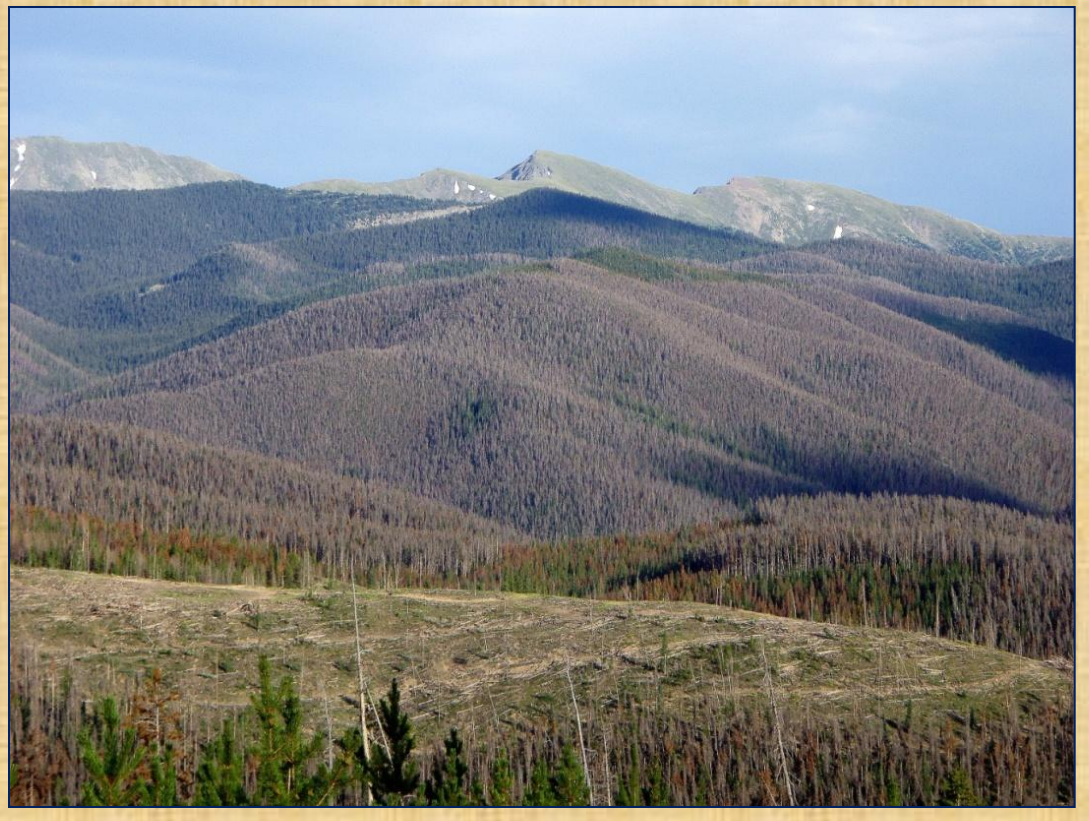
Ecosystem Changes after Pine Beetle and Salvage Logging in Colorado Subalpine Forests



*Presented by
Byron Collins at:

Front Range Fuels Treatment Partnership Implementers' Meeting

Lakewood, CO
7 March 2012

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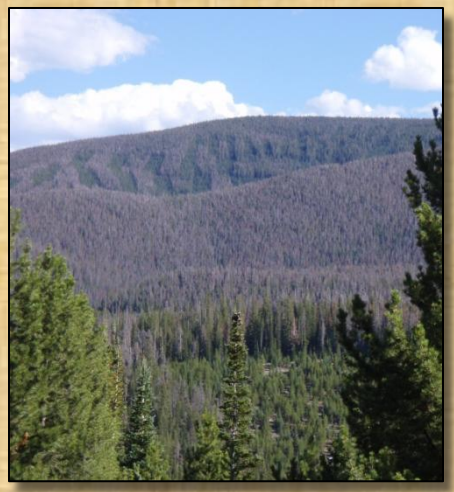
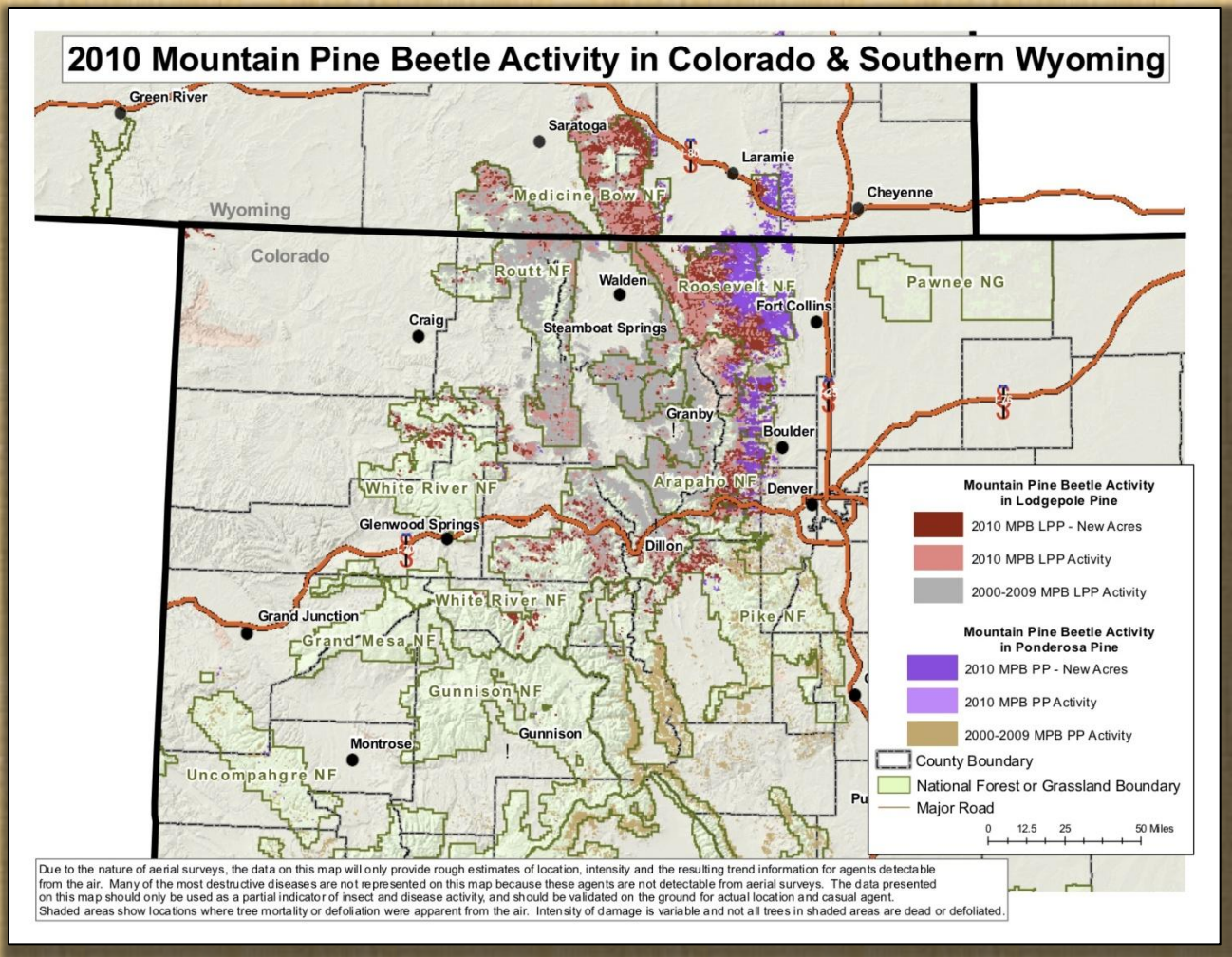
USFS Rocky Mountain Research Station
Fort Collins, CO

