

Climate Change and Bark Beetle Outbreaks in Whitebark Pine Stands of the Western United States

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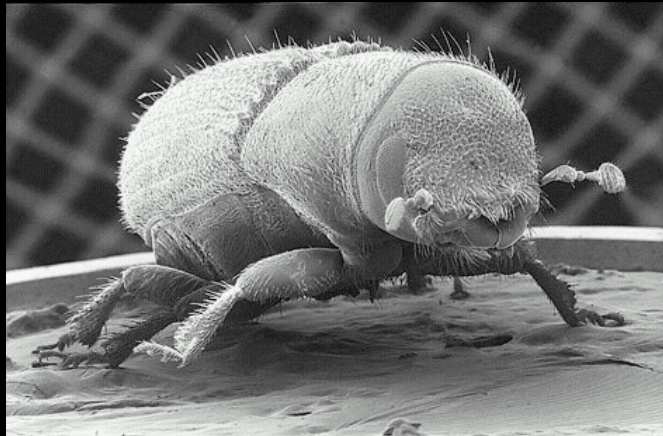
Kenneth Raffa, U. Wisconsin

Jesse Logan, USDA Forest Service (retired)

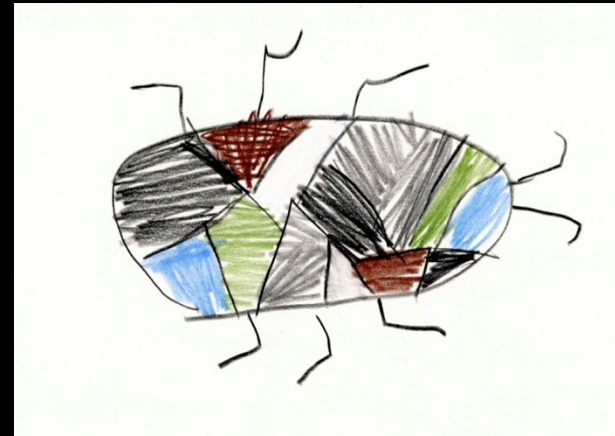
John Abatzoglou, U. Idaho

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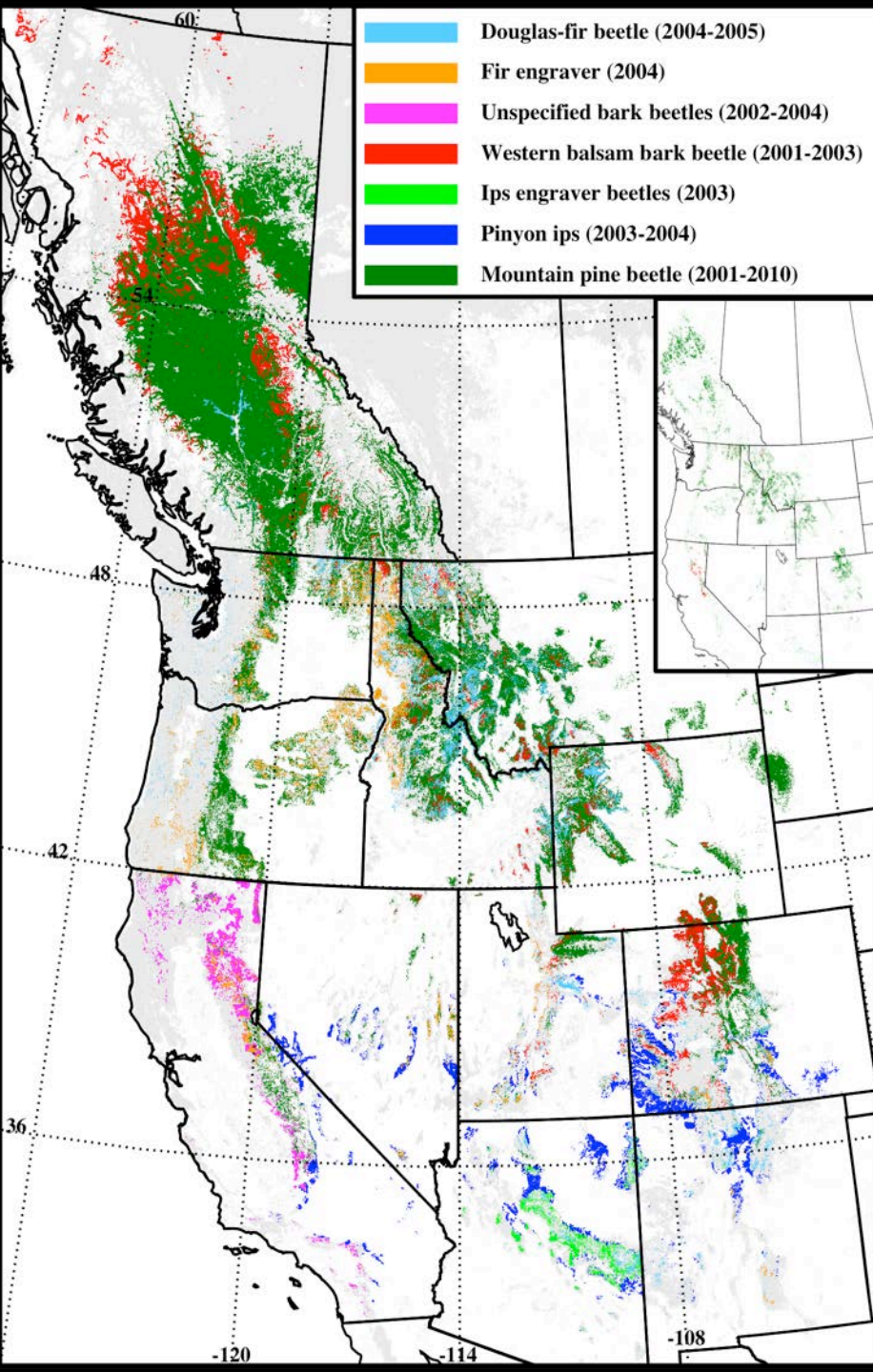
Mountain pine beetle, electron microscope
Leslie Manning, Canadian Forest Service



Mountain pine beetle, colored pencil
Ava H., Age 6



Bark beetle outbreaks are important forest disturbances in the West



- beetles killed 7% of forested area
- more than wildfires
- about ½ of harvest

Factors influencing mountain pine beetle epidemics

Factors related to trees:

- presence of host tree species
- stem density
- stand age
- drought stress on trees

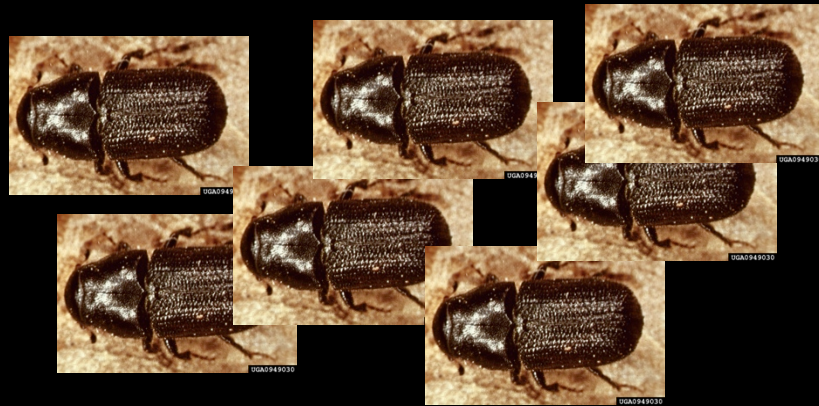
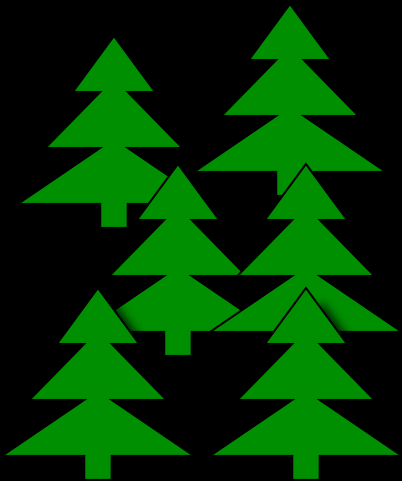


Photo courtesy USDA Forest Service, www.forestryimages.org

Safranyik et al. 1975; Shore and Safranyik 1992; Carroll et al. 2004; Logan and Powell 2001

