

# Effects of fire and post-fire seeding on understory vegetation in a ponderosa pine forest in northern Arizona



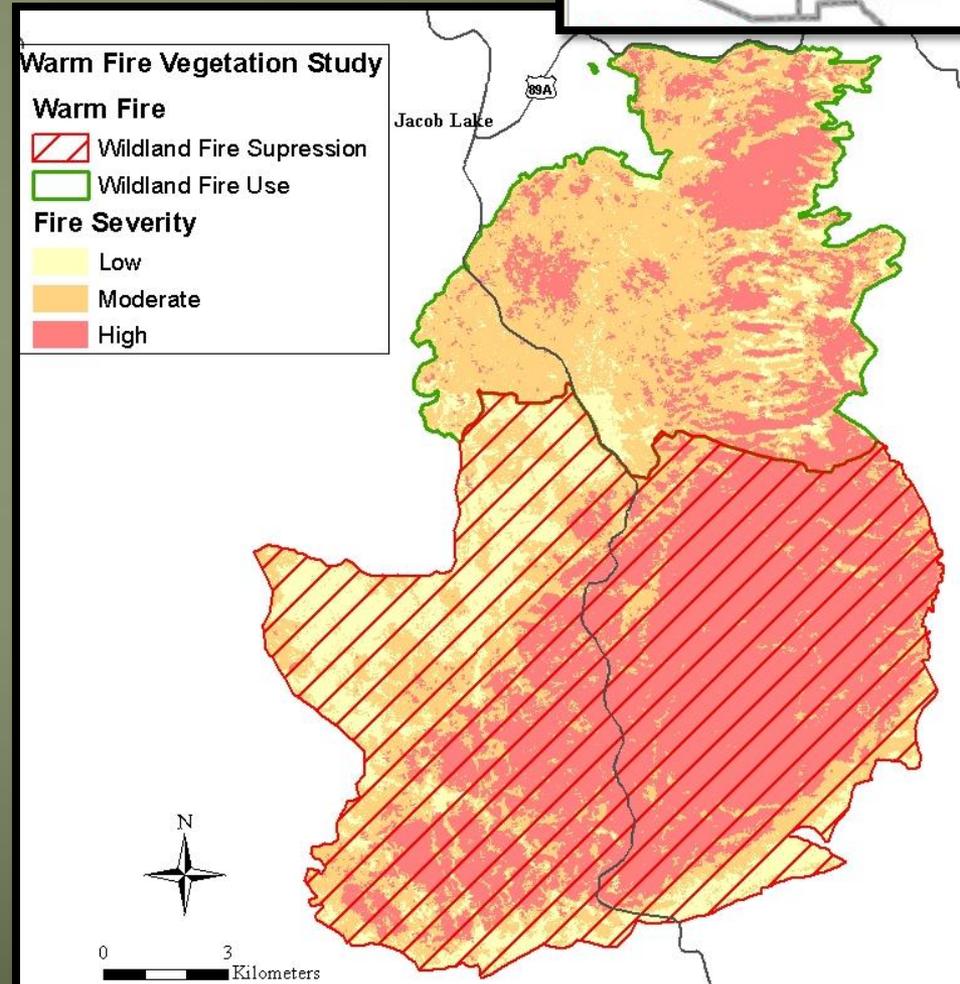
Melissa A. McMaster  
May 6, 2010



# Kaibab Plateau

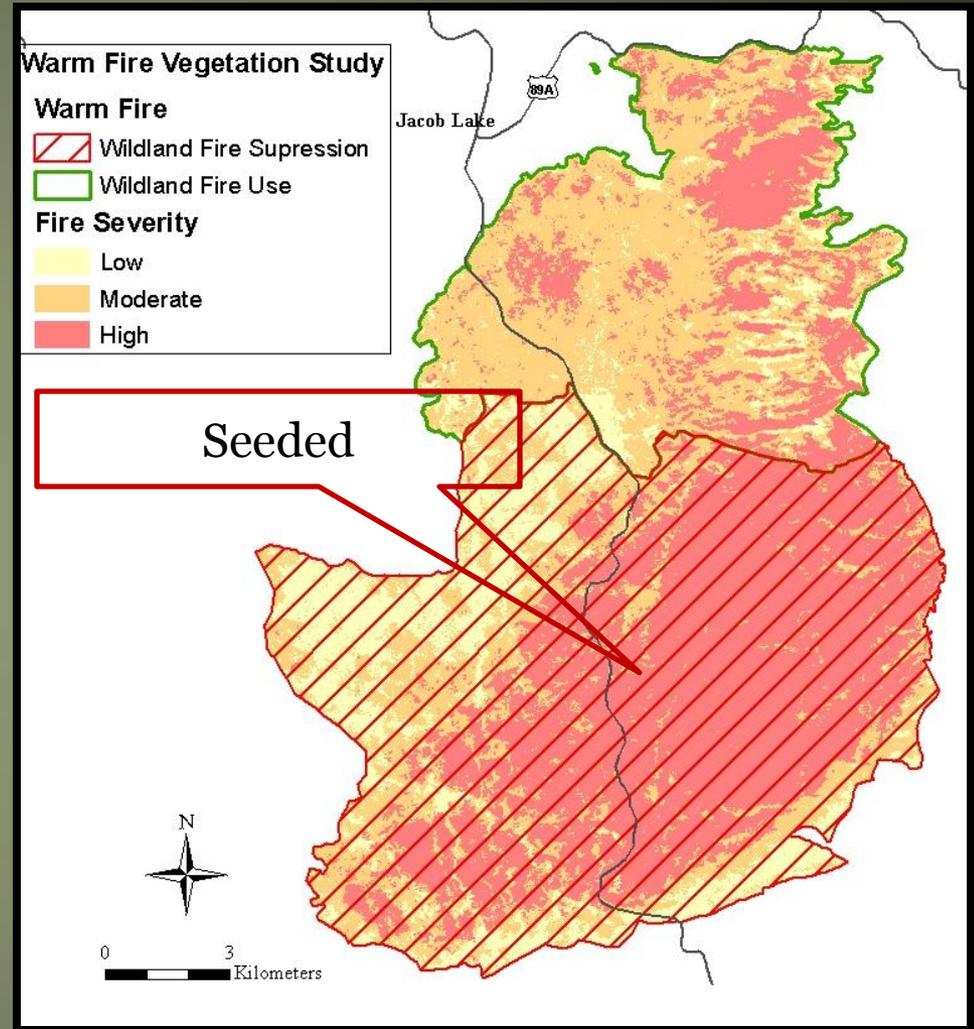
## Warm Fire- June 8, 2006

- Wildland Fire Use (13,000 ha)
- Wildland Fire (11,000 ha)
- Mixed severity
- Vegetation types
  - Pinyon-Juniper: 1,500 ha
  - Ponderosa: 18,000 ha
  - Mixed conifer: 4,000 ha
- Controversy
  - Fire management policies
  - 2x's the acreage
  - High severity crown fire
  - Loss of resources



# BAER treatment

- Wildfire section only
- High/moderate severity
- Goals
  - Decrease exotic invasion
    - *Bromus tectorum*  
cheatgrass
    - *Carduus nutans*  
Musk thistle
  - Soil erosion/stabilization
- Post-fire seeding
  - Ryegrass
    - Aerial seeding- 4800 ha
    - Monoculture of ryegrass
    - 3.92 kg/ha (3.5 lb/ac)
    - July - monsoons



# Ryegrass

*Lolium perenne ssp. multiflorum*



## Advantages

- Immediate ground cover-germinates quickly
- Exits the system in 2-3 years

## Disadvantages

- Readily hybridizes with perennial taxa
- Outcompetes native vegetation
  - Utilization of nitrogen and light
  - Allelopathic properties
  - Disrupt root establishment
- Decreases native cover, richness and diversity

