Watershed & Forest Change after Bark Beetle & Management



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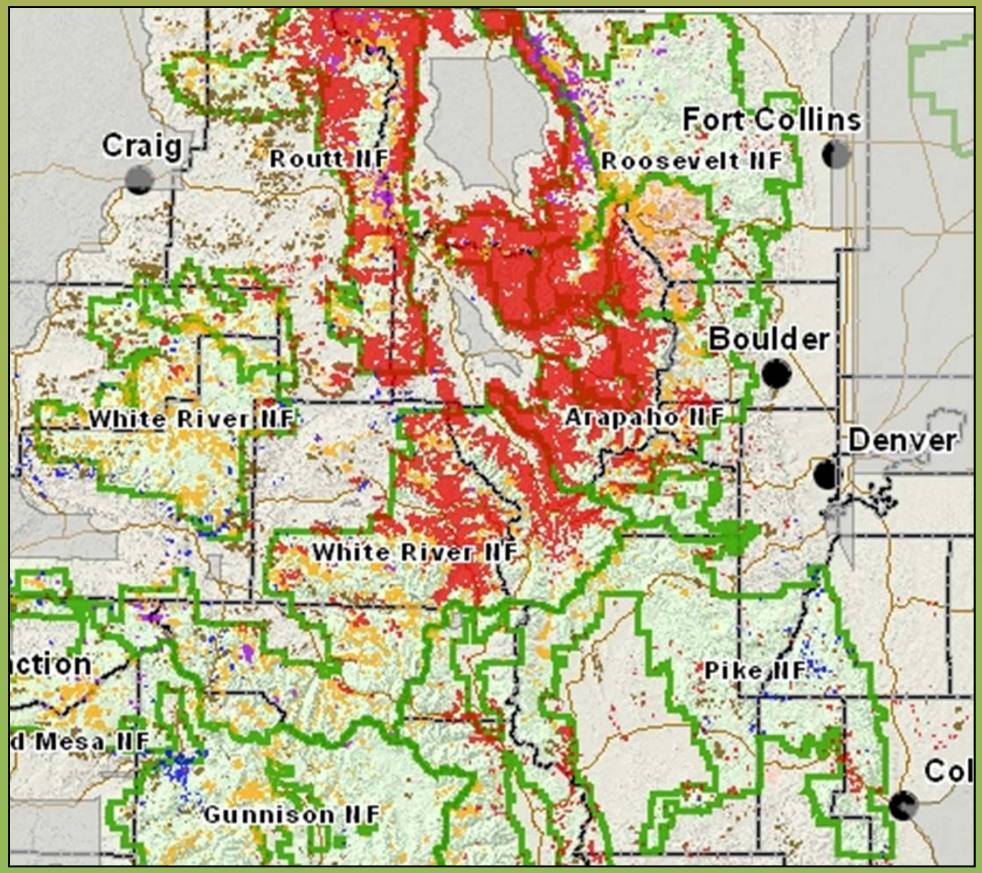
USFS - Rocky Mountain Research Station
Fort Collins, Colorado

Sustaining Colorado Watersheds; October 5, 2010

Colorado's Forest Health Headlines



"Catastrophic"

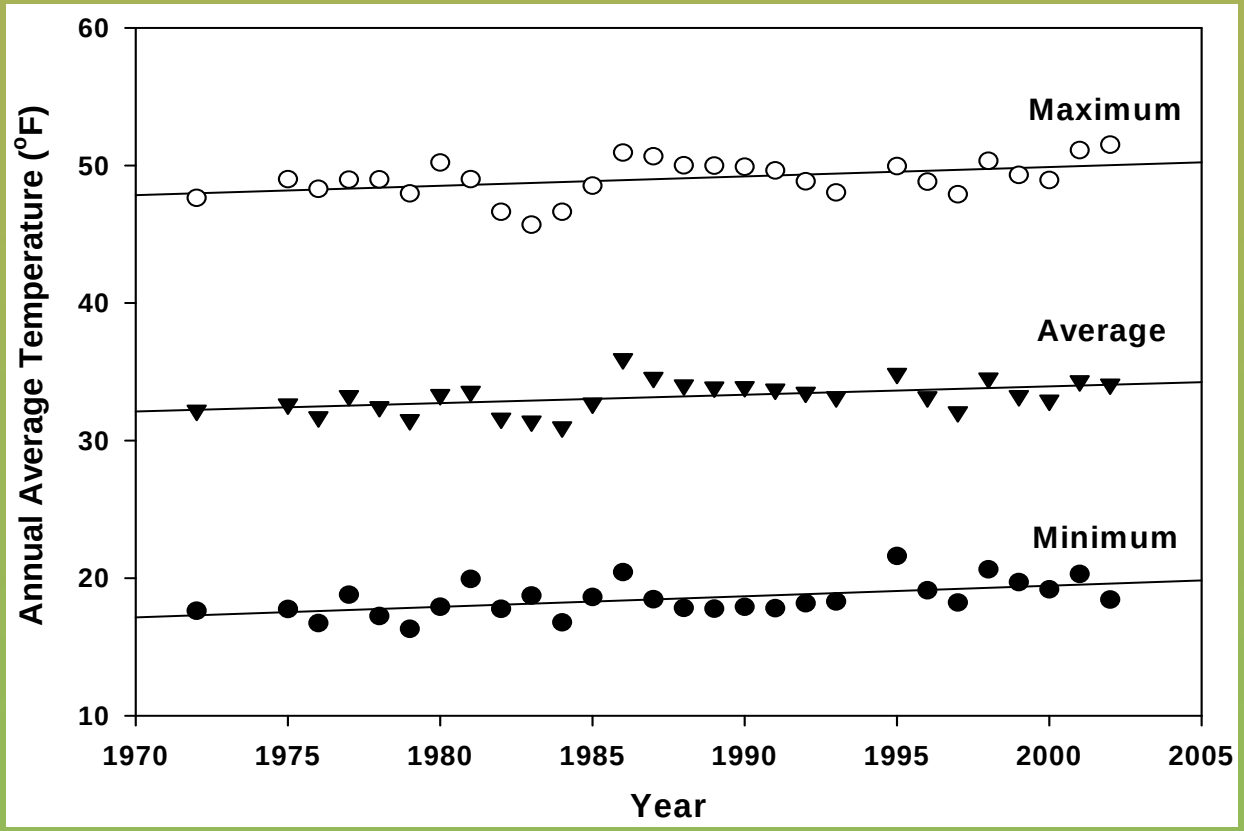
A beetle infestation expected to kill all of Colorado's mature lodgepole pine forests within five years is spreading to southern Wyoming and the Front Range.

The Denver Post

January 15, 2008

Climate Change in Colorado

Air Temperature (Fraser, CO)



Mean Min temperatures have increased over last 30 yrs.

Fewer extreme cold events

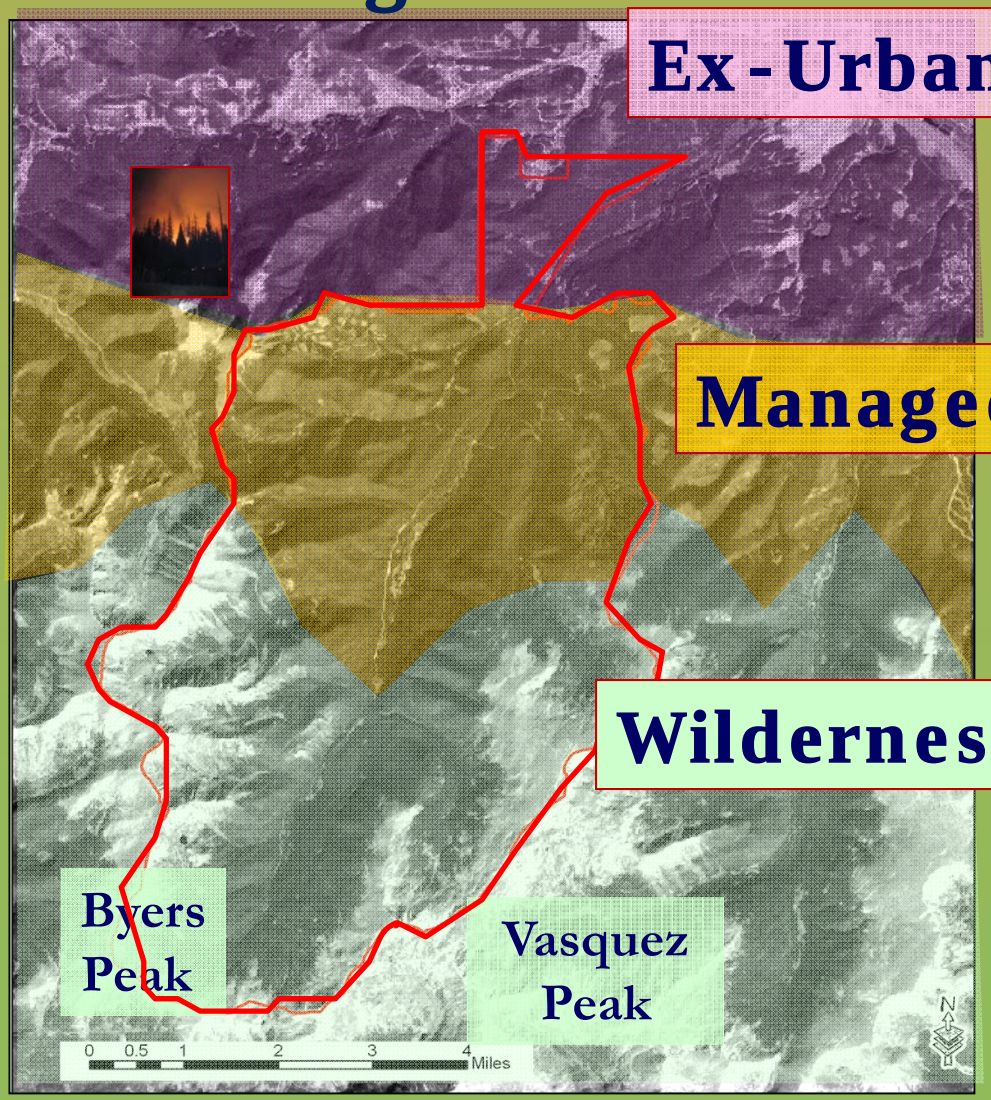
Peak flow is 1-2 weeks earlier

Another Victim of Climate Change:

In 2007, Fraser lost "Icebox of the Nation" status

Fraser Experimental Forest

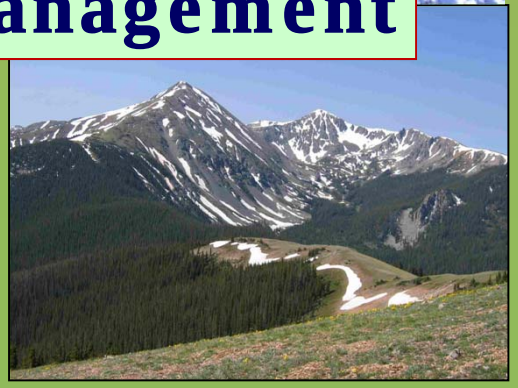
High Elevation Land Use Gradient



Ex-Urban Landscape

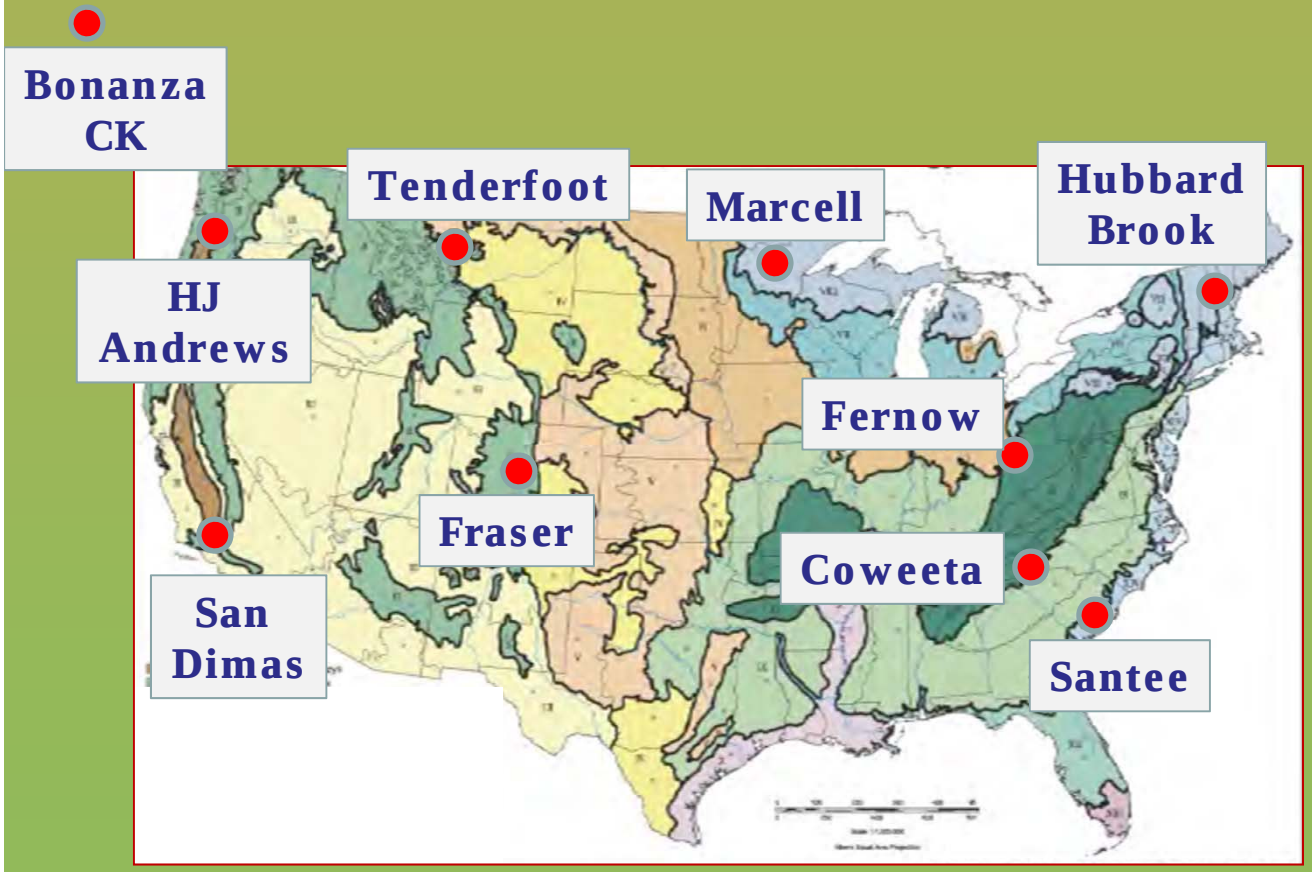
Managed Forest

Wilderness Management



USFS Experimental Forest

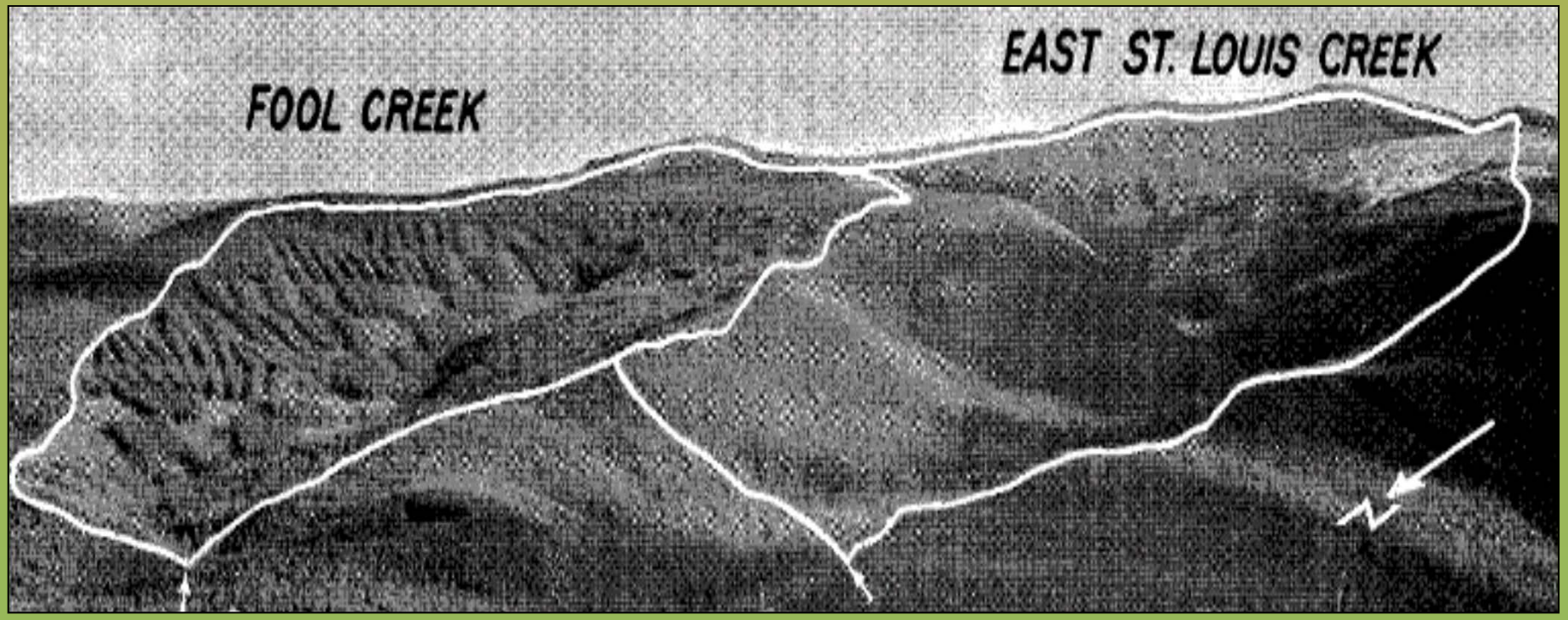
Long-Term Stream Nutrient Research



Hubbard Bk	1963
Marcell	1966
H.J. Andrews	1968
Fernow	1969
Coweeta	1969
Santee	1976
San Dimas	1979
Fraser	1982
Luquillo	1983
Bonanza Ck	1986
Tenderfoot	1992

Fraser Experimental Forest

Watershed Research since 1937



Talk Overview – MPB x Water & Watersheds

- Background & Expectations
- Initial Observations for Subalpine Watersheds
- Management Responses & Forest Recovery

Harvesting Effects

Trees, Snow → Streamflow

Reduced interception & sublimation of snow

Reduced plant water and nutrient uptake

More snow accumulation

More stream flow

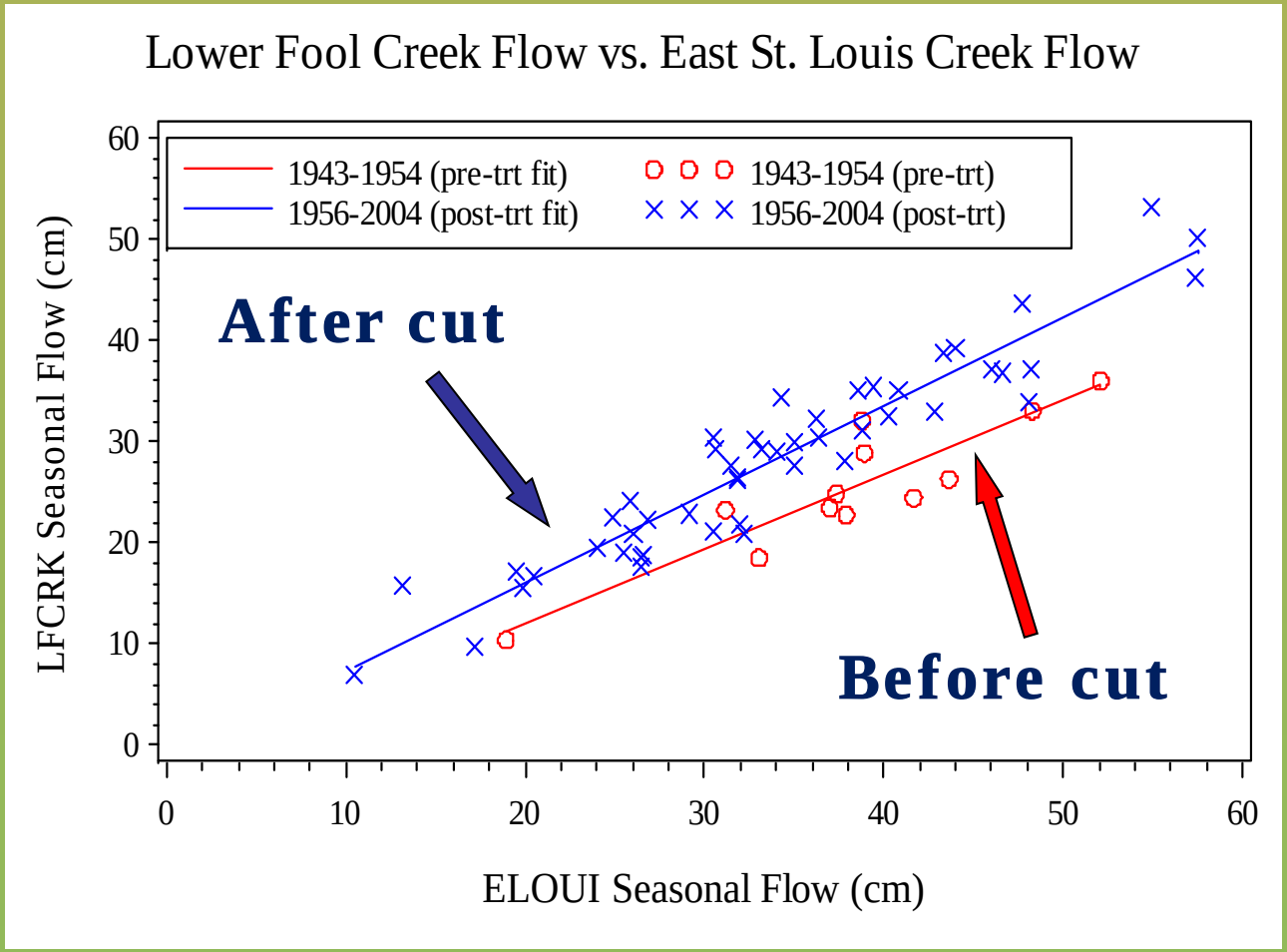
- **Increased spring flow**
- **Earlier runoff**
- **Effect greatest in wet yrs**

