Grassland Resilience Workshop Series
Brush Management and Soil Health
Virtual Kick Off

Overview presentation

Santa Rita Experimental Range

Altar Valley

Las Cienegas National Conservation Area

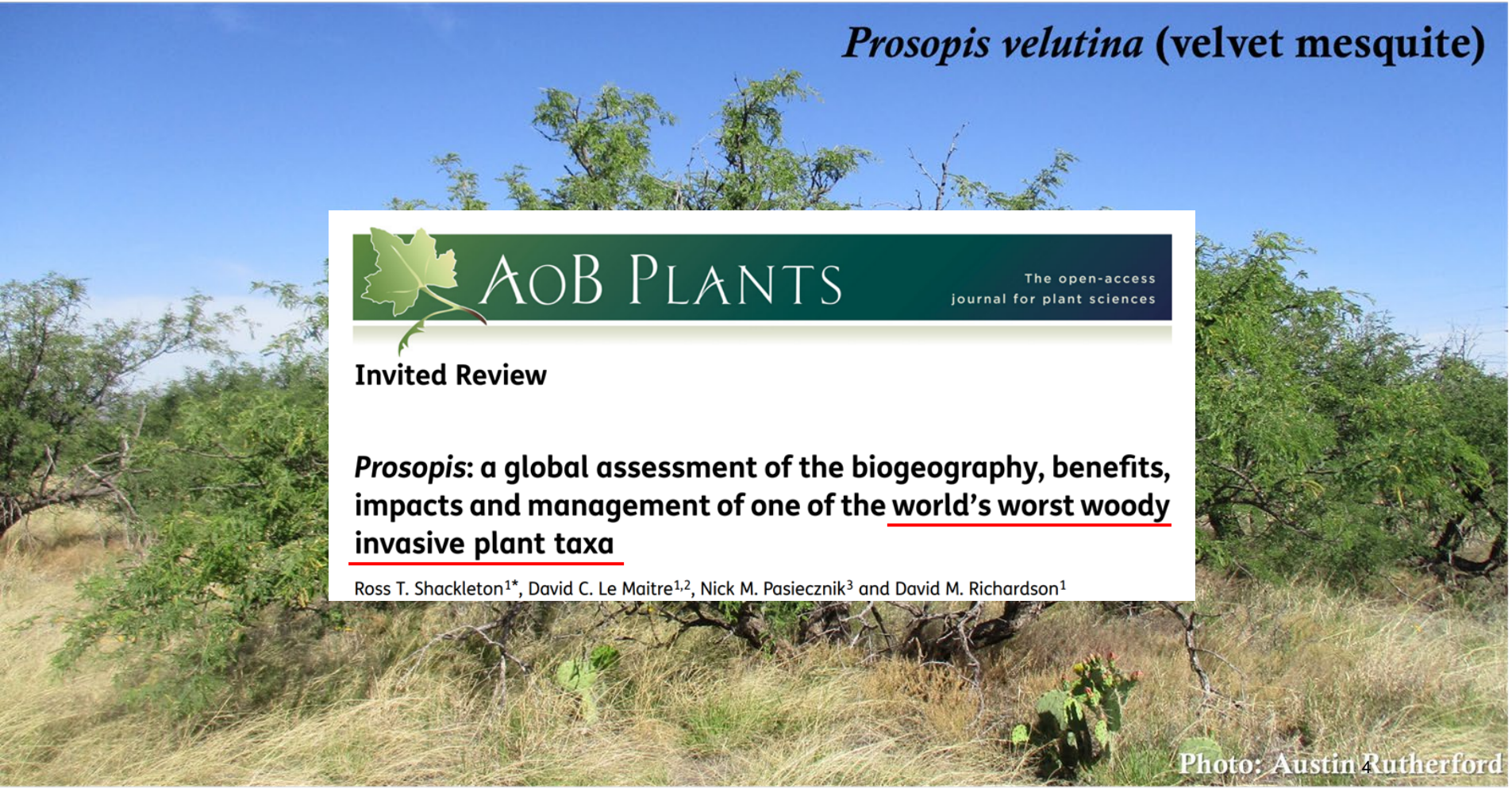
Brush Treatments and Soil Health

CART Introductory Workshop
Tuesday, October 10, 2023

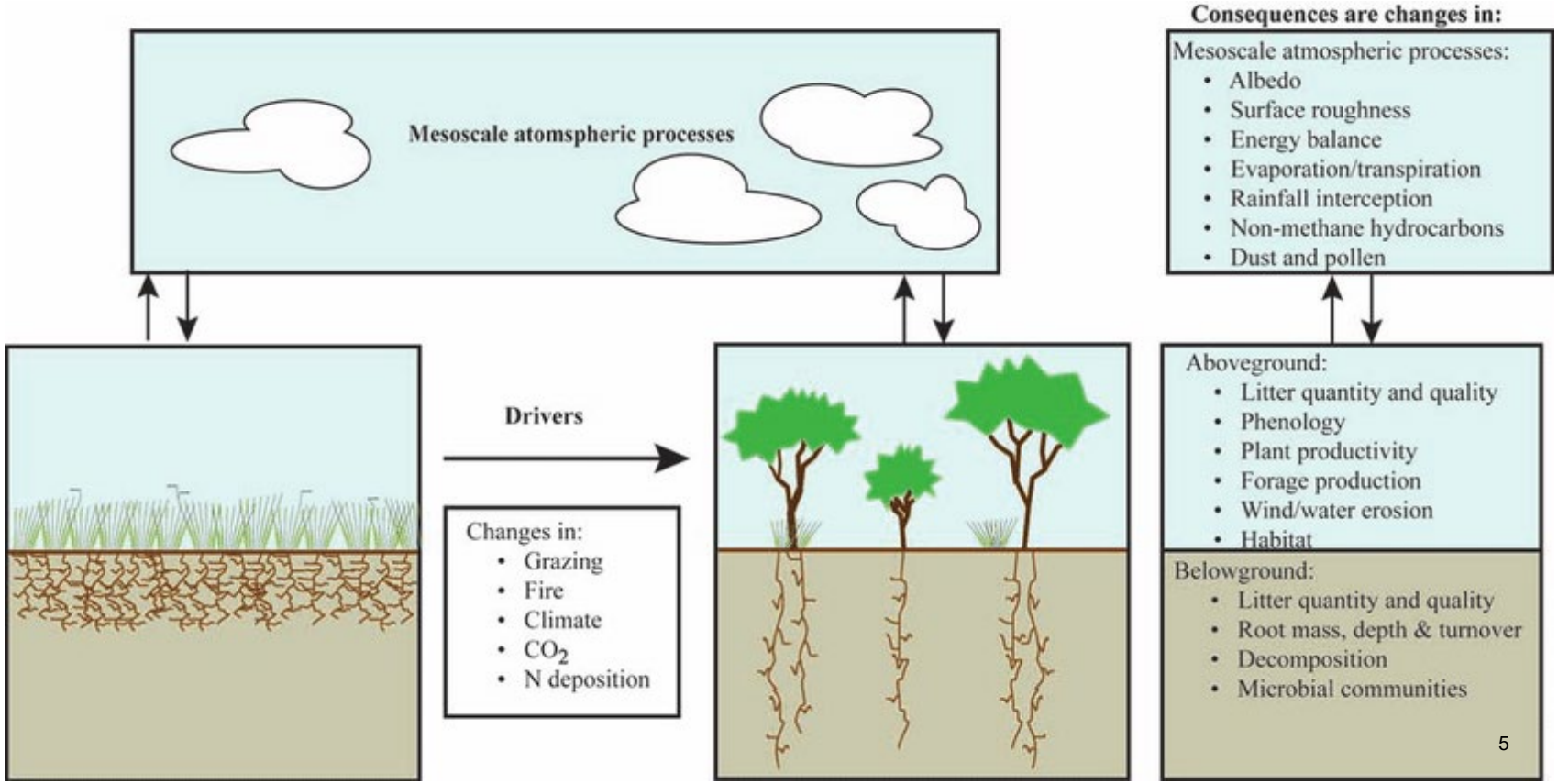
Shrub Encroachment

A Global Issue!

https://ag.arizona.edu/srer/photos/PS332/ps332.htm

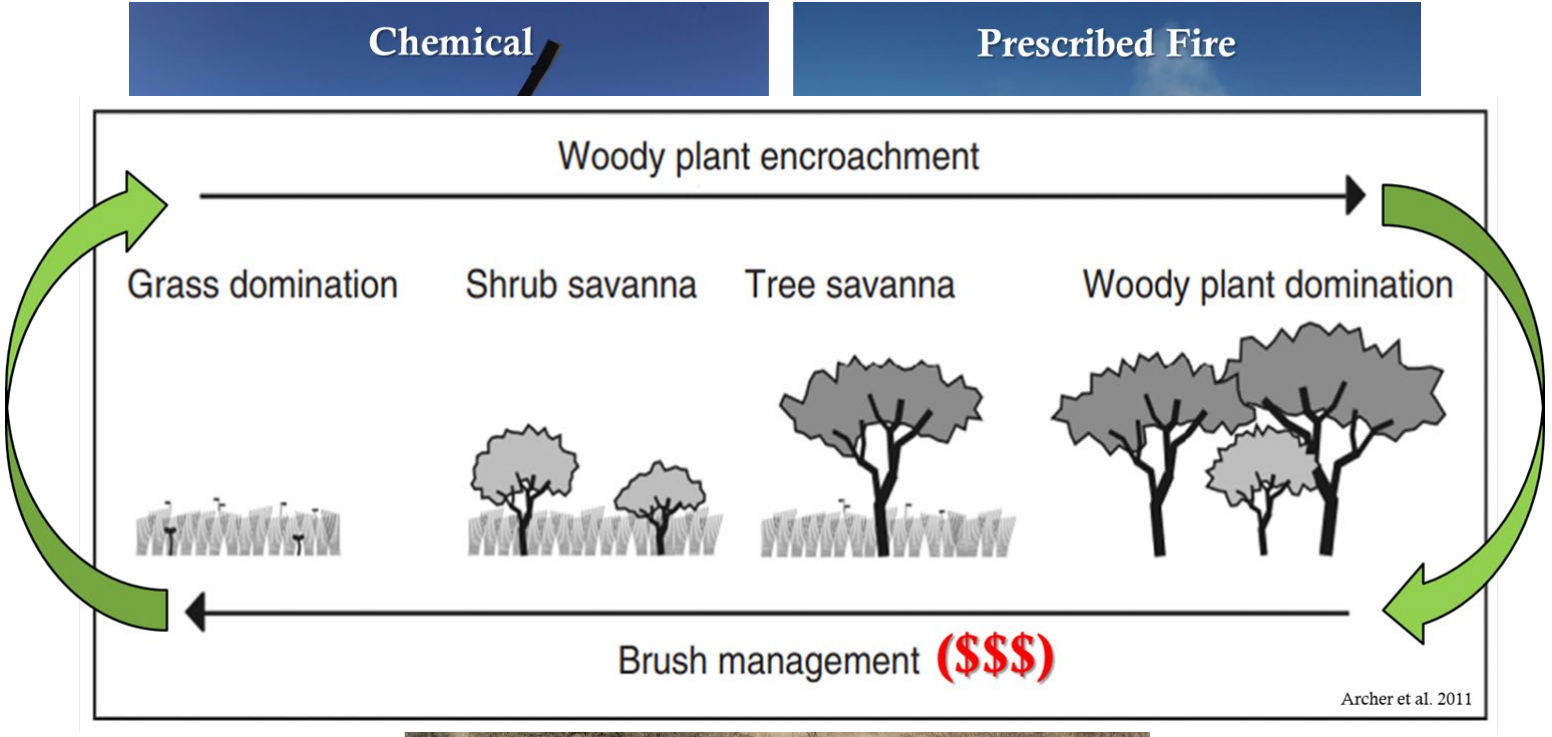

Prosopis velutina (velvet mesquite)
AoB PLANTS
The open-access journal for plant sciences
Invited Review
Prosopis: a global assessment of the biogeography, benefits, impacts and management of one of the world's worst woody invasive plant taxa
Ross T. Shackleton[1*], David C. Le Maitre[1,2], Nick M. Pasiecznik[3] and David M. Richardson[1]
Photo: Austin Rutherford

Consequences of Shrub Encroachment



Archer et al. 2011

Brush Management




1 Year Later

Reasons for Brush Treatments

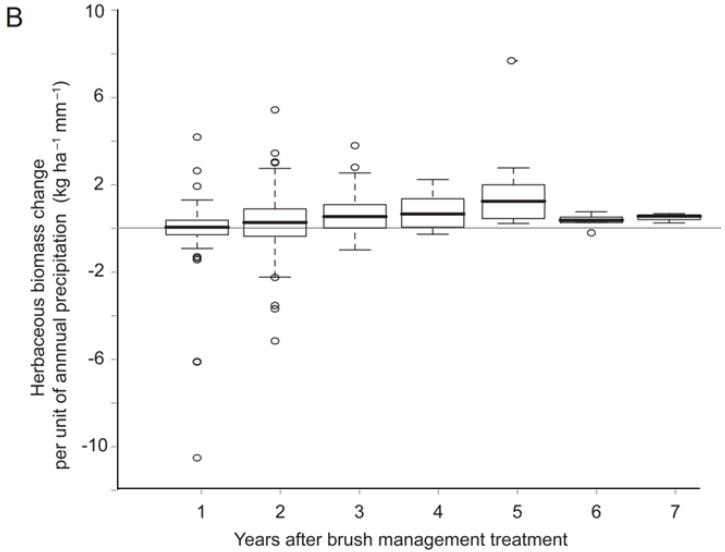
Every area has different reasons for treating brush. Some examples:

- Las Cienegas National Conservation Area - Multiple use (recreation, wildlife, grazing)
- Altar Valley - Livestock operations, wildlife species are grassland obligates; soil retention; many land ownerships
- Santa Rita Experimental Range - Initially livestock forage; transitioning into wildlife, fuel load production supporting ranchers

What is possible with brush treatments?

- Treatments have shown that a series of brush treatments CAN:
  - Decrease the density and size of mesquite
  - Directly kill some mesquite
  - Change habitat conditions for wildlife
  - Modify fuel conditions to faster-burning fuels
  - Keep ground cover and soils (with certain methods)

- We are NOT sure if brush treatments can:
  - Result in a self-sustaining, biodiverse grassland
  - Increase ground cover (e.g. grasses and forbs)
  - Always reduce soil erosion?
  - Directly influence the diversity of soil communities



Archer et al. 2011

Site Selection

- Topo-edaphic characteristics of the site
- Current condition of the site
- Potential treatment methods
- Land ownership
    - Some methods are not feasible on public land
    - Permitting easier for private land

Treatment Timing

When choosing a treatment, consider the timing:

- Mechanical - timing is flexible but resource intensive
- Herbicide - intense requirements for temperature, rainfall, wind, and mesquite phenology
- Prescribed fire - enough fuel to carry a fire? Climatic conditions
- After treatment:
  - Rain?
  - Re-seeding

Treatment Cycle

All treatments need follow-up maintenance!

Follow-up treatments

Timing

- Best to re-treat before mesquite are mature (1-7 years)

Potential combinations that seem to be working (i.e., kept mesquite cover down):

- Grubbing + grubbing
- Grubbing + herbicide
- Backpack herbicide + backpack herbicide
- Aerial herbicide + backpack herbicide
- Fire + grubbing

Monitoring

- Common methods:
  - Photos
  - Line point intercept
  - Live canopy cover
  - Tree size/age
  - Utilization by wildlife
  - Precipitation
- Connection to soils
  - Sampling of soil microbial community
  - Runoff models - KINEROS, RHEM
    - How are models effective and ineffective at considering appropriate variables to convey erosion and soil health?
  - Vegetation species presence as indicator of soil conditions

Remaining Questions

- What are the impacts of mesquite treatments on soil health?
  - Different methods have different impacts
  - What should we be measuring?
    - Soil hydrology
    - Microbial communities
    - Volume of soil retained/lost
    - Rangeland health indicators (soil/litter movement, pedestaling, etc.)
- How to monitor across treatment areas (and get resources for it?)
- What to do with remaining skeletons/brush?
- Are mesquite treatments worth it?
  - What have we accomplished? What is the cost of continuing to maintaining the modified landscape?

What do you see?

