Resilience Concepts: State-and-Transition Model Development

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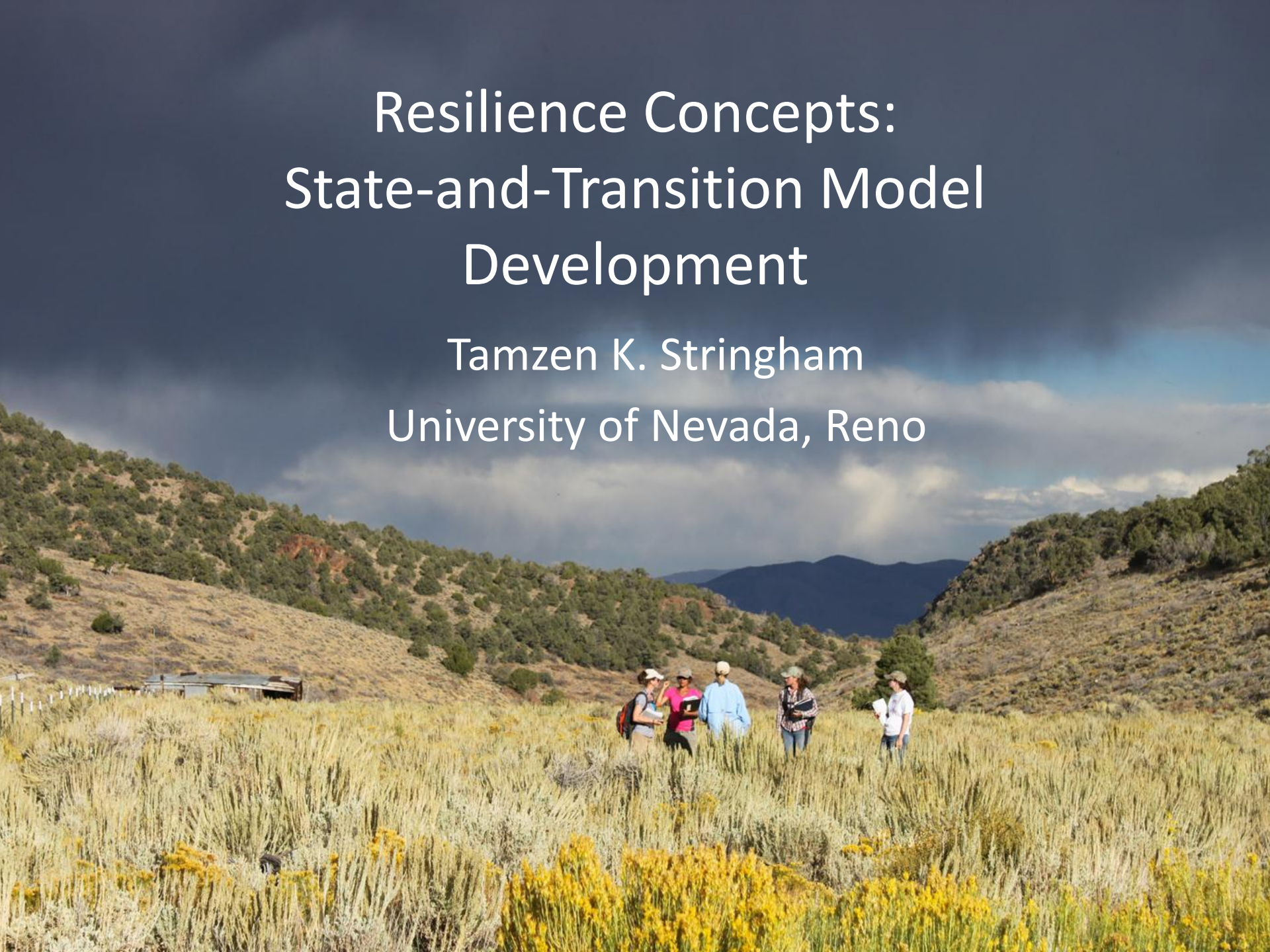


