Collaborative Management and Research in the Great Basin — Examining the Issues and Developing a Framework for Action

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Introduction

The Great Basin is considered to be one of the most endangered ecoregions in the United States (Noss and others 1995, Wisdom and others 2005). The population is expanding at the highest rate in the nation, and major sociological and ecological changes are occurring across the region. These changes can be attributed to numerous interacting factors including urbanization, changing land use, climate change, limited water resources, altered fire regimes, invasive species, insects, and disease. The consequences have been large-scale vegetation type conversions, loss of watershed function, and degradation of stream, riparian, and aquatic ecosystems. Biodiversity has decreased, and a high number of species are at risk of extinction or extirpation. Ecosystem services such as water resources for agriculture and fish, habitat for aquatic and terrestrial plants and animals, forage and browse for native herbivores and livestock, and recreational opportunities are rapidly diminishing. These losses have had adverse social and economic impacts on urban, suburban, and rural areas. Managers across the Great Basin are increasingly challenged to maintain or improve the ecological condition of these systems and the services that they provide while meeting the needs of a growing number of user groups with diverse and often opposing interests.

Sustaining the ecosystems, resources, and human populations of the Great Basin will require strong collaborative partnerships among the major research and management organizations in the region. The first steps toward effective collaboration, as addressed in this report, are to clearly identify the research and management issues and develop the mechanisms for increasing collaboration among the many research and management entities in the Great Basin. This General Technical Report (GTR) contains information resulting from a workshop on Collaborative Watershed Management and Research that was held in Reno, Nevada, November 28 through 30, 2006.

The vision for the workshop and the efforts that have followed is multi-disciplinary, multi-organizational teams working together to develop solutions to critical ecological and socio-economic issues in the Great Basin using a collaborative management and research framework. Many excellent Great Basin collaborative research and management projects already exist. However, there are relatively few that are regional in scope and information sharing among the existing collaborations has been limited. A mechanism is needed for identifying and prioritizing regional issues, expanding upon existing efforts, facilitating new teams to address emerging issues, and sharing information among existing and new collaborative teams.

Although good progress has been made in understanding Great Basin ecosystems and in developing effective management techniques, many Great Basin issues are of such complexity and scale that many critical research and management issues still need attention. Researchers and managers alike need to address larger spatial scales and longer time scales than have typically been dealt with in the past. Collaborative projects need to be developed across administrative boundaries to address the underlying causes of undesirable ecosystem change. Specific areas that need research and management attention include:

- **Science-based information and large-scale assessments** of the interacting effects of the primary ecosystem drivers, such as urbanization, changing land use, climate change, fire, and invasive species, on Great Basin ecosystems (vegetation type conversion, watershed functioning, stream, riparian and aquatic systems, and biodiversity).
- **Prediction and modeling** of the rates and magnitude of change, areas affected, and future consequences.

- **Management tools** to address the ongoing and predicted changes in Great Basin ecosystems such as methods for improving use of existing water resources; methods for the early detection and control of invasive species; and treatment and management options for restoring and maintaining ecosystems affected by altered fire regimes.

Close collaboration among managers and researchers is needed to identify and prioritize research and management issues and to develop effective collaborative efforts. Large-scale management "experiments" and ongoing adaptive management that involve the public and other partners are proven approaches for answering science questions and for developing widely accepted management techniques. Science information already serves as a basis for management planning efforts; meeting NEPA and regulatory requirements; and inventories, assessments, and trend monitoring. The majority of agencies and land managers recognize the critical need for sound scientific information to support management decisions. For example, on July 21, 2006, the director of the Fish and Wildlife Service communicated his vision for the future of the Service to all employees as including "A Service that is grounded in sound science where we articulate the strengths of that science and its confidence limits in making our decisions." Increased management and research collaboration will ensure that accurate and reliable information is available to resource managers and decision makers.

Historically, both research and management activities in Great Basin ecosystems have been severely under-funded. Monitoring information, including precipitation and stream gauging data, is the sparsest in the nation. Additionally, the Great Basin is one of the few ecoregions in the nation that does not have a National Science Foundation sponsored Long-Term Ecological Research site. Research and management collaboration at the regional scale can be used to leverage limited funds, reduce overlap, and increase efficiency.

This technical report includes an overview of the critical research and management issues facing the Great Basin. It also includes a summary of the workshop's sessions on (1) developing collaborative management and research programs and (2) devising mechanisms for organization and communication among collaborators. Issues papers on the many critical research and management problems within the region follow. It is hoped that the information contained in this technical report will serve as a first step in the process of developing more effective and larger-scale collaborations in the Great Basin.