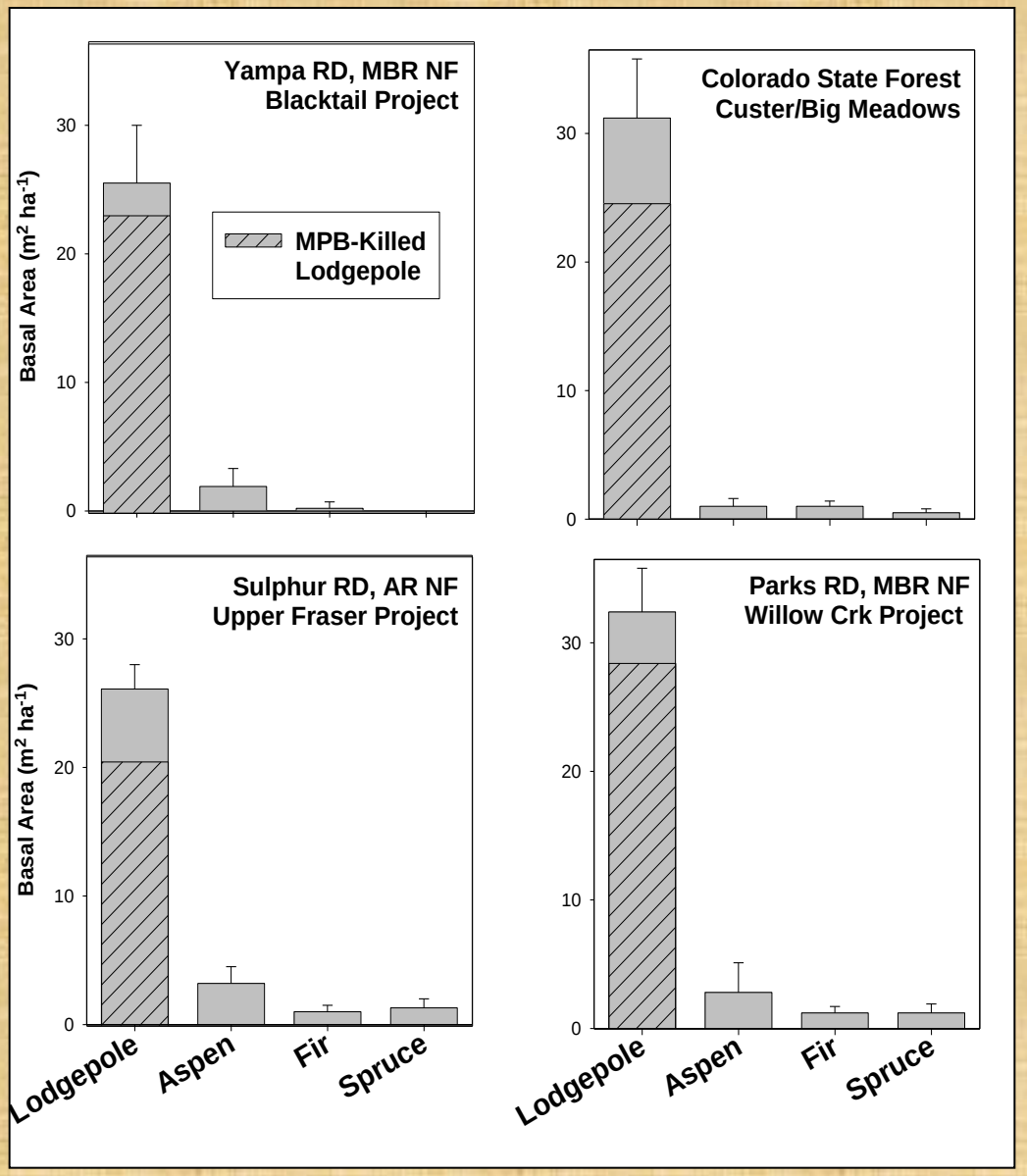
Current Outbreak

> 1.4 million hectares in CO & Southern WY since 1996





Overstory Mortality in Colorado



Pine losses

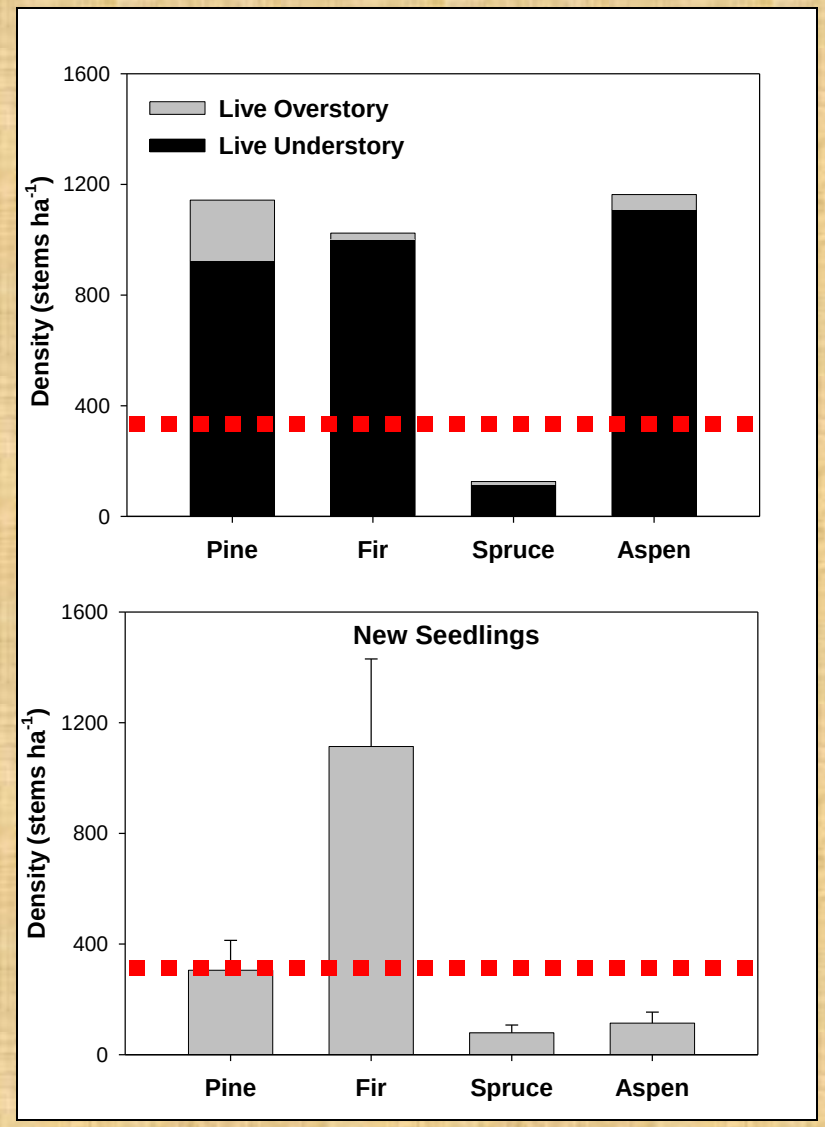
80-90% of basal area

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



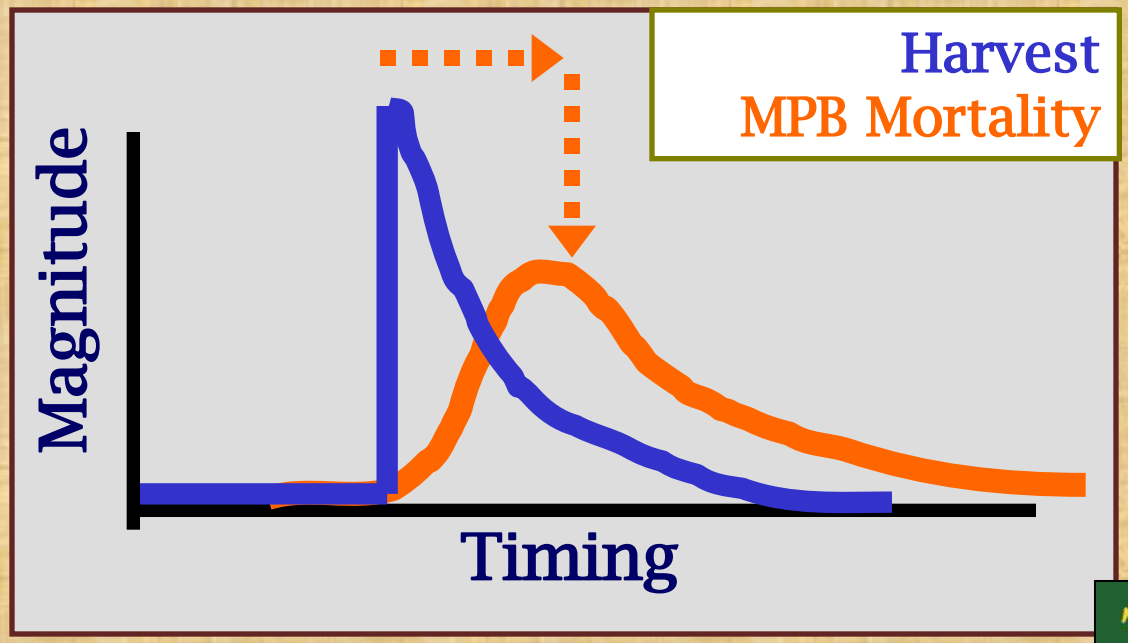
Overstory
- 312 t/ha (126 t/acre)
- 71% LPP; 18% AS; 7% SF

