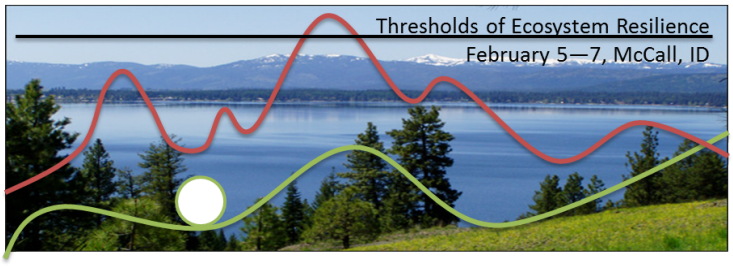
Summary Report

Identifying complementary indicators of ecological thresholds in a changing climate

Innovative Working Group meeting



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Project Statement

Ecosystems respond nonlinearly to environmental stressors which can lead to drastic and irreversible change. This Innovative Working Group (IWG) met to identify cross-disciplinary approaches for detecting trends of ecosystem response amidst natural variability via complementary and quasi-orthogonal indicators.

The ability to predict, identify and manage ecosystems at the brink of unexpected thresholds clear of historical and current experience is critical for environmental management. The inelasticity of societal responses to abrupt changes in ecosystems and associated dramatic reductions in ecosystem services highlights the urgency regarding thresholds because of the escalating pace of changing drivers and increasing vulnerabilities of ecosystem services. A spectrum of indicators is currently being used to track these responses and identify tipping points for vulnerable ecosystems, especially in regards to climate change. However, complexities and insufficient deterministic understanding of ecosystem functions suggest that not one indicator may describe ecosystem resilience, but that integrated or cascading indicators may provide better predictive measures for ecosystem change triggers. This IWG examined approaches for detecting trends of ecosystem response amidst natural variability across different disciplines. We convened a cross-disciplinary group of researchers to explore a collaborative process of model development including a wide spectrum of metrics. The interdisciplinary nature of the problem suggested a unique opportunity to leverage efforts across disciplines and apply it to study risks in coupled ecosystem-human interactions. IWG Participants represented ecology, hydrology, socioeconomics, sociology, statistics, and remote sensing, with foci's integrating across different spatial and temporal scales. Immediate results of the IWG include proposing two sessions at the 2011 American Geophysical Union meeting, developing a synthesis paper of approaches for interdisciplinary indicator assessment, and pursue two grant opportunities.

IWG Meeting

The IWG was held from February 2–5, 2011 at the McCall Outdoor Science School in Central Idaho. Our group of participants (see Table) included all three EPSCoR states in the Western Tri-State Consortium (Idaho, Nevada and New Mexico) as well as participants from Washington State and Colorado.

List of IWG participants

Participant	Area of Expertise	Institution[†]
Caiti Steele	Remote sensing	ARS/NMSU
Franco Biondi	Dendrochronology	UNR
Heather Lintz	Statistical ecology	OSU
Kelly Cobourn	Resource economics	BSU
Laura Applegate	Natural resource management	WSU
Laurel Saito	Water resources	UNR
Robert Heinse	Soil and environmental physics	UI
Sarah Karam	Evolution and conservation biology	UNR
Scott Peckham	Geomorphology/coupled modeling	CSDMS/CUB
Interesents that could not attend the IWG, but are contributing participants		
Amanda White	Ecohydrology	LANL
George Fernandez	Statistics	UNR
J. D. Wulfhorst	Community and Natural Resources	UI
Li Dong	Climate modeling	UNM
Marjori Matocq	Evolutionary genetics	UNR

[†] ARS USDA-Agricultural Research Service; BSU Boise State University; CSDMS/CUB Community Surface Dynamics Modeling System/University of Colorado at Boulder; LANL Los Alamos National Laboratory; NMS New Mexico State; OSU Oregon State University; UID University of Idaho; UNM University of New Mexico; UNR University of Nevada Reno; WSU Washington State University

