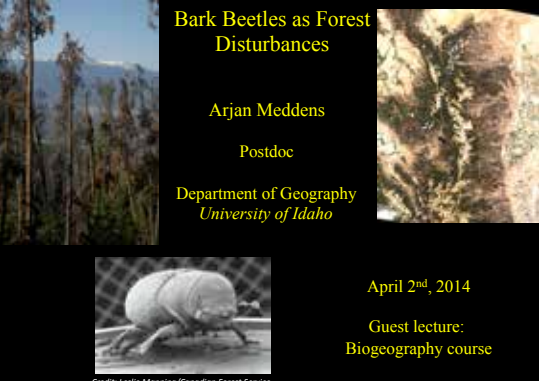


Bark Beetles as Forest Disturbances

Arjan Meddens
Postdoc
Department of Geography
University of Idaho

April 2nd, 2014
Guest lecture:
Biogeography course



Credit: Leslie Manning/Canadian Forest Service

Tree mortality resulting from insect outbreaks

Southwestern US British Columbia





Photo by Craig Allen - USGS © Parks Canada/Ross MacDonald/KNP/2004



October 2004, Sylvan Pass, Yellowstone NP, photo by J. Hicke

Outline

1. Life-cycle of bark beetles
2. Interactions with climate
3. Maps of tree mortality
4. Effects on the ecosystem
5. Conclusions




Photo by J. Hicke

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Photo by J. Hicke

Bark beetles

- Majority of life time in stem of tree
- Beetles emerge late-summer to mass attack healthy trees and carry blue stain fungi into tree
- Females deposit eggs in phloem of the tree



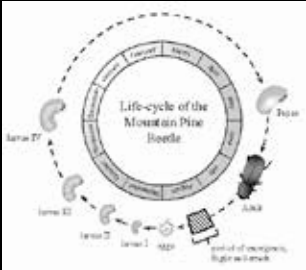


Illustration: USDA FS - Rocky Mountain Region Archive.
The Mountain pine beetle (*Dendroctonus ponderosae* Hopkins) size from 3.5 - 6.5mm in body length.



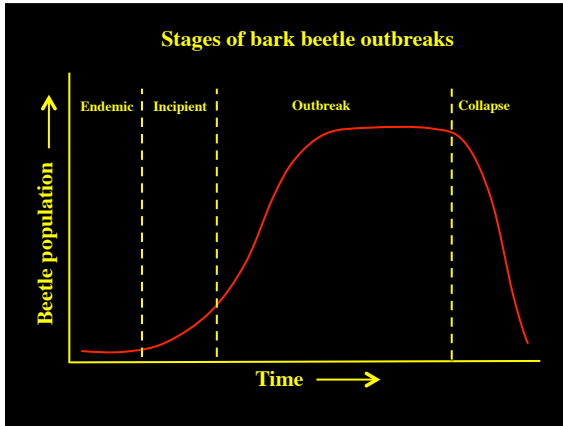
- Larvae feed on the phloem girdling the tree
- Preference for larger diameter trees
- Life stage development of bark beetles is affected by temperatures
- Outbreaks are favored by: abundance of large diameter host trees and favorable climate conditions

Life-cycle mountain pine beetle



Development (rate) is governed by temperature (increasing with warmer temperatures)

Adaptive seasonality: **life cycles of one year** (univoltinism) which lead to **synchronous emergence** of adults from host trees at an appropriate time of year in order **to overwhelm tree defenses**



Factors influencing mountain pine beetle epidemics

Factors related to trees:

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

stand structure

climate

The slide includes an illustration of a forest of green trees on the left, labeled "stand structure", and a cluster of brown, dead trees on the right, labeled "climate". Below the dead trees are several images of bark beetles.

Photo courtesy USDA Forest Service, www.forestimages.org
Safarynik et al. 1975; Shore and Safarynik 1992; Carroll et al. 2004; Logan and Powell 2001

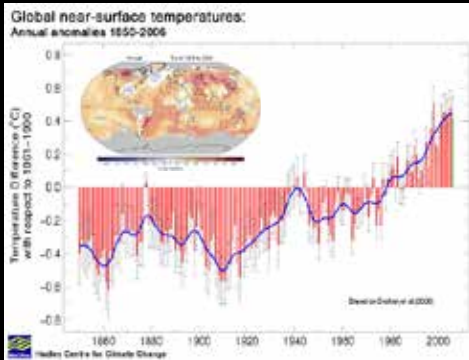
Outline

A photograph of a tree with significant bark beetle damage, showing large areas of dead, brown bark and sparse green needles.

