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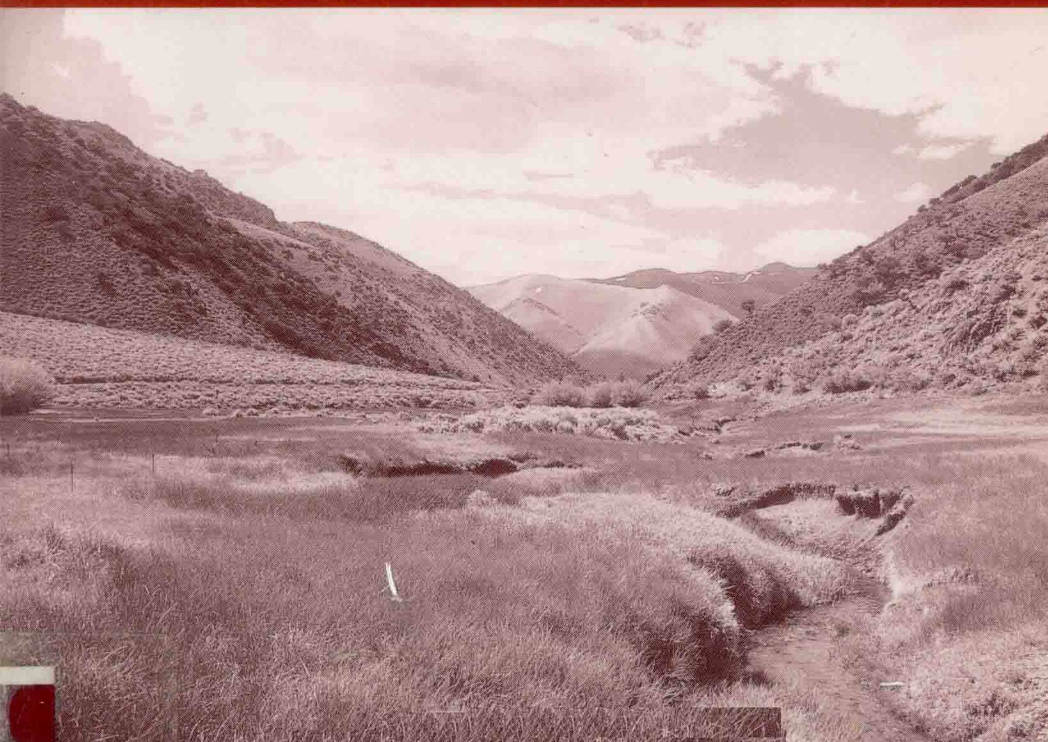
Great Basin Riparian Ecosystems

ECOLOGY, MANAGEMENT, AND RESTORATIC



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JEANNE C. CHAMBERS AND JERRY R. MILLE

FOREWORD BY JAMES A. MACMAHON

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FOREWORD

The Great Basin is big and diverse. The physiographic boundaries of the basin encompass over 650,000 square kilometers of land that occupies most of the state of Nevada, the western third of Utah, as well as small portions of California, Idaho, Oregon, and Wyoming. The Rocky Mountains to the east and the Sierra Nevada to the west form the most obvious boundaries to the basin. The entire basin is dotted with more than 200 mountain ranges containing over 500 mountains that often attain elevations in excess of 3300 meters, with a few greater than 4000 meters. The vegetation of the Great Basin is as diverse as its topography, varying from barren salt flats fringed with a few highly adapted, salt-tolerant plants, through an "ocean of sagebrush," to a variety of coniferous forests, and upward past treeline to areas of starkly beautiful alpine vegetation. The landscape is dotted with over seventy basins that receive the input of rivers and streams from the surrounding mountains. Most basins have no outlets, so ephemeral lakes, dry most of the time, form. Interspersed in this landscape are ribbons of riparian vegetation that, while occupying only 1 percent of the land surface, are inordinately important for sustaining the biodiversity of plants and animals, as well as for humans because water is such a scarce commodity across the Great Basin.

These riparian areas are so important that they have been extensively and intensively used for decades by humans for a variety of purposes that range from providing well-vegetated sites for grazing to places of beauty and solace that renew the spirits of visitors.

