Forest & Watershed Responses to Beetle-Related Management

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US Forest Service

Mountain Pine Beetle Science Symposium

Impacts on the Hydrologic Cycle and Water Quality

8 April 2010; Boulder, CO

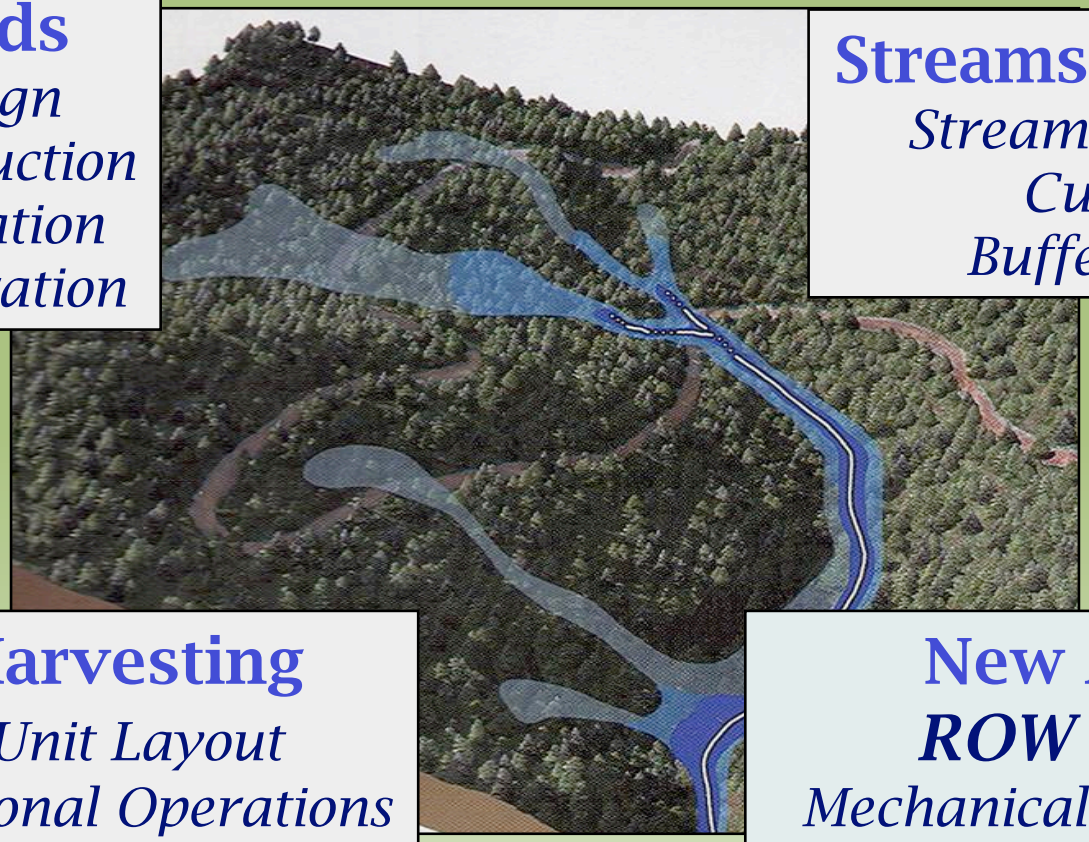
How Does Management Fit In?

- Management Happens
- Significant Short & Long-Term Effects
- Watershed Research Opportunities

