Soil nitrogen and microbial response to fuel reduction treatments in Pinyon-Juniper woodlands of southwest Colorado

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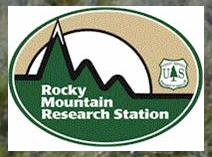


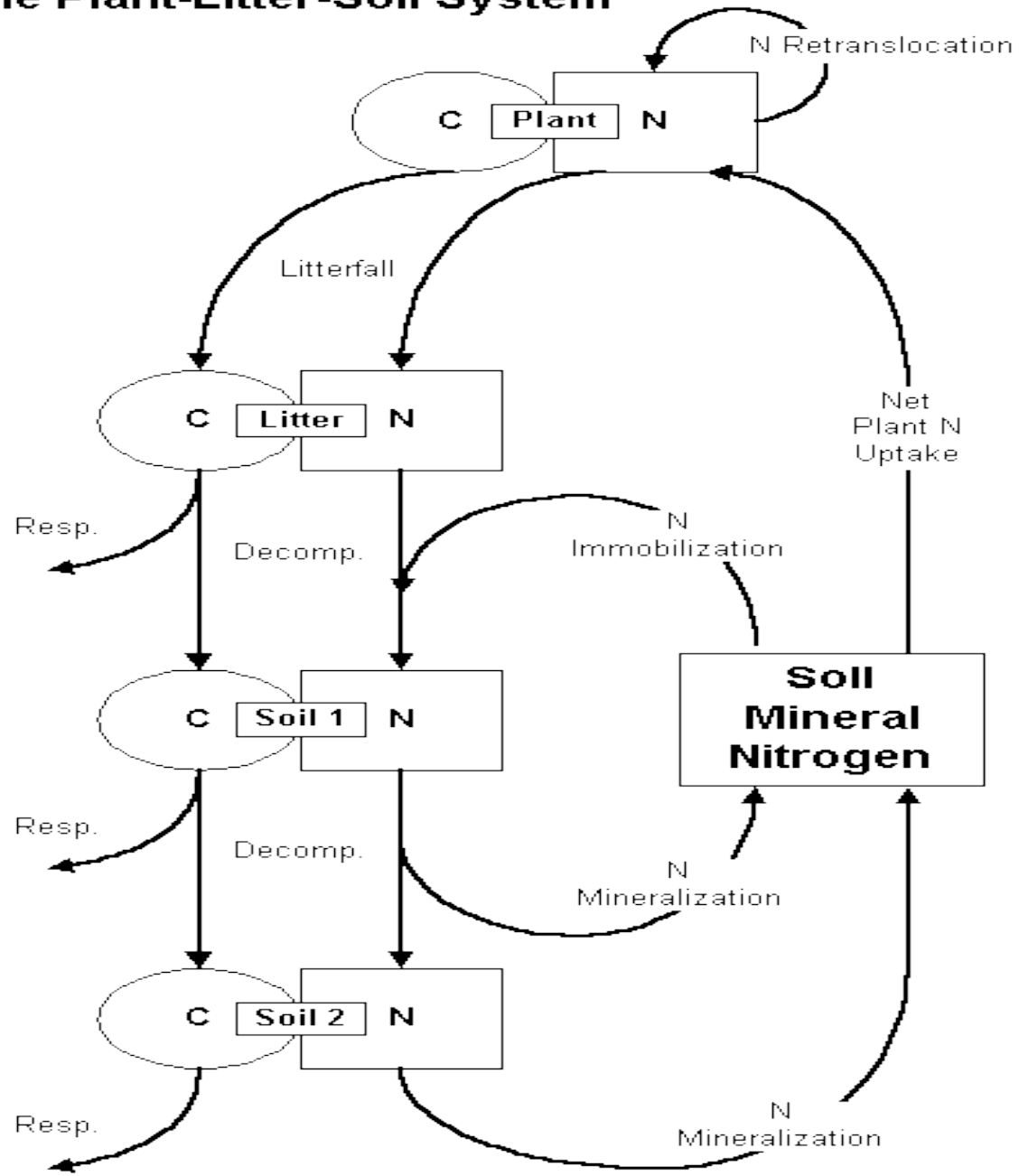
San Juan National Forest

Fuels treatments to alter fire behavior

Thin and pile burn – large losses due to oxidation of biomass and surface organic matter, reduced microbial populations that are important in N mineralization

Mastication – additional inputs of recalcitrant material (high C/N ratio) slowing decomposition and altering microbial populations (greater F/B ratios) while immobilizing N in surface mineral soil.

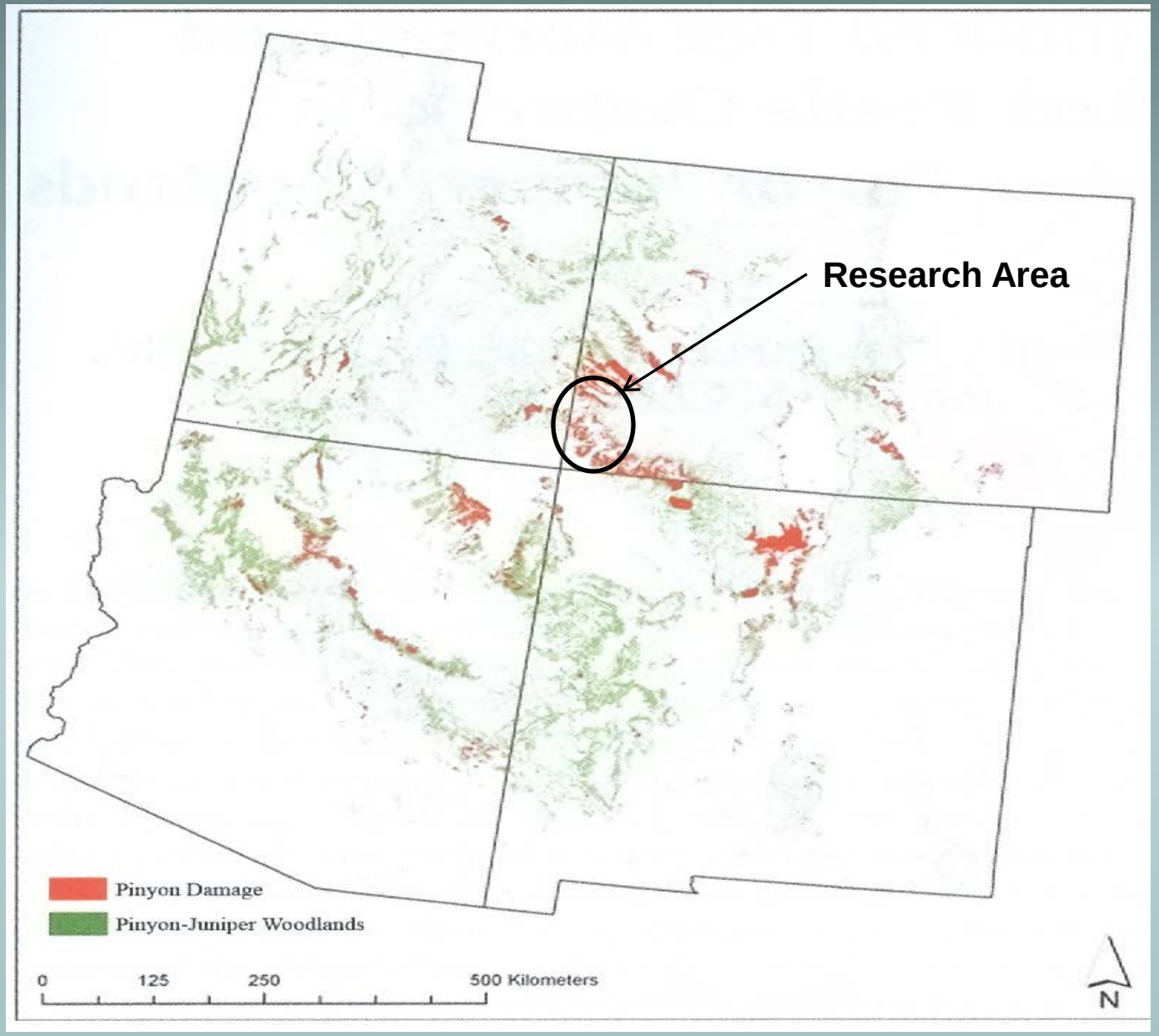
Primary Linkages between C and N in the Plant-Litter-Soil System



Pinyon Mortality: 2001-2005

Year	Colorado	New Mexico	Arizona
2001	0	104,000	7,000
2002	6,000	4,128,000	199,000
2003	4,071,000	44,705,000	18,863,000
2004	4,789,000	5,575,000	47,000
2005	104,000	62,000	8,000
Total	**8,970,000**	**54,574,000**	**19,124,000**

Forest Health Protection, USDA Forest Service



Forest Health Protection, USDA Forest Service
Aerial survey of pinyon mortality 2000-2005.

