Forest Mortality & Regeneration: Life after Beetle

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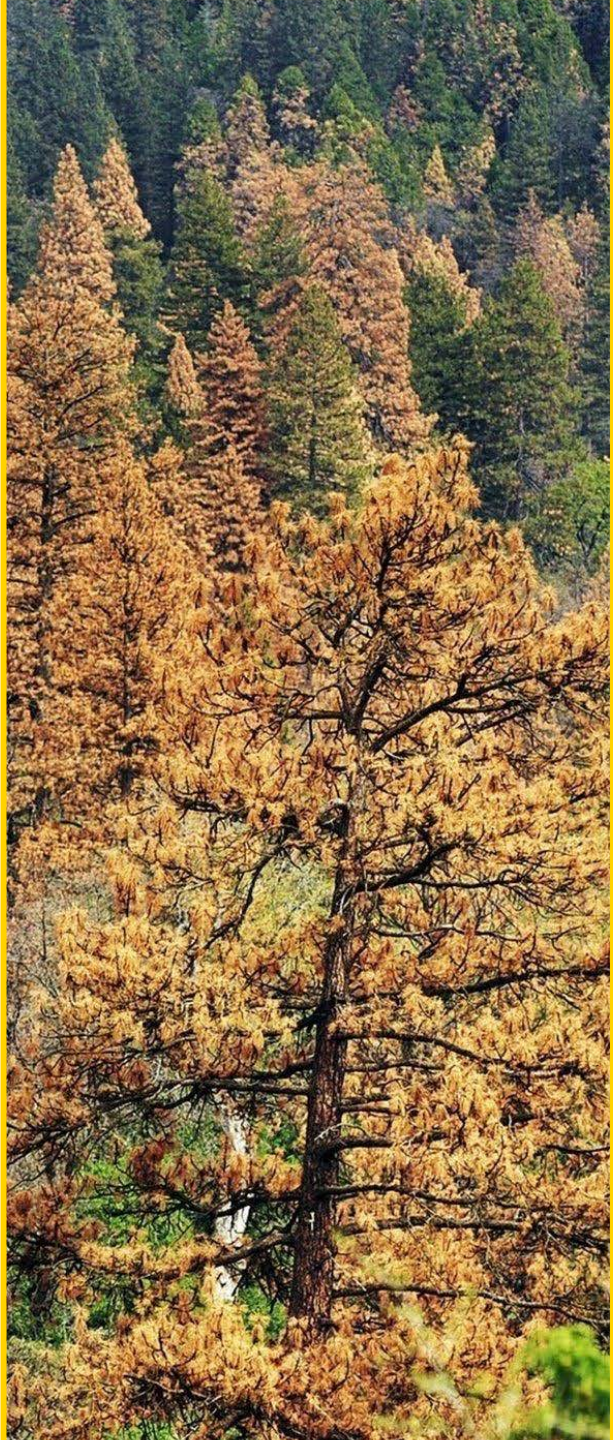


Forest Dynamics

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

Terminology

Overstory

Canopy

Sub-canopy

Understory

Sapling

Seedling

Disturbance Characteristics

Key attributes of disturbances include:

- Type
- Severity
- Spatial and temporal characteristics
  - ➢ stand level vs landscape level
  - ➢ short-time frame vs long-time frame
  - + return interval & historical range of variability
- Disturbance **interactions**

