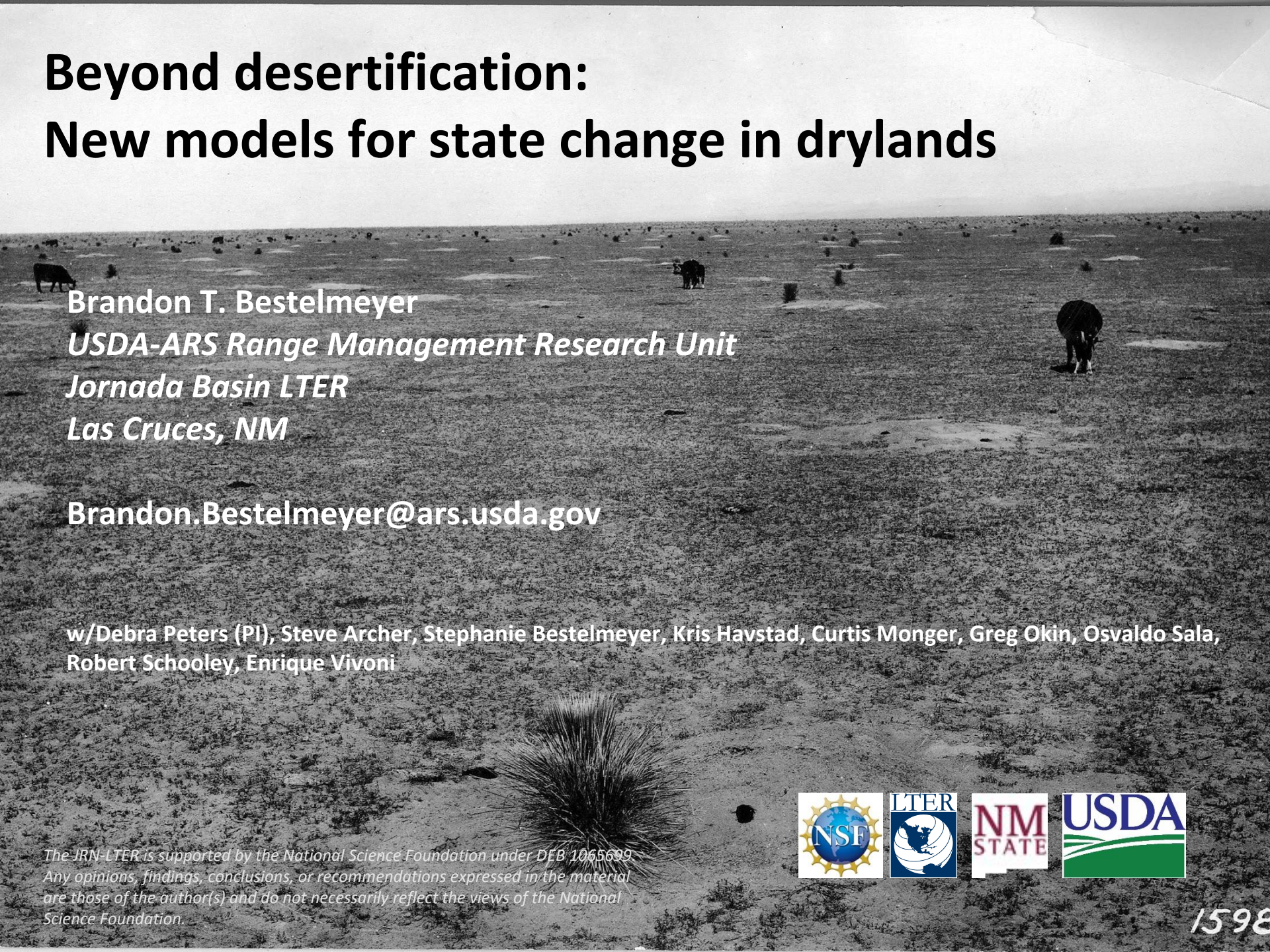
Beyond desertification:
New models for state change in drylands



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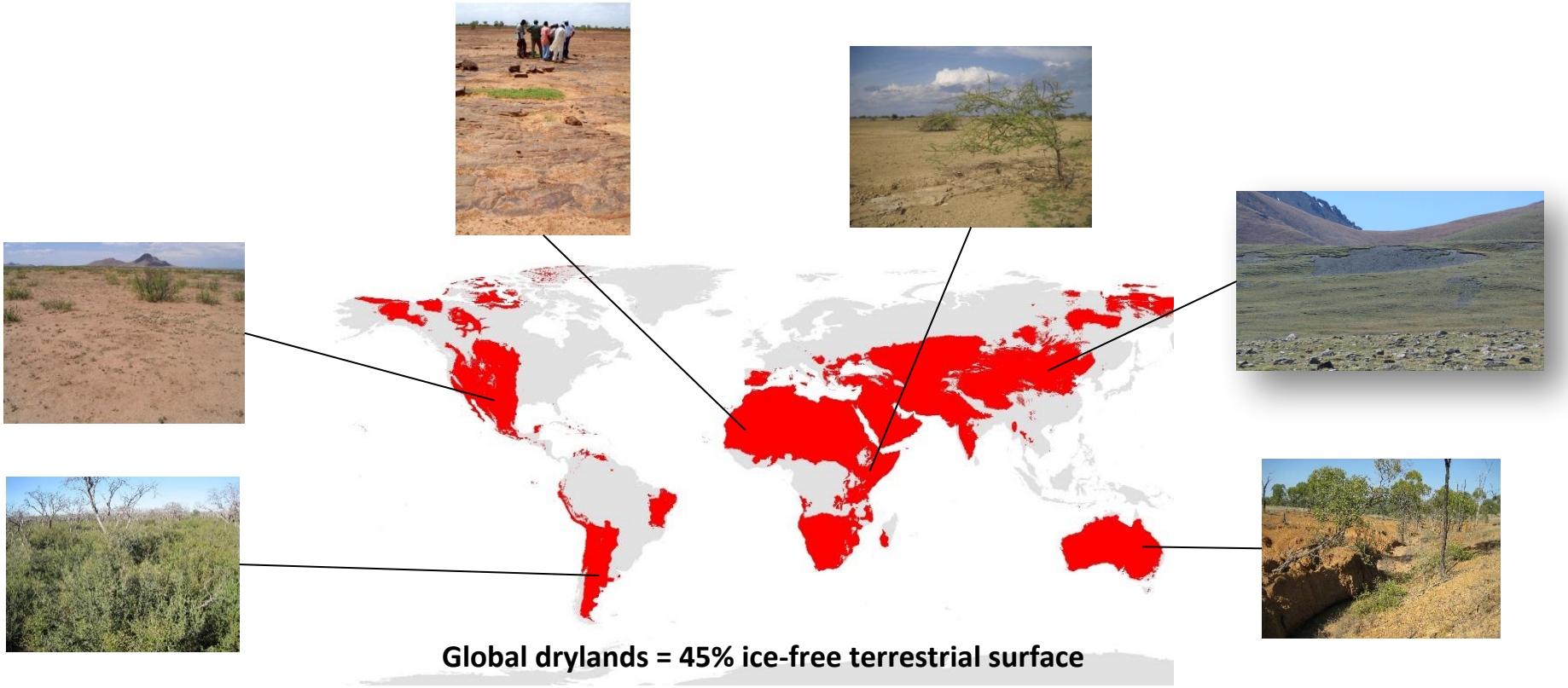
The Jornada Basin LTER site