The Santa Rita Experimental Range

a brief history of brush management

BRETT BLUM

DIRECTOR, UA SOUTHERN ARIZONA EXPERIMENT STATION

BCB@EMAIL.ARIZONA.EDU

Amon Carter Museum of American Art and Library of Congress

Grazing in the Arizona Territory

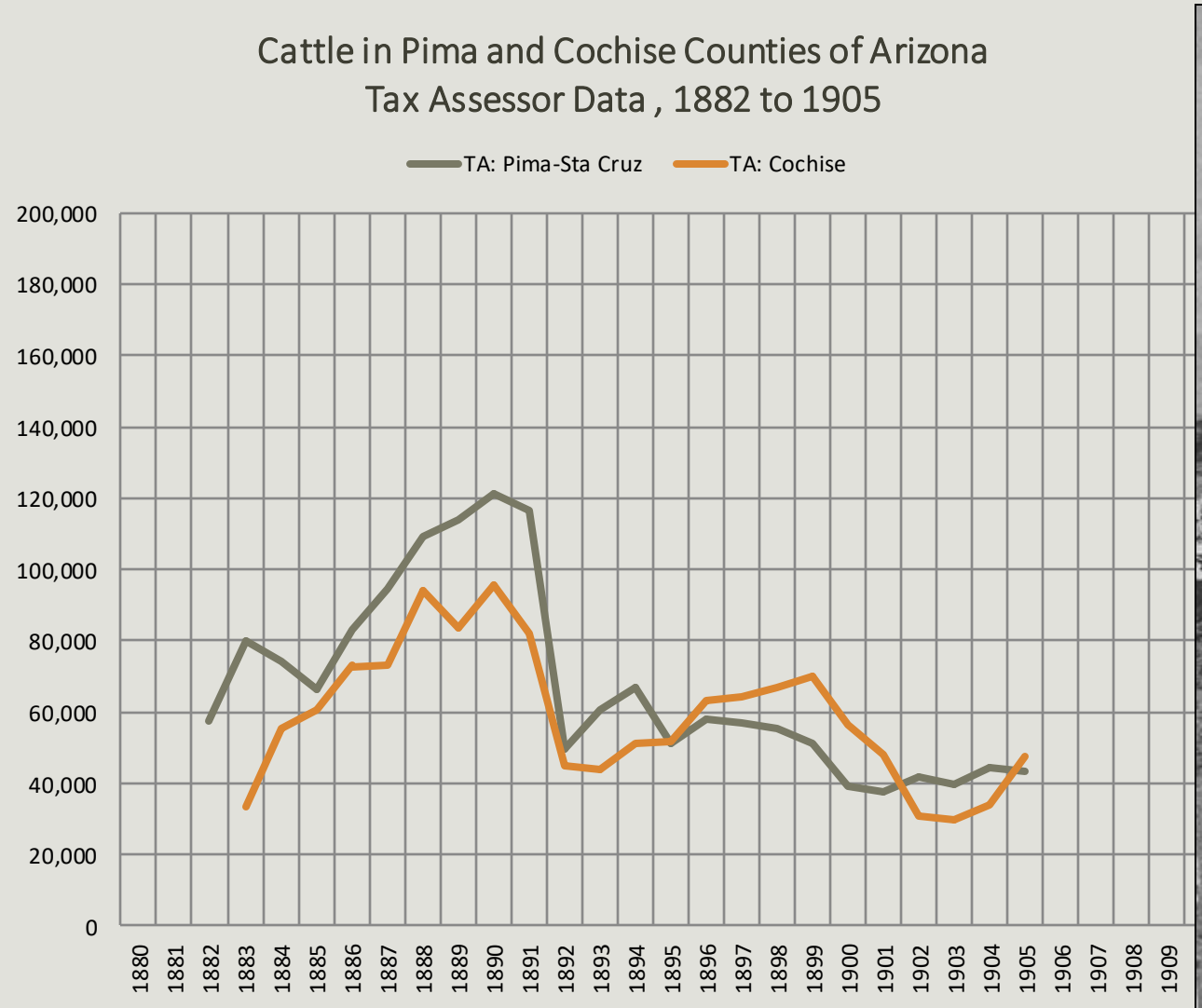


Figure 5.
Dead cattle near Aivaca, Arizona, April 10, 1903. Photography by D. A. Griffiths.
Courtesy of the National Archives, Washington, D.C.
(Photograph No. 823-FB-1700.)

VIEW TAKEN IN A GLADE IN THE CAPITAN MOUNTAINS, NEW MEXICO, TEN MINUTES AFTER A SUMMER SHOWER, SHOWING THE WATER BREAKING THE SOD ON A CATTLE TRAIL, MAKING THE FIRST WASH OR CUT IN THE VALLEY.

Robert H. Forbes

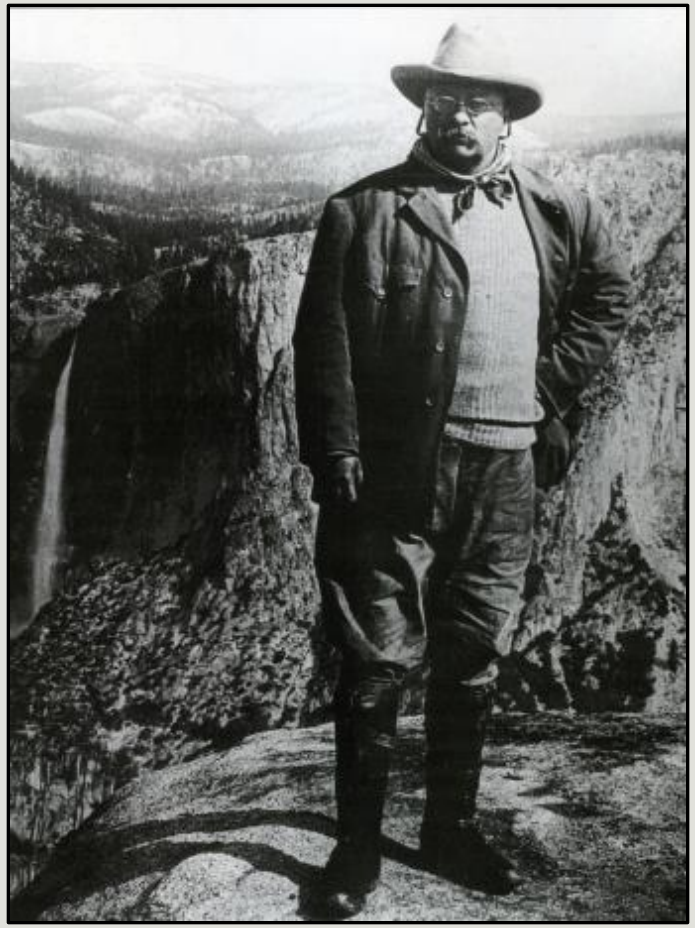
"The ruinous methods which seem inevitable upon a public range, which, being everybody's property, is nobody's care…"

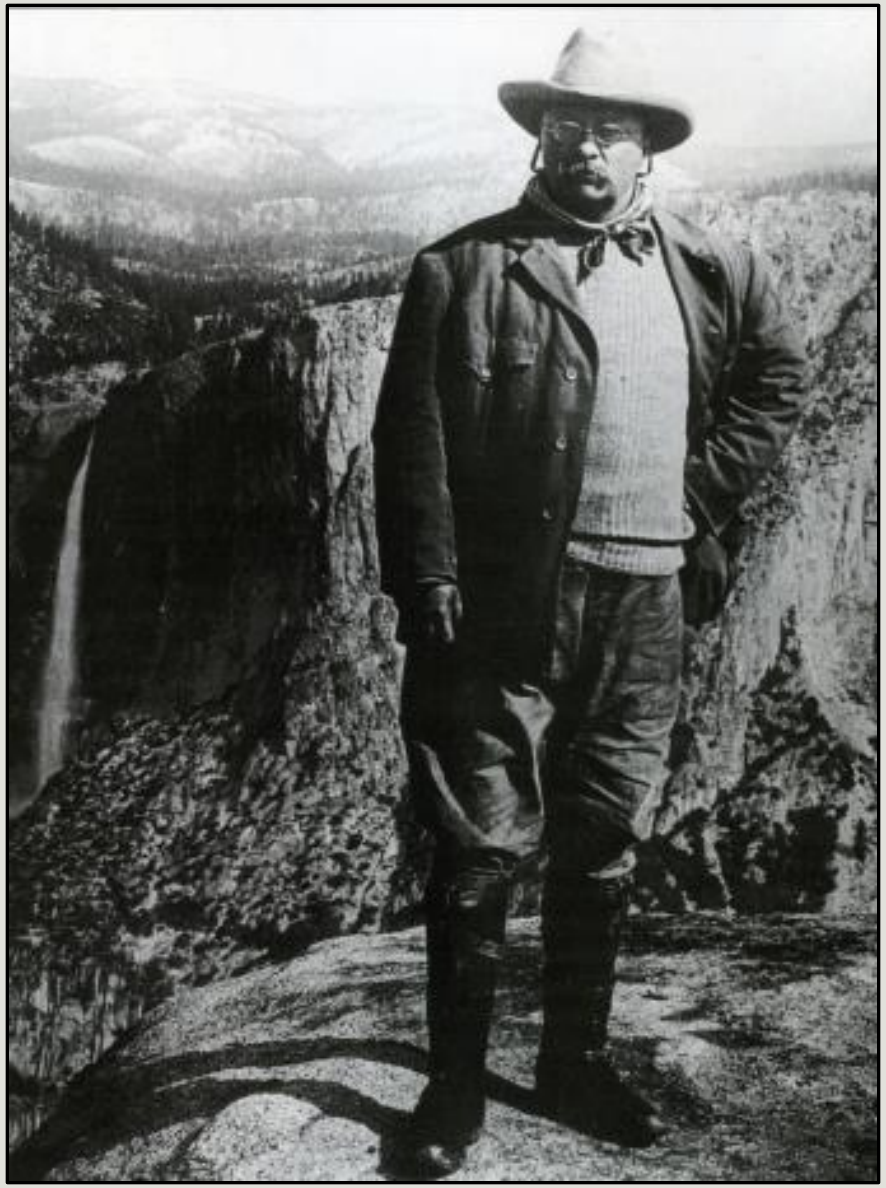
-Robert H. Forbes 1901

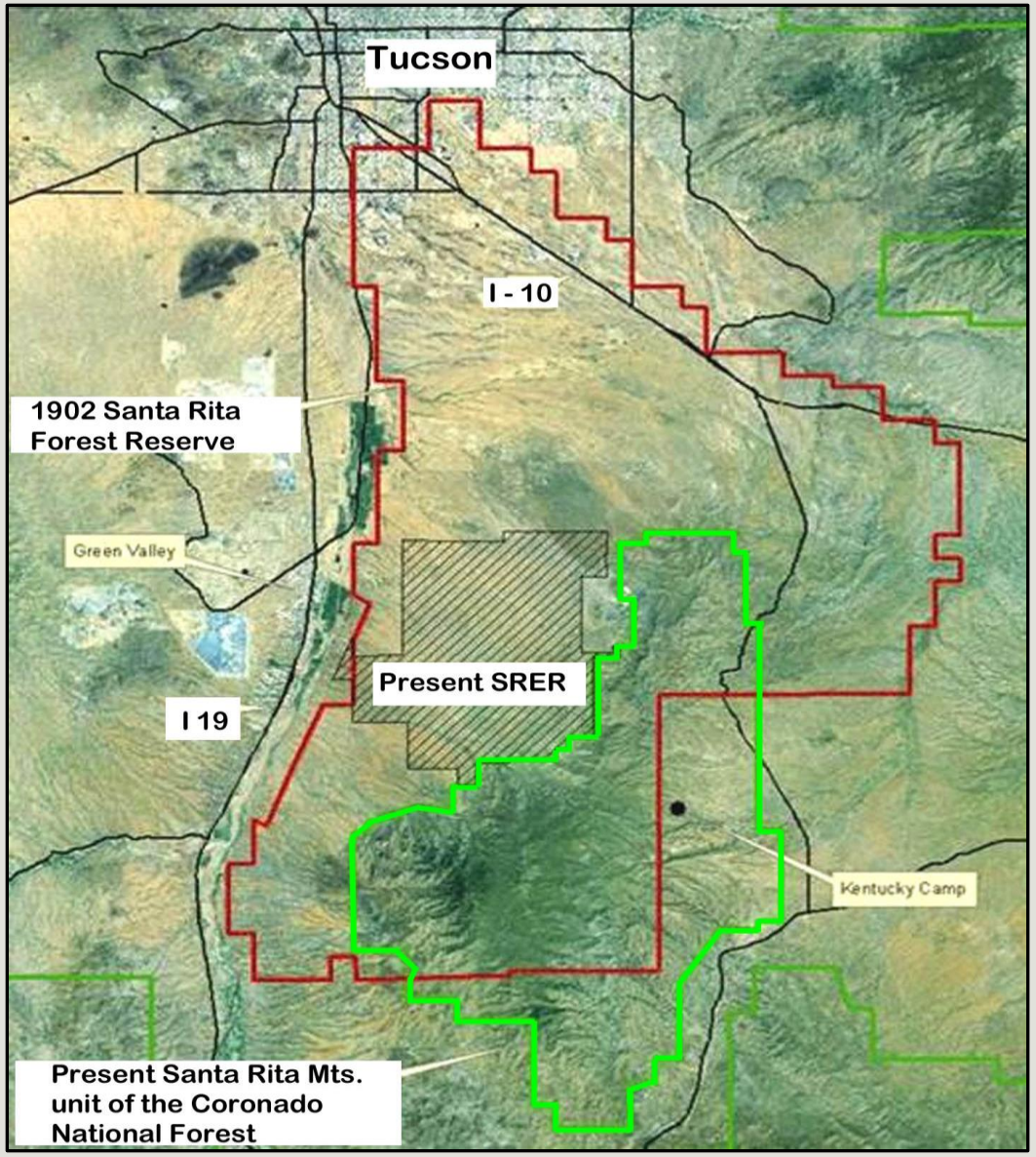
President Theodore Roosevelt

- On April 11, 1902 President Roosevelt issued *Proclamations 467* and *468* establishing the San Isabel Forest Reserve of Colorado and the Santa Rita Forest Reserve (Santa Rita Experimental Range today) of Arizona
- Very first of the public lands designated and reserved under the presidency of Theodore Roosevelt
- *"its [SRER] purpose was expressly understood to be the study of grazing range problems with a view, if possible, to a demonstration on a large and convincing plan, of range restoration and control."*

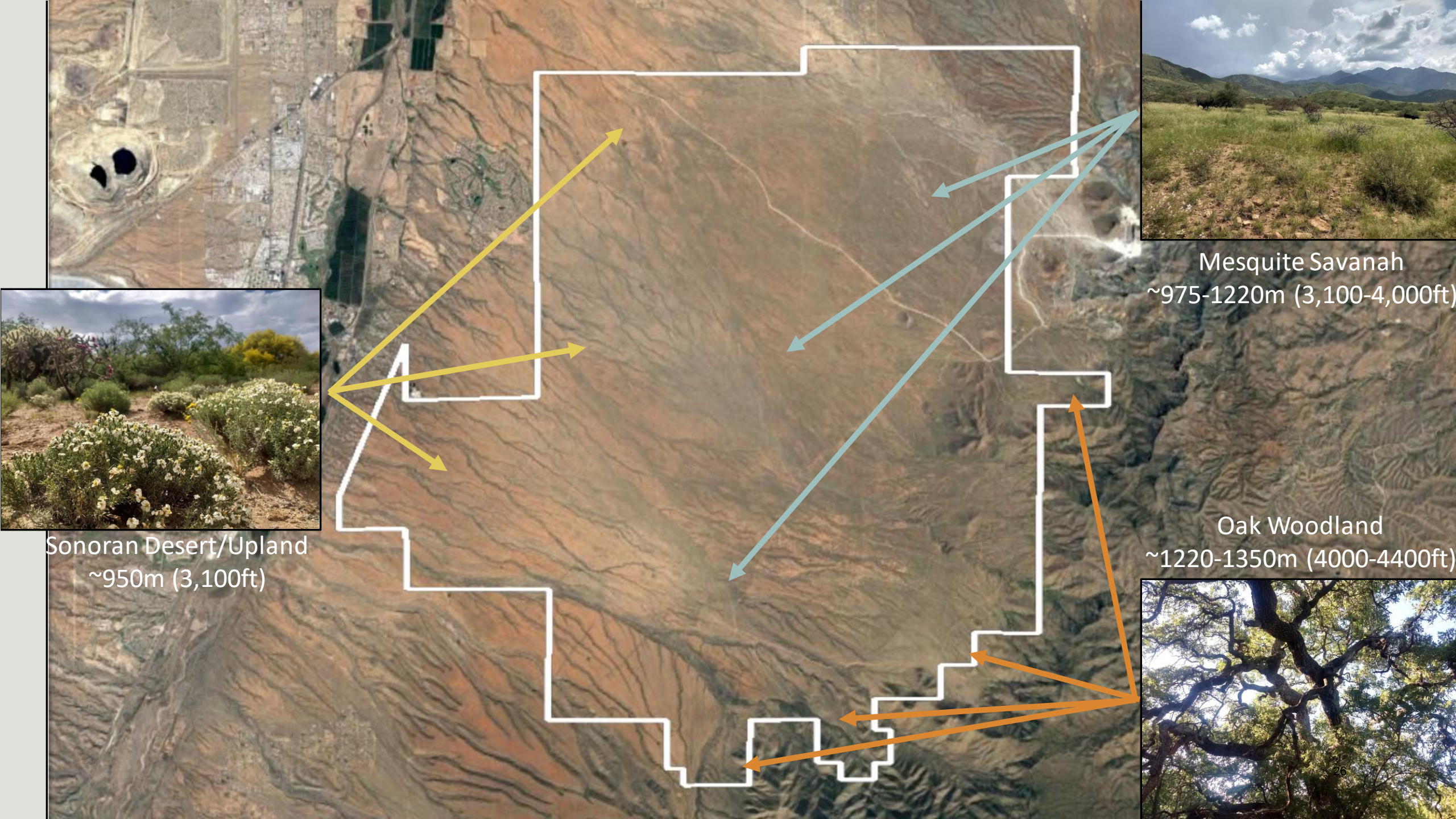
-JJ Thornber






Tucson
I - 10
1902 Santa Rita
Forest Reserve
Green Valley
Present SRER
I 19
Kentucky Camp
Present Santa Rita Mts.
unit of the Coronado
National Forest