Disturbance Impact

Thinning from below – removes small trees – e.g., low severity fire

Disturbance Impact

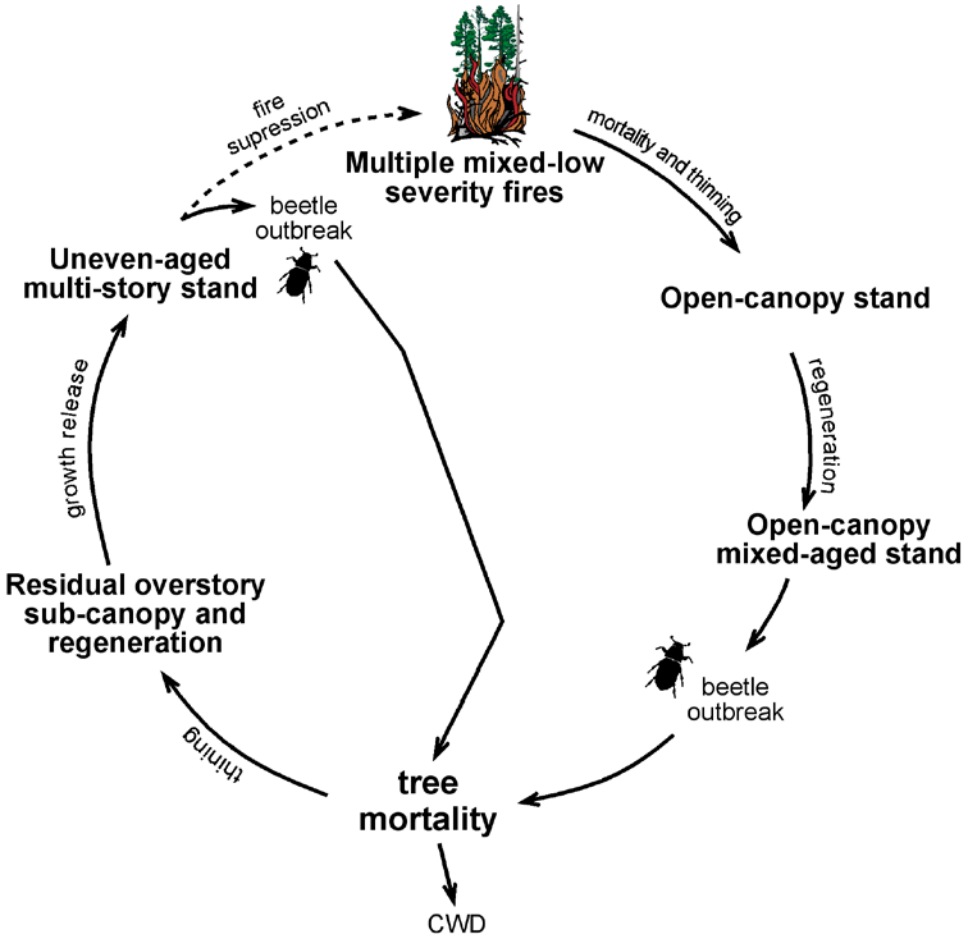
Thinning from above – removes large trees – e,g., bark beetle

Post-MPB in Central BC

In the central BC on the Chilcotin plateau long-term plots illustrated a **shift** in the size structure of stands but not species

- Overstory shifted to **uneven-aged** lodgepole pine forest
- Understory returned to lodgeople pine and increased in aspen