While the Great Basin has a history of occupation by Native Americans, their populations were not numerous. The landscape escaped many of the effects of early European settlement because the land was considered barren and, thus, not useful for agriculture. This began to change in the mid-1800s when the Mormon pioneers arrived. Today various municipalities in the Great Basin are among the fastest growing in the United States, the little available farmland is being subdivided for housing, and the constant call for more water continues. The past and present uses of riparian areas has left marks that signal a degree of degradation that suggests that the land cannot continue to support sustainably the inevitable increase of human activities into the future.

The future scenario is even more complicated because of the prospects global warming carries with it, including the possibility not only of increasing temperatures, but, more important, the seasonality and total annual precipitation. Even the dominant forms of precipitation (water versus snow) may change. Some of these changes may be positive, however, many are predicted to have negative consequences for the population as a whole, and they may have more pervasive effects on the human lifestyles of the Great Basin than in many other parts of the country.

How do we stem the tide of degradation and renew or recreate these systems so they can continue to support a reasonable human population, as well as their constituent plants and animals, as they have in the past? This is the topic of *Great Basin Riparian Areas: Ecology, Management, and Restoration*, an important and timely book that emanates from a research program funded by the U.S. Forest Service that commenced in 1993. The project took a fresh approach to addressing problems of riparian ecosystem restoration and management. Instead of jumping right into a restoration project based on past practices, as is often the case in the United States, this group of scientists decided to attempt to understand the natural functioning of riparian systems, including all the usual biological processes, but with unusual attention to the physical processes associated with the system's geomorphology and hydrology. The result of this research protocol is the knowledge needed to develop effective restoration and management plans, based on sound principles derived from attention to natural systems. This approach, in my opinion, is the way to do restoration science. Rather than creating schemes that rely only on principles derived from the applied sciences, such as agriculture or engineering, we need to learn how a system came to be, how it functions, and how it persists. As the natural systems reveal their intricate inner workings to us, then and only then can we develop the mechanistic plans to restore or manage them in the most efficient ways, often saving time and money in the process.

The eighteen authors of this book, under the guidance of Jeanne C. Chambers and Jerry R. Miller, have produced a volume that represents a substantial contribution, is packed with innovative thinking, and addresses not just the surprisingly limited literature on the Great Basin but, more importantly, includes consideration of the burgeoning recent literature on restoration elsewhere. Surely, Great Basin riparian zones will be more persistent and productive because of this careful research and synthesis. Of even greater potential significance, the entire field of restoration will be better because its practitioners are sure to adopt much of the general approach and many of the insights presented here as they tackle restoration problems in a wide variety of vegetation types, not just those in the arid American West.

This team took the time to listen to the lessons natural systems offer. Their example is one restorationists and land managers should all follow. I know I will and I thank them for their hard work, careful thought, and inspiration.

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PREFACE

In 1993, the USDA Forest Service initiated a series of Ecosystem Management Projects across the United States. When the supervisor of the Humboldt-Toiyabe National Forest (1.3 million acres that encompass most of the national forest lands within the Great Basin) was asked what was the Forest's priority for research within an ecosystem management context, he immediately replied, "riparian areas." For much of their history, the major land management agencies in the region, the Forest Service and the Bureau of Land Management, have largely treated riparian areas as sacrificial. Many were adversely affected by stream diversions or water-spreading, degraded by road systems, and severely overgrazed by livestock. The passage of a series of legislative acts in the mid-1970s, however, including the Forest and Rangeland Renewable Resources Planning Act, the National Forest Management Act, and the Endangered Species Act, drew needed attention to these valuable but often neglected ecosystems. The role of riparian ecosystems in supplying important commodities, such as livestock forage, had always been recognized, but now their role in providing other critically important ecosystem services, such as an adequate source of high-quality water and habitat for a diverse array of both terrestrial and aquatic organisms, was receiving increasing attention.