Whitebark pine: Ecologically important

A keystone and foundation species



Whitebark pine: recommended as threatened/endangered

climate



white pine blister rust



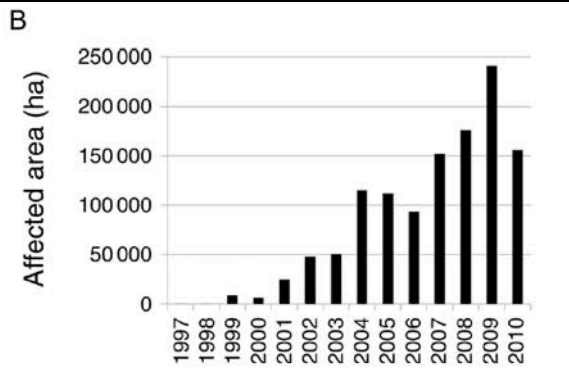
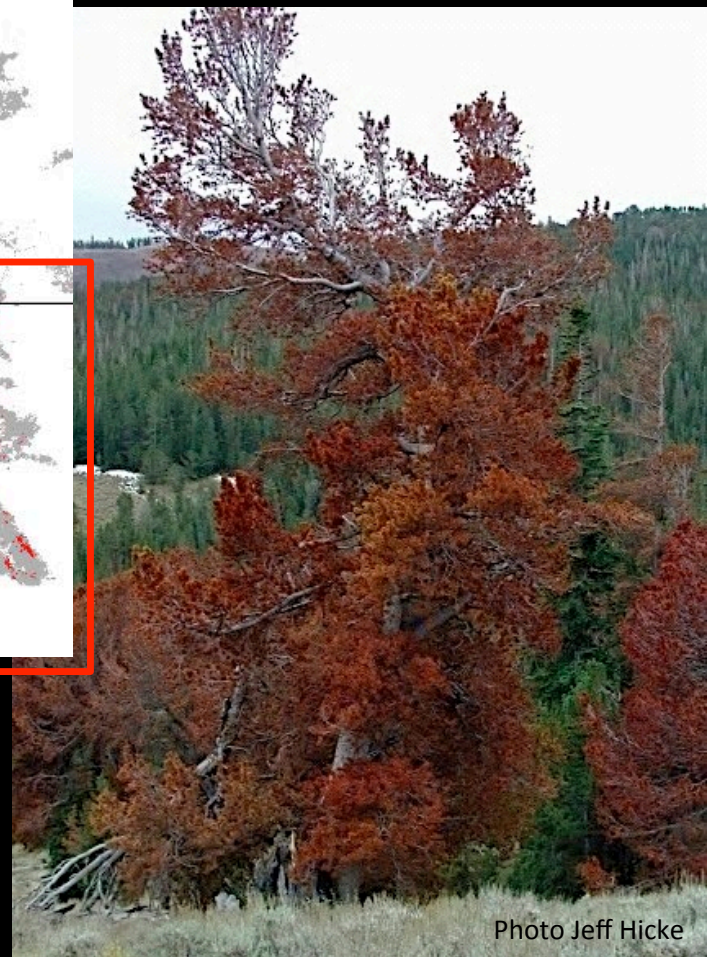
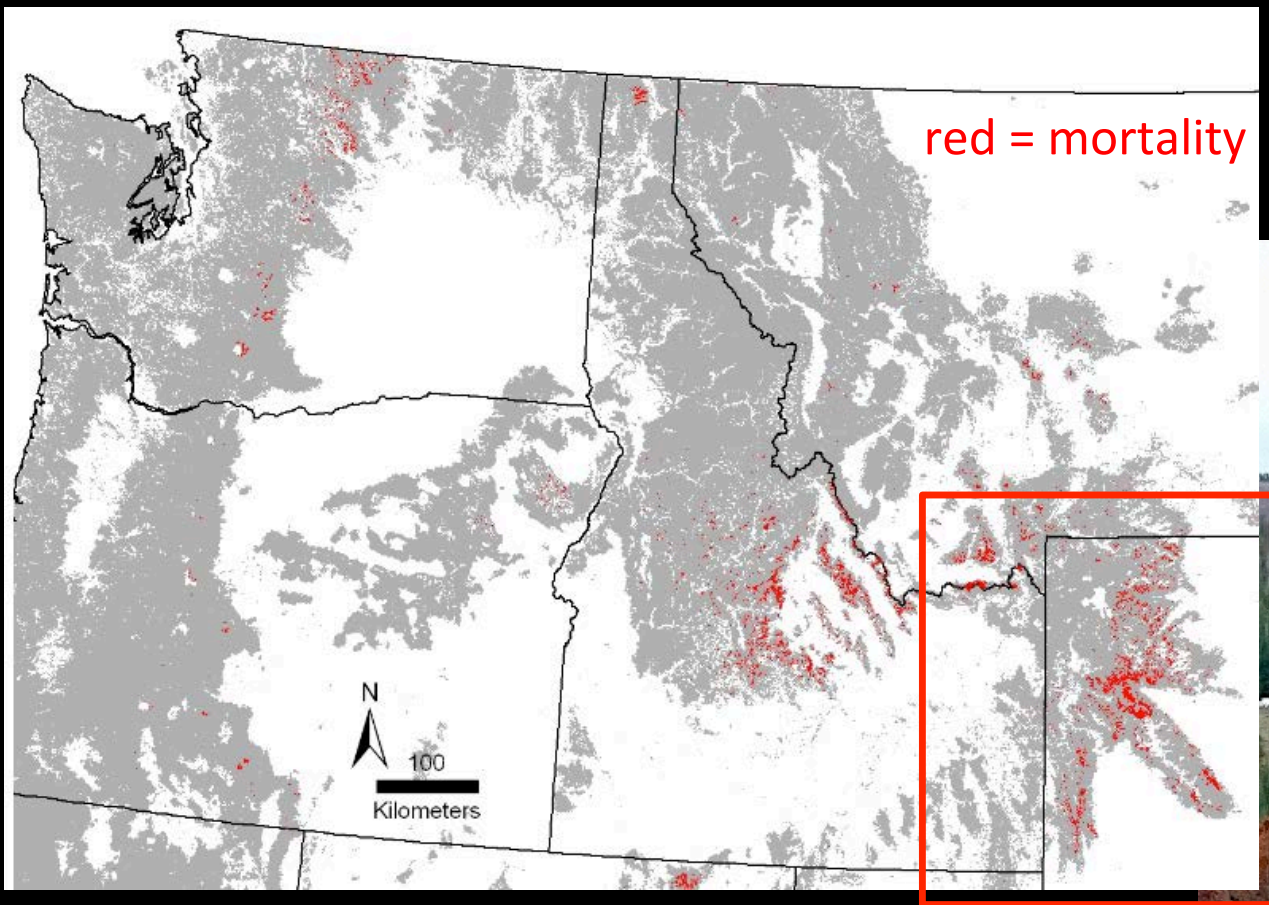
fire suppression



mountain pine beetles

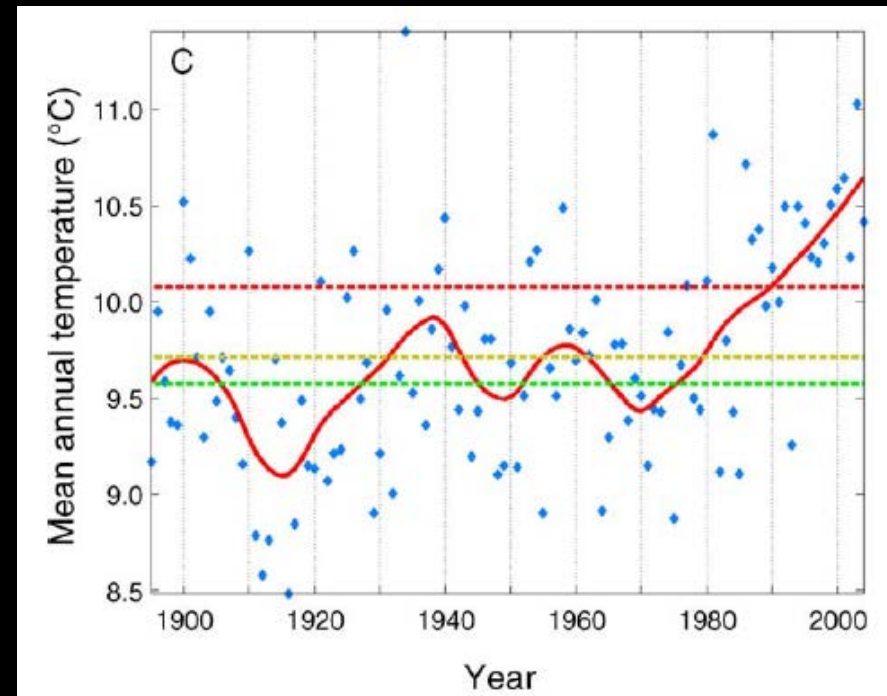
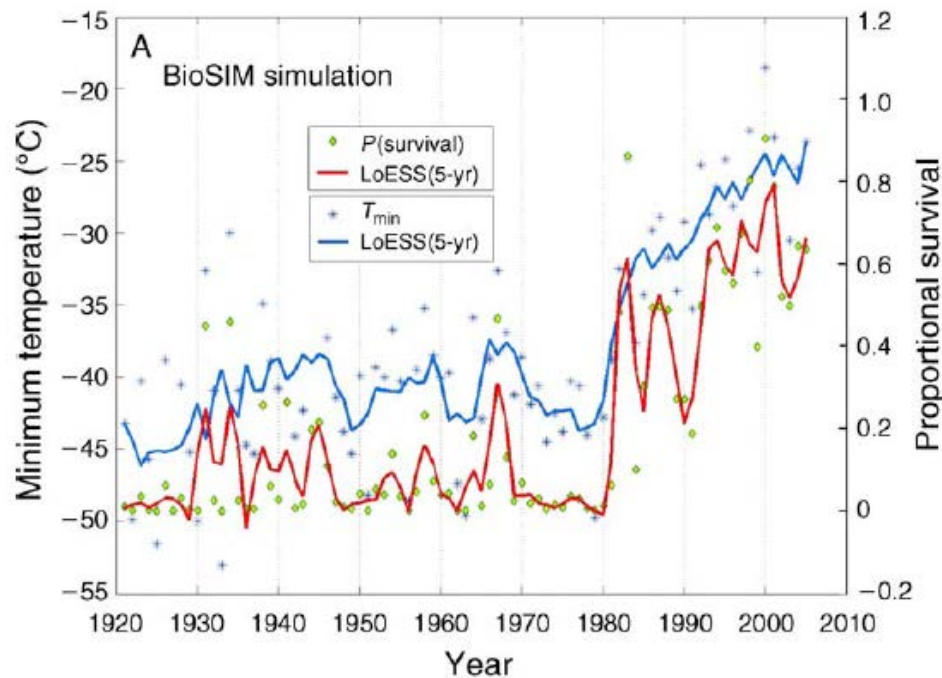


