Use of early seral species to improve restoration outcomes

Mark Paschke, Jayne Jonas, and Brett Wolk

Restoration Ecology Lab

Colorado State University

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Community development following disturbance

- Early seral species (ESS) first colonizers
  - Adapted to high nutrient soils
  - Fast growth and invest largely in seed production
  - Typically annuals or short-lived perennials
- Replaced by later seral species (LSS) over time
  - Adapted to low nutrient soils
  - Slower growth and invest resources in root development and vegetative reproduction
  - Mostly perennials

Native ESS may be more competitive with invasive species

- Many invasive species are early colonizers
- Native and invasive ESS share many life history traits
  - Affinity for high nutrient soils
  - Fast growth and reproductive output
- Native ESS may improve soil microbial community for LSS
  - Invasive species associated with different soil biota than native species

Overarching assumptions

- Native ESS are now rare in western rangelands
  - Turn of century grazing
  - Broadleaf herbicides
  - Fire suppression
  - Planting of improved grasses
  - Increased deer/elk populations
- Native ESS create favorable conditions for establishment and growth of LSS

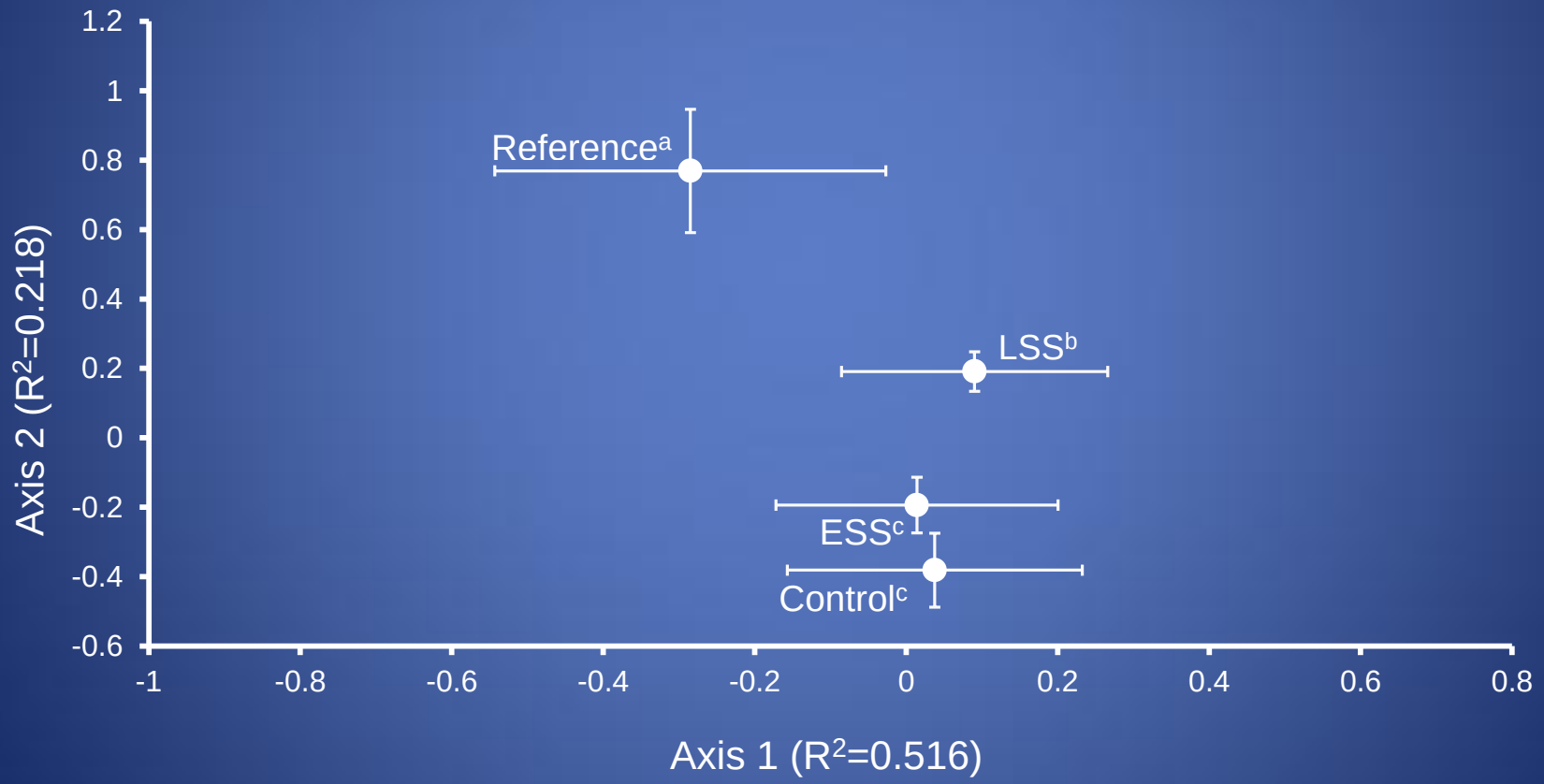
Overarching hypothesis

- Including ESS in restoration seed mixes will facilitate native community development over time.

