Patterns in Chihuahuan Desert state-and-transition models

MLRA 42 Ecological Site Description Workshop
Alpine TX

Brandon Bestelmeyer, USDA-ARS Jornada Experimental Range
bbestelm@nmsu.edu

What are state-and-transition models?

Diagrams, photos, text, and associated data that describe possible changes in *vegetation and soils* and their causes for particular ecological sites

State and transition models are repositories of information that aid development of management hypotheses at particular places

Models will be maintained with Ecological Site Descriptions by the USDA Natural Resources Conservation Service and revised as information accumulates

Two basic classes of vegetation/soil change

A. “Community pathway within states”

Changes in plant abundance that are promoted or reversed with changes in *rainfall* or *disturbance pattern* (grazing, fire)

B. “Transition between states”

Changes in plant abundance that cannot be reversed until competitors or fire-adapted species are removed

OR

erosion is stabilized and soil fertility, soil physical properties, or previous hydrology is restored.

Six patterns of vegetation/soil change

Community pathways within states

1. Stability: no significant change observed
2. Size oscillation: no change in composition, but cover and production varies
3. Loss and recovery: composition may change within functional groups and cover and production varies

Transitions among states

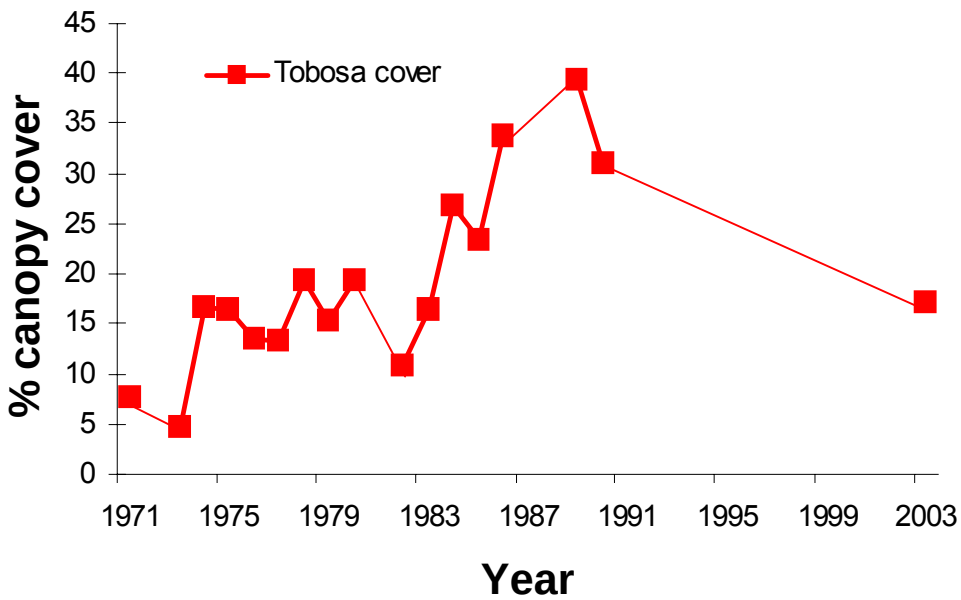
4. Loss and replacement: local change in key functional groups and their production
5. Hydrological reorganization: part of production moves to another part of the landscape (usually downslope)
6. Cascading transition: wind and water erosion spreads and production is lost

1. Community pathway: vegetation stability (and vehicular replacement)

Ridge top, dissected alluvial fan
Carbonatic, shallow gravelly ecological site
Loamy-skeletal, carbonatic Calcic Petrocalcid

- **this ecological site may have always been creosotebush dominated, or degraded long ago.**

2/3. Community pathway: oscillation or loss and recovery

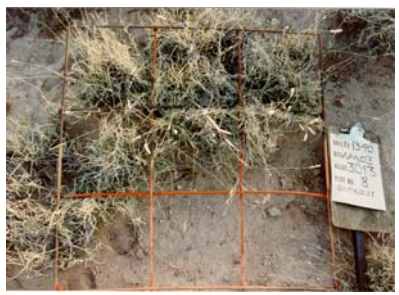


Basin floor
Silt loam ecological site
Fine-silty Haplocalcid

- **Recovery possible even at very low grass cover values**
- **System resistant to soil degradation**

