Managing Post-Beetle Outbreak Forests, Fuels & Fire
Tuesday August 21st 2012

Session Topics and Approximate Schedule

Stop 1 (9-10am)

Tour Overview, Study Design and History (Handout 1 and 2 - Rhoades, Hubbard, Elder)
Forest and Watershed Responses to MPB

Stop 2 (10-11am)

Overview of Management History of the Outbreak (Craig Magwire USFS; John Twitchell CSFS)
Regeneration and Forest development following MPB and Management (Handout 3 - Collins)
Fuels and potential fire behavior in MPB Forests (Handout 4 – Collins; Handout 5 - Pelz)
Discussion – Forest Development and Future Management

Stop 3 (11-12 am)

Surface Fuel Alternatives (Handout 6 - Rhoades, Hubbard, Elder)
Understory Plant Responses (Handout 7 - Fornwalt)
Mastication (Handout 8 – Battaglia)
Pile Burning (Handout 9 – Rhoades, Fornwalt and others)
Discussion – Fuel Management Alternatives

Lunch & Travel to Church Park (12 to 1pm)

Stop 4 (1-4 pm)

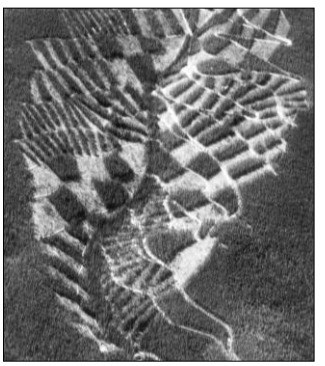
Church Park Fire Event (Deanna Harms, Eric Schroder, USFS)
Treatment Effects Prelim Data (Handout 10 – Rhoades, Fornwalt, Cheng)
Discussion Session – Fuel treatments, effects and fire Behavior in MPB forests

Tour Organizers/ Sponsors: USFS-Rocky Mountain Research Station
Colorado Forest Restoration Institute
Southern Rockies Fire Science Network
Joint Fire Sciences Program

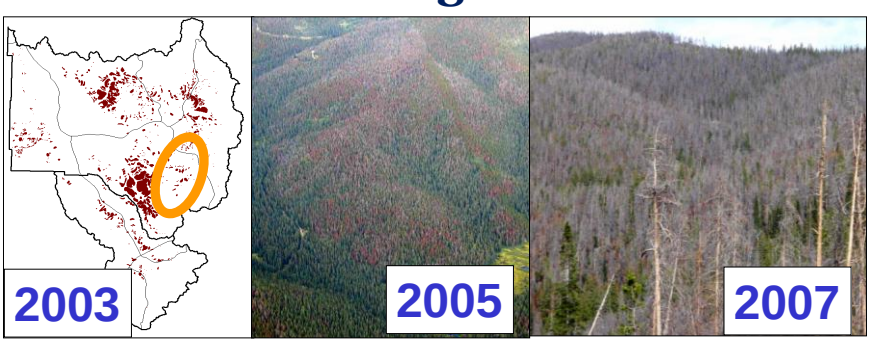
Research Support: US Forest Service – Chief's Emergency Fund
R2 Bark Beetle Incident and MPB Forests
Rocky Mountain Research Station
Colorado Water Conservation Board
Joint Fire Sciences Program
Colorado Forest Restoration Institute

More Information: Chuck Rhoades, USFS Rocky Mountain Research Station
crhoades@fs.fed.us; 970 498-1250

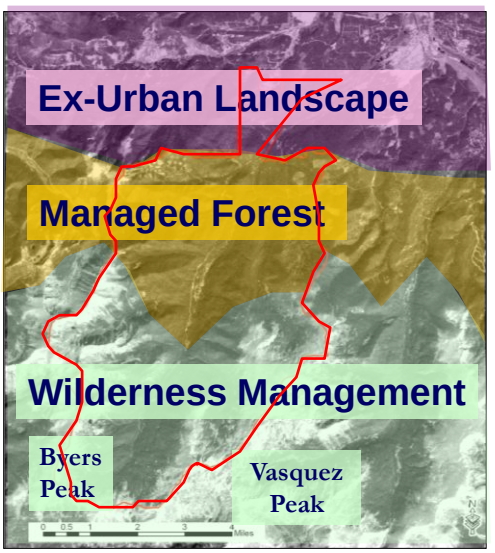
Mountain Pine Beetle Effects on Watersheds & Forest Ecosystems



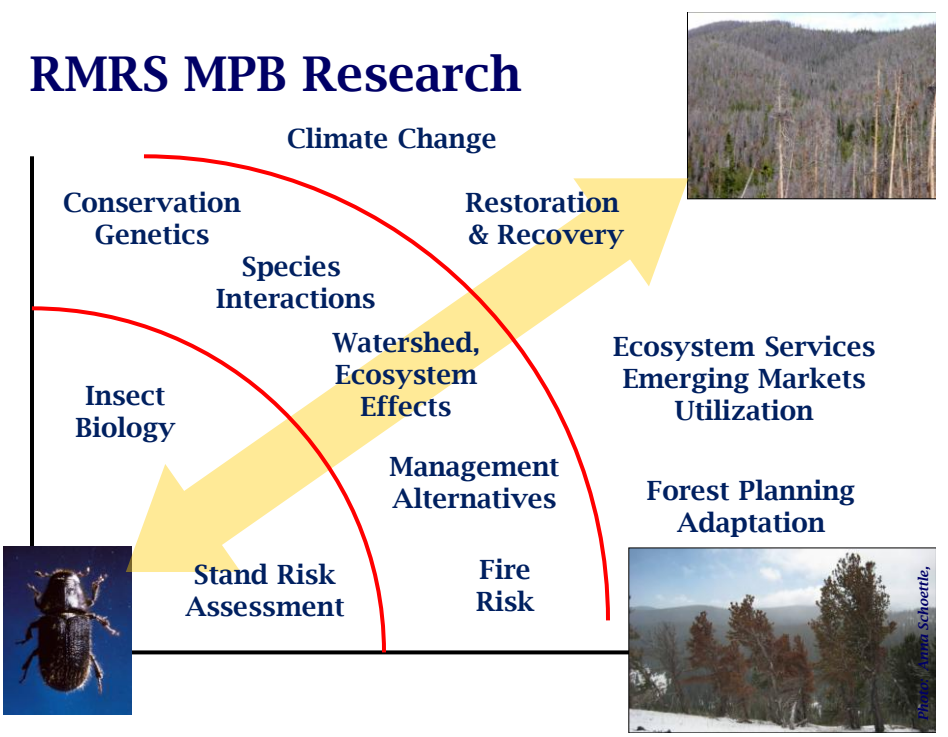
Watershed Change after MPB

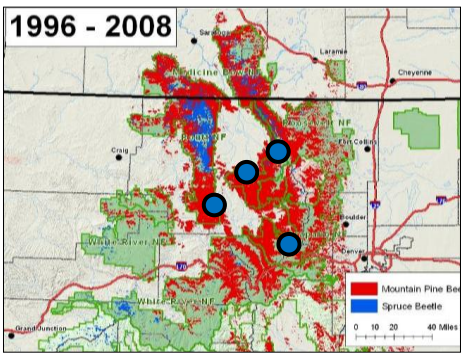


High Elevation Land Use Gradient



RMRS MPB Research





Harvesting Completed 2008 & 2009

Research Areas

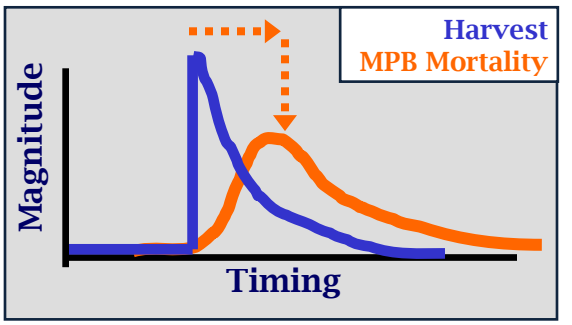
North Platte Basin

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

Watershed Change = Forest Change



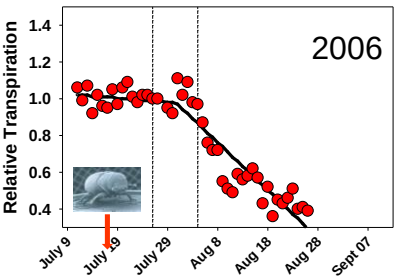
Forest Canopies Regulate Key Watershed Conditions

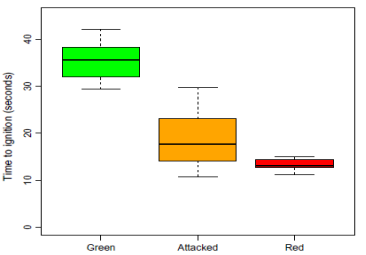
Canopy interception & snowpack accumulation
Water uptake & nutrient use

Complicating Factors

Time lag, complex spatial & temporal patterns
Interactions with residual vegetation

Tree Water Use Declines… Fast





Begins to decline 2 weeks after MPB attack

60% declines by the end of the first growing season

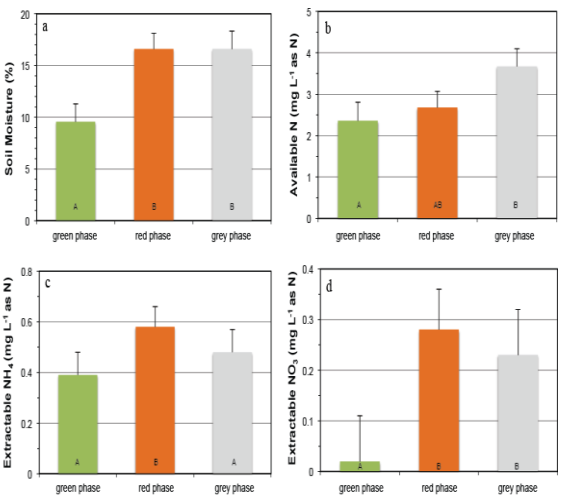
No transpiration the second growing season

Hubbard et al. Forest Ecology and Management (*In Review*)

Altered foliar moisture + chemistry = increase flammability

Jolly et al. Forest Ecology and Management (*2012*)

Soil Resources Increase Under Faders



Soil Moisture
Highest under red, gray

Soil N Availability
Lowest under live trees
Highest under gray

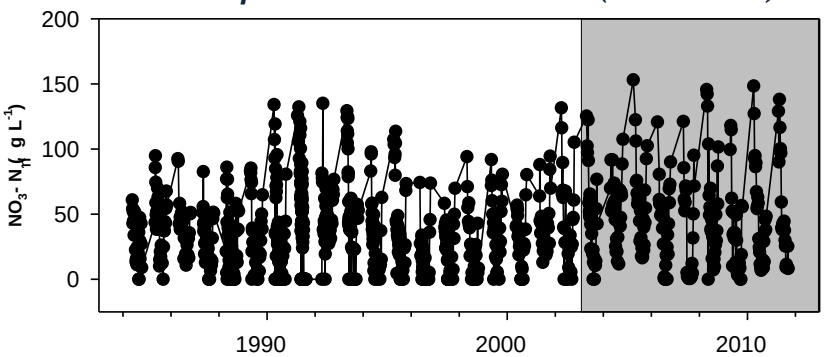
Factors Responsible
Lack of plant uptake
Soil N turnover
Litter inputs

11 sites – Grand Cty, CO
Green: Healthy
Red: 1-3 yr post-attack
Gray: ≥4 yr post attack

Clow et al. 2011 Applied Geochem

Long-Term Stream Nitrate

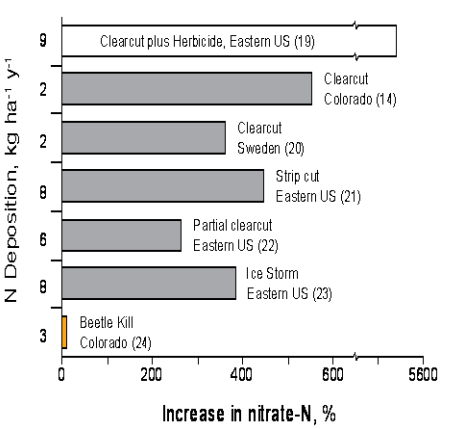
USFS Fraser Expt Forest – East St Louis (1984-2011)

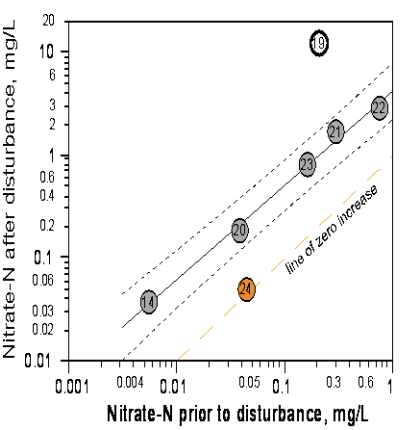


Pattern has persisted for nearly a decade (9 post infestation yrs) during wet and dry years.

Seasonal and multi-year factors complicate LT trends

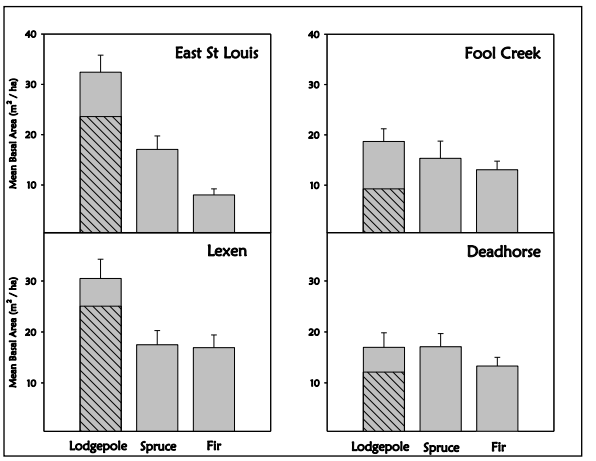
MPB Relative to Other Disturbances





(J. McCutchen, W. Lewis et al. *under revision*)

Degree of Overstory Mortality –
Species Composition & Stand Structure



Old Growth

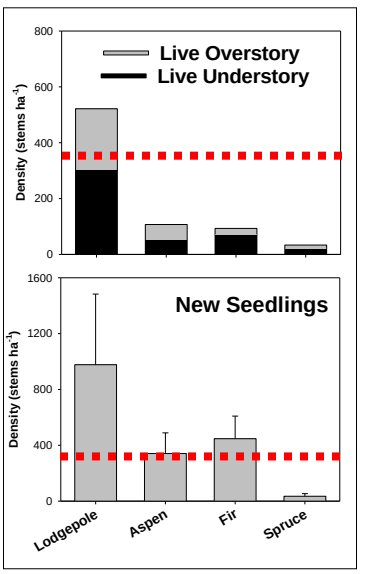
Mixed Young/Old

Basal Area Loss

Old Growth
- **73- 83% LPP loss**
- **39 - 41% total loss**

Mixed Age/Managed
- **50-70% of LPP**
- **20-25% of total**

Growing Stock in MPB Forests
Residual Live & New Trees



Overstory **(> 4" DBH)**
126 t/acre (310 t/ha)
71% LPP; 17% AS; 7% SF

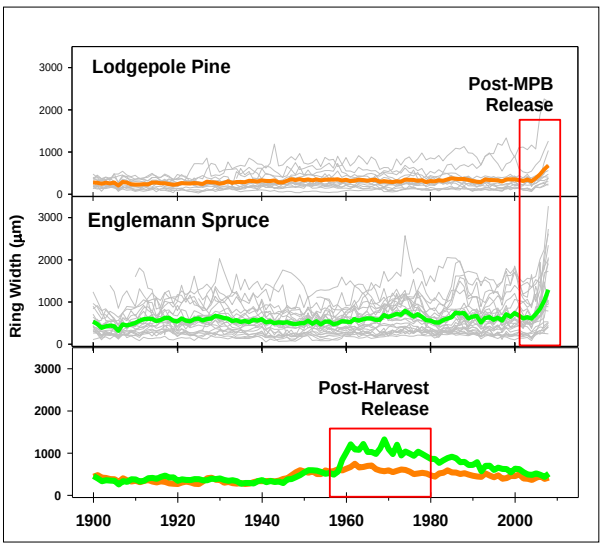
Understory **(1-4" DBH)**
180 t/acre (445 t/ha)
68% LPP; 12% AS; 15% SF

New Recruits
736 t/acre (1820 t/ha)
54% LPP; 19% AS; 25% SF

***Stocking Levels**
150 t/acre (370 t/ha)

(Collins et al. 2011)

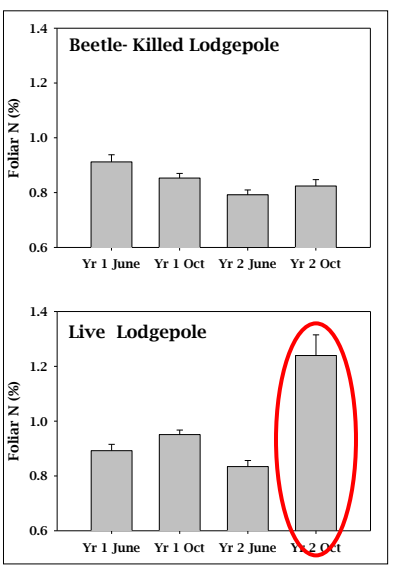
Forest Response – *Overstory Growth*



- **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

Forest Response – *Foliar Nutrition*



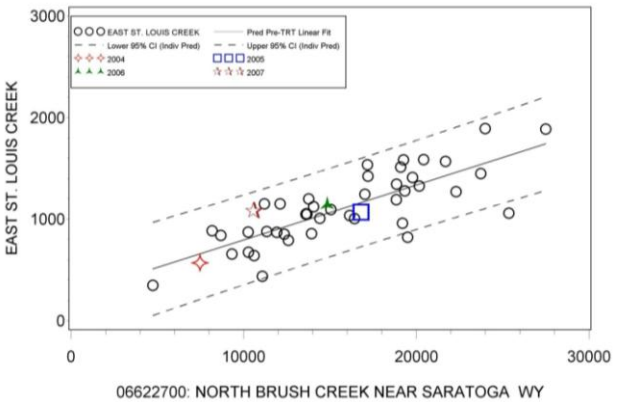
Foliar N decreases in fading canopies as trees die

