Ecology of Lodgepole Pine Forests and the Future of Post-beetle Forests

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Outline for Discussion

1. Lodgepole pine disturbance ecology
2. Influence of bark beetles on future fire activity
3. How are forests responding to current bark beetle epidemic?
4. How has/will continued climate change influence future lodgepole pine forests in the Intermountain West?

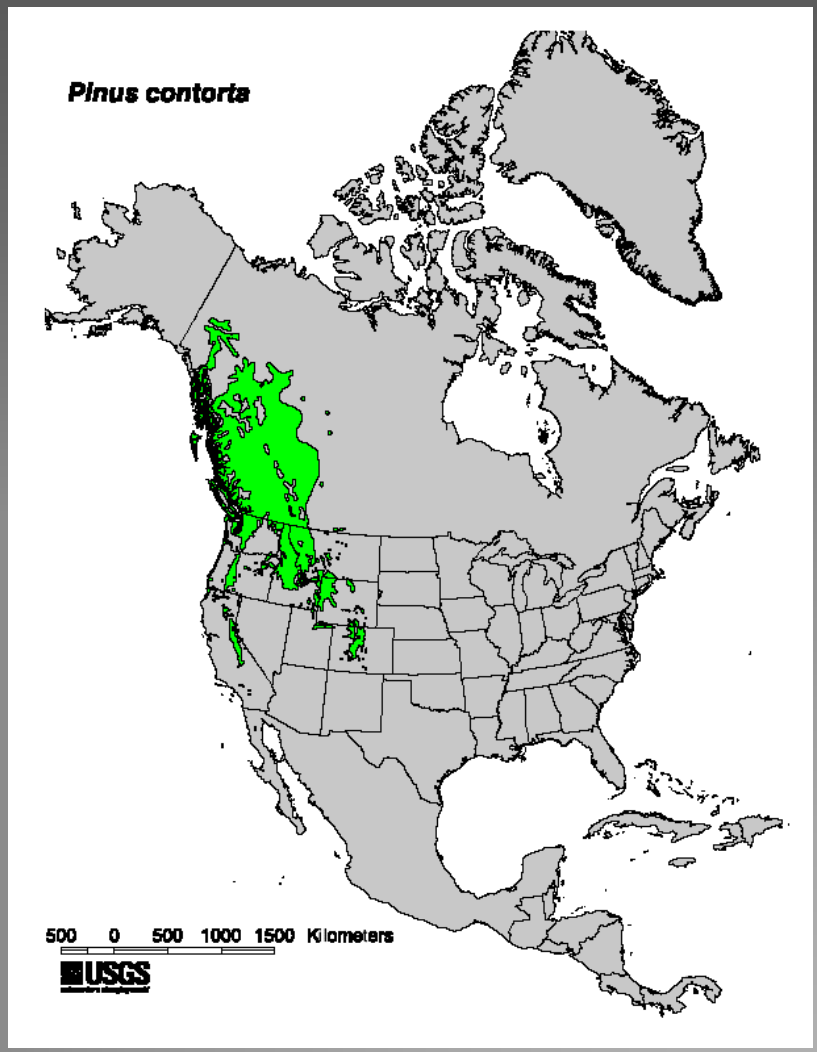
We Should Consider Western Forests in the context of The Four "R"s

1. **Redefining** our forests (and our vision)
2. **Resilience** should be our focus; resistance is less certain
3. **Recovery** of forests via natural processes
4. **Restoration**, when appropriate, may be effective

Lodgepole Pine Forests of the Intermountain West

- Extensive forests dominated by lodgepole pine
- Stand-replacing fires have occurred at 100 to 500 yr intervals throughout the Holocene
- Lodgepole often early successional species