Tanque Verde
Tucson
Green Valley
SRER
Las Ciengas
Altar Valley
Sierra Vista
Image Landsat / Copernicus
© 2020 Google
© 2020 INEGI
Google Earth


Mesquite Savanah
~975-1220m (3,100-4,000ft)
Sonoran Desert/Upland
~950m (3,100ft)
Oak Woodland
~1220-1350m (4000-4400ft)

The mesquite problem

SRER: *stocking rate*

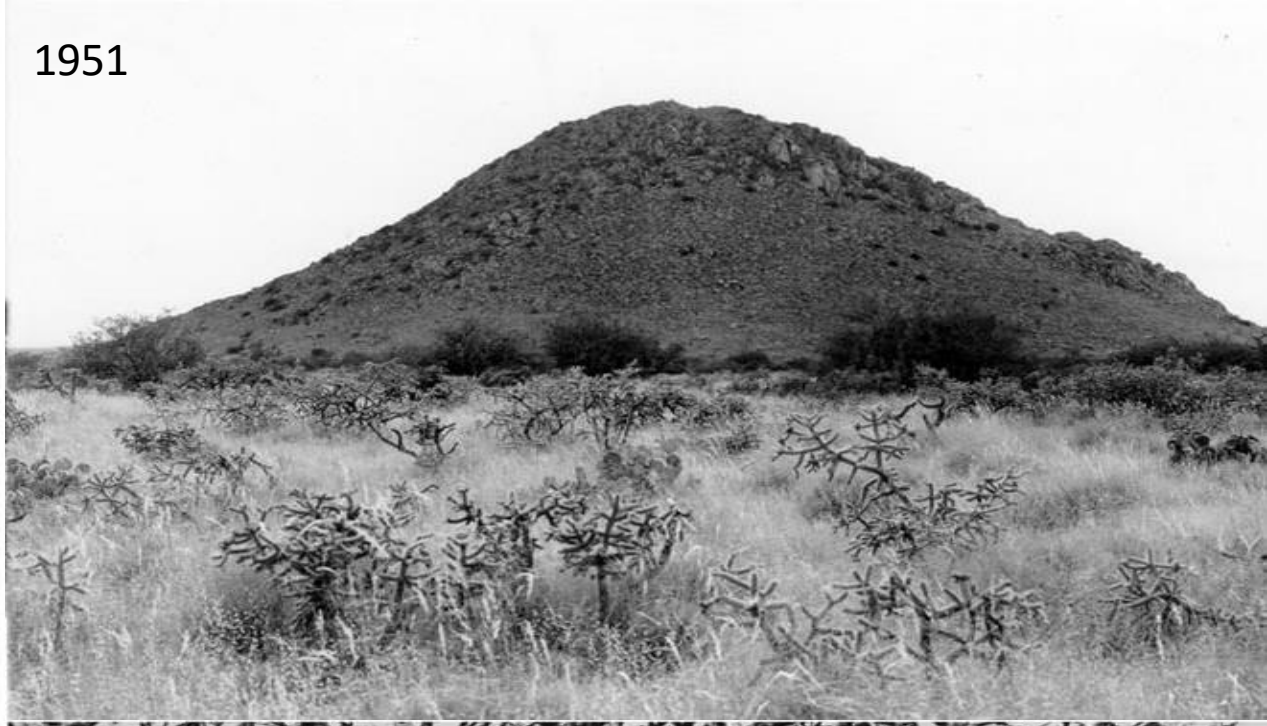
- David Griffith's was original full time researcher on SRER
- Tasked with establishing a standardized stocking rate for cattle across the American West
- This imperative highlights the inherent difficulty in ecological study
- "*in a region where the seasons, the altitude, the slope and the rainfall are so variable*."-David Griffith's, 1904

Huerfano : 1902

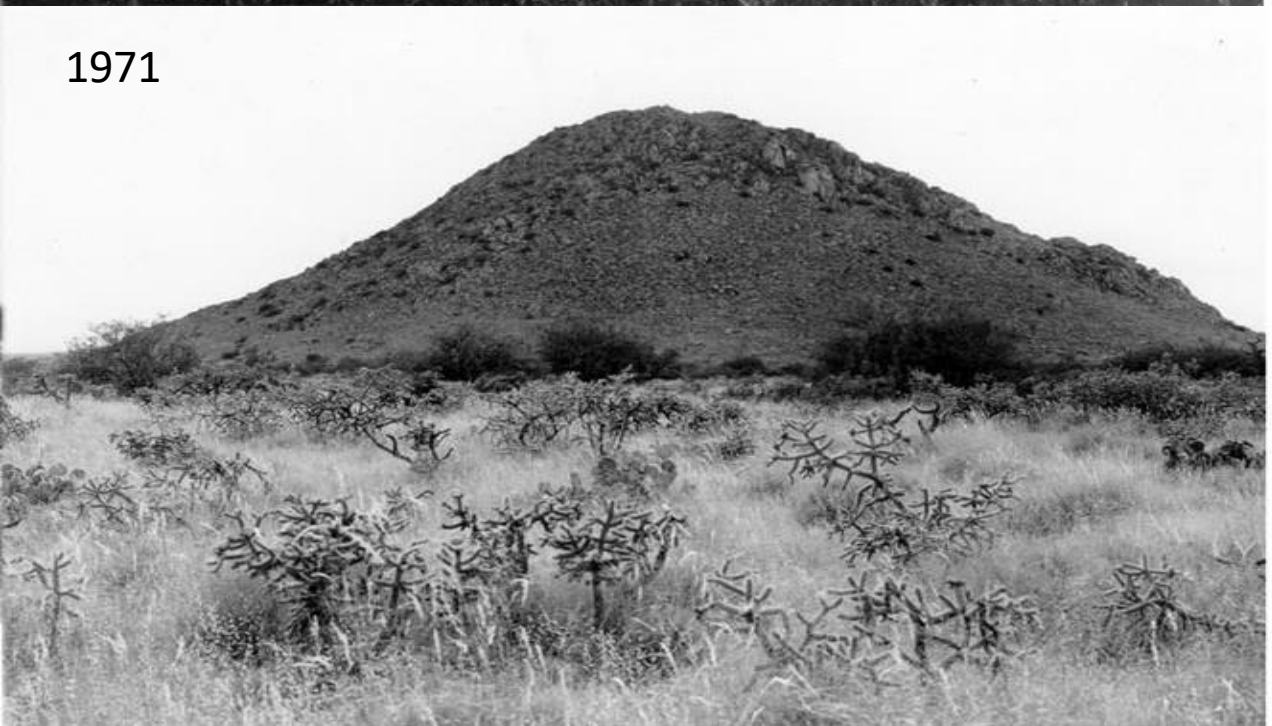

Huerfano : 2019

1902

1951



1971

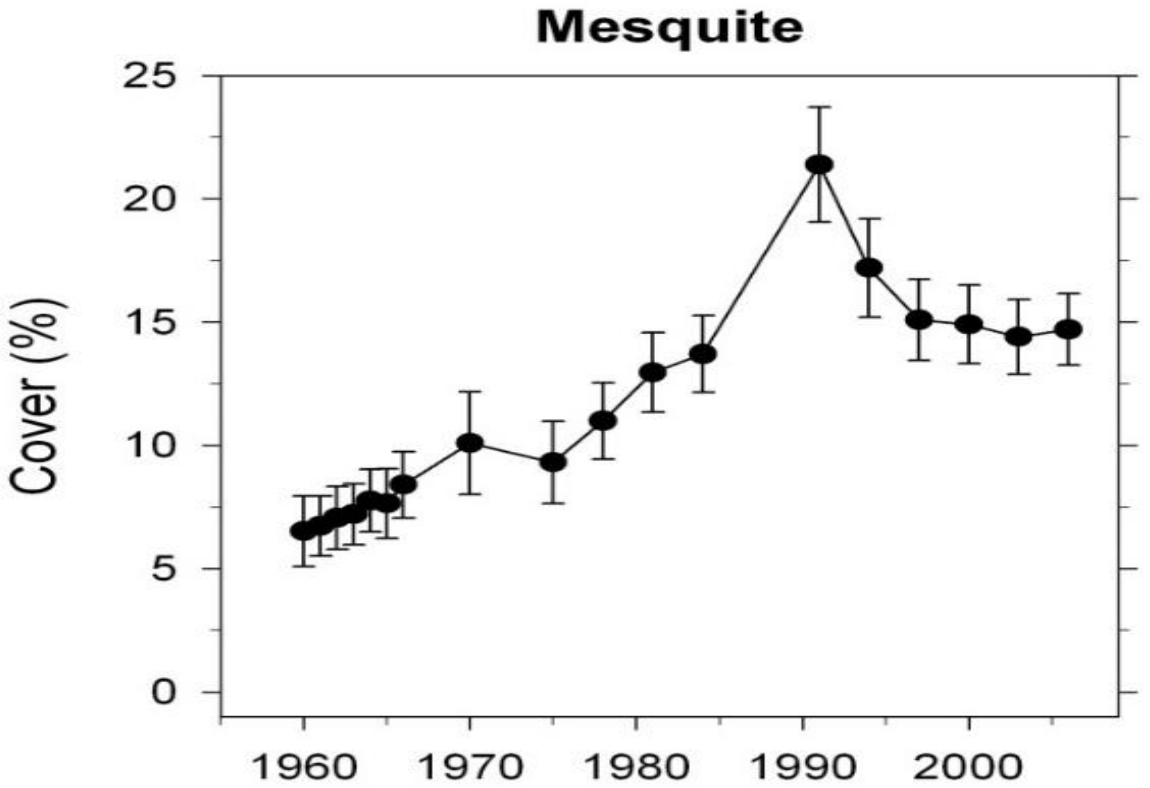


2003

Pasture 8 (looking north over SRER) : 1936

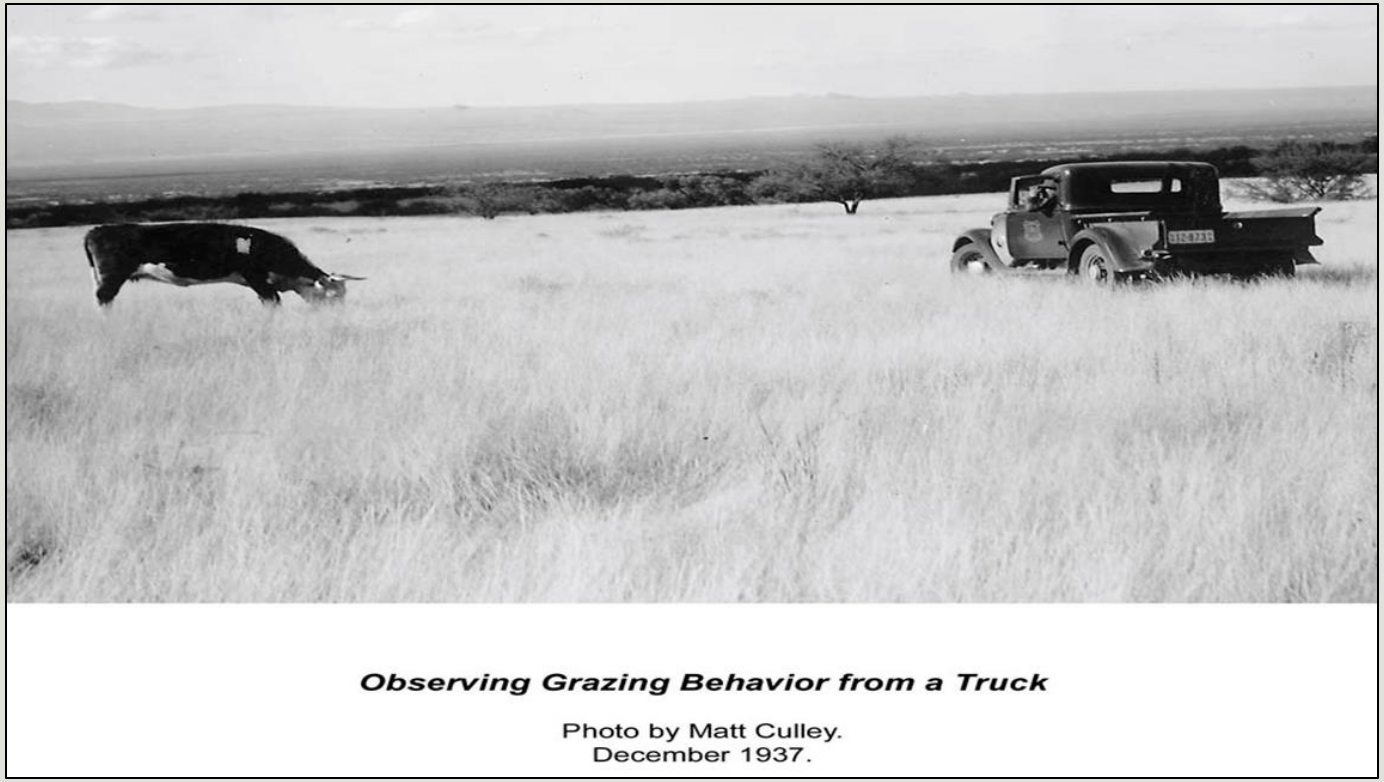
Pasture 8 (looking north over SRER) : 2000

Change in Density and Canopy Cover



Why?

- Mammals as a vector
- Fire suppression/reduction
- Drier and varied precip. regime



Observing Grazing Behavior from a Truck

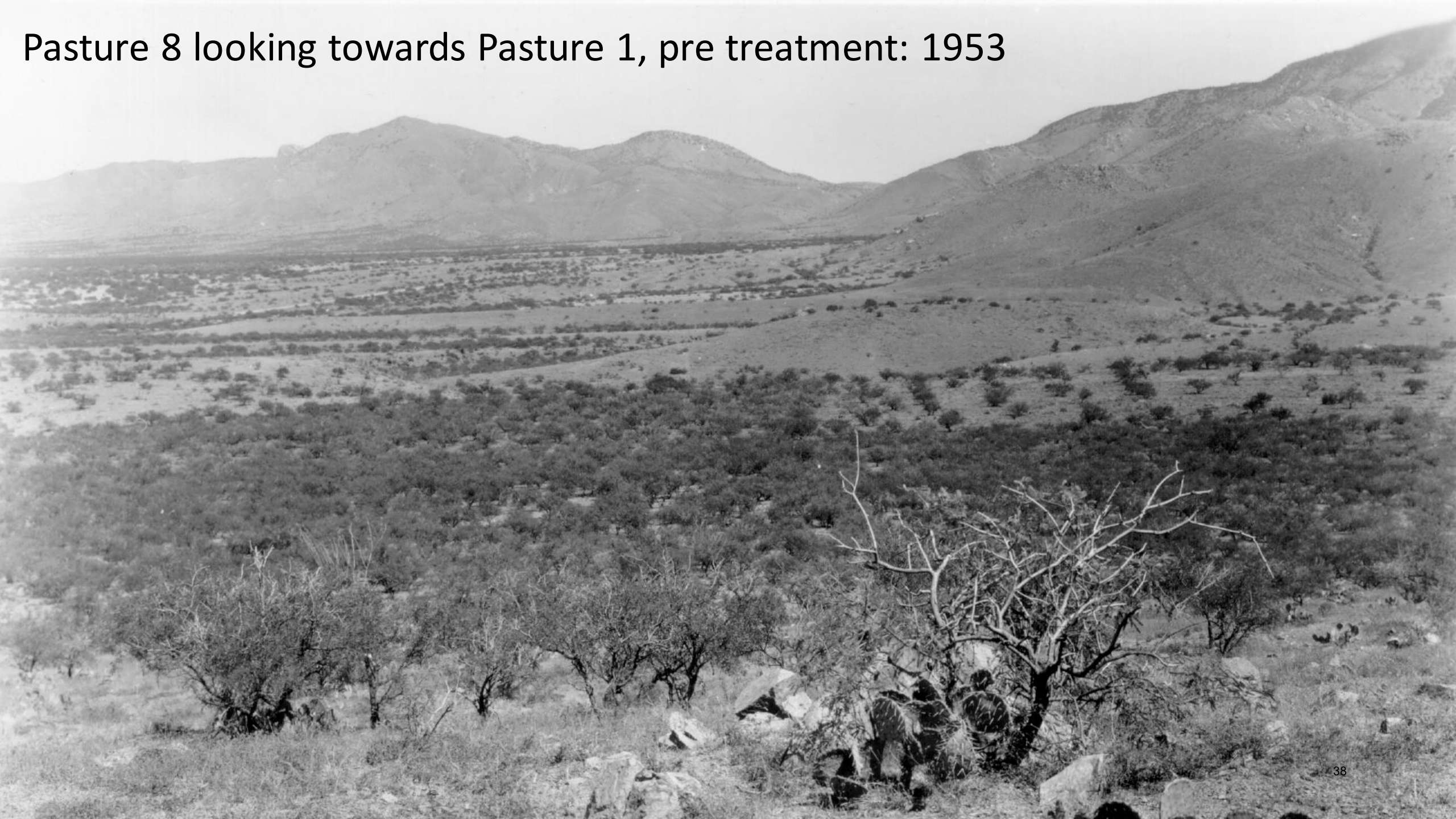
Photo by Matt Culley.
December 1937.

