Resilience in STMS:
Understanding Disturbance Response

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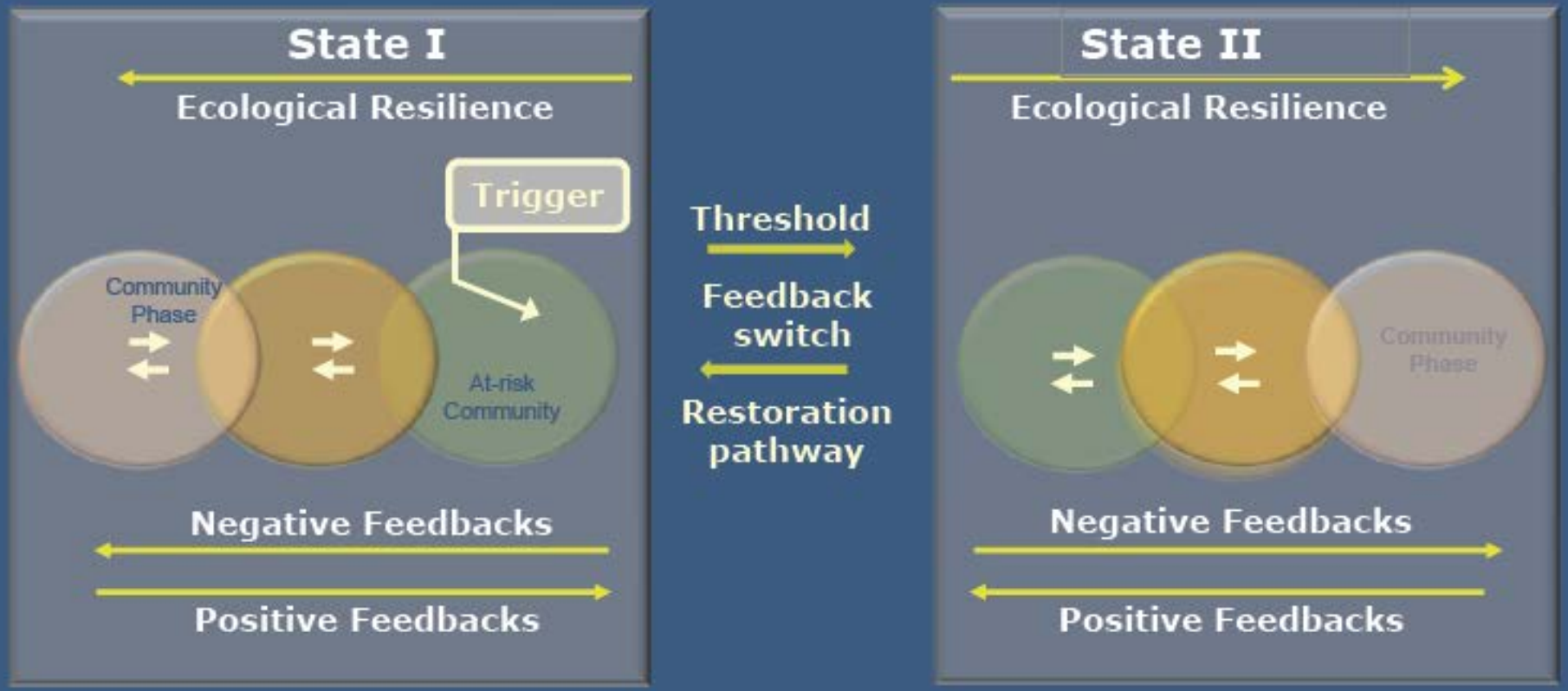
STM Fundamentals
Know the Subject Matter

- Briske, D.D., B.T. Bestelmeyer, T.K. Stringham and P.L. Shaver. 2008. Recommendations for development of resilience-based state-and-transition models. *Rangeland Ecology and Management* 61:359-367.

- Stringham, T.K., W.C. Krueger and P.L. Shaver. 2003. State and transition modeling: A process based approach. J. Range Management 56:106-113. Featured Article.

- Stringham, T. K. and J.P. Repp. 2010. Ecological Site Descriptions: Considerations for Riparian Systems. Invited Paper. *Rangelands* 32(6):43-48.

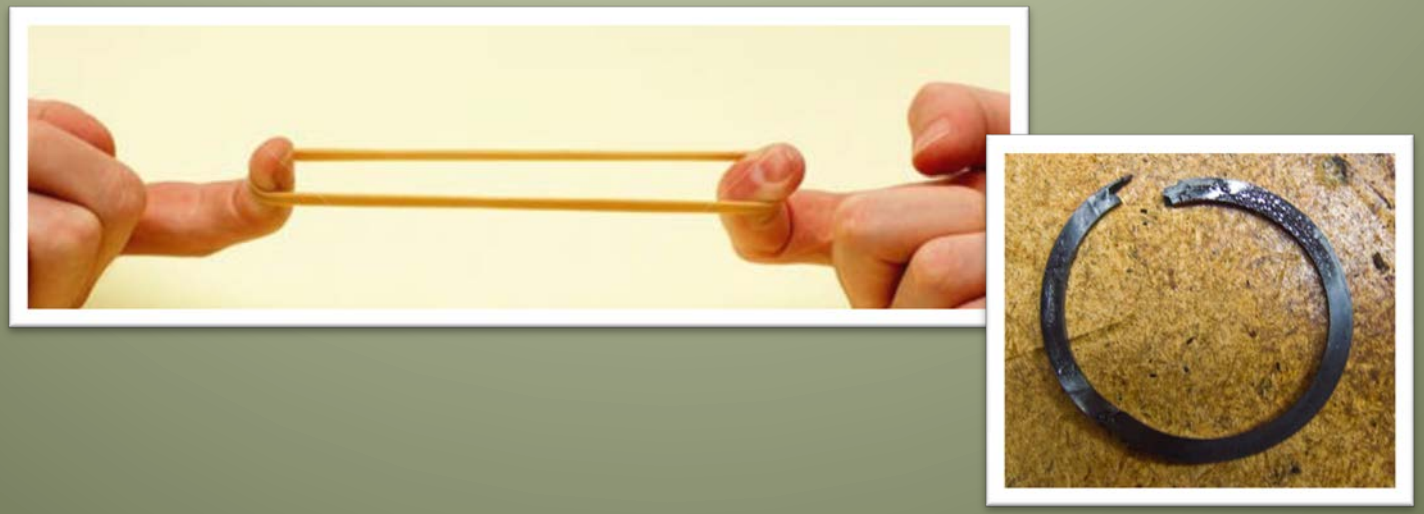
Resilience-based Management



Thresholds vs Resilience

- Resilience = extent of modification required to transform an ecosystem to an alternative state

- Threshold – defines the limits of resilience for an ecosystem



Resilience-based Concepts

- *At-risk community phase* – plant community phase most vulnerable to exceeding state *resilience*

- *Feedback mechanisms* – ecological processes that enhance or decrease ecosystem *resilience*

- *Feedback switch* – point at which feedbacks shift from negative to positive and exceed *resilience* limits. Typically associated with a trigger event or successful rehabilitation of processes.

