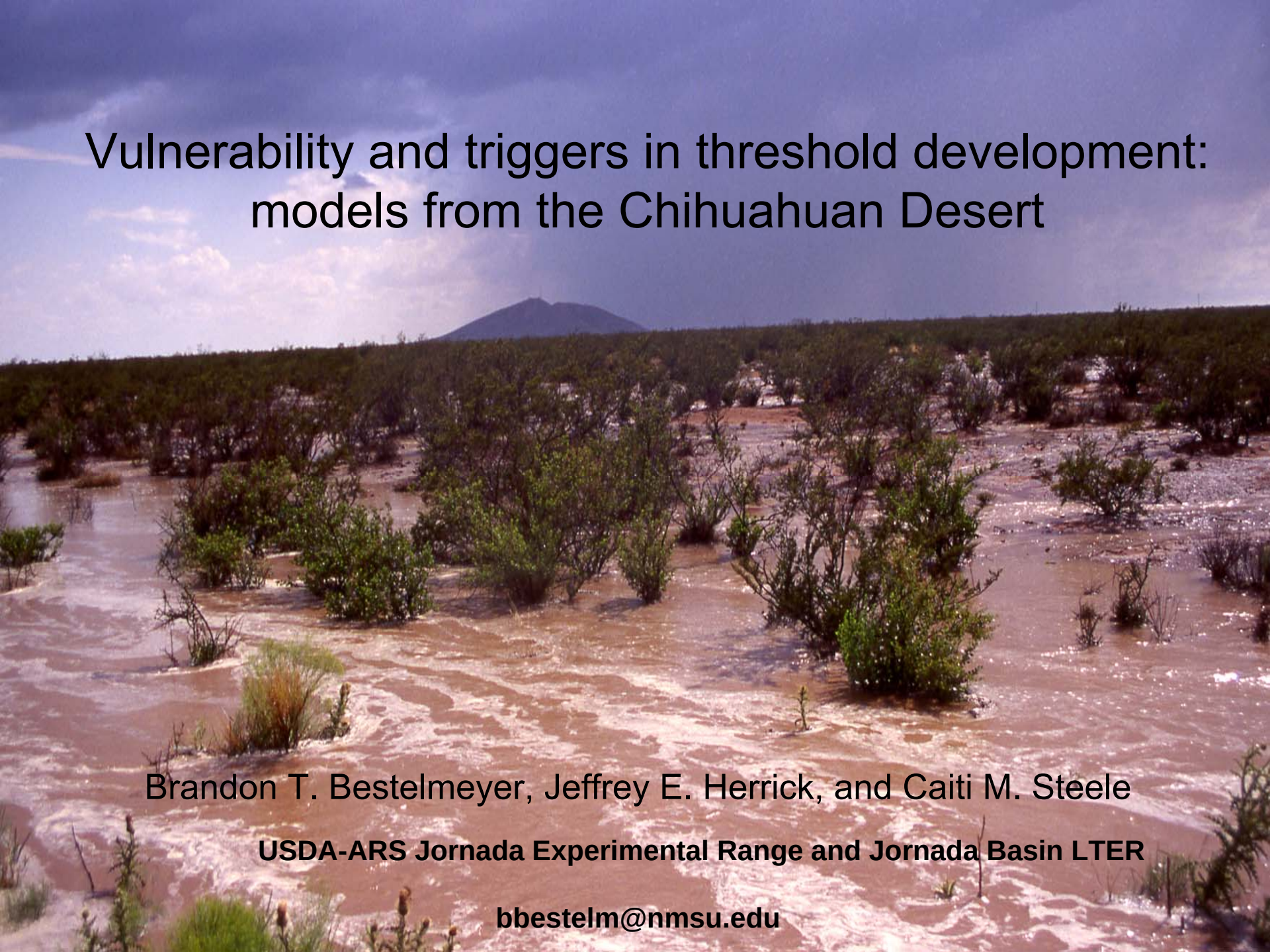

Vulnerability and triggers in threshold development: models from the Chihuahuan Desert

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Challenges for state-and-transition models

-Thresholds are difficult to detect or observe directly

- Many transitions (e.g., grassland→shrubland) occurred long ago

- Present day transitions are patchy

- Existing experiments have a limited context

How can we assemble data to support resilience-based state-and-transition models applicable to regions?

1. Initial ecological sites adapted from USDA Soil Conservation Service range sites (MLRA 42, SD-2)

2. Workshops and literature review to develop initial models

3. **Do the data support the state-and-transition model and site concepts?**

4. Refine ecological site classes, models, revise Ecological Site Descriptions with NRCS New Mexico staff

Data used in revising/developing ecological sites and state-and-transition models

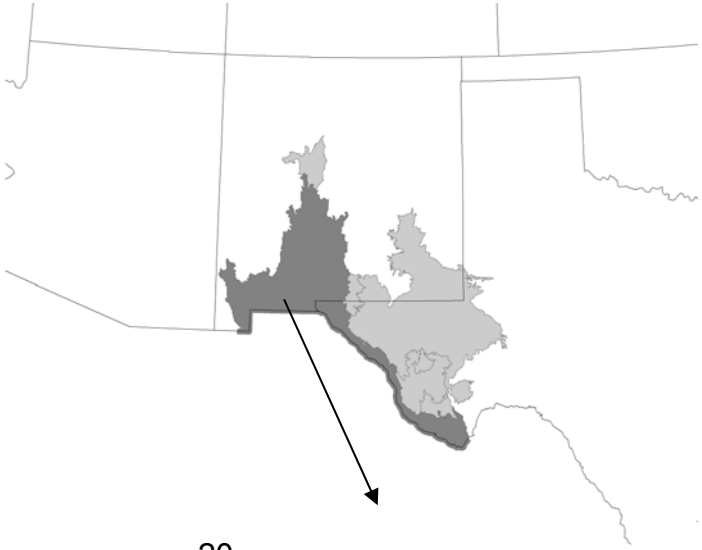
1. *Inventory*: what is the relationship between states and soil-climate gradients?