For the remaining live trees, foliar N increased following mortality of neighbors (0.8 to 1.3%)

Hubbard et al. in review

Streamflow Response

MPB-Infested Basin (East St Louis)



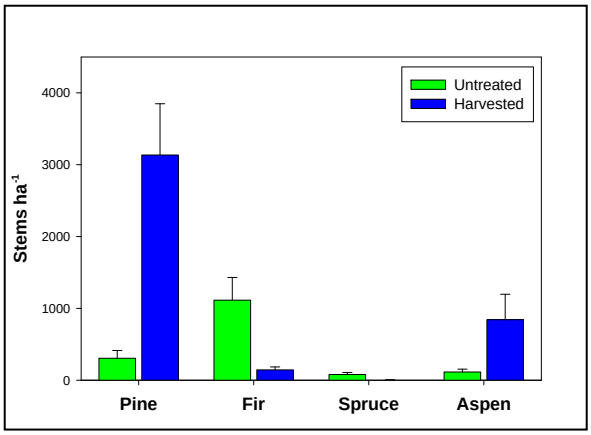
Uninfested Reference Basin

30 years pre-MPB comparison (through 2003)

4 post-MPB years (2004 - 2007)

No change in discharge compared to uninfested basin

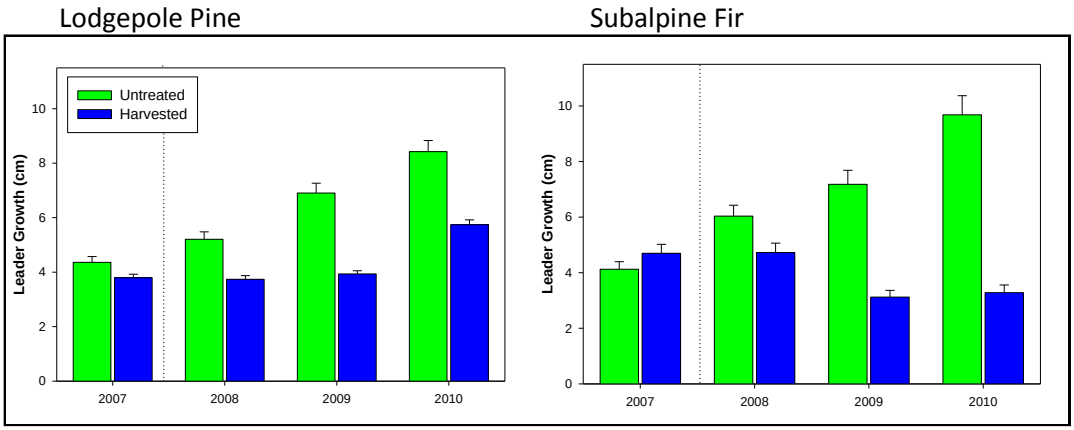
What's Next for Beetle-Killed Lodgepole Pine Forests?



Seedling Recruitment

Harvested areas had > 2x higher seedling recruitment compared to untreated stands

Pine and aspen were most abundant in harvested stands, fir was more common in untreated stands

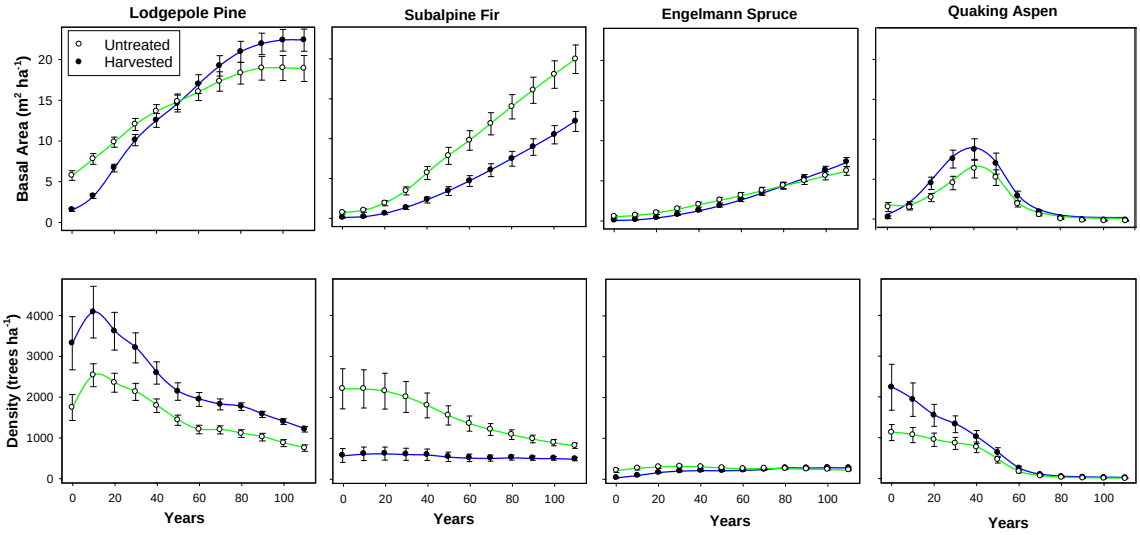


Understory Growth

Annual height growth of pine and fir doubled since infestation beneath dead canopy, but was delayed in harvested areas

Future Forests

Aspen will increase in untreated and harvested forests in the first few decades; fir will become increasingly common in untreated stands

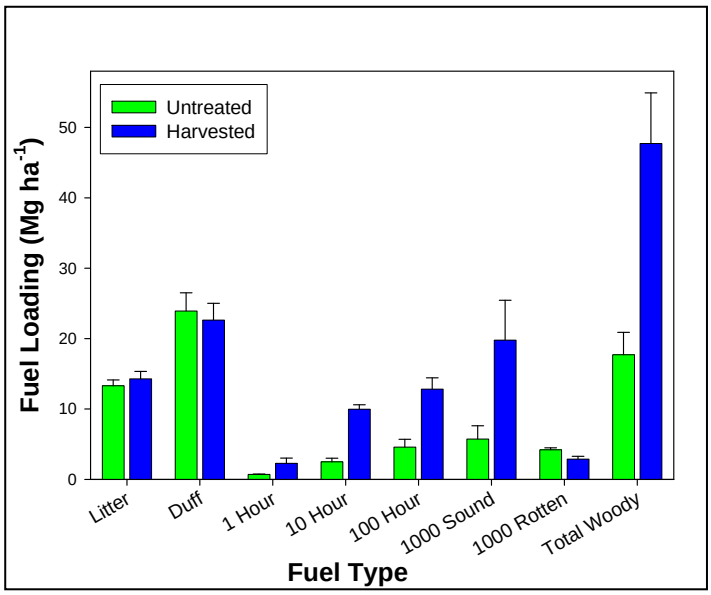


Further Reading: Collins B.J., Rhoades, C.C., Battaglia, M.A., Hubbard, R.M. 2012. The effects of bark beetle outbreaks on forest development, fuel loads and potential fire behavior in salvage logged and untreated lodgepole pine forests. *Forest Ecology and Management*. 284: 260-268.

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.

Effects of Salvage Logging on Fuels following Mountain Pine Beetle

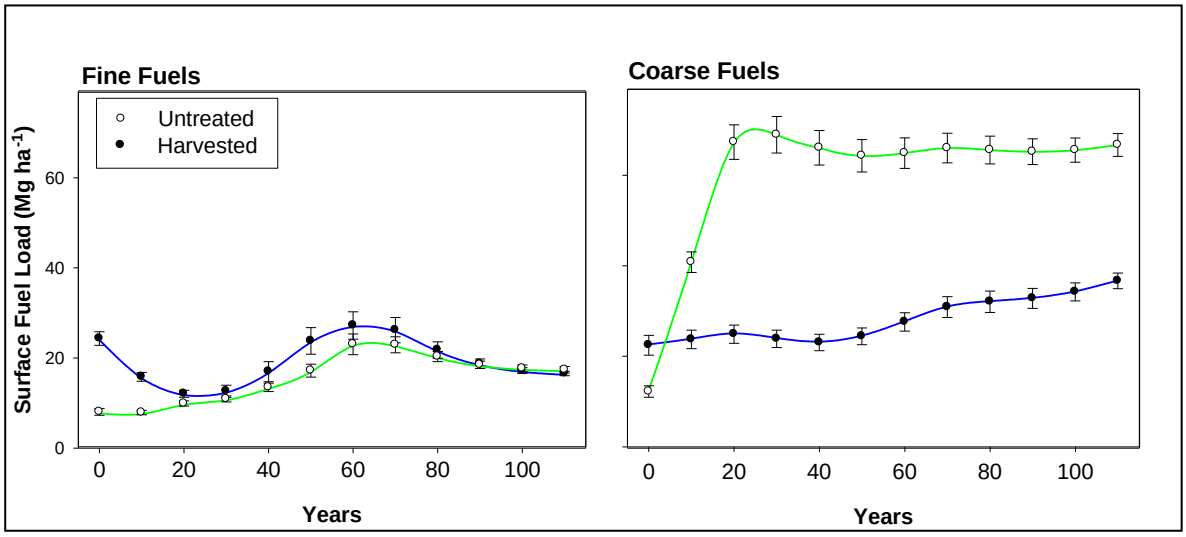
Surface Fuels



Fine fuels (1, 10, 100 hour) increased by > 3x following harvest compared to untreated stands initially

Owing to decomposition and sparse canopy input, there was no significant difference between treatments within two decades

Surface Fuel Dynamics



Coarse fuels (1000 hour) will increase dramatically (by 55 Mg ha^{-1}) in the first two decades as dead overstory trees fall

Coarse fuels are predicted to persist for more than a century, promoting prolonged smoldering, soil heating and hampering fire suppression

Further Reading: Collins B.J., Rhoades, C.C., Battaglia, M.A., Hubbard, R.M. 2012. The effects of bark beetle outbreaks on forest development, fuel loads and potential fire behavior in salvage logged and untreated lodgepole pine forests. *Forest Ecology and Management*. 284: 260-268.

Management for the other 90%:
Future treatment options in untreated MPB-affected stands

K.A. Pelz, C. R. Rhoades, M. A. Battaglia, R.M. Hubbard

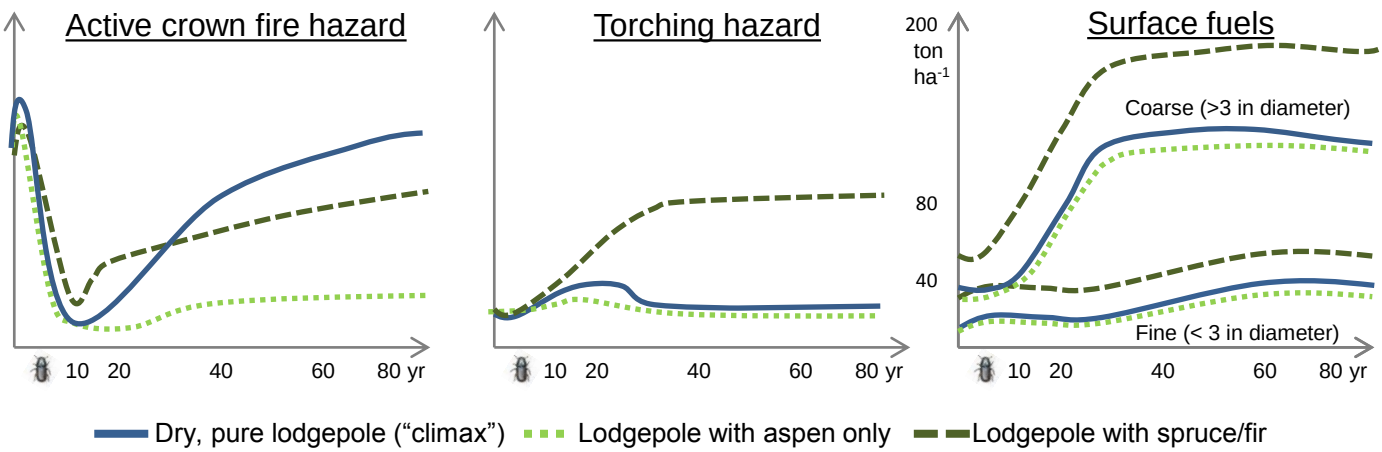
Current management of MPB mortality is focused on <10% of the affected landscape. What management options are available for the remaining forests and do they promote desired future conditions?

Forests of the MPB-affected landscape vary in species composition (pure lodgepole pine, lodgepole pine with aspen, lodgepole pine with subalpine fir and Engelmann spruce, etc.), though research has primarily focused on pure or nearly-pure lodgepole pine forest. What are desired future conditions at stand level for forests of different species compositions? We may want to:

- Reduce active crown fire hazard
- Reduce torching hazard
- Promote aspen or lodgepole pine regeneration
- Protect lynx/snowshoe hare habitat
- Etc.

What are the post-MPB management options in forests with different species compositions that will allow us to reach our goals/objectives?

Stand-level effects of MPB will differ with forest species compositions; management must vary accordingly. Graphs are theoretical based on Page & Jenkins (2007), Klutsch et al. (2009), Diskin (2010), Simard et al. (2011), Collins et al. (2010, 2011, 2012), Jenkins et al. (2012), Pelz & Smith (2012).



Example treatments by forest type.

Forest species	*Treatment*	*Timing*	*Objective(s)*	*Concerns/Contradictions*
Dry, pure lodgepole pine ("Climax")	Prescribed surface fire	10 - 30 yr post MPB	Reduce surface fuels, promote establishment of lodgepole pine	Fire hot enough to reach consumption targets could result in high heat residence time and soil/root damage, undesired tree mortality, possible loss of fire control
Lodgepole pine with aspen only	Prescribed surface fire	10 - 30 yr post MPB	Reduce surface fuels, promote establishment of aspen & lodgepole pine	Fire hot enough to reach consumption targets could result in high heat residence time and soil/root damage, undesired tree mortality, possible loss of fire control
Lodgepole pine with spruce, fir	Thin-from-below of fir	10 - 40 yr post MPB	Reduce fir/spruce in understory to reduce probability of torching, promote establishment of shade-intolerant lodgepole and aspen	Thinning increases surface fuels, potentially increasing wildfire spread. Depending on landscape, reduction of fir may not be compatible with lynx management.

Surface Fuel Alternatives on MPB Acres

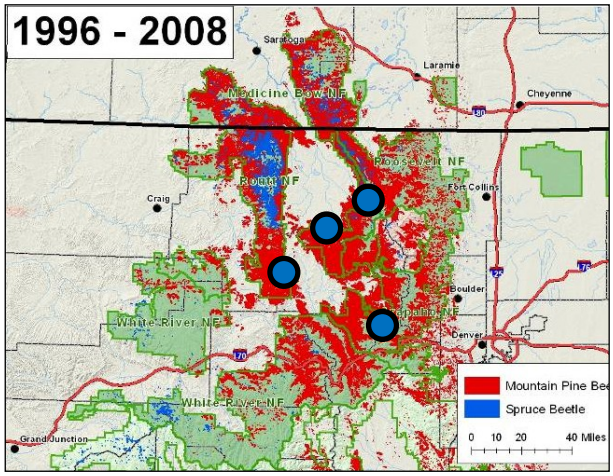
No Action
Untreated Beetle-Killed Stands

Water Delivery
Lop and Scatter Slash Retention

Fuel Reduction
Whole Tree Harvest

Forest Regeneration
Mechanical Scarification Site Prep

Forest & Watershed Responses
to Beetle-Related Management



Harvesting Completed 2008 & 2009

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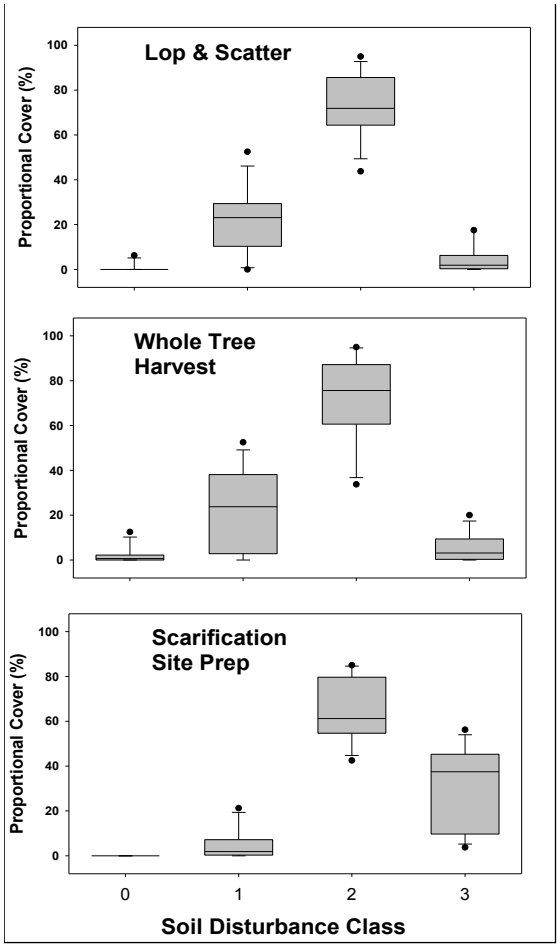


