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Symposium C-7

Resilience and Resilience-based Management Derived from Long-term Vegetation Records

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US-IALE

Current Status of Resilience?

RESILIENCE:

An Operating System for the 21^{st} Century?

Forum

Feature Issue: Some Thoughts on Resilience

What do you mean, 'resilient'?

Dave Hodgson, Jenni L. McDonald, and David J. Hosken

Policy Review

The End of Sustainability

MELINDA HARM BENSON

Department of Geography & Environmental Studies, University of New Mexico, Albuquerque, New Mexico, USA

ROBIN KUNDIS CRAIG

S. J. Quinney College of Law, University of Utah, Salt Lake City, Utah, USA

Ecosystems (2006) 9: 1–13
DOI: 10.1007/s10021-003-0142-z

ECOSYSTEMS

MINI REVIEW

Ecological Thresholds: The Key to Successful Environmental Management or an Important Concept with No Practical Application?

Peter M. Groffman,[1]* Jill S. Baron,[2] Tamara Blett,[3] Arthur J. Gold,[4]

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Presentation Objectives

Describe resilience and resilience-base management

- Assess resilience with long-term empirical data
  - ✓ Three grassland sites
  - ✓ Two sagebrush steppe sites
- Develop inferences for ecosystem management

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Resilience Theory

Capacity of ecosystems to absorb disturbances and reorganize *while undergoing change* so as to retain similar function, structure, identity and feedbacks.

- Engineering resilience– rate of ecosystem recovery within a single equilibrium state.
- Ecological resilience– existence of multiple equilibrium states for a specific ecological site.

Walker et al. 2004 E&S

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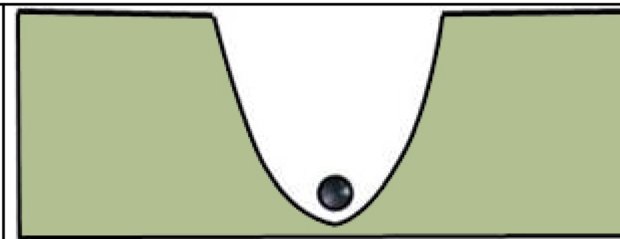
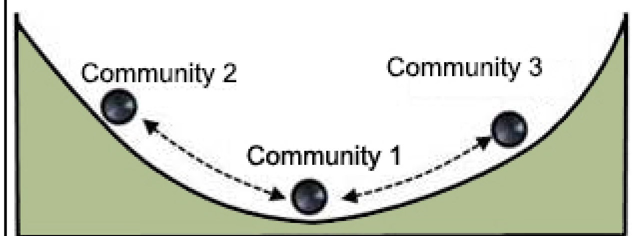
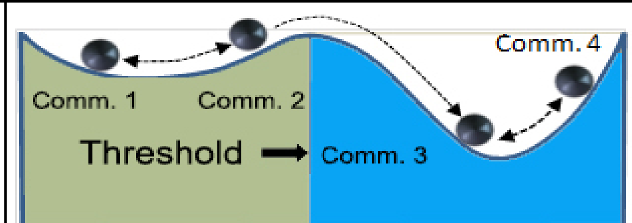
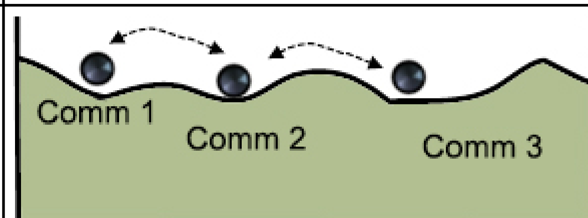
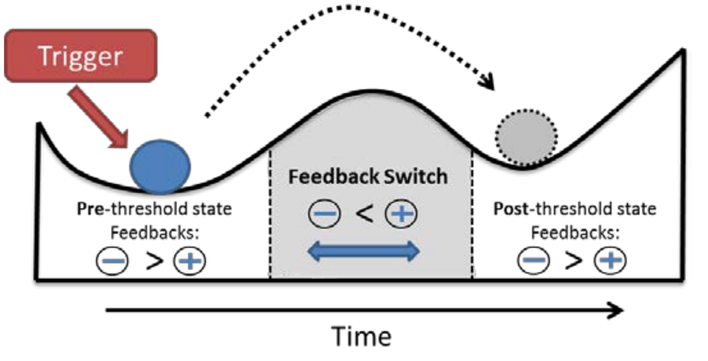
Potential Community Dynamics

Global stability Strong attractor	
Engineering resilience Reversible change	
Ecological resilience Abrupt nonlinear change	
Non-directional change Weak attractor	

Paucity of Empirical Evidence

Synthetic approach of observation, experimentation, concept models, simulation, and narrative is required.

