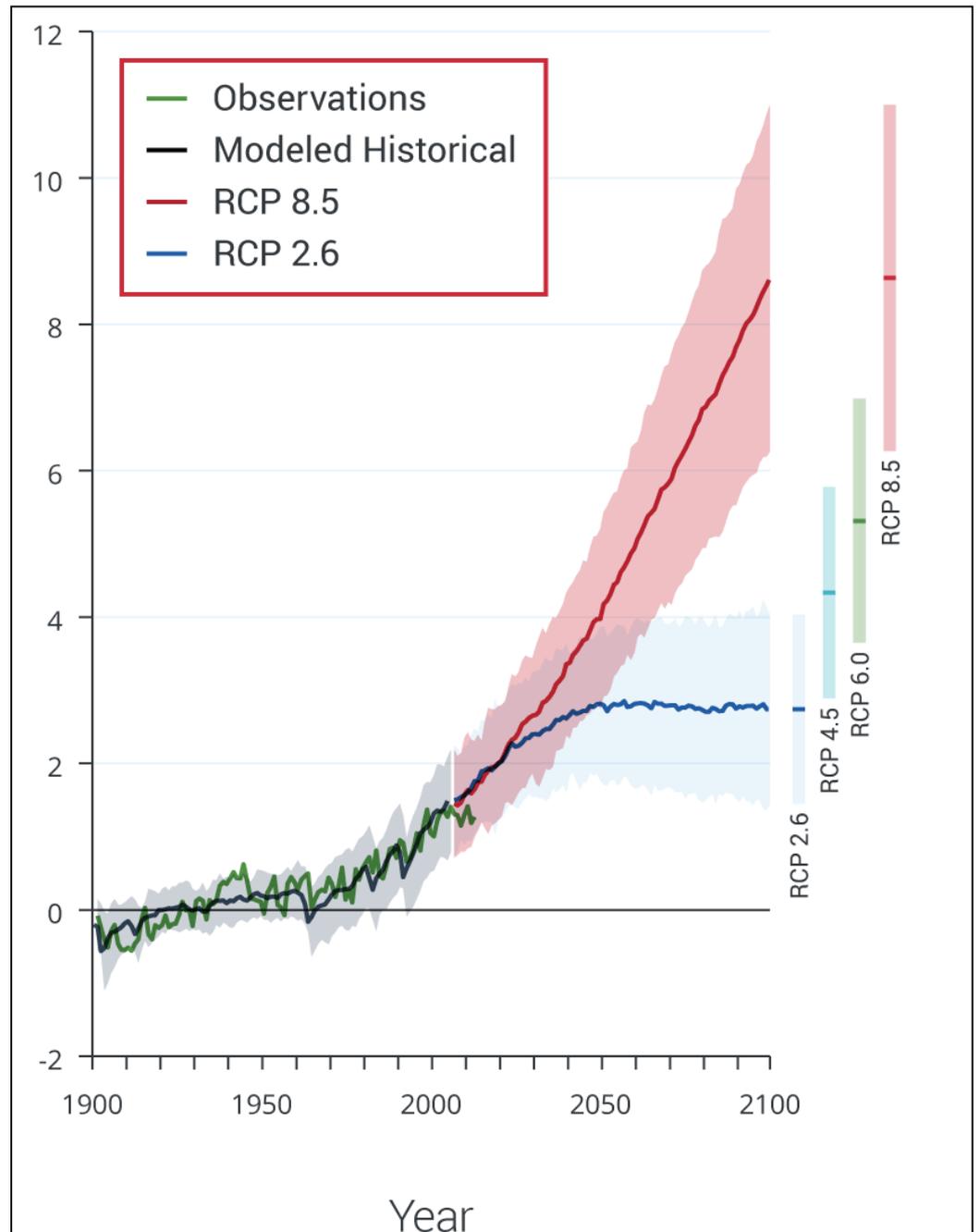


Stabilizing Carbon in a Flammable Forest

Matthew Hurteau

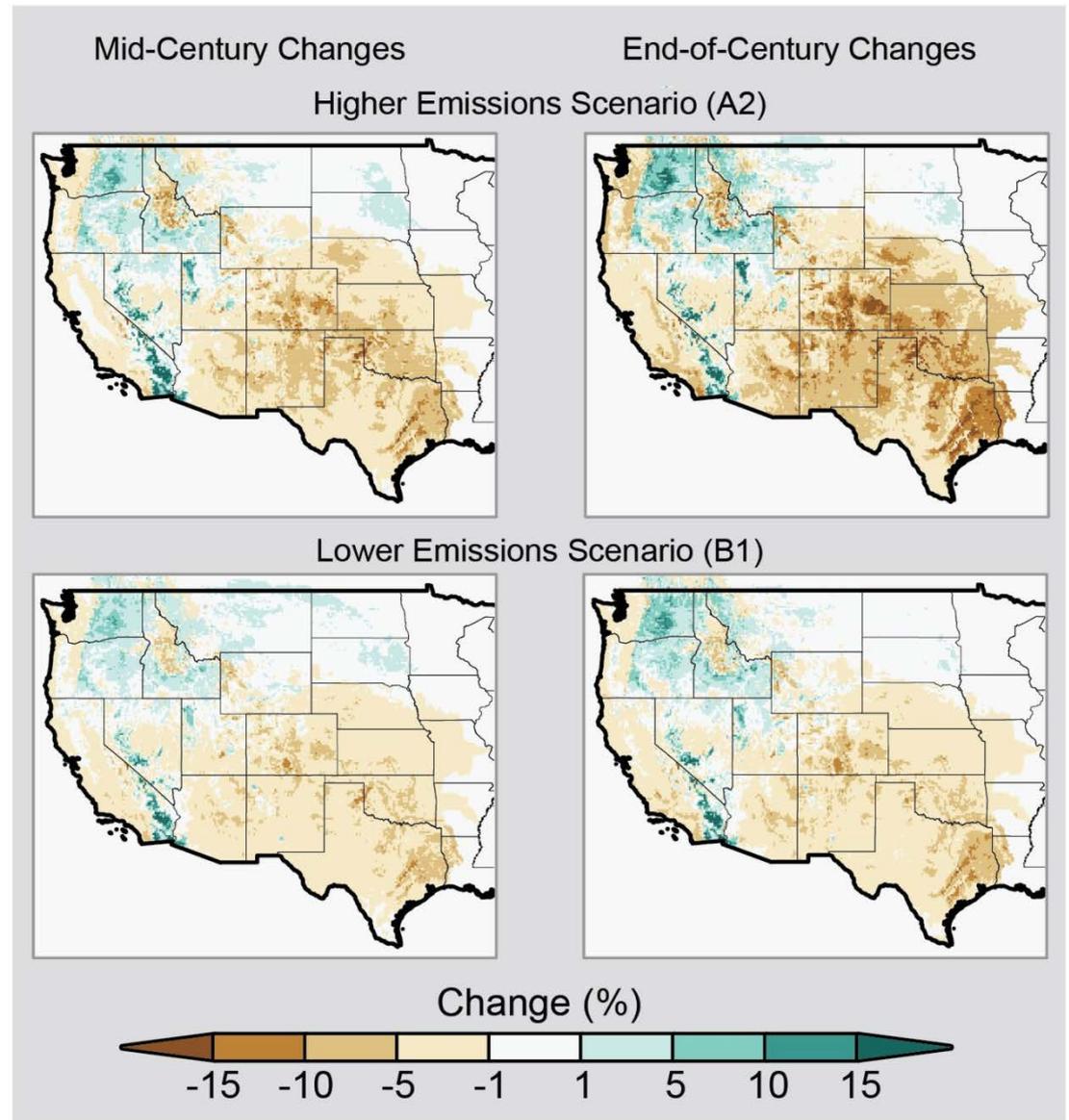


A warmer future...



...and as a result,
largely drier future

Projected Changes in Soil Moisture for the Western U.S.