Higher N losses

Troendle and King 1985
Elder and Porth 2006

Harvesting Effects

Runoff Quantity



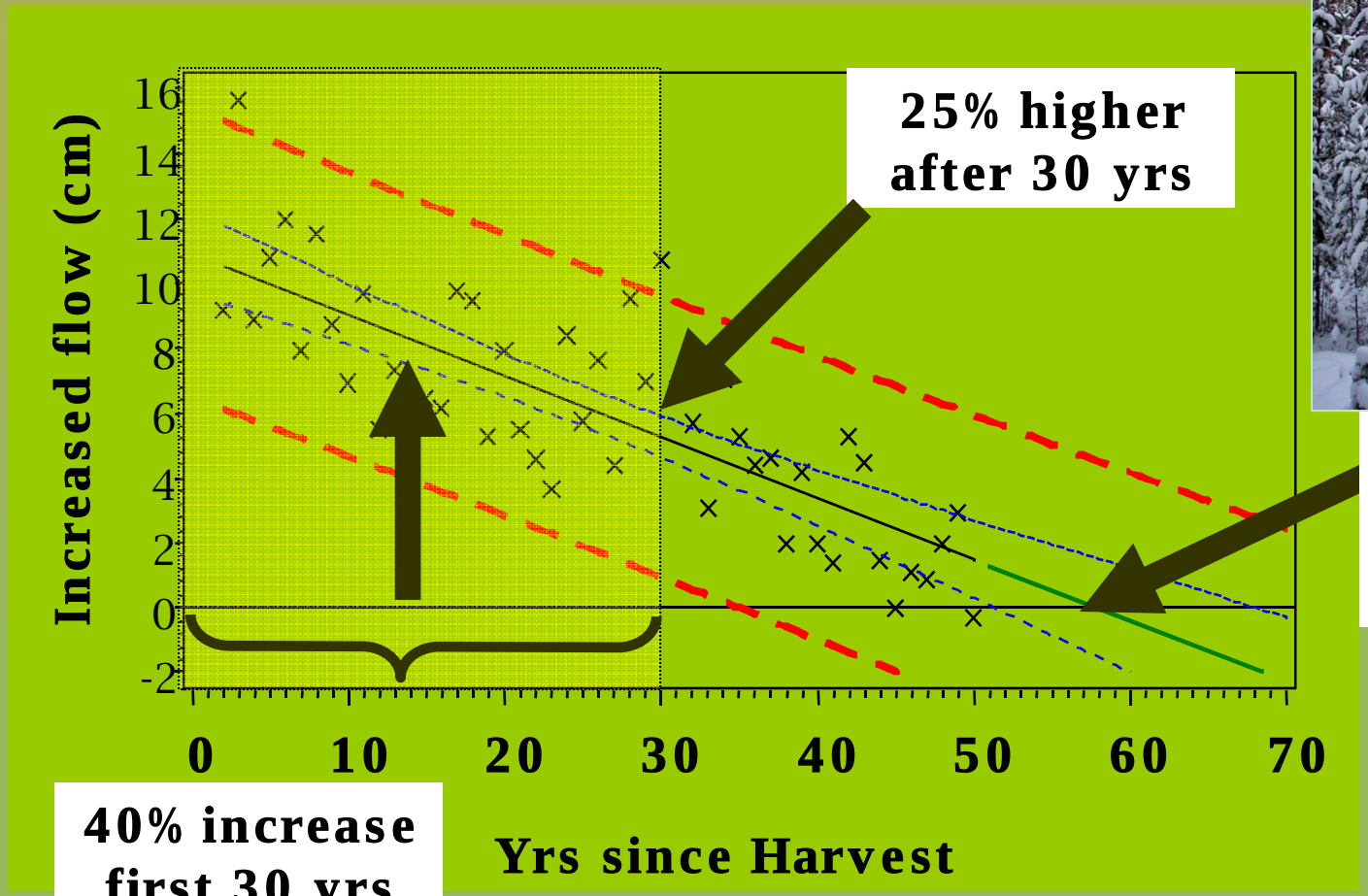
Paired Watershed Comparison:

29% increase in annual flow (6 cm)

Largest differences in years with greater flow (wet years)