With the support of both the Humboldt-Toiyabe National Forest and the research branch of the Forest Service, in this case the Rocky Mountain Research Station, the Great Basin Ecosystem Management Project for Restoring and Maintaining Sustainable Riparian Ecosystems (EM Project) was funded. The Project was structured as a collaborative effort between management and research, and initial meetings focused on the overall direction and objectives of the project. Some objectives and approaches received complete agreement. For example, all agreed that permanent stream cross sections, wells, and vegetation transects should be established in key riparian ecosystems to determine existing ecological conditions and to monitor change over time. Other objectives were more difficult to decide upon. Some individuals wanted to begin restoration activities immediately, and it was suggested that contractors be hired to lay back the banks of incised streams and realign stream channels to their "predisturbance" pattern and form. Others argued, however, that without an understanding of the geomorphic and hydrologic processes influencing the streams and their relationships to riparian vegetation, these types of restoration efforts could fail. Several managers thought that a major focus of the project should be on the effects of overgrazing by livestock, a widespread problem in the Great Basin. A review of the literature on riparian areas in the semiarid regions of the western United States indicated that a number of studies had been conducted on the effects of livestock on stream channels and riparian ecosystems. However, study results depended on stream attributes, hydrologic regimes, and vegetation characteristics, and, again, conflicting findings were attributed to a lack of understanding of underlying processes (Trimble and Mendel 1995; Belsky et al. 1999). Ultimately, it was decided that to develop viable management and restoration approaches for riparian areas in the Great Basin, it would be necessary to first acquire an understanding of the interrelated responses of geomorphic, hydrologic, and biotic processes to both natural and anthropogenic disturbances. Because semiarid ecosystems like the Great Basin are highly sensitive to climate change, effective restoration and management also would require an understanding of how these processes are affected by past and present climates. Finally, in the context of ecosystem management, knowledge of these processes would have to be obtained over a continuum of temporal and spatial scales. Although not the major focus of the EM Project, it has been possible to examine the effects of overgrazing by livestock on key riparian ecosystems. And the knowledge obtained on the geomorphic, hydrologic, and biotic processes that characterize these ecosystems has allowed us to develop process-based restoration approaches that now are being put into practice.

This book presents the approach used by the EM Project to study and understand Great Basin riparian areas. It attempts to summarize the current state of knowledge about these areas and to provide insights into the use of this information for the restoration and management of riparian ecosystems. There are many ways to structure ecosystem management projects, and questions still remain regarding the management and restoration of Great Basin riparian areas. Nonetheless, we hope that both the approaches described and the information provided will serve to stimulate and guide future research on the topic.

Many individuals have made significant contributions to the EM Project. We thank M. Dean Knighton (Rocky Mountain Research Station, now retired) for his help in developing the EM Project and Larry J. Schmidt (director, Stream Systems Technology Center) for his technical guidance as well as financial support. Humboldt-Toiyabe National Forest staff were instrumental in conducting all aspects this work: Jim Nelson and Bob Vaught (past and present forest supervisors), Dale Flannigan and Laurence Crabtree (past and present district rangers), Jerry Grevstad, Ron Burraycheck, Dave Weixelman, Desi Zamudio, Karen Zamudio, Randy Sharp (Ecology Team), Jim Bergman (forest hydrologist), Dave Haney and Stuart Volkland (Fire Management), Terry Nevius, Bryan Watts, Will Wilson, Wayne and Peggy Frye, Joe and Christy Shaw, Liz Bergey, and Michael Croxen (Austin Ranger District personnel), and many others. The University of Nevada, Reno, provided administrative support and helped eight graduate students complete their degrees: David Martin, Amy Linnerooth, Regine Castelli, Catherine Davis, Danielle Henderson, Pam Wehking, Michael Wright, and Dan Lahde. Finally, we thank the EM Project's research collaborators (most are included in the section About the Editors and Authors) who have shared the project's meager budget, contributed their own time and finances, and helped to obtain additional resources to continually address "the next set of critical questions."

James Aronson and Don Falk, the editors of the SERI book series, supported the project from its beginnings, and Barbara Dean and Laura Carrithers of Island Press guided us through the process of turning a collection of papers into a book volume.

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Restoring and Maintaining Sustainable Riparian Ecosystems: The Great Basin Ecosystem Management Project

Jeanne C. Chambers and Jerry R. Miller

In the Great Basin, as in other semiarid regions, riparian areas exhibit widespread degradation. It has been estimated that more than 50 percent of the riparian areas (streams and their associated riparian ecosystems) in the Great Basin are currently in poor ecological condition (Jenson and Platts 1990). The ongoing deterioration of these areas is of significant concern to land managers and other stakeholders who value these watersheds for a variety of purposes. Riparian areas are important components of all landscapes, but in the semiarid Great Basin they constitute an especially vital resource. Although they comprise less than 1 percent of the Great Basin, they supply many critical ecosystem services. Riparian areas supply water for both culinary and agricultural uses, forage and browse for native herbivores and livestock, and recreational opportunities. In addition, they serve as the foundation for much of the region's biodiversity. Riparian areas in the Great Basin provide habitat for a wide array of organisms such as butterflies (Fleishman et al. 1999) and Neotropical migrant birds (Martin and Finch 1996), and support a relatively high number of endemic species, including the Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*), which is listed as threatened under the U.S. Endangered Species Act (Dunham et al. 1997).

