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
1 December 2011

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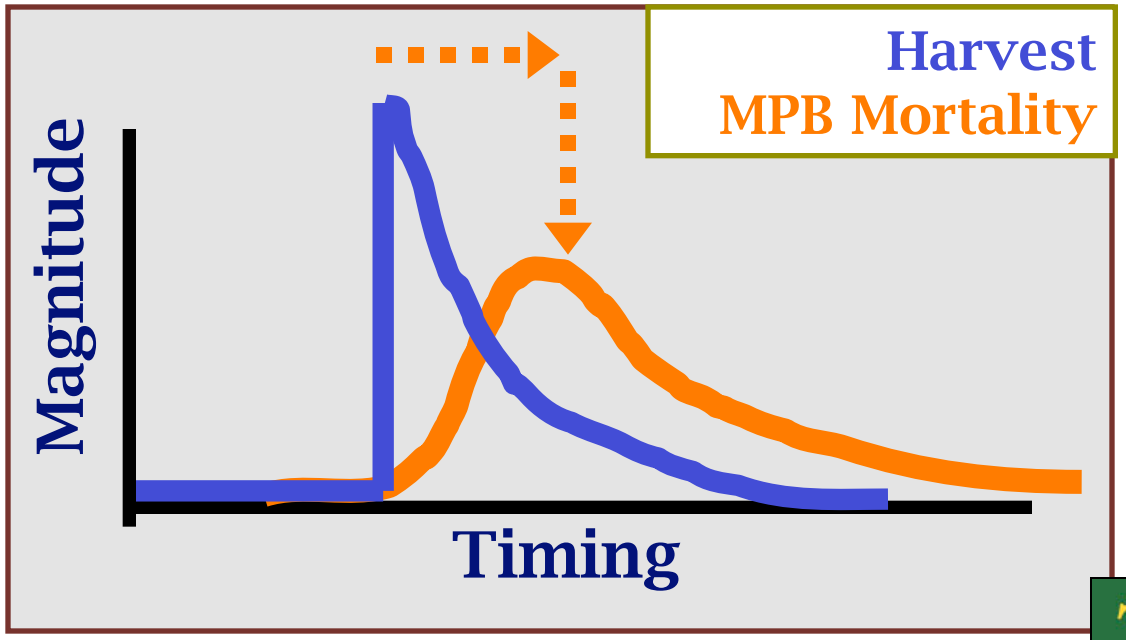
Watershed Change



Trees are the answer

Responses Regulated by Change in

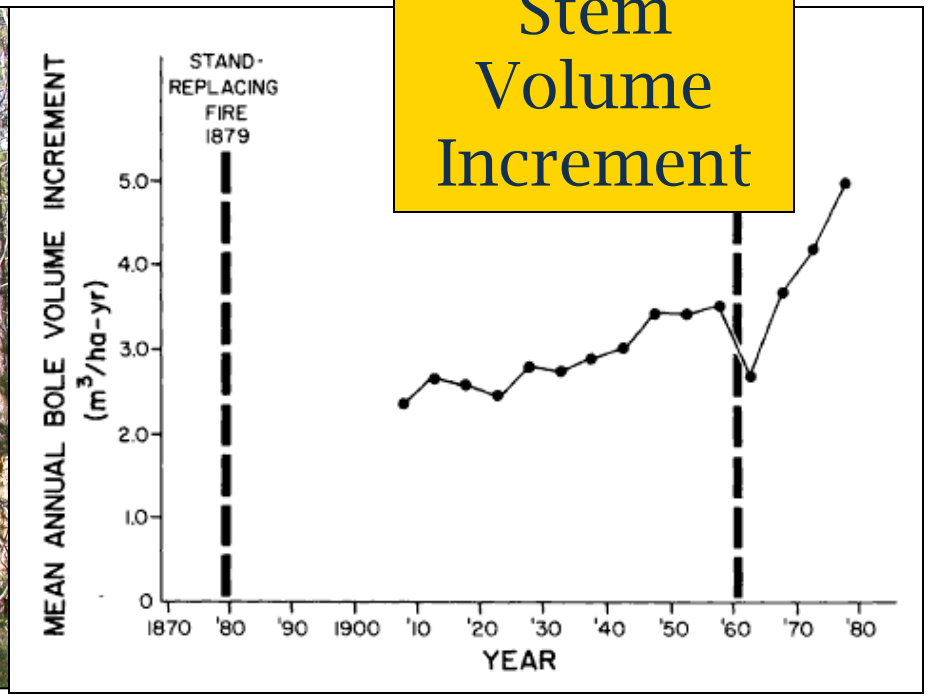
Canopy interception & Snowpack accumulation
Water uptake & Soil nutrient use

Complicating Factors

Responses may lag, difficult to detect, prolonged
Complex spatial & temporal patterns