Protecting Clean Water Delivery

Best Management Practices

Roads
Design
Construction
Utilization
Obliteration

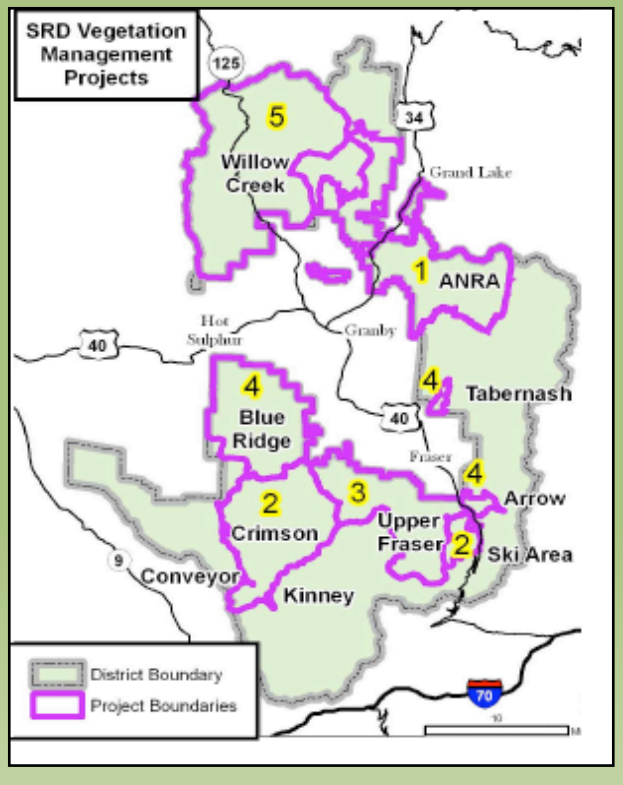


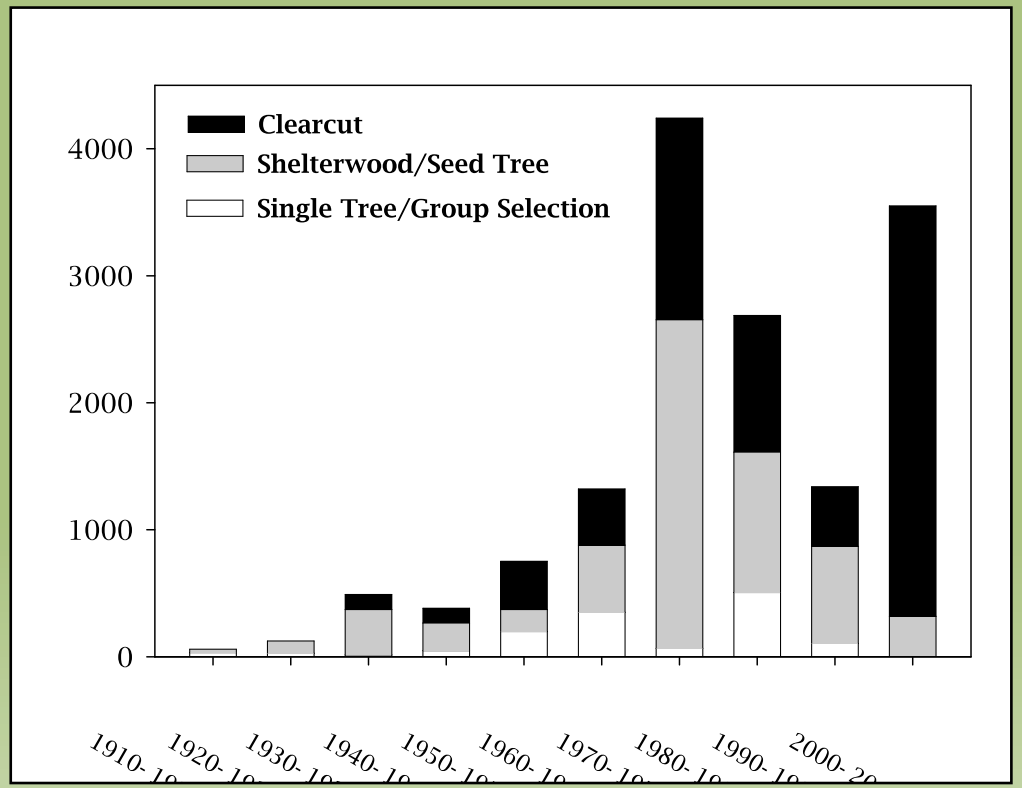
Streams, Wetlands
Stream Crossings
Culverts
Buffer Zones

Harvesting
Unit Layout
Seasonal Operations
Slash Management

New Activities
ROW Corridors
Mechanical Fuel Treatments
Biomass Utilization
C Accounting
Soil Productivity

The Management Response





Sulphur Ranger District - Arapaho-Roosevelt NF

½ of District is high-Risk LPP

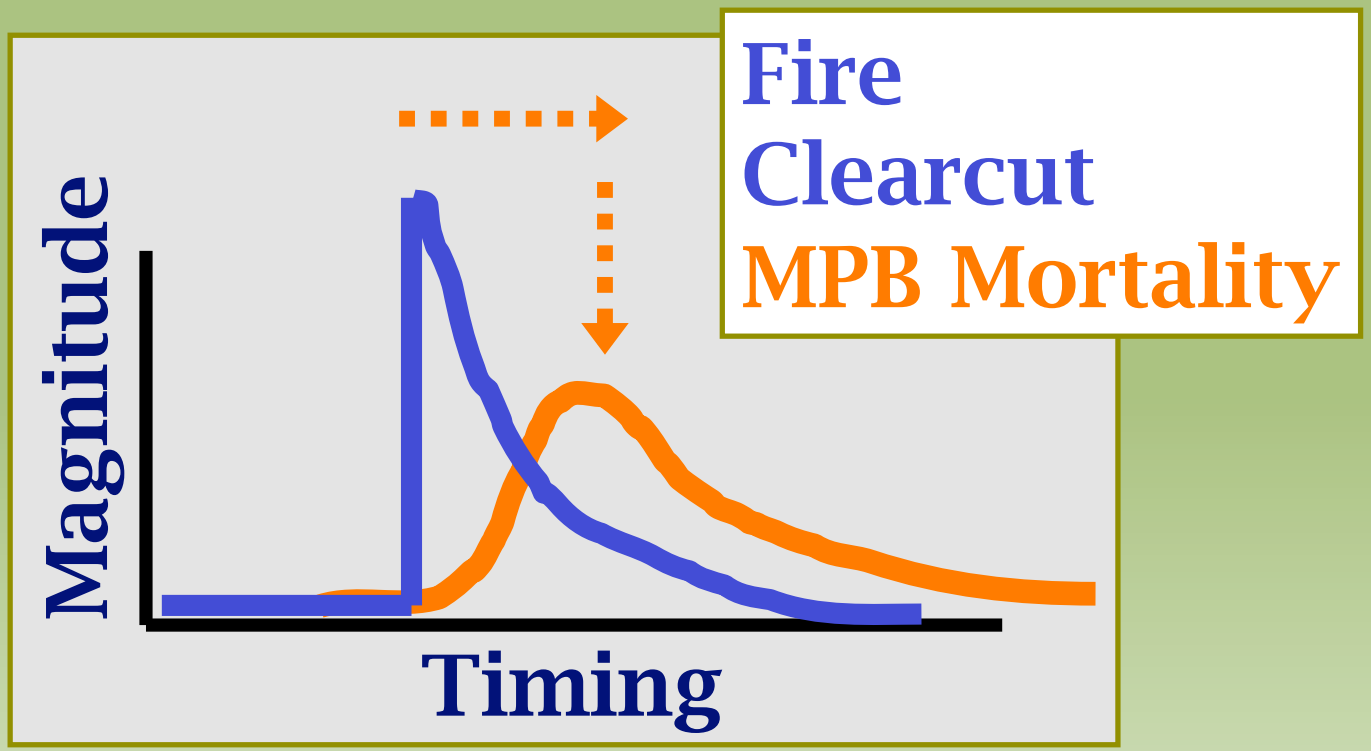
½ of that area is treatable (i.e., slopes, roads)