How do ESS and LSS seed mixes influence long-term plant community development?

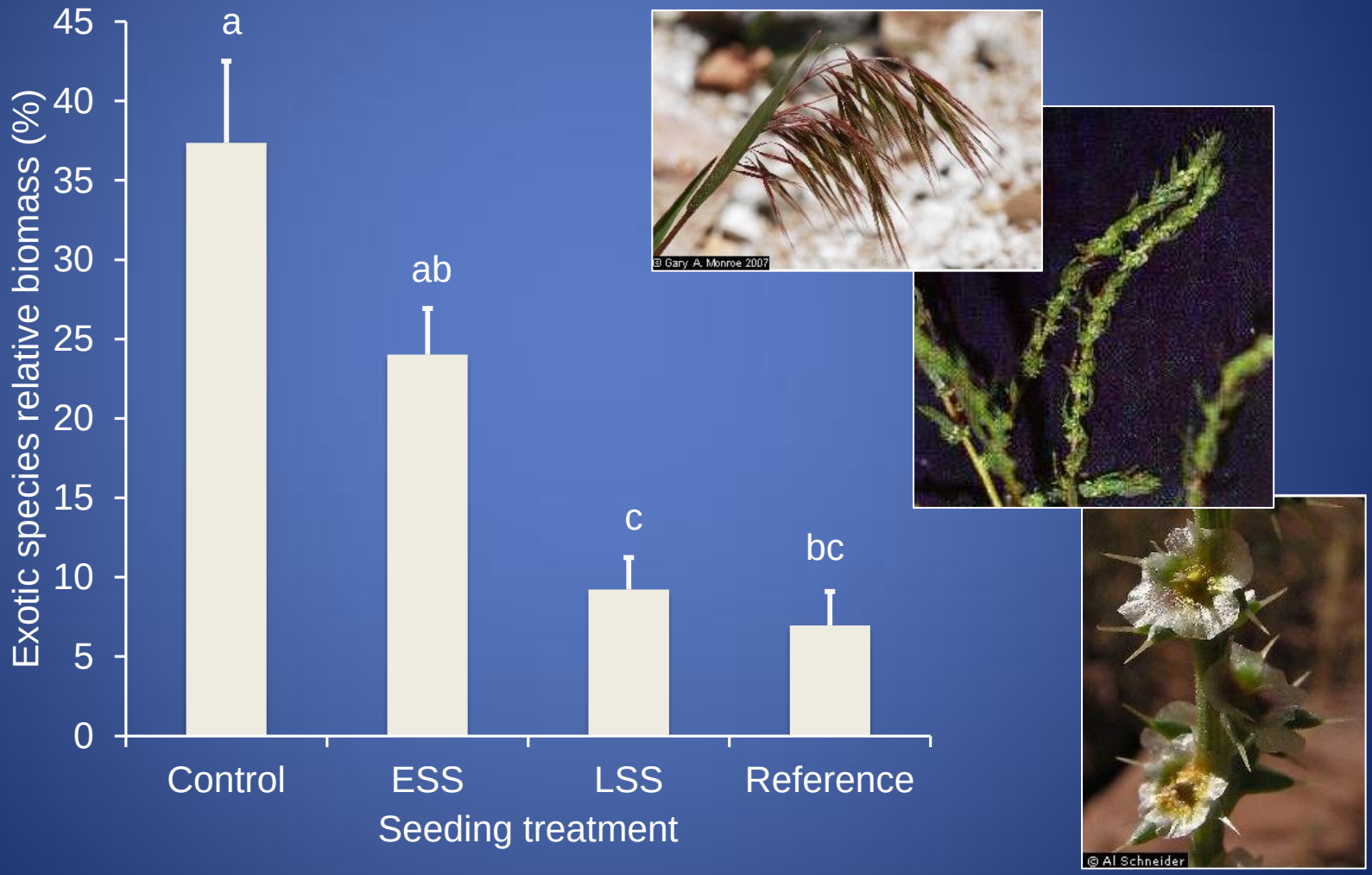
- Piceance Basin (CO)
- Established Fall 1984
- Severely disturbed experimental plots
- 4 treatments
  - ESS seed mix (11 spp.)
  - LSS seed mix (12 spp.)
  - Unseeded control
  - Undisturbed reference

Neither ESS nor LSS seeded plots similar to reference after 25 years



Hoelzle et al. (in review)