Soil Disturbance

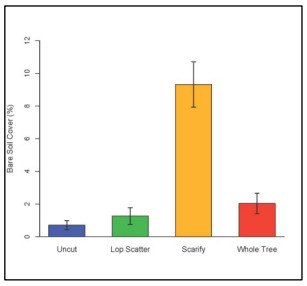
Scarification increased:

Forest Floor displacement

< 5% in WTH, Lop & Scatter

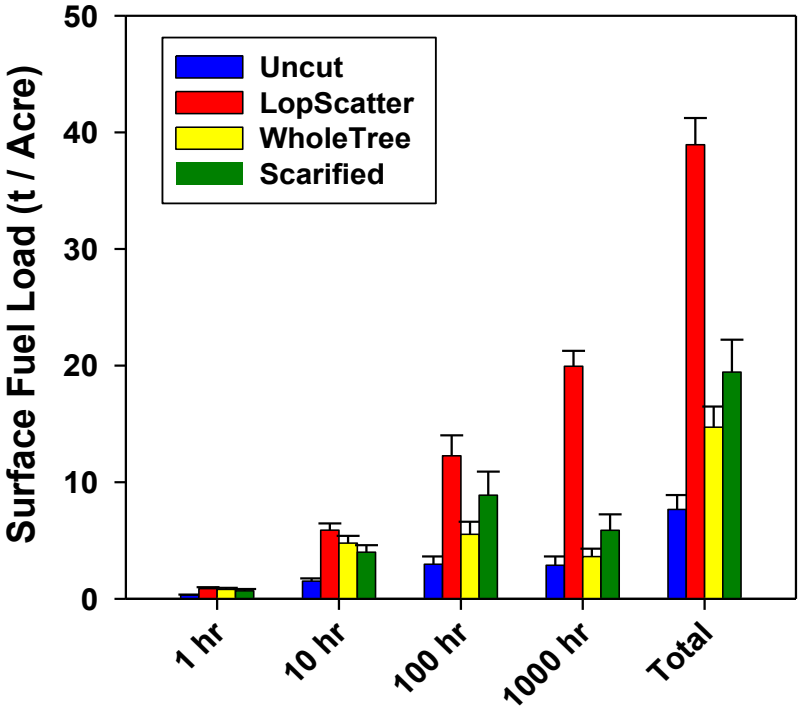
> 40% in Scarify

90-100% undisturbed in Uncut



Herbaceous biomass declined 30% compared to WTH

Surface Fuels

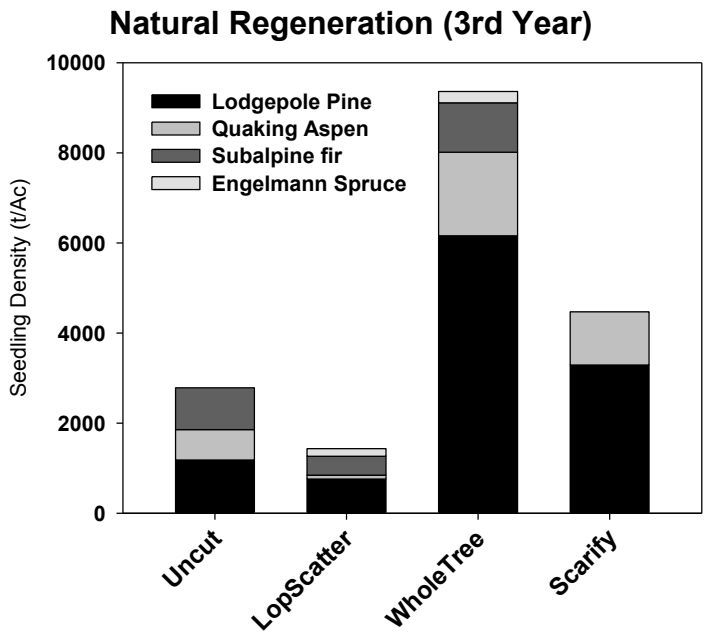


Lop & Scatter more than doubled the total surface fuels found in the other treated units

Coarse fuels (1000 hrs) were 3 to 6X higher

Roughly equal to mass expected in windthrow

Tree Regeneration



Frequency	2011	2012
WTH	58	83% of units
Scar	50	67%
LS	33	58%
Uncut	42	58%

Treatment Effects:

Whole Tree Harvest - Highest density

Lop & Scatter Lowest -

Scarification - No increase in density (1/12 sites)

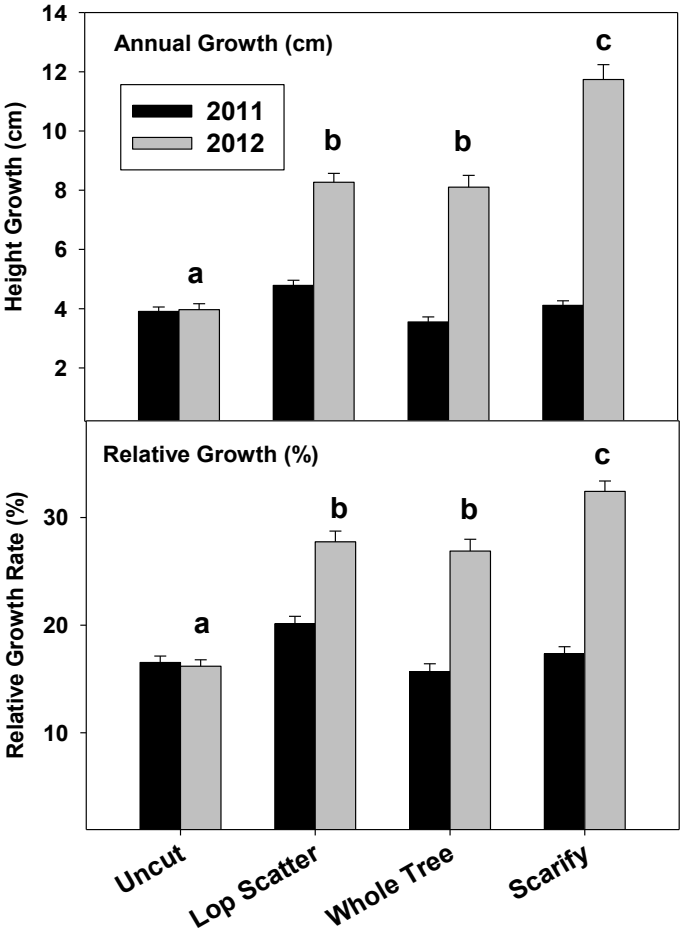
Species Patterns:

Pine is most abundant species overall

Pine, Aspen do best in WTH, Scarify

Fir does best in Uncut, Lop & Scatter

Seedling Growth



Pine seedlings added most growth in scarified plots

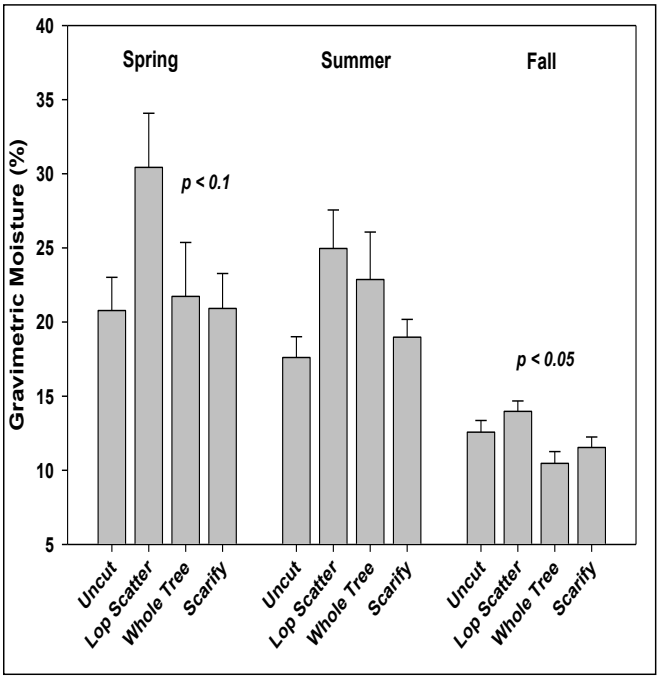
1.4X higher than other treatments ($p < 0.01$)

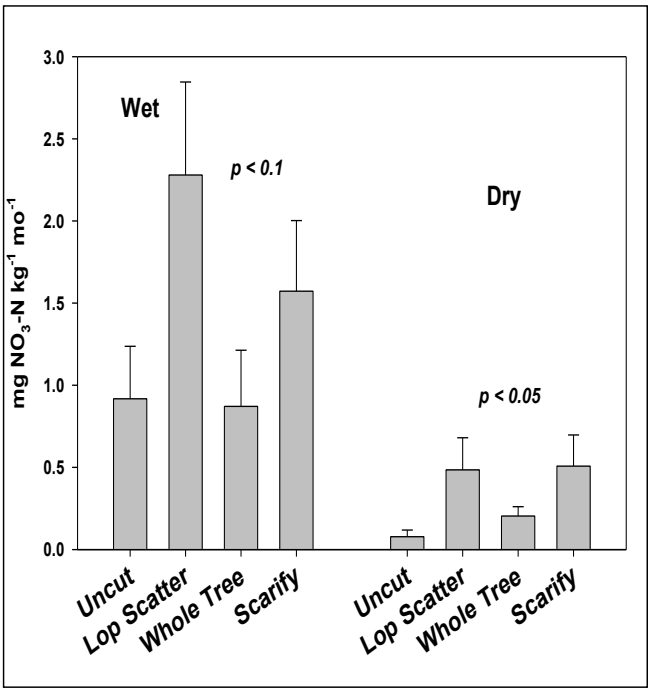
In harvested areas pine growth was 2X that measured in MPB-killed stands

Trees are adding up to 25 cm (11”) per year in all treated units

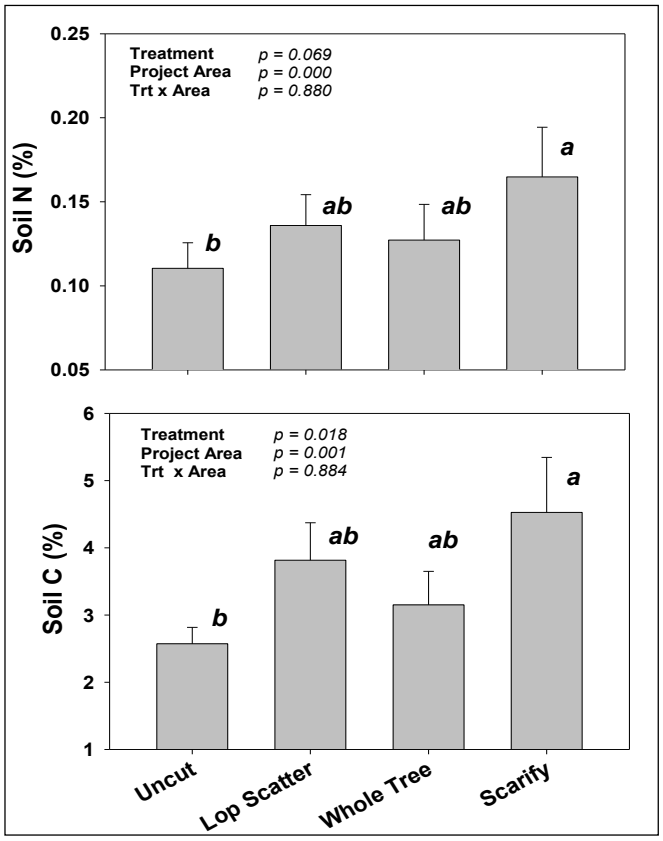
Survival (62%) , herbivory were uniform

Soil Moisture and Nitrogen





Lop & Scatter: highest soil moisture, available N
Scarification: increased nitrate production



Soil Total N & C

(0-15 cm mineral soil)

Harvesting increased C & N (52 and 27%)

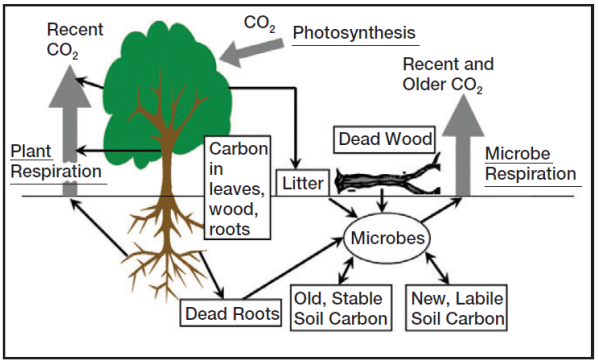
Only scarification differed from uncut (80 and 45%)

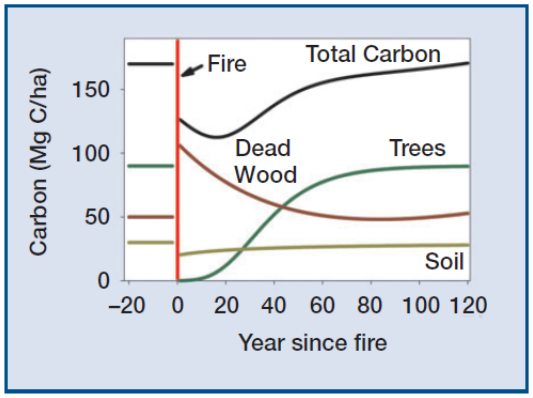
No change in C:N (24 – 26 Range)

Project areas differed, but treatment effects were consistent among them.

Carbon Dynamics

Forest Carbon Budgets and Disturbance





Carbon is stored mostly in live and dead wood as forests grow.

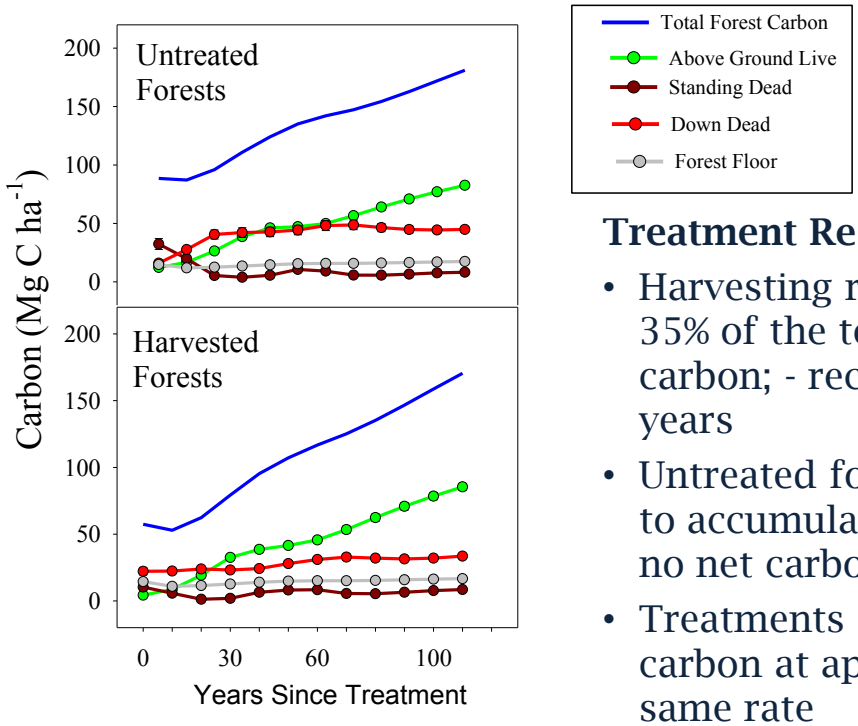
Following a disturbance, if the forest regenerates, lost carbon is recovered with forest re-growth.

Carbon loss following harvest depends on how material is utilized (e.g. lumber vs. wood pellets).

