Forest Mortality & Regeneration: Life after Death

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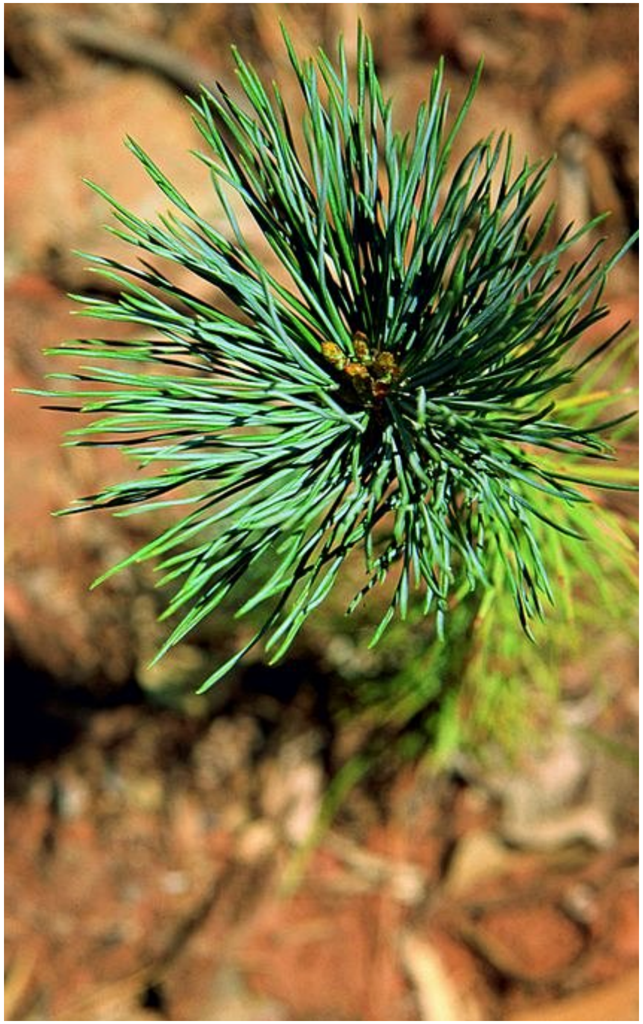
Outline

- Forest dynamics
  - – Terms and Definitions
- Ecosystem disturbances
- Post-disturbance regeneration
- Tree mortality in CA
- Silvics of pine
- Research in Sierra Nevada
- Take home messages



Forest Dynamics

The term **forest dynamics** describes the underlying physical and biological forces that shape and change a forest ecosystem

Forests are continuously changing and can be summarized with two basic elements:

- –Disturbance
- –Succession

Forest Dynamics

Definitions

Disturbance…

"Any relatively discrete event in time that disrupts ecosystems, community, or population structure and changes resources, substrate availability, or the physical environment."

White and Pickett 1985

Definitions

Succession…

The process by which the structure of a biological community evolves over time. Two types:

- Primary succession occurs in essentially lifeless areas, regions in which the soil is incapable of sustaining life (e.g., lava flows, newly formed sand dunes)
- **Secondary** succession occurs in areas where a community that previously existed has been removed through smaller-scale disturbances that do not eliminate all life and nutrients from the environment

https://www.britannica.com/science/ecological-succession

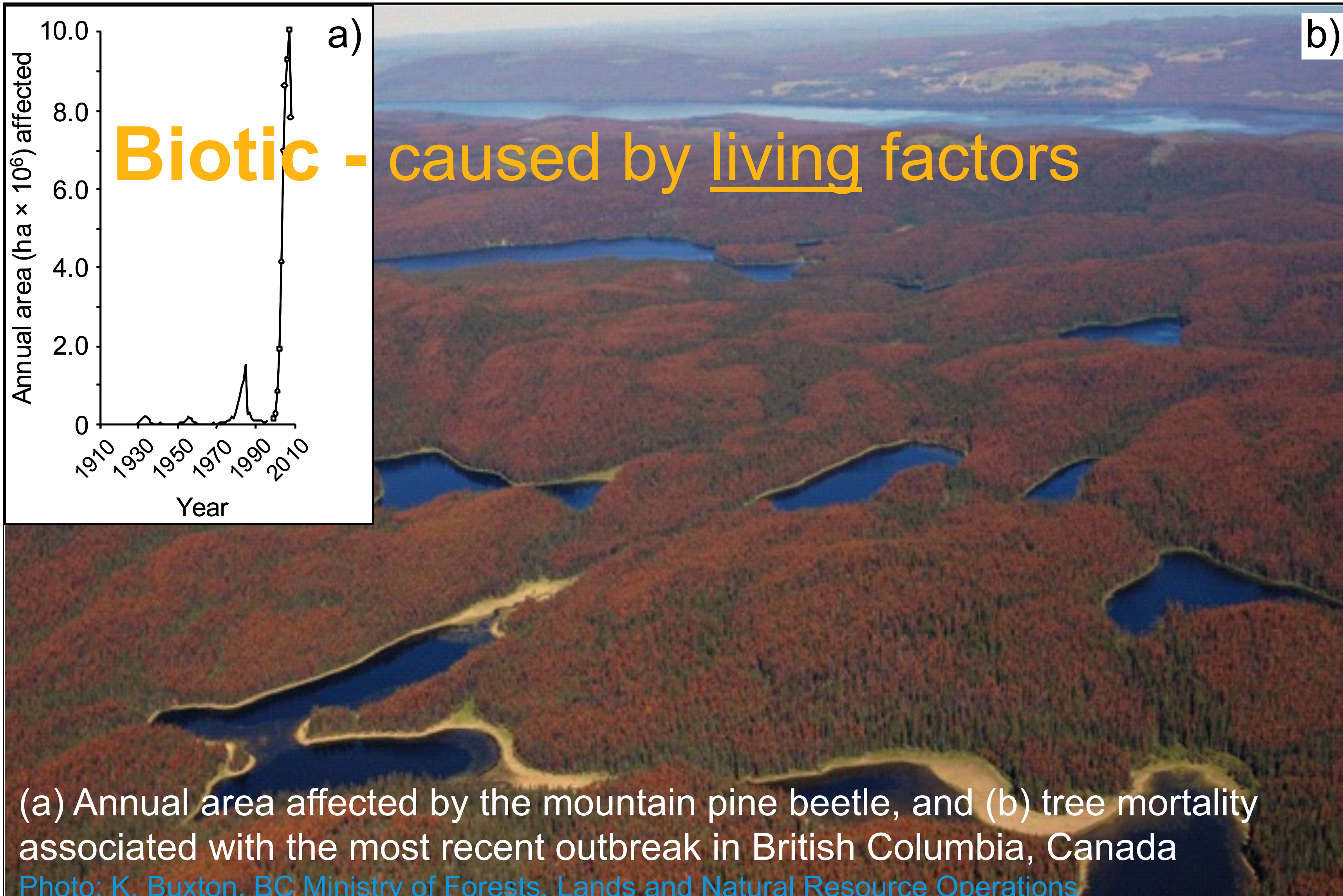
Types of Disturbance

Key attributes of disturbances include:

- Type – what happened?
- Severity - how bad was it?
- Spatial and temporal characteristics
  - stand level vs landscape level
  - short-time frame vs long-time frame
- Disturbance **interactions**

