Ecological Thresholds:
Bridging Theory and Application

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Presentation Objectives

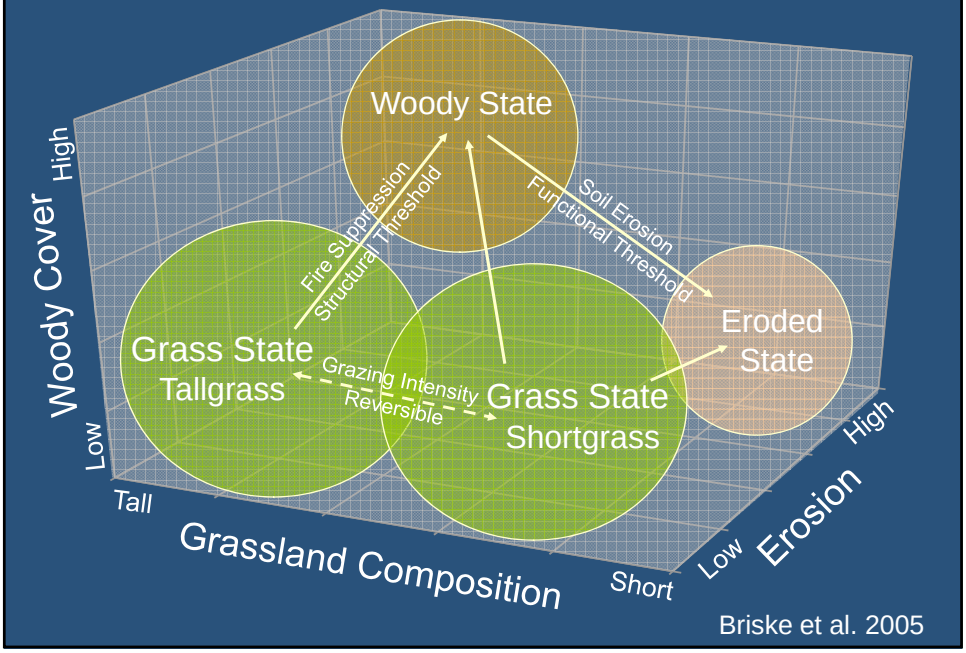
- Evaluate the linkage between theory and application of ecological thresholds.
- Outline a framework to interpret and apply ecological thresholds for land management.

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



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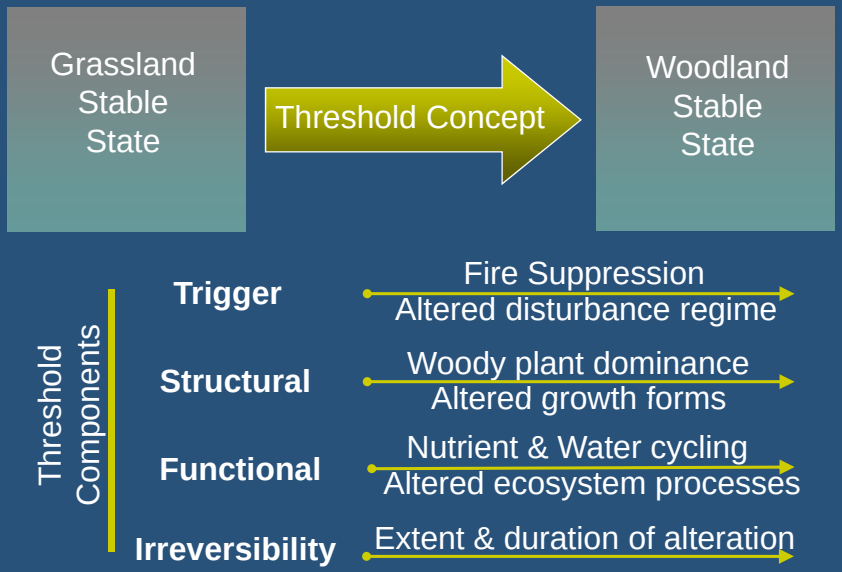
Do We Understand Thresholds?