- Jornada Basin LTER at New Mexico State University (est. 1982)
- Hosted at the USDA-ARS Jornada Experimental Range (est. 1912) and NMSU Chihuahuan Desert Rangeland Research Center (est. 1927)

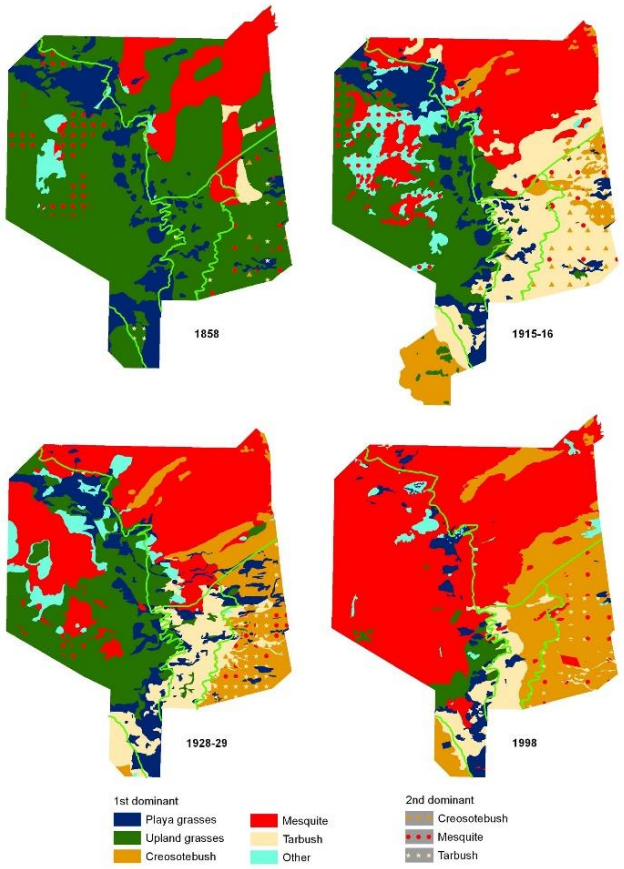
What are the causes of and solutions to desertification?

A loss of ecosystem services in drylands due to persistent transitions

Controversial because there is seldom evidence for transitions or their reversibility



Evidence for grassland to shrubland transition in desert grassland region over the last ~150 years



1935

1952

2016

Estimated that two thirds of former grassland area has been significantly altered

Gori and Enquist 2003, Yanoff et al., 2008

Why the transition matters

Loss of long-lived perennial grasses…

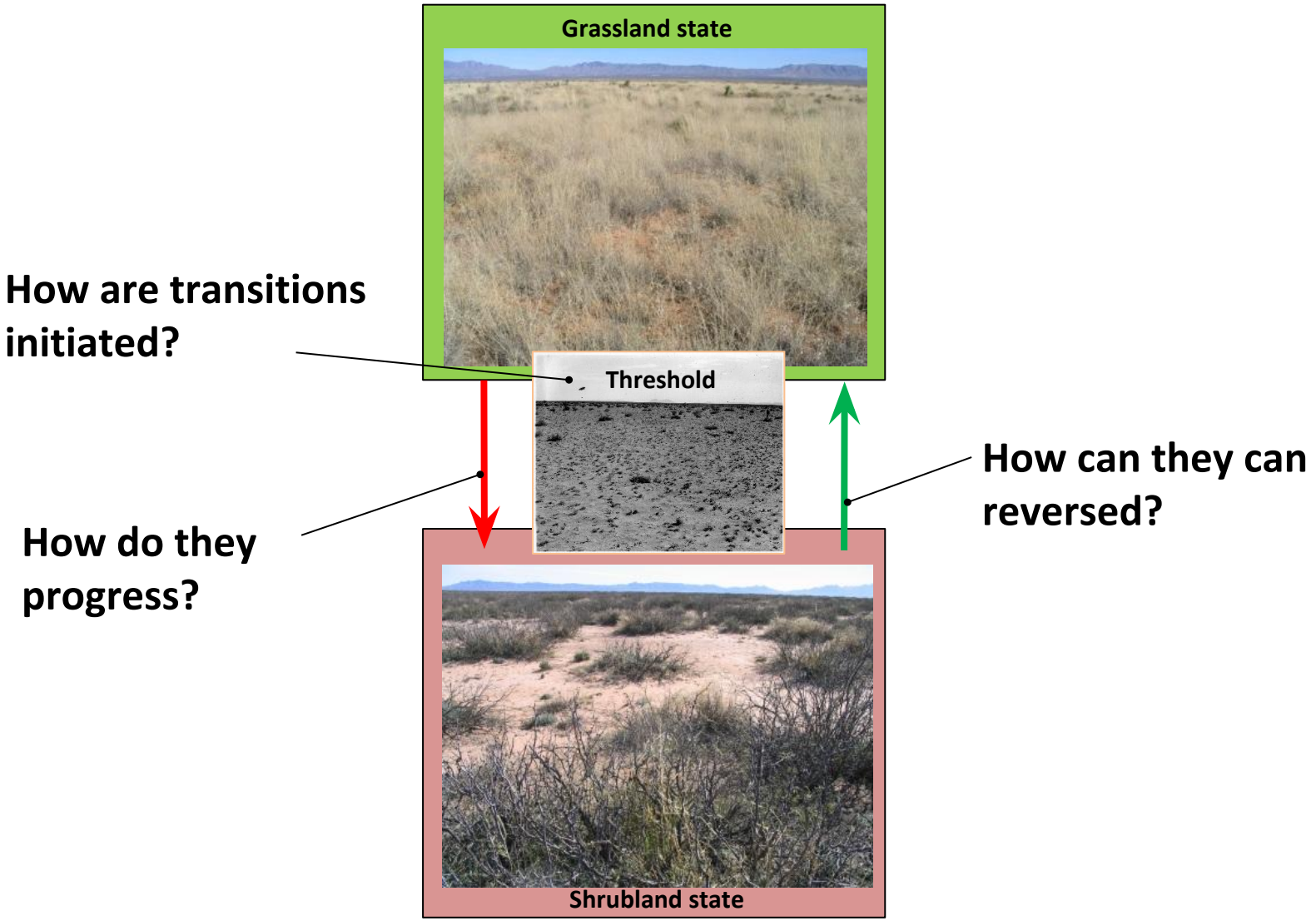
…diminishes plant and animal biodiversity and game populations

…reduces forage availability and rural sustainability in predominantly rural region

