Belowground perspectives in southern California grassland restoration

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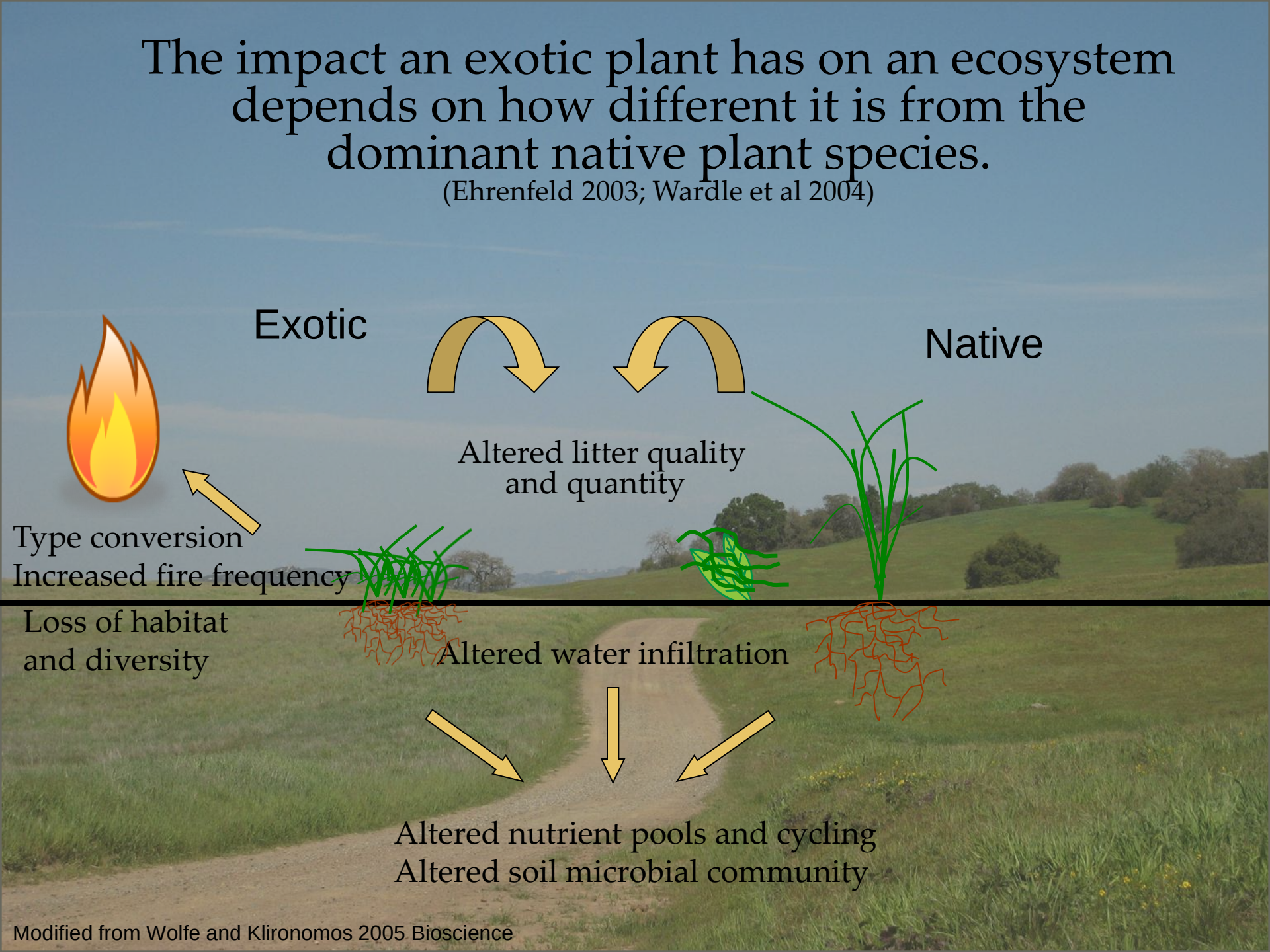
The impact an exotic plant has on an ecosystem depends on how different it is from the dominant native plant species.