Disturbance Types

Disturbance Types



Biotic - caused by living factors

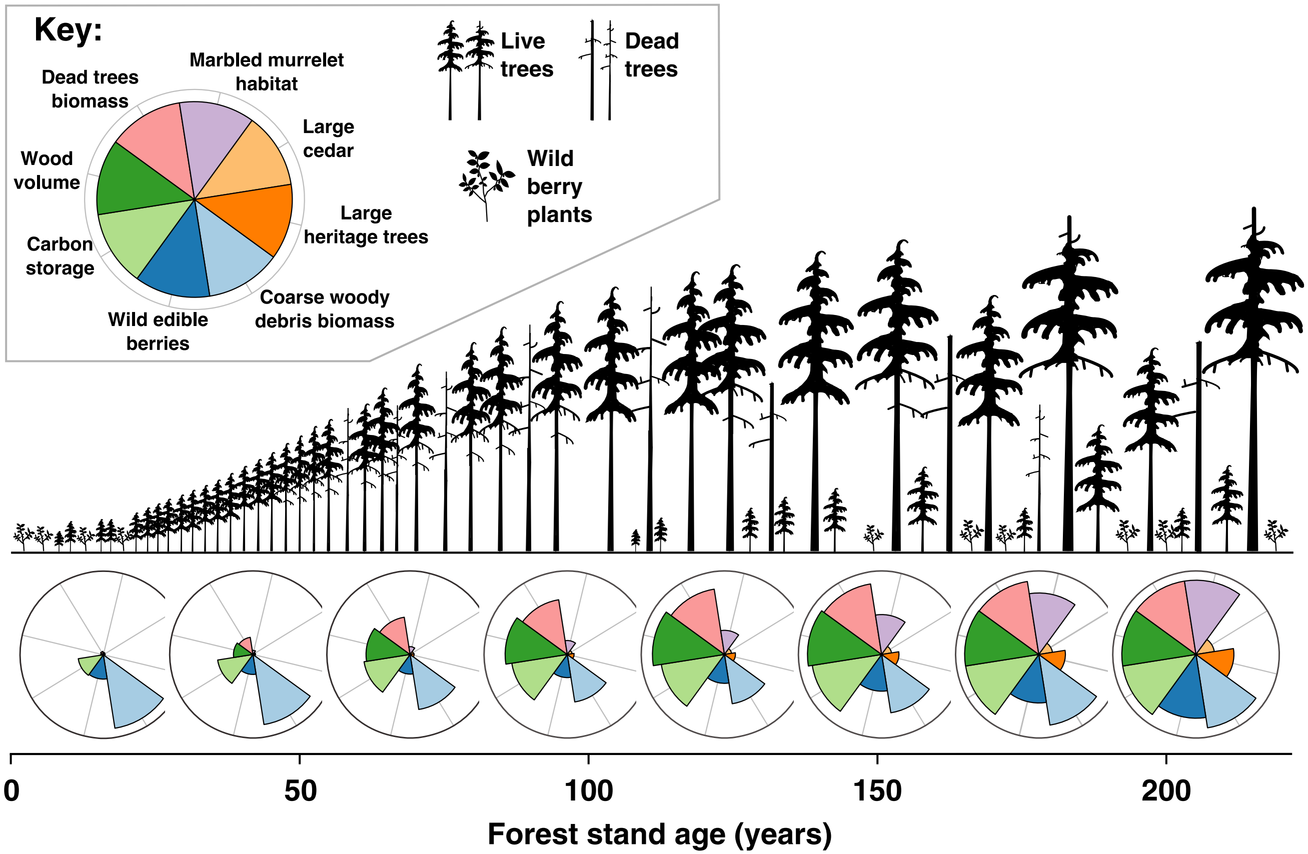
(a) Annual area affected by the mountain pine beetle, and (b) tree mortality associated with the most recent outbreak in British Columbia, Canada

Photo: K. Buxton, BC Ministry of Forests, Lands and Natural Resource Operations

Disturbance Types

Forest Succession

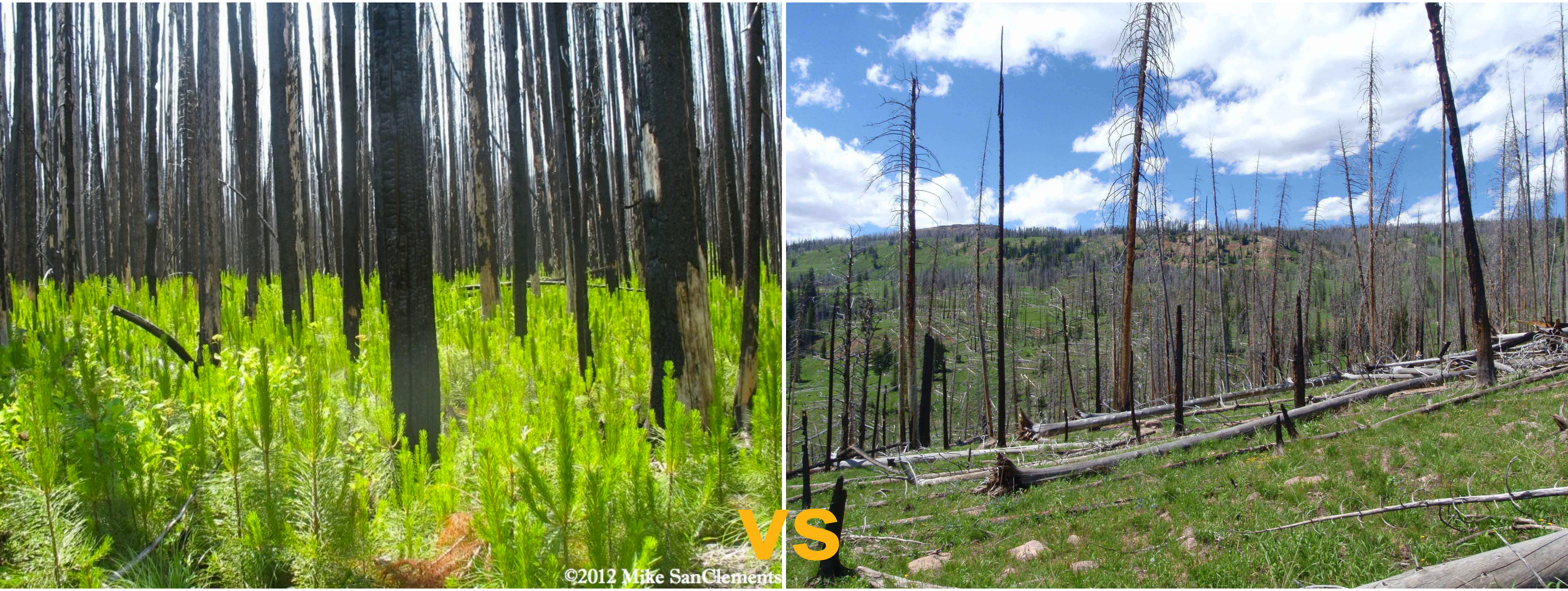
Succession normally thought of as an orderly **predictable** pattern