Three exotics in ESS seed mix; exotics still common in ESS plots

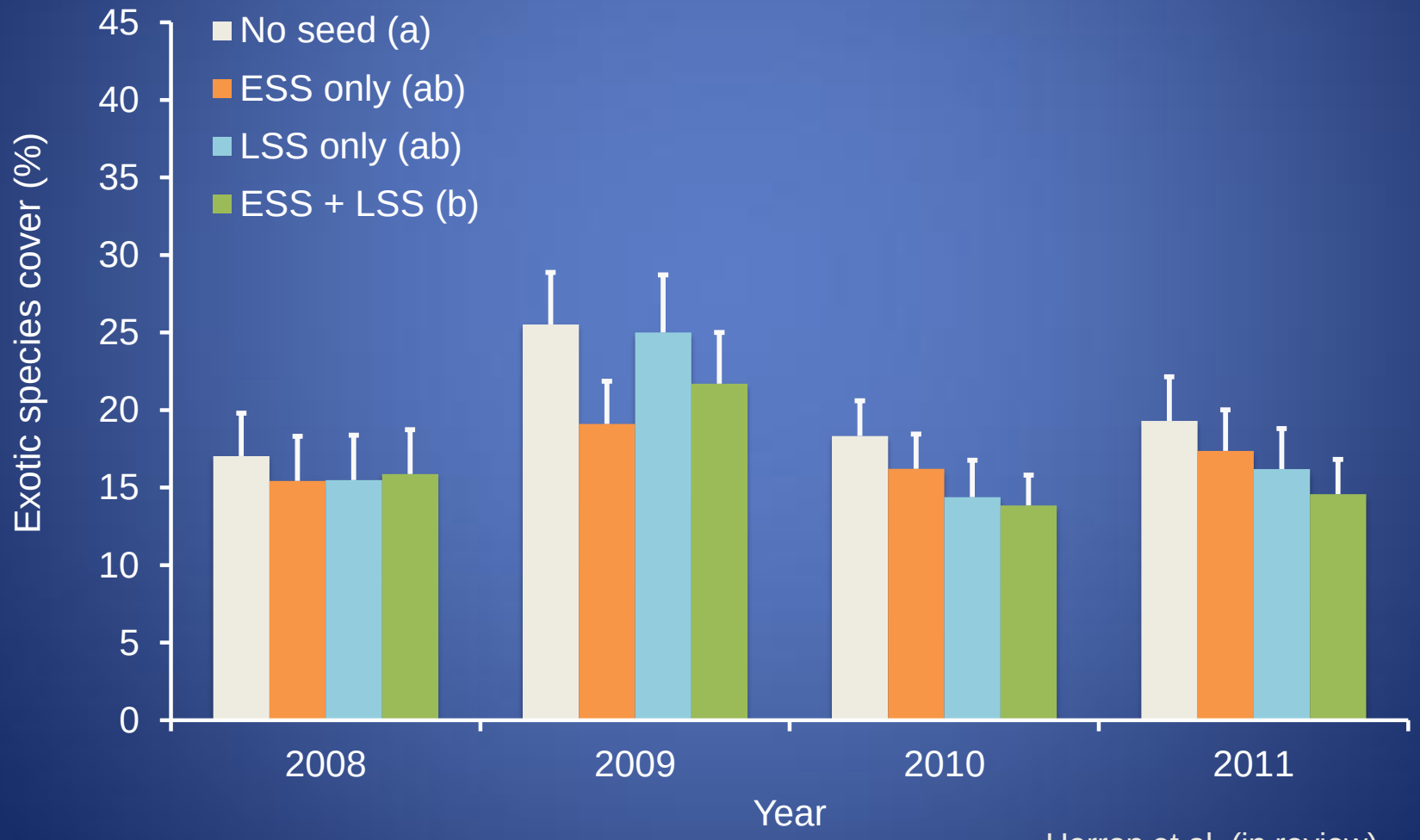


Hoelzle et al. (in review)

Does seeding native ESS with LSS improve post-fire recovery of natives?

- Concern about post-fire increase of *B. tectorum*
- 3 sites in CO and ID
- Established 2007 after summer and fall wildfires
- 4 treatments
  - Native ESS mix (8 spp.)
  - Native LSS mix (9 spp.)
  - Both ESS and LSS mixes
  - Unseeded control