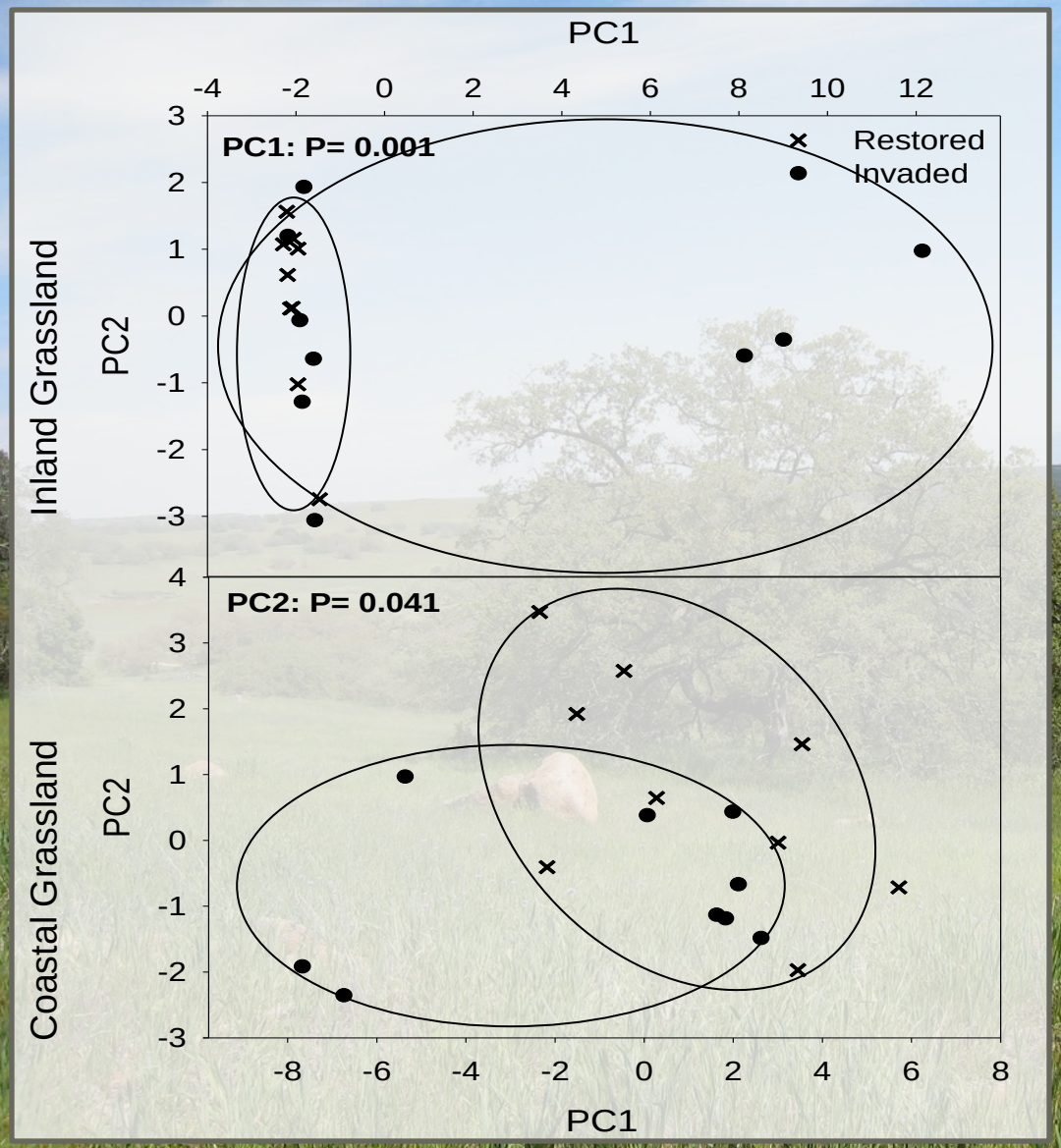
(Ehrenfeld 2003; Wardle et al 2004)



Modified from Wolfe and Klironomos 2005 Bioscience

Objectives

- Determine changes in soil ecology (mycorrhizae, nutrients, soil seedbank) caused by invasive species, and ability to restore soil biological and chemical characteristics
- Restore grasslands and forblands historically grazed and farmed, currently with high exotic grass cover
- Test various techniques: mulch, herbicide, grazing, dethatching, mowing, solarization, fire



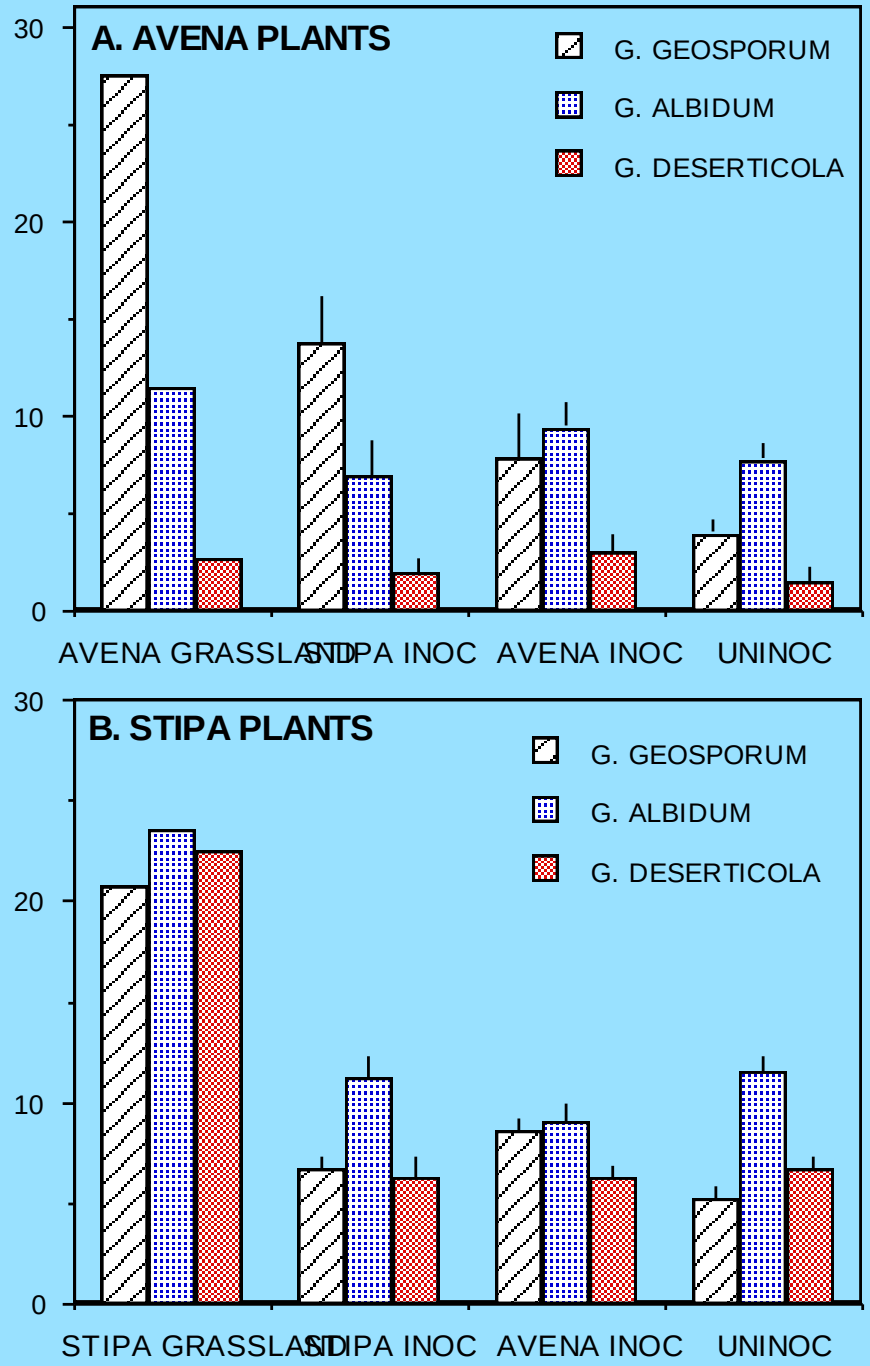
Microbial community composition was altered by invasion.