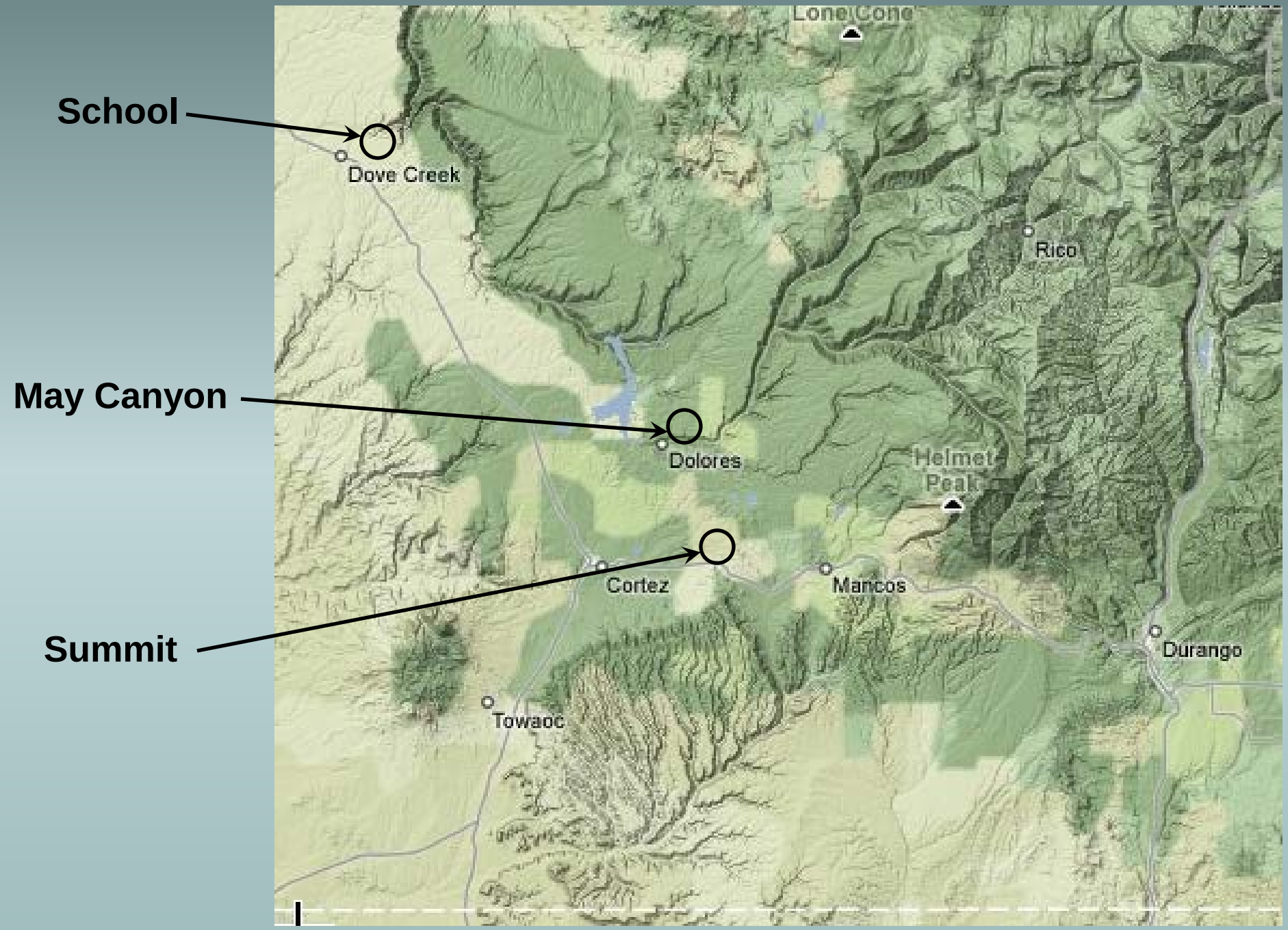
Management Issue
Alter wildfire behavior

Mastication

- Pros
  - Economical
  - Can work in the wildland-urban interface.
- Cons
  - Retains fuels
  - Machinery cannot work on slopes of > 25%
  - Unknowns
    - Decomposition
    - Nitrogen dynamics
    - Increased non-natives
    - Tree regeneration
    - Fire behavior??

Hand thin and pile burn

- Pros
  - Reduces fuels
  - Reintroduces fire back into the ecosystem.
- Cons
  - Costs
  - Often cannot utilize in the wildland-urban interface
  - Increased non-natives


School
May Canyon
Summit
Lone Cone
Dove Creek
Rico
Dolores
Helmet Peak
Cortez
Mancos
Durango
Towaoc

May Canyon
2223 ± 14 m elevation

Wauquie – Loamy-skeletal, Mixed,superactive, mesic Aridic Haplustalfs Granite, sandstone, shale parent material

Granath - Fine-silty, mixed, superactive, frigid Typic Argiustolls sandstone parent material

Dolcan - Loamy, mixed, superactive, calcareous, mesic, shallow Aridic Ustorthents sandstone and shale parent material

School
2339 ± 13 m elevation

Fivepine - Clayey, smectitic, frigid Lithic Argiustolls sandstone parent material

Nortez - Fine, smectitic, frigid Typic Argiustolls sandstone parent material

Summit
2133 ± 25 m elevation

Sideshow - Fine, smectitic, mesic Aridic Haplusterts shale parent material

Zigzag - Clayey, smectitic, calcareous, mesic, shallow Aridic Ustorthents shale parent material

Overstory conditions pre-treatment 2005 (trees per acre)

	Pinyon live	Pinyon dead	Juniper live & dead	Total
School				
Control	99	5	37	141
Mastication	111	25	22	158
Thinning	112	8	17	137
Summit				
Control	113	157	108	378
Mastication	127	153	111	391
Thinning	83	153	156	392
May				
Control	69	51	72	192
Mastication	139	53	15	207
Thinning	85	42	27	154

Multi-response Permutation Procedure of understory frequency, SW Colorado P-J sites

	Groups Included in Subset			Simultaneous evaluation Ho: groups are similar
	May Canyon	School	Summit	Decision for alpha = 0.05
2005 Pre-treatment	1	1	0	reject
	1	0	1	accept
	0	1	1	reject