Control methods

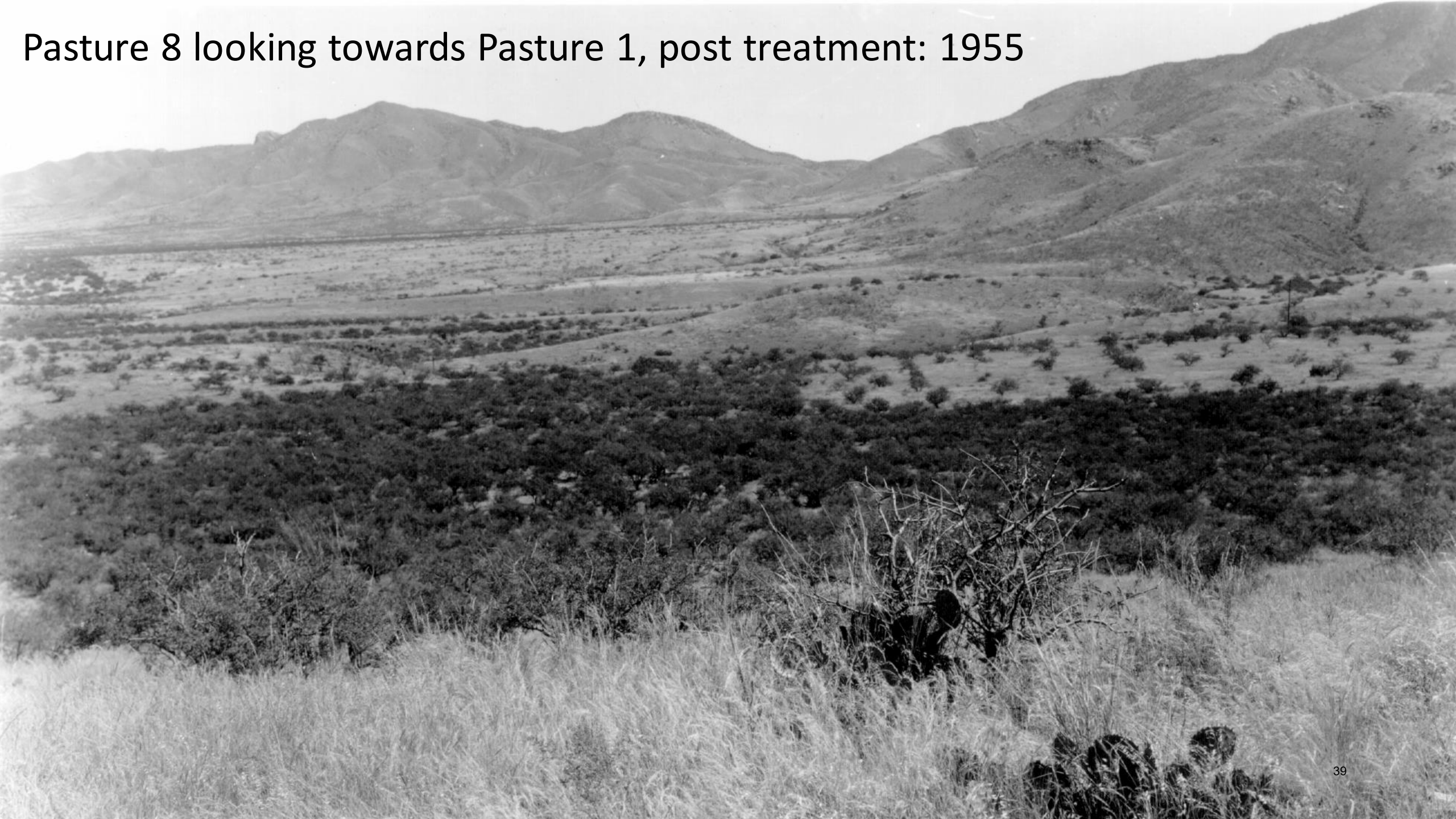
Treatments

- Hand cutting
- Grubbing/chaining
- Pushing
- Fire
- Herbicide (aerial and hand application)
- pH adjustment
- Alkalinity adjustment
- Combination of allof the above

Pasture 8 looking towards Pasture 1, pre treatment: 1953



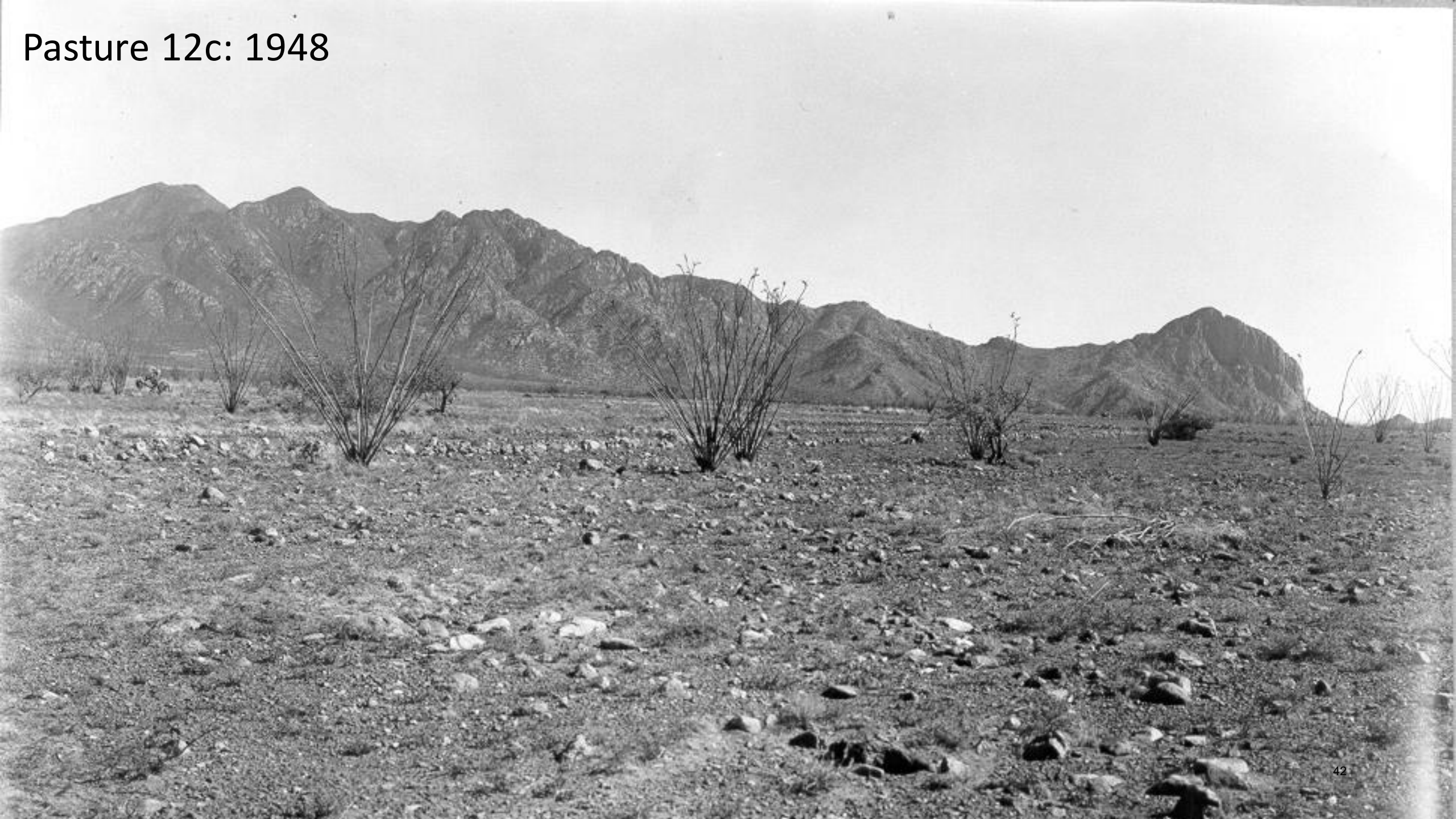
Pasture 8 looking towards Pasture 1, post treatment: 1955