- Study #1: Effects and effectiveness of post-fire seeding



- Study #2: Effects of low and high severity fire on understory vegetation

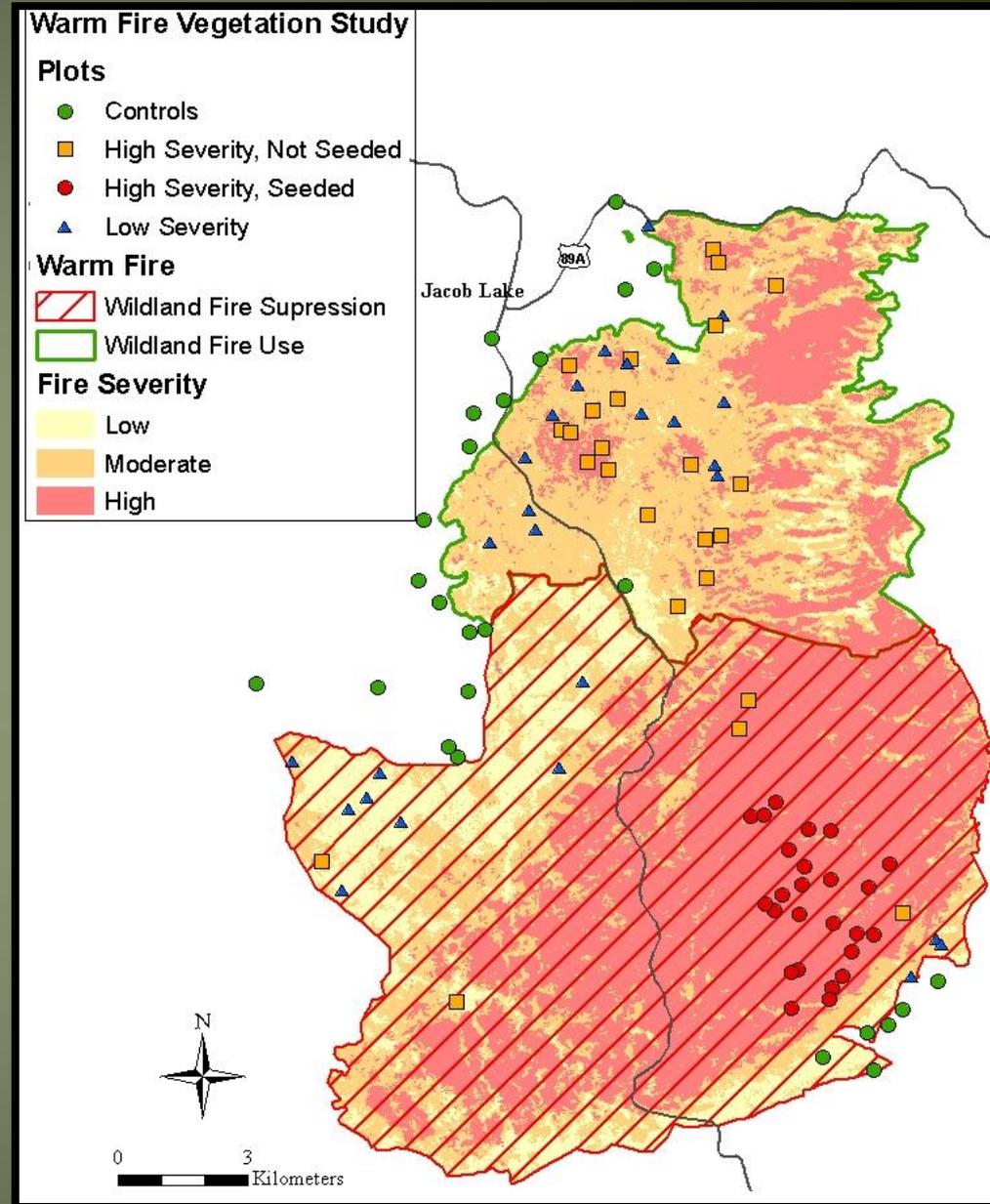


# Methods



# Plot stratification

- Ponderosa pine dominated forest
- Low and high fire severity
- 2300-2590 m elevation
- Mollic Eutroboralf soils- derived from Kaibab Limestone parent material
- Slope <math>< 28^\circ</math>
- Treatment



# Treatments

- Treatment
  - Seeded vs. Non-seeded
  - Unburned vs. Low vs. High
- Total plots n=94
  - Unburned 25
  - Low 25
  - High severity
    - non-seeded 22
  - High severity
    - seeded 22

## Warm Fire Vegetation Study

### Plots

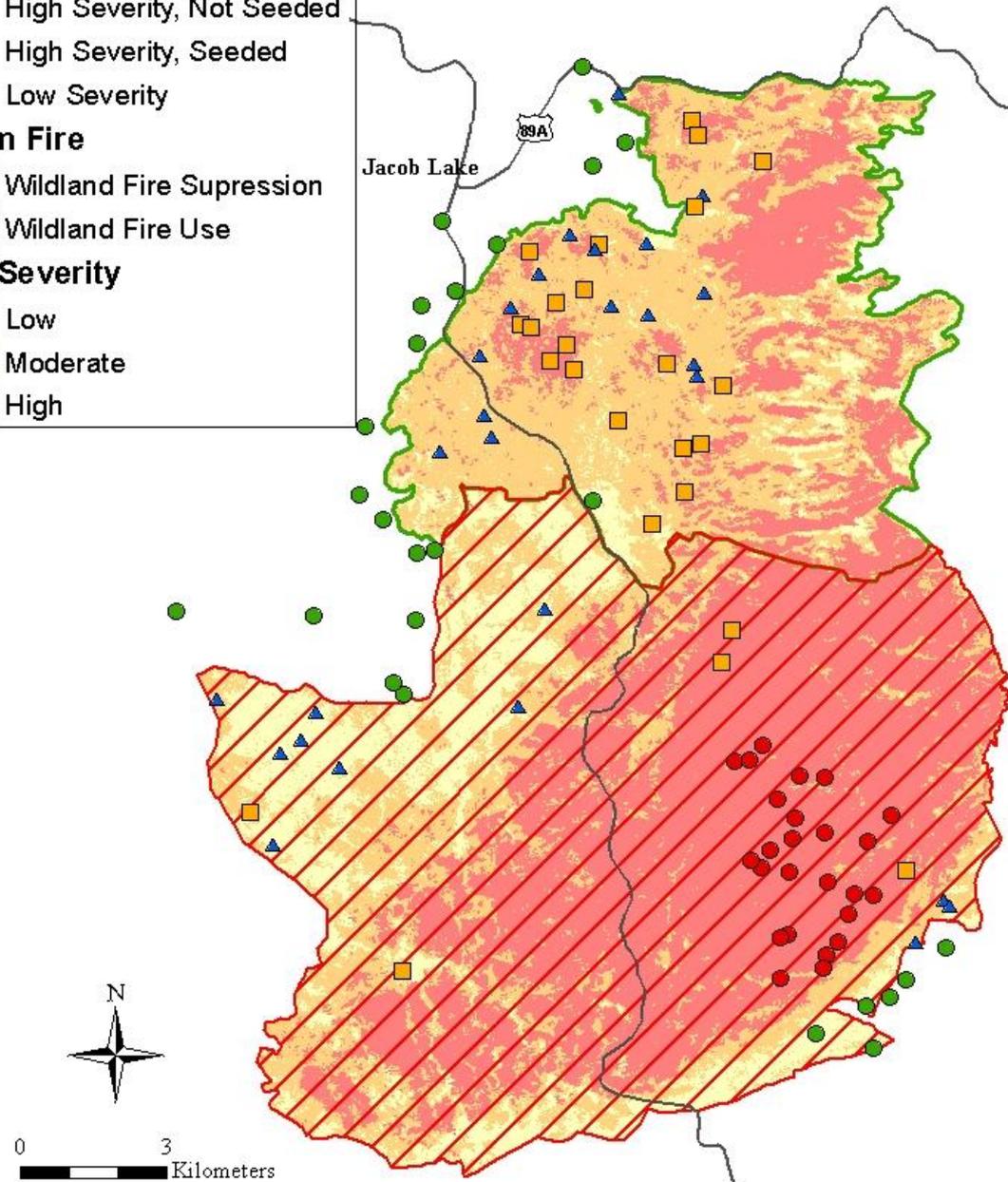
- Controls
- High Severity, Not Seeded
- High Severity, Seeded
- ▲ Low Severity