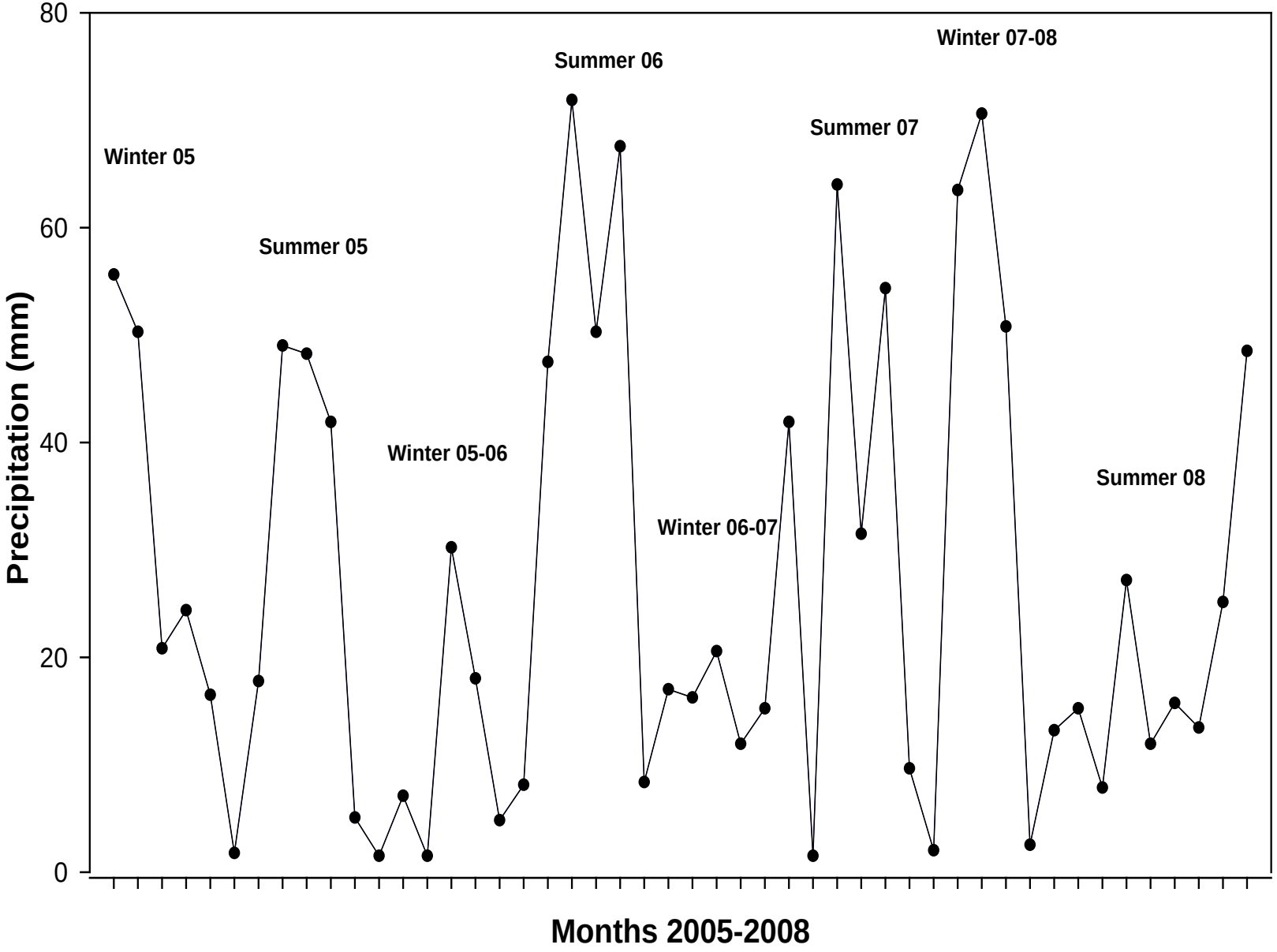
May Canyon

School

Summit

Monthly Precipitation 2005-2008

Cortez Station, ID 51886Elevation-- 1865 meters



Thinning Guidelines

Thin between 40 to 60% of canopy cover.

Target dead pinyon and dense pockets of trees.

Leave good trees > 8” d.b.h. and good saplings.

Leave clumps of 0.25-2 acres in size.

Cut 50% of brush canopy in a mosaic pattern.

Leave designated snags.

May Canyon

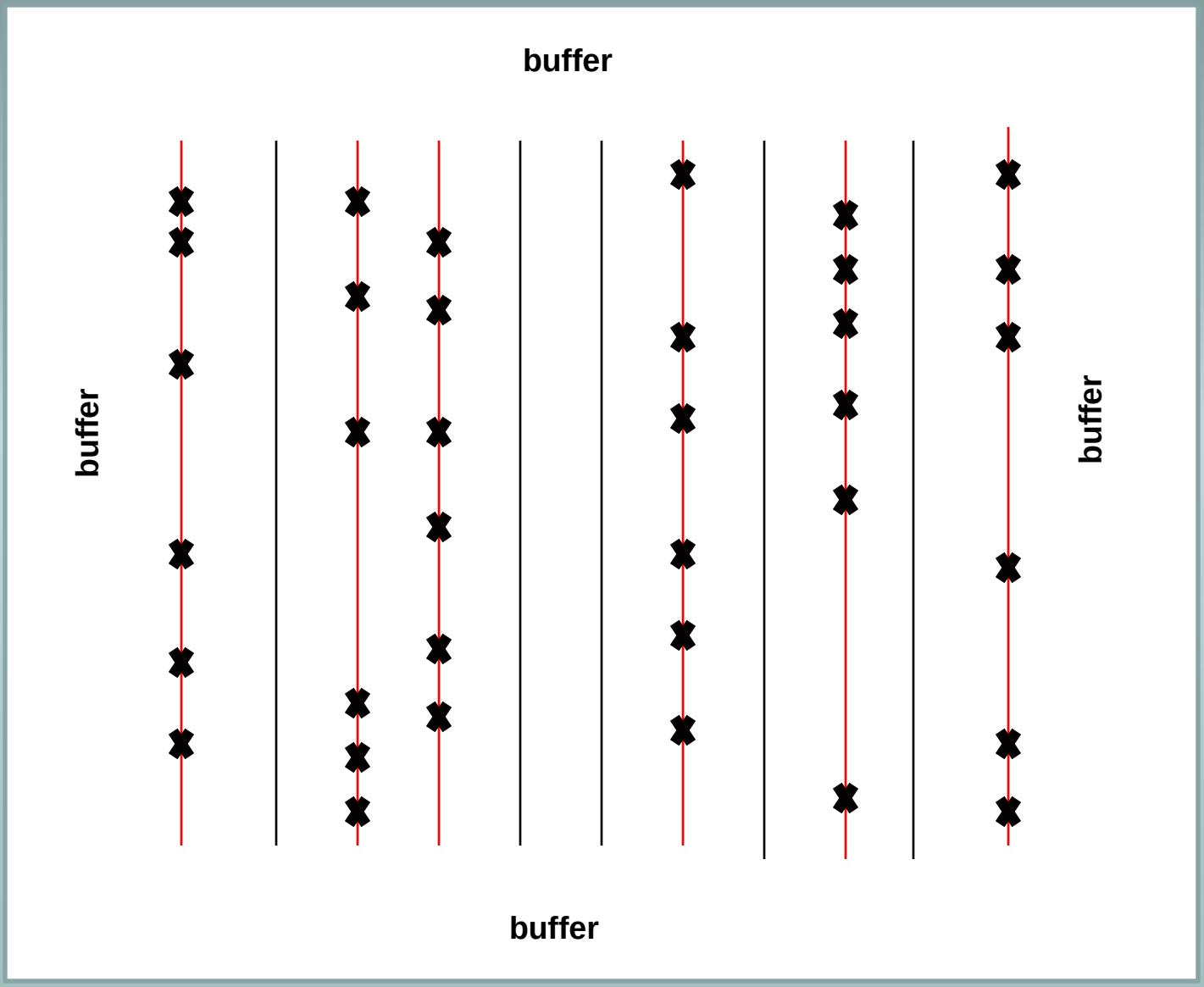
August, 2009

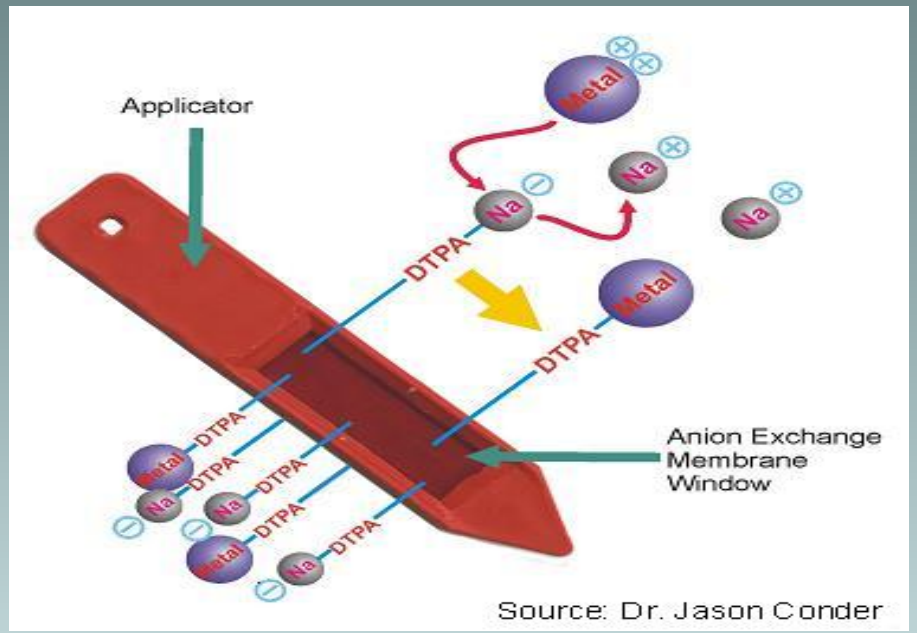
N

Plot layout

6 randomly selected transects (minimum 100 ft. apart)

6 randomly selected points per transect (minimum 100 ft. apart)