ESS + LSS seed mix decreased exotic species over 4 years

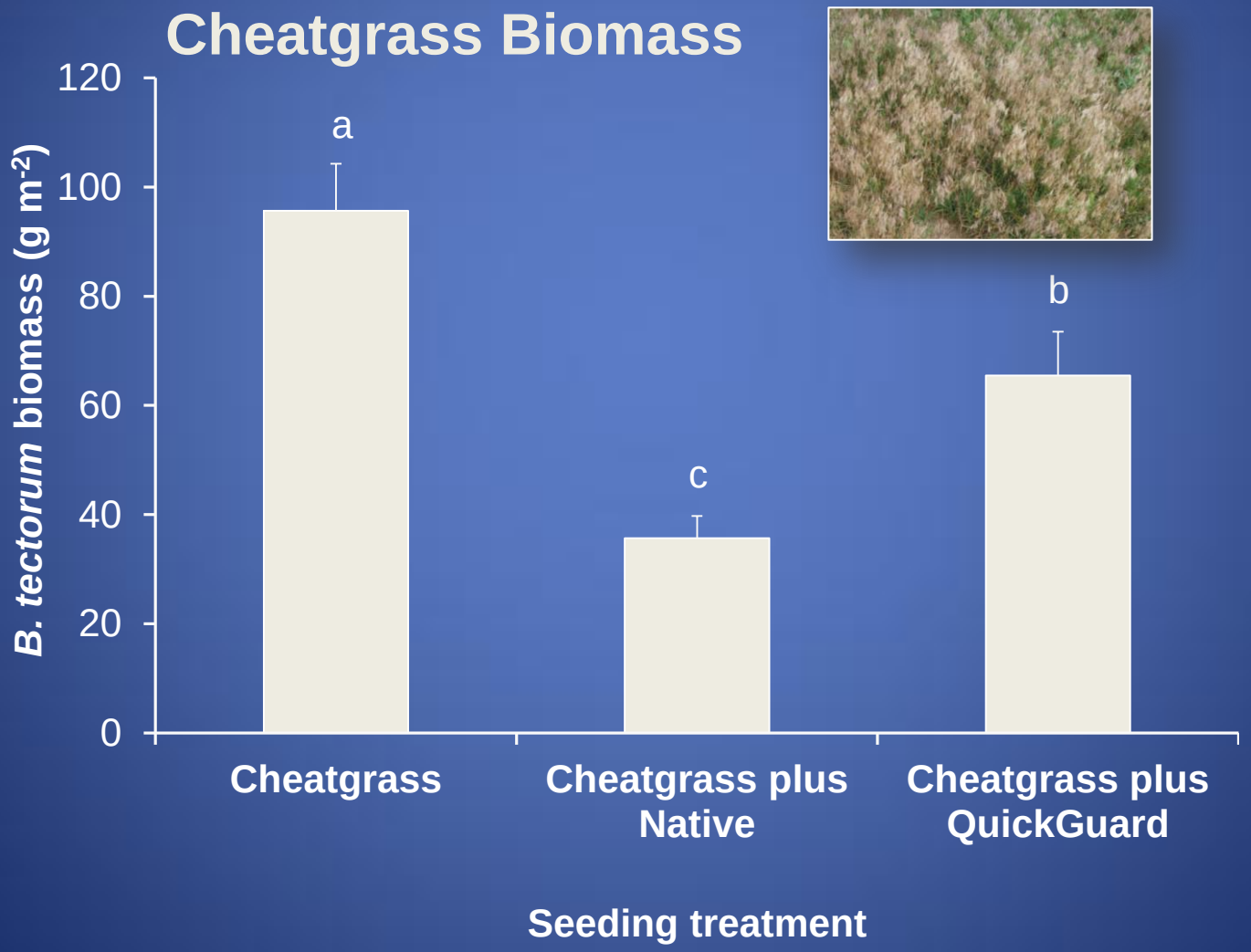


Herron et al. (in review)

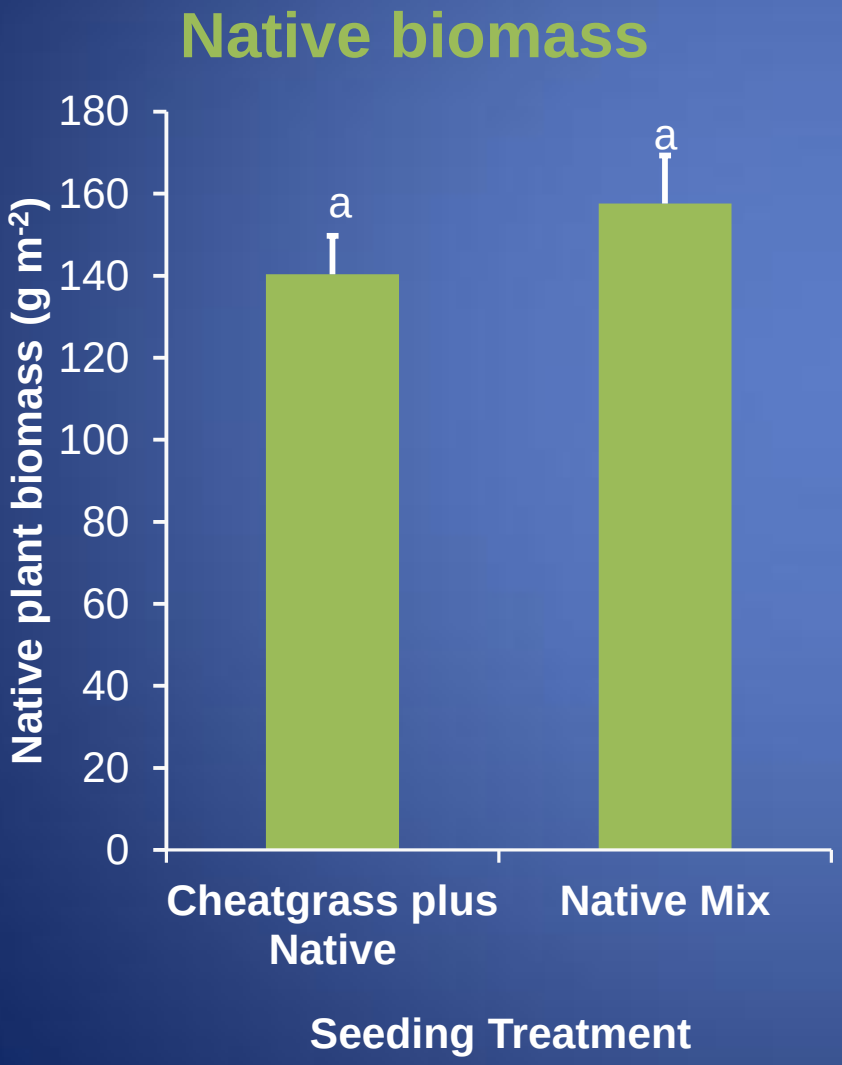
Can native ESS inhibit establishment of an invasive ESS

