Ecological Thresholds:
Bridging Theory and Application

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Presentation Objectives

- Evaluate the linkage between theory and application of ecological thresholds.
- Outline a framework to interpret and apply ecological thresholds for land management.

Bridging Theory and Application

Non-Equilibrium Paradigm

Ecological Site Descriptions

Multiple Stable States

Multiple Pathways

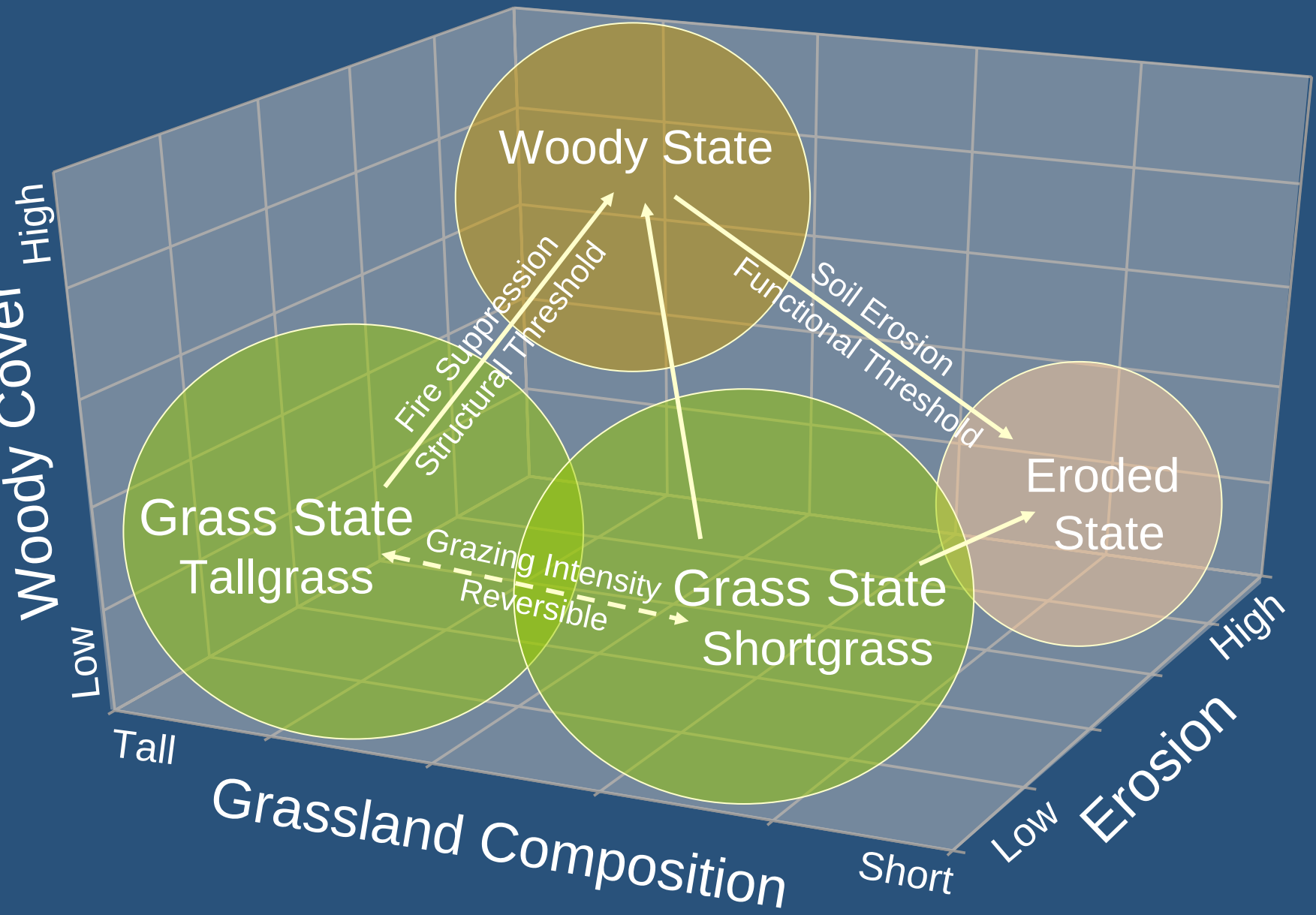
Ecological Thresholds

State & Transition Models

Thresholds

Rangeland Health

Multiple Stable State Concept



Briske et al. 2005

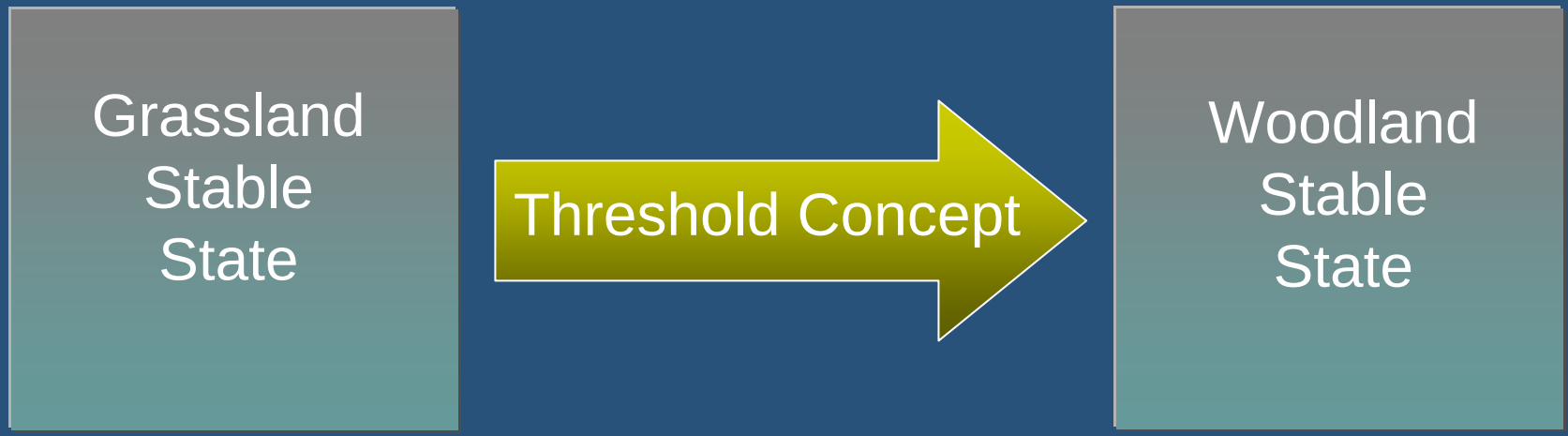
Do We Understand Thresholds?

- What events initiate threshold development?
- What ecological mechanisms establish thresholds?
- At what point do thresholds become irreversible?
- Can threshold occurrence be anticipated?
- Do all thresholds possess similar components?
- Can thresholds be applied to land management?

Threshold Definitions

- Ecosystems may move from one stable domain to another and remain in an altered configuration – (Holling 1973)
- Boundaries in time and space between two states that are not reversible on a practical time scale without management intervention – (Friedel 1991)
- Boundaries in time and space between any and all states, such that one or more of the primary ecological processes has been irreversibly changed and must be actively restored before return to the previous state is possible – (Stringham et al. 2003)

Threshold Components



Threshold Components

Trigger — Fire Suppression / Altered disturbance regime

Structural — Woody plant dominance / Altered growth forms

Functional — Nutrient & Water cycling / Altered ecosystem processes

Irreversibility — Extent & duration of alteration

Briske et al. 2005

Threshold Components

- Triggers - event(s) that initiate threshold occurrence by inducing a switch from negative to positive feedbacks.
- Feedbacks - ecological processes that reinforce (e.g., negative) or degrade (e.g. positive) resilience of a stable state.