Post-MPB in Central BC



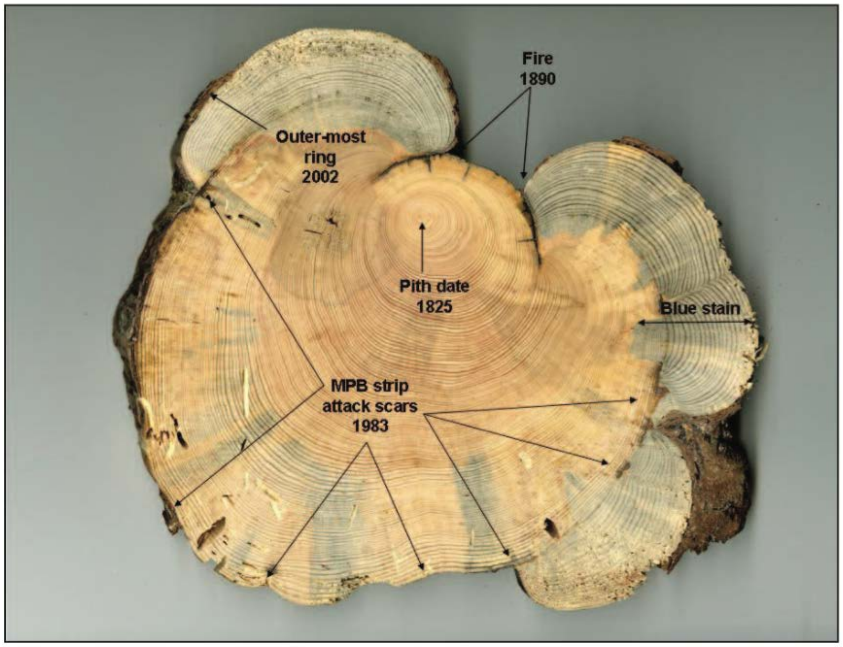


Fig. 2. Example of lodgepole pine lower bole section used to date past fire and mountain pine beetle (MPB) disturbances. This tree had a pith date of 1825; a single fire scar indicating a surface fire in 1890, MPB strip scars in 1983, and a successful MPB attack (with blue-stain fungus) in 2002 killing the tree (original in color).

Axelson J., R. Alfaro, B. Hawkes. 2010. Changes in stand structure in uneven-aged lodgepole pine stands impacted by mountain pine beetle epidemics and fires in central British Columbia. *The Forestry Chronicle* 86: 87-99.

Post-MPB in Southern BC

In the southern BC forest plots illustrated a **shift** in the size structure of stands **+** shift in regenerating species

- **Even-aged** stand with closed canopy
- Heavy pine grass and moss covering forest floor

Post-MPB in Southern BC

Table 2
Composition of advance regeneration and seedlings in three stands sampled near Logan Lake, BC, used to study the impacts of past beetle and fire disturbances.

Stand no.	Trees/ha	Mean DGH[a] (cm) (S.E.)	Mean height (m) (S.E.)	Percent species[b]
Advance regeneration				
1	650	1.65 (0.02)	0.83 (0.01)	88 Fd; 12 Sx
2	125	1.32 (0.14)	0.73 (0.05)	60 Fd; 40 Sx
3	50	0.55 (0.05)	0.76 (0.05)	100 At
Mean	275	1.17	0.77	49Fd; 33 At; 18 Sx
Seedlings				
1	275	–	–	82 Fd; 18 Sx
2	450	–	–	72 Pl; 28 Fd
3	25	–	–	100 Fd
Mean	250	–	–	70 Fd; 24 Pl; 6 Sx

[a] dgh: diameter-at-ground-height, measured above root collar.
[b] Species abbrev: At: Trembling aspen; Fd: Douglas-fir; Pl: Lodgepole pine; Sx: Interior spruce.

