Ecosystem Responses to Mountain Pine Beetle & Management in Colorado Forests

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

San Juan Bark Beetles and Watersheds Workshop

Durango, CO
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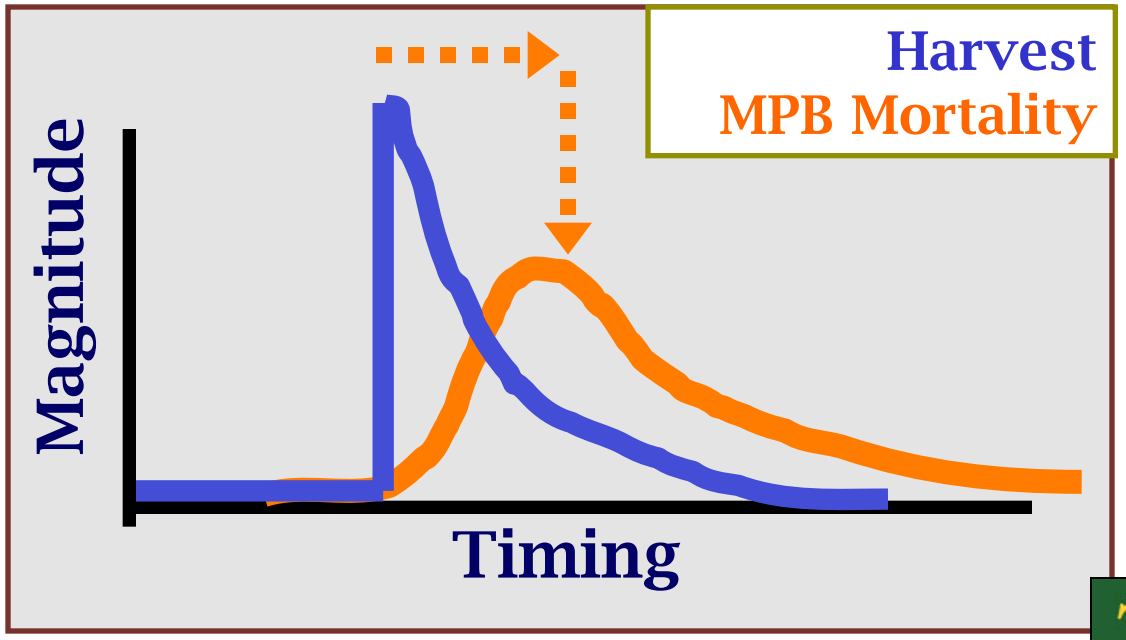
Watershed Change