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

Carbon Dynamics

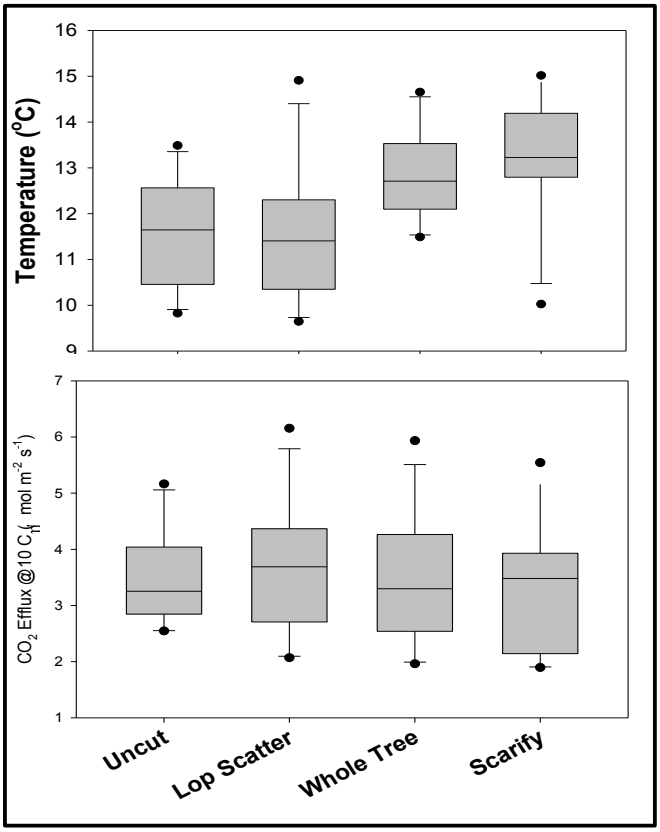
Effects of MPB and Harvest on C Stocks



Treatment Response

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

Soil Temperature & C Efflux



WTH and Scarification increased growing season soil temp

1.5-2.0 °C

Lop & Scatter = Uncut

CO2 efflux is similar among treatments.

variance is higher

Take Home Messages

Fuel Reduction (Whole Tree Harvest)

Highest seedling density

Slash Retention (Lop and Scatter)

Reduced colonization of new seedlings

Highest moisture and nutrient content

Site Preparation (Scarification)

Lower seedling density than WTH, but best growth

Highest total soil C, N

Nitrification similar to Lop & Scatter

Understory plant response to salvage logging in MPB-impacted lodgepole pine stands

Paula Fornwalt, Chuck Rhoades, Rob Hubbard, Akasha Faist & Byron Collins, Rocky Mountain Research Station; **Rebecca Harris**, University of Colorado

Background

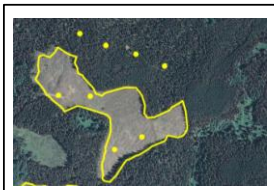
- There is little information available to land managers on how salvage logging may impact understory plant communities in MPB-impacted lodgepole pine forests
- The MPB outbreak has the potential to reinvigorate the understory plant community due to the increased availability of resources such as light, nutrients, and water
- However, the heavy machinery used during salvage logging operations may damage existing understory plants
- In areas where salvage logging exposed the soil seedbed, the establishment of exotic species may be promoted

Research objectives

- Objective 1: Identify the short-term impacts of salvage logging on understory composition and cover
- Objective 2: Assess the potential for exotic plant species to invade in salvage logged areas
- Objective 3: Evaluate how variations in salvage logging prescriptions influence understory plant communities

Objectives 1 & 2 methods: salvage logging impacts on understory plants, exotics

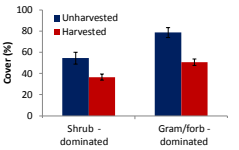
- 4 study areas with 6 sites each (24 sites total):
  - CO State Forest
  - Routt NF @ Willow Pass
  - Routt NF @ Gore Pass
  - Arapaho NF @ FEF



- Each site = paired salvage logged and unlogged stands
- Salvage logging occurred in 2008-09
- Understory measurements were made in 2010-11, 2 years post-harvest
- 50-m^2 understory plots per site (192 plots total)

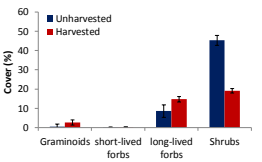
- Sites were classified into 1 of 2 understory community types for analyses:
- Shrub - dominated sites (L): *Vaccinium* (whortleberry) and *Sheperdia canadensis* (buffaloberry) comprised >50% of total plant cover
- Graminoid/forb - dominated sites (R): >50% of total cover in grasses, sedges, forbs, and other shrubs

Objective 1 findings: salvage logging and understory composition / cover



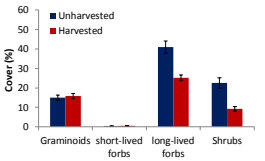
Total plant cover

- Total cover was lower in shrub-dominated community types
- Total cover was lower in salvage logged plots



Understory cover by functional group: shrub - dominated sites

- The decline in total cover due to salvage logging was driven by a decline in shrub cover – *Vaccinium* in particular
- *Vaccinium* cover decreased 3-fold following salvage logging, from 36% to 12%



Understory cover by functional group: graminoid/forb - dominated sites

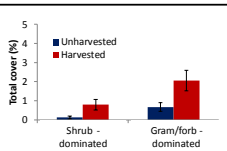
- The harvesting - related decrease in total cover was due to the response of long-lived forbs and shrubs
- Long-lived forb cover decline was driven largely by the response of *Arnica cordifolia* (heartleaf arnica)
- Shrub cover decline was driven largely by *Juniperus communis* (common juniper) and *Vaccinium*

Objective 2 findings: Salvage logging and exotics

Exotics

- 14 exotic species were found, the vast majority of which were more common in harvested than unharvested plots
- The noxious weed *Cirsium arvense* (Canada thistle) was found in 9% of the unlogged plots but 28% of the logged plots, and accounted for 8% of total exotic cover
- The most ubiquitous exotic was *Taraxacum officinale* (dandelion); it occurred in 44% of unharvested plots and 81% of harvested plots, and accounted for ~50% of total exotic cover

		% unharvested plots	% harvested plots
Bromus inermis	**smooth brome**	**10**	**2**
Chenopodium album	**lambsquarters**	**0**	**8**
Chenopodium foliosum	**leafy goosefoot**	**0**	**5**
Cirsium arvense	**Canada thistle**	**9**	**28**
Dactylis glomerata	**orchardgrass**	**0**	**1**
Gnaphalium uliginosum	**marsh cudweed**	**0**	**2**
Phleum pratense	**timothy**	**4**	**14**
Poa compressa	**Canada bluegrass**	**1**	**5**
Poa pratensis	**Kentucky bluegrass**	**1**	**16**
Spergula arvensis	**corn spurry**	**0**	**4**
Spergularia rubra	**red sandspurry**	**0**	**2**
Taraxacum officinale	**dandelion**	**44**	**81**
Tragopogon dubius	**yellow salsify**	**5**	**13**
Trifolium hybridum	**alsike clover**	**0**	**1**

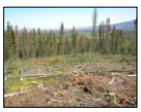


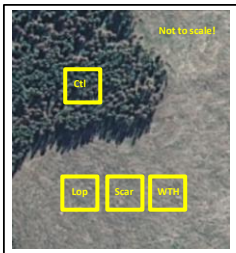
Exotic cover

- For both community types, exotic cover was greater in salvage logged areas, but values were very low
- Exotic cover averaged <1%, and rarely exceeded 10% in any particular plot

Objective 3 methods: gradients of disturbance and understory plants

- 4 study areas with 6 sites each (24 sites total):
  - CO State Forest
  - Routt NF @ Willow Pass
  - Routt NF @ Gore Pass
  - Arapaho NF @ FEF
- Management alternatives on MPB acres (from low to high disturbance)
  - Alternative 1: The "do nothing" treatment
  - Alternative 2: Whole tree harvest (left)
  - Alternative 3: Lop and scatter (center)
  - Alternative 4: Scarification following whole tree harvest (right)

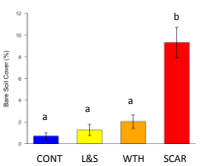




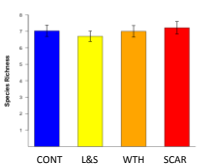
- Experimental approach
- Treatments implemented in fall 2009
- Each site includes 3 management treatment alternatives (Whole Tree Harvest, Lop & Scatter, Scarify) plus a Control
- Understory measurements made in 2010 and 2011

Objective 3 findings: gradients of disturbance and understory plants

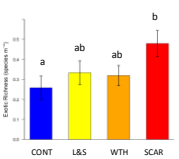
Bare soil
- Scarification (red) leads to higher bare soil
- ~10% bare soil cover in scarified areas
- ~1 – 2% bare soil cover in all other areas

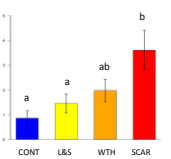


Total plant species richness (number of species per 1m² quadrat)
- No significant trends



Exotics
- Only scarification stimulated exotic richness & cover relative to controls

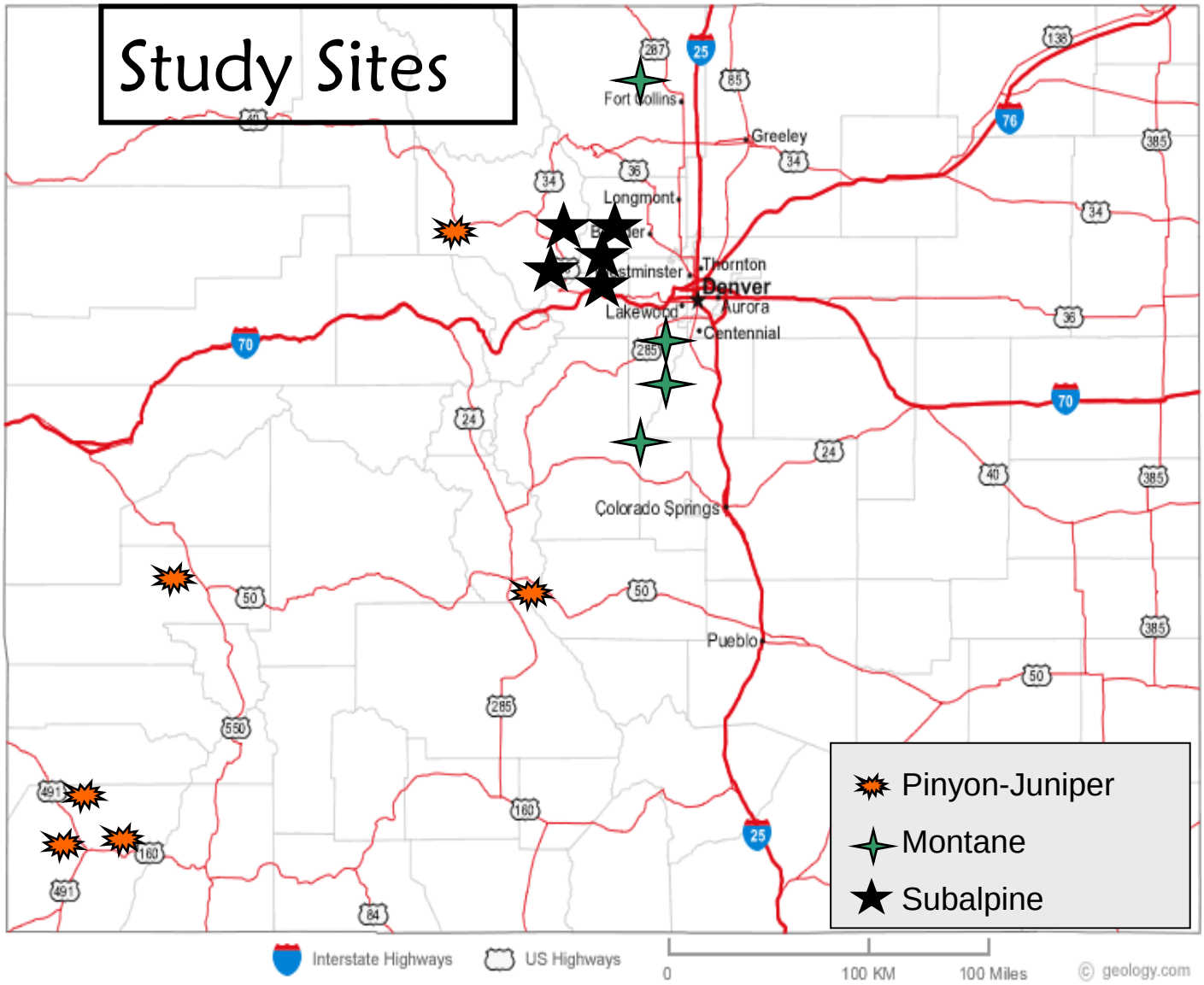




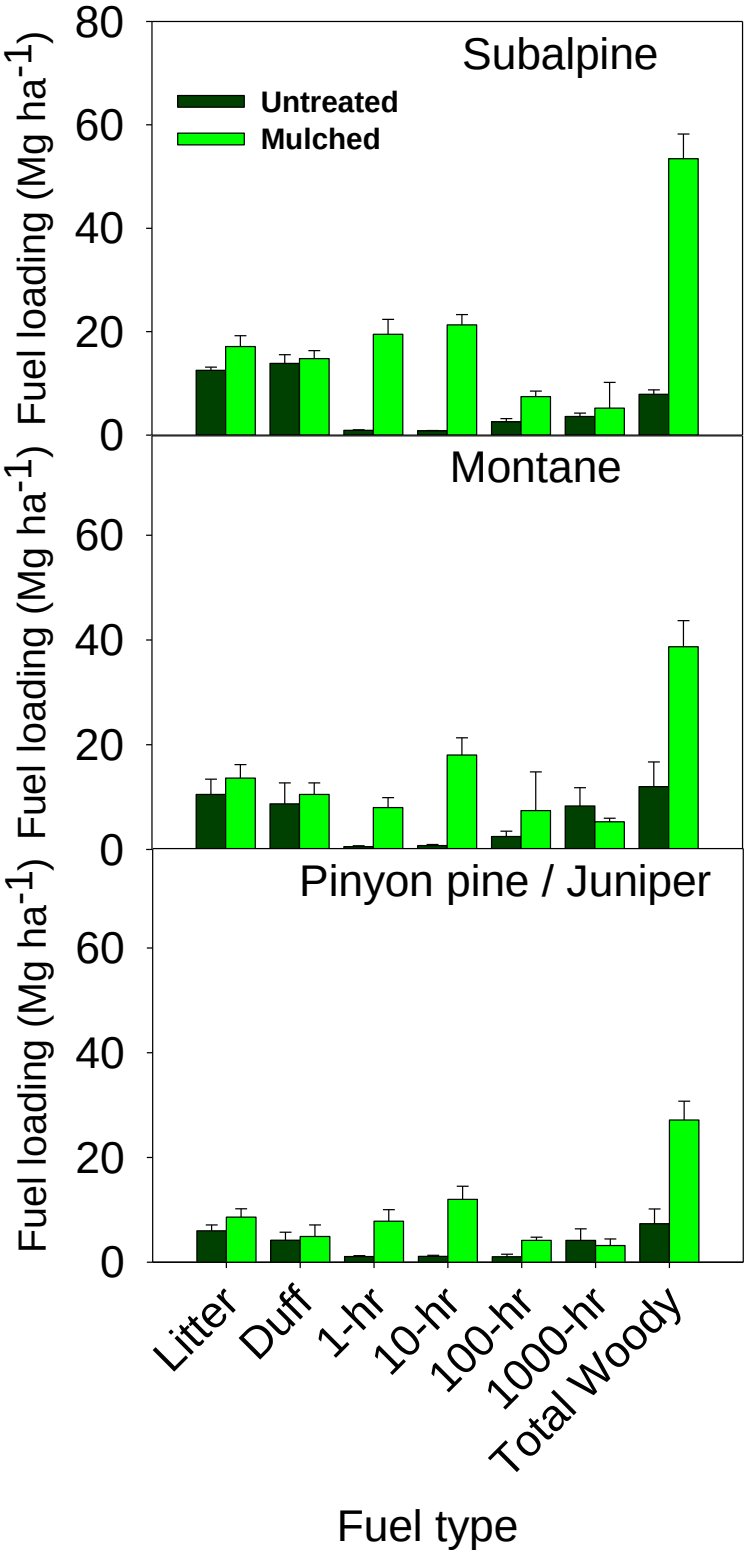
Mastication as a fuels treatment: Short-term implications of mulching the forest

Battaglia, Rhoades, Rocca, Fornwalt, Ryan

Study Sites

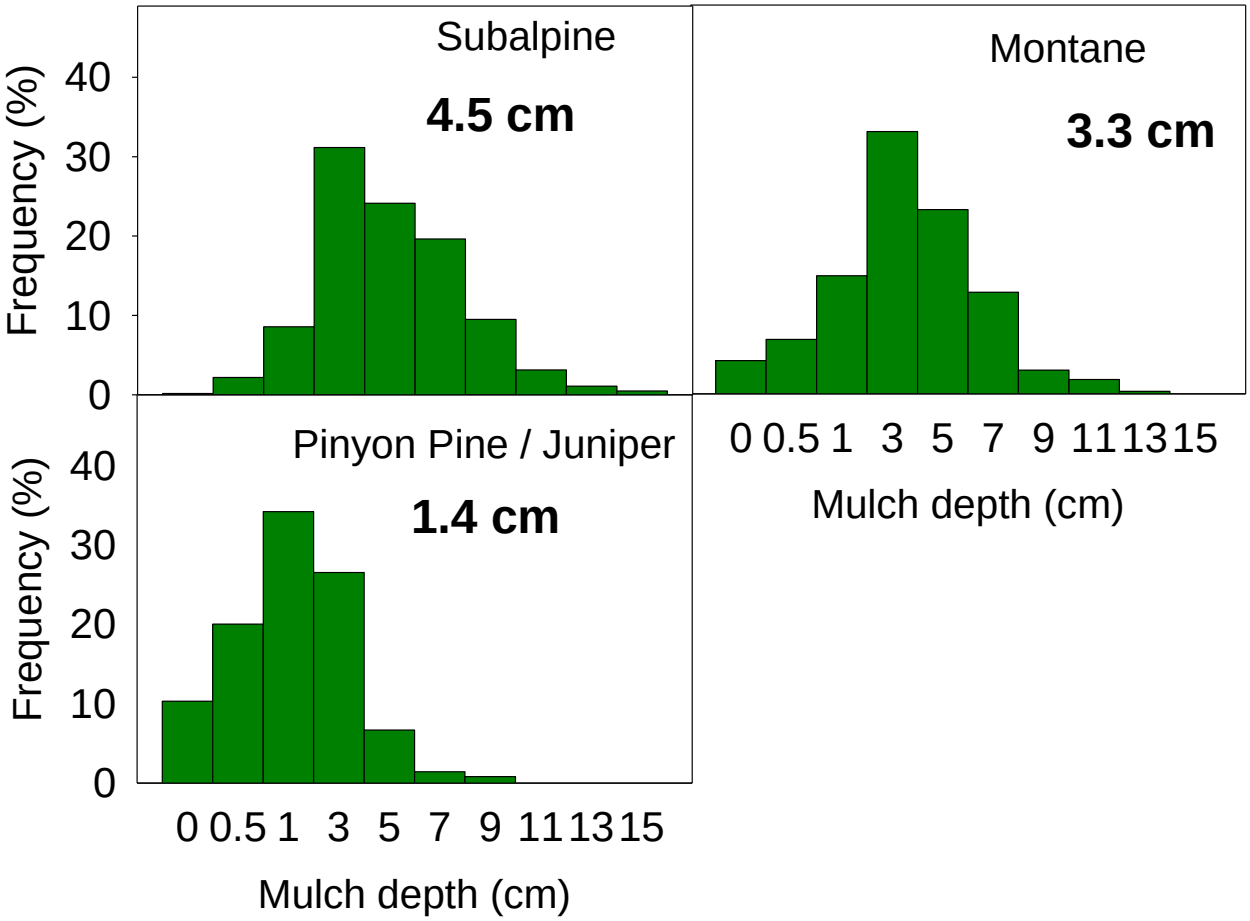

Fort Collins
Greeley
Longmont
Westminster
Thornton
Denver
Aurora
Lakewood
Centennial
Colorado Springs
Pueblo
Pinyon-Juniper
Montane
Subalpine
Interstate Highways
US Highways
0
100 KM
100 Miles
© geology.com