Photo by B. Romme



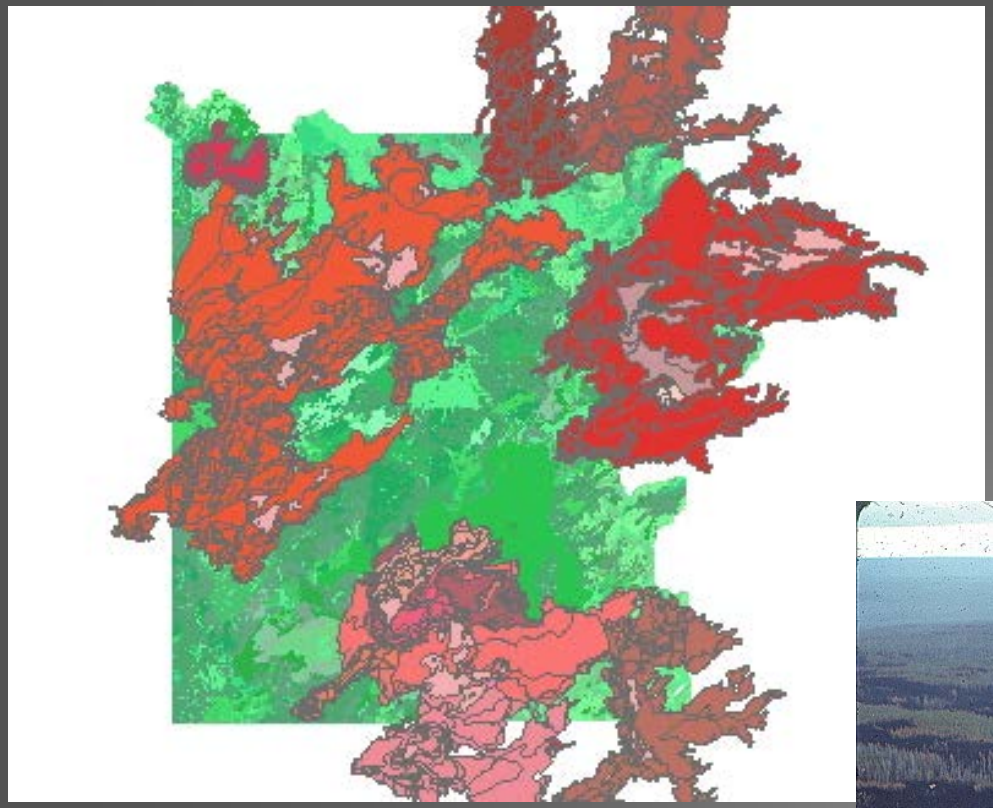
Lodgepole Pine Disturbance Ecology

1. Wildfire
   - Typically large, infrequent, stand-replacing
   - Importance of weather conditions
2. Insects and Pathogens
   - Many native insects and pathogens
   - More recently, many non-native organisms
3. Wind
   - Often localized and episodic
   - Can act as catalyst for subsequent disturbance

1. Wildfire
The 1988 Yellowstone Fires

- Burned under conditions of severe drought and high winds
- Affected ~40% of the park
- Burned in all ages of forest
- Stopped by snow in mid September

1988 Fires – Yellowstone National Park



Where is the Resilience?

BECAUSE OF SEROTINOUS CONES AND VARIATION IN FIRE SEVERITY…

- Variability in post-fire seedling establishment across the landscape
- Varies by five orders of magnitude
  - From near 0 to > 500,000/ha

~ 30 seedlings/ha

~ 1200 seedlings/ha

~ 5000 seedlings/ha

~ 450,000 seedlings/ha

2. Insects

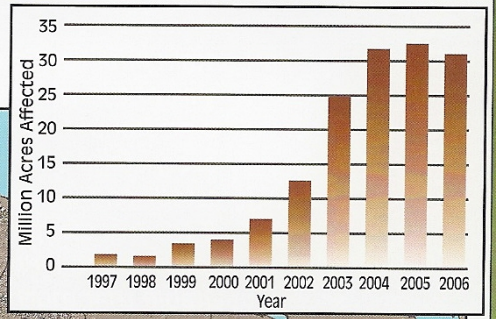
- Current beetle outbreak in Western US is unprecedented in extent and severity for recorded epidemics
- Most beetles infest specific tree species
- Numerous species of beetles active in many different forest types

Bark Beetle Outbreak in N. America

- Current extent from N. Mexico to British Columbia, Canada
- Approximately 3 million acres of forests affected by bark beetles in Wyoming and Colorado – predicted to increase to over 5 million acres
- Estimates for BC are over 30 million acres and 150 million in N. America
- Recent wind events have transported beetles across continental divide to Alberta

FIGURE 5.