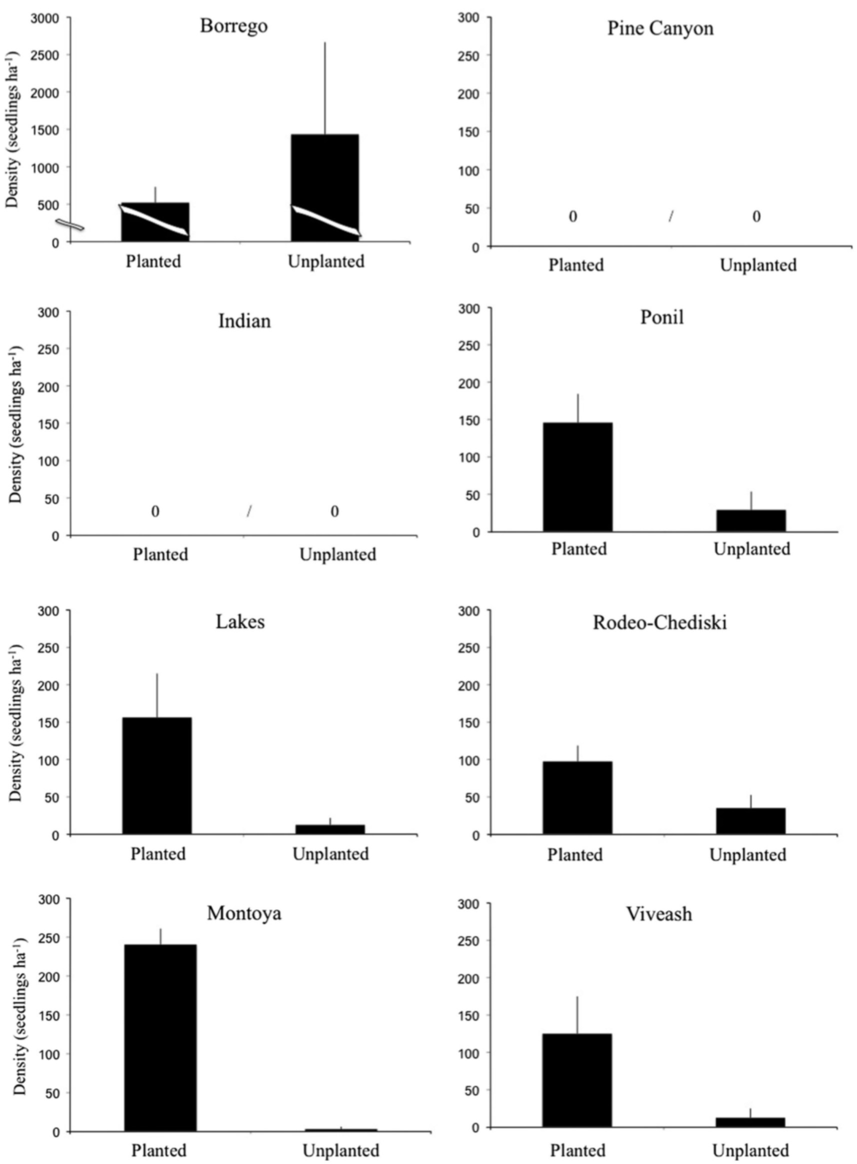
Sutherland et al. 2016

Succession Post Fire

In reality succession is often highly **variable** and dependent on, for example, disturbance type, severity and timing

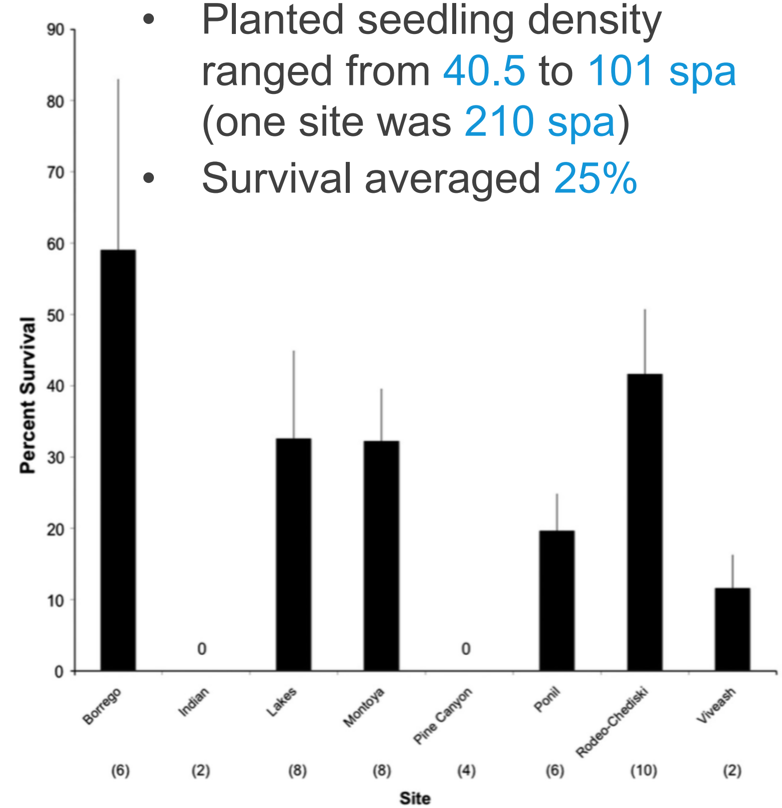


Succession Post Fire



Ponderosa pine regeneration in **Arizona** and **New Mexico**:

- Natural regeneration produced less than 13 spa (one site was 580 spa)
- Planted seedling density ranged from 40.5 to 101 spa (one site was 210 spa)
- Survival averaged 25%



Ouzts et al. 2015

Bark Beetle Outbreaks

Not all trees are killed in a bark beetle outbreak – **why?**

- Host specific:
  - Western pine beetle - ponderosa pine & coulter pine
  - Mountain pine beetle - many pine species including sugar pine
  - Jeffery pine beetle - Jeffery pine
- Size specific: prefer larger trees – trees smaller than 6 inches in diameter rarely attacked

➢ Can be though of as a natural **thinning** agent

Feedbacks and Interactions

Direct:

- Temperature - all aspects of bark beetle biology, e.g., overwinter survival, initiation of flight, flight duration, number of generations/season

Indirect:

- Drought - impairs tree resistance to attack, e.g. pitch-outs
- Stand structure – density leads to greater moisture stress, e.g., carrying capacity

Western Pine Beetle

- Start flying in early spring (~ 60°F) and continue until stopped by cold weather (less than 50°F)
- Parent females produce 1 to 3 broods a year = overlapping generations