Trees are the answer

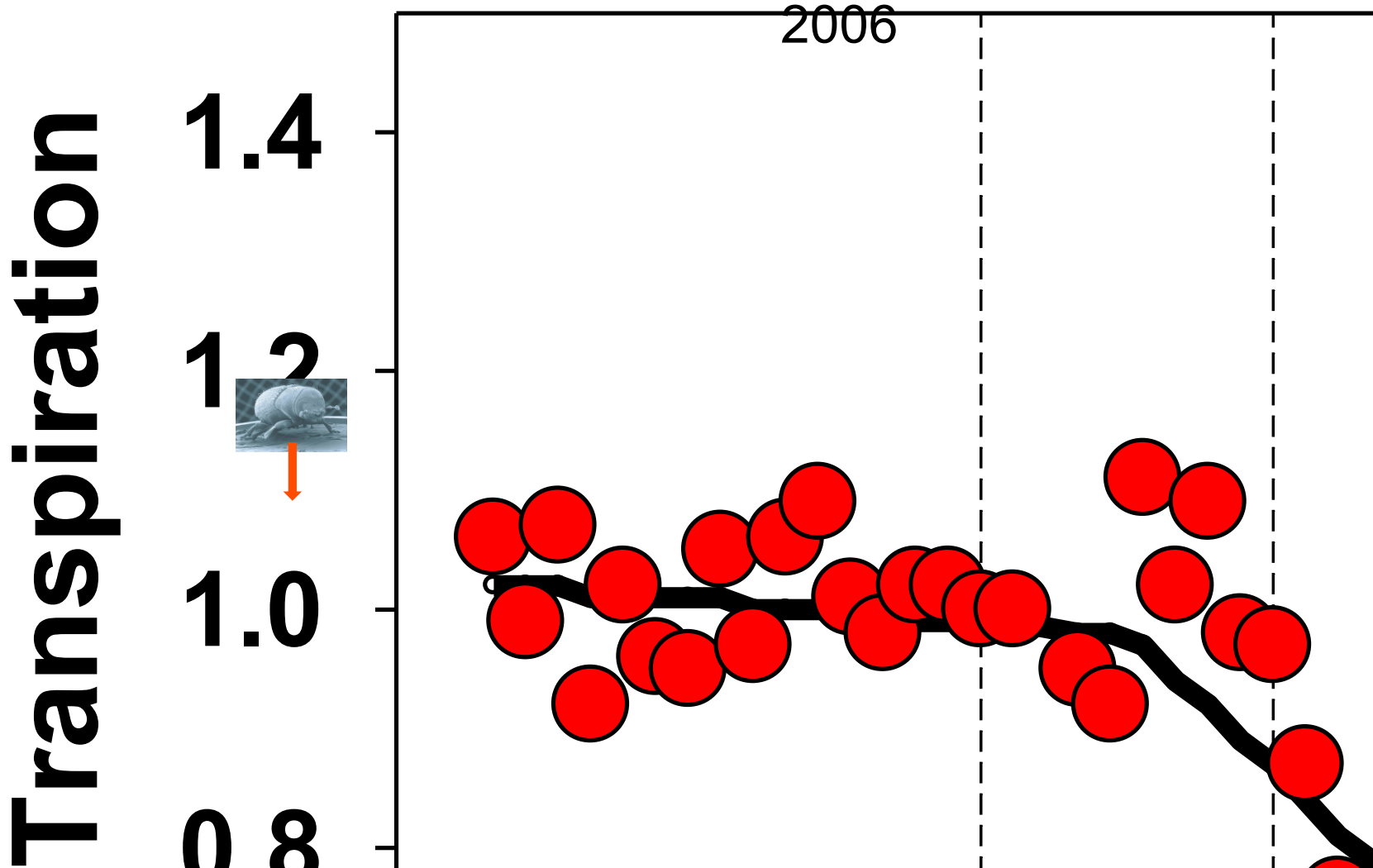
Responses Regulated by Change in

Canopy interception & Snowpack accumulation
Water uptake & Soil nutrient use

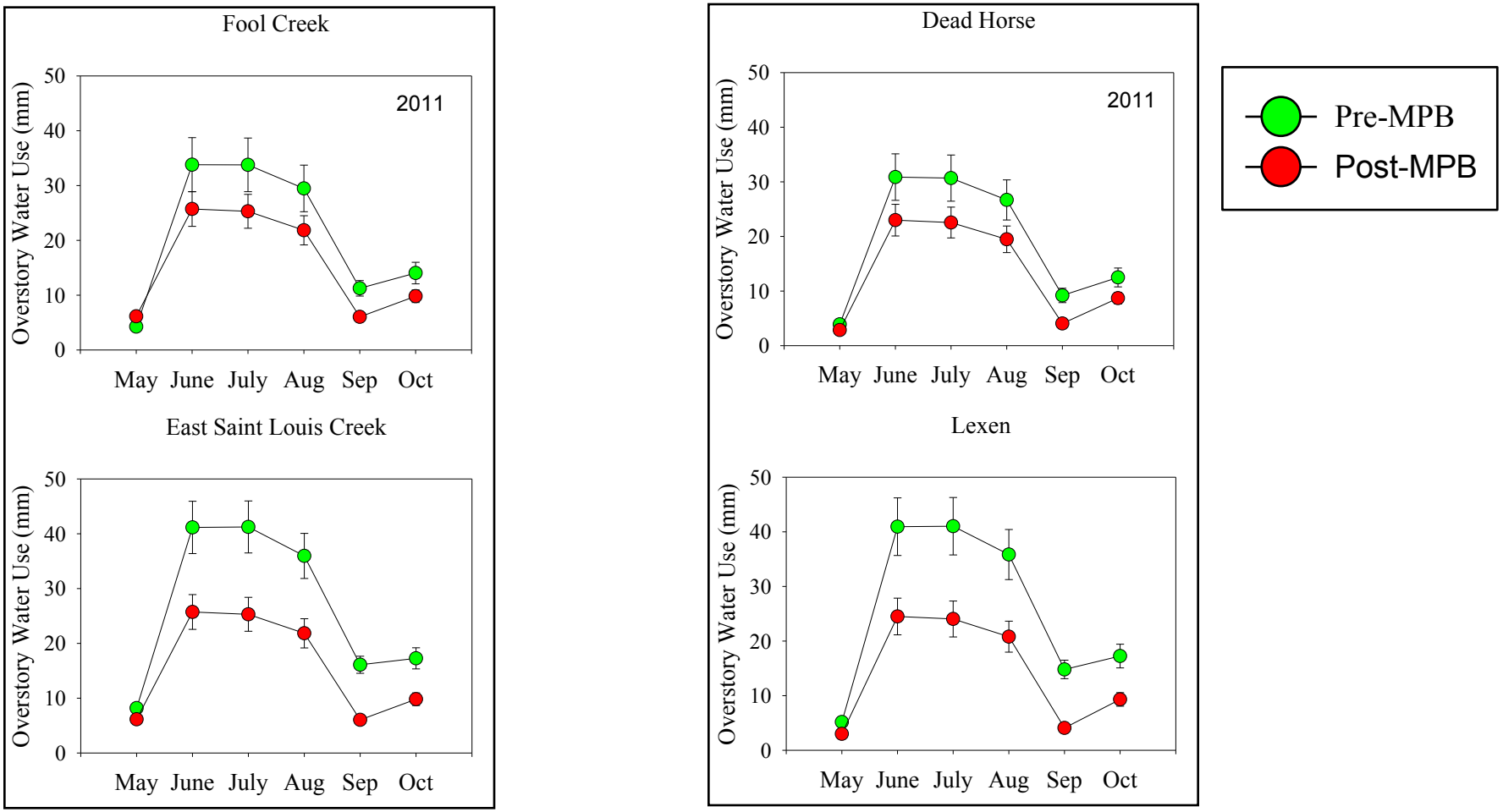
Complicating Factors

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

Tree Response -
Effects of MPB on Tree Water Use



2000s MPB Response - *Stand Water Use*

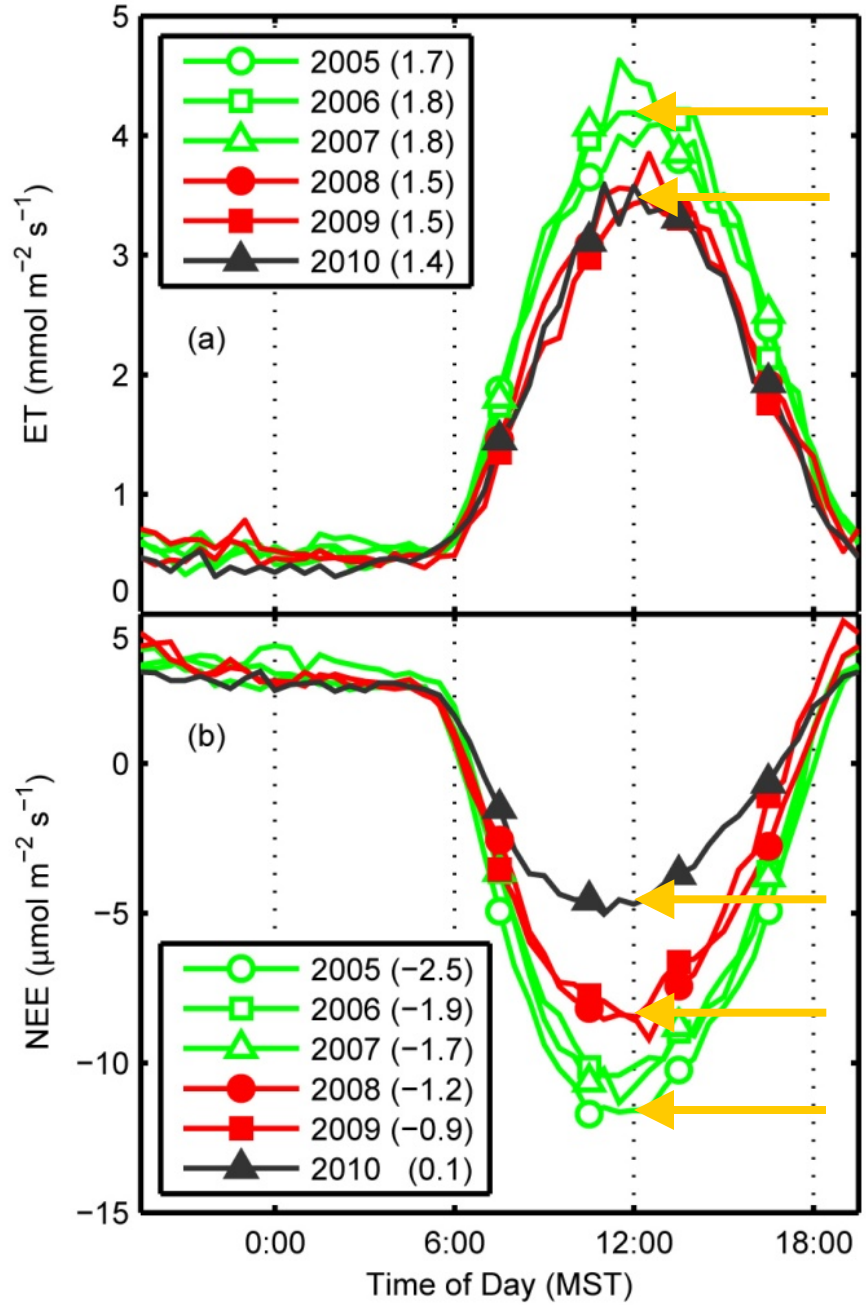


Overstory transpiration has decreased by 20 – 40% in watersheds at FEF Post MPB

Magnitude depends on management history

Spruce beetle epidemic at GLEES, southern Wyoming

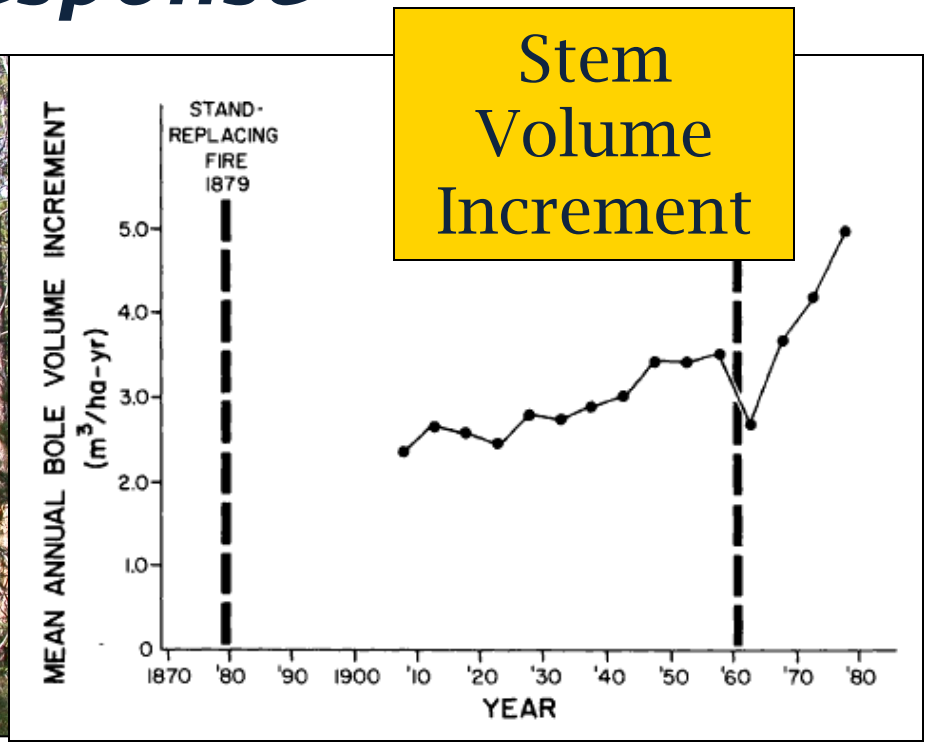
- ~70% of basal area affected since 2008
- Decline in average summer ecosystem fluxes and total uptake (July-September)
- Reduction in cumulative ET from 251 mm to 210 mm during the epidemic
- Reduction in total carbon uptake from 190 to 100 gC m^{-2} during epidemic I; further reduction to 0 gC m^{-2} in epidemic II



Frank et al. *Ecology* (*in review*)