Previous Outbreak

Forest Growth Response



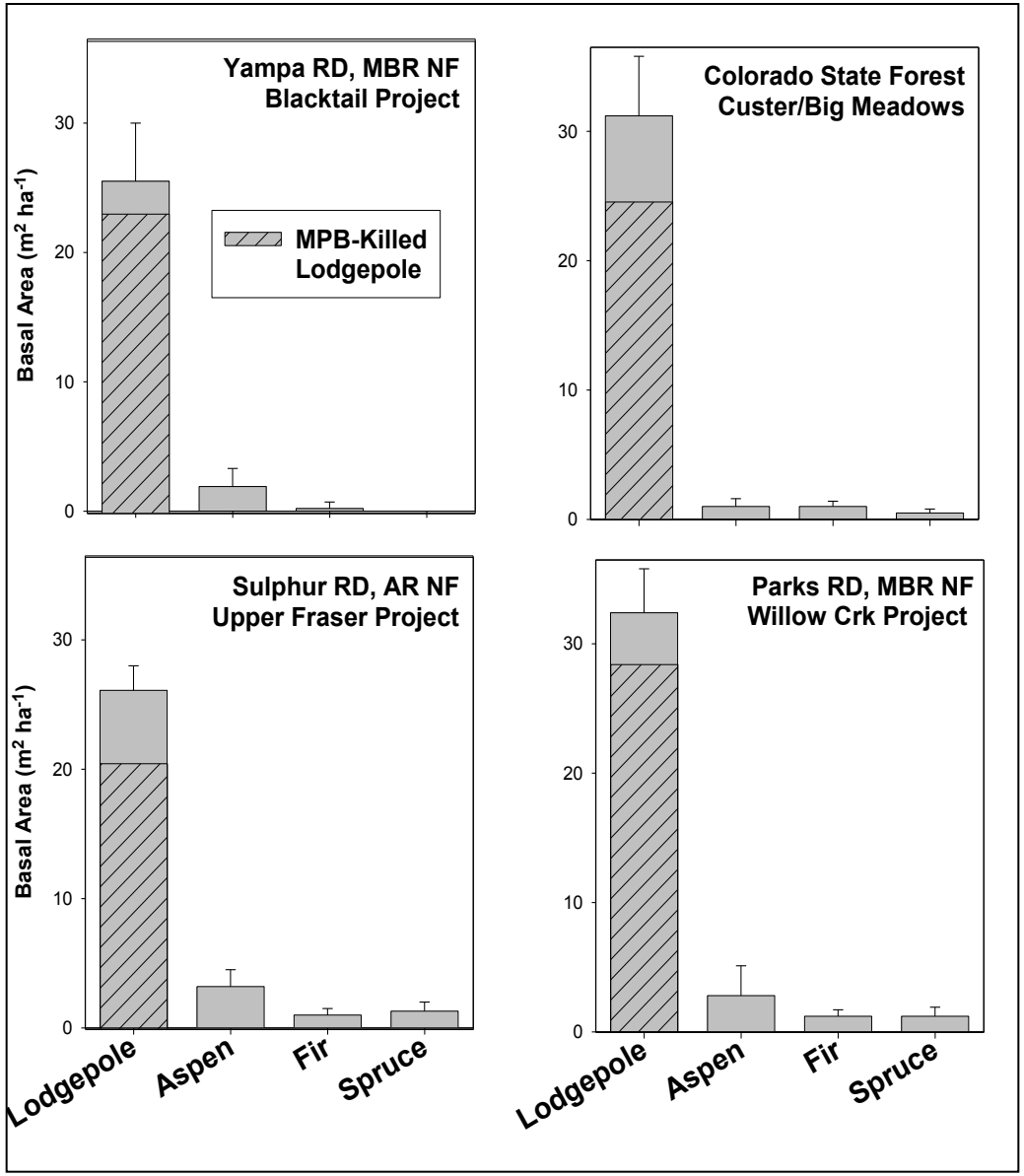
Yellowstone Area '60 & '70s

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

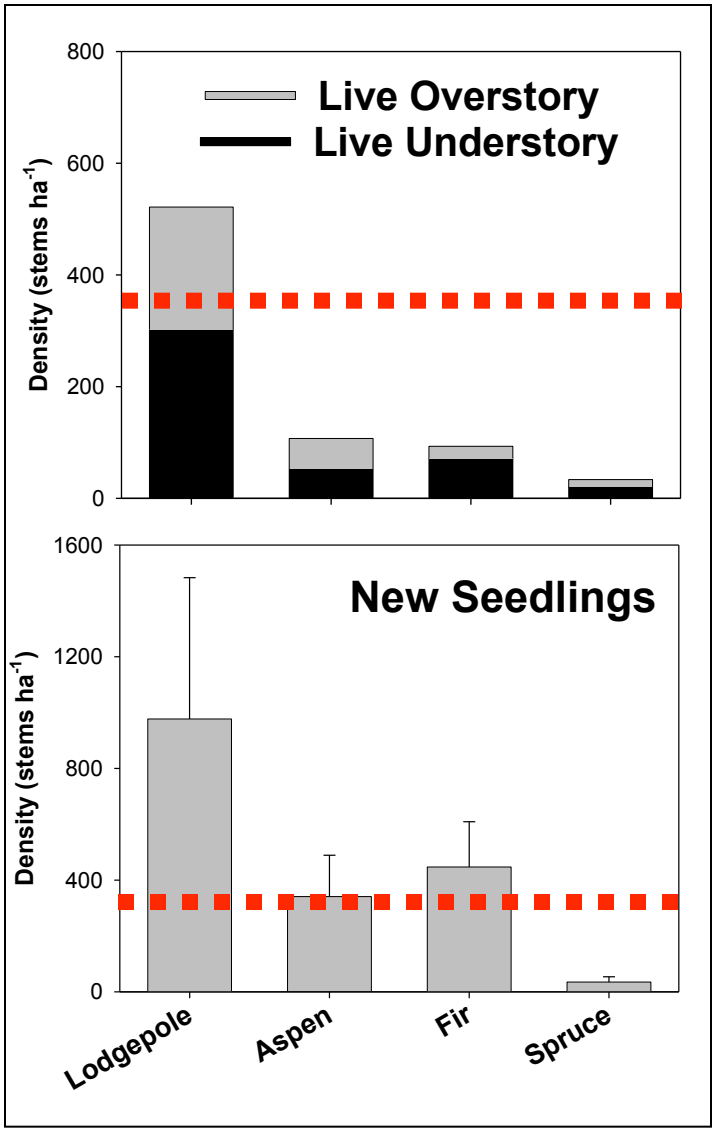
80-90% of basal area

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

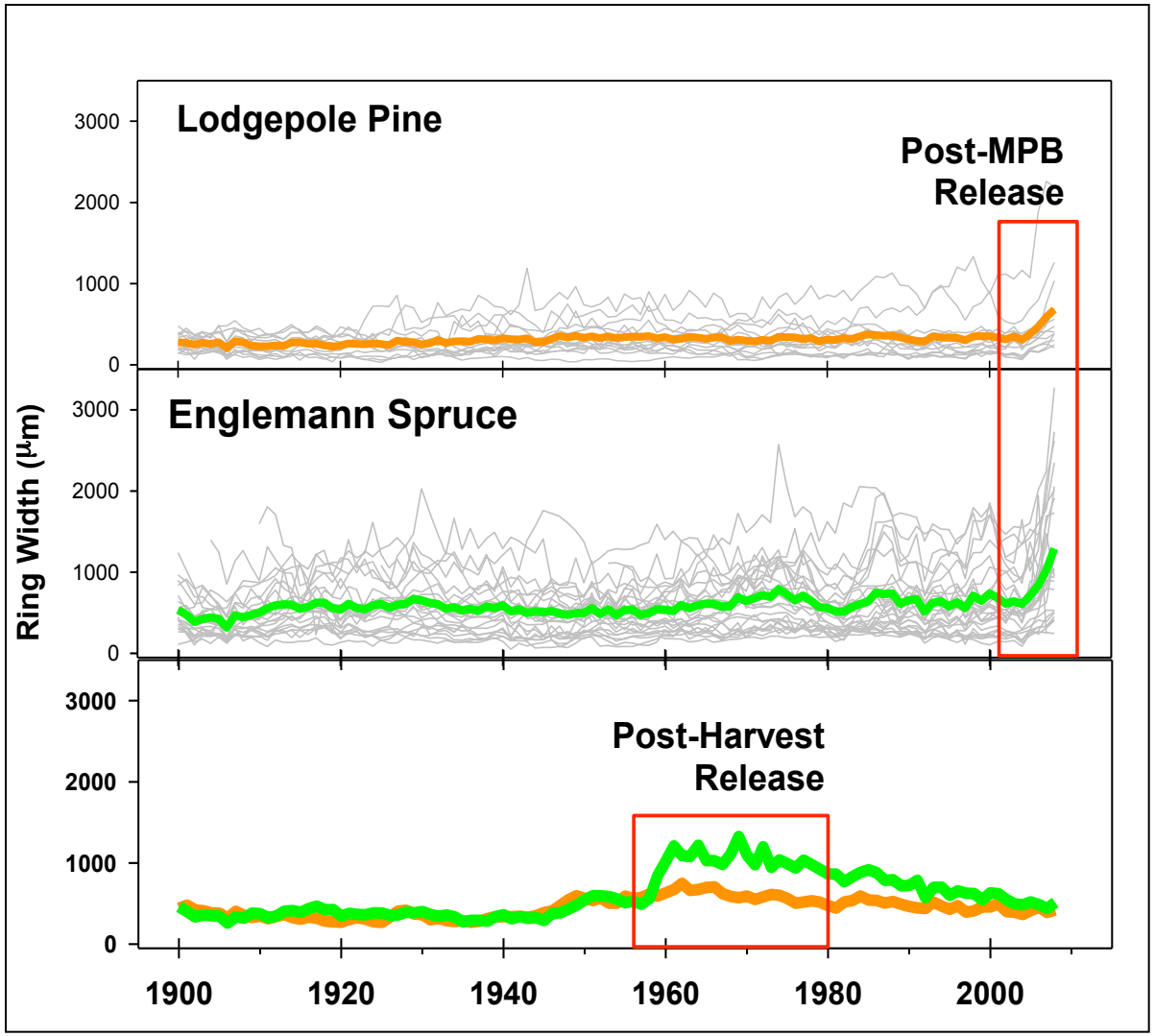
New Recruits

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

***Stocking Levels**

370 t/ha (150 t/Ac)