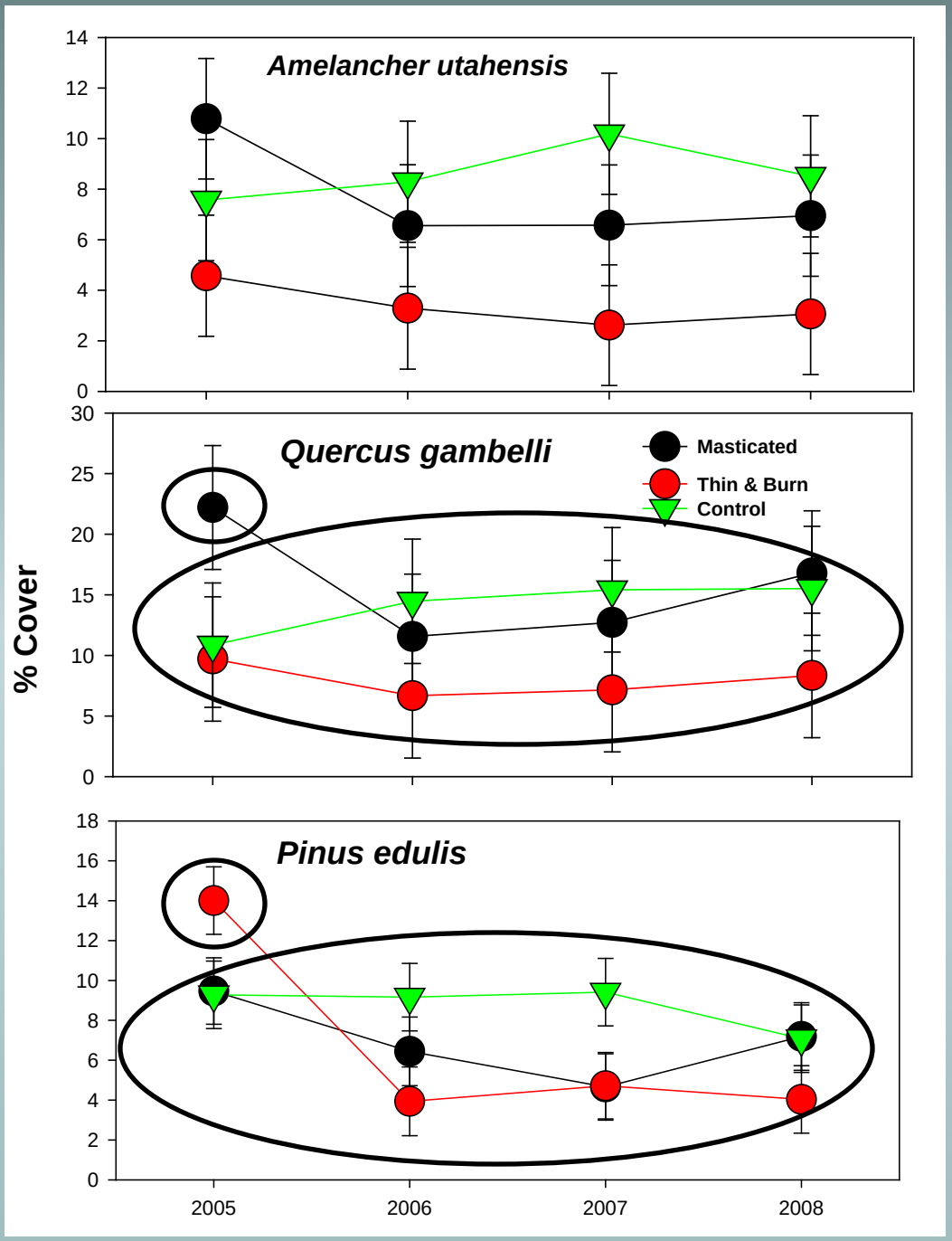




Available N

Plant Root Simulator probes (WesternAg, Inc.) inserted 5 cm deep within a 10 cm diameter pvc pipe driven to 15 cm when possible within the mineral soil.

Plant Root Simulator probes retrieved and analyzed every July and November from 2006 to 2008.



% cover by major species

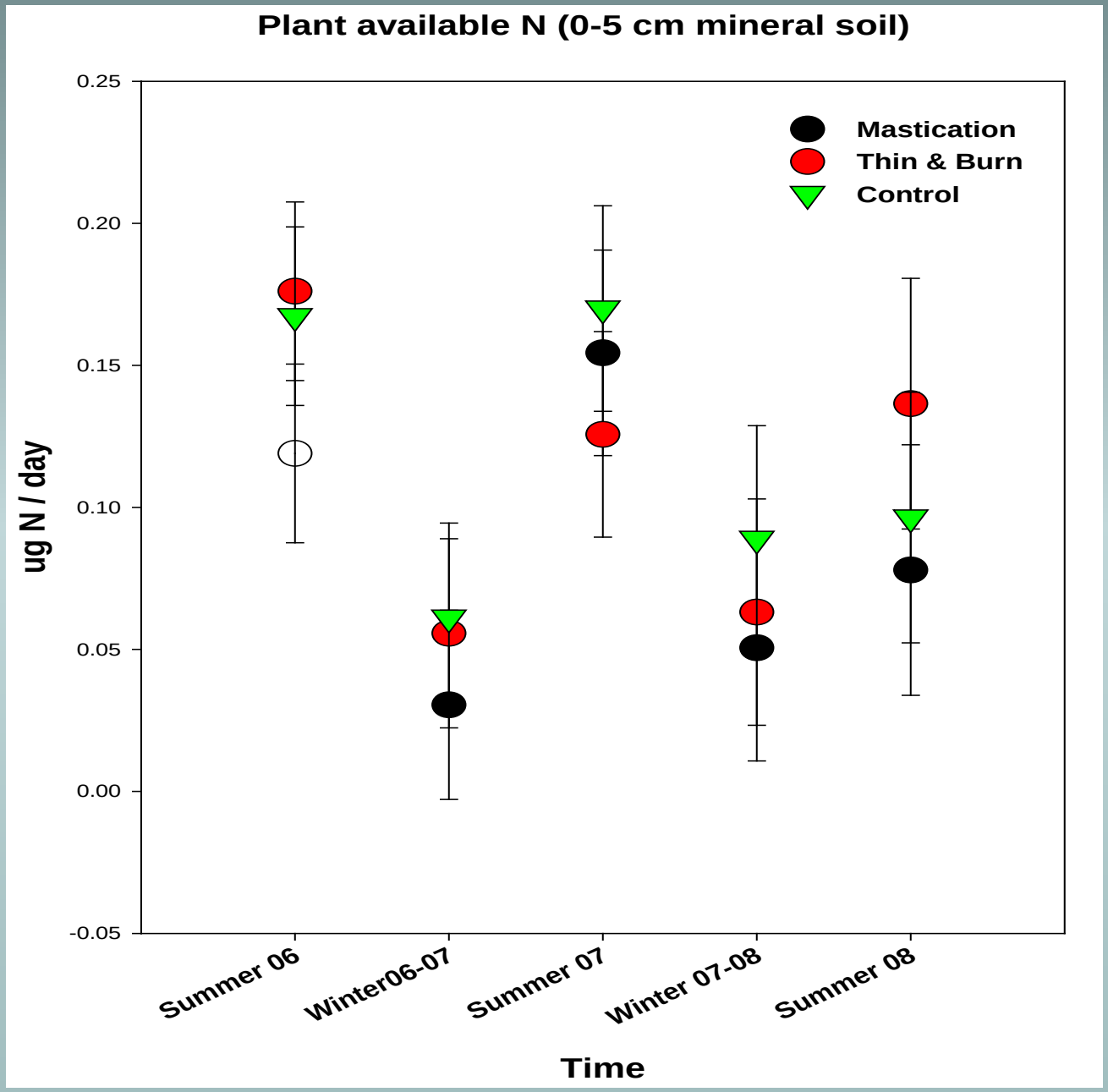
Mastication appears to have removed greater proportion of shrubs than hand thinning and burning.