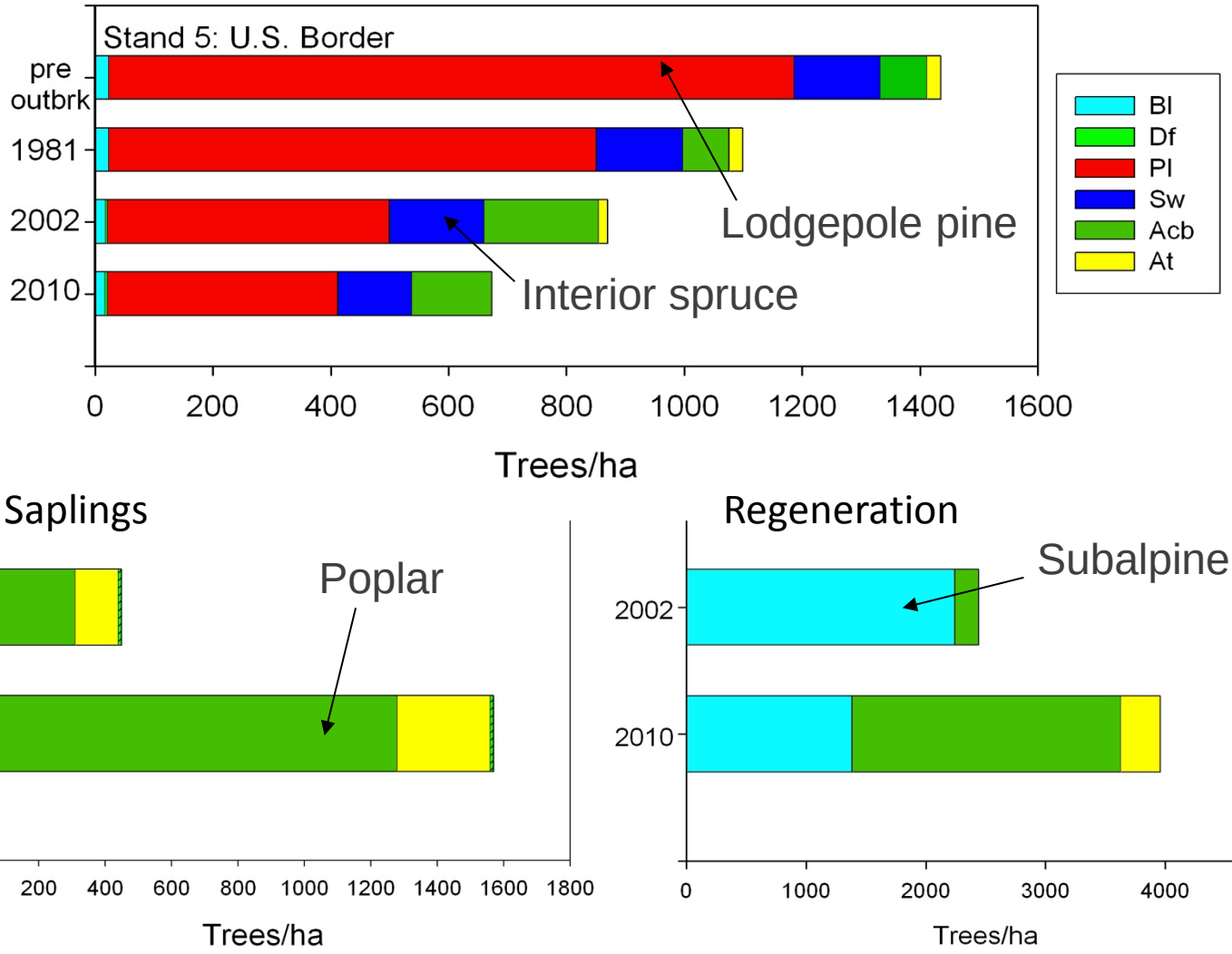
Axelson J., R. Alfaro, B. Hawkes. 2009. Influence of fire and mountain pine beetle on the dynamics of lodgepole pine stands in British Columbia, Canada. *Forest Ecology and Management* 257: 1874-1882.

Post-MPB in Southern Alberta

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

- Overstory shifted from lodgepole pine to canopy of mixed species
- Understory dominated by shade tolerant species with **no** pine regeneration