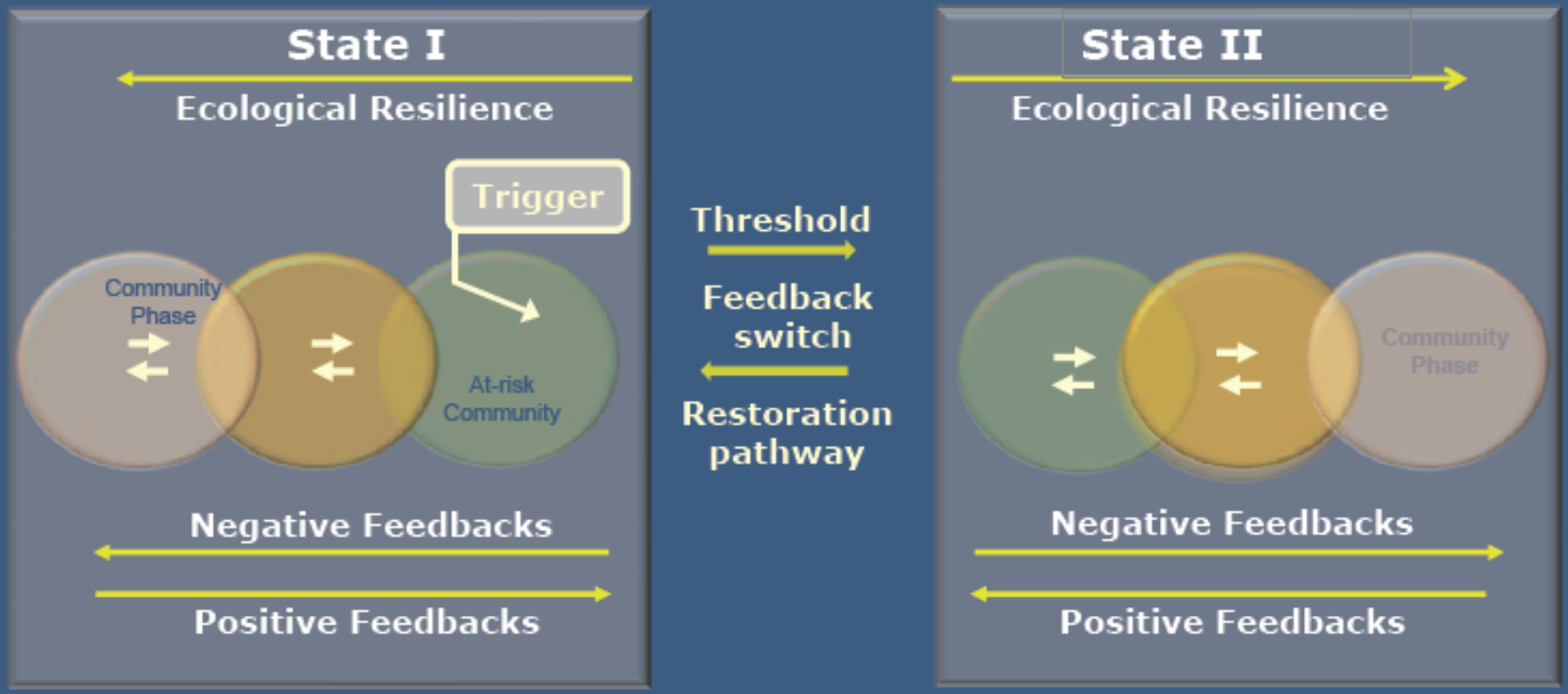
STM Fundamentals
Know the Subject Matter

- 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 (negative) or decrease (positive) ecosystem resilience
- *Feedback switch* – point at which feedbacks shift from negative to positive and exceed resilience limits