4 out of 6 are influenced by climate

Climate Influenced

Drought

Wildfire

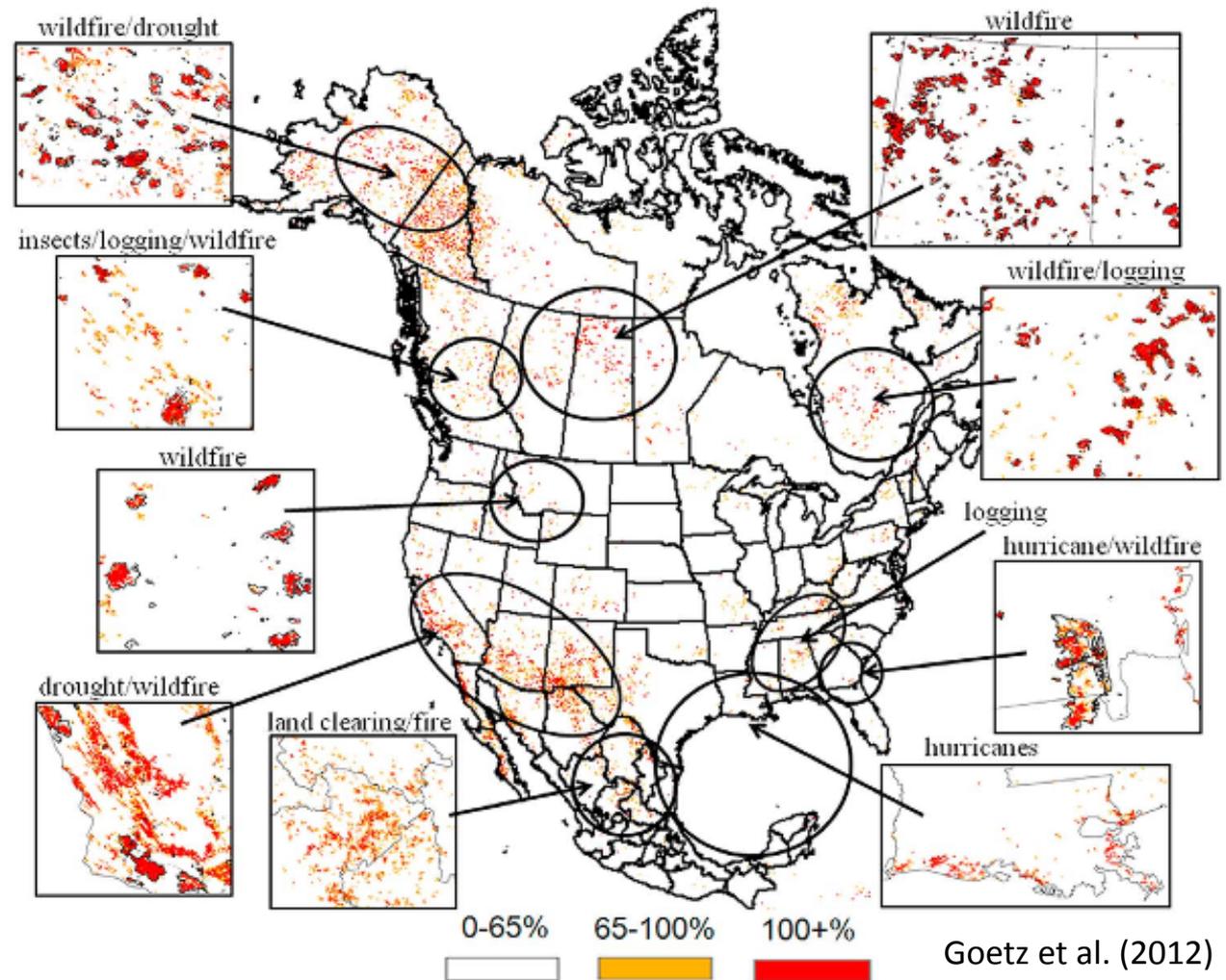
Insects

Hurricane

Non-climate

Logging

Land clearing



2005-2009 Disturbance from MODIS

1°C temp increase=
73-656% increase in
burned area

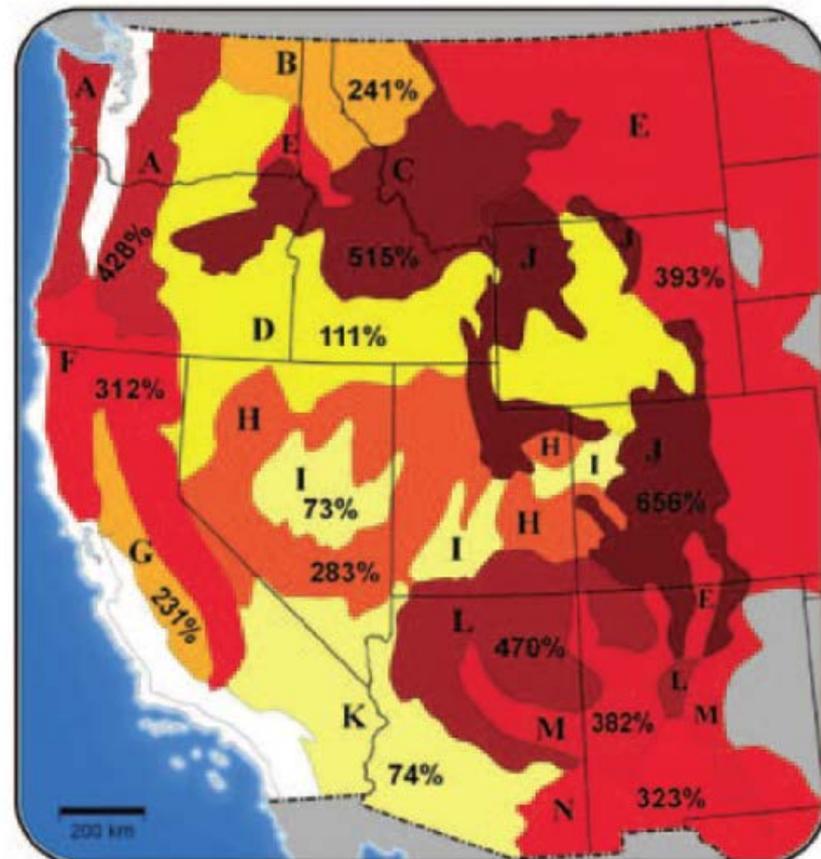
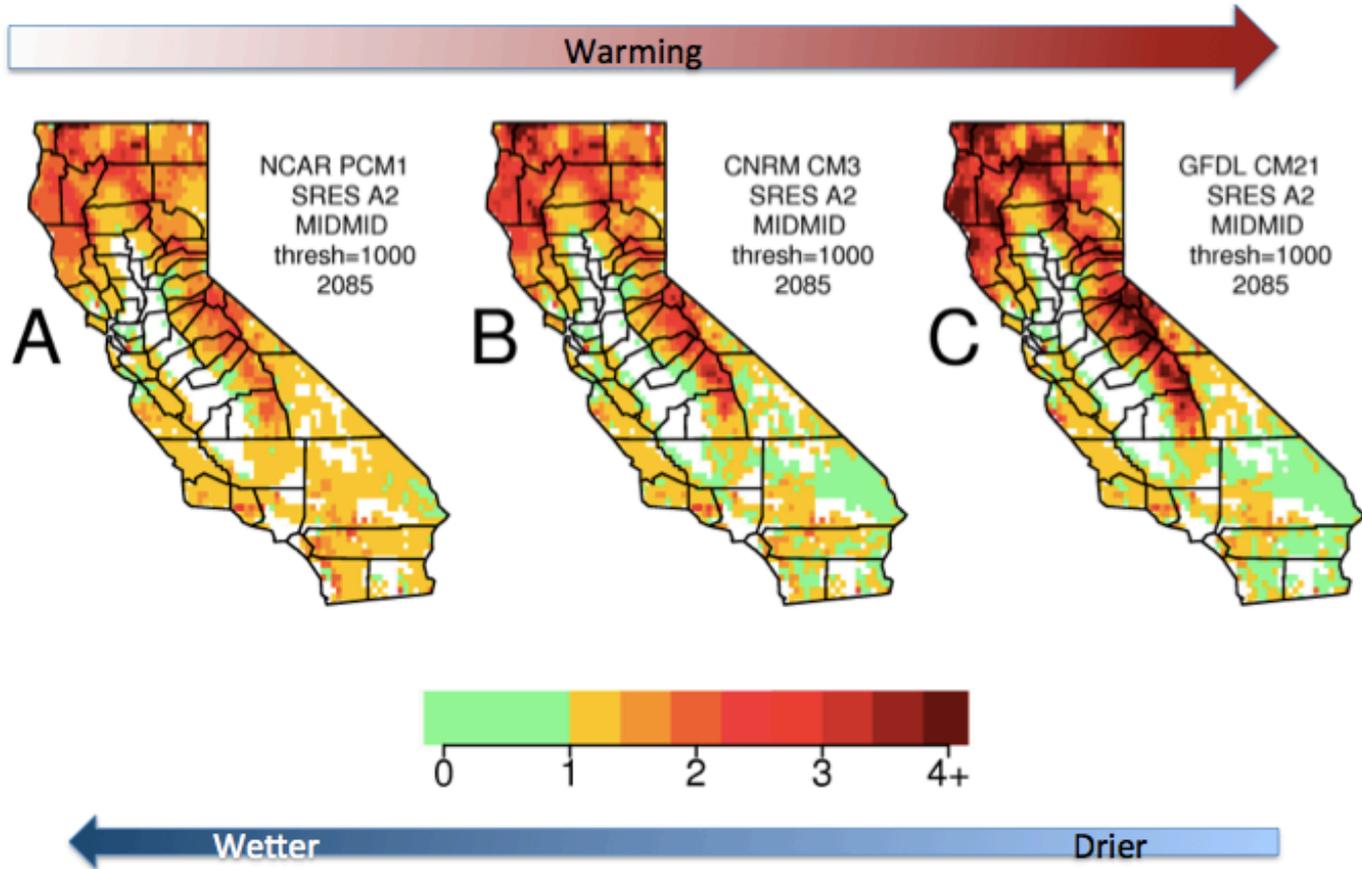