6–10k ha have been analyzed for treatment

(~10 – 15% of treatable area)

Relative Consequences

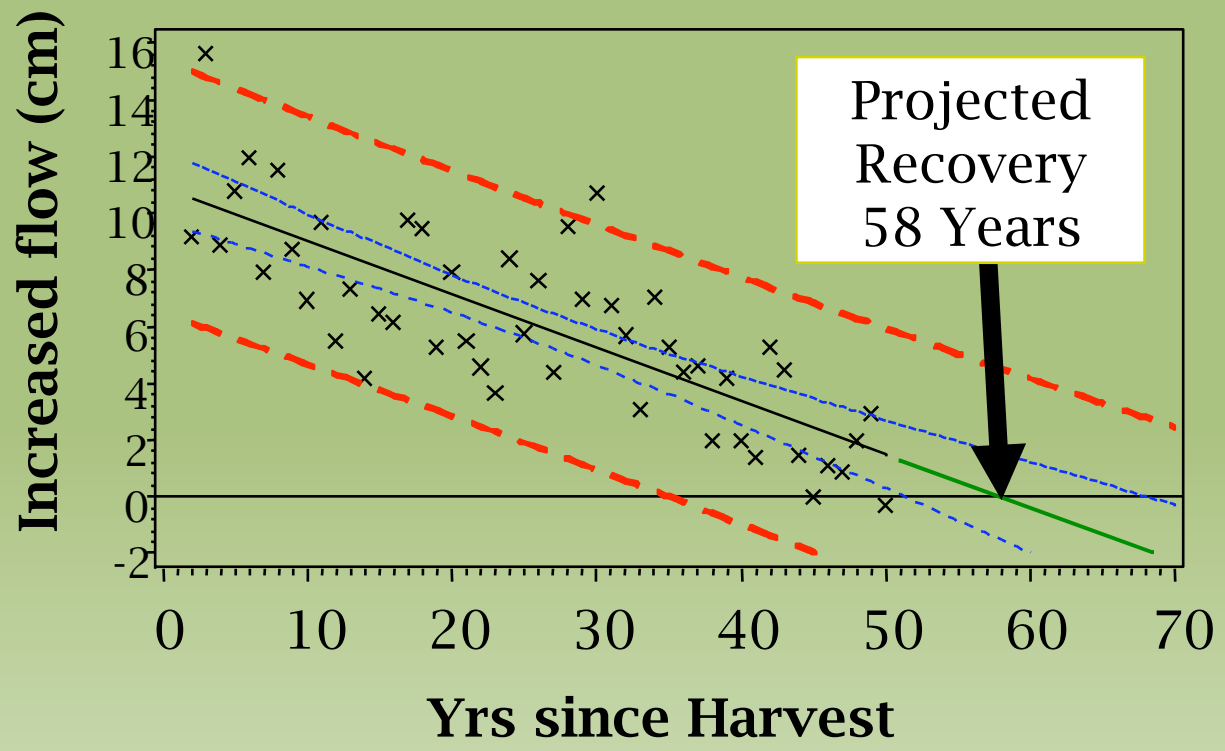
Beetles, Management, Fire



Relate to change in canopy interception & snowpack
Responses may lag and could be prolonged
Complex spatial & temporal patterns