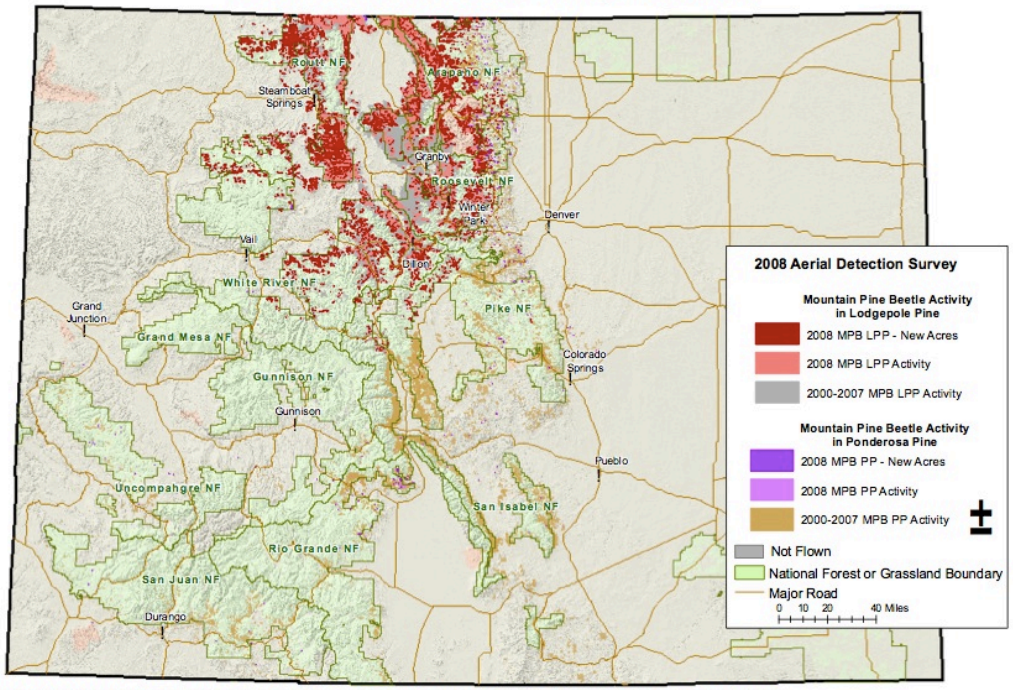
Bark Beetle Outbreaks in Western North America



SOURCE: NATURAL RESOURCES CANADA, CANADIAN FOREST SERVICE; USDA FOREST SERVICE, FOREST HEALTH PROTECTION

Native bark beetles have affected more than 150 million acres of western North American forests during the past 10 years.

2008 Mountain Pine Beetle Activity in Colorado



Due to the nature of aerial surveys, the data on this map will only provide rough estimates of location, intensity and the resulting trend information for agents detectable from the air. Many of the most destructive diseases are not represented on this map because these agents are not detectable from aerial surveys. The data presented on this map should only be used as a partial indicator of insect and disease activity, and should be validated on the ground for actual location and casual agent. Shaded areas show locations where tree mortality or defoliation were apparent from the air. Intensity of damage is variable and not all trees in shaded areas are dead or defoliated.

Bark Beetle Biology/Ecology

- Several “aggressive” bark beetle species now active (all are native to Colorado and Western N. America)

  - **Mountain Pine Beetle** (*Dendroctonus ponderosae*)
    - Infests most native and introduced species of pines (lodgepole, ponderosa, limber, whitebark, bristlecone, western white)
  - **Spruce Beetle** (*Dendroctonus rufipennis*)
    - Infests Engelmann spruce/Colorado blue spruce
  - **Douglas-fir Beetle** (*Dendroctonus pseudotsugae*)
    - Infests Douglas-fir
  - **Western Balsam Bark Beetle** (*Dryocoetes confusus*)
    - Infests Subalpine fir