F:B ratio was altered by invasion , but the direction depended on season.

Mycorrhizal inoculation experiment

Avena roots have dominant *Glomus geosporum* spores, *Stipa* roots have equal abundance of three species. Five months after inoculation, both grass species recovered their mycorrhizal species composition, showing rapid response by the fungi.
(Nelson & Allen 1993)

Glomus deserticola

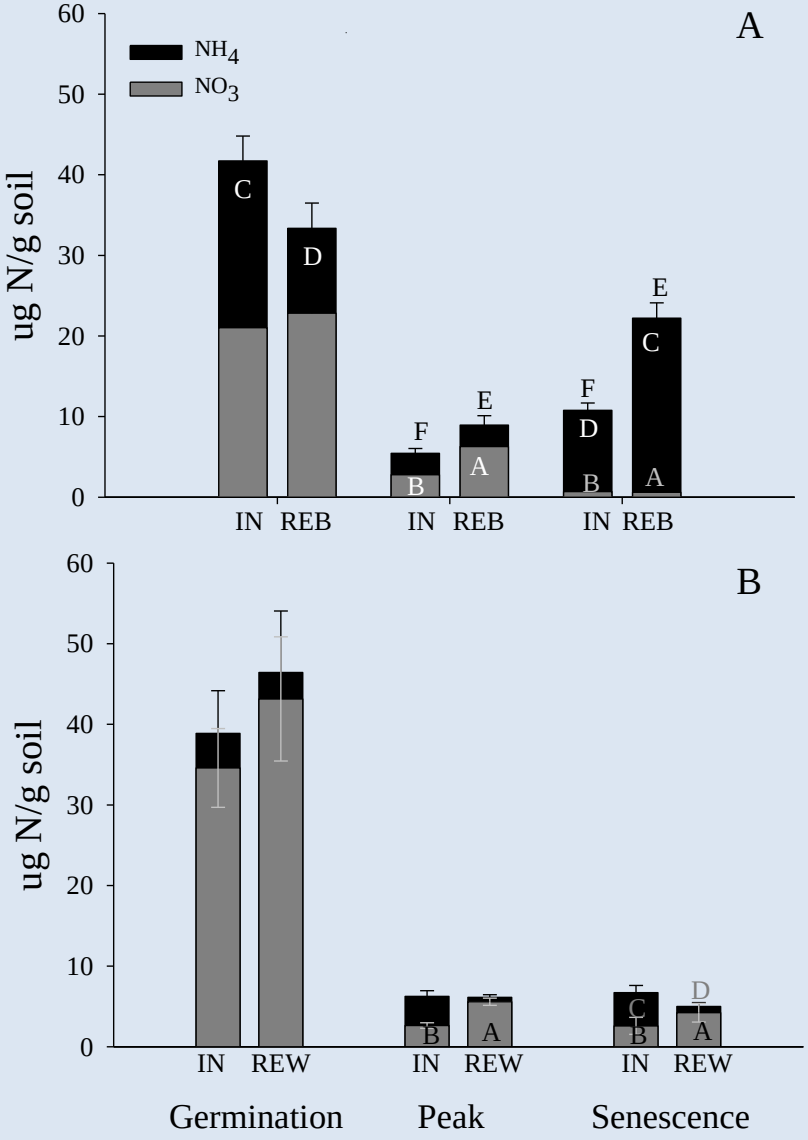


Establishing *Stipa* requires control of *Avena*, even with mycorrhizal inoculum

Avena dominates in mixture, Stipa dies

Stipa monoculture

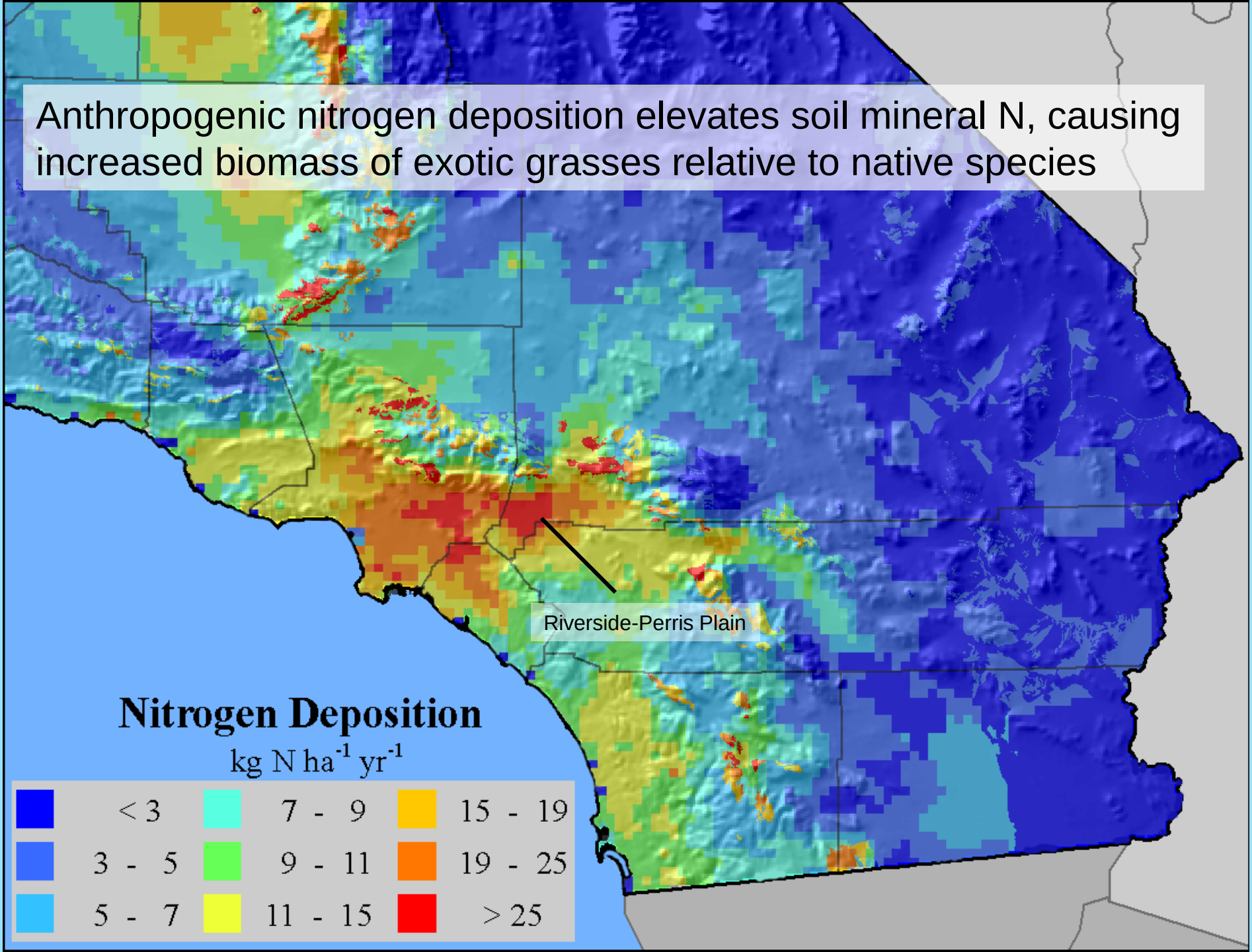
Invasion Alters Nitrogen Availability



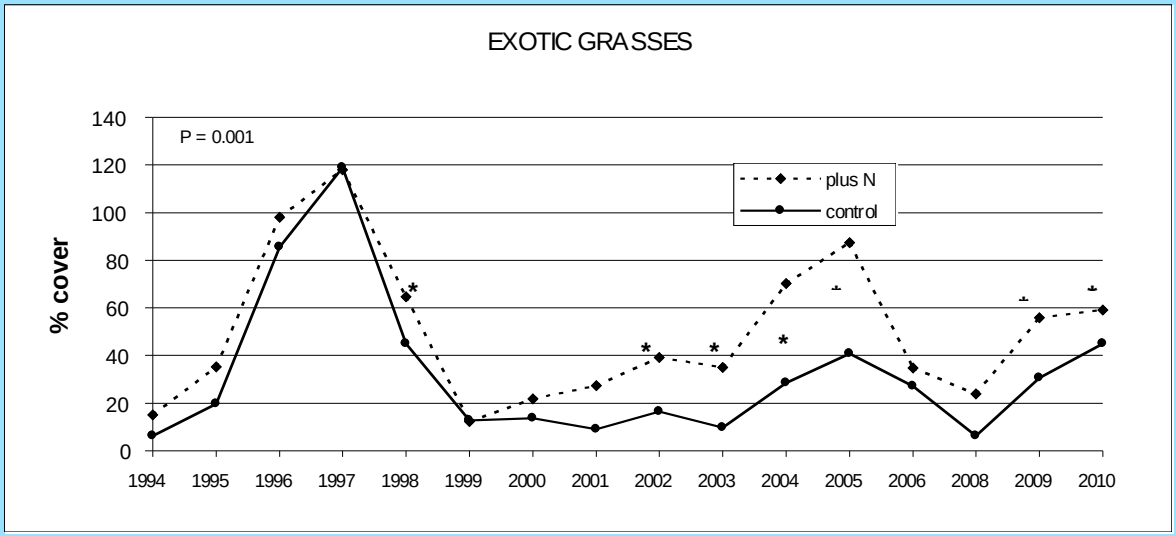
- Invaded soils had reduced extractable nitrogen.
- Nitrogen cycling rates were increased by invasion.