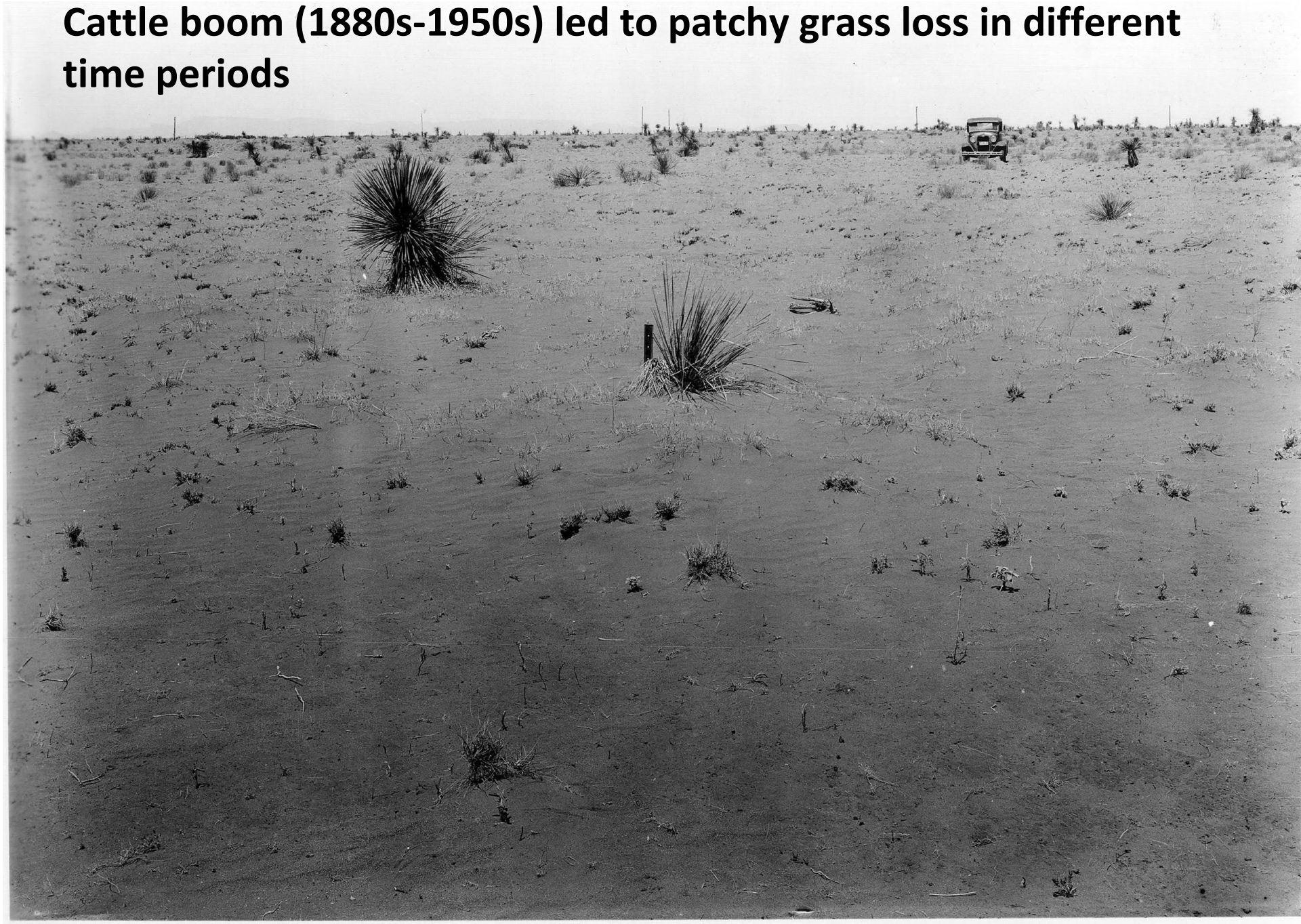
…increases soil erosion rates, decreases air quality,
and affects human health in rural and urban areas

