Forest Carbon in the Rockies: Past and Future

Michael G. Ryan
Mike.Ryan@colostate.edu
nrel.colostate.edu/ryan-lab/

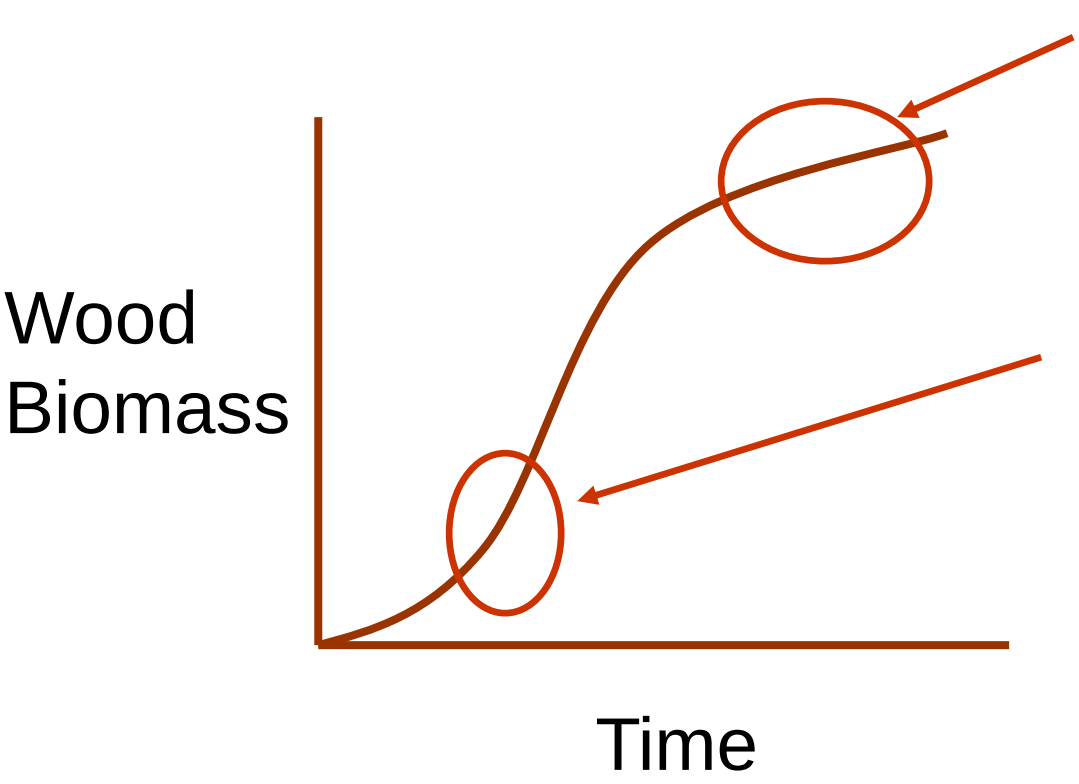
Project Learning Tree, March 1, 2016

Forest carbon has a cycle: loss after disturbance, then recovery

Net carbon change over the cycle is 0, *if* the forest regenerates *and if* given enough time

Wood growth and storage depend on forest age

- Wood growth is rapid for young forests
- Later, growth slows and trees die. Carbon accumulation slows (storage is large)

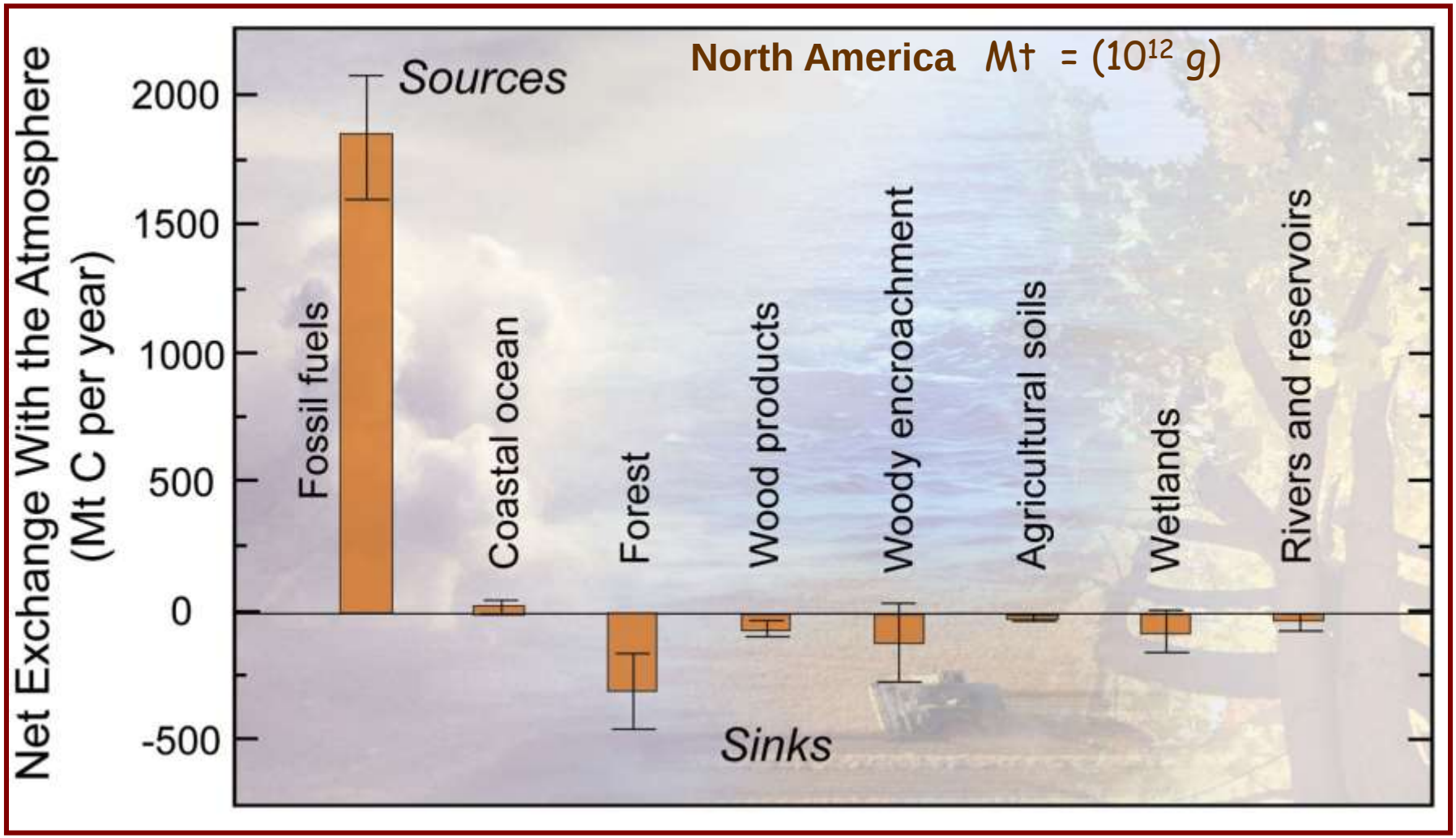


Older forests have much higher carbon stores

Younger forests have a greater carbon uptake

Most disturbances don’t kill all trees

Big Picture: US forests and wood products offset ~16% of our fossil-fuel emissions