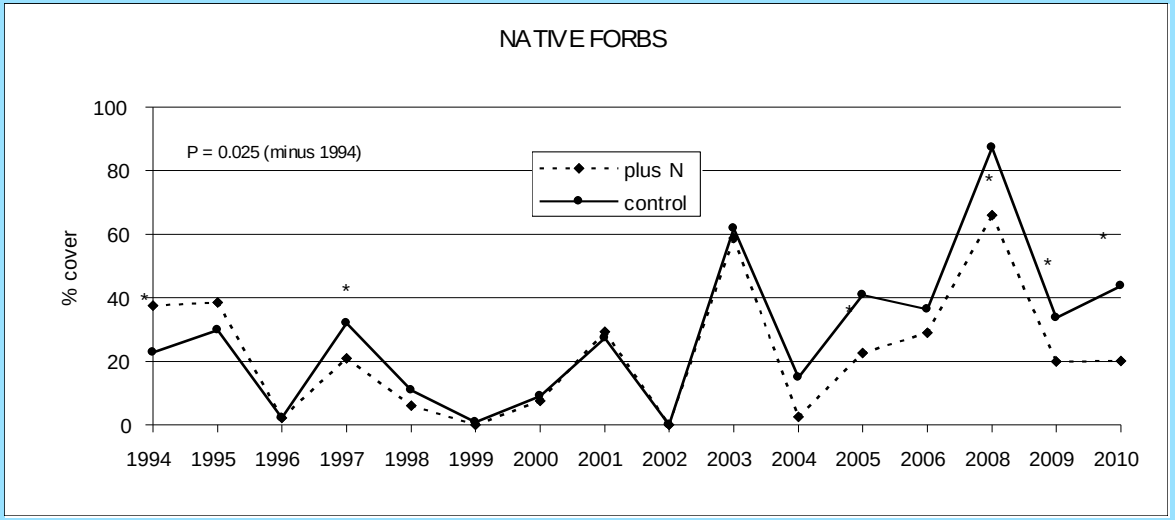
IN = Invaded
REB = Restored by burn
REW = Restored by weeding

Anthropogenic nitrogen deposition elevates soil mineral N, causing increased biomass of exotic grasses relative to native species



Nitrogen fertilization increased exotic grass cover and reduced native cover





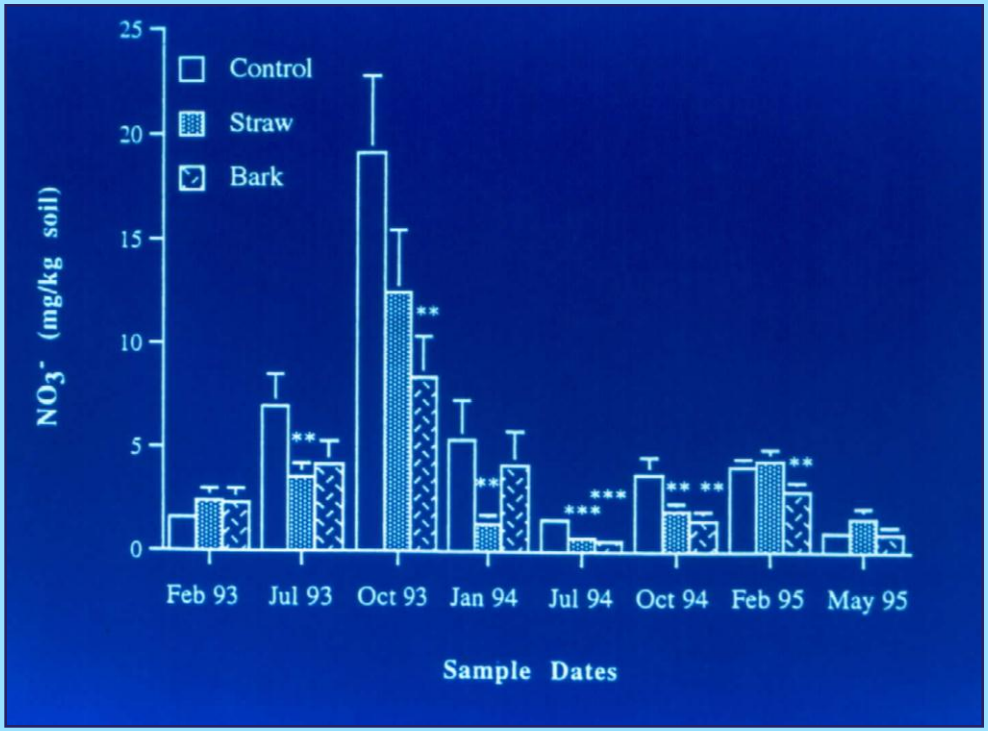
Plus N

Control

Vegetation response following the 1993 fire at Lake Skinner plus N fertilization and control (no fertilization). *p* is repeated measures probability, * is *p* = 0.05 by year.

