Great Basin Rare and Vulnerable Species

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Many native species of plants and animals in the Great Basin have a restricted geographic distribution that reflects the region's biogeographic history. Conservation of these species has become increasingly challenging in the face of changing environmental conditions and land management practices. This paper provides an overview of major stressors contributing to species' rarity and vulnerability and discusses associated management challenges and research needs. For more detailed information, please see the list of references and recommended links.

As the climate of the Great Basin became warmer and drier after the Pleistocene, pronounced land-cover differences emerged between mountain ranges and the intervening valleys, with woodlands and riparian areas restricted primarily to higher elevations (Brown 1978, Wells 1983, Grayson 1993). There is substantial evidence that individual mountain ranges currently function as permeable but distinct islands of habitat for many taxa, such as terrestrial invertebrates, birds, and some mammals, for which resources in the arid valleys are scarce (McDonald and Brown 1992; Murphy and Weiss 1992; Skaggs and Boecklen 1996; Lawlor 1998). The isolation of valley aquatic systems (Sada and Vinyard 2002) and unconsolidated sand dunes (Pavlik 1989, Britten and Rust 1996) similarly was exacerbated by long-term climate change. The specialized resource requirements and low mobility of many species, native or endemic to the Great Basin, limits their ability to adapt rapidly to natural and anthropogenic environmental change. Growth of human populations and supporting infrastructure in the Great Basin places additional demands on limited resources for these species, especially water, and creates artificial barriers to dispersal.

Contemporary changes in climate, fire regimes, and land-use patterns, and invasion of non-native species, pose threats to the viability of many species in the Great Basin that historically were widely distributed and abundant. As formerly-extensive stands of sagebrush (*Artemesia tridentata* ssp.) have become smaller and fragmented, numerous associated plants and animals have declined. Scientists, practitioners, and some local communities are collaborating to develop conservation strategies that may benefit multiple sagebrush-dependent species (Knick and others 2003, Wisdom and others 2005). These efforts may obviate the need to confer statutory protection on species such as the Greater Sage-grouse (*Centrocercus urophasianus*) (Rowland and others 2006), pygmy rabbit (*Brachylagus idahoensis*) (Rachlow and Svancara 2006), and the Great Basin population of the Columbia spotted frog (*Rana luteiventris*).

Key Issues

Interactions among major stressors, such as human population growth, increased demand for water diversion, and climate change, affect the probability that native and endemic species will persist in the Great Basin.

Climate change—Native species in the Great Basin are adapted to extreme and variable weather patterns on daily to decadal or longer time scales. The magnitude and speed of climatic changes anticipated by 2100 may exceed the plasticity of many species with respect to their phenology and patterns of resource use. Differences in plant phenology between low and high elevations may affect invertebrates, birds, and species with elevational migrations, as well as behavior of species that hibernate during the winter (Inouye and others 2000). Buildings and infrastructure further impede movement of native species (Hansen and others 2005, Vesk and Mac Nally 2006). Many native animal species tend to avoid dispersing through urban and agricultural areas in favor of remnants or corridors of native vegetation (Atwood and others 2004). It is difficult to predict how plants and animals that currently inhabit the Great Basin will interact with species that may colonize the region in response to climate change (Hooper and others 2005).

Human settlement—Urbanization and the expanding wildland-urban interface are changing the current mosaic of land cover and land use in the western United States

(Hansen and others 2005). Environmental changes include shifts in the distribution and composition of species, altered patterns of land cover, modified disturbance regimes, and perturbations to biogeochemical cycles (Dale and others 2005). Houses and roads can have ecologically deleterious effects many hundreds of meters from their specific location (Forman and Alexander 1998, Forman 2000). Roads, ornamental vegetation, domestic animals, and recreational use can serve as conduits for non-native invasive species (Bock and others 1999, Odell and Knight 2001). Development of urban areas and infrastructure has been hypothesized to have greater influence on biotic diversity and ecological processes than traditional extractive uses (Hansen and others 2005).