Whitebark pine mortality from beetles 1997-2010



Climate is an important driver of these outbreaks

Climate observations, model results suggest warming as drivers



Study questions

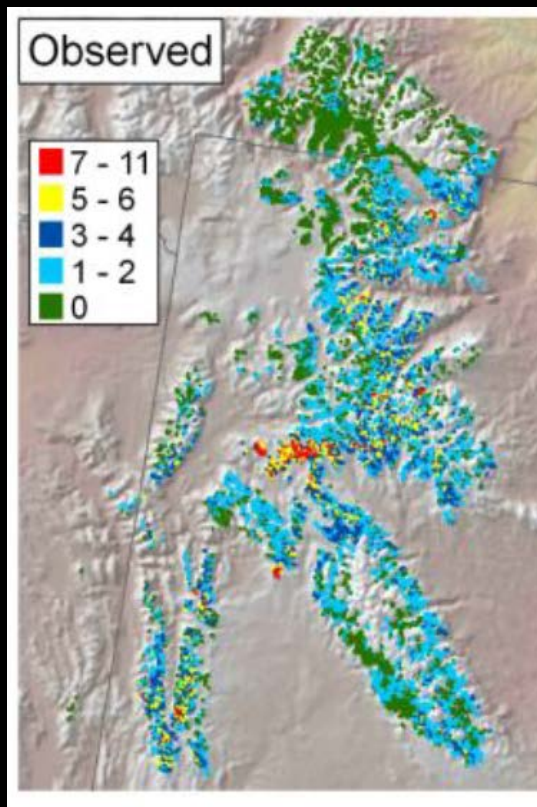
1. What were climate-beetle relationships?
2. What were the most important drivers of mountain pine beetle outbreaks in whitebark pine stands in the GYE?
3. What are projections of future outbreaks given expected climate change?