FIGURE 24

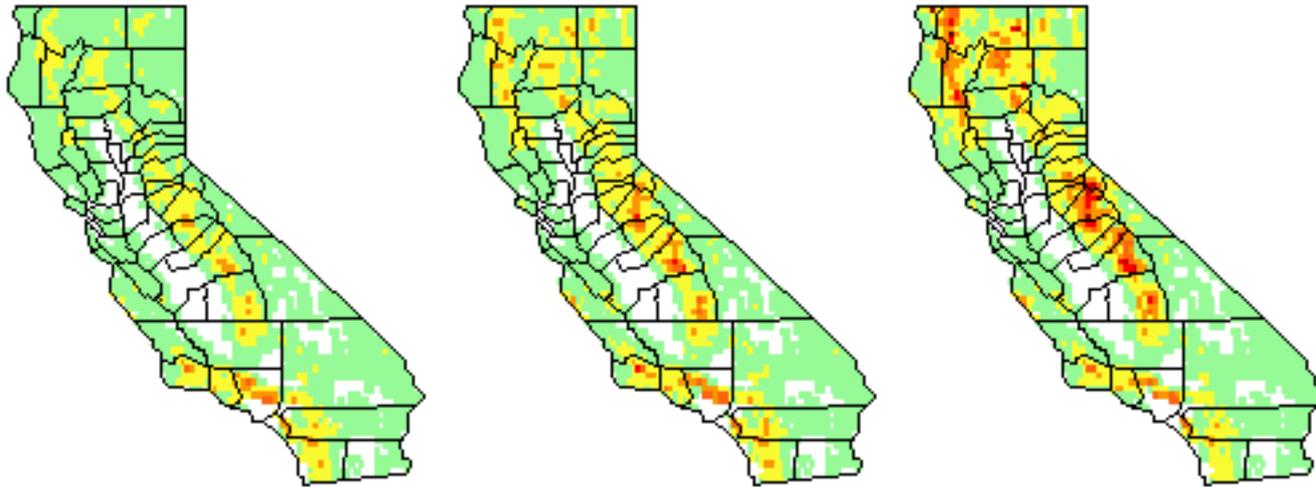
Increased Risk of Fire Rising temperatures and increased evaporation are expected to increase the risk of fire in many regions of the West. This figure shows the percent increase in burned areas in the West for a 1°C increase in global average temperatures relative to the median area burned during 1950-2003. For example, fire damage in the northern Rocky Mountain forests, marked by region B, is expected to more than double annually for each 1°C (1.8°F) increase in global average temperatures. Source: National Research Council, 2011a

Fire Projections

Projected Changes in Burned Area



Projected Fire Emissions

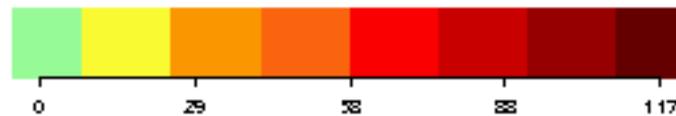


Historic

Mid-Century

Late-Century

CO₂ (Gg)



19-101% Increase in Emissions

Hurteau et al. (2014)

A photograph of a large fire burning in a forest. A massive plume of orange and yellow smoke rises into the sky from the center of the fire. The fire is visible at the base of several tall, thin trees. The overall scene is dark and dramatic, with the fire providing the primary light source.

A fuel & climate
problem

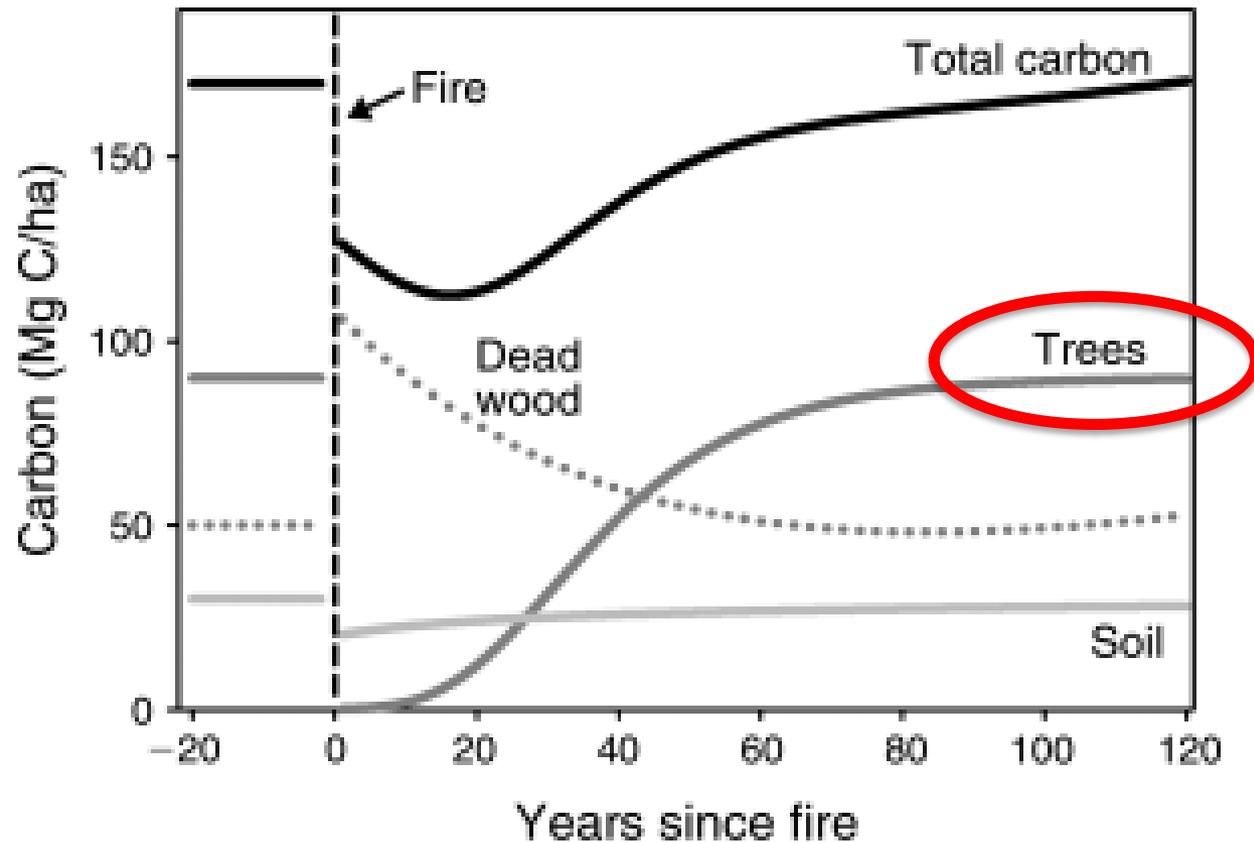
And we don't have
direct control over
the climate

Photo: © B. Oberhardt

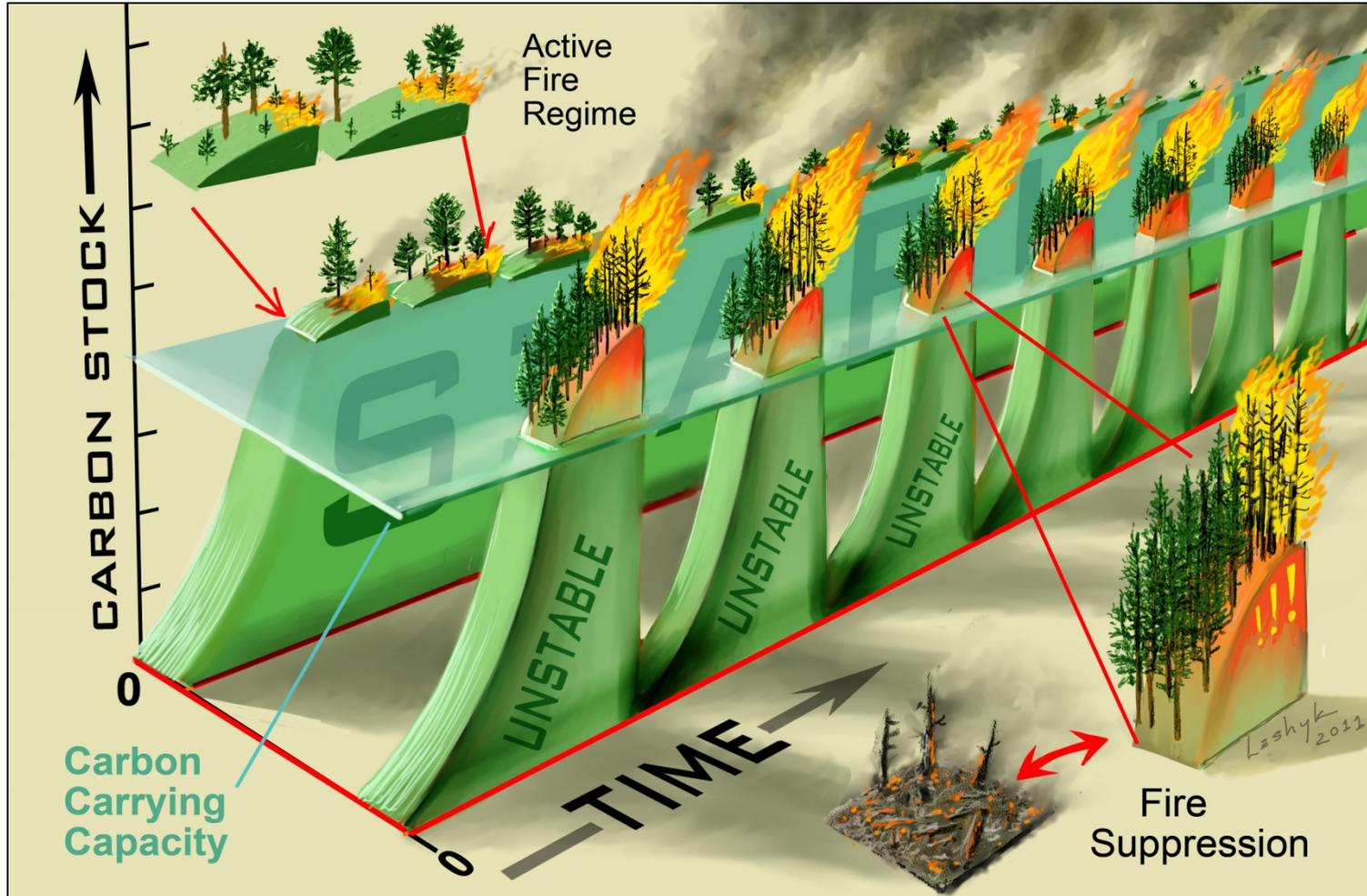
Forest Carbon

- Individual Tree Scale:
 - “Rate of tree carbon accumulation increases continuously with tree size” Stephenson et al. (2014)
- Stand Scale:
 - Carbon carrying capacity is the amount of carbon that can be stored under prevailing climate and natural disturbance conditions