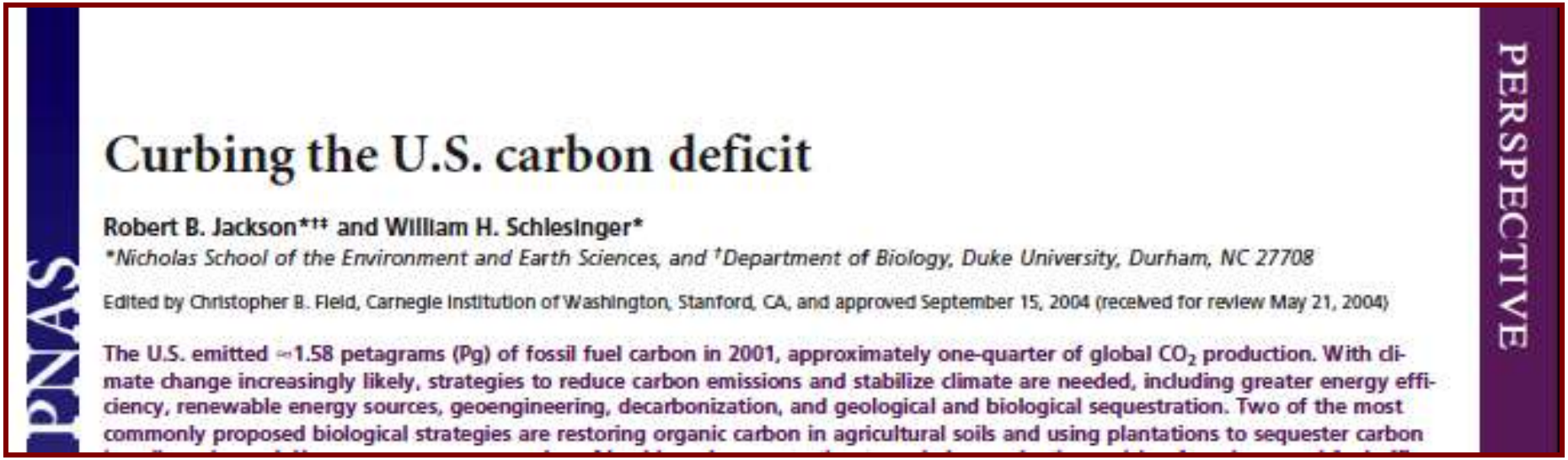


CCSP, 2007. *The First State of the Carbon Cycle Report (SOCCR): The North American Carbon Budget and Implications for the Global Carbon Cycle*.

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

10% is Huge!

- To get another 10%:
- All US autos get hybrid gas mileage (from 25 to 50 mpg)
- Convert 1/3 current Ag land to forests (~664,000 square miles – size of Alaska; 6.4 x area of Colorado).



PNAS

PERSPECTIVE

Curbing the U.S. carbon deficit

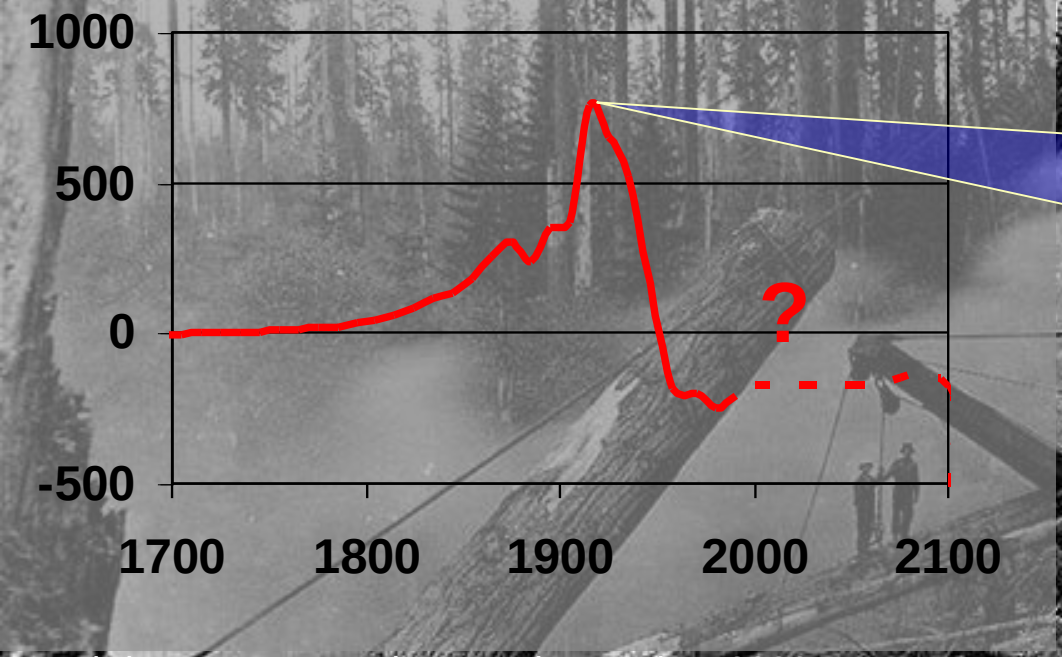
Robert B. Jackson*†‡ and William H. Schlesinger*

*Nicholas School of the Environment and Earth Sciences, and †Department of Biology, Duke University, Durham, NC 27708

Edited by Christopher B. Field, Carnegie Institution of Washington, Stanford, CA, and approved September 15, 2004 (received for review May 21, 2004)