- Natural experiments
- Soil isotopic signatures
- Vegetation reconstruction
- Historic monitoring records



Bowman et al. 2015 TREE

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Vegetation Records

Three Grassland Records

- Stavely, Alberta; 1949-1981; n=27 plots x 28 census dates
- Fort Hays, Kansas; 1932-1972; n=47 plots x 41 census dates
- Jornada, NM; 1915-1979; n=69 plots x 59 census dates

Two Sagebrush Steppe Records

- Idaho National Lab; 1950-2006; n=34 plots x 10 census dates
- US Sheep Station; 1930-1957; n=26 plots x 29 census dates

Data Analysis

Dr Sumanta Bagchi

Center Ecological Studies, Indian Institute Science, Bangalore

Identify unique communities in vegetation record

- Cluster analysis & Bayesian Information Criteria (BIC)
- Tested w/ Analysis of Similarity & DCA performed

Assign individual plots to unique communities

- Bray Curtis dissimilarity index & Correspondence analysis

Categorize community transition attributes in time

- Frequency, magnitude, directionality and temporal scale

Ecological Applications 2012 22(2):400

Rough Fescue Grassland

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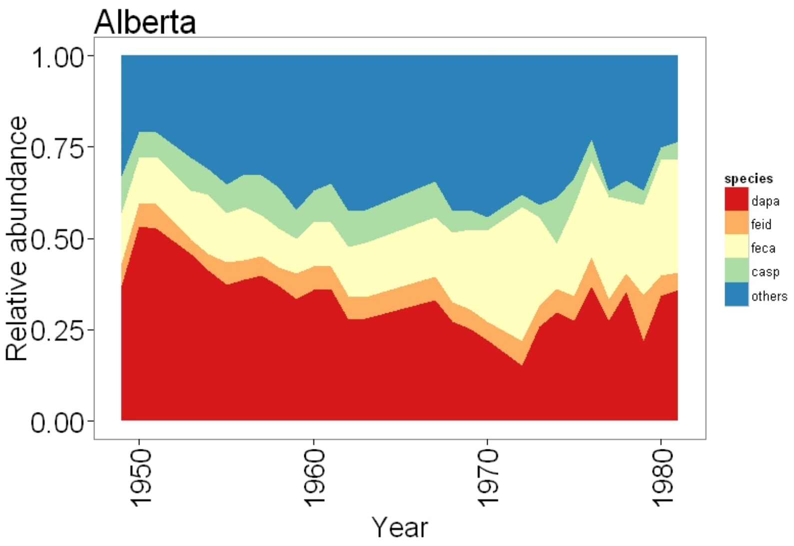
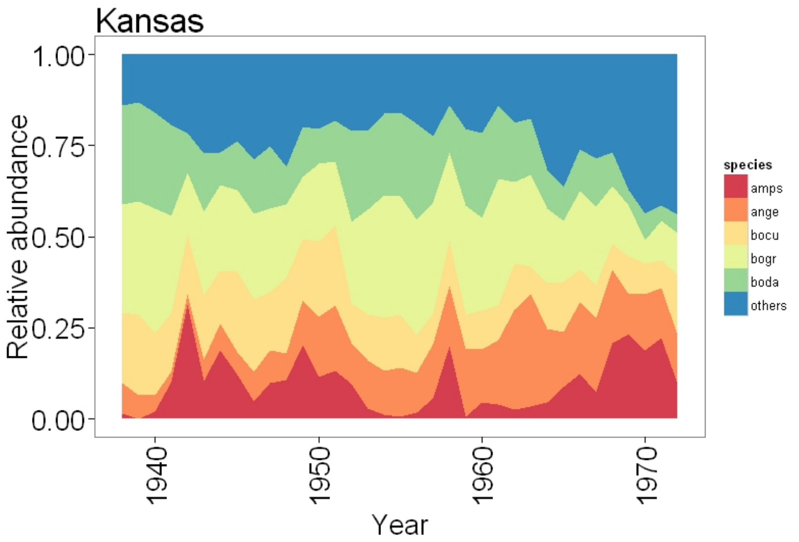
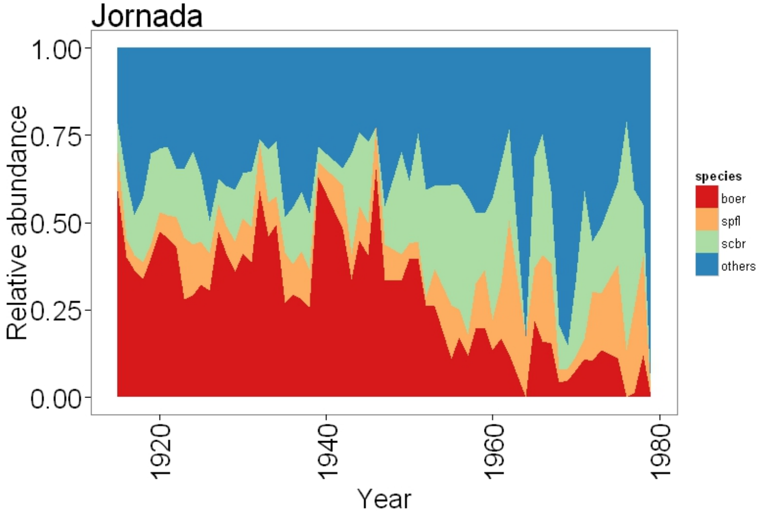
Relative Species Abundance