Resilience-based Concepts *cont.*

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

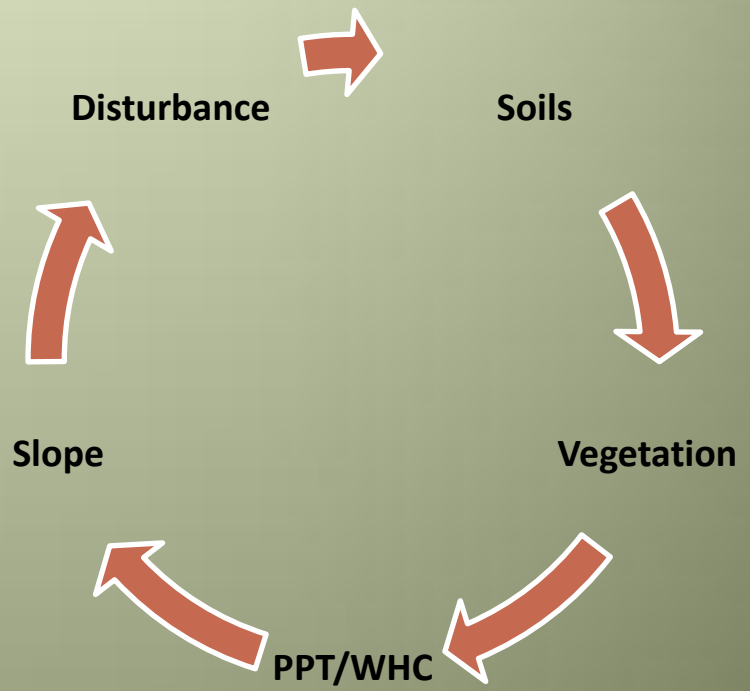
- *Restoration pathways* – re-establishment of pre-threshold states following active restoration of self repair mechanism

What is “resilience based” thinking?

- Understanding that what we see is created by the inherent capability of the site & the functional capacity of ecological processes
- STMs describe ecological dynamics
- *Sensitivity of ecological processes to disturbance(s) = resilience*

Ecological Dynamics
Response to Disturbance = Resilience

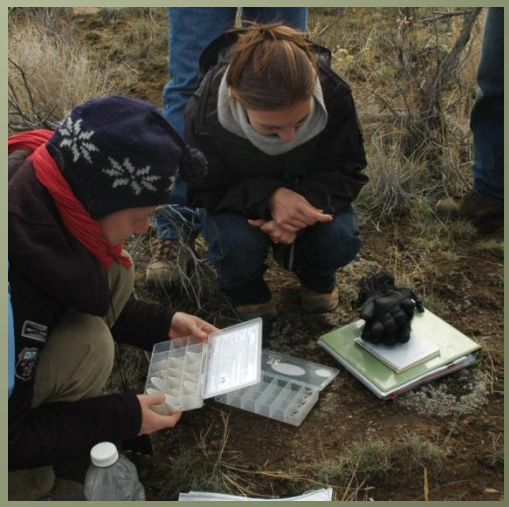
- Response to different disturbances
  - Fire
  - Grazing
  - Flooding
  - Drought
  - Insects
  - Invasive species, etc.
  - Any combo of the above



- Current condition = state & plant community phases

What are ecological processes?

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



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

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

At-Risk Phase

- Community Phase with lowest resiliency thus most likely to transition to an alternate state following disturbance
- 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?

STM Development Utilizing Resilience Concepts *equals* Disturbance Response Groups

- Build a team of experts on the area
- Members
  - STM developer = team lead
  - Range ecologist = senior level (more than one)
  - Soil scientist = senior level
  - GIS specialist = field worthy
  - Wildlife biologist
  - Land Managers

Range Ecologist / STM

Experience

Range / Plant

GIS

Soils

Range / Plant

STMs and DRGs cont.