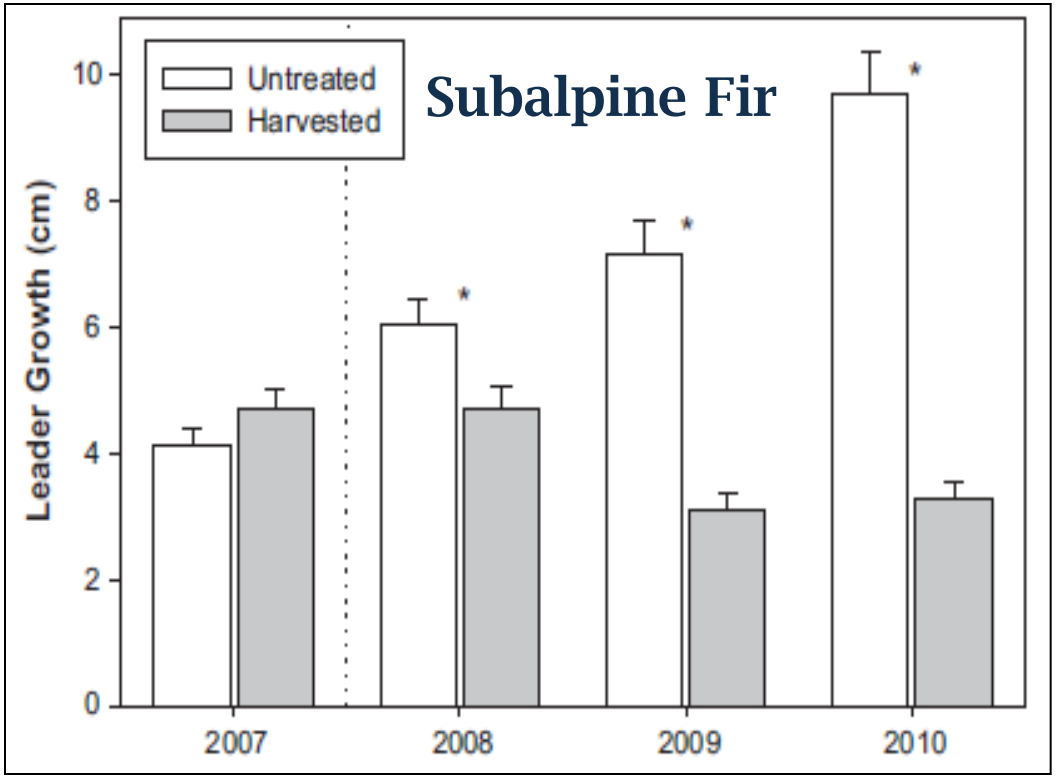
Overstory Growth Response



- **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

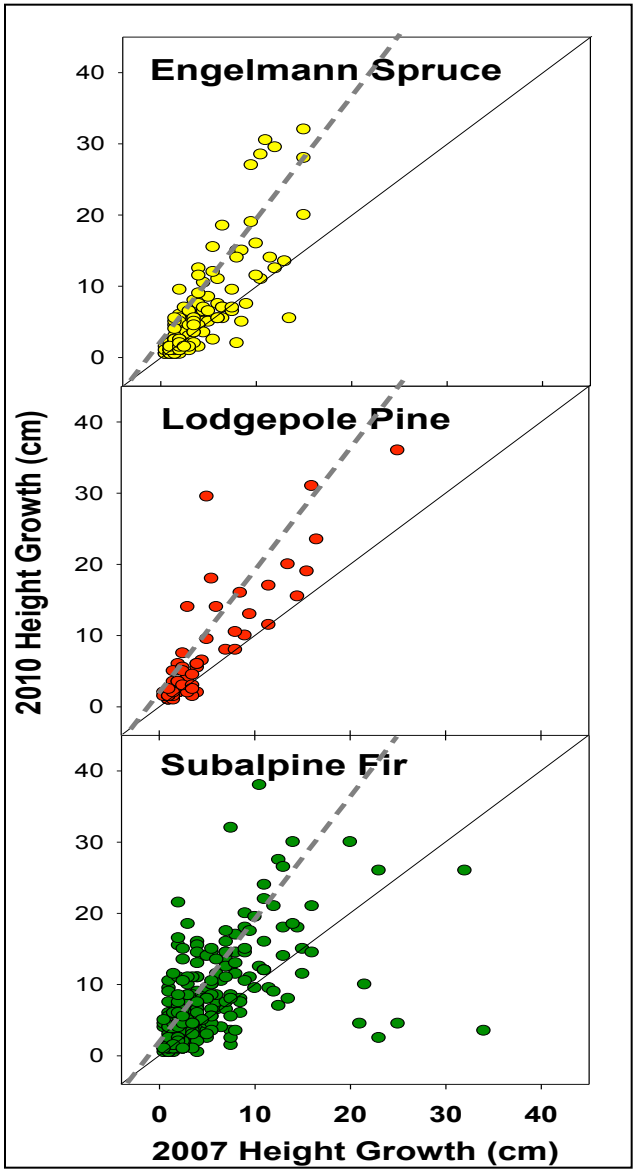
*Assessed 123 cores in 4 basins

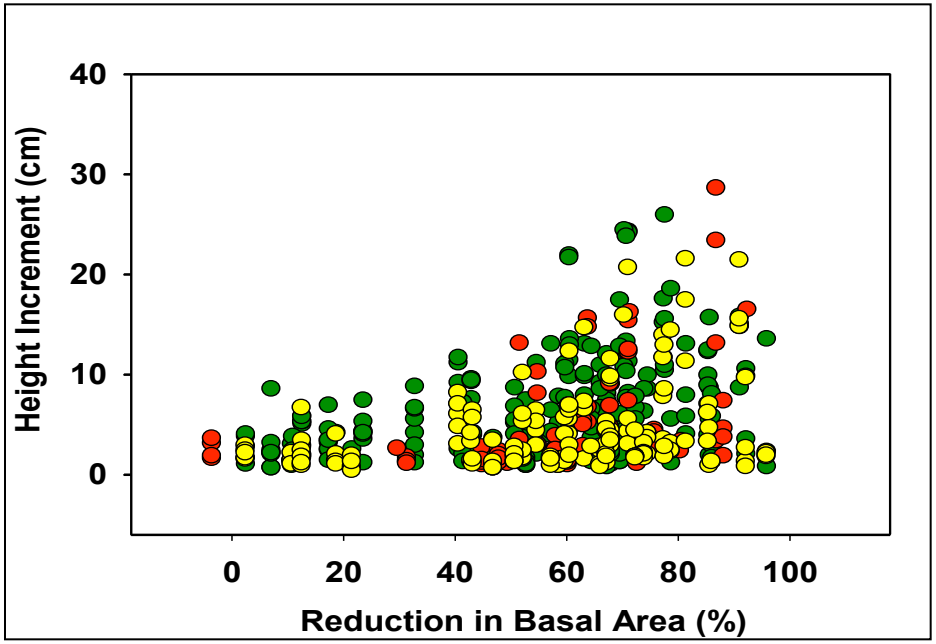
Understory Growth



Annual height growth of Fir & Pine has doubled since infestation beneath the dead overstory, but neither has responded in cuts.