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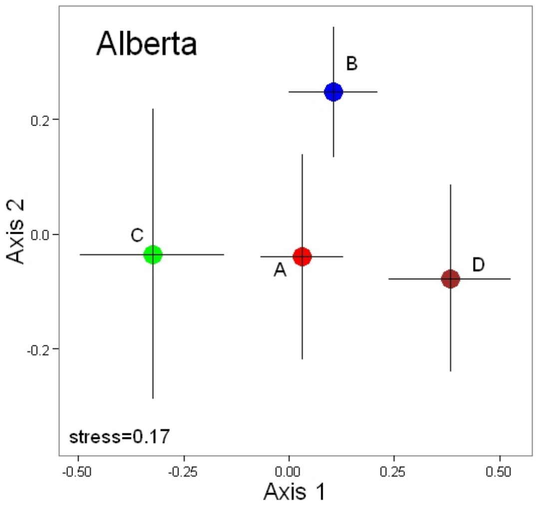
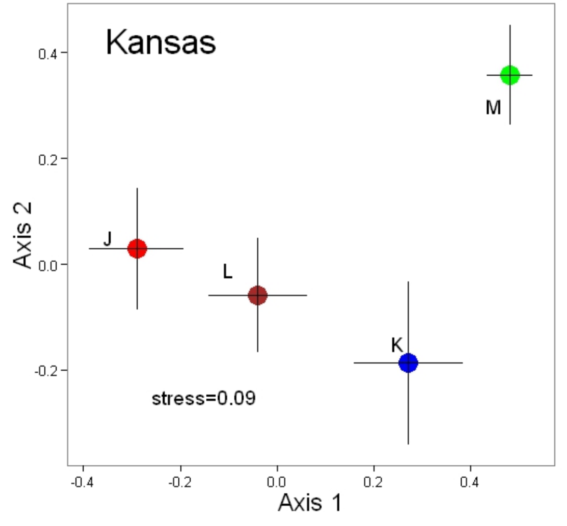
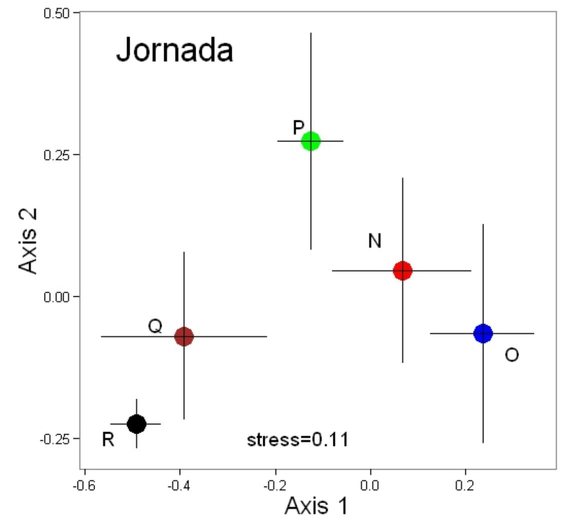
Plant Community Identification