2. *Century-scale dynamics*: what is our best estimate of “reference conditions” and how have they changed?

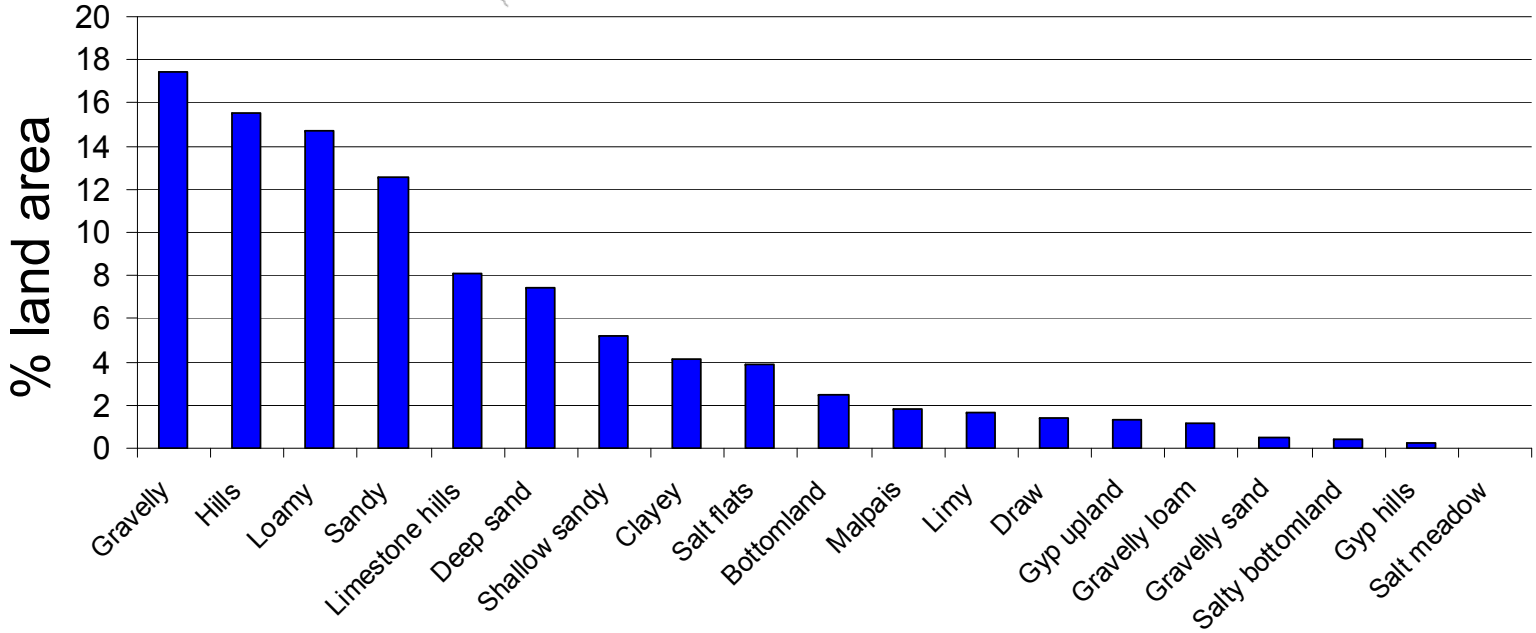
3. *Decade-scale dynamics*: how are ecosystems changing recently?

4. *Experiments*: are processes, constraints to restoration, and indicators consistent with descriptions in models?