Pasture 1 : 67 years post treatment

Areas of limited change

Pasture 12c: 1948

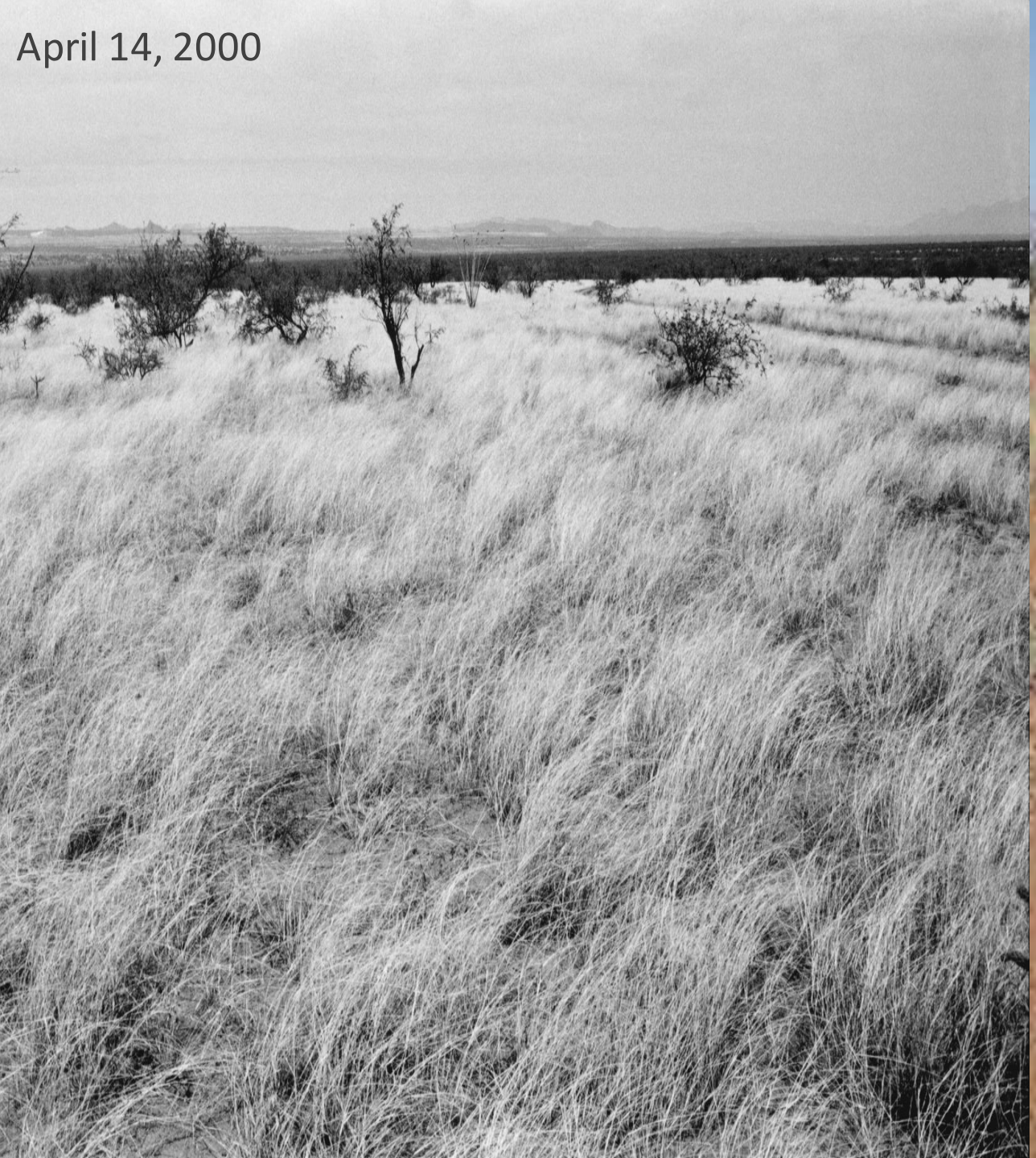


Pasture 12c: 2019

Pasture 1: 1948

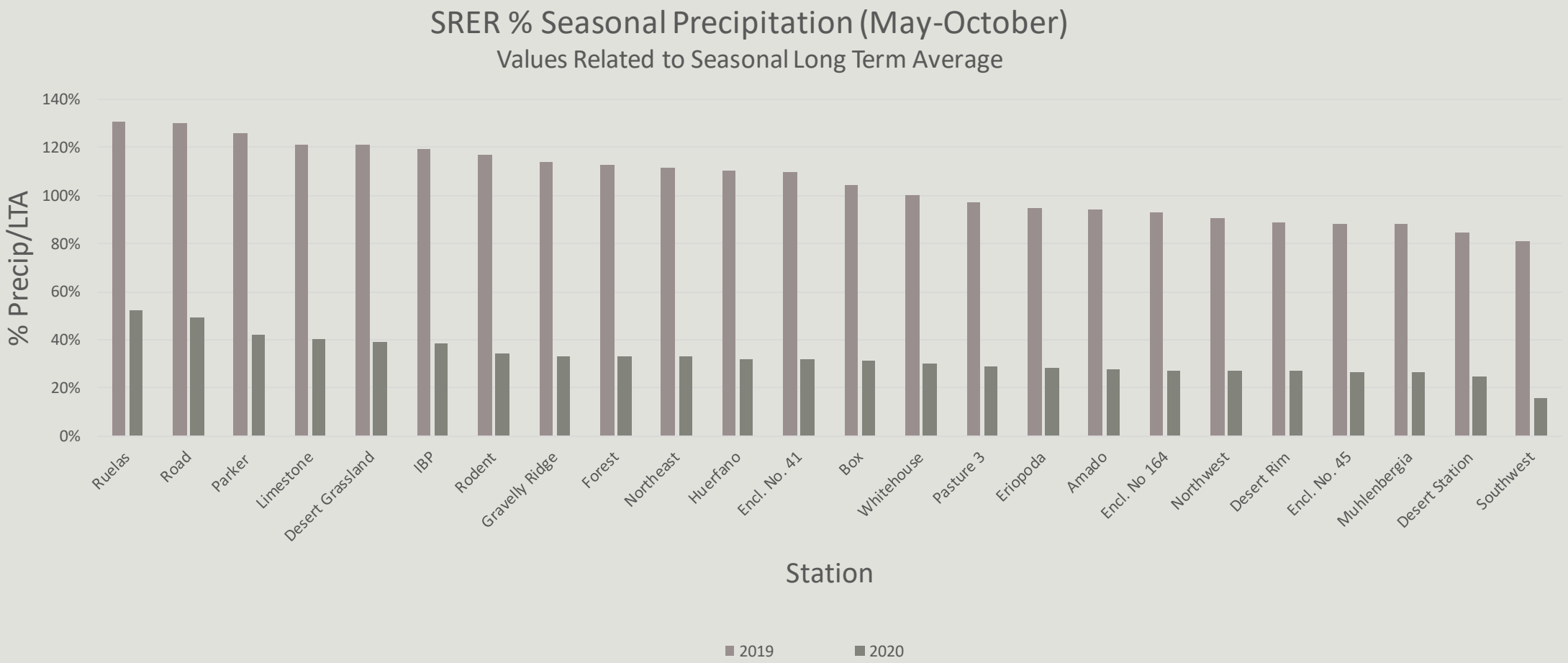
Pasture 1: 2019

It's complicated…


April 14, 2000


March 15, 2007

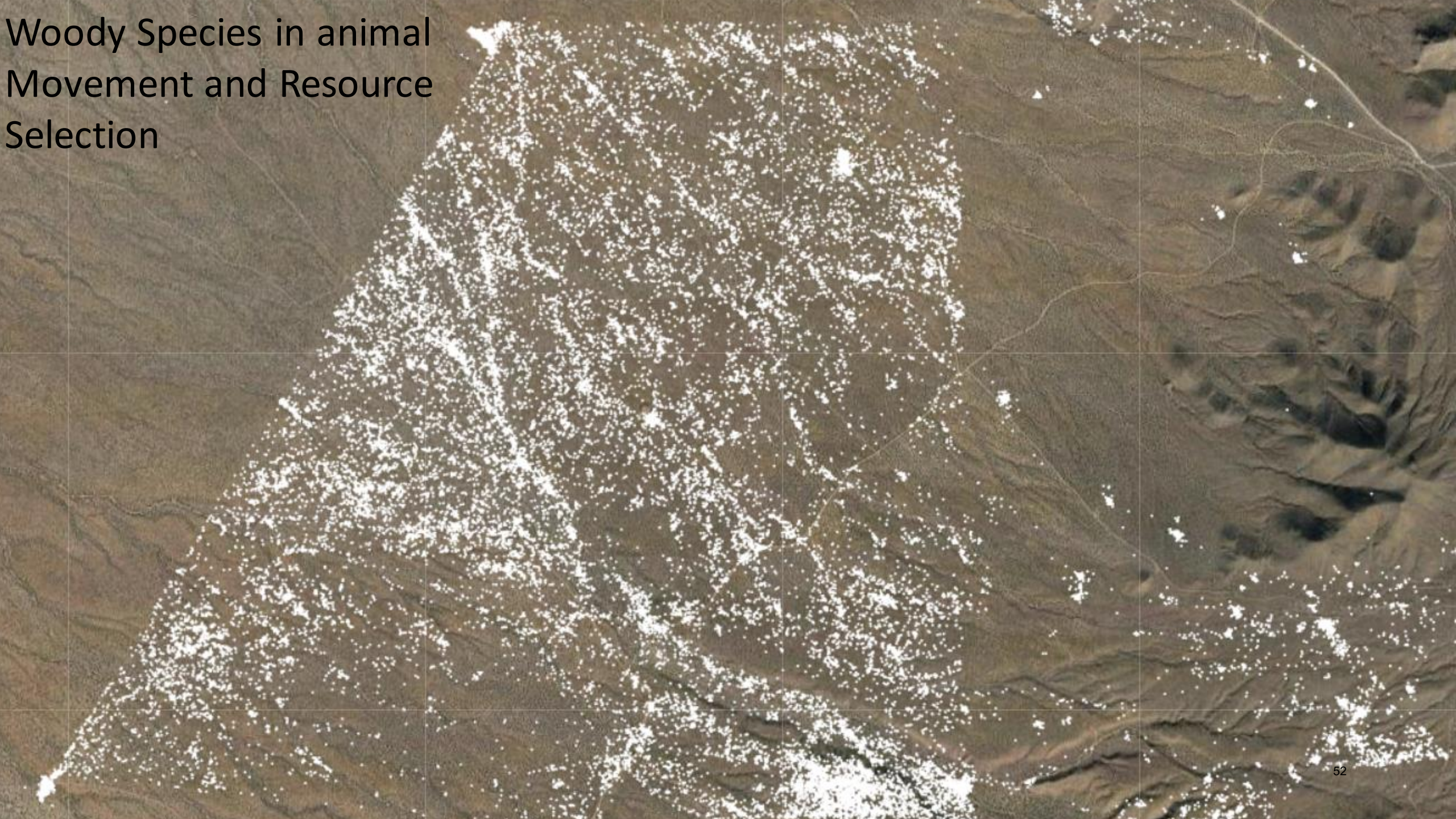
Variation in space and time




Paleocene
Pleistocene

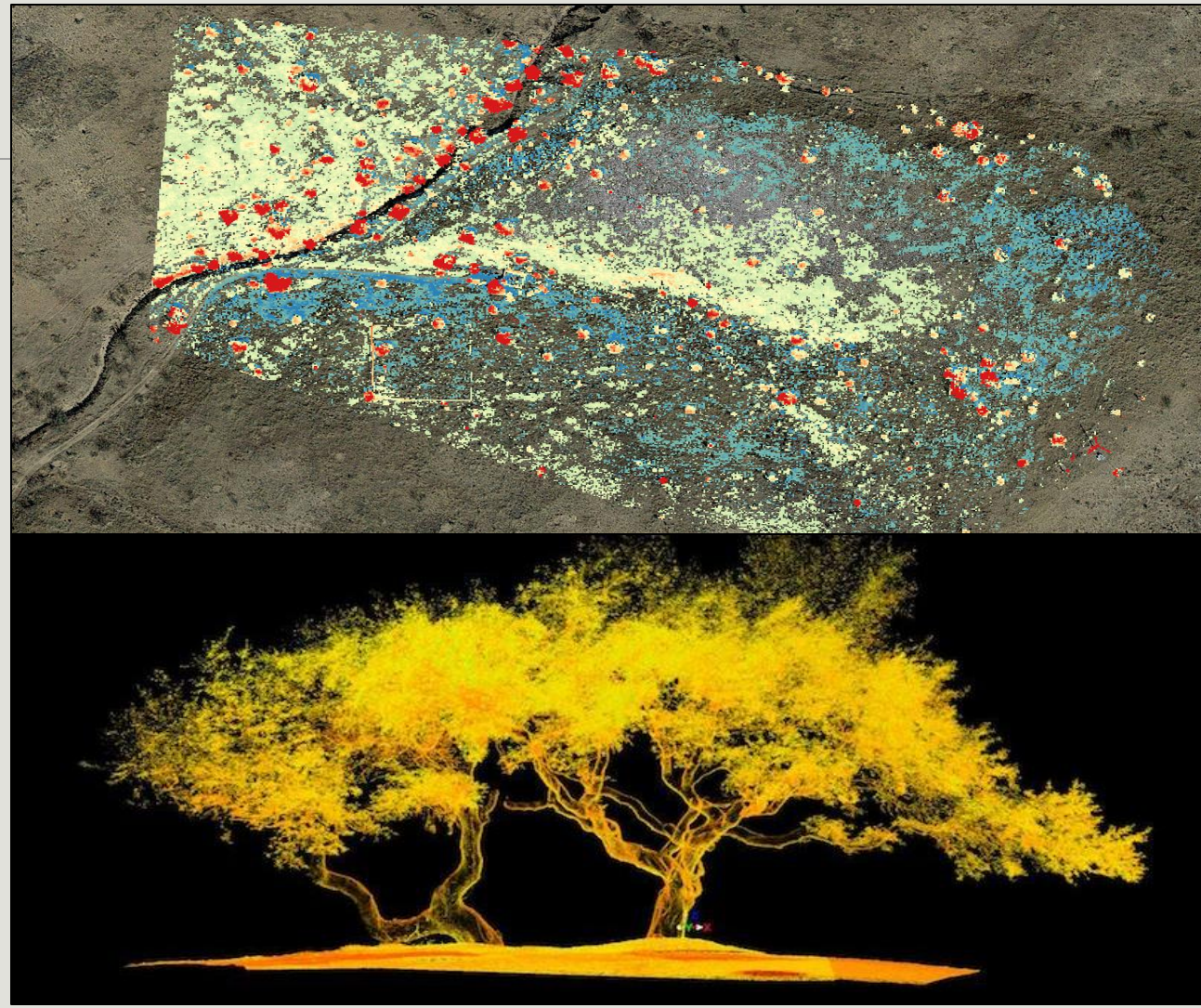
Future efforts

Woody Species in animal Movement and Resource Selection



SRER: *future*

- Application of new methodologies, treatments and technologies
- Dynamic grazing strategy and adaptive management
- Sustainability and balance
- LiDAR driven terrain and vegetation modeling/ remote sensing
- Multi-faceted application methodologies
- Silviculture and commoditization?



SRER: *research, change, and perspective*

"A science of land health need, first of all, a base datum of normality, a picture of how healthy land maintains itself as an organism" *-Aldo Leopold, A Sand County Almanac [Wilderness as a Laboratory]*

Questions?

Brett Blum

bcb@email.Arizona.edu

https://cals.arizona.edu/srer/

THE UNIVERSITY OF ARIZONA
Arizona Experiment Station

College of Agriculture & Life Sciences

SRER Website as a Resource

https://cals.arizona.edu/srer/

-2,4,5-T widely used, combined with 2,4-D makes agent orange

-Mesquite largely dispersed as a result of livestock and packrats. Unknown viability rate of germination following rumination (8-76%) and pack rats eat most but not all seed after burying

-Soil type has big role to play

-Methods include cutting, brushing, grubbing, chain/pushing, aerial and hand herbicide application, diesel treatments, soil pH and alkalinity alteration and various combinations of all of the above. All mostly failed.

-Consideration for silviculture and economization of mesquite for fuel and boutique

- Outcome is complex, mesquites have potential benefits for native species of grass in presence of non native such as Lehman's, however, mesquites may limit extent of overall forage production and livestock movement and equal distribution of grazing pressure.

-include vence screenshot

-future SRER treatments likely to be targeted with focus on fire prevention, habitat and ecological restoration in conjunction with stakeholders

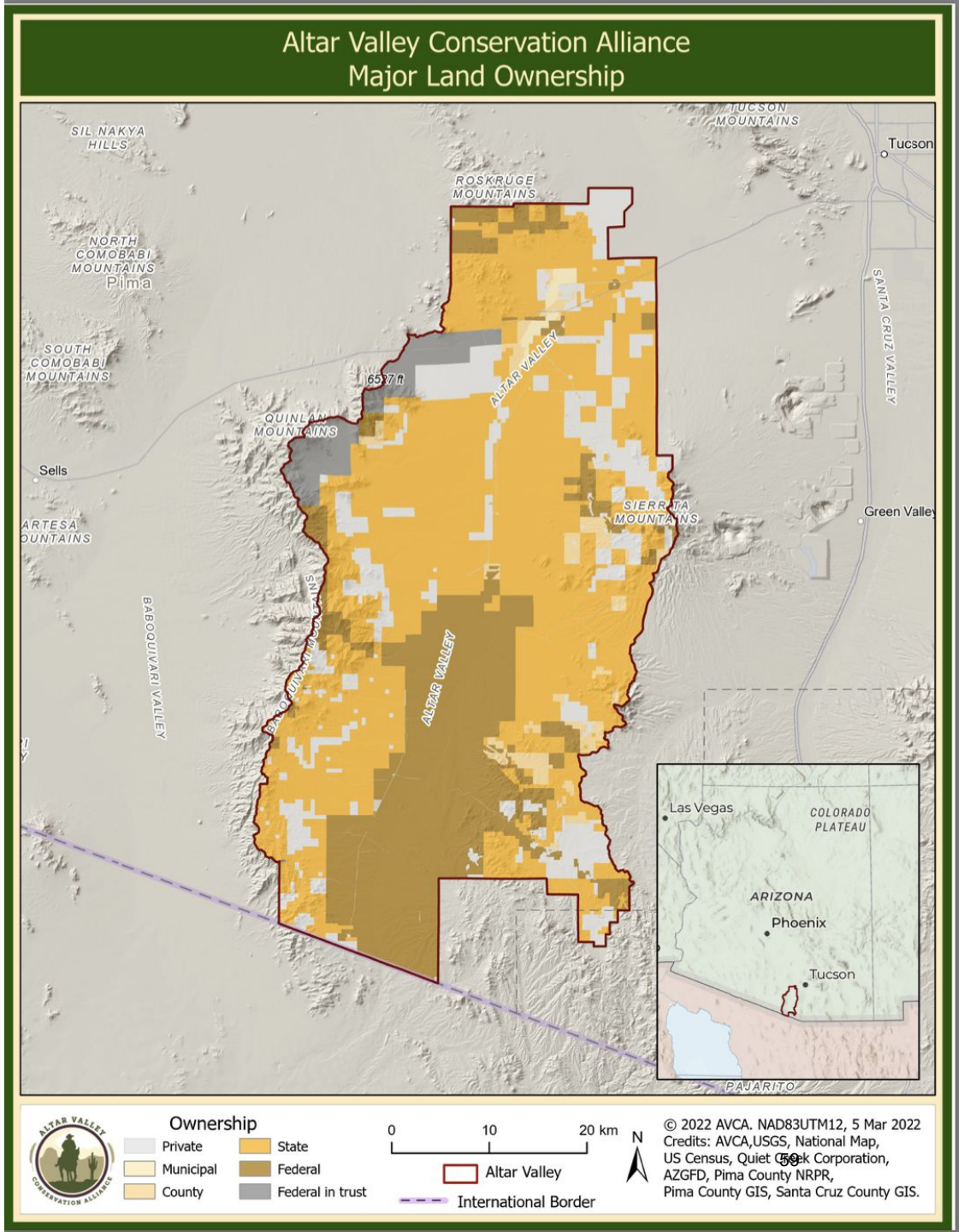
-efficacy of herbicide treatments varied consistently by site and location

Altar Valley Brush Treatments

The Altar Valley

Just southwest of Tucson, Arizona, the Altar Valley comprises approximately 610,000 acres of Sonoran desertscrub and semidesert grassland.

The Altar Valley Conservation Alliance is a watershed-based collaborative conservation organization founded in 1995 by landowners. We work to conserve the Valley for future generations.



Brush Encroachment

A century ago, the Altar Valley was a floodplain with uplands dominated by native perennial grasses. Mesquite was confined to drainages and margins of the floodplain and covered about 10-20 percent of the valley.

Since then, mesquite has heavily encroached on the uplands, and many washes throughout the valley have become significantly incised. Mesquite now dominates much of the uplands, outcompeting native perennial grasses.

METHODS USED IN THE ALTAR VALLEY

Grubbing

(State land, BANWR)

- Benefits - Completely removes tree (including roots) for minimal maintenance; can do almost any time of year
- Drawbacks - Expensive; need to decide how to handle the mesquite carcasses; may need to obtain permits for ground-disturbing activity
- Have followed with: grubbing, backpack herbicide

Fire

(State, federal, private land)

- Benefits - Natural process that can benefit other aspects of ecology; cheaper than using machines
- Drawbacks - Need the right fuel amount & type and good weather conditions; can be hard to find an organization/agency to conduct the burn (which involves liability, which can be complicated)
- Have followed with: Grubbing

Mastication

(Federal land)

- Benefits - Mulch facilitates water infiltration; no carcasses are left standing; herbicide may be applied by hand to minimize resprouting
- Drawbacks - Mesquite can resprout because their roots are still in ground; involves machines that disturb the ground
- Have not followed treatment; grew back too quickly

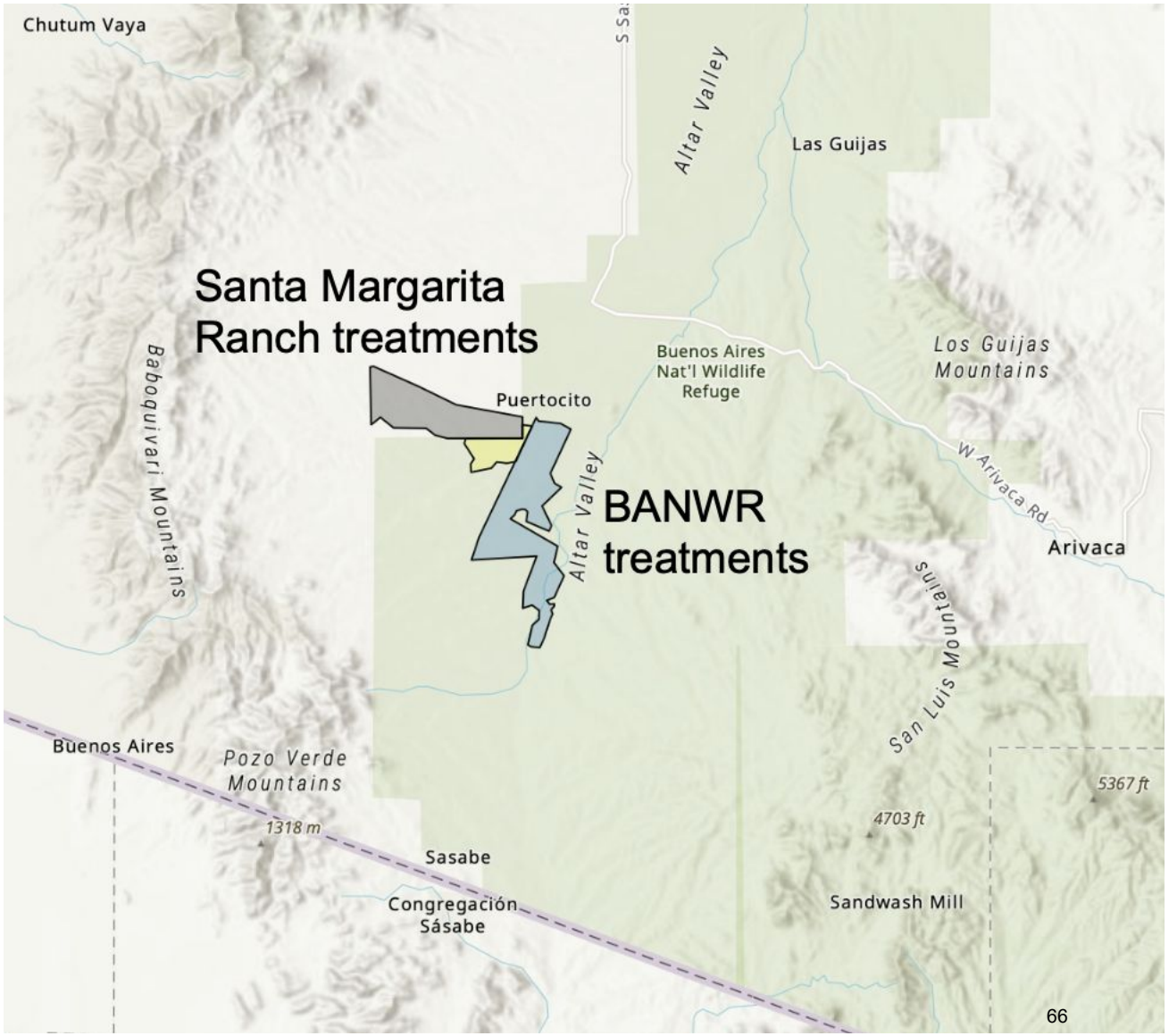
Herbicide

(Aerial – state land
Backpack – private land)

- Benefits - Minimal ground-disturbing activity (therefore cultural resource surveys are not needed except where equipment is staged), less expensive than most other methods (this project cost about $89/acre)
- Drawbacks – Need to consider potential effects on surrounding environment, need appropriate conditions of growth stage and climate
- Have followed with: Herbicide

Brush Treatment Corridor

- Creating and expanding a corridor of improved habitat east to west across the Altar Valley
- Crosses the only major highway in the Valley
- Grubbing, fire, herbicide, wildlife-friendly fencing
- Pronghorn are now crossing from the Refuge, over the road, and onto a ranch on State land



Monitoring Results

- **2019 Aerial Herbicide treatment**
  - Methods - Photos, vegetation frequency and composition, live mesquite canopy cover, NDVI/greenness; RHEM erosion model
  - Results – Mesquite lost cover during the year of treatment; understory vegetation has varied from year to year; soil retention did not show any difference after treatment; other affected species (acacia, hackberry) recovered

- **2021 Backpack herbicide follow-up treatment**
  - Methods - Photos, live canopy cover
  - Results – Trees less than 1” diameter are dead; about half of other trees are dead; all are significantly defoliated

Monitoring Results

- **2019-2020 Grubbing + 2022-2023 herbicide**
  - Methods - Photos, pronghorn presence
  - Results – Trees grew back very quickly after grubbing; herbicide follow-up needed within first 3 years; pronghorn utilizing habitat

- **2018 Fire**
  - Methods - Established vegetation transects and read year after fire; aerial imagery; photos
  - Results – Fire successfully burned mesquite; vegetation seems to be growing back greener and more diverse

Field Trip

Sites:

- Backpack herbicide (oldest treatment)
- Aerial herbicide
- Grubbing + herbicide
- Fire + grubbing

Concepts to discuss:

- How could soil type affect the treatment potential + response?
- What are the most important monitoring techniques?
- What are the highest-value treatments (methods and locations?)
- What does extremely long-term care of the treated areas look like?