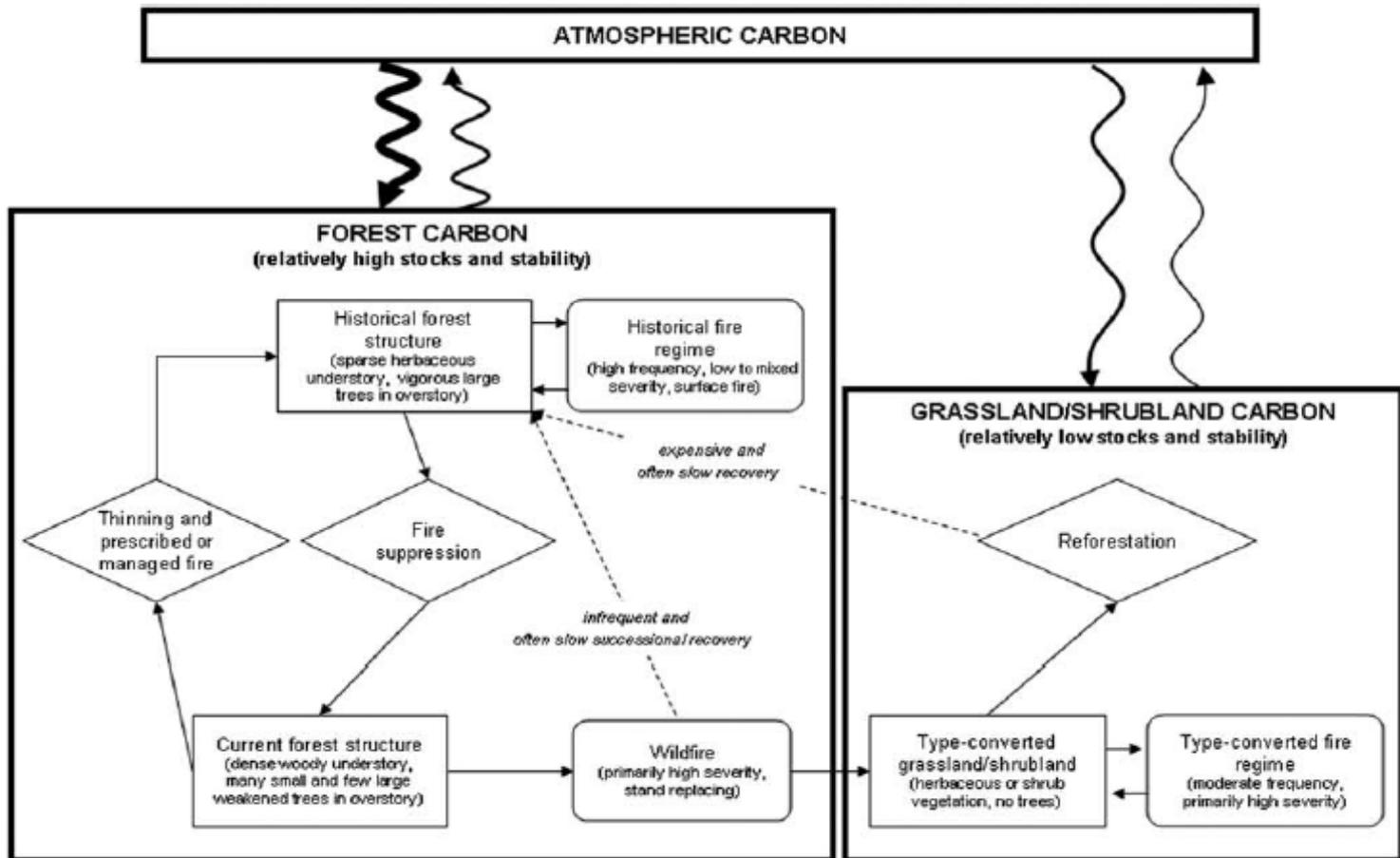
Stand Level Carbon Storage



Carbon Stability



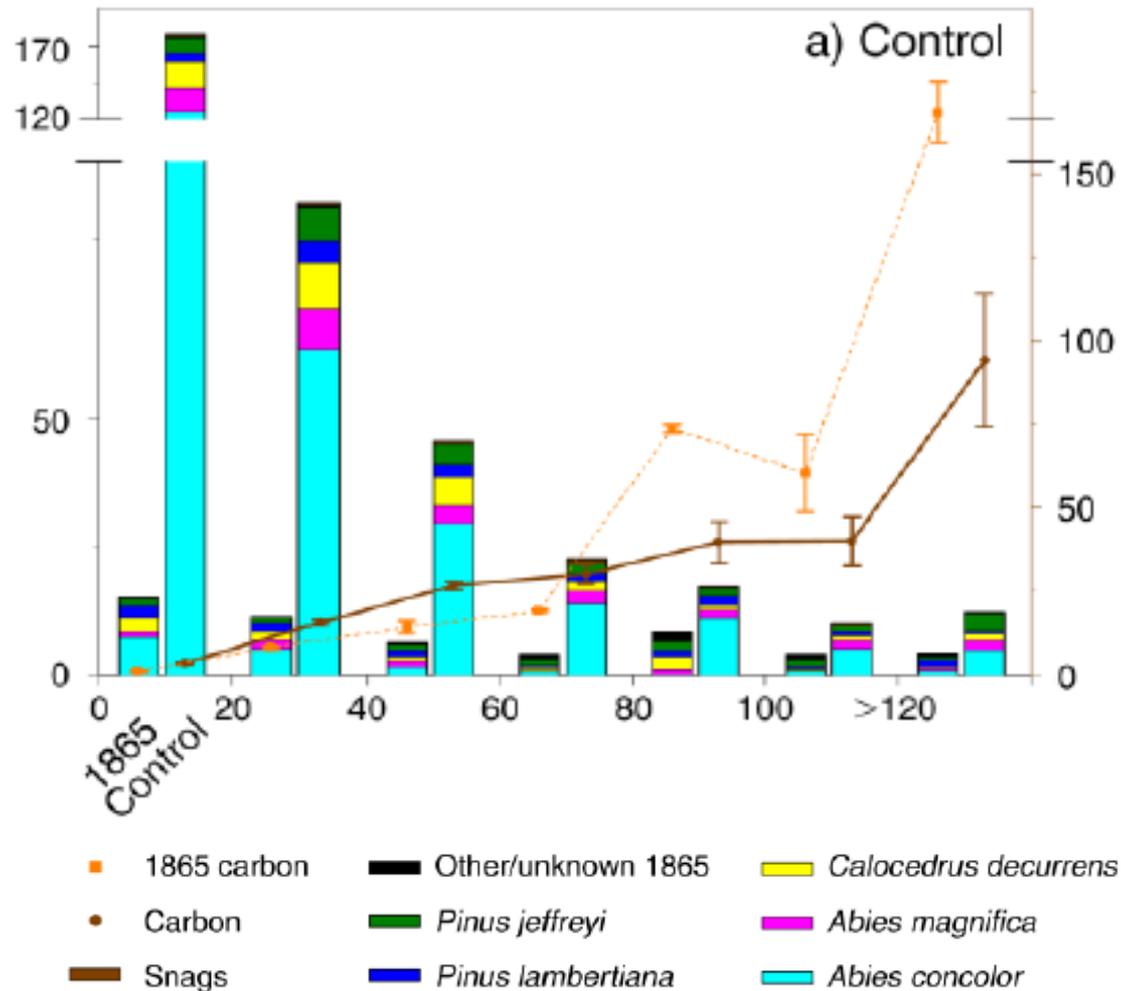
Post-fire Type Conversion To Lower Carbon State