Multiple ecosystem services are based on perennial grass cover

What we have learned from long-term monitoring and experiments

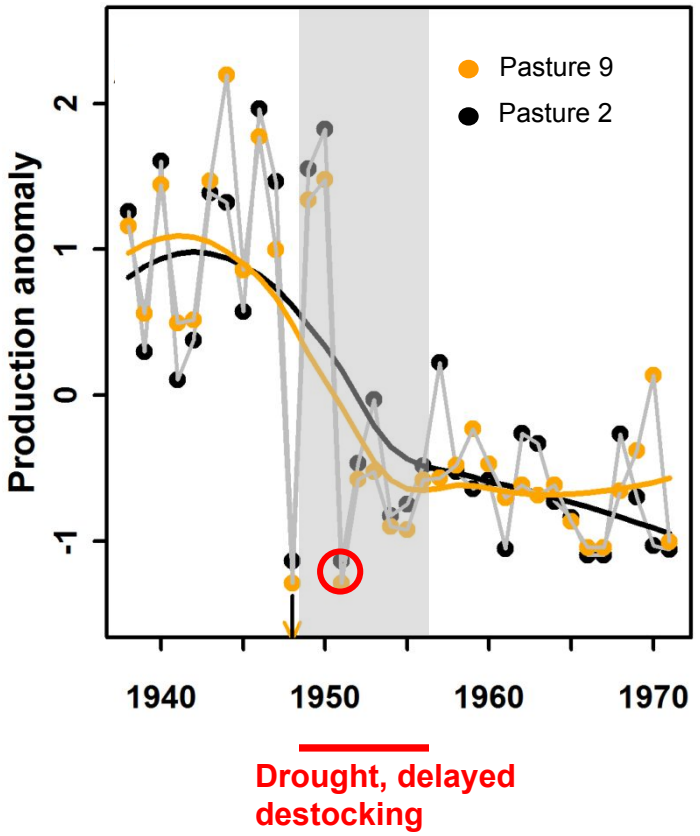


Cattle boom (1880s-1950s) led to patchy grass loss in different time periods

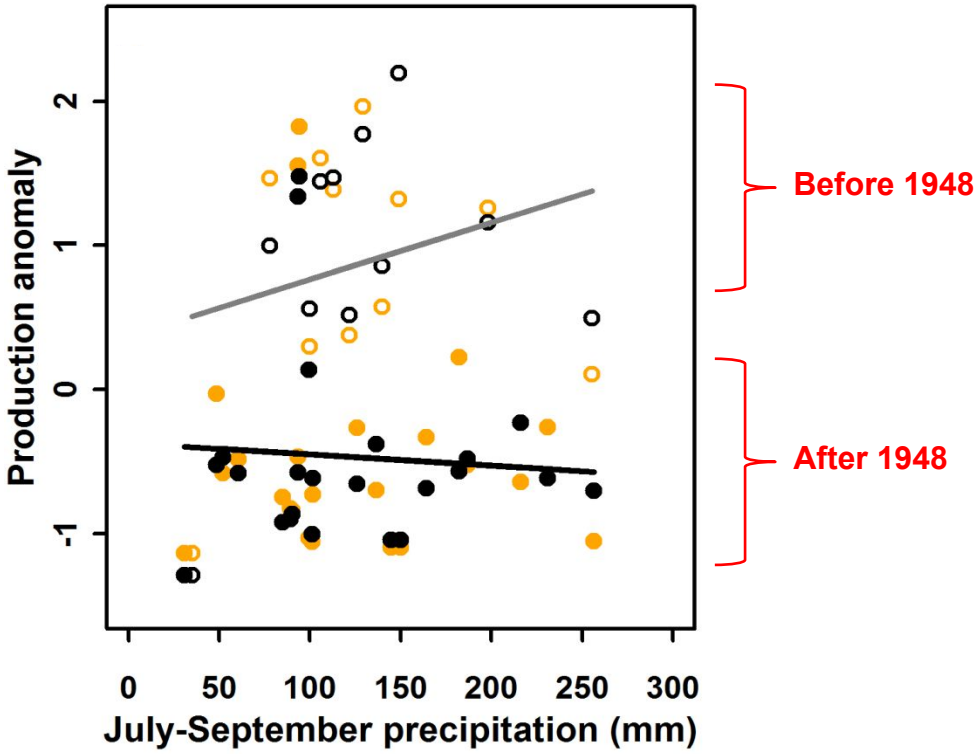


Grass loss was surprisingly abrupt and persistent

Grass production collapses rapidly without destocking during intense drought

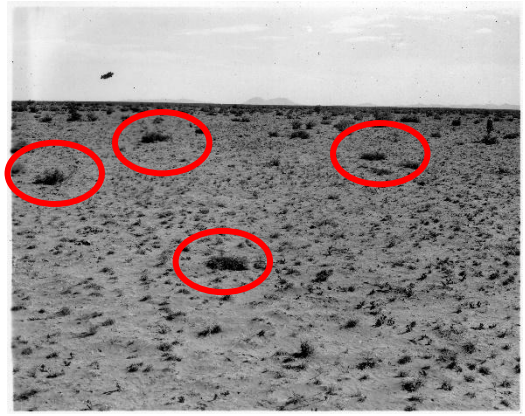


Grass recovery may not occur in high rainfall years

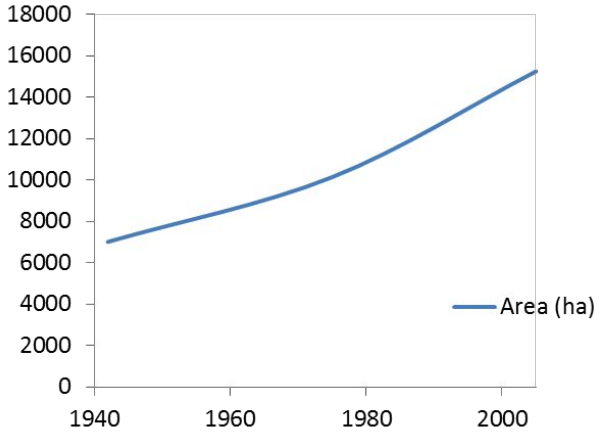


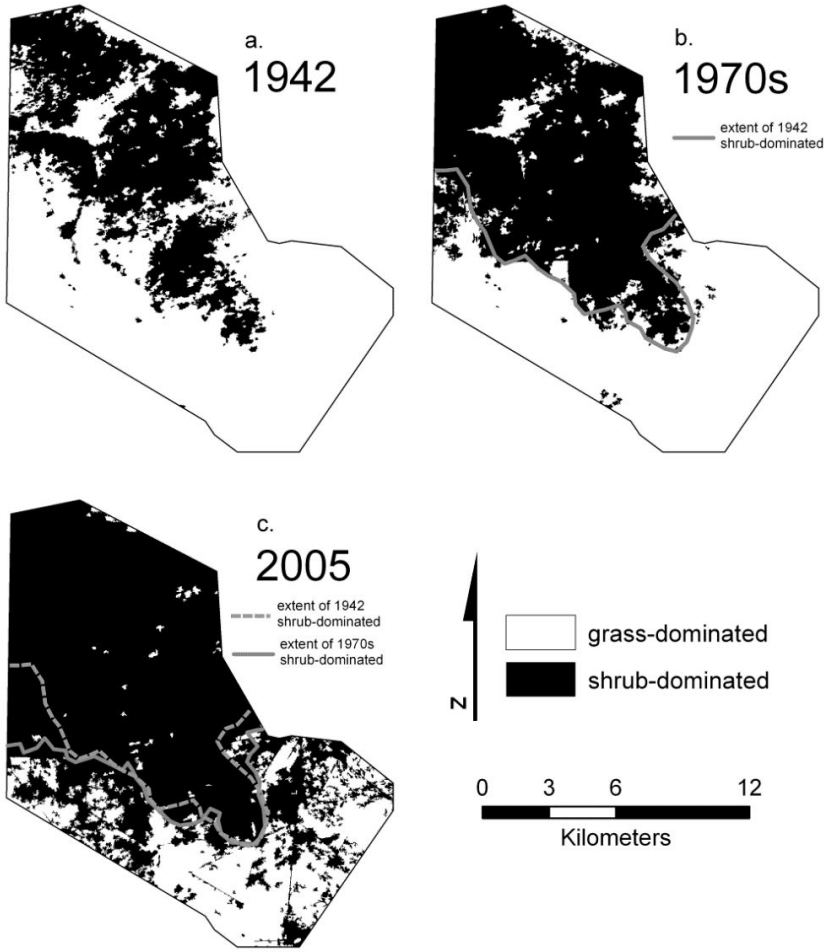
Bestelmeyer et al., Ecosphere, 2011

Bare ground and seed transport by cattle enabled shrub establishment and spread



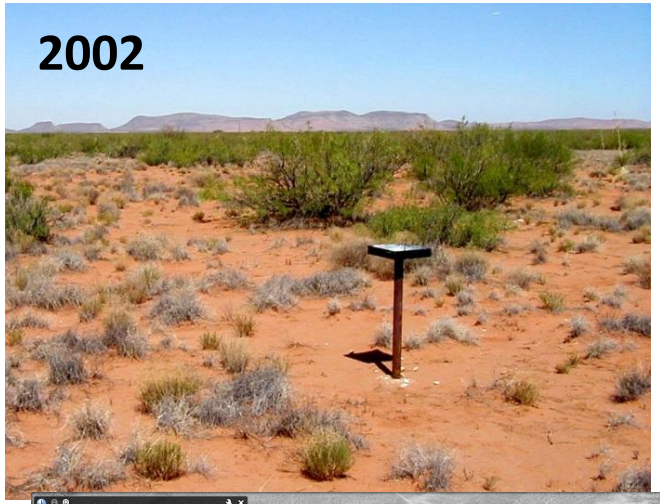
Prosopis shrub establishment





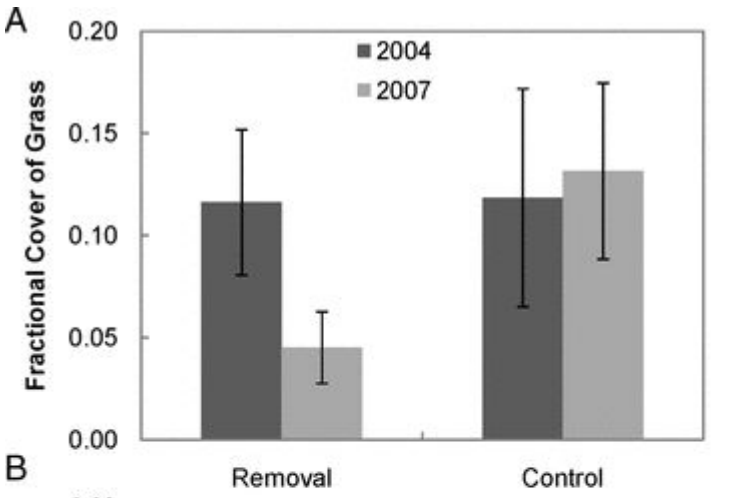
Prosopis spread based on aerial photographs