Prolonged Effects of Harvest

Streamflow



Hydrologic Recovery relates to Canopy Recovery

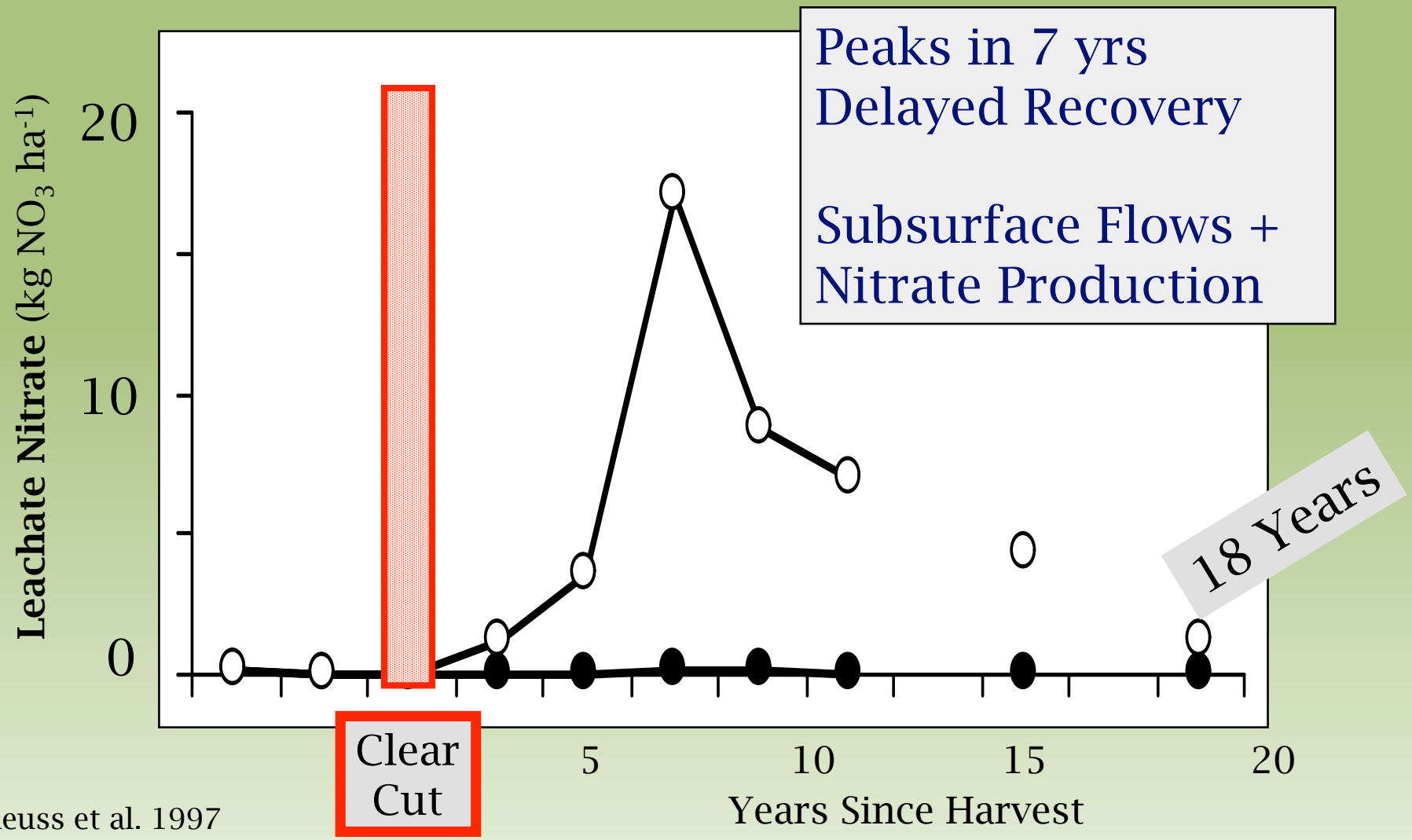
Snow Interception / Sublimation

Plant Water Use

Troendle and King 1985
Elder and Porth in prep

Prolonged Effects of Harvest

Nitrate Export



Reuss et al. 1997
Starr 2003

Prolonged Effects of Harvest

Nitrate Release from Soils

25 yr

50 yr

Years Since Harvest

Soil Nitrogen

Effects after 25 & 50 yrs

Nitrate > 2X higher in cuts

Nitrate is a greater part of IER soil N

Production of N

Higher in cuts

(net mineralization, nitrification)

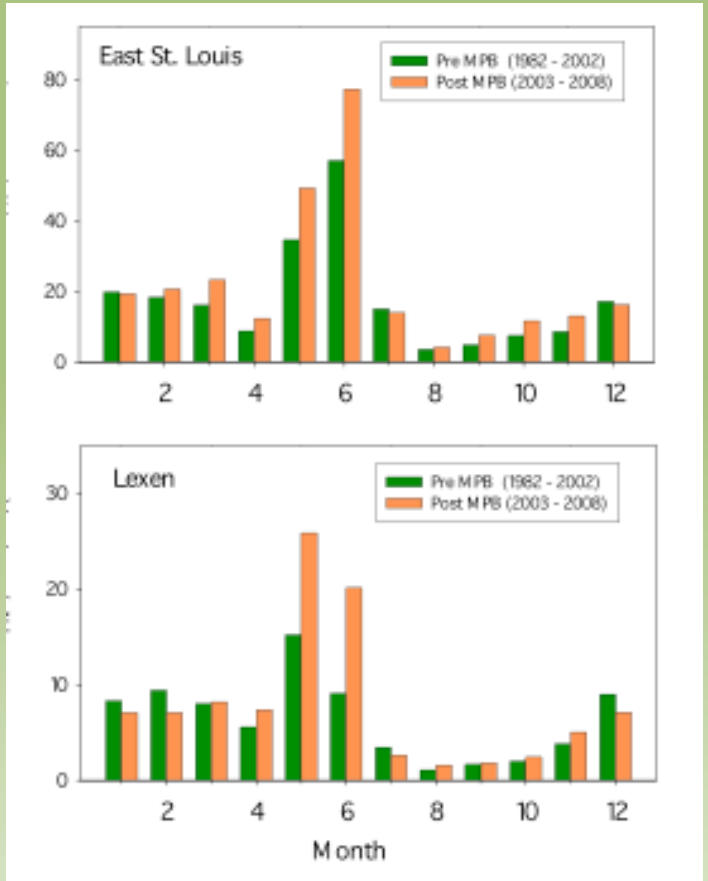
Magnitude of Increase

= Atmospheric Deposition

(2-3 kg N ha^{-1} yr^{-1})