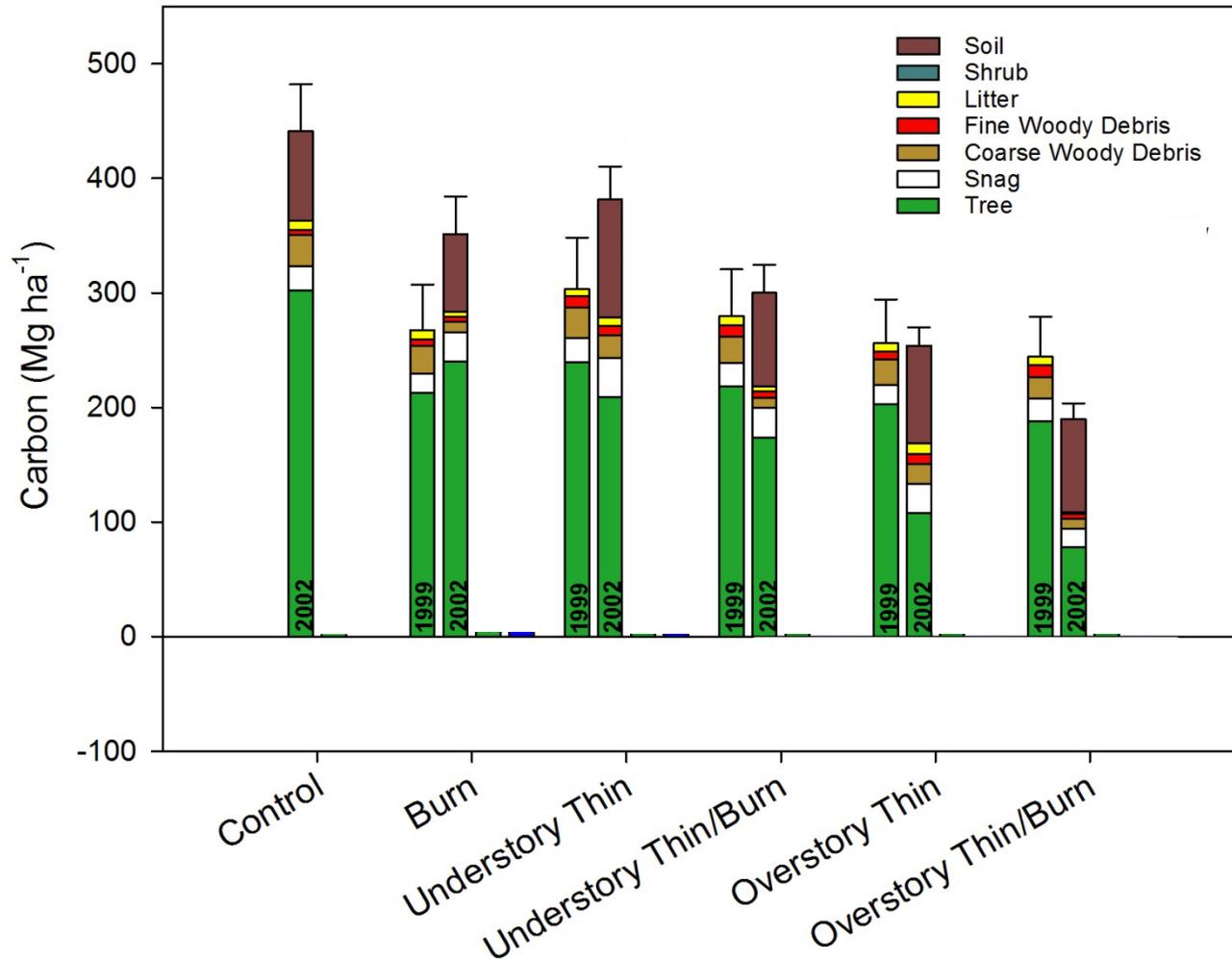
Forest Carbon & Fire Questions:

- Fire-suppressed forest versus fire-maintained forest carbon stock differences?
- Carbon costs of treatment without wildfire?
- Carbon balance of treatment with wildfire?
- Effects of climate and disturbance?

