Information Technologies for Rangeland Monitoring:
What Do They Need To Address?

D.D. Briske
Texas A&M University, USA

B.T. Bestelmeyer
ARS Jornada Experimental Range, USA

M. Fernandez-Gimenez
Colorado State University, USA

M. Stafford Smith
CSIRO, Sustainable Ecosystems, Australia

Why Monitor Rangelands?

- Diverse ecosystems representing 70% of Earth's land area that provide many ecosystem services.
- Basis for sustainable management to continue provisioning of ecosystem services.
- Anticipation of ecosystem change provides the opportunity to direct and manage change, rather than only react to it.

Monitoring Recommendations

1. Continue to improve models of ecosystem function to encompass the realities of complex, open and adaptive systems.

2. Capacity to scale from local to landscape and regional levels to address the complexity of multi-scale systems and interactions.

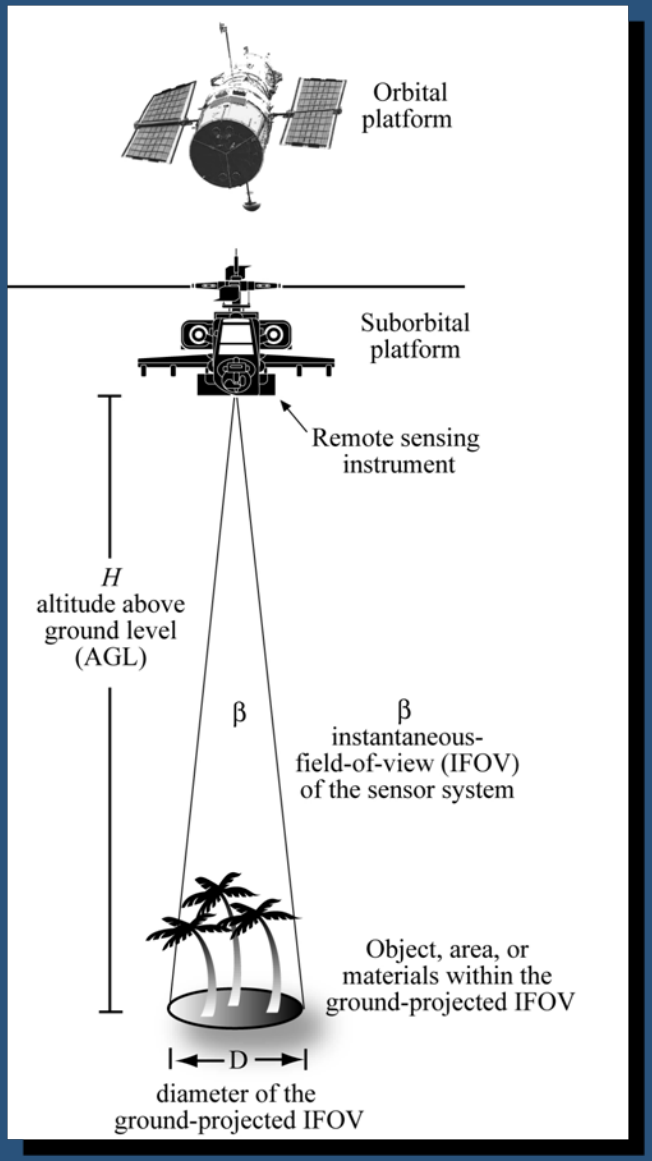
3. Recognize and address multiple stakeholder groups, including cultural, socio-economic and governance considerations.

Western 2003

Presentation Objectives

- Build upon these proposed monitoring recommendations by identifying approaches to address them.
- Major premise is that conceptual ability for data interpretation, is as important as technical capacity for effective monitoring.
- Important conceptual limitations include:
  - inadequate models to interpret monitoring data
  - inability to address multiple ecological scales
  - minimal incorporation of socio-economic, cultural and governance considerations .

Information Technologies



Jensen, 2004

Measurement of structural attributes that operate as surrogates of ecosystem function.