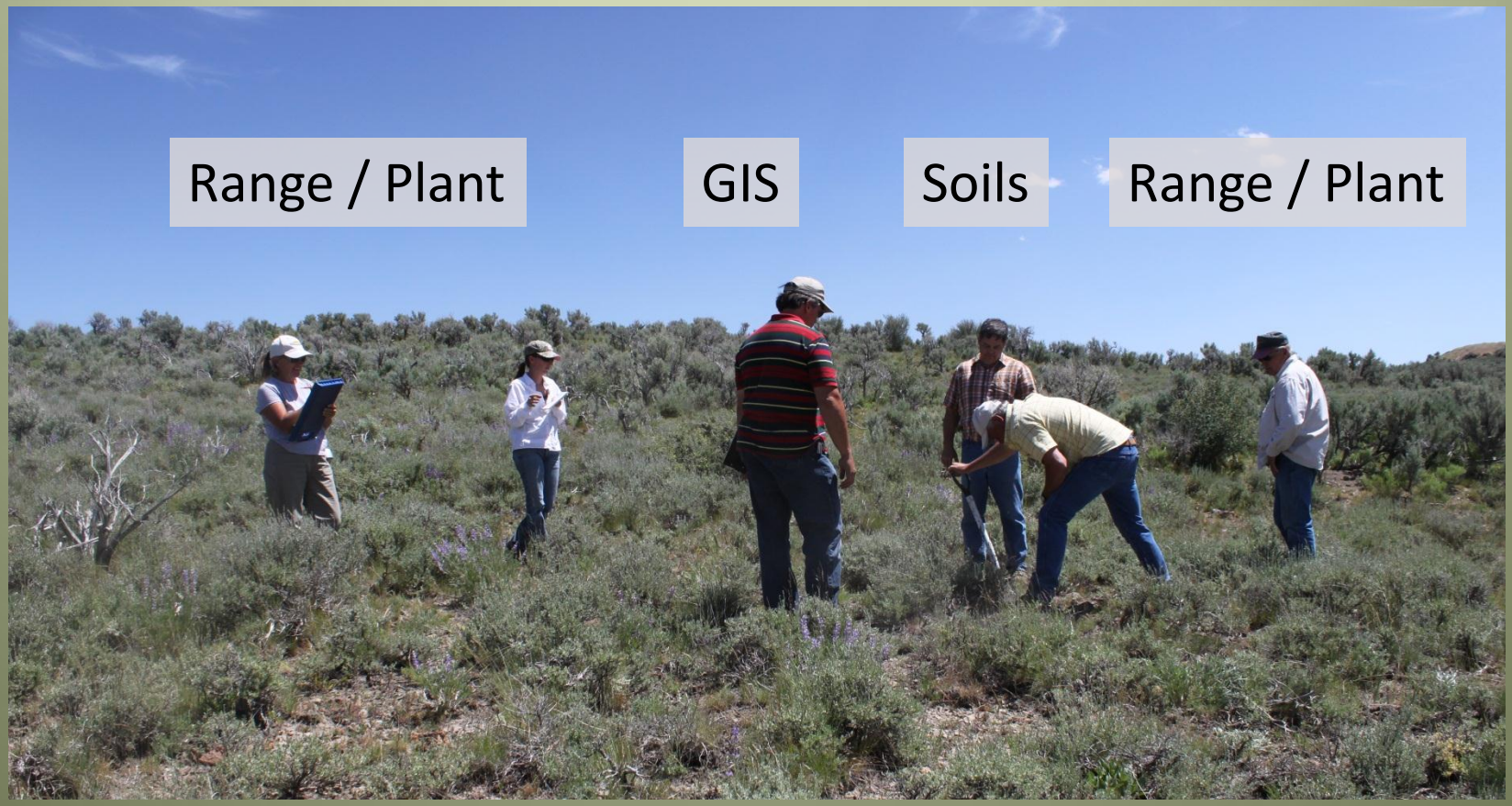
- Assemble the core TEAM
- Invite others to participate in office / field events
- Teach the STM concepts to the core TEAM
  - Multiple times; office & field

Experience is critical

Plant / soil relationships

Disturbance response

≠ STM Knowledge



STM Development Process
Disturbance Response Groups

- MLRA or LRU scale
  - Build understanding of the climate, soils, plants
    - Soil scientist teach geology, soils, etc
    - GIS specialist create data layers of soil map units; fire events; roads; public / private land; etc.

STM Development Process

- Range sites
  - Describe Reference Condition = State 1
  - Describes landscape, climate, soils, plants, production
  - Describes response to disturbance
- Team analyzes each site & determines how it responds to disturbance = Resilience
- Group sites into resilience or DRGs

STM Development Process
Disturbance Response Groups

- Grouping process leads to building blocks for STM
  - Discussion involves *Resilience*
    - Soils and soil differences within groups
    - Plant species response to numerous disturbances
    - Response to repeated disturbance
- Modal site
  - greatest amount of acres mapped or
  - typical disturbance response of the group