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



Trees are the answer

Responses Regulated by Change in

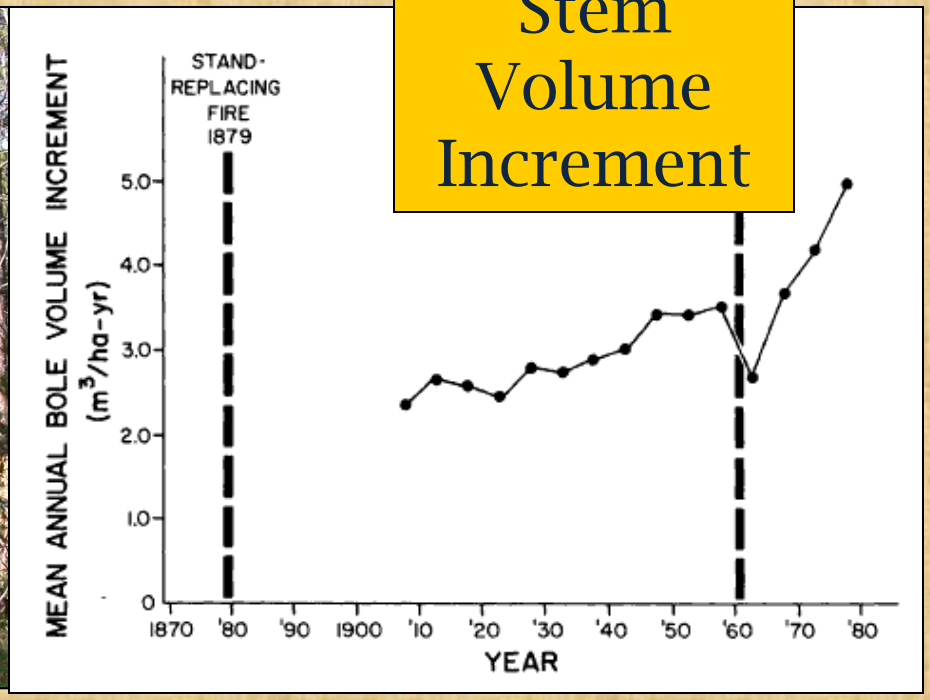
Canopy interception & Snowpack accumulation
Water uptake & Soil nutrient use

Complicating Factors

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

Previous Outbreak

Forest Growth Response



Yellowstone Area '60 & '70s

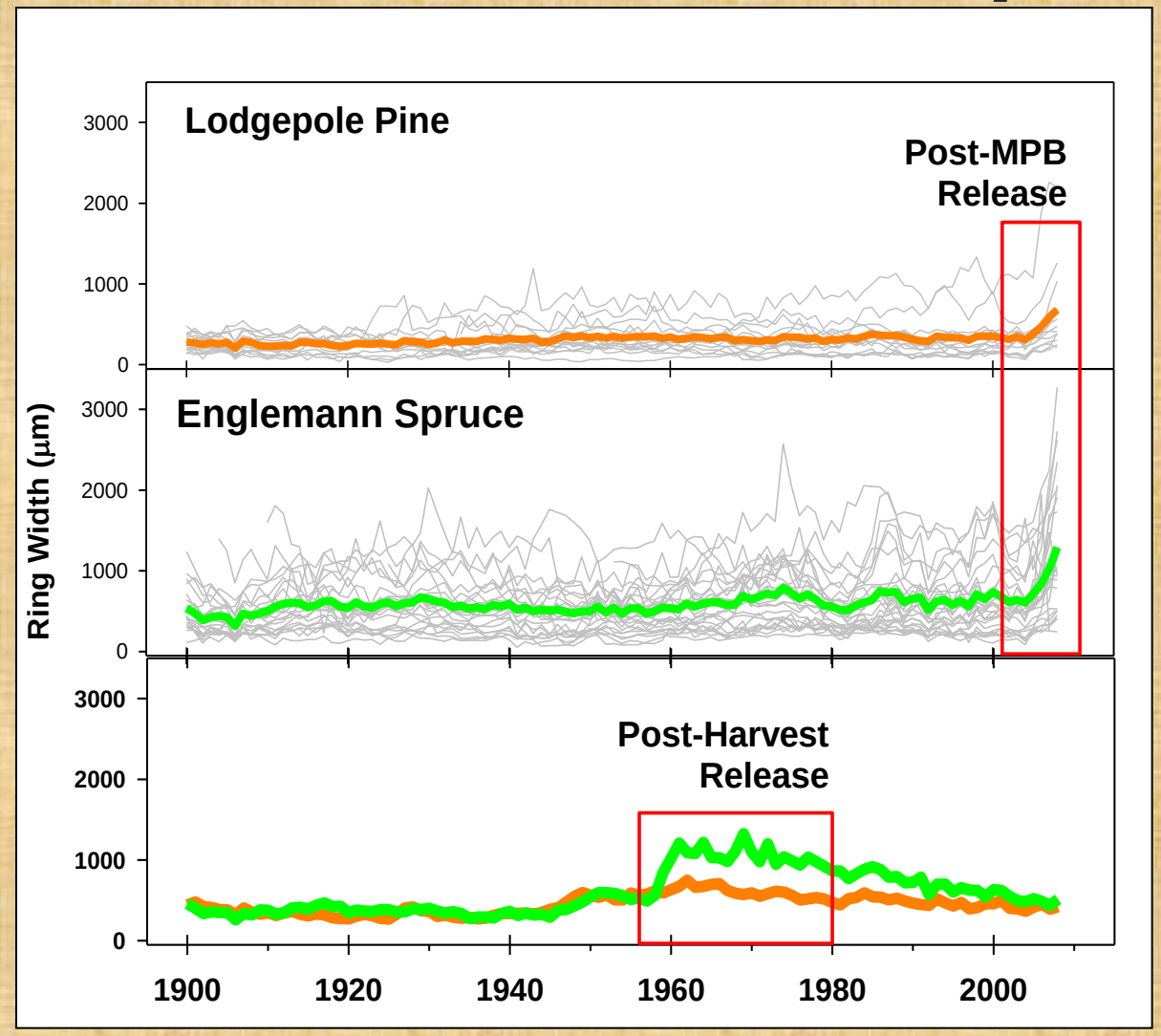
About 40-70% of the overstory trees died

Surviving trees increased growth by 2-3 fold for two decades

(Romme et al. 1986)

