THE GAME
STATE & TRANSITION MODELS

- Conceptual vegetation models
- Different succession models
- Depict changes rangelands
- Response to climate and/or mismanagement
STATE & TRANSITION MODELS

- Aid land managers
- Anticipate consequences of management decisions
- Identify management decisions leading to desired outcomes
What are the boxes & arrows?????
BOXES

• VEGETATION STATES
  – Different distinctive plant communities that may exist on an ecological site. Not easily reversible

• Communities
  – Changes in the dominant or significant species. Easily reversible
**ARROWS**

- **TRANSITIONS**
  - Events or actions that cause a shift from one state to another. **Not easily reversible**

- **COMMUNITY PATHWAY**
  - Changes in plant abundance. **Easily reversible**
Climate Change & Range Management: The Game of States and Transitions

Sideoats grama, other grasses 20-35%
False mesquite, shrub buckwheat 5-15%
Other shrubs 1-10%
Annual forbs & grasses fluctuate (drought/ El Nino)

Shrubs succulents dominate
Lesser perennial grasses
Annual grasses fluctuate with climate (drought/ El Nino)

Roads, Trails introduce lovegrass
Drought / Fire
Continuous heavy grazing

Lehmann lovegrass invades
Drought / Fire
Continuous heavy grazing

Mimosas and mesquite 10-35%
Other shrubs/succulents 5-20%
Understory annuals and half-shrubs
Trace perennial herbs

Lehmann lovegrass more dominant with repeated fire
Native plants persist in rock outcrops and canyons

Unknown
Unknown

D. Robinett, NRCS

NATIVE GRASS, FORB
HALF SHRUB

D. Robinett, NRCS
Climate Change & Range Management: The Game of States and Transitions

**MLRA 41-3 (12-16”), Granitic Hills**

**HCPC**
- Shrubs, succulents dominate plant community with lesser amounts of perennial grasses. Annuals* fluctuate with climate (drought / El Nino).
- Minor invasion of woody plants.

**Native grass, forb, shrub, tree**
- Fire / Drought / Grazing

**1a**
- Lehmann lovegrass invades and dominates the community. Native perennial herbs exist only in minor amounts. Native plants still persist in the plant community due to rock outcrop and canyons. With repeated fire, Lehmann becomes more and more dominant.

**1b**
- Unknown. Possible herbicide treatment of exotics species and seeding of native grasses.

**2a**
- CHG with drought, climatic warming. Increase by mimosas and / or mesquite. Other shrubs and succulents can increase also. Shrubs quickly re-sprout after fire. Remnant perennial grasses cannot re-colonize areas with shrub competition.

**2b**
- Unknown. PG/NG with herbicide shrub control. Possible seeding of native grasses, maintenance treatments for shrubs (fire, herbicide).

**Shrub Increase**
- Climatic warming

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*Native annuals dominant, may be patches of some non-natives

CHG – continuous heavy grazing
PG/NG – proper grazing, no grazing
CAER – false mesquite, ERWR – shrub buckwheat
BOER – black grama, BOCU – side oats grama
Objectives

1. Use state & transition models
   - illustrate interactions between climate variability/change and range management activities
Objectives

2. Explore how state and transition models are constructed
   – highlight strengths/weaknesses
   – assumptions
   – new information needs
Objectives

3. Assess needs
   – research
   – applications
   – tools
   – data
Situation

- Small groups are management teams
- 1000 acre sacaton/loamy bottom parcel
- ‘birdseye view’ of 60-year management period with 10-year decision windows
- parcel has been historically grazed (60 years)
- currently has stocking rates based on site potential
- management objective (continued grazing or towards protection) will be determined
What you need to play

• Instruction Sheet

**Climate Change and Rangeland Management: The Game of States and Transitions**

**Objectives**
- Use state and transition models to illustrate the complex interactions between climate variability/change and range management activities
- Explore how state and transition models are constructed highlighting strengths/weaknesses, assumptions, and where more information is needed to make useful in everyday applications with respect to climate variability and change
- Assess additional research and application needs to integrate climate change information into range management planning and decision-making

**Situation**
- Small groups are tasked to manage a 1000-acre wetland / bottomland parcel of rangeland over a 60-year period into the future taking into account changes in temperature and precipitation. The parcel has been grazed for the past 60 years and currently has stocking rates based on the potential. The overall management objective (continued grazing or towards protection) for the parcel will be determined in the final steps of the exercise.