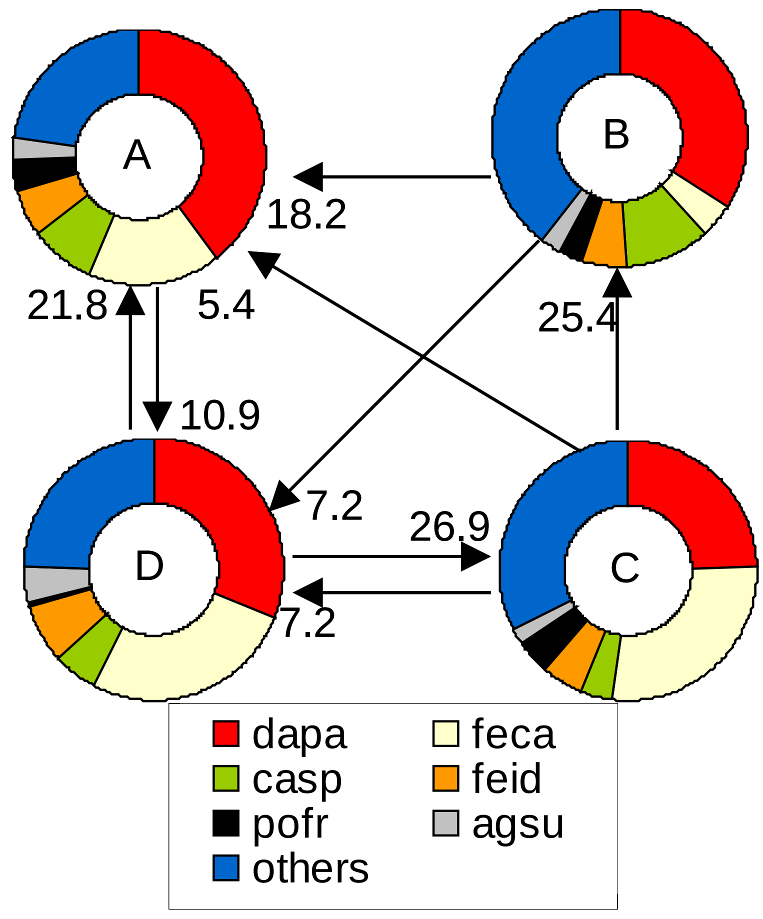


Stavely, Alberta

Spp. Dissimilarity
21-40%; X = 33%

Asymmetric transitions from comm D to C and B to A

Parrys's oatgrass being replaced by Rough fescue



Bagchi et al. in preparation

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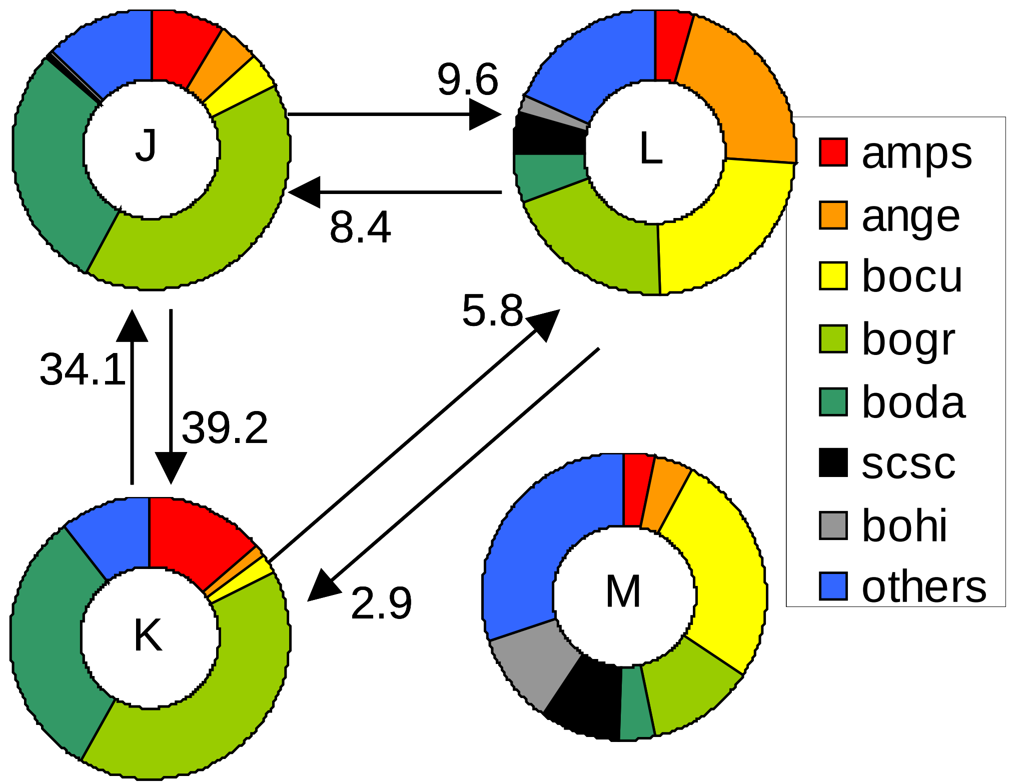
Fort Hays, Kansas