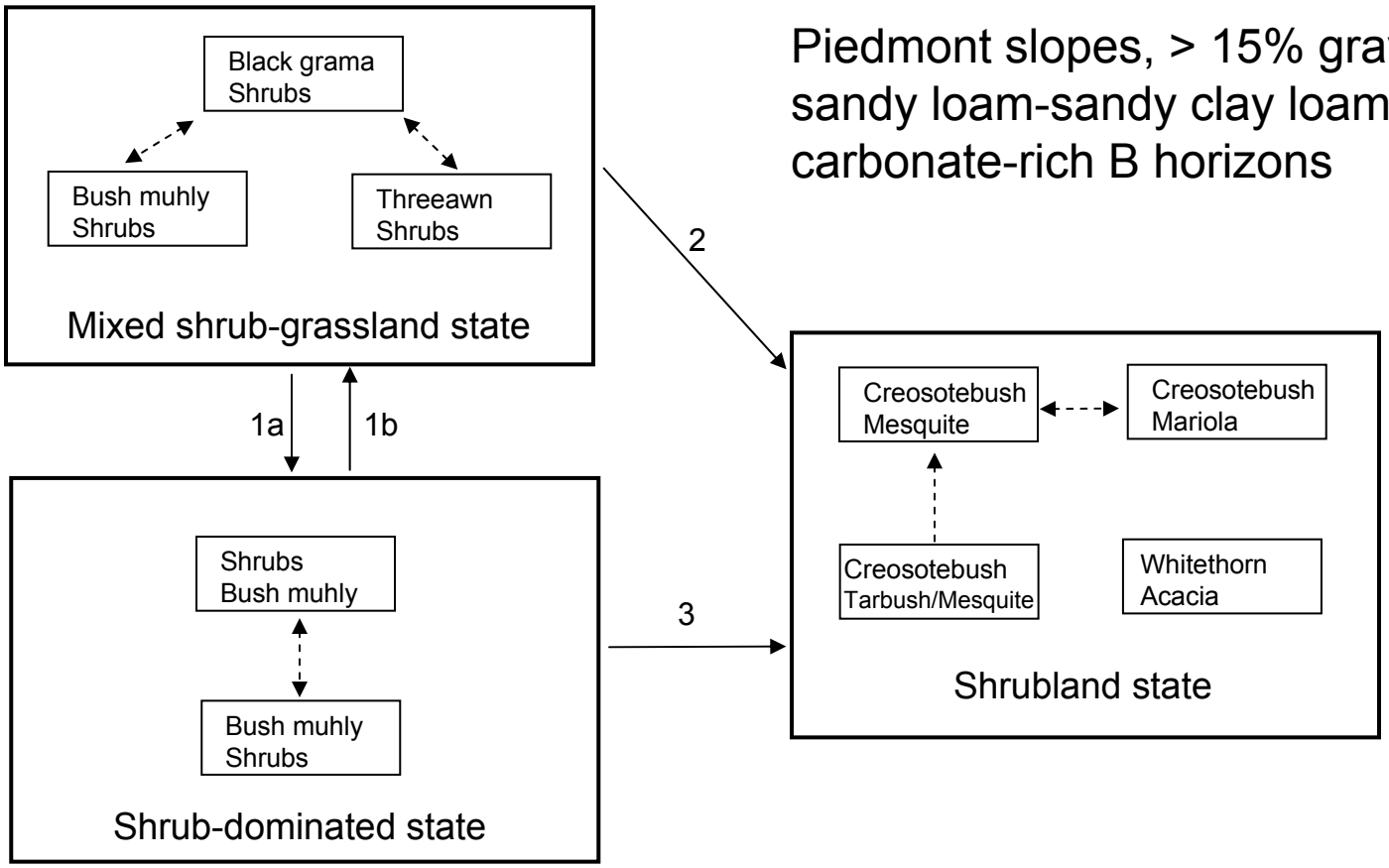
Where we work



60% of the Land Resource Unit area
is classified to 4 of the 19 ecological sites



An initial state-and-transition model for Gravelly, 8-10” zone, MLRA 42.2



Piedmont slopes, > 15% gravel,
sandy loam-sandy clay loam B horizon,
carbonate-rich B horizons

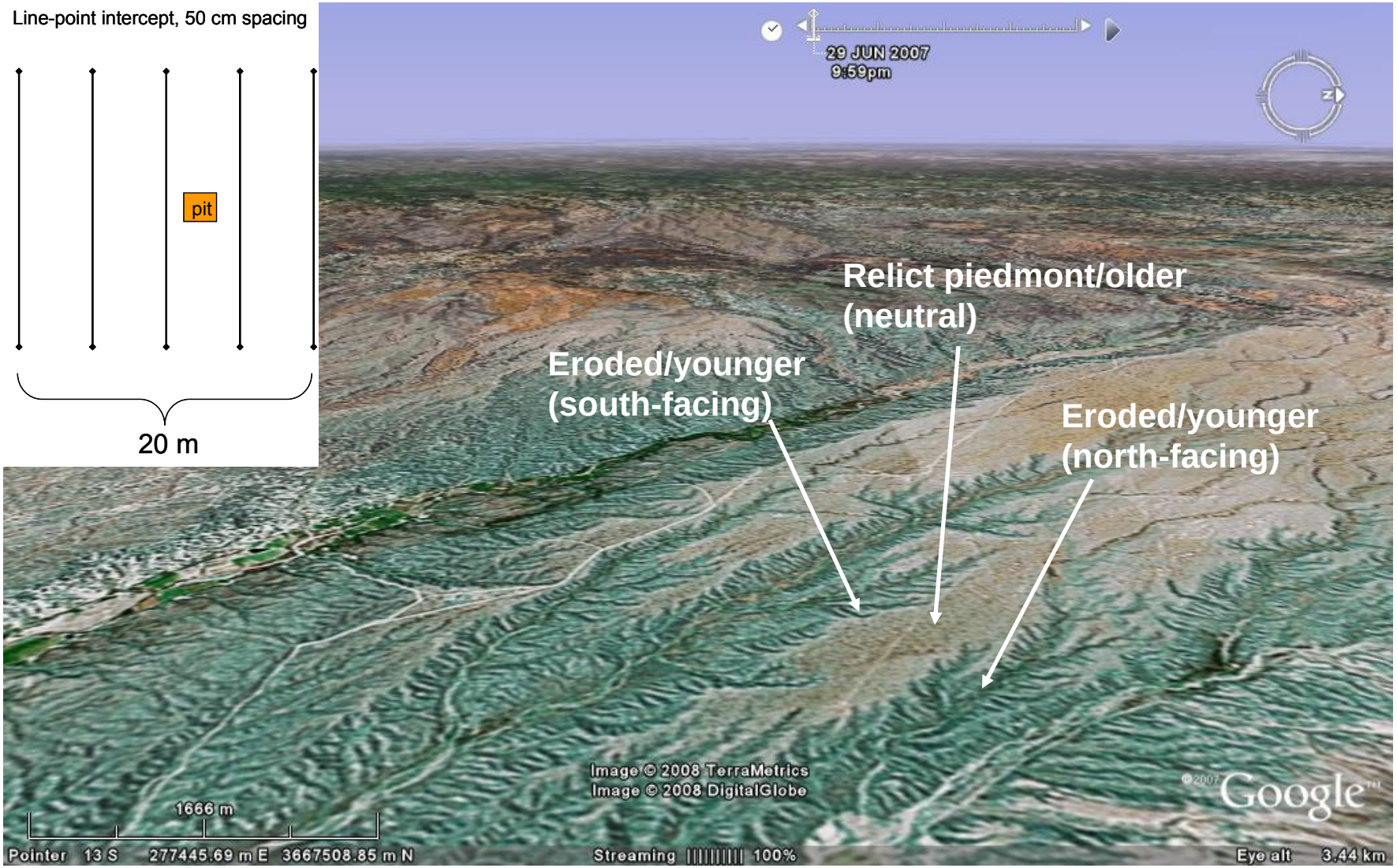
1a. Heavy grazing, summer drought, or lack of fire; 1b. Shrub control
2. Heavy grazing, widespread grass mortality, with erosion and soil truncation
3. Persistent reduction in grasses, competition by shrubs, erosion and soil truncation