The U.S. emitted ≈1.58 petagrams (Pg) of fossil fuel carbon in 2001, approximately one-quarter of global CO_2 production. With climate change increasingly likely, strategies to reduce carbon emissions and stabilize climate are needed, including greater energy efficiency, renewable energy sources, geoengineering, decarbonization, and geological and biological sequestration. Two of the most commonly proposed biological strategies are restoring organic carbon in agricultural soils and using plantations to sequester carbon

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

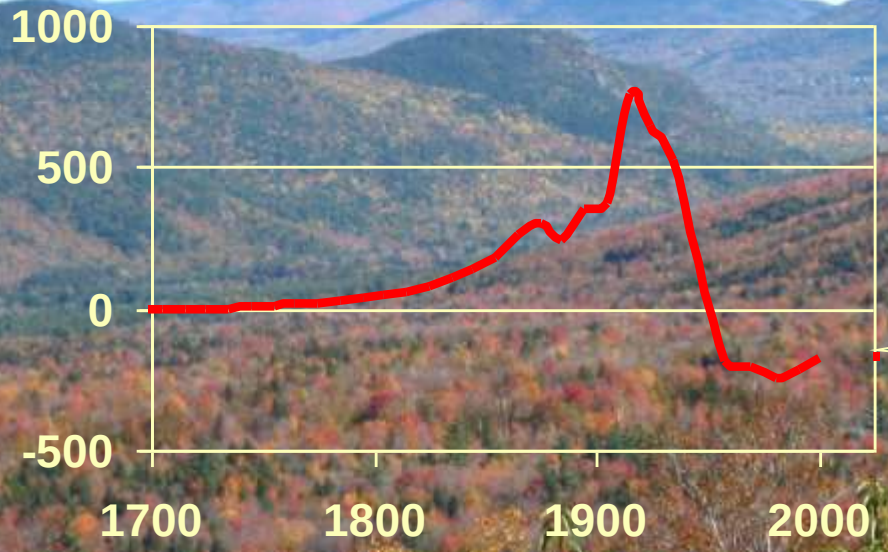


In 1915, emissions from forests were 760 million tons C per year

Birdsey, R., K. Pregitzer, and A. Lucier. 2006. Forest carbon management in the United States: 1600-2100. Journal of Environmental Quality 35:1461-1469.

Photo courtesy of University of Washington Libraries, Special Collections, KIN084.

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



In 2000, sequestration by forests was ~200 million tons C per year

Birdsey, R., K. Pregitzer, and A. Lucier. 2006. Forest carbon management in the United States: 1600-2100. Journal of Environmental Quality 35:1461-1469.

Photo by Mike Ryan

Rocky Mountain Forests: *Retain* as much as possible

- Fire
- Insects & Disease
- Drought
- Current Status

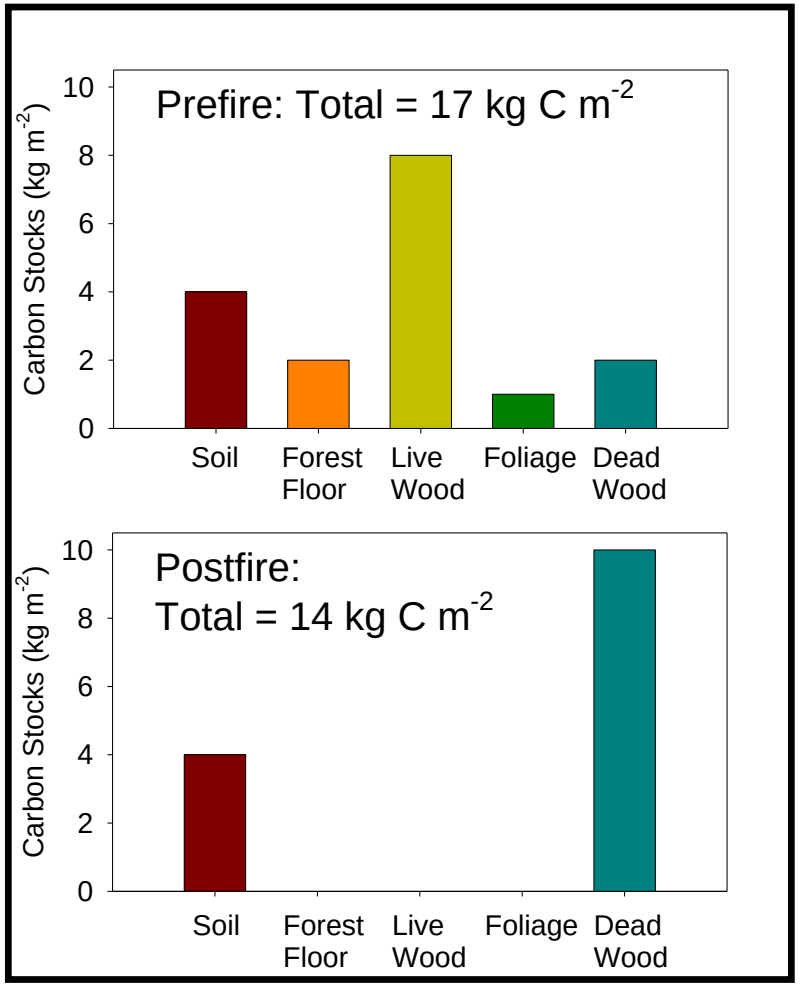
Many RM forests have more trees = more carbon than before European settlement

- Fires convert montane conifer stands to shrublands or meadows (no regeneration)
- Higher susceptibility to bark beetle mortality
- Higher susceptibility to drought mortality