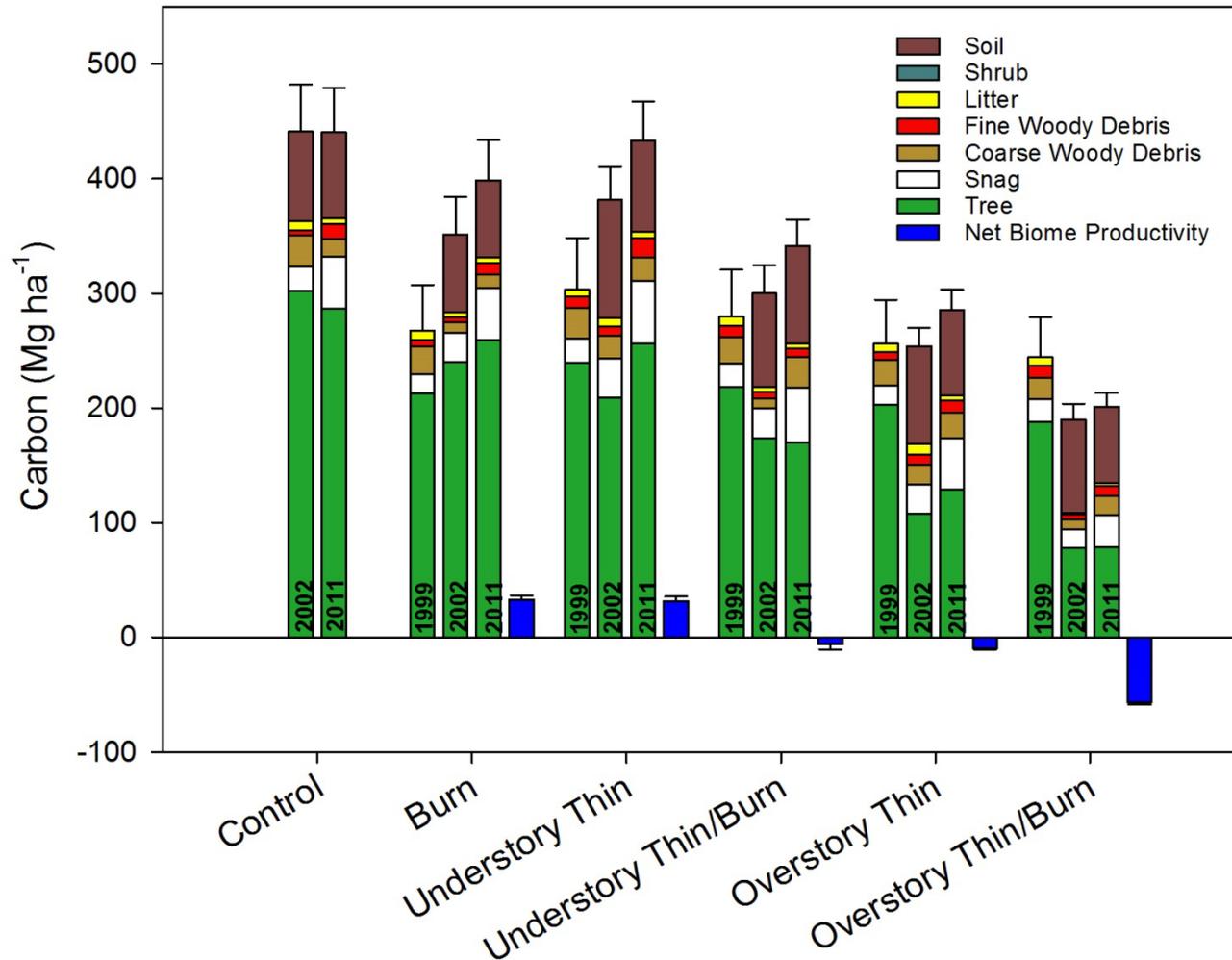
Fire-maintained forest had more C



Treatments Incur a C Penalty



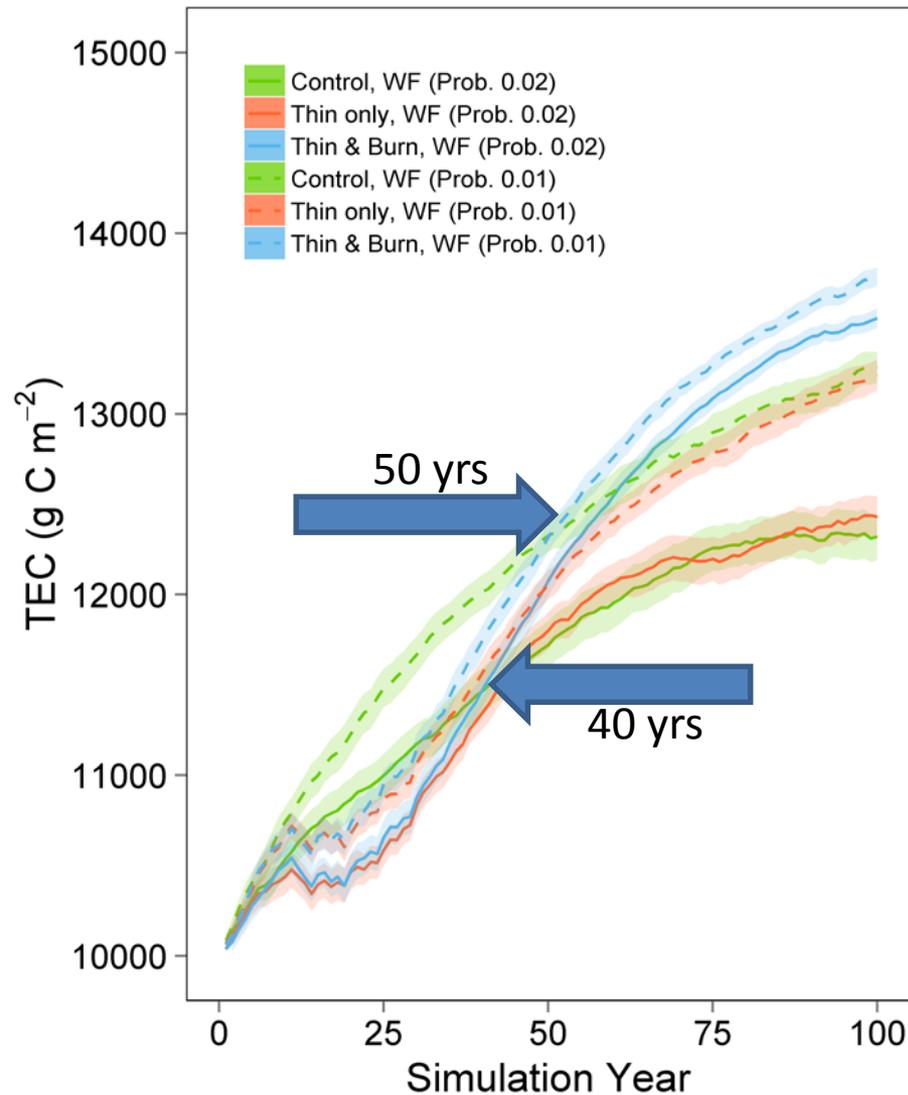
C Does Recover Over Time



Treatment C Balance with Stochastic Wildfire?

- Treatments
 - No-action control
 - Thin-only
 - Thin and Burn
- Wildfire Probability
 - 1 in 50 chance of wildfire
 - 1 in 100 chance of wildfire

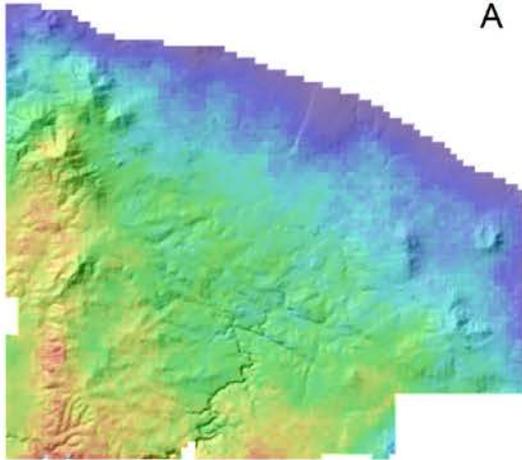
With wildfire, treatments store more C...



...because mean fire severity is lower...

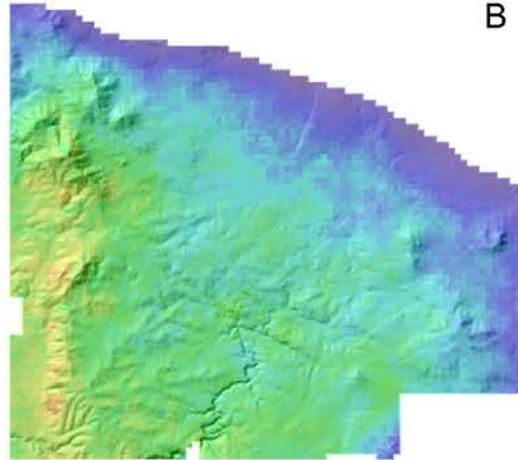
Control

A



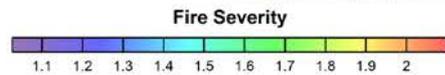
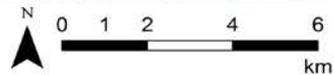
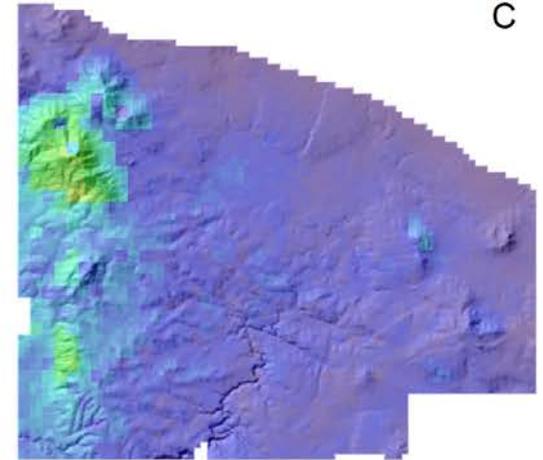
Thin-only

B



Thin & Burn

C

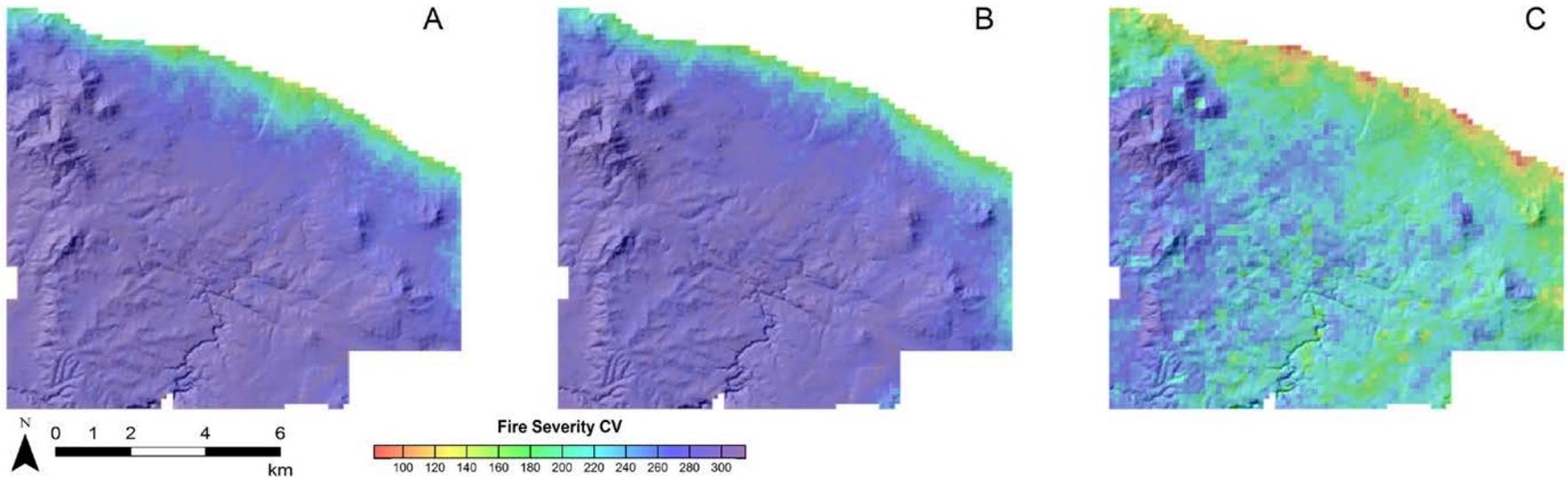


...and variation in severity is lower too.

Control

Thin-only

Thin & Burn

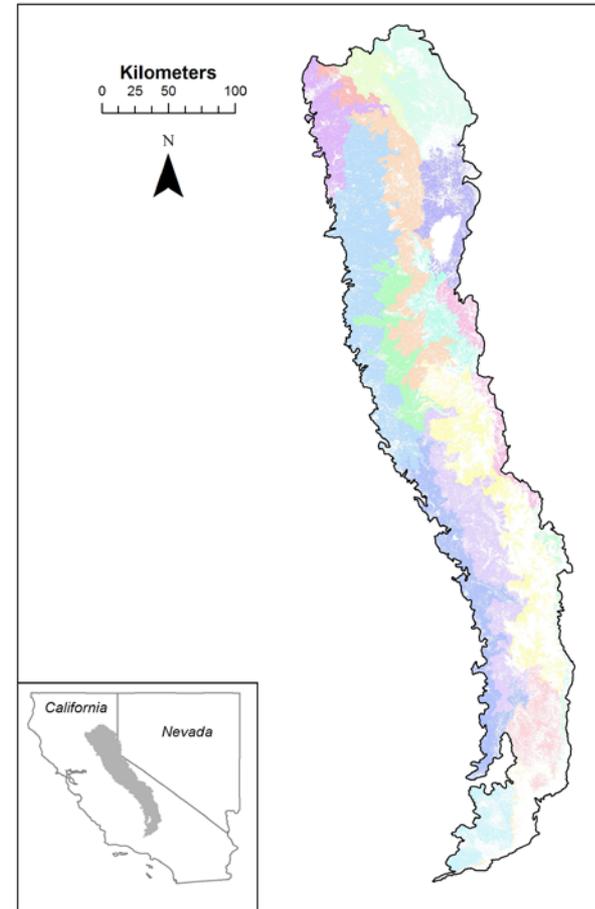


Forest Carbon & Fire Questions:

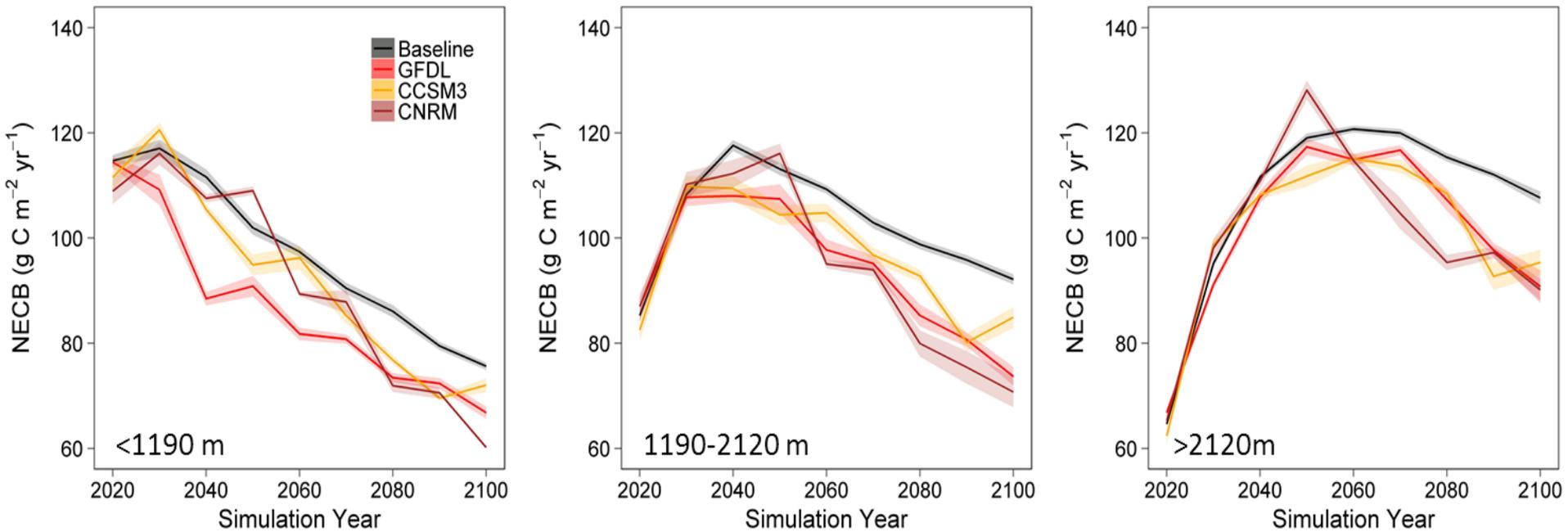
- Fire-suppressed forest versus fire-maintained forest carbon stock differences?
 - Fire-maintained forest had more C and it is stored in fewer, larger trees
- Carbon costs of treatment without wildfire?
 - Treatments require a C stock reduction
 - Treated forest can sequester C faster
 - No change in the control (carbon carrying capacity)
- Carbon balance of treatment with wildfire?
 - Treated forest reduces fire severity and stores more C

Climate Change, Wildfire, Carbon

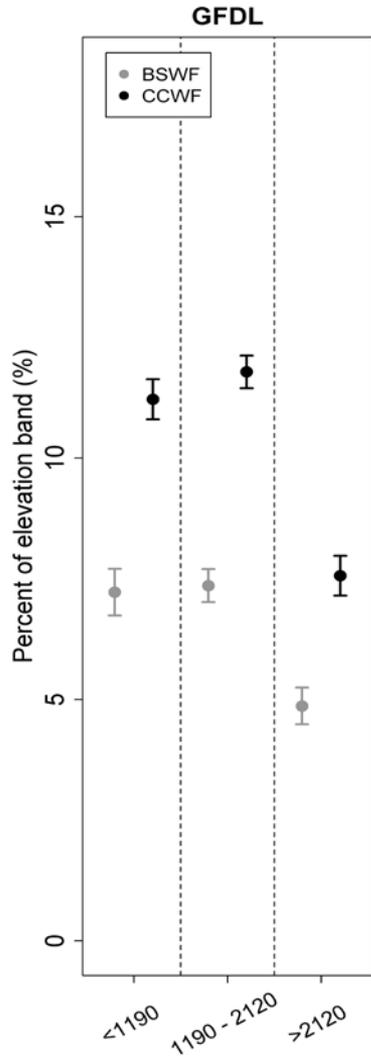
- Climate projections from three models
- Fire projections from Westerling et al. (2011)



Decreasing Carbon Sink

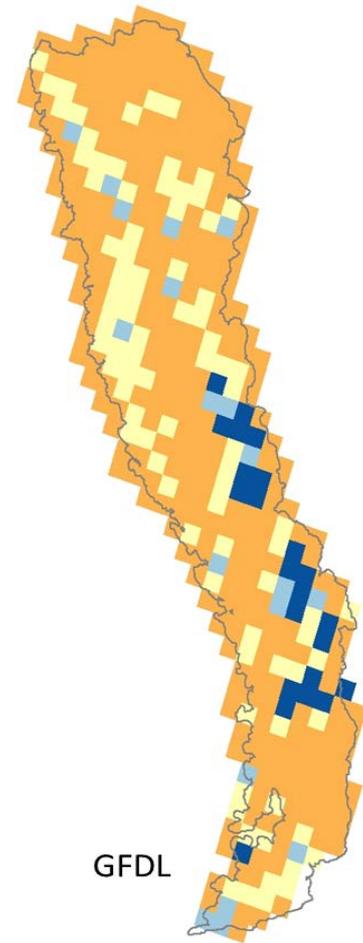


Increase in area that is C source



% change in recruitment

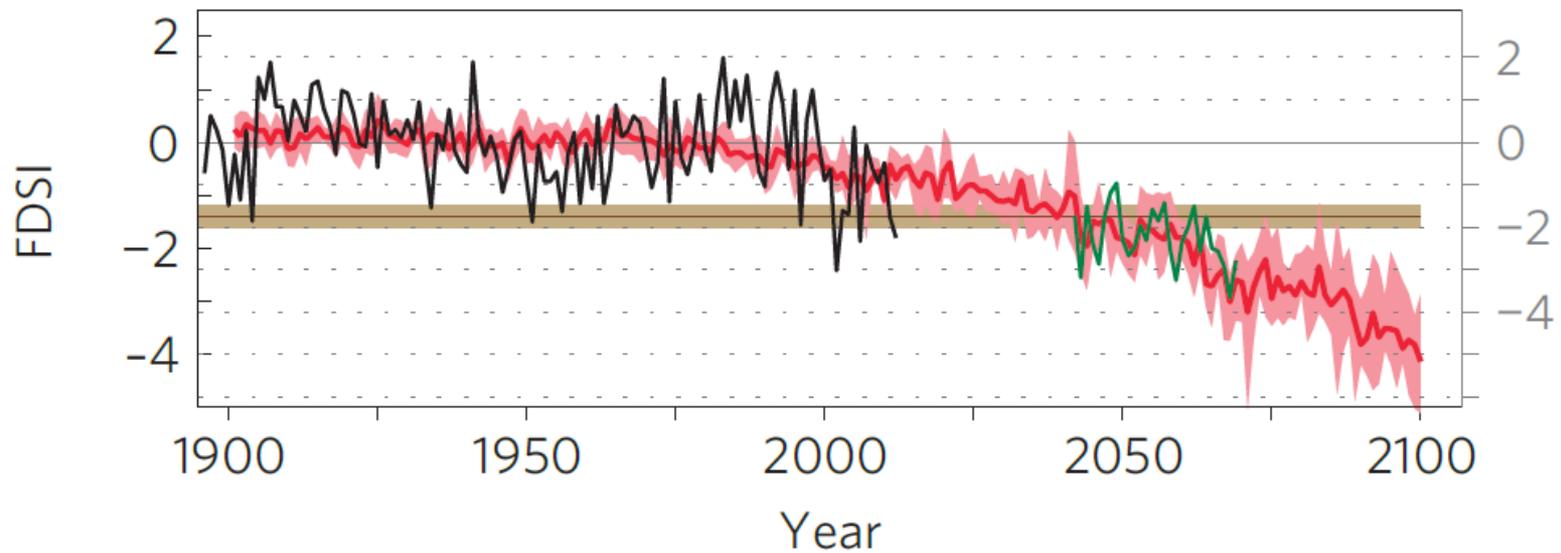
- >50
- 0 - 50
- 50 - 0
- <-50



Forest Carbon & Fire Questions

- Effects of climate and disturbance?
 - Warmer temperature and decreasing precipitation increase large wildfire frequency
 - Decrease in forest carbon sink strength
 - Increase in forested area that is a carbon source
 - Increase in fire emissions