Understory Growth

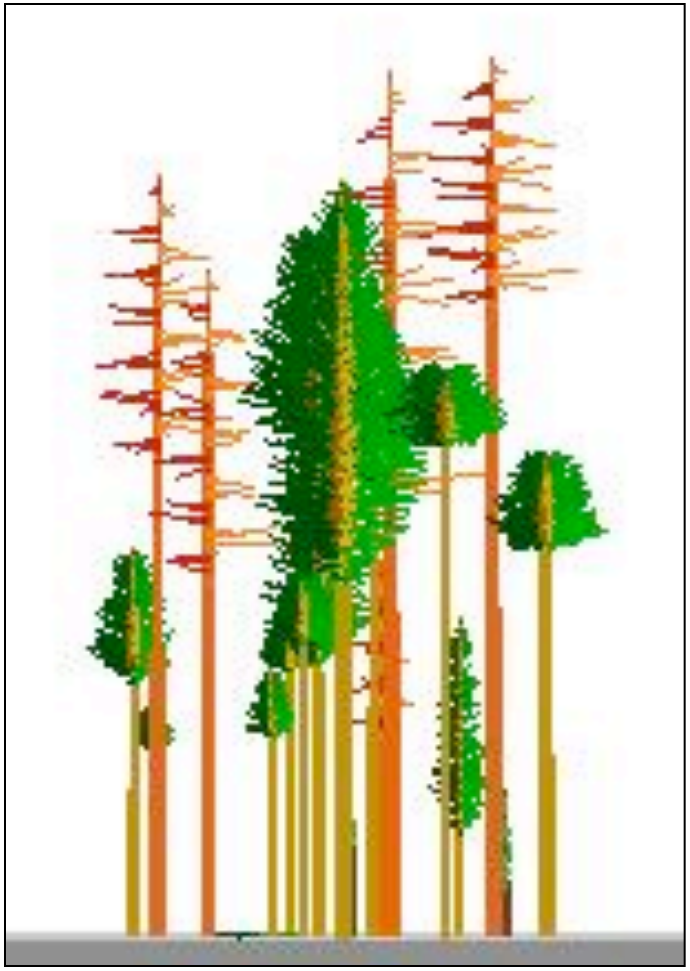


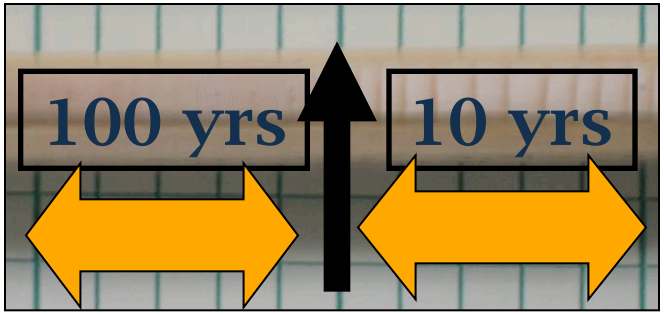


40% of trees added > 2X more height in '10 as in '07. Proportionally, fir was most likely to double height; spruce was least likely.

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

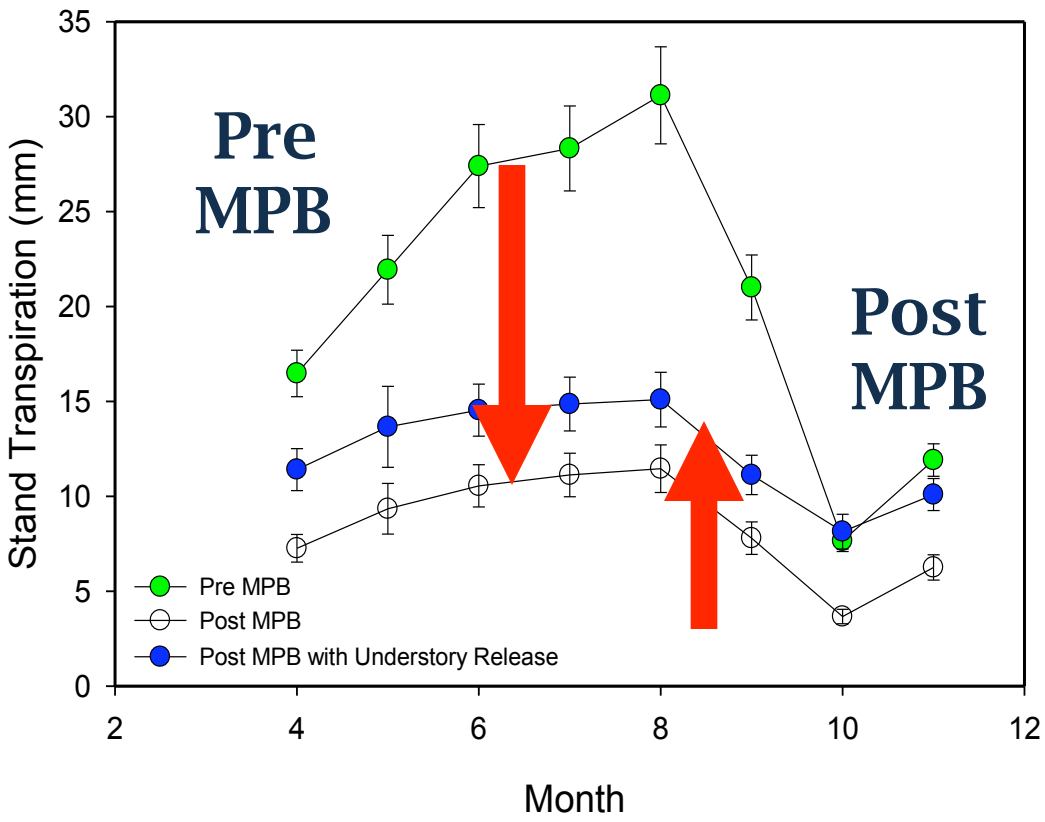
Young trees use more water for a given amount of needles than old trees.

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

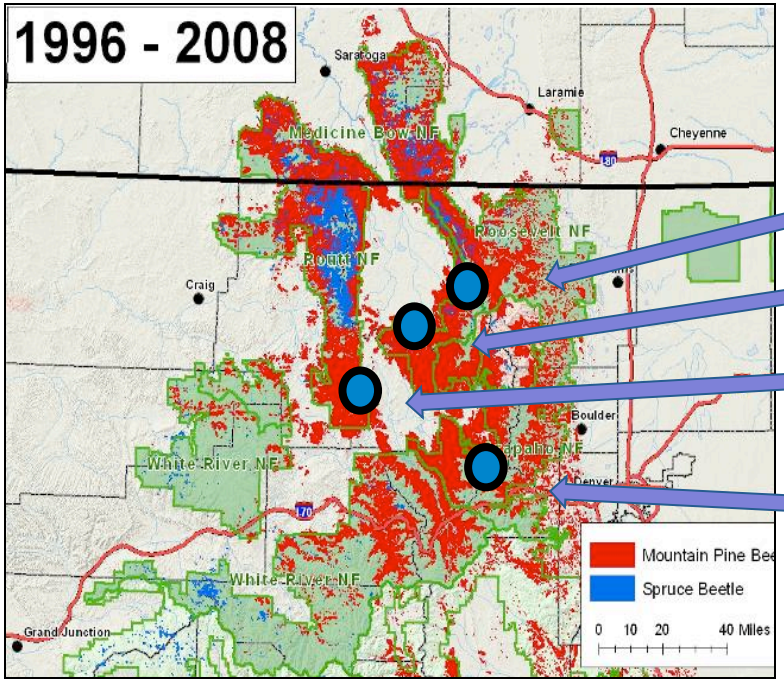


R. Hubbard, unpublished

Part 2 - Management Implications

Harvest vs. Retain?