The probability of fire increases at the wildland–urban interface as people, homes, and other urban and suburban structures expand into areas of natural vegetation (Radeloff and others 2005, Vince and others 2005). Changes in the composition and structural complexity of the vegetation mosaic affect the distribution of animal species that may rely on different successional stages during their life cycle (Richards and others 1999, Saab and Powell 2005).

Water diversion—The availability of water in the Great Basin limits human domestic activities, agriculture, extractive uses such as mining, and the distribution of native species (Shepard 1993). The viability of fish species in terminal wetlands is compromised by increasing levels of dissolved solids as upstream water is diverted. Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) are unlikely to persist in Walker Lake over the long term (Dickerson and Vinyard 1999) and viability of cui-ui (*Chasmistes cujus*) in Pyramid Lake depends heavily on water supplementation (Emlen and others 1993). Climate change and population growth are leading to diversion of water from rural to urban areas and to groundwater withdrawals – the ecological effects of which are largely unknown. Aquatic species that inhabit groundwater-fed springs may be at greatest risk (Minckley and Deacon 1968, Sada and Vinyard 2002).

Status and trend of riparian systems—Even when water is not diverted, the condition of streams, stream beds, and riparian vegetation affects fish and aquatic macroinvertebrates, breeding birds, and other species of animals and plants (Eby and others 2003, Fleishman and others 2006). Nest success of songbirds tends to be higher in riparian areas without major anthropogenic impacts (Heltzel and Earnst 2006). Many permanent and ephemeral streams currently are deeply incised. Mechanisms of incision and the relative magnitude of their influence vary among locations and operate across time scales from years to millennia. Influences on incision are generally understood to be a combination of geomorphic and hydrologic processes, climate, and human land use (Chambers and Miller 2004).

Non-native invasive species—Extensive areas of native shrublands and grasslands in the Great Basin are being converted to virtual monocultures of invasive non-native species. Among the most invasive non-natives are cheatgrass (*Bromus tectorum*) and salt-cedar (*Tamarix* spp.). Cheatgrass tends to be most prevalent in basins, although it increasingly is colonizing higher elevations (Bradley and Mustard 2006). Salt-cedar is spreading rapidly along riparian corridors (Cleverly and others 1997, Sher and others 2000). Some native species of birds, including the endangered southwestern willow flycatcher (*Empidonax traillii extimus*), can nest in salt-cedar. However, salt-cedar cannot serve as an ecological replacement for native trees and shrubs.

Cheatgrass-dominated systems are typically less complex than systems dominated by native plants. As a result, invasion of cheatgrass can affect the viability of birds and other species that are strongly influenced by vegetation structure and composition (Wiens and Rotenberry 1981, Rotenberry 1985). Because cheatgrass senesces earlier than many native perennial grasses, its value as a food source for native herbivores is low. Cheatgrass also is highly flammable, increasing the frequency and magnitude of fire and creating ecological conditions that can be exploited by other invasive non-native grasses and forbs.

Management Challenges and Research Needs

Diversity of resource needs and life history strategies—Species of conservation concern in the Great Basin range from endemic dune beetles, springsnails, and forbs to resident large mammals and neotropical migrant birds. There is considerable variation in the spatial and temporal distribution of habitat for different species and taxonomic groups. Even within the same land-cover type, management actions intended to benefit one species inadvertently may harm other species of concern. Improved understanding of the natural and anthropogenic drivers of species distributions, and whether those drivers generalize within apparent functional groups, may help identify tradeoffs among alternative management approaches.