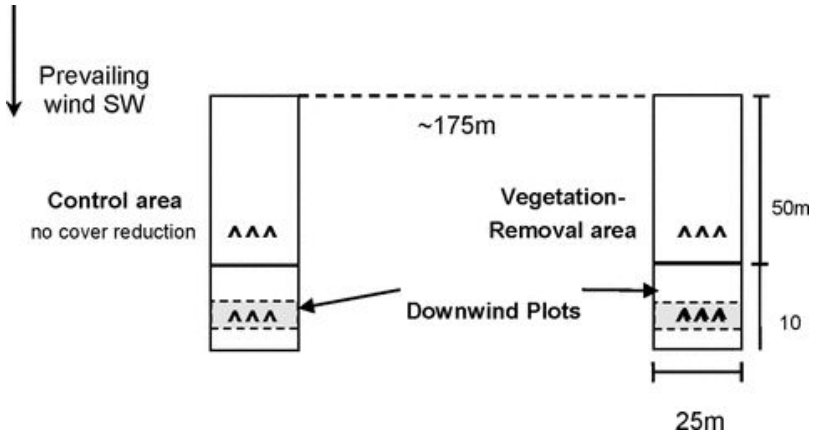
On wind-erodible soils, subsequent grassland-shrubland transitions are independent of grazing



Grass cover collapse and shrub expansion in large area with no grazing since 1940s

Differential responses of grasses and shrubs to wind erosion is a key mechanism for contagious transitions



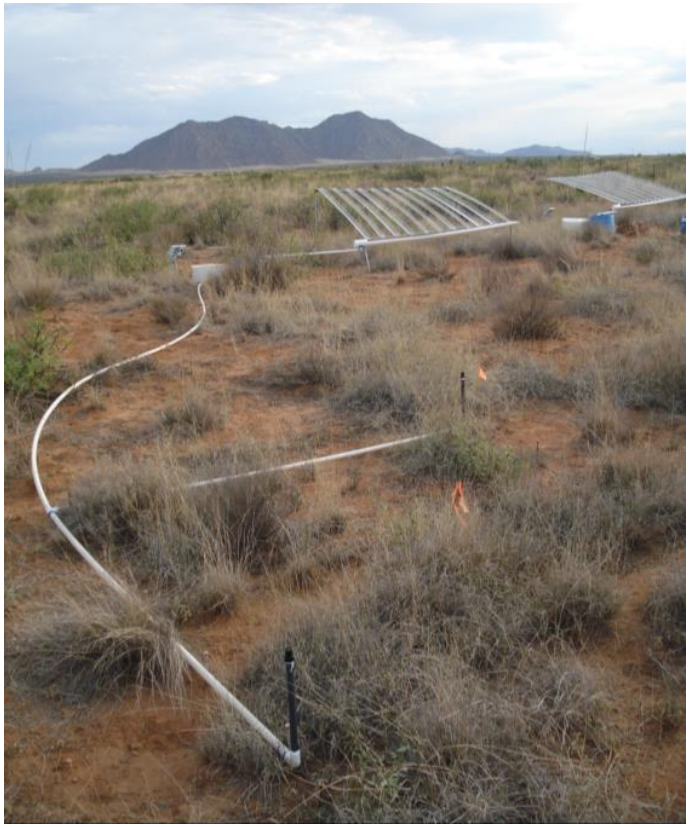


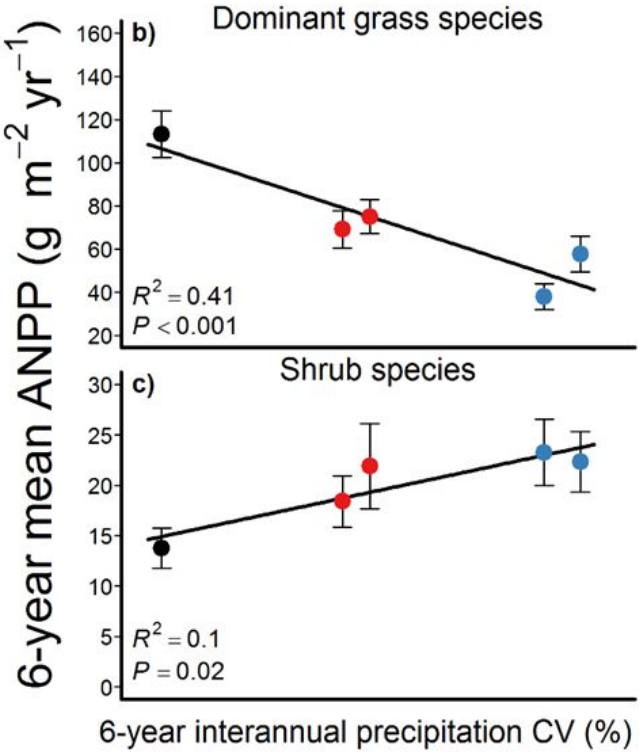
Removed grass in upwind areas, measured response downwind

Alvarez et al., 2012, Ecology and Evolution

Shrub dominance will intensify if precipitation becomes more variable

Experimental enhancement of interannual rainfall variability (more extreme dry and wet years)