1. Inventory sampling of vegetation and soils

a) Alternative states occur on similar soils: *site and model are valid*

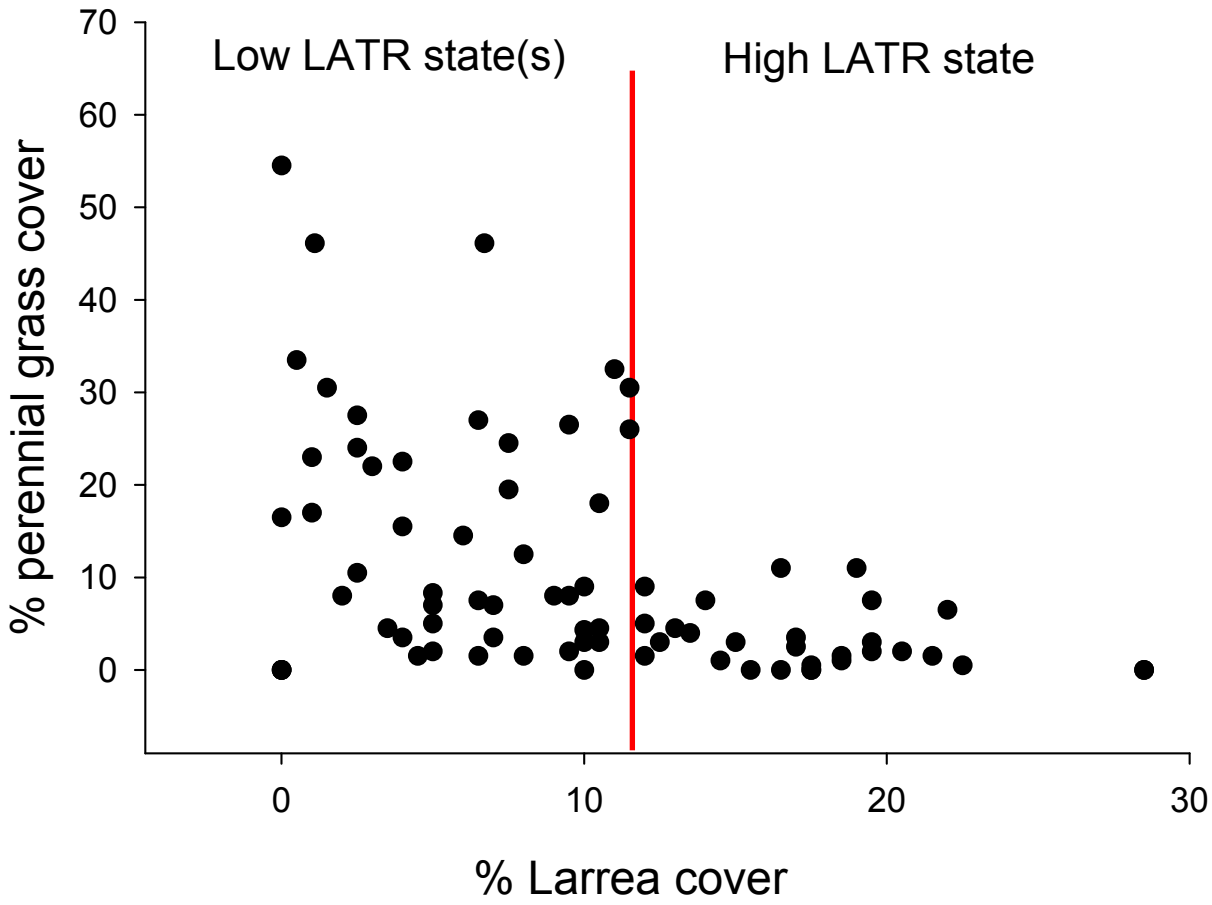
b) Alternative states vary systematically with soil or climate properties combined within ecological site: *new site or model concepts needed*

