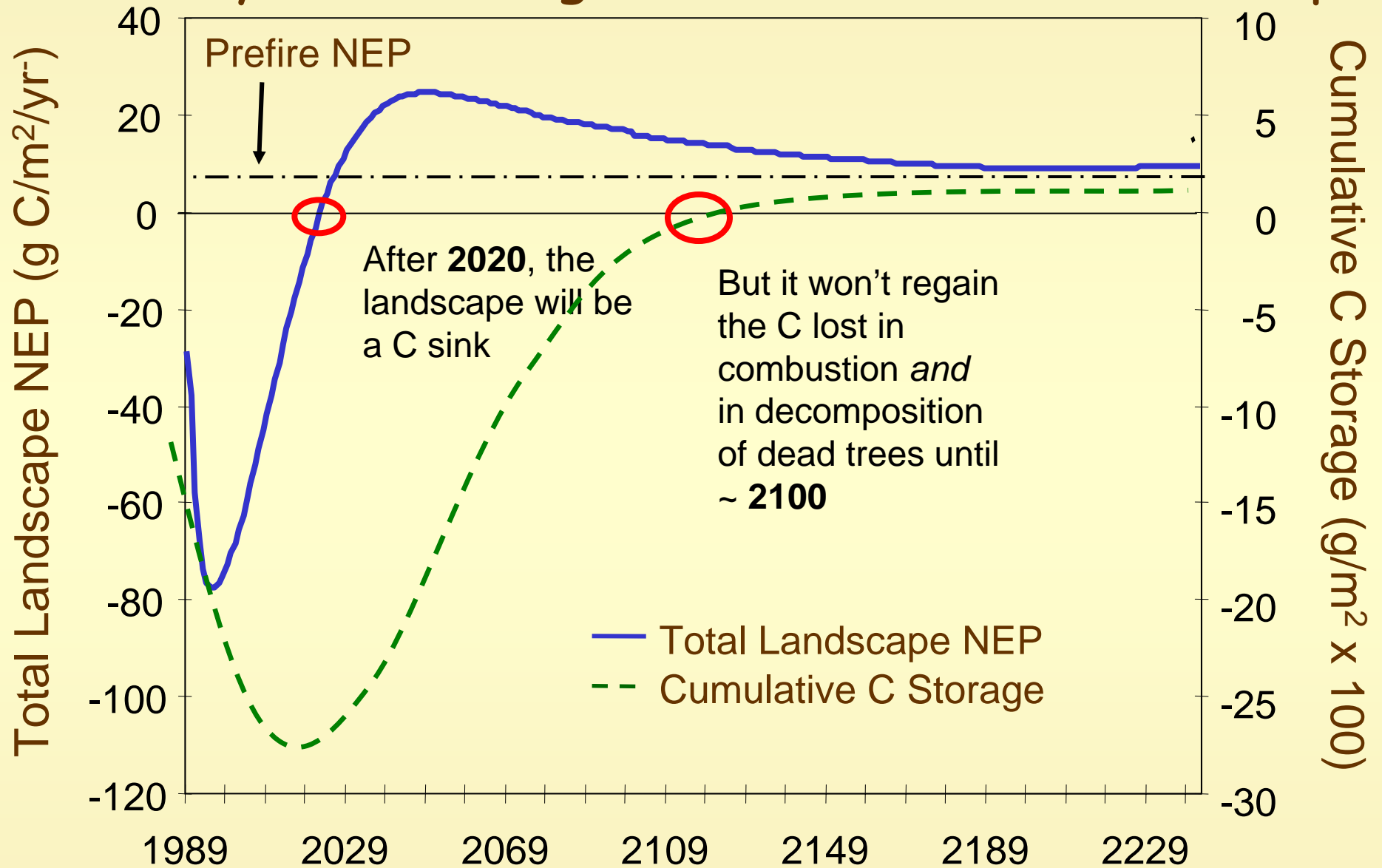


Kashian DM, WH Romme, DB Tinker, MG Turner, and MG Ryan. 2006. Carbon storage on coniferous landscapes with stand-replacing fires. *BioScience* 7:598-606. Copyright, American Institute of Biological Sciences.