Overview of Great Basin Issues

The Great Basin is a large, semi-arid region that includes most of the state of Nevada and parts of California, Oregon, Idaho, and Utah. The focus of this technical report is on the Great Basin as defined by similar climatic and floristic relationships (fig. 1). The Region extends from the Sierra Nevada Range in California to the Wasatch Range in Utah, and from southeastern Oregon and Idaho to southern Nevada. The majority of the land (about 72 percent) is under federal management. Sparsely populated until recently, the Great Basin is undergoing major sociological and ecological changes. The human population is growing at one of the highest rates in the nation. In 1990, the population of the Great Basin was 2.9 million with 9.1 million ha (22.6 million acres) uninhabited (Torregrosa and Devoe, this volume).

Figure 1—Map of the Great Basin as defined by similar climatic and floristic relationships.

The population had grown to 4.9 million by 2004 with fewer than 1.2 million ha (3 million acres) uninhabited. Most individuals, 2.6 million, live in urban areas that are located at the base of watersheds on the periphery of the region and have populations greater than 50,000 (Salt Lake City, Ogden-Layton, Provo-Orem, Reno, Boise, Nampa, Logan, Idaho Falls, Pocatello, Carson City, and Bend). From 1973 to 2000, these developed areas have increased in population by 43 percent. This rapid growth is overtaxing the infrastructure for the region's limited water resources, increasing fire and wildlife problems at the wildland-urban interface, and increasing recreational pressure on the region's wildlands. Managers are challenged to maintain sustainable ecosystems while considering the desires of a growing number of users. Public involvement in land management activities is increasing through the proliferation of advocacy groups.

The Great Basin is a cold desert characterized by limited water resources and periodic droughts (Wagner 2003). Precipitation is spatially and temporally variable and the distributions of species and ecosystems are greatly influenced by temperature and precipitation regimes. A high proportion of the year's precipitation falls as winter snow, and spring snowmelt and runoff provide the necessary water resources to maintain stream and river channels that support reproduction and survival of riparian and aquatic species. Spring runoff, stored in reservoirs, provides much of the region's water supply for irrigation, urban areas, and industry. Most of the Great Basin's surface water resources are fully or over-allocated and there is increasing reliance on ground water sources (Wagner 2003). Federal, state, and local governments are challenged to provide water resources for expanding population while maintaining the integrity of wetland, riparian, and aquatic ecosystems.

Widespread degradation of Great Basin ecosystems has occurred since settlement of the region in the mid-1800s. Land uses including road development, recreation, mining, energy development, agriculture, urbanization, and livestock production have caused widespread disturbance (Wisdom and others 2005). Energy development is currently one of the most significant causes of new disturbances within Great Basin ecosystems. The U.S. Energy Policy Act of 2005 encourages increased energy production and energy infrastructure and, in Nevada alone, 25 additional power plants are in the planning stages. Oil and gas leasing is expanding throughout the Great Basin and wind and geothermal energy is being further developed in several states. Energy production, development, and use have significant environmental costs including air and water pollution, noise, and visual impacts. In addition, the infrastructure associated with energy production, power plants, roads, transmission lines, pipelines, and wells reduce wildlife habitat and habitat continuity and disrupt seasonal and annual wildlife migration.

Because the Great Basin is a semi-arid region, the changing climate is likely to have a greater influence than in more mesic regions. The Great Basin warmed by 0.6° to 1.1 °F (0.3° to 0.6 °C) in the last 100 years and is projected to warm by an additional 3 to 6 °F by the end of this century (U.S. Environmental Protection Agency 1998, Wagner 2003). Precipitation increased 6-16 percent in the last 50 years and is projected to continue to increase in the future (Baldwin and others 2003). However, snow pack has declined and the decreases in the Great Basin have been among the largest in the nation (Mote and others 2005). Both the onset of spring and the timing of spring snowmelt-driven streamflow are now about 10 to15 days earlier than 50 years ago (Cayan and others 2001; Baldwin and others 2003; Stewart and others 2004). In the future, it is likely that spring peak flows will be reduced and arrive even earlier as more winter precipitation falls as rain. The frequency of droughts and floods is predicted to increase. These changes in flow regimes will result in management challenges related to water storage, channel maintenance, floods and droughts, pollutants, and biodiversity (Baldwin and others 2003). Water resources now used for hydropower, irrigation, riparian and aquatic habitat, and fisheries may all be negatively affected. The overall changes in climate may alter the structure and species composition of wildlands (Murphy and Weiss 1992), increase the invasion potential of exotic species (Smith and others 2000; Ziska and others 2005), and result in longer fire seasons and larger fires (McKenzie and others 2004).

Past and present land uses, coupled with invasion of exotic species and altered fire regimes, are influencing many of the region's ecosystems and resulting in large-scale vegetation type conversions. In forested systems, a decrease in fire frequency due to fire exclusion has resulted in a shift in species composition from early-seral, shade intolerant species to late-seral shade tolerant species (Keane and others 2002). Shade intolerant species, such as aspen, that provide critical wildlife habitat are being out-competed and increases in vertical stand structure (fuel ladders) and biomass (fuel loads) are resulting in more severe fires. Sagebrush ecosystems, which dominate much of the Basin, have been identified as the most endangered ecosystem type in the United States (Center for Science, Economics and Environment 2002). In the pinyon-juniper woodland zone, decreased fire frequency

due to fire exclusion, overgrazing through the mid-1900s and climate change have facilitated expansion of pinyon and juniper trees into mid-upper elevation sagebrush ecosystems (Miller and others, in press). As stands mature and canopies close, understory sagebrush species are eliminated through tree competition and the risk of higher-severity crown fires increases. In arid and semi-arid shrublands and lower-elevation pinyon-juniper woodlands, an increase in annual invasive grasses, such as cheatgrass, coupled with higher fire frequencies, is resulting in progressive conversion to homogenous grasslands dominated by invaders (Brooks and Pyke 2001). In many low to mid-elevation sagebrush ecosystems, an annual grass fire cycle now exists and areas that burned every 60 to 110 years in the past now burn as often as every 5 years (Whisenant 1990). Annual grasses have begun to invade lower elevation salt desert shrublands and these ecosystems are now burning for the first time in history (Brooks and Pyke 2001). Nonnative forbs (for example, knapweeds, rush skeletonweed, yellow star thistle) are beginning to spread throughout the region with unknown consequences for native ecosystems and fire regimes. In many areas, there has been a loss of watershed functioning due to changes in erosion and sedimentation, biogeochemical cycling, and thermal regimes (albedo, and so forth.). Changes within the watersheds, coupled with water diversions, water extraction, and point and non-point source pollutants, have resulted in the degradation of wetlands and riparian and aquatic ecosystems (National Research Council 2001).

The Great Basin has a high proportion of endemic species that occur only within the region due to its unique geography (basins and ranges) and climatic history. Ecosystem degradation poses serious threats to the viability of many of these species. Populations of many sagebrush-associated species are currently in decline and approximately 20 percent of the ecosystem's native flora and fauna are considered imperiled (Center for Science, Economics and Environment 2002). A recent risk assessment indicated that the sagebrush biome has 207 species of concern – 133 plants, 11 reptiles and amphibians, and 63 birds and mammals (Rowland and others 2005). Streams, springs, and their associated riparian and wetland ecosystems provide critical water sources and habitat in this semi-arid region and a high percentage of the species are strongly associated with these areas. Widespread habitat loss has occurred due to groundwater extraction, surface diversion of streams and rivers, and excessive use of riparian areas (National Research Council 2001). Fifty nonnative fish taxa and several invertebrate species have been introduced in the region by the public or fishery management agencies (Sada and Vinyard 2002). Habitat modifications, coupled with the introduction of nonnative taxa, have caused the extinction of 16 endemic species, subspecies, or other distinctive populations (12 fishes, three mollusks, and one aquatic insect) since the late 1800s (Sada and Vinyard 2002). Federal, state, and private land managers are increasingly concerned about the fate of Great Basin ecosystems and their associated species and they are actively seeking approaches to restore and maintain them.

Increasing human populations, land degradation, and climate change have increased the risk of both insect and disease outbreaks in native Great Basin ecosystems and species. These ecosystems are subject to periodic outbreaks of a variety of plant-feeding insects. The economic and ecological effects of such outbreaks are far-reaching, as intense and widespread insect herbivory can lead to complex changes in diverse ecosystem attributes, including plant community structure and dynamics, population levels of other animals (for example, insectivorous predators), and rates of nutrient cycling. The most prominent among insect outbreaks in Great Basin rangelands are grasshoppers and Mormon crickets (Orthoptera). In forested ecosystems, mountain pine beetles (Coleoptera: Curculionidae, Scolytinae) are causing increasing tree mortality. Climate change and warming temperatures, coupled with a recent drought, may also be responsible for tree mortality in pinion-juniper woodlands.