Bark Beetle Biology/Ecology

- Life History of bark beetles
  - Host specific, native insects
  - Except for emergence and dispersal, all phases of life cycle occur beneath bark of tree
  - Adult beetles attack trees in summer, aided by pheromones
  - Eggs laid in early fall, larval phase during winter; pupal phase in spring; brood adults emerge in summer (synchronous)
  - Both adults and larvae feed in phloem layer of inner bark (small trees often not selected)

Mountain Pine Beetle Galleries Beneath Bark

Photo by William Ciesla

Photo by Ladd Livingston

Photo by Ronald Billings

Bark Beetle Biology/Ecology

- Fungal mutualism with blue stain fungi (*Ophiostoma sp.)*
  - Fungal mycelium penetrate water and nutrient conducting cells (xylem), accelerating tree death
  - Fungal spores are important food source for beetle larvae

Endemic to Epidemic Levels

- Seem to be three major factors that have combined to create the current outbreak:
  1. Extended period of drought stress; weakens trees and increases susceptibility to insect attack
  2. Increased winter survival of larvae due to fewer days of extremely low winter temperatures
  3. Abundance of suitable host trees (forest structure)

Bark beetle/blister rust infected whitebark pine (*Pinus albicaulis*) in Yellowstone National Park

3. Wind

Disturbance Interactions and the Influence of bark beetles on future fire activity

- How do various natural and anthropogenic disturbances interact?
  - Beetle/ fire
  - Beetle/ blister rust
  - Fire/ salvage logging
  - Beetle/ salvage logging

No consensus on direct influence of beetle outbreaks and subsequent fire occurrence and severity

- Lynch et al. 2006
  - Used remotely sensed imagery
  - 1972-75 outbreak statistically increased odds of burning in 1988 by 11% (MINOR EFFECT)
- Bebi et al. 2003
  - GIS and vegetation maps in spruce/fir forests
  - Stands affected by 1940s beetle outbreak did not exhibit higher susceptibility to subsequent fires (NO EFFECT)
- Page and Jenkins 2007
  - Predicted fire behavior in lodgepole pine
  - Crown fires more likely in post-epidemic stands, but harder to sustain (INCREASED RISK OF FIRE)
- Simard et al. 2011
  - Reduced risk of active crown fires (LOWER RISK OF ACTIVE CROWN FIRE)

How are forests responding to current bark beetle epidemic?

- Advance Regeneration in post-outbreak lodgepole pine forests
  - Young trees (seedlings and saplings) that are not killed by the bark beetles
- Many of these small trees will be “released” by the death of mature overstory trees, and will grow quickly

RESULTS OF RECENT STUDIES

- Collins et al. 2011 (Fraser Exp. Forest, CO):
  - Seedling establishment extensive following bark beetle activity
  - Four times higher in post-outbreak harvested stands than in untreated stands
- Diskin et al. 2011 (Rocky Mtn. N.P., CO):
  - Surviving small trees exceeded minimum stocking densities in RMNP
  - Lodgepole pine still dominating landscape