Harvesting Effects

Hydrologic Recovery

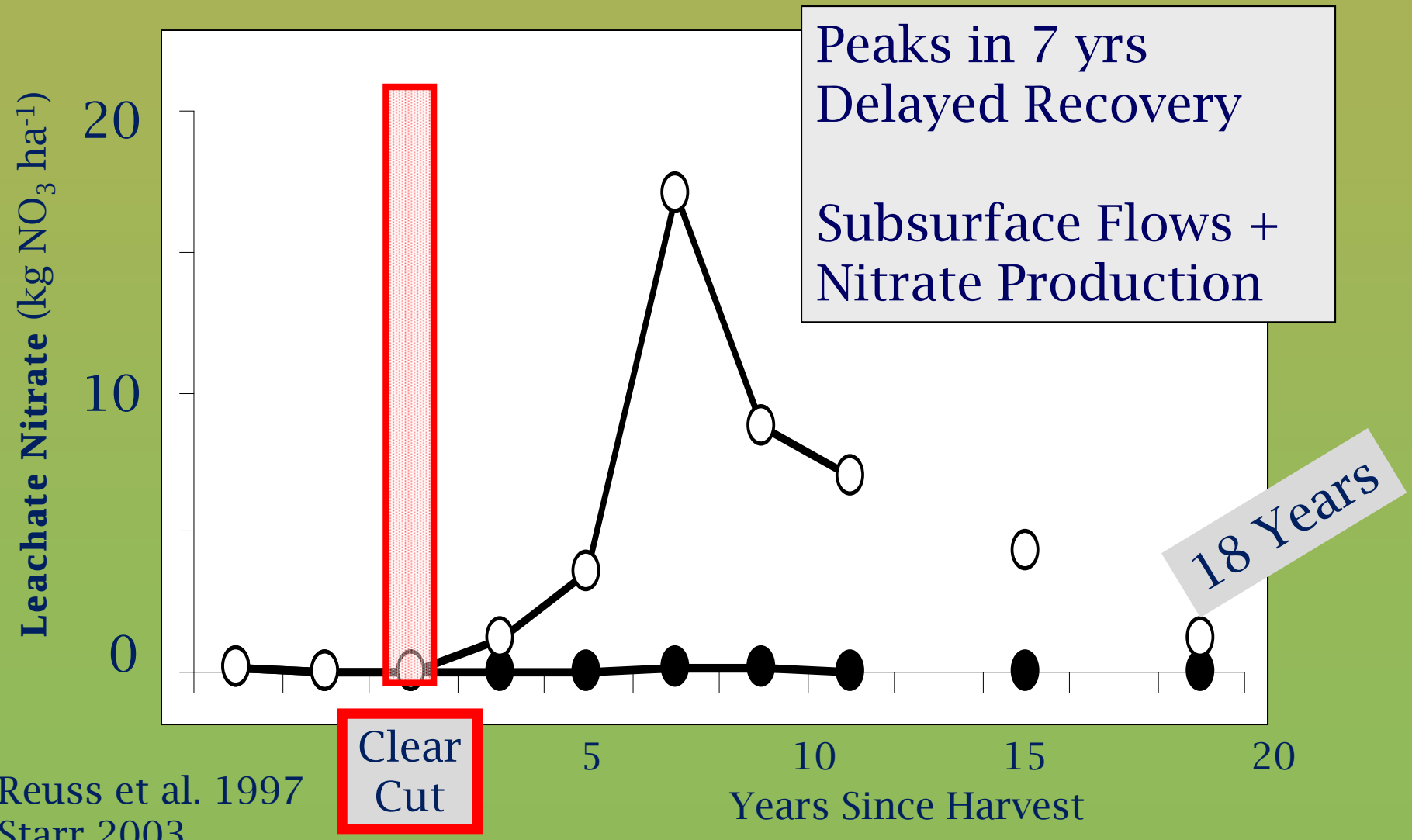


Troendle and King 1985
Elder and Porth 2006

Hydrologic Recovery Follows Canopy Recovery

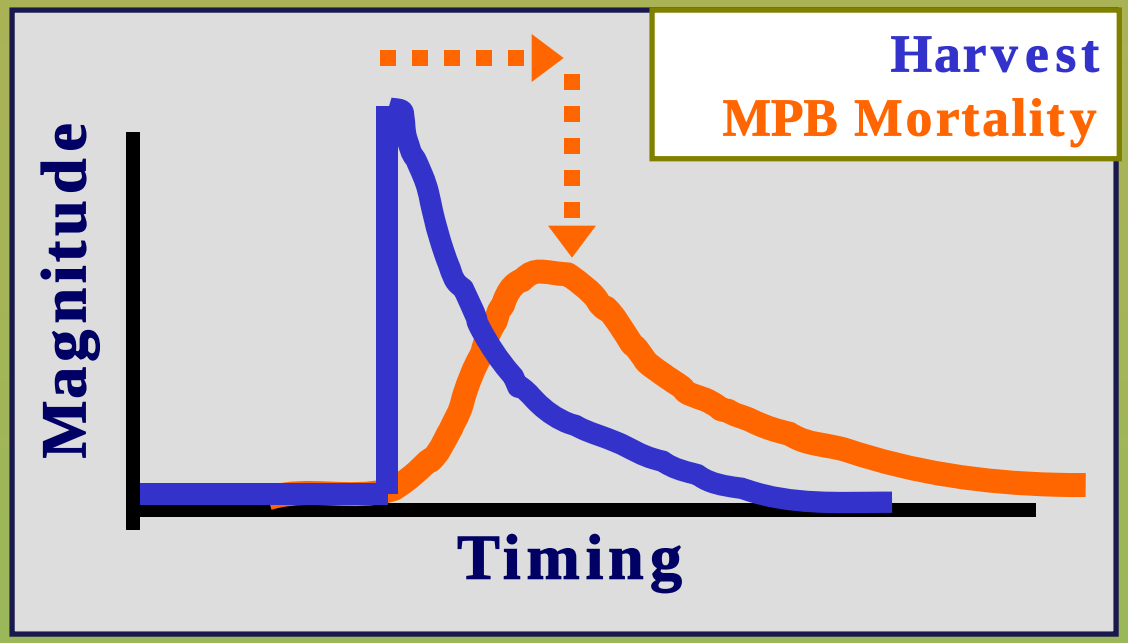
Harvesting Effects

Streamwater Nitrate



Reuss et al. 1997
Starr 2003

Projected Changes from MPB



Watershed Responses Regulated by Change in

Canopy interception & Snowpack accumulation

Water uptake & Soil nutrient use

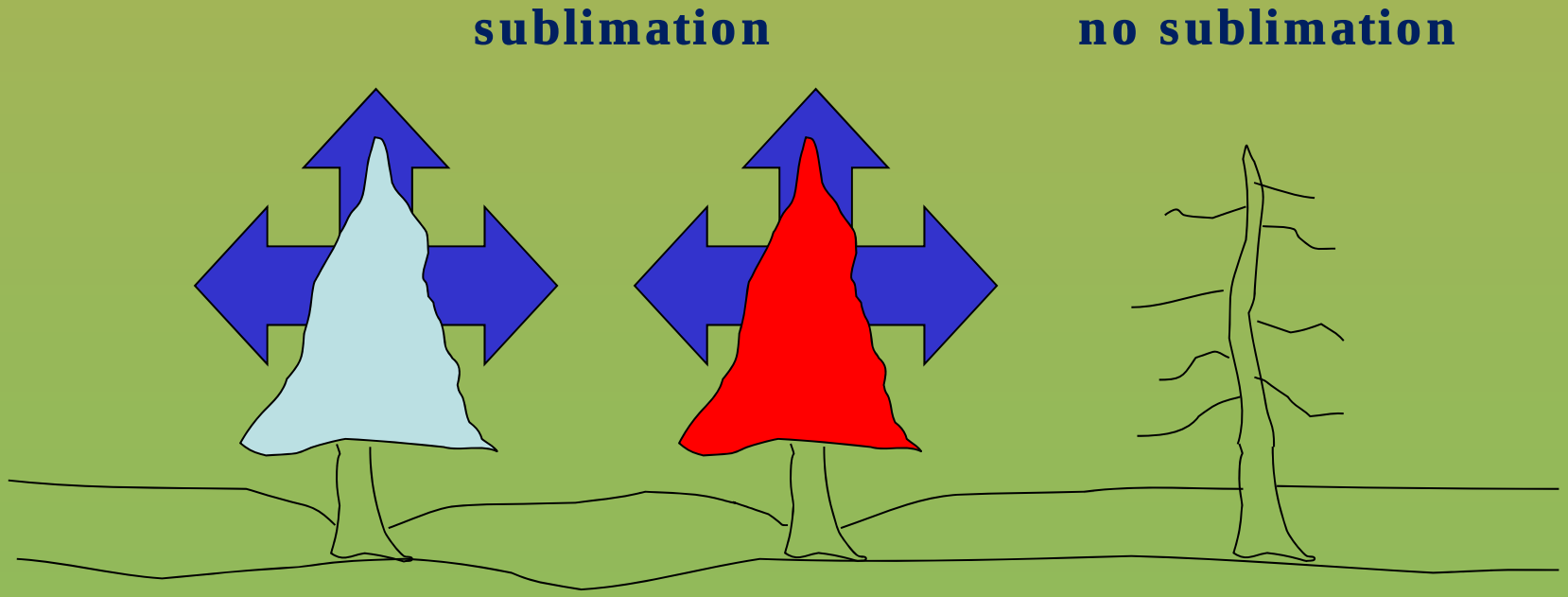
Complicating Factors

Responses may lag, difficult to detect, prolonged

Complex spatial & temporal patterns

Projected Changes – Interception

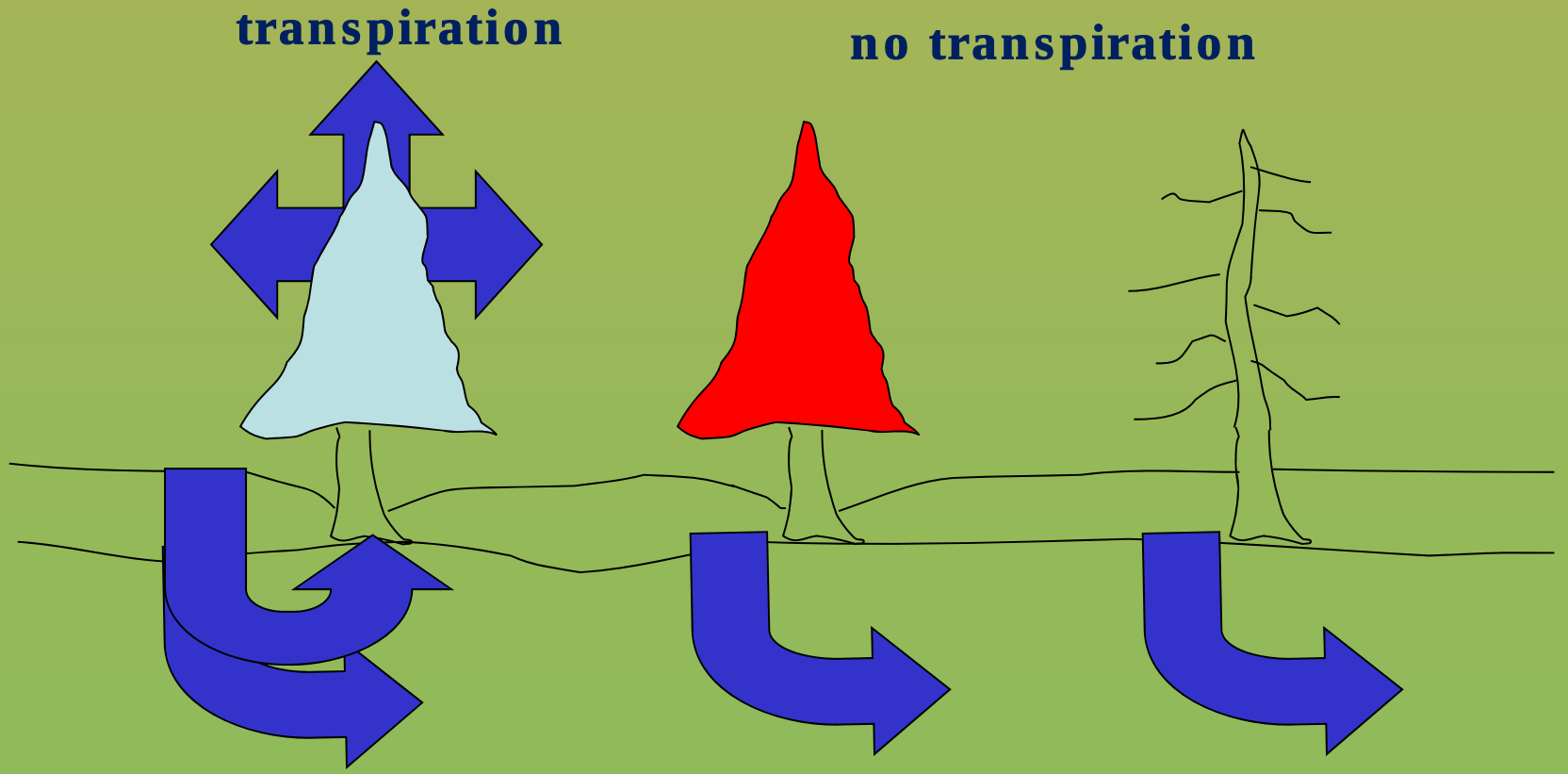
Interception losses from canopy are significant with green or red needles



Projected Changes – Water Use

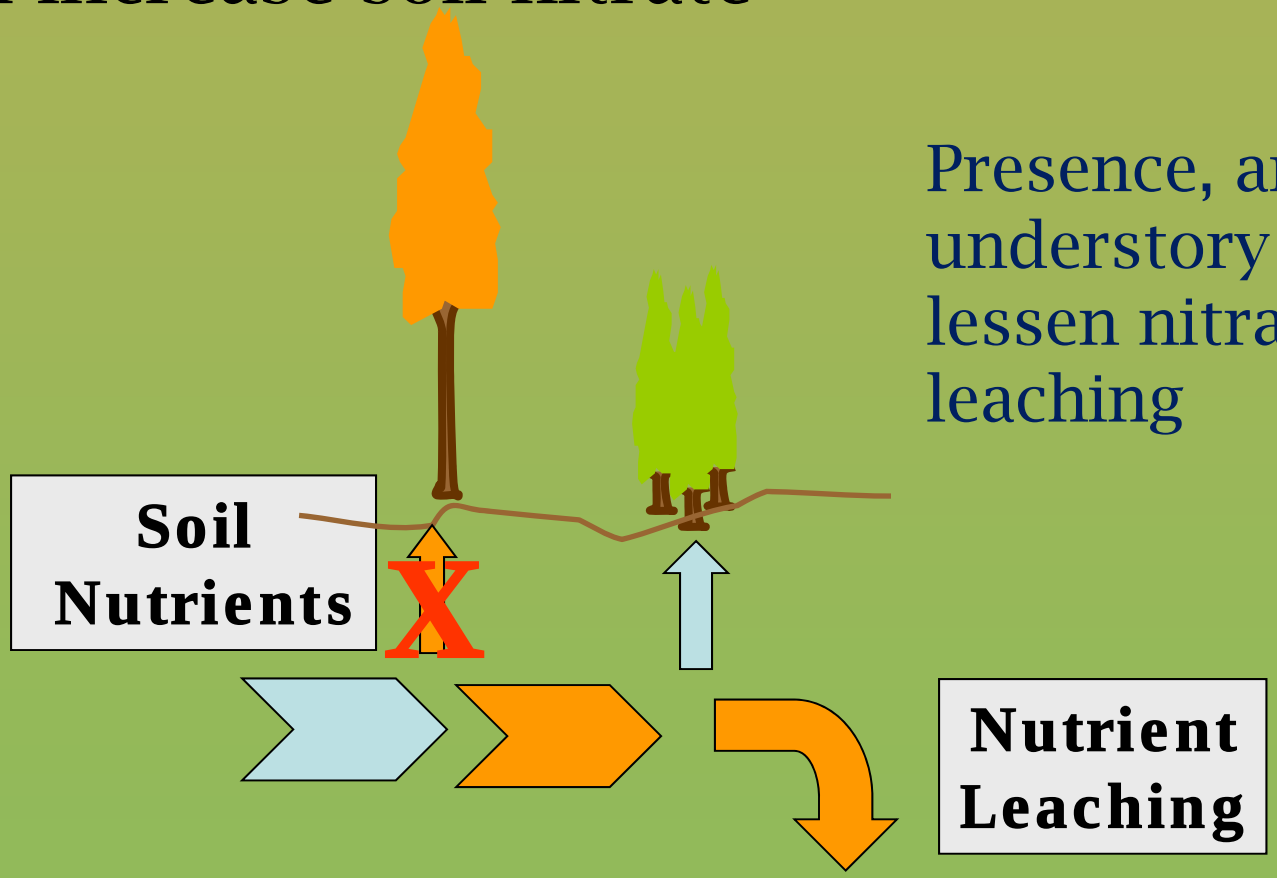
Significant portion of meltwater used by live trees (ET).

Available for runoff under dead canopy.