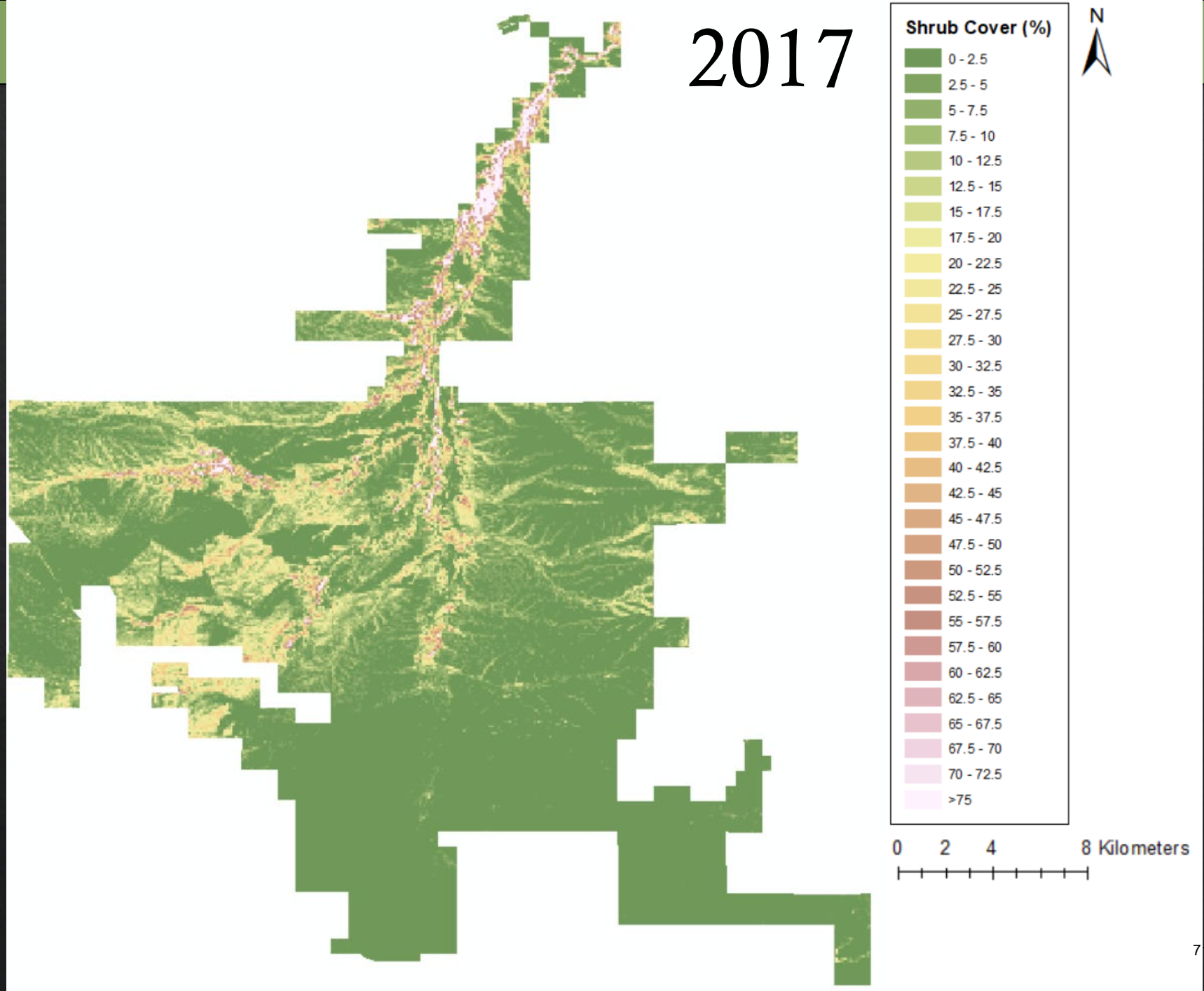
Shrub Encroachment across LCNCA

Las Cienegas National Conservation Area (LCNCA)

- 45,000 Acres
- "Working landscape"
- ~ 400 mm MAP
- 1300-1550 m elv.
- Five rarest plant communities in Southwest
- Undergone shrub encroachment

Active brush management program

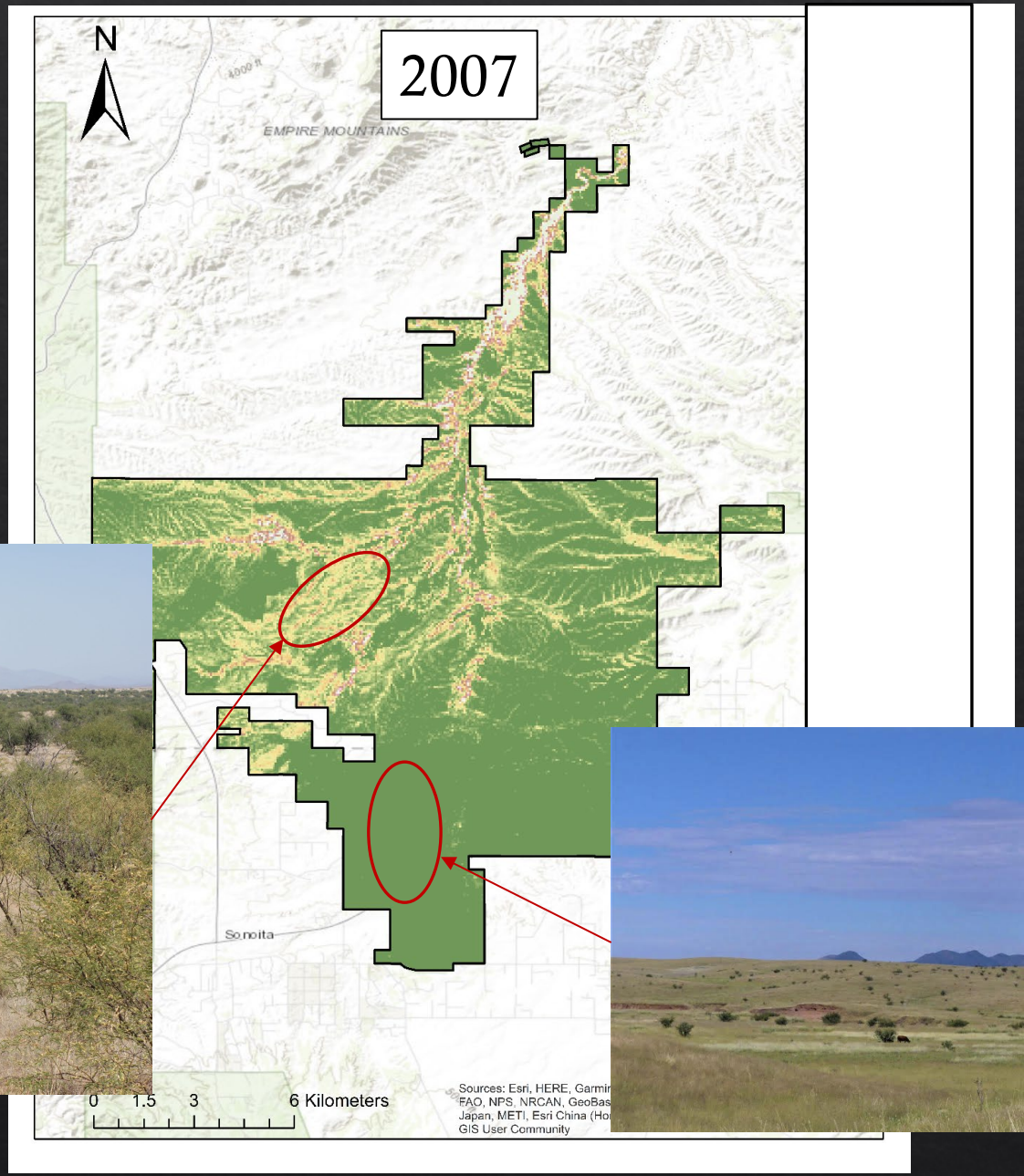
Shrub Cover Change:
Las Cienegas Conservation Area (LCNCA)



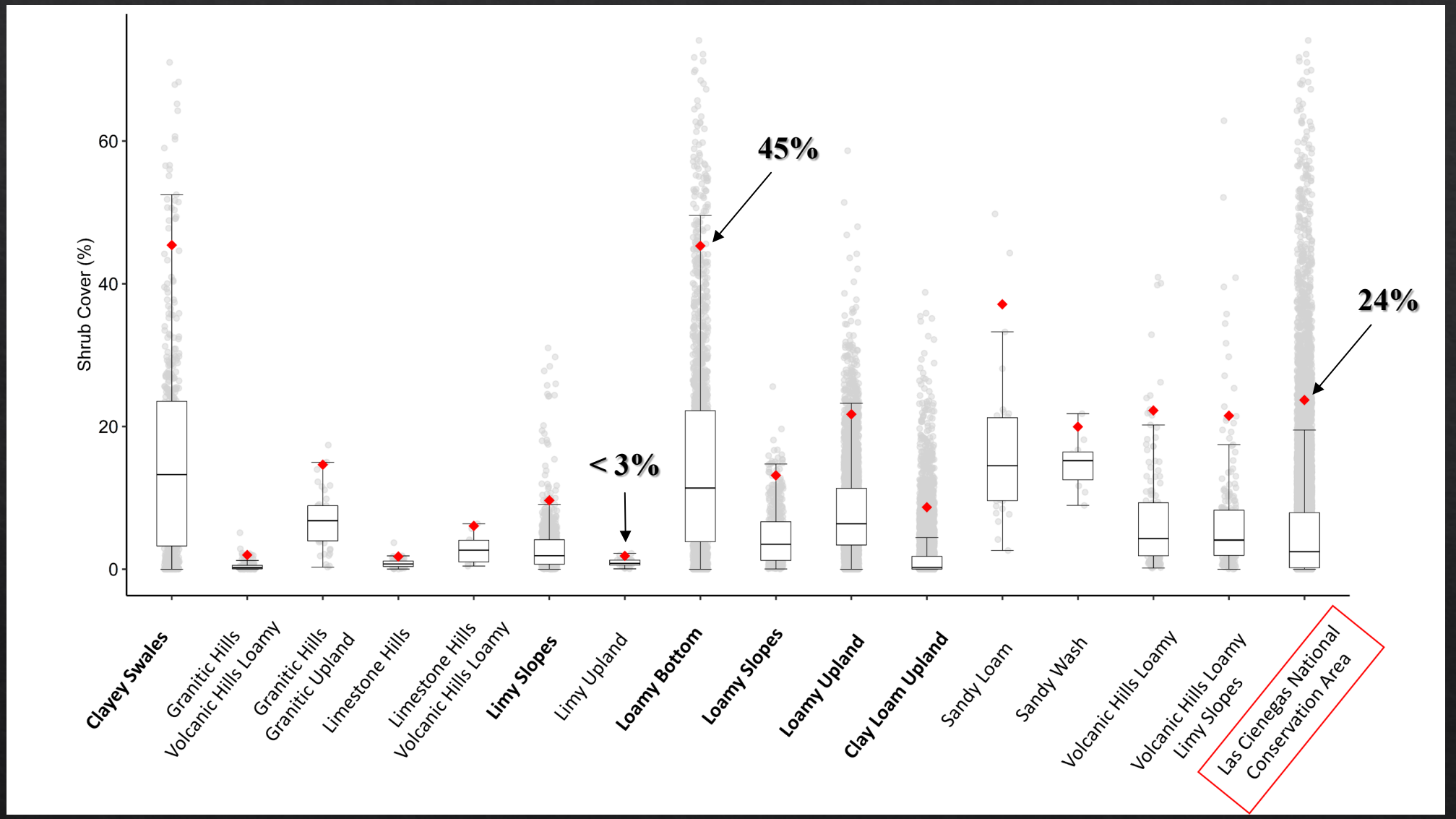
Shrub Encroachment across LCNCA

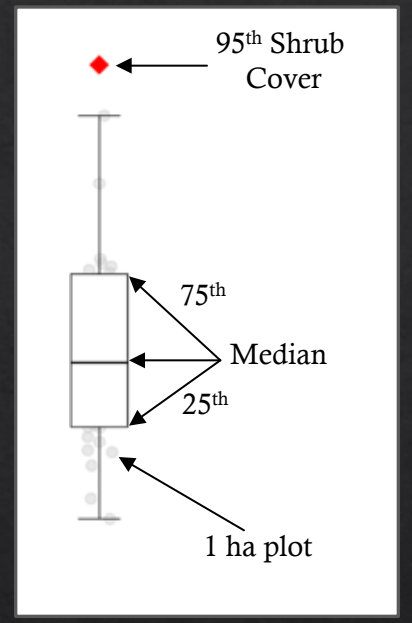
Why does shrub cover vary across the landscape?

Topo-edaphic variables control (in part) shrub encroachment



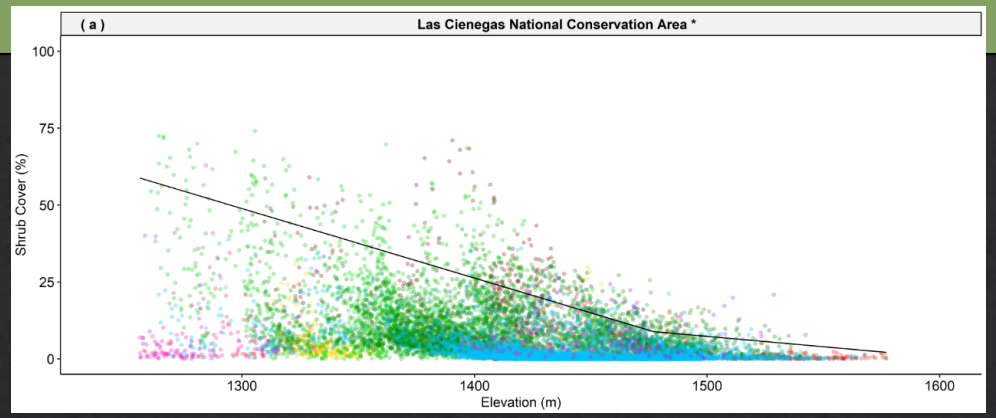
Shrub Encroachment across LCNCA



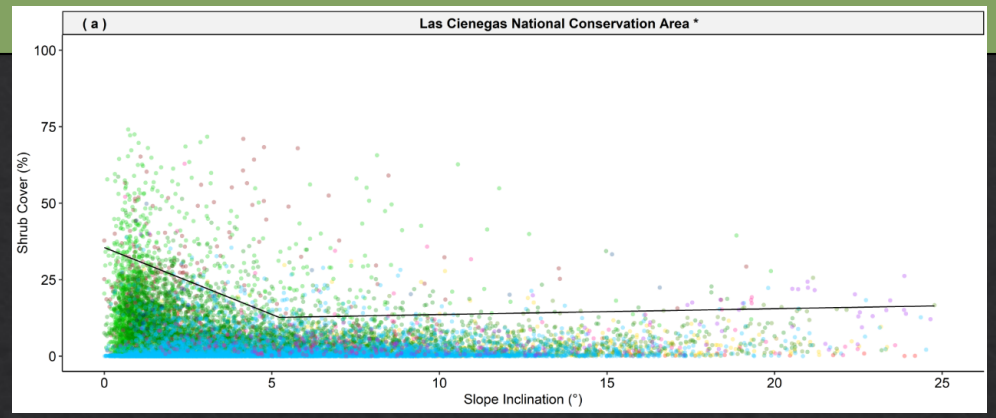


Maximum shrub cover is highly variable across the landscape

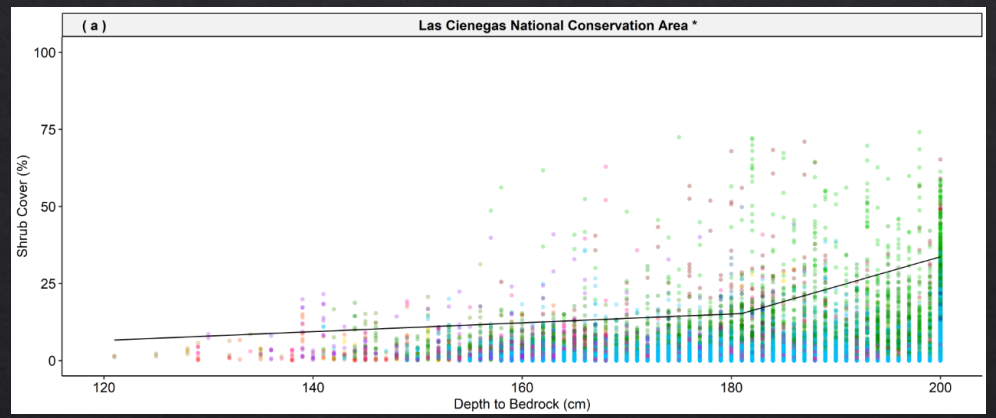
Elevation (m)