Mulch can be used to:

- immobilize excess N
- decrease exotic grass cover
- increase establishment of native plants
- bark was more effective than straw



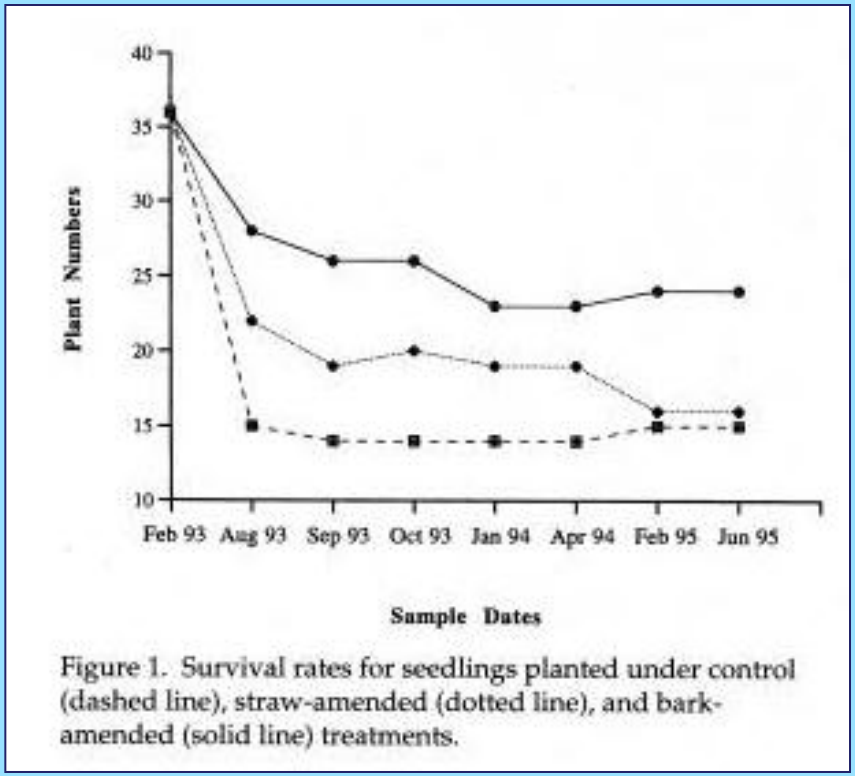


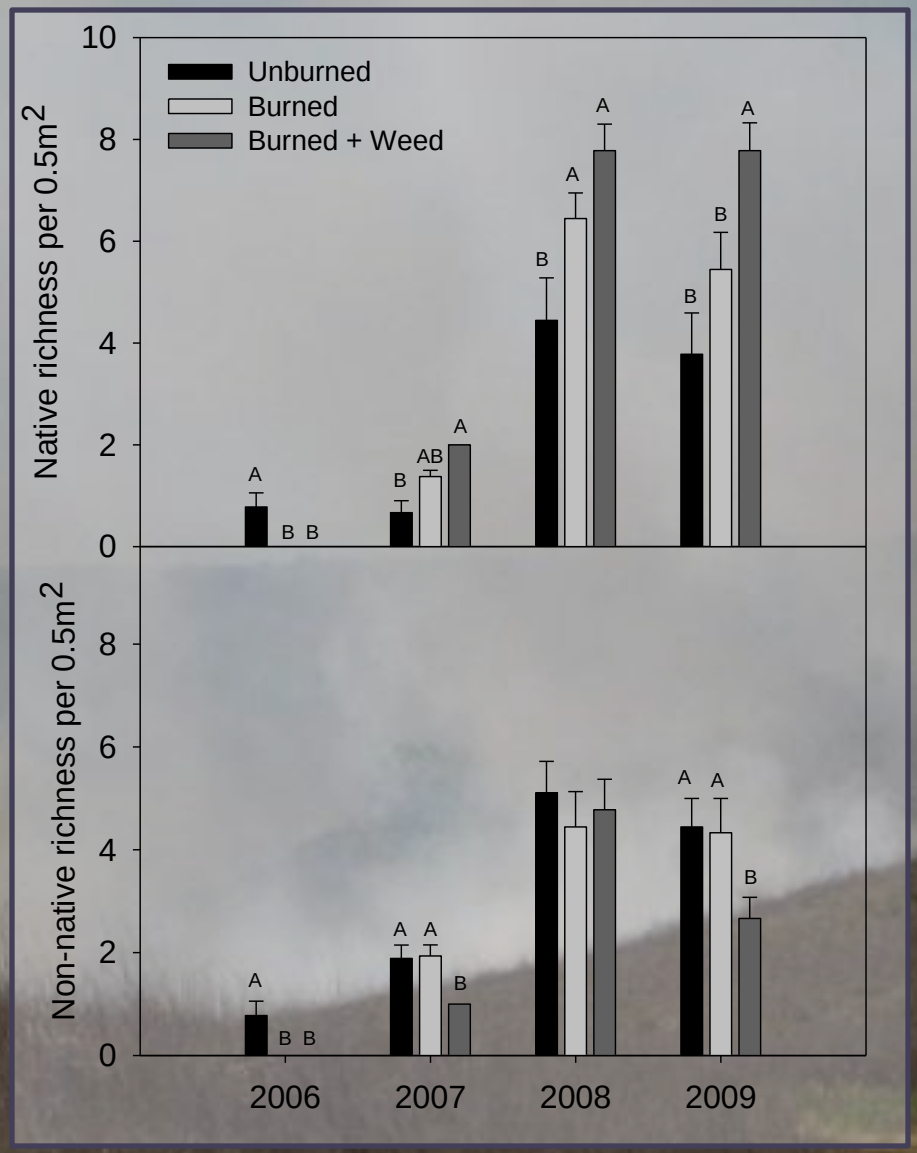
Figure 1. Survival rates for seedlings planted under control (dashed line), straw-amended (dotted line), and bark-amended (solid line) treatments.

Seedbank of exotic grassland, native CSS with grass understory, and adjacent burned and unburned sites after the October 2003 fire, Shipley Reserve.