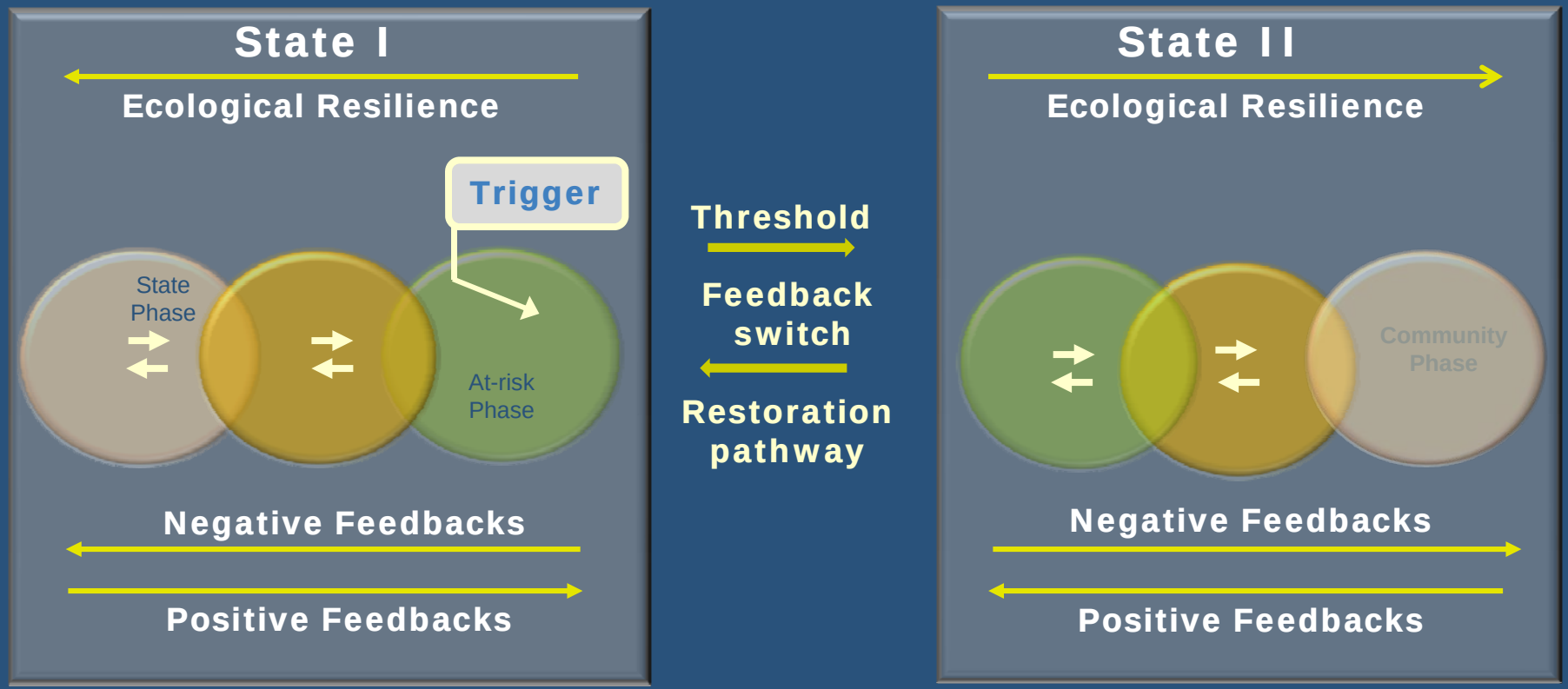
Monitoring Recommendation I: Appropriate Ecological Models