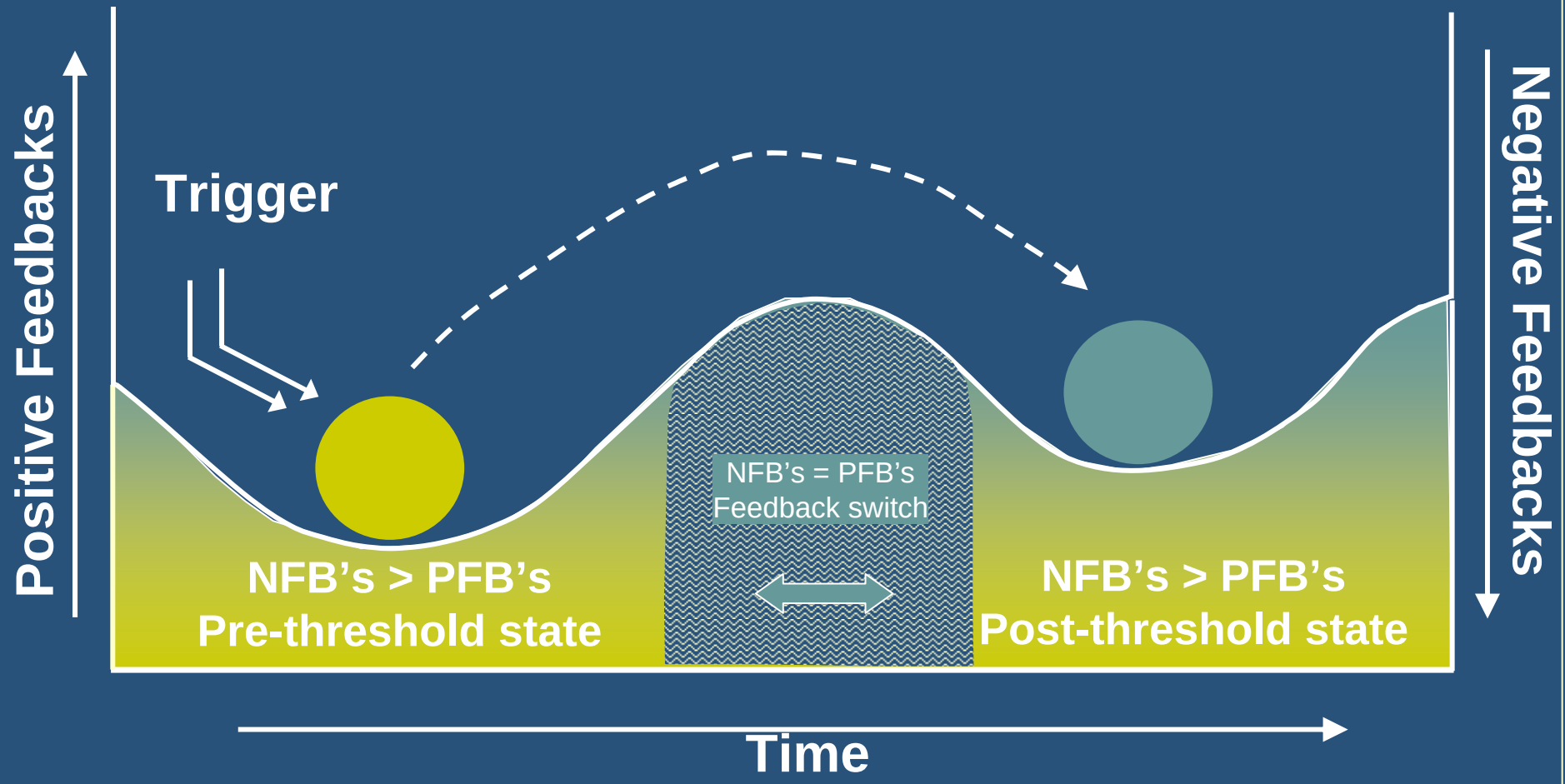
Briske et al. 2006

Threshold Components

- Threshold categories – series of ecological processes that degrade resilience of residual pre-threshold properties during threshold progression.
- Threshold trajectories – developmental pathways of post-threshold states after a threshold has been exceeded.
- Operational thresholds – series of probabilities that determine threshold occurrence, trajectories, and reversibility.

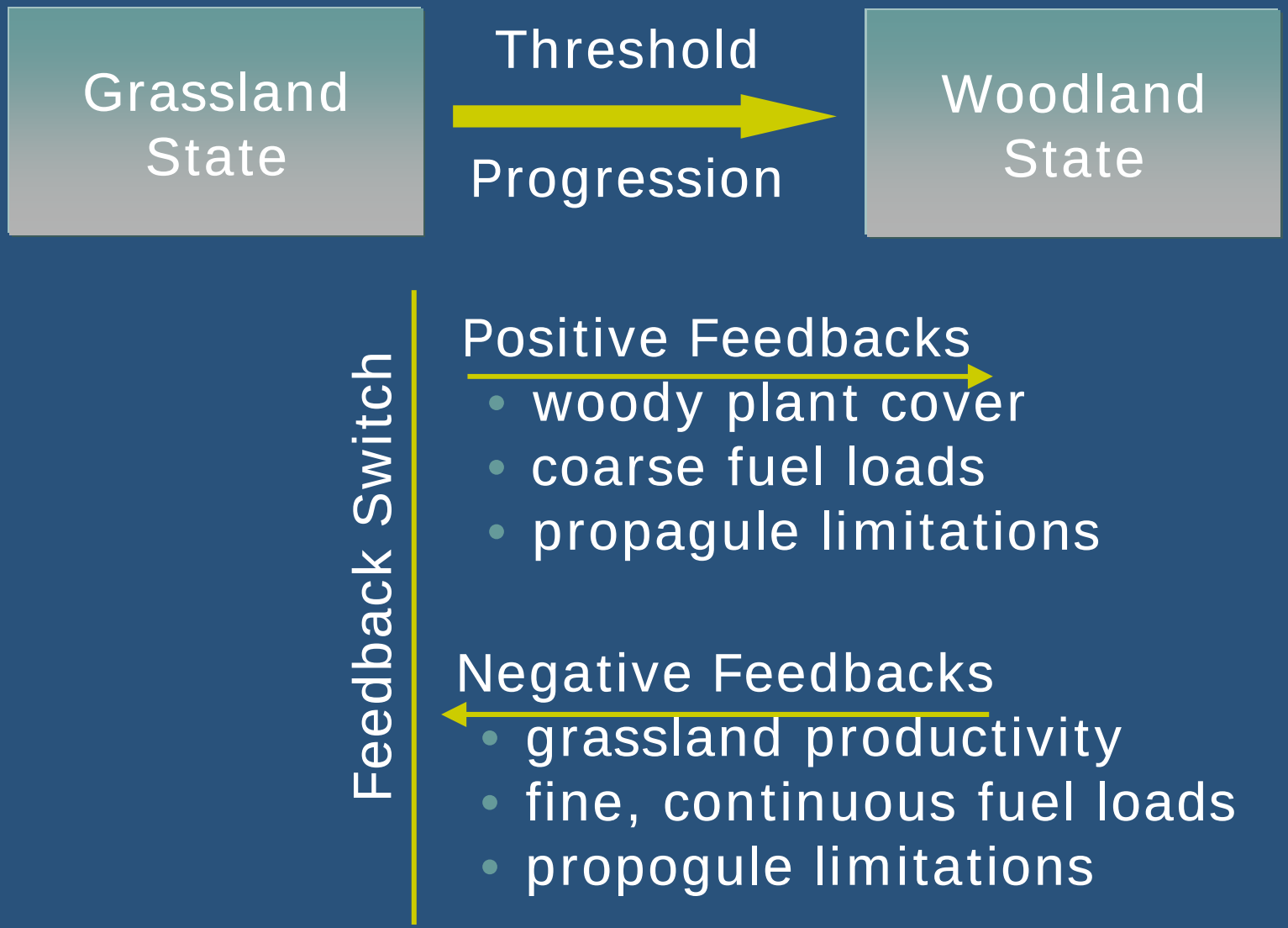
Briske et al. 2006

Feedback Switch Mechanism

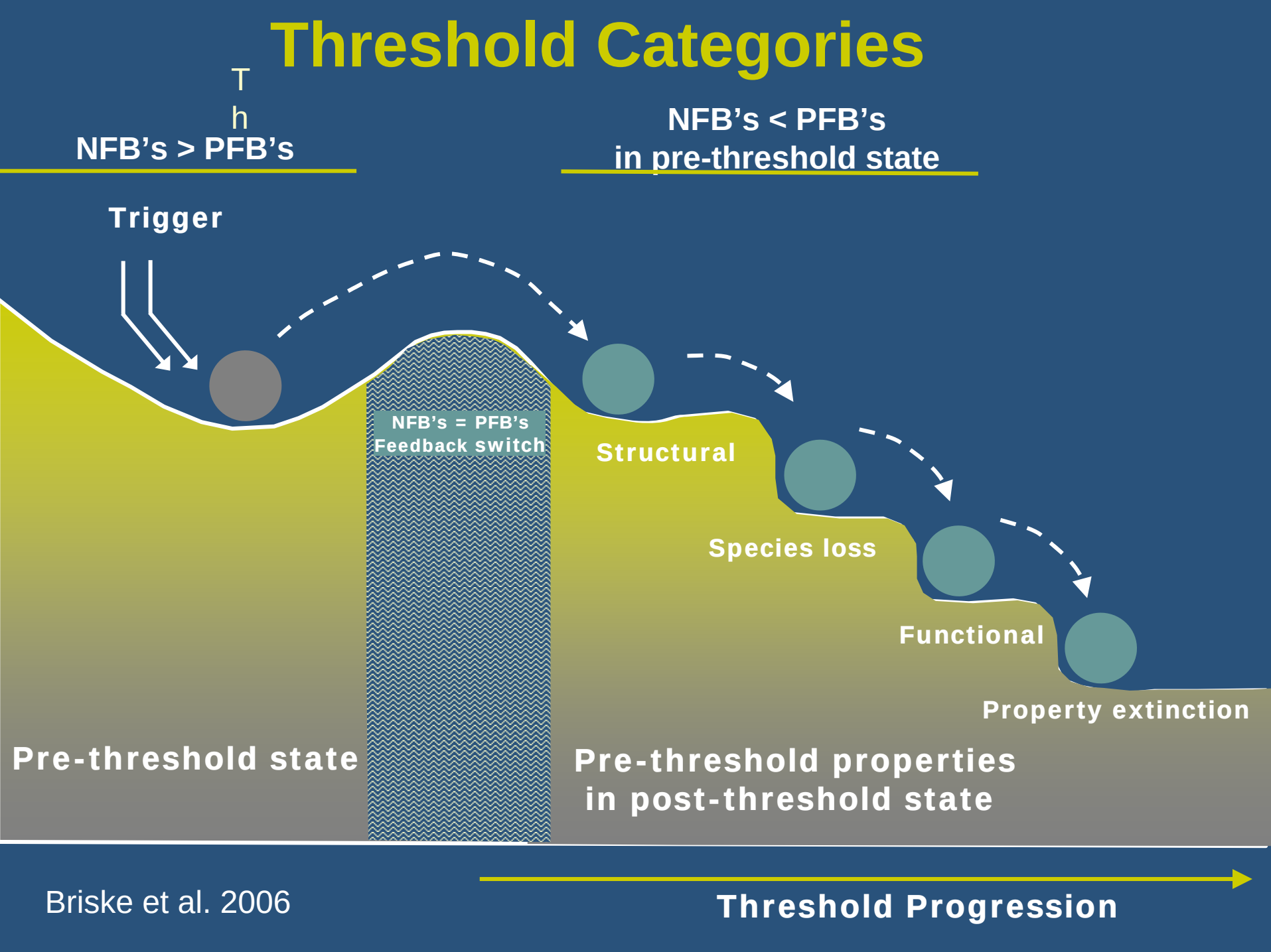


Briske et al. 2006

Positive and Negative Feedbacks



Threshold Categories



Briske et al. 2006

Threshold Categories

- Structural category - modification of species and growth form composition, spatial vegetation distribution, and the presence of invasive species; removal of dominant species from the post-threshold state will reverse the threshold.
- Species loss category - species and genetic diversity of the pre-threshold state have been greatly reduced; propagule addition will be required to reverse the threshold.