Initial Effects of MPB

Streamwater Nitrate Export



Comparison

5 yrs Post-Infestation vs.
20 yrs Pre-Outbreak

Spring Nitrate Pulse

1.4 & 2.0 fold increase

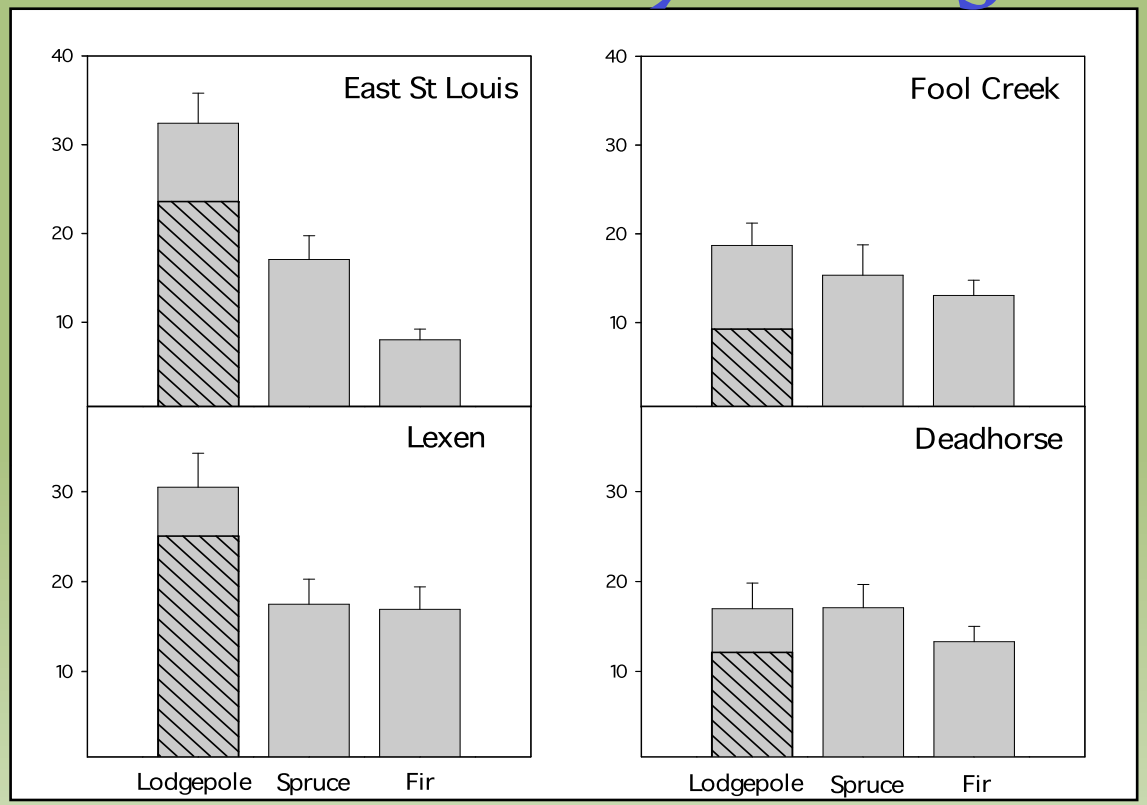
Magnitude of Change

20 g N ha^{-1} yr^{-1}
~1% of N deposition

*Non-MPB N Retention
~ 95% of N deposition

Initial Effects of MPB

& Overstory Change

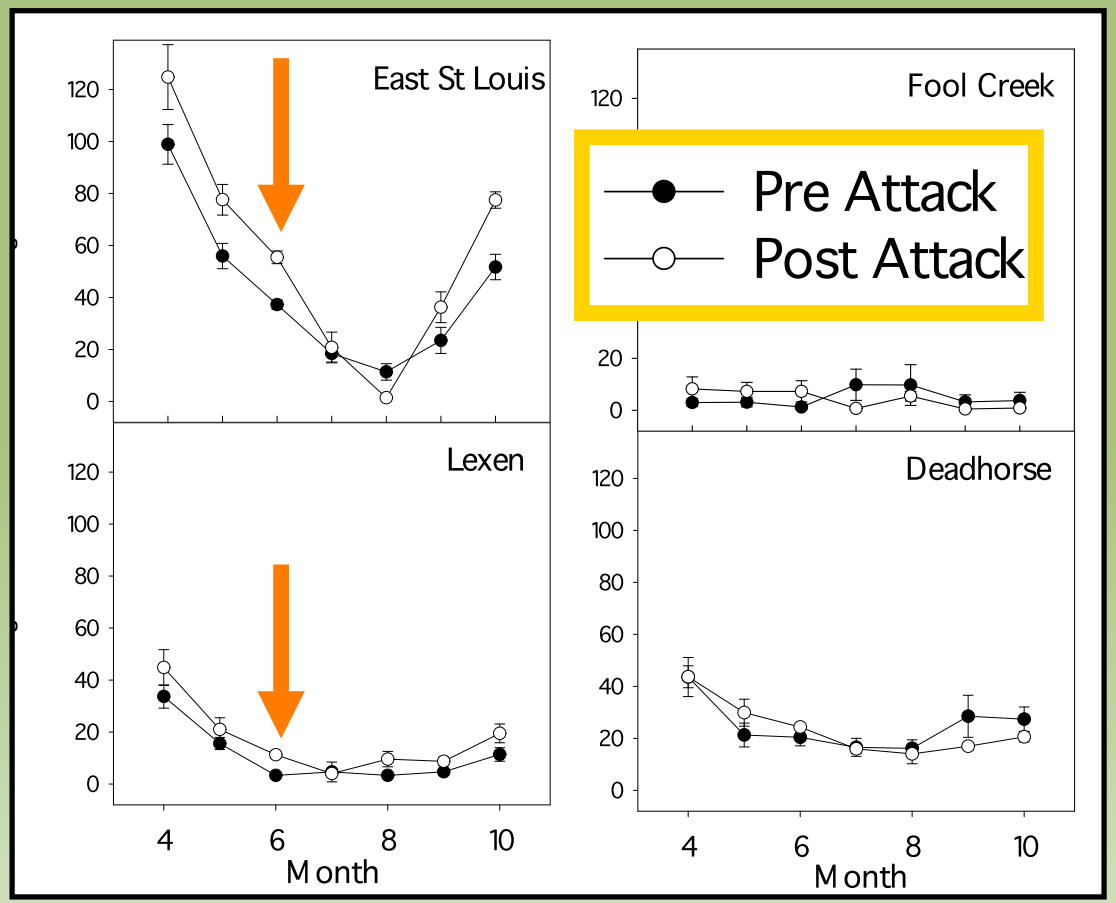


Current stand condition, MPB susceptibly relate to historic management

Old Growth	*Mixed Young/Old*	
39-41% **Basal Area**	20-25%	**Loss of Stand**
73-83% **Basal Area**	50-70%	**Loss of LPP**

