Ecosystem Changes after Pine Beetle and Salvage Logging in Colorado Subalpine Forests

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> 1.4 million hectares in CO & Southern WY since 1996
Overstory Mortality in Colorado

Pine losses
80-90% of basal area
Residual live trees
15-35% of stand BA

24 pine-dominated stands
Trees >10 cm DBH
Growing Stock in MPB Forests

Residual Live & New Trees

Overstory
- 312 t/ha (126 t/acre)
- 71% LPP; 18% AS; 7% SF

Understory Trees
- 3144 t/ha (1272 t/Ac)
- 35% AS; 32% SF; 29% LP

New Recruits
- 1612 t/ha (652 t/Ac)
- 69% SF; 19% LP; 4% AS

* Stocking Levels
370 t/ha (150 t/Ac)
Watershed Change

Responses Regulated by Change in
Canopy interception & Snowpack accumulation
Water uptake & Soil nutrient use

Complicating Factors
Responses may lag, difficult to detect, prolonged
Complex spatial & temporal patterns
Yellowstone Area ‘60 & ‘70s
About 40-70% of the overstory trees died
Surviving trees increased growth by 2-3 fold for two decades

(Romme et al. 1986)
35% of trees grew > 25% faster since the infestation
16% of trees grew faster than ever
Unrelated to precipitation
Decline in basal area explained 10-20% of response
*Assessed 123 cores in 4 basins
40% of trees added > 2X more height in ‘10 as in ’07. Proportionally, fir was most likely to double height; spruce was least likely.

Loss of basal area explains 13 - 23% of height increment. Pine most sensitive to BA; spruce least sensitive.
Management Response to MPB

Arapaho-Roosevelt NF, Colorado
Most harvesting since 1970s
Greatest extent of clear cutting

However:
<50% of infested area is treatable;
of that < 30% will be cut
90% of infested area will be untreated
Are there concerns about seedling colonization after harvest of MPB stands?

Since the outbreak, pine recruitment has been at least equal to previous decades

> 90% of units meet minimum stocking requirements

Compared USFS stocking surveys in pre- and post-outbreak harvest units. n = 30 stands; 3rd yr surveys; AR NF; Sulphur RD

(Collins et al. 2010)
Study Areas

Harvest vs. Retain?

Specific harvesting practices

CO State Forest
Willow Ck, Parks RD
Gore Pass, Yampa RD
Fraser Expt Forest
Methods

- 4 sites x 6 pairs of harvested and untreated stands (n = 24 total pairs)

- Overstory transects (5 x 100m)

- Surface fuel transects (15m)

- Seedling plots (1/100 acre; 3.6m radius) plots
Species Composition of Recruits

Harvesting stimulates new pine seedlings and aspen sprouts.

5 times more pine, aspen compared to uncut stands

Fir recruitment is promoted in uncut stands

*Cut stands meet minimum stocking requirements (i.e., > 150 t/acre)

*24 paired sites

(Collins et al. 2011)
Annual height growth of Fir & Pine has doubled since infestation beneath the dead overstory, but delayed in cuts.
**Stand Dynamics**

**Future Species Composition**

**Forest Recovery** - MPB-killed stands recover to pre-MPB stand structure in a century

**Uncut & Partial Cut Stands**
Dominated by fir

**Clear Cut Stands**
Similar to pre-MPB stands
Dominated by pine

(Collins et al. 2011)
Harvesting adds
- ~4X fine fuels (1, 10, 100 hr)
- ~3X total surface fuels

The increase in surface fuels may result in greater flame lengths (i.e., under extreme weather conditions: 2.3 vs 1.7 m compared to uncut).
- 1.2 m - halt direct-attack
- 2.5 m - halt dozers

Windthrow will increase the surface load in uncut areas
- ~2x higher than cut areas
Response to Management

Fire Behavior

Recovery of the forest canopy determines fire behavior

Risk of crown fire is low and will differ little between treated & uncut stands until crown develops (~20 yrs).

More fir in uncut stands = increases canopy BD and lower base height.

(Collins et al. in review)
Management Alternatives on MPB Acres

**No Action**
Untreated Beetle-Killed Stands

**Fuel Reduction**
Whole Tree Harvest

**Water Delivery**
Lop and Scatter Slash Retention

**Forest Regeneration**
Mechanical Scarification Site Prep
Effects of Slash Treatments on Surface Fuels

Lop and scatter treatments had 5x more fuel than control, ~2.3x more than WTH and scarification.

Coarse fuels predicted to persist for more than a century.
Response to Management Options

Soil Moisture

Soil moisture was highest in slash retention treatment

Scarification driest cut option

Gravimetric Moisture (%)

Spring

- p < 0.1

Summer

Fall

- p < 0.05

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<th>Treatment</th>
<th>Spring</th>
<th>Summer</th>
<th>Fall</th>
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<tbody>
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<td>Uncut</td>
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<td>Lop Scatter</td>
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<td>Whole Tree</td>
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Response to Management Options

Soil Moisture
Response to Management Options

Soil Nitrogen Fertility

Soil N was highest in slash retention treatment

Ammonium ($\text{NH}_4^+$)
- 35% to 2.5X > uncut
- 20 - 30% > Whole Tree

Nitrate ($\text{NO}_3^-$)
- 1.3 to 5.2 fold > uncut

Cut vs Uncut
- 3 to 6 fold increase

*Extractable Soil N (0-15 cm mineral soil)
Response to Management Options

Seedling Height Growth

Greater in lop & scatter than other treatments \((p = 0.1)\)

74% survival overall commonly greater on scarified plots \((i.e., \text{in 5 of 6 plots})\).
Response to Management Options

Seedling Establishment

Seedling Occurrence

Whole Tree     58% of plots
Scarification  50%
Lop and Scatter 33%
Uncut          42%

Harvested areas were dominated by pine seedlings and aspen sprouts (i.e., 80-100% of recruits)

Uncut stands were dominated by fir and spruce

Seedling density: 9 – 18 k seedlings/ha

Adequately stocked units require 370 trees/ha
Take Home Messages

1. Tree regeneration is abundant in beetle-infested stands
2. Growth of residual overstory & understory trees are responding to loss of lodgepole
3. Harvesting leads to development of different stand types - with likely implications on future fire potential and effects
4. Slash Retention (Lop and Scatter) has positive effect on soil resources and seedling growth; Reduced colonization of new seedlings
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Further Reading:
