Resilience-based Application of State-and-transition Models

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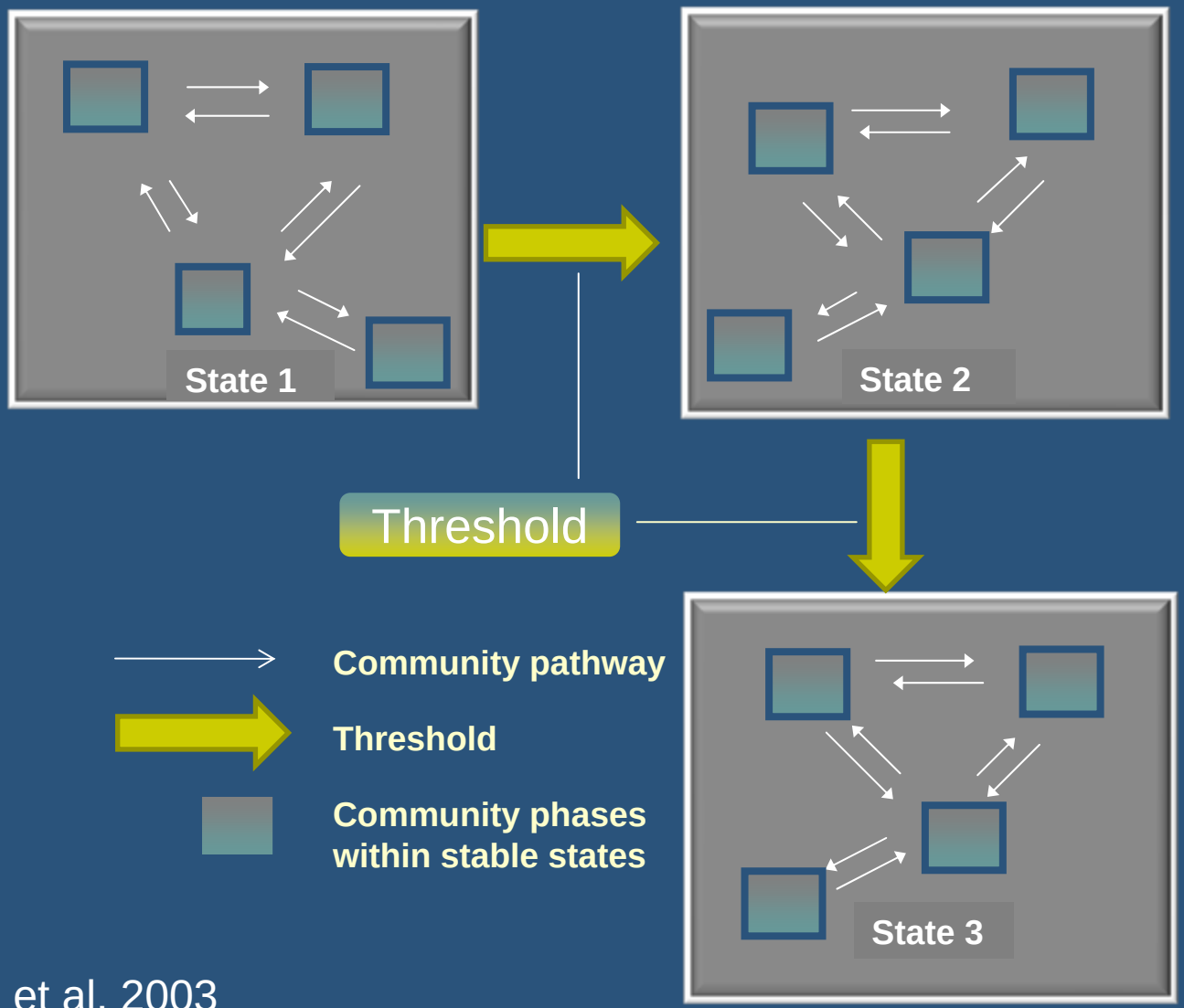
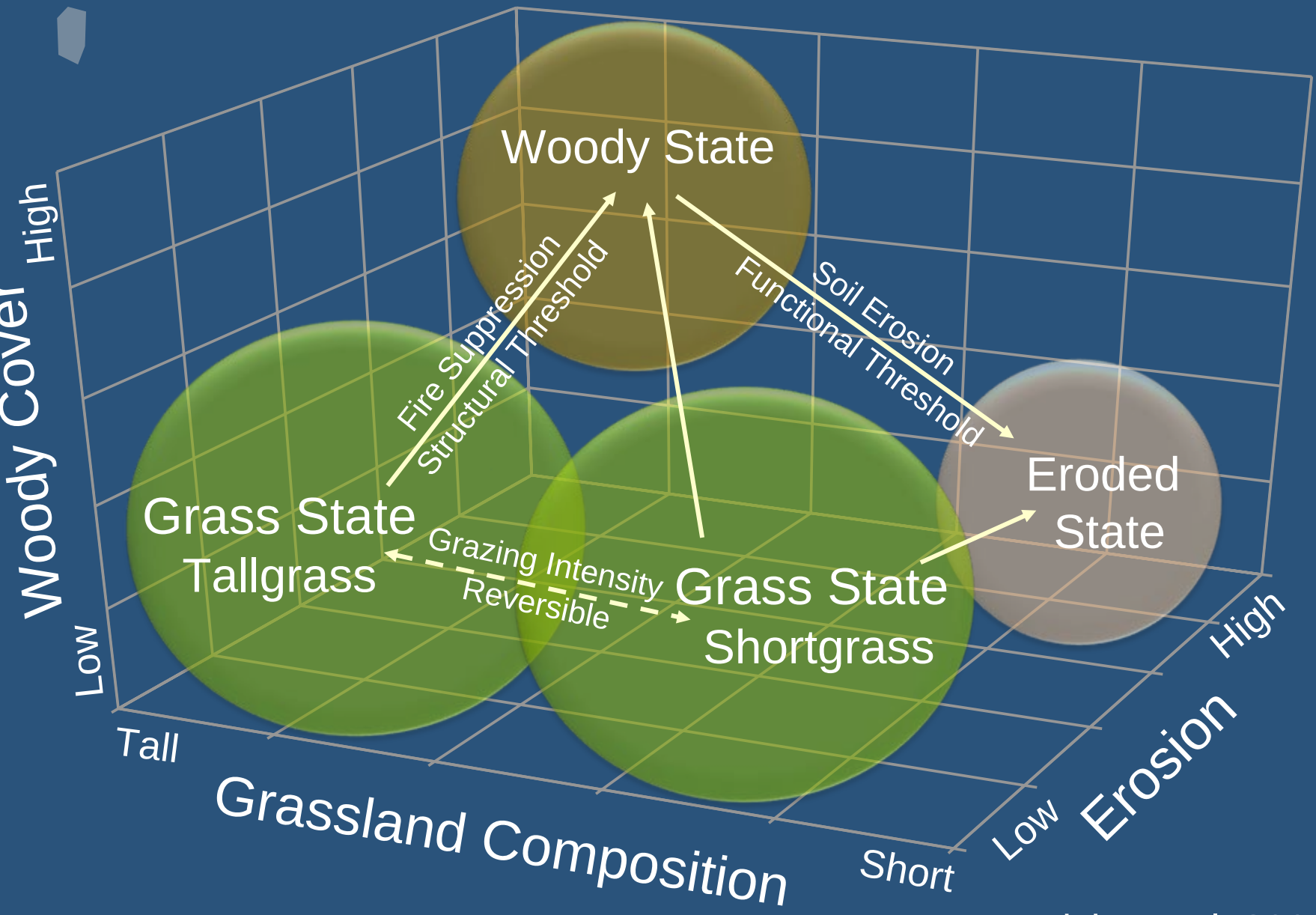
State-and-transition Model Framework



Stringham et al. 2003

Multiple Stable State Concept



Briske et al. 2005

Professional Reinvention

Rangeland Health?

Woodland Encroachment?

Ecological Scale

Multiple States

Range Condition?

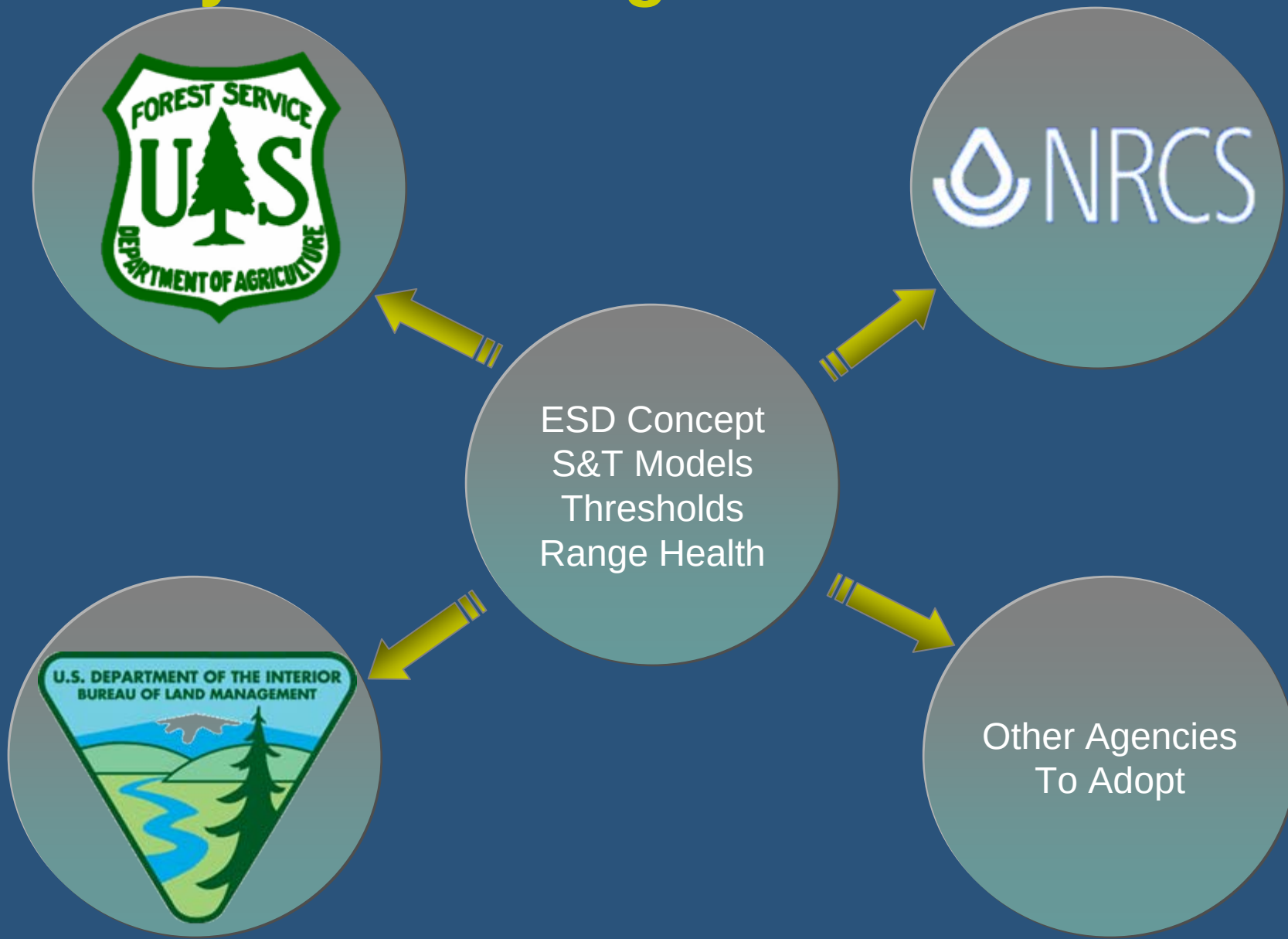
Threshold Application?

Rangeland Profession

SRM

Society for Range Management

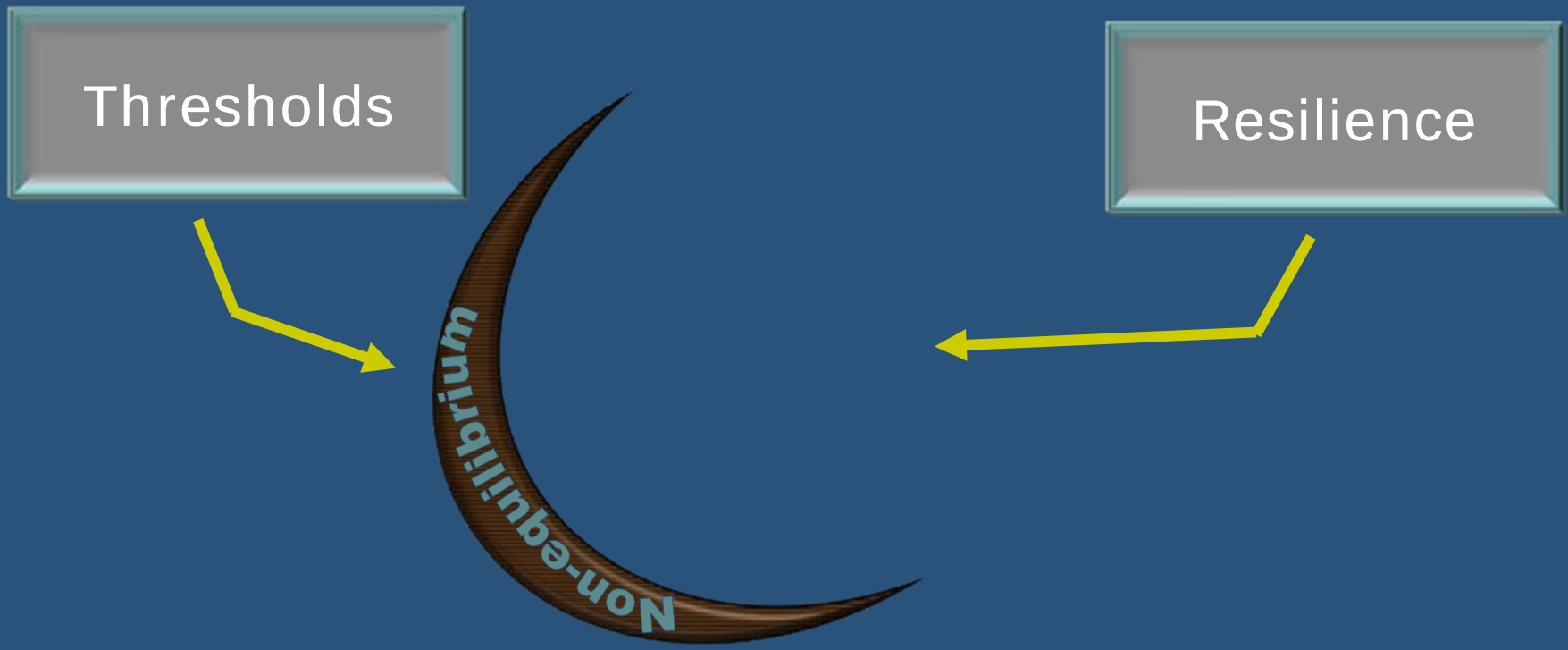
Ecological Site Descriptions: Ecosystem Management Framework



Presentation Objectives

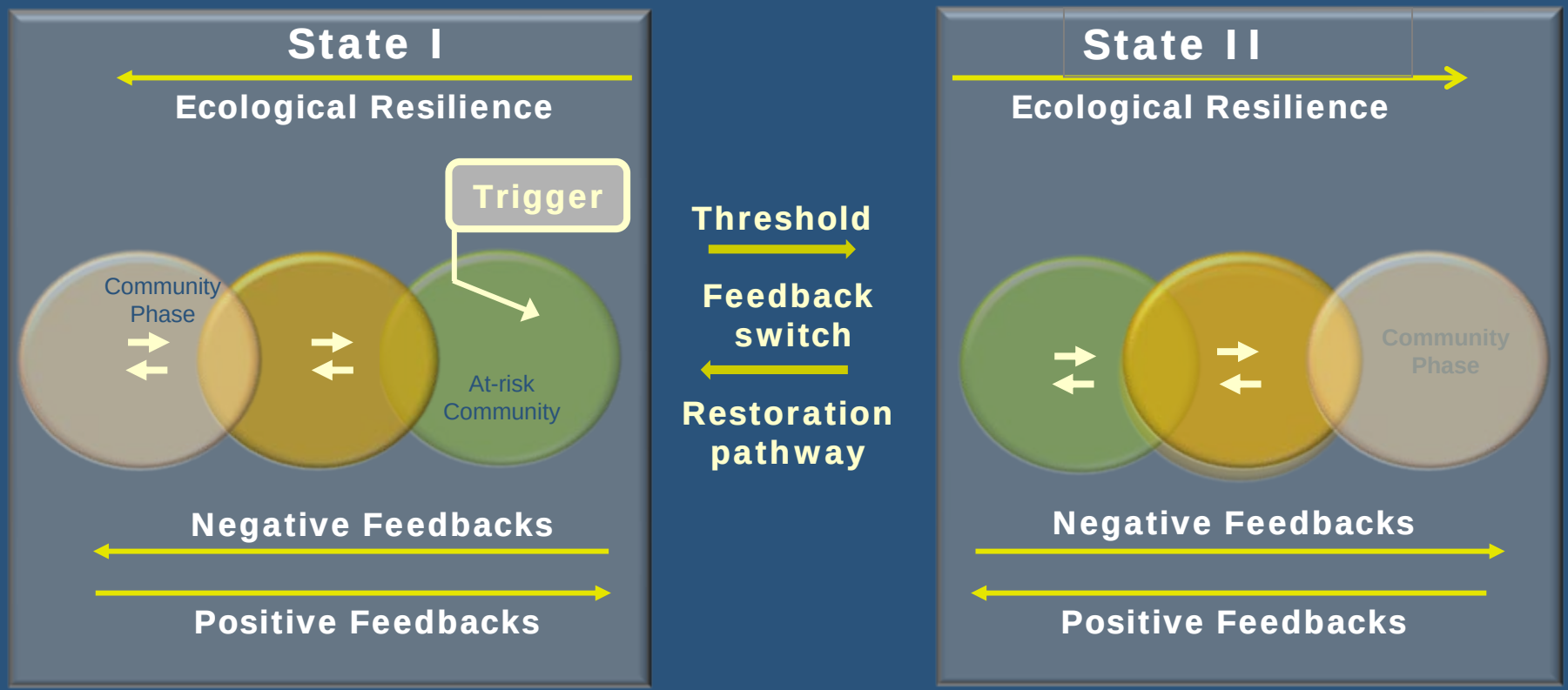
- Propose several recommendations to make ecological resilience more explicit in STMs
- Illustrate application to STM framework
- Emphasize the potential value of resilience-based STM's

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.

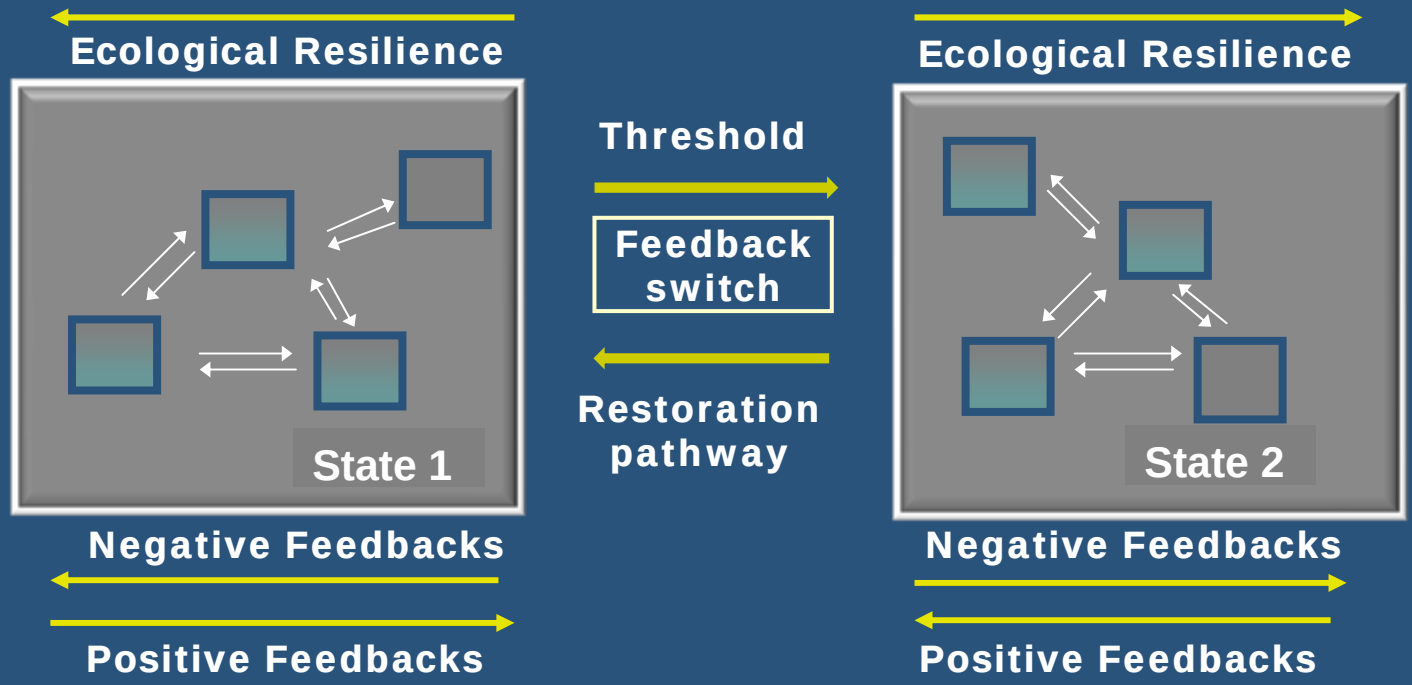
Resilience-based Management



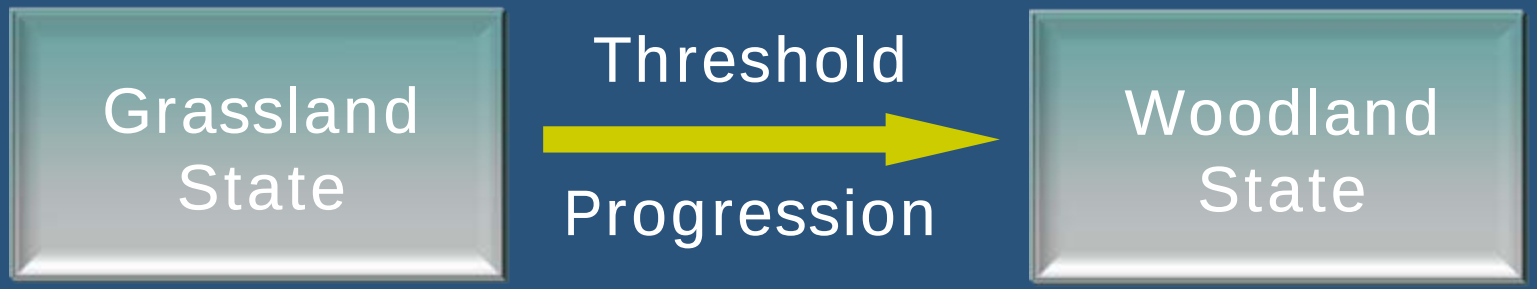
Resilience-based Concepts

- ***At-risk community phase*** **-** plant community phase that is 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.
- ***Restoration pathways*** – re-establishment of pre-threshold states following active restoration of autogenic repair mechanisms.
- ***Triggers*** - variables or events that initiate thresholds by contributing to the immediate loss of ecosystem resilience.

Resilience-based STMs



Positive and Negative Feedbacks



Feedback Switch

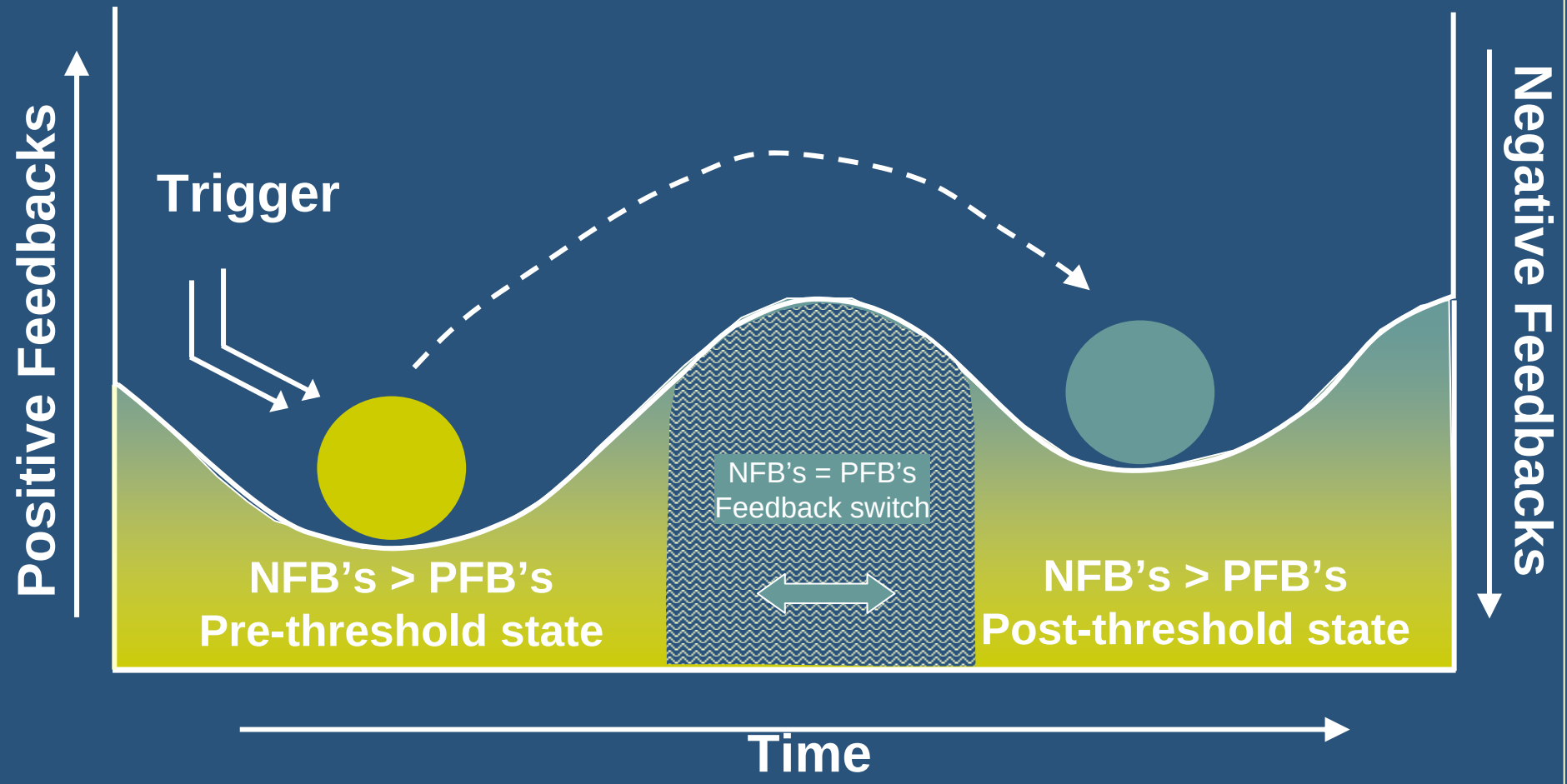
Positive Feedbacks

- woody plant cover
- coarse fuel loads
- propagule limitations

Negative Feedbacks

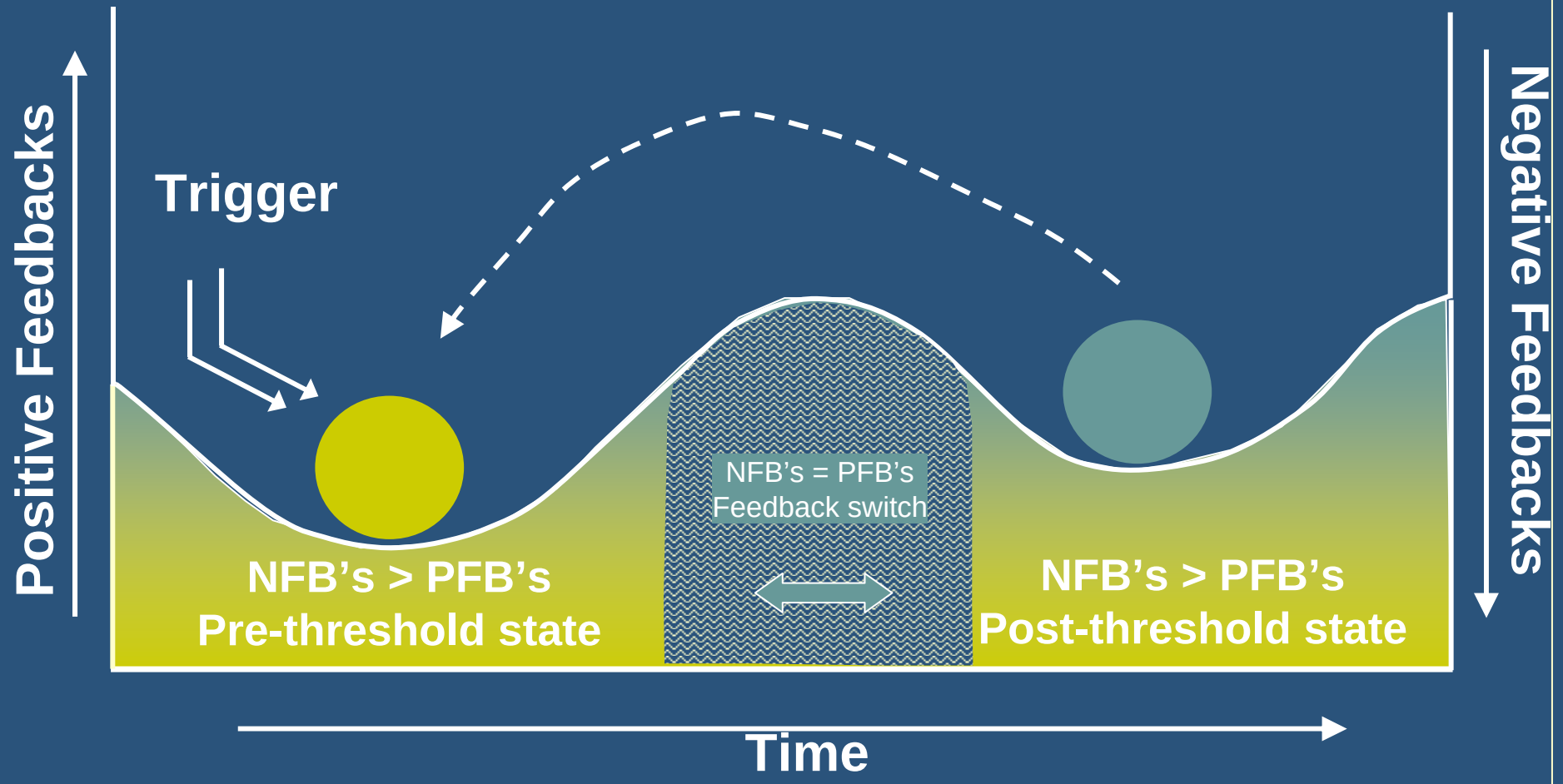
- grassland productivity
- fine, continuous fuel loads
- propogule limitations

Feedback Switch - Thresholds



Briske et al. 2006

Feedback Switch – Restoration Pathways



Briske et al. 2006

Restoration Pathways

- *The re-establishment of former states following active restoration of autogenic repair mechanisms and feedbacks.*
- Minimizes the inconsistency of suggesting that thresholds are reversible, which they are not without management intervention.
- Provide information concerning the probability and type or restoration required.

Benefits of Resilience-based STMs

- Explicitly connect the STM framework to ecological resilience e.g., relevance to broader ecological community
- Refocus management attention toward attributes and management actions that affect resilience in addition to thresholds e.g., threshold are undefined endpoints
- Capture a broader set of variables necessary to anticipate and identify resilience e.g. excessive emphasis on management variables

Benefits Justification

- Resilience-based management emphasizes the conditions and dynamics that influence state proximity and vulnerability to thresholds.
- This distinction increases the ability to manage ecosystem change rather than merely react to it.
- Adaptive management can maintaining state resilience without necessarily affecting the conditions that precipitate thresholds.

Bridging Theory and Application

Non-Equilibrium Paradigm

Ecological Site Descriptions

Multiple Stable States

Multiple Pathways

Ecological Thresholds

State & Transition Models

Thresholds

Rangeland Health

Indicators and Assessment

- State Vulnerability to Thresholds
  - Triggers
  - Feedbacks
- Potential Restoration Pathways
  - Resilience of Alternative State
  - Residual Properties of Former State

Indicators and Assessment Triggers

Indicators	Assessment
Drought	Weather record, mortality
Fire regimes	History, spp composition
Grazing	History, spp. composition
Invasive spp.	Spread, dominance
Episodic events	Climate records, soil loss

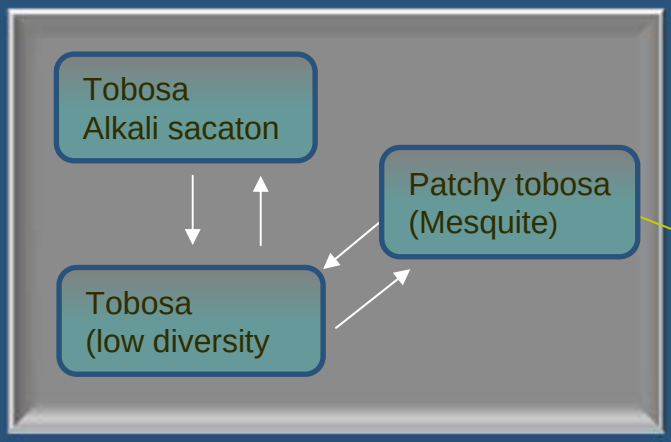
Indicators and Assessment Feedbacks

- Soils
  - Bare soil/patch size
  - Soil/nutrient redistribution
- Vegetation
  - Functional group loss
  - Increase invasive species
- Function
  - Productivity
  - Runoff rate and pattern

Indicators and Assessment Potential Restoration Pathways

- Resilience of Alternative State
  - Functional group composition
  - Soil modification
- Residual properties of Former State
  - Reproductive plants/seed
  - Soil/nutrient availability

Draw Ecological Site, New Mexico



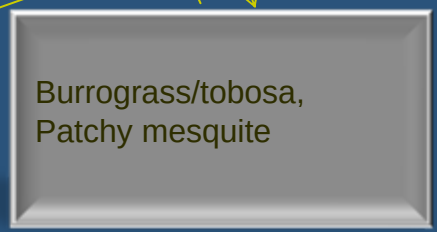
Reference State
Indicators: High perennial grass cover, minimal soil movement, bare patches small and unconnected.
Feedbacks: Perennial grasses minimize soil, nutrient and water movement from high-intensity storms.

At-risk Community Phase: Perennial grass cover low, patchy, with large interconnected areas of bare ground in response to intensive grazing and drought.

Trigger: Intensive grazing/drought that predisposes site to gully formation following intense rainfall event.

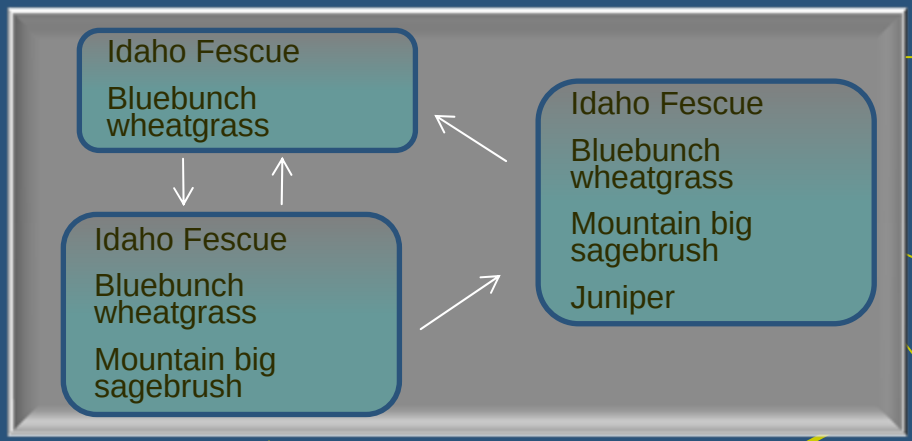
Threshold: Gully development channels water, soil and nutrients away from grasses, initiates greater soil erosion, and leads to additional grass loss.

Restoration Pathway: Gully plugs and water spreaders to slow and redistribute water movement to facilitate grass recolonization. May require decades with periodic maintenance and light grazing.



Alternative State
Indicators: Major soil and water movement, gullies continue to deepen, and shortgrass dominance.
Feedbacks: Few perennial grasses and continued water, soil and nutrient losses with subsequent rain storms that lead to additional grass loss.

Mountain Clay Ecological Site, Oregon



Reference State
Indicators: High perennial grass cover, dispersed sagebrush cover, minimal juniper and bare soil.
Feedbacks: Herbaceous cover retains water on site and provides fuel to support a fire return interval of less than 50 years.

At-risk Community Phase: Herbaceous cover reduced, sagebrush decadence, juniper visible and bare soil patches increasing, potential fire frequency reduced.

Trigger: Drought and intensive grazing promote juniper establishment through reduced fire frequency.

Threshold: Juniper attains a height and density that reduces fine fuel load and fire-induced tree mortality. Large, inter-connected bare soil patches occur with redistribution of nutrients/soil beneath juniper canopies.

Restoration Pathway: Bunchgrass (BG) density > 1 m^2 requires mechanical juniper removal only;
BG density < 1 m^2 requires juniper removal and grass reseeding, if soil is intact.

Alternative State
Indicators: Mature juniper dominant, Idaho fescue only beneath juniper canopies, large interconnected bare soil patches, sagebrush decadence..
Feedbacks: Juniper dominates resource use, water and wind redistribute soil and nutrients beneath juniper, minimal grass and sagebrush establishment .

Potential Value Added

- Resilience-based STMs will promote adaptive management by emphasizing assessment of state resilience in addition to threshold identification.
- Identify additional resilience indicators to better inform ecosystem managers of risk and restoration options.
- Promote greater international dialogue between ecologists and ecosystem managers on the general nature of ecosystem dynamics.