Draft STM Development

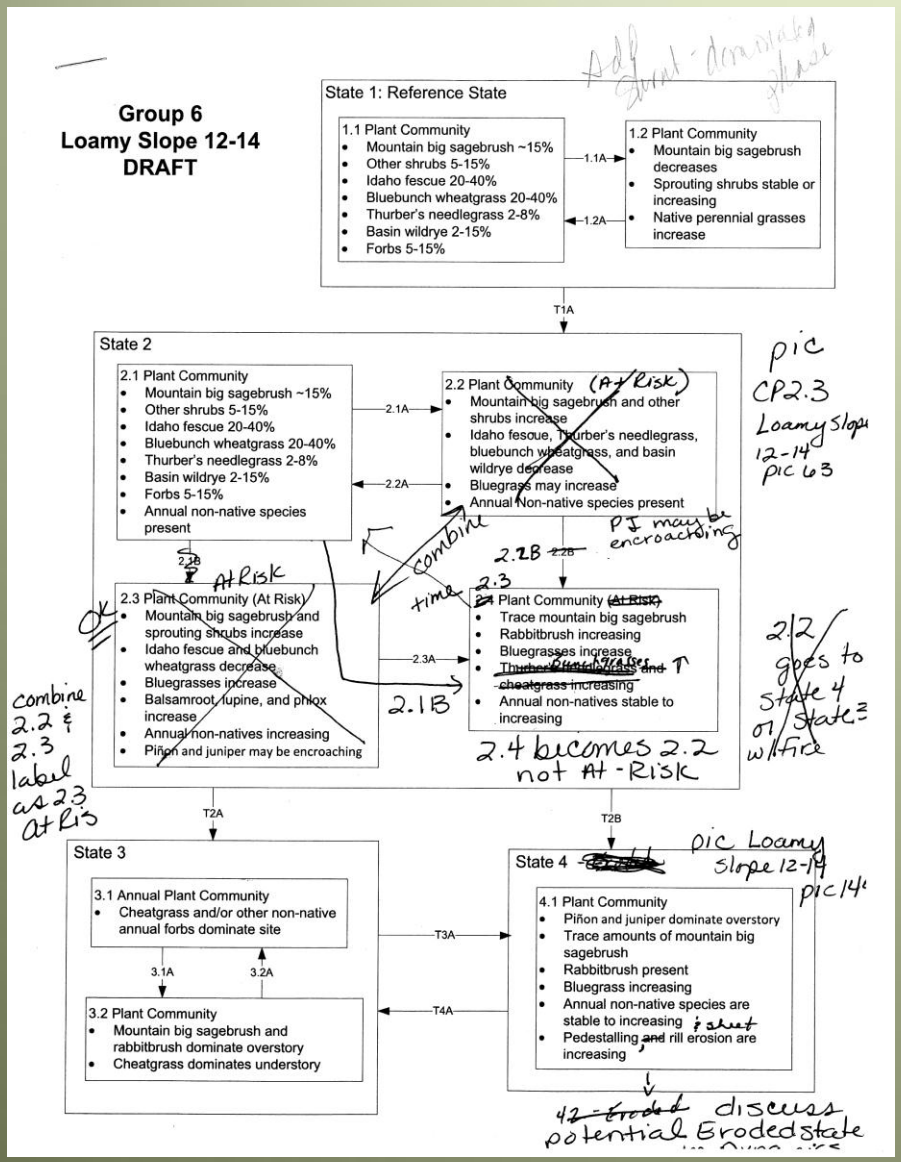
- Range/Ecological Site
- Describes Reference Condition = State 1
- Provides landscape, soil, climate, production
- Disturbance response
- Community Phases
- Community Pathways

- Triggers, Feedbacks
- Thresholds
- Restoration pathways
- Additional States
- Literature review on species response to disturbance modified by soil
- Local & professional knowledge
- Research data

Draft STM Development – Tier 2

- Site verified
- Plant list
- Range Health Assessment
- Photos
- DISCUSSION
- DISCUSSION
- DISCUSSION

Tier 2 – Field Validation



Document
Location: GPS
Map Unit
Soils
Elevation
Landform
Range Health
Production
Fire History
Disturbance: farming, ground water Pumping, herbivory etc.