In the past decade, hosts of new (or newly recognized) diseases have been shown to be threats to wildlife, agricultural operations, and human health in both rural and urbanizing areas in the Great Basin (Chang and others 2003). These are in addition to the chronic challenges presented by tularemia (Friend 2006), salmonella (Daszak and others 2000), rabies (Krebs and others 2005), plague (Centers for Disease Control 2006), brucellosis (McCorquodale and DiGiacomo 1985), anthrax, and clostridial diseases (Williams and others 2002). Addressing both the primary and secondary effects of these diseases, and difficulties in managing impacts across departmental and jurisdictional boundaries, represents one of the most significant challenges to fish and wildlife managers in the 21st century.

Framework for Collaboration

Effective research and management collaboration requires a framework for both coordination and communication among the many diverse research and management entities in the Great Basin. Breakout sessions at the Workshop on Collaborative Watershed

Management and Research were used to address two questions: (1) How do we develop collaborative management and research programs to address critical Great Basin issues? and (2) How do we devise mechanisms for organizing and communicating? This section synthesizes the results of the breakout sessions.

Purpose and Scope of Collaboration

There was consensus among the workshop participants that the overarching purpose of increasing collaboration was to maintain sustainable ecosystems and a healthy environment. It was agreed that addressing the many urgent issues facing the Great Basin requires active collaboration among research and management organizations in the region. It was also agreed that these collaborations need to be both multi-organizational and inter-disciplinary and include public participation. Primary outcomes of these collaborations were envisioned to include (1) data and information that can be used for science-based management by participating agencies, NGOs, and other partners and (2) an information clearing house to increase information sharing among researchers, managers, and the public. Another important outcome would be the ability to leverage limited funds, reduce overlap, and increase efficiency.

Galvanizing Issues

Workshop participants agreed that there was a need to identify galvanizing issues to provide vision, unifying themes, and common commitment. Major issues identified at the workshop included climate change, changing land use, waters resources, fire, and invasive species. It was suggested that once priority issues were determined, they would need to be translated into terms with which the public can identify. For example, drought is an issue that everyone relates to in the West. It was suggested that economic incentives or disincentives could be used for obtaining public support for issues related to drought, such as the costs of obtaining new water resources. There was agreement that any new collaborative efforts that are initiated should be linked to existing programs. Successful collaboration will require recognizing different levels of issues and solutions as well as the inter-connections among both issues and collaborative programs.

An Organizational Structure for Collaboration

Workshop participants discussed several approaches to developing an organizational structure for collaboration. All the approaches included an umbrella organization. The purpose of an umbrella organization would be to establish a single entity to identify common problems and vision, provide leadership commitment, identify and build upon successful collaborative efforts that are currently in place, facilitate the necessary research to provide for science-based management of Great Basin ecosystems, and develop metrics of success. The umbrella structure would also provide an information clearinghouse to increase communication among researchers and managers in the Great Basin. It would develop mechanisms to increase science translation and a public awareness strategy. A tiered organizational structure was envisioned in which the umbrella organization would build upon existing organizations and collaborative programs (like the Great Basin Cooperative Ecosystem Studies Unit and the Great Basin Restoration Initiative). It would promote complementary and comprehensive collaborations and provide cohesion among the smaller-scale efforts within the Great Basin. The collaborative program should provide a higher-level organization capable of crossing political and administrative boundaries. Existing agencies and institutions operating in a collaborative framework, regardless of their structure, should implement the program. It was suggested that components of such an umbrella organization could include an executive committee to focus priorities and ensure commitment, a science advisory group or coordinating committee, technical teams to address research and management needs, and an information clearing house that would include a searchable website of Great Basin research programs and scientific information.

Elements of an Effective Collaboration Program

The need for information packaging to market the idea of an umbrella organization was discussed. This packaging should clarify the geographic scope of the effort, prioritize issues and hot spots of concern, and illustrate the infrastructure available in these areas and the cross-linkages among groups. It should also demonstrate efficiency and cost-savings of increased collaboration and show that the new organization will not jeopardize funding for current research. The interests of all five states within the Great Basin should be acknowledged and, to that end, the Western Governor's Association should be involved.