Specific harvesting practices



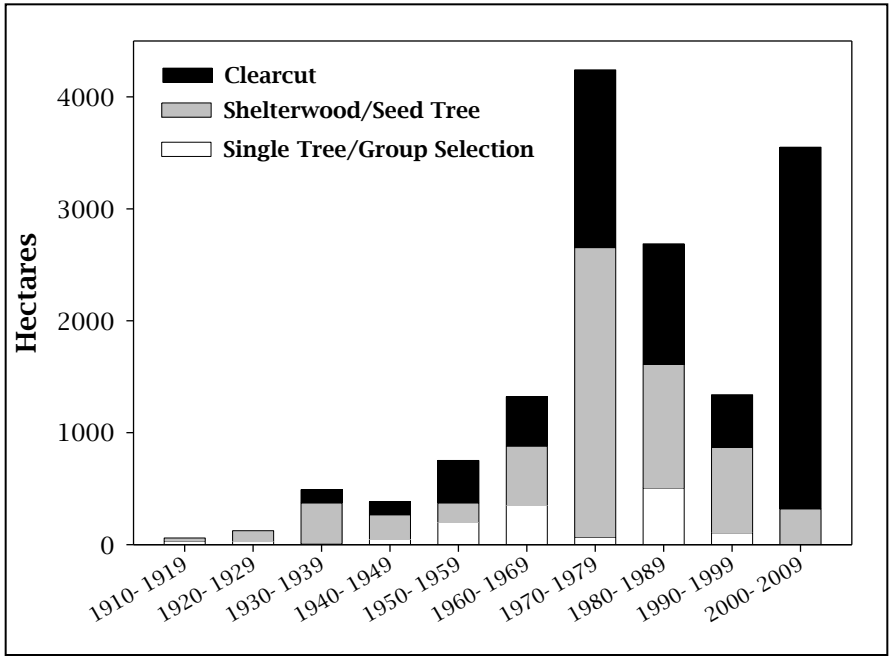
CO State Forest

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

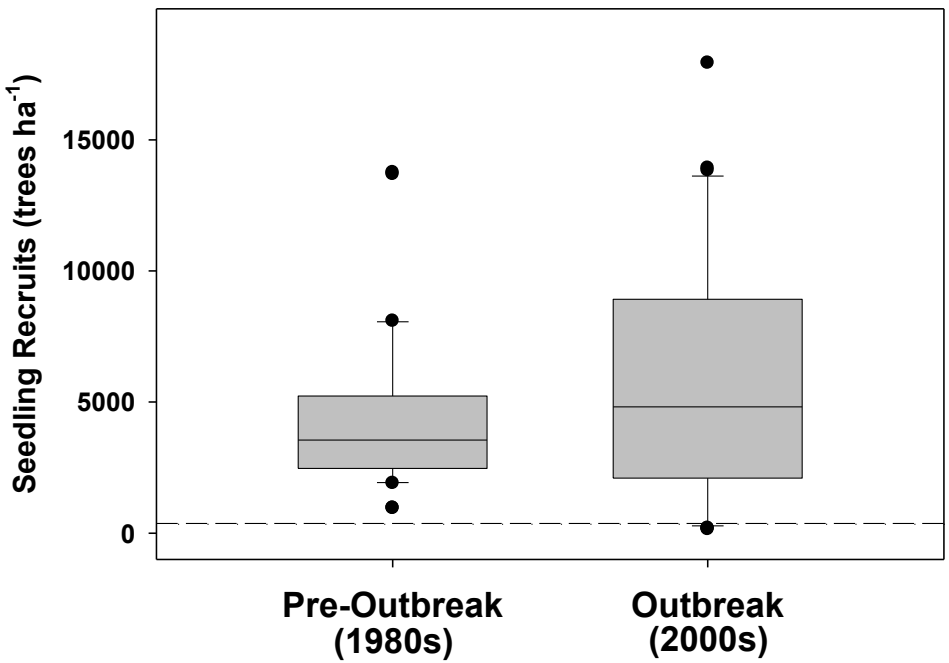
However:

<50% of infested area is treatable;

of that < 30% will be cut

90% of infested area will be untreated

Post-Harvest Recruitment



Are there concerns about seedling colonization after harvest of MPB stands?

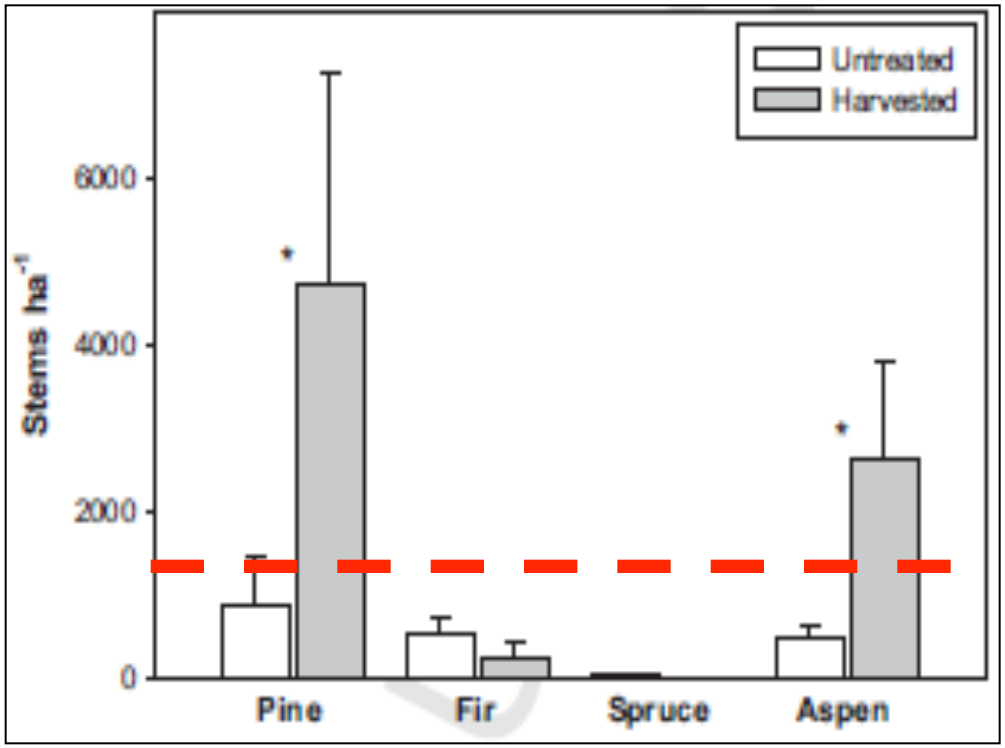
Since the outbreak, pine recruitment has been at least equal to previous decades

> 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

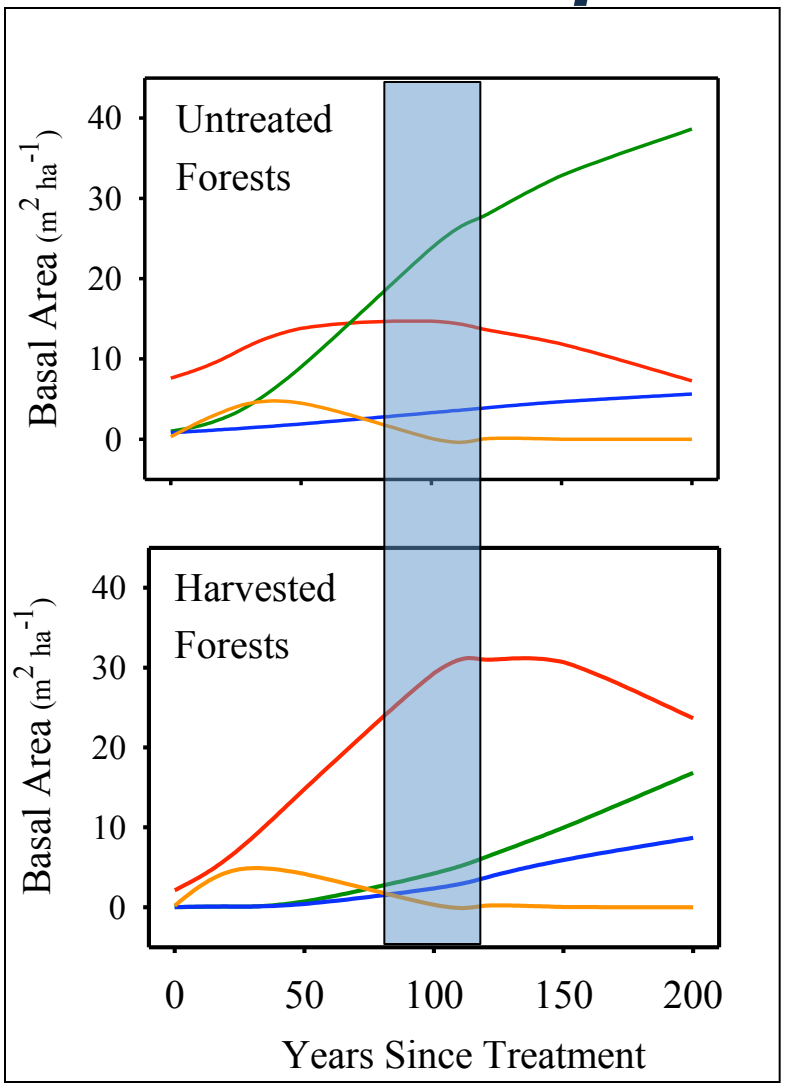
*Cut stands meet minimum stocking requirements
(i.e., > 150 t/acre)