Current Outbreak

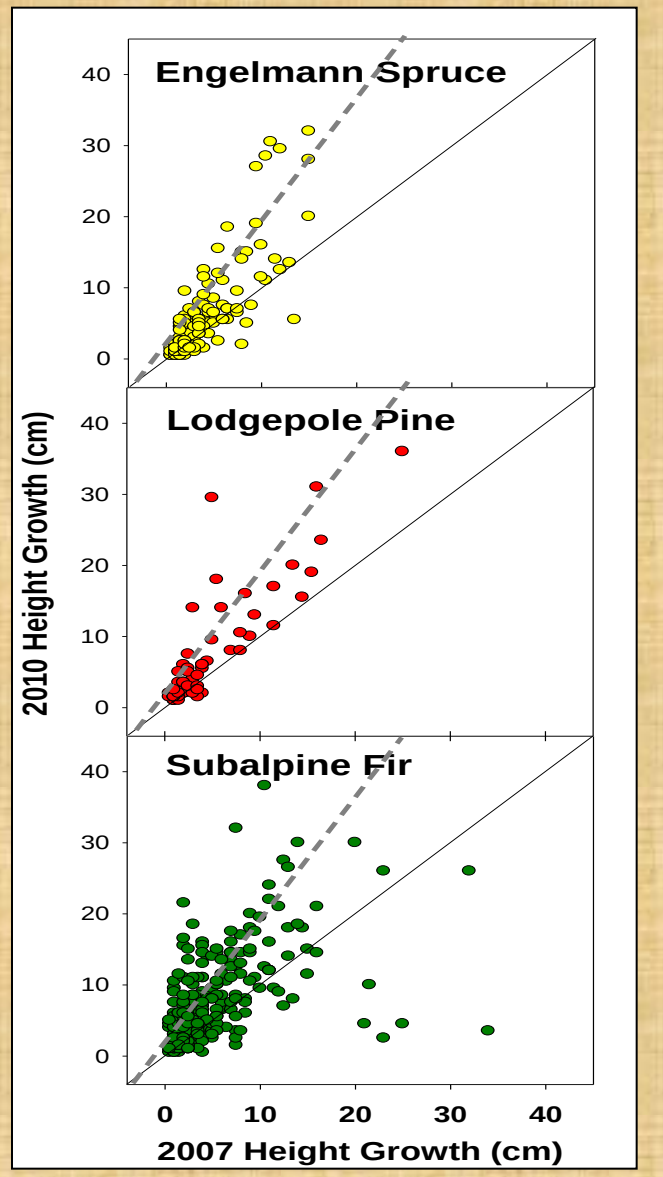
Forest Growth Response

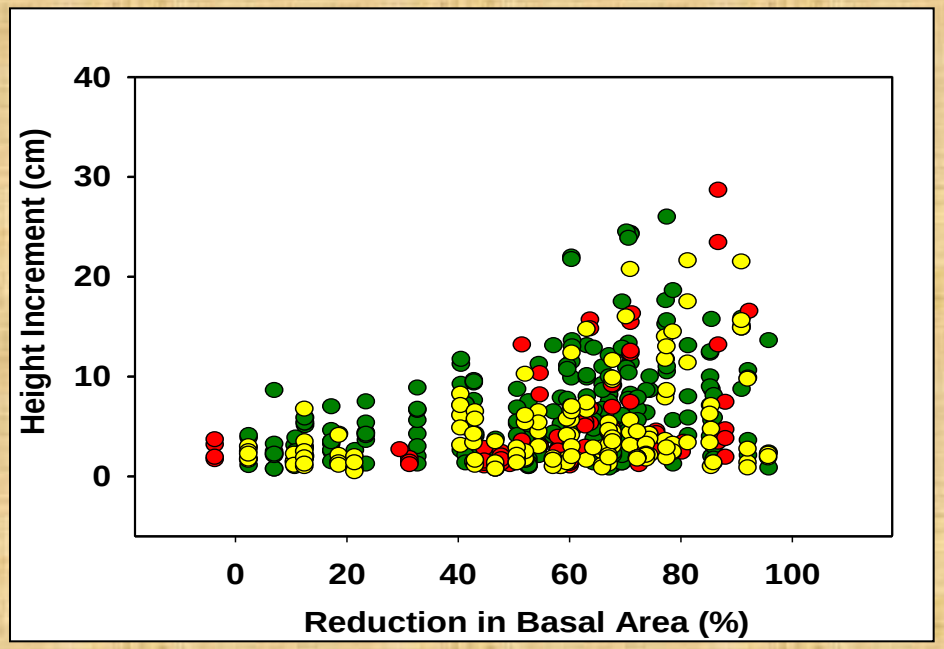


- 35% of trees grew > 25% faster since the infestation
- 16% of trees grew faster than ever
- Unrelated to precipitation
- Decline in basal area explained 10-20% of response

*Assessed 123 cores in 4 basins

Understory Tree Growth

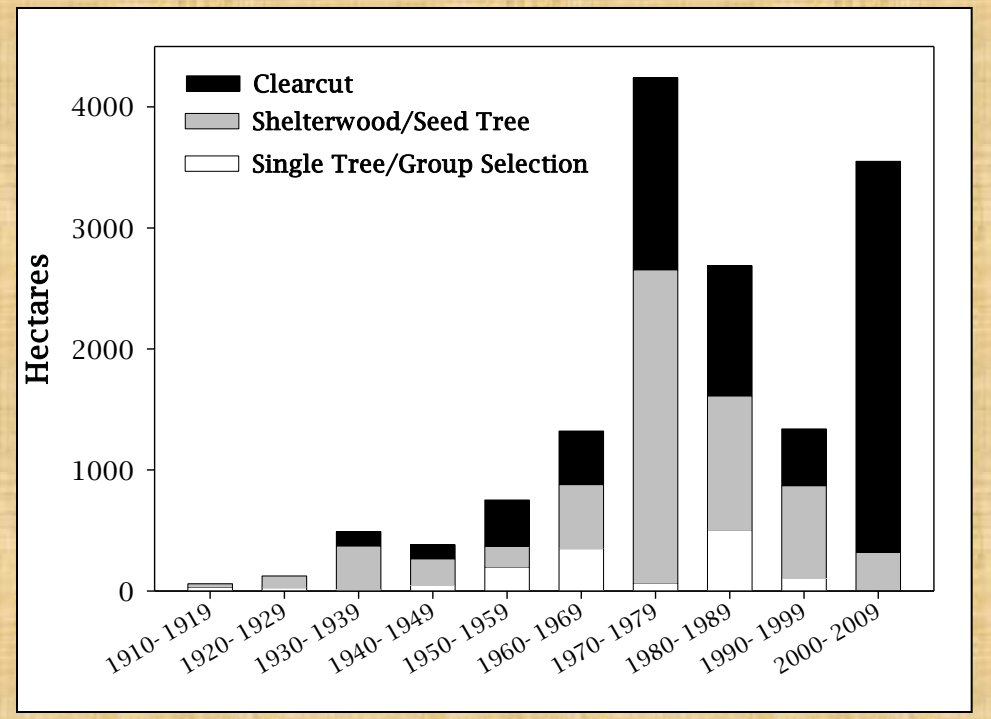




40% of trees added > 2X more height in '10 as in '07. Proportionally, fir was most likely to double height; spruce was least likely.

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

Management Response to MPB



Arapaho-Roosevelt NF, Colorado

Most harvesting since 1970s

Greatest extent of clear cutting

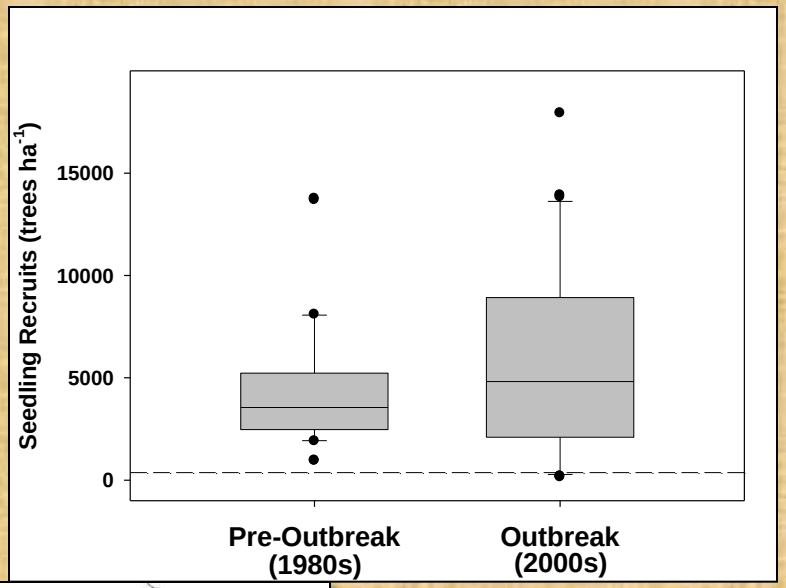
However:

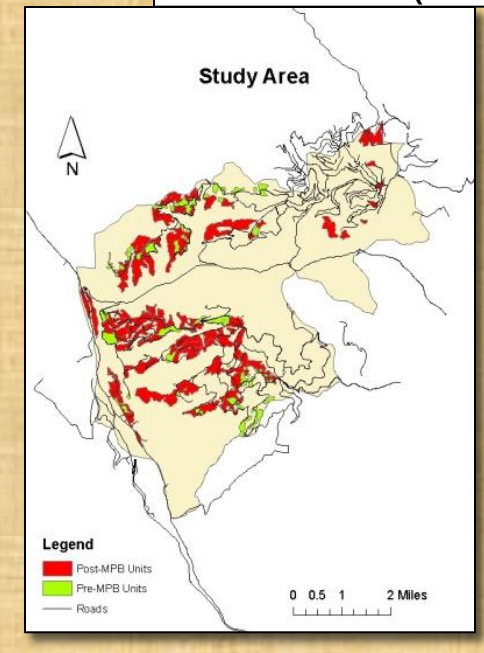
<50% of infested area is treatable;

of that < 30% will be cut

90% of infested area will be untreated

Post-Harvest Recruitment





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)

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

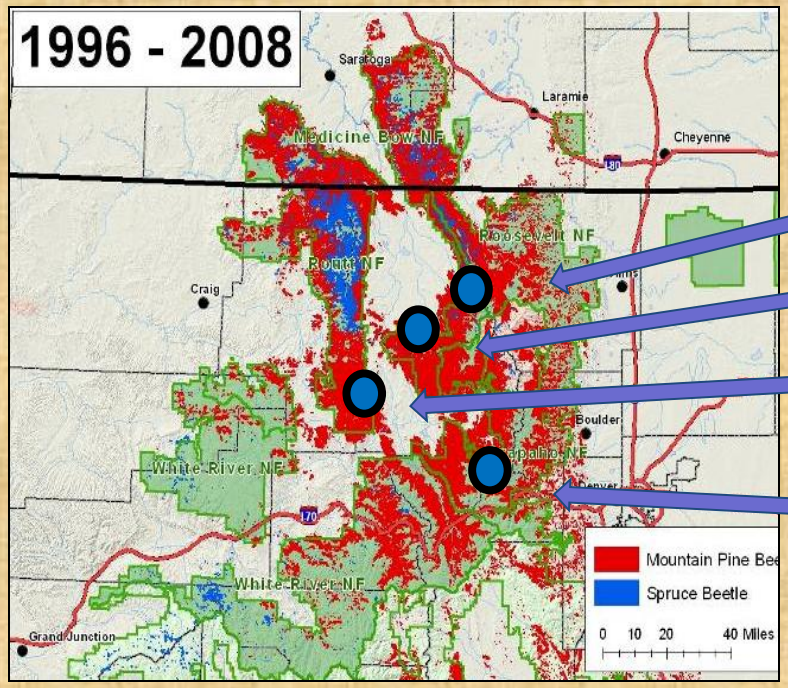
Since the outbreak, pine recruitment has been at least equal to previous decades

> 90% of units meet minimum stocking requirements

Study Areas

Harvest vs. Retain?