Yellowstone 1970s MPB Outbreak

Forest Growth Response

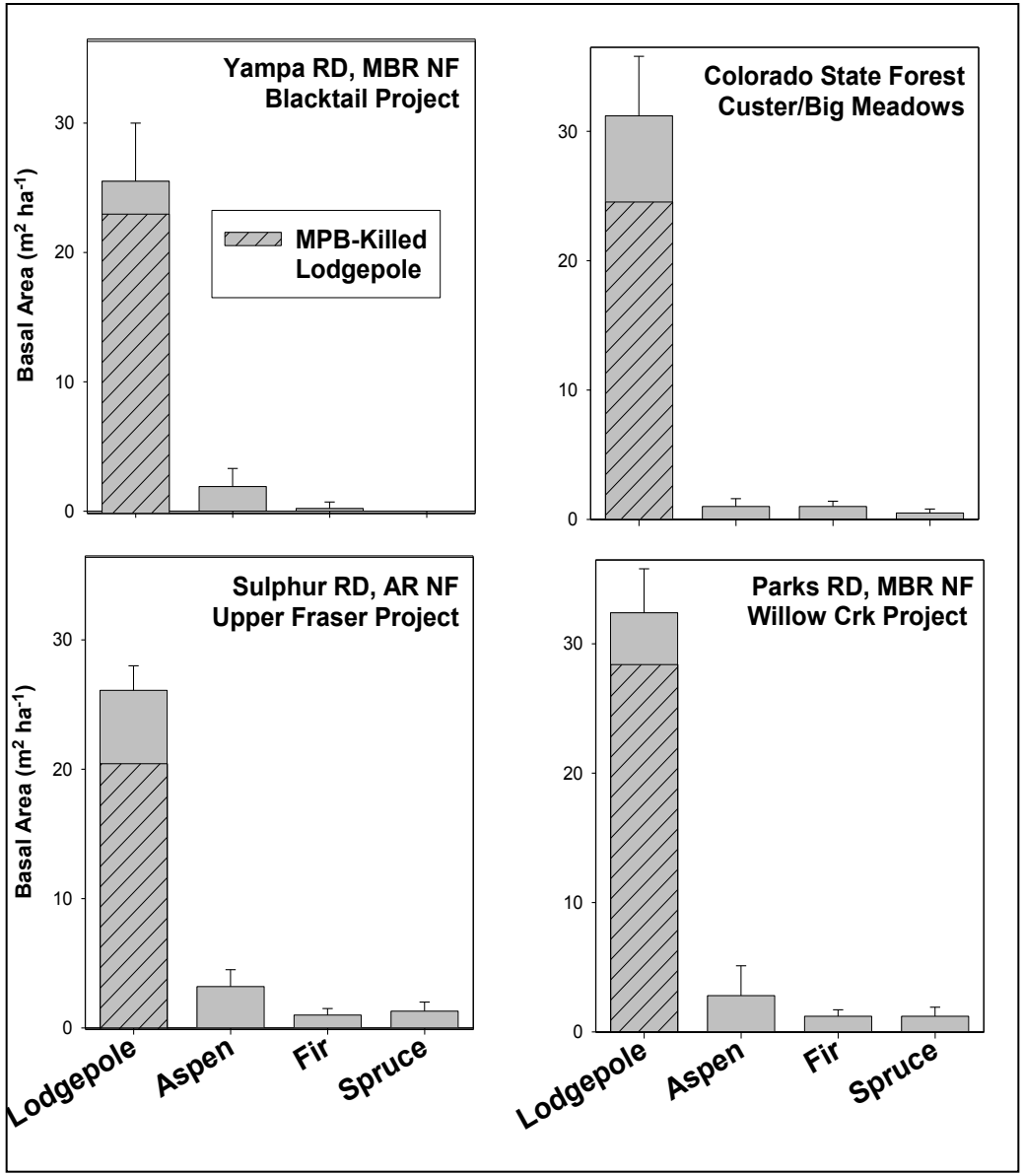


About 40-70% of the overstory trees died

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

Romme et al. 1986

2000s MPB - Overstory Mortality



Pine losses

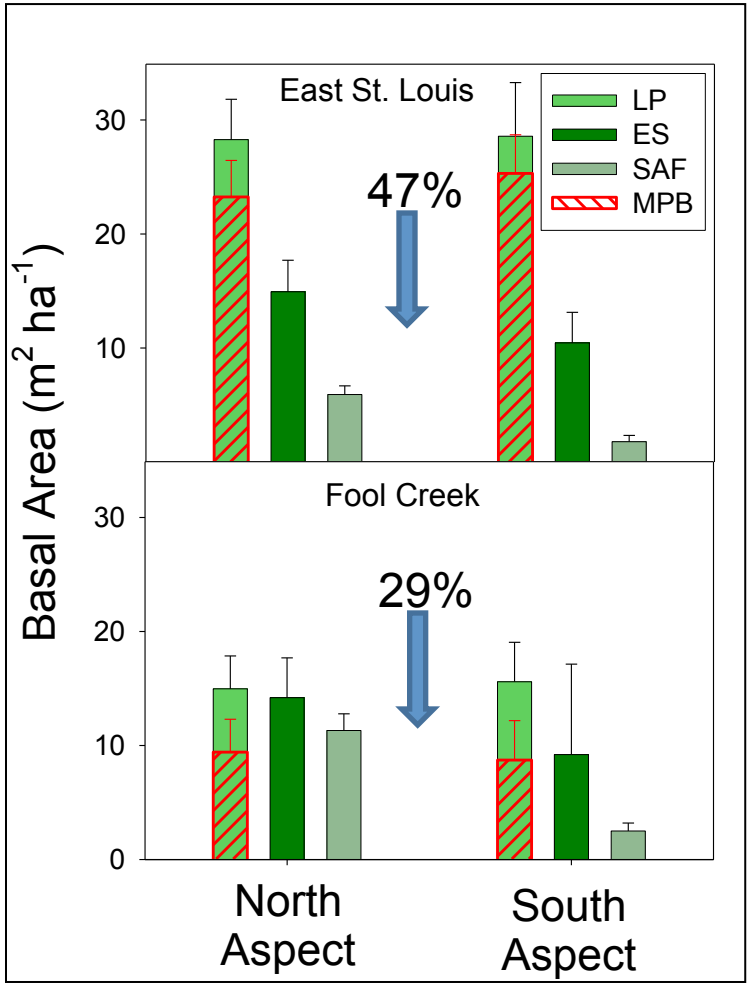
80-90% of basal area

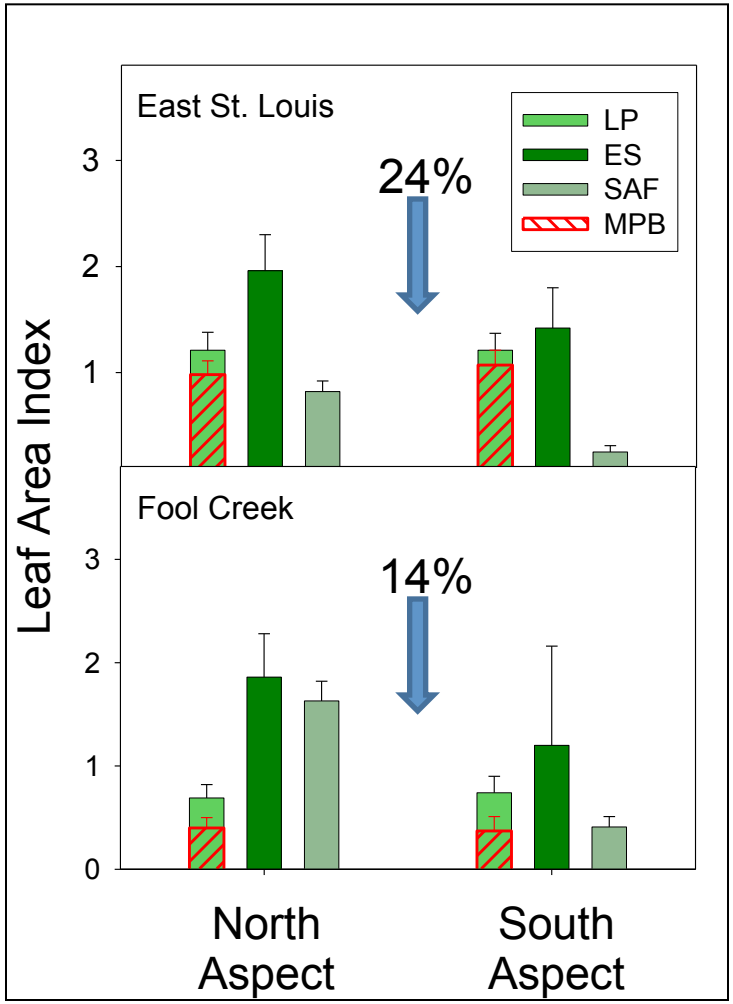
Residual live trees