- 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



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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.

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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.

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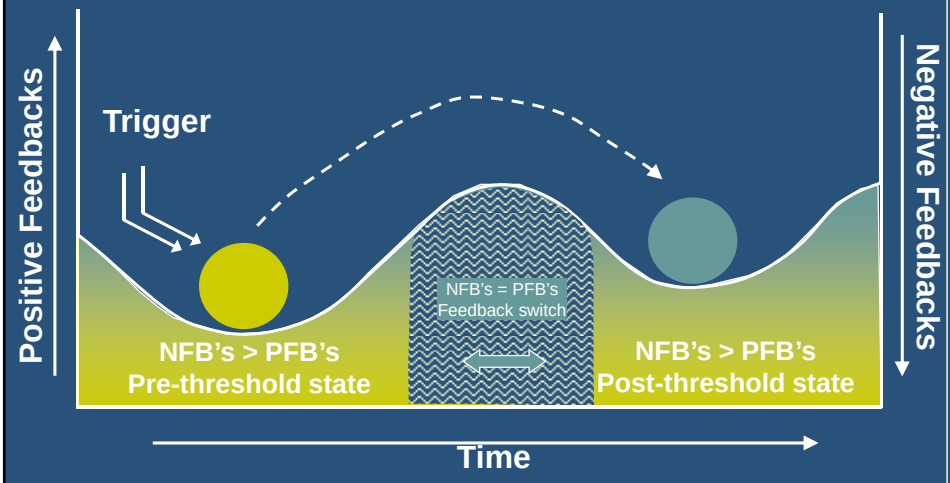
Feedback Switch Mechanism



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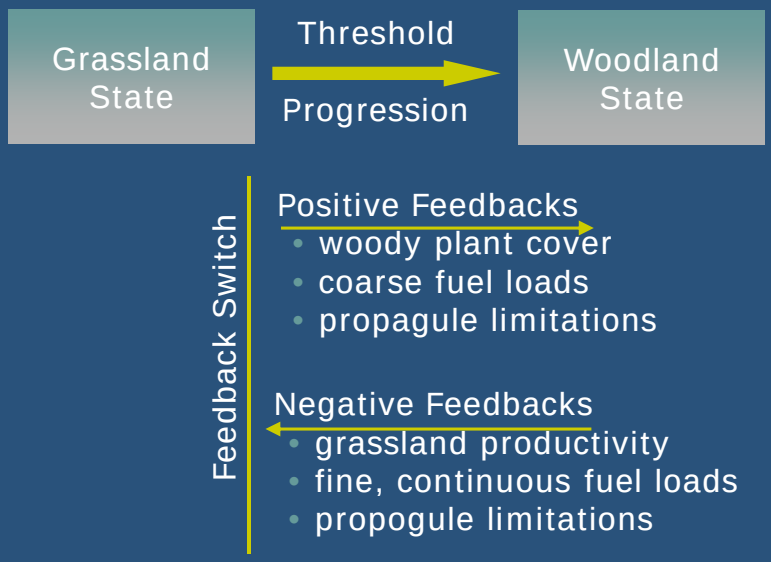
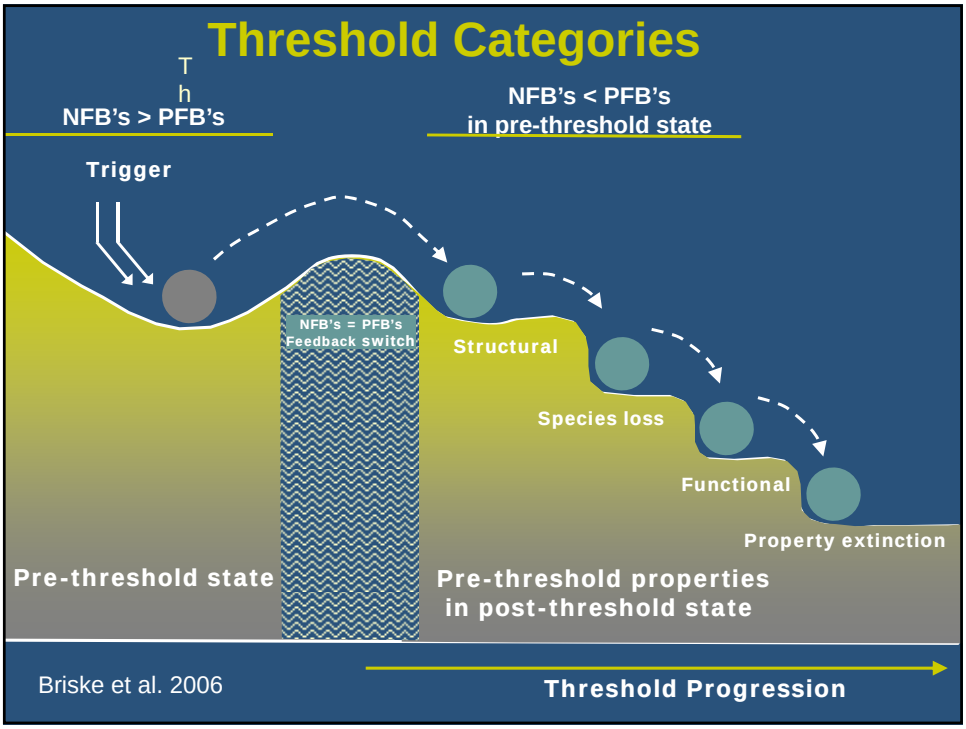
Positive and Negative Feedbacks