Specific harvesting practices



CO State Forest

Willow Ck, Parks RD

Gore Pass, Yampa RD

Fraser Expt Forest

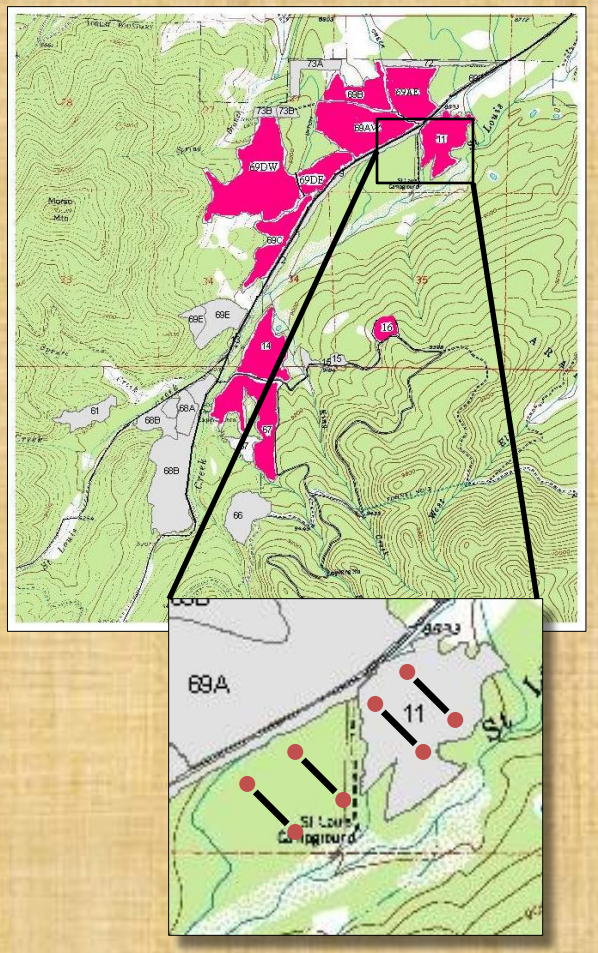
Methods

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

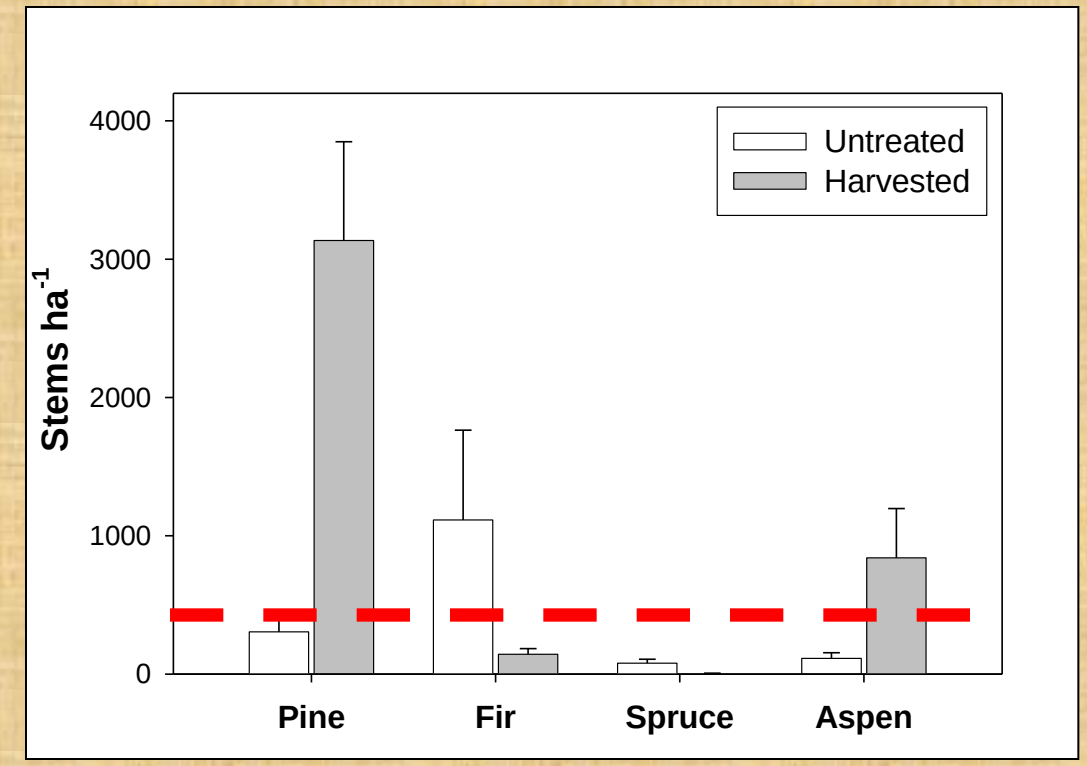
- Overstory transects (5 x 100m)

- 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

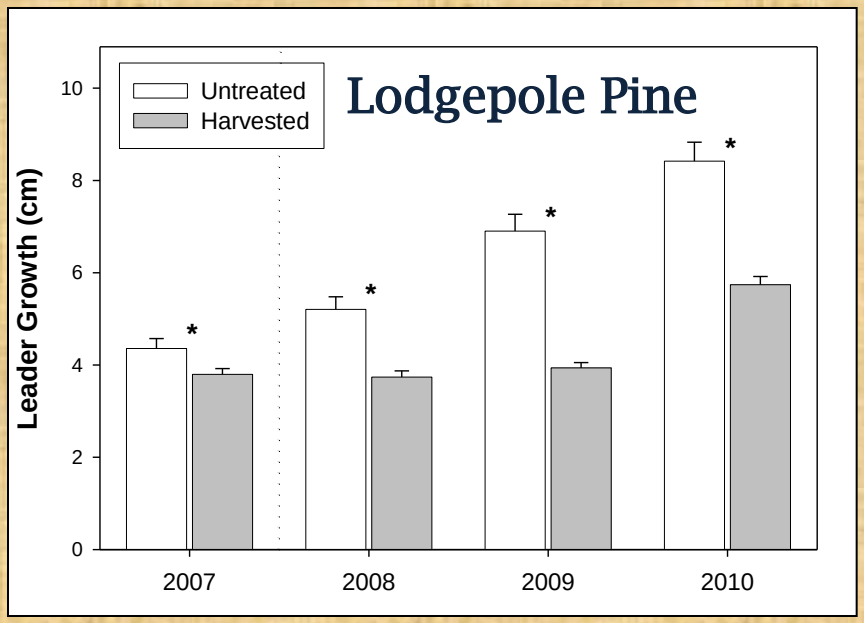
Fir recruitment is promoted in uncut stands

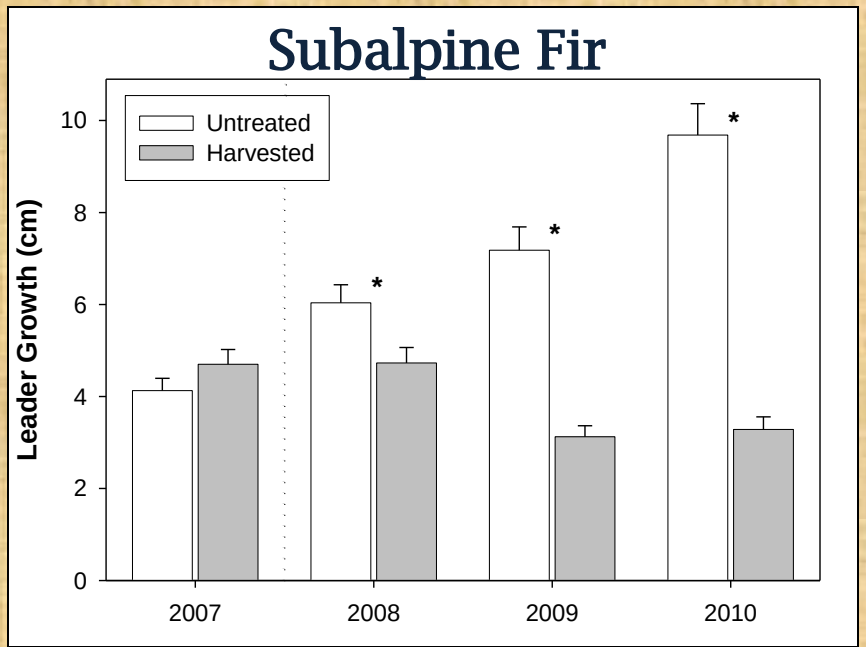
*Cut stands meet minimum stocking requirements
(i.e., > 150 t/acre)