Many of the discussions focused on obtaining public support and funding. It was suggested that seeking broad support would be necessary to effectively address the existing issues. Non-federal sources could be used to pursue federal and state appropriations, but because federal budgets are extremely limited, requests should be for new funding. Congressional delegations should

be approached at the same time with the same funding requests.

Several ideas were discussed to ensure effective collaboration. It was suggested that an effective collaborative program needed to be all inclusive. Research and management collaboration should be a requirement for funding, and the collaborative nature of the projects should be clearly addressed in the project goals and objectives. Every effort should be made to ensure communication among program activities and ground-based management needs through activities such as co-locating agency/entity offices and reaching out to those not near the project area. The public should be included throughout the process and project goals should have a public education component.

Communication and Data Management

Workshop participants agreed that a comprehensive communications plan should be developed as part of any collaboration framework. There was considerable interest in the idea of an information clearinghouse that would identify existing collaborative efforts and provide supporting information. It was suggested that the clearinghouse include an interactive, searchable website with the following components:

- A research catalog and database allowing easy access to work that is underway or has already been completed.
- A database of "experts" working on regional problems (Who is available to conduct research and in what areas of expertise?).
- Email lists and chat rooms for communication.
- A directory of information sources and links. Existing websites across organizations should be reviewed to determine how to best integrate and link them.
- A directory of information on available funding sources for research and projects.
- A data repository for safeguarding data. This should include metadata files of data availability with links to the data source and data managers contact information.
- Information for citizens on what is available, who to contact, and who is available for collaboration.
- Information on available science syntheses, links to existing bibliographies, and other relevant information.

Alternative communication venues for individuals and organizations without electronic access would need to be addressed in the communication plan. In addition, the communication plan should not only address the need to frame the issues and information in lay terms, but include higher level information such as scientific research data and results.

Successful collaboration requires a high level of interaction among managers, scientists, and other stakeholders. Suggested venues for interaction to enhance understanding and communication include:

- Workshops (such as the November 2006 Collaborative Research and Management Workshop and the Colorado Plateau Biennial Science Conference) that involve both researchers and managers.
- Details/work exchanges between organizations.
- Regularly scheduled meetings.
- Scientists working together with stakeholders.
- Citizen science opportunities (for example, Master Naturalist Program).
- Joint fact finding that involves inviting public and target audiences, which are often excluded from the scientific process, to participate in defining needs and framing the problems for study.

Education and Information

The need for a strong and user-friendly education/extension component was discussed. Management agencies need to understand and use the mechanisms available for conducting research and management projects and for sharing existing data with research. Research organizations need to better understand the management-associated opportunities that are available for research. Closer linkages between management and research are needed to improve science translation and application. Educational activities need to include both technology transfer and public education.

References

Baldwin, C. K., Wagner; F. H.; Lall, U. 2003. Water Resources. Pages 79-112, in Wagner, F. H. (editor). Rocky Mountain/Great Basin Regional Climate-Change Assessment. Report of the U.S. Global Change Research Program. Utah State University, Logan, UT: IV 240pp.

Brooks, M. L.; Pyke D. A. 2001. Invasive plants and fire in the deserts of North America. In: Galley, K. M.; Wilson, T. P., eds. 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.; 2000 November 27-December 1; San Diego, CA. Misc. Publ. No. 11, Tallahassee, FL: Tall Timbers Research Station: 1-14.

Cayan, D. R.; Kammerdiener, S. A.; Dettinger, M. D.; Caprio, J. M.; Peterson, D. H. 2001. Changes in the onset of spring in the western United States. Bulletin American Meteorological Society. 82: 399-415.

Centers for Disease Control and Prevention. 2006. CDC Plague Home Page [Homepage of Centers for Disease Control and Prevention], [Online]. Available: http://www.cdc.gov/ncidod/dvbid/plague/ [2007, July 17].

Center for Science, Economics and Environment. 2002. The state of the nation's ecosystems: measuring the lands, waters and living resources of the United States. Cambridge, United Kingdom: Cambridge University Press. 288 p. Available: http://www.heinzctr.org/ecosystems/report.html, with 2005 updates [2007, July 17].

Chang, M.; Glynn M. K.; Groseclose, S. L. 2003. Endemic, notifiable, bioterrorism-related diseases, United States, 1992-1999. Emerging Infectious Diseases. 9(5): 556-564.

Daszak, P.; Cunningham, A. A.; Hyatt, A. D. 2000. Emerging infectious diseases of wildlife: threats to biodiversity and human health. Science. 287(5452): 443-449.