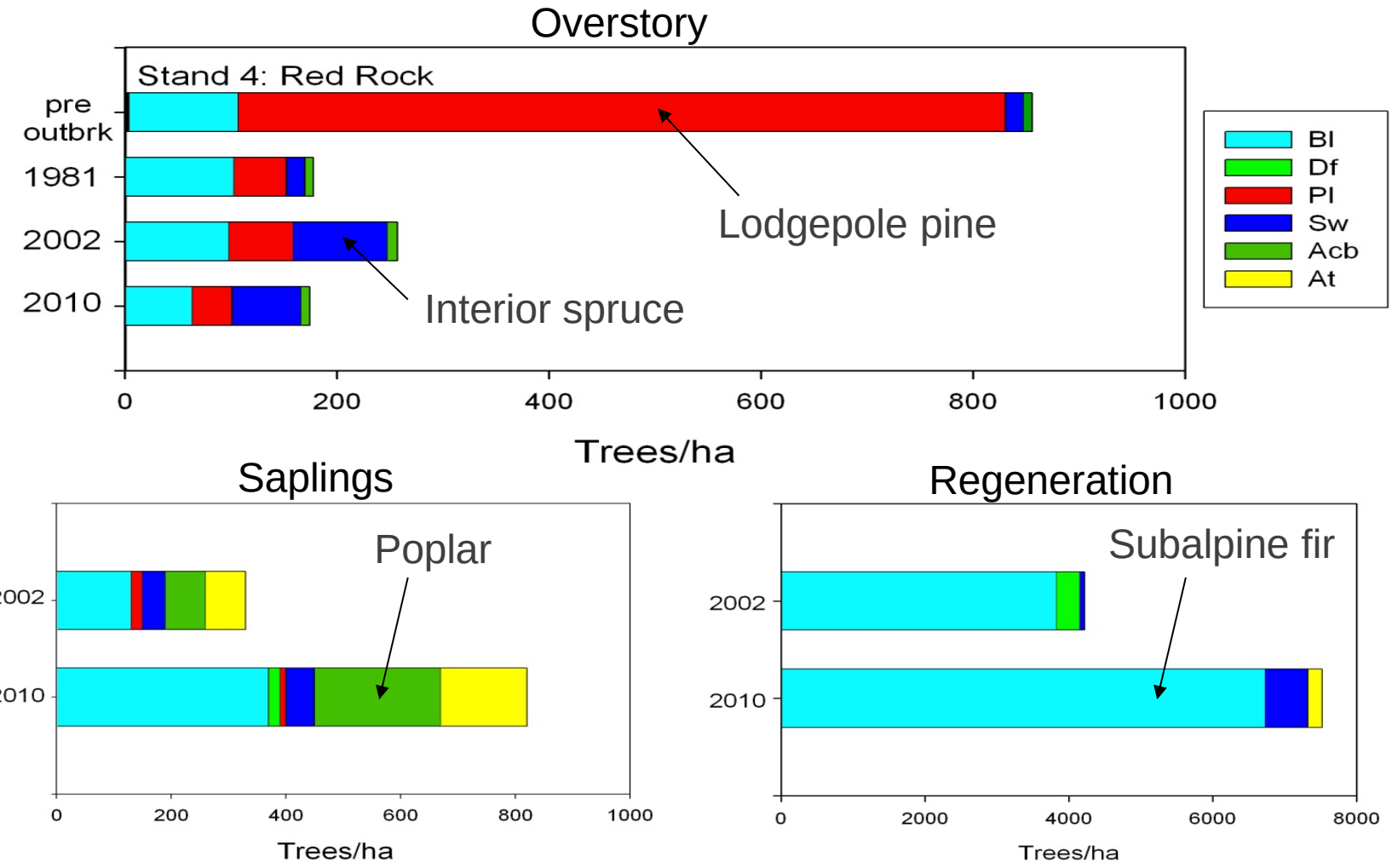
Post-MPB in Southern Alberta



29% Overstory Mortality

Axelson et al. in preparation

Post-MPB in Southern Alberta



93% Overstory Mortality

Axelson et al. in preparation

Post-MPB in Southern Alberta

Waterton Lakes National Park 30 years after mountain pine beetle outbreak demonstrates resilience:

- Changes in both stand composition and structure – greater **heterogeneity**
- Higher components of non-pine species - subalpine fir, white spruce, balsam poplar
- Greater variety of stand structures due to canopy mortality, tree fall, and regeneration
- Reduced probability of severe mountain pine beetle outbreaks spreading across the landscape in the future due to species shifts

California Mortality – Caveats!

