Ecosystem Responses to Mountain Pine Beetle & Management in Colorado Forests

(aka: Hydrologic Implications of Beetle-Related Management and Composition of Post-Infestation Forests)

Western Water Assessment Beetle-Water Workshop
Salt Lake City, UT
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Fort Collins, CO
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

Trees are the answer

Harvest
MPB Mortality
Previous Outbreak

*Forest Growth Response*

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
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**
- 310 t/ha (126 t/acre)
- 71% LPP; 17% AS; 7% SF

**Understory Trees**
- 445 t/ha (180 t/Ac)
- 68% LPP; 12% AS; 15% SF

**New Recruits**
- 1820 t/ha (736 t/Ac)
- 54% LPP; 19% AS; 25% SF

*Stocking Levels*
- 370 t/ha (150 t/Ac)
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
Annual height growth of Fir & Pine has doubled since infestation beneath the dead overstory, but neither has responded in cuts.
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.
Understory Trees May Reduce Transpiration Loss

Understory tree growth & water use increase after overstory mortality

Young trees use more water for a given amount of needles than old trees.
How Will MPB Influence Stream Flow?

Understory may Change Outcome

Transpiration savings from dead LPP

1) Reduced Annual transpiration by 60%

2) Water use by understory returns 20% of savings

R. Hubbard, unpublished
Part 2 - Management Implications

Harvest vs. Retain?
Specific harvesting practices

CO State Forest
Willow Ck, Parks RD
Gore Pass, Yampa RD
Fraser Expt Forest
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. 2010a)
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)

*8 paired sites at Fraser

(Collins et al. 2010b)
**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. 2010b)
Harvesting adds
~4X fine fuels (1 + 10 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 5m).

1.2 m - halt direct-attack
2.5 m - halt dozers

Windthrow will increase the surface load in uncut areas
~1.4x higher than cut areas
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, crown base height and flame length.

**Green Stands** – Greater risk, intensity of crown fire:
*6m total flame length
*Crowing Index 55 km/hr (34 mph – moderate risk)

(Collins et al. under review)
Previous MPB Outbreak
White River NF 1980s

Recovery in uncut stands depends on pre-outbreak composition

Lodgepole Stands
  62% aspen, 27% fir, 7% lodgepole

Mixed Conifer Stands
  87% fir, 7% spruce, 3% aspen, 3% lodgepole

Downed Wood
  70 Mg/ha in affected stands
  Mostly large diameter
  Highly variable (0.5 to 314Mg/ha)

(Pelz, 2011 MS Thesis)
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
Response to Management Options

Soil Moisture

Soil moisture was highest in slash retention treatment. Scarletification was the driest cut option.
Response to Management Options

Soil Nitrogen Fertility

Soil N was highest in slash retention treatment

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

Nitrate (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 \( (i.e., \) 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
### Untreated

#### Percentile Weather

- **97th**
- **90th**
- **80th**
- **50th**

#### Fire Type

- **Active/Conditional Crown Fire**
- **Passive Crown Fire**
- **Surface Fire**

#### Canopy Bulk Density (kg m\(^{-3}\))

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### Harvested

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- **Passive Crown Fire**
- **Surface Fire**

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