Warmer temperature means more tree-killing days

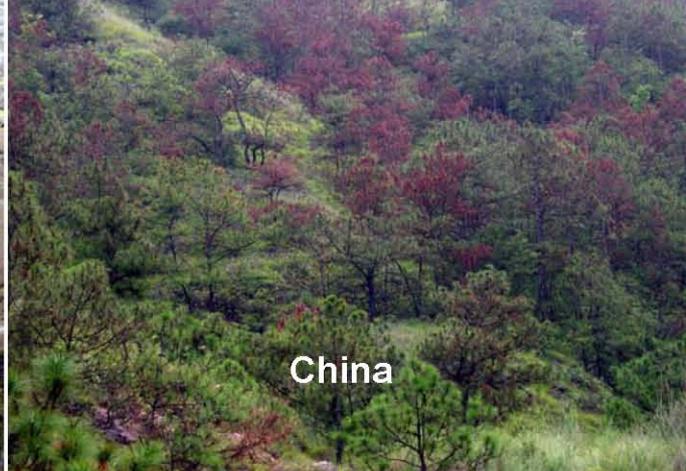




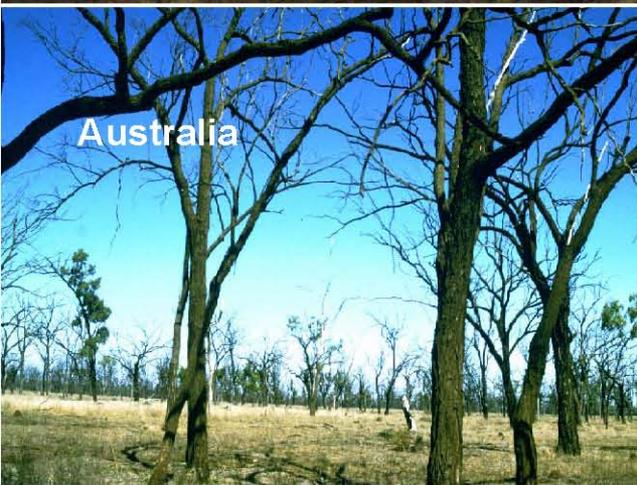
New Mexico



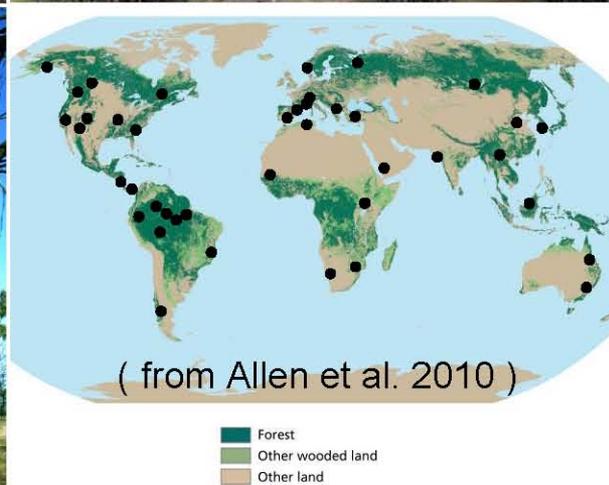
Alberta



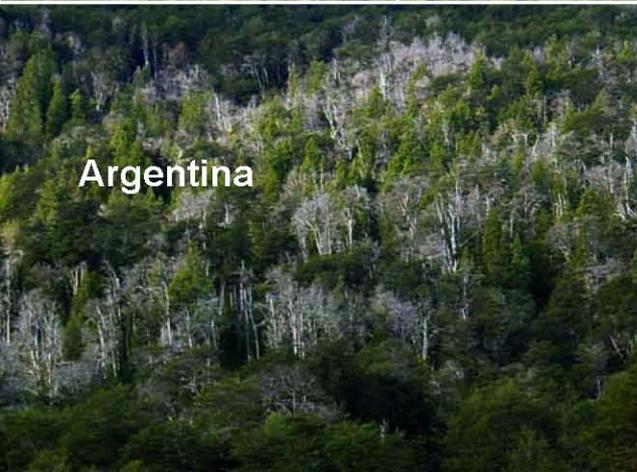
China



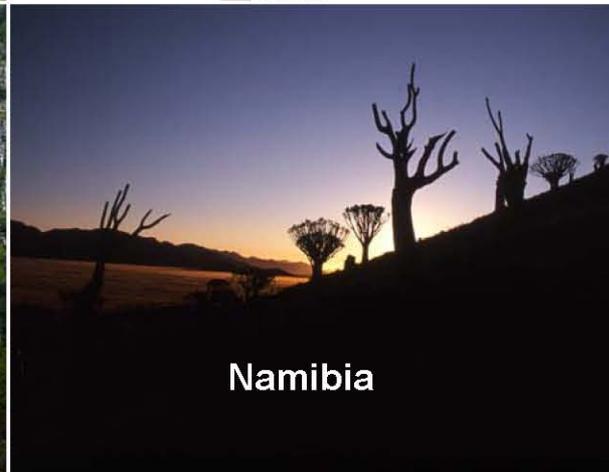
Australia



Spain



Argentina



Namibia



Algeria

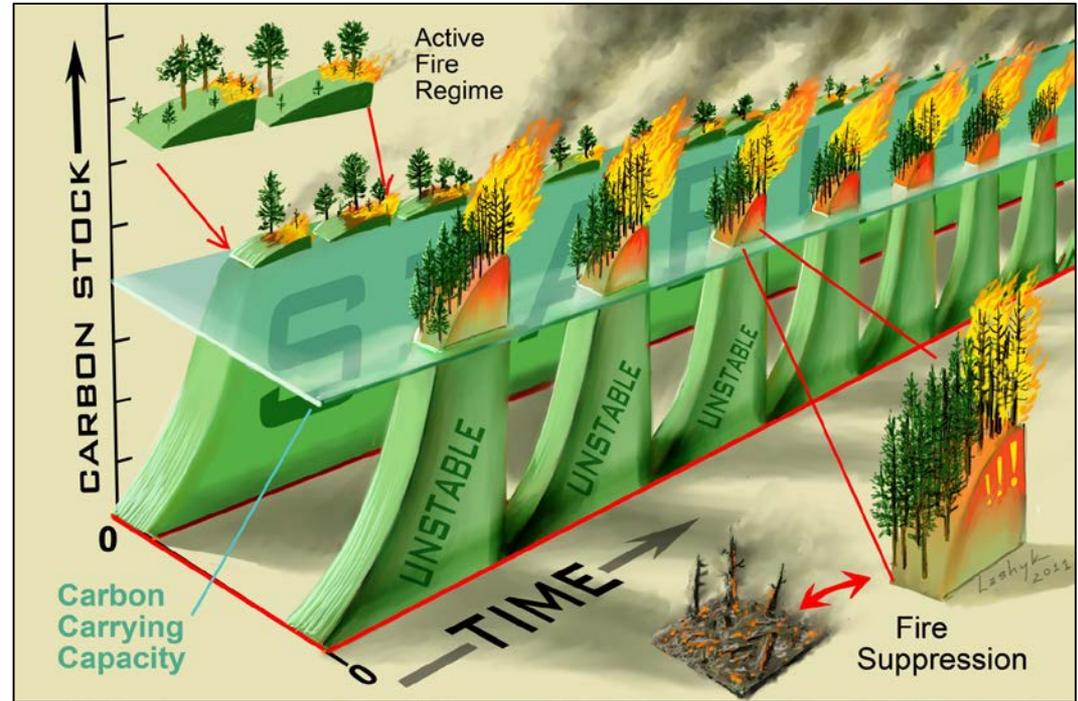
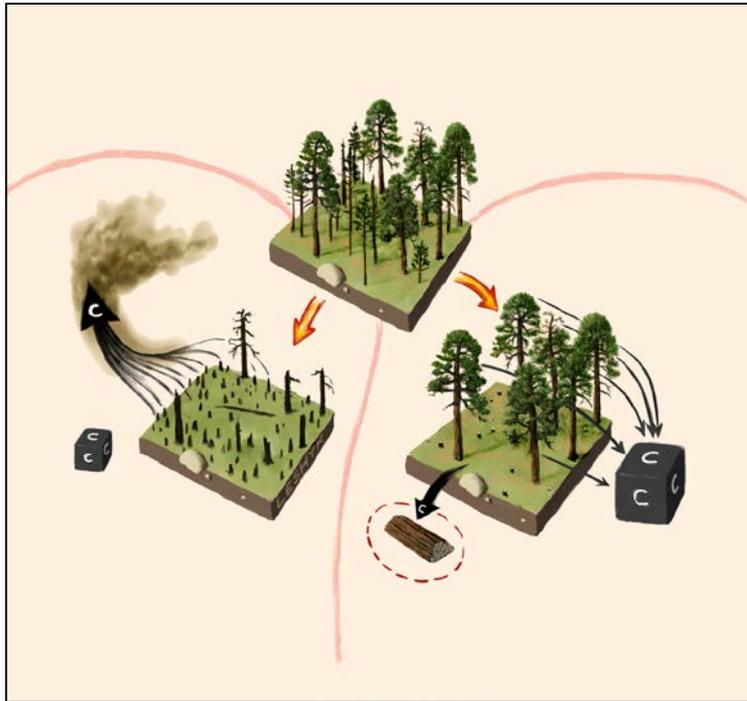
Risks to Forest Carbon

- High-severity wildfire
- Increasing fire frequency
- Insect outbreaks
- Drought
- Increasing temperature
- **Interactions between these factors**

Mitigating Risks – Local Options

- Thinning small trees and reintroducing surface fire lowers high-severity fire risk
- Species-specific thinning reduces beetle host density
- Thinning small trees reduces resource competition for large trees
 - Increased water availability
 - Increased growth
 - Decreased growth impacts during drought years

Stabilizing forest C incurs short-term C costs with mid-term C benefits



A photograph of a forest at sunset. The scene is dominated by tall, slender pine trees with textured bark. The sky and the background are filled with a warm, golden-orange light, suggesting the sun is low on the horizon. The foreground shows the dark green needles of a pine tree on the left and right, and some grass at the bottom. The overall mood is peaceful and serene.

Thank You

© B. Oberhardt

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