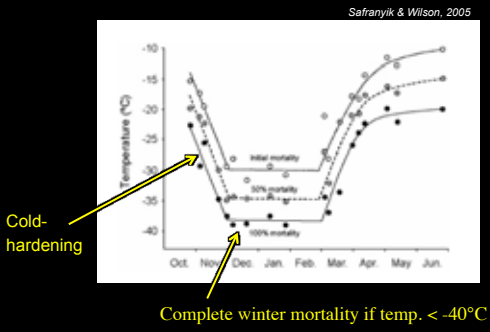
Photo by J. Hicke

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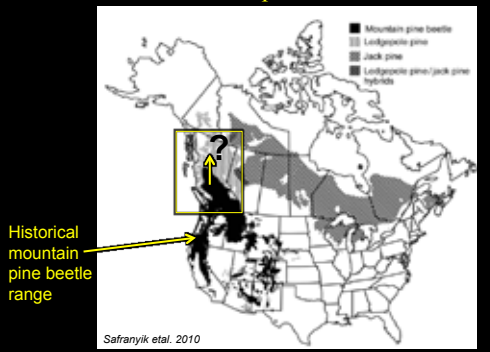
Change in temperature over last 150 years

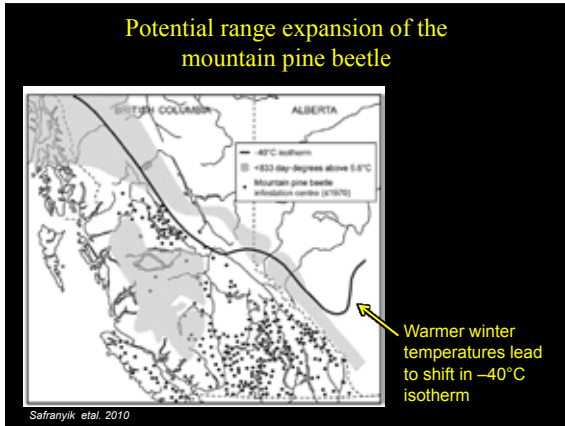


Cold tolerance in the mountain pine beetle



Potential range expansion of the mountain pine beetle





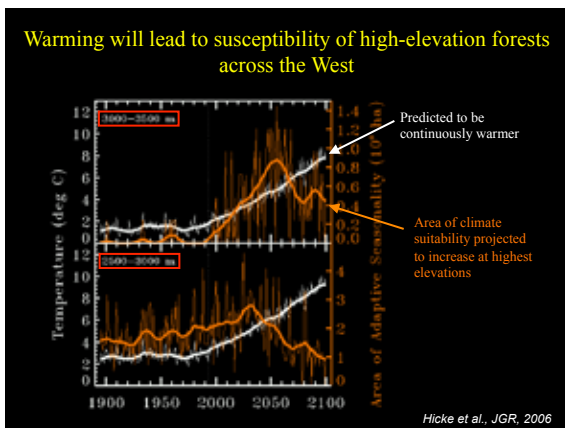
The whitebark pine

©2000 California Academy of Sciences

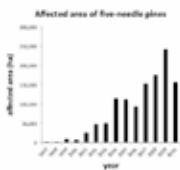
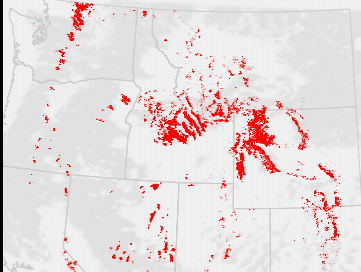
1. Five-needle pine
2. High (or highest)-elevation species
3. Provides food for:
 - Clark's nutcracker (caches)
 - Grizzly bears
4. Maintains snow pack (regulates spring runoff)

Threats:

1. Mountain pine beetle
2. Blister rust
3. Fire suppression



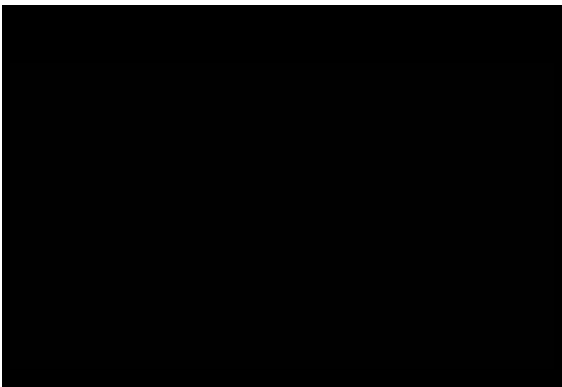
Insect outbreaks: Mountain pine beetle in whitebark pine