1971

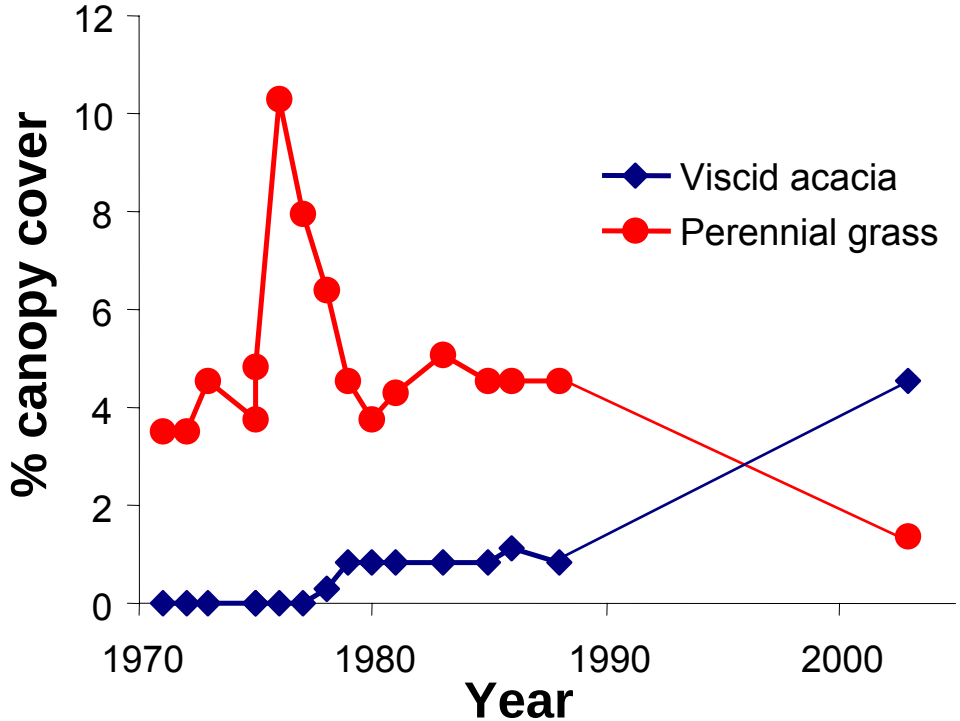
1980



1990

2003

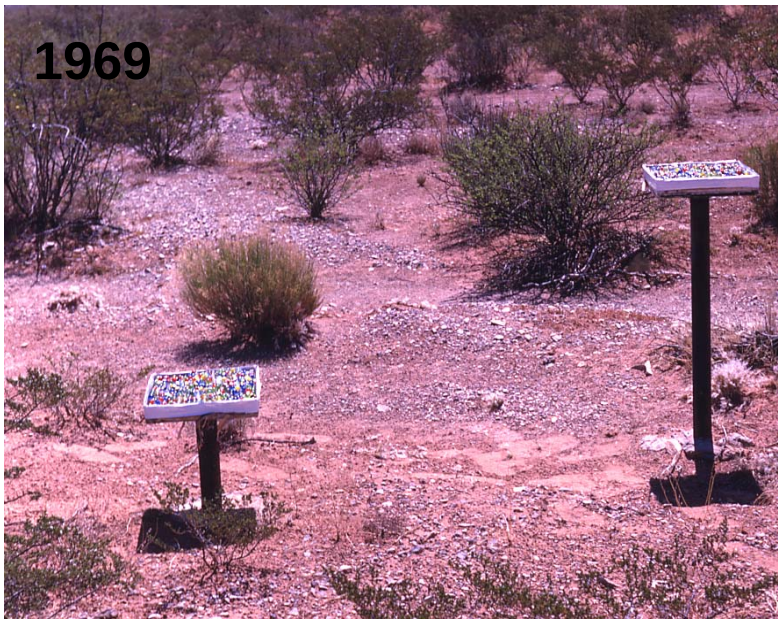
4. Transition: grass loss → shrub invasion → soil erosion



Relict piedmont
Gravelly clay ecological site
Clayey-skeletal Calciargid

- **Site was vulnerable for years**
- **Shrub establishment in wet winter year**
- **Prolonged low grass cover leads to soil erosion**

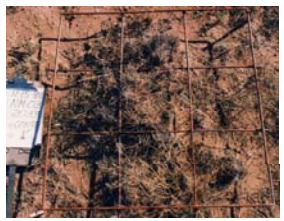
5. Transition: altered hydrology and sedimentation



Middle piedmont slope
Gravelly loam ecological site, (gravelly) fine-loamy Calciargid

- **Exclosure ungrazed since 1911**
- **Surrounding area is eroding**
- **18 cm of sediment accumulation parallels grass recovery**

