A Century of Drought-Related Mountain Pine Beetle Disturbance throughout Northern Region Forests from 1915-2016

Joel M Egan, Entomologist
U.S. Forest Service
Forest Health Protection
Missoula Field Office

Improving Drought Resilience Workshop
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Presentation Topics

- MPB outbreaks throughout past century
- Drought and MPB outbreak interactions
- Ecosystem impacts
- Management opportunities and constraints

Recent Bark Beetle Outbreaks

Mortality across Western North America

- 1999 – present
  - *Ips* in piñion
    - Across 6 western states 2001-2004 > 3 million acres
  - Mountain/western pine beetle in ponderosa pine
    - South Dakota, CO, MT, & adjacent areas: 2005-present
    - Southern California: 2001-2004
  - Mountain pine beetle (MPB) in lodgepole pine
    - Across 8 western US states: 1999-2015 nearly 20 million acres
    - BC Canada: 1999-present > 25 million acres
  - Mountain pine beetle in high elevation white pines
    - Across 8 western US states and BC Canada: 1999-present at >1.2 million acres
  - Spruce beetle in Engelmann/Sitka spruce
    - Alaska: 1987 – 1997 Kenai Peninsula at > 1.6 million acres w/ near 100% mortality
    - Colorado & Utah: 2005-present; MT: 2010 isolated locations

Source: USDA Forest Service National Conditions Reports to Congress 2005-2015

MPB in Northern Colorado Lodgepole Pine, 2008

Photo by Sheryl Costello

Severe and Widespread Mortality Event in MT and Northern ID
2010 MPB Photo from Granite Reporting Area, BVRD National Forest

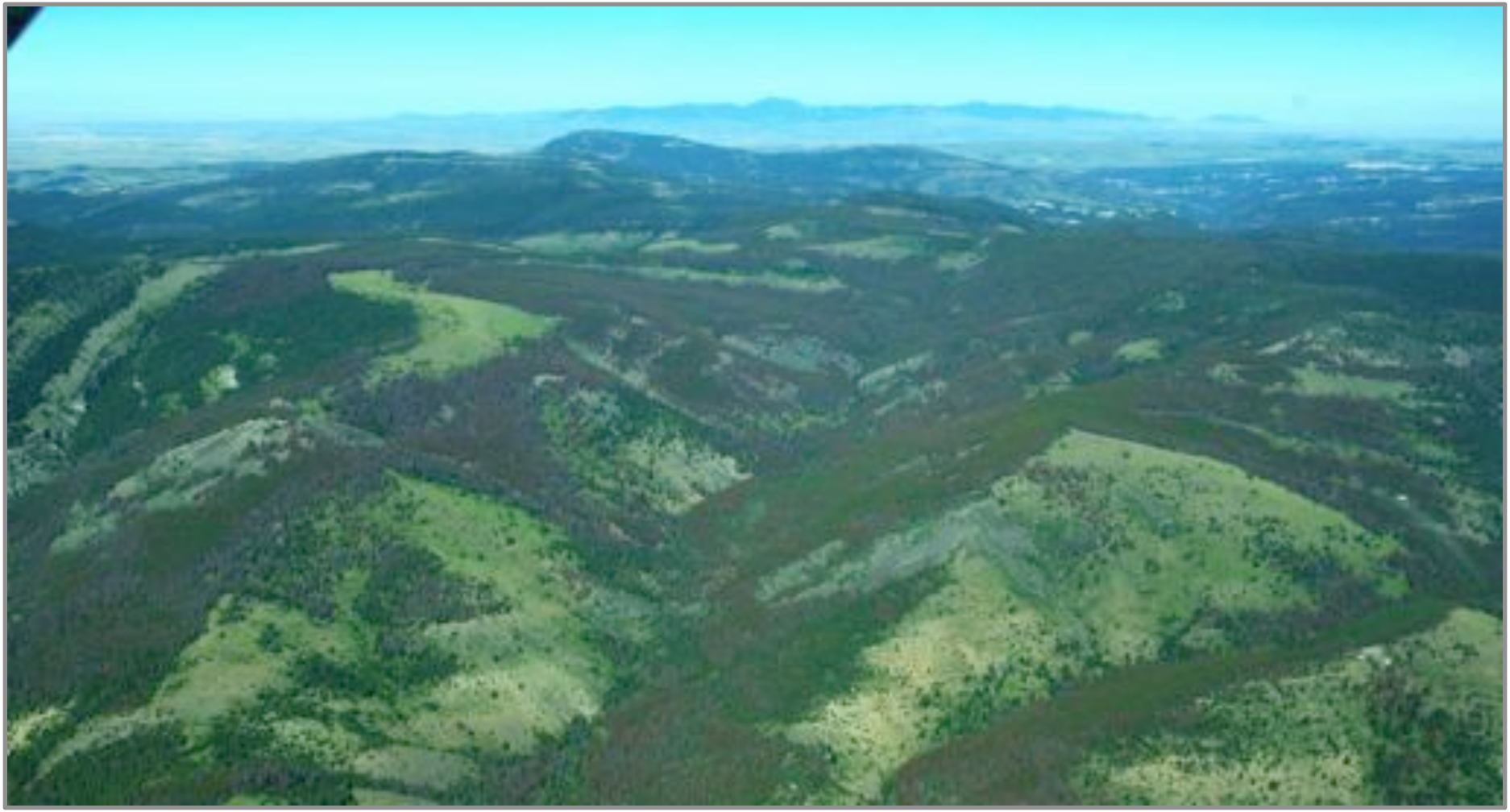
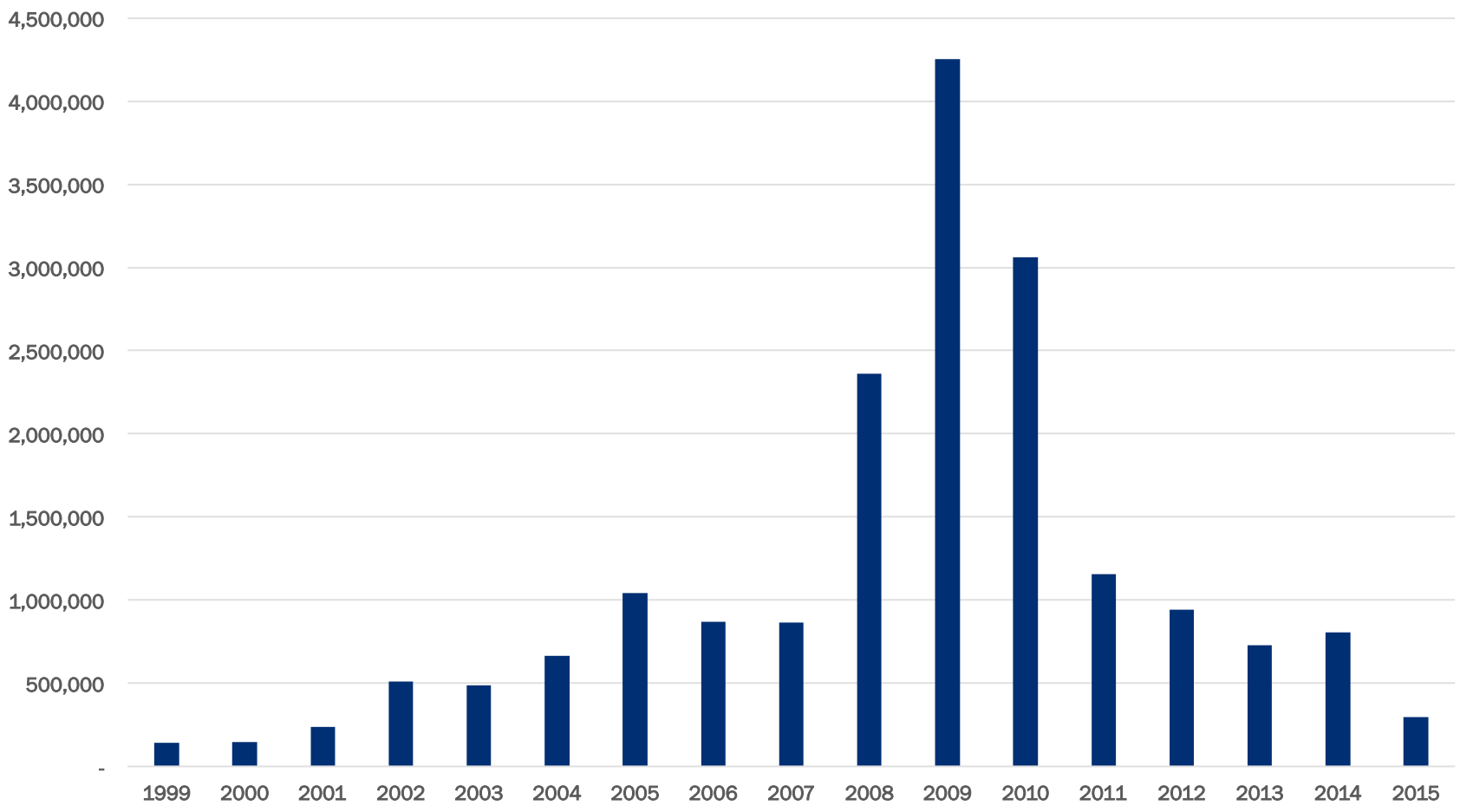