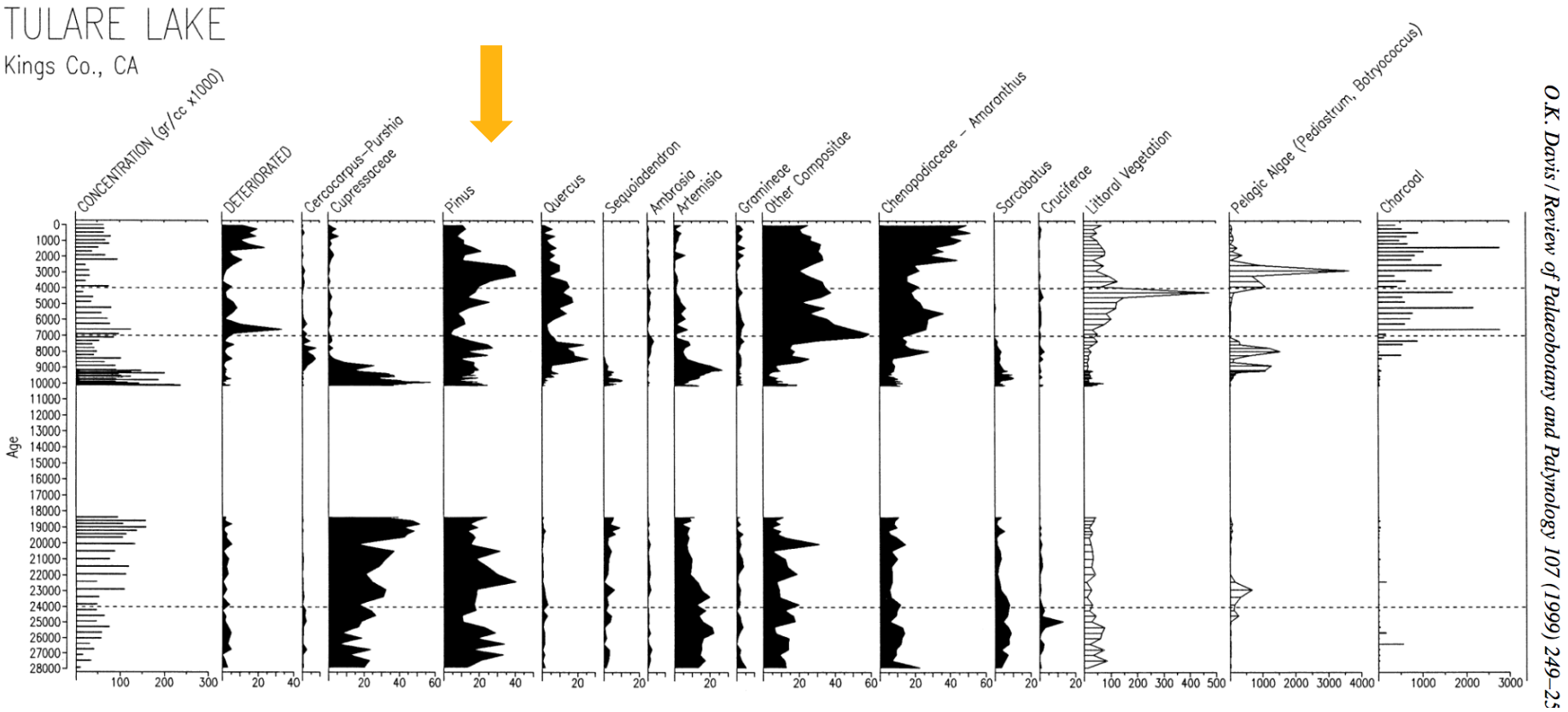
- Even in the absence of drought tree mortality is likely to continue - **legacy effects** of drought and continued bark beetle pressure
- Unknowns -
  - Loss of ponderosa pine at lower elevations?
  - Conversion to other forest types or shrubs?
  - Will pine species across affected areas regenerate?
  - Lag between tree mortality and tree fall down - how long for the canopy to open up?
  - Fuels – will accumulation change fire behavior and or impede regeneration?