Degradation of riparian areas in the Great Basin is the result of complex and interrelated responses of geomorphic, hydrologic, and biotic processes to climate change and natural and anthropogenic disturbances. These disturbances can alter the hydrologic or sedimentologic regime of a fluvial (river or stream) system and produce changes in the physical foundations of riparian ecosystems, such as stream channel characteristics and surface-groundwater interactions. Ultimately, they alter the structure and functioning of riparian ecosystems. In this volume, anthropogenic disturbances refer to all human activities that affect physical and biological processes within a watershed, while natural disturbances include phenomena such as floods, landslides, and wildfires. Although climate change could be considered to be a type of natural disturbance, it operates over longer temporal scales and larger spatial scales than most other forms of natural disturbance. Also, current shifts in climate arguably are related to human activities. Thus, climate change is treated as a special form of disturbance herein.

Much of the research on stream and riparian ecosystem degradation in arid and semiarid regions of the western United States has focused on the effects of anthropogenic disturbances. Consequently, the degradation of these riparian areas has been attributed largely to human activities, and management and restoration strategies have focused primarily on anthropogenic disturbances. In the Great Basin, riparian areas and their associated uplands have been subjected to various anthropogenic disturbances since European settlement of the region around 1860. The most extensive disturbances have been overgrazing by livestock (Kauffman and Krueger 1984; Fleischner 1994; Ohmart 1996; Trimble and Mendel 1995; Belsky et al. 1999) and road construction in the valley and canyon bottoms. Local alterations of hydrologic regimes via dams and water diversions, mining operations, and recreational activities also have had negative influences on riparian ecosystems (Sidle and Amacher 1990; Sidle and Hornbeck 1991). The influences of these disturbances on riparian areas have been well documented and management strategies for mitigating their effects are discussed in numerous locations (e.g., Kusler and Kentula 1990; National Research Council 1992, 2002; Briggs 1996; Kauffman et al. 1997; Williams et al. 1997).

The effects of past and present climate change on stream and riparian ecosystems have received considerably less attention than the influences of anthropogenic disturbance. This is surprising given that arid and semiarid regions like the Great Basin are more sensitive to the effects of both past and present climate change than humid regions. The sensitivity of these regions to climate change has important implications for the types and characteristics of disturbances that riparian areas experience, and the effects of these disturbances on riparian ecosystems. In comparison to humid regions, arid and semiarid regions generally exhibit amplified runoff responses to precipitation change (Dahm and Molles 1991), have higher streamflow variability (Poff 1991; Osterkamp and Friedman 2000), and have more severe flash floods (Graf 1988; Osterkamp and Friedman 2000).

In the Great Basin, paleoecological and geomorphic records indicate that there have been significant fluctuations in climate during the Holocene (approximately the past ten thousand years) (Tausch and Nowak 2000), and that these fluctuations have had major effects on disturbance regimes (Miller et al. 2001). Changes in hillslope processes, stream channel pattern and form, surface and groundwater interactions, and riparian vegetation composition and structure over time scales of hundreds of years have all been attributed to Holocene shifts in climate (Chambers et al. 1998; Miller et al. 2001). Perhaps more important from a management and restoration perspective is that the effects of these changes on hillslope processes and landforms have persisted for hundreds to thousands of years. For example, a shift from moister to drier conditions during the mid- to late-Holocene led to accelerated hillslope erosion, sediment deposition on alluvial fans and in valley bottoms, and a depletion of hillslope sediment supplies in upland watersheds of the central Great Basin (Miller et al. 2001). These climate-induced changes still influence geomorphic processes and, thus, channel pattern and form.