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

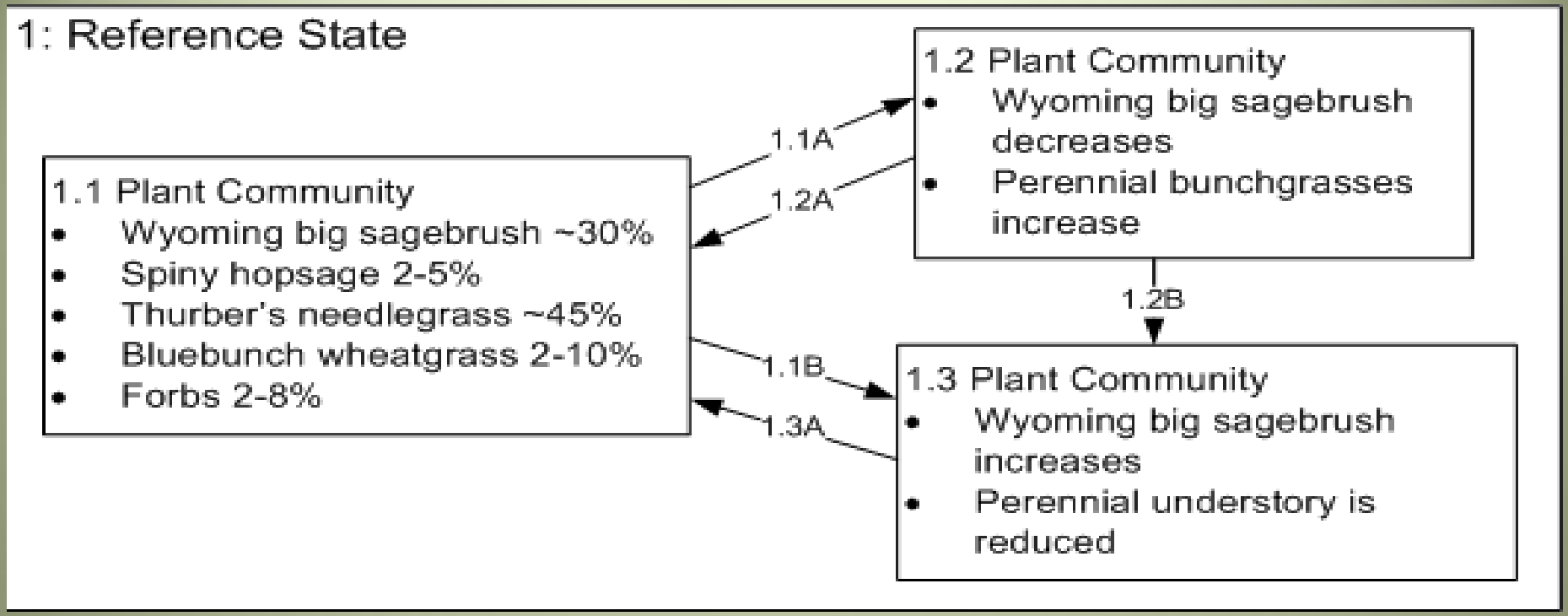
1.2 Plant Community
- Wyoming big sagebrush decreases
- Perennial bunchgrasses increase