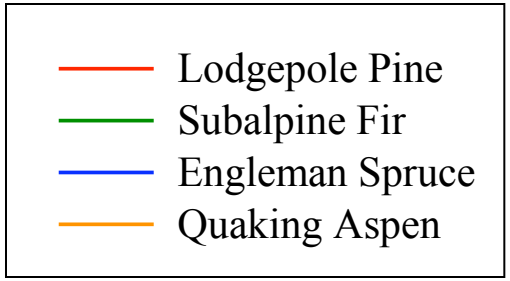
*8 paired sites at Fraser

(Collins et al. 2010b)

Stand Dynamics

Future Species Composition





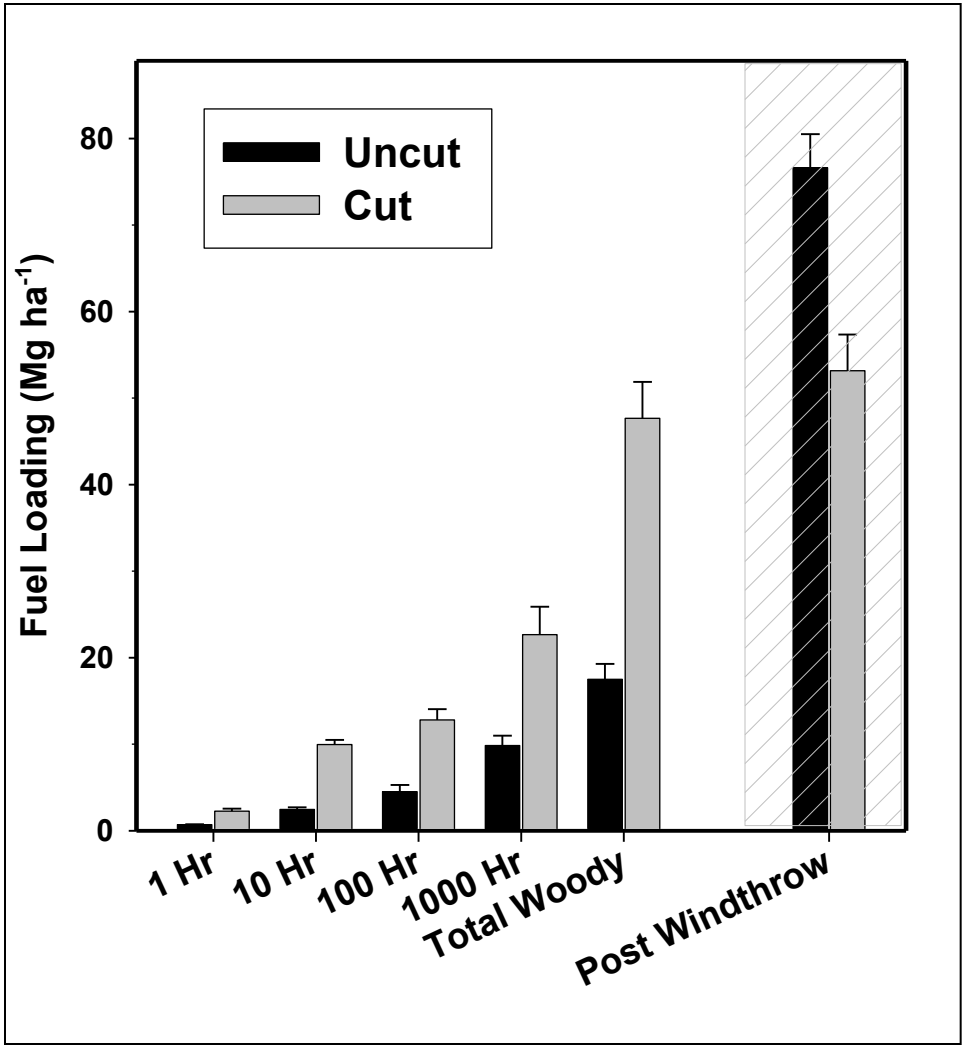
Forest Recovery -
MPB-killed stands recover to pre-MPB stand structure in a century

Uncut & Partial Cut Stands
Dominated by fir

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

(Collins et al. 2010b)

Response to Management
Surface Fuels



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

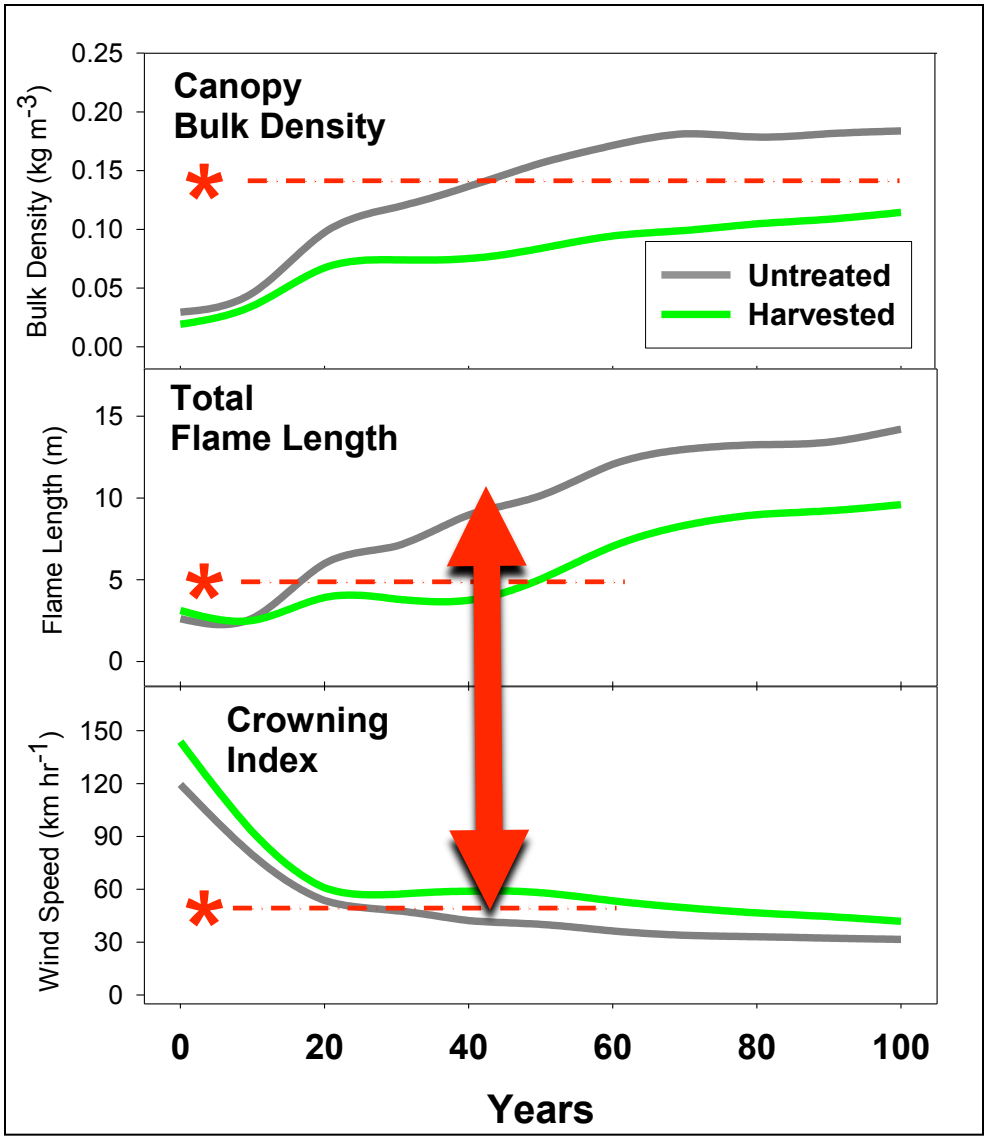
2.5 m - halt dozers

Windthrow will increase the surface load in uncut areas

~1.4x higher than cut areas

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, 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