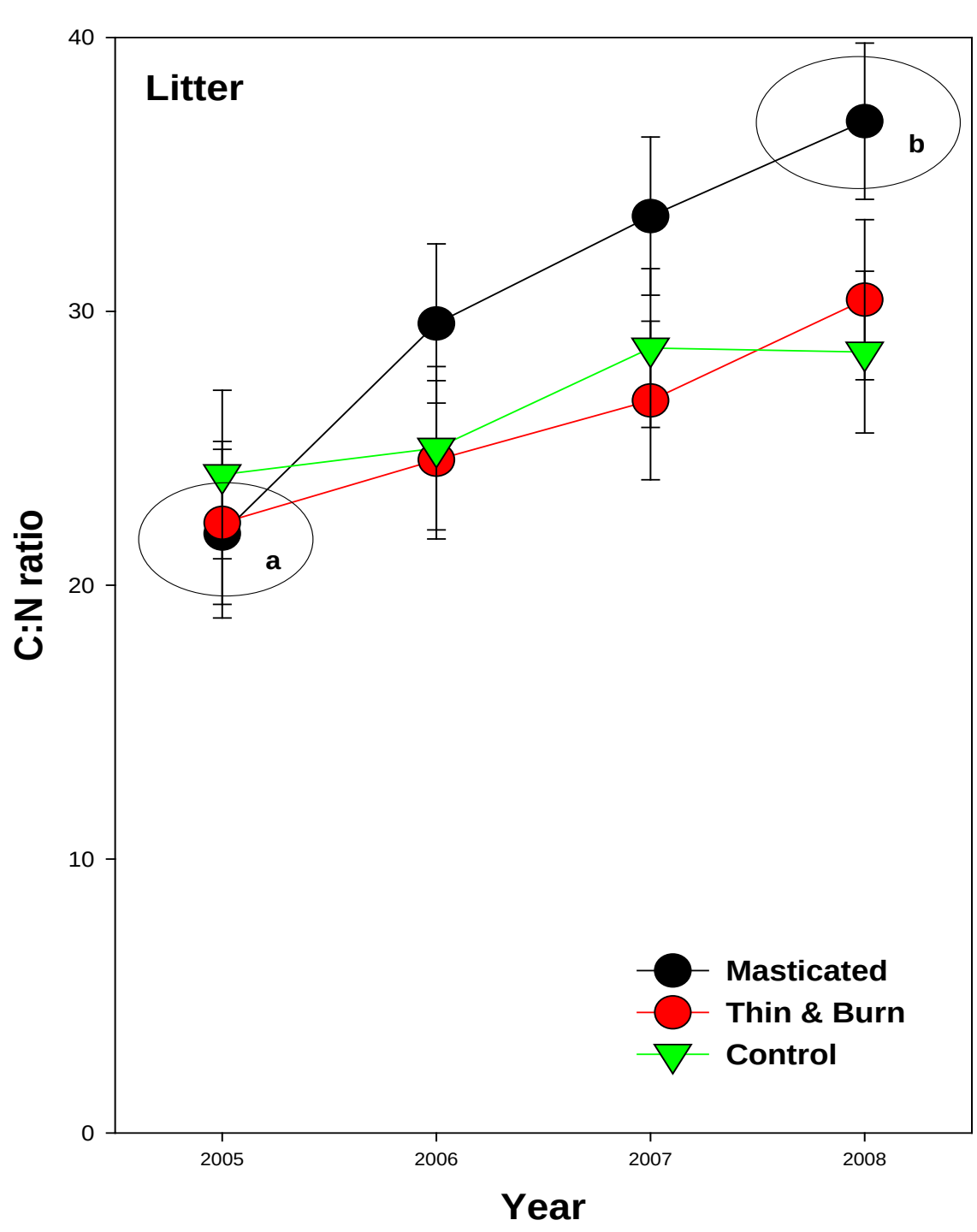
Hand thinning and burning reduced canopy cover significantly.

Multi-response Permutation Procedure of understory frequency for May Canyon and Summit, SW Colorado P-J sites

	Groups Included in Subset				Simultaneous evaluation Ho: groups are similar
	Mastication	Thin & Burn	Control	Single test p-value	Decision for a = 0.05
May Canyon	1	1	0	0.1	reject
	1	0	1	0.1	reject
	0	1	1	0.1	reject
Summit	1	1	0	0.0452	reject
	1	0	1	0.0011	reject
	0	1	1	2.38E-04	reject

Available N


Plant available N (0-5 cm mineral soil)
Mastication
Thin & Burn
Control
ug N / day
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
Summer 06
Winter06-07
Summer 07
Winter 07-08
Summer 08
Time

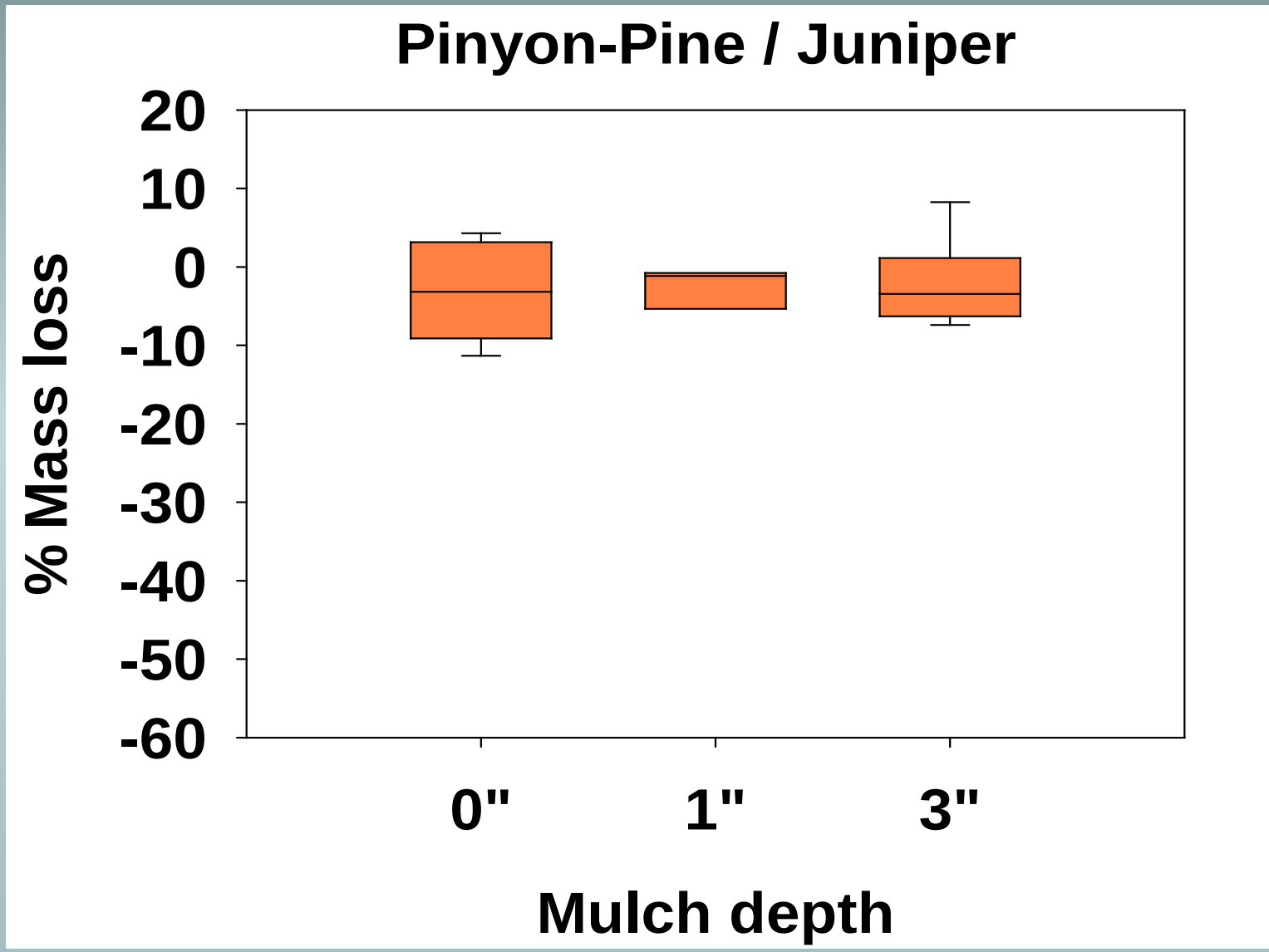


Total Carbon to Nitrogen ratio of the surface organic horizon.

Pre-treatment mastication is significantly different than the third-year post-treatment mastication.

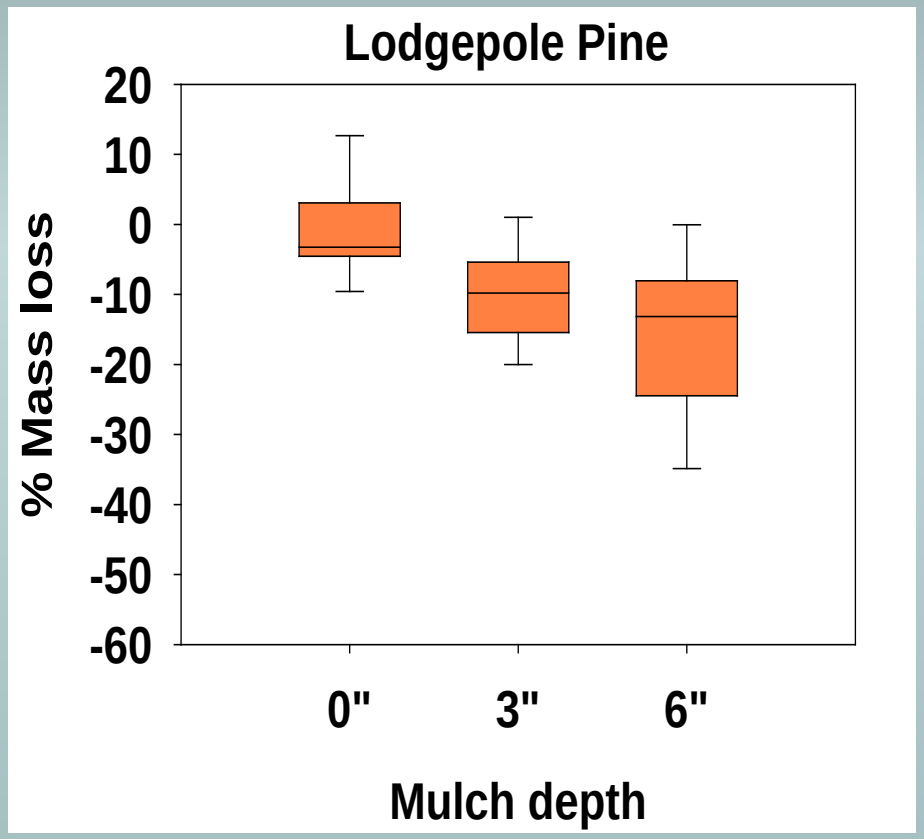
Mastication in the second and third year post-treatment > 30:1 ratio.