*24 paired sites

(Collins et al. 2011)

Understory Tree Growth

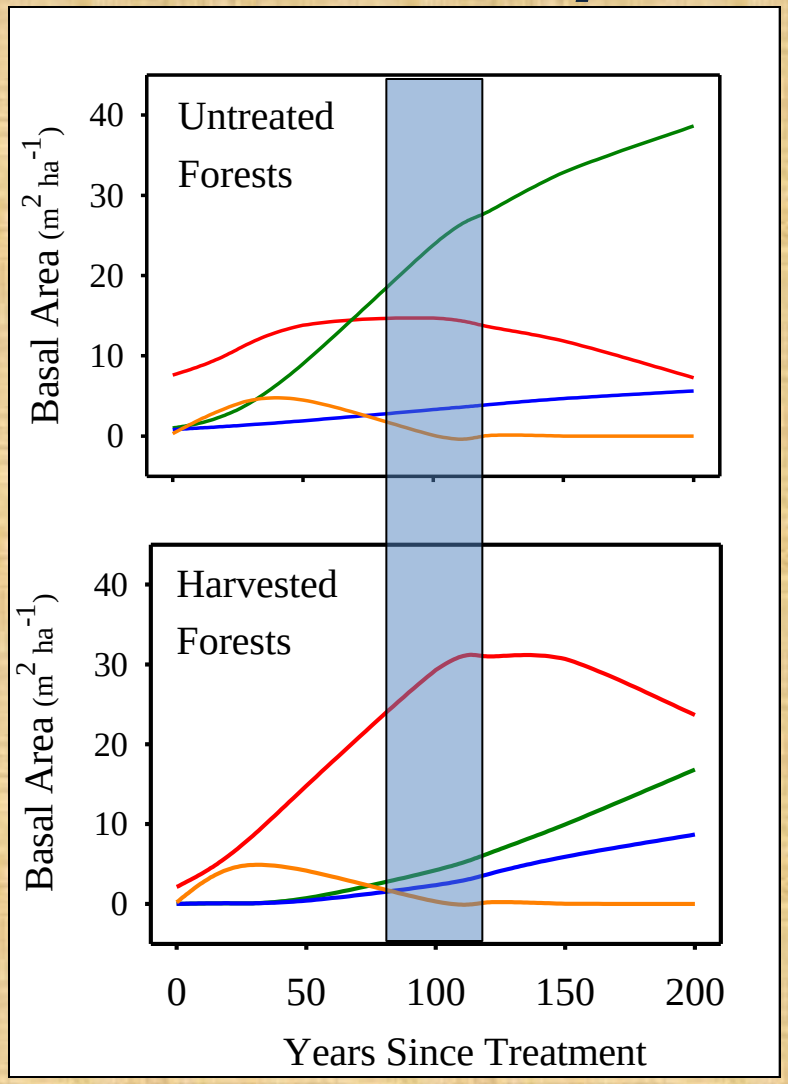


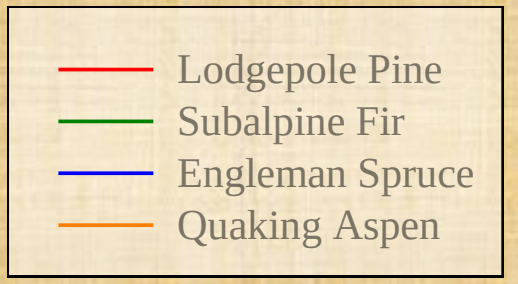


Annual height growth of Fir & Pine has doubled since infestation beneath the dead overstory, but delayed in cuts

Stand Dynamics

Future Species Composition





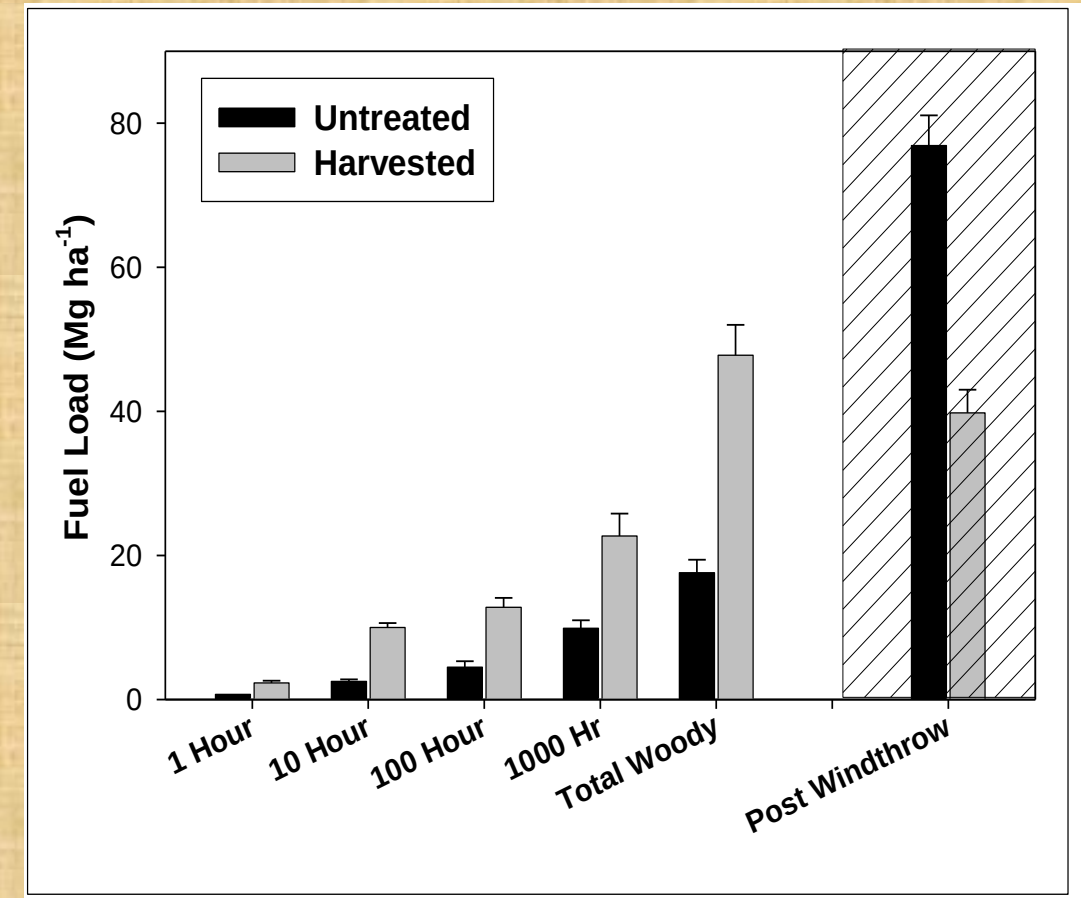
Forest Recovery -
MPB-killed stands recover to pre-MPB stand structure in a century

Uncut & Partial Cut Stands
Dominated by fir

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

(Collins et al. 2011)