15-35% of stand BA

24 pine-dominated stands
Trees >10 cm DBH

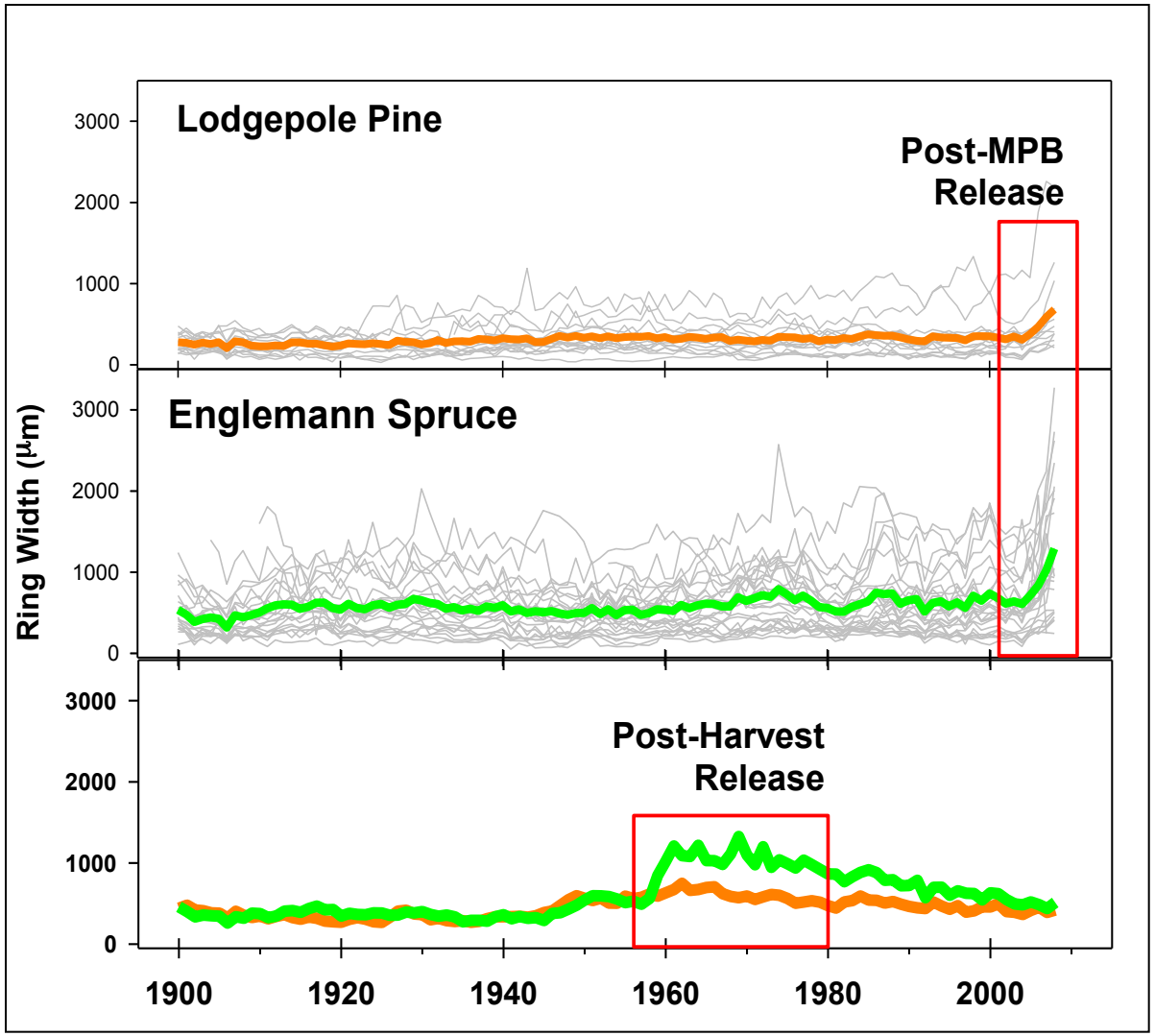
2000s MPB – *Δ in BA ≠ Δ LAI*





Spruce have significantly more Leaf Area per unit Diameter

2000s MPB - Overstory Growth Response



35% of trees grew > 25% faster since the infestation

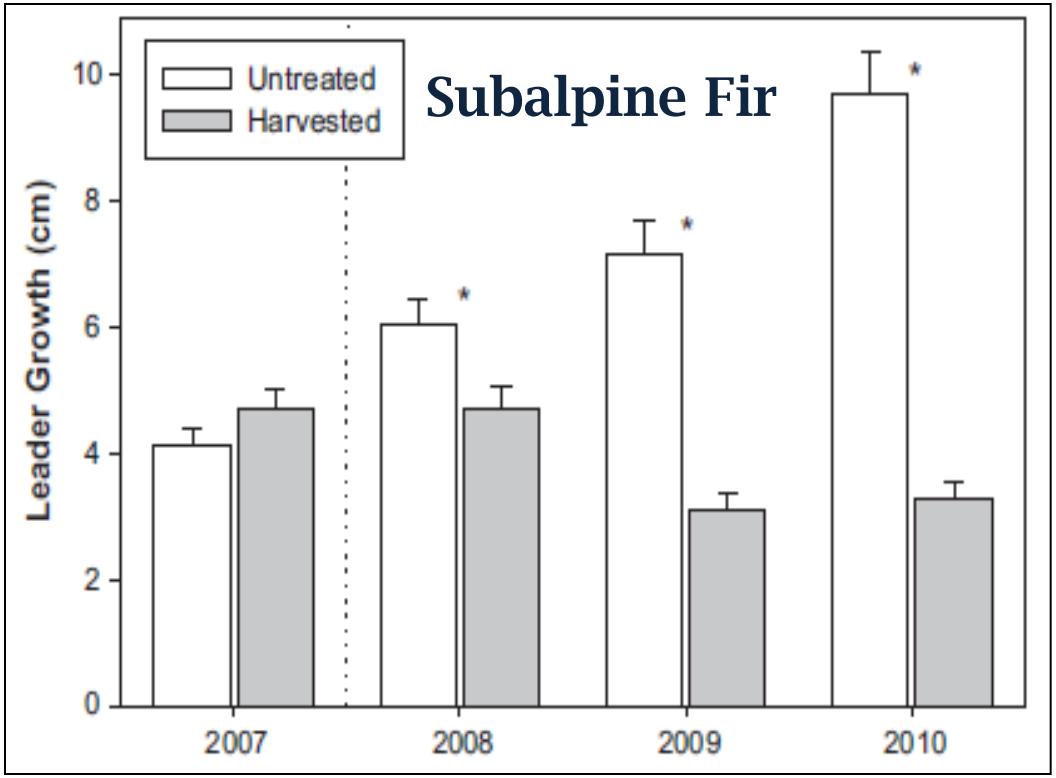
16% of trees grew faster than ever.