Adult beetle: length 0.12 - 0.20 inches & dark brown

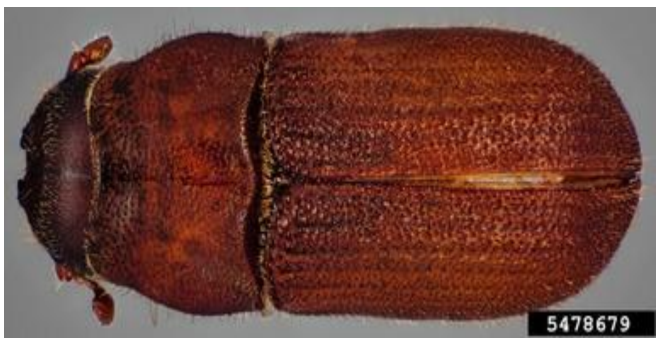


Photo Credit: Steven Valley, Oregon Dept. of Agriculture, Bugwood.org

Larval galleries

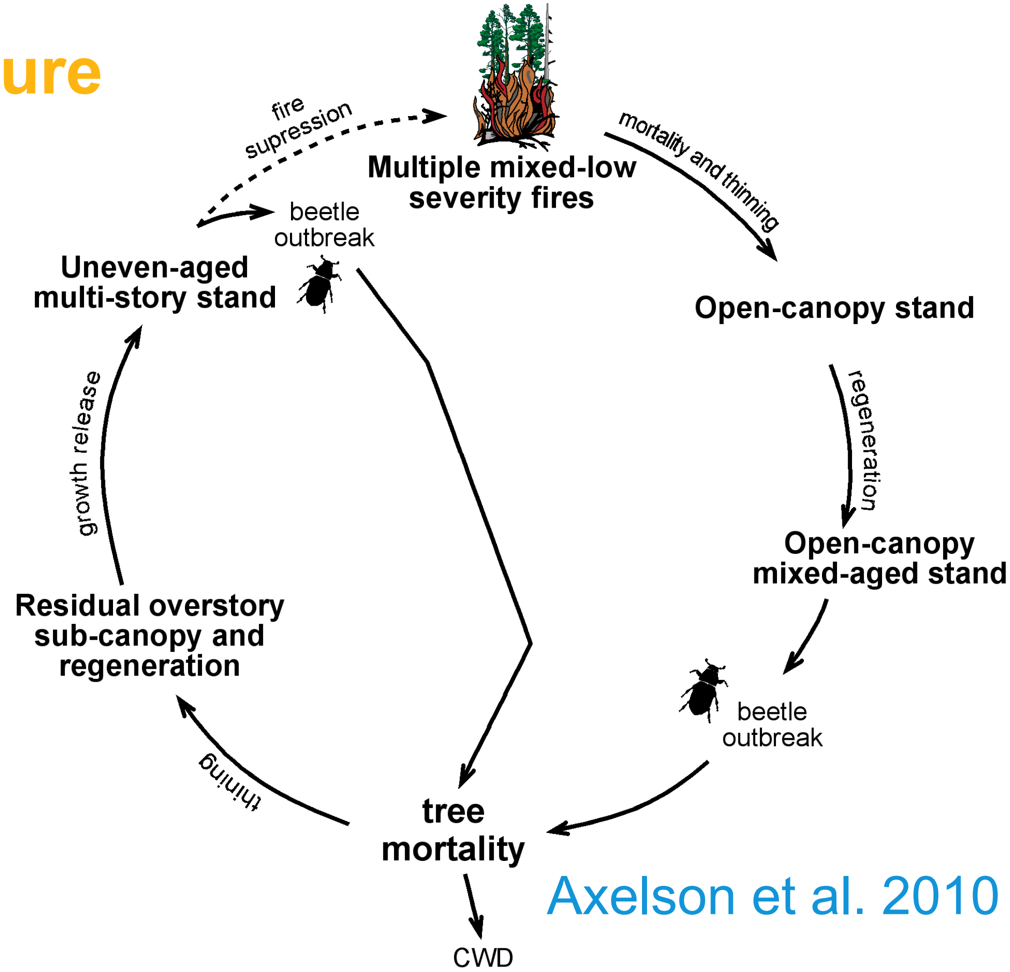
Photo Credit: David McComb, USDA Forest Service, Bugwood.org

Succession Post Bark Beetle

In central British Columbia **shift** in disturbance regime from fire to bark beetle outbreaks

Outbreaks shifted **structure** but not species

- Regeneration = lodgepole pine



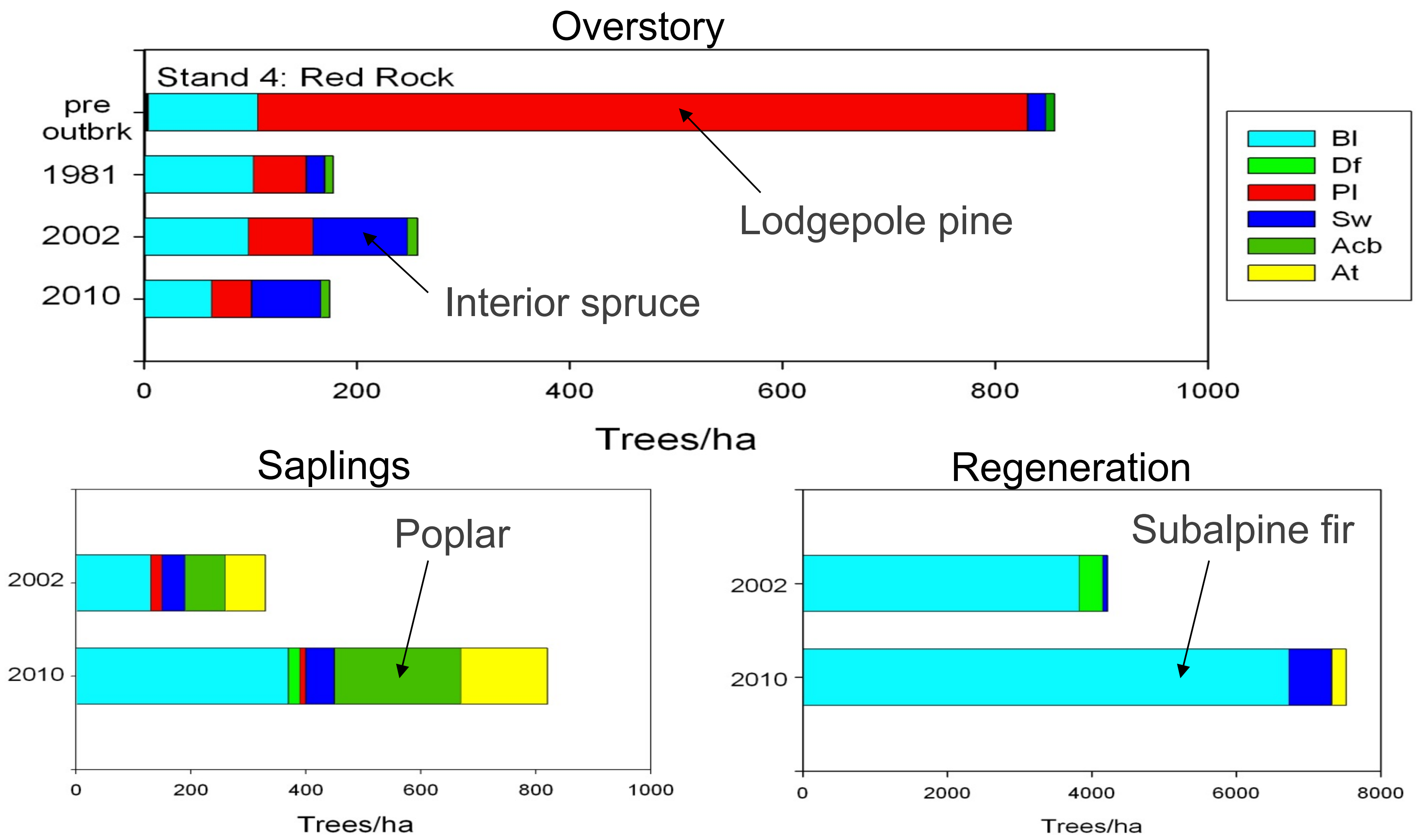
Axelson et al. 2010

Succession Post Bark Beetle

In the Rocky Mountains of Alberta long-term plots illustrated a **shift** in age and species

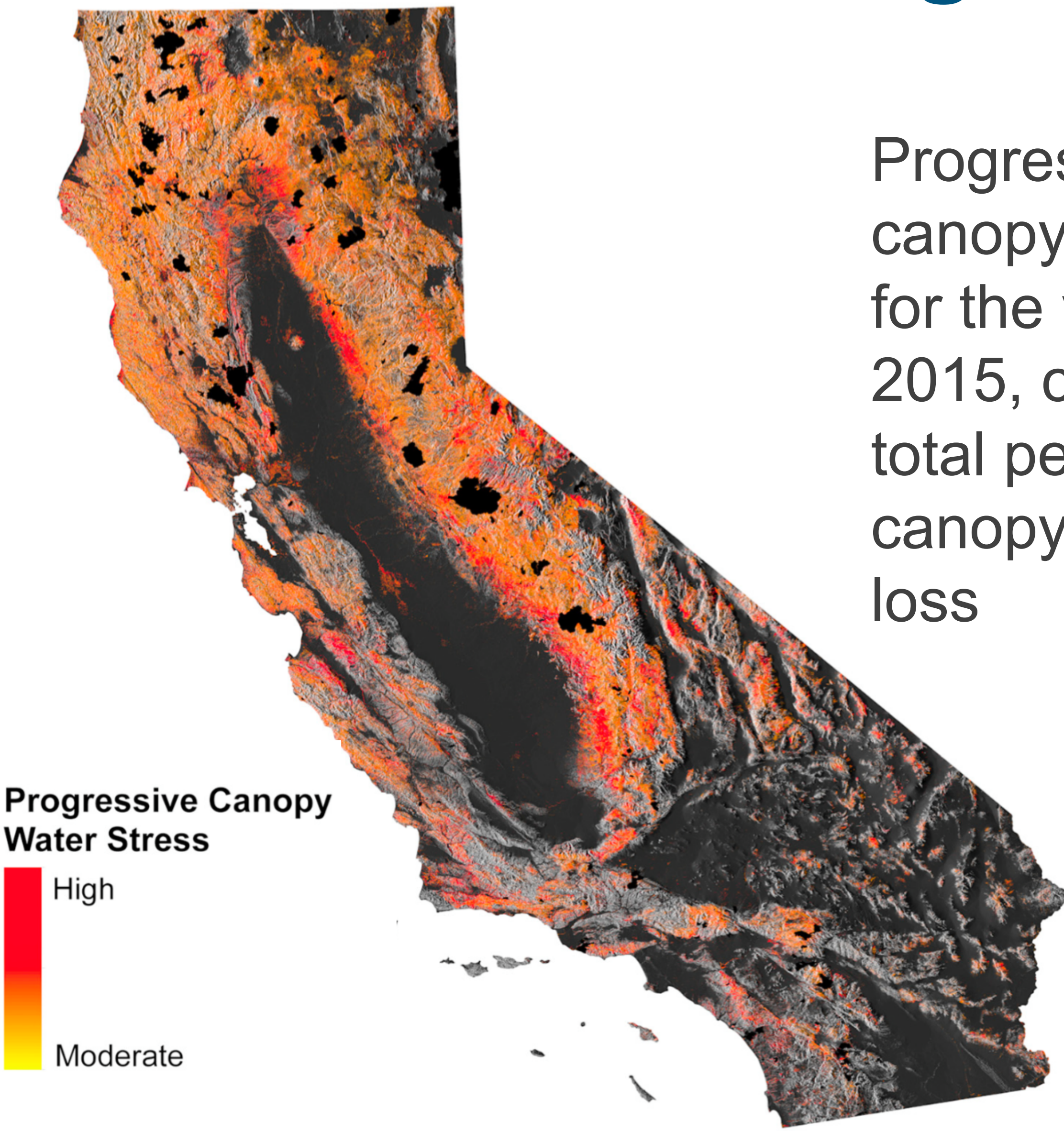
- Overstory shifted from lodgepole pine dominated to mixed species
- Understory dominated by shade tolerant species and no pine regeneration