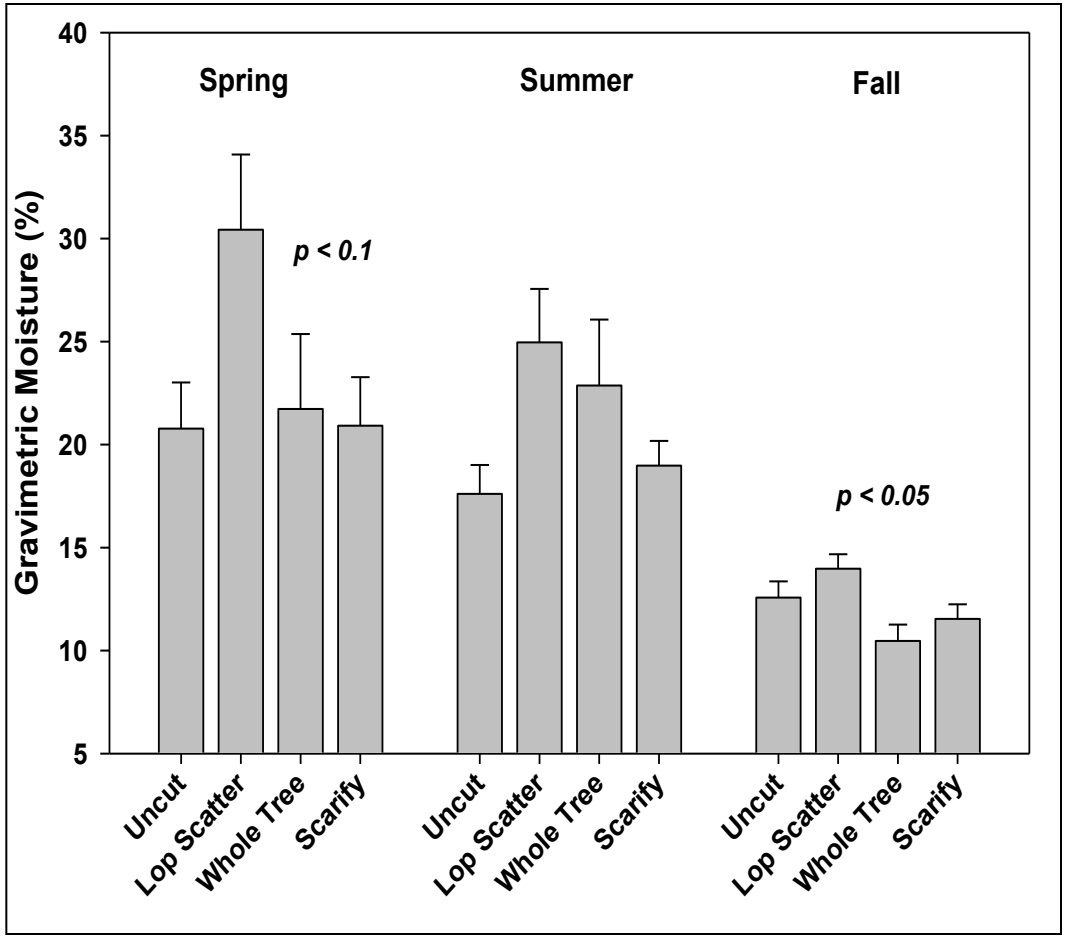
Water Delivery
Lop and Scatter Slash Retention

Fuel Reduction
Whole Tree Harvest

Forest Regeneration
Mechanical Scarification Site Prep

Response to Management Options

Soil Moisture



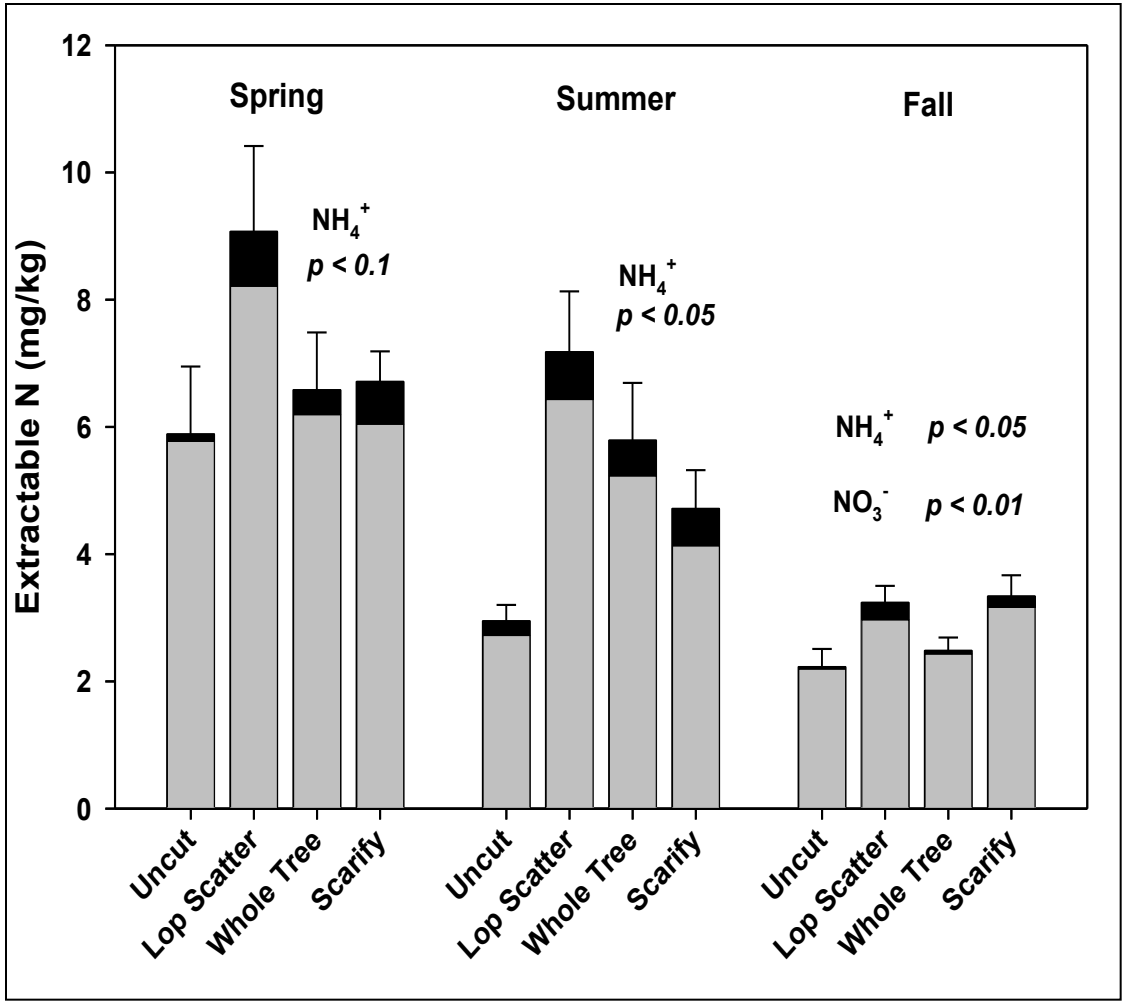
Soil moisture was highest in slash retention treatment