Legacy of Management

Nitrate Concentrations



Old Growth *Mixed Young/Old*

Response in Old Basins

Response relates to basal area loss

None in Mixed Basins

Higher N retention in regenerating forests

Magnitude of Change

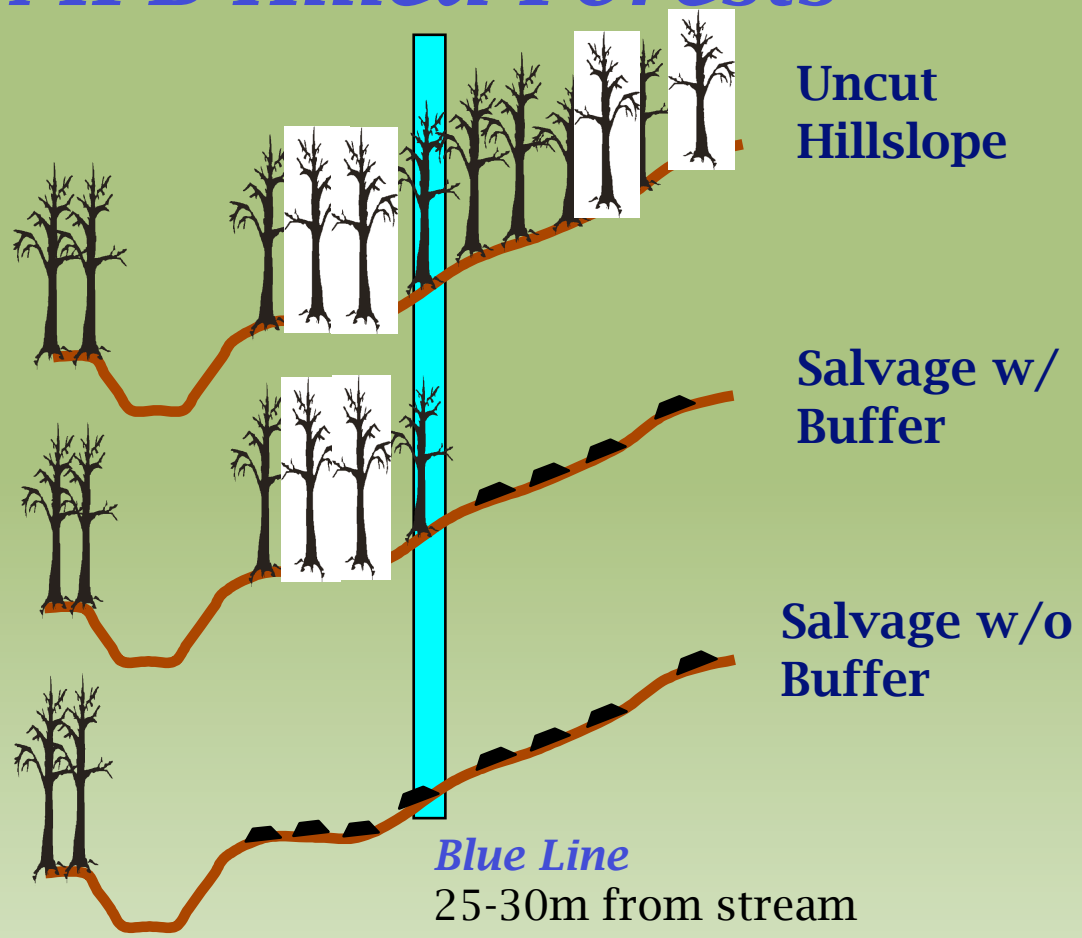
10 - 20 μg N L^{-1}

10% of seasonal change

EPA Reference Condition

14 μg NO_3-N L^{-1}

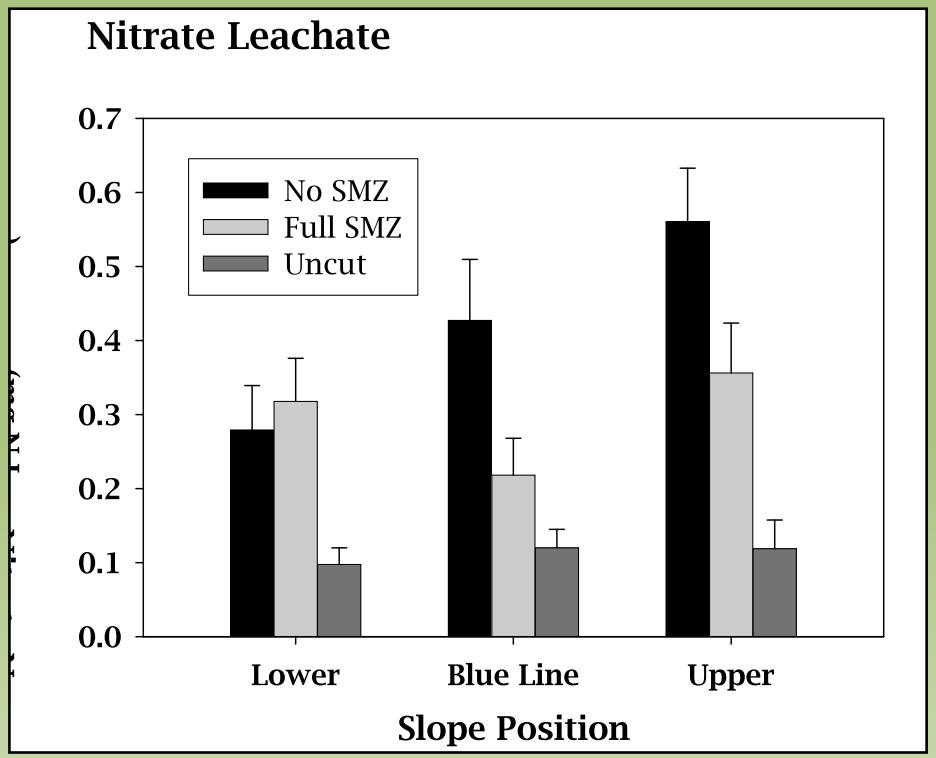
Comparing Uncut & Cut
MPB-Killed Forests



Do dead riparian buffers protect water quality?