Projected Changes – Water Quality

Tree mortality will reduce nutrient uptake and increase soil nitrate



Presence, amount of understory will lessen nitrate leaching

Previous Outbreak

Streamflow

1950s Spruce Beetle Outbreak

White River & Routt National Forests

Beetles destroyed 4 billion BF of standing timber

80% trees covering 30% of watershed infested

- **16% increase in average annual yield (35 mm)**
- **14% increase in high flow; 10% increase in low flow**

Greatest increase 15 yrs post outbreak

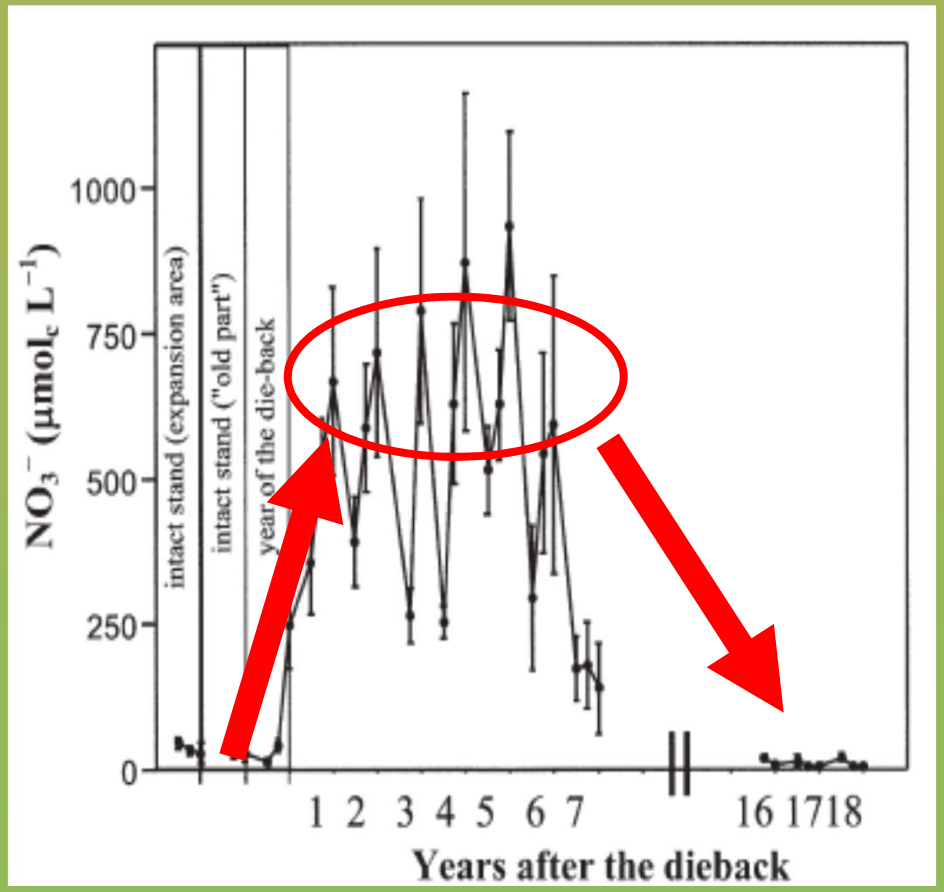
Annual variability related to snowpack

>25 year recovery period

Love 1955
Bethlahmy 1973 & 1975

Previous Outbreak

Water Quality



Huber 2005.
J. Env. Quality 34:1772-1779

Bavarian Spruce Forest
85% tree mortality by Ips

Nitrate Export
- **10X higher post outbreak**
- **Peak - 5 yrs**
- **Baseline Recovery - 15 yrs**

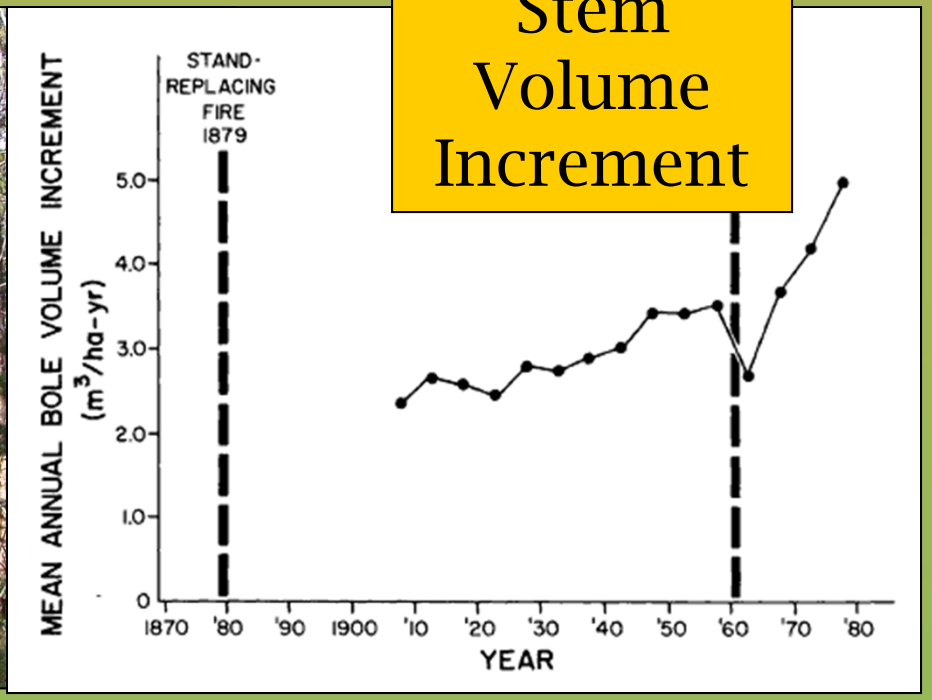
Decrease attributed to uptake by understory

Longer recovery than from harvest or windthrow

Previous Outbreak

Forest Growth Response

Stem Volume Increment



Yellowstone Area '60 & '70s

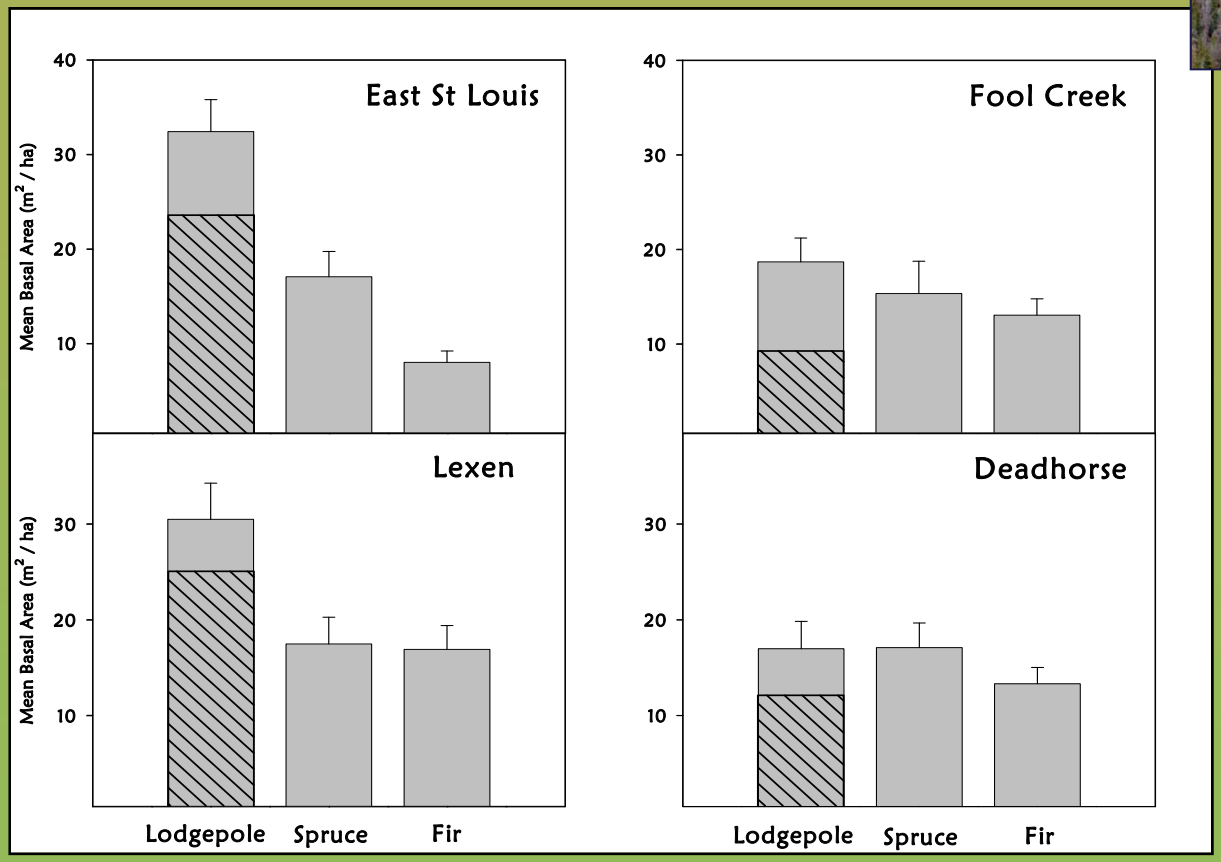
About 40-70% of the overstory trees died

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

Romme et al. 1986

Current Outbreak

Extent of Mortality



Basal Area Loss

Old Growth

73- 83% of LPP

39 - 41% of total

Managed

50-70% of LPP

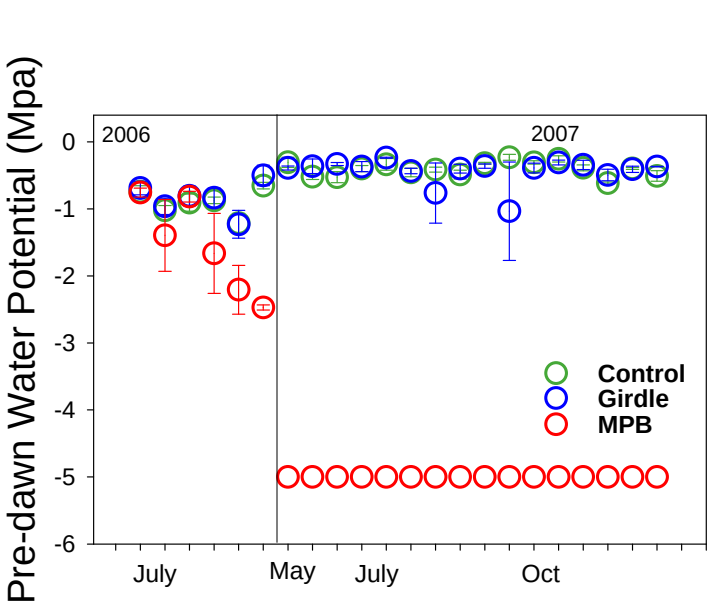
20-25% of total

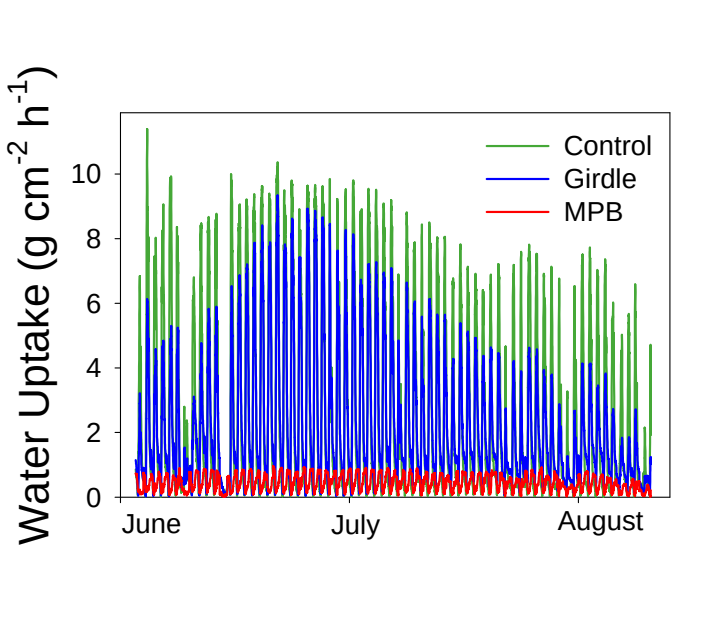
Old Growth

Mixed Young/Old

Current Outbreak

Tree Water Use … (+ +)