### Warm Fire

- ▨ Wildland Fire Suppression
- ▭ Wildland Fire Use

### Fire Severity

- Low
- Moderate
- High



# Sampling methods

July & August, 2007-2009

7.32 m radius

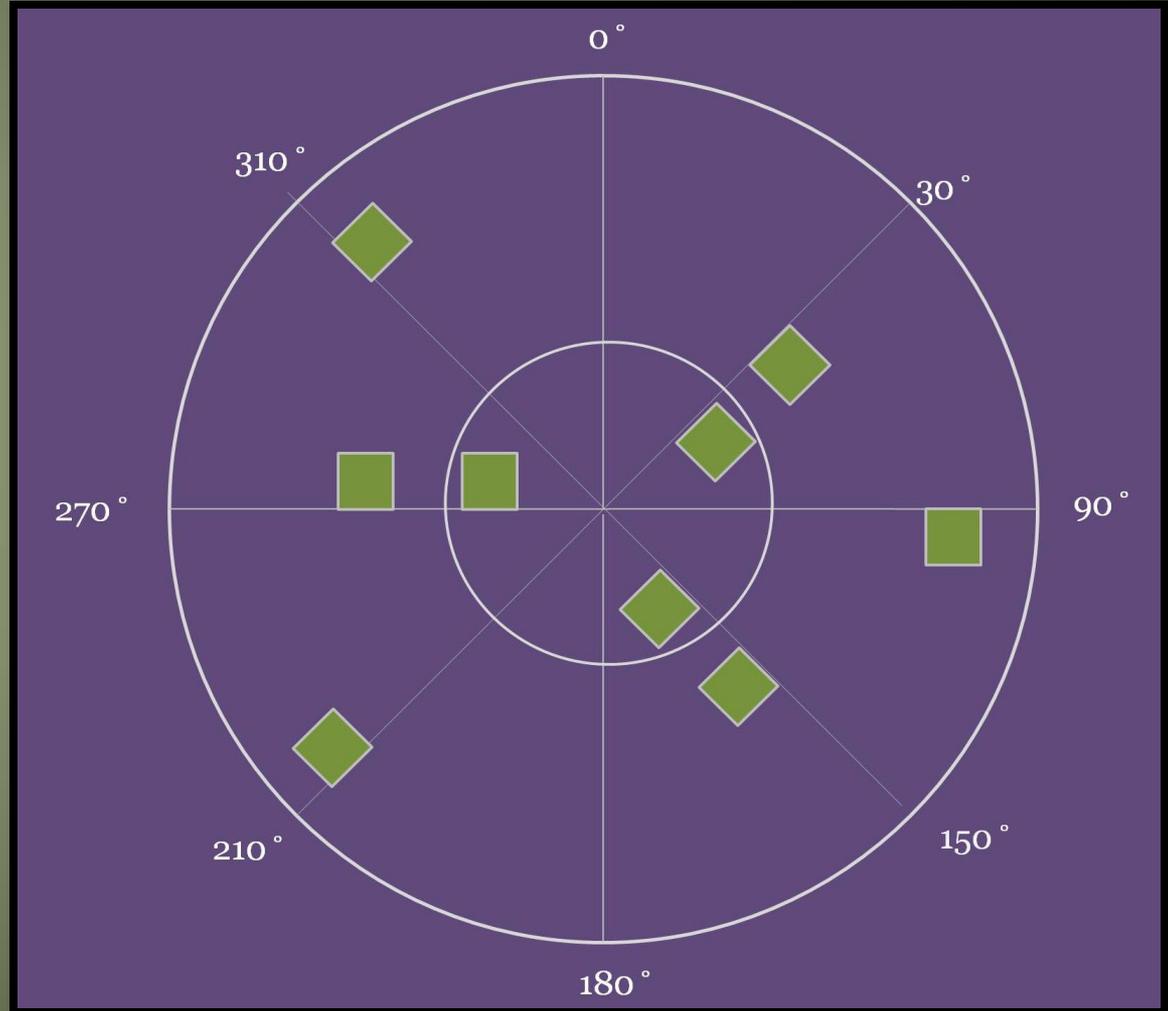
168 m<sup>2</sup>

9 1x1 m frames

Foliar plant cover

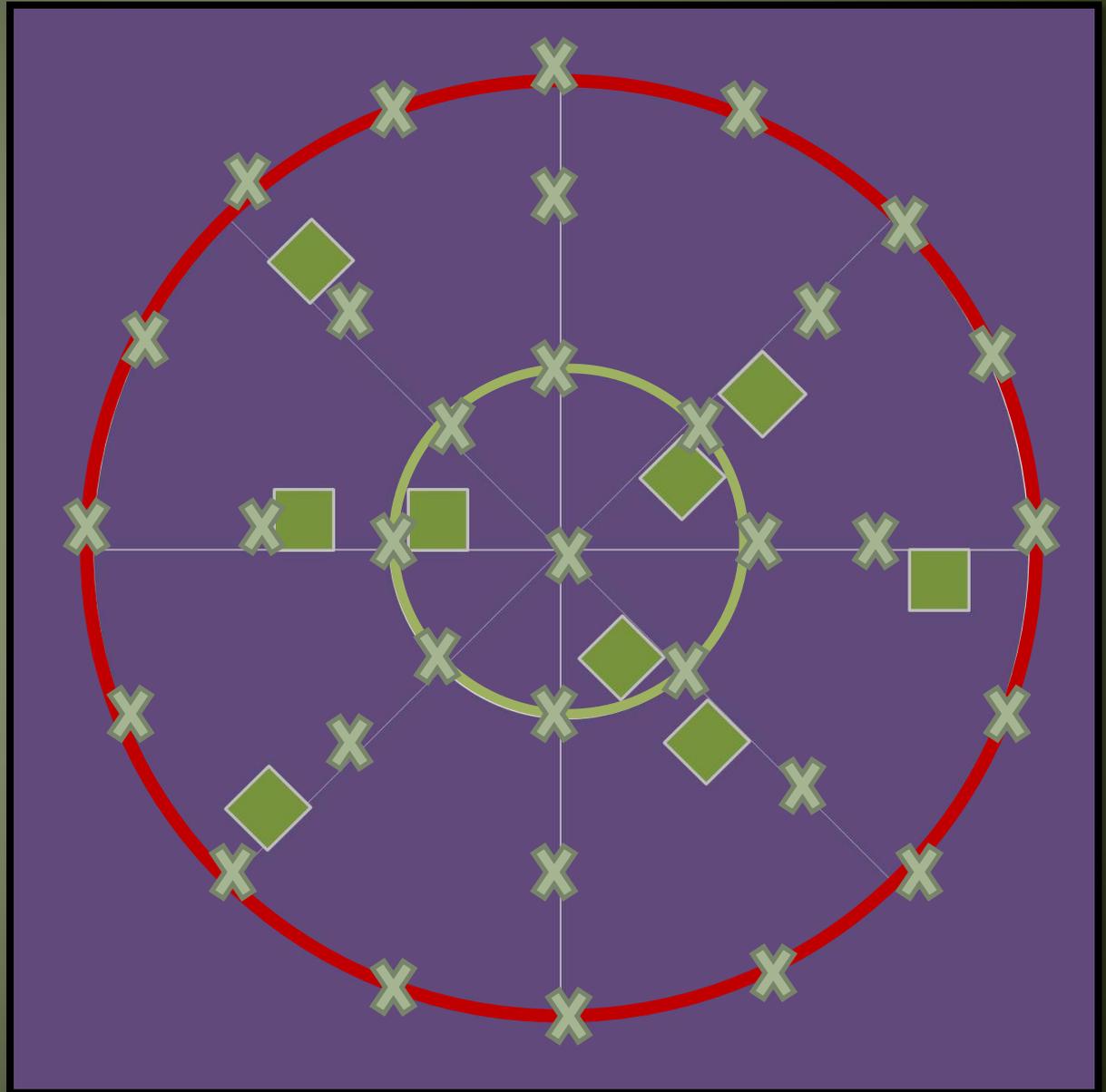
- Species
- Total cover
- Graminoids
- Forbs

Ground cover



# Sampling methods

- Species richness & Shrubs > 20 cm
- Tree seedling search
- × Overstory canopy cover



# Statistical analyses

## PERMANOVA

- community composition
- foliar cover
- functional groups
- substrate cover
- rate of change
- $p < 0.05$

## Indicator species analysis

- $p < 0.05$  IV > 30

## Non-metric multidimensional scaling

### NMDS ordinations

# Study #1: Effects and effectiveness of post-fire seeding



# Warm Fire Vegetation Study

## Plots

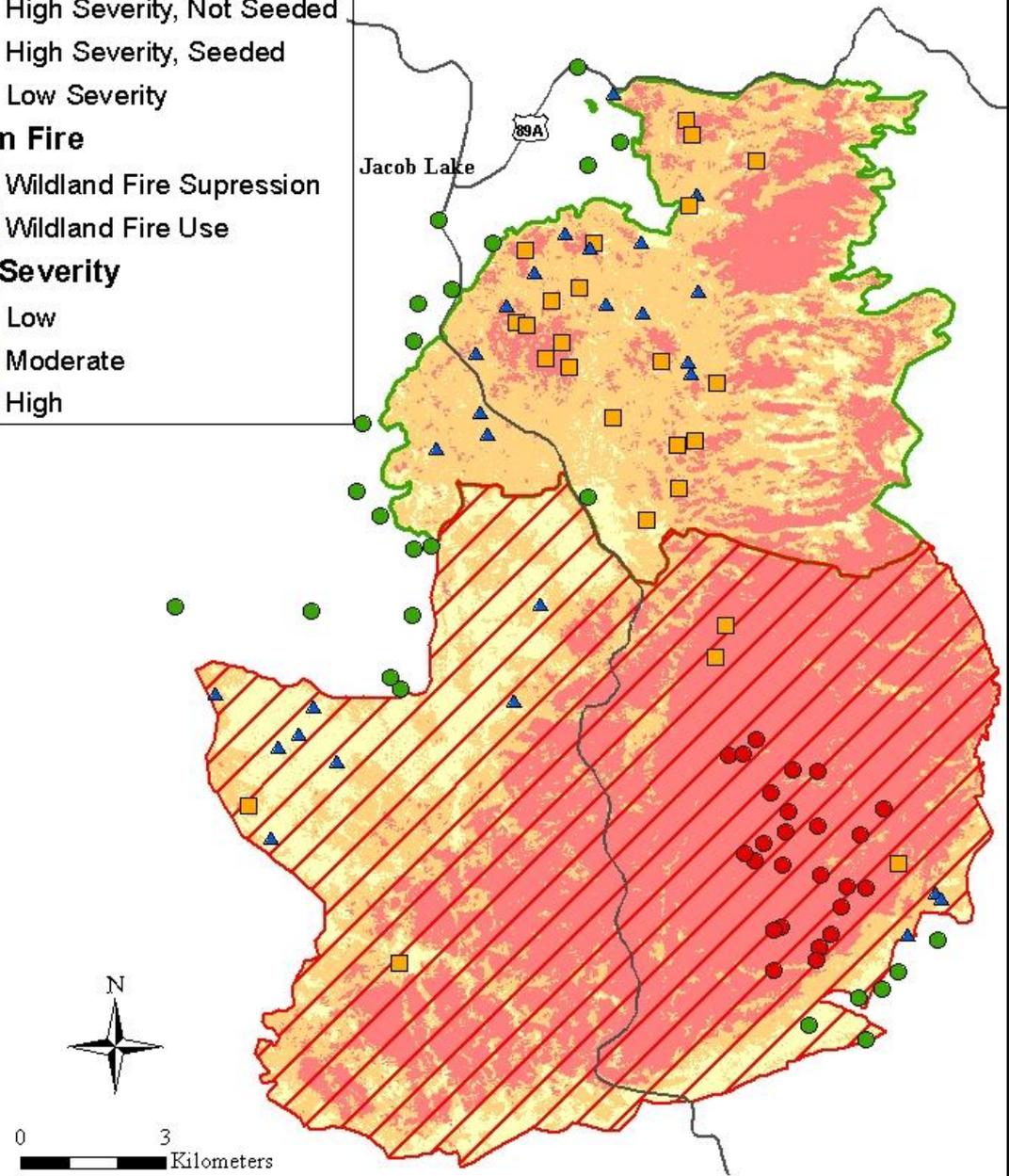
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# Study #1 Effects and effectiveness of post-fire seeding