Riparian Fuel Management – Fuels reduction underway in riparian zones on > ½ of western USFS districts.
(Stone et al. 2010 *in press)*

Comparing Uncut & Cut
MPB-Killed Forests



Uncut Hillslopes

NO_3 uniform downslope

Cut Hillslopes

3.6X increase

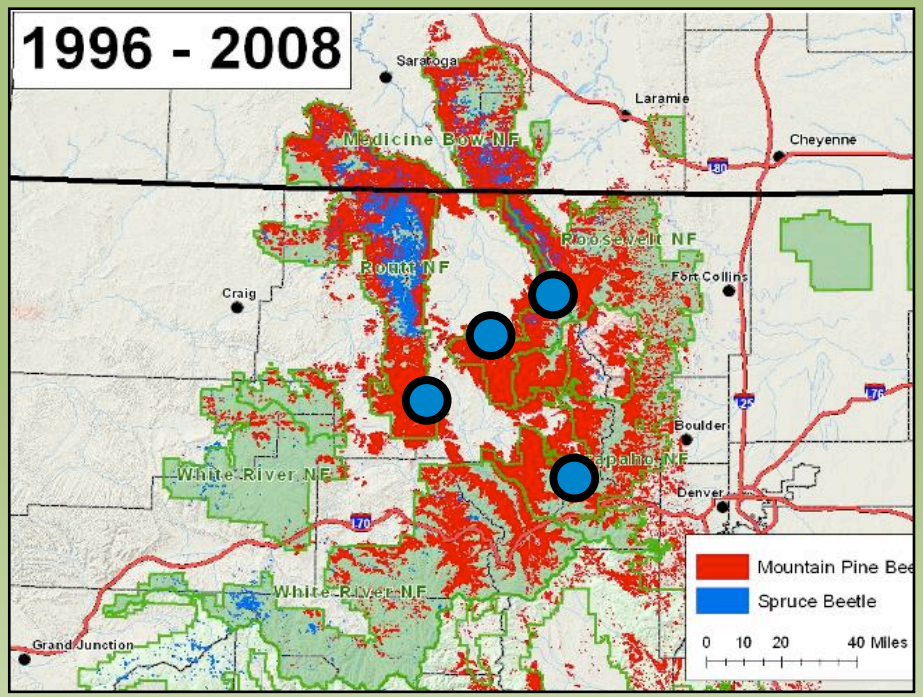
NO_3 moving downslope

Dead trees = No Trees

Magnitude of Change

Cut leachate	0.50 mg N L^{-1}	
Uncut		0.14
$Deposition_w$	0.22	
Stream		0.03

Forest & Watershed Responses
to Beetle-Related Management



Research Areas

North Platte Basin

1) Colorado State Forest
2) Routt NF – Parks RD

Upper Colorado Basin

3) Arapaho-Roosevelt NF
   Sulphur RD/ Fraser EF
4) Routt NF – Yampa RD

Harvesting Completed 2008 & 2009

Management Alternatives

Varying Environmental Conditions

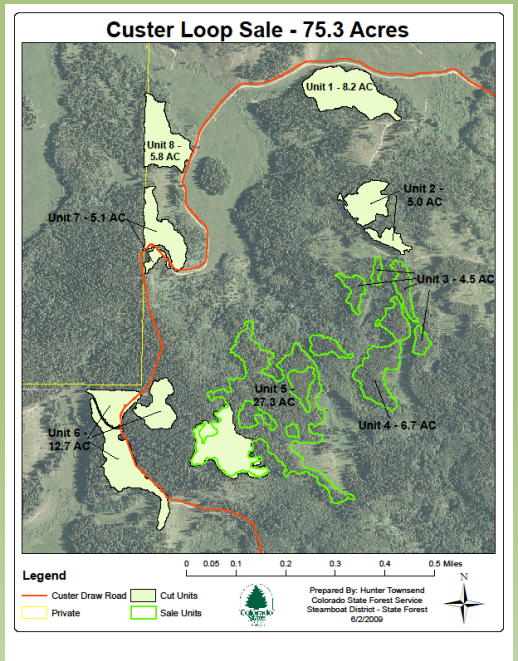
No Action
Untreated Stands

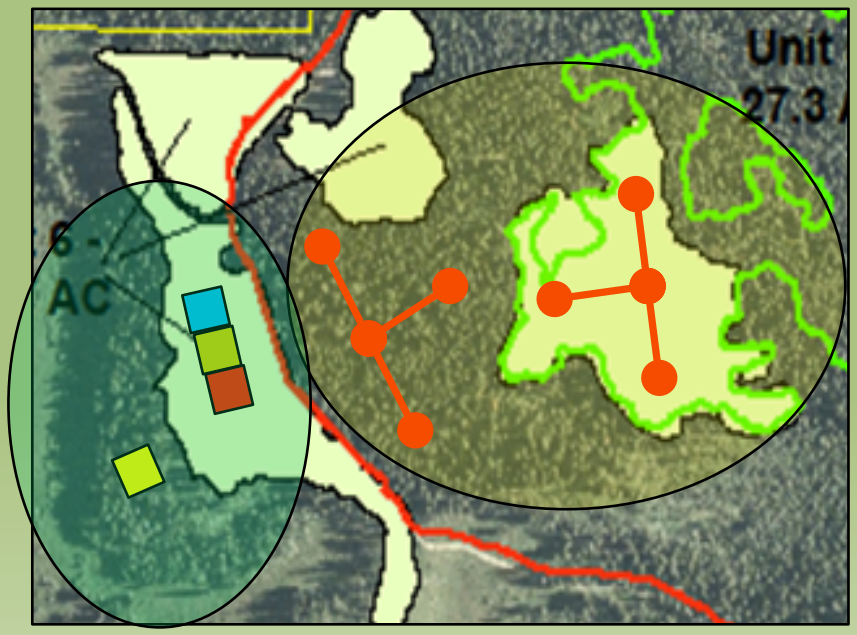
Fuel Reduction
Whole Tree Harvest (WTH)