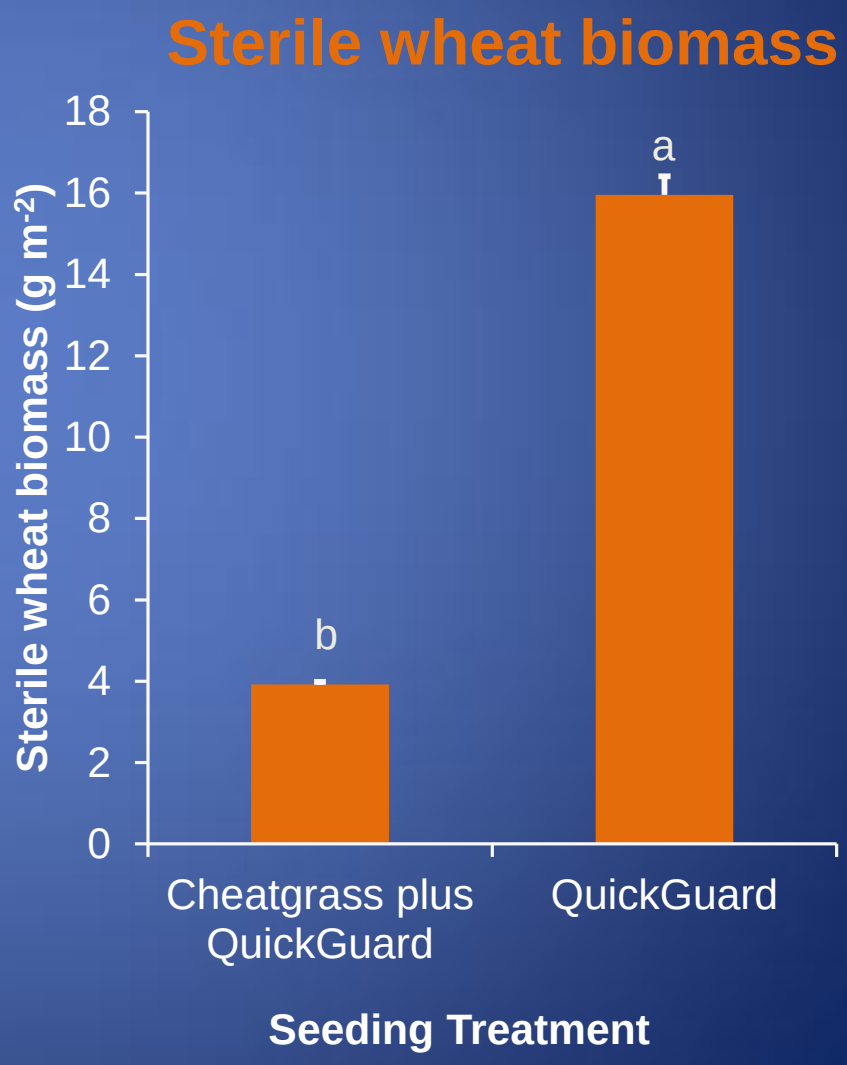
- Fort Collins (CO)
- Established Fall 2010
- Soil disturbed to 10 cm
- 6 treatments
  - *Bromus tectorum*
  - Sterile wheat
  - ESS mix (9 spp.)
  - *B. tectorum* + sterile wheat
  - *B. tectorum* + ESS mix
  - Unseeded control