**H1:** Post-fire seeding provides an immediate increase in vegetation cover and decrease in bare soil to prevent erosion

**H2:** Post-fire seeding with ryegrass will decrease the spread and invasion of other more undesirable exotic species

**H3:** The presence of ryegrass in the system will alter the plant community composition

# RESULTS

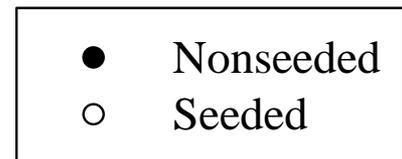
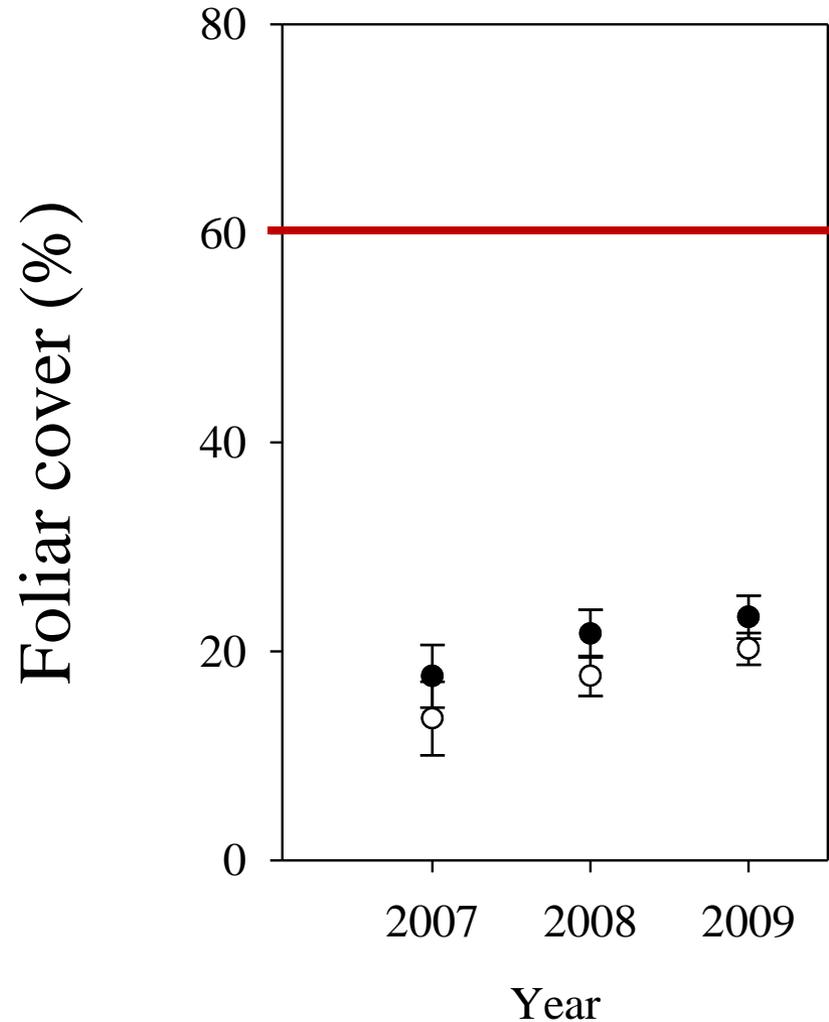


# Total plant cover

60% ground cover to decrease erosion potential

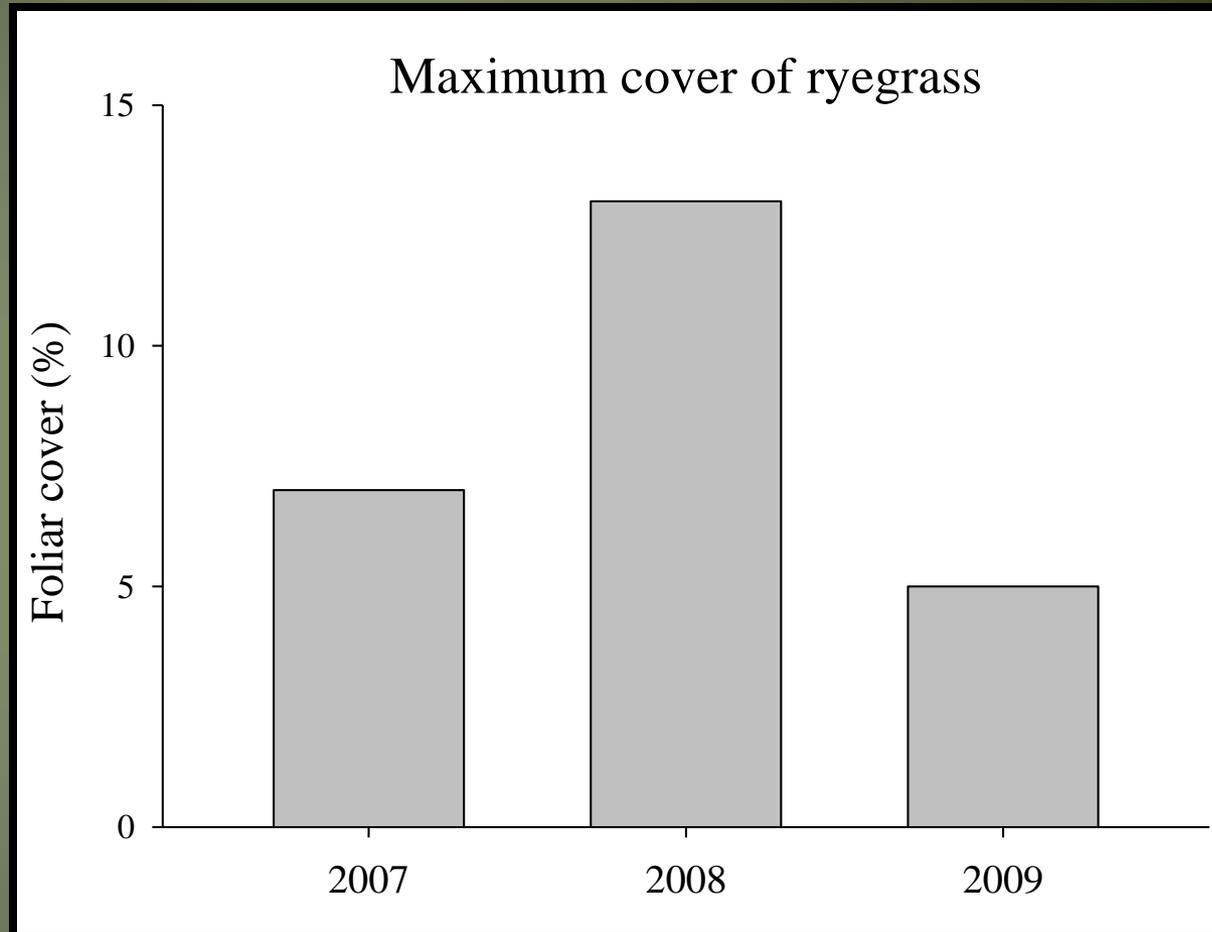
Neither seeded or non-seeded plots had 60% cover