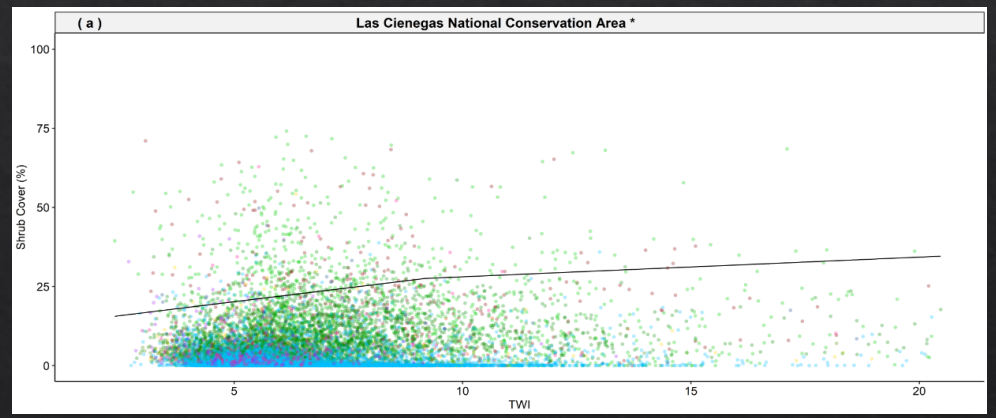
Slope (°)



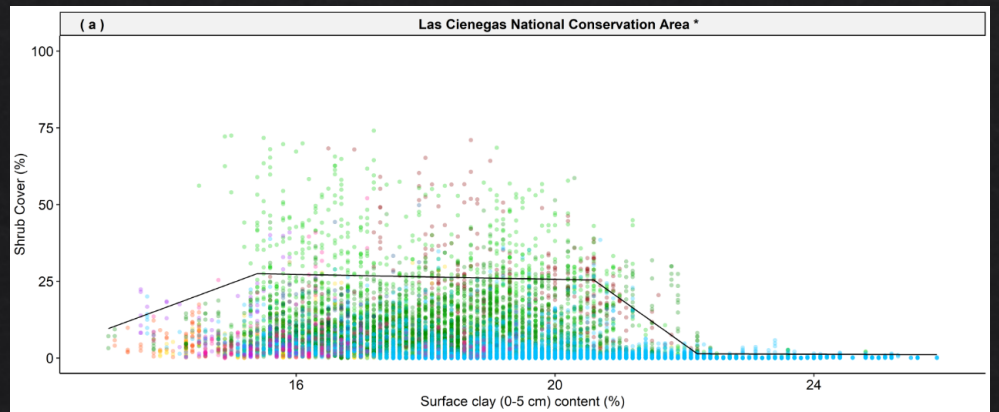
Depth to Bedrock (cm)



Water Availability



Surface clay (%)



Jones et. al (2023) Topoedaphic constraints on woody plant cover in a semi-arid grassland

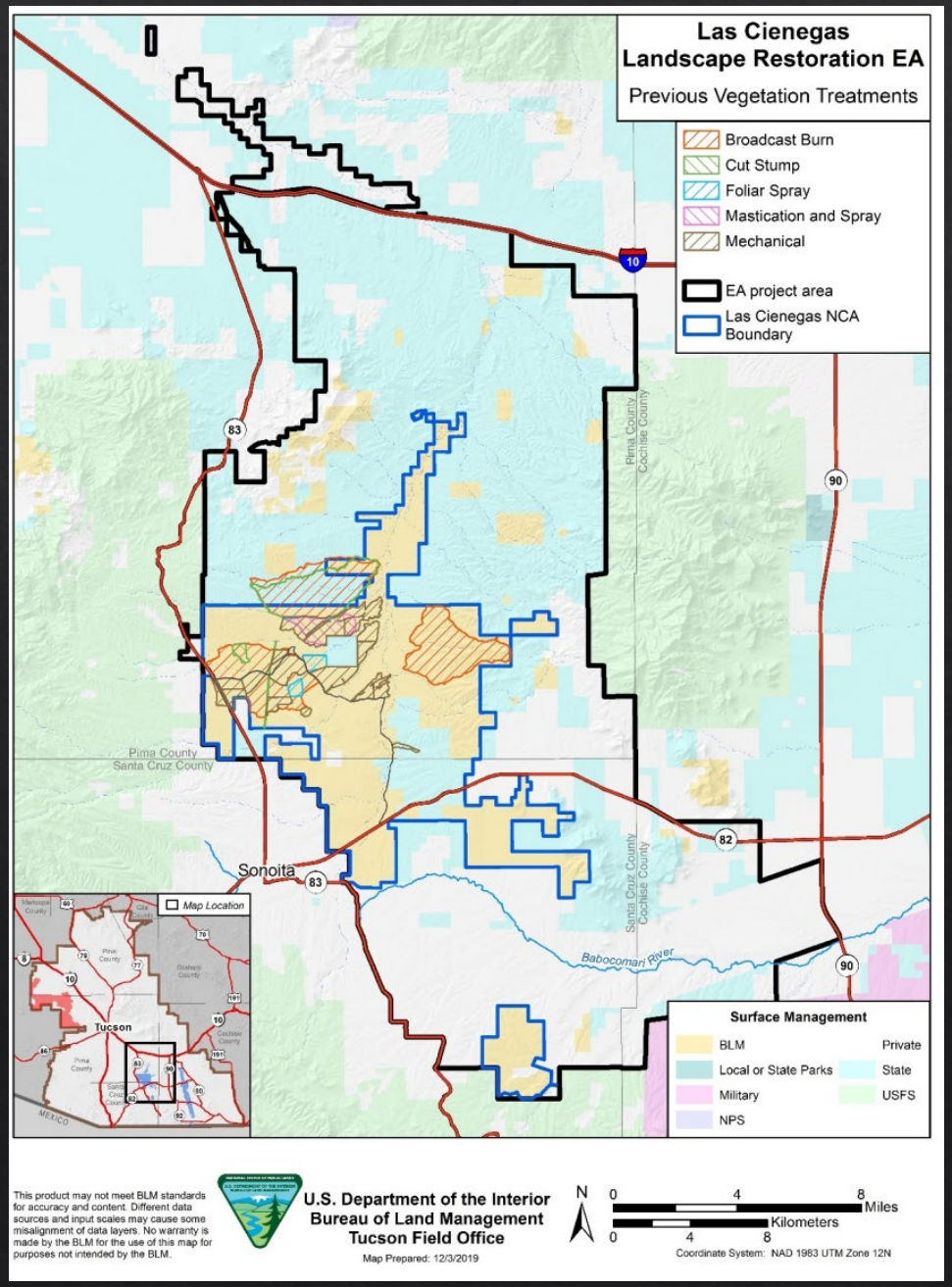
Brush Management at LCNCA

- Long history of brush management
- Recent brush management dictated by 2003 Resource Management Plan (RMP)
  - Mesquite < 10%
    - Uplands < 5 %
    - Bottoms 0-15%
- Current EA (2020) allows for diverse use of treatment methods.

Brush management conducted on the LCNCA (2007-2016)

Vegetation Treatment Type	Acres
Prescribed fire	9,827
Chemical treatment	1,615
Mechanical treatment	5,167
Total	**16,609**

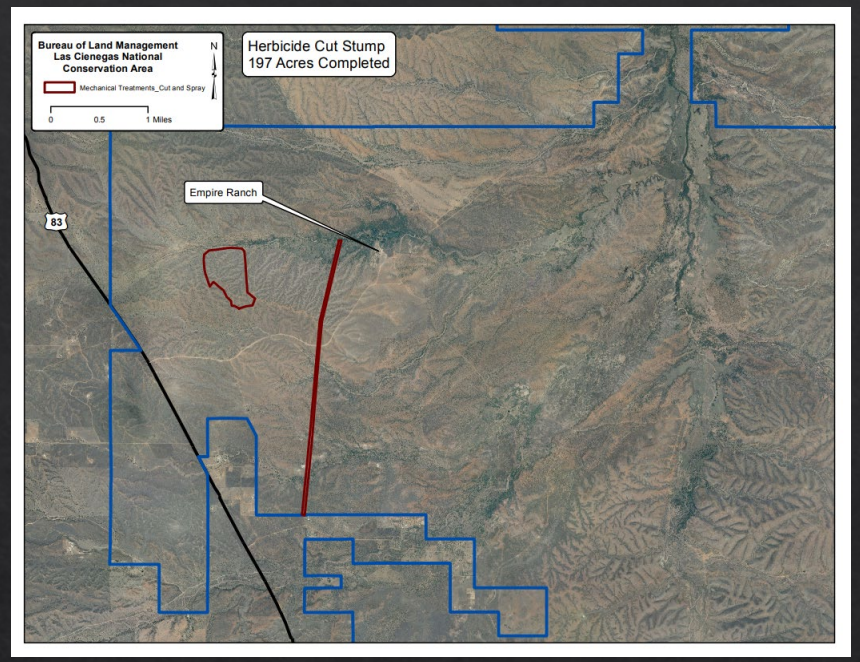
From: Las Cienegas Landscape Restoration Environmental Assessment, 2020

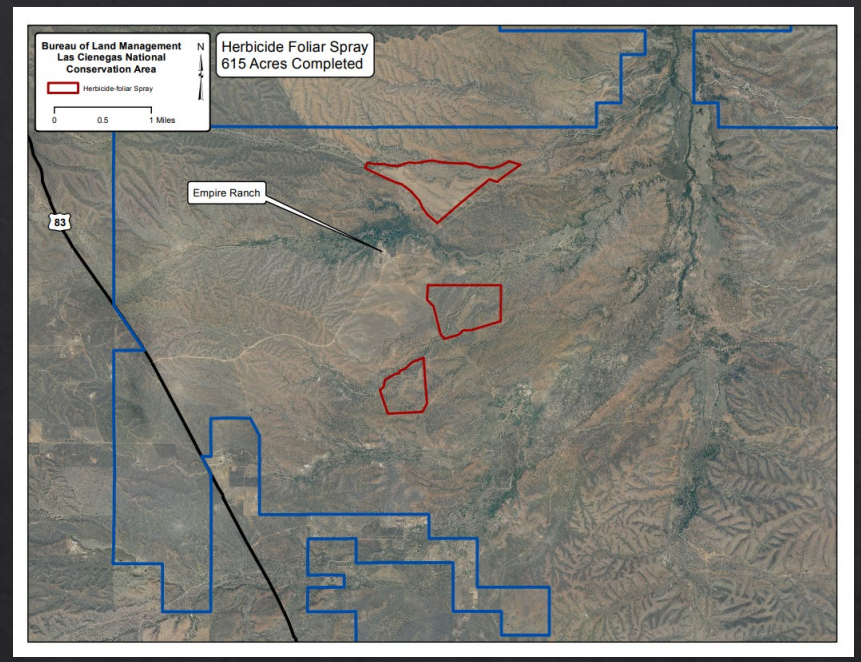


Brush Management at LCNCA

Herbicide Treatments

- Cut-stump
- Basal bark
- Foliar
- Broadcast aerial/ground





Tiller et. al 2012

Mechanical Trea

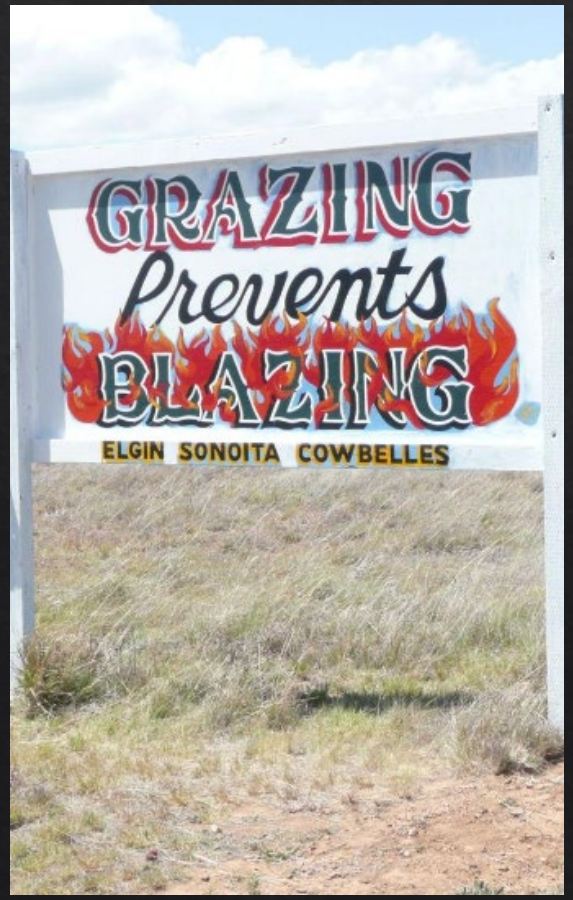
- Mastication
- Grubbing
- Thinning

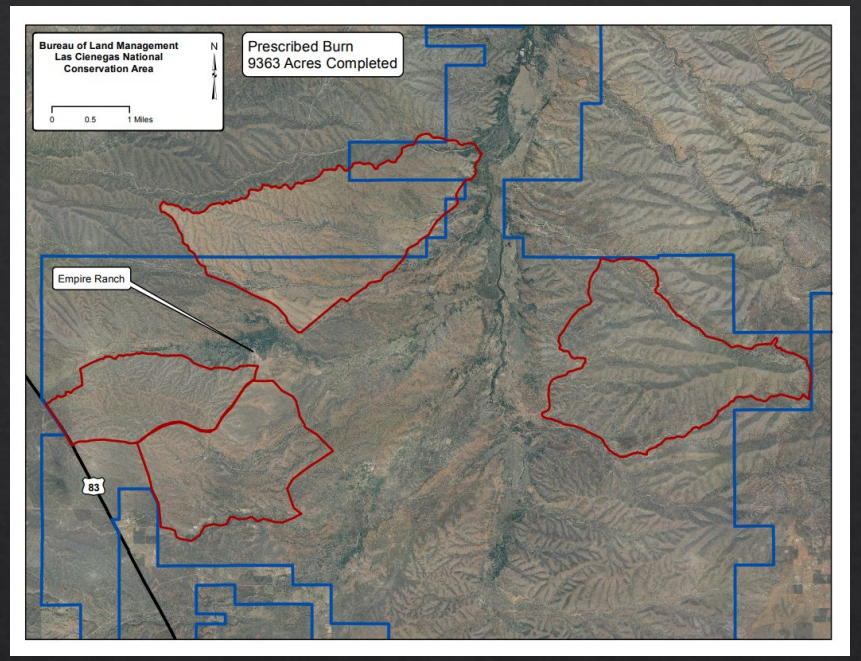
What to do with material?