Changes in surface fuel loadings and fuelbed characteristics



- Surface fuel loadings increased substantially in the mulched treatments.
  - Total Woody fuels: 27 to 60 Mg ha^{-1}
- Majority of masticated fuels concentrated in the 1-hr and 10-hr fuels (67 – 78%)
  - Untreated fuels concentrated in the 1000-hr fuels
- Shift in fuelbed from needle litter dominated in untreated stands to compact, woody/needle fuelbed in mulched stands
- Equations developed that predict mulch fuelbed load based on depth

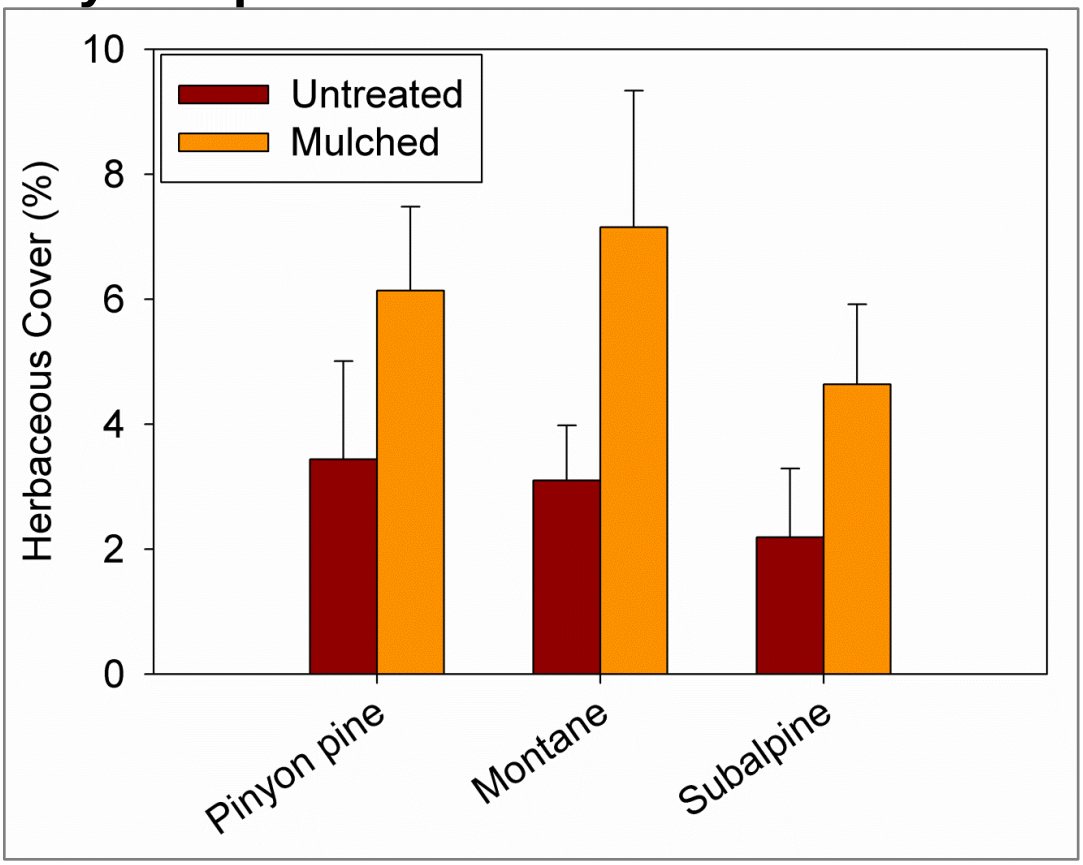
Mulched fuelbed depth distribution



- Mulched fuelbed depth variable across forest types and within forest types

- Variability in mulched fuelbed depths could influence:
  - Vegetation recovery
  - Tree regeneration
  - Soil nutrients and site productivity
  - Soil moisture and temperature
  - Decomposition rates of mulched fuels

Increased herbaceous cover, but variability high 2 to 4 years post-mastication



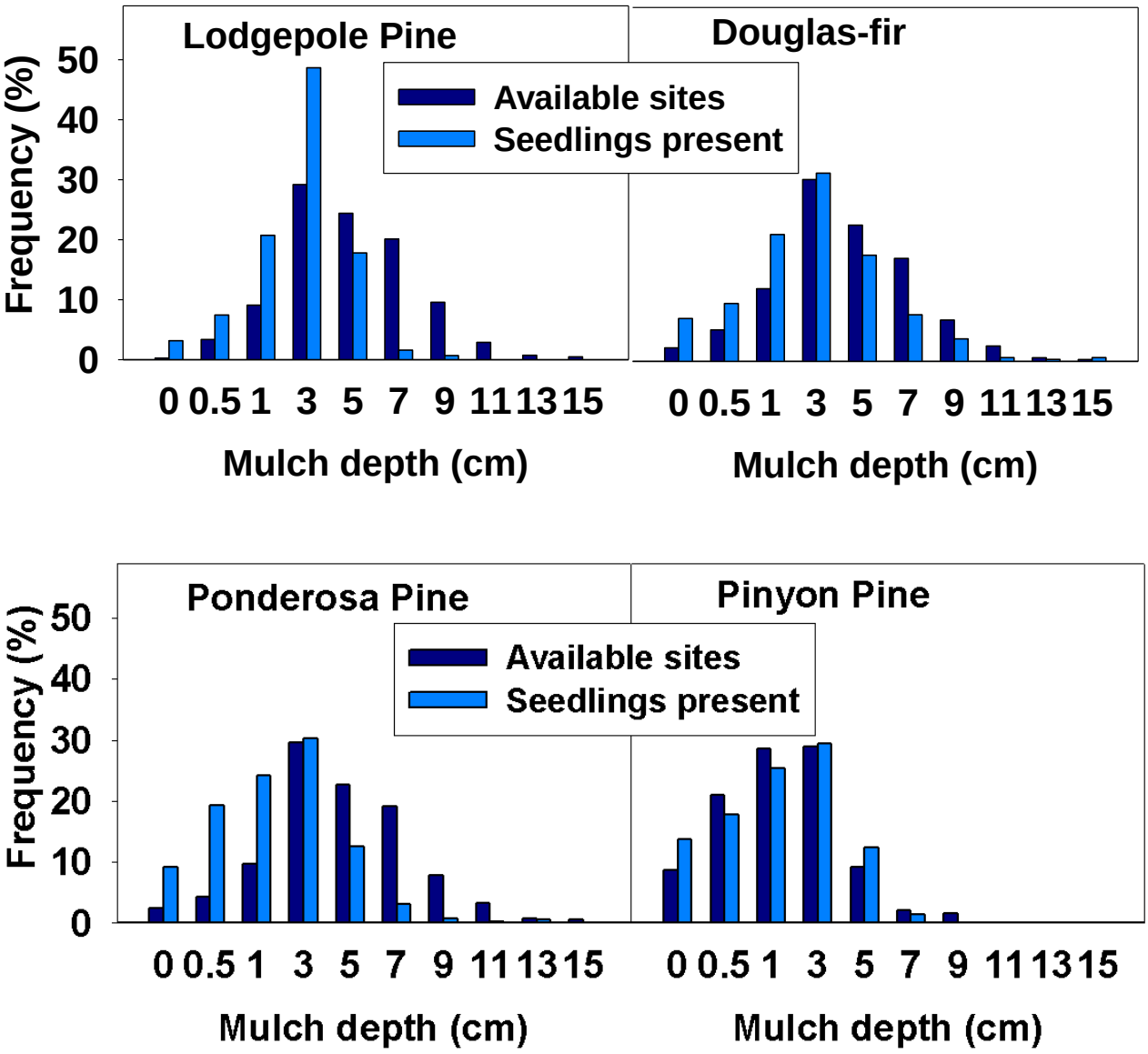
Exotics across the ecosystems *2 to 4 years post-treatment*

Ecosystem	Untreated	Mulched
Subalpine	▪ essentially absent	▪ 6 species ▪ Canada thistle most common
Montane	▪ essentially absent	▪ 11 species ▪ Canada thistle, prickly lettuce, mullein, dandelion common
Pinyon-Juniper	▪ 6 species	▪ 16 species ▪ cheatgrass at essentially the same sites

Presence of exotic plant species increased in mulched areas, but cover was low

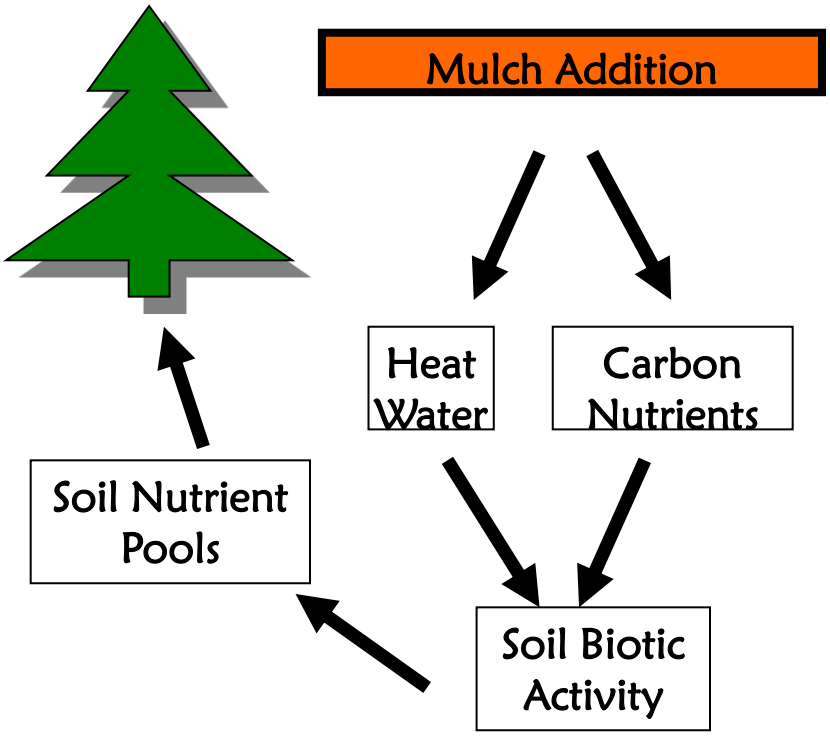
Species preferences for mulch depth

6 to 8 years post-treatment



- Tree Seedlings are able to establish in depths up to 7 to 9 cm, but preferentially established in depths less than 3 to 4 cm

Mulching impacts on Soil Nitrogen

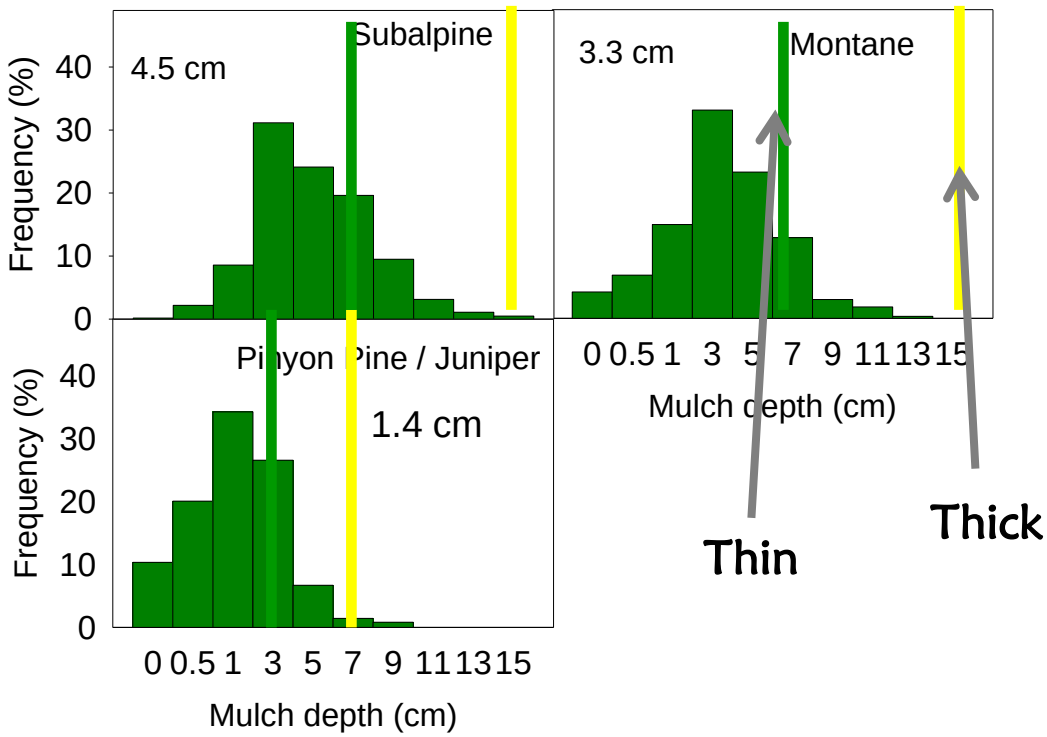


Mulch effects on Soil N: Operational scale

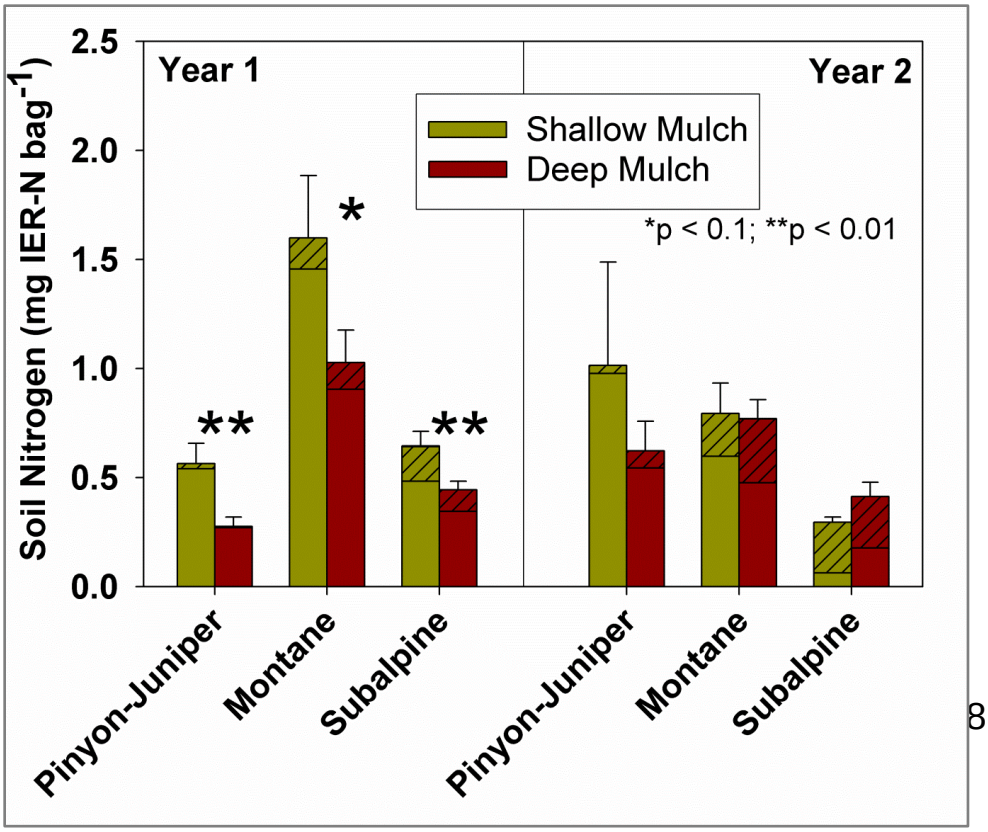
Forest Type	Total IER Nitrogen Untreated	Total IER Nitrogen Mulched
Subalpine	1.04 (0.11)	1.51* (0.19)
Montane	0.96 (0.10)	1.46* (0.15)
Pinyon-Juniper	0.98 (0.10)	0.98 (0.09)

