Great Basin Riparian and Aquatic Ecosystems

Don Sada

Desert Research Institute, Reno, NV

Most Great Basin riparian and aquatic ecosystems are associated with streams and springs that are comparatively small and isolated from one another because of the naturally arid climate. There are few rivers and lakes in the region. Surface waters and aquifers that support springs provide the only water available to humans and wildlife. Springs occur at all elevations, but most streams and lakes are in the mountains. Many issues affecting riparian and aquatic ecosystems are similar to those outlined in the Water Resources section, which focuses on water quantity and water use by humans. Issues involving riparian and aquatic systems are focused on environmental integrity, which is strongly related to goods and services provided by natural wetland ecosystems.

Riparian and Aquatic Ecosystems

Great Basin riparian and aquatic ecosystems comprise only about 1 percent of the land surface—They are supported by the only surface water in the region and most are small and isolated from one another (Skudlarek 2006, Sada and others 2001). Despite their small size, these ecosystems support most of the biodiversity in the region.

Streams and most springs are supported by mountain runoff—Streams are supported by mountain runoff and springs. Springs are supported by aquifers whose physical and chemical characteristics are influenced by geology, climate, and topography. Montane aquifers are generally small and local, while other aquifers are large and comprised of ancient water (Thomas and others 1996).

Current stream processes have been influenced by past climate change—Because the Great Basin is a semi-arid region, it is highly susceptible to climate change. Paleoecological and geomorphic data for upland watersheds in the central Great Basin indicate that past climate changes have had significant effects on the response of current stream systems and riparian ecosystems to both human-caused and natural disturbances (Chambers and Miller 2004). This indicates that these systems are highly susceptible to future climate.

Most riparian and aquatic systems have been altered from historical conditions—The changes in riparian and aquatic system condition have resulted from altered discharge due to dams and diversions, excessive use by non-native ungulates, road construction in valley bottoms, and invasions of non-native vegetation and aquatic animals. In areas prone to stream incision, these perturbations have increased the rate and magnitude of downcutting (Chambers and Miller 2004). In most aquatic and riparian communities, composition has been functionally altered from organisms that are intolerant of harsh and degraded conditions to organisms that tolerate pollution and harshness. In addition, the vast majority of springs have been seriously degraded by lower surface discharge caused by groundwater pumping and diversions and by non-native ungulate grazing (Sada and others 1992).

Great Basin riparian and aquatic systems are characterized by high biological diversity—Many species are limited to single basins and specialized habitats. Diversions, excessive groundwater pumping, livestock use, and non-native species introduction have caused extinctions and decreased the abundance and distribution of many endemic species. This has justified formal listing of many fish and riparian plants as threatened or endangered by State and Federal governments.

Key Issues

Land management/land use—The Great Basin is the driest region in the United States. Water is limited in quantity and distribution, and aquatic and riparian systems are typically small and the only source of water. As a consequence, human activity has concentrated in areas adjacent to springs, streams, and rivers resulting in degraded riparian and aquatic ecosystems. Riparian vegetation is now sparse at most springs and lower elevation streams because of excessive grazing by non-native ungulates and diversion of surface flow (Fleischner 1994). Changes in land and water management are needed to determine sustainable levels of human uses of aquatic and riparian systems, arrest their continued degradation, and restore their environmental integrity (Karr 1981; Shepard 1993; Skudlarek 2006).

Expanding urbanization—Urban needs for clean water will exceed the amount that is available from proximate sources in the near future. The potential to increase supplies from surface waters is limited because rights to these waters are fully allocated (and often over allocated) to existing uses. Urban centers acquire water from distant, rural areas to meet current and future water needs. Los Angeles currently receives most of its drinking water from surface and ground waters in the Owens River basin (along the west side of the Great Basin), and Las Vegas and Reno are pursuing groundwater acquisitions from eastern and western Nevada, respectively. Water importation is unlikely to affect montane streams but likely to affect valley floor springs, which are dependent on local groundwater supplies. If not properly managed, increasing groundwater extraction and use will decrease spring discharge and further degrade spring-fed aquatic and riparian systems by reducing surface water quantity and quality.