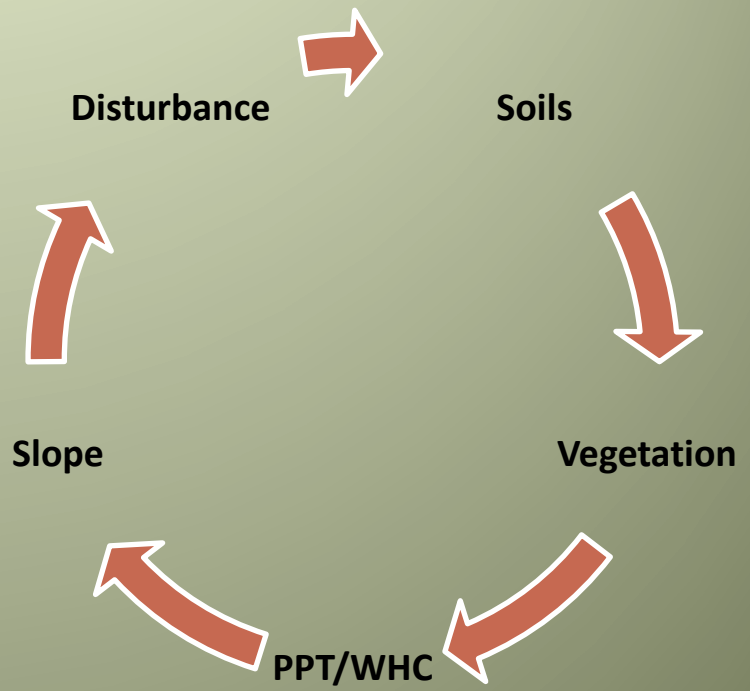
Resilience-based Concepts *cont.*

- *Triggers* – variables or events that initiate thresholds by contributing to the immediate loss of ecosystem *resilience*

- *Restoration pathways* – re-establishment of pre-threshold states following active restoration of self repair mechanism

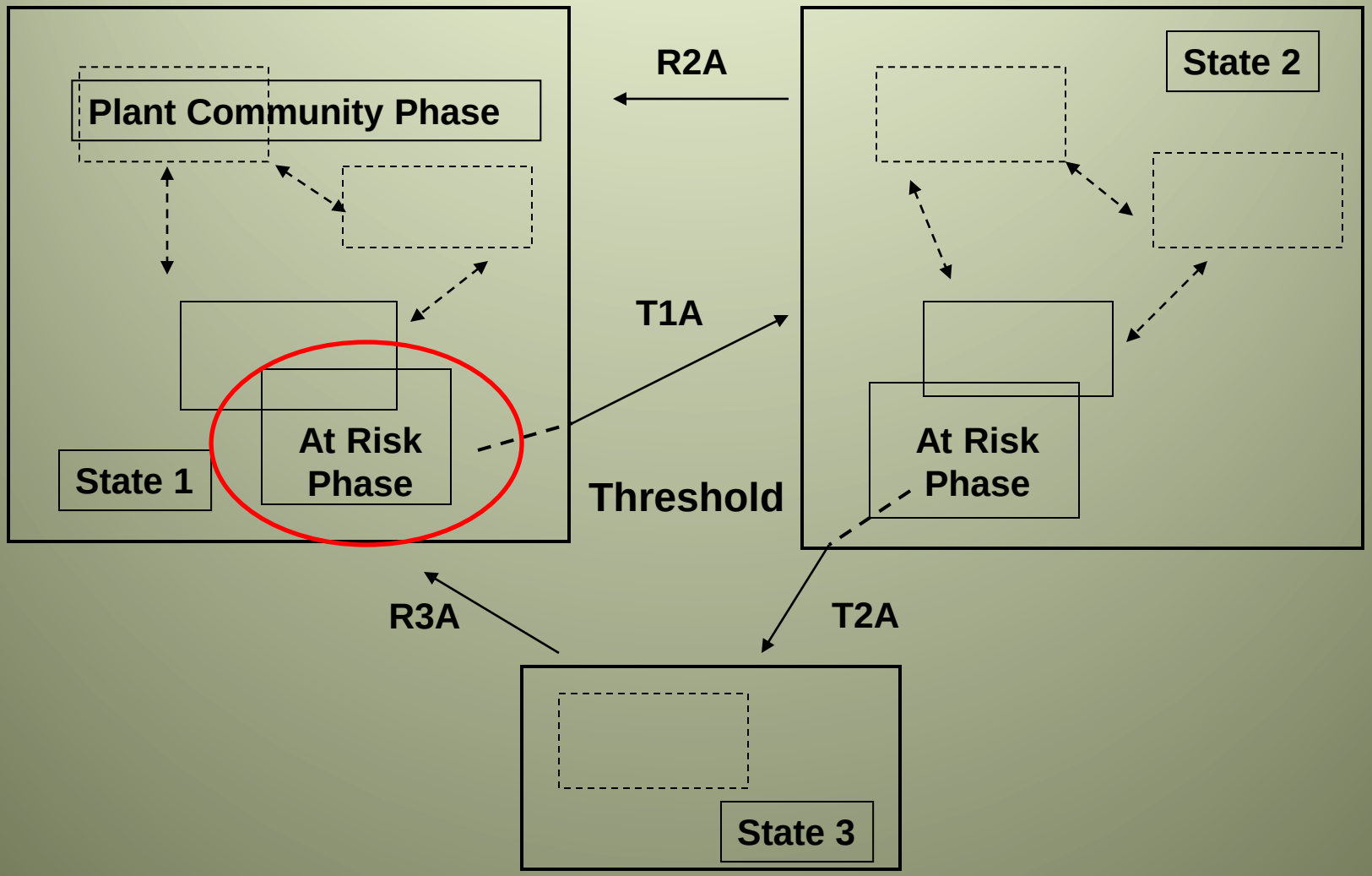
What is Resilience? Really

- Response to different disturbances
  - Fire
  - Grazing
  - Flooding
  - Drought
  - Insects
  - Invasive species, etc.
  - Any combo of the above



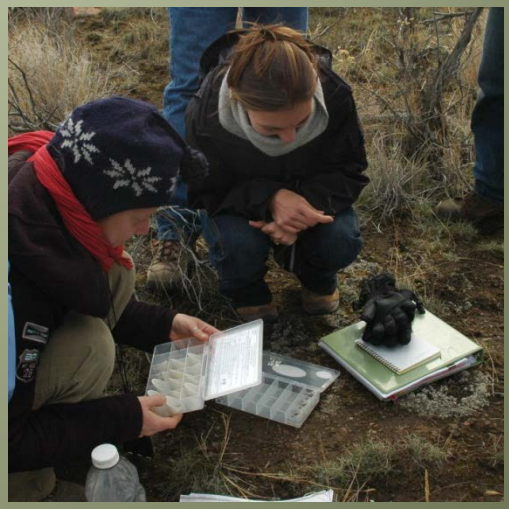
- Current condition = state & plant community phases

PROCESS BASED STATE-AND-TRANSITION MODEL



What are ecological processes?