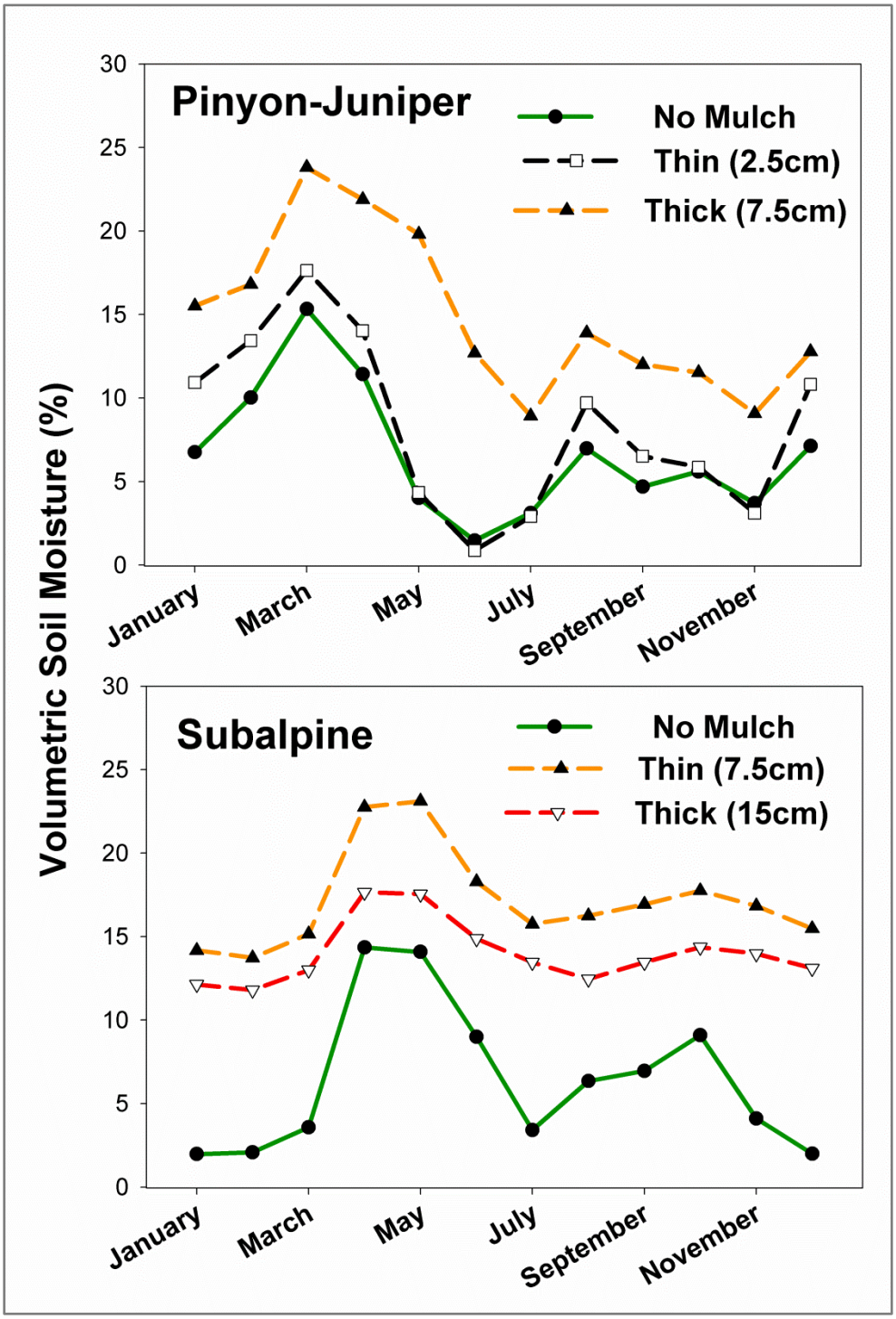
IER-N was about 50% higher in mulched areas in subalpine and montane forests

Operationally, mulch wasn't that deep. So we created some experimental plots to look at ecological responses to deeper mulch

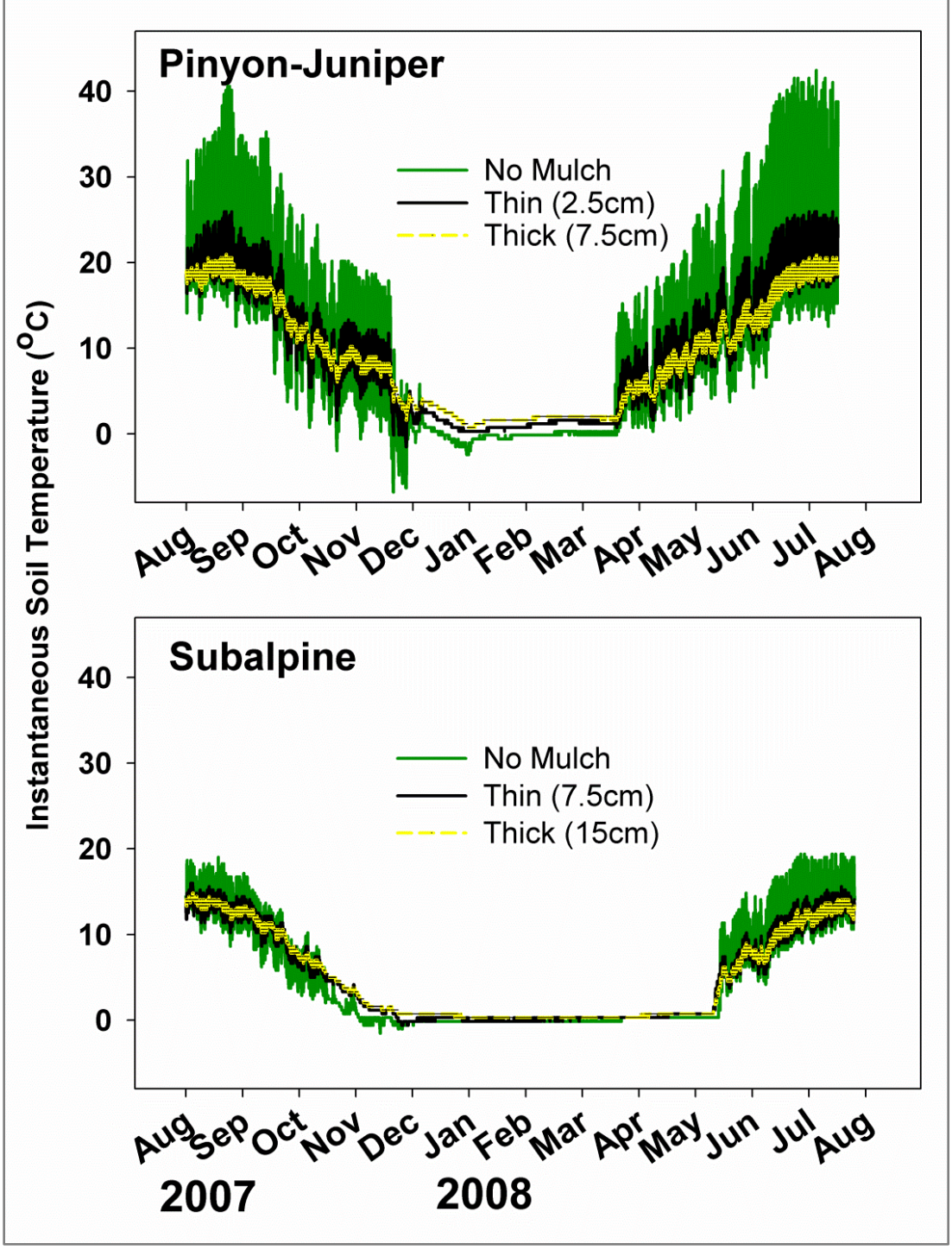


- Plant available soil N was reduced under heavily-mulched plots the first year, but the effect did not persist





- Soil moisture greater in deeper mulch
- In PJ, effect not as large in thin mulch
- Soil moisture in subalpine remains high throughout the growing season



- Soil temperature extremes moderated by mulch

- Maximum and average summer temperatures lowered as mulch depth increased

Current research on mastication

- Long-term effects
  - Continued monitoring of plant recovery and soil N
  - Decomposition of woody fuels
  - Tree growth
  - Test influence of mulch depth on seed germination, soil N, and seedling growth

Legacy Effects of Pile Burning

As Old as Dirt

Sara Bridges
Chad Kurtenbach
Ric Ondrejka
Liz Schnackenberg
Mark Westfahl

Med-Bow Routt NF

Paula Fornwalt
Chuck Rhoades
RMRS

Photo Credit: Erick Stahlin; Routt Zone, District AFMO

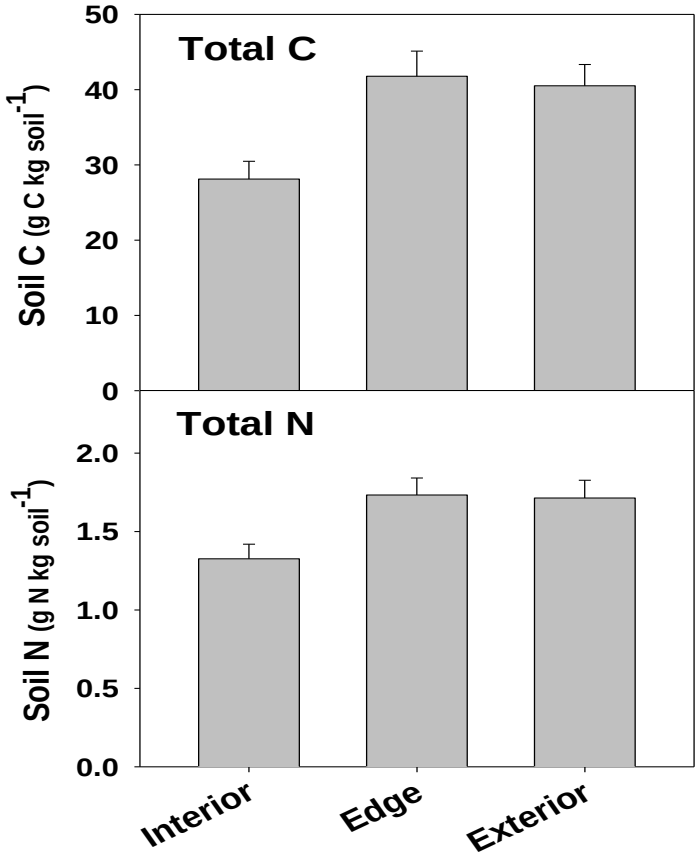
Current Situation

National Forest	RD/Zone		Hand	Machine		Total	Jan 2012
White River			461	416		877	**591**
Med Bow Routt	BrushCk/Hayden		400	1000		1400	**2,400**
	Laramie		5000	1500		6500	
	Routt All*		885	1988		2873	
	Douglas		300	0		300	
Arapaho Roosevelt	N.Zone		79,059	79		79,138	**140,391**
	S. Zone		38,000	105		38,105	
	Sulphur		40,000	100		40,100	
FY 2010 Total			164,105	5,188		169,293	**143,382**

(J. Krugman, R2 Regional Office)

Soil Effects

Extreme soil heating degrades soil structure, oxidizes soil carbon and nitrogen and changes soil chemistry. The effects on soil water, gases and nutrients influence plant establishment and growth.



(Shanklin et al. *in preparation*)

Plants Effects

Bare soil, high nutrients and low native plant cover result in non-native plant colonization of burn scars. Sprouting colonizers are sometimes limited to the edge where fire effects are less severe.

A Lasting Impact

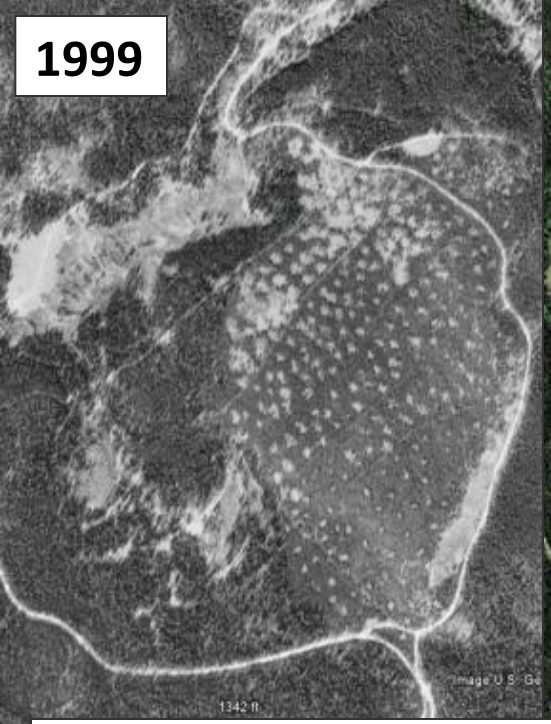
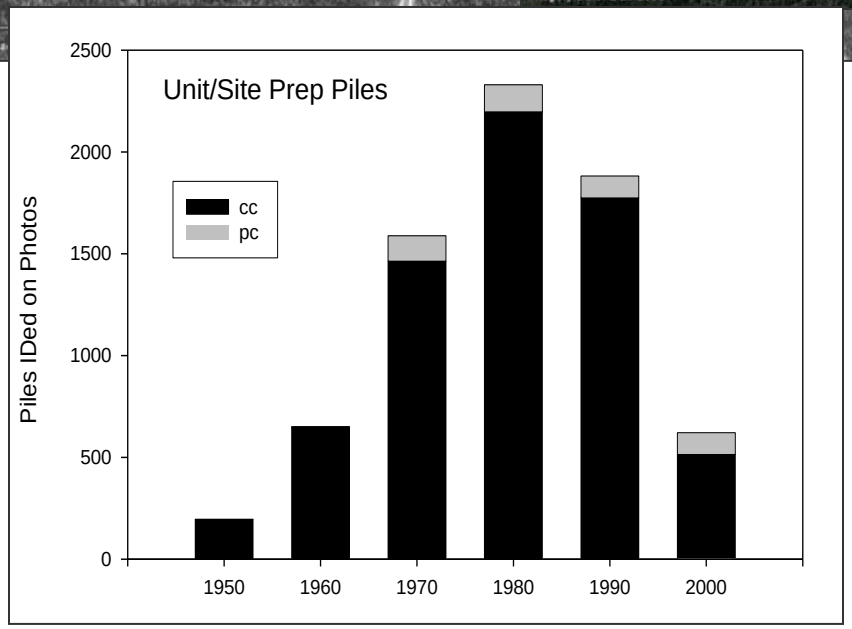
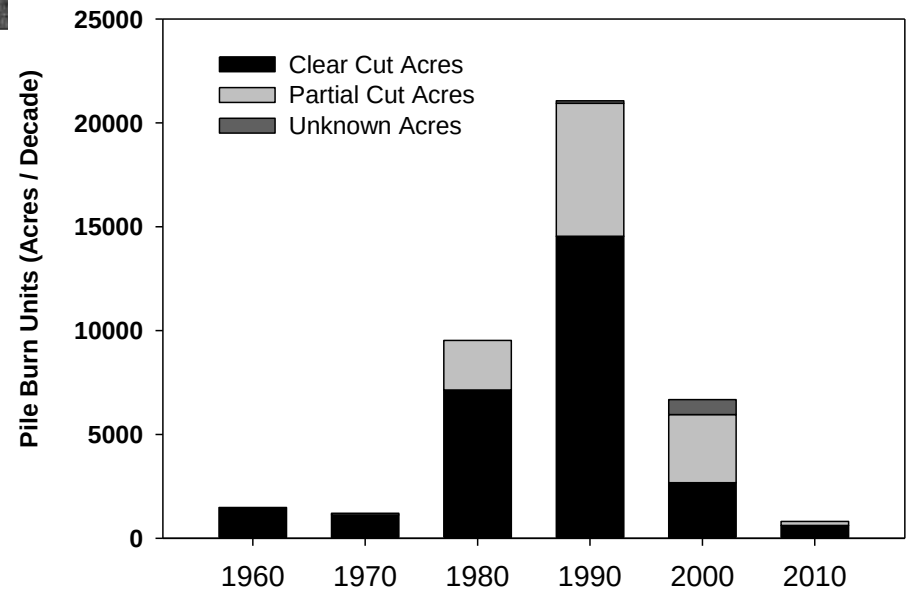


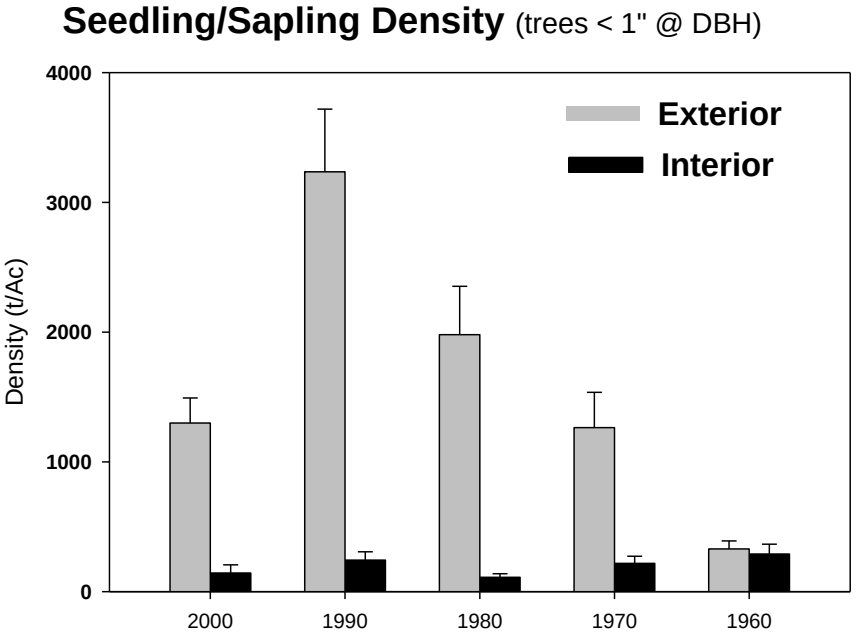
Photo Record:
~12,000 piles were located during a GIS photo survey of the Med-Bow Routt NF;