Photo by Scott Sontag

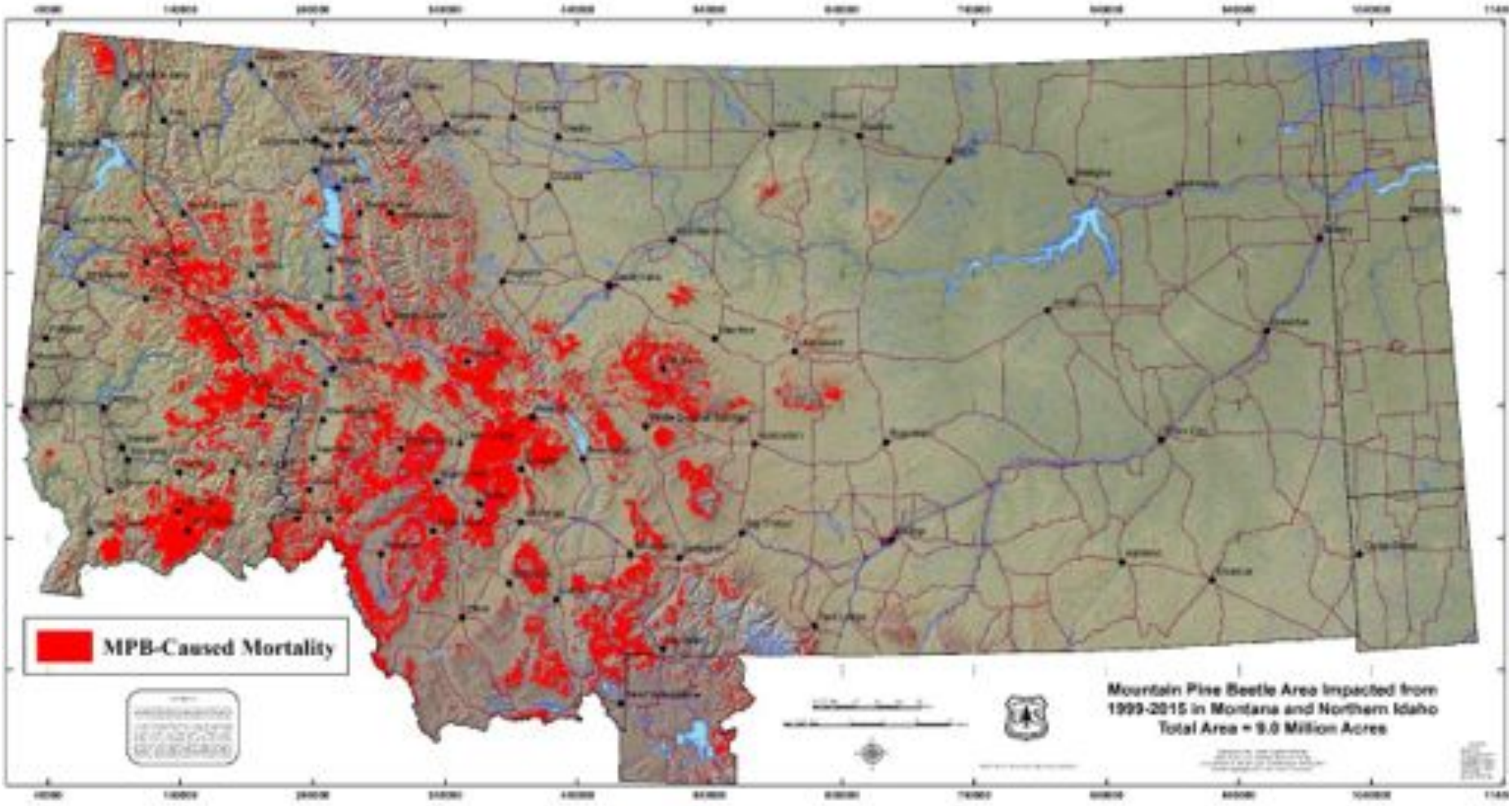
Severe and Widespread Mortality Event in MT and Northern ID 2010 MPB Photo from Georgetown Lake, BVRD National Forest

Photo by Scott Sontag

Area Impacted by MPB across MT and Northern ID 1999-2015 MPB Outbreak



Cumulative Area Impacted by MPB across MT and Northern ID 1999-2015 MPB Outbreak



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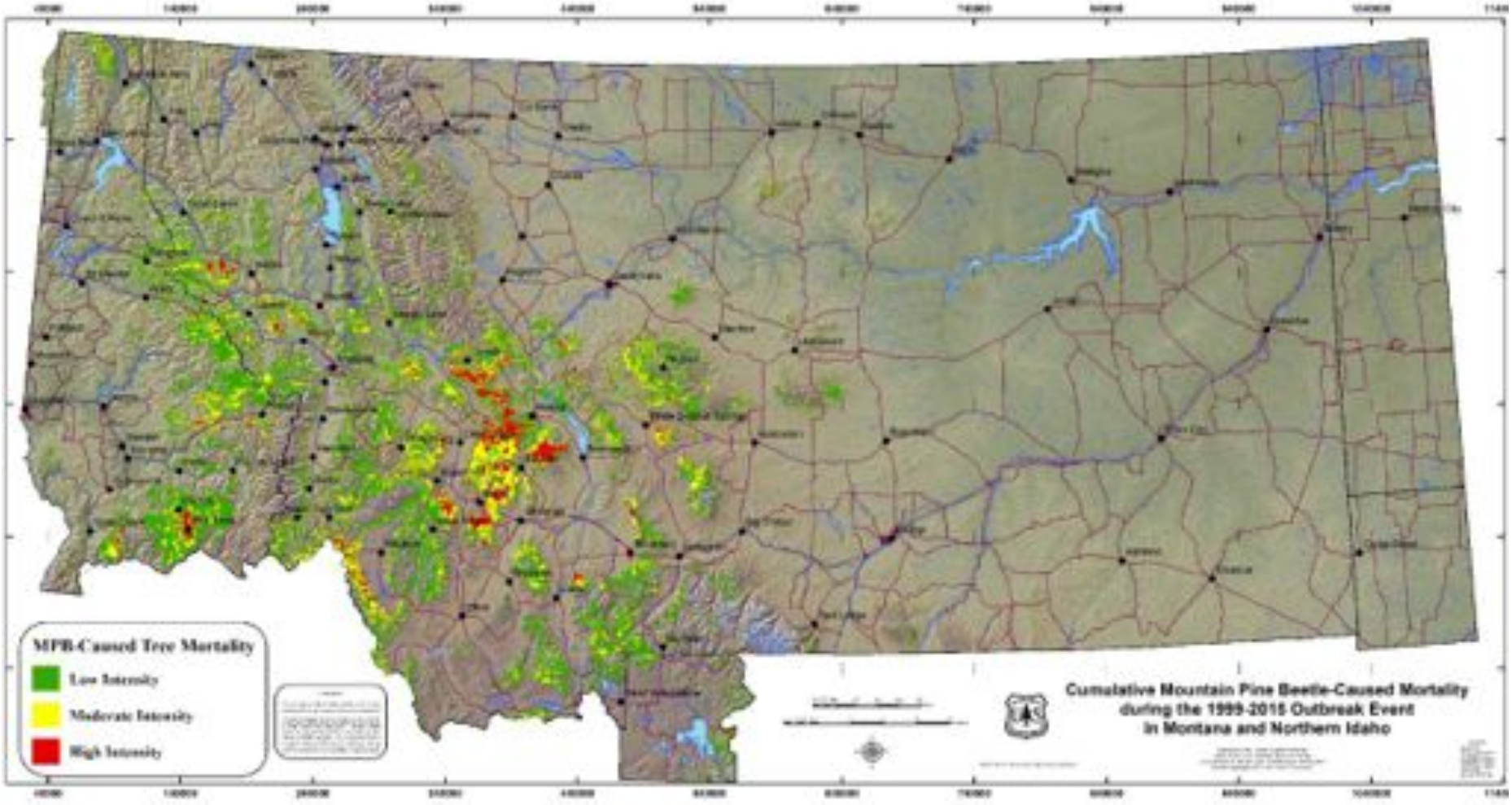

Historical Context for the 2000s MPB Outbreak

- Unprecedented term used frequently especially by mass-media
- To-date minimal quantitative comparisons of known MPB outbreak events through early 1900s
- Why was 2000s outbreak so severe and widespread?
- Reconstructed past severe and widespread MPB outbreak events

Severe and Widespread Mortality Event in MT and Northern ID 1971-1989 MPB Outbreak

Yellowstone National Park Photo by Jed Dewey

Severe and Widespread Mortality Event in MT and Northern ID 1971-1989 MPB Outbreak

Glacier National Park Photo by Bill Ciesla

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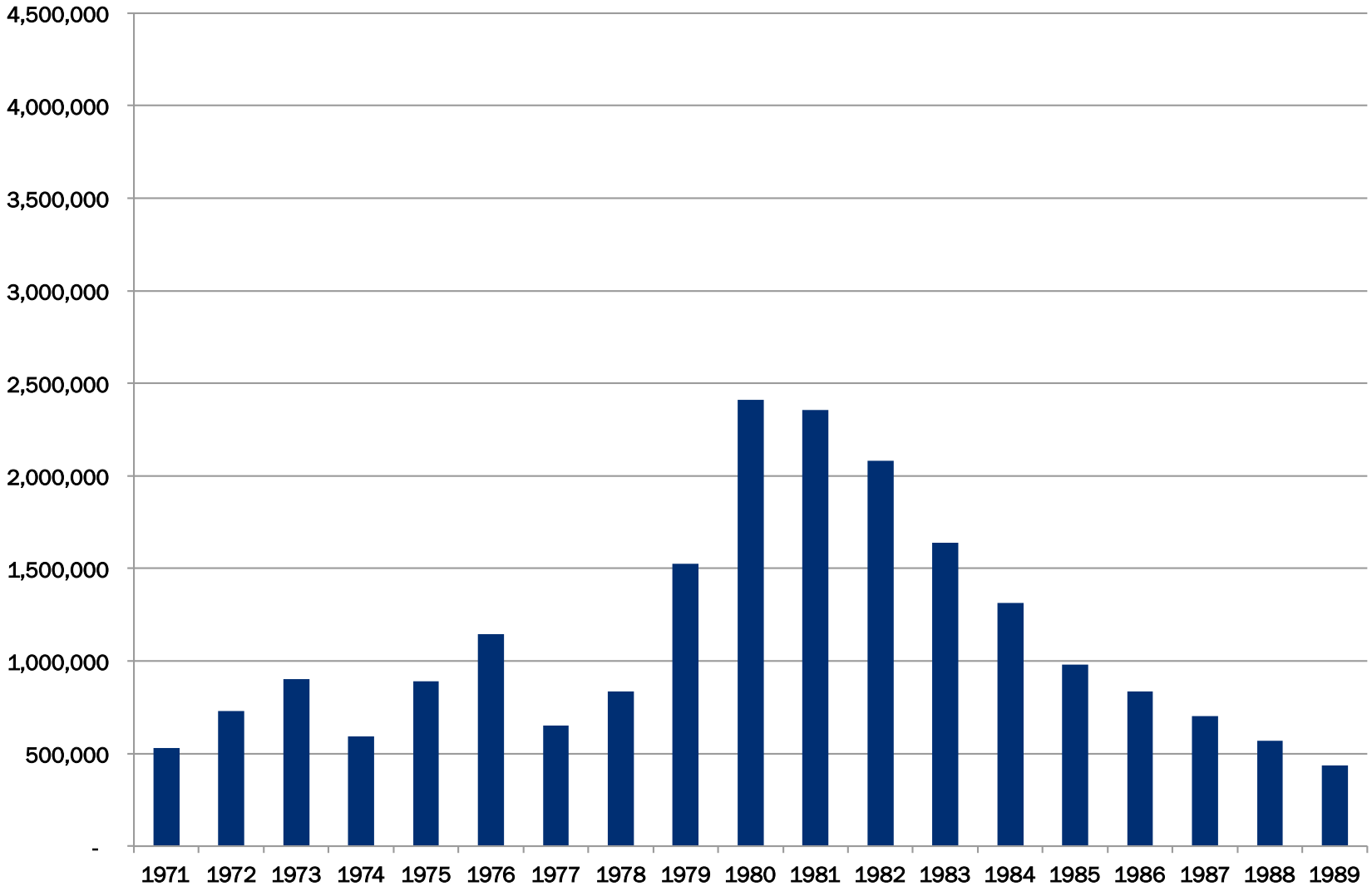