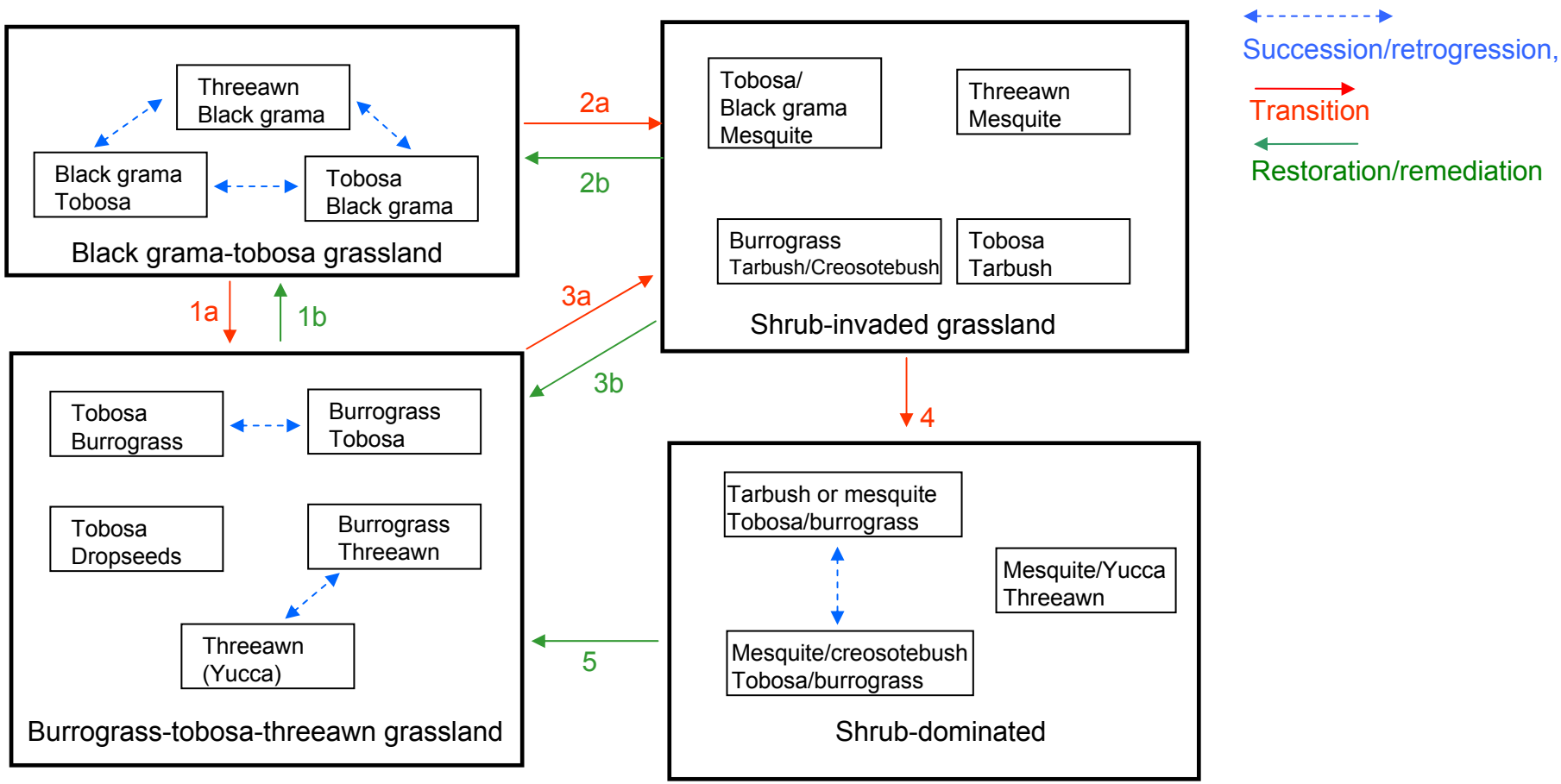
6. Transition: sediment deposition and grass loss



Basin floor: Loamy site adjacent to degrading Loamy sand site (was a fine-loamy Calciargid)

- **25 cm of fine sand accumulation abrading and burying tobosa**

State and transition models have 5 parts



1a. Continuous heavy grazing, soil fertility loss, erosion and sand loss. **1b**. Soil stabilization, soil amendments
2a. Shrub invasion due to overgrazing and/or lack of fire. **2b**. Shrub removal, restore grass cover
3a. Shrub invasion. **3b**. Shrub removal
4. Persistent reduction in grasses, competition by shrubs, erosion and soil truncation
5. Shrub removal with soil addition?

Photos, text, and data are the “meat”

Shrub-invaded state, threeawn-mesquite

•Threeawn dominant, some burrograss and fluffgrass. Mesquite and tarbush present
•Cover of grasses low (18/3%)
•Evidence of wind erosion and pedestalling, large bare patches.
•Algerita sandy loam, eroded phase, Jornada Exp. Range, Dona Ana Co.