Ideas and Outcomes

This IWG was designed to bring together a cross-disciplinary group of scientist to develop our idea of identifying complementary indicators of ecological thresholds in a changing climate. The IWG enabled our team to brainstorm and formulate new ideas regarding the identification of key gaps in the current knowledge of ecological drivers, triggers, responses and thresholds. We discussed the following directions and outcomes for the IWG:

1. Research directions
   - Climate variability over common era (last 2011 years) and how it affects thresholds (3)

- Create database of interdisciplinary thresholds data (2)
- Identify a threshold example with an economic component
- Look at thresholds as they are linked to water (3)

2. Publications
   - Review paper on threshold types
   - Synthesis paper on indicators/threshold approaches that may work in an interdisciplinary context (6)
   - Review paper or book chapter on methods for detection or modeling thresholds
   - Book outline and what kind of book/paradigm/coordinators? (3)
   - Paper/pilot analysis (or meta-analysis) for proposal on looking at systems to look at threshold strength (5)
   - Paper/book chapter of critiques of the concepts/methods regarding thresholds
   - JWRPM editorial about the need for interdisciplinary threshold approach (2)
3. Grants and collaboration
   - AGU session on methods for detecting thresholds and/or threshold strength (1)
   - AGU Session on thresholds (non-methods oriented)
   - Proposal to use data sets from different disciplines to test one or more threshold approaches (5)
   - Proposal to do work on life cycles/windows of opportunity (cheat grass, growing degree days)
   - Proposal on similarity/dissimilarity of thresholds across scales (2)

We identified the interactive role of climate, disturbance, and management as key to a mechanistic understanding of critical thresholds. Our current understanding of the complex interactions between management practices, natural processes and climate change in ecosystems is framed in conceptual state-transition models. However, these models do not account for the effects and interactions among variable rates and trends in climatic, disturbance, and management regimes. Further, these conceptual models are limiting in their predictive capacity for future, novel climates and circumstances.

This IWG's paradigm is: *The major outcome of our IWG was to develop a framework to move beyond traditional conceptual models towards quantitative models that integrate the complex and nonlinear relationships among drivers of critical thresholds.*

These quantitative models will address ecosystems across the semi-arid western U.S. where management practices interact with disturbance regimes and climatic trends to influence the sustainability of and returns to livestock production. Each of these factors-management, disturbance, and climate-varies temporally and spatially.

The proposed project will characterize the spatiotemporal dynamics of each of these variables and their interactions with one another to better understand the processes that move semi-arid rangelands towards critical thresholds. We use a novel method that describes will describe the interaction of these variables in state space in order to identify if the system is moving towards critical thresholds. We apply the results of this novel quantitative analysis to construct interdisciplinary indicators of how close a system is to thresholds that threaten sustainable agricultural production. We focus specifically on semi-arid rangelands because they are especially vulnerable to irreversible change due to water limitation and the high variability and episodic nature of climate variables.

Our overall goal is to develop interdisciplinary indicators of distance and direction of rangeland agro-ecosystems from critical thresholds. These novel interdisciplinary indicators will integrate complex and nonlinear relationships among climatic, disturbance, and management drivers. Specific objectives: 1) Characterize rates and trends of drivers. 2) Characterize the interactions among rates and trends in drivers. 3) Identify unique circumstances among drivers that move semi-arid rangelands towards critical thresholds. 4) Determine if distance and direction from those circumstances (or domains) can serve as indicators to guide management.

We will use existing data that measure system characteristics through time for rangelands at a landscape level using (i) remotely sensed indicators of vegetation productivity and ecosystem state, (ii) field-based vegetative cover data, plant species richness data, soil moisture data, instrumental and proxy wildfire records, rancher surveys, and(iii) interpolated climate data (including drought indices), and (ivii) secondary data on grazing management practices and other leading economic variables. We will identify interactions among rates and trends of natural processes and management actions using a novel non-parametric statistical approach. We will apply these quantitative results to characterize those natural and economic circumstances that may lead to thresholds. Finally, we will use the analysis to guide development of numerical models that will serve as working hypotheses for mechanisms behind state transitions or thresholds in semi-arid rangelands. We will examine the potential effects of changes in management, disturbance, and climate for future rangelands by combining our empirical

and numerical approaches.