Restoration and reconstruction—Long-term viability of many rare and vulnerable species in the Great Basin depends on whether their habitat can be restored or reconstructed in portions of their historic range. Restoration refers to reestablishment of vegetation or ecological function at small scales. Reconstruction refers to extensive land-cover change to arrest declines in biotic diversity and ecological function. Either approach may consider both site-level factors and landscape-level allocation of effort. Little information exists on presettlement distributions of land cover and species across the Great Basin. When presettlement conditions are known, ecological or socioeconomic constraints may preclude a return to that state. Methods are needed to classify land-cover types and landscape features according to their potential for restoration or reconstruction. In particular, little is known about the effects of alternative water reallocation schemes on the status and restoration potential of springs, wet meadows, and riparian areas.

Alternative futures—Major land cover and land use changes are affecting ecological status and reconstruction potential across the Great Basin. Research is needed to examine interdependence among multiple land uses, vegetation structure, climate change trajectories, and management actions. An enhanced understanding of species responses to topography and vegetation may facilitate prediction of the impact of alternative land-cover scenarios on the distribution of rare and vulnerable taxa.

Fire and fire surrogates—Prescribed fire and other types of fuels treatments have been proposed as tools to limit expansion of pinyon-juniper woodlands into sagebrush systems, restore native understory plants, and minimize the risk of fire at the wildland–urban interface. Little is known about the effects of ecological starting conditions on the outcome of small-scale and large-scale fire and fuels treatments. Further, relatively little is known about the response of rare and vulnerable species to implementation of prescribed fire and fire surrogates.

Surrogate measurements—There is a common assumption within the research and management communities that monitoring a limited number of species can serve as a surrogate measure of the distribution and response to environmental change of many species. Rarely has this hypothesis been subjected to rigorous conceptual and empirical evaluation. In the event that scientifically reliable, cost-effective surrogates can be identified for a given purpose, location, and time, additional research is needed to understand whether those relationships are spatially and temporally transferable.

Existing Programs and Resources

University of Nevada, Reno. Great Basin Ecology Laboratory, Great Basin Ecosystem Management Project. http://www.ag.unr.edu/gbem/aboutGbem.htm [2007, July 17]

Sagebrush Steppe Treatment Evaluation Project. 16 Apr. 2007. http://www.sagestep.org / [2007, July 17]

Greater Sage-Grouse Range-Wide Issues Forum. http://sagegrouse.ecr.gov/ [2007, July 17]

Utah State University, Sage-grouse Restoration Project. http://sgrp.usu.edu/htm/ [2007, July 17]

USGS Snake River Field Station, Great Basin Information Project. http://greatbasin.nbii.gov [2007, July 17]

USGS Snake River Field Station, Sagebrush and Grassland Ecosystem Map Assessment Project (SAGEMAP). http://sagemap.wr.usgs.gov/ [2007, July 17]

Nevada Natural Heritage Program. http://heritage.nv.gov/index.htm [2007, July 17]

Wilburforce Foundation, Analysis and conservation prioritization of connectivity in Nevada.

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Northern Arizona University, Center for Environmental Sciences and Education, Forest Ecosystem Restoration Analysis (ForestERA). http://www.forestera.nau.edu/ [2007, July 17]

Strategic Plans

Nevada Partners in Flight. Bird Conservation Plan. http://www.blm.gov/wildlife/plan/pl-nv-10.pdf [2007, July 17]

Nevada Natural Heritage Program. Scorecard of Highest-Priority Conservation Sites for Nevada http://heritage.nv.gov/scorecrd.htm [2007, July 17]

USDI Bureau of Land Management. National Strategy for Conserving Sage-Grouse on Public Lands. http://www.blm.gov/nhp/spotlight/sage_grouse/ [2007, July 17]

References

Atwood, T. C.; Weeks, H. P.; Gehring, T. M. 2004. Spatial ecology of coyotes along a suburban-to-rural gradient. Journal of Wildlife Management. 68:1000–1009.

Bock, C. E.; Bock, J. E.; Bennett, B. C. 1999. Songbird abundance in grasslands at a suburban interface on the Colorado High Plains. Studies in Avian Biology. 19: 131–136.