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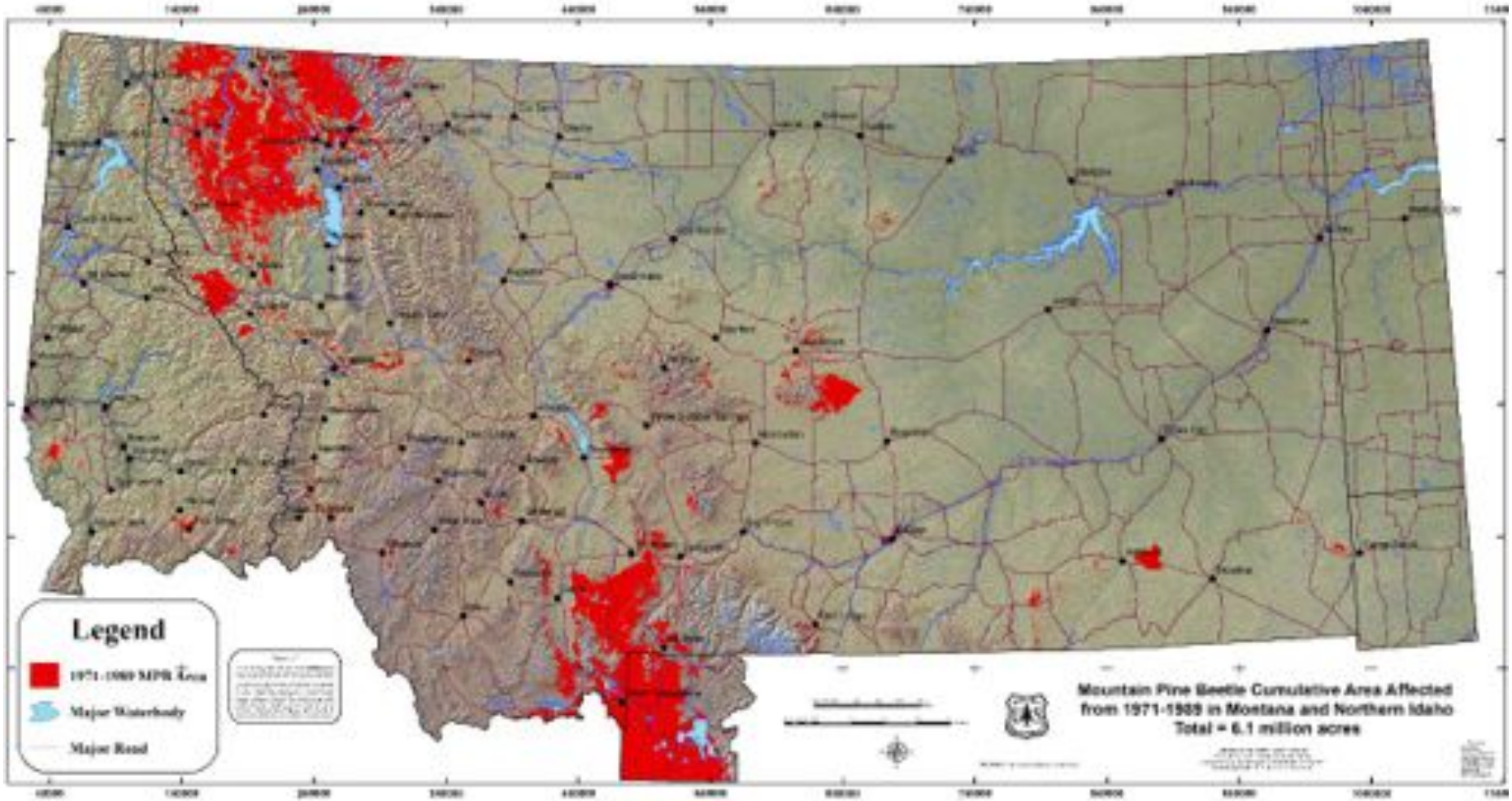
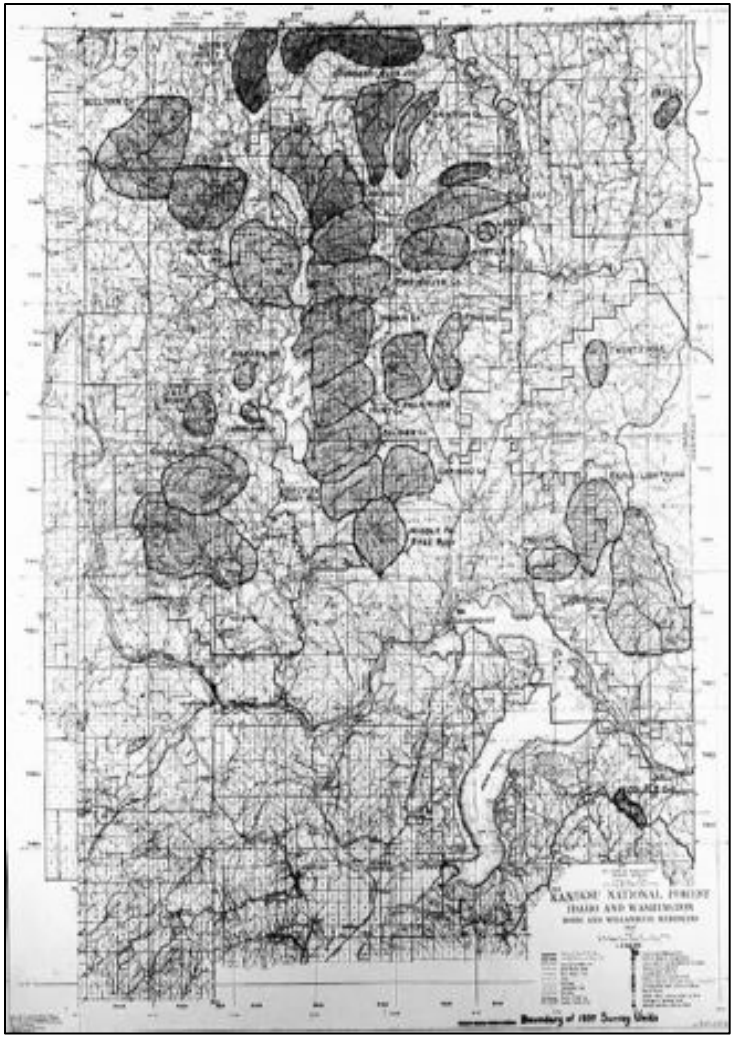


Severe and Widespread Mortality Event in MT and Northern ID Early 20th Century MPB Outbreak

- Outbreak reconstructed from early 20th century ground surveys
- Detailed reports of MPB :
  - 65 Bureau of Entomology and Plant Quarantine field reports
    - Direct control focused
  - Published scientific literature
  - > 1000 pages of text gone through
- Created database w/ 428 entries of outbreak information
- Converging lines of evidence used
  - Spatially rendered severe MPB area
  - Temporally reconstructed area impacted by decade
  - Species impacted



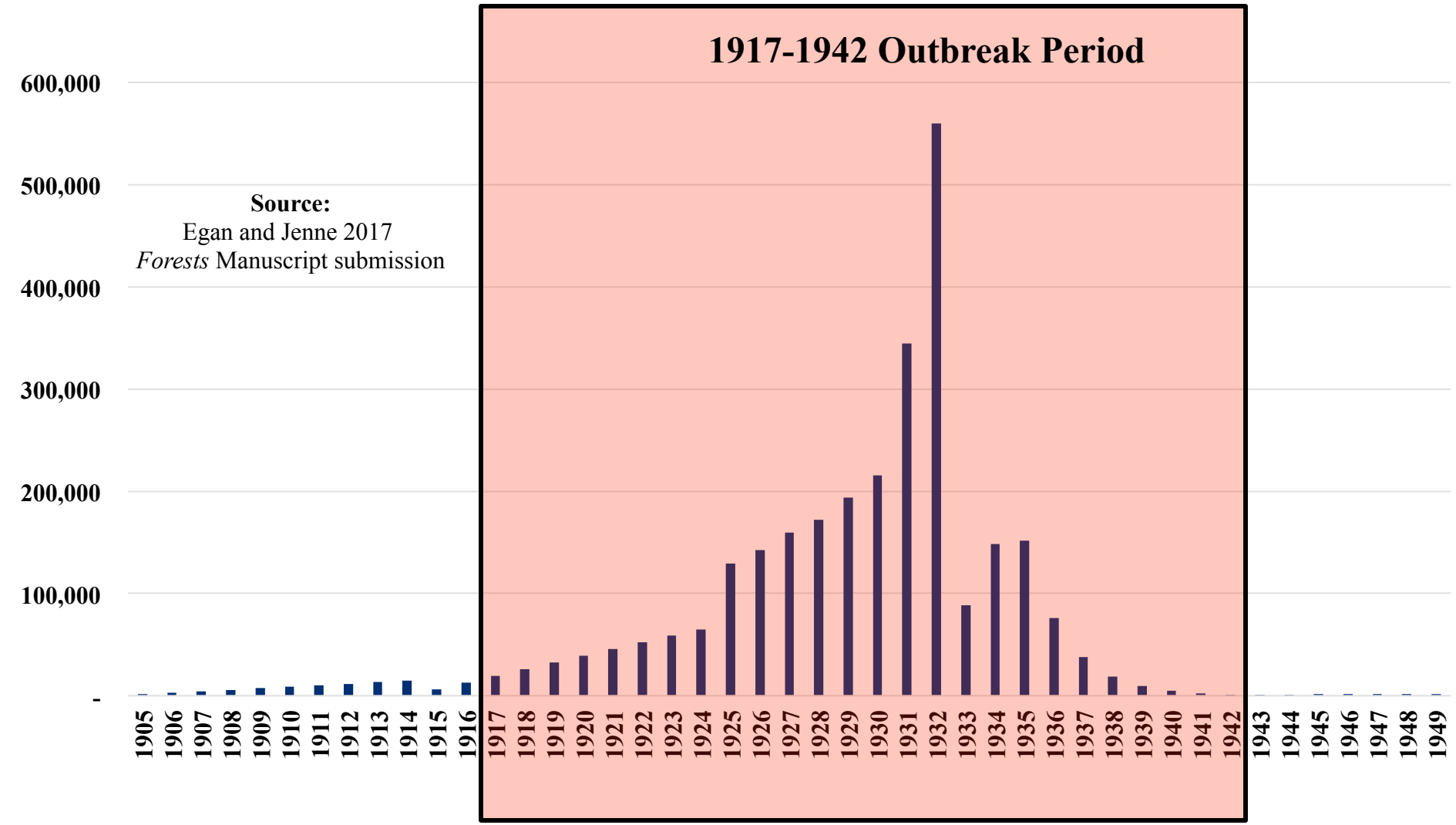
Terrell and Evenden 1938: Kaniksu National Forest

Severe and Widespread Mortality Event in MT and Northern ID Early 20th Century MPB Outbreak

Pic.1 Mountain pine beetle infestation in the lodgepole pine stands on the East Fork of the Bitterroot River. This area is just across the Continental Divide from the Big Hole Basin. The white trees are insect-killed, the foliage being red at the time the picture was taken. The remaining green trees are Douglas fir.