1. Inventory sampling of vegetation and soils



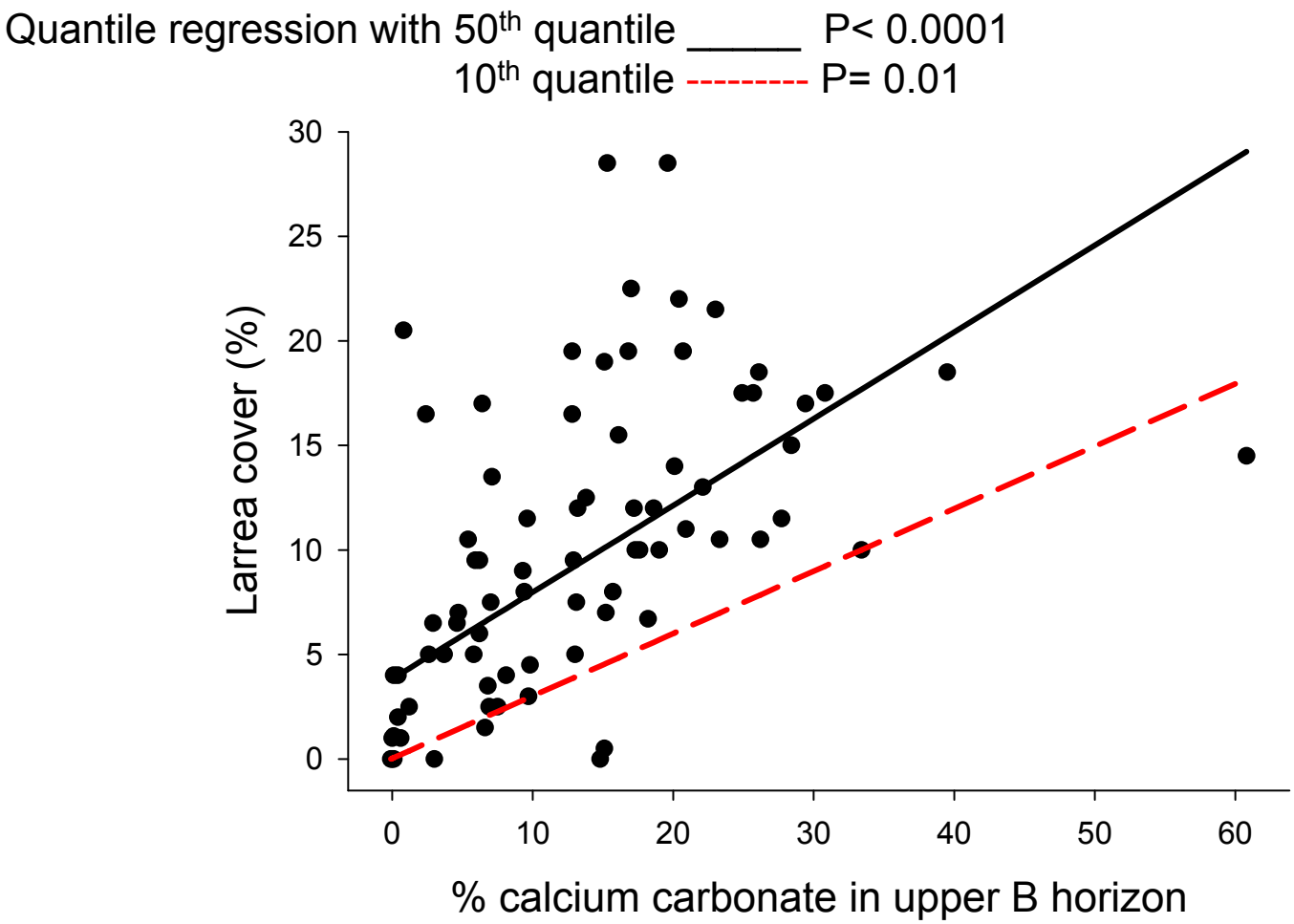
80 plots distributed across varying soil-geomorphic conditions

1. Inventory sampling of vegetation and soils



Field data consistent with idea of alternative states
(12% creosotebush canopy cover)

1. Inventory sampling of vegetation and soils



The “Gravelly site” is complex of at least two ecological sites

2. Century-scale reconstruction

Survey crew on the Jornada Experimental Range, 1912

2. Century-scale reconstruction

Gravelly soil clip of vegetation/condition maps; Jornada Experimental Range

1858 General Land Office

1915 Jornada

1998 Jornada

- Very good grass
- Good grass
- Fair grass

- Creosotebush
- Tarbush
- Grass-dominated

Gibbens et al., 2005, Journal of Arid Environments 61: 651-668

2. Century-scale reconstruction

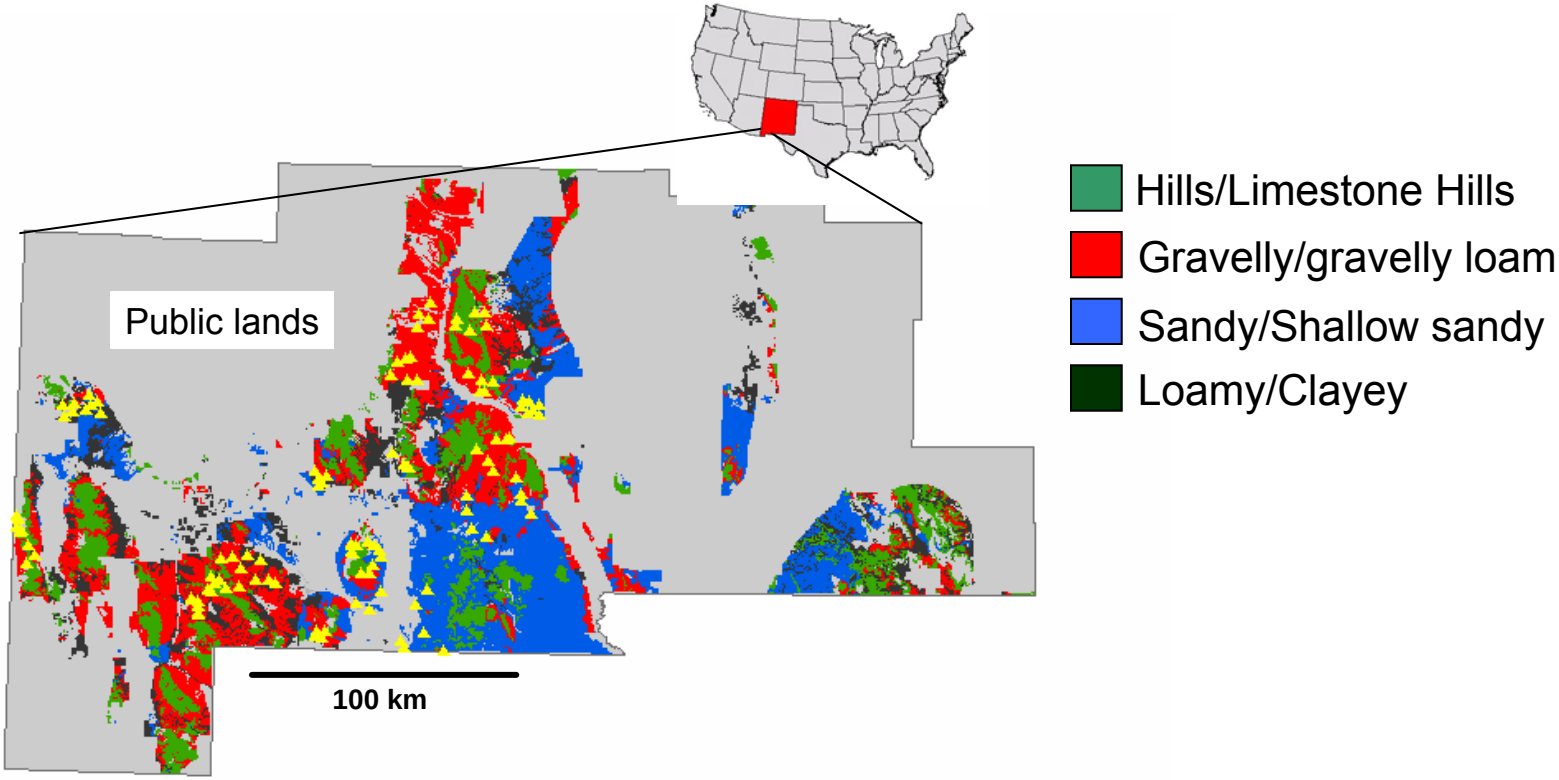
High carbonate, shallow, San Andres piedmont, NM