Spp. Dissimilarity
18 – 68; X = 31

Large, symmetrical transitions among comm J & L, and J & K

Comm M highly stable



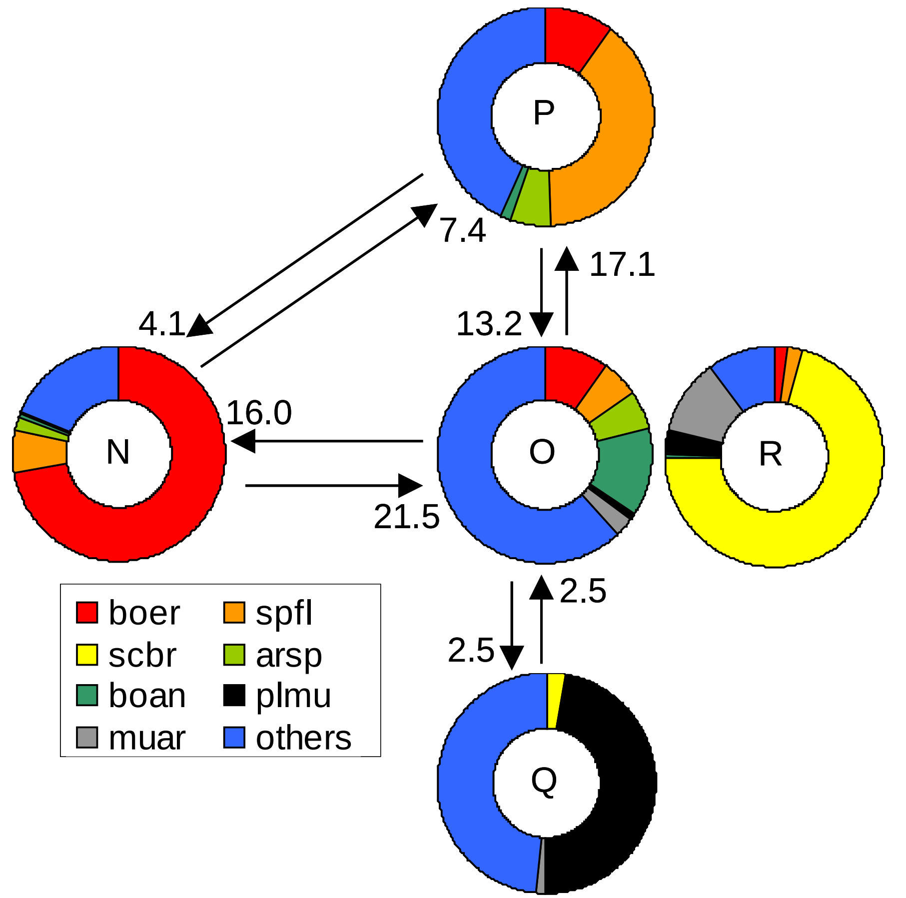
Bagchi et al. in preparation

Jornada, New Mexico

Spp. Dissimilarity
16 – 92%; X = 30%

Black grama shows major decline in mid-record following drought of 1950's.

Loss of major dominant contributed to a threshold



Bagchi et al. in preparation

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Grassland Results

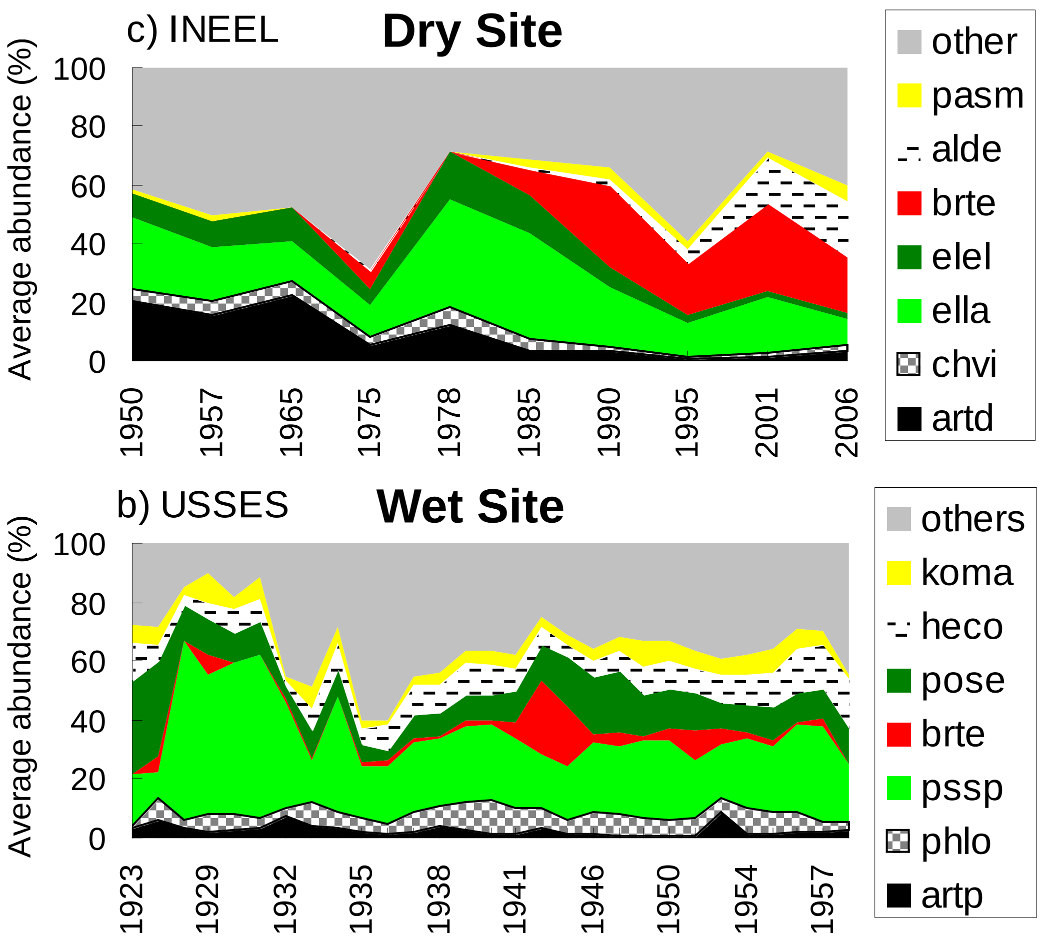
- Highly dynamic, but resilient.
  - ✓ Numerous community transitions, but often symmetrical
  - ✓ High species dissimilarity common to transitions
  - ✓ Minimal evidence for existence of ***thresholds***
- High dissimilarity due to fluctuation of ***subordinate*** species within basins of attraction (i.e., resilience) anchored by few ***dominant*** species (i.e., resistance).
- Transitions among subordinate species associated with above average precipitation, whereas transitions among dominants were related to severe drought.