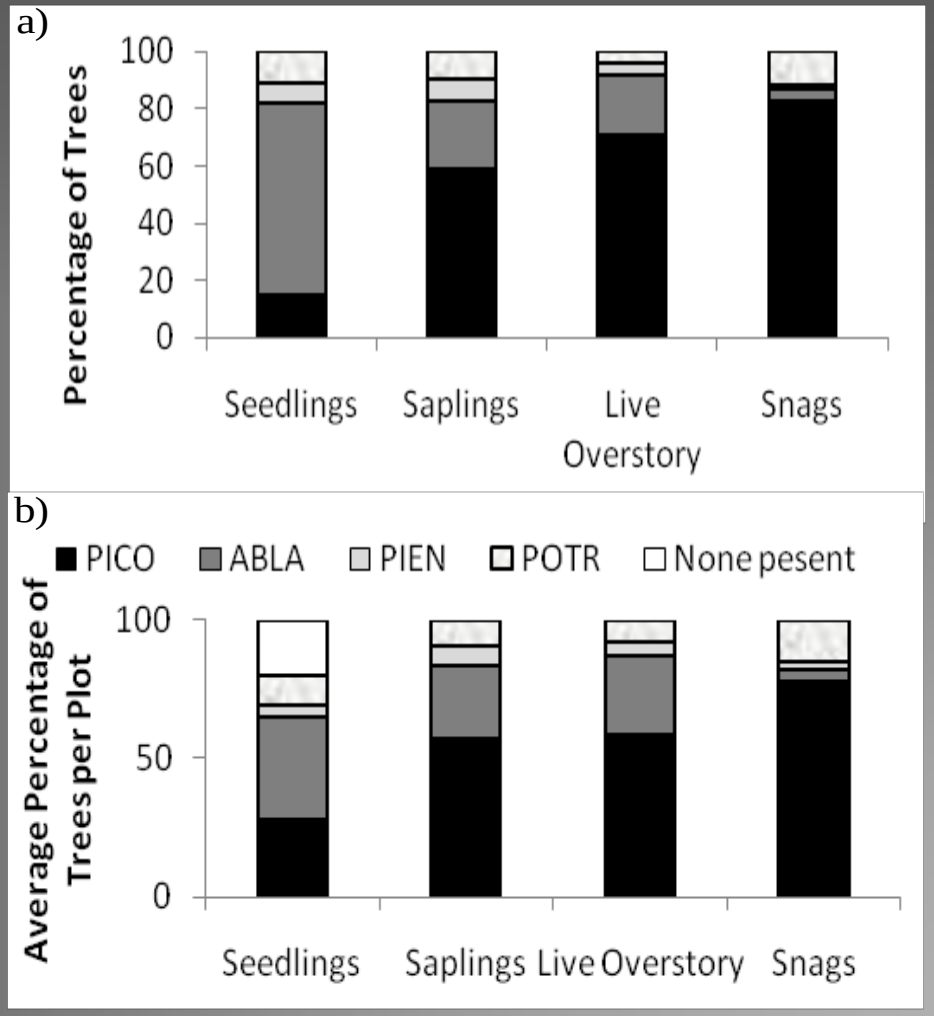
RESULTS OF RECENT STUDIES

- Klutsch et al 2009 (Arapaho N.F., CO):
  - Abundant seedling/saplings following outbreak
  - Average density > 2900/ha
  - Future forests likely uneven-aged, mixed species
- Kayes and Tinker 2012 (Medicine Bow N.F., WY):
  - The density of advance regeneration varied widely, from 100 to 12,933 stems per hectare for all species combined.
  - The density of advance regeneration exceeded 1,000 stems per hectare in all but three stands.

Kayes and Tinker, 2012

Kayes and Tinker 2012, continued:

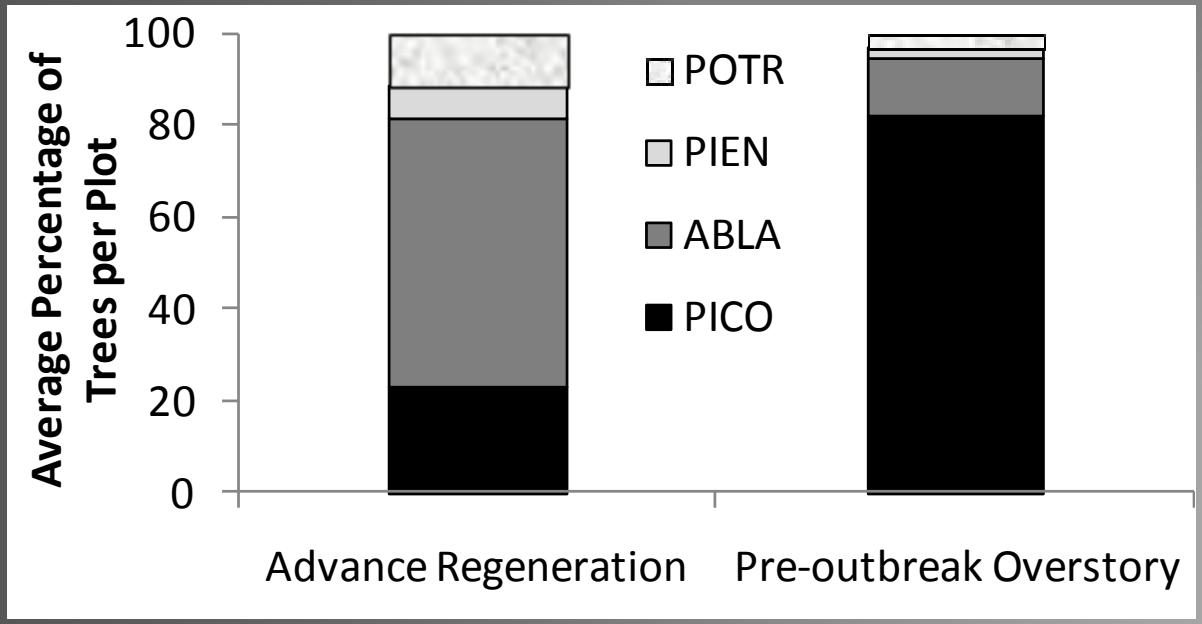
- Subalpine fir was the most abundant seedling overall, accounting for almost 70% of all seedlings (a).
- However, at the stand level, subalpine fir seedlings comprise only 37% of seedlings (b).



Kayes and Tinker, 2012

Kayes and Tinker 2012, continued:

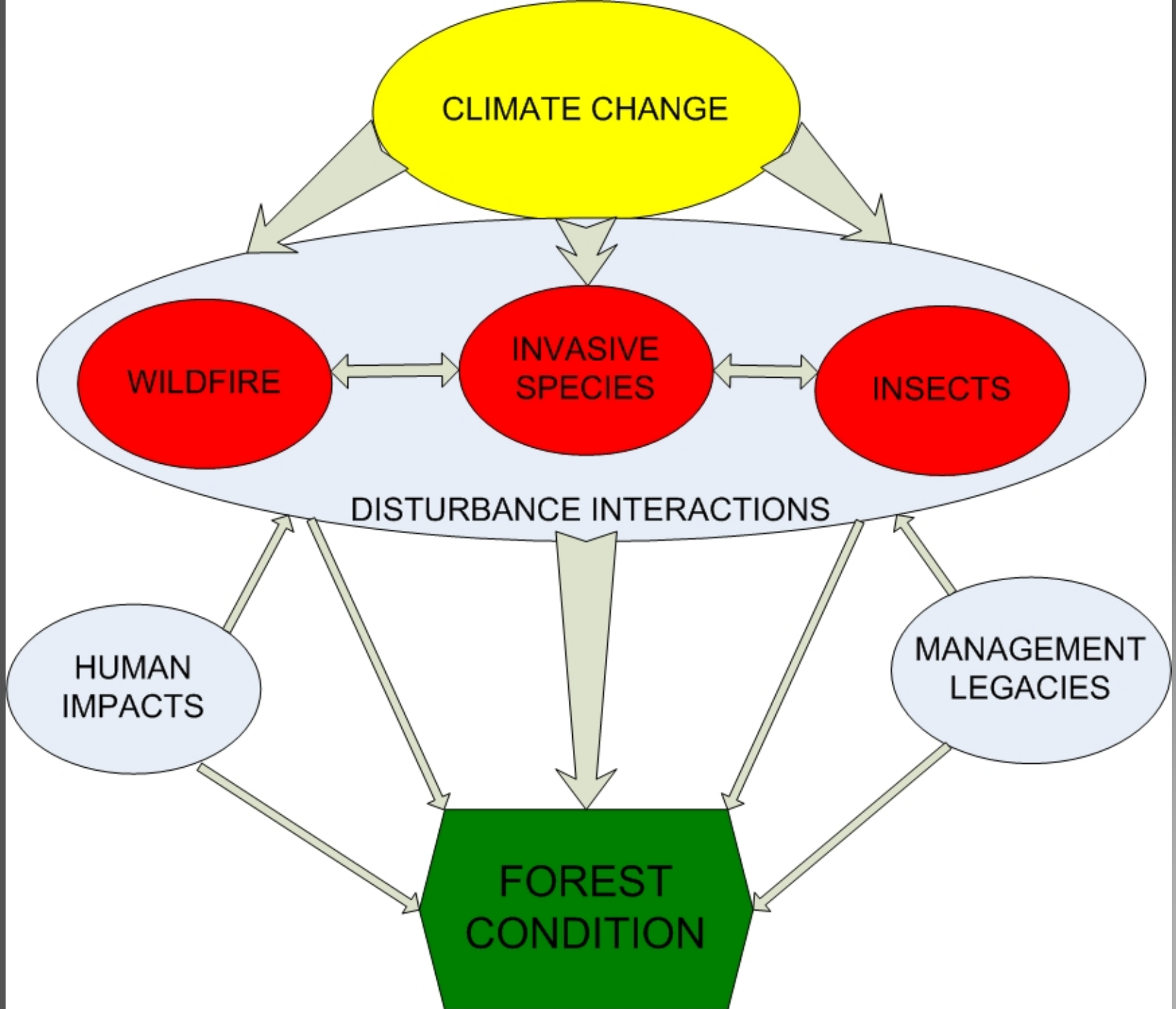
- Pre-outbreak overstory was comprised of 82% lodgepole pine, while the advance regeneration was only 23% lodgepole pine, and was dominated by subalpine fir, suggesting a potential shift in dominant species in some stands.