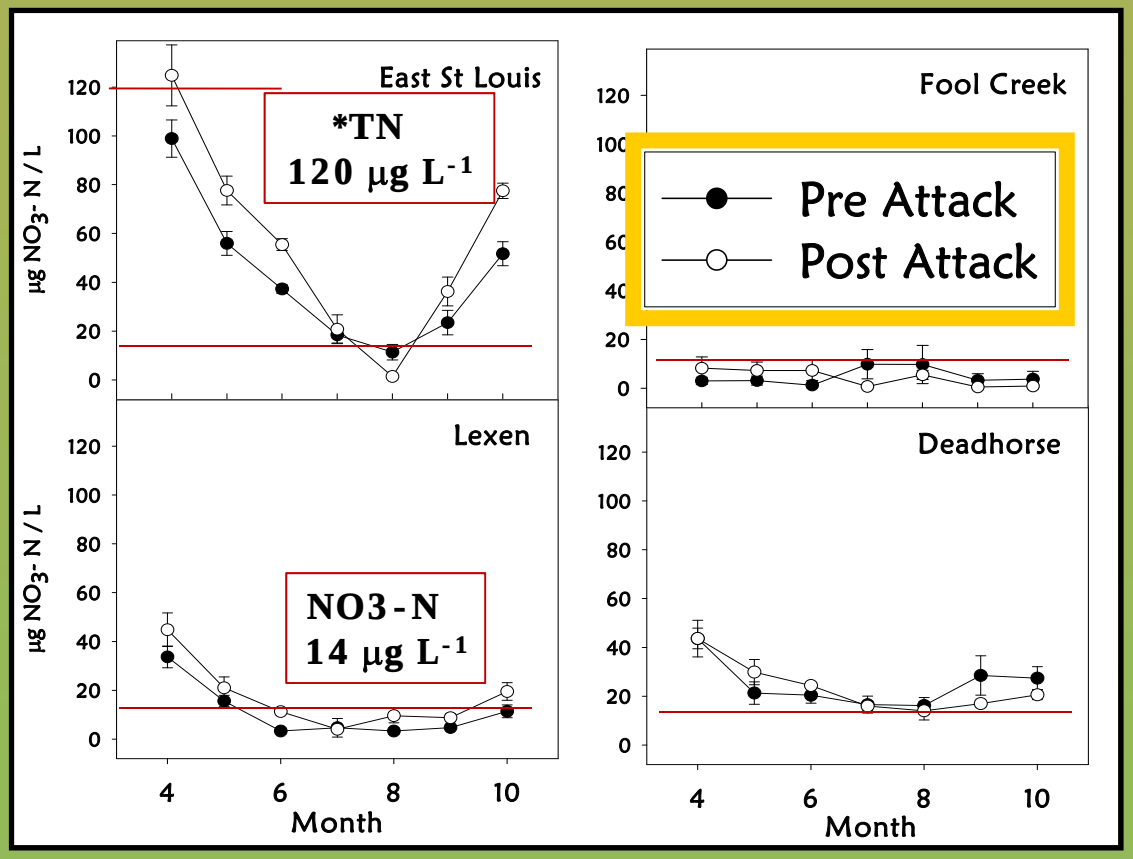
Transpiration drops ~50% within 3 weeks of MPB

Water status of girdled trees unchanged – continued growing for 1 year after attack

Blue-stain fungus: primary mortality agent

Current Outbreak

Stream Nitrate … (+ / -)



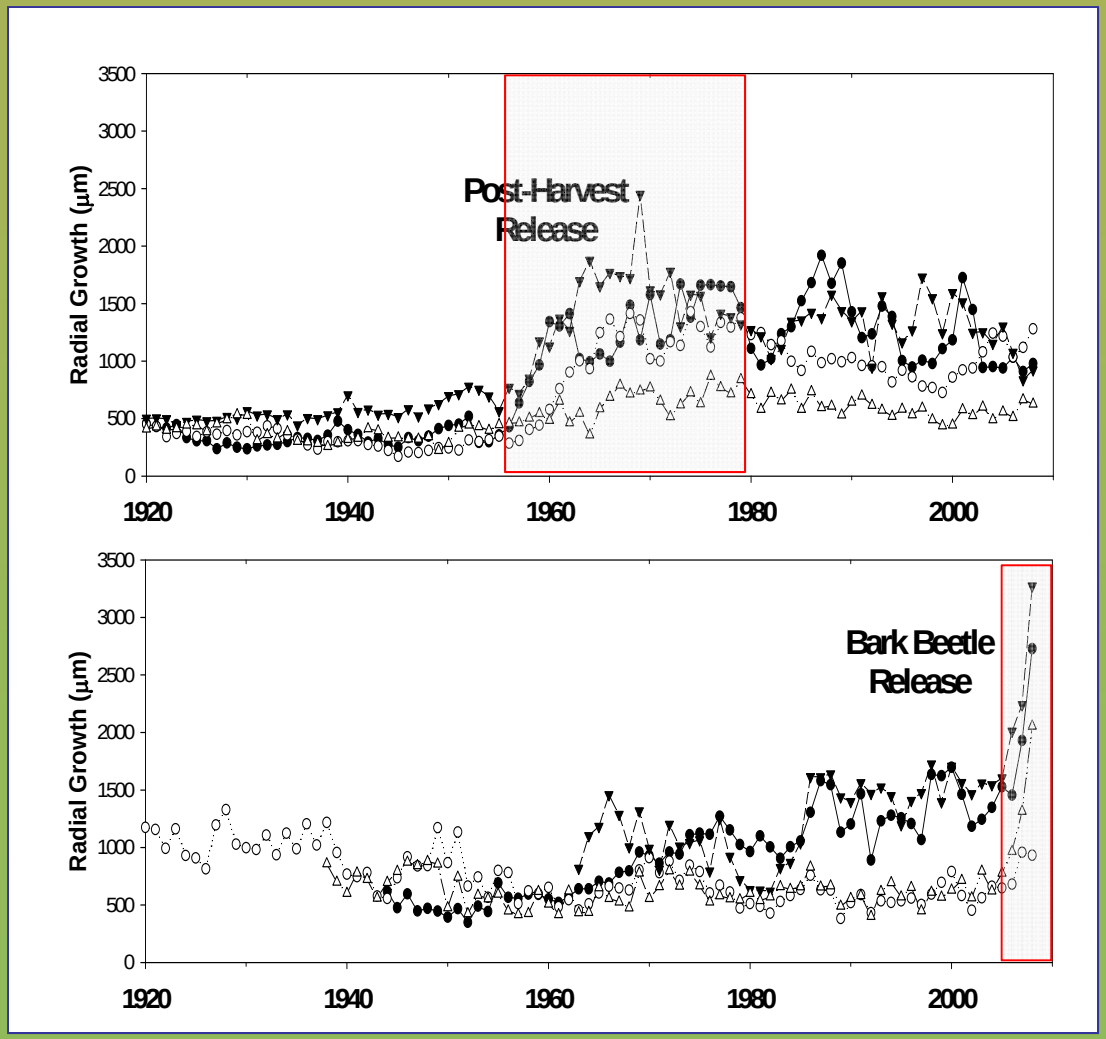
Old Growth

Mixed Young/Old

Magnitude of Change

- *Draft Stream N Levels
- ~1% of N Deposition
- Seasonal Fluctuation
- Harvest Legacy

Tree Growth Response
Radial Increment

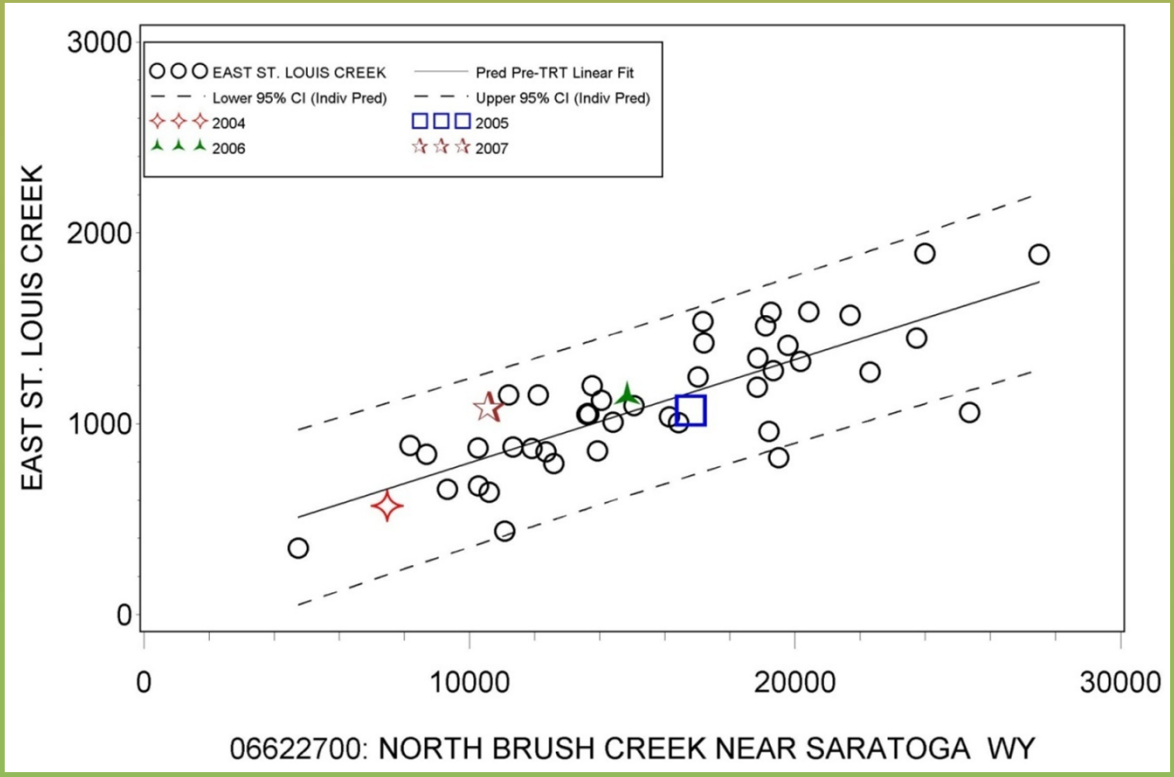


- Increased radial growth after mid ‘50s harvest.
- Change after MPB
- Foliar N also responds

Current Outbreak

Streamflow … (??)