Observations used in statistical analysis

aerial surveys of beetle outbreaks in whitebark pine

1. response variable
2. beetle populations last year



climate data

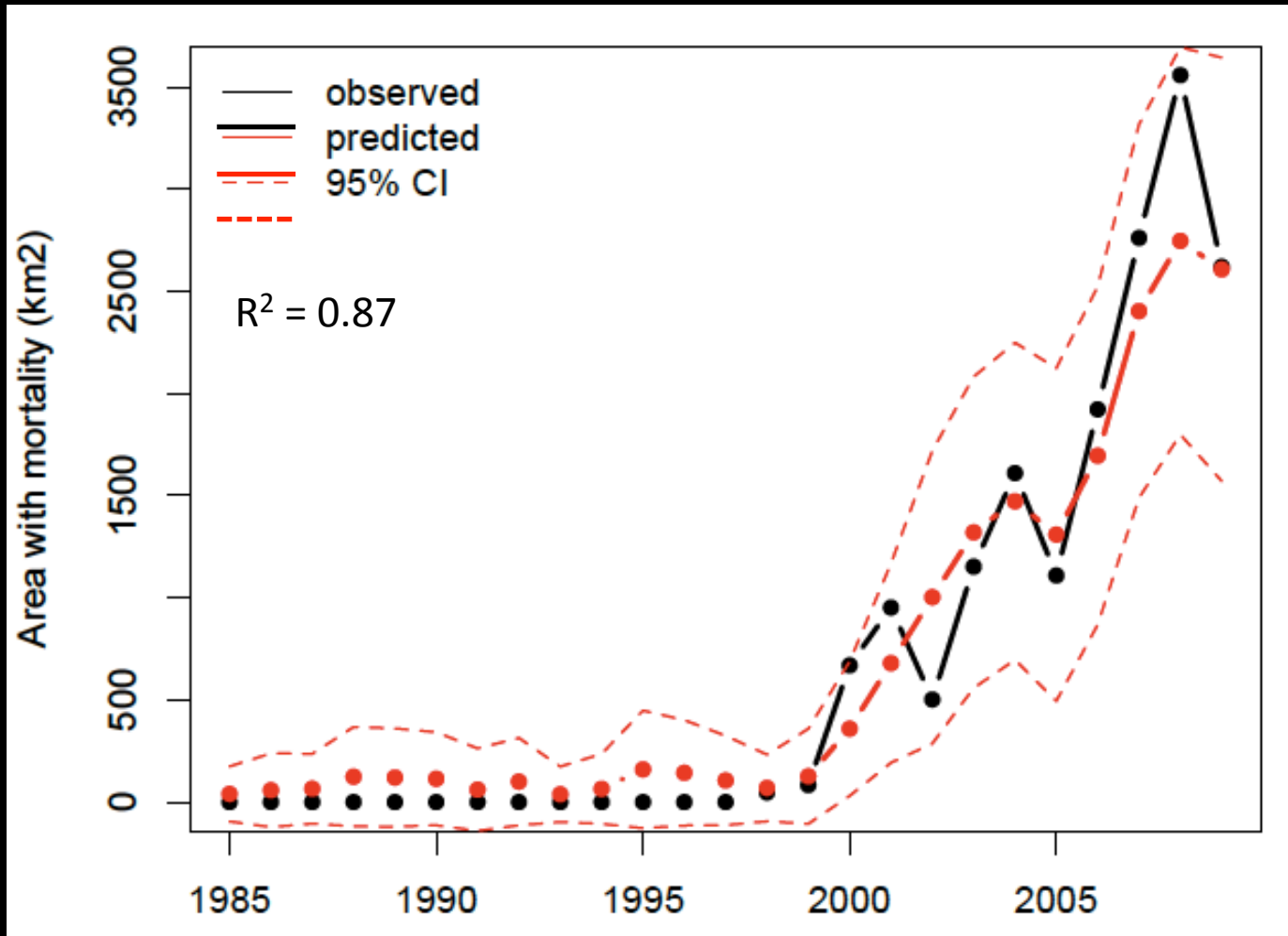


stand structure

biomass/age/size
amount of whitebark pine

Confidence in model

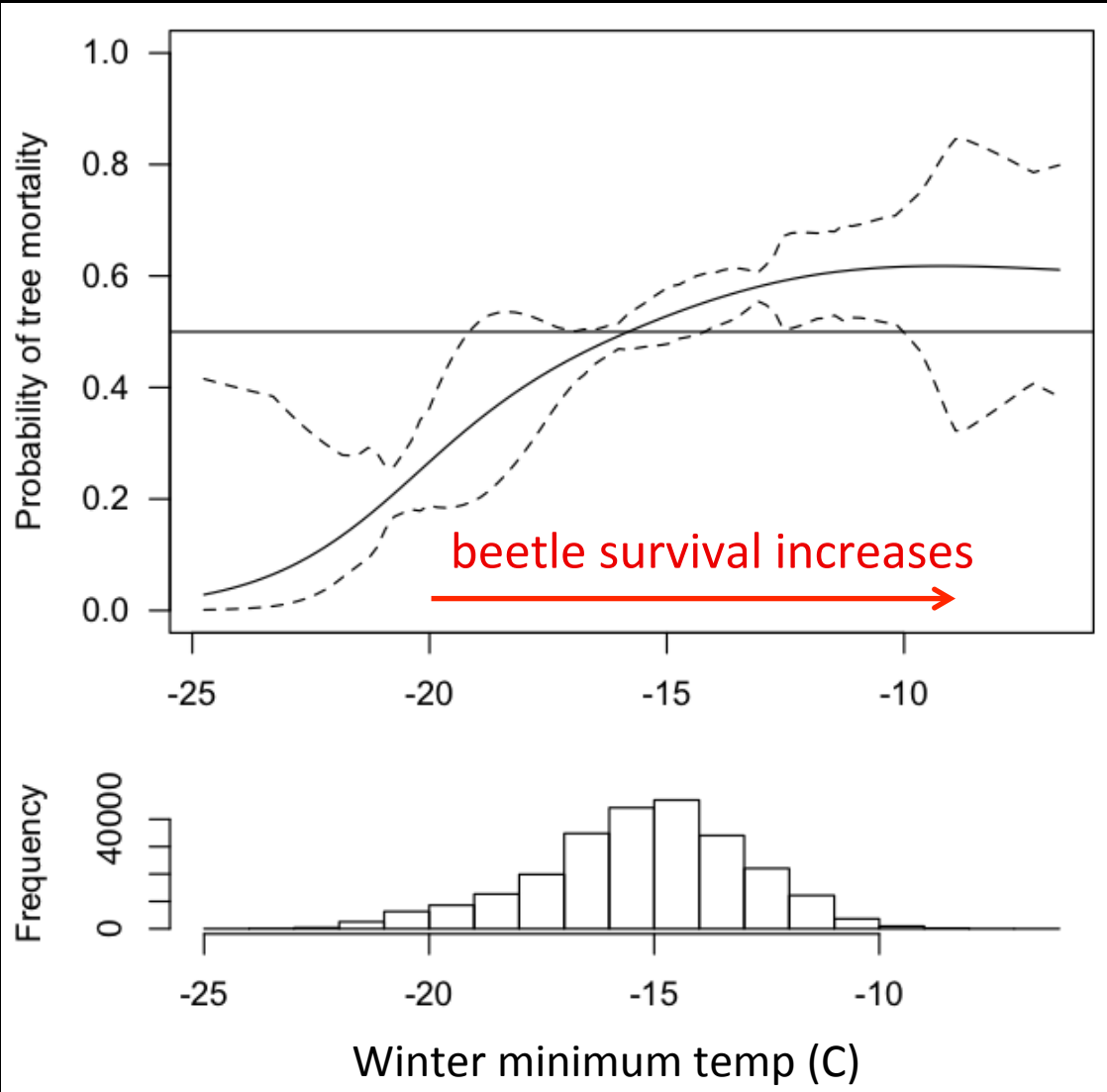