1.2B

1.1B

1.3A

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



Community Pathways

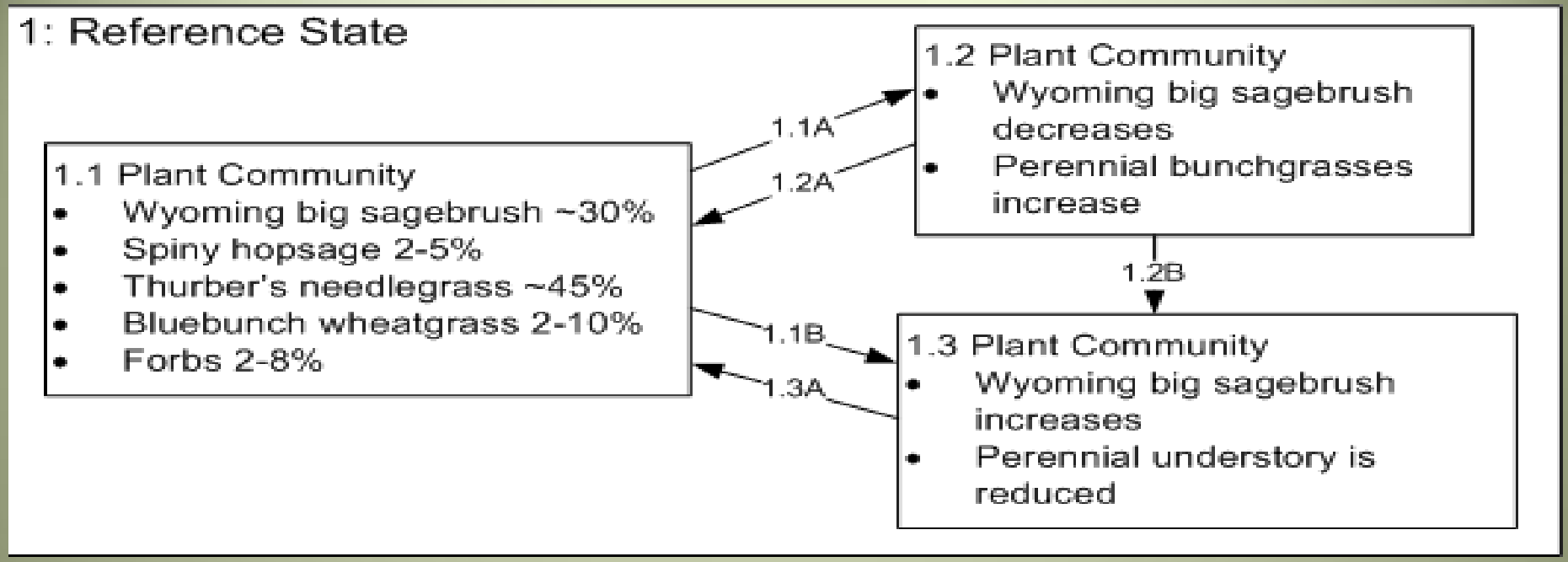
1. What would cause increase/decrease in sagebrush?
2. What would cause increase/decrease in understory?

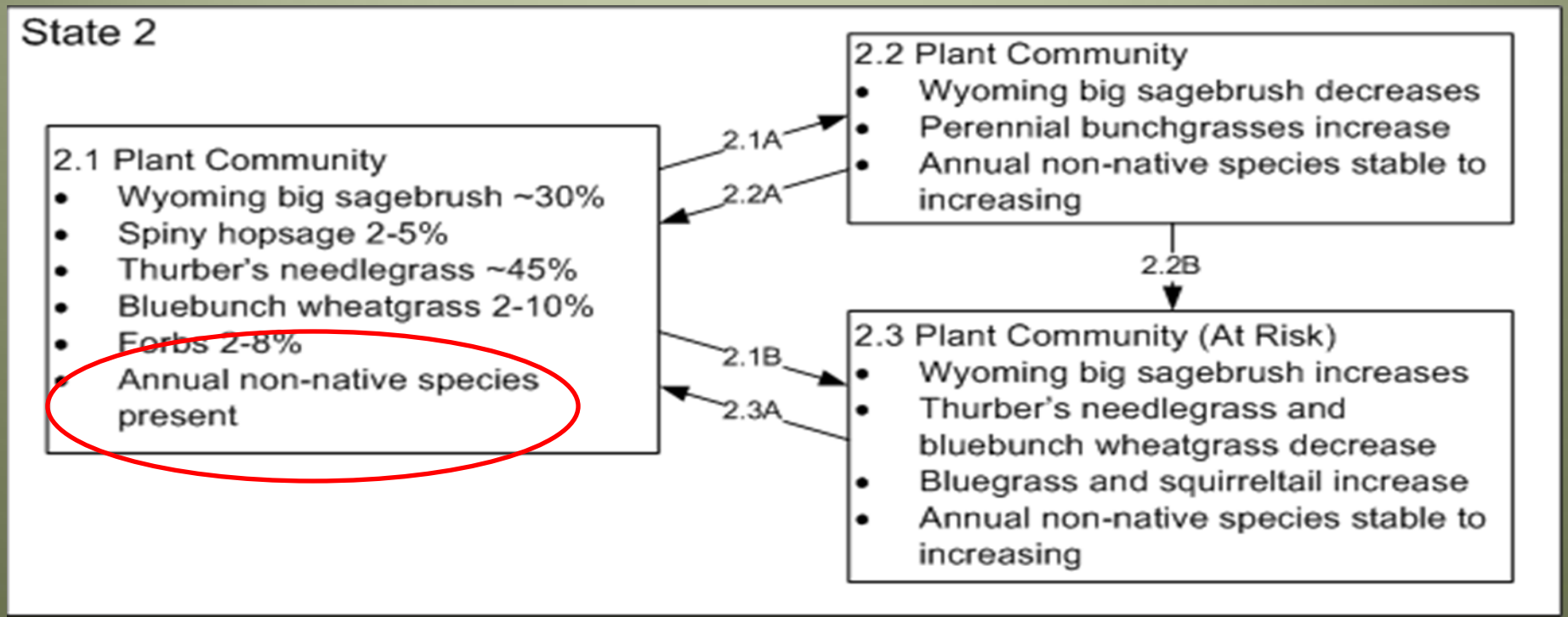
Make a list of possibilities: competition; fire; grazing; drought; aroga moth; combinations