Sagebrush Steppe – Idaho, USA

Cheatgrass – Bromus tectorum

Exotic, invasive annual grass that increases fire frequency to reduce native species

Relative Species Abundance



Sagebrush

Cheatgrass

Bagchi et al. 2013

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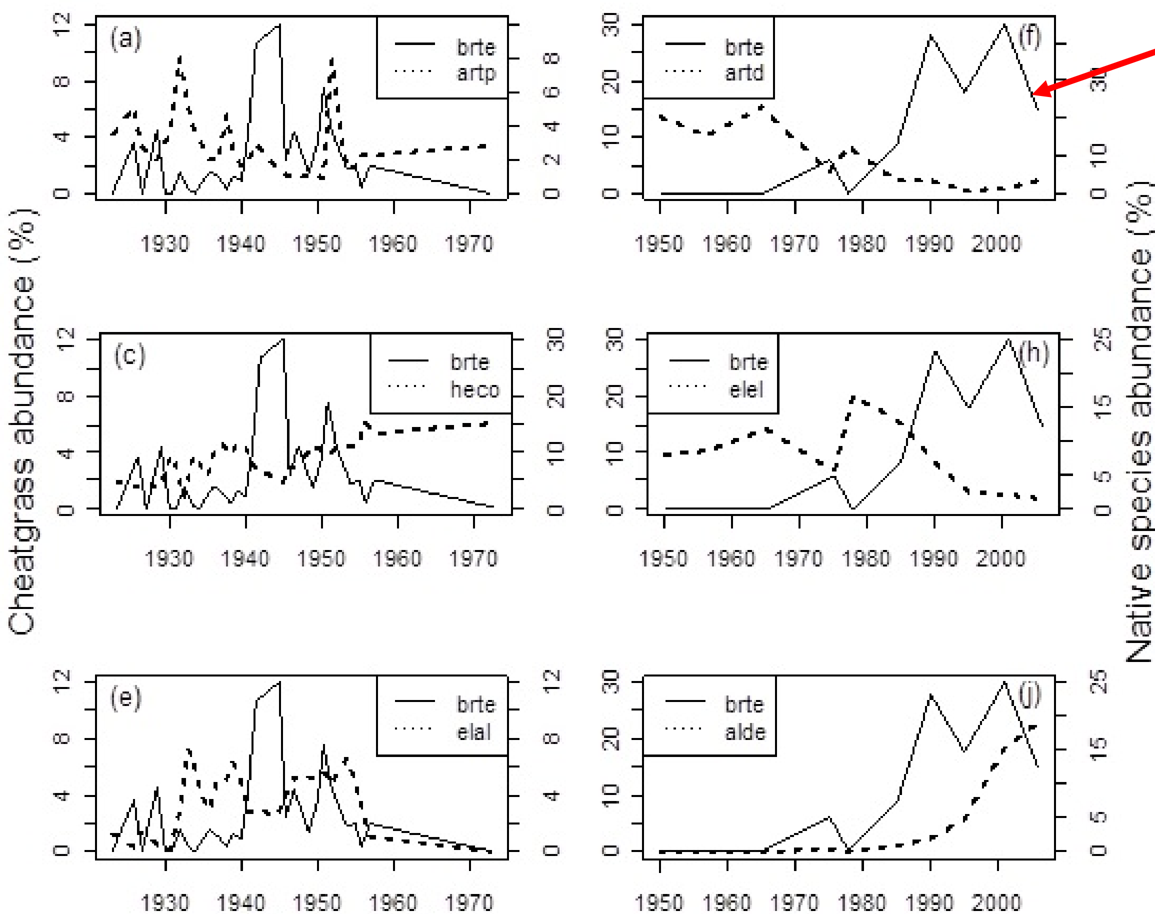
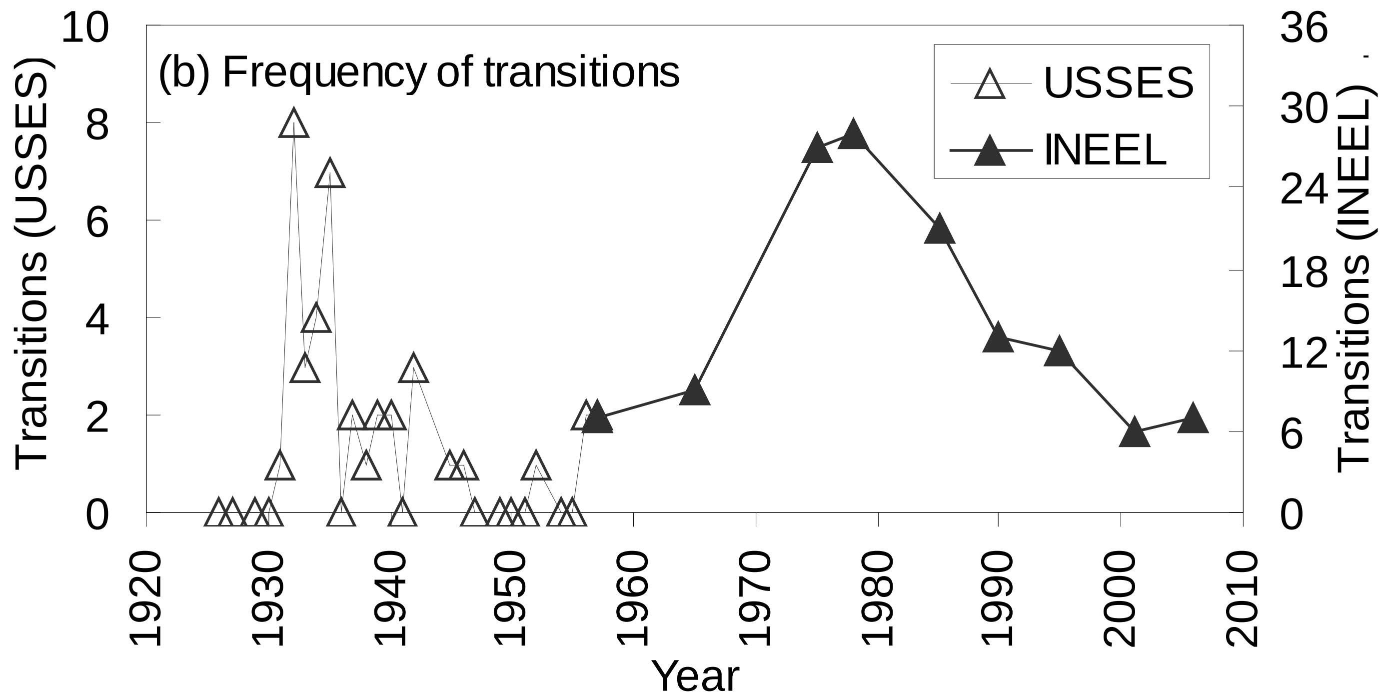
Cheatgrass vs Native Species

USSES - Wet | INEEl - Dry



Bagchi et al. 2013

Temporal Pattern of Transitions



Bagchi et al. 2013

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Sagebrush Steppe Summary

- Cheatgrass is a ‘biotic driver’ impacting resilience
  - ✓ Interaction with precipitation patterns
- Community transitions occurred in a 10 yr window
  - ✓ Associated with ***increasing*** cheatgrass density
- Feedbacks rapid and unrelated to fire
  - ✓ Likely induced by plant-soil processes
- Threshold evident at only the warmer, drier site

Management Implications

- Proportion of dominant and subordinate species may represent an important grassland state variable.
- Identify thresholds with caution because high, reversible species dissimilarly in all grassland records.
- Recognition of temporal scale critical to distinction of transient behavior and alternative stable states.
- Are vegetation thresholds indicative of functional thresholds?

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Current Status of Resilience?

- Useful alternative to stability that explains dynamics within persistent systems.
- System dynamics are mechanistically bounded by feedbacks mechanisms and controlling variables.
- Should resilience be operationalized as a tool for conservation and ecosystem management?