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

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Funding: USGS NWCSC, USDA NIFA (FMEC)
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

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

Photo Jeff Hicke

Warwell et al., 2007
Whitebark pine mortality from beetles 1997-2010

red = mortality

Weed et al., Ecological Monographs, 2013
Climate is an important driver of these outbreaks

Climate observations, model results suggest warming as drivers

Logan et al., 2010
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

Buitte et al., Ecol. App., in press
1. Climate-beetle relationships

winter mortality

Probability of tree mortality

Probability of tree mortality

beetle survival increases

Winter minimum temp (°C)

Buotte et al., Ecol. App., in press
1. Climate-beetle relationships

tree drought stress

BuoTe et al., Ecol. App., in press
1. Climate-beetle relationships

year-round temperatures

Buotte et al., Ecol. App., in press
2. Climate influences on recent outbreak

Buotte et al., Ecol. App., in press
2. Climate influences on recent outbreak

Climate influences on recent outbreak were investigated. The figure shows the relationship between winter minimum temperature and the area with mortality. The climate suitability index reflects the impact of climate on outbreak occurrences.
2. Climate influences on recent outbreak

Climate influences on recent outbreak

summer precipitation

climate suitability index

area with mortality (km²)

Buotte et al., Ecol. App., in press
2. Climate influences on recent outbreak

- Climate suitability index
- Area with mortality (km²)

- Fall temperature

Buotte et al., Ecol. App., in press
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

Buotte et al., Ecol. App., in press
What’s next?
climate-beetle relationships in other regions

winter minimum $T = -9^\circ C$

winter minimum $T = -16^\circ C$

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