Affected area of five needle classes

Now bark beetle outbreaks are occurring in whitebark pine ecosystems:
"where outbreaks either did not previously occur or were limited in scale" (Logan et al. 2010)

Photo by J. Hicks




Video: treefight.org

Drought in the US

May 8, 2012

Illustration: NPR.org



Abnormally Dry Moderate Drought Severe Drought Extreme Drought Exceptional Drought

Mountain pine beetle outbreaks in Colorado enhanced by:

- a. Low diversity in age and tree species (logging and fire)
- b. Drought (e.g., 2002 drought in Colorado)

The graph plots Mortality area (10³ ha) on the left y-axis (ranging from -20 to 60) and Wateryear precip. (mm) on the right y-axis (ranging from 50 to 250) against Year on the x-axis (1995 to 2010). A vertical grey shaded area highlights the period from approximately 2001 to 2003, with a yellow arrow pointing to it labeled 'Drought'. The mortality area (solid line with square markers) remains near zero until 2002, then rises sharply to a peak of about 55 in 2005 before declining. The precipitation (dashed line with circle markers) shows a notable dip in 2002.

Piñon pine die-off in the Southwest

- Extent: 1.2 million ha
- Cause: extreme drought, warming, piñon ips

The figure includes a map of the Southwest United States showing cumulative piñon pine mortality from 1997-2010, with a color scale from 0 to 50+ percent mortality. To the right is a bar chart titled 'Anomaly annual precipitation' showing precipitation anomalies from 1990 to 2006. A yellow arrow points to the 2002 bar, which is significantly below the zero line, labeled 'Drought'. Below the map is a photograph of a piñon pine forest showing extensive tree mortality.


Piñon pine die-off in the Southwest

- Extent: 1.2 million ha
- Cause: extreme drought, warming, piñon ips (needs drought to kill trees)


The figure includes a map of the Southwest United States showing cumulative piñon pine mortality from 1997-2010, with a color scale from 0 to 50+ percent mortality. To the right is a bar chart titled 'Anomaly annual precipitation' showing precipitation anomalies from 1990 to 2006. A yellow arrow points to the 2002 bar, which is significantly below the zero line, labeled 'Drought'. Below the map is a line graph titled 'Piñon pine mortality x1000 ha' showing mortality from 2000 to 2010. A yellow arrow points to the sharp peak in 2005, labeled 'Explosive piñon mortality following drought'.

Note that:

1. Insect populations responsive to climate change:
 - physiological sensitivity to temperature
 - high mobility
 - short generation times
 - explosive reproductive potential
2. Tree health is related to climate changes with less favorable conditions:
 - At higher temperatures
 - At lower precipitation/moisture






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Photo by J. Hicke

Stages of trees after beetle attack

			
Postattack stage	Green trees	Red attack stage	Gray attack stage
Timing	Before beetle attack	1 to 3 years after attack	3 to 5 years after attack

Insect outbreaks are major forest disturbances in North America

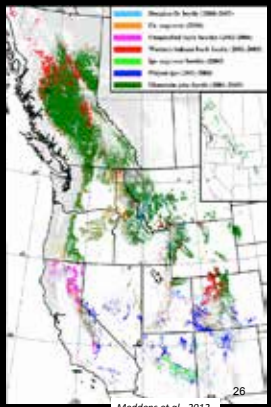
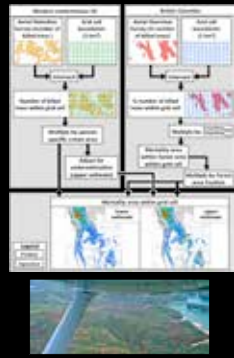
affected area reported by aerial surveys, 1997-2010



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Hicke et al., *Global Change Biology*, 2012

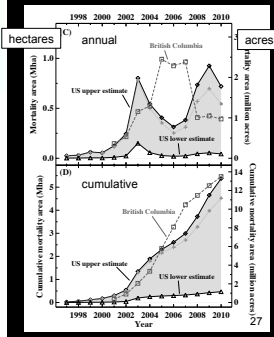
Aerial detection surveys



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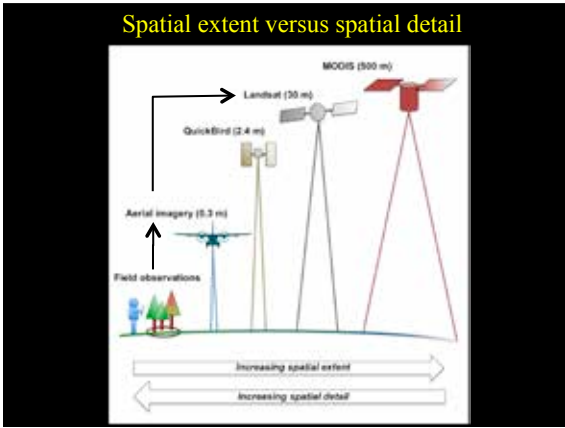
Meddens et al., 2012