predictions similar to observations



1. Climate-beetle relationships

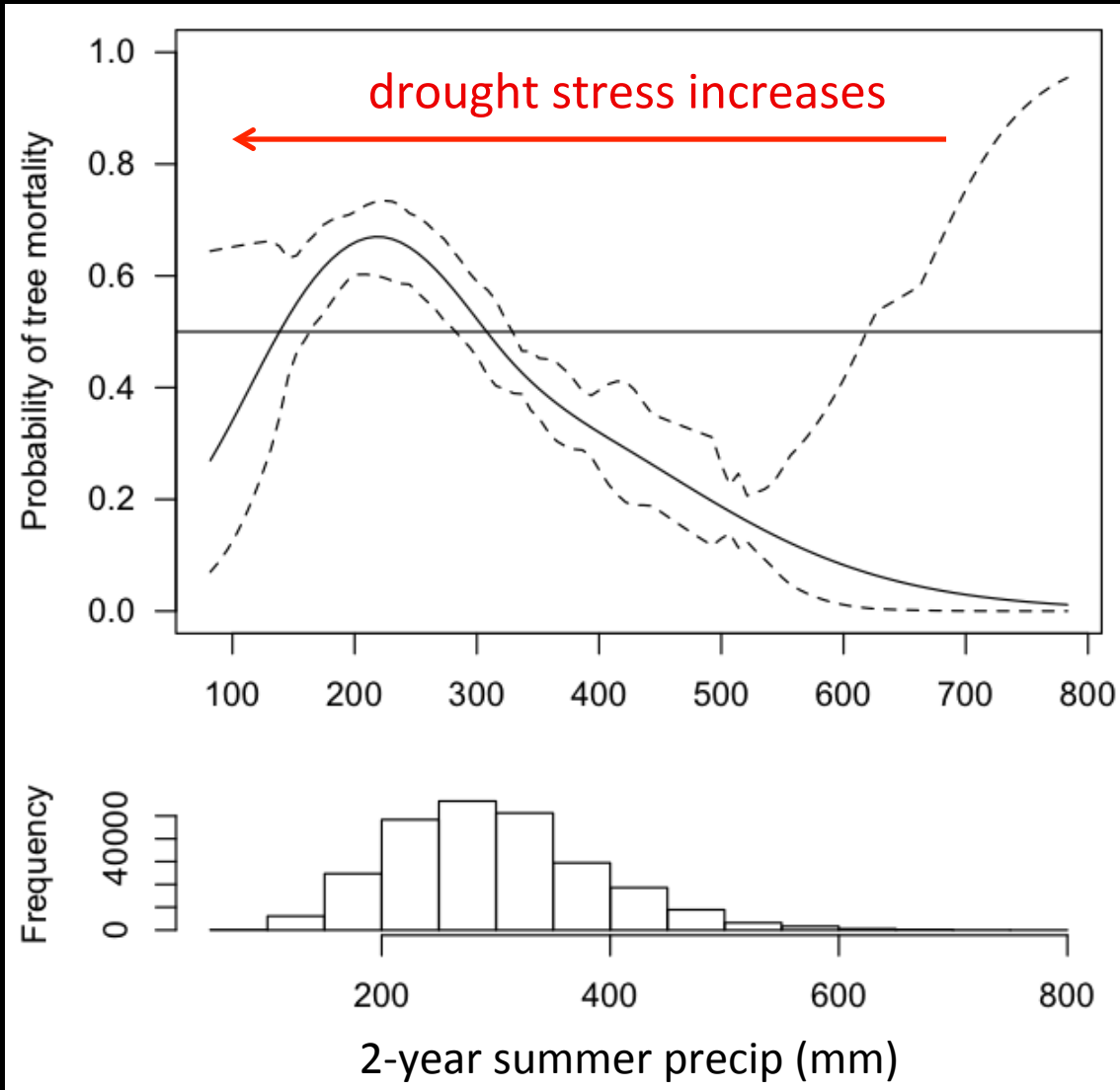
winter mortality

Probability of tree mortality



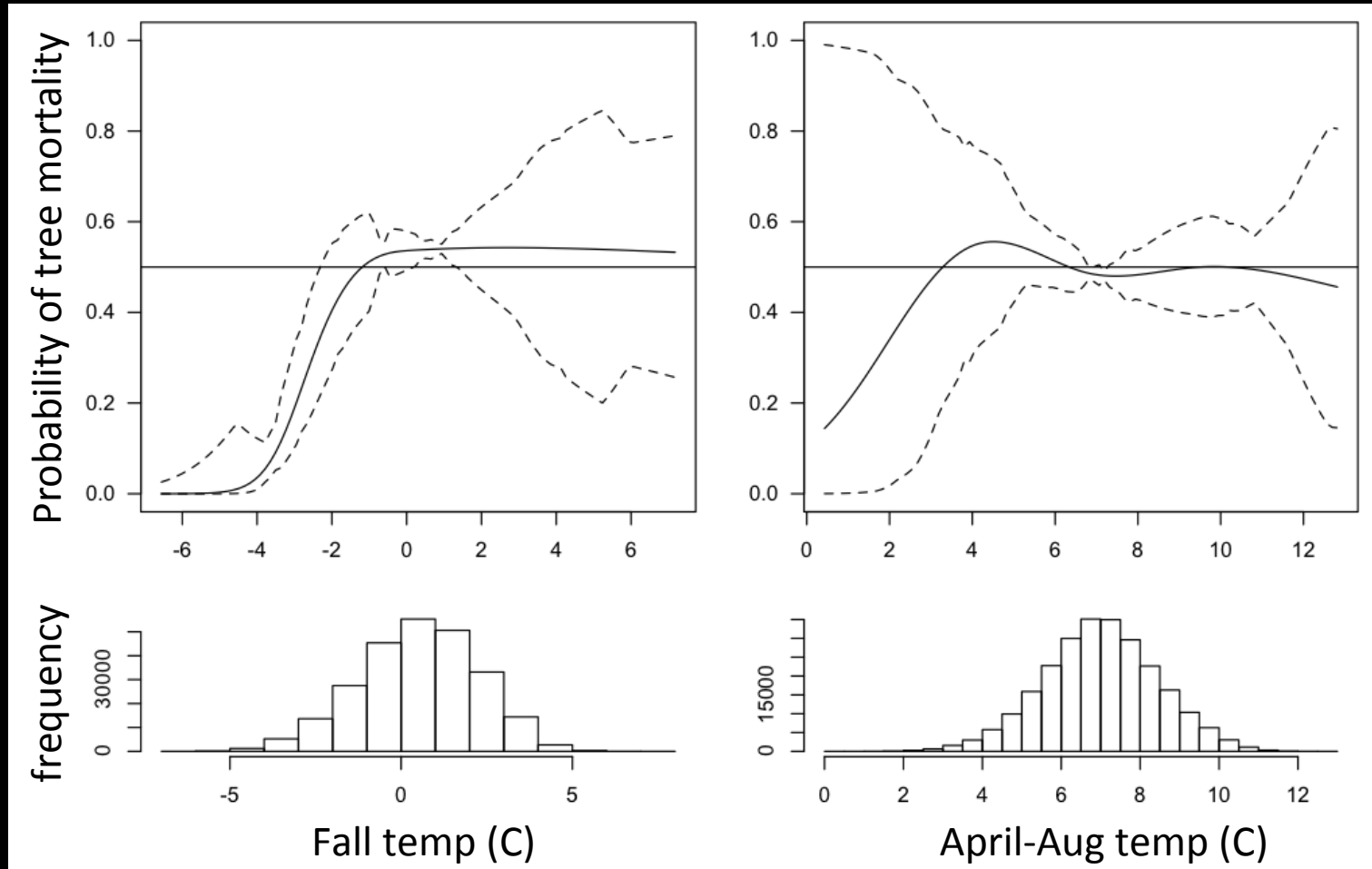
1. Climate-beetle relationships

tree drought stress

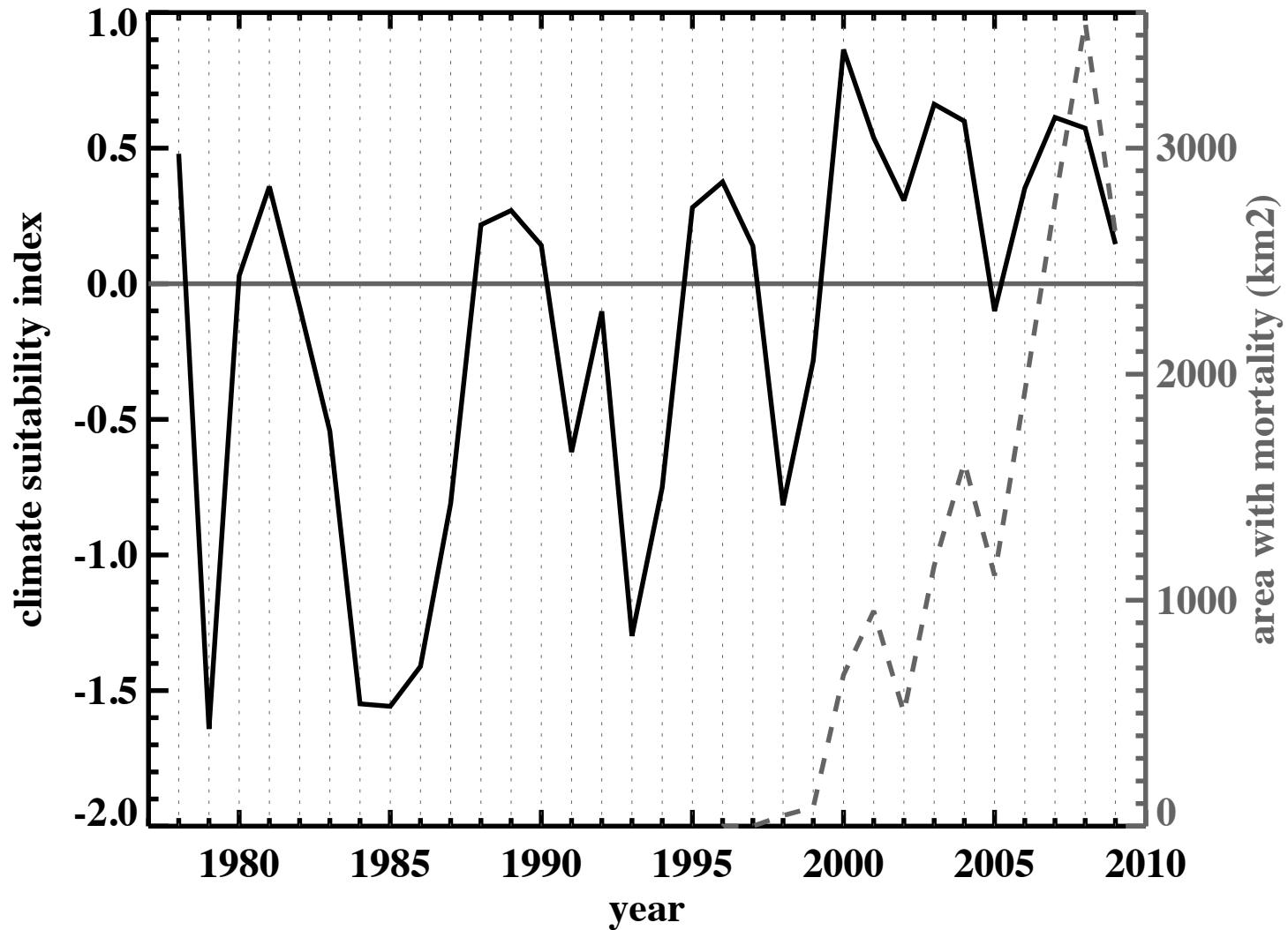