Response to Management
Surface Fuels



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

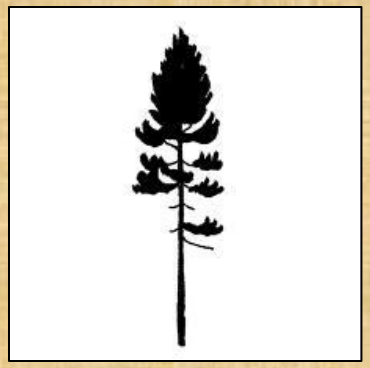
~2x higher than cut areas

Response to Management

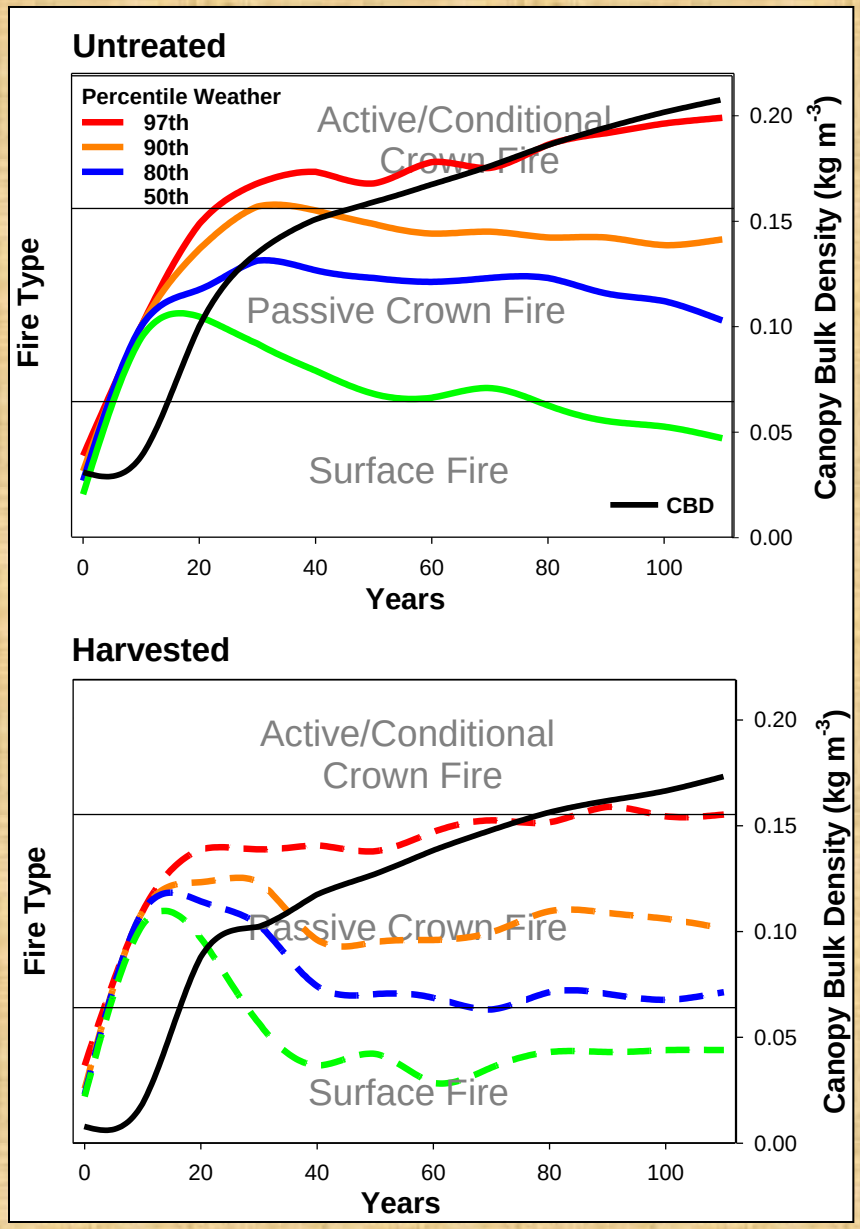
Fire Behavior

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

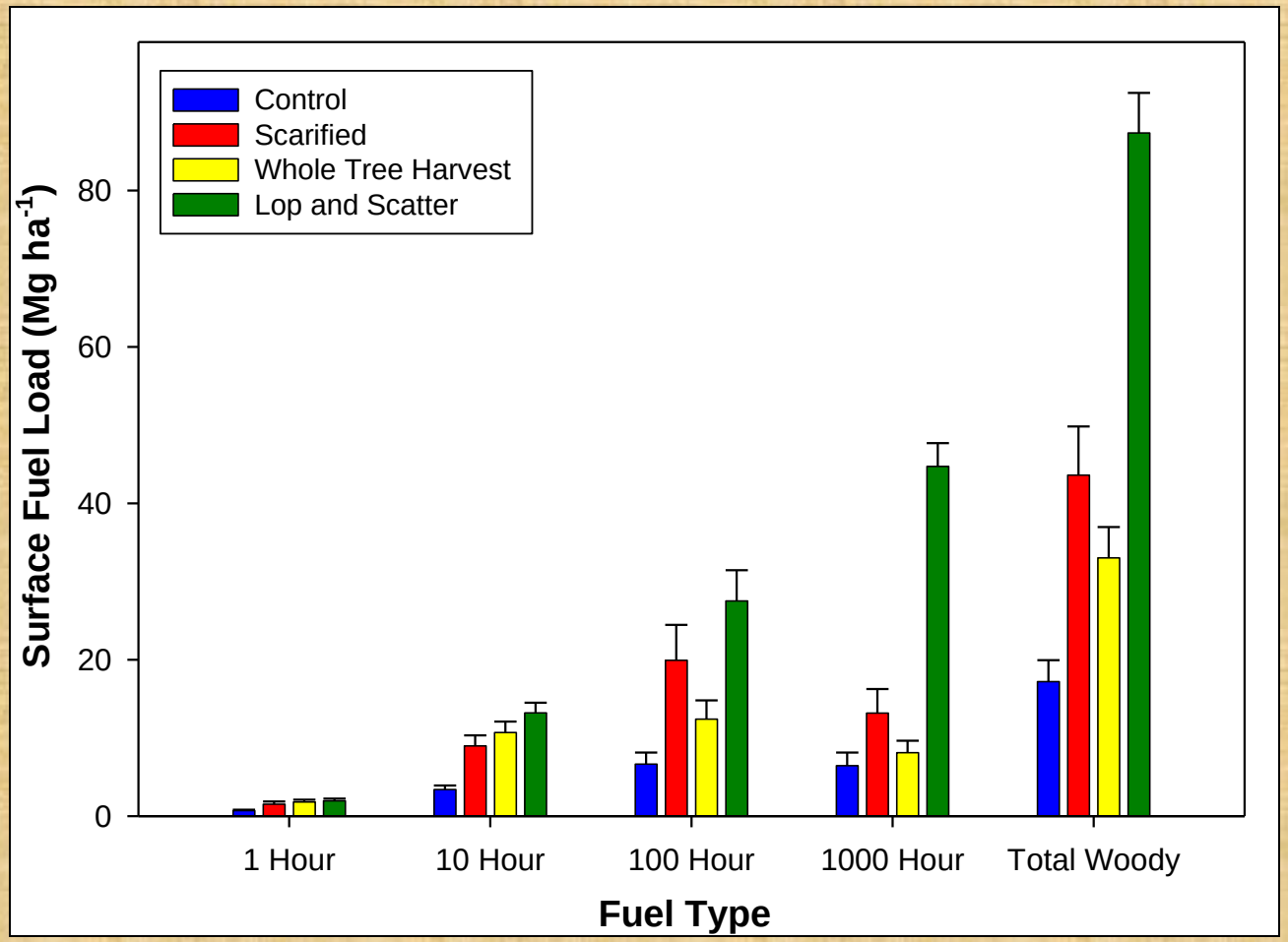
No Action
Untreated Beetle-Killed Stands

Water Delivery
Lop and Scatter Slash Retention

Fuel Reduction
Whole Tree Harvest

Forest Regeneration
Mechanical Scarification Site Prep

Effects of Slash Treatments on Surface Fuels

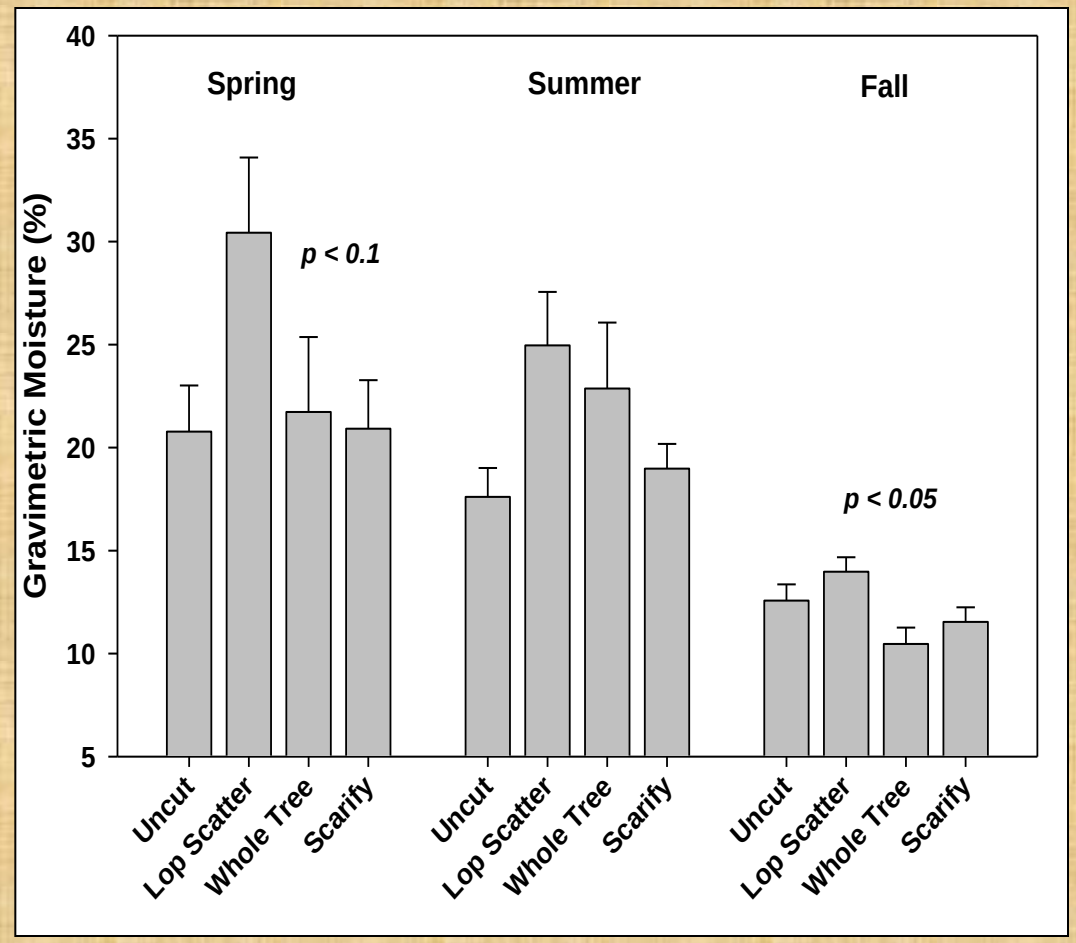


Lop and scatter treatments had 5x more fuel than control, ~2.3x more than WTH and scarification