Many RM forests have more trees = more carbon than before European settlement

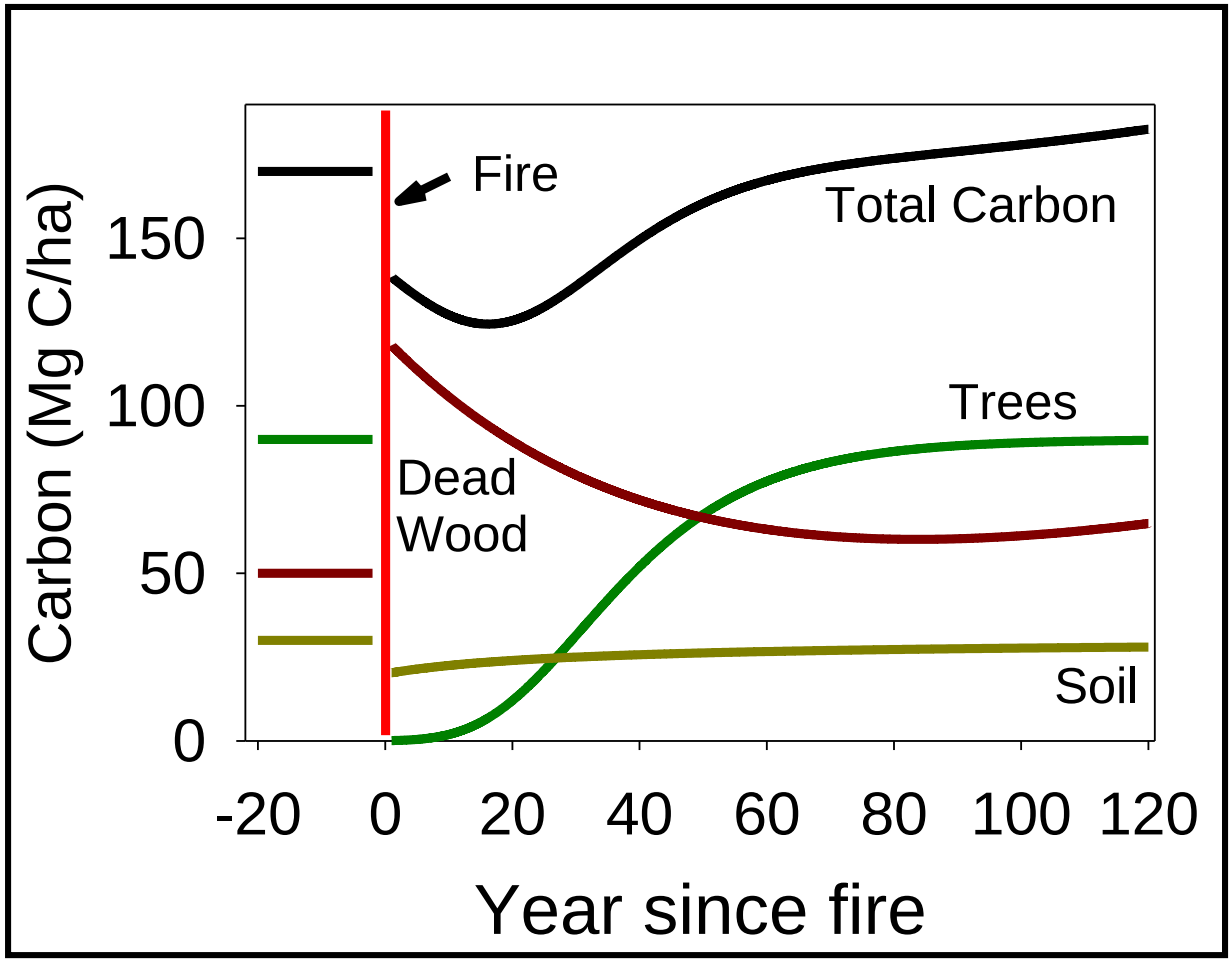
How Does Fire Change Forest Carbon?

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



DM Kashian and others, unpublished data from Yellowstone NP, WY

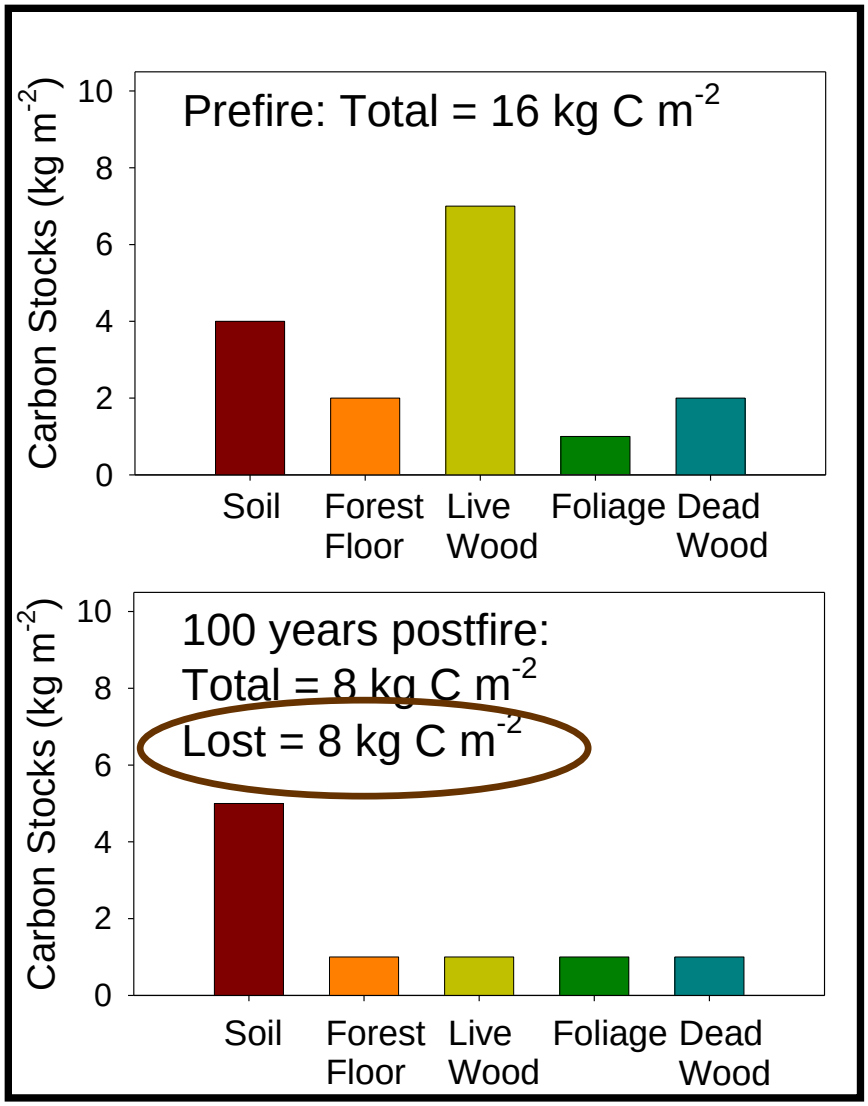
Ecosystems that *regenerate* forests after disturbance will recover all of the carbon lost, *given time*



DM Kashian and others. 2006. *BioScience 56:598-606*

What happens with no regeneration?