Pic.2 Mountain pine beetle infestation in the lodgepole pine stands on the East Fork of the Bitterroot River. This area is just across the Continental Divide from the Big Hole Basin. The white trees are insect-killed, the foliage being red at the time the picture was taken. Many trees can be seen from which the foliage has fallen. The red tops (white trees) represent the 1926 attack.

Cumulative Area Impacted by MPB across MT and Northern ID 1917-1942 MPB Outbreak



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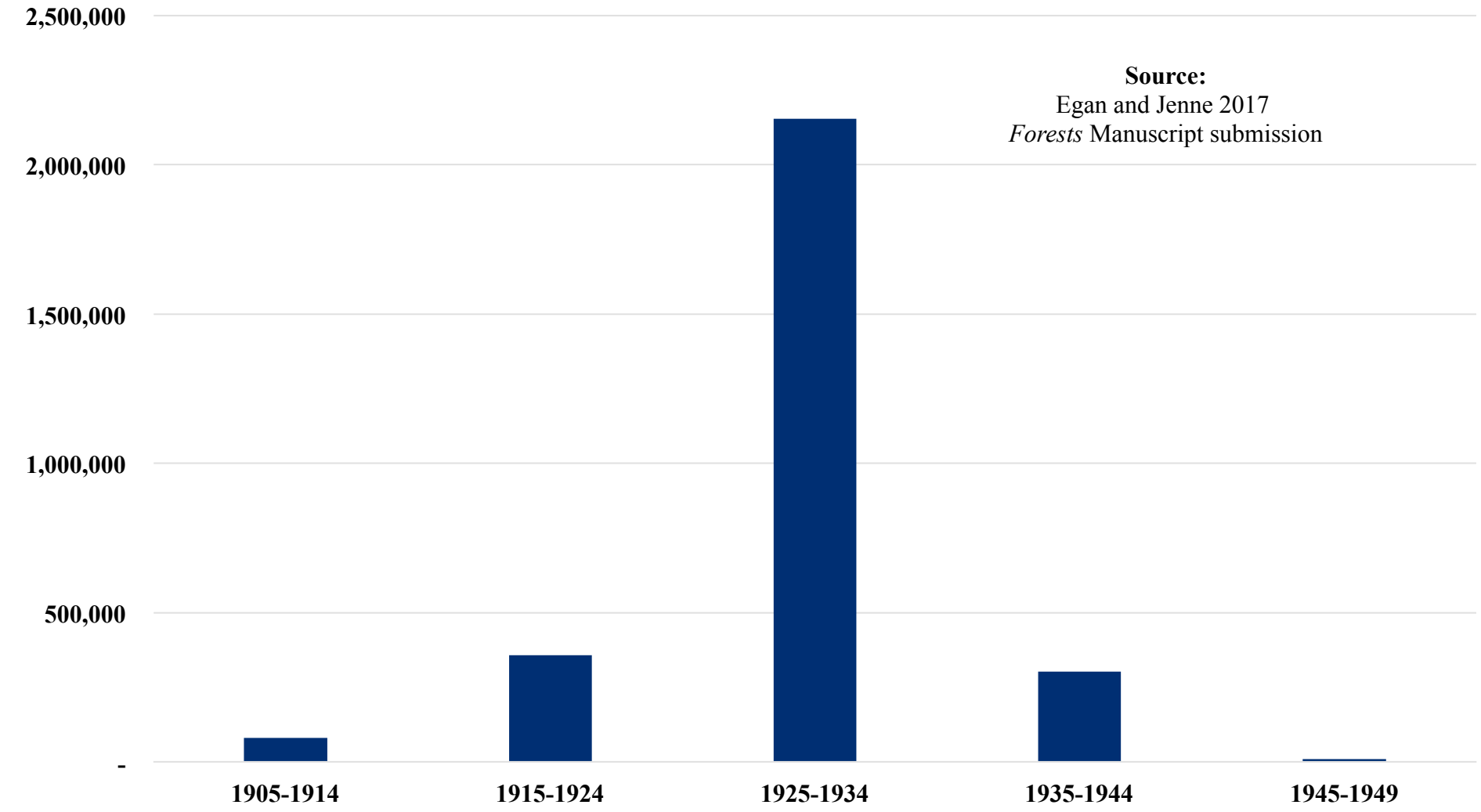
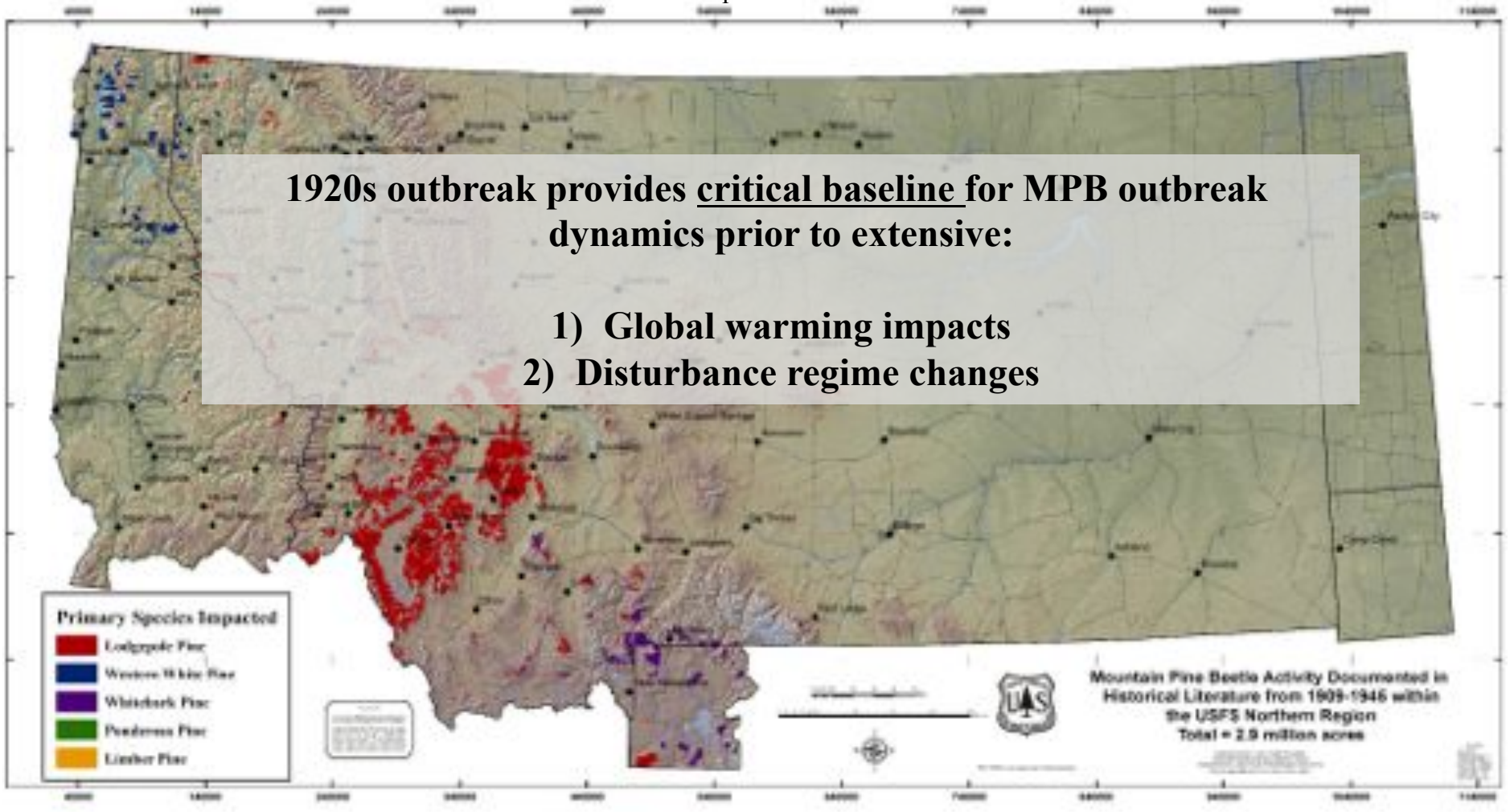


Cumulative Area Impacted by MPB across MT and Northern ID 1917-1942 MPB Outbreak

Source:
Egan and Jenne 2017
Forests Manuscript submission



1920s outbreak provides <u>critical baseline</u> for MPB outbreak dynamics prior to extensive:

1) **Global warming impacts**
2) **Disturbance regime changes**

Summary of MPB across MT and Northern ID 1917-1942, 1970-1988, 1998-2014 MPB Outbreaks

- Outbreaks occurred every 30-40 years during beneficial climate
- Temporal initiation: catalyst protracted drought and tree stress
- Temporal duration: 17-25 year outbreak events
- Spatial distribution throughout susceptible host
  - Outbreak progressive from numerous smaller, spatially segregated infestations
- Species impacted
  - Lodgepole pine host driving each outbreak event
  - 1920s and 2000s outbreak: whitebark pine heavily impacted
  - 1980s outbreak: whitebark pine less impacted

Why was 2000s Outbreak so Severe?

Susceptible Host

Beneficial Climate

2000s Host Susceptibility Driven by 20th Century Disturbances History

1. Forest disturbance from 1910-1930s

- Wildland fires of 1910, 1919, & others
- MPB outbreak 1917-1942
- Timber harvesting

2. Disturbance exclusion

- Wet years limited fire & MPB events 1940s-1960s
- Indirect fire exclusion grazing and fuel reduction
- Direct fire exclusion: fire suppression