ESS suppressed *B. tectorum* more effectively than sterile wheat



ESS not affected by *B. tectorum*; *B. tectorum* inhibited sterile wheat

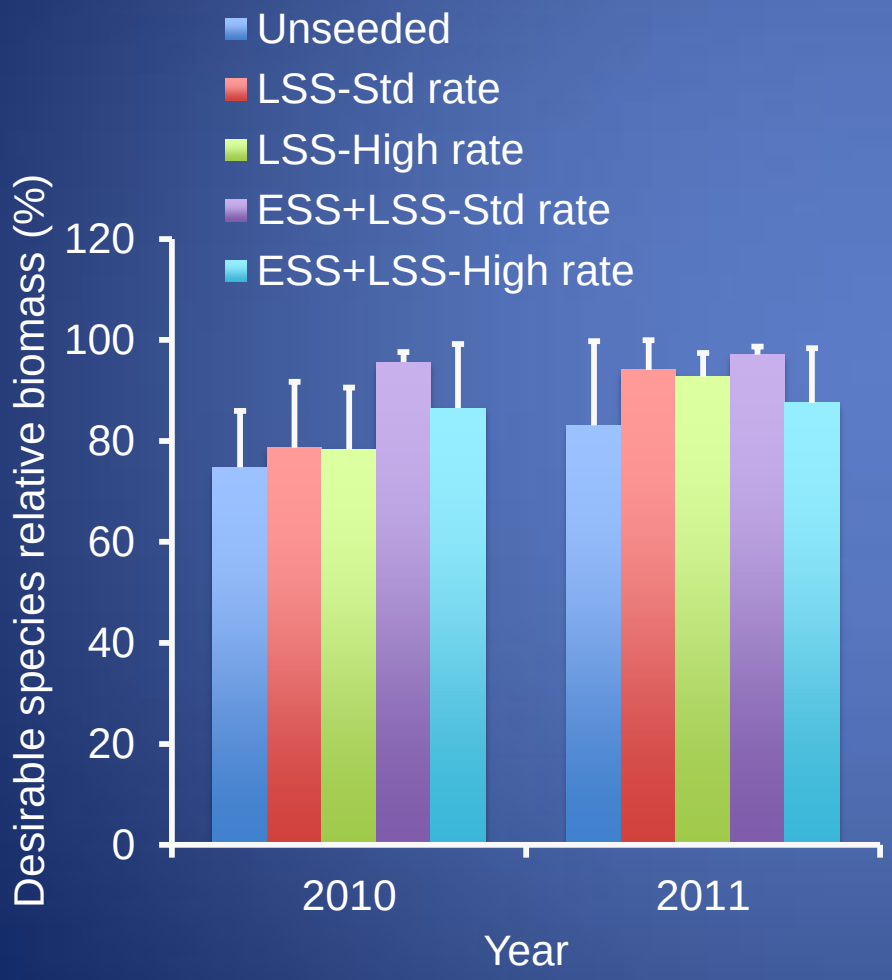


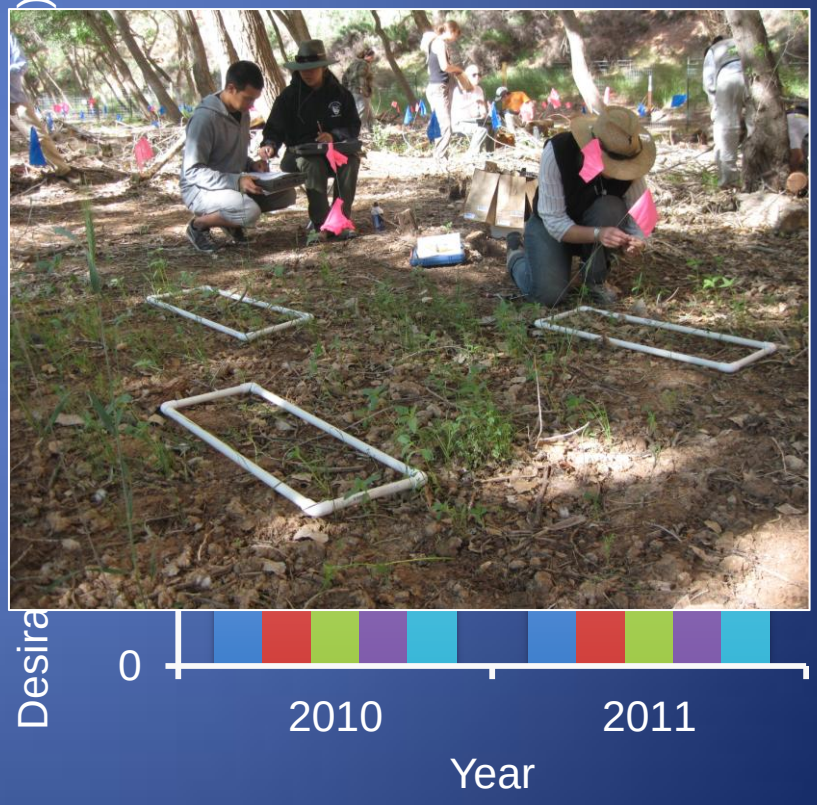


Does seeding both ESS & LSS promote native plants after exotic tree removal?