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?

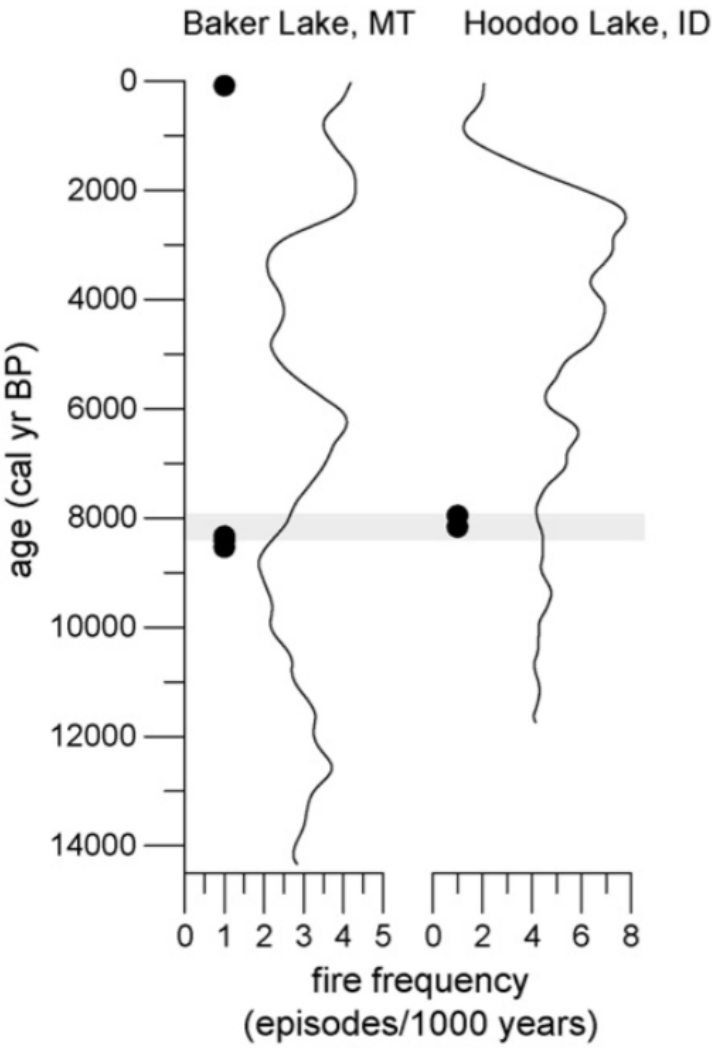
➢ What does history and ecology **teach us**

Historical Perspective



Davis, O. 1999. Pollen analysis of Tulare Lake, California: Great Basin-like vegetation in Central California during the full-glacial and early Holocene. *Review of Palaeobotany and Palynology* 107:49–257.