Ecological Resilience

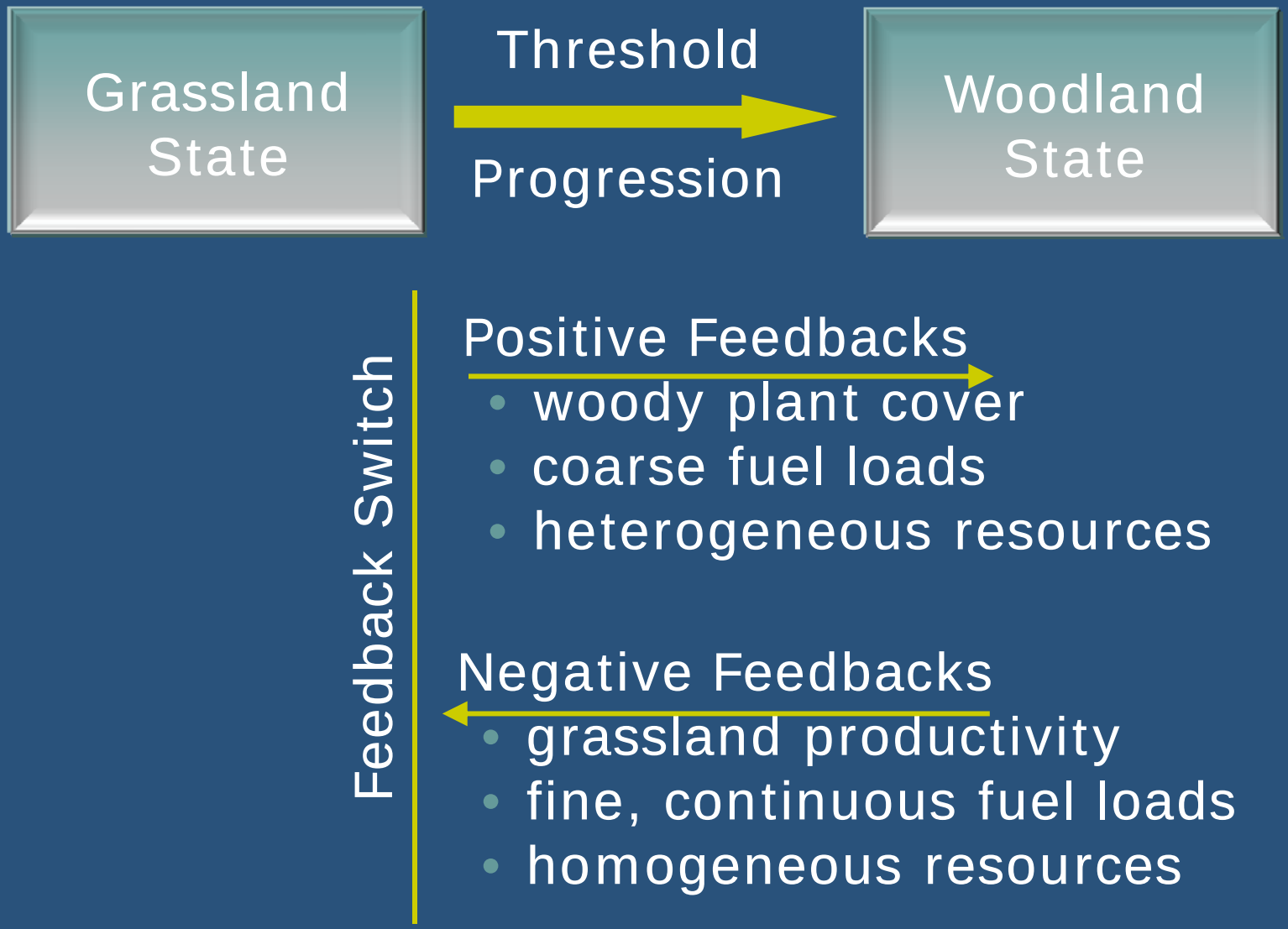
- Ecological resilience - amount of change required to transform an ecosystem from being maintained by one set of mutually reinforcing processes and structures to another (Peterson et al., 1998).
- Concept describes ecosystem behavior near the limits of resilience and emphasizes the expression of alternative stable states.
- Thresholds represent the conditions at which the limits of state resilience have been exceeded to form alternative states.