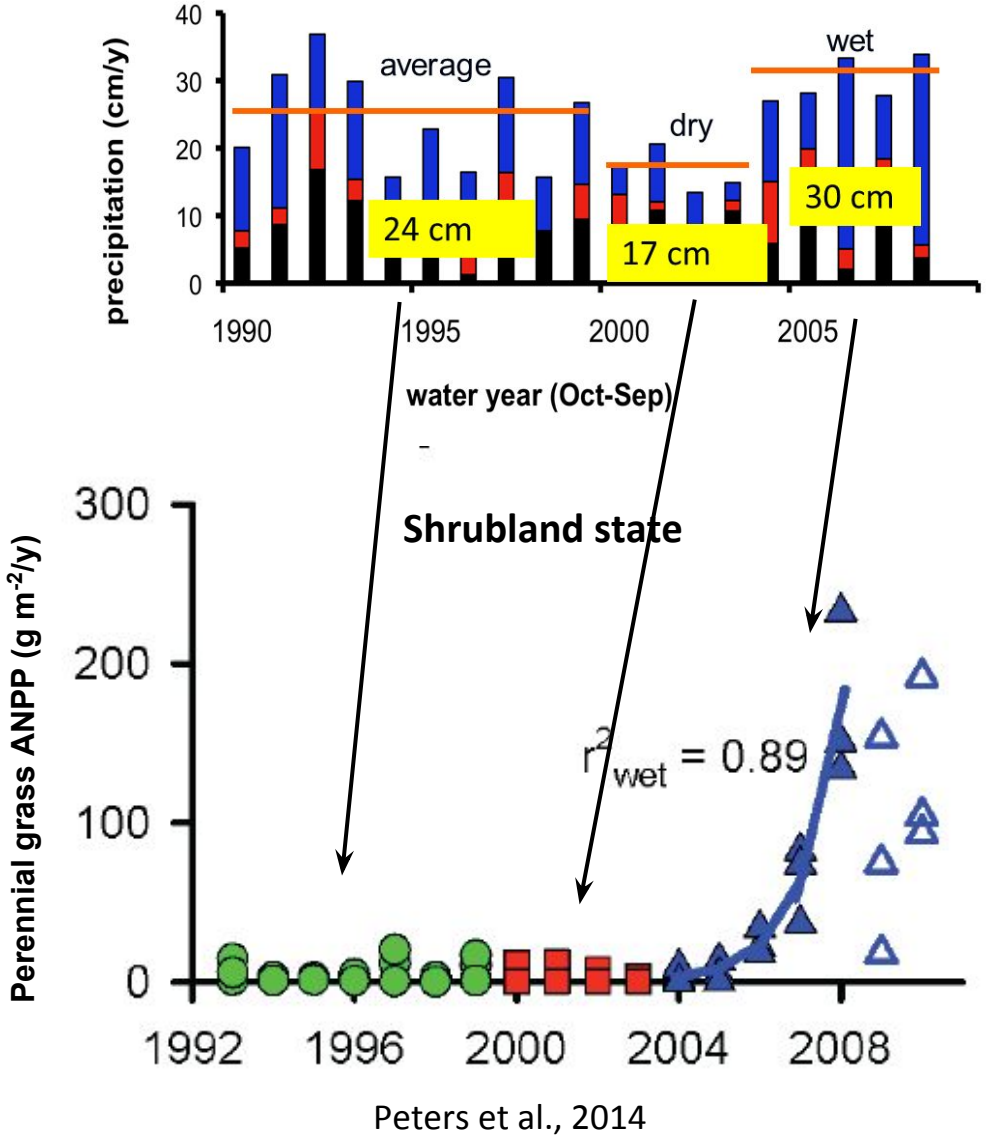




As variability increases, grasses lose, shrubs win

Gherardi and Sala, PNAS, 2015

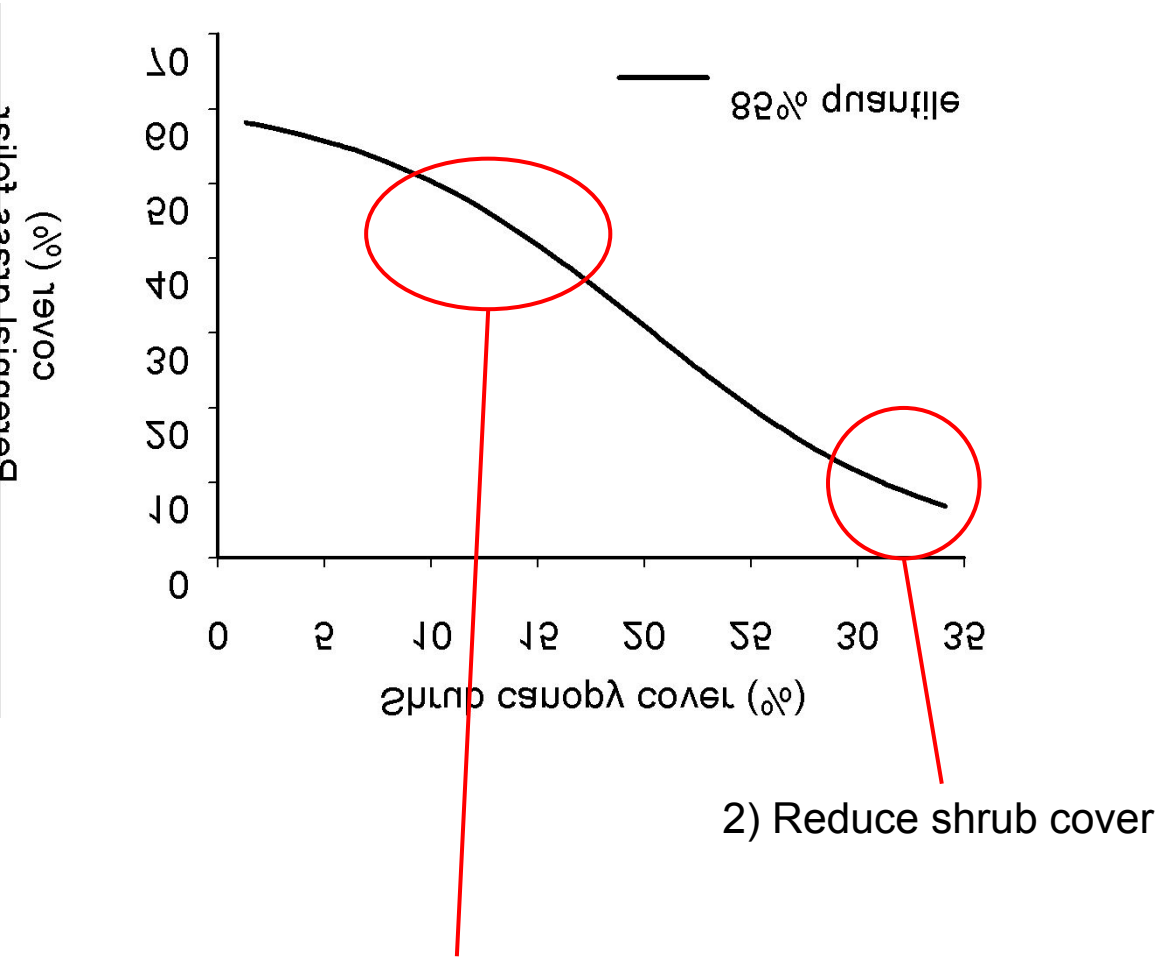
But extreme rainfall years can catalyze abrupt grass recovery



Peters et al., 2014

Non-linear response of grass production to a sequence of 5 wet years

How to promote grass cover within increasingly shrub-dominated environments?