Example: Hayman Fire, Colorado, 2002



Regeneration of severe fires will be key for carbon and forests!

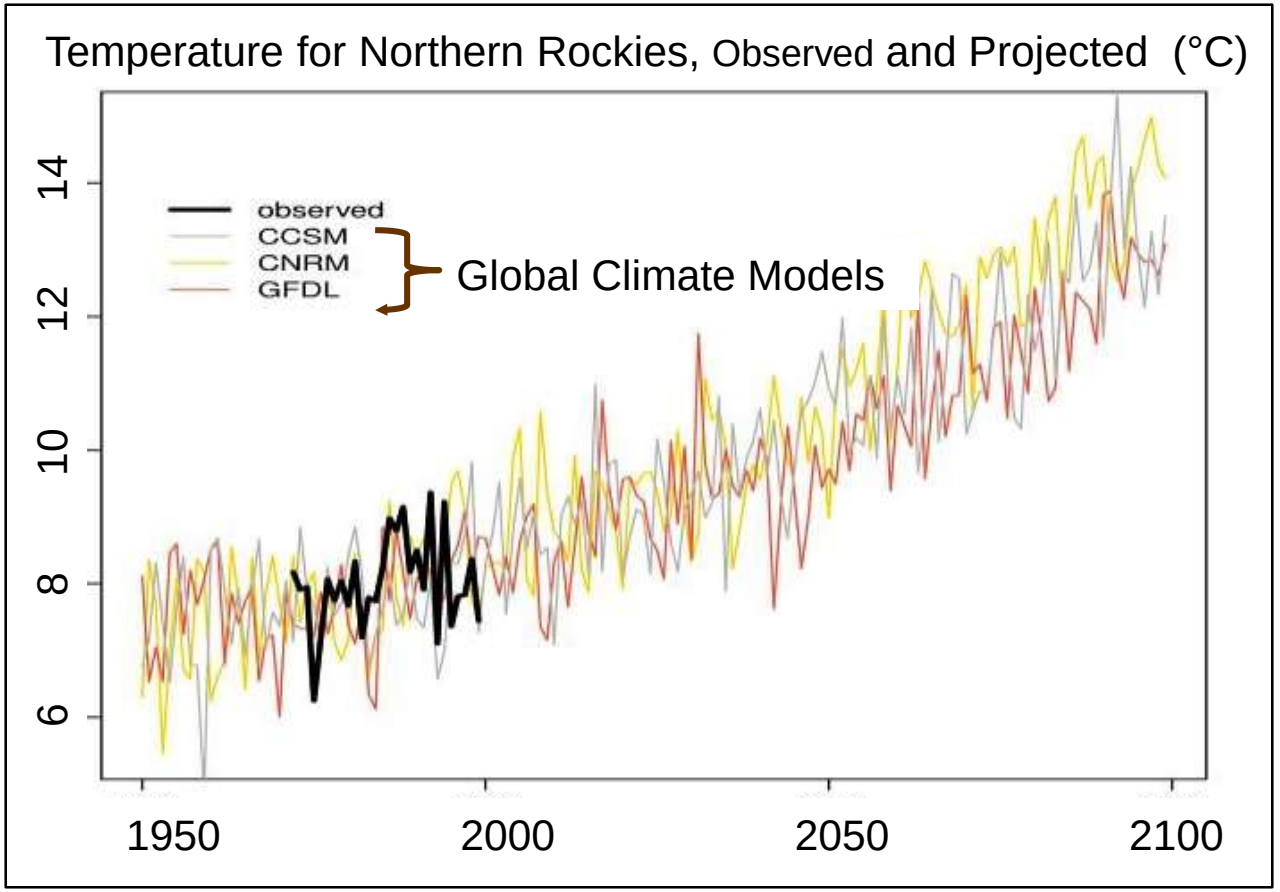
MG Ryan and others, unpublished data from Manitou Experimental Forest, CO

What about the future?

Stand replacing fires are a large problem and will become larger:

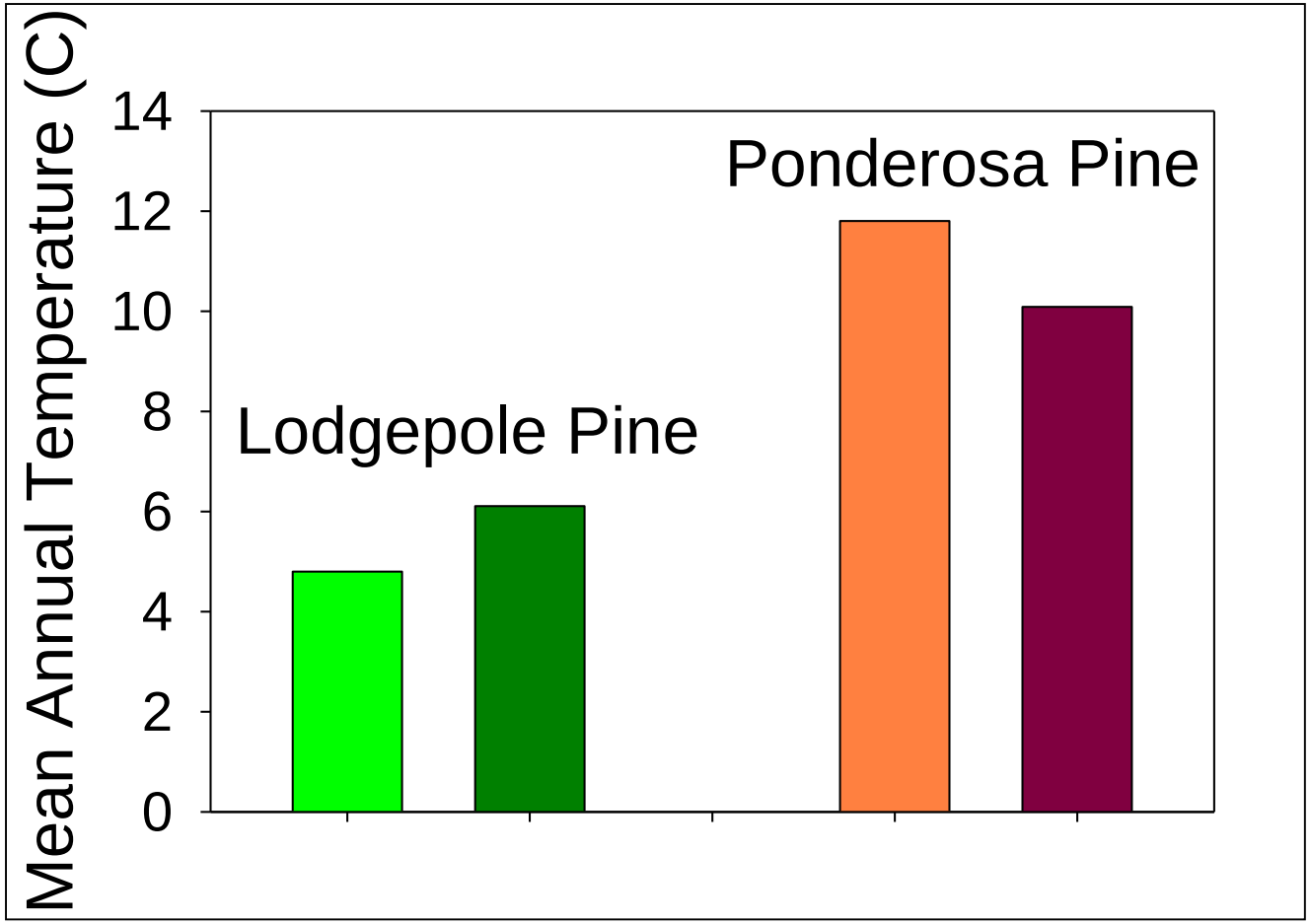
- Climate change will likely increase fire occurrence, extent and severity
- Restoration can help retain forests, perhaps at the expense of some carbon