Succession Post Bark Beetle



Axelson et al. in preparation

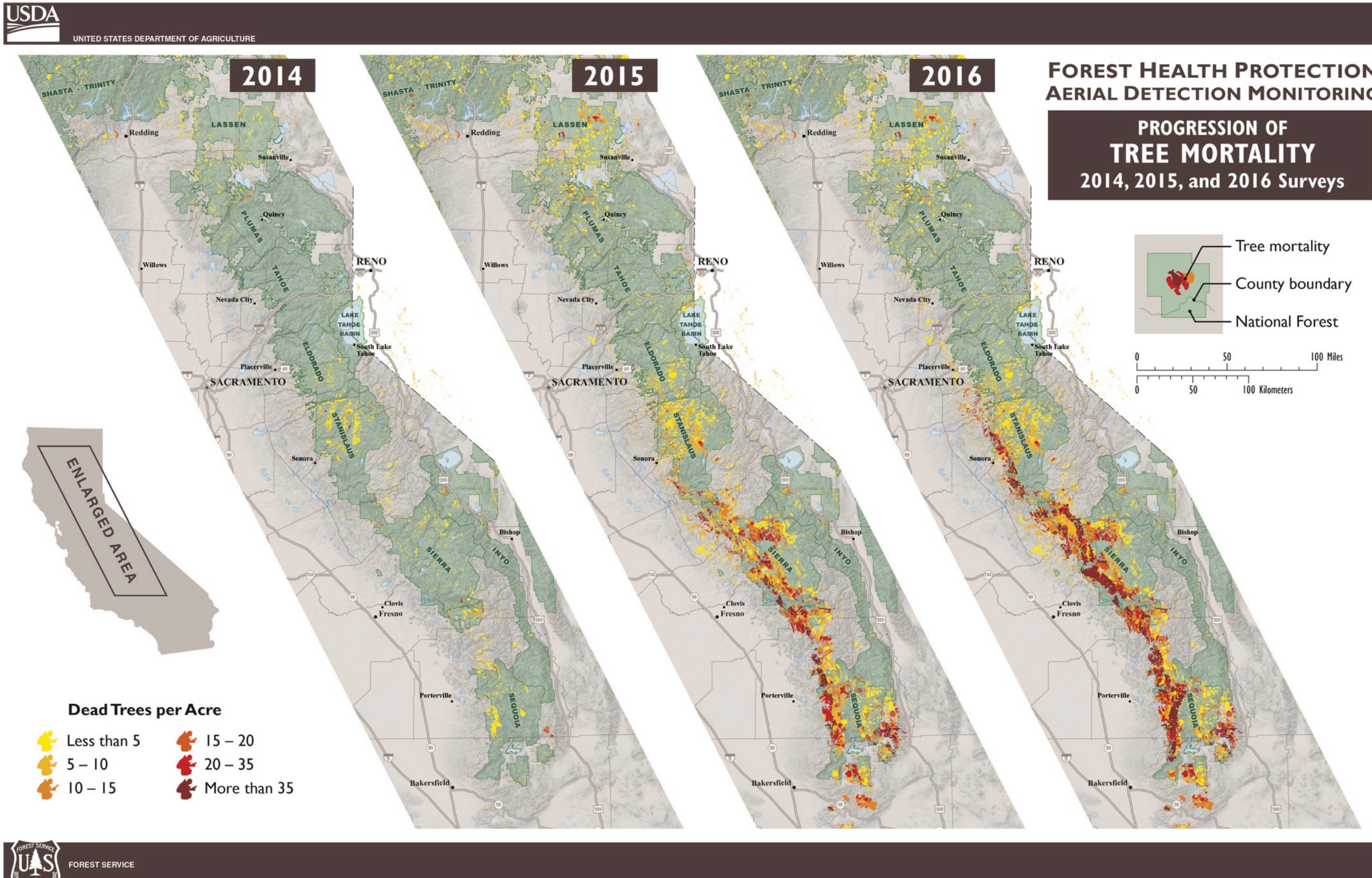
Conditions of Drought



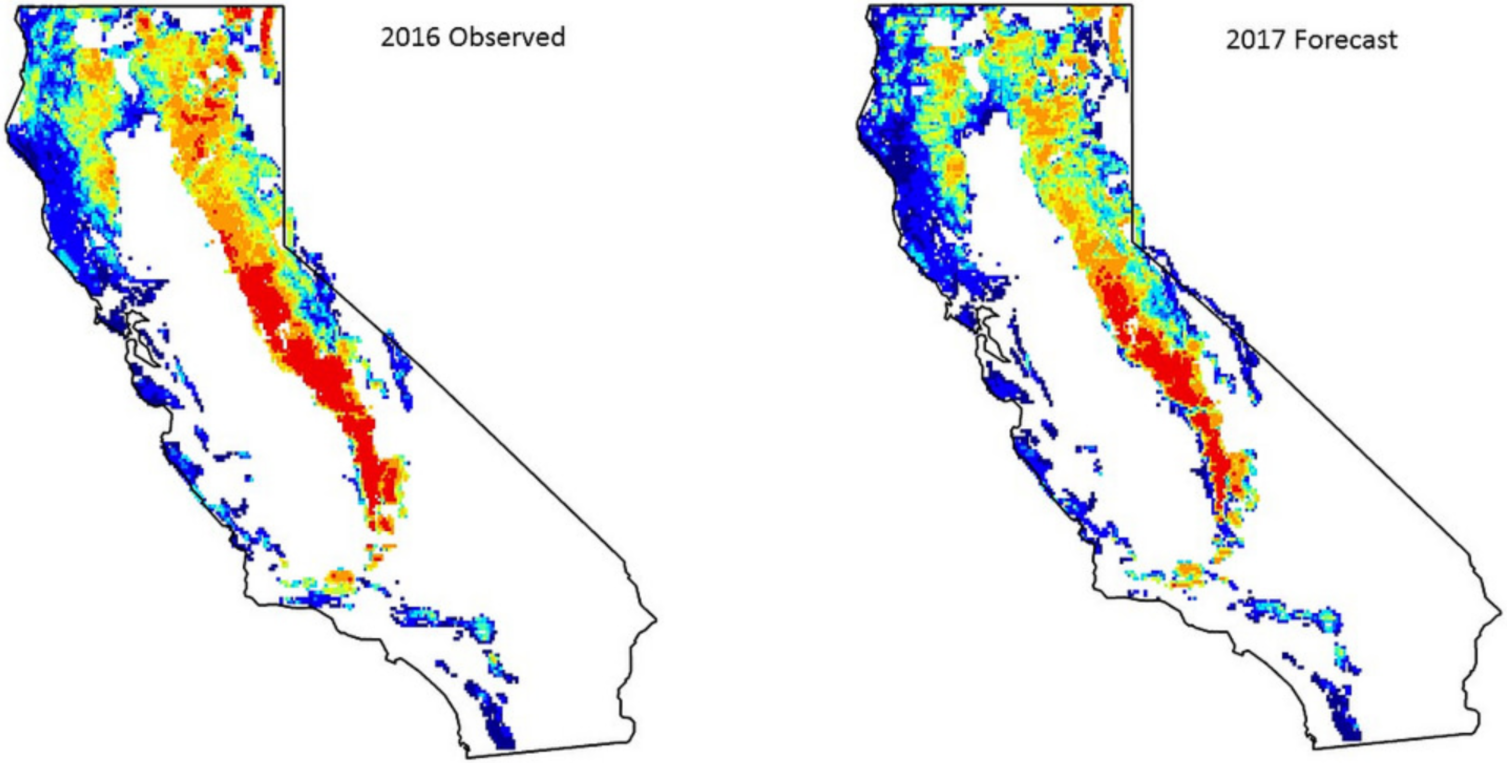
Progressive forest canopy water stress for the years 2011-2015, computed as the total percentage canopy water content loss

Asner et al. 2015

Disturbance - Tree Mortality



Disturbance - Tree Mortality



Map of 2016 observed mortality (left) and the 2017 forecasted mortality (right). The forecast suggests that bark beetle-caused mortality should subside in many parts of California

http://usfs.maps.arcgis.com/apps/MapJournal/index.html?appid=7b78c5c7a67748808ce298efefceaa46

Tree Mortality Questions

- Trees have died on my property – **now what**?
- If I plant ponderosa pine will what happen in the next drought and bark beetle outbreak?
- What species are best adapted to my property?

➢ What does history and research **teach us**

Historical Perspective

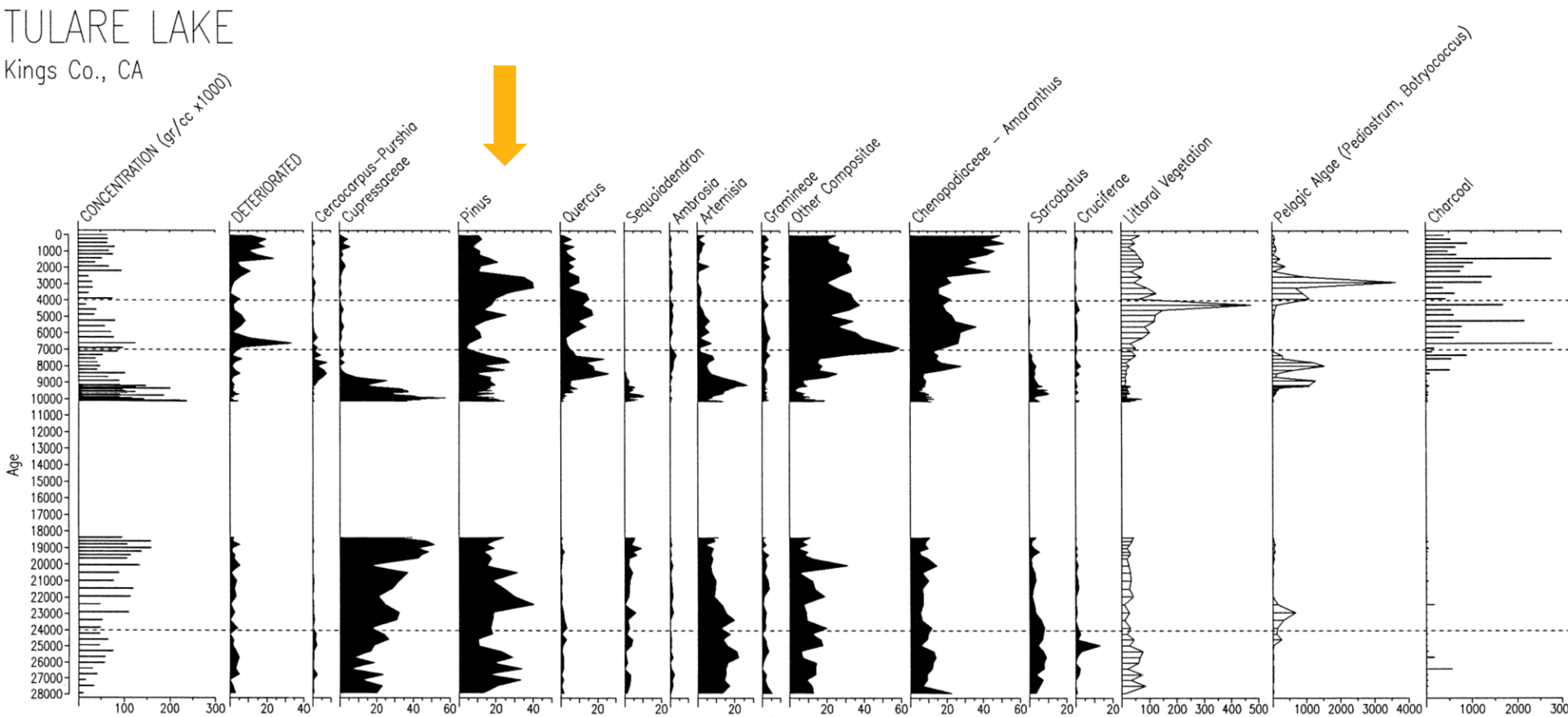


Fig. 3. Percentage pollen diagram for selected (abundant) palynomorphs from Tulare Lake core 2. Types right of Cruciferae are not included in the pollen sum (divisor for pollen percentages). Horizontal lines denote important events in the record (not zone boundaries) the lowest line at 24,000 yr B.P. marks a decreased sedimentation rate and a decrease in lake level. The 7000 yr B.P. line marks the last occurrence of the pollen of *Sarcobatus* a Great Basin species. The 4000 yr B.P. line marks the beginning of higher lake levels during the late Holocene.

O.K. Davis / Review of Palaeobotany and Palynology 107 (1999) 249–257

Davis 1999

Historical Perspective

- Historical data and reconstruction studies in the Sierra indicate mixed-conifer forests were highly clustered, example - gaps
- Gaps important for regenerating shade-intolerant pine

Near Ackerson Meadow, Toulumne County. Old growth stand of ponderosa pine

UC Library, Digital Collections

Ponderosa pine, sugar pine, black oak type, with manzanita and grass as associated dominants - poorly stocked. Mariposa County

Old Growth stands of sugar pine-white fir with ponderosa pine and Incense cedar. Toulumne County.