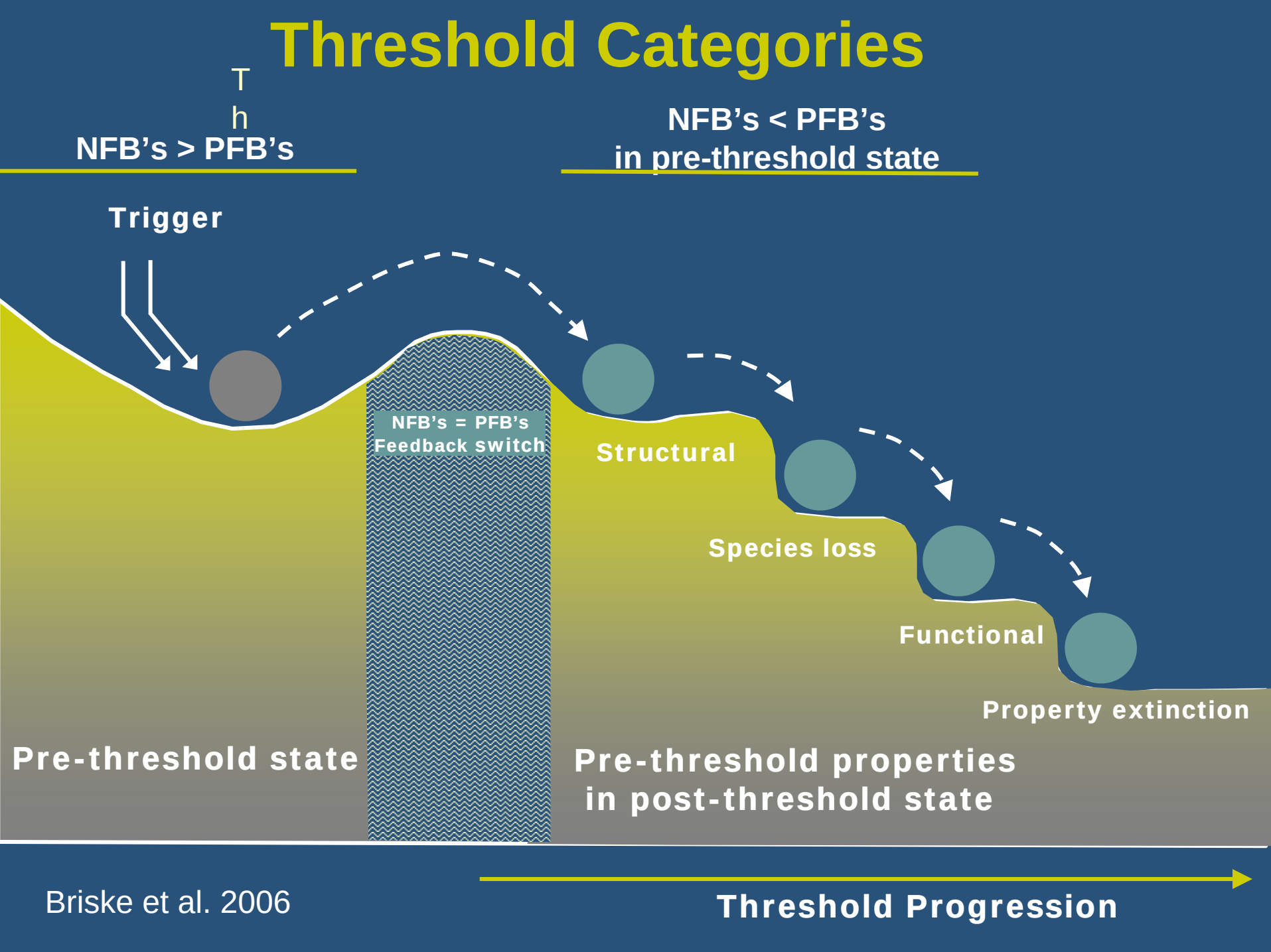
Briske et al. 2006

Threshold Categories

- Functional category - positive feedbacks have progressed to the extent that ecological processes will no longer support dominants of the pre-threshold state; restoration prescriptions will be required to reverse the threshold.
- Property extinction category – residual pre-threshold properties have become extinct so that the post-threshold state completely dominates the site; opportunity for threshold reversal has been lost.