The failure of past restoration activities in semiarid riparian areas to meet desired goals has been attributed to a general lack of understanding of existing physical and biotic processes and the causes of disturbance (Elmore and Kauffman 1994; Kauffman et al. 1997; Goodwin et al. 1997), and to the use of small-scale, site-specific approaches that fail to consider watershed scale processes (Roper et al. 1997; Williams et al. 1997). Clearly, developing appropriate management and restoration approaches for riparian areas in the Great Basin requires an understanding of the responses of geomorphic, hydrologic, and biotic processes not only to natural and anthropogenic disturbances, but also to climate change. It also requires knowledge of these processes over sufficiently large temporal and spatial scales.

The Great Basin Ecosystem Management Project

In 1992, a USDA Forest Service Research ecosystem management project, "Restoring and Maintaining Sustainable Riparian Ecosystems," was initiated to address the problem of stream and riparian ecosystem degradation within the central Great Basin. The Great Basin Ecosystem Management (EM) Project uses an integrated, interdisciplinary approach to increase our understanding of the effects of climate change and anthropogenic disturbance on riparian areas, and to elucidate the connections among watershed and channel processes, hydrologic regimes, and riparian ecosystem dynamics. The EM Project is unique in that it addresses temporal scales ranging from the mid-Holocene to the present and spatial scales ranging from entire watersheds to localized stream reaches. The project's process-based and multiscaled approach is used to develop guidelines and methods for maintaining and restoring sustainable riparian ecosystems.

Definitions and Concepts

Ecosystem management uses ecological, economic, social, and managerial principles to maintain, restore, or create ecosystems that are capable of sustaining desired uses, products, values, and services over long time periods (modified from Overbay 1992). Thus, restoration is an integral component of contemporary ecosystem management. The Society for Ecological Restoration International's (SERI) definition of restoration is consistent with the concepts inherent in ecosystem management. Ecological restoration is defined by SERI as the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (Society for Ecological Restoration International 2002). Ecosystem management has focused on watershed and regional scales, regardless of ecological condition, and emphasized the need to include both larger spatial and longer temporal scales. In contrast, restoration ecology has focused on degraded, damaged, or destroyed ecosystems but increasingly recognizes the need to consider larger scales in developing viable restoration approaches (Naveh 1994; Hobbs and Harris 2001). At the core of both ecosystem management and restoration ecology is the concept of sustainability. Sustainable ecosystems, over the normal cycle of disturbance events, retain characteristic processes including hydrologic flux and storage, geomorphic processes, biogeochemical cycling and storage, and biological activity and production (modified from Chapin et al. 1996 and Christensen et al. 1996). Because riparian areas serve as the interface between upland and stream ecosystems, sustainable stream and riparian ecosystems exhibit physical, chemical, and biological linkages among their geomorphic, hydrologic, and biotic components (Gregory et al. 1991). Thus, for the purposes of this volume, managing and restoring riparian areas is defined as maintaining or reestablishing sustainable fluvial systems and riparian ecosystems that exhibit both characteristic processes and related biological, chemical, and physical linkages among system components (modified from National Research Council 1992). Inherent in this definition is the notion that sustainable ecosystems supply important ecosystem services.