Resilience-based Monitoring



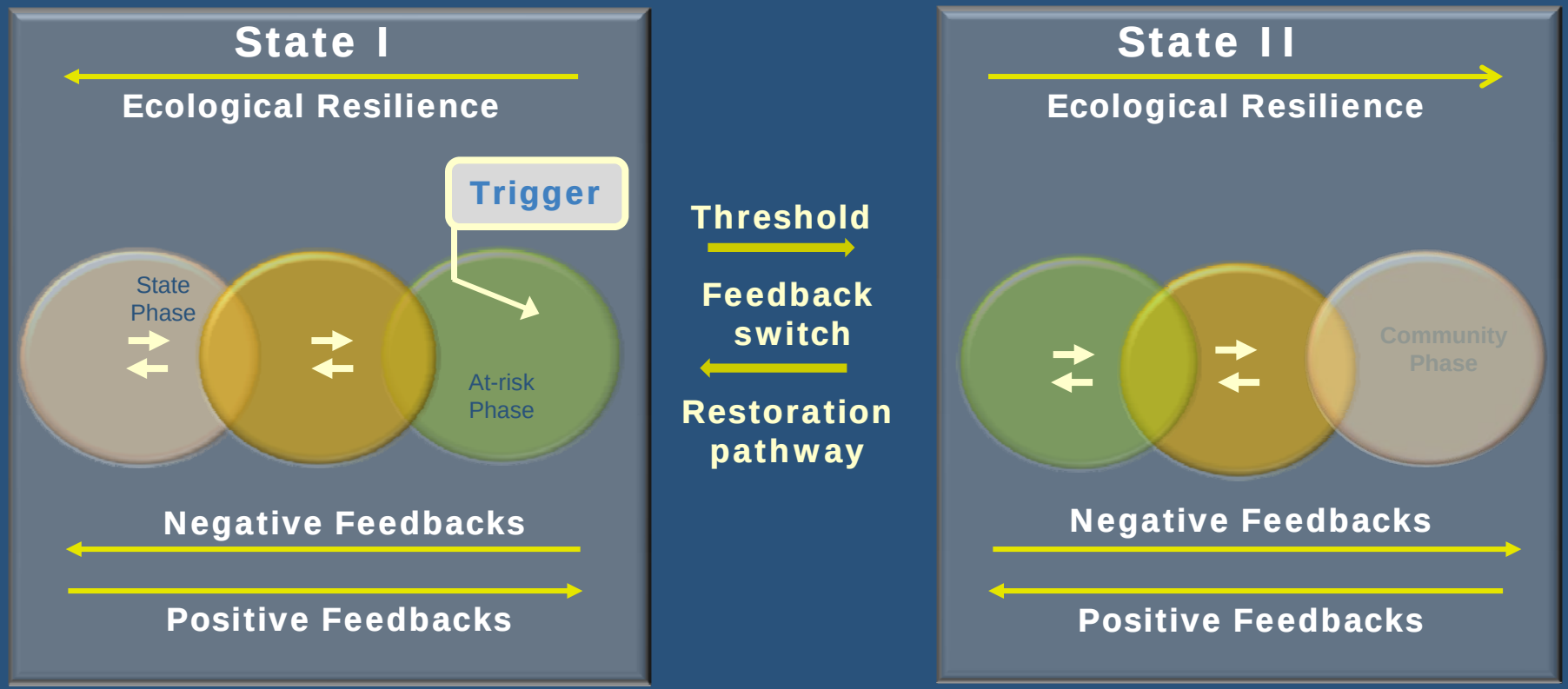
Positive and Negative Feedbacks



Resilience-based Monitoring

- Resilience of desirable states can be reduced slowly by improper land use practices or rapidly by severe episodic events.
- Indicators identify state movement toward thresholds as well as movement beyond thresholds when crossed.
- Indicators of decreasing resilience forewarn managers that actions must be taken to stabilize resilience and minimize thresholds.
- Indicators of alternative state resilience after thresholds are crossed can provide information concerning restoration of former states.