Briske et al. 2006

Threshold Categories



Briske et al. 2006

Threshold Trajectories

Post-threshold state

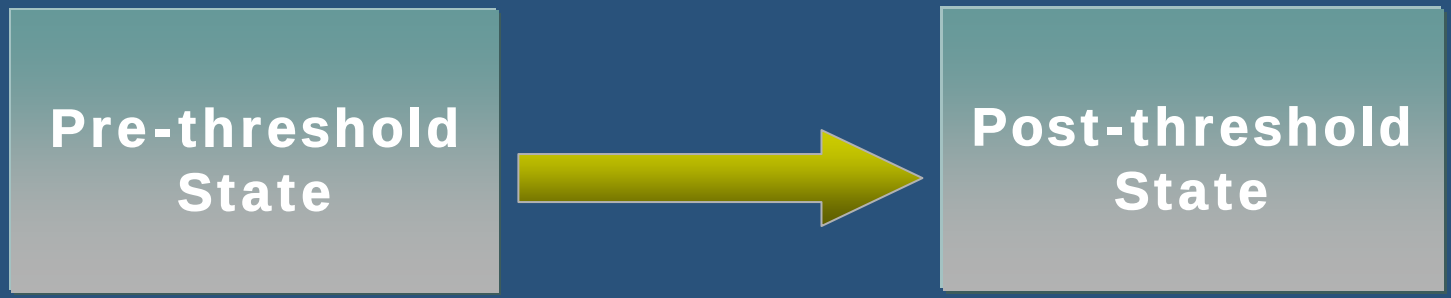
Degraded State	Exotic Species State	Semi-arid Shrubland State	Mesic Woodland State

Positive Feedbacks

Resource loss Impaired function Native species loss Low productivity	Species introduction Intense competition Native species loss Modified function	Woody plant increase Fine fuel loss Herbaceous spp. loss Nutrient redistribution	Woody plant increase Fine fuel loss Herbaceous spp. loss Nutrient accumulation

Ecosystem Controls

Operational Thresholds



Examples:			
	Frequent fire	Mesic woodland	Structural
	Fire suppression	Semiarid shrubland	Species loss
	Drought	Exotic species	Functional
	Intensive grazing	Degraded state	Extinction

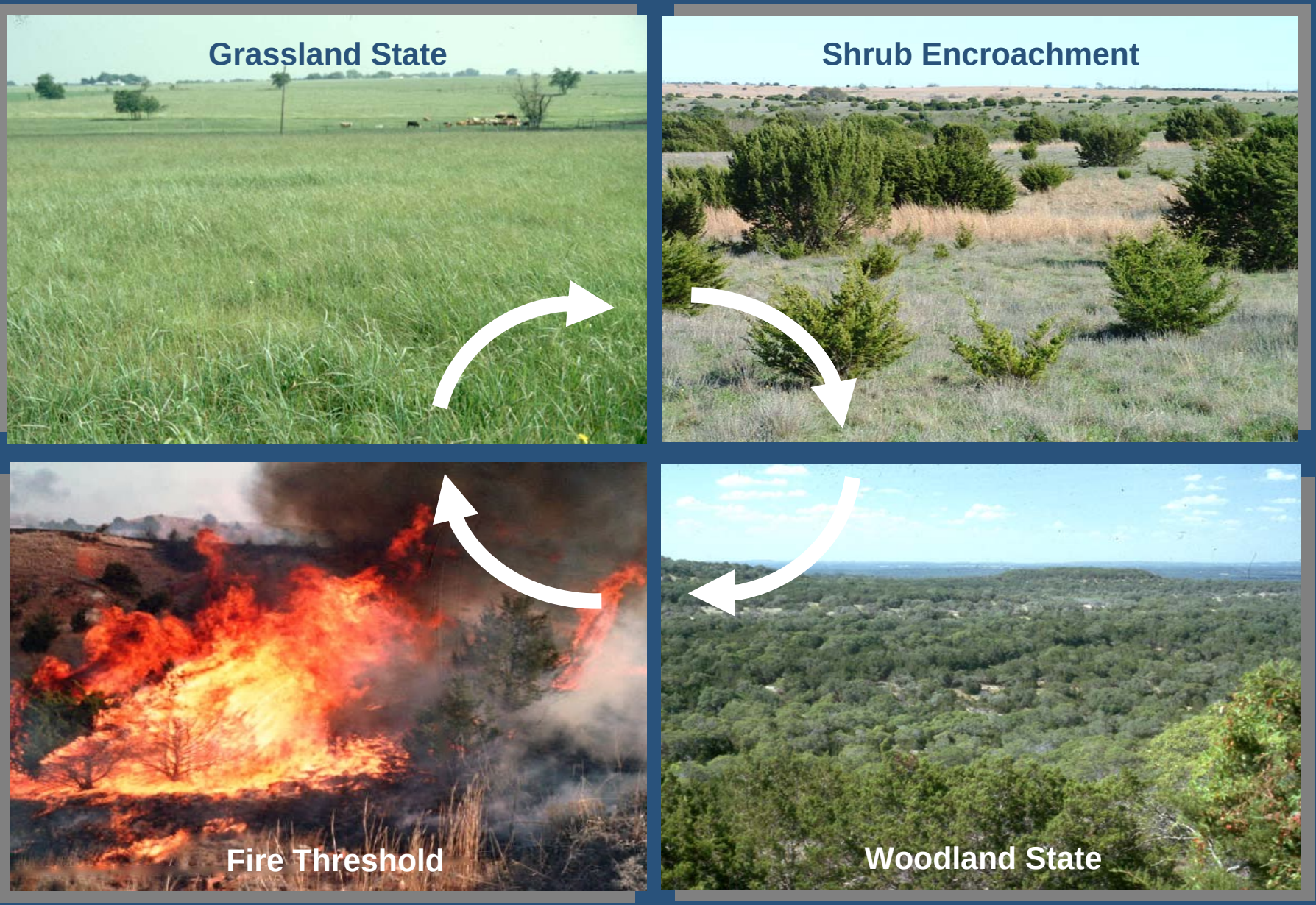
Probability I: Trigger will occur to initiate threshold progression; probabilities can be developed for various triggers or trigger combinations.