1912

2002

Shrub domination was substantial on shallow convex surfaces by 1912 but grasses remained.

3. Decade-scale reconstruction



Bureau of Land Management photo-trend plots
- Initiated in 1969
- Photographed yearly until 1990s
- 200 plots located in key areas with >20 year history

3. Decade-scale reconstruction

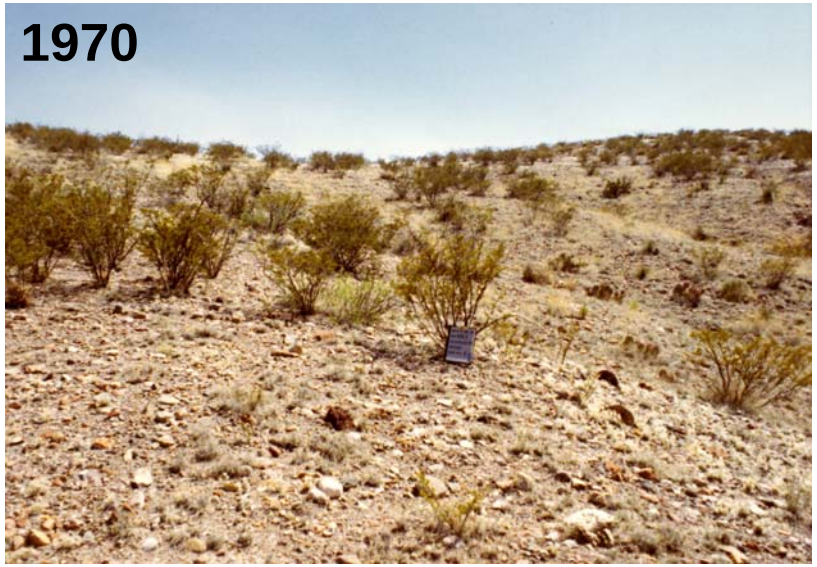
Soil Conservation Service Desert Soils-Geomorphology Project photos
- Initial photos 1959-1972 taken by Leland Gile
- Photographed in 2002-2005, relocated with Leland Gile
- 80 sites

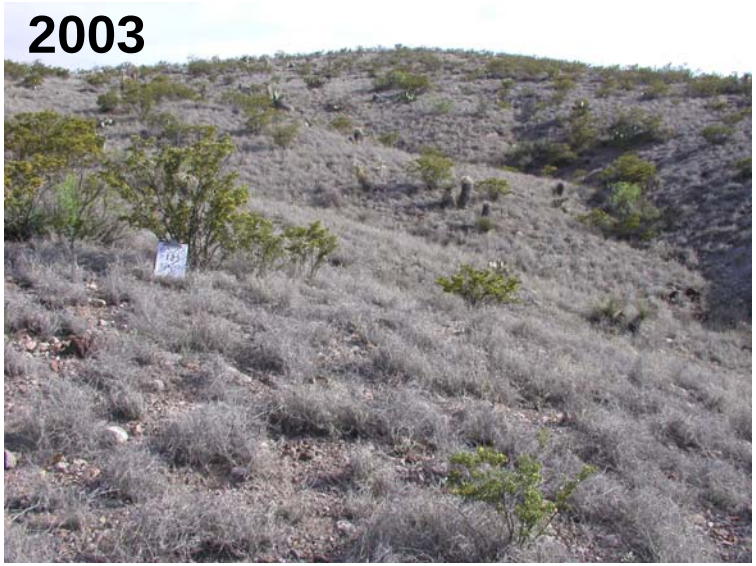
3. Decade-scale reconstruction

High carbonate, shallow

- **light-moderately grazed BLM land**
- **No evidence for recovery; *shrubland state***

3. Decade-scale reconstruction

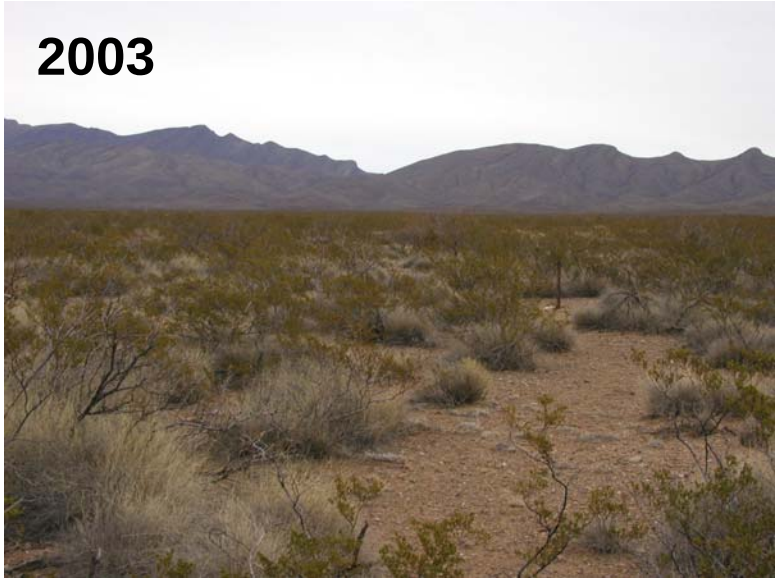




Moderate carbonate, shallow

- **A water well malfunctioned in 1970**
- **Black grama recovery has been dramatic; *mixed shrub-grassland state***