- Process = amount per time (rate)
  - Infiltration rate
  - Nutrient cycling
  - Energy capture
  - Soil development
  - Soil erosion
  - Etc.
  - NOT A SPECIES LIST



Connection to Resilience….

- Disturbance influences ecological process
  - Infiltration rate
  - Nutrient cycling
  - Energy capture
  - Soil erosion
  - Etc.

Defined vs Described

- How do you measure or identify?
  - Feedback
  - Feedback Switch
  - Trigger

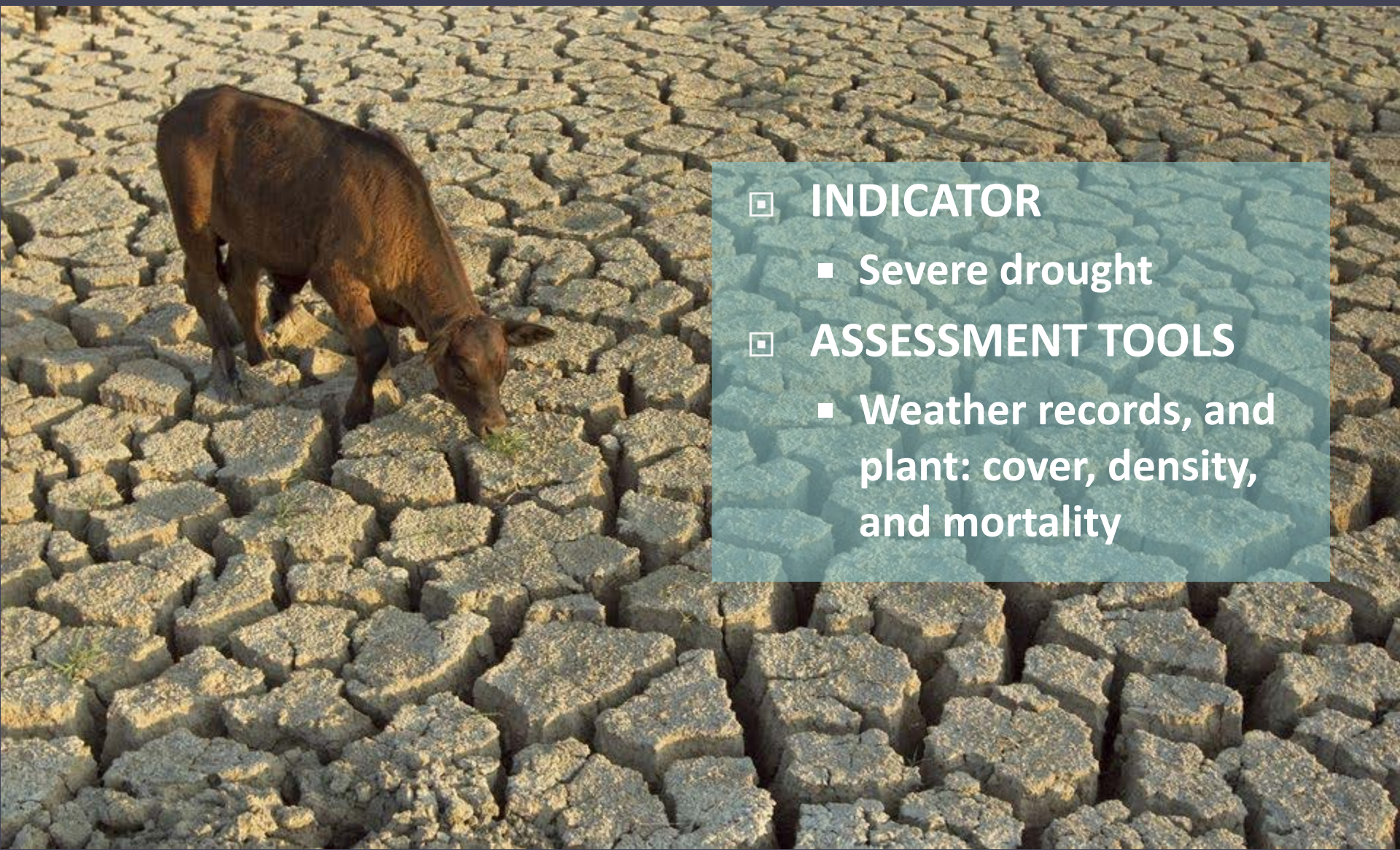
FEEDBACKS - SOILS

INDICATOR	ASSESSMENT
Soil erosion or nutrient loss	Soil loss, rills pedestals
Soil surface degradation	Aggregate stability, organic matter, microtopography
Nutrient redistribution	Desert pavement, coppice dunce
Bare soil/patch size	Area, distribution, connectivity

FEEDBACKS - COMMUNITY

- **INDICATOR**
  - Invasive species increases
  - Fine fuel load and continuity
  - Plant reproductive potential
  - Species/Functional group loss
- **ASSESSMENT Tools**
  - Density, rate of spread, dominance
  - Amount, pattern
  - Reproductive structures, plant size
  - Species inventory/monitoring

