

SPECIAL SECTION

Introduction to the Special Section on Alternative Futures for Great Basin Ecosystems

Erica Fleishman,^{1,2} Jeanne C. Chambers,³ and Michael J. Wisdom⁴

Abstract

Natural and anthropogenic processes are causing extensive and rapid ecological, social, and economic changes in arid and semiarid ecosystems worldwide. Nowhere are these changes more evident than in the Great Basin of the western United States, a region of 400,000 km² that largely is managed by federal agencies. Major drivers of ecosystems and human demographics of the Great Basin include human population growth, grazing by domestic livestock, extraction of minerals, development and production of energy, changes in fire and other disturbance regimes, and invasion of non-native annual plants. Exploration of alternative futures may increase the ability of management and policy to maximize the system's resistance and resilience

to changes in climate, disturbance regimes, and anthropogenic perturbations. This special section examines the issues facing the Great Basin and then provides examples of approaches to predicting changes in land cover and avifaunal distributions under different management scenarios. Future sustainability of the Great Basin's natural and human systems requires strong, collaborative partnerships among research and management organizations that are capable of obtaining public support and financial resources and developing effective policies and institutional mechanisms.

Key words: climate change, ecosystem management, Great Basin, invasive species, land cover change, land use change.

Natural and anthropogenic processes are causing extensive and rapid ecological, social, and economic changes in arid and semiarid ecosystems worldwide. Nowhere are these changes more evident than in the Great Basin of the western United States. This expansive region, 72% of which is under federal management, encompasses approximately 400,000 km² within Nevada, Utah, Idaho, Oregon, and California. Native land cover types include salt desert (*Atriplex* spp.), sagebrush (*Artemisia* spp.), and pinyon (*Pinus monophylla*) and juniper (*Juniperus osteosperma*, *J. occidentalis*) woodlands. Anthropogenic causes of change are both direct and indirect. The region's human population, sparse until the last several decades, now is growing at one of the highest rates in the United States. Between 1990 and 2000, human populations in Nevada and Utah increased by 66 and 30%, respectively (U.S. Census Bureau 2007). Past and ongoing land uses like grazing by domestic livestock, extraction of minerals, and development and production of energy further influence the ecosystems and

human demographics of the Great Basin (Wisdom et al. 2005). Fire regimes have been altered and the frequency, severity, and spatial extent of fires are increasing dramatically (Keane et al. 2002). For example, a single wildfire in 2007 burned more than 2,600 km² in Nevada and Idaho. Rapid invasion of non-native annual grasses like cheatgrass (*Bromus tectorum*) in many parts of the region has resulted in an annual grass–fire cycle and conversion of native shrublands and woodlands to homogenous annual grasslands with little ecological or economic value (Whisenant 1990; Brooks & Pyke 2001). Climate change already is affecting water availability, disturbance regimes, and species distributions across the region (Stewart et al. 2004; Deacon et al. 2007).

Ecological, social, and economic shifts across the Great Basin present substantial management challenges, especially given the region's aridity and concentration of endemic and threatened species. Exploration of alternative futures may increase the ability of management and policy to maximize the system's resistance and resilience to changes in climate, disturbance regimes, and anthropogenic perturbations. In this special section, we first examine the issues facing the Great Basin (Chambers & Wisdom 2009) and then provide examples of approaches to predicting changes in land cover (Bradley & Wilcove 2009) and faunal distributions (Dickson et al. 2009; Fleishman & Dobkin 2009) under different management scenarios. Application of remote sensing, geospatial analyses, and advanced spatial modeling can provide guidance on where restoration efforts are most likely to be effective,

¹ National Center for Ecological Analysis and Synthesis, 735 State Street, Suite 300, Santa Barbara, CA 93101, U.S.A.

² Address correspondence to E. Fleishman, email fleishman@nceas.ucsb.edu

³ USDA Forest Service, Rocky Mountain Research Station, 920 Valley Road, Reno, NV 89512, U.S.A.