1. Climate-beetle relationships

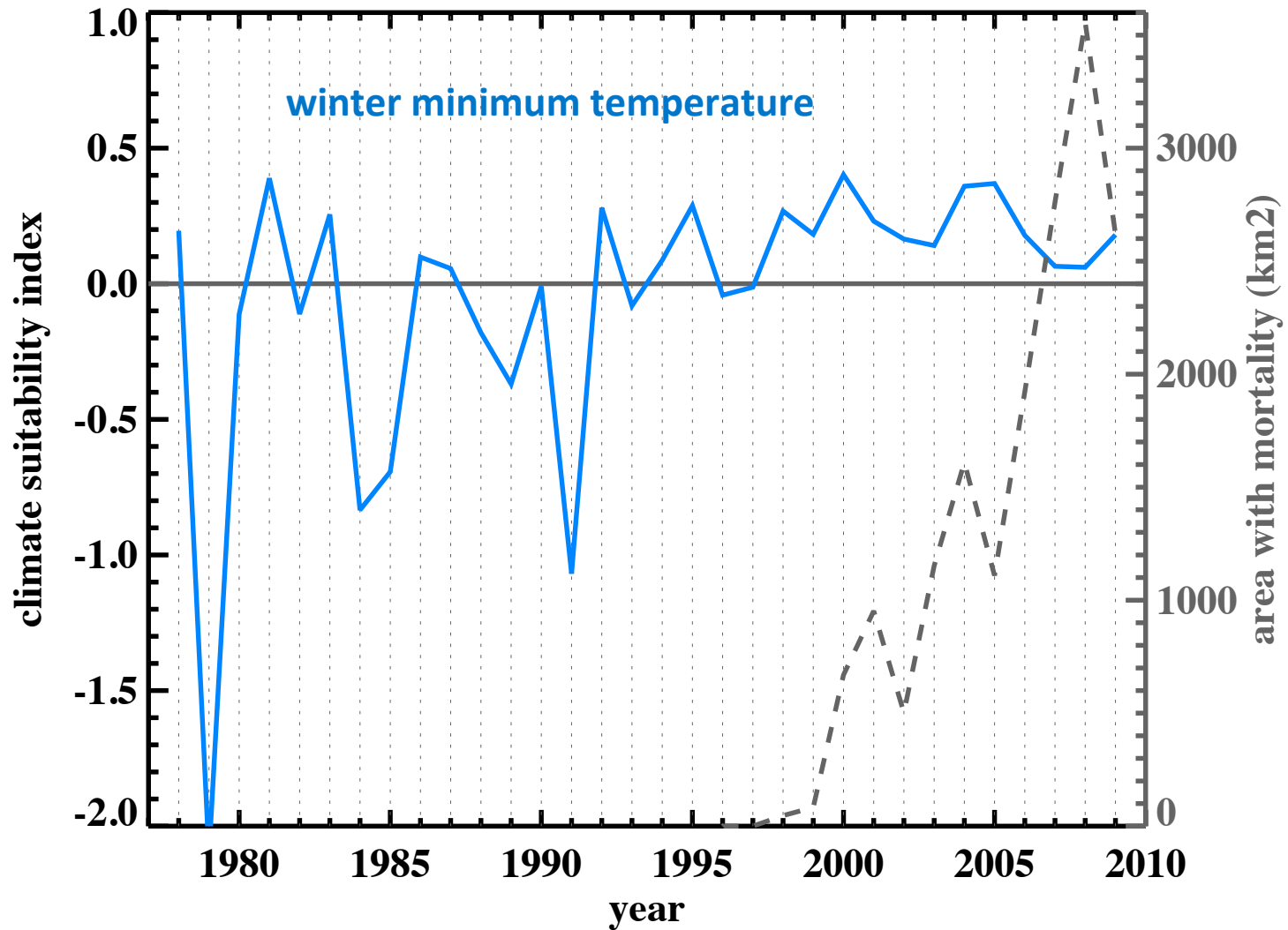
year-round temperatures



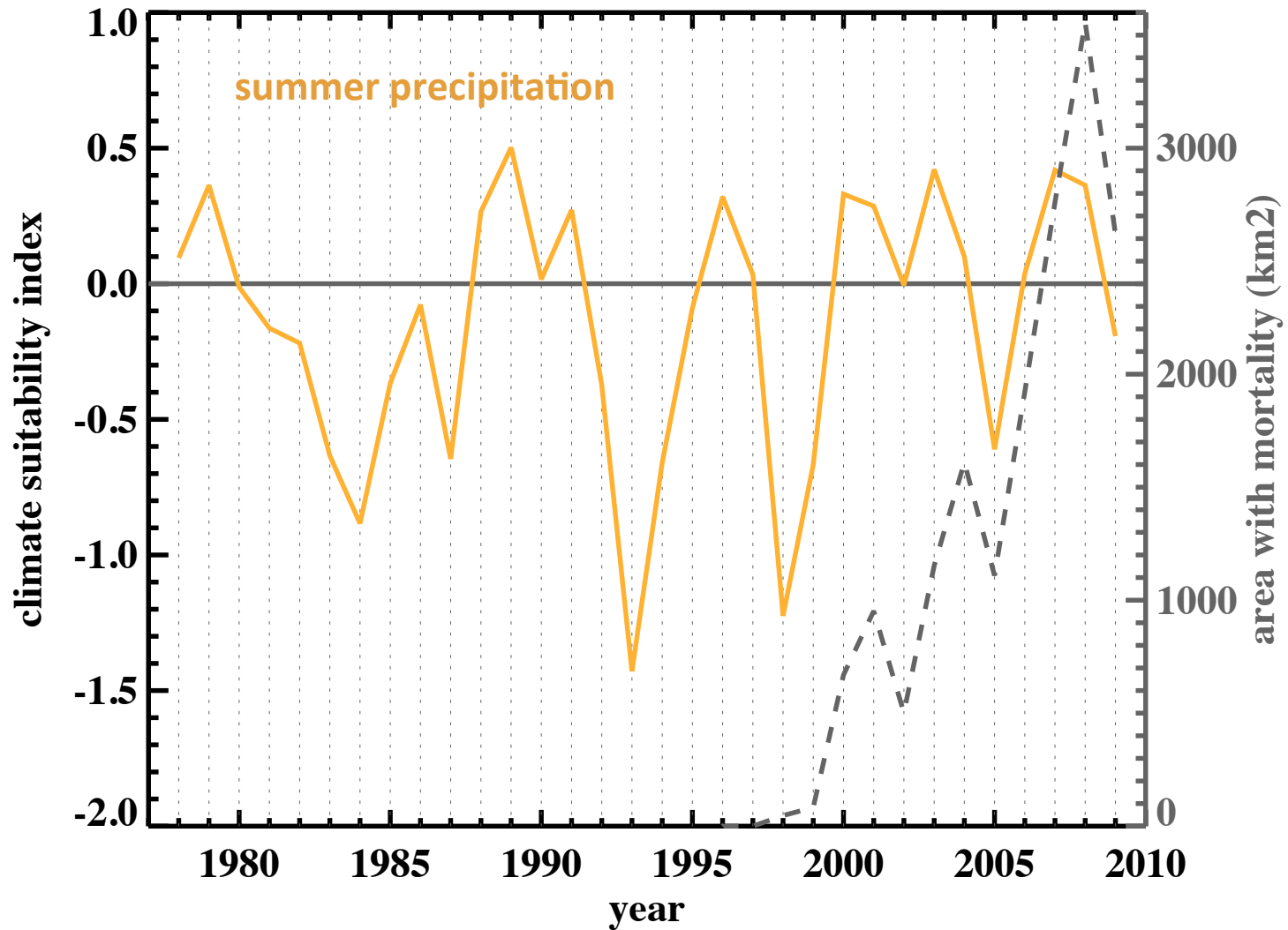
2. Climate influences on recent outbreak



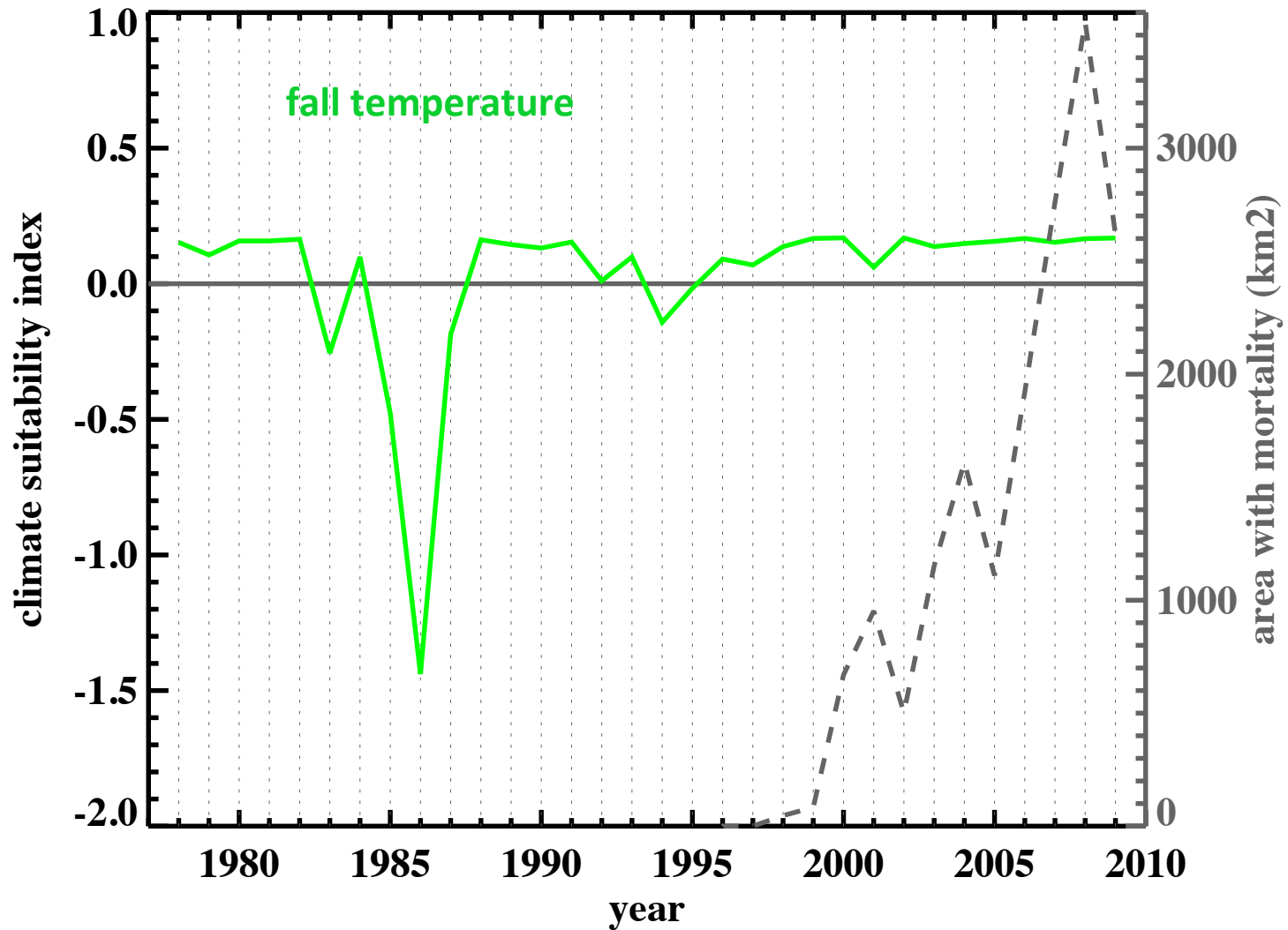
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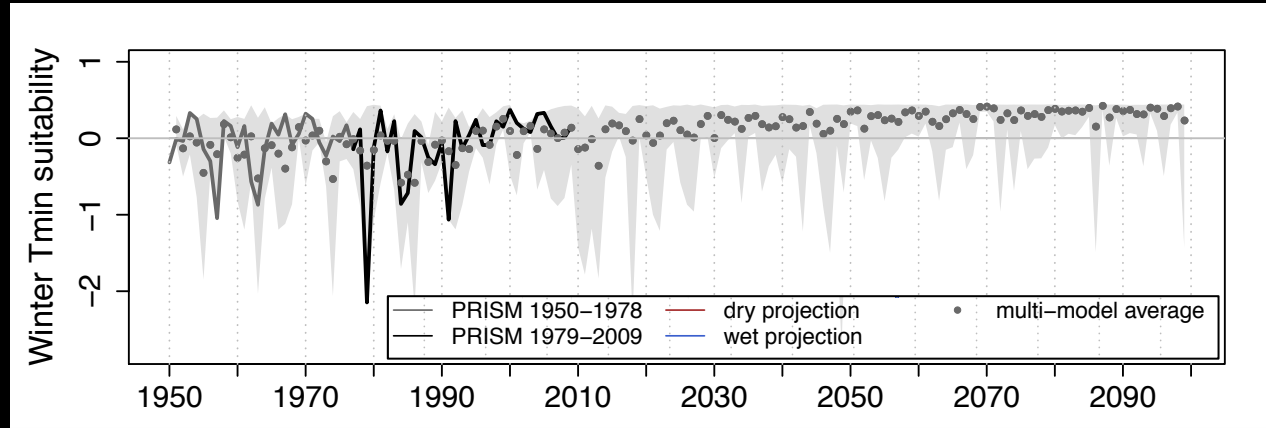