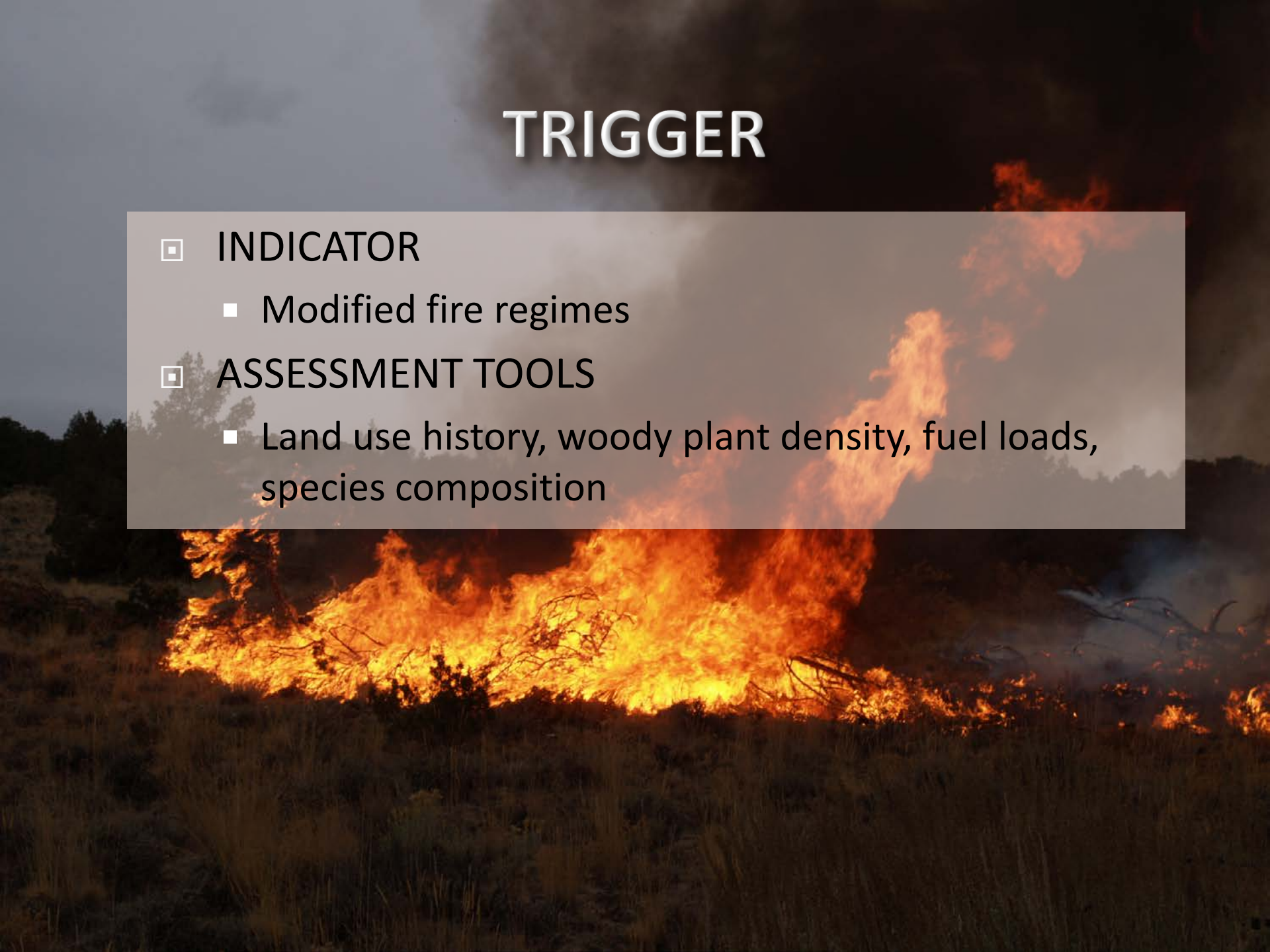
TRIGGER



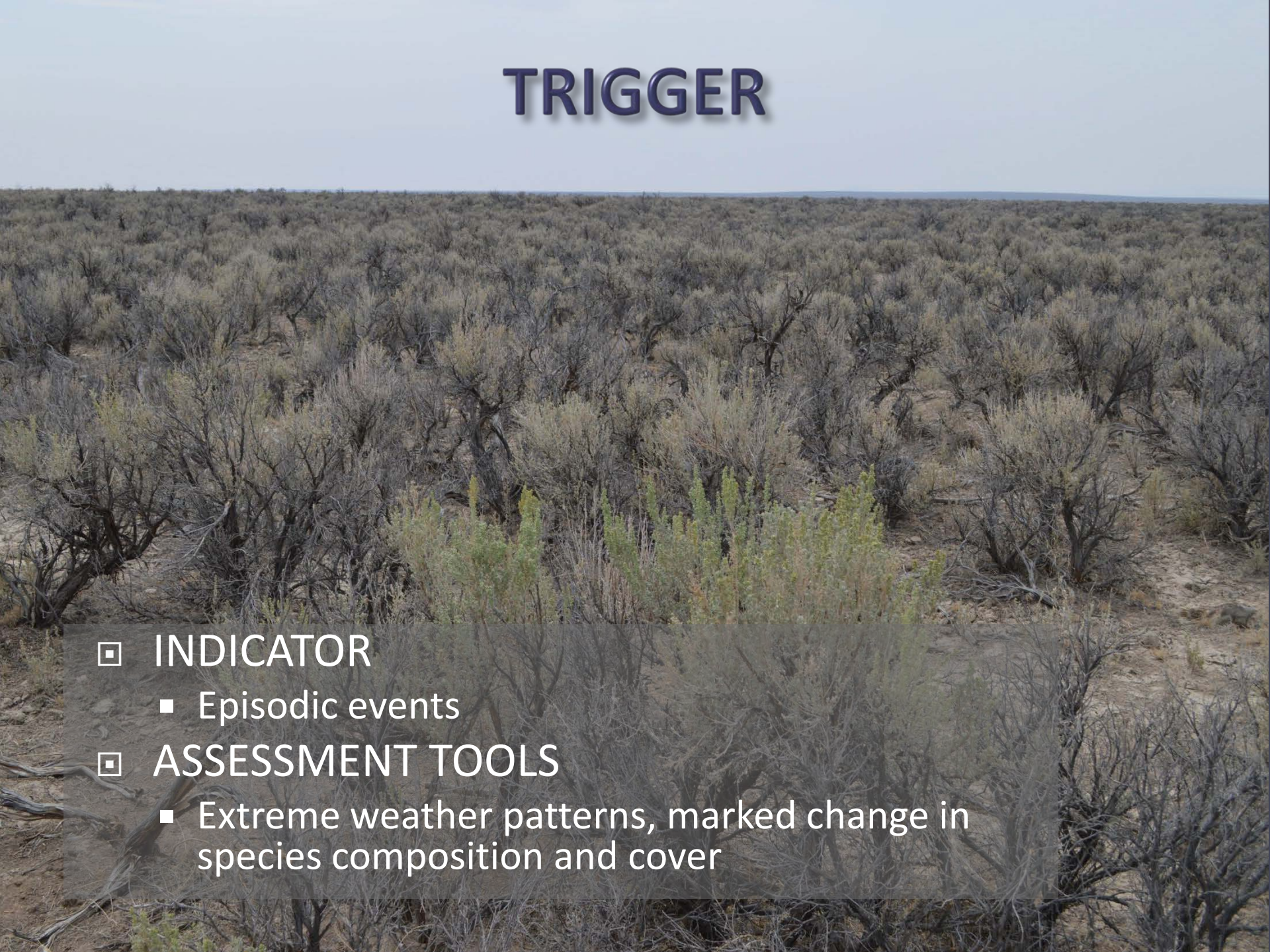
- **INDICATOR**
  - Severe drought
- **ASSESSMENT TOOLS**
  - Weather records, and plant: cover, density, and mortality

TRIGGER

- INDICATOR
  - Modified fire regimes
- ASSESSMENT TOOLS
  - Land use history, woody plant density, fuel loads, species composition



TRIGGER



- INDICATOR
  - Episodic events
- ASSESSMENT TOOLS
  - Extreme weather patterns, marked change in species composition and cover

Concept Summary

- STMs describe ecological dynamics
- Resilience varies by ecological site and current condition
- Resilience = sensitivity of ecological function to disturbance
- Condition = what state and what plant community phase
- At-risk plant community phase – most vulnerable

Application of Theory

Understanding disturbance response / resilence

- taking it to the field

Resilience in STMS: Understanding Disturbance Response

- Inherent Resilience
  - Assumption = ecological site scale
- Know the ecological site / region
  - Climate
    - Loamy 5-8 vs Loamy 8-10

    Which is more resilient?
  - Loamy 5-8
    - Mrs. Indian Ricegrass is looking for a new home does she prefer the 5” area or the 8”?