Models project temperatures in Northern Rockies to increase 4-6 °C by 2100



Westerling, Turner, Smithwick, Romme, Ryan. 2011. PNAS 32: 13165

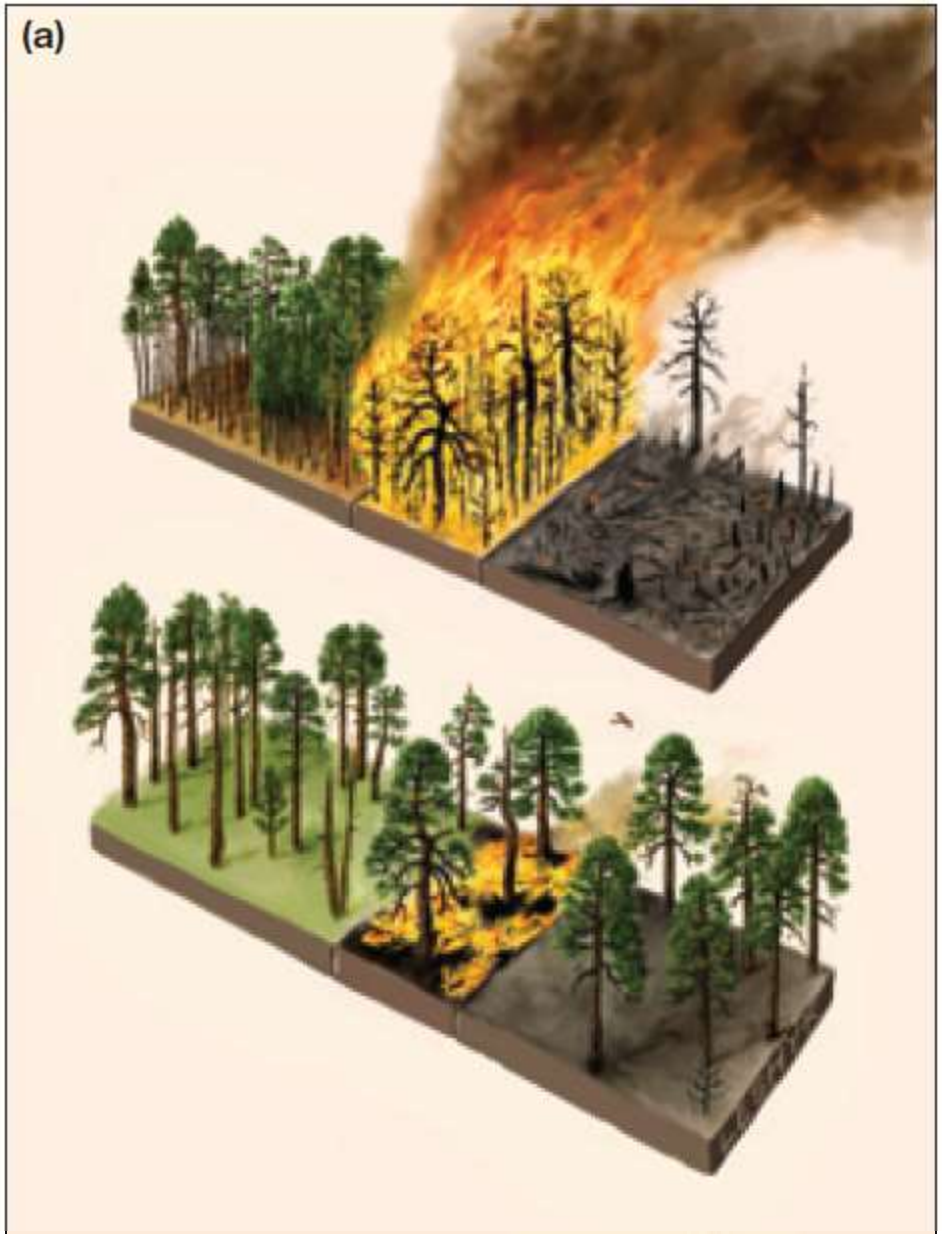
What is the difference between lodgepole and ponderosa pine? 4-6 °C



Western Regional Climate Center, Western U.S. Climate Historical Summaries http://www.wrcc.dri.edu/Climsum.html for West Yellowstone, WY; Dillon, CO; Cheeseman, CO; Fort Valley, AZ. All with ~100 years of record

Can we be proactive?
Fuel Treatments and Carbon

- Fire in a less dense forest may reduce tree mortality
- But, we also need to consider probability of fire and amount removed.



(Hurteau et al 2008 – Frontiers in Ecology and Environment 6: 493-498) Copyright by the Ecological Society of America

Fuels Treatments and Carbon

Fuels treatments move 1/3 to 1/2 of forest carbon to the atmosphere.