- Canyon de Chelly National Monument (AZ)
- Removal of exotic trees *Tamarix* and *Elaeagnus angustifolia*
- Seeded June 2009
- 3 seed treatments
  - Standard LSS mix
  - Diverse ESS + LSS mix
  - Unseeded control
- 2 seeding rates
  - Standard rate
  - High rate

Seed mix with ESS promoted desirable species compared to control in first year



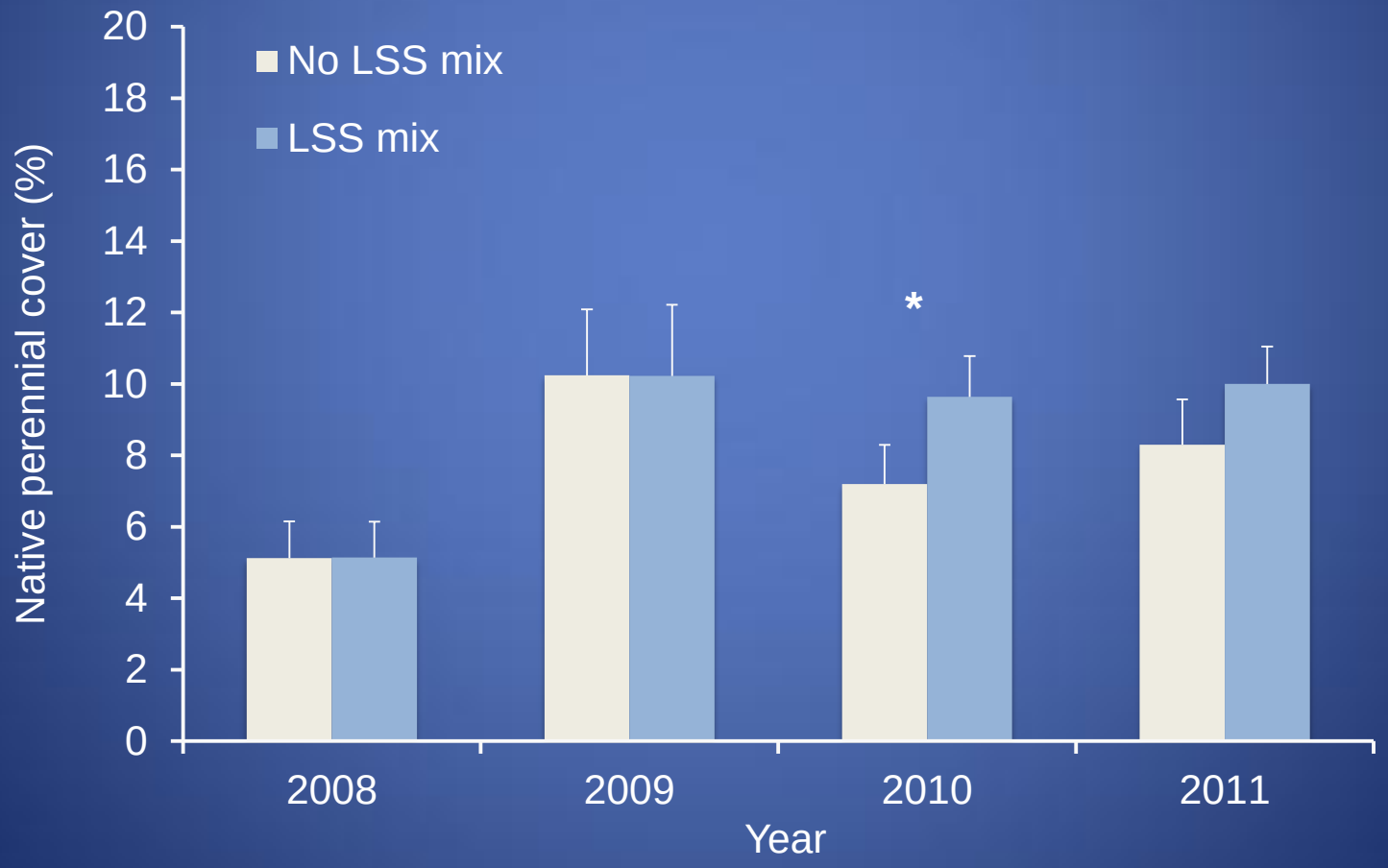


*Significantly different from unseeded control in same year

Putting it all together

- Importance of ESS for later community development suggested by others, but little previous research
- Our long-term study indicates that development of native LSS communities takes time
- Our findings indicate native ESS may be important for promoting native plant community development and slowing the spread of invasive species.