UC Library, Digital Collections

Tree Species Tolerance

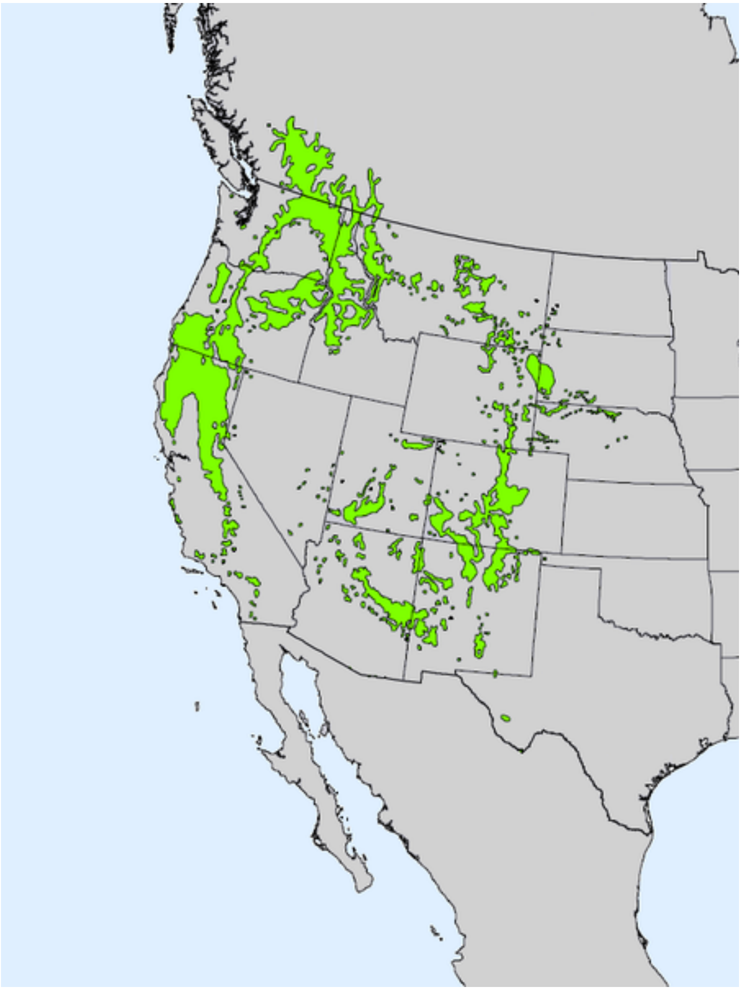
Table 1. Comparative tolerances of common California trees, listed from most tolerant to least tolerant

Shade	Drought	Fire	Snow damage
white fir	Oregon white oak	ponderosa pine	red fir
red fir	California black oak	Douglas-fir	white fir
Douglas-fir	Jeffrey pine	sugar pine	Jeffrey pine
sugar pine	ponderosa pine	white fir	Douglas-fir
incense cedar	lodgepole pine	incense cedar	sugar pine
lodgepole pine	incense cedar	lodgepole pine	ponderosa pine
ponderosa pine	Douglas-fir		
black oak	sugar pine white fir red fir		

Kocher and Harris 2007

Ecology of Ponderosa Pine

- A major source of timber, ponderosa pine forests are also important as wildlife habitat, for recreational use, and for esthetic values
- In California, ponderosa pine is usually found at elevations from 500 to 3,500 ft in the north, and from 5,300 to 7,300 ft in the south



https://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/ponderosa.htm

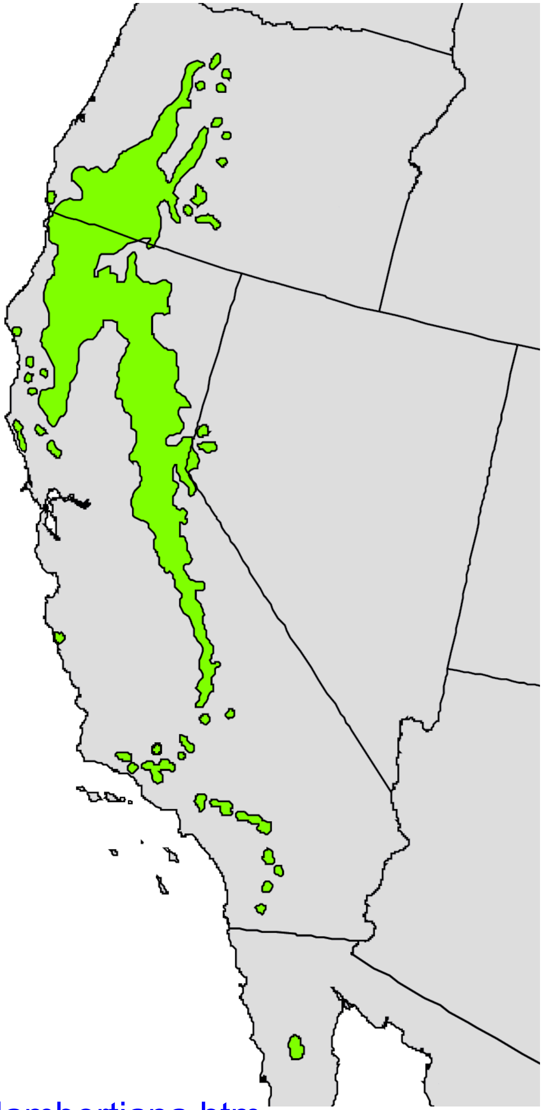
Ecology of Ponderosa Pine

- In California, the associated tree species are true firs, incense cedar, Jeffrey pine, sugar pine, Douglas-fir, and black oak
- However, ponderosa pine is less shade tolerant than all of its major competitors in mixed-species stands

➢ competitive **disadvantage**

Ecology of Sugar Pine

- The tallest and largest of all pines, second only to giant sequoia in volume
- Across it range found near sea level in the Coast Ranges to more than 10,000 ft.
- Sugar pine usually occurs in mixed-conifer forests with many of the same associates as ponderosa



https://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/lambertiana.htm

Ecology of Sugar Pine

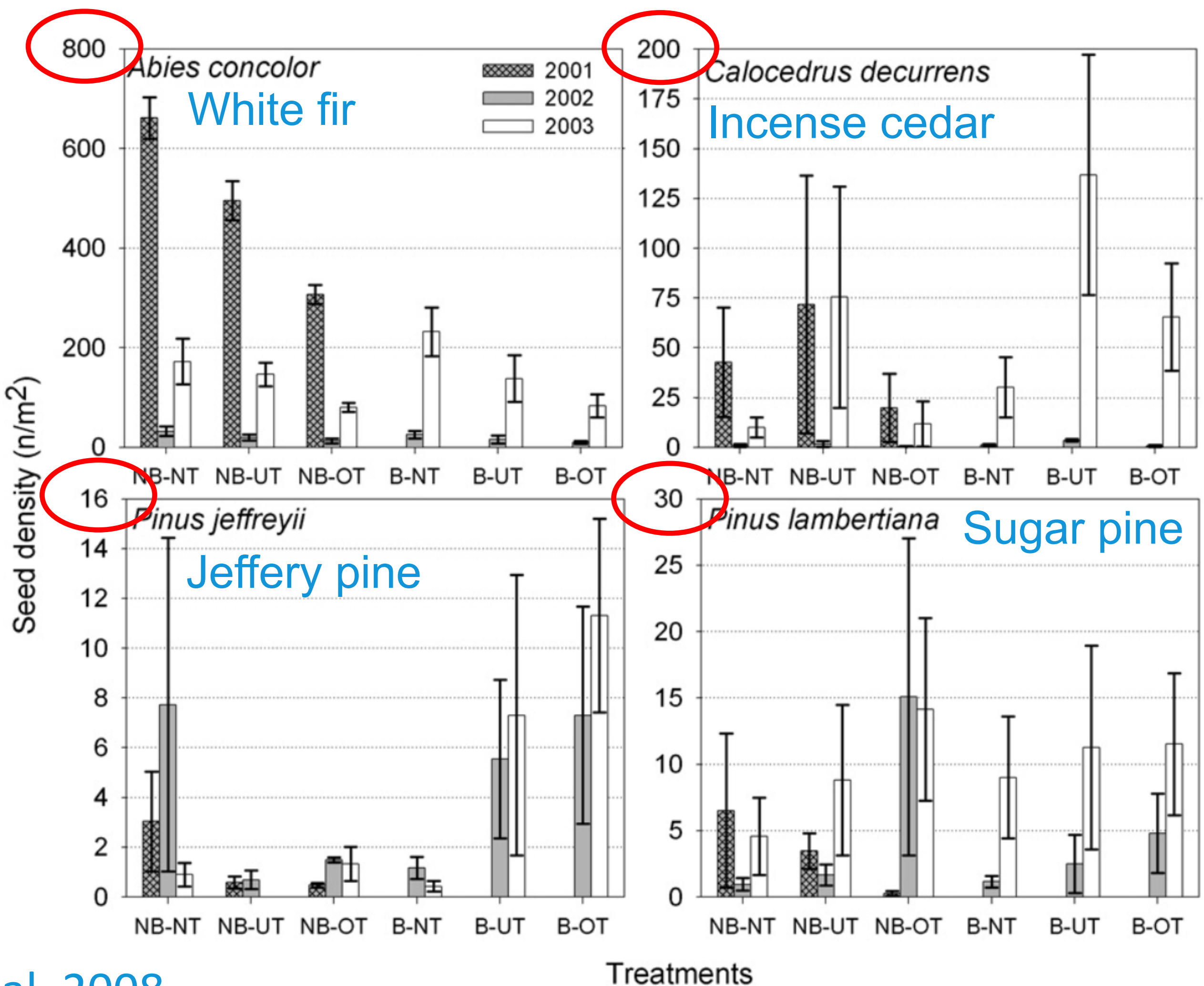
- Seedlings will germinate on both litter and bare mineral soil, but development is **slow** under shade conditions
- Sugar pine is well adapted to
- grow in gaps created by disturbances
- Competition from brush severely impedes seedling establishment and growth