	Average Seedlings per m^2			
Species	**Grassland**	**Shrubland**	**Unburned**	**Burned**
Exotic Grasses	7261	3932	7339	147
Exotic Forbs	4714	1126	1440	969
Native Forbs	407	800	211	121
Native shrubs	14	0.5	6.3	0

Exotic seeds overwhelm native seedbank. Fire reduces exotic grass seedbank, providing a window of opportunity for restoration (Cox and Allen 2008).

Limited Soil Seedbanks



- Fire and weeding increased native richness and cover, but not substantially.
- Seedbank germination experiments show limited native species richness, indicating the need for seeding.

Controlling the Exotic Grass Seedbank

Methods

- Grazing
- Grass-specific herbicide
- Mowing
- Dethatching
- Solarization

Prescribed Fire

Properly timed prescribed burns can removal 90% of exotic seed input and reduce thatch.

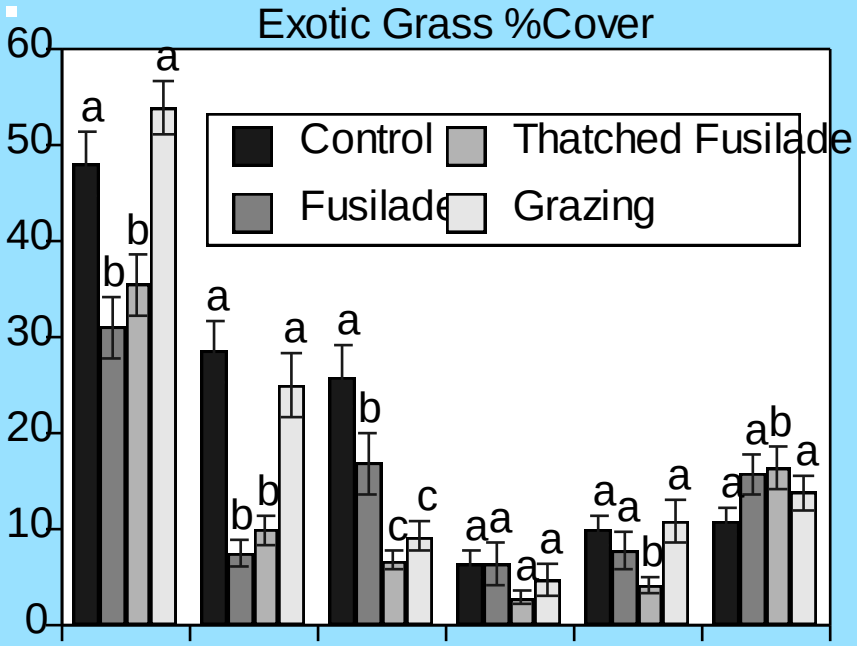
(Hervey 1949; Gillespie & Allen 2004; Moyes et al. 2005; White et al. 2006)

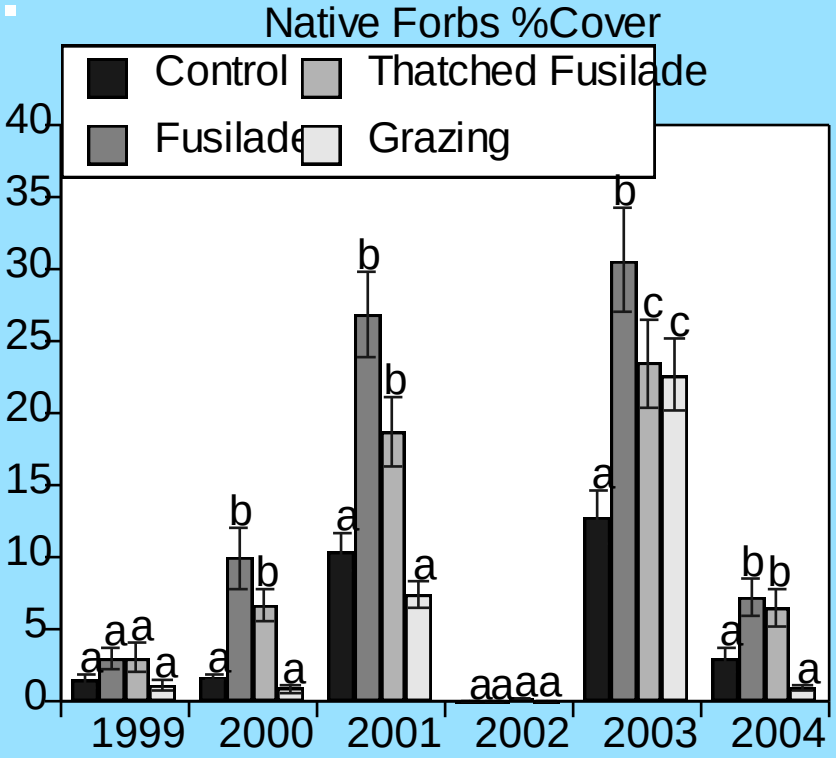
Sheep grazing to control exotic grass

200 sheep per hectare for 2 days in Mar/Apr

Grass-specific herbicide (Fusilade)

Dethatching treatment to remove standing litter





Exotic grass and exotic forb cover after two years of Fusilade application (‘99, ‘00) and 3 years of sheep grazing (‘99, ‘00, ‘01).