We will increase our understanding of how management interacts with disturbance and climate to affect critical thresholds in agro-ecosystems. Also, this work will help optimize management for sustainability in rangelands by developing indicators that can help to prevent rangeland ecosystems from crossing thresholds that threaten the sustainability of livestock production.

To pursue our paradigm, we are actively working on the following outcomes:

1. Foster collaboration
   - Propose AGU Session I methods (C. Steele, F. Biondi, R. Heinse)
   - Propose AGU session II non-methods (H. Lintz, S. Peckham)
2. Publications
   - Synthesis paper of approaches for interdisciplinary indicator assessment
3. Proposal preparation
   - USDA-AFRI: Thresholds in agroecosystems; LOI due 3/3/11; final proposal due 6/3/11. Research question: How do changing rates and trends of climate and management lead to critical thresholds in agroecosystems?
   - NSF Dimensions of Biodiversity: due 3/28/11: needs to address integrated taxonomic genetic, functional aspects of biodiversity. Hypothesis: interaction of venn diagram is optimum for sustainable management.

Summary

The IWG enabled a team of cross-disciplinary scientists to formulate innovative ideas and solutions centered around ecosystem thresholds. The meeting in particular facilitated interactions between physical, biological and social sciences and included the participation of graduate students, postdocs and early career faculty members as well as senior faculty. The stated research objectives and targeted outcomes center around our idea of quantitative models where management practices interact with disturbance regimes and climatic trends to influence the sustainability of, and returns to, ecosystem resilience. With each of these factors–management, disturbance, and climate–varying temporally and spatially we anticipate developing interdisciplinary indicators that can help to prevent ecosystems from crossing

thresholds. Outcomes of the IWG include responding to calls for proposals by the USDA and NSF, as we well as furthering collaboration via the proposal of two targeted topical sessions at an international meeting (AGU) and the development of a synthesis paper. The stated research meets EPSCoR stated functions by advancing the understanding of climate change affects and develop joint research, education, and outreach capacity within the Tri-State Consortium via groundbreaking and transformative research. Based on comments after the meeting, all of the participants felt the IWG was a great success, are excited about working together and have firm plans for future collaboration.

IWG Meeting Agenda

Friday			
2:00	–	6:00pm	Participants arrive
6:00	–	6:30	Dinner
7:00	–	9:00	Rest and relax
Saturday			
8:00	–	8:30am	Breakfast
8:30	–	9:00	Introduction of IWG
9:00	–	10:30	Introduction of participants I
10:30	–	10:45	Break
10:45	–	12:00pm	Introduction of participants II
12:00	–	12:30	Lunch
1:00	–	3:00	Discussion of key aspects and brainstorming
3:00	–	3:15	Break
3:30	–	6:00	Identification of research areas and consensus on work topics
6:00	–	6:30	Dinner
7:00	–	9:00	Enjoy the McCall winter carnival
Sunday			
8:00	–	8:30am	Breakfast
9:00	–	10:30	Guided tour of restoration ecology in the Ponderosa State Park
10:30	–	10:45	Break
10:45	–	12:00pm	Breakout groups discuss research topics
12:00	–	12:30	Lunch
1:00	–	3:00	Presentation of ideas and discussion
3:00	–	3:15	Break
3:30	–	6:00	Identification of research areas and consensus on work topics
6:00	–	6:30	Dinner
7:00	–	9:00	Explore the Ponderosa state park
Monday			
8:00	–	8:30am	Breakfast
8:30	–	10:30	Breakout groups identify possible RFP's
10:30	–	10:45	Break
10:45	–	12:00pm	Wrap up and planning a path forward
12:00	–	12:30	Lunch
12:30			Meeting adjourned