Diversions—Diversions (including dams, channelization, and spring boxes with pipes) have altered most Great Basin aquatic and riparian ecosystems. Portions of all Great Basin rivers have been impounded for flood control and agricultural and municipal uses. This has decreased the amount of flowing water; altered the frequency, duration, and magnitude of flood events; decreased riparian vegetation; and degraded aquatic communities by facilitating establishment of non-native species and aquatic communities that are pollution tolerant (Rood and others 2003). Diversions have also dried springs, streams, and rivers and altered morphology by armoring stream banks with gabions and other hard structures. As a consequence, Great Basin riparian and aquatic habitats have been reduced because there is less water available to maintain conditions that are necessary to support healthy communities. Management strategies are needed to ameliorate the ecological effects of diversions by mimicking the natural hydrograph, minimizing the quantity of water diverted, and restoring channelized reaches.

Non-native Species—Habitats associated with many Great Basin streams, rivers, and large springs support non-native animals (including aquarium and sport fishes, amphibians, crustaceans, and mollusks) and a diversity of non-native invasive plants. Diversity and distribution of non-native species is increasing. The number of non-native fish species in the Great Basin currently exceeds native species. Functional characteristics, trophic dynamics, and energy flow in these riparian and aquatic systems do not resemble historic healthy ecosystems. New technologies are needed to reduce the extent and abundance of non-native species, prevent the establishment of new arrivals, and retain natural elements that characterize Great Basin aquatic and riparian ecosystems.

Unique Plants and Animals—Aquatic and riparian habitats in the Great Basin support a wide diversity of plants and animals that do not occur elsewhere. These include butterflies, dozens of plant species, and more than 200 types of aquatic animals. The distribution and abundance of these species has declined from historical conditions and many are extinct or are listed as threatened or endangered by Federal and State agencies (Sada and Vinyard 2002). Decline of these species has been caused primarily by habitat alteration (mostly groundwater use and surface water diversion) and interactions with non-native species (Miller 1961, Minckley and Deacon 1968). Continued declines are likely to cause additional threatened or endangered listings that may conflict with future development of water resources.

Pollution—Point and non-point sources of pollution from nutrients, metals, sediment, elevated temperature, and total dissolved solids have degraded water quality in many Great Basin streams, rivers, wetlands, lakes, and reservoirs. In Nevada, this includes approximately 1,930 km (1,200 miles) of stream, 30,350 ha (75,000 acres) of lakes and reservoirs, and 7,689 ha (19,000 acres) of wetlands (NDEP 2004). Approximately 402 km (250 miles) of impaired waters occur in the Great Basin portion of Utah (UDWQ 2004). Improving the conditions in these streams will increase their ecological integrity and the goods and services they provide to urban and rural economies.

Climate change—Climate change will influence the quantity and timing of flows in streams and rivers and affect groundwater recharge and spring discharge. These changes are likely to further degrade aquatic and riparian systems in the Great Basin because of increased flood frequency, lower groundwater recharge rates, and the consequential increase in human demands for water.

Ecosystem services—Healthy riparian and aquatic ecosystems provide services that include clean water for diverse aquatic communities, freshwater for human consumption, natural flood,and erosion control, and recreational opportunities that enhance the quality of life (Gregory and others 1991, Baron and others 2002). Improving the condition of Great Basin aquatic and riparian systems will help restore their ecological health and provide for increased ecosystem services. Restoration actions will partially mitigate the impact of increasing demands on these systems.

Management Challenges

Federal, state, and local governments are challenged to respond to a number of threats to Great Basin aquatic and riparian resources through:

Sustainable management of water resources for multiple uses.

Increasing recreation opportunities while minimizing environmental impacts.

Protection of aquatic and riparian biodiversity.

Rehabilitation of degraded and unstable river and stream channels and spring systems.

Mitigation of impacts associated with development in flood plains of rivers and tributaries.

Mitigation of river channel modifications and floodplain instability from diversion dams, channel straightening, and flood protection structures.

Research and Management Questions

Riparian and Aquatic System Use

What flow regimes and hydrographs are required to maintain channel processes and support the ecological integrity of riparian and aquatic ecosystems?

What are the flow regimes, quantities, and hydrographs required to support sensitive, threatened, and endangered species and prevent future listings?

What levels of human disturbance can be tolerated by rare aquatic and riparian species to prevent declines in their abundance and distribution?

What are the effects of incremental differences in land use and land management, water quality, and quantity, and on the ecological integrity of riparian and aquatic systems?

What are reference conditions for Great Basin aquatic and riparian systems?

Predictive tools

How can we better predict the response of aquatic and riparian resources to varying types and intensities of human use?