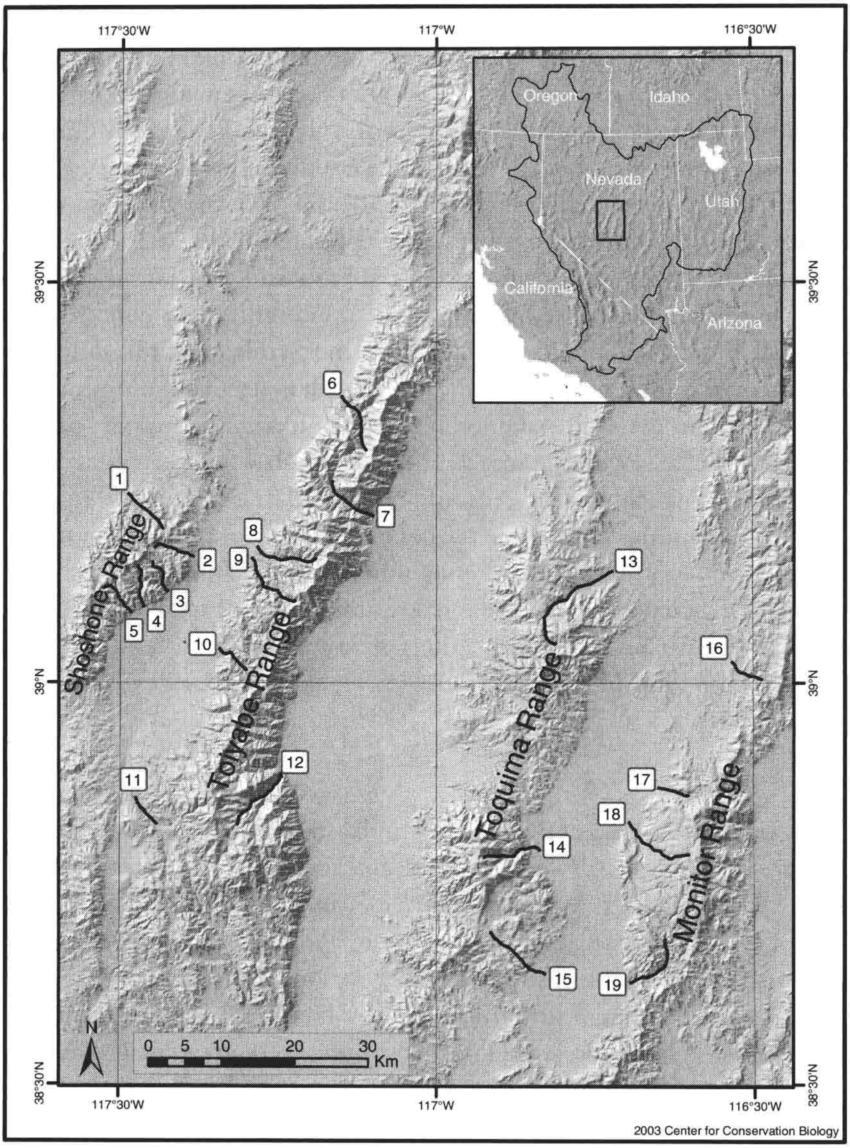

FIGURE 1.1. The distribution of the Great Basin in the western United States, and the locations of selected study watersheds in central Nevada: (1) Schoonnorer, (2) Underdown, (3) Riley, (4) Becker, (5) Barrett, (6) Big Creek, (7) Kingston, (8) Washington, (9) San Juan, (10) Marysville, (11) Upper Reese, (12) South Twin, (13) Stoneberger, (14) Pine, (15) Meadow Canyon, (16) Willow, (17) Morgan, (18) Mosquito, and (19) Barley.

To establish viable management and restoration goals, it is necessary to understand the current ecosystem or restoration potential. A frequent goal of both management and restoration has been to re-create and manage for the predisturbance condition (National Research Council 1992). In many cases, the predisturbance condition has been assumed to be the state of the stream or riparian ecosystem prior to European settlement. Several problems exist with this approach. First, we seldom understand the structure or processes of stream and riparian ecosystems prior to settlement. More important, using presettlement conditions as the goal of management or restoration assumes stable or equilibrium conditions over hundreds of years and ignores changes in stream processes and ecosystem dynamics due to changes in climate, hydrology, or land uses (Wade et al. 1998). A more realistic approach is to base management and restoration goals on the current potential of the streams and riparian ecosystems to support a given set of conditions. This approach requires an understanding of the types and magnitudes of biotic and abiotic thresholds that may have been crossed as a result of climate change or anthropogenic disturbance, and of the alternative states that currently exist for these systems (e.g., Hobbs and Norton 1996; Whisenant 1999; Hobbs and Harris 2001).

Objectives

The primary emphasis of the Great Basin EM Project has been on the geomorphic processes, hydrologic regimes, and vegetation dynamics of the systems. A parallel effort by the Nevada Biodiversity Initiative has examined the relationships among faunal distributions and the physical environment, and this volume includes an overview of various approaches for studying and managing faunal distributions in the Great Basin. The results of the EM Project that are presented in this volume were generated to accomplish the following series of interrelated objectives.

1. Reconstruct the vegetation and geomorphic history of central Great Basin watersheds to increase our understanding of the effects of past and present climate change on ecosystem processes.
2. Elucidate the underlying geomorphic and hydrologic processes that characterize the watersheds and riparian areas, and evaluate the effects of both past and present climate change and anthropogenic disturbance on these processes.