



ELSEVIER

Journal of Arid Environments 65 (2006) 193–195

www.elsevier.com/locate/jnlabr/yjare

Journal of
Arid
Environments

Editorial

Introduction to special issue—Landscape linkages and cross-scale interactions in arid and semi-arid ecosystems

The conversion of grasslands to shrublands in arid and semi-arid ecosystems is a serious global problem. Although a great deal of research has been conducted on these conversions, we lack a complete understanding of the processes underlying the transitions. More importantly, our ability to predict when and where desertification will occur and our ability to manage landscapes to prevent degradation and restore degraded landscapes is limited. Research being conducted at the Jornada Experimental Range (JER) is addressing these problems in a new, synthetic way. The JER, established in 1912, is a USDA Agricultural Research Service field station located in the northern Chihuahuan Desert (southern New Mexico, USA; 32°37'N, 106°44'W). The original mission of this federal research facility was to improve forage and livestock production on arid and semi-arid rangelands. As the science of rangeland management evolved and the scope of study expanded (e.g., hydrology, ecology, wildlife, etc.), the research mission of the JER evolved as well; however, livestock management has continued to be a central theme of the research program. Since 1981, scientists affiliated with the Jornada Basin Long-Term Ecological Research site (funded by the National Science Foundation) in collaboration with scientists from the JER and New Mexico State University generated a number of new ideas and concepts regarding the processes governing desertification that changed our thinking about how these systems operate. Our focus now emphasizes cross-scale spatial and temporal heterogeneity in vegetation patterns and dynamics that have been difficult to explain using traditional approaches (Peters and Havstad, 2006; and references within).

The following series of papers summarizes information presented in a special session entitled 'Landscape Linkages and Cross-Scale Interactions in the Chihuahuan Desert' at the 6th Symposium on the Natural Resources of the Chihuahuan Desert (organized by the Chihuahuan Desert Research Institute; October, 2004; Alpine, TX, USA) by scientists working at the JER. This series begins with a conceptual framework to increase our understanding of how landscapes change over time, followed by seven papers that examine ideas and research supporting this

framework, and concludes with a science-based management framework. Much of the experimentation and observations reported in the following papers occurred on or near the JER; however, the implications and applications extend beyond the Chihuahuan Desert to arid and semi-arid ecosystems worldwide.

The realization that our current knowledge often cannot explain the existing variability among land units led to the development of a conceptual model (Peters and Havstad, 2006) that considers nonlinear dynamics and connections among land units across scales. These authors propose a conceptual framework that identifies five hierarchies of scale (plant/interplant, patch, patch mosaic, landscape unit, and geomorphic unit) and five key elements (historic legacy, dynamic template, resource redistribution, feedbacks, and transport) that interact across scales to explain the variable and nonlinear spatial and temporal responses. The historical legacy of a land unit can have profound influences on current vegetation patterns. Fredrickson et al. (2006) suggest that mesquite invasion may be, in part, a response to changing cultures and lower usage of mesquite beans as a food source; thus, preexisting conditions for desertification may have been established centuries ago. Soils, soil parent material, and topography form a soil-geomorphic template that interacts with biotic and climatic factors across scales to influence the conversion of grasslands to shrublands (Monger and Bestelmeyer, 2006). Plant-associated fungal communities associated with desert plants appear to modify plant morphology and survival (Lucero et al., 2006). While this study was conducted at the finest scale (plant/interplant and smaller), the findings likely have implications for vegetation dynamics that propagate across landscapes.

Variable vegetation cover renders landscapes more susceptible to wind erosion than suggested by average cover (Okin et al., 2006; and references within). Saltation and suspension of sand/dust operate at different scales to connect landscapes via transport/feedback processes (e.g., horizontal particle flux increases with fetch) and nonlinear thresholds (e.g., minimum gap size thresholds for erosion). Precipitation cycles (pulse/interpulse) vary at several temporal scales from within season to over centuries, and the variability in water availability at different scales interacts to influence vegetation patterns via several of the key processes and factors identified above (Snyder and Tartowski, 2006). Islands of hydrologically enhanced productivity accumulate water as a result of landscape heterogeneity and subsequent runoff/runon (Rango et al., 2006). These islands exist at scales ranging from the area under a single plant to large drainage basins and have critical implications for remediation (i.e., capitalizing on natural circumstances and/or creating islands via dikes, water spreaders, etc.).

Bestelmeyer et al. (2006) outline a new approach for classifying vegetation dynamics that consists of six transition types (stable, oscillation, loss/reestablishment, loss/replacement, patch reorganization, and cascading transition). Distinctions among these classes are a function of the dominant processes and their scales of action described earlier. Herrick et al. (2006) describe a science-based land management system that incorporates existing knowledge with new information as it is generated. Their approach integrates state and transition models with ecological site descriptions and a suite of assessment and soil- and vegetation-based monitoring

indicators to produce a flexible rangeland management framework. This approach also identifies locations in greatest need of information about the processes and factors that connect landscape units across scales.

The following manuscripts that arose from these presentations generated a number of stimulating and exciting ideas about how landscape units are linked and how this information can be used for rangeland restoration. We believe that this cross-scale landscape ecology approach will further our understanding of critical processes occurring in arid regions globally and will provide insight to help us to identify mechanisms to address the pressing issue of desertification. We expect this collection of papers will provide a springboard for novel collaborative research among scientists working in arid and semi-arid systems.

References

- Bestelmeyer, B.T., Trujillo, D.A., Tugel, A.J., Havstad, K.M., 2006. A multi-scale classification of vegetation dynamics in arid lands: what is the right scale for models, monitoring, and restoration? *Journal of Arid Environments* 65, 296–318.
- Fredrickson, E.L., Estell, R.E., Laliberte, A., Anderson, D.M., 2006. Mesquite recruitment in the Chihuahuan Desert: historic and prehistoric patterns with long term impacts. *Journal of Arid Environments* 65, 285–295.
- Herrick, J.E., Bestelmeyer, B.T., Archer, S., Tugel, A.J., Brown, J.R., 2006. An integrated framework for science-based arid land management. *Journal of Arid Environments* 65, 319–335.
- Lucero, M.E., Barrow, J.R., Osuna, P., Reyes, I., 2006. Plant–fungal interactions in arid and semiarid ecosystems: large scale impacts from microscale processes. *Journal of Arid Environments* 65, 276–284.
- Monger, H.C., Bestelmeyer, B.T., 2006. The soil-geomorphic templates and biotic change in arid and semiarid ecosystems. *Journal of Arid Environments* 65, 207–218.
- Okin, G.S., Gillette, D.A., Herrick, J.E., 2006. Multi-scale controls on and consequences of aeolian processes in landscape change in arid and semiarid environments. *Journal of Arid Environments* 65, 253–275.
- Peters, D.P.C., Havstad, K.M., 2006. Nonlinear dynamics in arid and semiarid systems: interactions among drivers and processes across scales. *Journal of Arid Environments* 65, 196–206.
- Rango, A., Tartowski, S.L., Laliberte, A., Wainwright, J., Parsons, A., 2006. Islands of hydrologically enhanced biotic productivity in natural and managed arid ecosystems. *Journal of Arid Environments* 65, 235–252.
- Snyder, K.A., Tartowski, S.L., 2006. Multi-scale temporal variation in water availability: implications for vegetation dynamics in arid and semiarid ecosystems. *Journal of Arid Environments* 65, 219–234.

R.E. Estell, E.L. Fredrickson, D.P.C. Peters
USDA ARS, Jornada Experimental Range, Las Cruces, NM 88003-0003, USA
E-mail address: restell@nmsu.edu (R.E. Estell)