Probability II: Pathway of post-threshold trajectory associated with thresholds; probabilities can be developed for various post-threshold states.

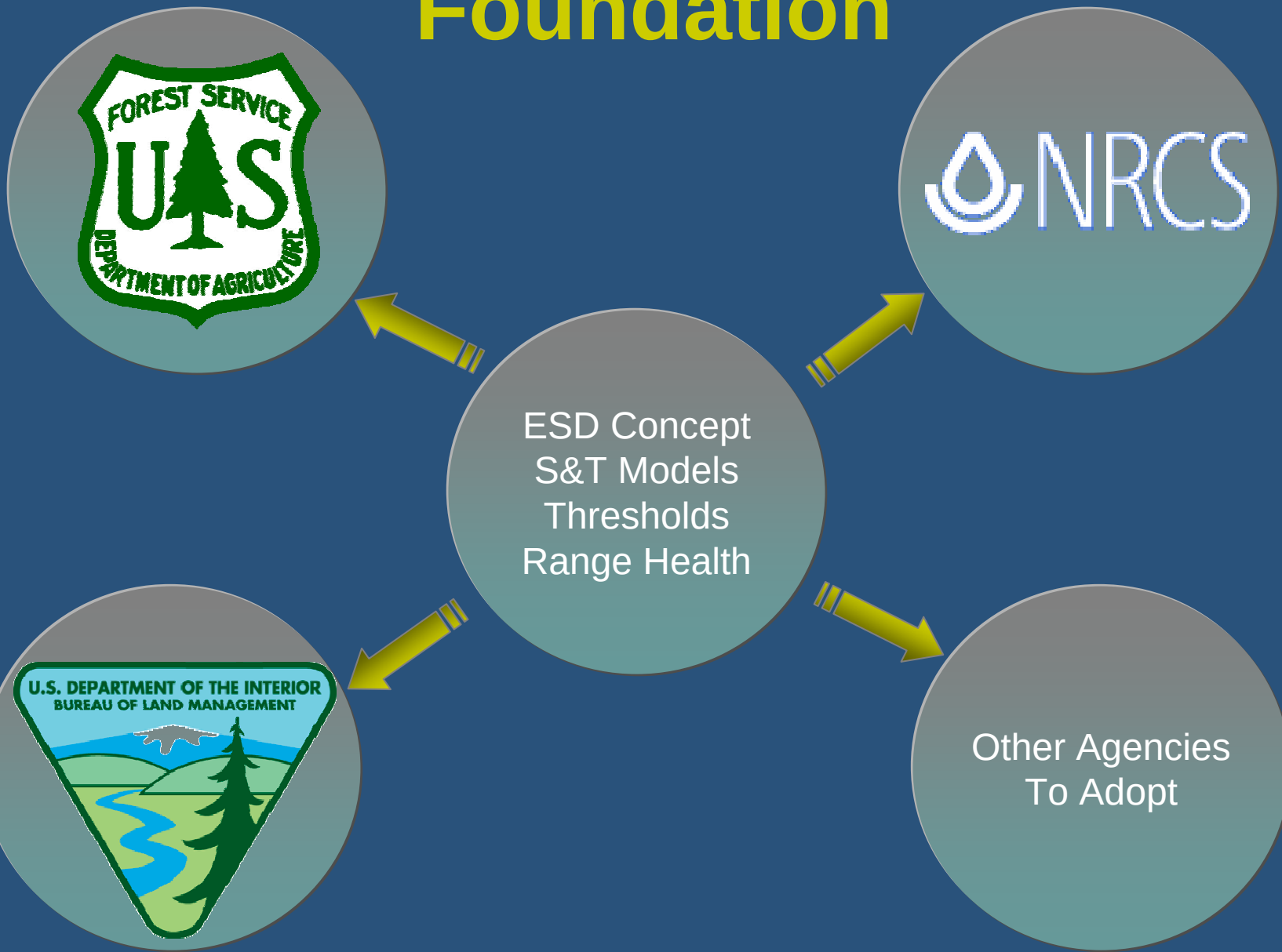
Probability III: Fate of pre-threshold state after a threshold has been crossed; the probabilities can be developed for threshold reversal.

Operational Threshold Value

- Defines thresholds components to better interpret and forecast their occurrence.
- Probabilities derived from a combination of ecological knowledge and field experience.
- Evaluates temporal threshold progression rather than a static boundary in time.
- Emphasizes information vital for land management decisions that can be incorporated into both S&T models and ESD's.