Bradley, B. A.; Mustard, J. F. 2006. Characterizing the landscape dynamics of an invasive plant and risk of invasion using remote sensing. Ecological Applications. 16: 1132–1147.

Britten, H. B.; Rust, R. W. 1996. Population structure of a sand dune obligate beetle, *Eusattus muricatus*, and its implications for dune management. Conservation Biology. 10: 647–652.

Brown, J. 1978. The theory of insular biogeography and the distribution of boreal mammals and birds. Great Basin Naturalist Memoirs. 2: 209–228.

Chambers, J. C.; Miller, J. R. eds. 2004. Great Basin riparian ecosystems – ecology, management, and restoration. Island Press, Washington, D.C.

Cleverly, J. R.; Smith, S. D.; Sala, A.; Devitt, D. A. 1997. Invasive capacity of *Tamarix ramosissima* in a Mojave Desert floodplain: the role of drought. Oecologia. 111: 12–18.

Dale, V.; Archer. S.; Chang, M.; Ojima, D. 2005. Ecological impacts and mitigation strategies for rural land management. Ecological Applications. 15: 1879–1892.

Dickerson, B. R.; Vinyard, G. L. 1999. Effects of high levels of total dissolved solids in Walker Lake, Nevada, on survival and growth of Lahontan cutthroat trout. Transactions of the American Fisheries Society. 128: 507–515.

Eby, L. A.; Fagan, W. F.; Minckley, W. L. 2003. Variability and dynamics of a desert stream community. Ecological Applications. 13: 1566–1579.

Emlen, J. M.; Strekal, T. A.; Buchanan, C. C. 1993. Probabalistic projections for recovery of the endangered cui-ui. North American Journal of Fisheries Management. 13: 467–474.

Fleishman, E.; Murphy, D. D.; Sada, D. W. 2006. Effects of environmental heterogeneity and disturbance on the native and non-native flora of desert springs. Biological Invasions. 8: 1091–1101.

Forman, R. T. T. 2000. Estimate of the area affected ecologically by the road system in the United States. Conservation Biology. 14: 31–35.

Forman, R. T. T.; Alexande, L. E. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics. 29:207–231.

Grayson, D. K. 1993. The desert's past: a natural prehistory of the Great Basin. Smithsonian Institution Press, Washington, D.C.

Hansen, A. J.; Knight,R. L.; Marzluff, J. M.; Powell, S.; Brown, K.; Gude, P. H.; Jones, K. 2005. Effects of exurban development on biodiversity: patterns, mechanisms, and research needs. Ecological Applications. 15: 1893–1905.

Heltzel, J. M.; Earnst, S. L. 2006. Factors influencing nest success of songbirds in aspen and willow riparian areas in the Great Basin. The Condor. 108: 842–855.

Hooper, D. U.; Chapin, F. S., III; Ewel, J. J.; Hector, A.; Inchausti, P.; Lavorel, S.; Lawton, J. H.; Lodge, D. M.; Loreau, M.; Naeem, S.; Schmid, B.; Setala, H.; Symstad, A. J.; Vandermeer, J.; Wardle, D. A. 2005. Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. Ecological Monographs. 75: 3–35.

Inouye, D. W.; Barr, B.; Armitage, K. B.; Inouye, B. D. 2000. Climate change is affecting altitudinal migrants and hibernating species. Proceedings of the National Academy of Sciences of the United States of America. 97: 1630–1633.

Knick, S. T.; Dobkin, D. S.; Rotenberry, J. S.; Schroeder, M. A.; Vander Haegen, W.M.; Van Riper, C. III. 2003. Teetering on the edge or too late? Conservation and research issues for the avifauna of sagebrush habitats. The Condor. 105: 611–634.

Lawlor, T. E. 1998. Biogeography of Great Basin mammals: paradigm lost? Journal of Mammalogy. 79: 1111–1130.