Unrelated to precipitation

Decline in basal area explained 10-20% of response

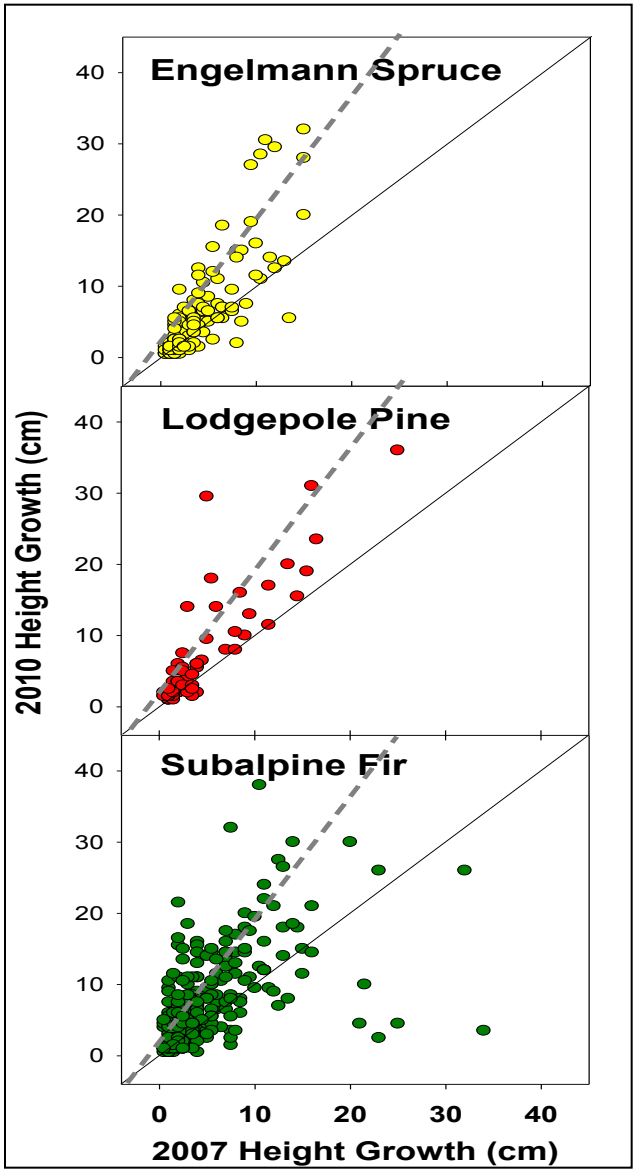
*Assessed 123 cores in 4 basins

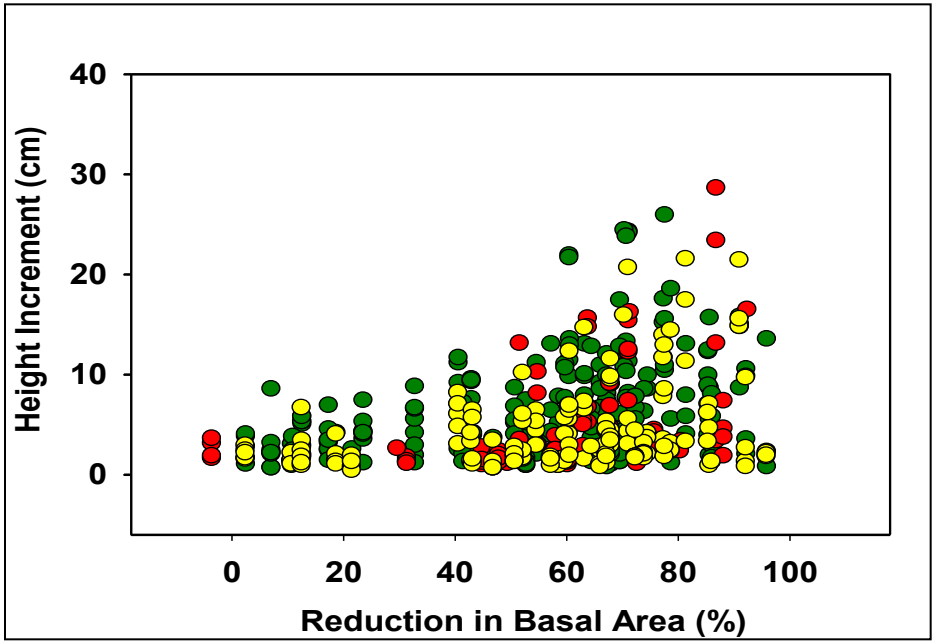
2000s MPB - Understory Growth



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

2000s MPB - Understory Growth

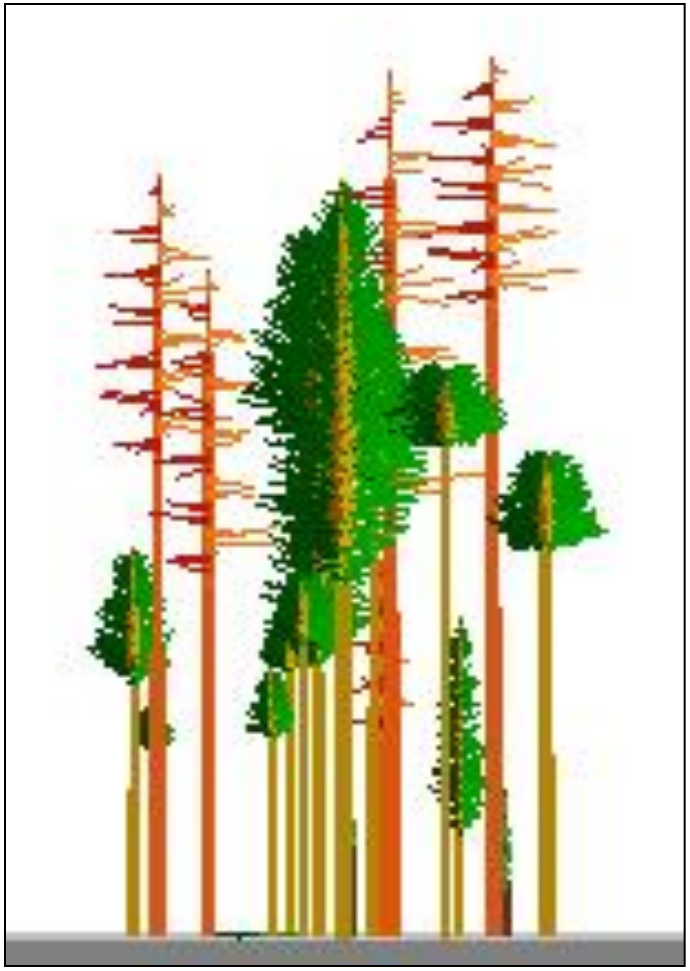


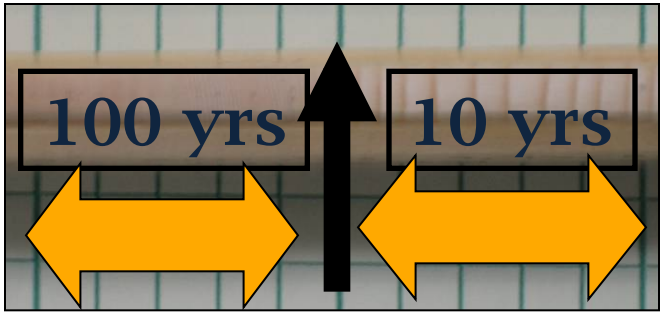


40% of trees added > 2X more height in '10 as in '07. Proportionally, fir was most likely to double height; spruce was least likely.

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

Understory Trees May Reduce *Transpiration Loss*

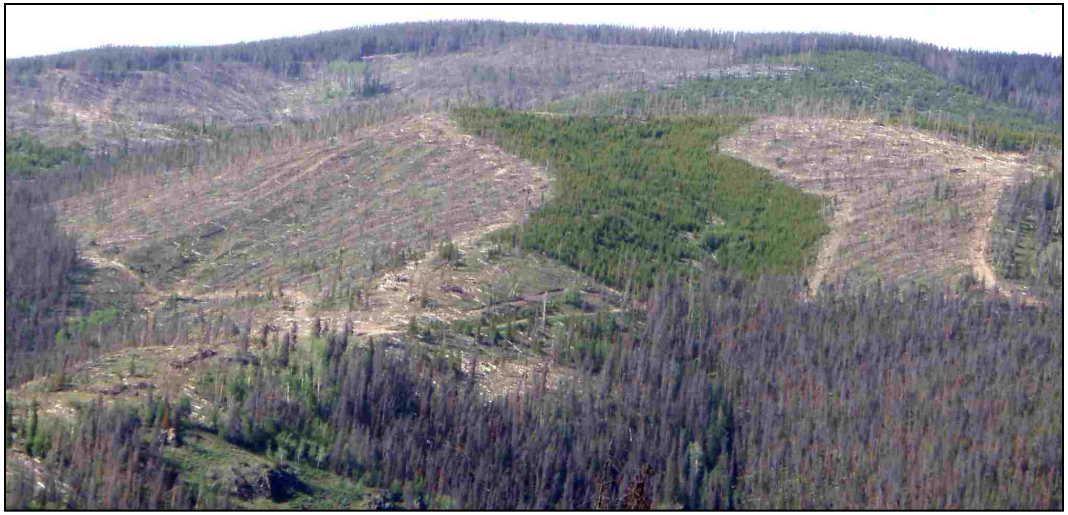




Understory tree growth & water use increase after overstory mortality

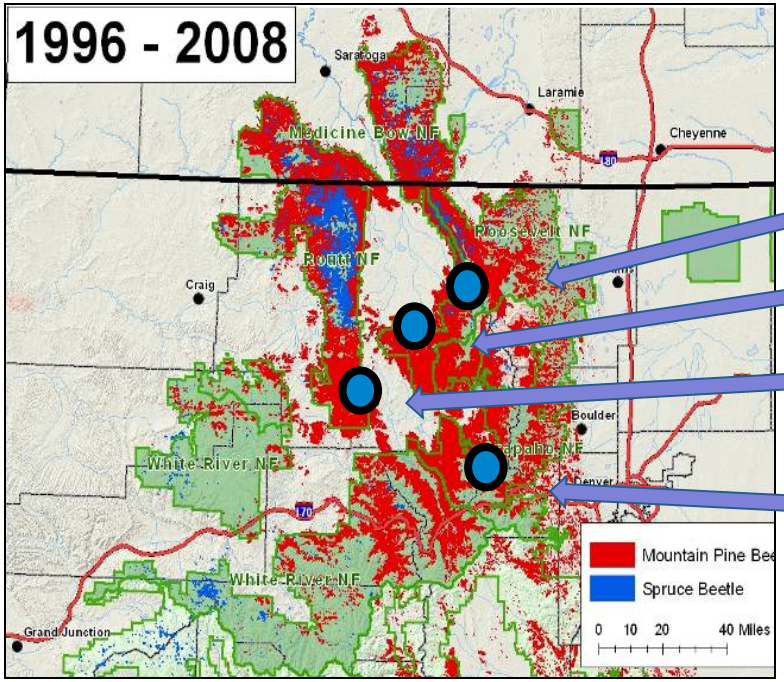
Young trees use more water for a given amount of needles than old trees.