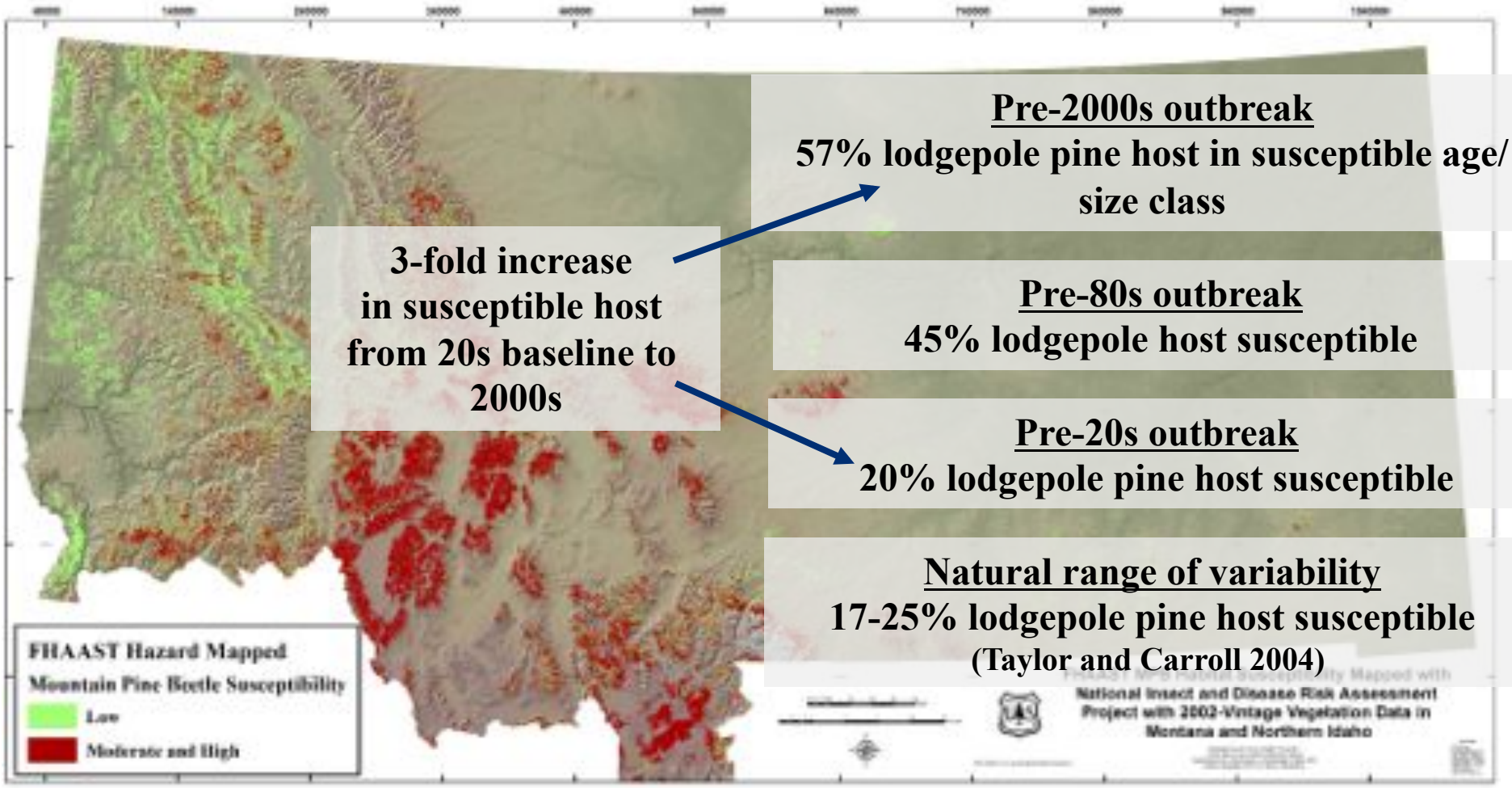
Video footage:
The Greatest Good
USFS Centennial video

2000s Host Susceptibility
Importance of Age-Class Lodgepole Pine Distributions

Photo by Ron Billings

2000s Host Susceptibility
National Insect and Disease Forest Risk Assessment (2002-vintage)

Sources:
Krist et al. 2014 and Losensky 1993



3-fold increase in susceptible host from 20s baseline to 2000s

Pre-2000s outbreak
57% lodgepole pine host in susceptible age/ size class

Pre-80s outbreak
45% lodgepole host susceptible

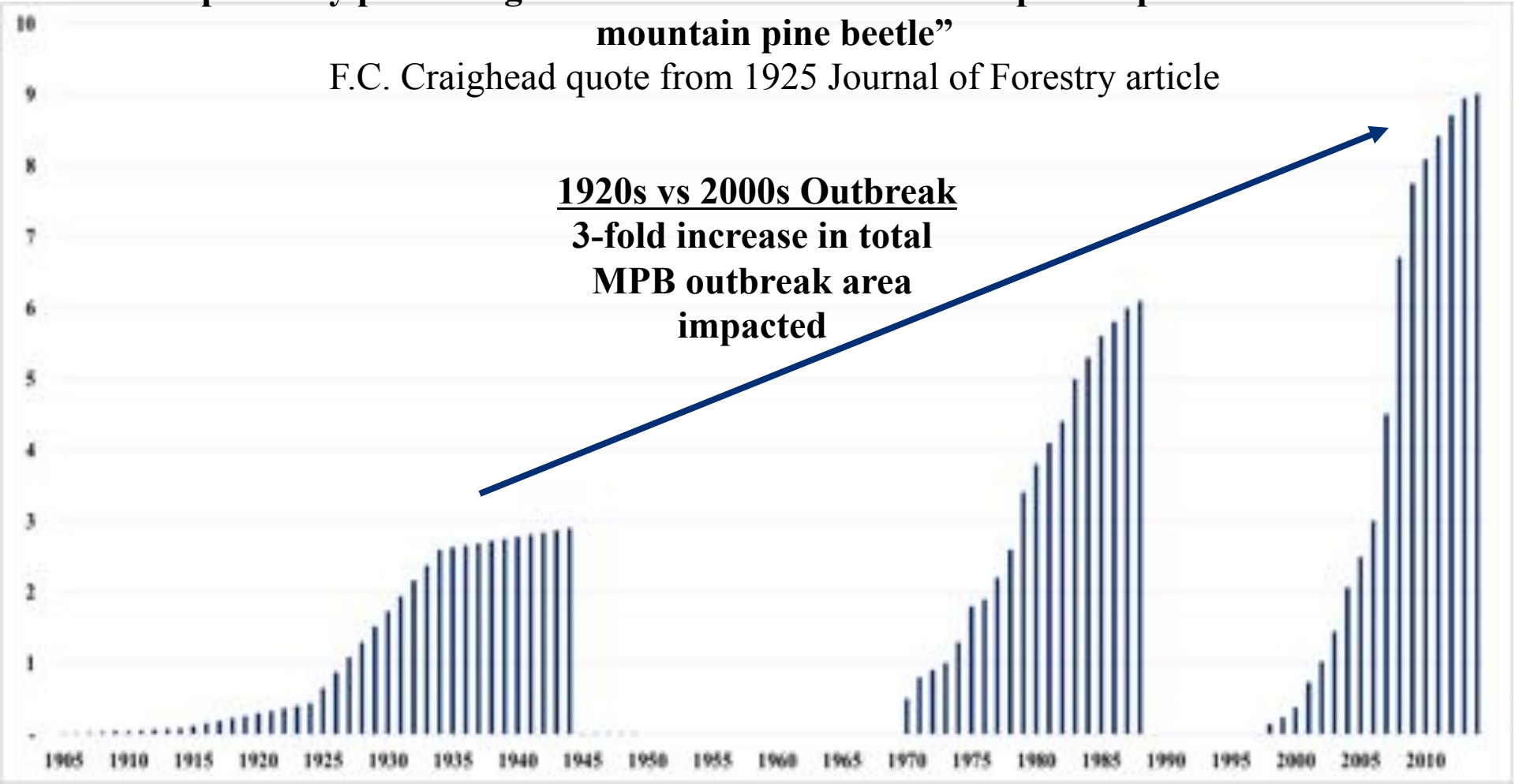
Pre-20s outbreak
20% lodgepole pine host susceptible

Natural range of variability
17-25% lodgepole pine host susceptible
(Taylor and Carroll 2004)

Cumulative Area Impacted by MPB across MT and Northern ID 1917-1942, 1970-1988, 1998-2014 MPB Outbreaks

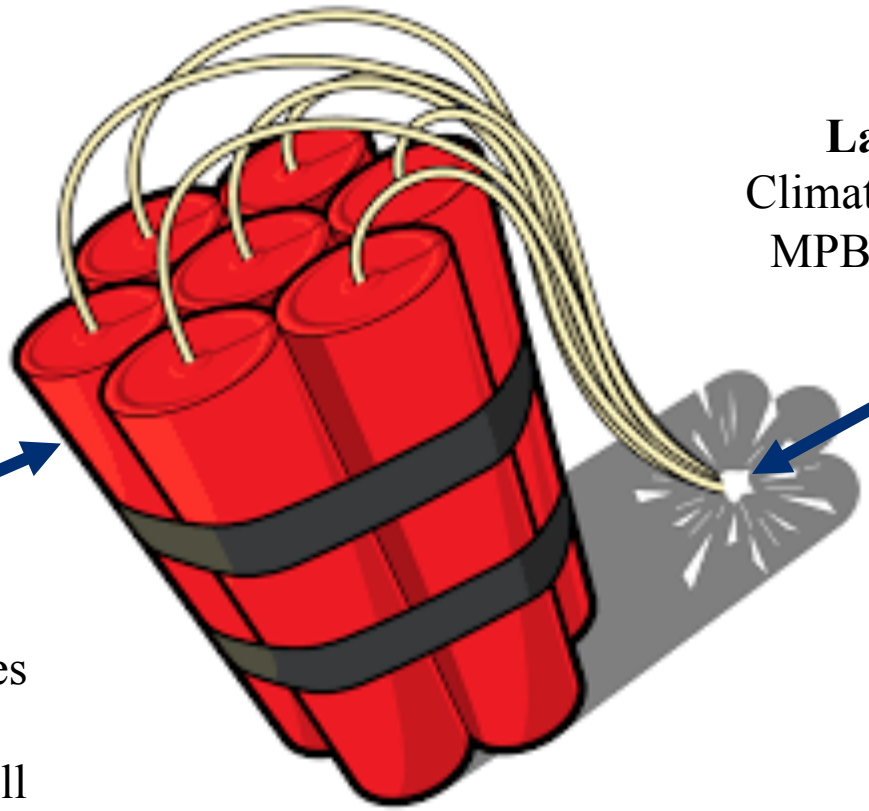
"The intensive fire protection of overmature lodgepole pine stands is not improbably producing a condition favorable to widespread epidemics of the mountain pine beetle"