1. Grazing was not effective until the third year because of drought
2. Native forbs were consumed by sheep, but recovered from seedbank
3. Thatch removal had no positive effect.
4. Grasses began to recover from grazing and herbicide after 2 years
5. Native forb response to herbicide still positive after 4 years

Solarization in Abandoned Agricultural Land

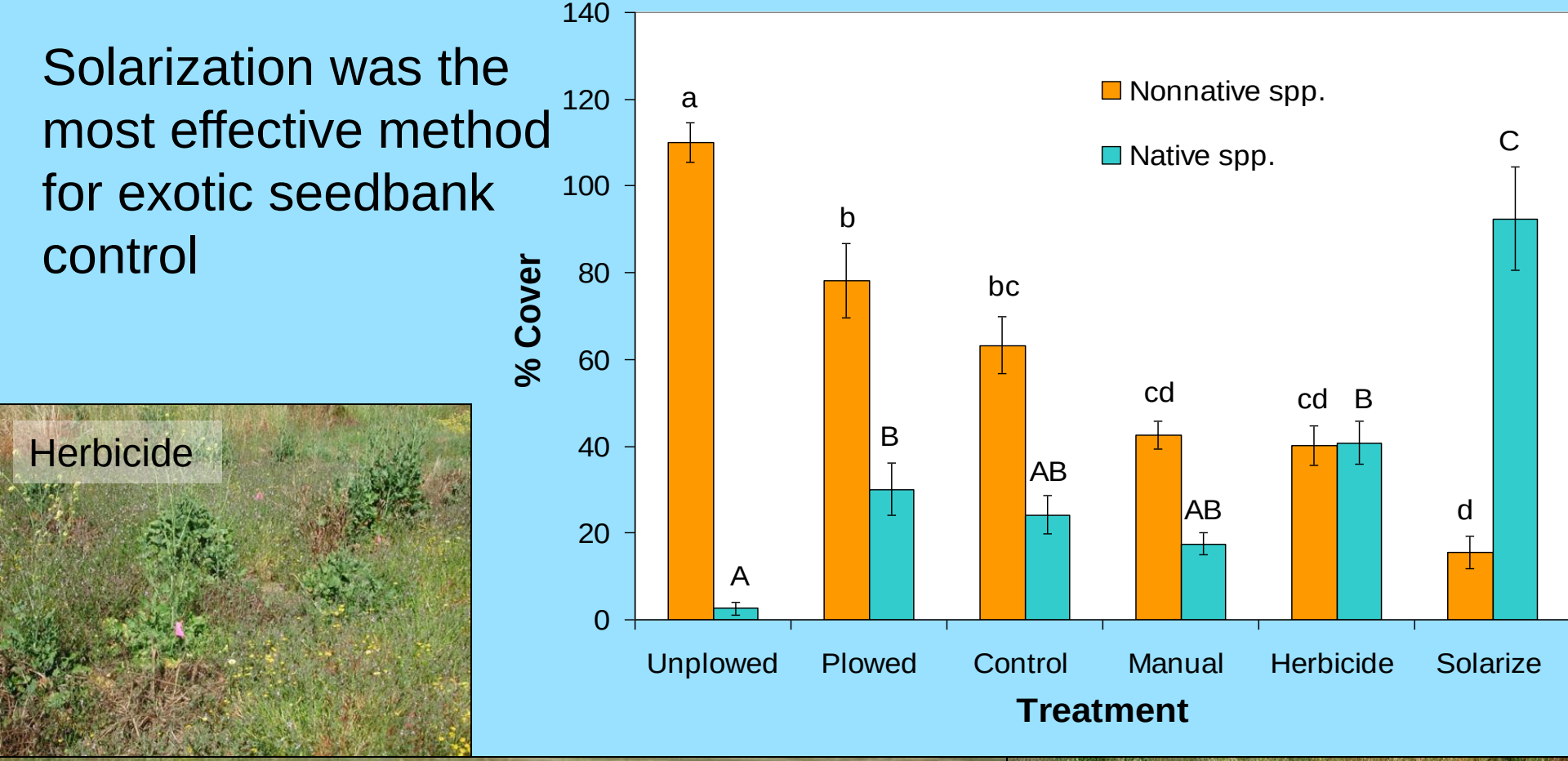
- 6 x 6 m sheets applied Nov. 2004
- Removed Jan. 2005 and native forb seed mix applied (tidy tips dominate)

Nov. 2004

Feb. 2005

Apr. 2005

Solarization was the most effective method for exotic seedbank control



Conclusions

- Mycorrhizal fungi spore species composition recovered within 5 months of revegetation with *Stipa pulchra*, however, inoculation with mycorrhizal fungi did not overcome negative completive effects of exotic annual grasses on *Stipa* growth.
- Extractable nitrogen, nitrogen cycling rates and microbial community composition also recovered within a growing season following exotic grass removal.
- Nitrogen deposition and elevated soil N from past fertilization increases productivity of exotic annual grasses, with concomitant reduction in native forb productivity.
- Mulches to immobilize soil N and control of exotic grasses are effective, but the best large scale solution is to control N deposition.

Conclusions (continued)

- Seed bank control of exotic grass is the most urgent need. Solarization is the most effective method, but works only in tilled, level land and moist soil (abandoned agriculture in winter-spring months)

- Grazing is only effective in years with sufficient grass productivity. Grazed native forbs recover from the seedbank and exotic grasses recover from grazing after 2 years.

- Fusilade is an effective treatment for control of *Bromus, Avena* and *Schismus* but not *Vulpia*. It also controls *Erodium* spp.

Conclusions (continued)

- Early season mowing and disking can be used to control exotic grasses.

- Spring fire is most effective to control the seed bank, but fall fire is also effective especially if combined with seeding.

- Any of these exotic grass control methods will require reapplication at intervals of 2-5 years depending on effectiveness of the initial treatment.

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