No significant difference in total plant cover in any year



# Cover of ryegrass

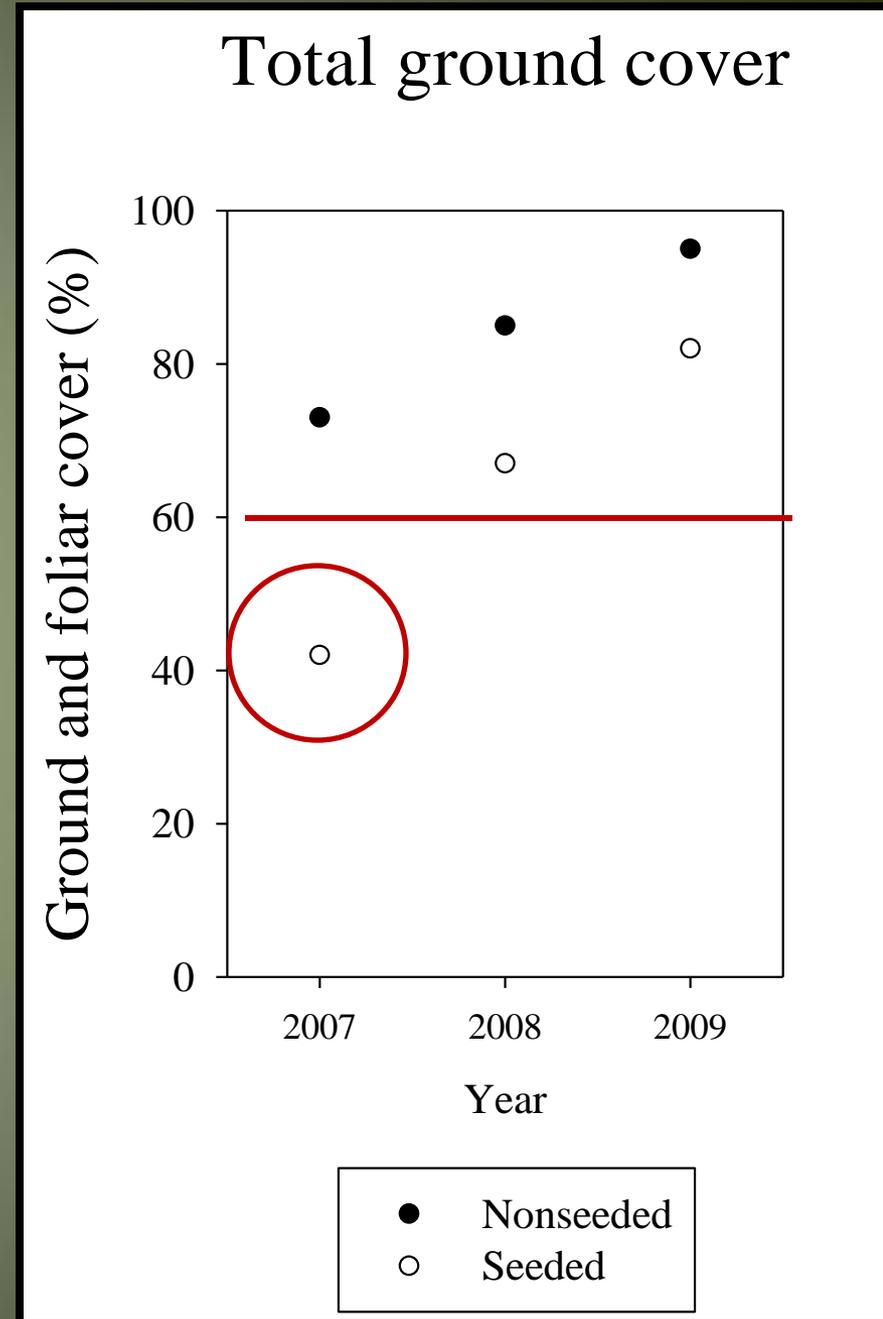
- 2007  
0.05% – 7%  
Avg. 1.9%
- 2008  
0.05% – 13%  
Avg. 1.3%
- 2009  
0.05% – 5%  
Avg. 0.06%



Initial cover of ryegrass was not adequate to prevent erosion

# Total ground cover

- Including: litter, duff, wood, rock and live vegetation
- Significantly lower in 2007 in Seeded plots