Management Response to MPB



Harvest vs. Retain?

Specific harvesting practices



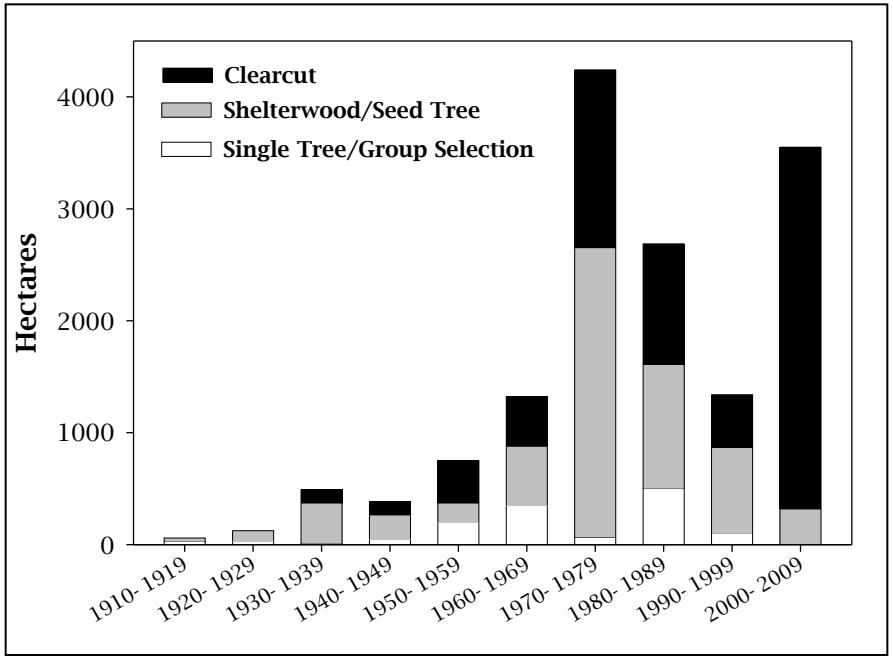
CO State Forest

Willow Ck, Parks RD

Gore Pass, Yampa RD

Fraser Exp. Forest

Management Response to MPB



Arapaho-Roosevelt NF, Colorado

Most harvesting since 1970s

Greatest extent of clear cutting

However:

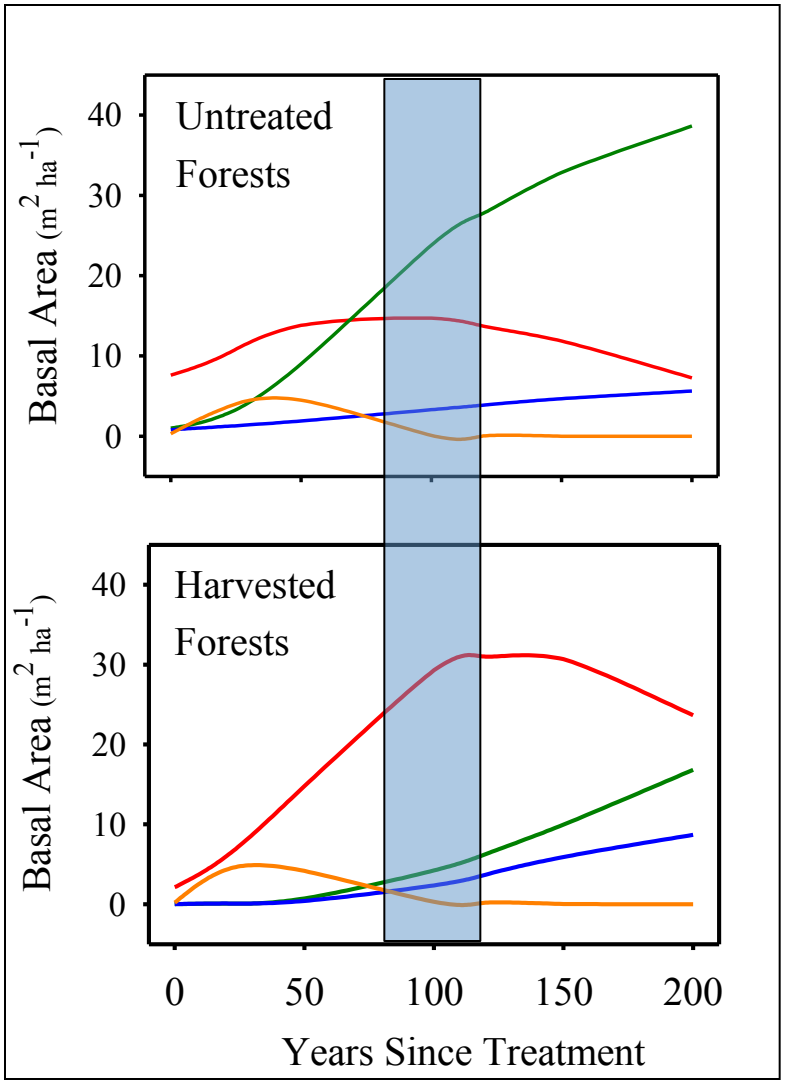
<50% of infested area is treatable;

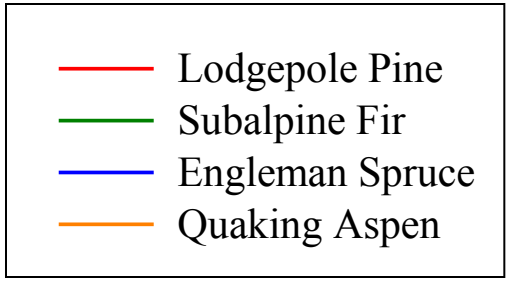
of that < 30% will be cut

90% of infested area will be untreated

Stand Dynamics post-MPB

Simulations - 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

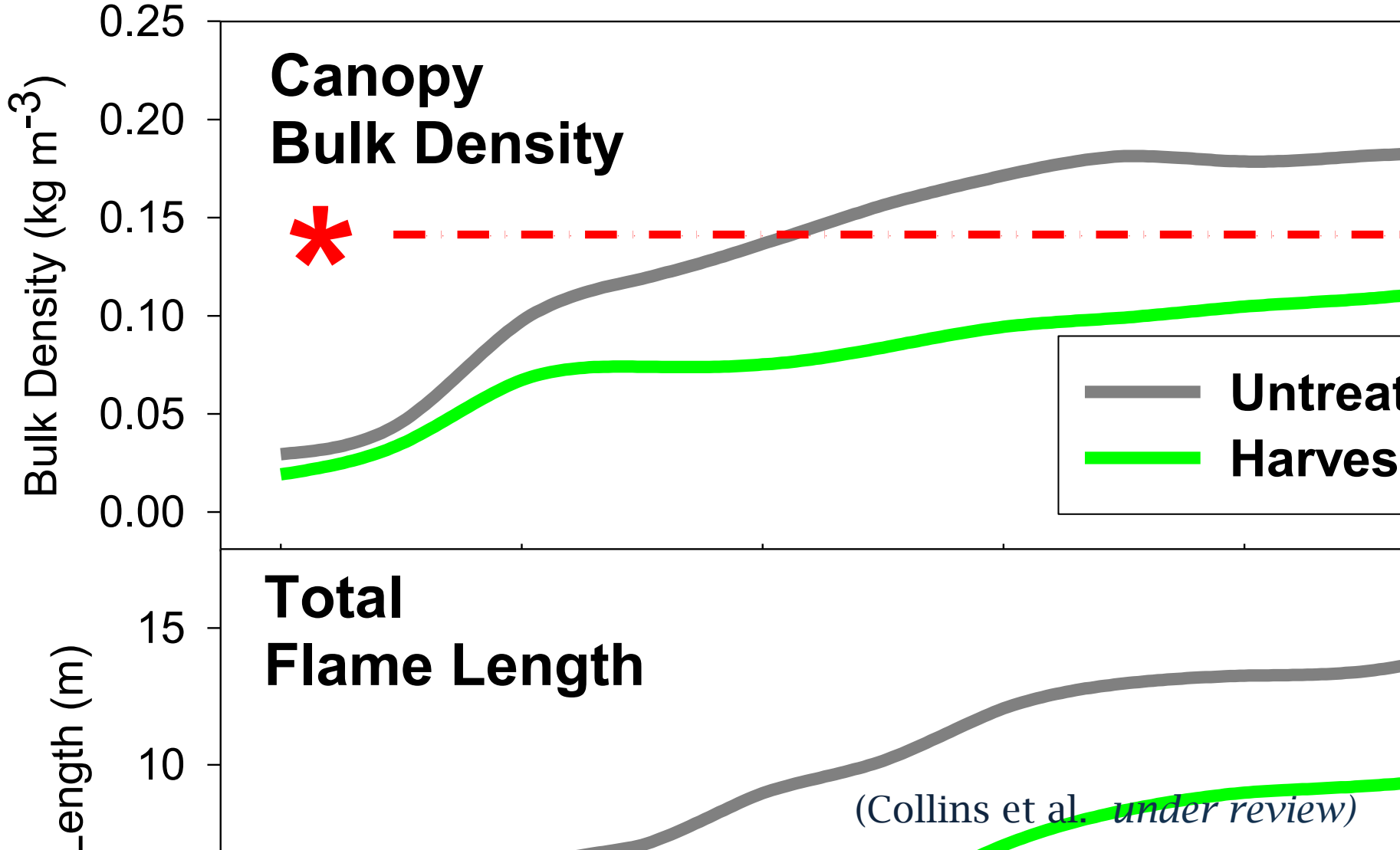
Similar to pre-MPB stands
Dominated by pine