**How are the game rules?**
- Each group will begin with their parcel at a discrete state. The initial state for the first decision period will be assigned to each group. Disturbances, financial condition, and overall management objectives will be determined by rolling dice and looking up numbers on a table.
- Climate data are presented in 10-year decision periods. Each decision period has a corresponding time series of artificial precipitation and temperature data generated to simulate future potential climate change. The precipitation time series is taken from seasonal precipitation maximum for Arizona for the past 60 years with extended dry and wet years included. The temperature time series is taken from Arizona seasonal average temperatures for the past 60 years with a linear temperature trend imposed. These data series are not meant to represent climate projections for Arizona, but an artificial scenario that can be used in simulating management strategies under a changing climate.
- Transitions are determined by analyzing the climate time series for each decision period. Each group should discuss how the current state may transition to other states with the interaction between disturbances and the climate time series over the decision period. Will exceptionally dry or wet periods drive a transition to another state? How may increasing temperatures interact with precipitation amounts to affect soil moisture and vegetation condition?
What you need to play

- Worksheet

<table>
<thead>
<tr>
<th>Decision Period</th>
<th>Initial State</th>
<th>Disturbance</th>
<th>Financial Condition</th>
<th>Management Decisions</th>
<th>Reasons for Transition</th>
<th>Ending State</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tr>
</tbody>
</table>
What you need to play

• Lookup Table

### Lookup Table

<table>
<thead>
<tr>
<th>Number Rolled</th>
<th>Mgt Goals towards</th>
<th>Financial Standing</th>
<th>Disturbance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>continued production</td>
<td>Good</td>
<td>Climate &amp; Wildfire</td>
</tr>
<tr>
<td>2</td>
<td>continued production</td>
<td>Poor</td>
<td>Climate Only</td>
</tr>
<tr>
<td>3</td>
<td>preservation</td>
<td>Poor</td>
<td>Climate &amp; Invasive Species Introduction</td>
</tr>
<tr>
<td>4</td>
<td>preservation</td>
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<td>Climate &amp; Insect/Small Mammal Herbivory</td>
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</table>

### Management Options

<table>
<thead>
<tr>
<th>Management Options</th>
<th>Relative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescribed burning</td>
<td>Low</td>
</tr>
<tr>
<td>Herbicide control of mesquite</td>
<td>High</td>
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What you need to play

- **State & Transition Model (Game board)**

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Climate Change & Range Management: The Game of States and Transitions
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MLRA 41-3 (12-16”), Loamy Bottom

1a. Mesquite seed source present or introduced. Lack of fire for long periods of time. Mesquite increases to 20% canopy.
1b. Herbicide or mechanical means to remove mesquite. PG/NG
2a. CHG, Base level changes cause gully and headward erosion. Flooding reduced, water-table lowered to >20 feet.
2b. PG/NG, Mechanical control of gullies at headcuts.
3a. CHG (managing for annuals), burning (to freshen SPWR) plus CHG; Hay mowing, irrigated cultivation and abandonment. Base level changes in main stream causes down-cutting and gully formation on the floodplain, flooding reduced.
3b. PG/NG, Mechanical gully control measures. Seeding SPWR with weed control and water. Re-establish flooding
4a. CHG coupled with drought and, burning with low soil moisture. Reduction of A horizon OM and litter, compaction, sheet, rill erosion. Reduced infiltration, greatly increased runoff
Runoff, and very limited recruitment of perennial grasses. Base level change in main stream causes downcutting in swales.
5a. CHG, interruption of overland flow, diversion of runoff, Severe soil compaction from traffic (livestock or equipment) Base level changes in main stream causes down-cutting and gully formation on the floodplain.
5b. Mechanical control of gullies. Mesquite control or wood harvest with stump treatments (herbicide). Re-establish flooding.
6a. CHG combined with drought, burning with low soil moisture. Flowing of sacaton for cultivation with subsequent abandonment. Introduction or planting of seeds of exotic perennial grasses.
6b. Herbicide control of exotic grasses, seeding of sacaton with weed control and irrigation or flooding.