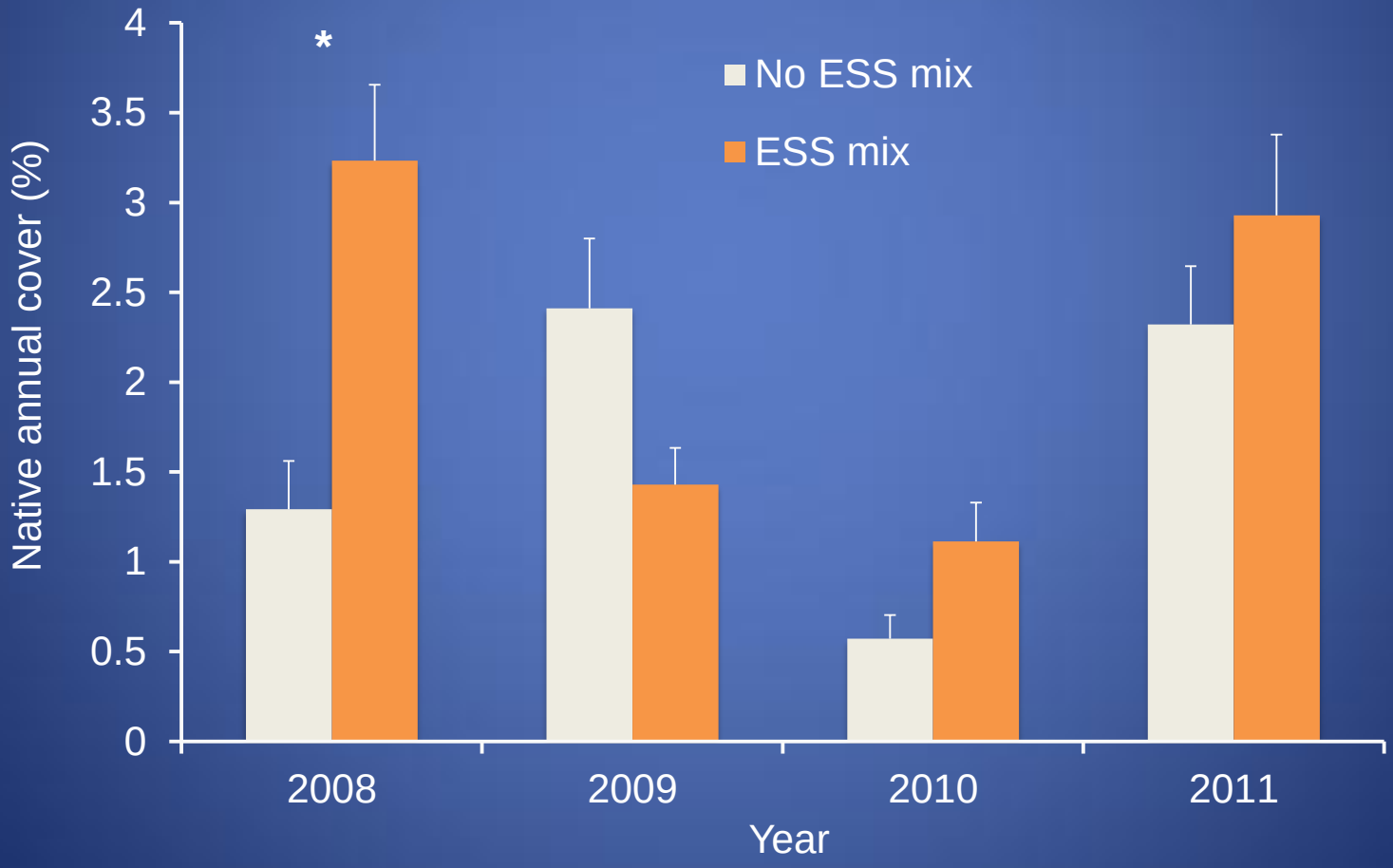
Slight increase in native perennials with LSS mix 3 & 4 years post-fire



*Significant, *P*<0.05

Herron et al. (in review)

ESS mix increased native annuals 1 year post-fire



*Significant, *P*<0.05

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Next steps

- How important are seeding rates? Does re-establishing a native ESS seedbank improve restoration success?
- Does identity of particular native ESS matter? Is a more diverse ESS mix better?
- How do ESS affect soil biotic and abiotic characteritics? To what degree do these effects influence LSS?

ESS may improve soil for LSS

- ESS exhibit variable responses to arbuscular mycorrhizal fungi (AMF)
  - May lead to diverse AMF community in soils
- ESS may facilitate restoration by
  - Improving AMF densities in soil
  - Promoting AMF species most beneficial to LSS
  - Preventing shift toward AMF species associated with invasive plants