Above- and Belowground Response to Tree Thinning Depends on Treatment of Tree Debris

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In review: Ecological Applications
Study Site: San Juan National Forest Near Dolores, CO

Site History:
Livestock grazing (before 1985), Fire suppression & Drought
Reduce wildfire risk around homes and Archaeological sites

Increase native understory and decrease soil erosion
Two Thinning Methods:

1) Slash pile burning

2) Mechanical mastication

Thin ~ 40-60% of overstory
Questions:
Will thinning treatments affect:

1) Soil Properties: physical or chemical?

2) Arbuscular Mycorrhizal Fungi (AMF): propagule abundance, species richness or community?

3) Plant Composition: Native or Exotic richness?
Arbuscular Mycorrhizal Fungi (AMF)

Vesicles

Hyphae

Spores

Arbuscules – nutrient exchange

Over 90% of plants rely on AMF

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AMF Promote Plant Growth and Increase Soil Stability

Soil hyphae and stability (Tisdall 1991)
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Elevation: 7,136ft (2,175 m)  
Soil: Alfisols               
Texture: Sandy loam          

6-months and 2.5-years post treatment
Hypotheses

Pile Burn

Mastication

[Available Nutrients]

pH

Soil temp

% Soil moisture

Soil stability

AMF & Plant abundance & richness

△ AMF & Plant community

% Soil moisture

Soil compaction

△ AMF & Plant community

Soil temp

Available N
Methods

• Soil (0-15 cm)
  – Soil moisture, Temperature, pH, Total N and C, NO₃⁻, NH₄⁺ (KCL extraction), PO₄³⁻, Bulk density, Soil stability (Slake test kit)

• AMF
  – Soil hyphae and spore abundance, richness

• Plants
  – Cover (Daubenmire), richness and native/exotic status
Results: PCA on Soil Properties

Axis 1: 41%
Driven by:
Temp. (.47)
NO₃⁻ (.37) and NH₄⁺ (.36)
Soil stability

Axis 2: 15%
Driven by:
Moisture (.35)
Temp. (.34)

Driven by:
- Mastication
- Pile burns
- Untreated

Soil stability
AMF Propagule Abundance and Richness Lower in Pile Burns

$F = 13.3, \ p<0.01$

$F = 15.3, \ p<0.01$

$F = 13.1, \ p<0.01$

![Graph showing AMF propagule abundance and richness](chart.png)

- **Soil Hyphae**: $F = 13.3, \ p<0.01$
- **Spore abundance**: $F = 13.1, \ p<0.01$
- **AMF richness**: $F = 15.3, \ p<0.01$
AMF Spore Community Different in Pile Burns

MRPP: $A=0.15$ $p<0.01$

- Mastication
- Pile Burn
- Untreated

G. constrictum
S. calospora
Plant Cover Lowest in Pile Burns

F=42.5, p<0.01

Mean Plant Cover (%)

Mastication  Pile Burn  Untreated

a

b
Plant Richness Lowest and % Exotics Highest in Pile Burns

F=45.6, p<0.01

Mean Plant Richness

Mastication | Pile burn | Untreated

21% Exotics

13% Exotics

80% Exotics

Exotic species

Native species

a

b
Trends 2.5-years post treatment

- **Pile Burns**: Same trends – except no difference in AMF spore abundance

- **Mastication**:
  - Plant cover
  - Exotic plants (cheatgrass) \([\text{NH}_4^+]\)
  - Temp
  - AMF Richness
How do Soil, AMF and Plants Interact?
SEM: Soil-Plant-AMF relationship

Mastication

-0.06

AMF hyphae

R² = 0.39

% Plant Cover

R² = 0.51

Pile Burn

-0.40

-0.23

-0.59

Soil Stability

R² = 0.51

-0.21

-0.16

χ²: 1.369
P = 0.242
GFI: 0.954
SEM Results: Plant, Soil and AMF Relationship

Treatments

R² = 51%

50%

R² = 39%

36%

R² = 51%

31%
Pile Burning Creates Long-Lasting Disturbance

• Soil Erosion
  – Exposed mineral soil and low soil stability

• Nutrient leaching
  – High [available nutrients] & low plant cover and moisture

• Loss of Native species (both plants and AMF)
Mechanical Mastication

• **Short term**: Only difference - \(\uparrow\) soil moisture and \(\downarrow\) soil temp.

• **2.5 years later**: Main concern is loss of AMF species and more cheatgrass over time
  (combination of disturbance, neighboring seed source and high soil moisture?)
Ecological & Management Implications

Mastication creates fewer disturbances (in the short term); Long-term?

Pile burns – may reduce functionality

Treat in only high-priority areas and continue monitoring for exotic species
Thank you!

NAU
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