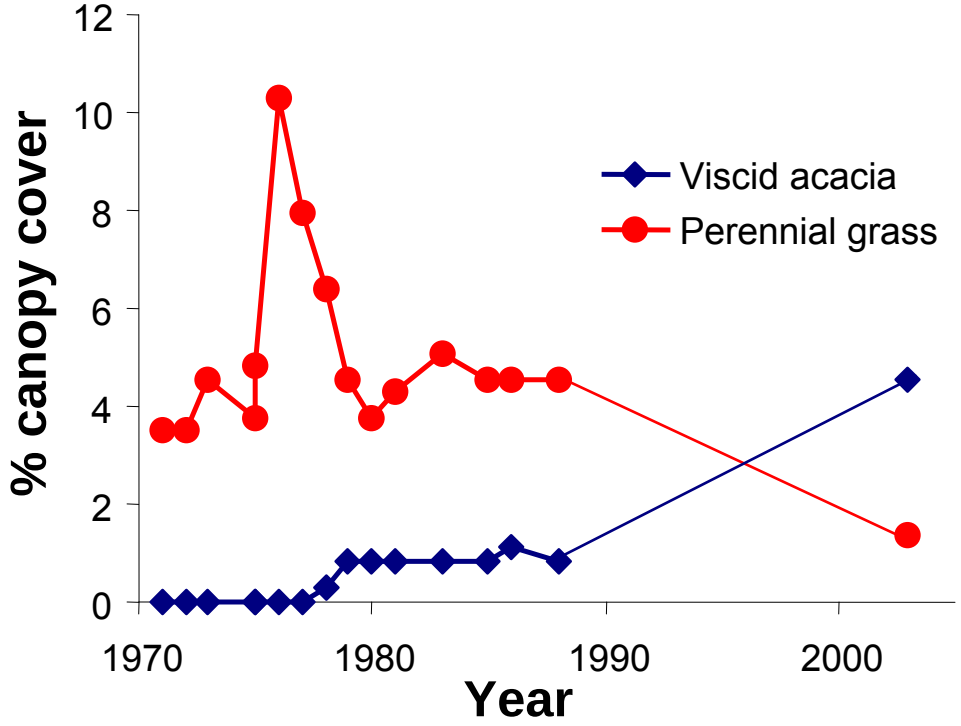
3. Decade-scale reconstruction



High carbonate, shallow

- **Exclosure, ungrazed since 1938**
- **Bush muhly colonized shrub bases but no recovery in interspaces; *shrub-dominated state***

3. Decade-scale reconstruction



Deep, higher clay

- **Site was vulnerable for years**
- **A wet winter year was a trigger for shrub establishment**
- **Prolonged low grass cover leads to soil erosion**
- ***Formation of shrubland state***