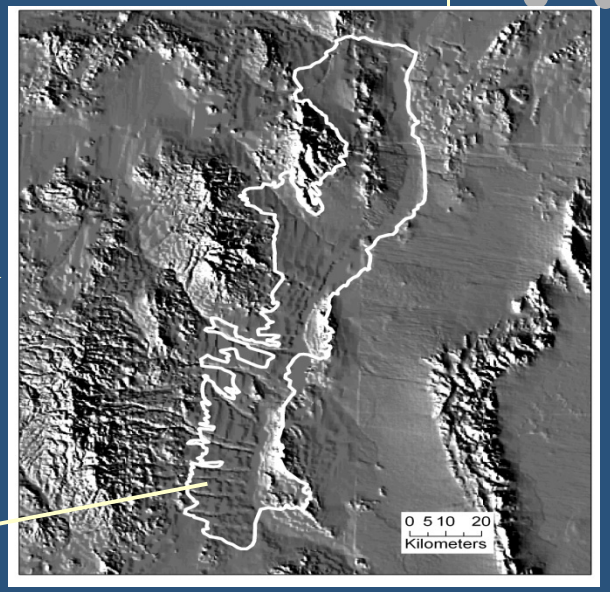
Resilience-based Monitoring



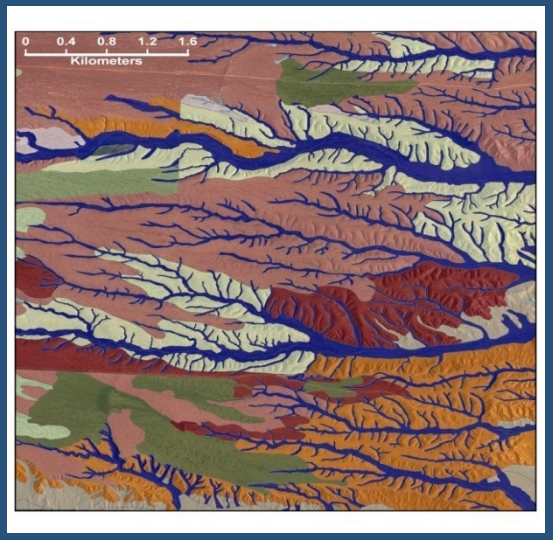
Monitoring Recommendation II: Multiple Ecological Scales

Multiple Ecological Scales

Climate zones



Soil-geomorphic system



Landscapes

Patches

Bestelmeyer et al., in review

Cross-Scale Interactions

- Cross-scale interactions include:
  - Individual plant responses affect local patch structure and broader-scale processes.
  - Regional changes in ground cover and land use that may modify atmospheric chemistry, dust emissions, and albedo.
  - Regional climate processes will in turn affect local-scale responses.
- Monitoring failures can result from a mismatch between scales of dominant processes and scales of assessment.

Fast vs Slow Variables

- ‘Fast variables’ – dynamic variables measured at a few discrete locations and points in time (e.g., plant cover and production)

- These variables are important for short-term tactical decisions, but may not be strongly correlated with long-term ecosystem resilience.

- ‘Slow variables’ - consistent variables that underlie long-term ecosystem change (e.g., nutrient redistribution, functional group replacement).