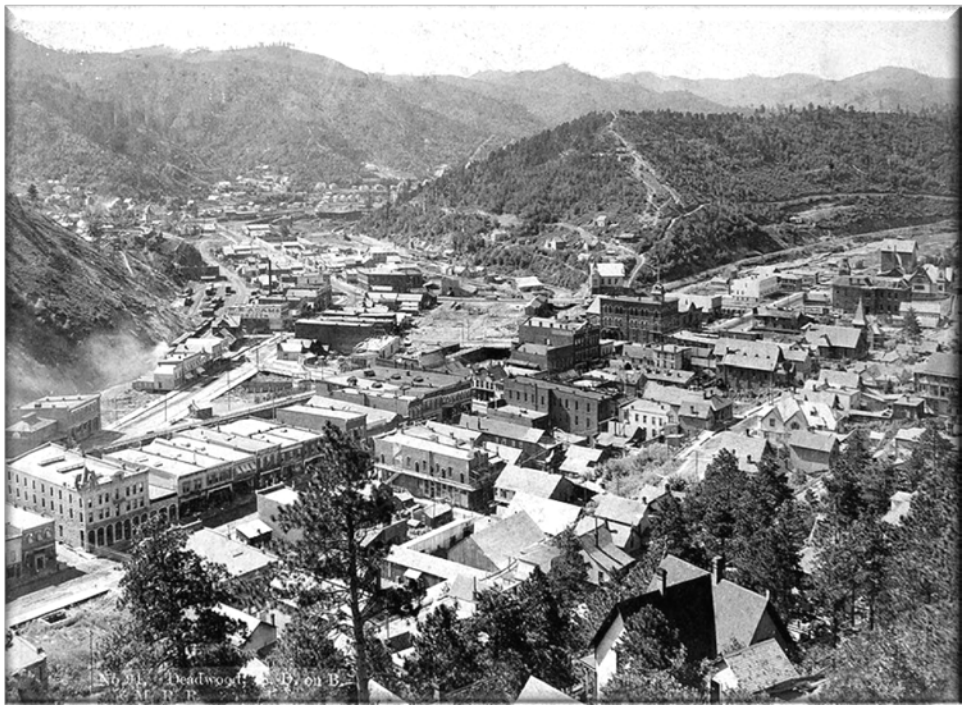
Historical Perspective



Brunelle, A, G. Rehfeld, B. Bentz, S. Munson. 2008. Holocene records of *Dendrotcontus* bark beetles in high elevation pine forests of Idaho and Montana, USA. *Forest Ecology and Management* 255: 836-846.

Historical Perspective

“After ruining a billion and a half feet of the choicest lumber in the Black Hills and ravaging thousands of acres of the finest pine trees in the West, the little bark beetle has robbed Uncle Sam's forestry division of $10,000,000 in the last ten years…” (Deadwood newspaper ~1890s)



Historical Perspective

Historical data and reconstruction studies in the Sierra indicate mixed-conifer forests were highly clustered with **gaps**

Near Ackerson Meadow, Toulumne County (1941) Old growth stand of ponderosa pine

UC Library, Digital Collections

Near Jenkins Hill, Tuolumne County (1941) Ponderosa pine, sugar pine, black oak type

UC Library, Digital Collections

A California Outbreak

- In the early 2000s, the mountain ranges in southern part of state started to experience elevated levels of tree mortality associated with **drought**
  - ➢ precipitation was the lowest in recorded history during 2001-02
  - ➢ stimulated increases in bark beetle and woodborer populations
- Walker et al. (2006) reported **~12.7%** of conifers (3.5 million trees) died between 2001 - 2004. Mortality was widespread and concentrated in several tree species, most notably ponderosa and Coulter pines

Chris Fettig personal communication

A California Outbreak

- WPB activity peaked in 2002-03, reported to be the most common mortality agent associated with dead and dying pines throughout the region (USDA Forest Service 2002)
- In some areas, mortality was **>80%**
- Ponderosa and Coulter pines > 17 inches DBH experienced 73.5% and 78% mortality, respectively
- Despite continuing drought and an availability of suitable hosts, WPB populations **rapidly declined** in 2004 (Hayes et al. 2009)

Chris Fettig personal communication

Ecology of Ponderosa Pine

In California, the associated tree species are true firs, incense cedar, Jeffrey pine, sugar pine, Douglas-fir, and black oak

- Shade intolerant
- Drought tolerant
- Fire resistant
- Host for western pine beetle

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

Ecology of Sugar Pine

Sugar pine usually occurs in mixed-conifer forests with many of the same associates as ponderosa

- Less drought tolerant than ponderosa pine
- Fire tolerant
- Host for mountain pine beetle and white pine blister rust

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

Silvics of Pine

Ponderosa and sugar pine:

- Require **gaps** with that create high light environment with minimal shade
- Planted or regenerate on bare mineral soil
- Little to **no** brush as presence severely impedes seedling establishment and growth
- Growing season **moisture**

Take Home Messages

- The modern 100 + 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** growth with planting assistance

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