F.C. Craighead quote from 1925 Journal of Forestry article



Landscape-Scale Outbreak Dynamics: Host vs Climate

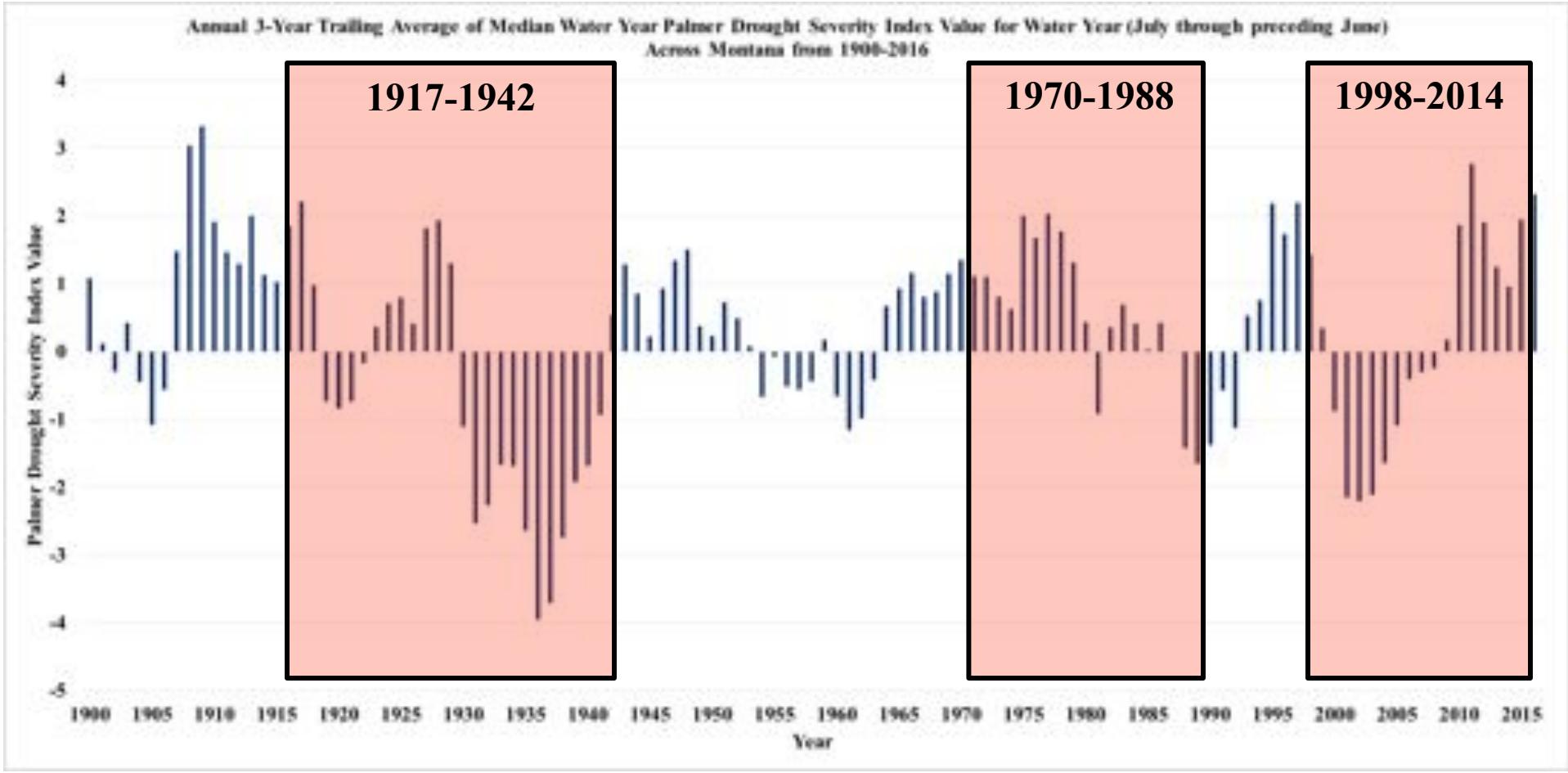
- Climate (protracted drought + warmer temperature trends) synchronize initiation of outbreak event
- Complicating matters: fine-scale impacts MPB/host & interactions



Landscape-scale:
Climate determines '**when**' MPB outbreak will occur

Landscape-scale:
Susceptible host determines '**how extensive**' and '**severe**' MPB outbreak will

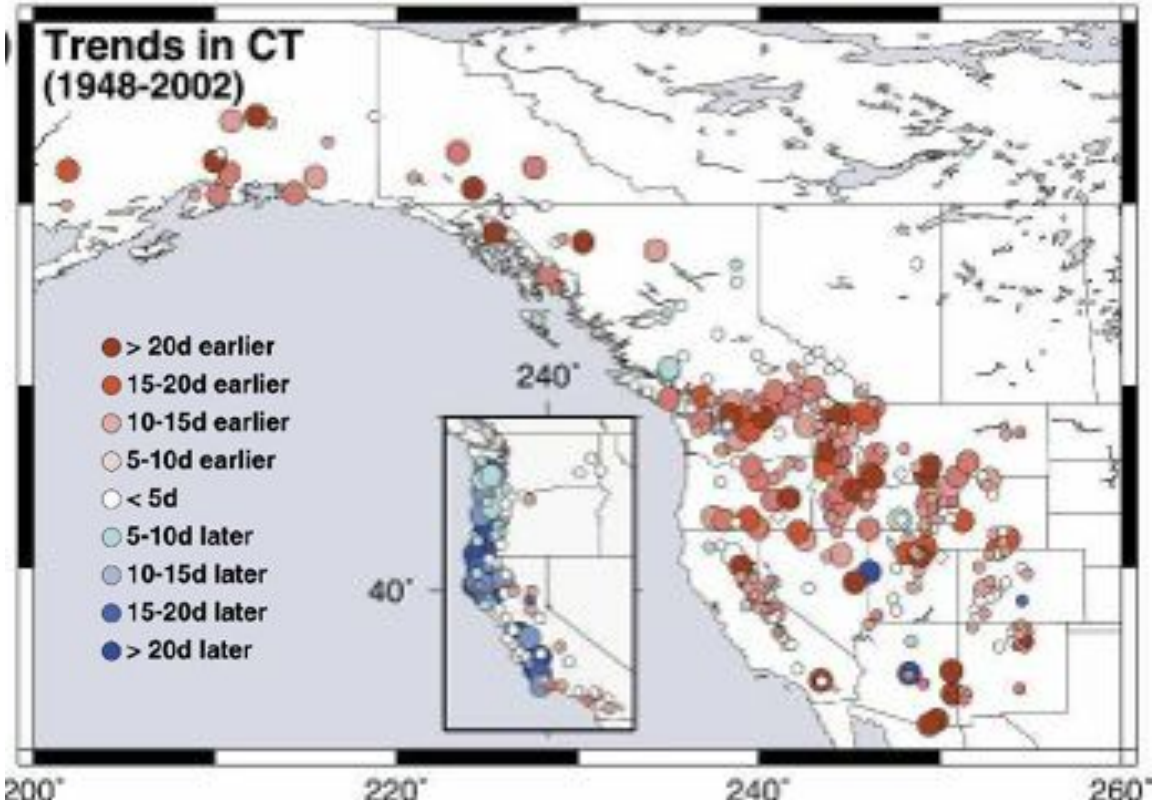
Interactions:
Broad Landscape-Scale: Montana PDSI



Interactions: Broad Landscape-Scale: NW MT 80s Outbreak

- Snow packs melting 1 - 4 weeks earlier
- Longer active growing season for trees
- Earlier flush of available water w/ less during peak beetle flight times

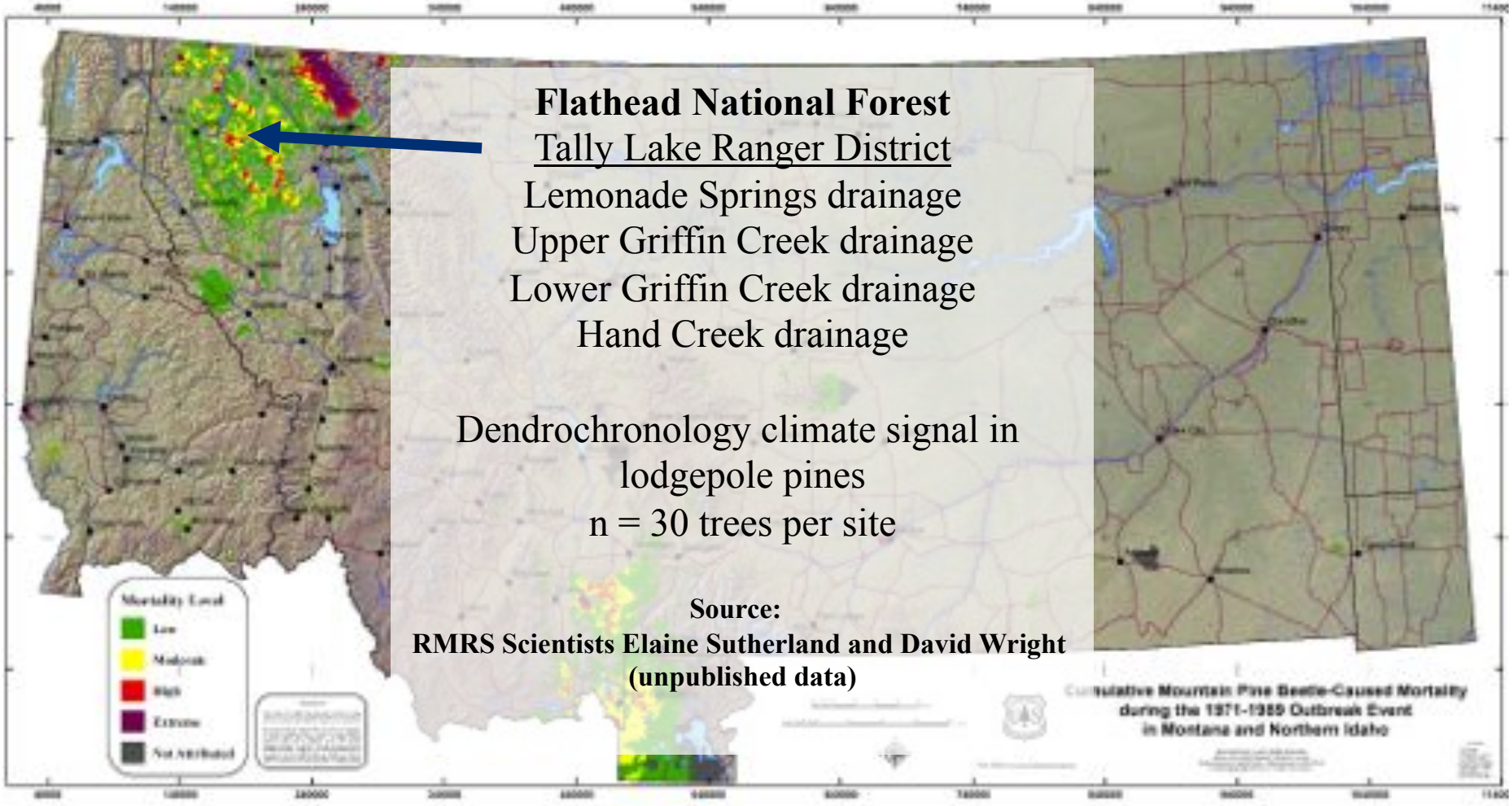
Map of center of mass annual flow (CT) trend from 1948-2002