Threshold Categories



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.

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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.

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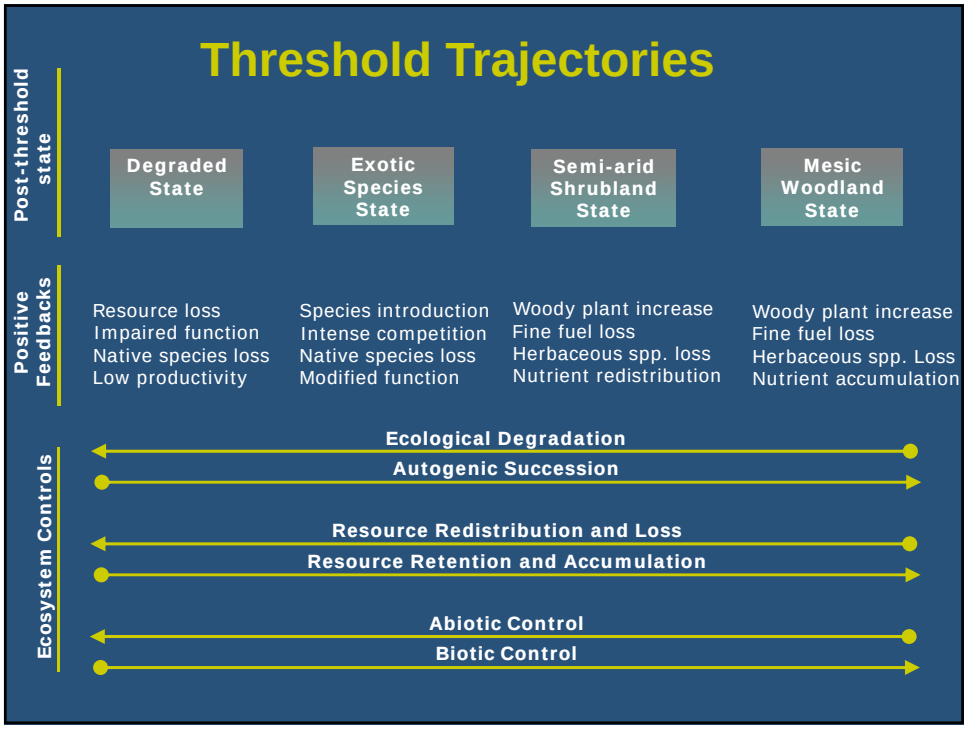
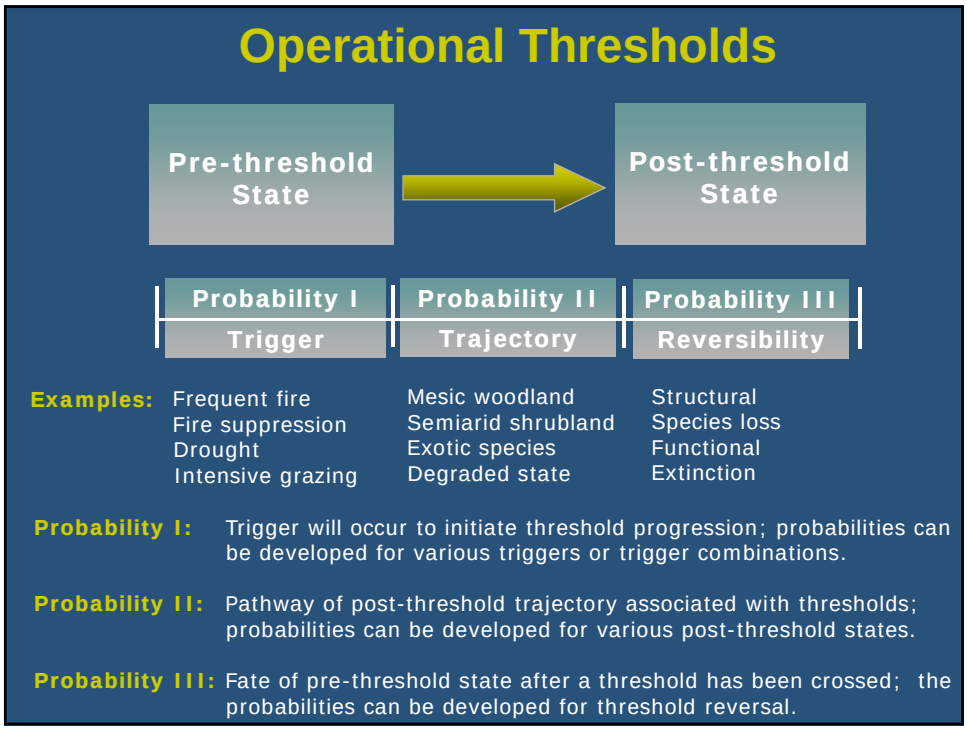

Threshold Trajectories
Post-threshold state
Degraded State
Exotic Species State
Semi-arid Shrubland State
Mesic Woodland State
Positive Feedbacks
Resource loss
Impaired function
Native species loss
Low productivity
Species introduction
Intense competition
Native species loss
Modified function
Woody plant increase
Fine fuel loss
Herbaceous spp. loss
Nutrient redistribution
Woody plant increase
Fine fuel loss
Herbaceous spp. Loss
Nutrient accumulation
Ecosystem Controls
Ecological Degradation
Autogenic Succession
Resource Redistribution and Loss
Resource Retention and Accumulation
Abiotic Control
Biotic Control


Operational Thresholds
Pre-threshold State
Post-threshold State
Probability I
Trigger
Probability II
Trajectory
Probability III
Reversibility
Examples:
Frequent fire
Fire suppression
Drought
Intensive grazing
Mesic woodland
Semiarid shrubland
Exotic species
Degraded state
Structural
Species loss
Functional
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

- Operational thresholds provide greater insight into threshold occurrence and interpretation.
- Probabilities derived from a combination of ecological knowledge and field experience.
- Probabilities are specific to unique time periods of threshold progression.
- Operational thresholds can be incorporated into both S&T models and ESD's.