Resilience in STMS: Understanding Disturbance Response

- Inherent Resilience
- Know the ecological site / region
  - Climate
  - Loamy 5-8
    - Mrs. Indian Ricegrass is looking for a new home for her family does she prefer the 5” area or the 8”?

Resilience in STMS: Understanding Disturbance Response

- Inherent Resilience
- Know the ecological site / region
  - Climate
  - Loamy 5-8
    - Mrs. Indian Ricegrass is looking for a new home for her family does she prefer the 5” area or the 8”?

Resilience in STMS: Understanding Disturbance Response

- Inherent Resilience
- Know the ecological site / region
  - Soil
    - Surface or near surface soil properties
    - Silt phase, sandy phase, gravelly phase

Resilience in STMS: Understanding Disturbance Response

- Inherent Resilience
- Know the ecological site / region
  - Loamy 8- 10 (MLRA 25NV)
    - Wyoming Sage / Thurbers needlegrass / bluebunch
    - Wyoming Sage / Bluebunch wheat /Thurbers

  Which grass is more fire tolerant?

  Grazing?

  Season, frequency, intensity?

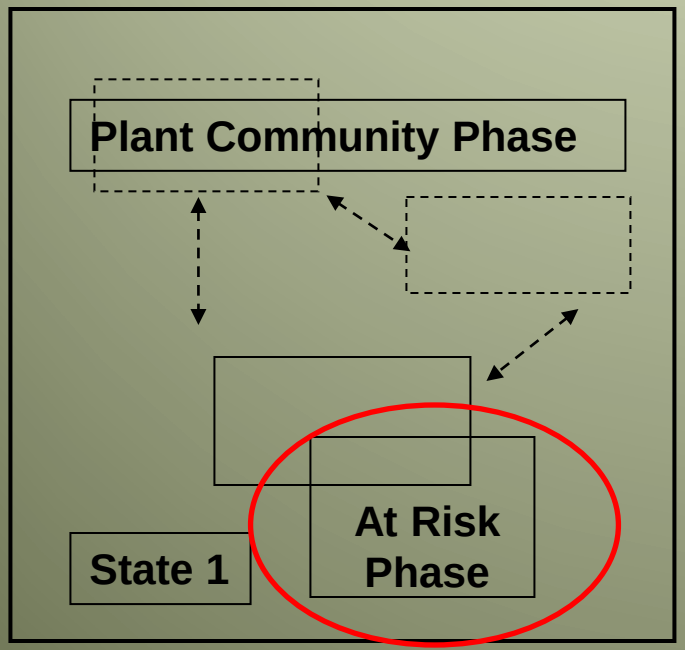
  Drought?

Resilience in STMS: Understanding Disturbance Response

- Inherent Resilience
- Know the ecological site / region
  - Discuss the range of RESILIENCE (variability) within the ecological site concept BEFORE model development
  - Resilience effects all components of STM

At-Risk Community Phase

Plant community phase within a state that is <u>most vulnerable</u> to exceeding the resilience limits of the state
(*Briske et al.2008*)



Identification of At-Risk Phase
- Development of STMs
-Utilization of STMs

At-Risk Community Phase

- How do you know when a site is “At-Risk”?
  - **NOT A NUMBER!**
  - **NOT A SPECIES LIST!**
- More about the discussion rather than getting the answer correct
  - What if…?
  - If we do treatment x, then…?
    - *RESILIENCE DISCUSSION*
- Leads to question of ecological process, function, and thresholds (continuum)

At-Risk Phase

- How do you determine the at-risk phase?
- ID the indicators suggesting a reduction in ecological function (Rangeland Health)
  - Change in plant functional/structural groups
  - Increased bareground
  - Decreased perennial vigor
  - Decreased soil surface stability
  - Increased water flow paths
  - etc

At-Risk Phase

- At risk to what?
  - ID disturbances or combination of disturbances likely to trigger a threshold event
  - Check with resources to verify this has happened
    - Multiple year drought combined with no grazing change
    - Wet year followed by drought = catastrophic fire
    - Etc
  - Describe transition in narrative
  - Next State?

At-Risk Phase

- At risk to what?
  - Describe transition in narrative
    - More than one possible trigger – describe
    - Combinations – describe
    - Range of variability within the ecosite or DRG must be mentioned
  - Next State?
    - More than one trigger may lead

    to more than one alternative state

Ecological Disturbance
Resilience

Fire #1: injures or kills plants; may cause soil damage

Fire #2: eliminates residual plants; conversion to weed dominated

Fire #3: plant cover significantly reduced; wind erosion

Resilience in STMS:
Understanding Disturbance Response

- Difficult task
- Disturbance Response Group
  - Group of ecological sites within an MLRA that exhibit similar resilience i.e., response to disturbance
  - Promotes resilience / disturbance thinking
- Expert Team

1: Reference State

1.1 Plant Community
- Wyoming big sagebrush ~30%
- Spiny hopsage 2-5%
- Thurber's needlegrass ~45%
- Bluebunch wheatgrass 2-10%
- Forbs 2-8%

1.1A

1.2A

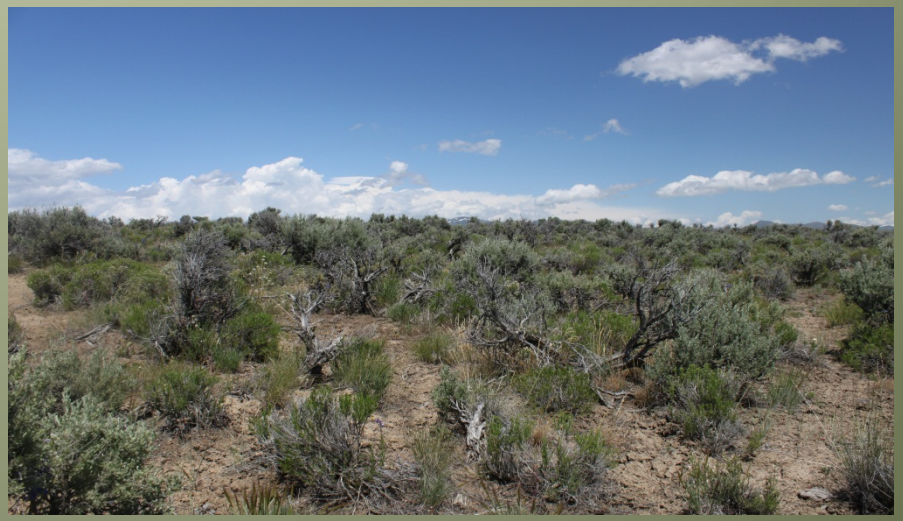
1.2 Plant Community
- Wyoming big sagebrush decreases
- Perennial bunchgrasses increase