Shrub-invaded state, burrograss-creosotebush

•Burrograss dominant, some tobosa. Creosotebush at moderate density
•Cover of grasses low-moderate (28/6%)
•Evidence of wind erosion and pedestalling, large bare patches.
•Dona Ana fine sandy loam, Jornada Exp. Range, Dona Ana Co.

Shrub-dominated state, creosotebush-tarbush

•Creosotebush dominant, some bush muhly among shrubs. Borders gravelly site.
•Cover of grasses very low (<1%)
•Evidence of wind erosion and pedestalling, nearly continuous bare ground, physical crusts.
•Dona Ana fine sandy loam, Jornada Exp. Range, Dona Ana Co.

Defining states and communities

States are defined by critical processes (e.g., eroded shrubland state)

There are different philosophies for defining communities:

- Usually differ in functional significance

- Functional groups: e.g. “mid-grass dominated community”

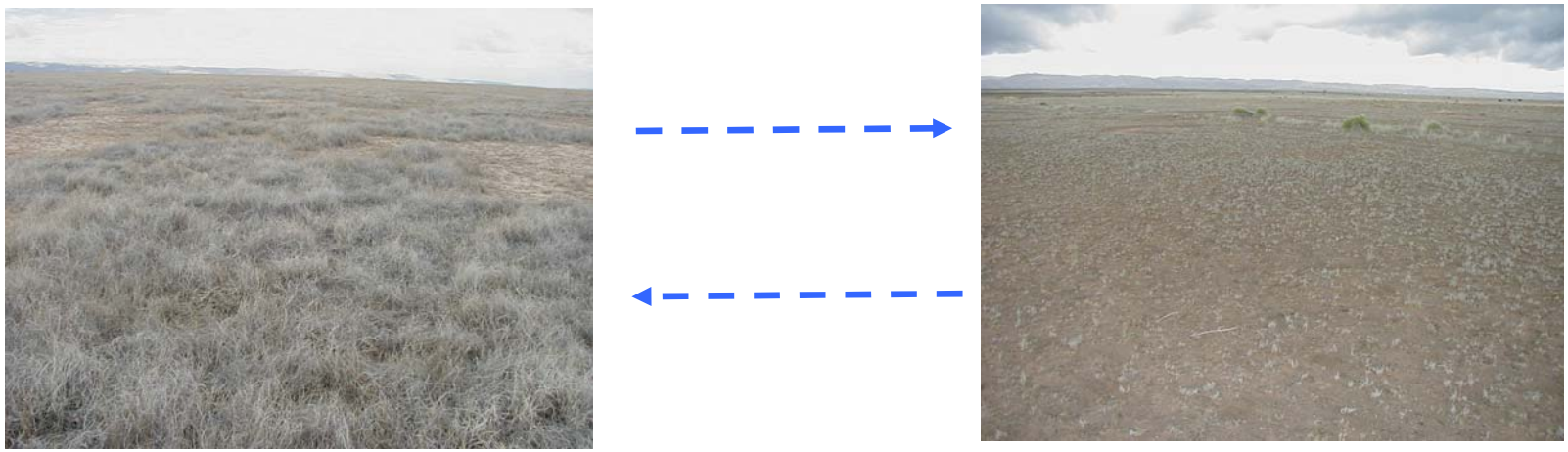
- Dominant or significant species: e.g. “Ricegrass-Big Sage-Cheatgrass”

- May be able to link communities in ST models with National Vegetation Classification community types and mapping efforts

http://www.natureserve.org/explorer/index.htm

Describing thresholds: risk and chance

1) Inappropriate grazing, low soil protection



2) Grazing management, good rainfall, high soil protection

In some periods, you take a risk and get lucky---succession leads to recovery

Transitions must be matched with a appropriate management response

1) Inappropriate grazing, low soil protection

2) Trigger and threshold: large storm produces gully

3) Livestock management: Gully deepens, adjacent soils dry, shrubs invade

4) Gully repair: shrubs maintain low grass cover, soils degrade

5) Shrub control with herbicide: soils already degraded

Transitions may not involve dramatic changes in vegetation

Nickel series, MLRA 42, typic aridic Calcareous Gravelly

Dark A

Light A

Recent grassland loss, potential
for recovery

Crossed a biotic threshold, soils not yet degraded

Grassland absent for decades, recovery unlikely

Already crossed a soil degradation threshold

The dynamic relationship between soil and vegetation is key to defining thresholds

Common processes causing transitions

Cause of transition	*Accelerating/restoration practice*
Directional climate change	None (redefine potential)
Loss of fire disturbance	Restore fuel loads
Soil degradation	Add organic matter, break p-crust
Altered hydrology	Gully plugs, create meanders
Undesired establishment	Selective herbicide application
Depletion of seed pool	Seeding

How the pieces fit together