Kayes and Tinker, 2012

What are the current critical impacts on Western forests?

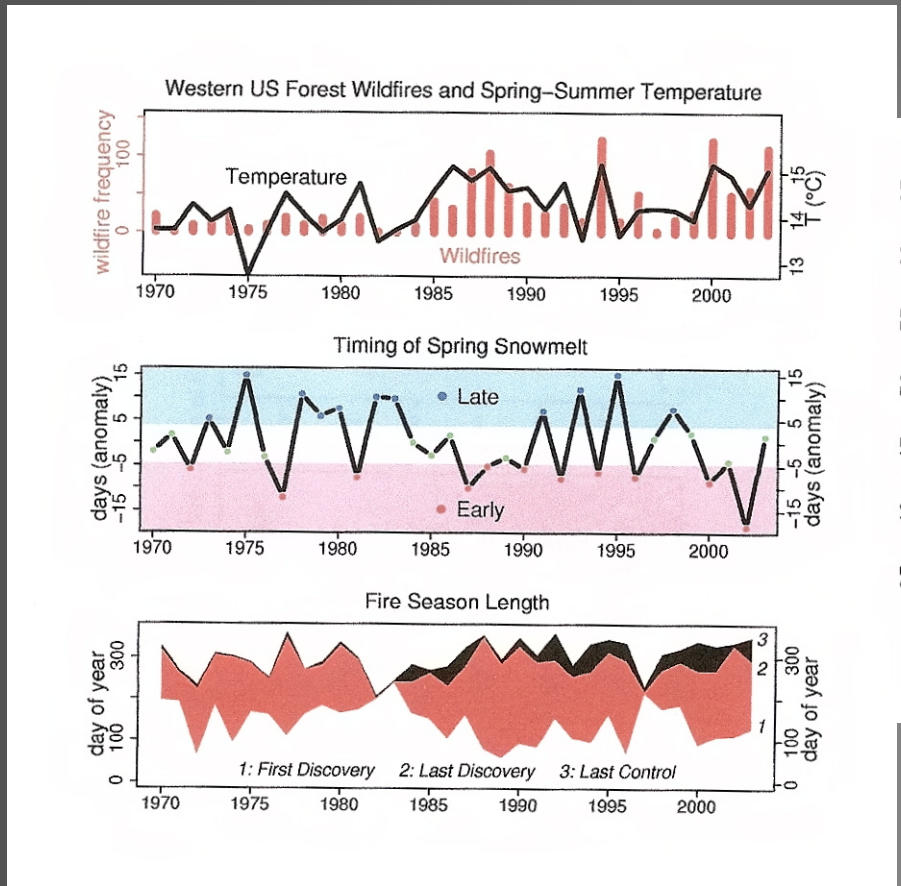
1. Wildfire
2. Insects
3. Disturbance Interactions
4. Invasive Species
5. Human impacts
6. Management legacies