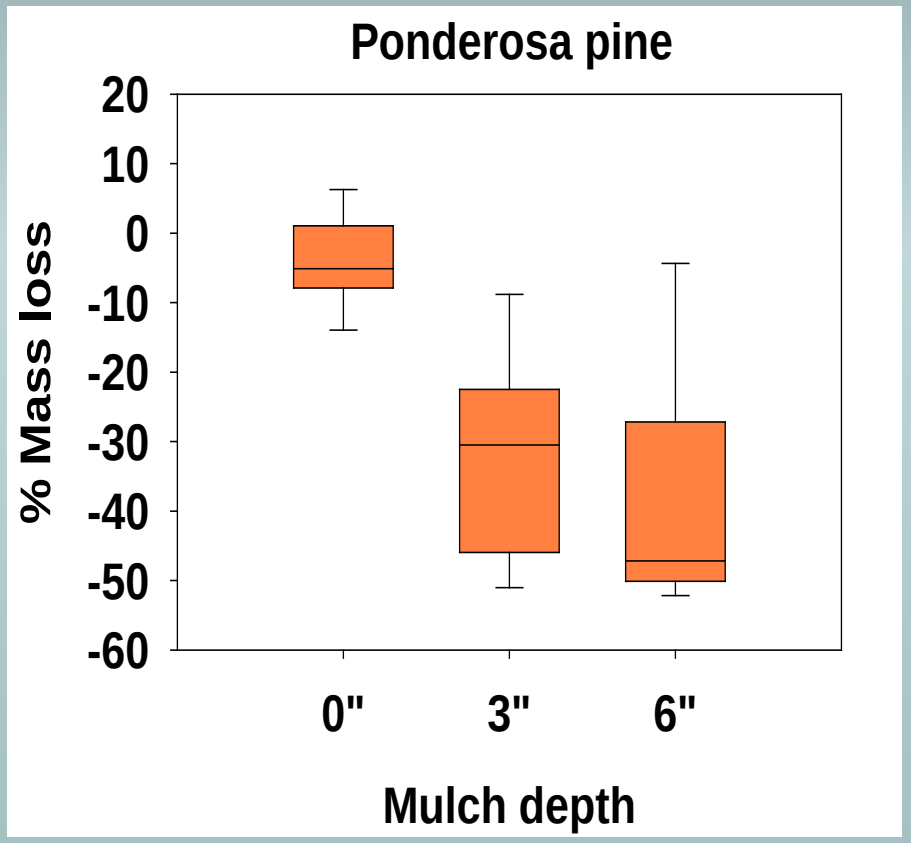
Decomposition rates of mulch did not increase with increased depth after 2 years



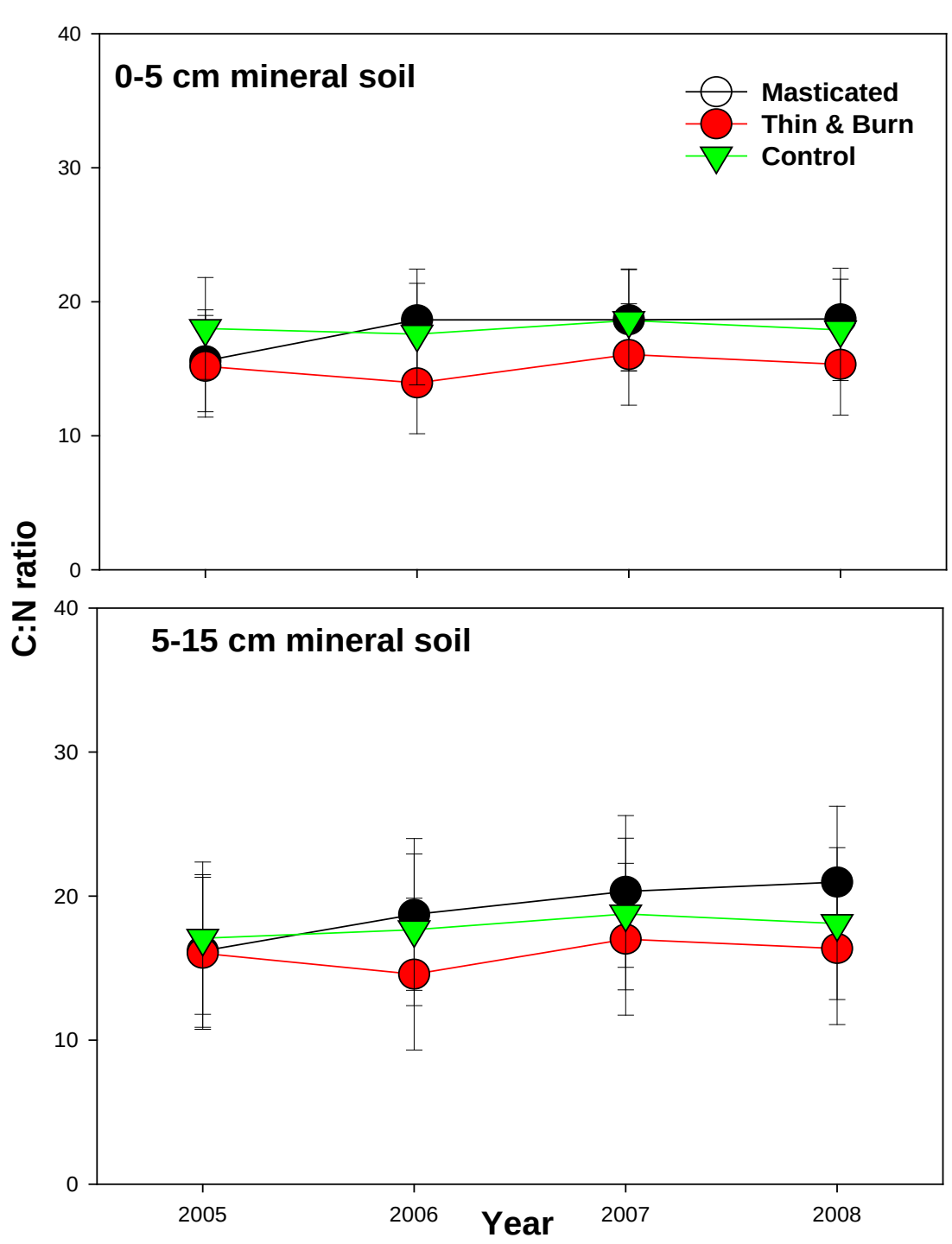
Courtesy Mike Battaglia, RMRS

Decomposition rates of mulch did increase with increased depth for other ecosystems after 2 years



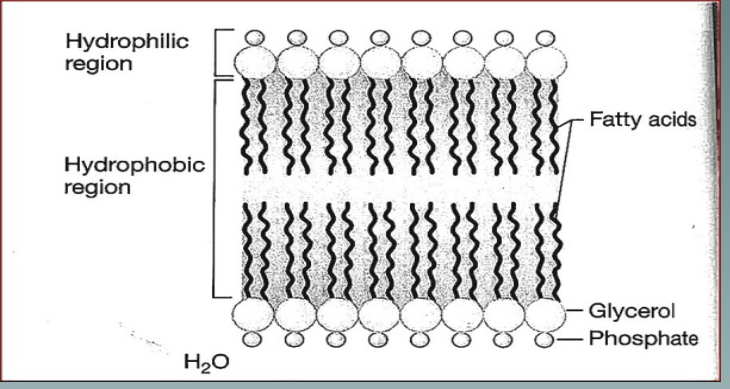


Courtesy Mike Battaglia, RMRS



Total Carbon to Nitrogen ratio of the Mineral soil

No significant differences Post-treatment.