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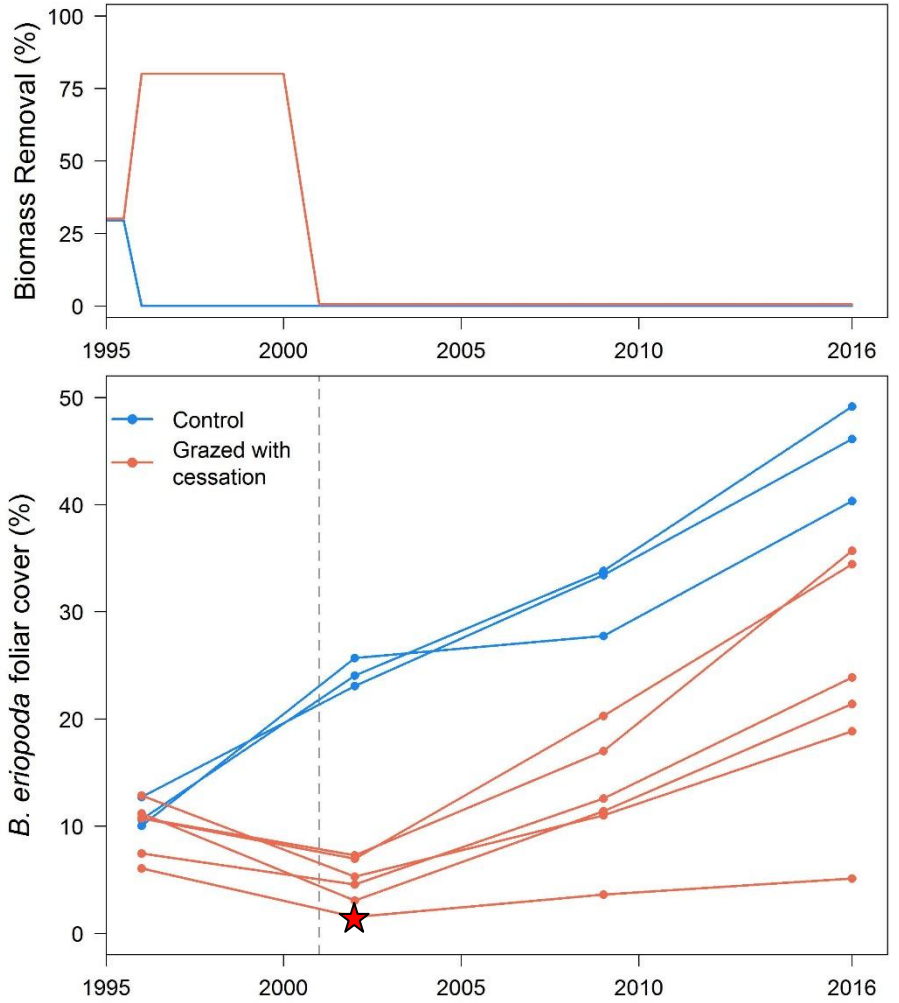
Can grasses recover with rest after heavy grazing episodes?

- **Started at moderate grazing pressure with moderate shrub and low grass cover**
- **Controls—no grazing for 20 years**
- **Treatments—very heavy grazing pressure for 4 years, then no grazing for 16 years**



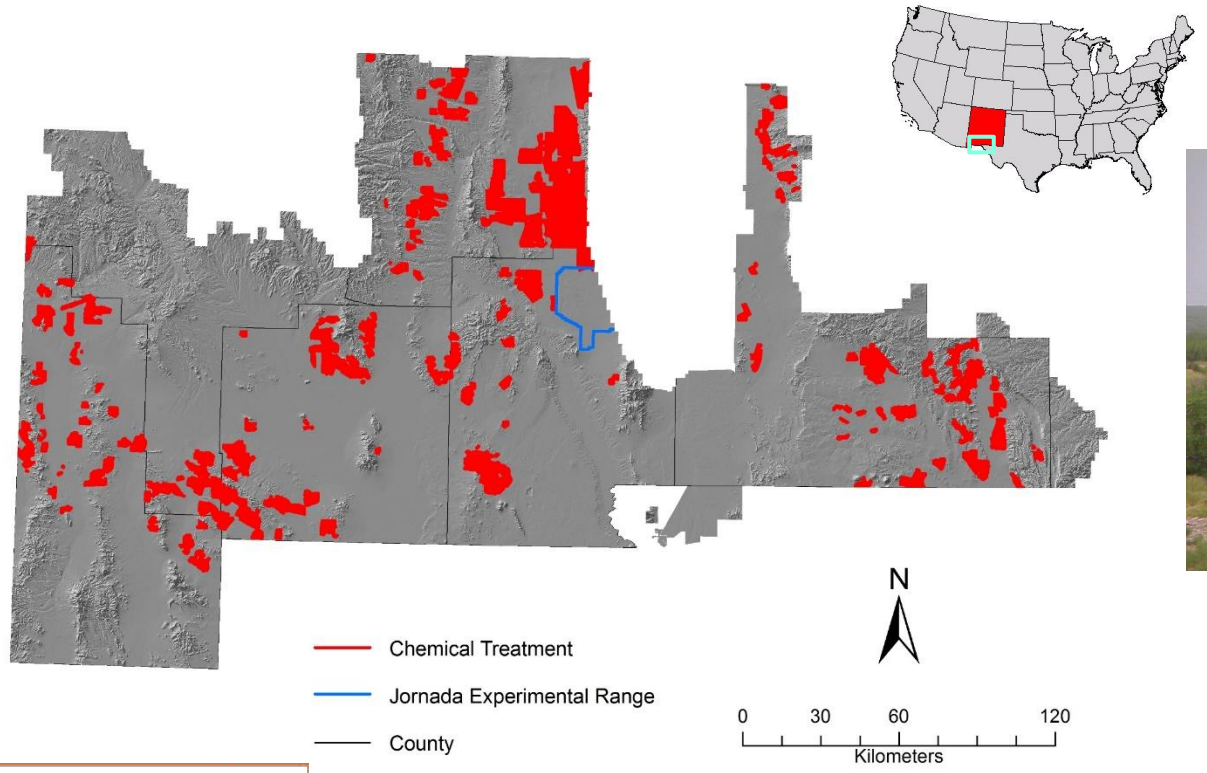
Bestelmeyer et al., Ecology Letters, 2013,
Ratajczak et al., in press.