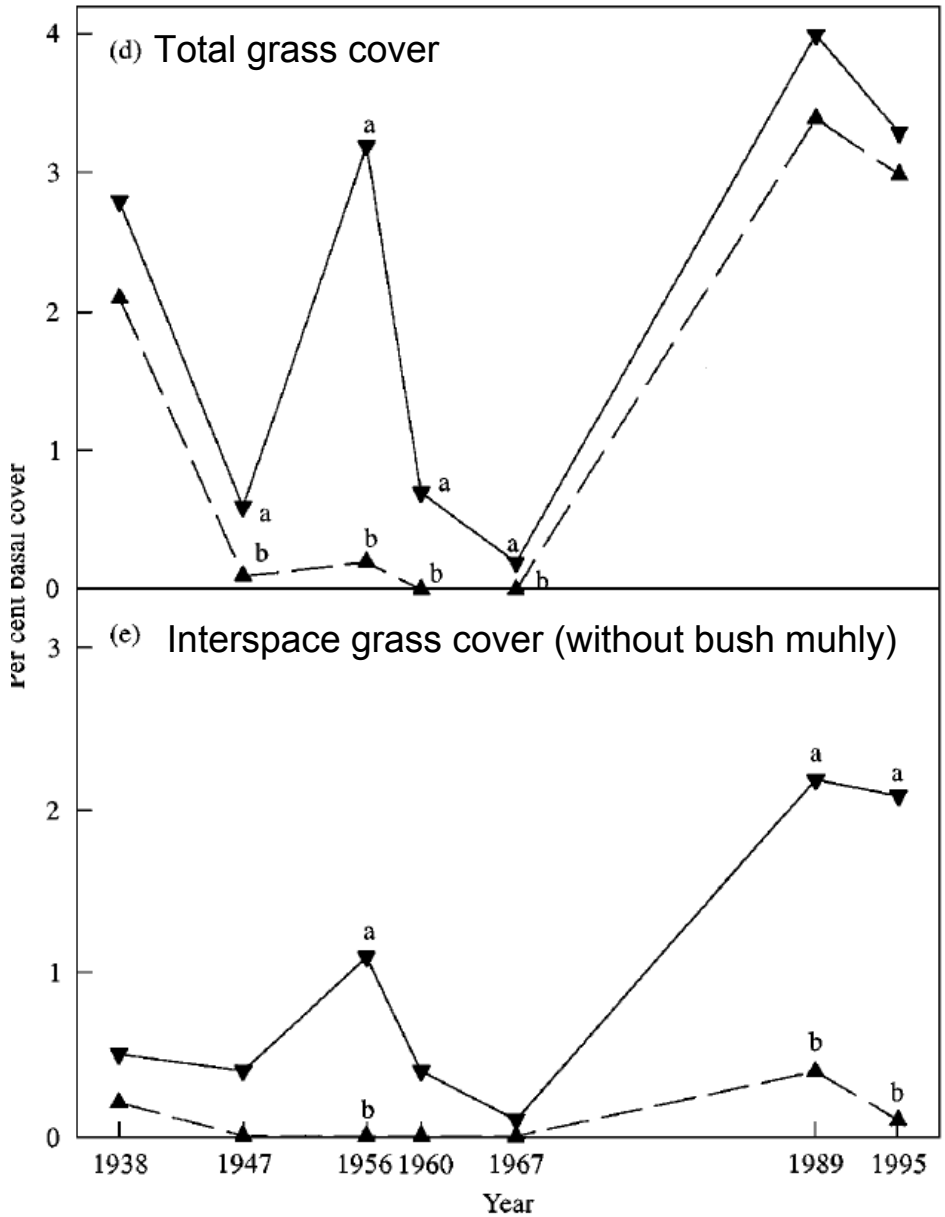
4. Decade-scale reconstruction

What happened to perennial grass over time (~1969-2003)?

Ecological site	Persisted	Lost
Gravelly loam	11	5
Gravelly	14	8

Perennial grasses have recently been lost in about one third of the cases

4. Experimental evidence



▼Treated (hand removal in 1939)
▲Untreated

- **Grass recovery in interspaces took several decades to get going**
- **Bush muhly does well in untreated shrublands and compensates for interspace grass cover**

Havstad et al., 1999, Journal of Arid Environments 42: 155

Modifications to the Gravelly model

1. High carbonate soils split out or described as non-resilient form

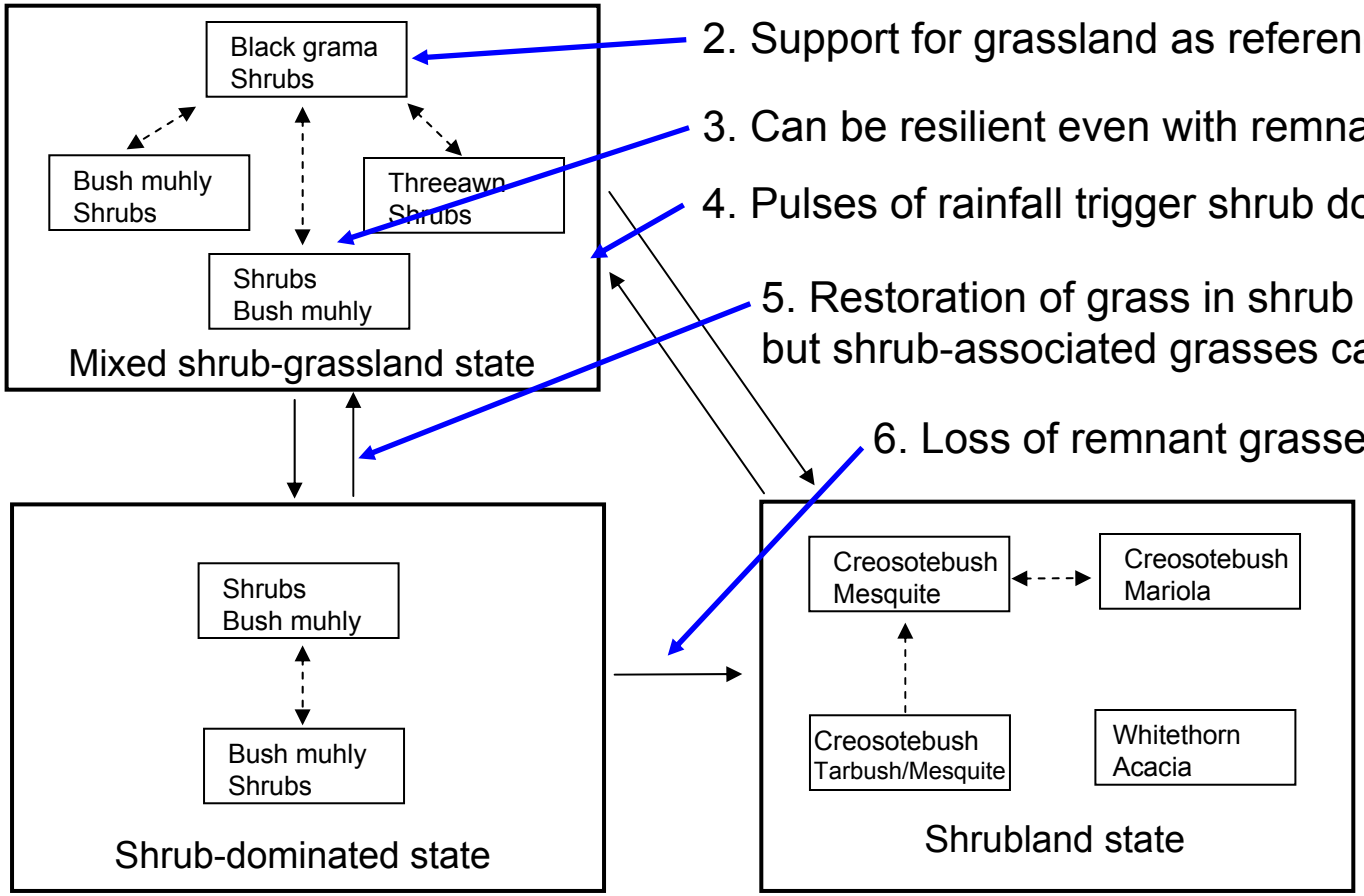
2. Support for grassland as reference

3. Can be resilient even with remnant grass cover

4. Pulses of rainfall trigger shrub dominance

5. Restoration of grass in shrub interspaces is possible, but shrub-associated grasses can be important too.

6. Loss of remnant grasses continues



General recommendations

- Detailed information from a relatively few ecological sites can provide information for large land areas

- A combination of expert knowledge, qualitative historical data, quantitative inventory, and well-chosen experiments *across a region* provide defensible support for models

- There is an urgent need to develop fiscal support, general protocols, and databases that assemble these diverse datasets