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

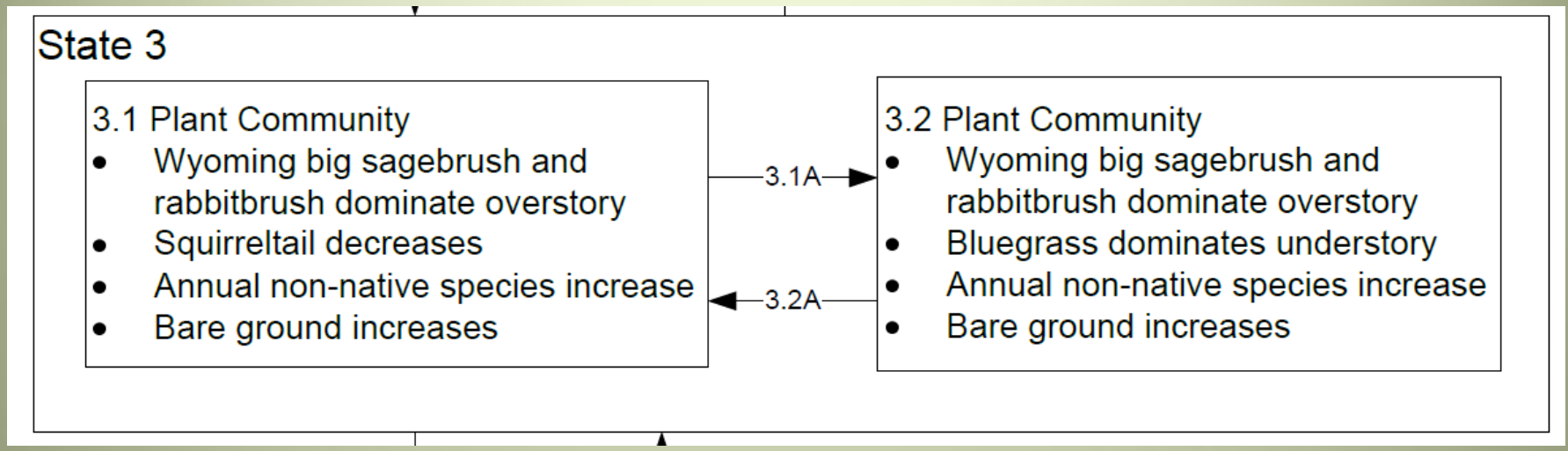
New State Description

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.**

Restoration Pathways

- Are there known techniques for restoring any identified State to a higher functioning State?
- Restoration is not a species list
- Restoration is focused on improving the ecological function utilizing vegetation
- If KNOWN describe and indicate potential for success



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

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

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
- Use to guide field discussions
- Revise
- Peer Review - Revise
- STMs ALWAYS DRAFT

Disturbance Response Groups
MLRA 24

DRG 1

Loamy 8-10 (modal)
Loamy 10-12
Droughty Loam 8-10
Stony Slope 6-10
South Slope 8-12
Steep North Slope 10-12
Shallow Loam 10-14
Eroded Slope 6-10
Shallow Loam 8-10
Sandy Loam 8-10

1,944,714 acres

DRG 2

Loamy 5-8 (modal)
Loamy Slope 5-8
Shallow Silty 8-10
Gravelly Loam 5-8
Shallow Silty 5-8

1,606,952 acres