FACTS includes 1700 SUIDs & 54,000 Acres

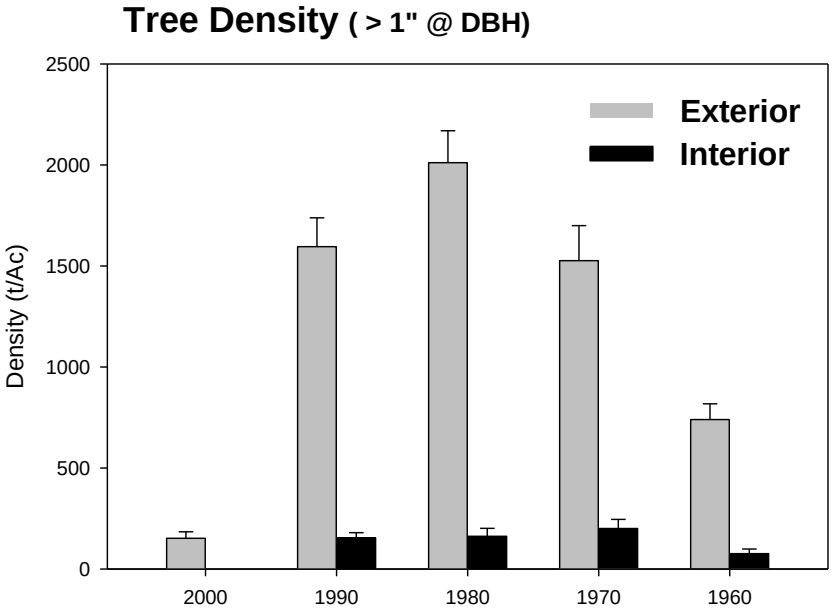


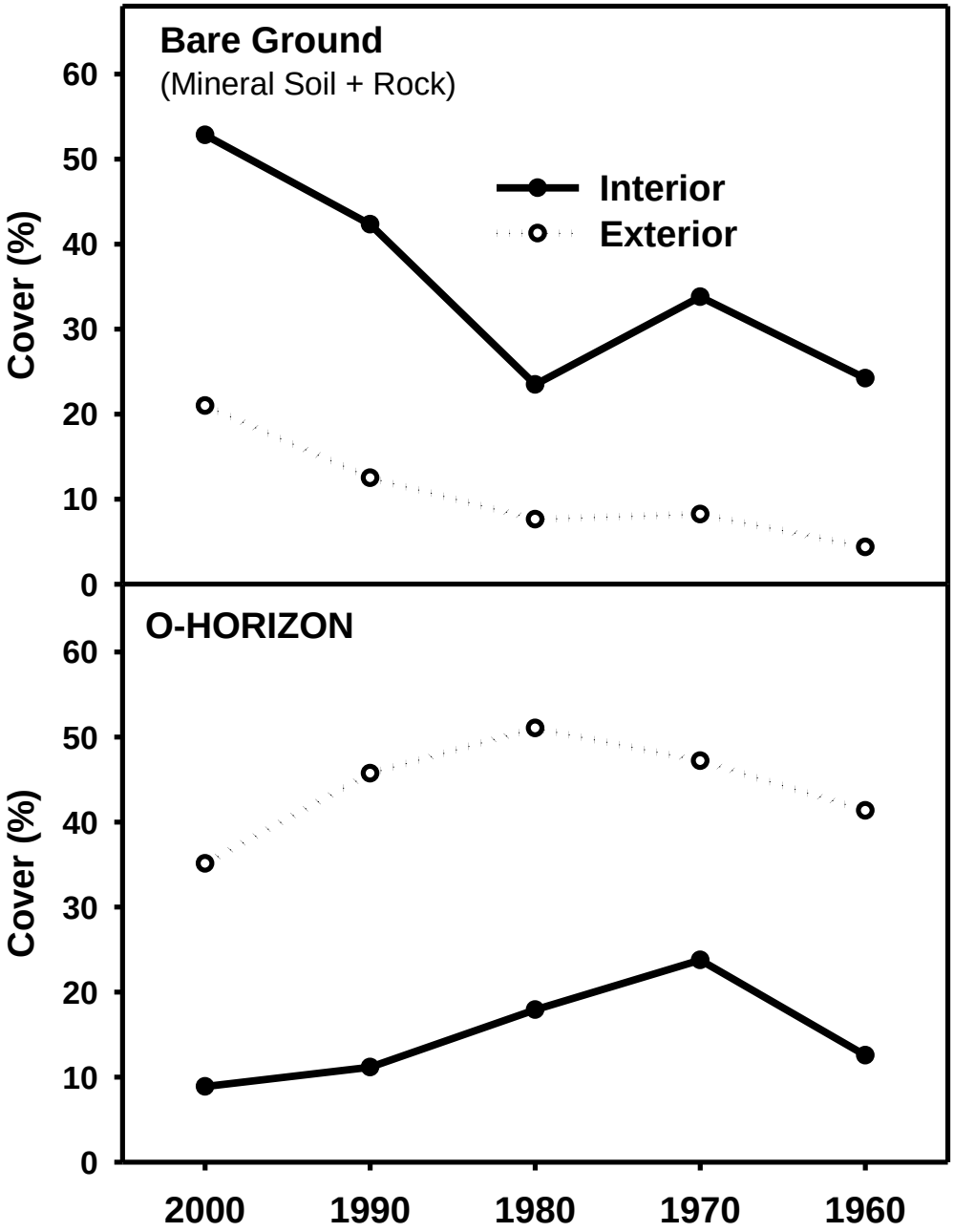


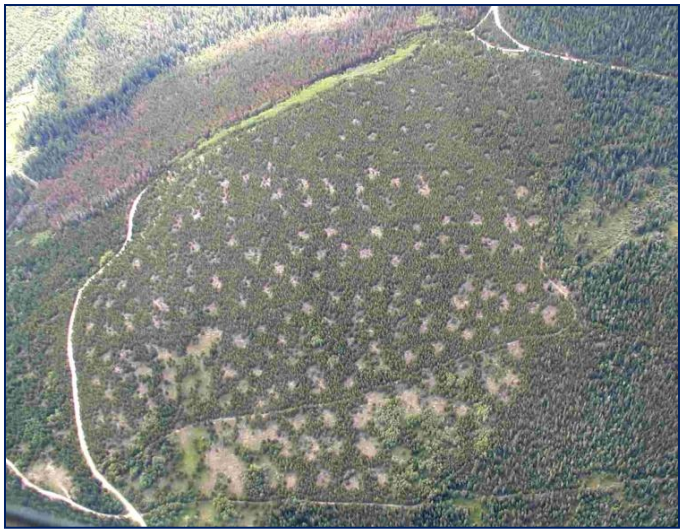
15 year old pile scar


Seedling/Sapling Density (trees < 1" @ DBH)
Exterior
Interior
Density (t/Ac)
4000
3000
2000
1000
0
2000
1990
1980
1970
1960

50 year old pile scar


Tree Density (> 1" @ DBH)
Exterior
Interior
Density (t/Ac)
2500
2000
1500
1000
500
0
2000
1990
1980
1970
1960

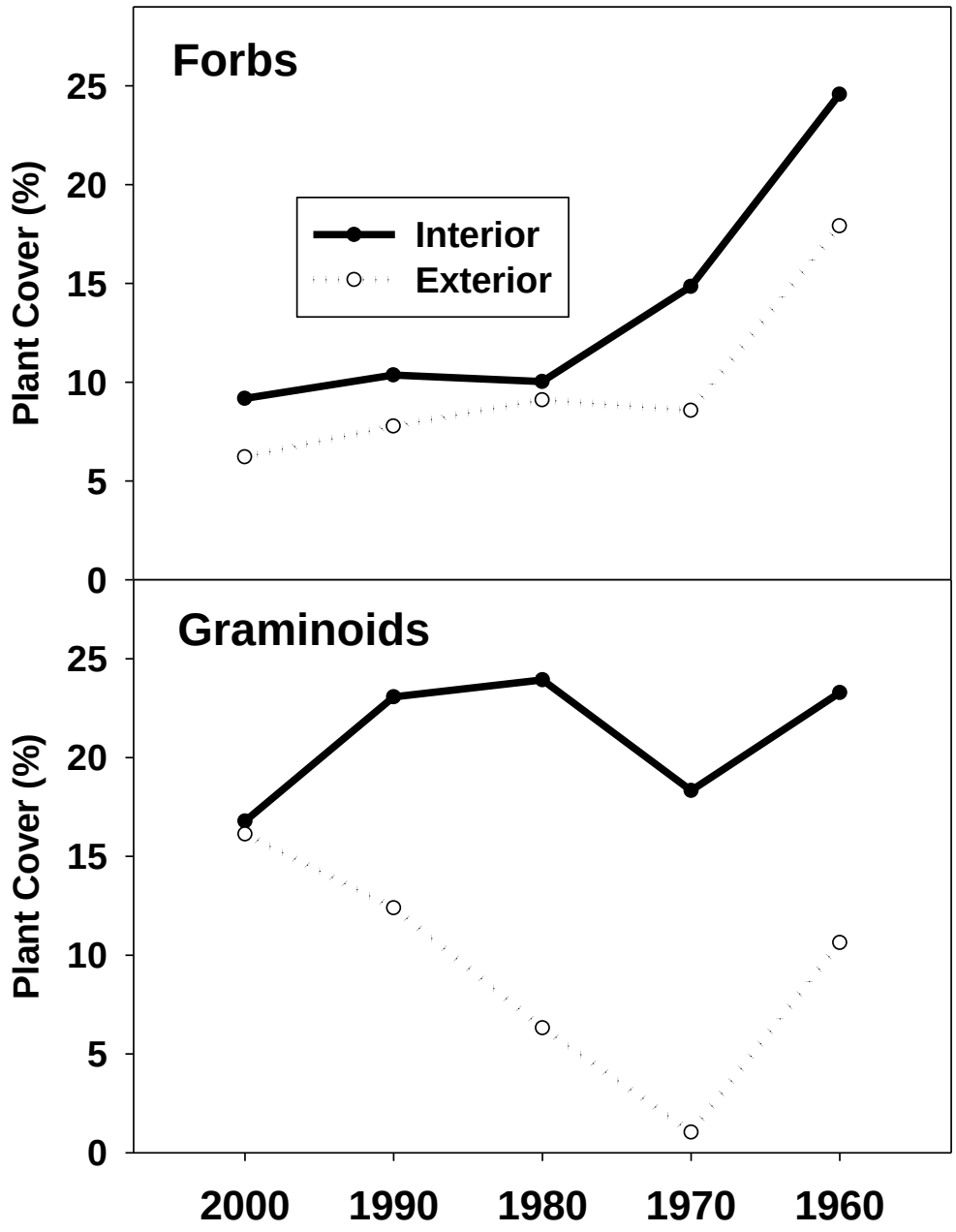




Persistent Soil Change

Heat reddened soil was found in 23% of younger piles ('90s and '00s).
Hardened red soil was occasionally found in piles created in the '60s and '70s.

Char layers (1-3 cm thick) were present in most piles regardless of age.



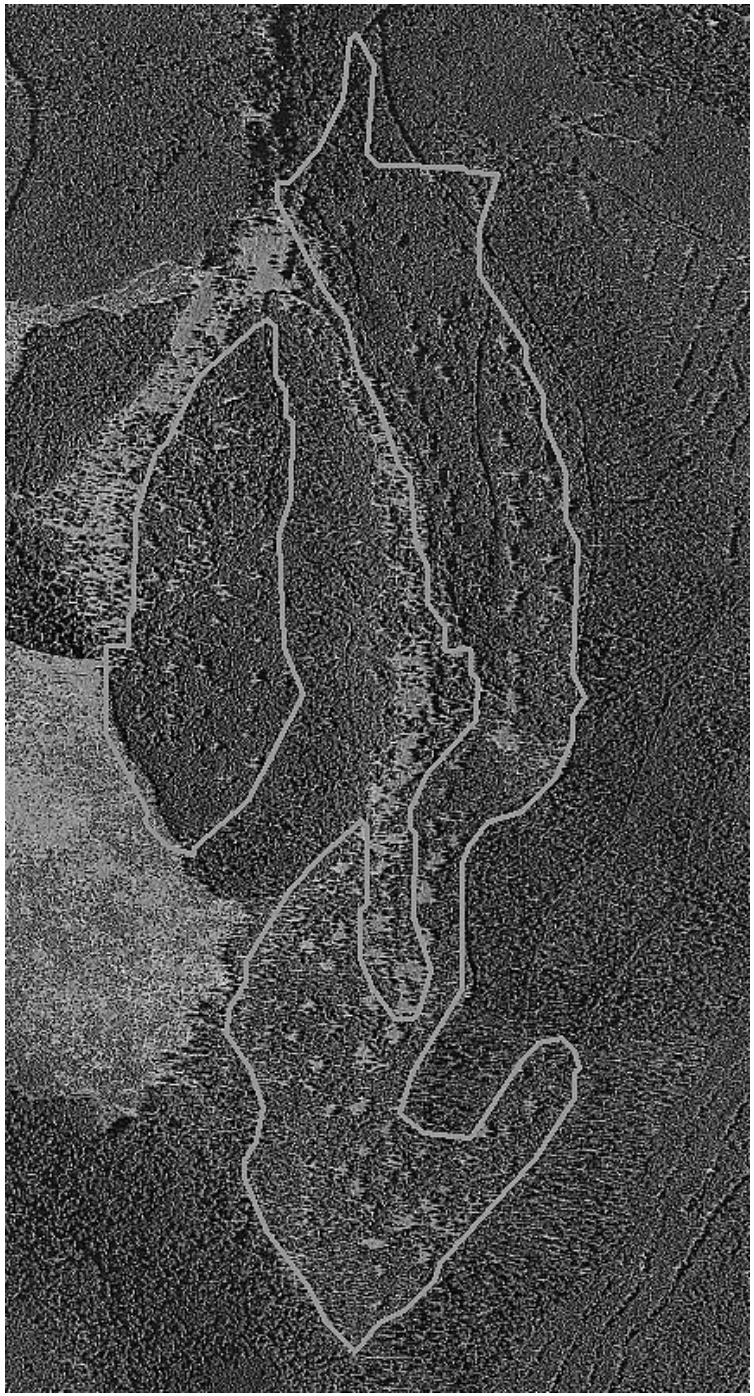
Plant Cover

Plant cover is consistently higher in pile burn scars than the surrounding forest.

Scar soils are capable of supporting understory plant communities.

Tree Growth

Where trees occurred inside piles they often grew better than in the surrounding stand (20-30% large diameter from ‘70s – ’90s).



Open Questions

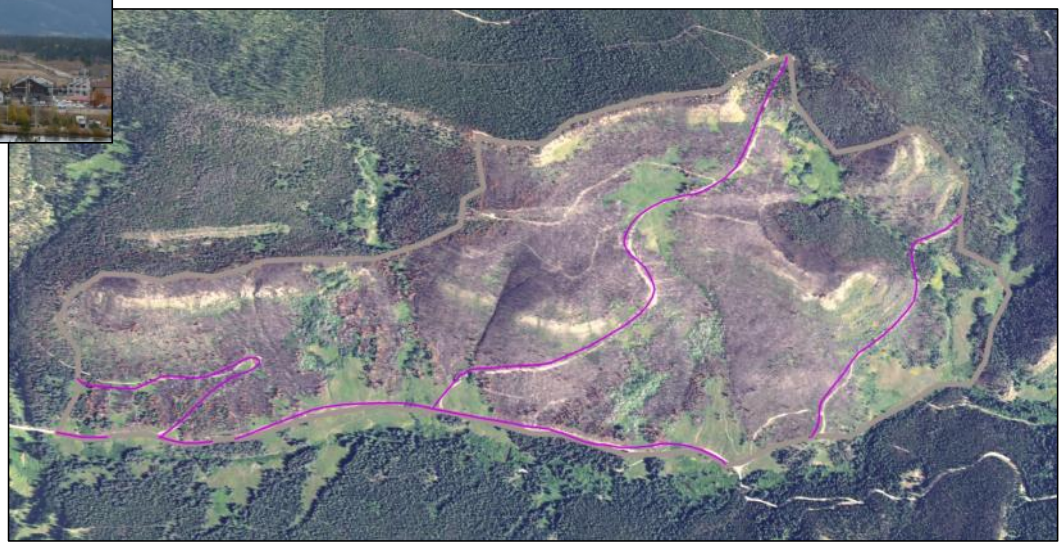
What are the causes & implications of scar persistence?

1) **Site degradation ?**
   - **tree growth - Yes**
   - **herb cover – Yes**
2) **Lack of propagules ?**
   - **Open Cones – Yes**
   - **(>95% of piles; all ages)**
3) **Site factors ?**
   - **Effect is uniform**
4) **MedBow version of crop circles ????**

Church Park Fire

Case Study

The October 2010 Church(’s) Park Fire created unique conditions that can help land managers better understand the ecological consequences of current pine beetle infestations and associated management.