Even when biomass removed is used instead of fossil fuel, it takes a long time until that carbon is recaptured by the forest

(McKenchie et al. 2011. *Environ. Sci. Technol.* ***45****: 789–795.*

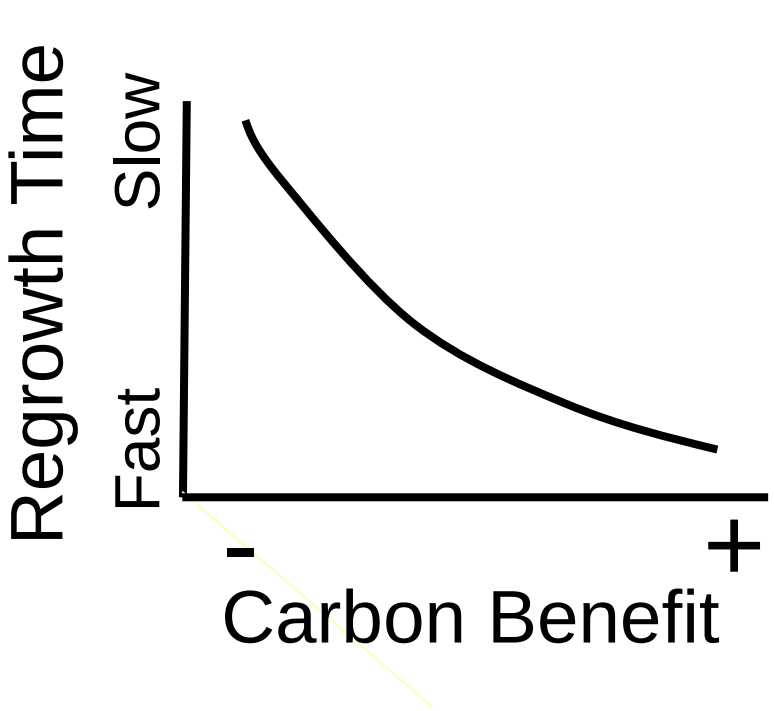
Kelsey et al. 2014. *Carbon Balance and Management* 9:6 doi:10.1186/s13021-014-0006-1

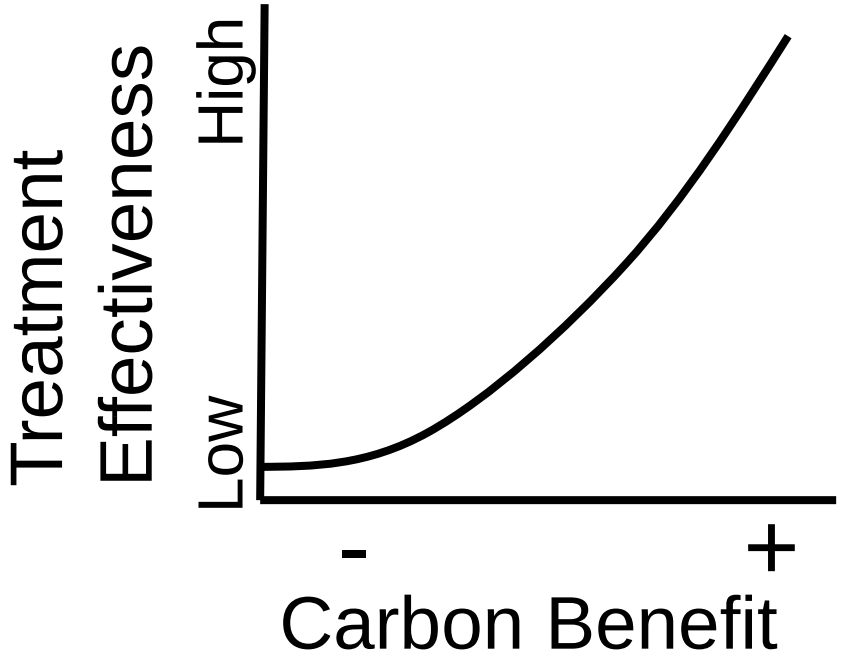
Photo by Richard Oakes, USFS

Fuels Treatments and Carbon

- When the fire return interval < regrowth time, and removals are used for energy, carbon benefits move towards positive.

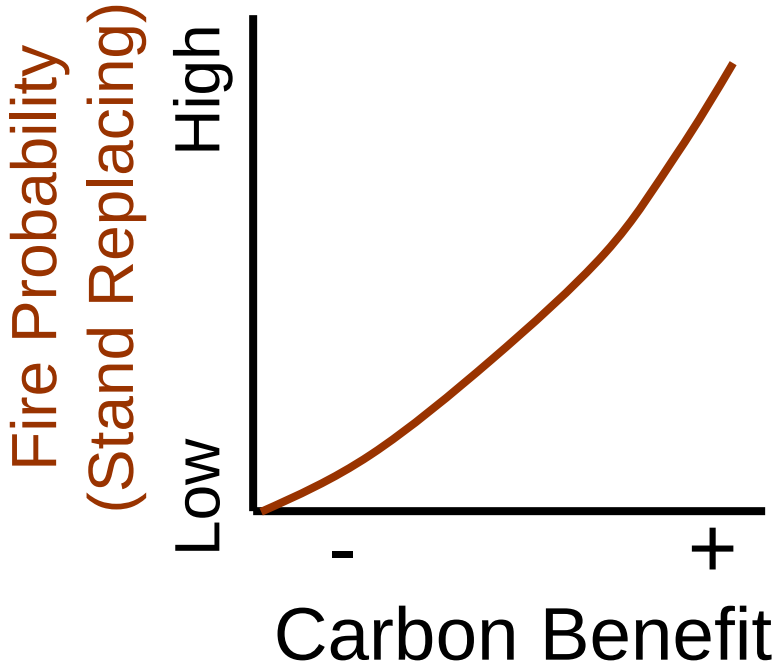
See Hurteau and Brooks (2011) Bioscience 61: 139-146 and Kelsey et al. 2014. Carbon Balance and Management 9:6 doi:10.1186/s13021-014-0006-1