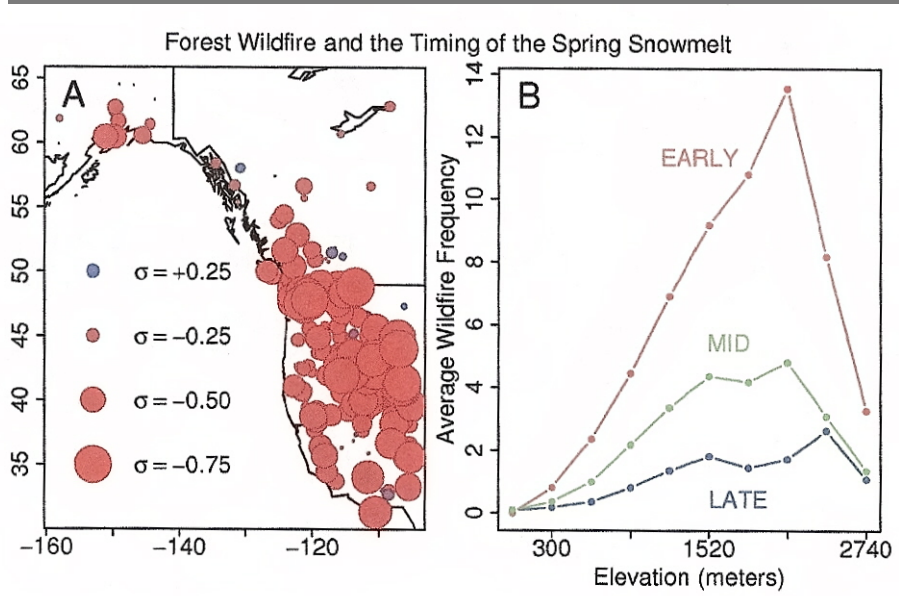

CLIMATE CHANGE
WILDFIRE
INVASIVE SPECIES
INSECTS
DISTURBANCE INTERACTIONS
HUMAN IMPACTS
MANAGEMENT LEGACIES
FOREST CONDITION

Changing climate is increasing the vulnerability of Western forests

- Disturbance and Invasion

- INCREASE in wildfire occurrence in past three decades (Westerling et al. 2006)
- Westerling et al. examined 1166 large (> 400 ha) wildfires, 1970-2003
  - Wildfires suddenly increased in mid-1980s (almost 4X more than 1970-1986)
  - Length of wildfire season increased





From Westerling et al. 2006

More recently, Westerling et al. 2011

- Projected climate change in Greater Yellowstone points to substantial increases in fire by mid-century
- New fire regime(higher fire frequency and extent) not consistent with persistence of current suite of conifer species
- Extensive lodgepole/conifer forests may disappear by mid-century in GYE

Redefining our Forests … Redefining our Vision

Are things getting better, or just getting worse more slowly?

- Are sustainable forests a possibility in the coming decades?
- Will the list of impacts change?
- What can we do to reduce vulnerability and increase the likelihood of sustainability?

4. Redefining our Vision, cont.

- Can we reduce the vulnerability of forests in the Western US?
  - Difficult to increase resistance – focus on resilience
- We may have to change the way we think about management
  - Artificial selection of whitebark pine (GTNP)
  - Forest Restoration
  - Emulation of Natural Forest Disturbance
- We should emphasize the important **ecosystem services** provided by forests

1984 Blowdown/1988 Fires in YNP


Blowdown

Acknowledgements

- Colleagues – Bill Romme, Monica Turner, Dan Kashian, Mike Ryan, Tania Schoennagel
- Field and Lab Assistants
- University of Wyoming
- Funding Sources
  - NSF
  - Andrew Mellon Foundation
  - Joint Fire Science Program
  - U.S. Forest Service
  - National Park Service