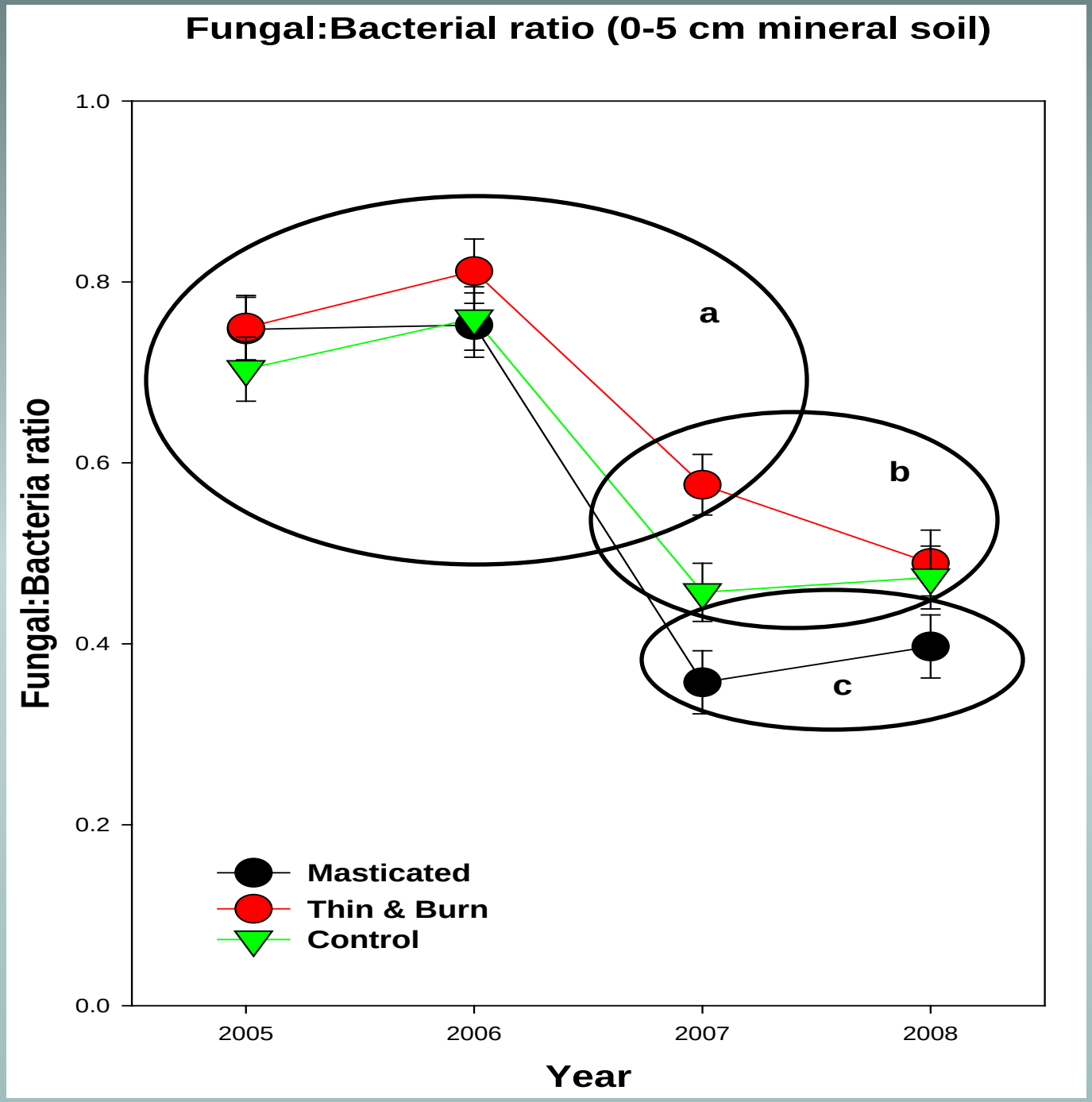


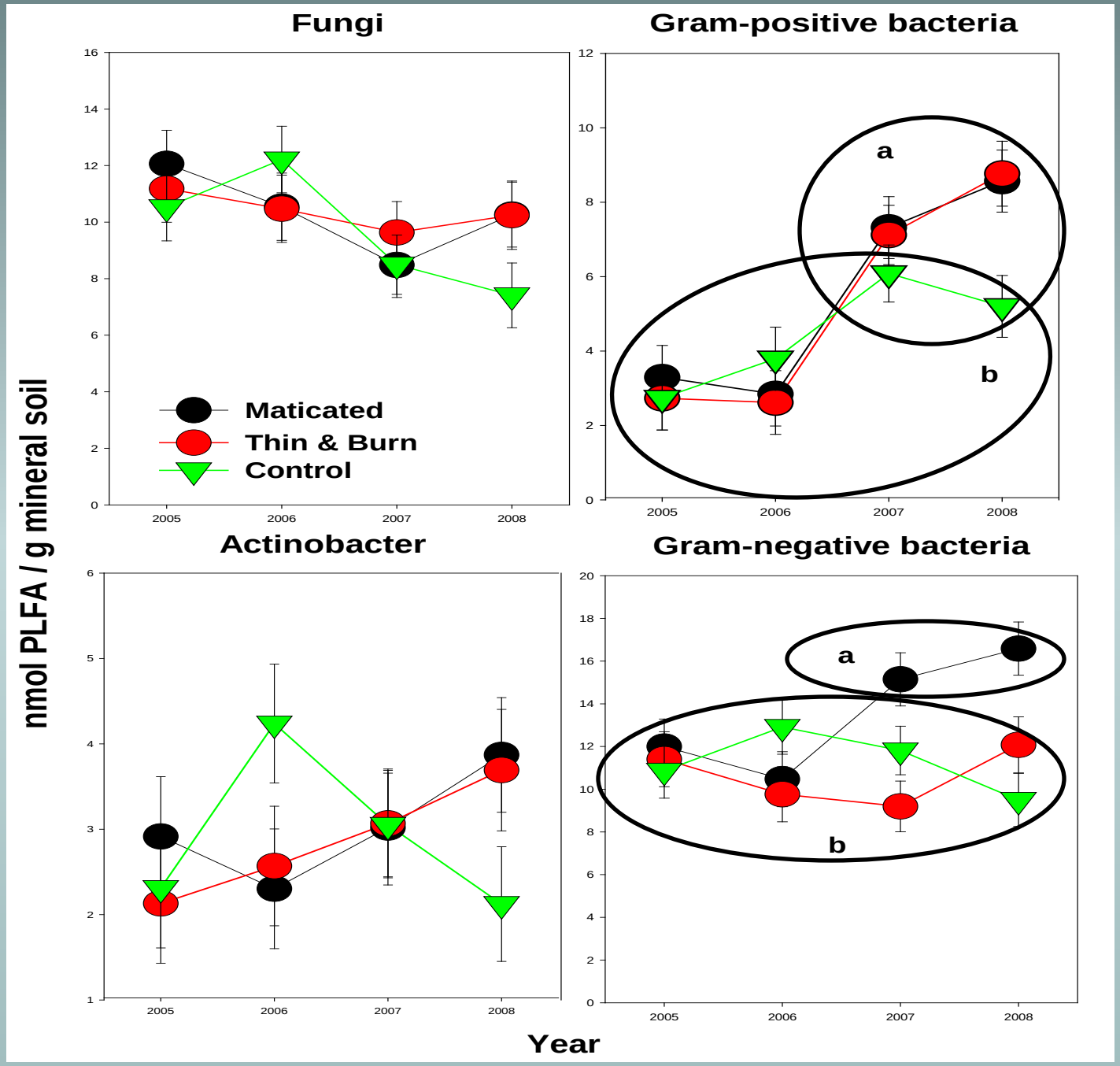
Phospho-lipid Fatty Acid Analysis (PLFA)

- **PLFAs are essential components of every living cell with high biological specificity.**
- **Used as a biomarker for active microrganisms and index for total microbial biomass.**
- **PLFAs are quickly degraded when an organism dies.**
- **PLFAs are not found in storage products.**
- **Total PLFA pattern by multivariate statistics (MRPP). Changes in PLFA fingerprint equates to changes in microbial community.**
- **Changes in specific PLFAs can be used as indicators of changes in specific organism groups.**