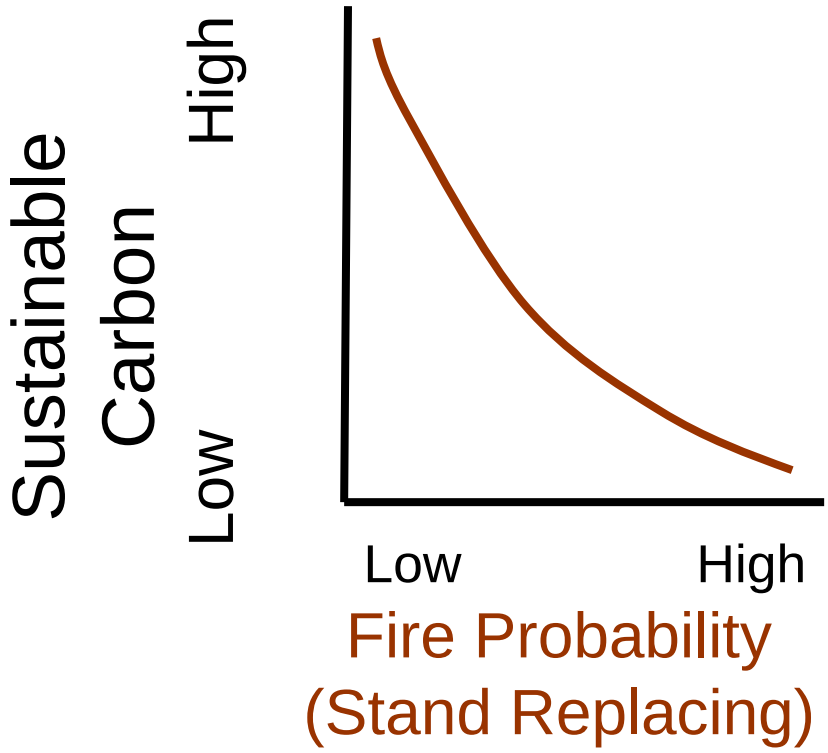




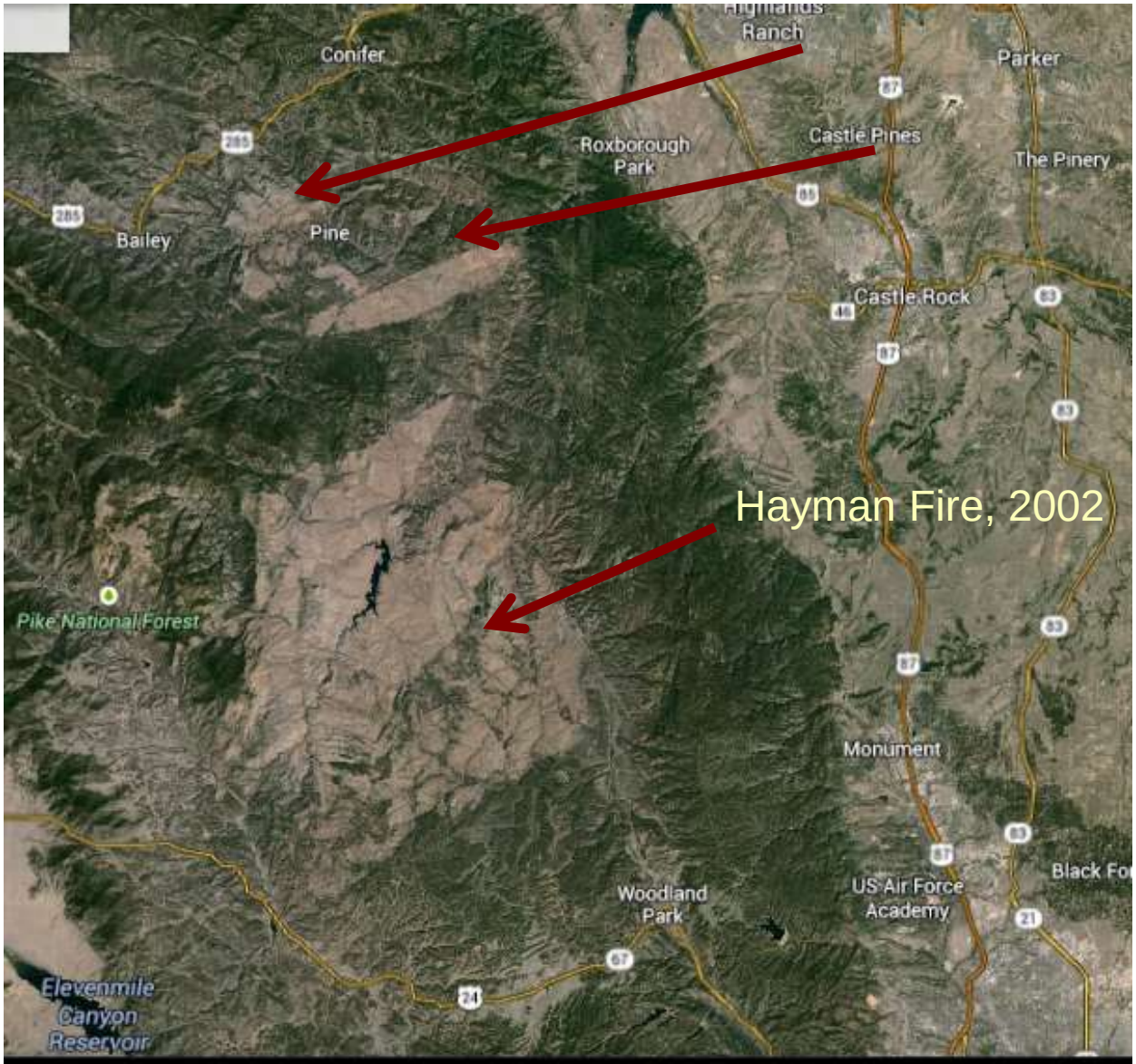
Fuels Treatments and Carbon

- But, it is a gamble (for carbon). We are putting lots of carbon from forests into the air now, betting on fire and forest growth for the next 50-100 years (Kelsey et al. 2014).





Intense fires in the Front Range suggest gamble is worth it!



Take Home

- Cycle: Forests recover what is lost in disturbance *if* they regenerate and *if* they have enough time
- Increased disturbance with climate change will jeopardize current Rocky Mountain and US forest sink
- Restoration, regeneration and fuel treatments can help retain forests
- For carbon management of forests, focus on retaining forests *and* rapid regeneration after disturbance.

Potential Exercises

- Carbon storage from tree planting in montane forests
- Forest area needed to offset carbon footprint