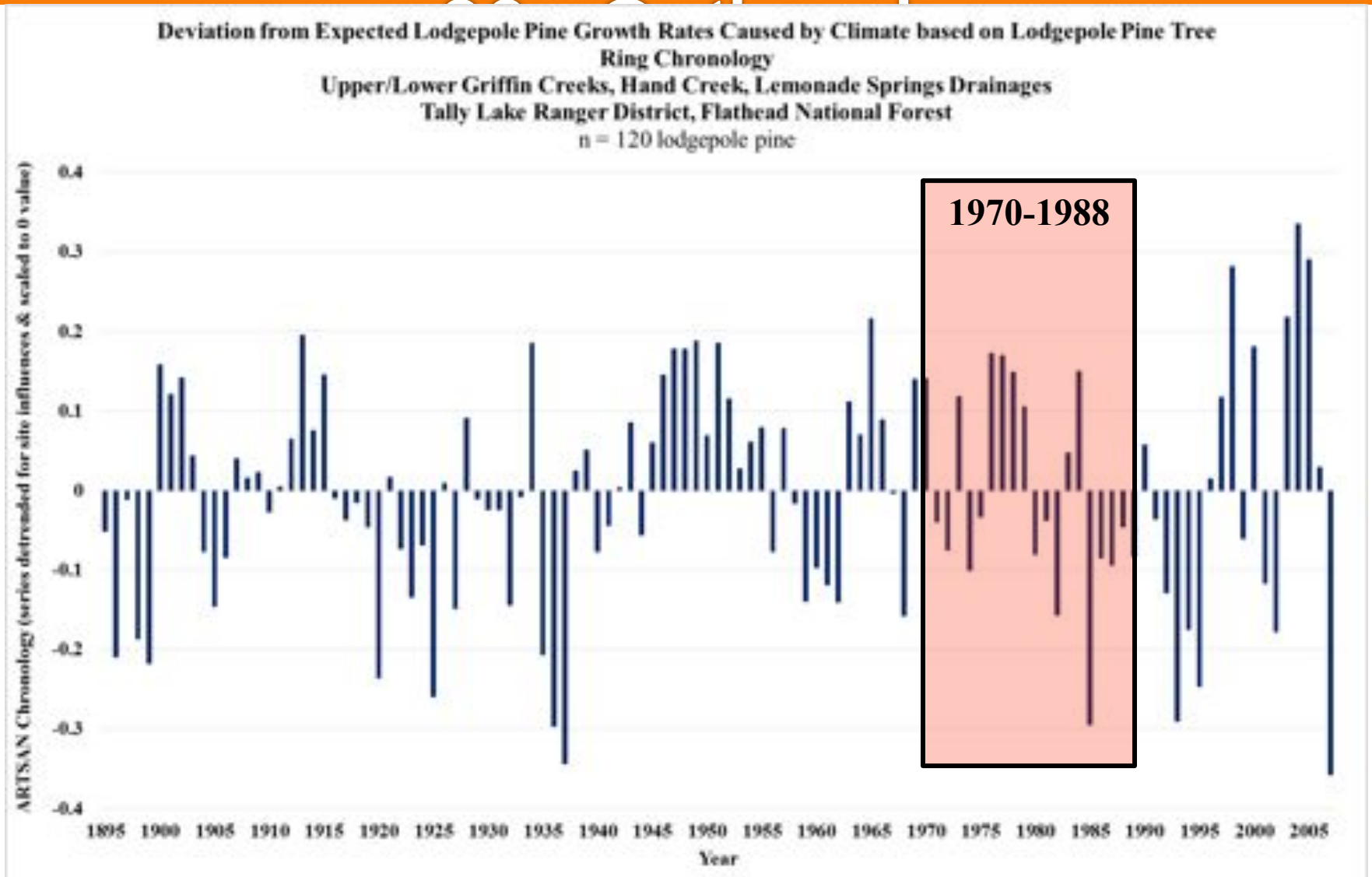
Source:

Stewart, I. T., D. R. Cayan, and M. D. Dettinger, 2005: Changes toward earlier streamflow timing across western North America. *J. Climate*, 18, 1136-1155

Interactions:
Broad Landscape-Scale: NW MT



Interactions:
Broad Landscape-Scale: NW MT



Drought Stress and Outbreaks Fine-Scale: Bark Beetle * Host Tree Interactions

- Oleoresin
  - Floods beetle galleries
- Drought-stressed trees unable to produce enough resin
  - Water deficit → less resin for defense
  - Targeted for attack
- Relatively weaker/ stronger hosts

Video Captured by Brytten Steed

Outbreaks
Fine-Scale: MPB * Host Tree Interactions

90% mortality rate
in lodgepole pine near
100 Mile House,
Cariboo-Chilcotin area,
Frasier Basin, British
Columbia, Canada

45% mortality rate
in Jeffrey pine near
Lake Tahoe, Nevada

Egan et al. 2016

Ecosystem Impacts from severe and widespread MPB-caused tree mortality events

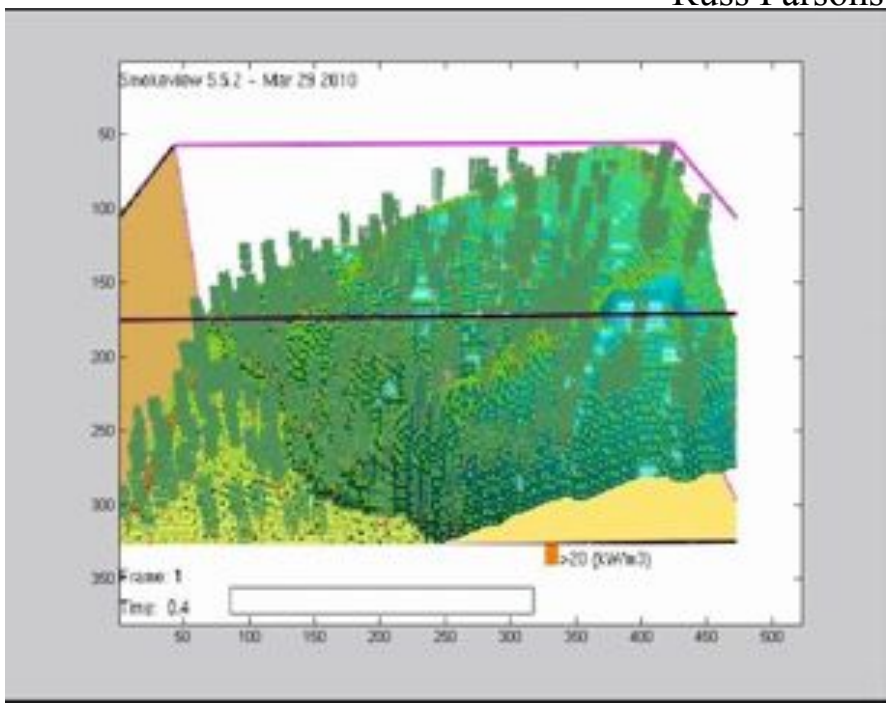
Ecosystem Impacts from Drought-Related Bark Beetle Eruptions and Widespread Tree Mortality

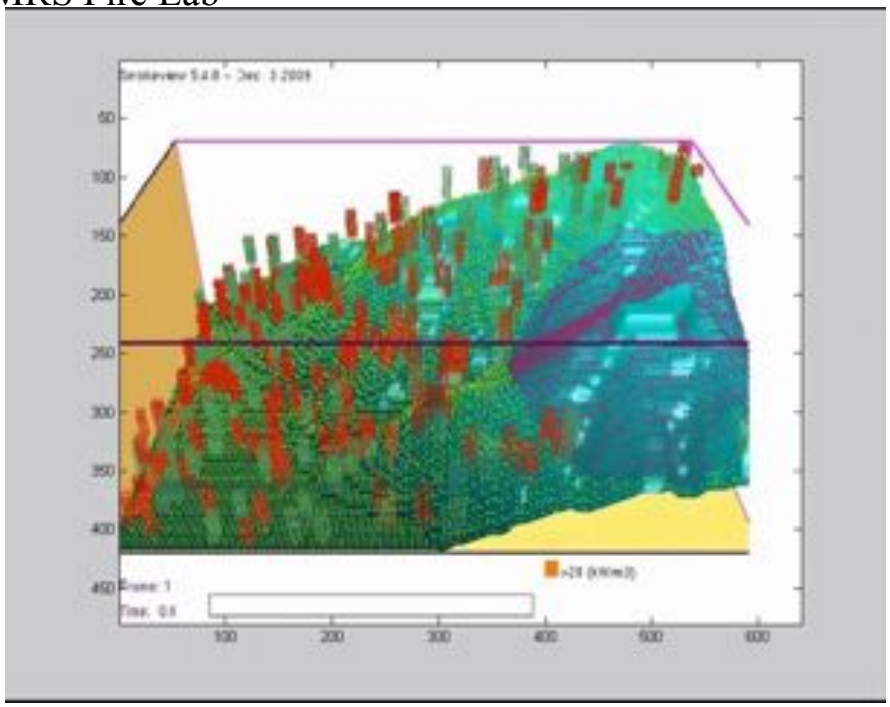
Boom and bust cycles of substantial tree mortality

- **Carbon fluctuations:** 15% carbon stocks of high-elevation forests across western North America released by beetles. 5-10% in low/mid elevation forests (Hicke et al. 2013)
- **Hydrology**: loss of tree cover and related evapotranspiration provided can alter peak flow rates and timing, reduce snowpack retention, and reduce water filtering/quality where erosion or toxins are issues.
- **Wildlife**: winners and losers. Impacts to elk overwintering range, jack-strawed mortality can impede wildlife migration and hunter movements, lynx habitat sustainability, black-backed woodpecker habitat temporary increases
- **Wildfire**: red-stage changes in fire behavior followed by muted impacts, new cohort in low/mod mortality stands can change fire behavior. Fire severity may or may not be impacted.

Bark Beetles & Wildfire Behavior: Physics-based Wildfire Simulation in Red-Stage

Source:
Russ Parsons RMRS Fire Lab





Scenario A:

- Live lodgepole pines
- No defensible space
- Dense forest & moderate fire weather

Scenario B:

- 60% red-stage dead lodgepole pines
- Defensible space
- Dense forest & moderate fire weather