(Collins et al. 2010b)

Response to MPB Management

Fire Behavior

Recovery of the forest



Management Alternatives on MPB Acres

No Action
Untreated Beetle-Killed Stands

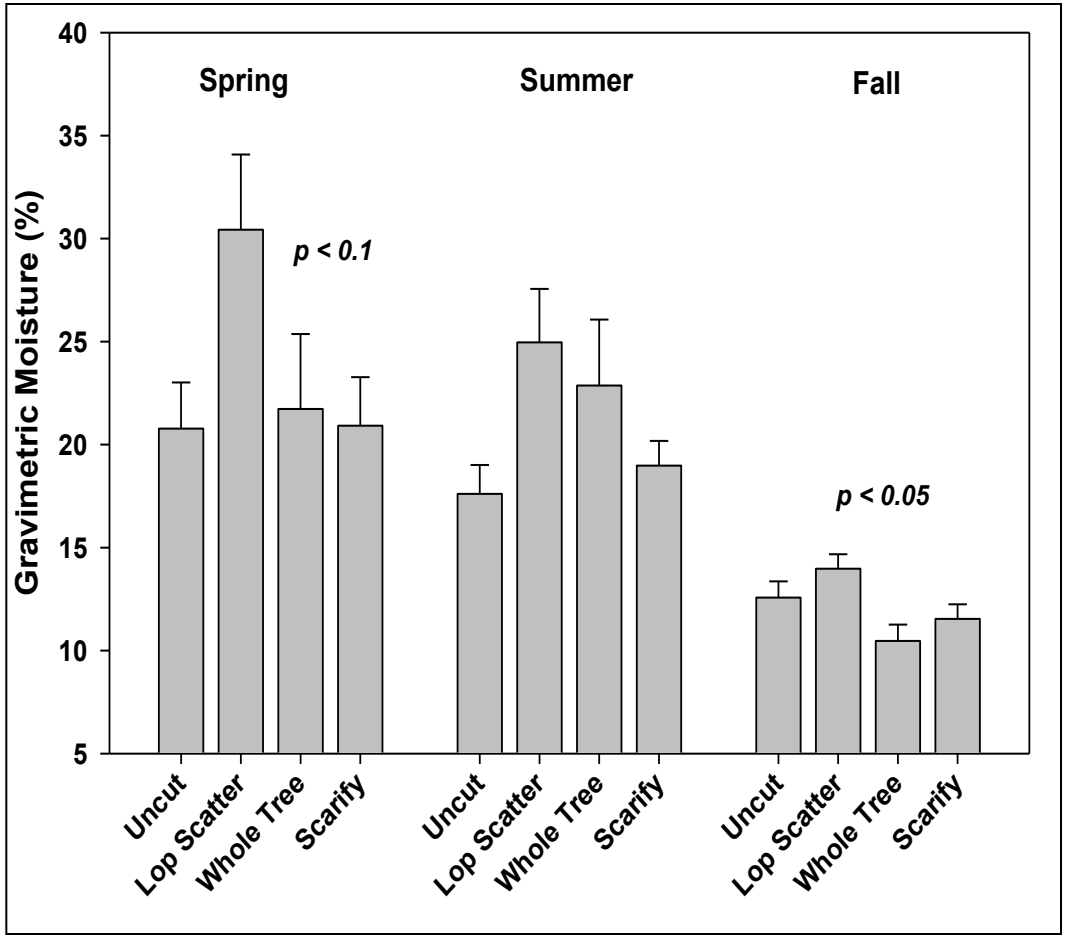
Water Delivery
Lop and Scatter Slash Retention

Fuel Reduction
Whole Tree Harvest

Forest Regeneration
Mechanical Scarification Site Prep

Response to Management Options

Soil Moisture



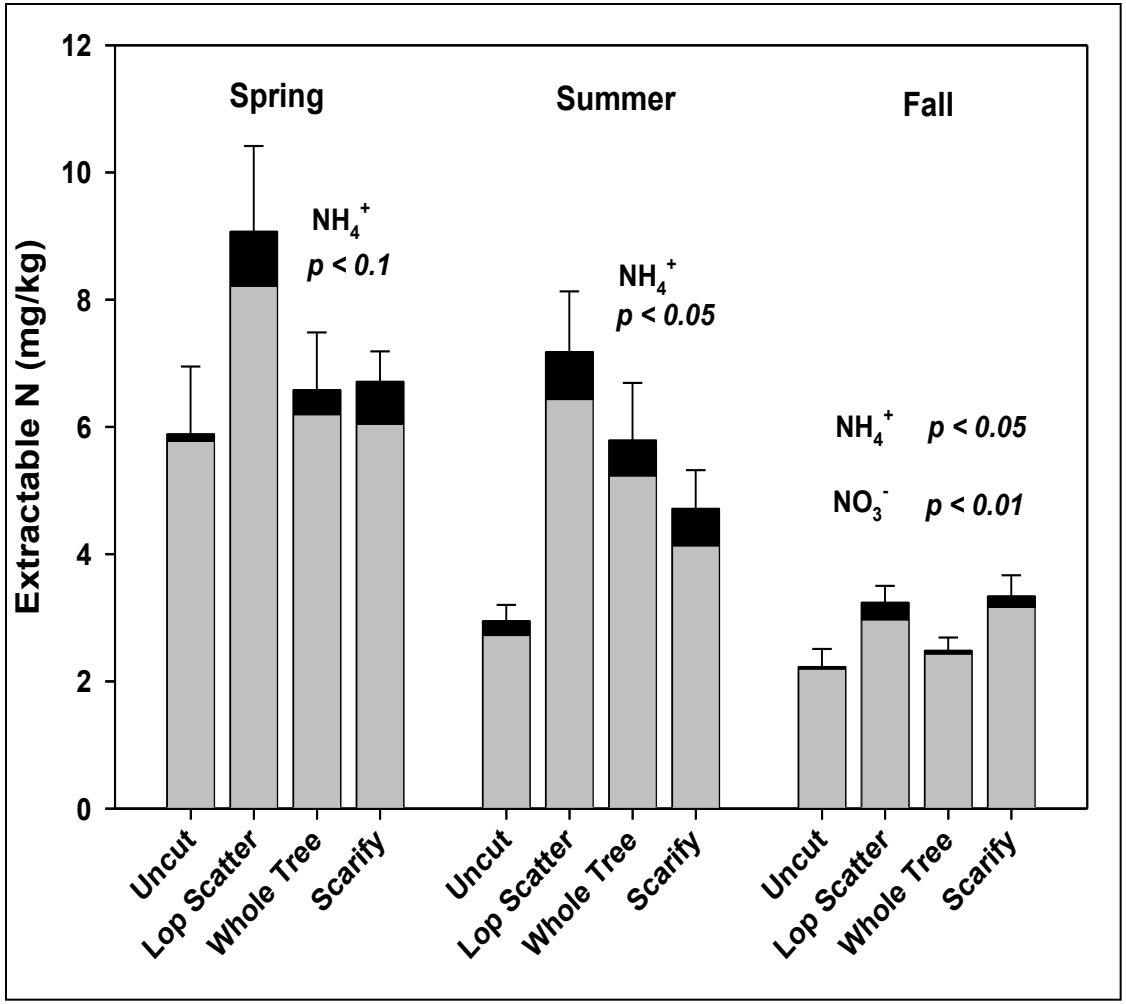
Soil moisture was highest in slash retention treatment