➢ Has a **low** drought tolerance

Recruitment

Teakettle Exp. Forest, Sierra National Forest, 6200-8500 ft

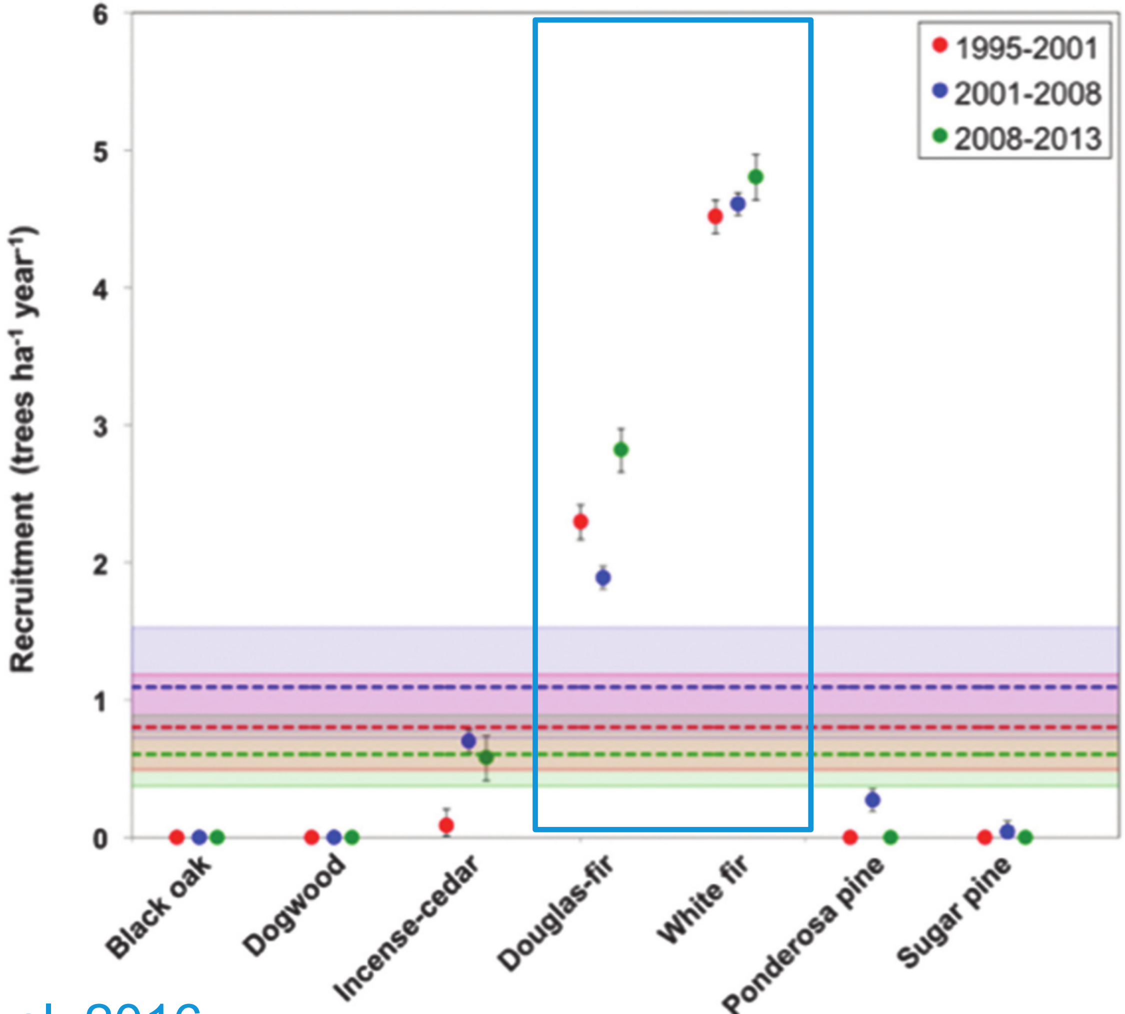
Seed Rain



Zald et al. 2008

Recruitment

Plumas National Forest, 3800-4000 ft



Levine et al. 2016

Recruitment

Stanislaus Experimental Forest, 5700-5900 ft

- Pine seedling density - sugar, ponderosa, and Jeffrey pine - **declined** significantly through time:
  - Pre-logging: 310 tress/acre (766 trees/ha)
  - Post-logging: 148 trees/acre (368 trees/ha)
  - 2008 re-measurement: 27.5 trees/acre (68 trees/ha)
- Seedling **abundance** change from pre-logging (1929) to 2008:
  - Biggest increase = incense cedar 33.7% to 56.8%
  - Biggest decrease = sugar pine 12.4% to 3.0%

Knapp et al. 2013

Blodgett Research Forest

Blodgett Research Forest

Blodgett Research Forest

Final Thoughts

- Even in the absence of drought tree mortality is likely to continue - **legacy effects** of drought and continued bark beetle pressure
- No forest management is **not** creating healthy resilient forests
- Despite the massive dieback observed in the Sierra Nevada there is an **opportunity** to change behaviour
- **Adaptive management** to make forests more resistant to disturbance and resilient overall to unknown future

Take Home Messages

- The modern 120 + year period without low severity fire has created conditions that do not favor pine regeneration
- The current **mortality event** has created the overstory gaps and large openings that are good for pine establishment and growth

Take Home Messages

- Pine species have been on the landscape a very long time and are well **adapted** to the environment
- Considerations:
  - site suitability (elevation, site prep), tree density (lower density, species mixes), seed source (moving between zones)
- Triage approach – **prioritize** restoration efforts

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Tree Mortality

Unprecedented Tree Mortality

Tree mortality resulting from the drought of 2012 to 2016 has been unprecedented. Trees have died throughout the state but especially in the southern Sierra Nevada.

Events

The University of California is collaborating with Cal Fire and the Society of American Foresters to reach out to landowners affected by tree mortality through workshops and educational materials.

The first workshop will be held Saturday February 11th, 2017 in Auberry, CA.

For more information, see this link: 2-11-2017 Auberry workshop.

Reforestation Workshop Press Release

http://ucanr.edu/barkbeetle

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