Modern Management

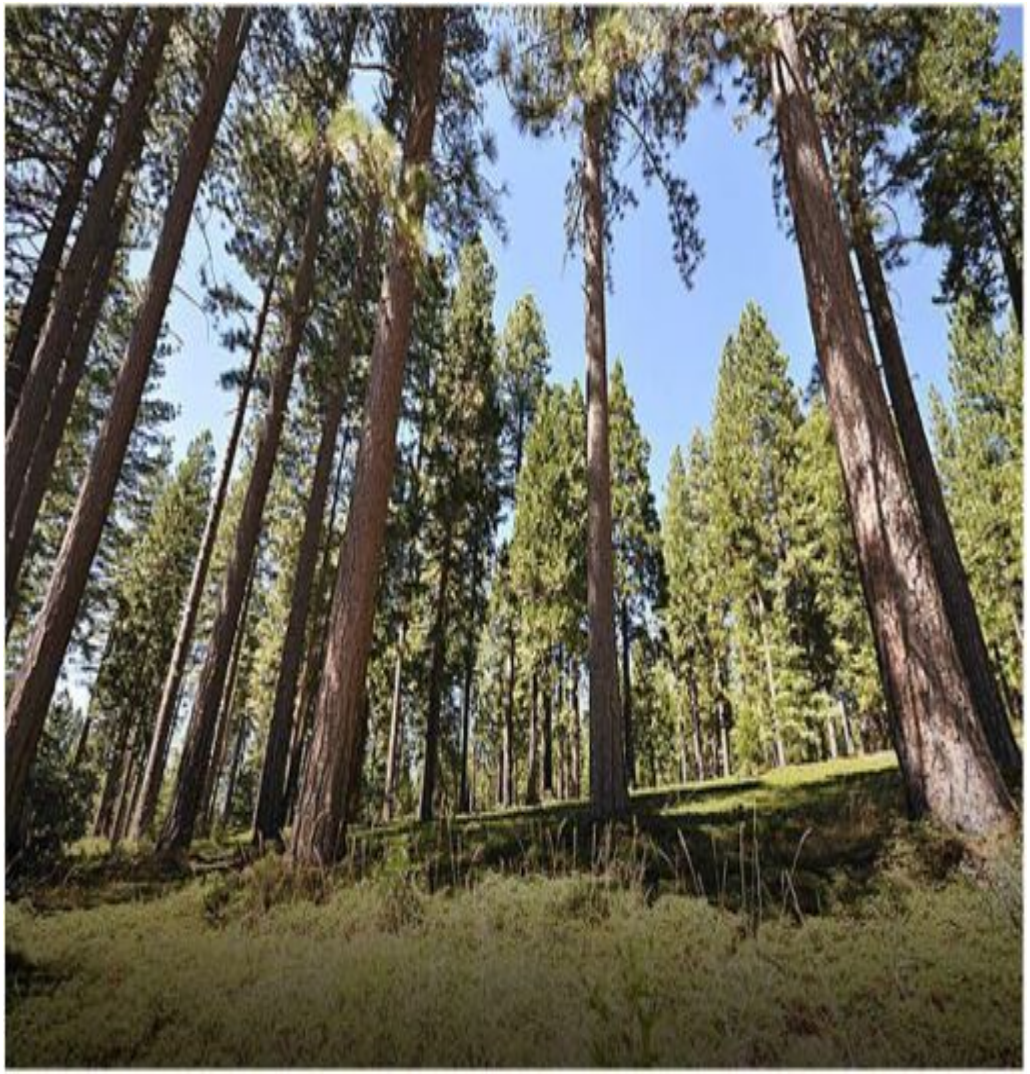
- Why is the host vs climate story important

- Implicate climate solely = **depressing**
  - Severe MPB events outside our direct sphere of influence

- Implicate host structure = **opportunity**
  - Within our sphere of influence

Thinning to Reduce Stand-Level Susceptibility

- **Thinning:** promote spacing between trees
  - Increases tree health
  - Microclimate created is less suitable for beetles
- Lodgepole forest type: potential windthrow and , snow breakage issues



Example: Thinned vs. Non-Thinned Stands

Flathead National Forest

Photo by Keith Konen

Promote Heterogeneous Forest Conditions
Landscape-Scale Prevention

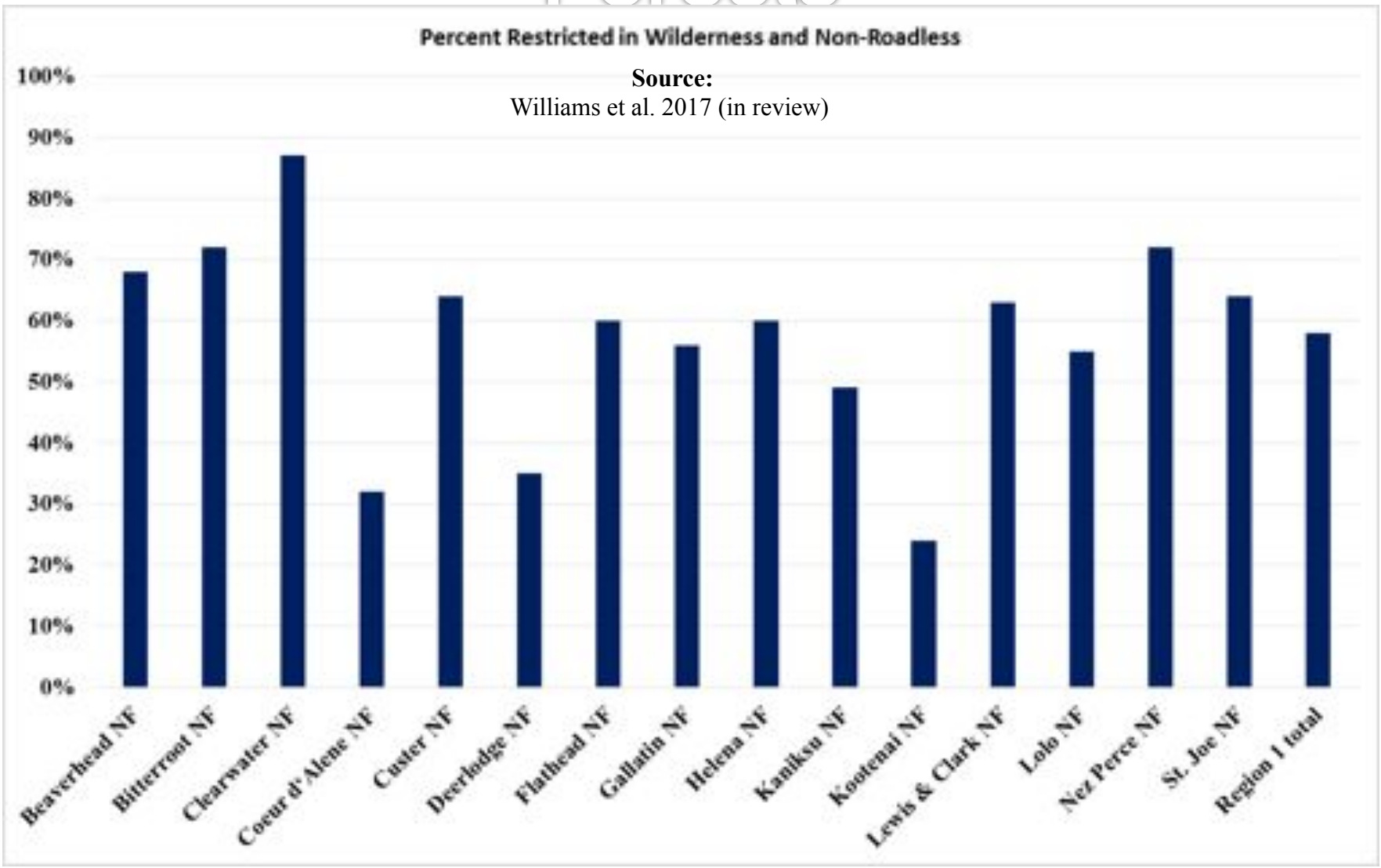
- Promote mosaics of size/age diversity at the stand and landscape-levels
- Vertical diversity in age/diameter classes
- Regeneration-based silviculture
  - Patch cuts, group selection, etc. to promote new cohort
  - Controversial on public lands
- 'Fire-use-fire' or 'let-burn' policy

Photo from: Fraser Basin Council
http://www.shim.bc.ca/atlases/fbc/ss3/Forest.html

MPB Resistance: Regeneration Harvests to Increase Age Diversity

Photo by Brian Howell

Lodgepole Pine Forest Harvest Restrictions in Region 1 National Forests



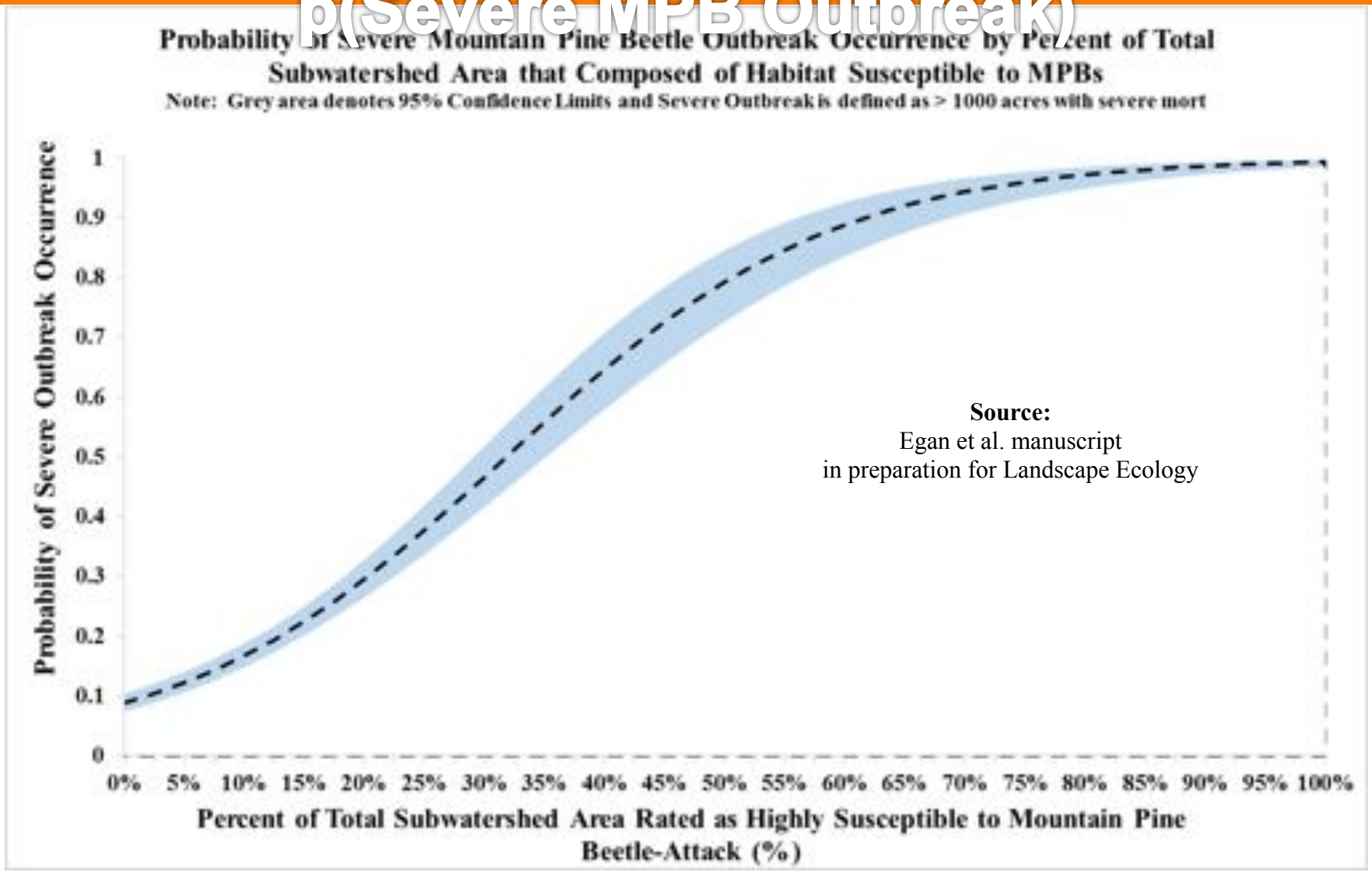
Source:
Williams et al. 2017 (in review)

Forest Resilience: Wildland Fire Let-Burn Policies to Increase Age Diversity

Photo by Ron Billings

Subwatershed Resistance to Severe MPB-attack

% Susceptible Host in Subwatershed & p(Severe MPB Outbreak)



Thanks for your time! Any Questions?