What are the best conceptual, spatial, and numeric models for integrating climate, surface and groundwater quantities, ecological constraints, and economics to assist decision makers in managing for sustainable riparian and aquatic ecosystems?

Existing Programs and Resources

U.S. Environmental Protection Agency. A national program for monitoring stream condition in the Western U.S. 4 Jan. 2007. http://www.epa.gov/esd/land-sci/water/streams.htm [2007, July 17]

USDA Forest Service, Rocky Mountain Research Station, Great Basin Ecosystem Management Project for Restoring and Maintaining Watersheds and Riparian Ecosystems, Reno, NV. http://www.ag.unr.edu/gbem/ [2007, July 17]

USDA Forest Service, Rocky Mountain Research Station, Boise Aquatic Sciences Laboratory, Boise, ID. http://www.fs.fed.us/rm/boise/index.shtml [2007, July 17]

USDA Forest Service, Stream Systems Technology Center, Fort Collins, CO. http://www.stream.fs.fed.us/ [2007, July 17]

USDI Bureau of Land Management, Riparian Service Team, Prineville, OR. http://www.blm.gov/or/programs/nrst/index.php [2007, July 17]

USGS, Fort Collins Science Center, Fort Collins, Co. http://www.mesc.usgs.gov/OurScience/ [2007, July 17

References

Baron, J.S.; Poff, N.L; Angermeier, P.L.; Dahm, C.N.; Gleick, P.H.; Hairston, Jr., N.G.; Jackson, R.B.; Johnston, C.A.; Richter, B.D.; Steinman, A.D. 2002. Meeting ecological and societal needs for freshwater. Ecological Applications. 12: 1247-1260.

Chambers, J.C.; Miller. J.R., eds. 2004. Great Basin Riparian Ecosystems – Ecology, Management and Restoration. Washington, DC: Island Press. 303 p.

Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology. 8: 629-644.

Gregory, S.V.; Swanson, F.J.; McKee, W.A.; Cummins K.W. 1991. An ecosystem perspective of riparian zones. Bioscience. 41: 540-551.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries. 6: 21-27.

Miller, R.R. 1961. Man and the changing fish fauna of the American southwest. Papers of the Michigan Academy of Sciences, Arts, and Letters. 46: 365-404.

Minckley, W.L.; Deacon, J.E. 1968. Southwestern fishes and the enigma of 'endangered species'. Science. 199: 1424-1432.

Nevada Division of Environmental Protection (NDEP). 2004. Nevada's 2004 303(d) impaired waters list. Draft, December 2004. Caron City, NV: Nevada Division of Environmental Protection, Bureau of Water Quality Planning.

Rood, S.B.; Gourley, C.R.; Ammon, E.M.; Heki, L.G.; Klotz, J.R.; Morrison, M.L.; Mosley, D.; Scoppettone, G.; Swanson S.; Wagner, P.L. 2003. Flows for floodplain forests: a successful riparian restoration. Bioscience. 53: 647-656.

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., eds. Great Basin Aquatic Systems History. Smithsonian Contributions to the Earth Sciences No. 33: 277-295.

Sada, D.W.; Vinyard, G.L.; Hershler R. 1992. Environmental characteristics of small springs in northern Nevada (abstract). In: Hendrickson, D.A., ed. Proceedings of the Desert Fishes Council, Volumes XXII & XXIII. Page 76

Sada, D.W.; Williams, J.E.; Silvey, J.C.; Halford, A.; Ramakka, J.; Summers, P.; Lewis, L. 2001. Riparian area management. A guide to managing, restoring, and conserving springs in the western United States. Technical Reference 1737-17. Denver, CO: Bureau of Land Management. BLM/ST/ST-01/001+1737.

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

Skudlarek, E., ed. 2006 [Draft]. Nevada Wetlands Priority Conservation Plan. Nevada Department of Conservation and Natural Resources, Nevada Heritage Program, Carson City, Nevada.

Thomas, J.M.; Welch, A.H.; Dettinger, M.D. 1996. Geochemistry and isotope hydrology of representative aquifers in the Great Basin region of Nevada, Utah, and adjacent states. U.S. Geological Survey Professional Paper 1409-C.

Utah Division of Water Quality (UDWQ). 2004. Utah's 2004 303(d) impaired waters list. April, 2004, Salt Lake City, UT: Utah Department of Environmental Quality, Division of Water Quality.