# Exotic cover (excluding ryegrass)

No significant difference in cover of exotics between seeded and non-seeded

$$p = 0.3226$$

- Avg. 2% cover of exotics
- 21 species of exotics

## Cheatgrass

2008: 43% of plots

2009: 50% of plots

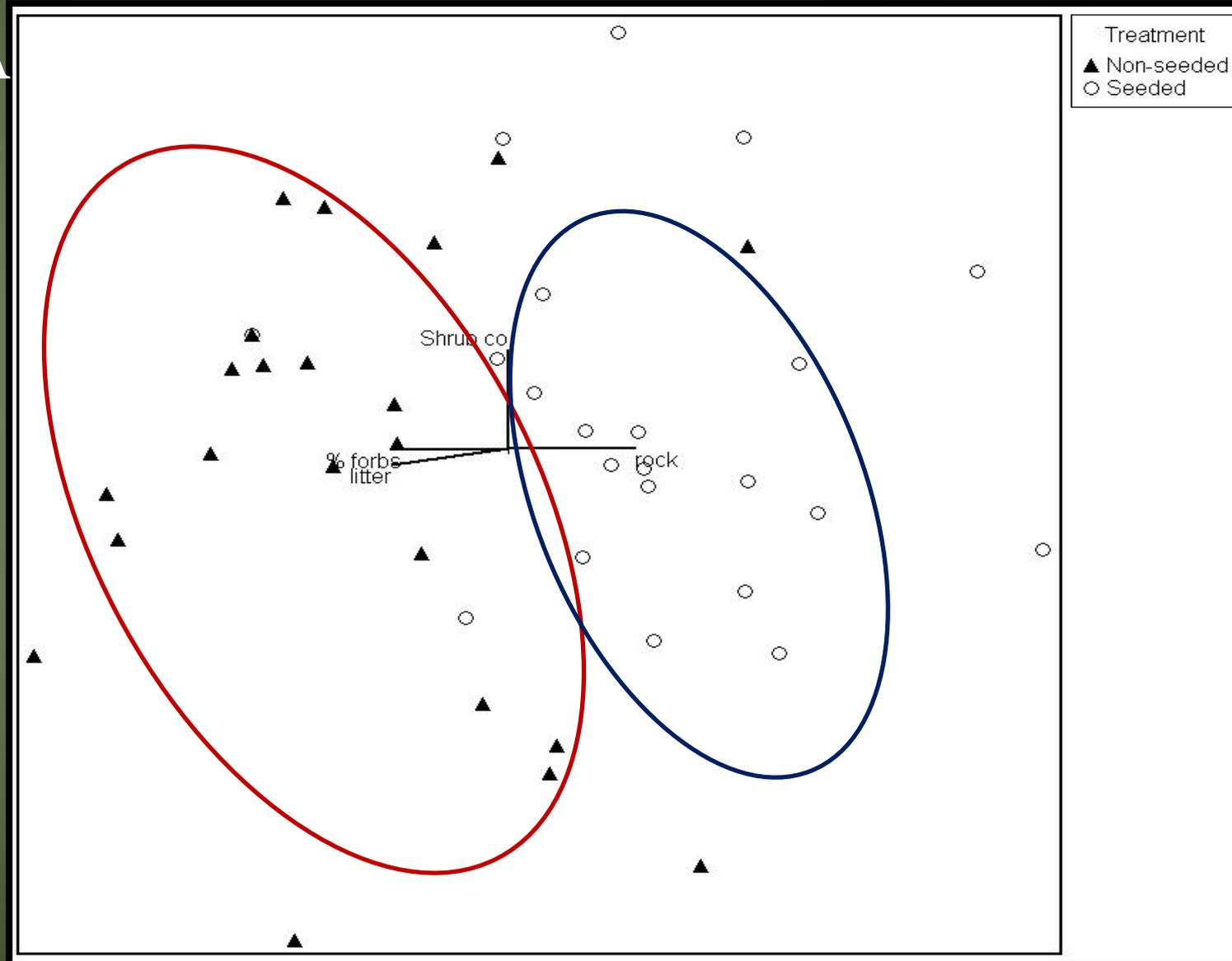
## Musk Thistle



# Community composition 2009

PERMANOVA

$p = 0.0002$



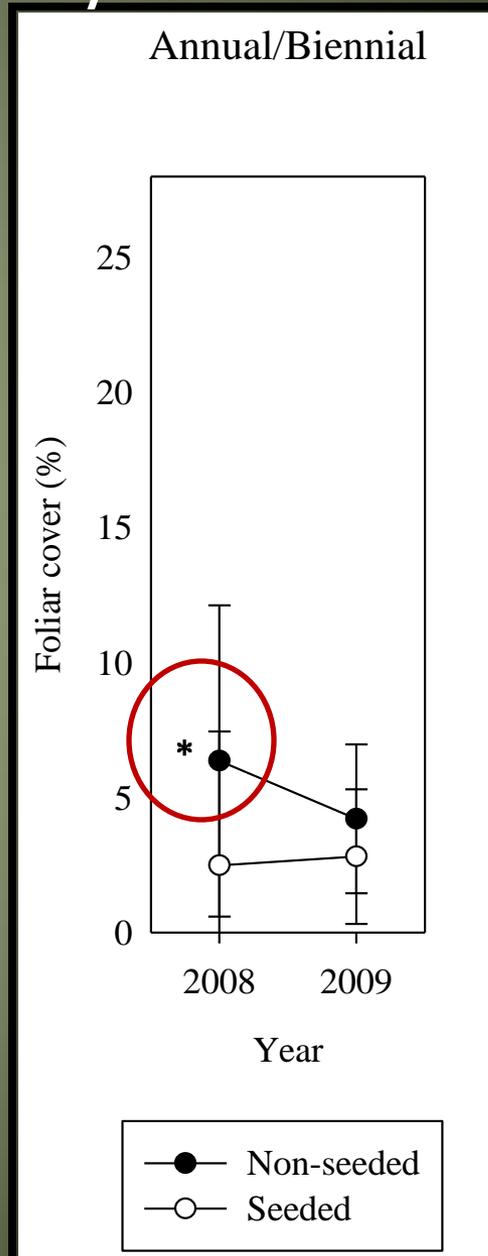
# Indicator Species Analysis

Treatment	Species	IV 2008	IV 2009	Life history	Life form
Non-seeded	<i>Antennaria parvifolia</i>	45.4	66.1	P	F
	<i>Androsace septentrionalis</i>	41.4	-	A	F
	<i>Arenaria lanuginosa ssp. saxosa</i>	40.8	48.5	P	F
	<i>Bromus tectorum*</i>	56.9	61.4	A	G
	<i>Chenopodium fremontii</i>	79.1	67.6	A	F
	<i>Elymus elymoides</i>	-	76.5	P	G
	<i>Hieracium fendleri</i>	33.7	38.9	B	F
	<i>Lupinus argenteus</i>	-	57.0	P	F
	<i>Muhlenbergia montana</i>	-	31.8	P	G
	<i>Packera multiobata</i>	63.8	71.7	A/P	F
	<i>Poa fendleriana</i>	-	66.8	P	G
	<i>Pinus ponderosa</i>	56.0	53.5	P	T
	<i>Populus tremuloides</i>	52.6	72.0	P	T
	<i>Pseudognaphalium macounii</i>	59.9	-	B	F
	<i>Taraxacum officinale*</i>	61.6	70.9	A/B	F
	<i>Verbascum thapsus*</i>	36.4	40.9	B	F
Seeded	<i>Astragalus amphioxys</i>	61.3	-	P	F
	<i>Conyza canadensis</i>	-	58.7	A	F
	<i>Erigeron divergens</i>	-	86.0	B	F
	<i>Hymenopappus filifolius</i>	-	39.9	P	F
	<i>Lolium perenne ssp. multiflorum*</i>	98.5	99.5	A/B/P	G
	<i>Lotus wrightii</i>	75.0	58.0	P	F
	<i>Robinia neomexicana</i>	57.0	59.1	P	S
<i>Tragopogon dubius*</i>	-	46.9	A/B	F	

\* = exotic; P= Perennial, A= Annual, B= Biennial, G= Grass, F= Forb, S= Shrub, T= Tree

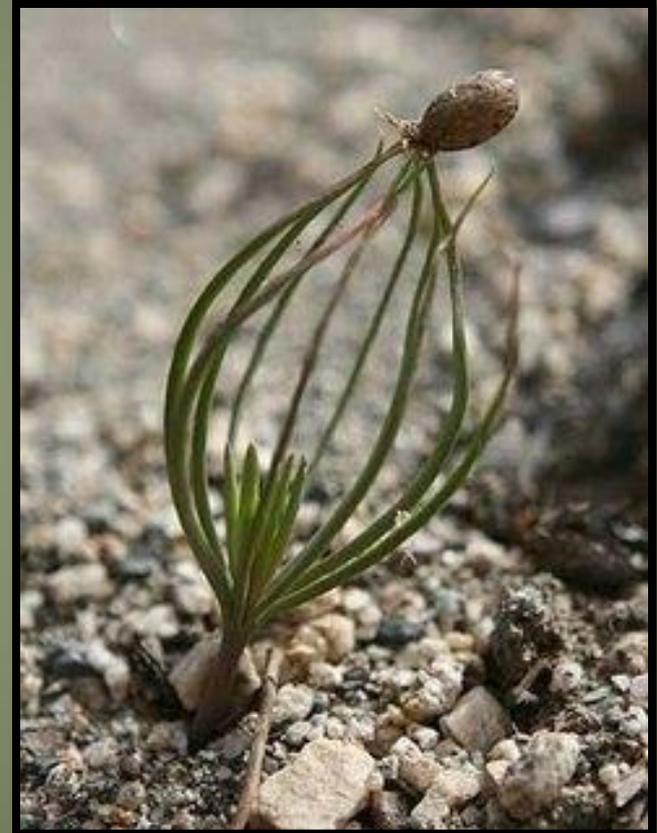
# Life History: annuals/biennials and perennials

- Significantly more annual and biennial cover in non-seeded sites in 2008



# Ponderosa pine seedlings

- 14 non-seeded plots
- 5 seeded plots
- No significant difference
- But, indicator species for non-seeded?
- Previous research: seeding inhibits ponderosa pine regeneration



# Conclusions

**H1:** Post-fire seeding provides an immediate increase in vegetation cover and decrease in bare soil to prevent erosion



**H2:** Post-fire seeding with ryegrass will decrease the spread and invasion of other more undesirable exotic species



- Cheatgrass

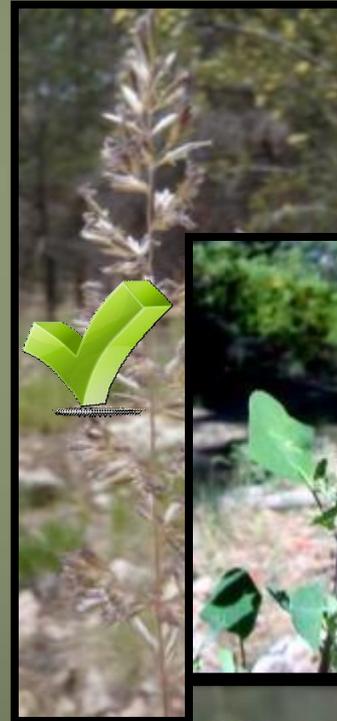
# Conclusions

**H3:** Seeding will alter the plant community composition



Results suggest:

- Bunchgrasses 
- Annual/biennial forbs 



# Study #2: Low and high severity fire effects on understory vegetation



# Warm Fire Vegetation Study

## Plots

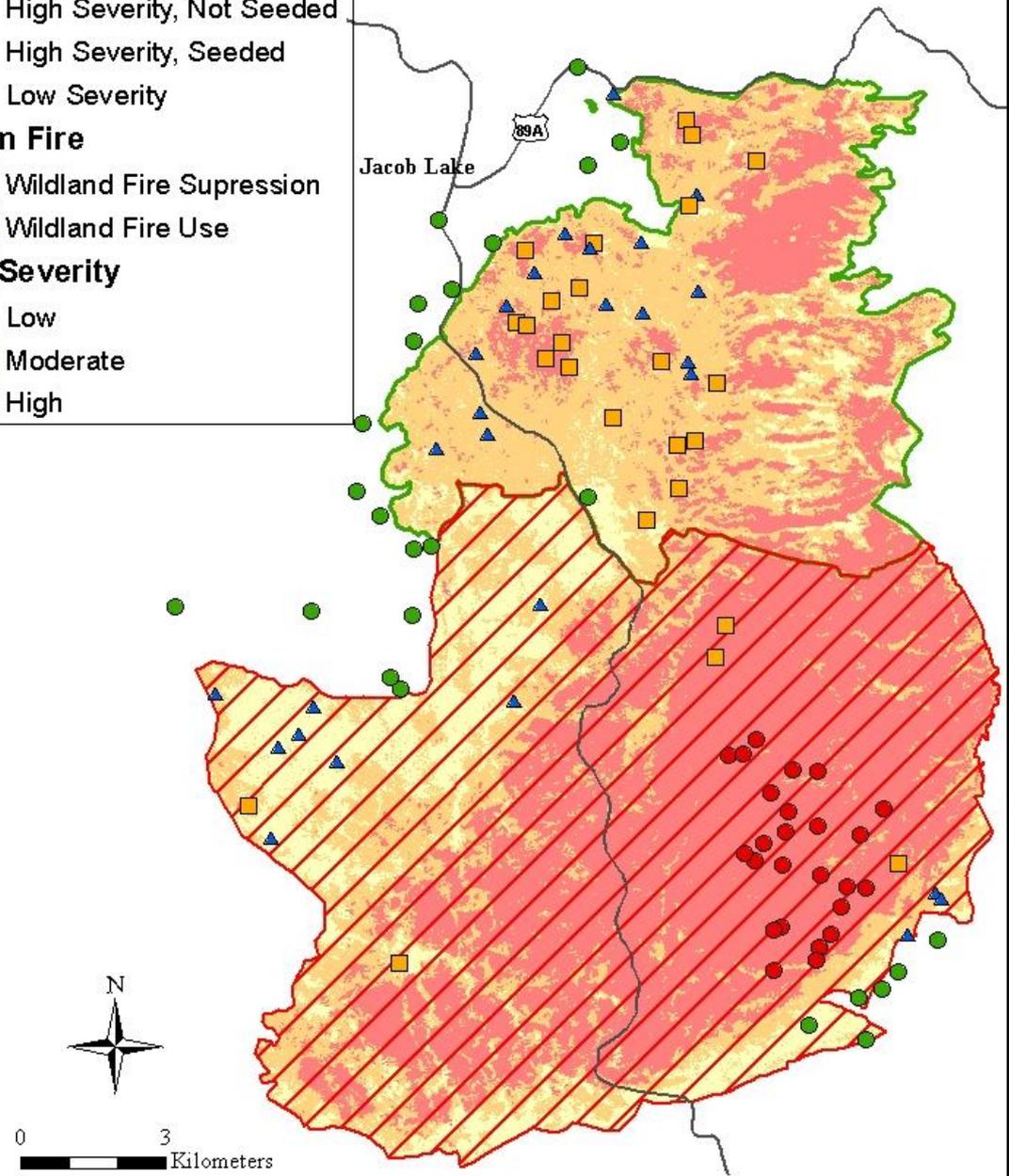
- Controls
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## Warm Fire