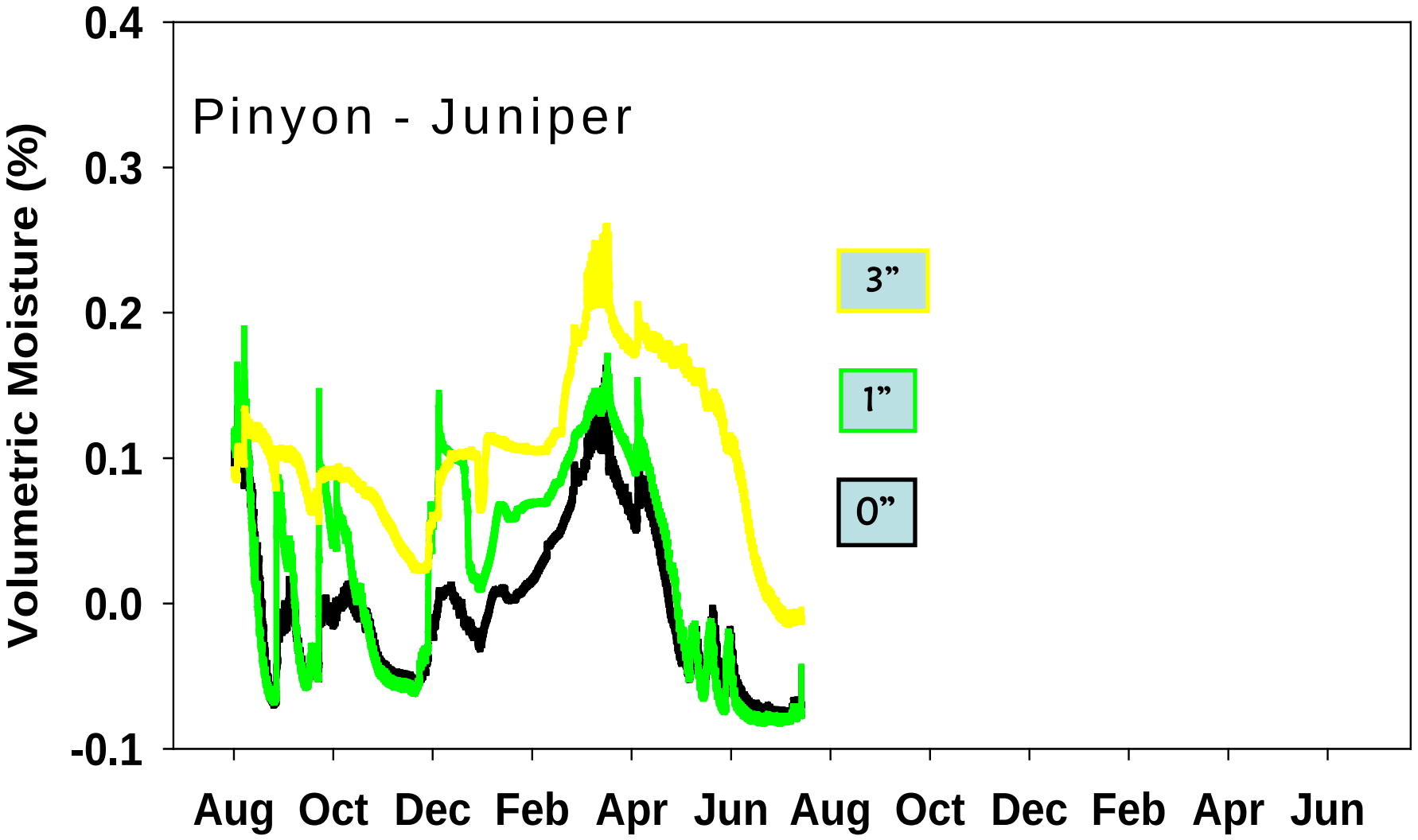
Multi-response Permutation Procedure of treatment effects on Microbial community structure (PLFA), SW Colorado P-J sites.

	Groups Included in Subset			Simultaneous evaluation Ho: groups are similar	
	Mastication	Thin & Burn	Control	Single test p-value	Decision for a = 0.05
2005 Pre-treatment	1	1	0	ns	accept
	1	0	1	ns	accept
	0	1	1	ns	accept
2006 Post-treatment	1	1	0	0.0452	reject
	1	0	1	0.0011	reject
	0	1	1		reject
2007 Post-treatment	1	1	0	4.81E-07	reject
	1	0	1	1.11E-06	reject
	0	1	1	0.0054	reject
2008 Post-treatment	1	1	0	3.54E-04	reject
	1	0	0	1.45E-07	reject
	0	1	1	7.10E-04	reject


Fungal:Bacterial ratio (0-5 cm mineral soil)
Fungal:Bacteria ratio
1.0
0.8
0.6
0.4
0.2
0.0
2005
2006
2007
2008
Year
a
b
c
Masticated
Thin & Burn
Control

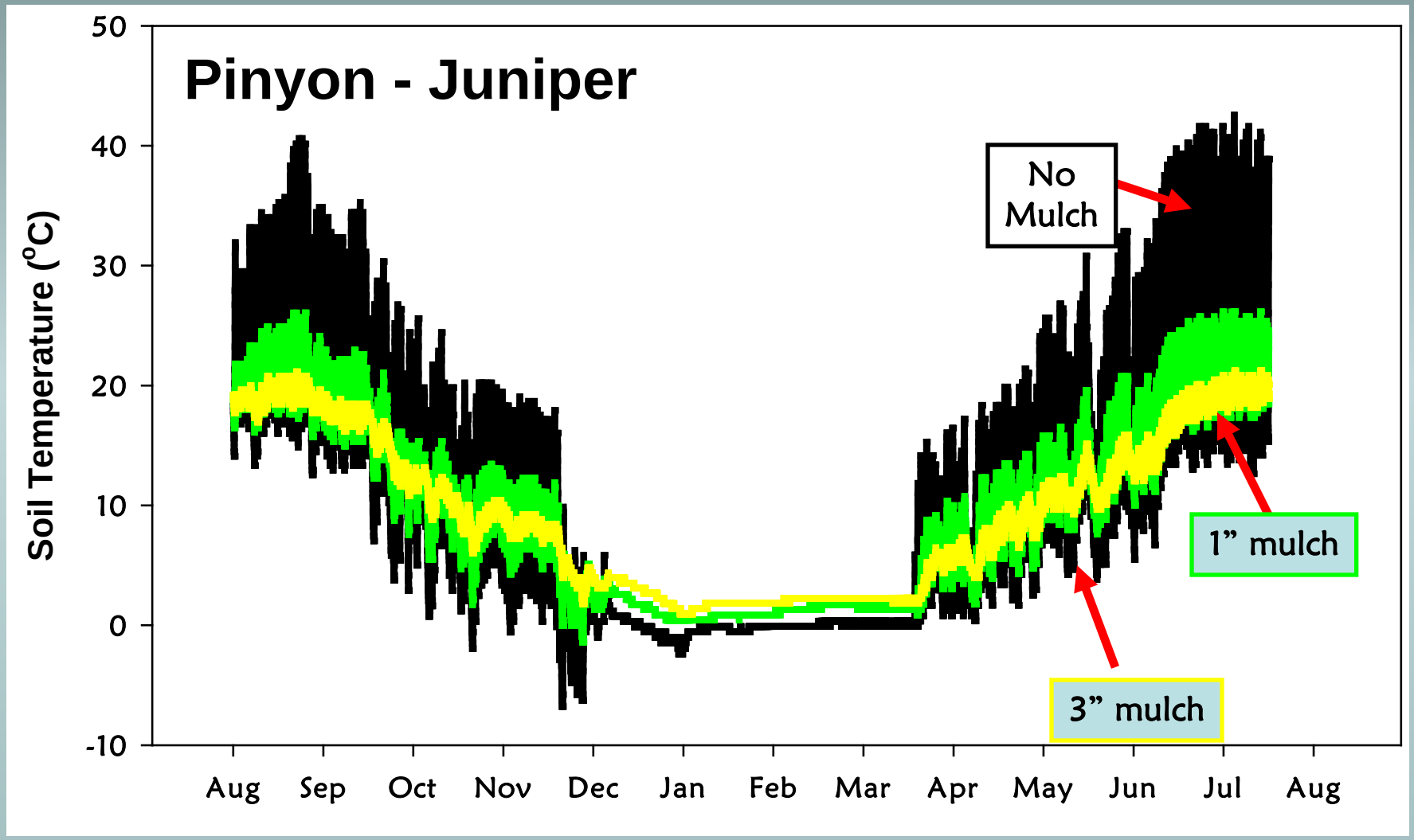

Fungi
Gram-positive bacteria
Actinobacter
Gram-negative bacteria
nmol PLFA / g mineral soil
Year
Maticated
Thin & Burn
Control
a
b
a
b
2005
2006
2007
2008

Soil moisture increases with mulch depth



Courtesy Mike Battaglia, RMRS

Soil temperatures cooler in summer and warmer in the winter with additional mulch



Courtesy Mike Battaglia, RMRS

Thin & Burn treatment (August 2009) at Summit

Mastication treatment (August 2009) at Summit

CONCLUSION

- Mastication altered carbon:nitrogen ratios in the litter layer compared to controls or thinning and burning, while the mineral soil was unaffected by treatments.
- Treatments had no detectable influence on N mineralization in the upper mineral soil layer.
- Mastication decreased F:B ratios in the second and third year post-treatment.
- Gram-negative bacteria favored by mastication, while both mastication and thin & burn treatments favored gram-positive bacteria.

Management Implications

- **Fuel reduction treatments, as applied at these sites, were not detrimental to N mineralization in the short-term.**
- **The very slow decomposition of masticated material and widening C:N ratios are of concern in the long-term.**
- **Thin & burn treatments increased the frequency of cheatgrass and musk thistle significantly, while mastication favored sprouters (Gambel oak) and stoloniferous plants (Canadian thistle).**

Questions