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 lodgepole pine and increased in **aspen**
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.

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

<sup>a</sup> dgh: diameter-at-ground-height, measured above root collar.

<sup>b</sup> Species abbrev: At: Trembling aspen; Fd: Douglas-fir; Pl: Lodgepole pine; Sx: Interior spruce.
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

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 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 $\sim12.7\%$ 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

Ecology of Sugar Pine

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

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

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