McDonald, K. A.; Brown, J. H. 1992. Using montane mammals to model extinctions due to climate change. Conservation Biology. 6: 409–415.

Minckley, W. L.; Deacon, J. E. 1968. Southwestern fishes and the enigma of 'endangered species.' Science. 159: 1424–1432.

Murphy, D. D.; Weiss, S. B. 1992. Effects of climate change on biological diversity in western North America: species losses and mechanisms. In: R.L. Peters and Lovejoy, T. E., editors. Global warming and biological diversity. Yale University Press, New Haven, Connecticut: 355-368.

Odell, E. A.; Knight, R. L. 2001. Songbird and medium sized mammal communities associated with exurban development in Pitkin County Colorado. Conservation Biology. 15: 1–8.

Pavlik, B. M. 1989. Phytogeography of sand dunes in the Great Basin and Mojave Deserts. Journal of Biogeography. 16: 227–238.

Rachlow, J. L.; Svancara, L. K. 2006. Prioritizing habitat for surveys of an uncommon mammal: a modeling approach applied to pygmy rabbits. Journal of Mammalogy. 87: 827–833.

Radeloff, V. C.; Hammer, R. B.; Stewart, S. I.; Fried, J. S.; Holcomb, S. S.; McKeefry, J. F. 2005. The wildland–urban interface in the United States. Ecological Applications. 15: 799–805.

Richards, S. A.; Possingham, H. P.; Tizard, J. 1999. Optimal fire management for maintaining community diversity. Ecological Applications. 9:880–892.

Rotenberry, J. T. 1985. The role of habitat in avian community composition: physiognomy or floristics? Oecologia. 67: 213–217.

Rowland, M. M.; Wisdom, M. J.; Suring, L. H.; Meinke, C. W. 2006. Greater Sage-grouse as an umbrella species for sagebrush-associated vertebrates. Biological Conservation. 129: 323–335.

Saab, V. A.; Powell, D. W., eds. 2005. Fire and avian ecology in North America. Studies in Avian Biology No. 30.

Sada, D. W.; Vinyard, G. L. 2002. Anthropogenic changes in historical biogeography of Great Basin aquatic biota. In: Hershler, R.; Madsen, D. B.; Currey, D. editors. Great Basin aquatic systems history. Smithsonian Contributions to the Earth Sciences No. 33: 277-293.

Shepard, W. D. 1993. Desert springs—both rare and endangered. Aquatic Conservation: Marine and Freshwater Ecosystems. 3: 351–359.

Sher, A. A.; Marshall, D. L.; Gilbert, S.A. 2000. Competition between native *Populus deltoides* and invasive *Tamarix ramosissima* and the implications for reestablishing flooding disturbance. Conservation Biology. 14: 1744–1754.

Skaggs, R. W.; Boecklen, W. J. 1996. Extinctions of montane mammals reconsidered: putting a global-warming scenario on ice. Biodiversity and Conservation. 5: 759–778.

Vesk, P.; Mac Nally, R. 2006. Changes in vegetation structure and distribution in rural landscapes: implications for biodiversity and ecosystem processes. Agriculture, Ecosystems and Environment. 112: 356–366.

Vince, S. W.; Duryea, M. L.; Macie, E. A.; Hermansen, L. A. 2005. Forests at the wildland–urban interface: conservation and management. CRC Press, Boca Raton, Florida.

Wells, P. V. 1983. Paleobiogeography of montane islands in the Great Basin since the last glaciopluvial. Ecological Monographs. 53: 341–382.

Wiens, J. A.; Rotenberry, J. T. 1981. Habitat associations and community structure of birds in shrubsteppe environments. Ecological Monographs. 51: 21–41.

Wisdom, M. J.; Rowland, M. M.; Suring, L.H. 2005. Habitat threats in the sagebrush ecosystem: methods of regional assessment and applications in the Great Basin. Alliance Communications Group, Lawrence, Kansas.