Fire would reduce carbon storage on the YNP landscape only if stand-replacing fires become much more frequent (return intervals < 50 yrs)



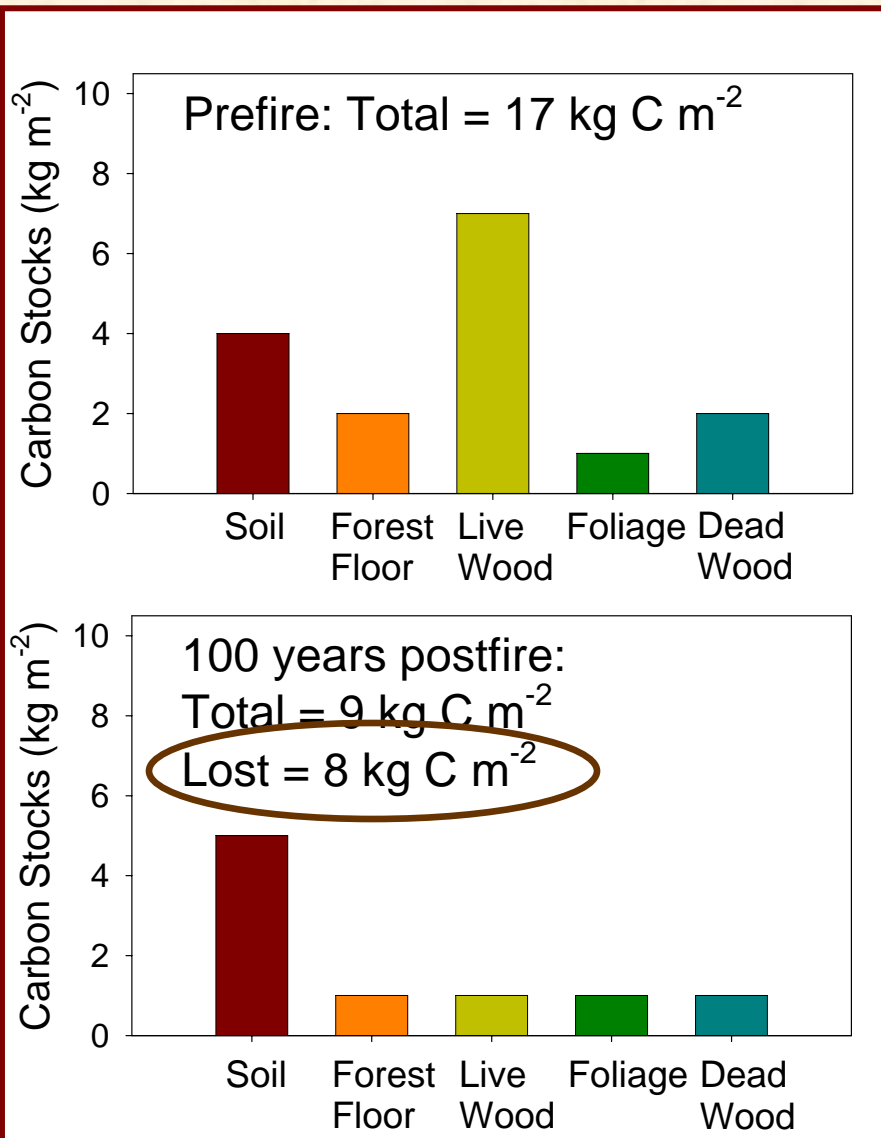
# Recovery of C storage for Yellowstone Landscape



Kashian DM, WH Romme, DB Tinker, MG Turner, and MG Ryan. 2006. Carbon storage on coniferous landscapes with stand-replacing fires. *BioScience* 7:598-606. Copyright, American Institute of Biological Sciences.

# What happens with no regeneration?

Example: Hayman Fire, Colorado, 2002



# 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

- Carbon in subalpine forests recovers 'quickly' after a fire ~50 years, regardless of tree density.
- 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.