Recovery is slow, and if threshold crossed, very slow

If shrub cover is high—shrub removal required to increase grasses

Over 2 million acres of treatments in last 30 years

Controversial because efficacy unknown



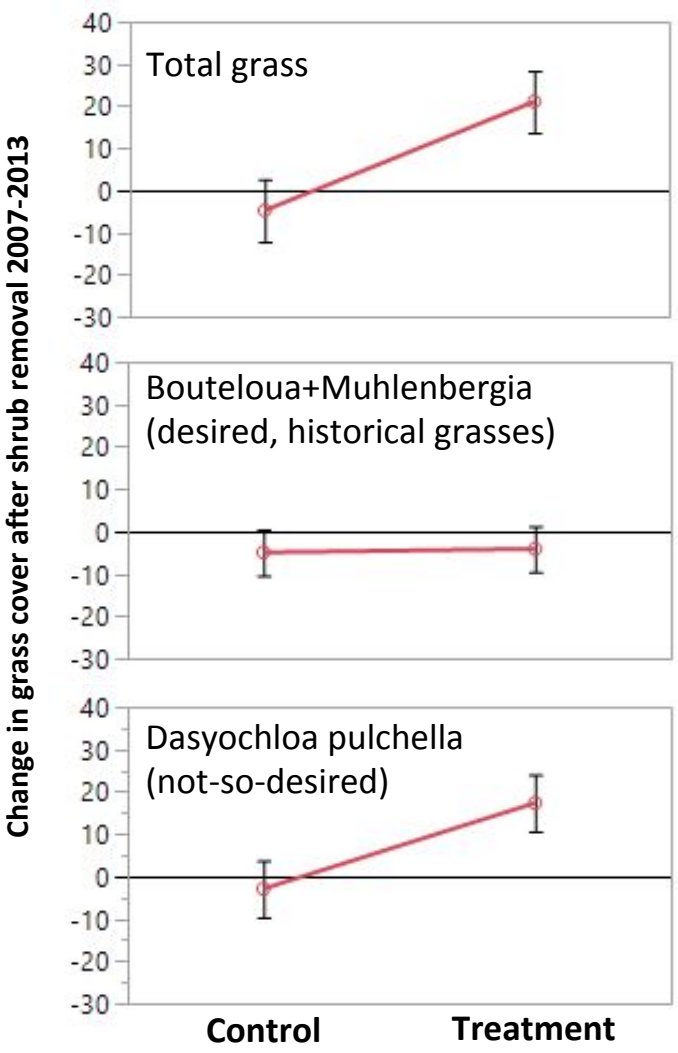
RESTORE NEW MEXICO

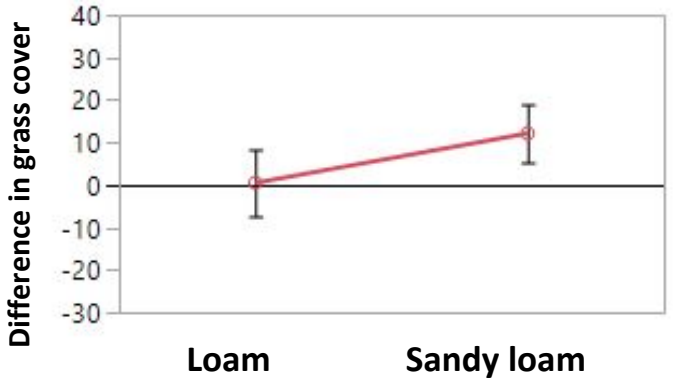
Collaborative long-term research with managers: is shrub removal effective?

- Quasi-experiments for older treatments (1982-2004)
- True experiments for newer treatments (2007-present)

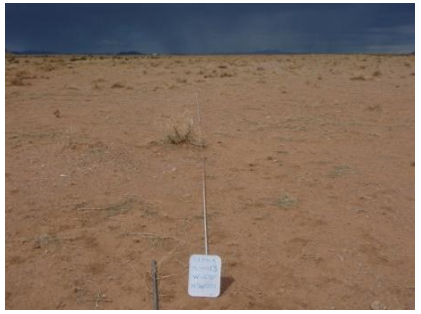
Grass recovery can occur on the right soils, but it's not "restoration"

Shrub thinning promotes grass, but not the original species

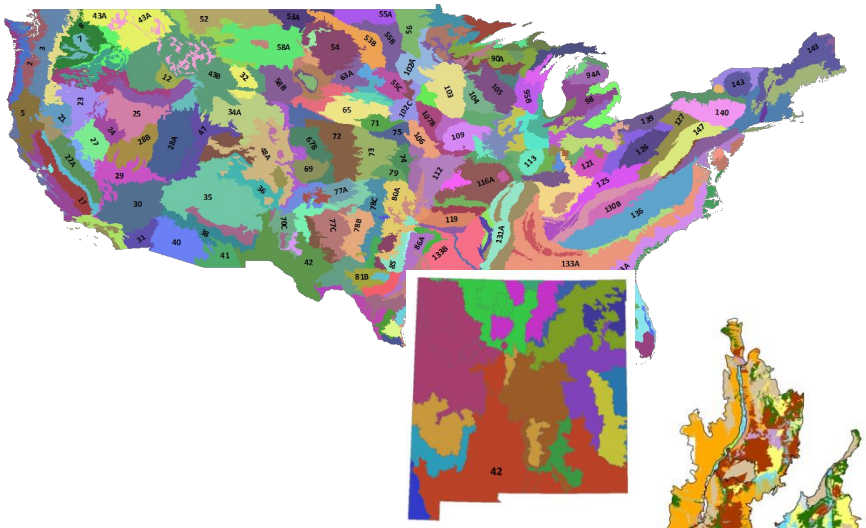


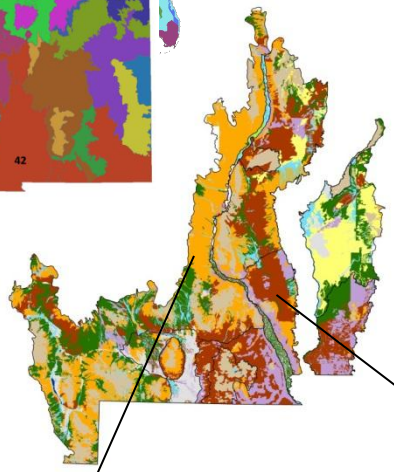


Avoid soils with loamy surface textures and signs of severe degradation



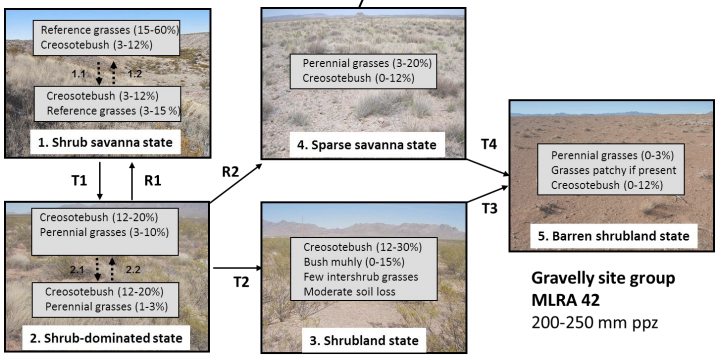
Synthesis of long-term data for management tools





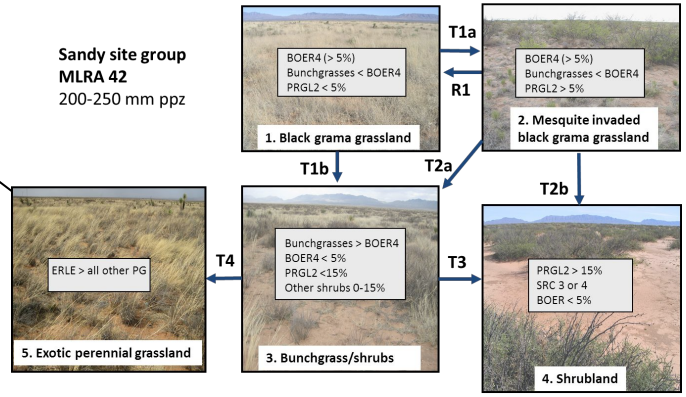
National Ecological Site Information System
(USDA Natural Resources Conservation Service)

- Ecological information linked to soil maps
- State-and-transition models synthesize ecological and management information
- LTER science refines guidelines for grazing, herbicide use, and monitoring



Gravelly site group
MLRA 42
200-250 mm ppz

Sandy site group
MLRA 42
200-250 mm ppz



JRN contributions to desertification and resilience science

- Abrupt grass loss triggers landscape-level feedbacks promoting shrub dominance
- Increased climate variability will further reinforce shrub dominance
- Management to promote grass recovery needs to account for ecological thresholds and accept novelty

The importance of long-term data and LTER

- Different processes cause change in different time periods
- Such insights essential to guide and adjust management and policy