⁴ USDA Forest Service, Pacific Northwest Research Station, Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850, U.S.A.

and which interventions may be most efficient in different situations (Wisdom & Chambers 2009). The issues and tools we highlight are germane not only to the Great Basin but also to management of arid and semiarid regions elsewhere in North America and worldwide.

The special section opens with an overview of priority research and management issues for the Great Basin (Chambers & Wisdom 2009). Cumulative effects of changes in the configuration, species composition, and connectivity of sagebrush ecosystems are resulting in vegetation type conversions, decreases in watershed functioning, losses of native species, and diminished economic potential. Minimizing undesirable effects on natural and human systems requires both societal consensus on priority issues and innovative research and management approaches that cross administrative boundaries and address large spatial scales and long-time periods. Integration of large-scale monitoring, scientific experimentation, and rigorous predictive modeling is essential to elucidate the rates and magnitude of change, locations affected, and potential ecological, social, and economic consequences. Future sustainability of the Great Basin's natural and human systems requires strong, collaborative partnerships among research and management organizations that are capable of obtaining public support and financial resources and developing effective policies and institutional mechanisms.

Climate change likely will reduce the local probability of persistence of many native species. Climate change also may both decrease habitat quality for some non-native invasive species and increase the probability of invasion by different non-native species. Thus, traditional restoration—efforts to reintroduce native species that have been extirpated—may have limited utility. An alternative is to explore transformative restoration—restoration with novel plant genotypes or species that could become locally viable as climate changes. Bradley and Wilcove (2009) used bioclimatic envelope modeling to identify locations across the Great Basin that are unlikely to support cheatgrass by 2100. They then selected one site from this set and assessed how its local climate is projected to change. As Bradley and Wilcove (2009) explain, candidate species for introduction or reintroduction can be evaluated on the basis of ensemble envelope models, experimental treatments, and models of local topography and soils.

The probability that many birds and other sagebrush-associated vertebrates will be listed as threatened or endangered under federal and state laws is increasing across the Great Basin (Rowland et al. 2005). Two papers in the special section suggest that regardless of vegetational association, conservation of breeding birds is more likely to succeed if both the native canopy and understory are maintained or restored. Fleishman and Dobkin (2009) examined current and potential future elevational distributions of eight species of passerine birds associated with pinyon and juniper woodlands. Although woodlands are expanding in distribution at intermediate to upper elevations that historically were dominated by native shrubs, breeding habitat for species dependent on mature trees may not be available in these expansion woodlands for several decades. Further, increased tree densities may have negative

effects on bird species that depend on native shrubs displaced by these woodlands.

Dickson et al. (2009) examined the association between occupancy, colonization, and local extinction of three obligate riparian species of songbirds and environmental and multiple habitat variables. Different components of riparian vegetation were good predictors of occupancy, colonization, and local extinction. Responses to biotic and abiotic variables within guilds of birds are sufficiently diverse, and responses of individual species sufficiently heterogeneous, that one management strategy is unlikely to meet the needs of all species in the group. Nevertheless, maintenance of a complex vegetation structure, again including native understory shrubs, may help maintain viable populations of multiple species.

Landscape management based on the concepts of resistance and resilience may increase persistence of native shrublands in arid and semiarid regions like the Great Basin. Wisdom and Chambers (2009) demonstrated a five-step application of these concepts to maintain habitat for Greater Sage-grouse (*Centrocercus urophasianus*) or other shrubland-associated species. Within a given spatial area, the probability of woodland expansion or invasion by cheatgrass is affected by the percentage of area dominated by sagebrush and by elevation and associated gradients in degree days and water availability. Knowledge of these effects allows for the development of active and passive management prescriptions that are spatially and temporally extensive but implemented at fine resolution. The landscape approaches for shrubland management outlined by Wisdom and Chambers (2009) should be applicable to other arid and semiarid ecosystems in which human land uses are causing undesired changes in vegetation composition and structure.