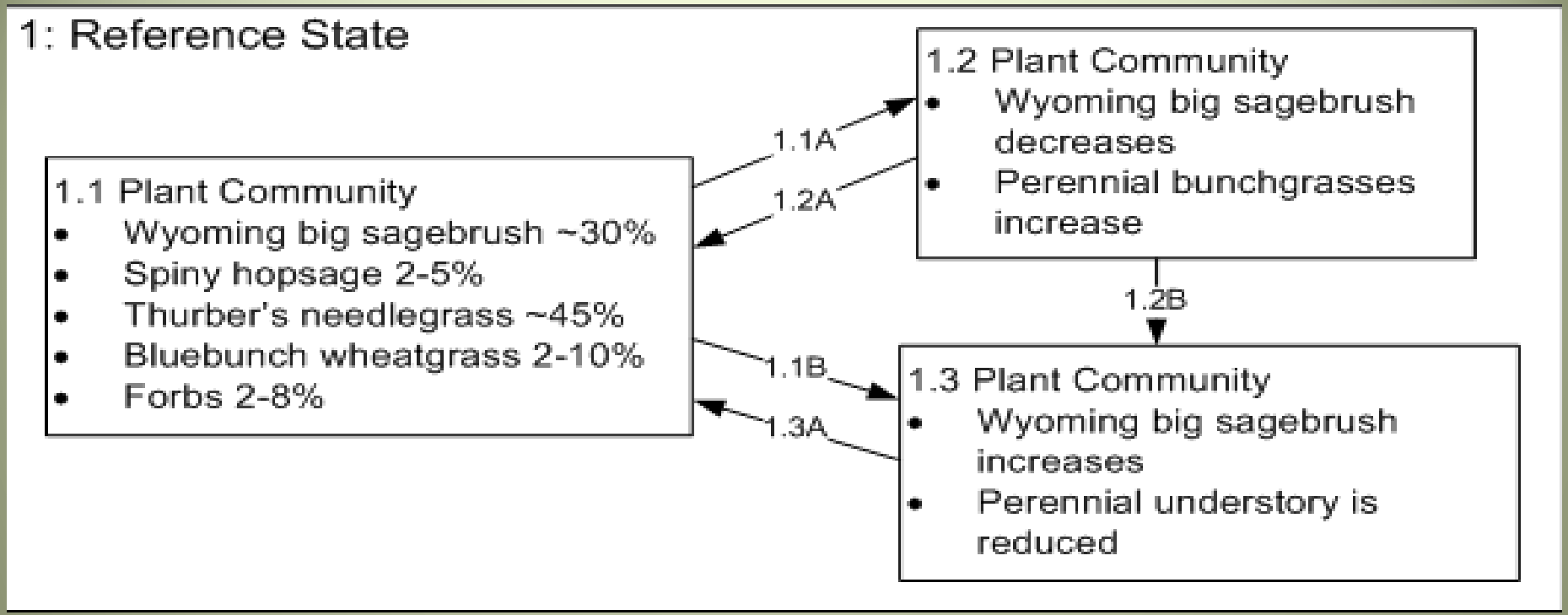
1.2B

1.1B

1.3A

1.3 Plant Community
- Wyoming big sagebrush increases
- Perennial understory is reduced





Community Pathways

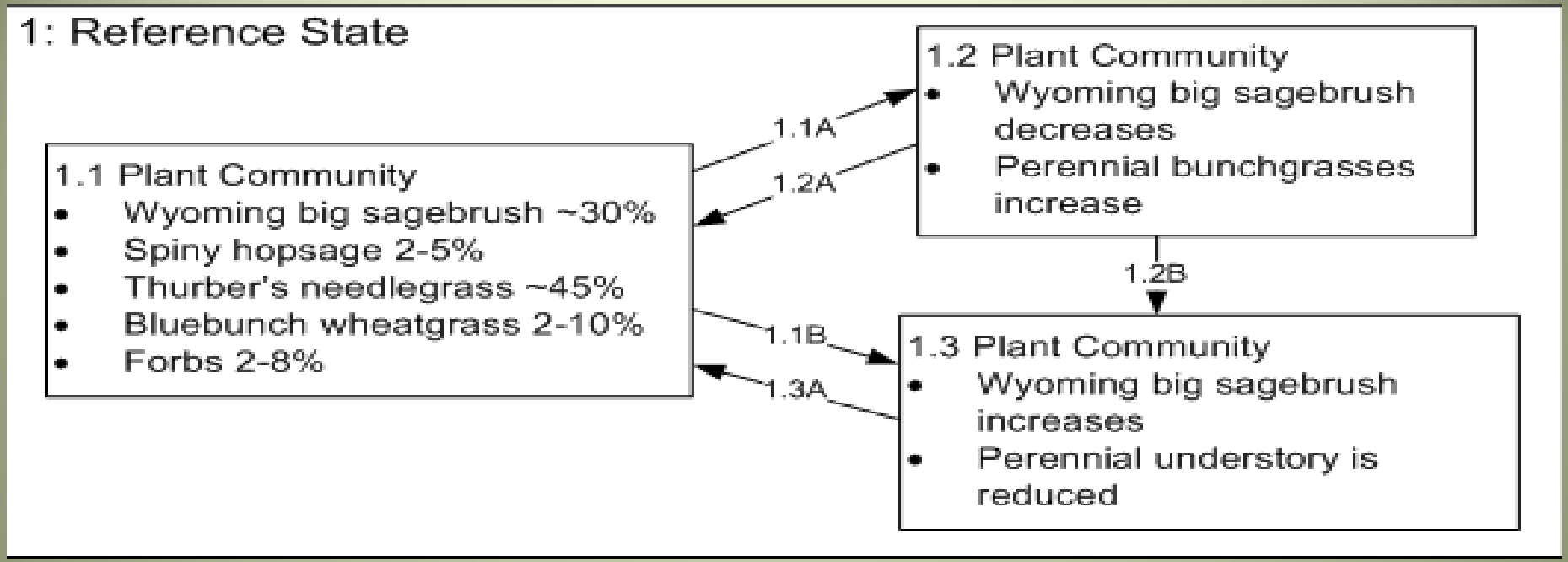
1. What would cause increase/decrease in sagebrush?
2. What would cause increase/decrease in understory?