MPB-Infested Basin (East St Louis)



Uninfested Reference Basin

30 yrs pre-MPB comparison (through 2003)

4 post-MPB years (2004 - 2007)

No change in discharge compared to uninfested basin

Initial Watershed Responses

Responses vary: Fast, Slow & No Effect

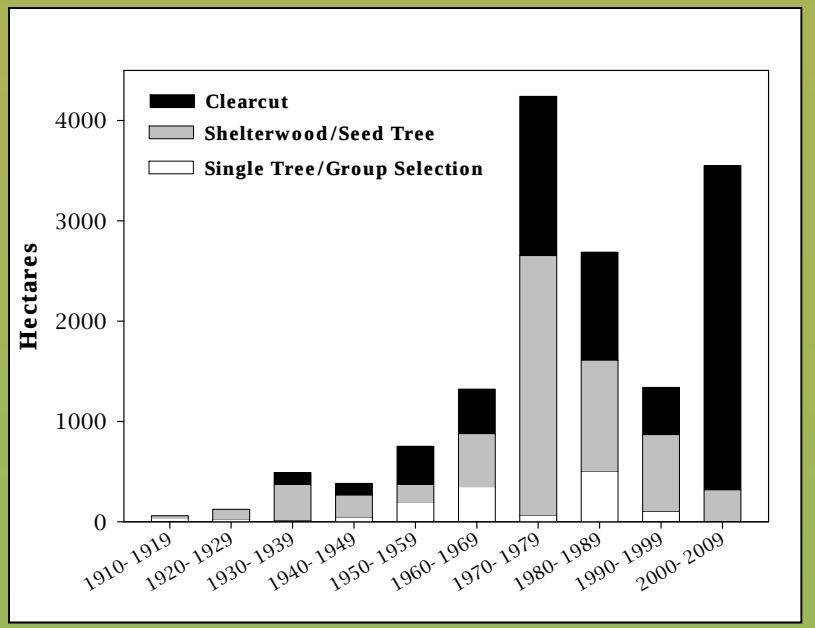
Decline in stand transpiration and nutrient use depends on extent of mortality, species composition, understory response

Magnitude and timing of changes in water differ from harvest response

In general, studies do not indicate nutrient loading or other water chemistry changes of the magnitude that would present problems for either human water use or aquatic ecosystems.

Lukas and Gordon, Western Water Assessment 2010

Management Responses to MPB



Sulphur Ranger District - Arapaho-Roosevelt NF

½ of District is high-Risk LPP

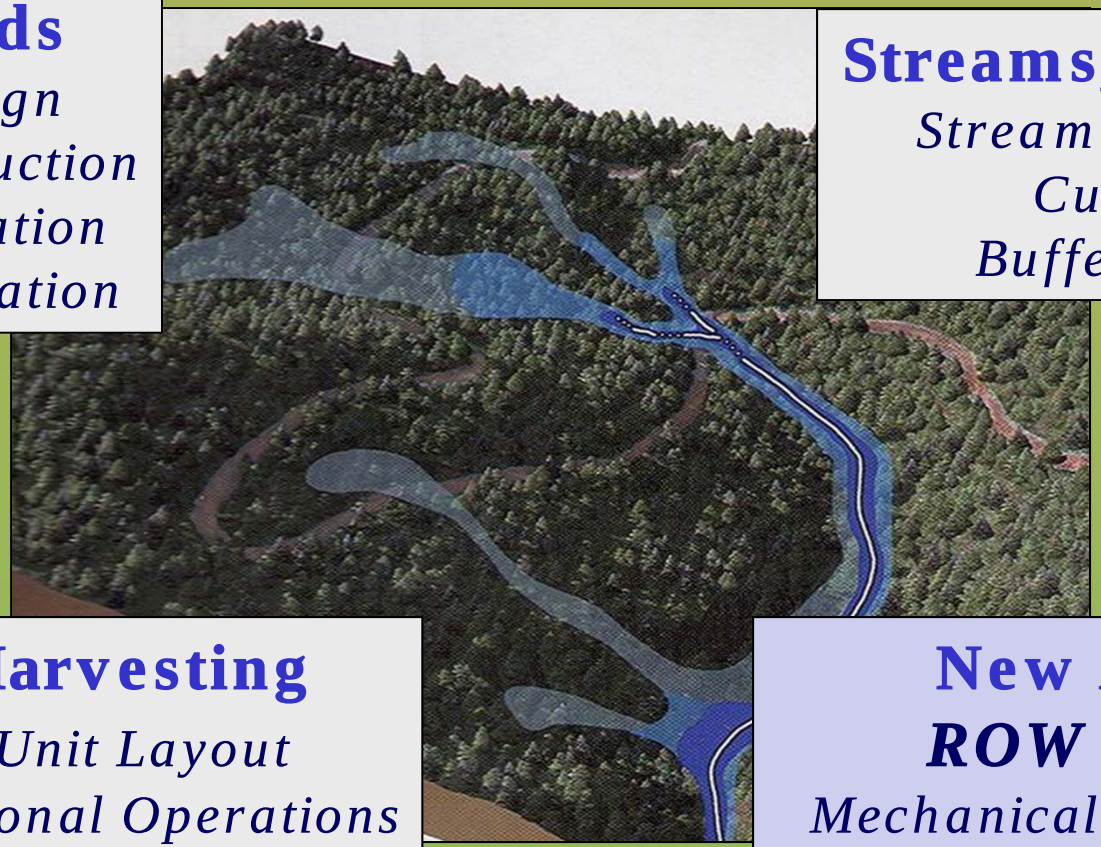
½ of that area is treatable (i.e., slopes, roads)

6–10k ha have been analyzed (~10 – 15% of treatable area)

Protecting Clean Water Delivery

Best Management Practices

Roads
Design
Construction
Utilization
Obliteration

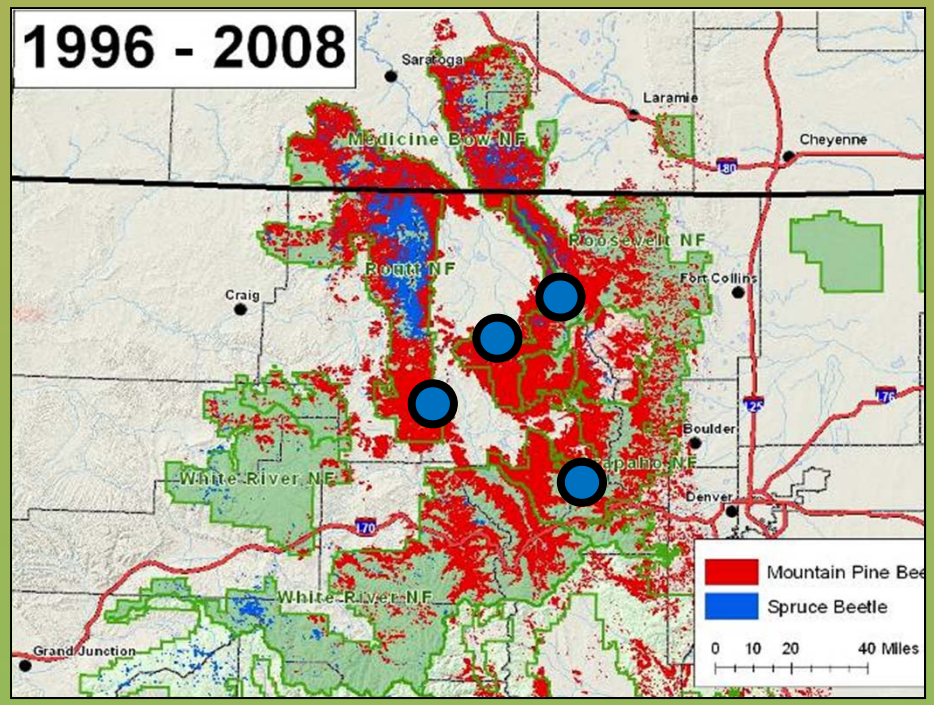


Streams, Wetlands
Stream Crossings
Culverts
Buffer Zones

Harvesting
Unit Layout
Seasonal Operations
Slash Management

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

Forest & Watershed Responses to Beetle-Related Management



Harvesting Completed 2008 & 2009

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

Management Partners

Brook Lee – Colorado State Forest Service
Andy Cadenhead, Jeff Underhill - US Forest Service

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

Rethinking Riparian Management

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)

Are current BMPs effective for ROW clearing?

Corridor clearing to protect power transmission lines, roads, trails, etc.

Slash Pile Burn Scar Rehabilitation

Effects of pile burning on understory plants, soils.

Compare effectiveness of rehabilitation treatments

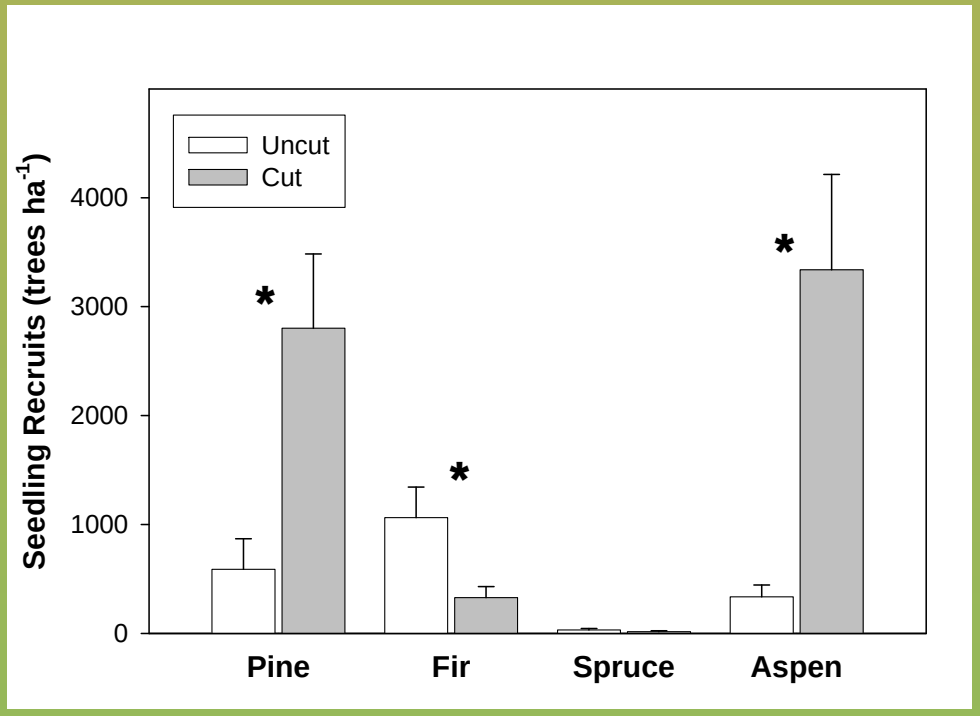
Develop soil treatment, seeding guidelines for pile burn rehabilitation.