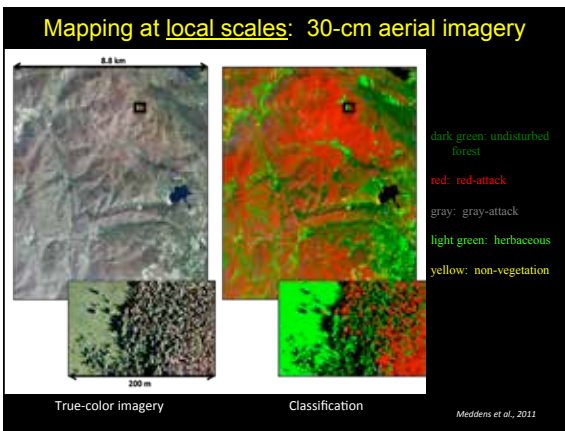
Bark beetle outbreaks are widespread and extensive in western North America

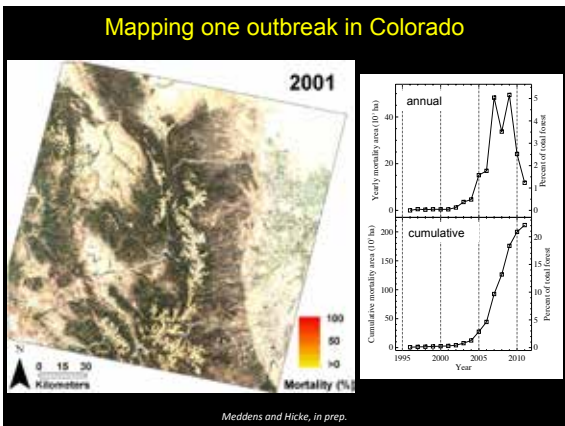


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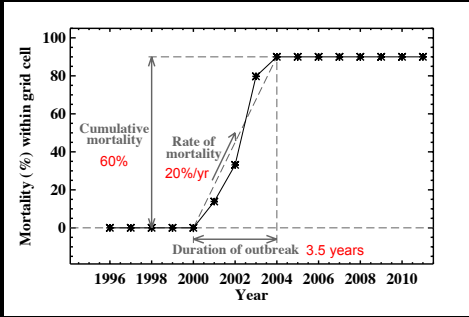
Meddens et al., 2012







Mapping one outbreak in Colorado



Meddens and Hicke, in prep.

Outline

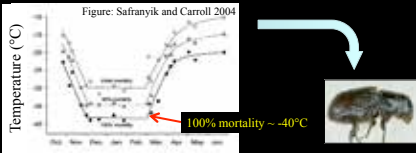


Photo by J. Hicke

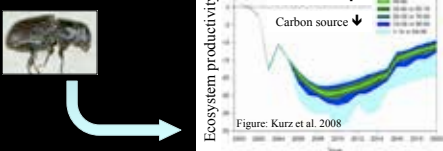
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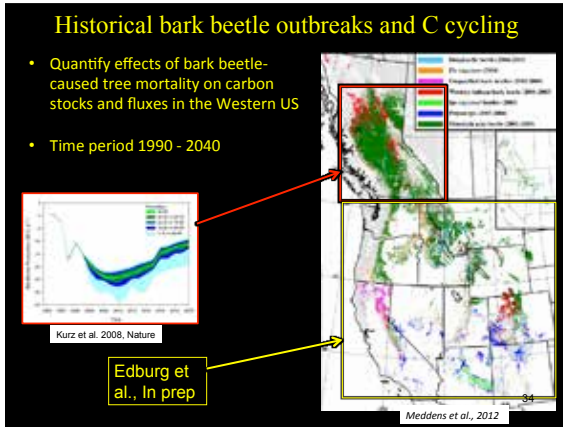
Bark beetles and climate