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# Study #2: Low and high severity fire effects on understory vegetation

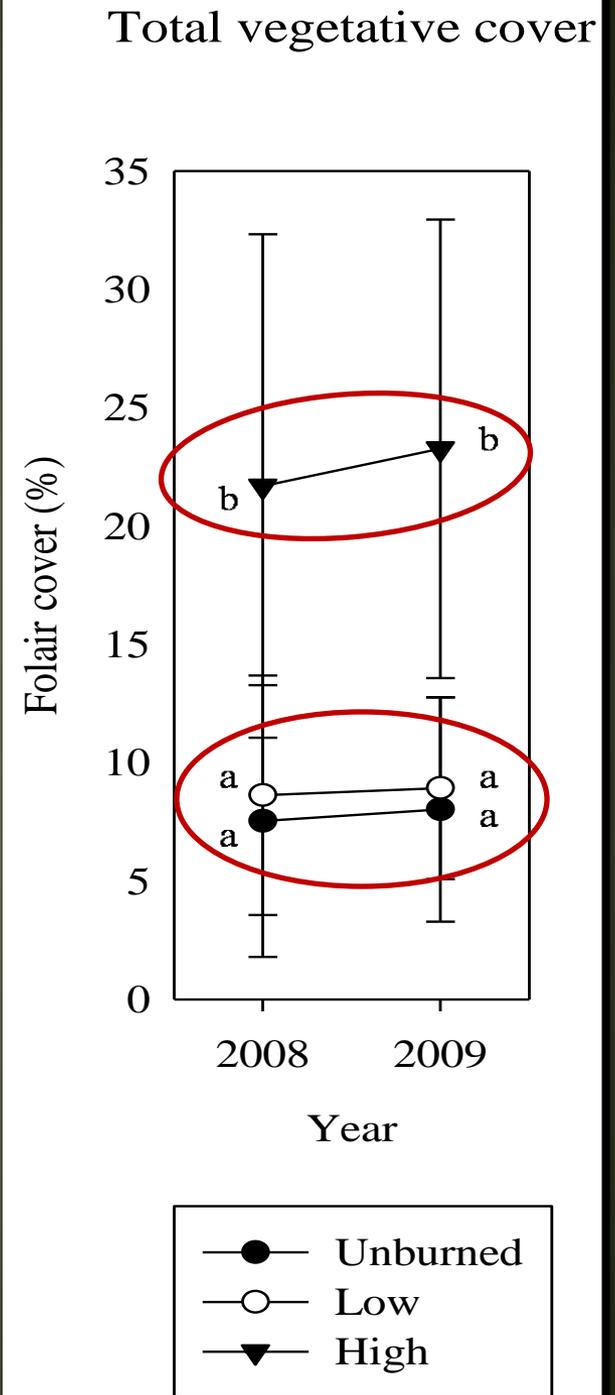
- H1:** Fire severity will determine magnitude of understory herbaceous and shrub response (increased cover)
- H2:** Exotic species cover and presence will be higher in burned areas
- H3:** Burned areas will have different floristic composition and higher species richness than unburned areas

# RESULTS

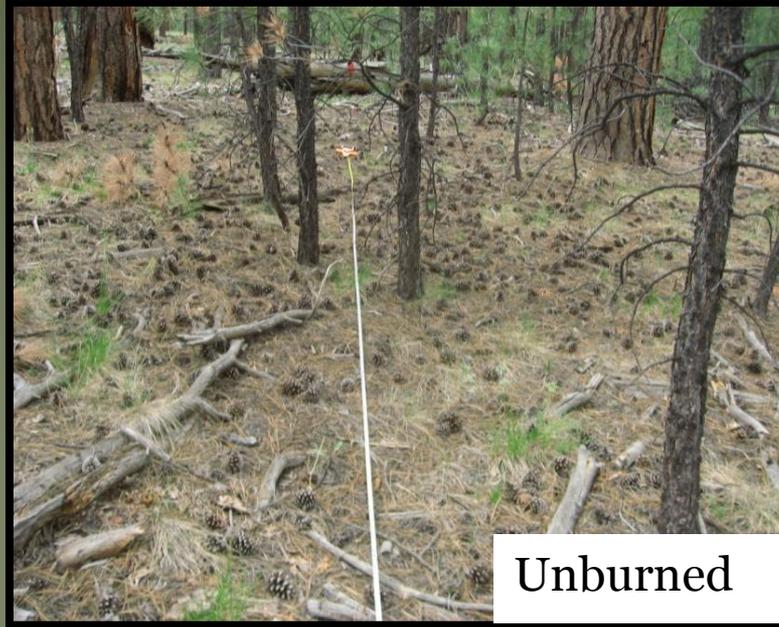


# Total vegetative cover

- Unburned and low severity had significantly less cover than high severity in both years