Maintenance and restoration of the Great Basin's native species and ecosystems is daunting. Current trends suggest that extensive losses of native plant and animal communities will continue unless new, holistic landscape strategies are effectively designed and implemented. Lack of ecological knowledge and severely limited financial and human resources are major obstacles to such management changes. By focusing on alternative futures with new knowledge, technologies, and approaches, we hope to increase the ability of management and policy to maximize the system's potential to adapt to environmental change.

LITERATURE CITED

- Bradley, B. A., and D. S. Wilcove. 2009. When invasive plants disappear: transformative restoration possibilities in the western United States resulting from climate change. *Restoration Ecology* 17:00.
- Brooks, M. L., and D. A. Pyke. 2001. Invasive plants and fire in the deserts of North America. Pages 1–14 in K. E. M. Galley and T. P. Wilson, editors. *Proceedings of the invasive species workshop: the role of fire in the control and spread of invasive species*. Fire Conference 2000: the first national congress on fire ecology, prevention, and management. Miscellaneous Publication No. 11, Tall Timbers Research Station, Tallahassee, Florida.
- Chambers, J. C., and M. J. Wisdom. 2009. Priority research and management issues for the imperiled Great Basin of the western United States. *Restoration Ecology* 17:00.

- Deacon, J. E., A. E. Williams, C. Deacon Williams, and J. E. Williams. 2007. Fueling population growth in Las Vegas: how large-scale groundwater withdrawal could burn regional biodiversity. *BioScience* **57**:688–698.
- Dickson, B. G., E. Fleishman, D. S. Dobkin, and S. R. Hurteau. 2009. Relationship between avifaunal occupancy, occurrence, and riparian vegetation in the central Great Basin (Nevada, U.S.A.). *Restoration Ecology* **17**:00.
- Fleishman, E., and D. S. Dobkin. 2009. Elevational distributions of pinyon–juniper associated birds in the central Great Basin as a function of current and potential future distributions of land cover. *Restoration Ecology* **17**:00.
- Keane, R. E., K. C. Ryan, T. T. Veblen, C. D. Allen, J. Logan, and B. Hawkes. 2002. Cascading effects of fire exclusion in Rocky Mountain ecosystems: a literature review. RMRS-GTR-91. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.
- Rowland, M. M., L. H. Suring, M. J. Wisdom, C. W. Meinke, and L. Schueck. 2005. Habitats for vertebrate species of concern. Pages 163–204 in M. J. Wisdom, M. M. Rowland, and L. H. Suring, editors. *Habitat threats in the sagebrush ecosystem: methods of regional assessment and applications in the Great Basin*. Alliance Communication Group, Lawrence, Kansas.
- Stewart, I. T., D. R. Cayan, and M. D. Dettinger. 2004. Changes in snowmelt timing in western North America under a ‘business as usual’ climate change scenario. *Climate Change* **62**:217–232.
- U.S. Census Bureau. 2007. Census 2000, summary file 3. <http://www.census.gov/main/www/cen2000.html> [accessed on 17 July 2007].
- Whisenant, S. G. 1990. Changing fire frequencies on Idaho’s Snake River Plains: ecological and management implications. Pages 4–10 in E. D. McArthur, E. M. Romney, S. D. Smith, and P. T. Tueller, compilers. *Proceedings of the symposium on cheatgrass invasion, shrub die-off and other aspects of shrub biology and management*. GTR INT-276, USDA Forest Service, Intermountain Research Station, Ogden, Utah.
- Wisdom, M. J., and J. C. Chambers. 2009. A landscape approach for ecologically based management of Great Basin shrublands. *Restoration Ecology* **17**:00.
- Wisdom, M. J., M. M. Rowland, and L. H. Suring. 2005. *Habitat threats in the sagebrush ecosystem: methods of regional assessment and applications in the Great Basin*. Alliance Communication Group, Lawrence, Kansas.