Coarse fuels predicted to persist for more than a century

Response to Management Options

Soil Moisture



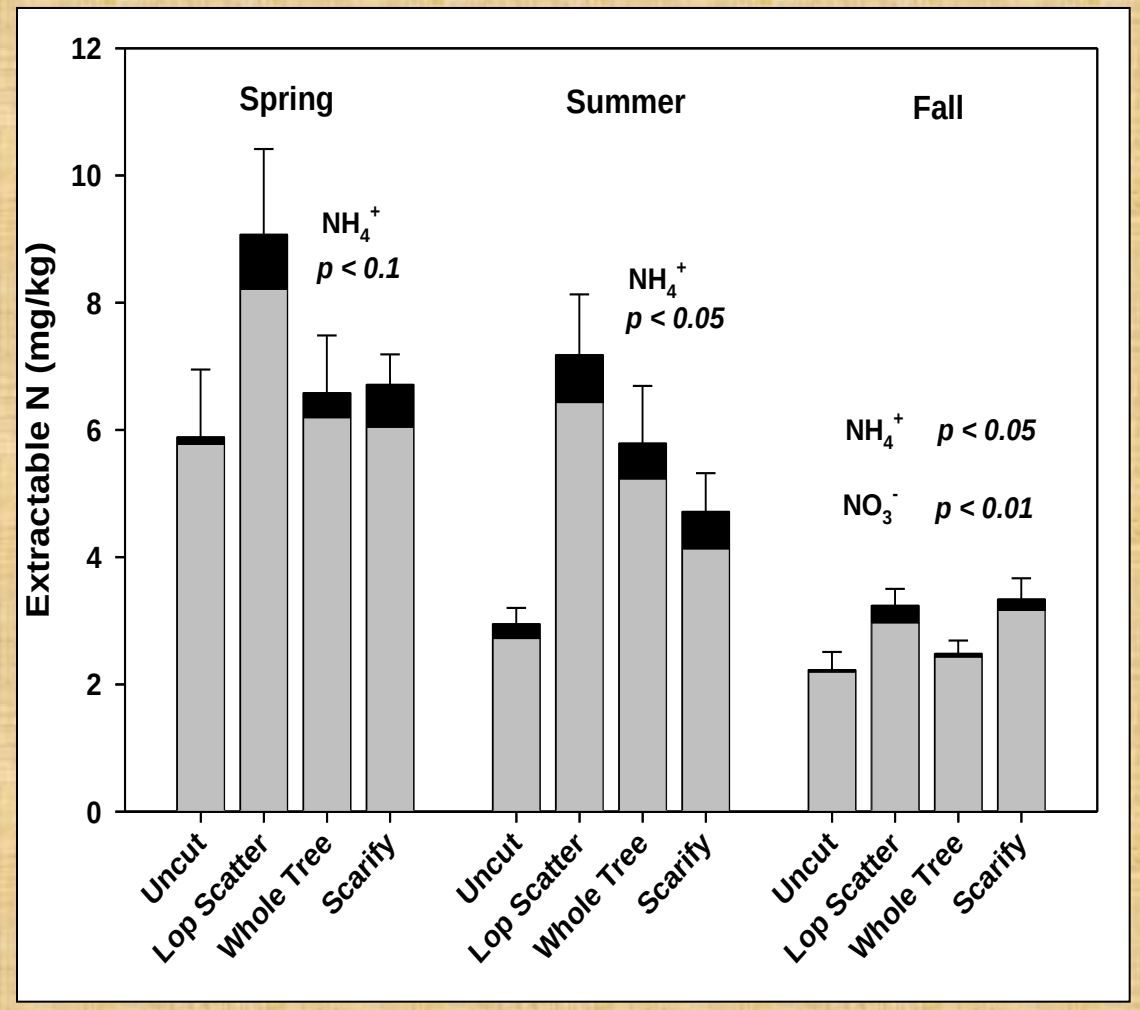
Soil moisture was highest in slash retention treatment

Scarification

driest cut option

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

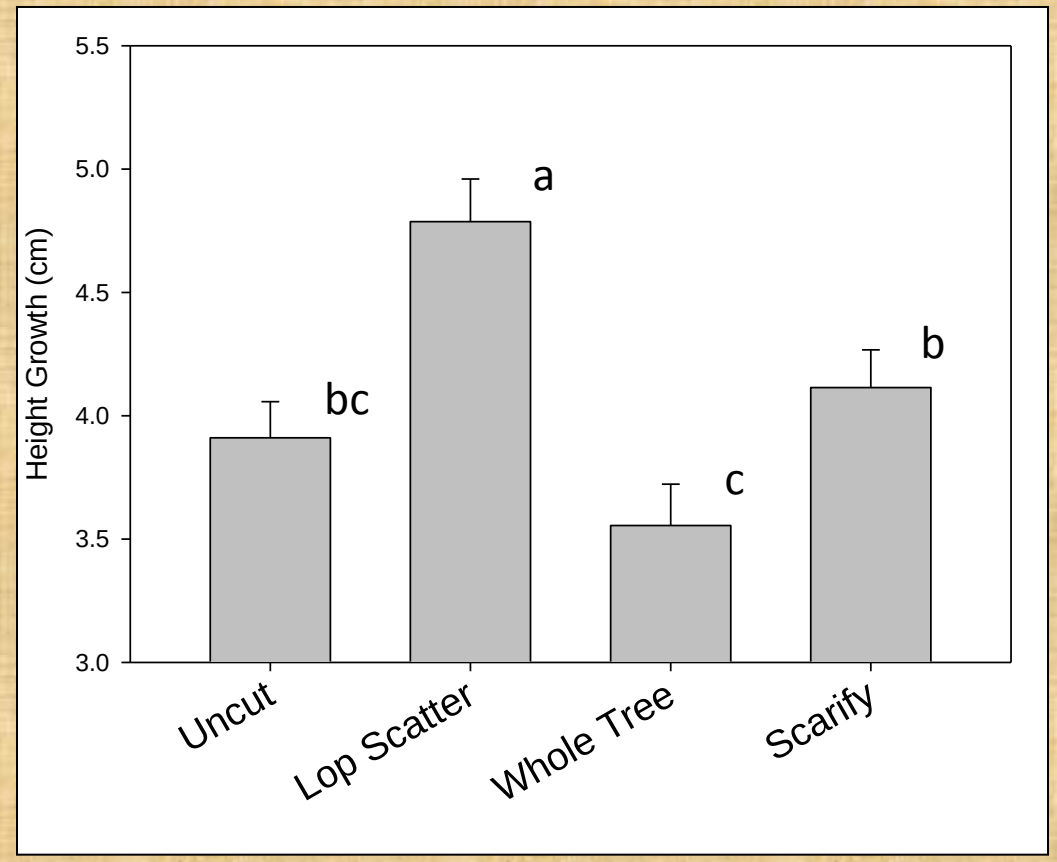
Cut vs Uncut

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

Thanks to:
Joint Fire Science Program, R2 Bark Beetle Incident Team, USFS Chief's Emergency Fund, Colorado Water Conservation Board, Colorado Forest Restoration Institute, Staff at Arapaho-Roosevelt, Medicine Bow-Routt National Forests and Colorado State Forest Service for logistical support and numerous field crew members

Further Reading:

Collins, B.J., Rhoades, C.C., Battaglia, M.A., Hubbard, R.M. 2012. Salvage logging reduces fire hazard after bark beetle outbreaks in lodgepole pine forests. Forest Ecology and Management *In Review*.

Collins, B.J., Rhoades, C.C., Hubbard, R.M. and Battaglia, M.A. 2011. Tree regeneration and future stand development after bark beetle infestation and harvesting in Colorado lodgepole pine stands. Forest Ecology and Management **261**:2168–2175 . doi:10.1016/j.foreco.2011.03.016.

Collins, B.J, Rhoades, C.C., Underhill, J. and Hubbard, R.M. 2010. Post-harvest seedling recruitment following mountain pine beetle infestation of Colorado lodgepole pine stands: A comparison using historic survey records. Canadian Journal of Forest Research **40**(12):2452-2456. doi:10.1139/X10-172.