Water Delivery
Harvest, retain slash

Forest Regeneration
WTH + Mechanical Site Prep

Forest & Watershed Responses
to Beetle-Related Management



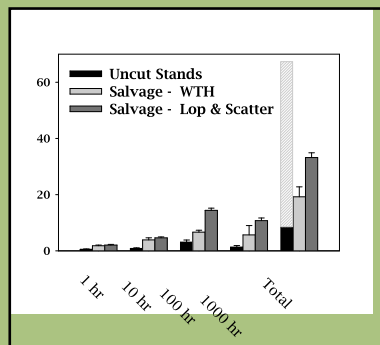


Response Variables

Snow Accumulation, Soil Moisture & Water Delivery
Tree & Herb Regeneration & Growth
N & C cycling, Soil Productivity
Fuels & Fire Behavior

Gradient of Conditions

Post-Treatment Surface Fuels



Harvesting adds -
4X fine fuels (1 + 10 hr)
3X total surface fuels

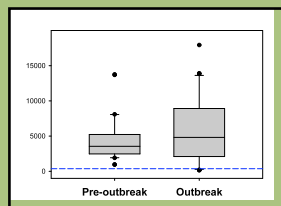
Lop & scatter retains -
1-2X more heavy fuels than whole tree harvest.

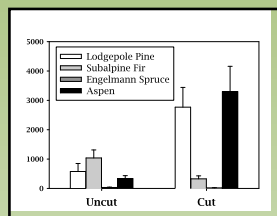
Windthrow of uncut canopy
Surface fuels will exceed those in managed areas.

Current fuel reduction will stimulate fine and ladder fuels.

What's Coming Back?

Seedling Recruitment





Green vs. Red

Pine recruitment during the outbreak is at least equal to previous decades

To Cut or Not to Cut…..?

New seedlings regenerate beneath dead overstory

Subalpine fir dominates

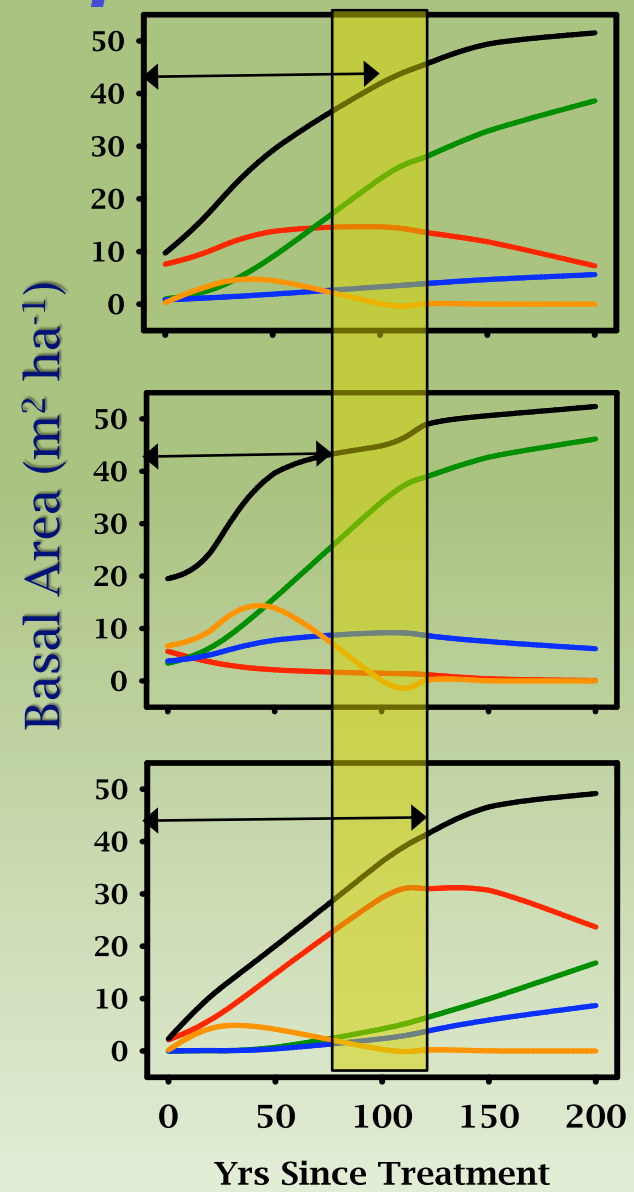
Harvesting stimulates pine and aspen regeneration

Cut stands meet minimum stocking requirements (i.e., > 150 t/acre or 370 t/ha)

(Collins 2010)
(Collins et al. 2010 *submitted)*

Stand Development

Depends on Management



Forest Recovery

Projections based on stand-level measurements

MPB-killed stands recover to pre-MPB basal area in 75 - 110 yr

Uncut & Partial Cut Stands

Dominated by fir

Clear Cut Stands

Similar to pre-MPB stands
Dominated by pine

(Collins 2010)

Thanks!

Project Partners

Colorado State Forest Service

USFS R2 - Bark Beetle Initiative

Colorado Water Conservation Board

Joint Fire Science Program

Colorado Forest Restoration Institute

Denver Water