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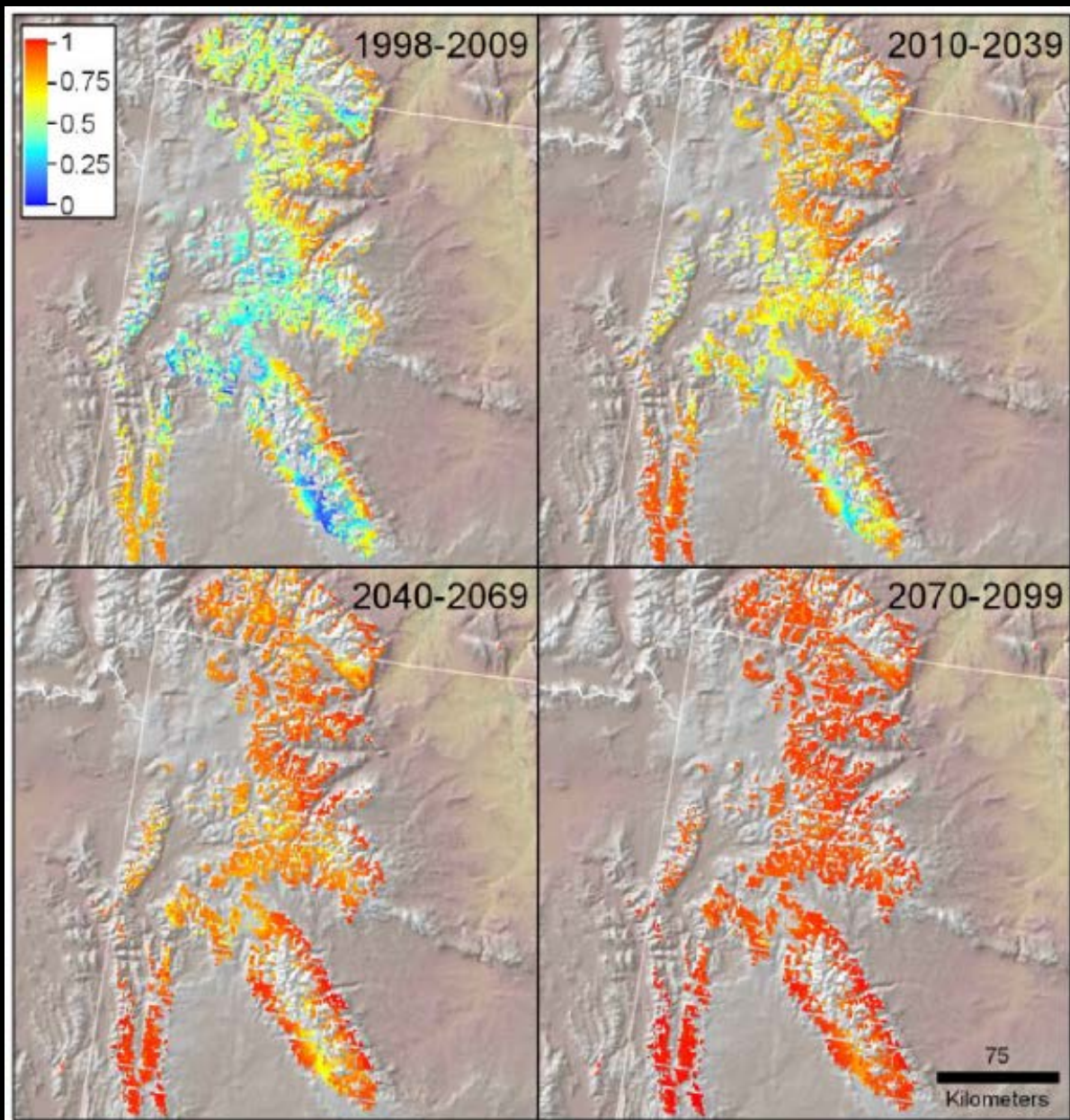


3. Estimates of future climate suitability

Winter temperature:
increased suitability
for outbreaks



3. Estimates of future climate suitability

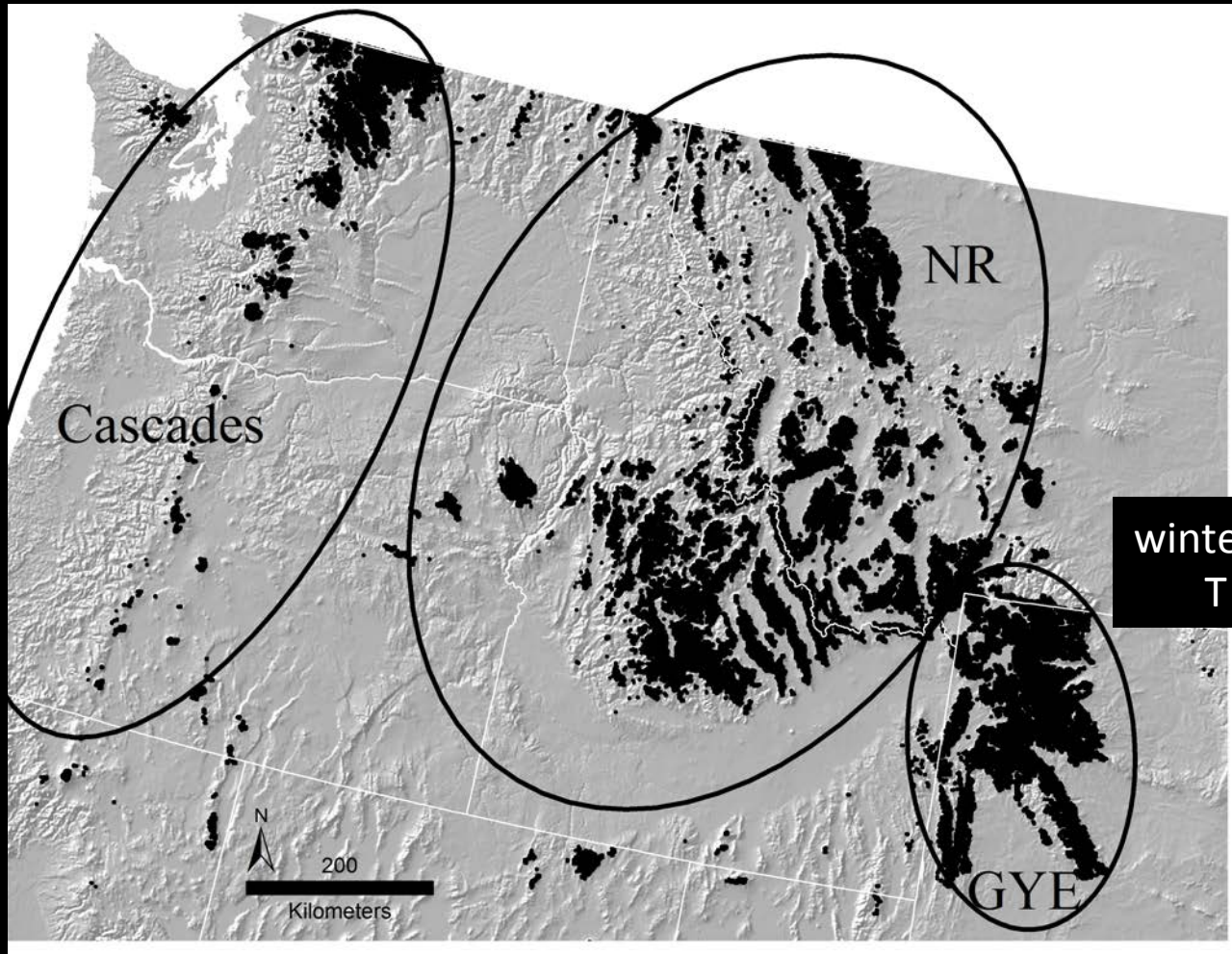


*fraction of years
with winter
temperature
suitable for beetle
outbreaks*

What's next?