Grassland State
Shrub Encroachment
Fire Threshold
Woodland State

ESD'S: New Rangeland Foundation

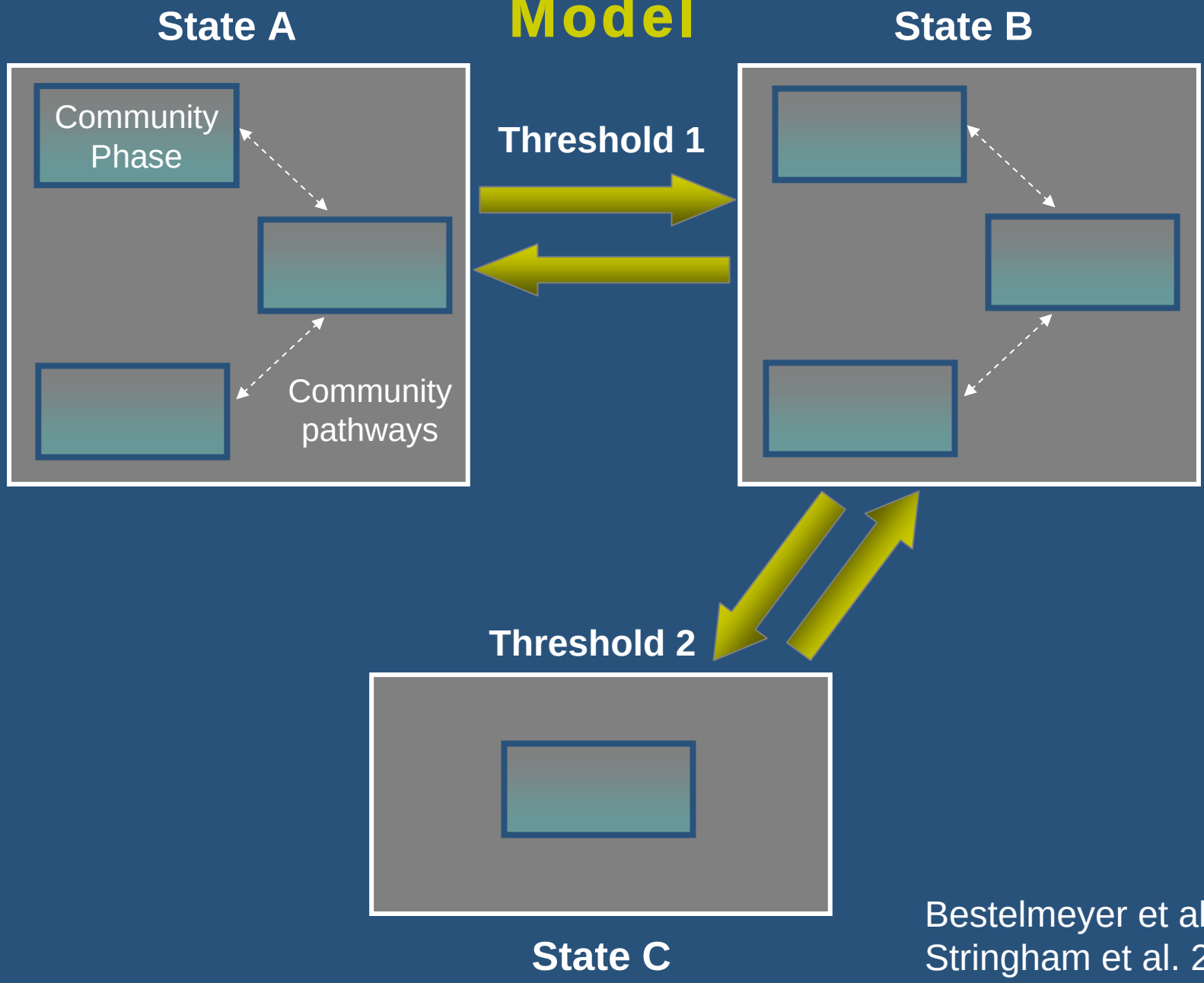


State and Transition Model Framework

- Represents a framework to organize information for management purposes.
- Does NOT constitute an ecological model of vegetation dynamics and does NOT represent an alternative theory for Clementsian succession.
- Information required to construct models include:
  - Recognition of potential alternative states
  - Identification of potential transitions between states
  - Knowledge to achieve favorable transitions and to avoid unfavorable transitions

Westoby et al. 1989

State-and-Transition Model



Bestelmeyer et al. 2003
Stringham et al. 2003

Management Implications

- Managers must consider both continuous vegetation dynamics within stable states as well as discontinuous vegetation change (i.e., thresholds) between states.

- Vegetation management within stable states enables managers to “condition the resource” to modify threshold occurrence (Watson et al. 1996).

- Perception that vegetation dynamics are driven entirely by episodic events decreases incentives for adaptive management and suggests that management is unimportant (Stafford Smith 1996; Watson et al. 1996).