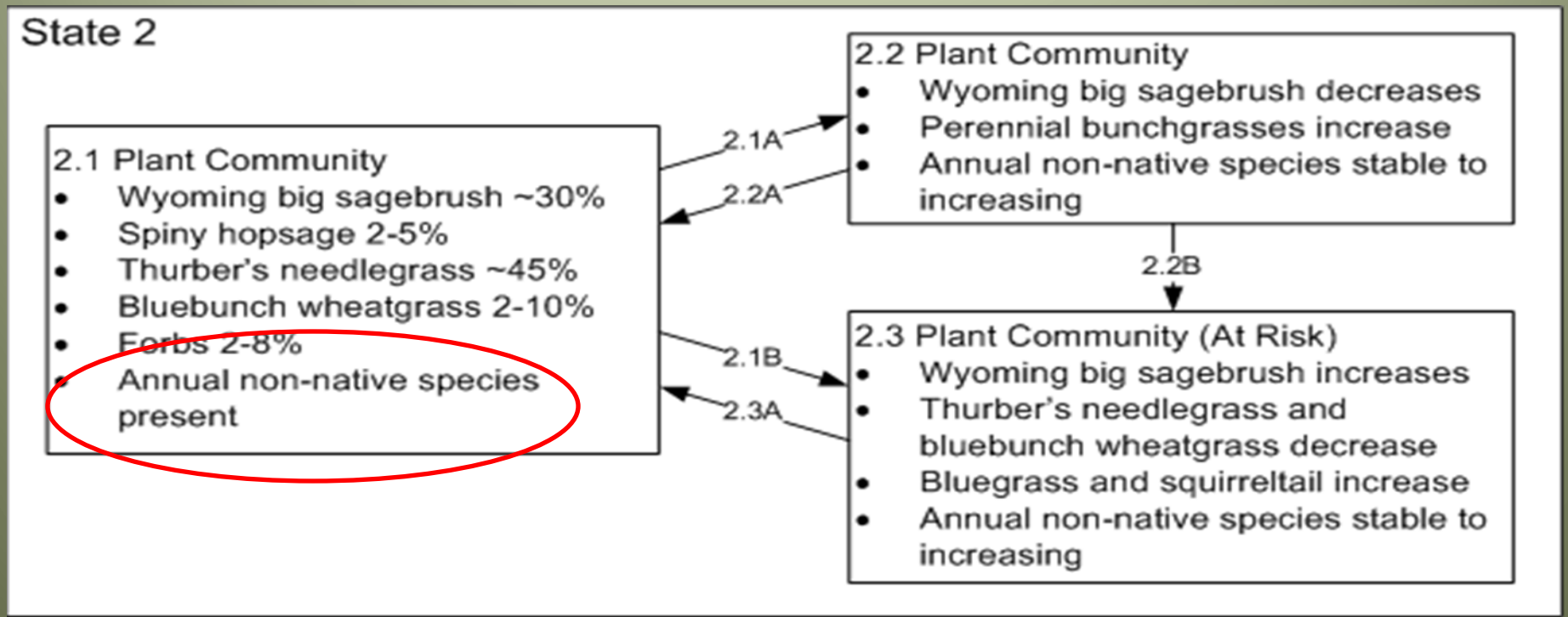
Make a list of possibilities: competition; fire; grazing; drought; aroga moth; combinations

3. Has anyone observed any of the above?

Thresholds

4. What would cause a threshold event to a new state?


1: Reference State
1.1 Plant Community
Wyoming big sagebrush ~30%
Spiny hopsage 2-5%
Thurber's needlegrass ~45%
Bluebunch wheatgrass 2-10%
Forbs 2-8%
1.2 Plant Community
Wyoming big sagebrush decreases
Perennial bunchgrasses increase
1.3 Plant Community
Wyoming big sagebrush increases
Perennial understory is reduced
1.1A
1.2A
1.2B
1.1B
1.3A


State 2
2.1 Plant Community
Wyoming big sagebrush ~30%
Spiny hopsage 2-5%
Thurber's needlegrass ~45%
Bluebunch wheatgrass 2-10%
Forbs 2-8%
Annual non-native species present
2.2 Plant Community
Wyoming big sagebrush decreases
Perennial bunchgrasses increase
Annual non-native species stable to increasing
2.3 Plant Community (At Risk)
Wyoming big sagebrush increases
Thurber's needlegrass and bluebunch wheatgrass decrease
Bluegrass and squirreltail increase
Annual non-native species stable to increasing
2.1A
2.2A
2.2B
2.1B
2.3A

Ecological Function & Thresholds

- State 2 mimics State 1 with the addition of non-native annual species being present
- Are the non-natives driving the bus? NO
- State 2 *resiliency to disturbance* is reduced by the presence of cheatgrass
- Function slightly modified by cheatgrass use of early season moisture and prolific seed
- Restoration to the Reference State requires elimination of cheatgrass, i.e., active management = threshold

State 2

2.1 Plant Community
- Wyoming big sagebrush ~30%
- Spiny hopsage 2-5%
- Thurber's needlegrass ~45%
- Bluebunch wheatgrass 2-10%
- Forbs 2-8%
- Annual non-native species present

2.1A

2.2A

2.2 Plant Community
- Wyoming big sagebrush decreases
- Perennial bunchgrasses increase
- Annual non-native species stable to increasing

2.2B

2.1B

2.3A

2.3 Plant Community (At Risk)
- Wyoming big sagebrush increases
- Thurber's needlegrass and bluebunch wheatgrass decrease
- Bluegrass and squirreltail increase
- Annual non-native species stable to increasing

Why is Phase 2.3 At-Risk? At-Risk to what?

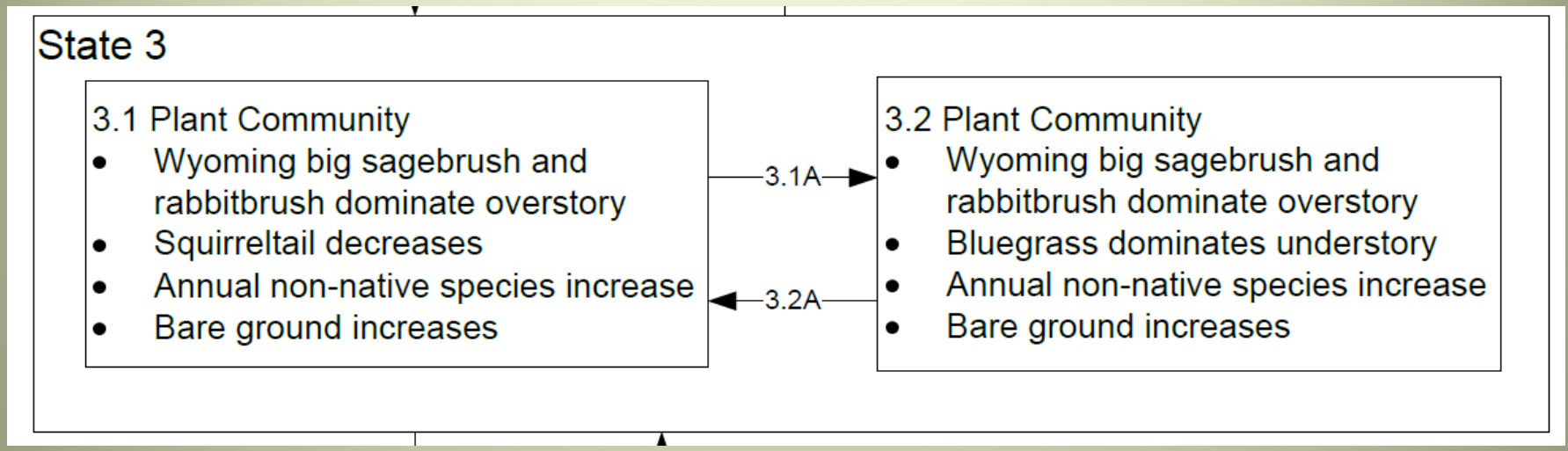
State Change

- Multiple Transitions
  - *Triggered* by different disturbances or combination of disturbances
    - Multiple year drought combined with no grazing change
    - What ecological process changes may occur?
  - Favors sagebrush relative to bunchgrass
  - Opens site to non-native annual invasion
  - Next State = Decadent sage
  - Describe transition in narrative
    - What can cause this threshold?
    - May be multiple different events