*Native annuals dominant, may be patches of some non-natives

CHG — continuous heavy grazing
PG/NG — proper grazing, no grazing
SPWR — sacaton
What you need to play

- Climate Data
Overview

- Use a state & transition model as the framework to discuss the complex interactions between climate and management actions.
  - Assigned initial state
  - 10-year decision windows
  - Disturbances and financial condition are determined by chance for each decision
Overview

- Climate data are presented in 10-year decision periods
  - Artificial future time series created from real Arizona climate data
  - Same precipitation time-series structure (interannual/interdecadal variability)
  - 1° F/decade trend in temperature imposed on historical Arizona time series
Overview

• Transitions are determined by analyzing the climate time series for each decision period
  – Patterns in temperature and precipitation (wet vs. dry periods)
  – Seasonality (winter vs. summer)
  – Interactions between temperature and precipitation (higher temperatures mean higher evapotranspiration rates)
  – Interactions with disturbances and management actions (financial condition governs possible management actions)

• Results from each group are discussed and transcribed at the end of the breakout period.
Example Game Board
Instructions

• Get all of the game parts organized and assign one person in the group to keep notes on the worksheet.
• Fill out first line of worksheet

<table>
<thead>
<tr>
<th>State and Transition-Climate Worksheet</th>
<th>Group Number</th>
<th>Management Objective</th>
<th>Desired State</th>
</tr>
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<tbody>
<tr>
<td>Decision Period</td>
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DESIRED PLANT COMMUNITY

• Vegetation state that has been identified to provide uses and values desired for the site.

• Must provide adequate protection for the site.
Instructions

• Get all of the game parts organized and assign one person in the group to keep notes on the worksheet.
• Fill out first line of worksheet
Instructions

• Look at the first entry on your worksheet labeled ‘1’ under the decision period column. If this is the first decision period, list your assigned initial state. List the ending state from the previous decision period if you are beyond first period.
Instructions

• Roll to determine your disturbance and financial condition for the decision period.
Instructions

• Analyze climate data for decision period (don’t peek ahead!)
  – Sequences of wet and dry years
  – Prolonged periods of above/below average temperature and/or precipitation
  – Extremes and their potential impact within the decision period
  – Seasonality of temperature and precipitation
Instructions

Disturbance within decision period? (Determine when you think the disturbance is most likely to occur with respect to the climate information given and use this in your discussions)
Instructions

• Use management options on lookup table
  – Manage to move to another state or stay at current state
  – Use management options in concert with climate data and potential disturbances
  – You can not use expensive management options during a decision period if you are in poor financial standing!

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Putting it all together!

Management Options | Relative Cost
--- | ---
Prescribed burning | Low
Herbicide control of mesquite | High
Herbicide control of non-native grasses | High
Rock and wire gabions | High
Earthen retention dams | Medium
Seeding of sacaton | High
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State and Transition-Climate Worksheet

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<td>1</td>
<td>native grasses</td>
<td>Climate &amp; Invasives</td>
<td>Good</td>
<td>Herbicide control of non-native species</td>
<td>No change; adequate precip through period; herbicide control effective</td>
<td>native grasses</td>
</tr>
<tr>
<td>2</td>
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Climate Change & Range Management: The Game of States and Transitions
Move on to next decision period...

- Discuss as a group the interaction between the climate time series, the disturbance, management options used and the state & transition model. This is a thought exercise with no right answers, so be creative!
- When finished with a decision period, move on to the next (repeat steps 4-7). There are a total of six decision periods that cover the period from 2010 to 2069.
- After all groups are finished with as many decision periods as possible in the time allotted, we will discuss results from each group worksheet.

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<td>Good</td>
<td>Rest Rotation Grazing</td>
<td>No change; adequate summer precip through period; quick recovery after fire</td>
<td>native grasses</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>native grasses</td>
</tr>
</tbody>
</table>

*Climate Change & Range Management: The Game of States and Transitions*
Continue with next decision period or finish up...

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<td>Climate &amp; Wildfire</td>
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Climate Change & Range Management: The Game of States and Transitions

Sacaton Grassland

1, 7

Eroded, Sacaton

Mesquite, Sacaton

Exotics

Annuals

Eroded, Mesquite

*Native annuals dominant may be patches of some r
Let the games begin!