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

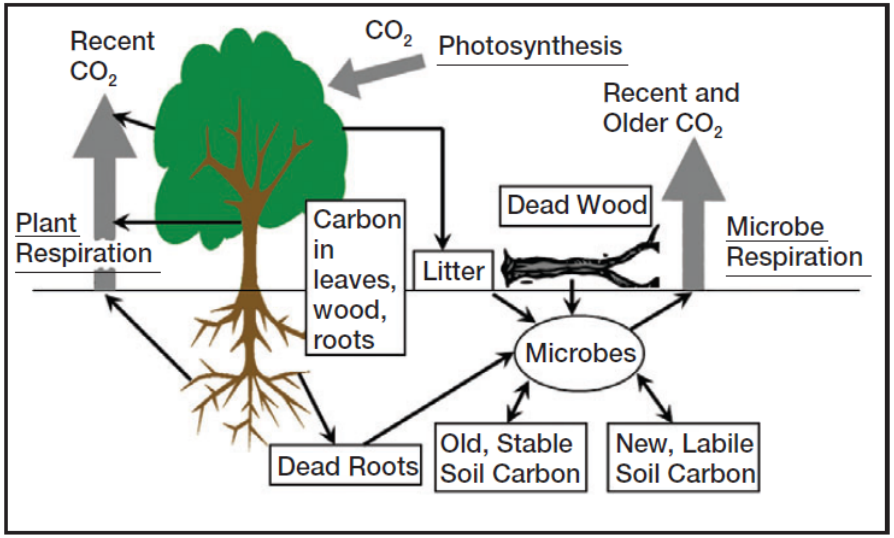
Cut vs Uncut

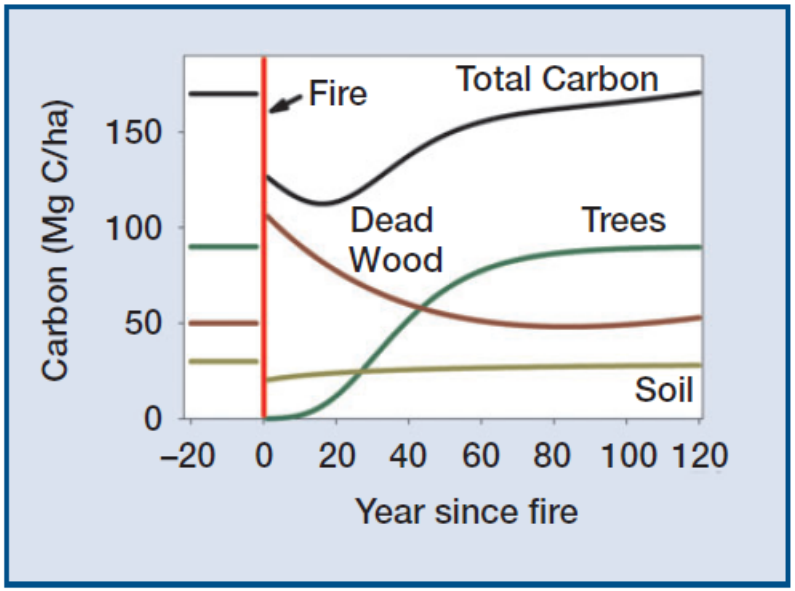
3 to 6 fold increase

***Extractable Soil N** (0-15 cm mineral soil)

Carbon Dynamics

Forest Carbon Budgets and Disturbance





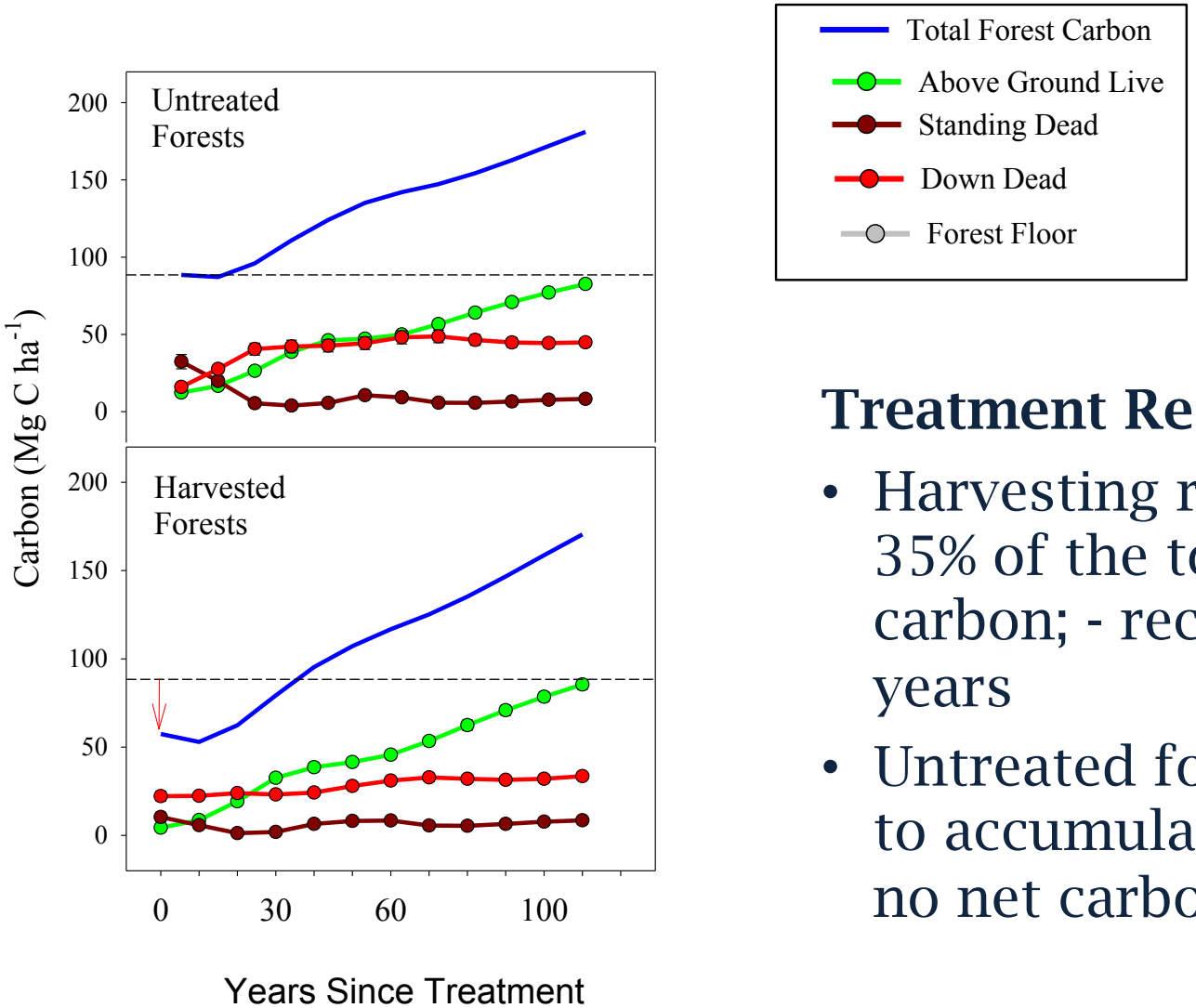
Carbon is stored mostly in live and dead wood and forest soils.

Following a disturbance, *if the forest regenerates*, lost carbon is recovered with forest re-growth.

Figures from Ryan et al. 2010 Issues in Ecology: Report 13.

Carbon Dynamics

Effects of MPB and Harvest on C Stocks



Treatment Response

- Harvesting removes about 35% of the total forest carbon; - recovers in ~40 years
- Untreated forests continue to accumulate carbon with no net carbon loss

Take Home Messages from MPB

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

Lessons for San Juan Spruce?

- Residual overstory & understory trees (spruce, fir, aspen) will respond to loss of spruce overstory; and take up some of the “slack” in the system

- Rate of re-establishment of forest will vary with the presence of these surviving trees

- Harvesting can lead to development of different stand types and different water outcomes