Brush Management at LCNCA

Prescribed Fire Treatments

- Broadcast burns
- Slash pile burns



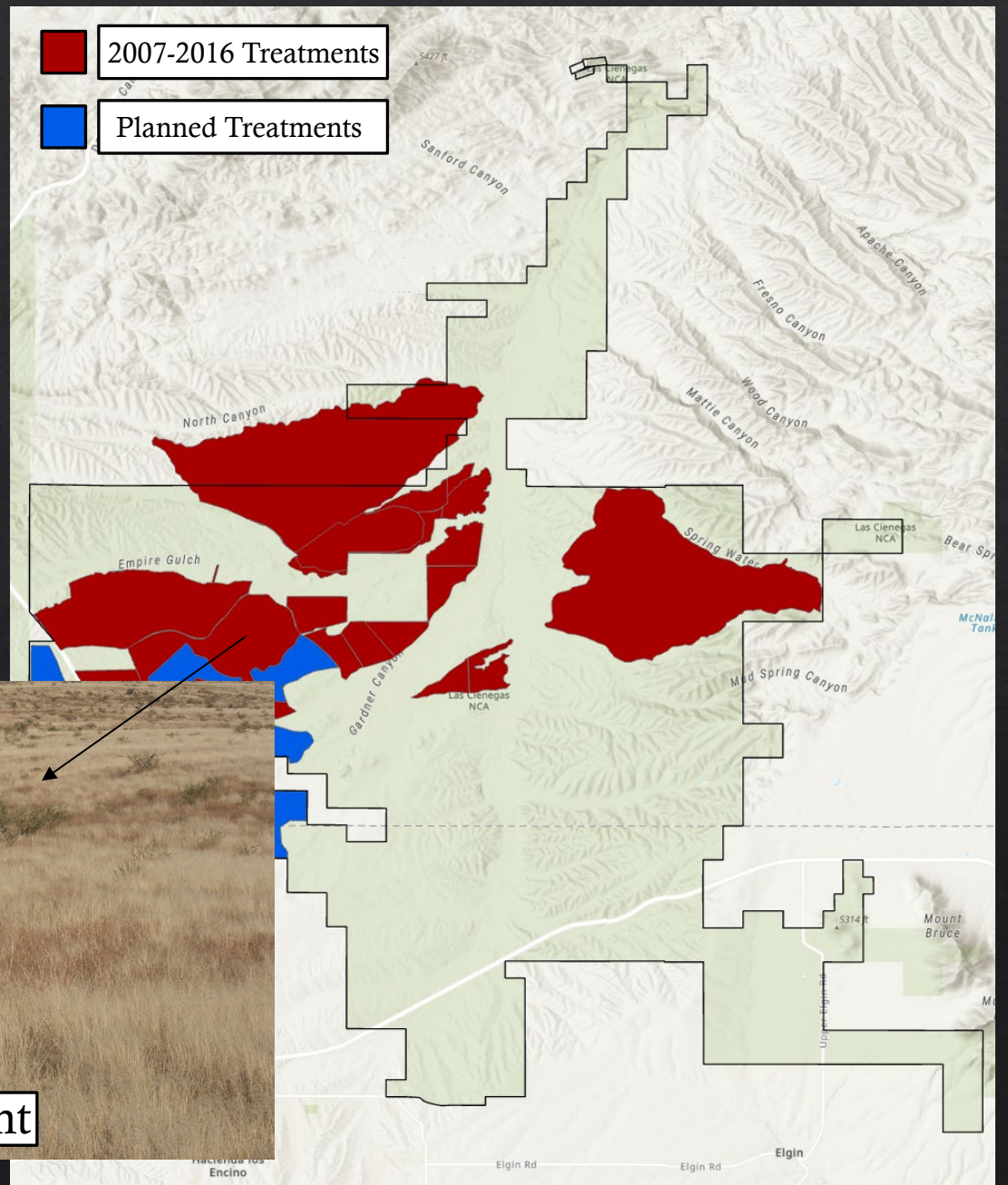


Brush Management at LCNCA

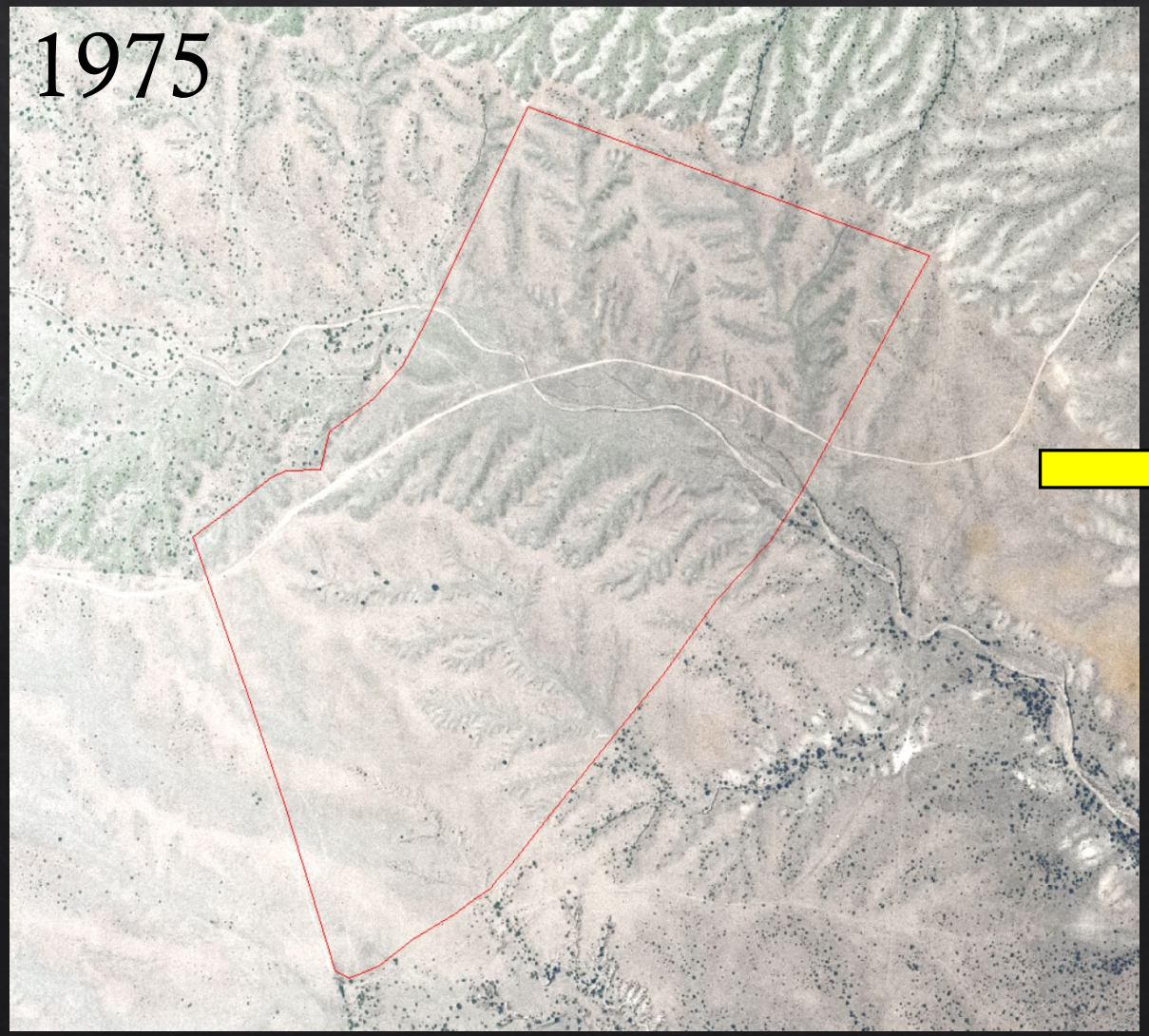
Future Brush Management

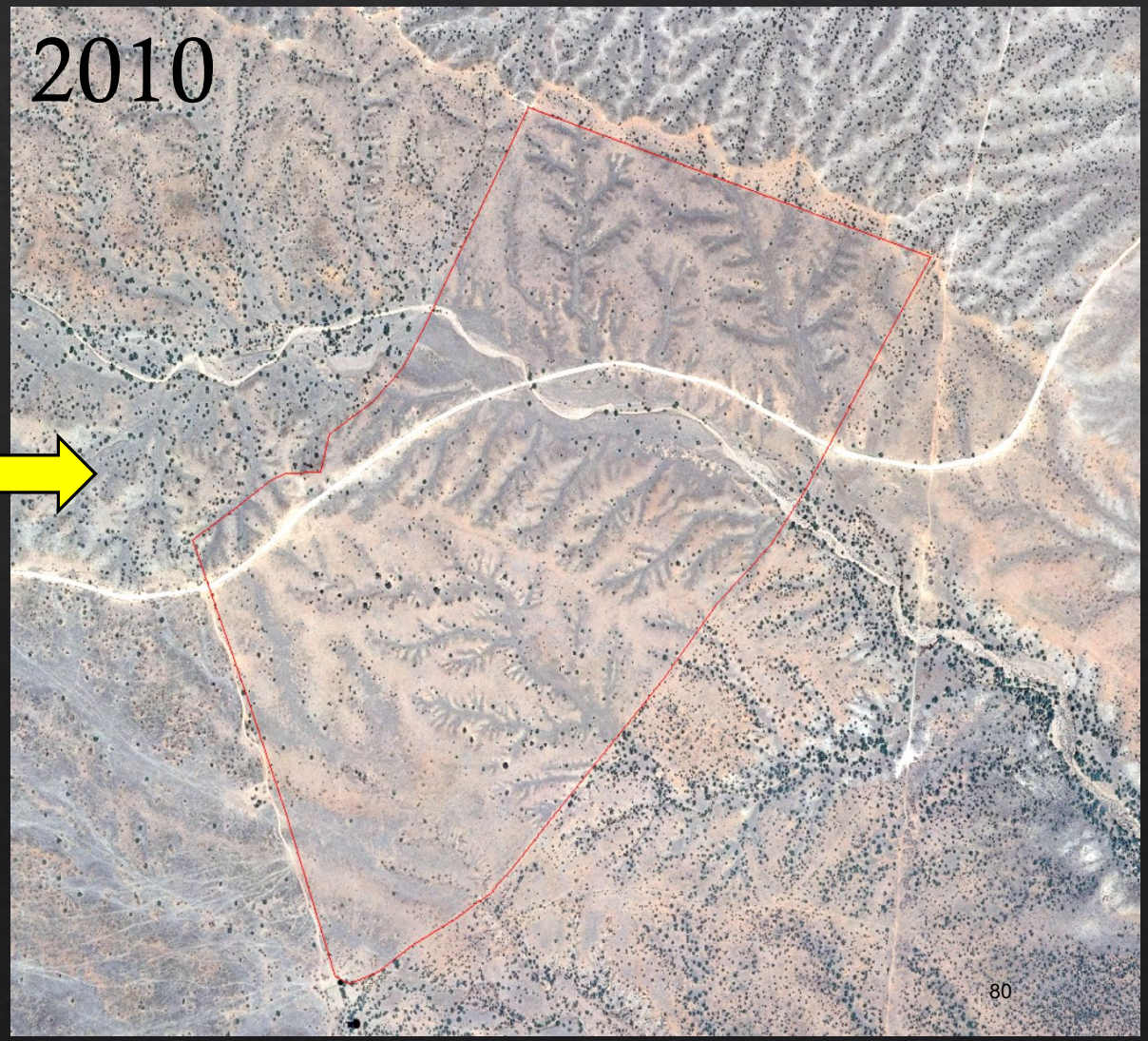
- Lessons learned 2007-2016 treatments
- New EA allows for more treatment options
  - Flexible follow-up treatments
- How do topo-edaphic variables dictate re-encroachment rates?

2020: Ten years after treatment

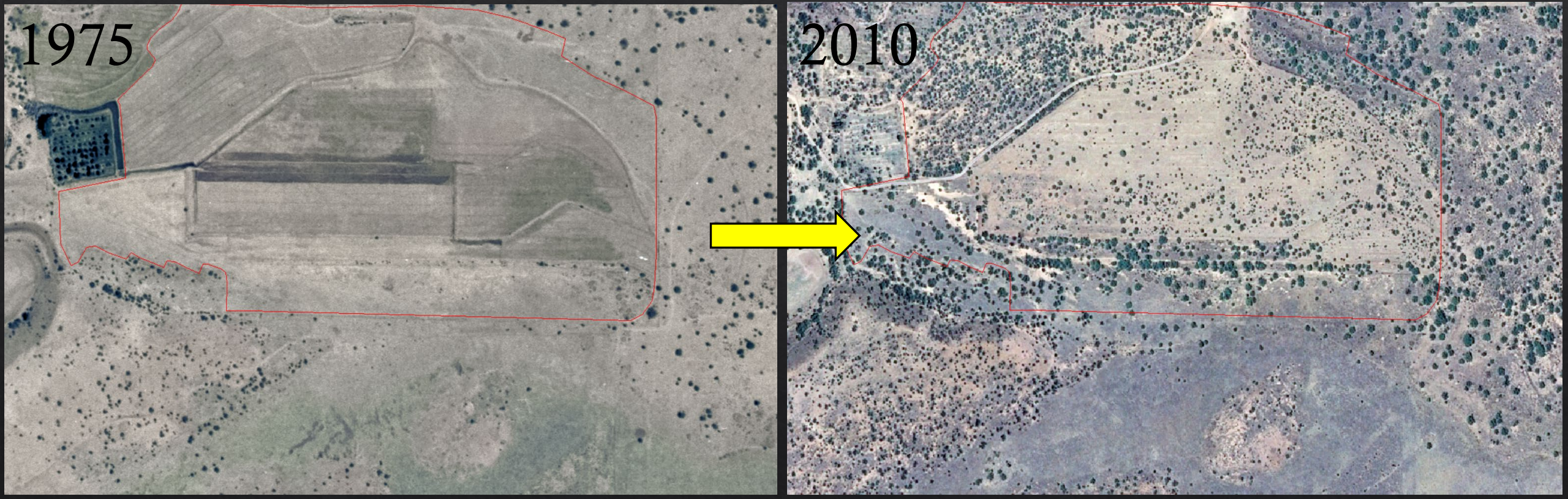


Loamy Upland





Loamy Bottom/Clayey Swale



Take-away / Follow-up Questions

I. Shrub cover is highly variable across a landscape and is dictated in part by topo-edaphic variables

- Most likely influence rates of re-encroachment

II. When, where, and why use brush management is dependent on what we are trying to promote from the landscape

- Important to understand peoples perspectives & conservation objectives

III. How should we leave the landscape following brush management projects?

Questions?

COLLEGE OF AGRICULTURE & LIFE SCIENCES
Natural Resources & the Environment

scottajones@Arizona.edu

WESTERN SARE
Sustainable Agriculture Research & Education

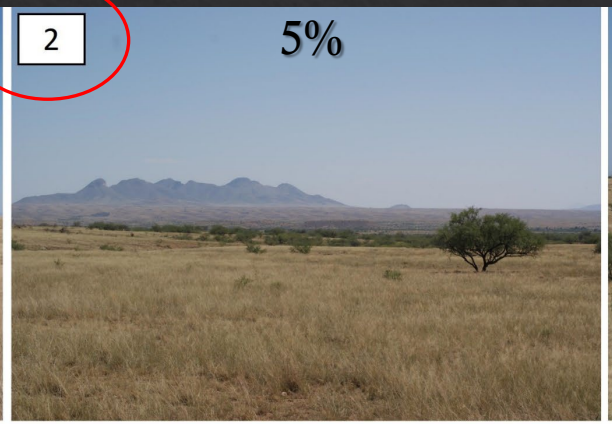
Take-away / Follow-up Questions

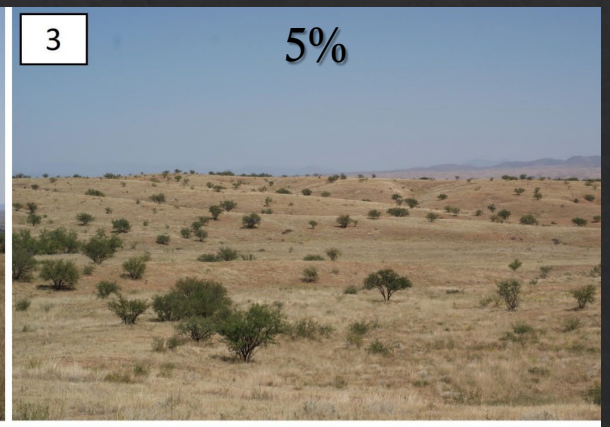
"Which of the following is the Most Important and Least Important reason to restore and conserve grasslands?"

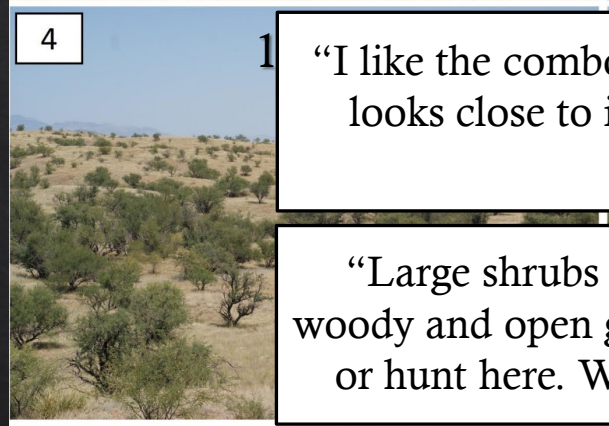
Increasing biodiversity highest rated

	Pooled				Education/Academic Research			
Ecosystem Service Category	**Most**	**Least**	**Score**	**Rank**	**Most**	**Least**	**Score**	**Rank**
Habitat for Biodiversity	293	12	0.68	**1**	63	4	0.62	**1**
Erosion Control	188	10	0.43	**2**	52	1	0.53	**2**
Water Quality & Quantity	144	40	0.25	**3**	29	16	0.14	**3**
Forage for Livestock	44	161	-0.28	**4**	12	20	-0.08	**4**
Recreation & Tourism	25	170	-0.35	**5**	4	42	-0.40	**6**
Cultural Heritage	11	157	-0.35	**6**	2	37	-0.37	**5**
Aesthetics	16	171	-0.38	**7**	6	48	-0.44	**7**
Government and Land Managers					**Non-profit/non-governmental**			
Habitat for Biodiversity	87	3	0.72	**1**	68	0	0.90	**1**
Erosion Control	52	0	0.45	**2**	33	0	0.43	**2**
Water Quality & Quantity	52	6	0.40	**3**	24	3	0.28	**3**
Forage for Livestock	2	67	-0.56	**7**	1	46	-0.59	**7**
Recreation & Tourism	5	53	-0.41	**6**	1	25	-0.32	**5**
Cultural Heritage	2	27	-0.22	**4**	3	24	-0.28	**4**
Aesthetics	3	47	-0.38	**5**	3	35	-0.42	**6**
Landowner (Rancher)					**Resident & Recreationist**			
Habitat for Biodiversity	35	4	0.48	**1**	40	1	0.65	**1**
Erosion Control	33	2	0.48	**1**	18	7	0.18	**2**
Water Quality & Quantity	19	4	0.23	**4**	20	11	0.15	**3**
Forage for Livestock	24	7	0.27	**3**	5	21	-0.27	**6**
Recreation & Tourism	0	34	-0.53	**7**	15	16	-0.02	**4**
Cultural Heritage	1	33	-0.50	**6**	3	36	-0.55	**7**
Aesthetics	0	28	-0.44	**5**	4	13	-0.15	**5**

Take-away / Follow-up Questions







"I like the combo of mesquite areas then open country. This site looks close to its grassland potential. I'd love to ranch, hunt, birdwatch, etc. here".

"Large shrubs for shade and dense pockets available. Mix of woody and open grass to support a higher biodiversity. Could hike or hunt here. Wouldn't think to spend money on restoration".