Friend, M. 2006. Tularemia. Reston, Virginia, U.S. Geological Survey Circular 1297. 68 p.

Keane, R. E.; Ryan, K. C.; Veblen, T. T.; Allen, C. D.; Logan, J.; Hawkes, B. 2002. Cascading effects of fire exclusion in Rocky Mountain ecosystems: a literature review. Gen. Tech Rep. RMRS-GTR-91. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 14 p.

Krebs, J. W.; Mandel, E. J.; Swerdlow, D. L.; Rupprecht, C. E. 2005. Rabies surveillance in the United States during 2004. Journal of the American Veterinary Medical Association. 227(12): 1912-1913.

McCorquodale, S. M.; DiGiacomo, R. F. 1985. The role of wild North American ungulates in the epidemiology of bovine brucellosis: a review. Journal of Wildlife Diseases. 21(4): 351-357.

McKenzie, D.; Gedalof, Z.M.; Peterson, D.L.; Mote, P. 2004. Climate change, wildfire and conservation. Conservation Biology. 18: 890-902.

Mote, P. W.; Hamlet, A. F.; Clark, M. P.; Lettenmaier, D. P. 2005. Declining mountain snowpack in western North America. Bulletin of the American Meteorological Society. 86: 39-49.

Miller, R. F.; Tausch, R. J.; McArthur, D. E.; Johnson, D.; Sanderson, S. C. [In Press]. Development of Post-Settlement Piñon-Juniper Woodlands in the Intermountain West: A regional perspective. Gen. Tech Rep. RMRS-GTR-TBD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Murphy, D. D.; Weiss, S. B. 1992. Effects of climate change on biological diversity in Western North America: Species losses and mechanisms. In: Peters, R. L.; Lovejoy, T. E., eds. Global warming and biological diversity, Castleton, NY: Hamilton Printing: Chapter 26.

National Research Council. 2001. Riparian areas: functions and strategies for management. National Academy Press. Washington, D.C. 444 p.

Noss, R. F.; LaRoe III; E. T; Scott., J. M. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. National Biological Service Biological Report 28, National Biological Service, Washington, D.C.

Rowland, M. M.; Suring, L. H.; Wisdom, M. J.; Meinke, C. W.; Schueck, L. 2005. Habitats for vertebrate species of concern. In: Wisdom, M. J.; Rowland, M. M.; Suring, L. H., eds. 2005. Habitat threats in the sagebrush ecosystem: methods of regional assessment and applications in the Great Basin. Lawrence, KS: Alliance Communications Group, Allen Press: 163-204.

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

Stewart, I. T.; Cayan, D. R.; Dettinger, M. D. 2004. Changes in snowmelt timing in western North America under a 'business as usual' climate change scenario. Climate Change 62: 217-232.

Smith, S. D.; Huzman, T. E.; Zitzer, S. F.; Charlet, T. N.; Housman, D. C.; Coleman, J. S.; Fenstermaker, L. K.; Seeman, J. R.; and Nowak, R. S. 2000. Elevated CO_2 increases productivity and invasive species success in an arid system. Nature. 408: 79-81.

U.S. Environmental Protection Agency. Office of Policy. 1998. Climate Change and Nevada. EPA 236-F-98-0070. (available for all states).

Wagner, F. H., ed. 2003. Preparing for a changing climate-the potential consequences of climate variability and change. Rocky Mountain/Great Basin regional climate-change assessment. A report of the Rocky Mountain/Great Basin Regional Assessment Team for the U.S. Global Change Research Program. Logan, UT: Utah State University. 240 p.

Williams, E. S.; Yuill, T.; Artois, M.; Fisher, J.; Haigh, S. A. 2002. Emerging infectious diseases in wildlife. Reviews in Science and Technology. 21(1): 139-157.

Whisenant, S. G. 1990. Changing fire frequencies on Idaho's Snake River Plains: ecological and management implications. In: McArthur, E. D.; Romney, E. M.;Smith, S. D.; Tueller, P. T., comps. Proceedings – Symposium on cheatgrass invasion, shrub 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. Lawrence, KS: Alliance Communications Group, Allen Press.

Ziska, L. H.; Reeves III, J. B.; Blank, B. 2005. The impact of recent increases in atmospheric CO_2 on biomass production and vegetative retention of cheatgrass (*Bromus tectorum*): implications for fire disturbance. Global Change Biology. 11:1325-1332.