Paula Fornwalt -Rocky Mountain Research Station

Mark Paschke – Colorado State University

What's Coming Back?

Seedling Recruitment



10 paired sites at Fraser

New seedlings regenerate beneath dead overstory
- Subalpine fir dominates

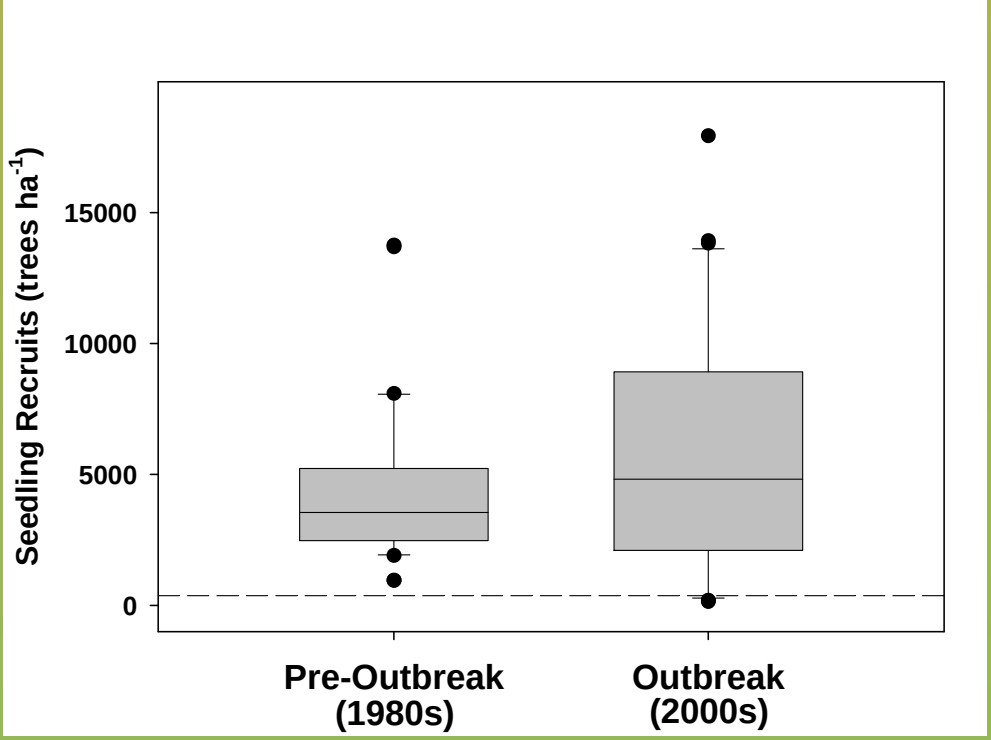
Harvesting stimulates pine and aspen regeneration

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

(Collins et al. 2010 *submitted)*

What's Coming Back?

Seedling Recruitment



Post-harvest Recruitment pre-outbreak vs. outbreak

30 stands

3 yr after harvesting

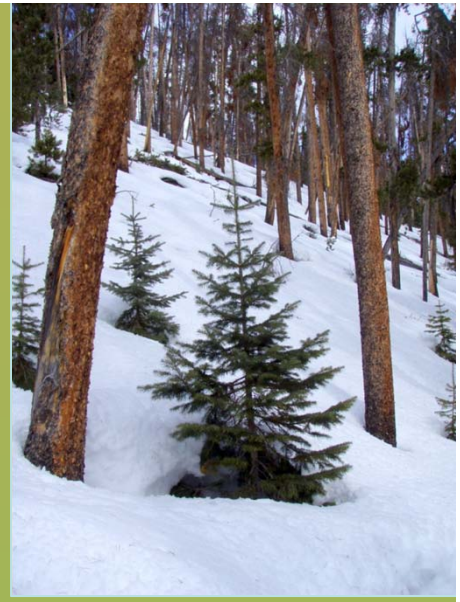
Sulphur Ranger District

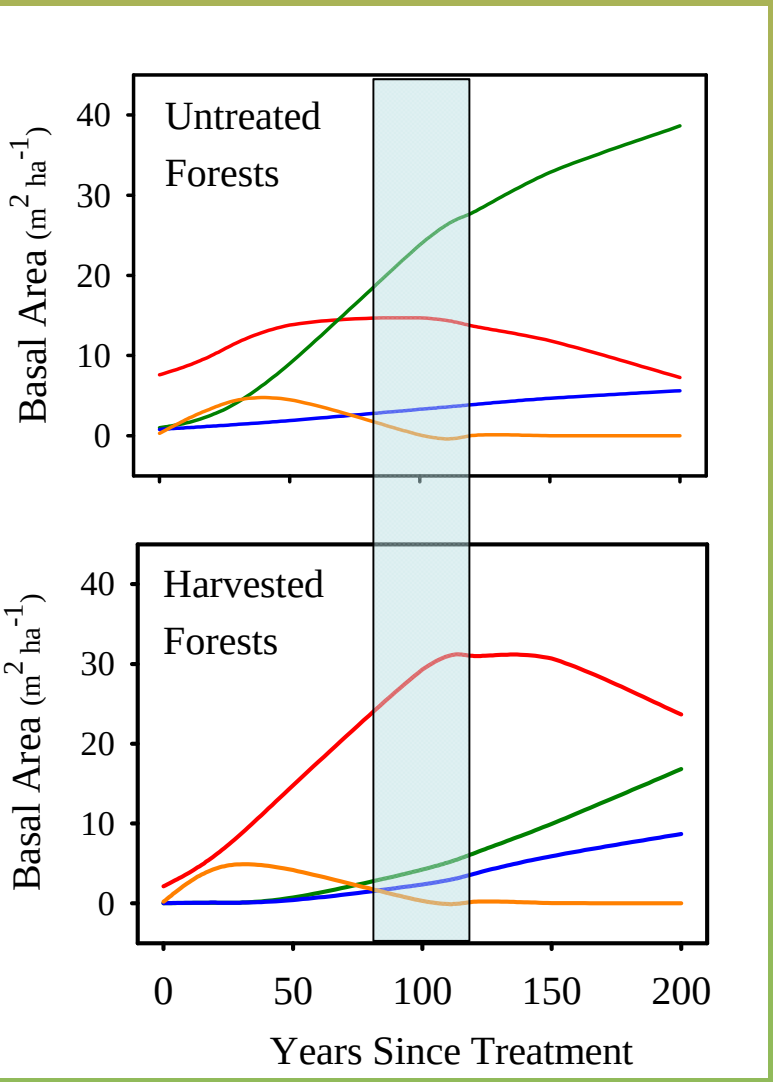
Pine recruitment during the outbreak is at least equal to previous decades

> 90% of stands meet minimum stocking requirements

(Collins et al. 2010; *in press CJFR)*

Stand Development
Depends on Management





- Lodgepole Pine
- Subalpine Fir
- Engleman Spruce
- Quaking Aspen

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

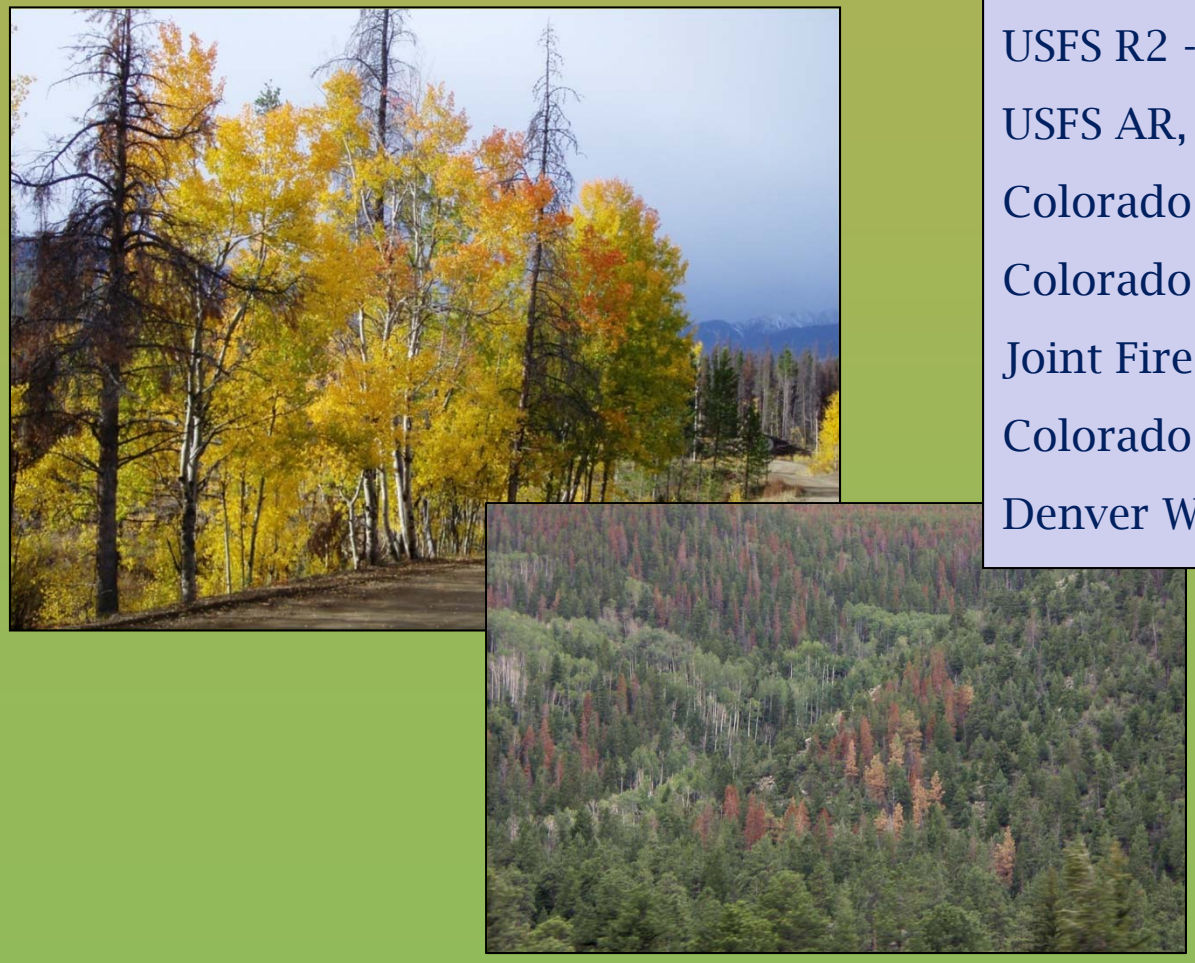
Dominated by fir

Clear Cut Stands

Similar to pre-MPB stands
Dominated by pine

(Collins 2010)

Many Thanks!



Project Support

USFS Chief's Emergency Funds

USFS R2 - Bark Beetle Initiative

USFS AR, MBR, WR NFs

Colorado State Forest Service

Colorado Water Conservation Board

Joint Fire Science Program

Colorado Forest Restoration Institute

Denver Water

Sustaining Colorado Watersheds; October 5, 2010