Scarification

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

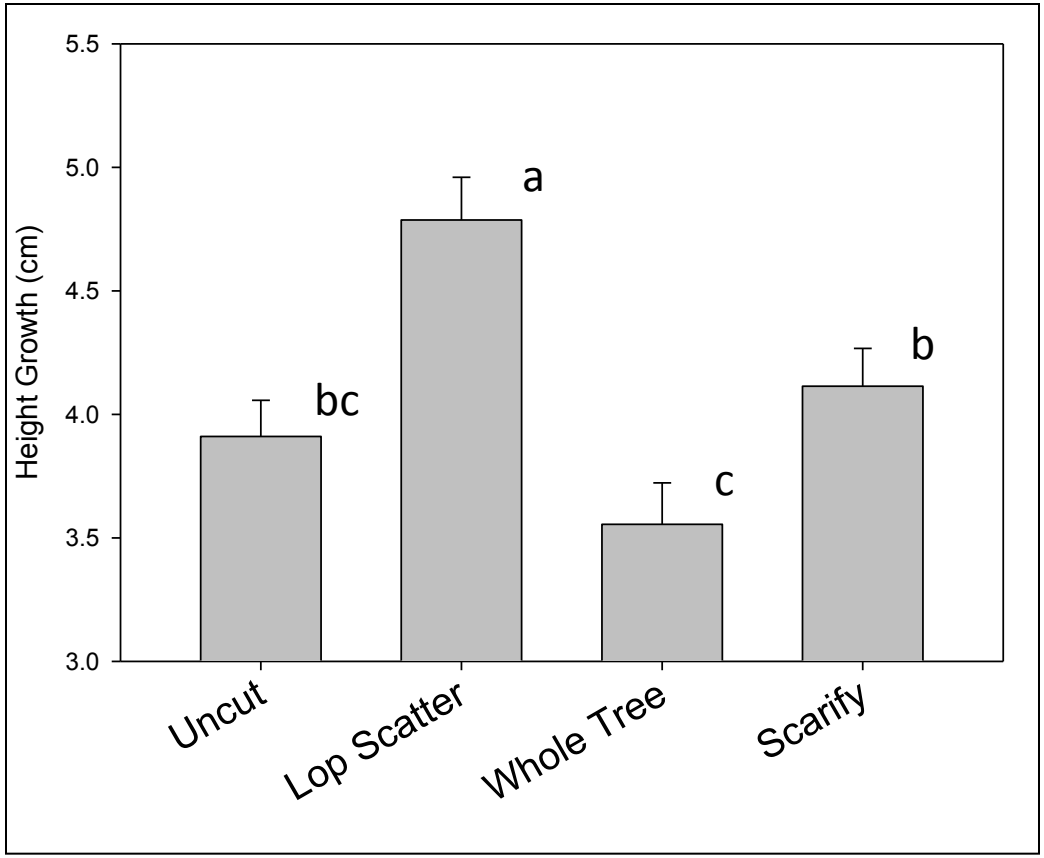
Cut vs Uncut

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)

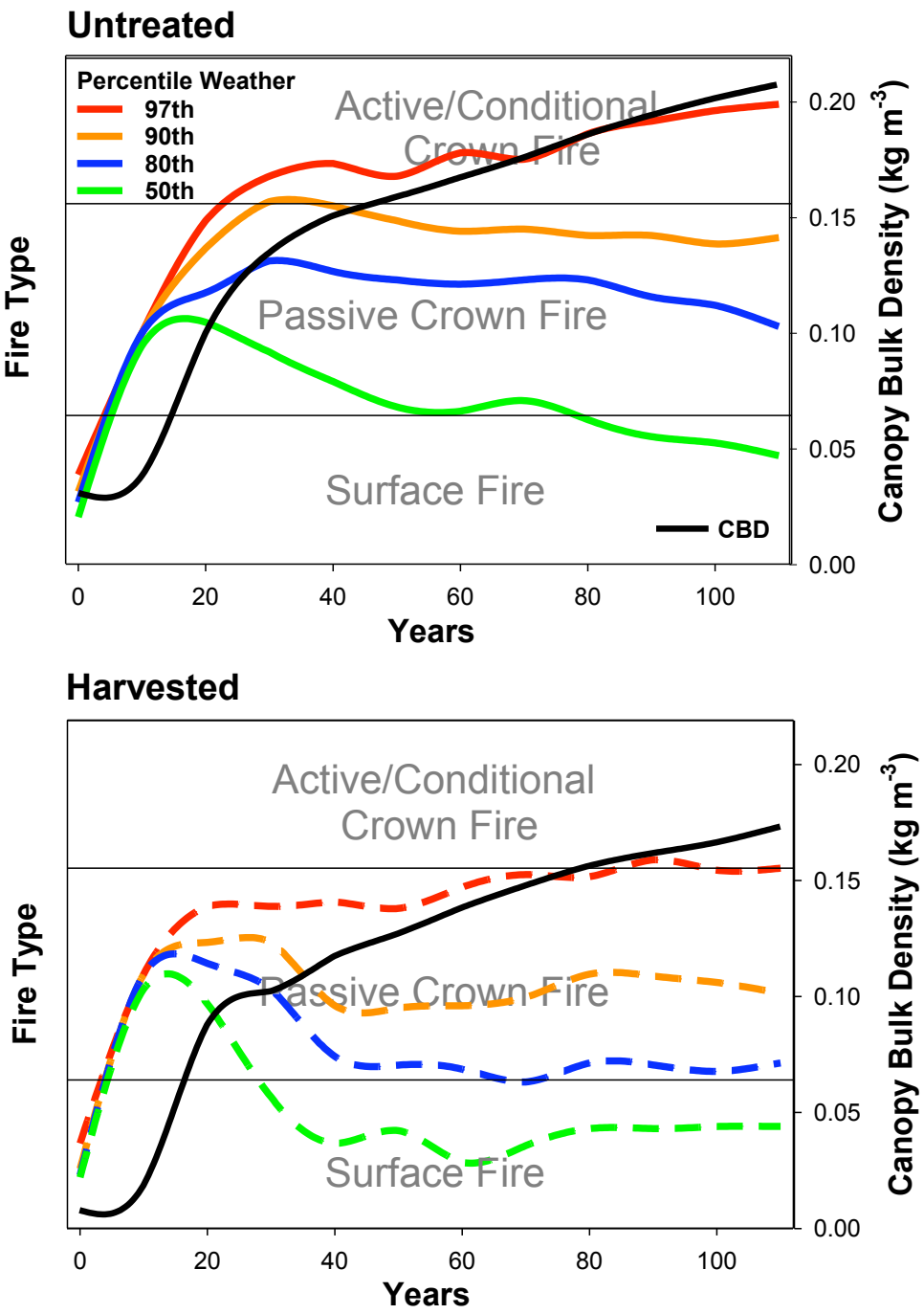
Uncut stands were dominated by fir and spruce

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
Active/Conditional Crown Fire
Passive Crown Fire
Surface Fire
CBD
Fire Type
Canopy Bulk Density (kg m-3)
0.00
0.05
0.10
0.15
0.20
0
20
40
60
80
100
Years
Harvested
Active/Conditional Crown Fire
Passive Crown Fire
Surface Fire
Fire Type
Canopy Bulk Density (kg m-3)
0.00
0.05
0.10
0.15
0.20
0
20
40
60
80
100
Years