New State Description

3.1 Plant Community

Wyoming big sagebrush is decadent with little recruitment. The perennial grass component is significantly reduced in both density and productivity. Cheatgrass, annual forbs, and/or Sandberg's bluegrass along with sagebrush, control site resources and drive ecological dynamics. Rabbitbrush has increased and bare ground is abundant. **Spatial and temporal energy capture and nutrient cycling has been truncated. Infiltration may be reduced due to lack of ground cover. Risk of conversion to a non-native annual weed state is high. Risk of soil erosion by both wind and water is increased.**



Which Community Phase is the "At-Risk"?

At-Risk Phase

- At risk to what?
  - At-Risk community phase description
  - “Cheatgrass, annual forbs, and/or Sandberg’s bluegrass along with sagebrush, control site resources and drive ecological dynamics”
  - ID potential triggers and next State
    - Wet spring = increased cheatgrass production
    - Wet year followed by drought = catastrophic fire
  - 2012
    - > 1 million acres

Wyoming sagebrush / Sandbergs Bluegrass

Fire

Sandbergs Bluegrass

Additional plant community phase in State 3?

Phase 3.3

- Bluegrass dominate
- Sagebrush trace
- Cheatgrass present

State 4

4.1 Annual Plant Community
- Cheatgrass and/or tansy mustard dominate site

4.1A →
← 4.2A

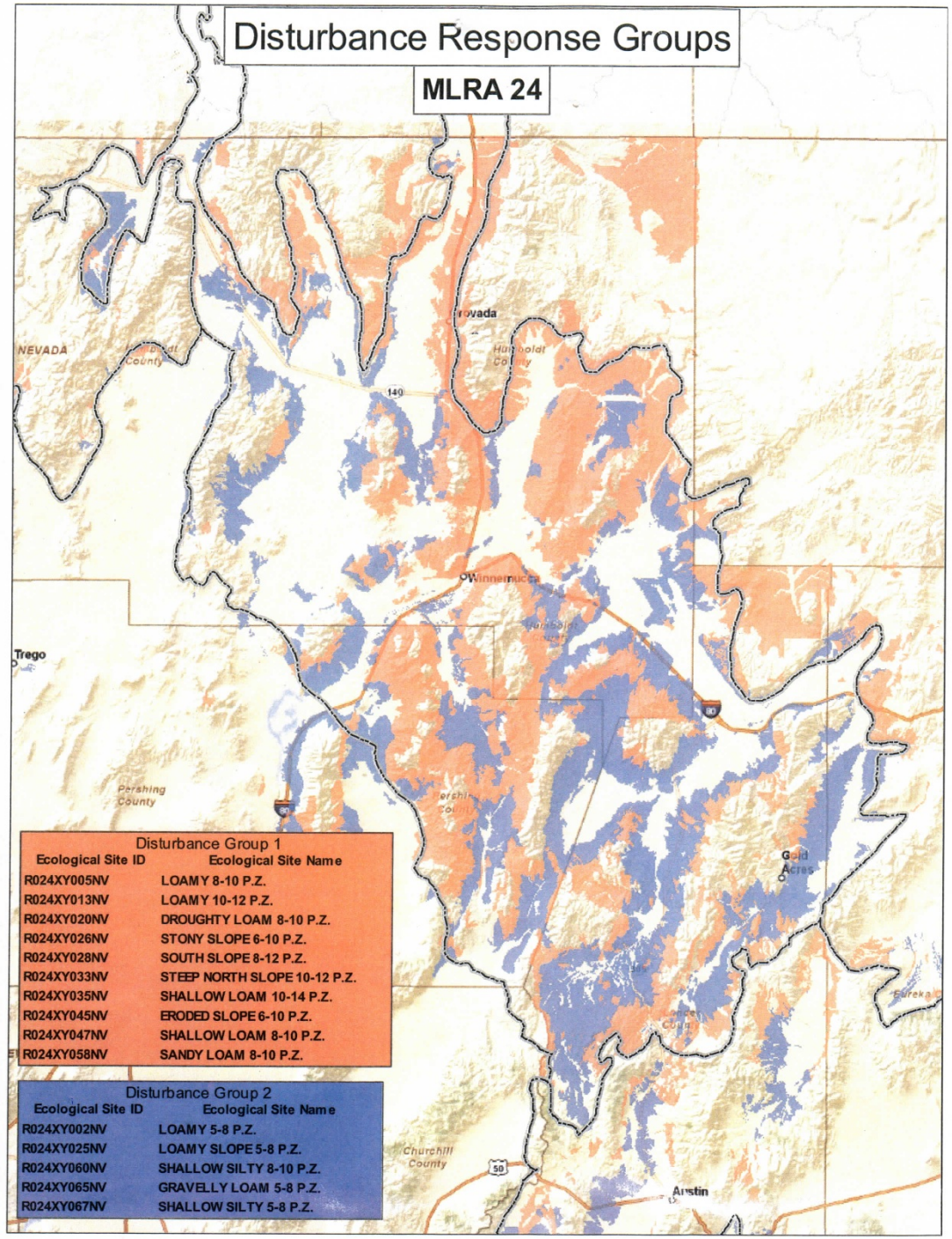
4.2 Plant Community
- Broom snakeweed and rabbitbrush dominate overstory
- Annual non-natives dominate understory
- Wyoming big sagebrush may be present in trace amounts
- Bare ground increases

State 4 Phase 4.1

MLRA 24 NV DISTURBANCE RESPONSE GROUPS

Group 1 ≈ 1.9 M ac
Wyoming Sage
Loamy 8-10 Modal
≈ 1.0 M ac

Group 2 ≈ 1.6 M ac
Salt Desert Shrub
Loamy 5-8 Modal
≈ 1.5 M ac



Group development

- **MLRA 24 Nevada example**

  54 ESD's  13 DRG's

- Each group has a "MODAL" ecological site
  - Largest acreage

- STM is developed for modal TIER 1

Field Validation

- Modal is focus
- EVERY ecological site in DRG – multiple states
- Soil-Site Correlation
- Expert Team discusses site dynamics = RESILIENCE
- Rangeland
  Health
- STM Tier 2
- Photos

Conclusions

- Disturbance Response Groups utilize resilience concepts for STM development
- Expert Team required
- STM concepts must be taught / reviewed
- Robust STMs require multiple site visits
- Develop draft STM in office
- Resilience knowledge requires field time
- Revise
- Peer Review - Revise
- STMs ALWAYS DRAFT