# Vegetation and substrate cover



Unburned



Low



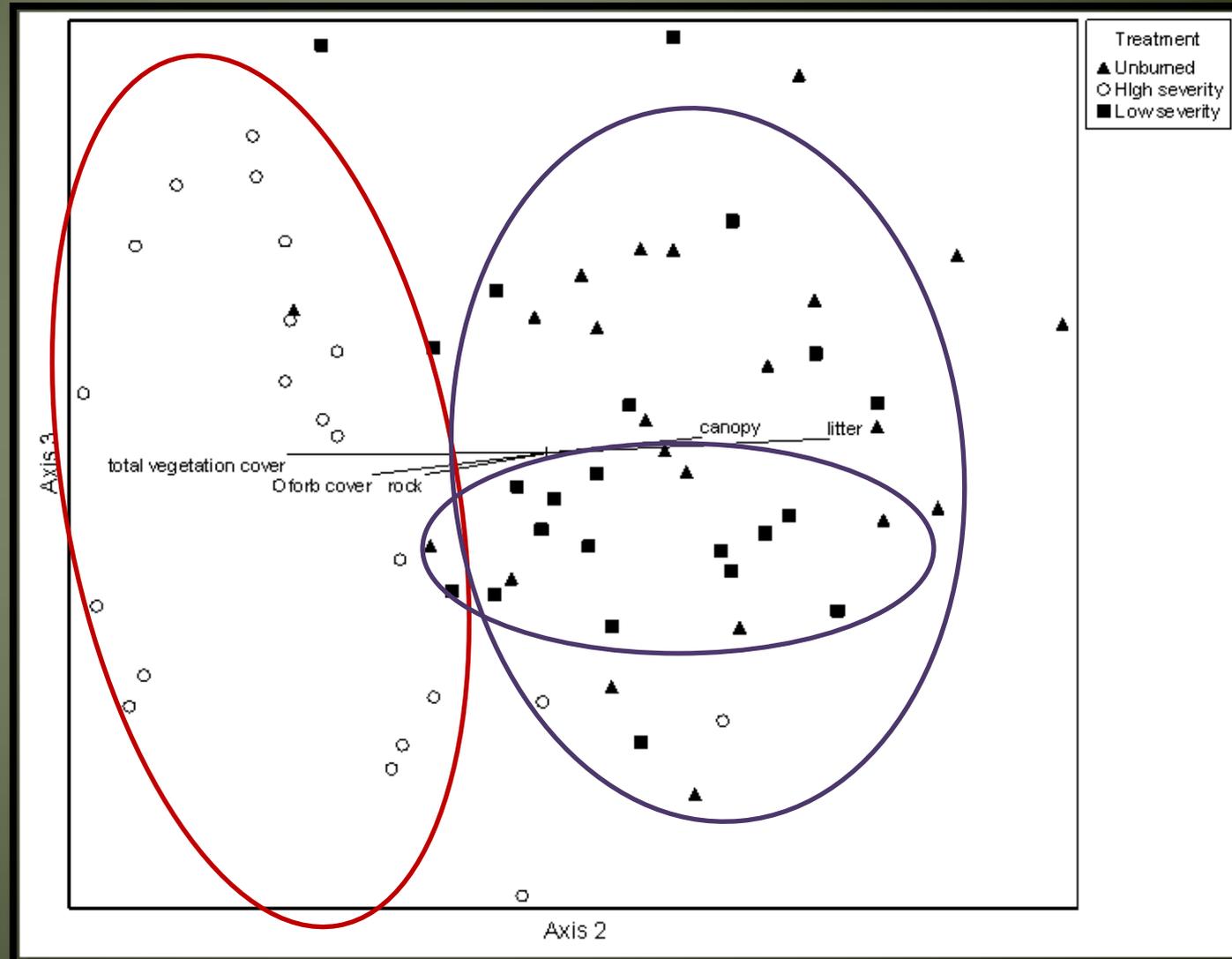
High

# Community composition 2009

## PERMANOVA

- U vs. L  
 $p=0.0252$
- U vs. H  
 $p=0.0002$
- L vs. H  
 $p=0.0002$

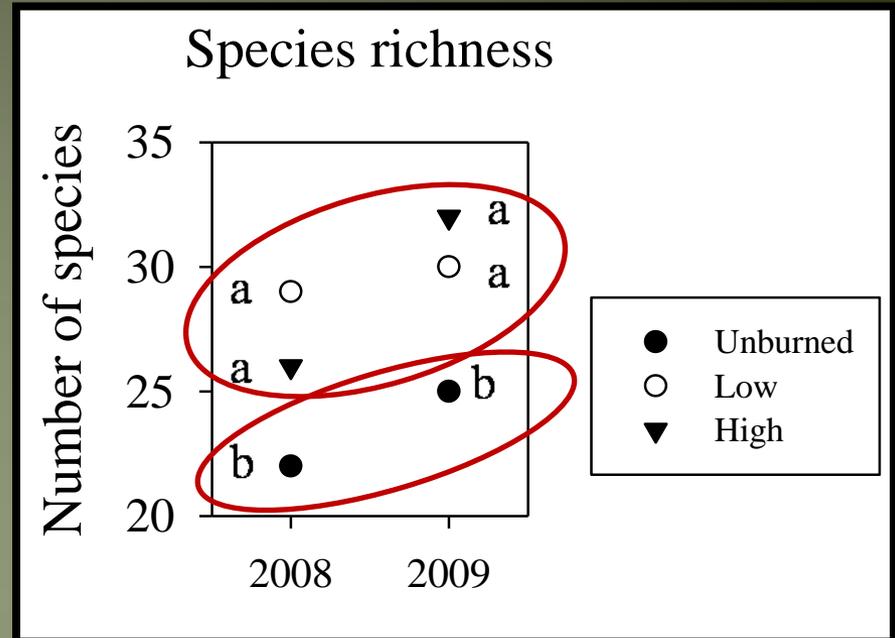
Community  
composition  
significantly  
different



Indicator species analysis				
Severity	Species	IV 2009	Life History	Life Form
Unburned	<i>Antennaria parvifolia</i>	-	P	F
	<i>Pinus ponderosa</i>	56.4	P	T
	<i>Potentilla hippiana</i>	54.6	P	F
Low	<i>Koeleria macrantha</i>	44.3	P	G
	<i>Penstemon barbatus</i>	48.6	P	F
High	<i>Agoseris glauca</i>	33.9	B	F
	<i>Androsace septentrionalis</i>	-	A	F
	<i>Arenaria lanuginosa ssp. saxosa</i>	44.9	P	F
	<i>Bromus tectorum*</i>	59.2	A	G
	<i>Chenopodium atrovirens</i>	36.4	A	F
	<i>Chenopodium fremontii</i>	72.3	A	F
	<i>Cirsium wheeleri</i>	65.6	A/B	F
	<i>Conyza canadensis</i>	45.4	A	F
	<i>Epilobium brachycarpum</i>	50.2	A	F
	<i>Erigeron divergens</i>	69.9	B	F
	<i>Erigeron flagellaris</i>	44.4	P	F
	<i>Eriogonum racemosum</i>	47.1	P	F
	<i>Gayophytum diffusum</i>	71.4	A	F
	<i>Heliomeris multiflora</i>	35.9	B	F
	<i>Lactuca serriola*</i>	81.0	A	F
	<i>Lupinus argenteus</i>	45.2	P	F
	<i>Packera multilobata</i>	63.1	B	F
	<i>Polygonum douglasii</i>	64.2	A	F
	<i>Poa fendleriana</i>	48.8	P	G
	<i>Pseudognaphalium macounii</i>	67.1	A/B	F
<i>Taraxacum officinale*</i>	71.3	A	F	
<i>Tragopogon dubius*</i>	40.6	B	F	
<i>Verbascum thapsus*</i>	40.9	B	F	

\* = exotic; F= Perennial, A= Annual, B= Biennial, G= Grass, r= forb, S= Shrub, T= Tree.

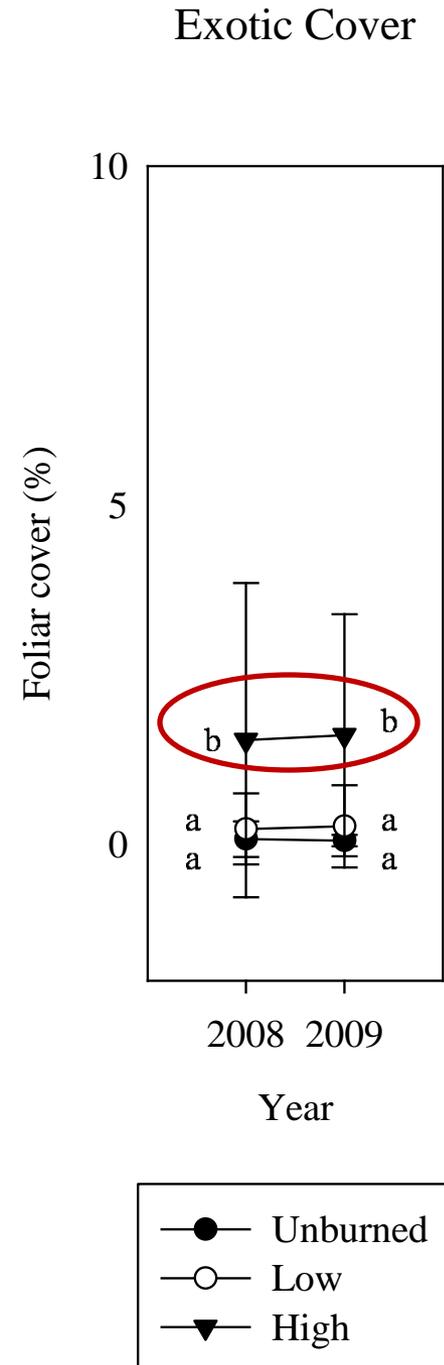
# Species richness



# Exotic cover



- Significantly greater cover in high severity plots



# Conclusions

**H1:** Fire severity will determine magnitude of understory herbaceous and shrub response



- Fire is an essential disturbance to maintain understory cover and richness
- Lack of response in low severity

**H2:** Exotic species cover will be higher in burned areas



# Conclusions

**H3:** Burned plots when compared to unburned plots will differ in:

1. Floristic composition
2. Higher species richness



*Cirsium wheeleri*



*Chenopodium fremontii*



*Androsace septentrionalis*



*Erigeron divergens*



*Epilobium brachycarpum*



*Lupinus argenteus*



*Penstemon barbatus*

# Overall conclusions

- Seeding did not provide adequate vegetative cover and results suggest it may inhibit bunchgrasses and annuals/biennials
- Fire is essential in ponderosa pine forests for maintaining understory species richness and diversity, especially annuals and biennials.
- Disturbances alter the plant community composition but will it lead ultimately to different trajectories?

# Recommendations

- Continue monitoring plots
- Before seeding conduct a thorough assessment
  - Evaluate potential impacts
  - Mitigate risk to the ecosystem
- Incorporate results from other studies on the Warm Fire for full picture and possible trends
  - Seeding with natives and non-natives (Stella 2009)
  - Grazing impacts on native regeneration and non-native invasion (Mork 2010)

# Acknowledgements

## Committee Members

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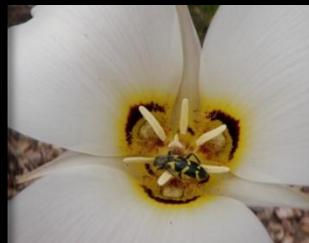
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Andrew Frost	Steve Till
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Laura Williams	Nate Cordova

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Questions?