Reynolds et al. 2007

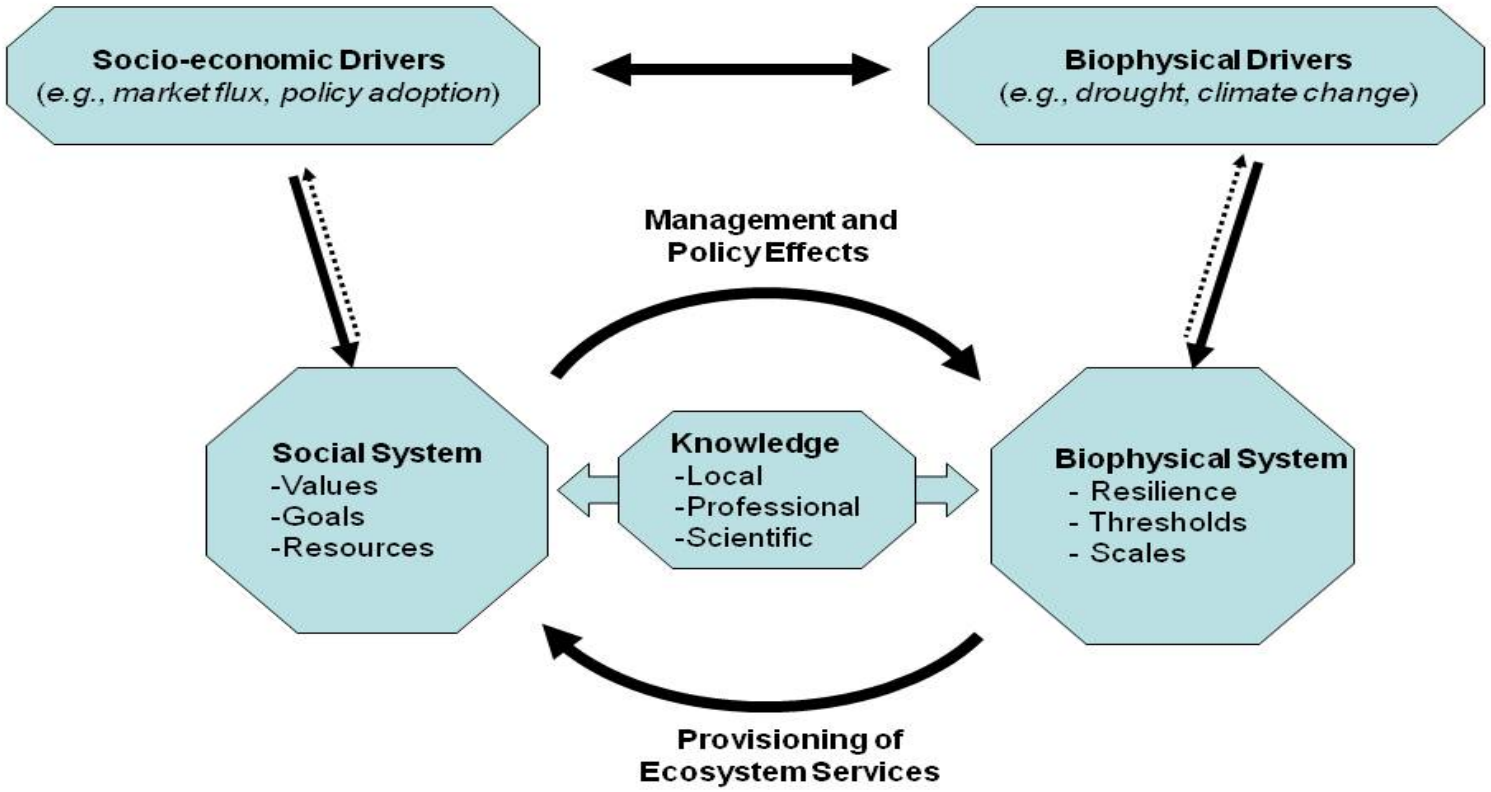
Practical Approaches

- Hierarchical stratification and sampling of regions in assessment and monitoring.
- Interpretation of point data with respect to fluxes (e.g. hydrology, aeolian processes, transhumance).
- Multiple attributes reflecting both fast and slow variables.

Bestelmeyer et al., in review

Monitoring Recommendation III: Social, Economic and Cultural

Social-Ecological Systems



Stafford Smith et al., 2007

Social Resilience Indicators

- Household well-being, poverty rates
- Trust, cooperation, social networks (e.g., social capital)
- Institutions that facilitate social learning
- Access to diverse knowledge sources and mechanisms to integrate them
- Multi-scale, transparent, and inclusive governance systems

Fernandez-Gimenez et al., in review

Social-Ecological Systems

- Development of effective monitoring protocols requires that rangeland ecosystems be viewed as integrally linked social-ecological systems (Stafford Smith et al., 2007).

- Knowledge of ecosystems, human and natural impacts, and feedbacks between ecological and social systems is critical to future management actions (Berkes et al., 2003).

- Monitoring is the foundation for social-ecological systems because it provides opportunities for collaborative learning and management action that is critical to ecosystem resilience (Fernandez-Gimenez et al., in review).

How Shall We Proceed?

- Ecological resilience
- Cross-scale interactions
- Human dimensions

Is it possible to integrate these components into a monitoring system?

Conclusions and Perspectives

- Embrace monitoring as a central component of ecosystem management.
- Identify and quantify resilience-based indicators to address threshold risks and restoration options.
- Adopt social-ecological systems to address all major drivers of ecosystem change.
- Resilience-based monitoring requires compromise by researchers and managers.