climate-beetle relationships in other regions

winter minimum $T = -9^{\circ}\text{C}$



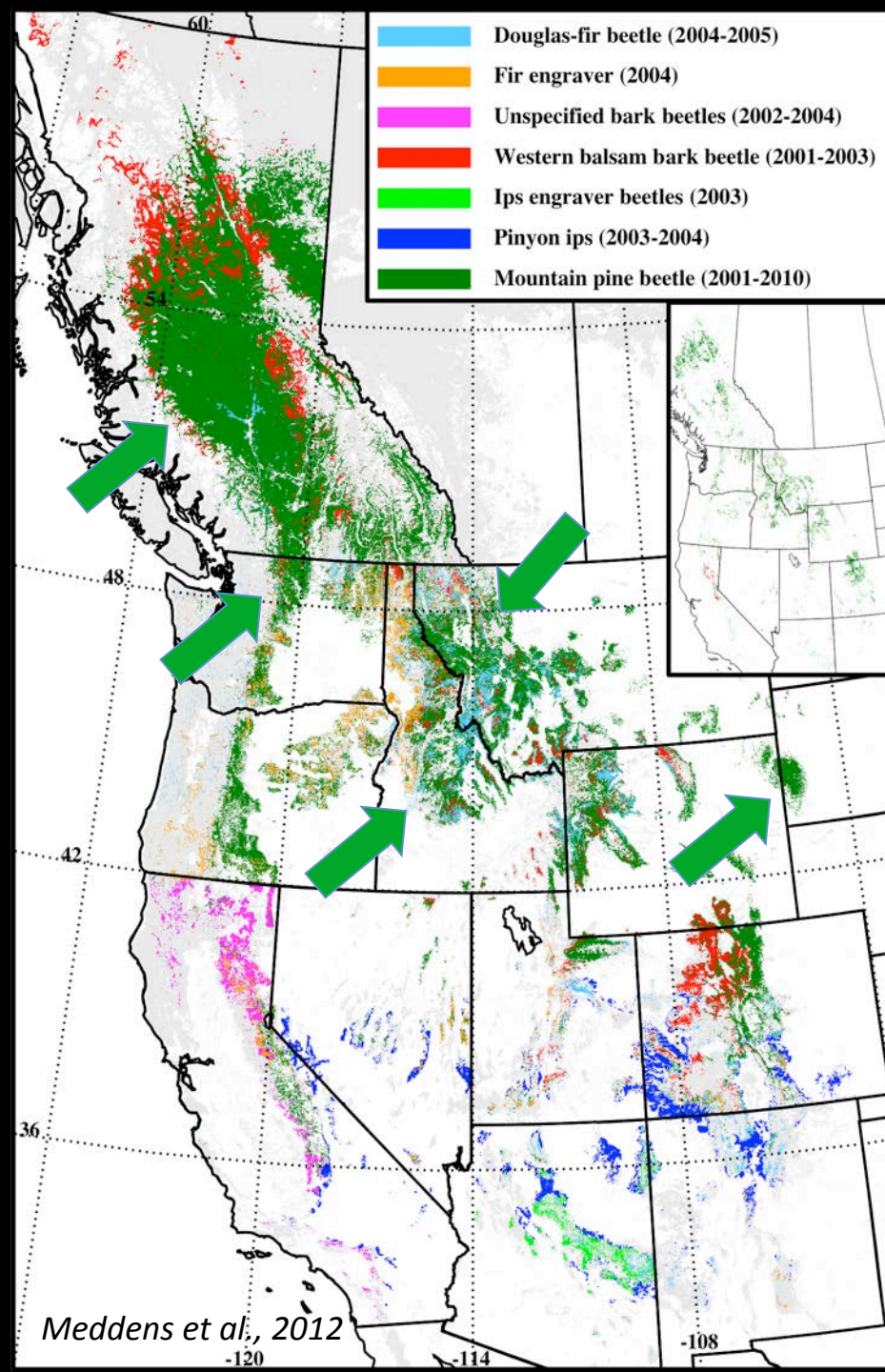
see also Weed et al., *Landscape Ecology*, 2015

What's next?

lodgepole pine, a less naïve, more widespread host



www.unitedwoodproductsinc.com/products/roughlumber.html

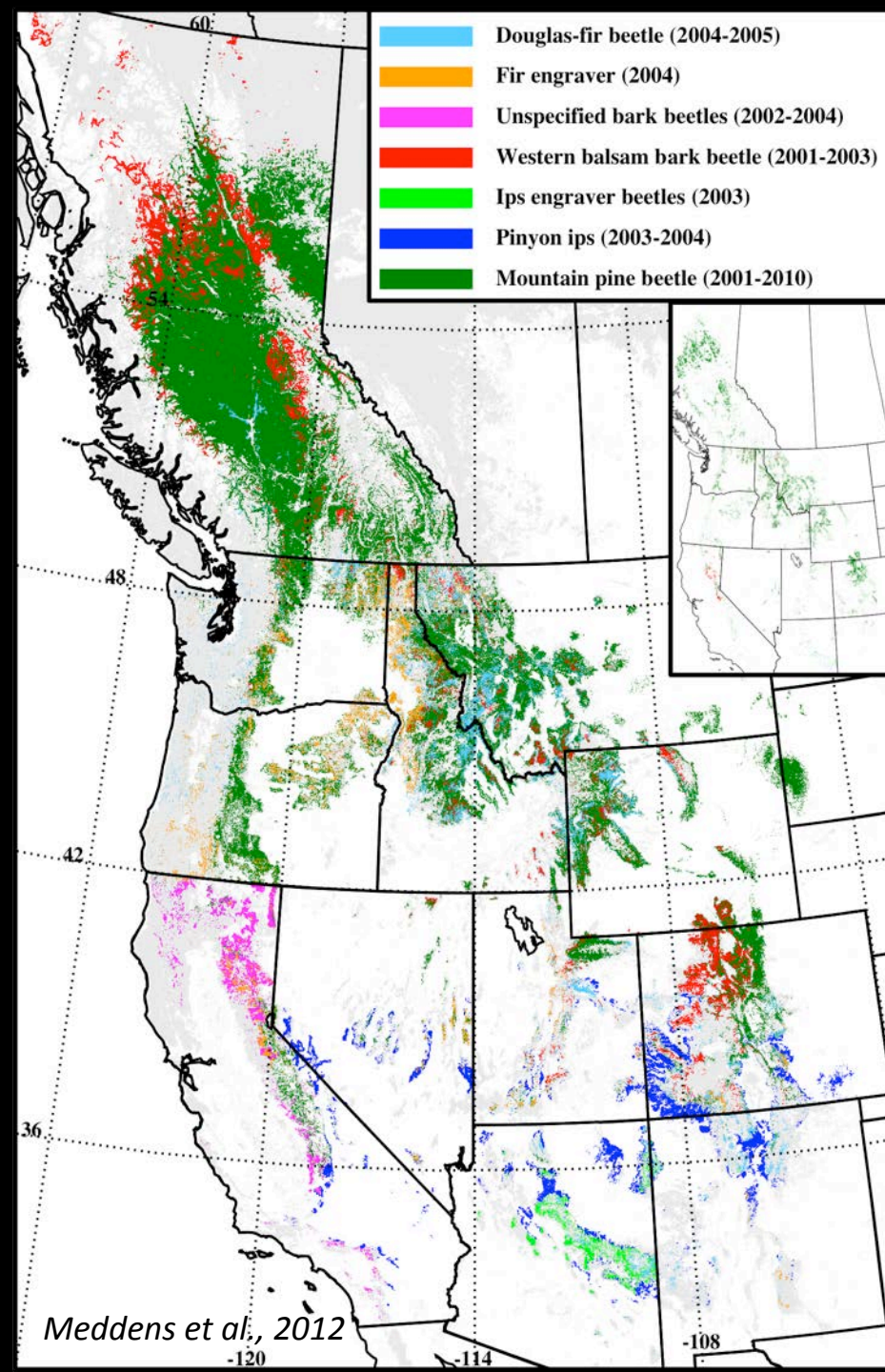


What's next?

other bark beetle
systems

climate effects similar...

...and different



Summary

- warming winters, drought contributed to recent outbreak in Greater Yellowstone Ecosystem
 - clear example of climate change impacts
- continued/increased climate suitability in future
- likely similar outcomes in related systems, with some differences