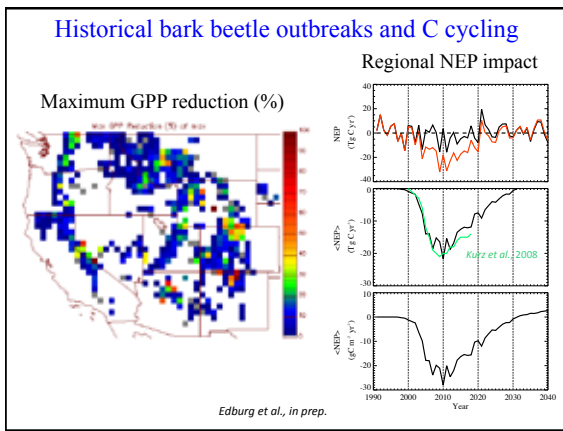
Climate affects beetles

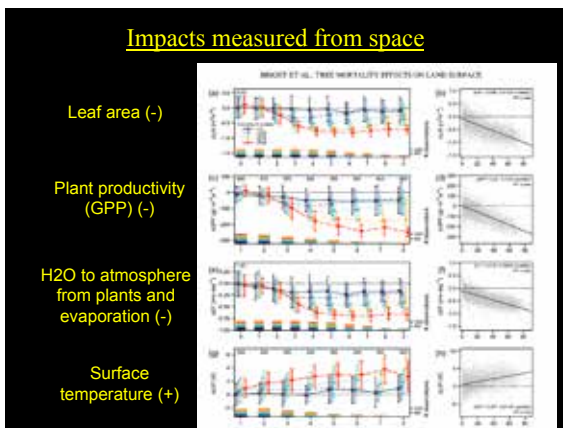


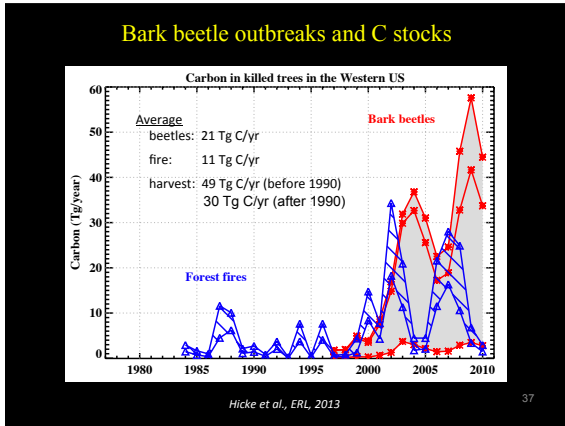
Beetles affect climate

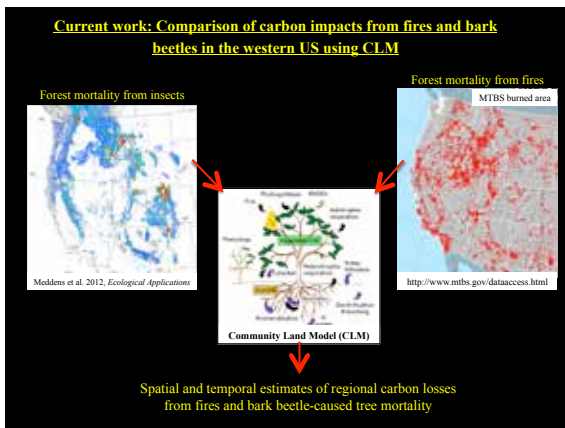












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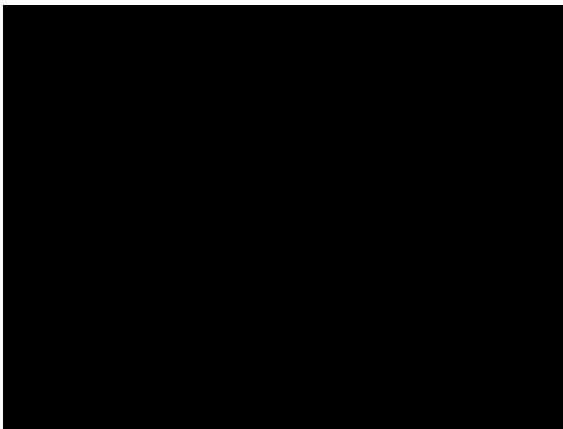
Photo by J. Hicke

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Conclusions:

1. Bark beetle cause large scale forest disturbances across North America
2. Bark beetles, their hosts, and climate are tightly coupled through:
 - a. Live-cycle development → Governed by year-round temperatures
 - b. Cold mortality → Cold temperatures kill beetles
 - c. Host trees → Negatively affected by dry and warm years
3. Beetle outbreaks occur outside the known historic range (higher elevations and more northern)
4. By killing trees beetles affect carbon uptake of forests and can turn forests from carbon sinks to carbon sources





Do beetle-killed trees affect forest fires?



Photo by Matt Steisland
www.steamboatplot.com/news2008/aug7/10
dying_forest_increase_wildfire_danger_across_west