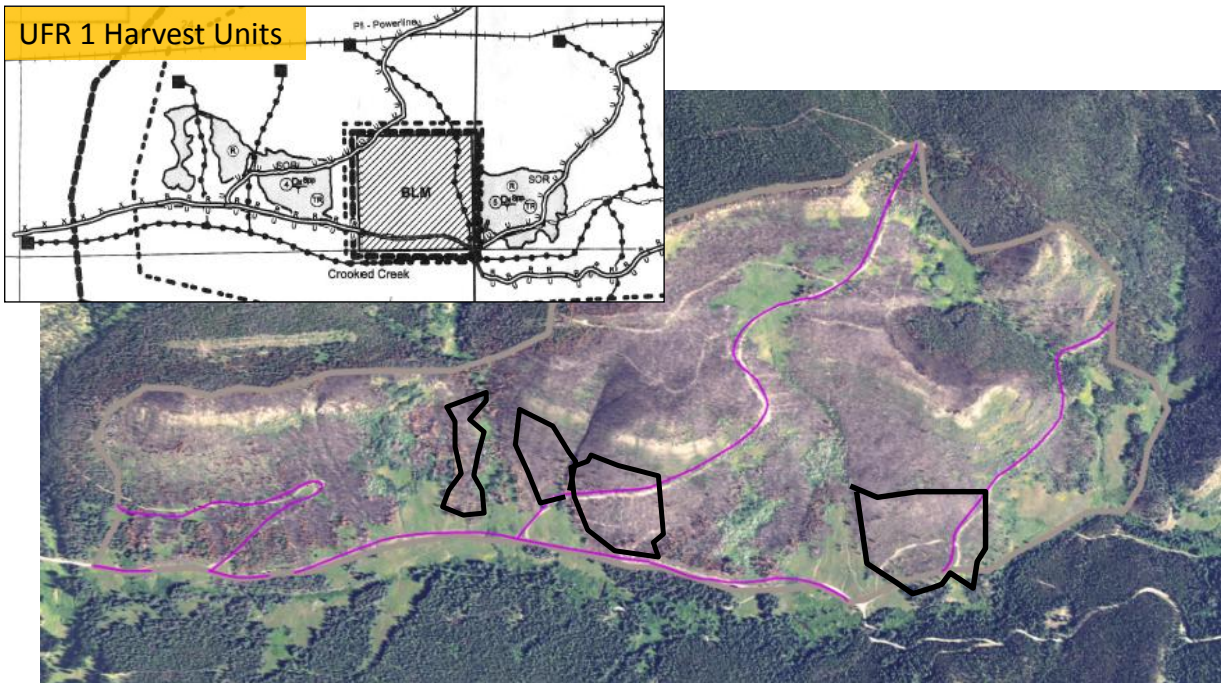


Grey-Phase Stands

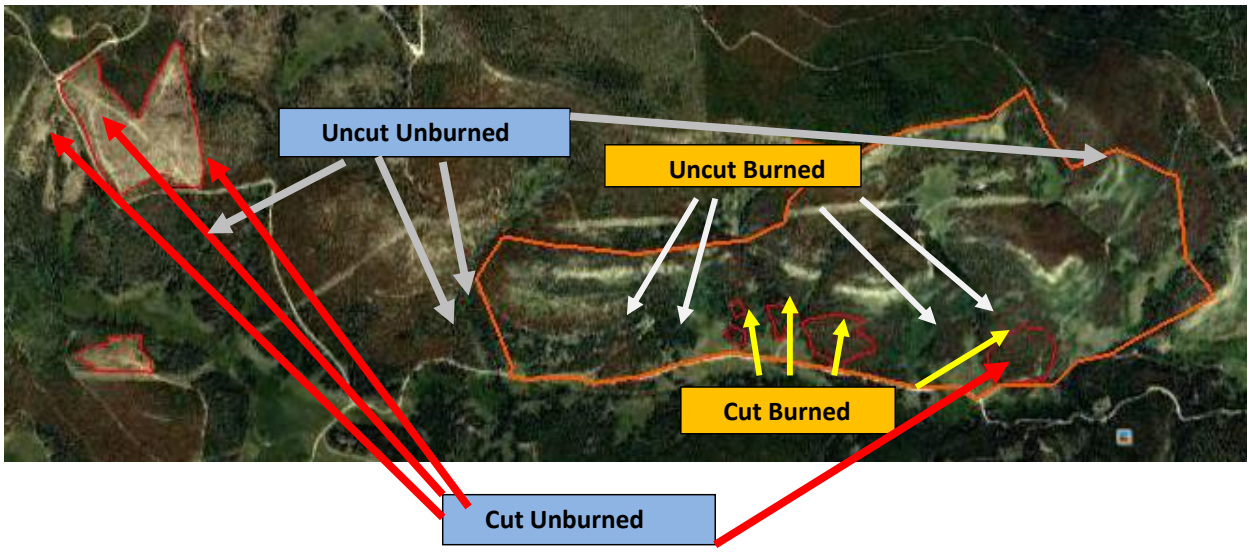
At the time of the Fire, needles had fallen from most of the overstory pine trees.

The Church Park Fire may be Colorado’s first ‘Grey Phase’ fire associated with the current outbreak.

Fuels Treatment Areas



Case Study Sample Design



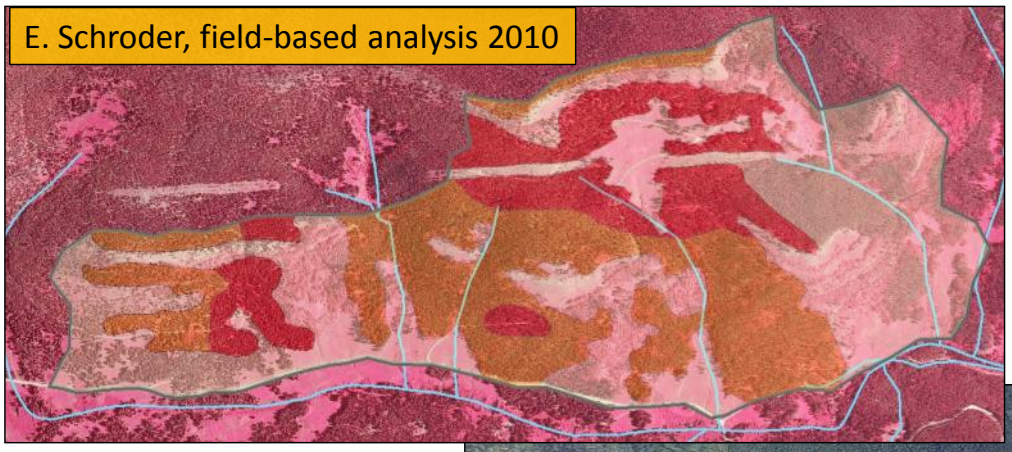
Cut / Uncut comparisons *Inside* the burn -

How does management influence fire effects, forest recovery and site productivity?

Cut / Uncut comparisons *Outside* the burn -

How does wildfire alter the trajectory of recovery in MPB-killed forests?

Diversity of Vegetation & Fire Conditions



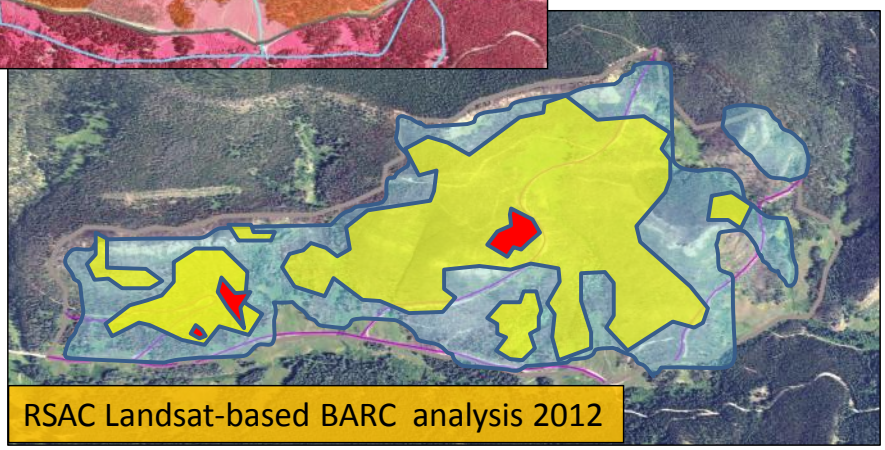
Fire severity

17% high
30% moderate
53% low

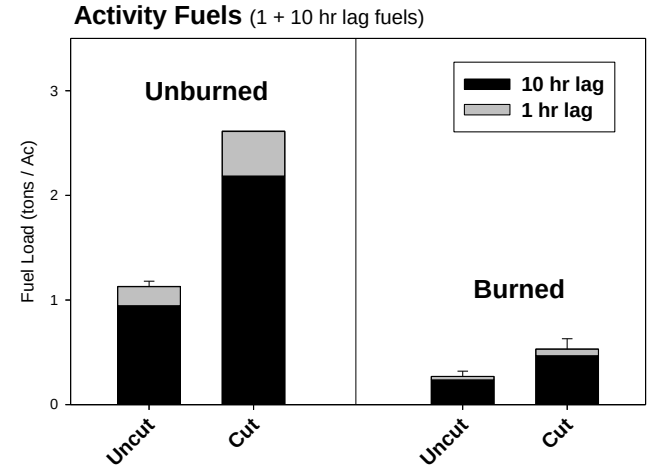
(E. Schroder, ARNF, 2010)

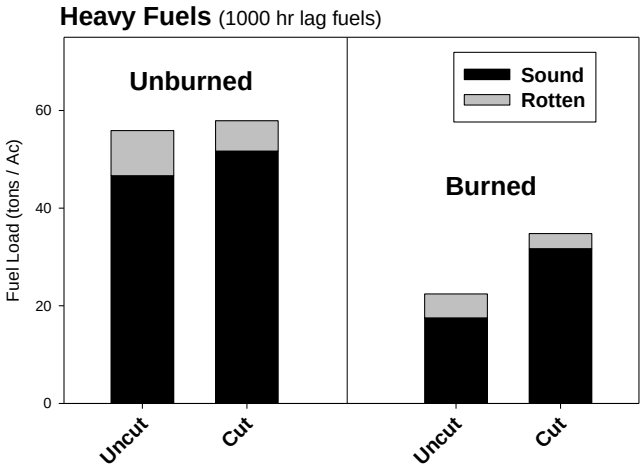
Mixed vegetation

lodgepole-dominated,
Mixed- sp subalpine forest,
aspen clones,
meadow



Fine & Heavy Fuels



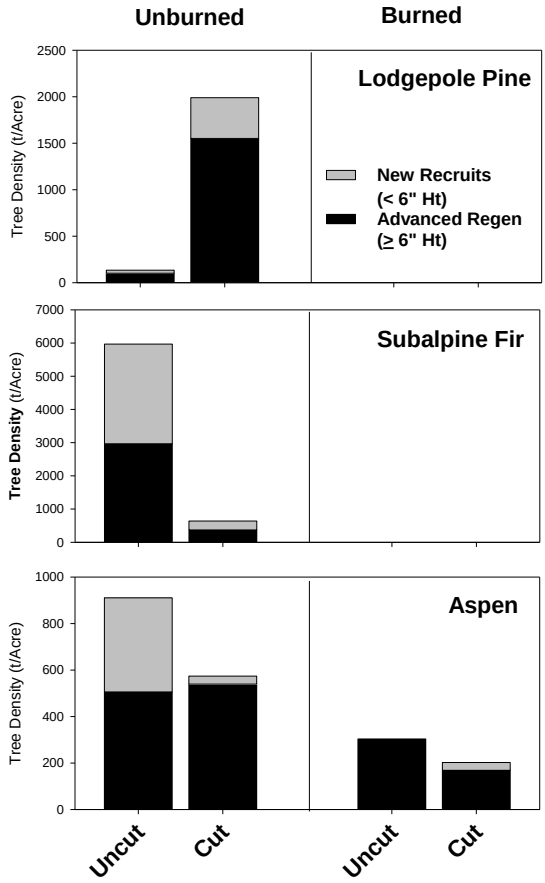


Harvesting doubles fine fuel loads but has little effect on heavy fuels

Burning reduces fine and heavy fuels by more than half

Consumption of fine fuels may be higher and that of heavy fuels may be lower in the treated units

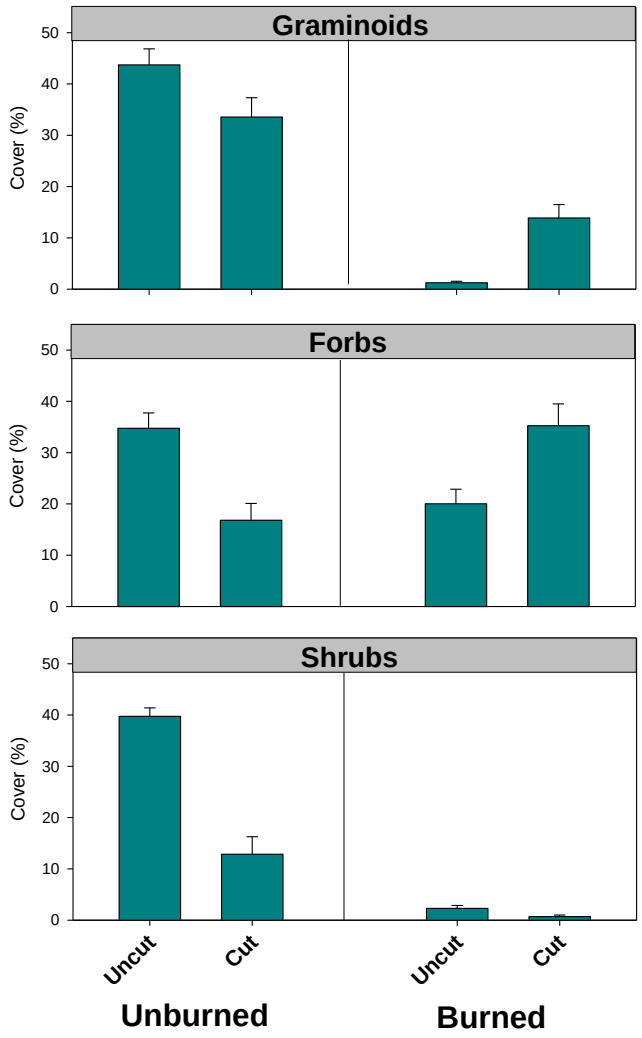
Tree Regeneration



High density of fir and aspen in uncut beetle-killed stands.

Pine seedling densities are higher in harvested units; fir and aspen are lower.

The second summer after the fire, regeneration is limited to aspen sprouts. Any effect of cutting + fire is unclear or minor.



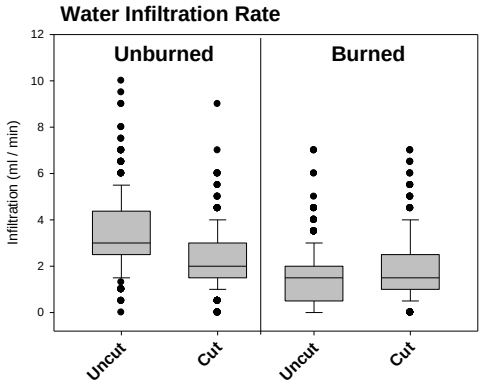
Understory Cover

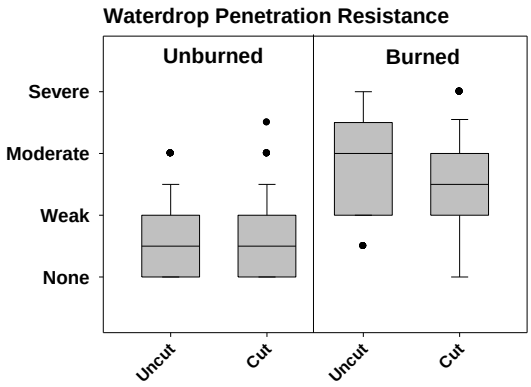
Cutting reduced all plant groups, and had the greatest effects on woody shrubs (*Vaccinium* spp.).

Forb cover recovered to pre-burn levels within 2 years.

Post-fire recovery of herbaceous plant cover was greater in the treated areas

The combination of cutting then burning was tough on shrubs





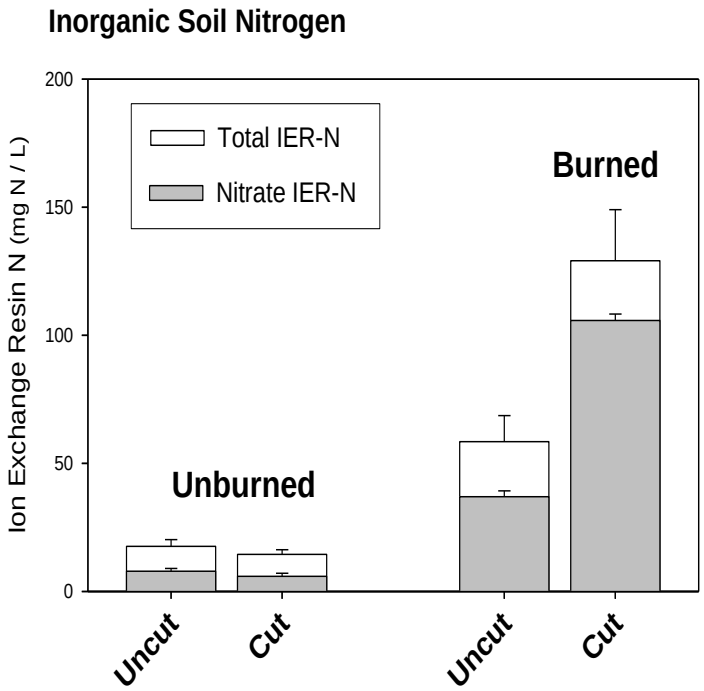
Soil Water Changes

Both logging and burning decreased water infiltration.

Only burning alters the resistance to water drop penetration (hydrophobicity index)

Harvesting effects are not evident in burned areas

Plant Available Soil N



Harvesting alone has no effect on nitrogen availability. In contrast, burning increases it 2 to 3 times

N in harvested, burned areas is 10X higher than uncut areas and 3X higher than other burned areas.

This N is both available to plants and susceptible to leaching losses.

Church Park Fire
Sampling Timeframe

<u>Summer 2011</u>

Plot establishment
Initial soil nitrogen and vegetation responses (10 month post-fire)
Surface fuel loads
Standing trees and snags measured and tagged.

<u>Summer 2012</u>

Enumerate new seedlings, measure seedling growth
Identify native and non-native herbaceous species
Conduct soil nutrient assays, herbaceous plant biomass
Characterize burn severity based soil indices
Fire Behavior – Fire Fighter Interviews

Project Contacts:

US Forest Service, Rocky Mountain Research Station
Chuck Rhoades and Paula Fornwalt
crhoades@fs.fed.us; pfornwalt@fs.fed.us

Colorado State University, Department of Forest and Rangeland Stewardship
Tony Cheng, Chad Hoffman, Skip Smith, Kevin Moriarty