

# Ecosystem Management in the Madrean Archipelago: A 10-Year (1994-2004) Historical Perspective

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**Abstract**—The USDA Forest Service implemented a more holistic form of ecosystem management than previously practiced in the early 1990s through several ecosystem programs implemented in the Western United States. The ecosystem program that concerns this conference was a collaboration on “Achieving Ecosystem Management in the Borderlands of the Southwestern United States through Research and Management Partnerships” among researchers, managers, conservationists, and local landowners. Concurrent with initiation of this program was the first conference on “Sky Islands of the Madrean Archipelago,” which brought together stakeholders and other interested parties from government agencies, universities, and private organizations. This paper describes the evolution of this ecosystem management program from a historical perspective and discusses some of the resulting activities.

## Introduction

The concept of ecosystem management is not new, but its role as a central theme of natural resources management gained renewed interest and greater emphasis in the early 1990s. In response to this increased interest and emphasis, the USDA Forest Service and others initiated a variety of ecosystem programs throughout the Western United States. The program that concerns this conference was collaboration on “Achieving Ecosystem Management in the Borderlands of the Southwestern United States through Research and Management Partnerships” among researchers, managers, conservationists, and private landowners. Concurrent with initiation of this program was the first conference on “Sky Islands of the Madrean Archipelago,” which brought together interested stakeholders and other interested parties from government agencies, regional universities, and private organizations. This paper describes the implementation of ecosystem principles in the management of the Southwestern Borderlands of the United States and Mexico. Several milestone activities in the 10 years since the first conference are also described in the paper.

## Background Perspective

The “ecosystem” concept has evolved from one representing a relatively stable biological-physical entity into a more dynamic form representing constantly interacting biological and physical processes in both time and space. Incorporation of the biological-physical processes of the ecosystem into a management-oriented perspective has led to still more complex landscape systems consisting of social, political, and economic dimensions. The term “ecosystem management” was coined in the early 1990s when ecosystem theory was implemented by managers in response to increasingly complex real-world management issues. It has since become embedded in the decision-making of managers, policy-makers, and the general

public (Grumbine 1994). However, the term has also been used to describe a vague concept of land stewardship and, unfortunately, lacks a consistent definition among its users. It has been used interchangeably with terms such as “ecosystem health,” “ecosystem integrity,” and “ecosystem sustainability” adding to the confusion. In matter of fact, no single or unifying definition of ecosystem management has been universally accepted by researchers, managers, or decision-makers. Nevertheless, there are some common principles and concepts that are present in most definitions including:

- Ecosystem management represents a balance between the physical and biological features of ecosystems and people’s needs for ecosystem resources. Ecosystem management, therefore, requires a balancing of the natural system with anthropogenic effects and other external influences impacting of the system.
- Ecosystem management requires that the functions and processes of biodiversity and productive capacity of the ecosystem be considered together in decision-making. Implementation of ecosystem management also requires that the levels of degradation below which ecosystems cannot be sustained without losing vital attributes be identified and that these thresholds be known to decision-makers.
- An appreciation and acceptance of “losses” is an essential part of ecosystem management. It is inevitable that some losses in ecosystem resources will occur in meeting societal demands. Choices and trade-offs are required and, therefore, the costs and benefits of making these choices and trade-offs must be fully assessed.
- The scale of ecosystem management implementation varies widely in time and space and must be flexible enough to respond to changing management goals and objectives. No single temporal or spatial scale is adequate for managing all ecosystems.
- Adaptive management is an essential part of ecosystem management. The criteria and rules for this management

must be flexible enough to adapt to changing biophysical conditions, human behavior, and scientific advances.

## **Applying Ecosystem Management in the Madrean Archipelago Region**

The USDA Forest Service became interested in implementing the “more contemporary” concept of ecosystem management in the early 1990s to insure diverse, healthy, productive, and sustainable ecosystems and to protect or, if necessary, restore the integrity of the soil, air, and water resources, biological diversity, and ecological processes on National Forests and Grasslands (Vogt and others 1997). This approach was viewed by the USDA Forest Service as a means to manage ecosystem resources for present and future generations as a continuous flow of multiple benefits in a manner that was largely harmonious with ecosystem sustainability. As a result of this interest, 19 ecosystem management research projects were initiated by USDA Forest Service Research throughout the United States in 1994, one of which was the Southwestern Borderlands Project.

### ***Initiation of the Southwestern Borderlands Project***

The Rocky Mountain Research Station became actively involved in the program when it was awarded an ecosystem management grant to conduct research within the Southwestern Borderlands area and the Colorado Front Range, the Great Basin, the Bitterroot, and the Middle Rio Grande. The main objective the Southwestern Borderlands Project was to achieve responsible ecosystem management in the region through coordinated research and management partnerships involving both the public and private sectors. Much of the information to be gained from the project could then be extended to management of the larger Madrean Archipelago region of mostly isolated mountains known as “Sky Islands” separated from each other by “seas” of desert shrubs and grasslands. The project’s plan of action included the preparation of appropriate strategies for restoring natural processes; improving the productivity of grasslands, woodlands, and forests, providing critical wildlife habitats; and sustaining open landscapes, viable rural economies, and social structures (Edminster and Gottfried 1999). The two initial problem areas for the research effort were to:

- Provide the scientific basis to establish the desired future conditions for the region based on the integration of the highest quality biological-physical science with desired future social and economic conditions in the context of public and private partnerships.
- Combine a long-term program of basic and applied research and coordinated monitoring efforts with ongoing activities of other management agencies and not-for-profit private organizations to integrate past and future research findings into management and contribute to developing

guidelines for sustaining a variable rural economy and open landscapes.

Assembling and comprehensively reviewing the existing body of scientific knowledge pertaining to the Madrean Archipelago was the first major assignment of the newly created project. A large amount of research-based information on the biological, physical, and social dimensions of the region had been generated in the past, but this information had not been thoroughly collated for the necessary integrative analysis. The two approaches posed to bring this information together and make it available to the project’s participants and others were:

- Organizing a conference where local and regional experts were asked to present materials relating to all aspects of the Madrean Archipelago region.
- Entering into partnerships with knowledgeable investigators to synthesize information on topical areas having significant research and management planning applications.

The first approach led to the first conference of the Madrean Archipelago region entitled “Biodiversity and Management of the Madrean Archipelago: The Sky Islands of Southwestern United States and Northwestern Mexico,” held in Tucson, Arizona, on September 19-23, 1994. Many of the contributions achieved in undertaking the partnerships to bring known information together resulted in a series of milestone activities, some of which are described in this paper.

### ***Implementation of the Long-Term Research Program***

Concurrent with the initial information-collecting phase of the Southwestern Borderlands Project was the planning and implementation of a long-term, systematic program of both basic and applied research endeavors to enhance ecosystem management in the Madrean Archipelago region. The Rocky Mountain Research Station initiated numerous studies on its own but, more importantly, developed effective investigative partnerships with researchers and managers from other Federal and State agencies, universities, conservation organizations, and independent investigators. These partnerships provided the expertise necessary to address the wide array of questions that were considered fundamental to the level of “good ecosystem management” required to create and sustain healthy and productive landscapes. The willing exchange of ideas and information among the collaborators in these efforts has been one of the major forces in the 10-year success of the project. Of particular note has been the close collaboration with the Coronado National Forest, the Natural Resources Conservation Service, the Bureau of Land Management, the Universities of Arizona, New Mexico, and Oklahoma and other organizations in the public sector; and the Malpai Borderlands Group, the Animas Foundation, The Nature Conservancy, the Hadley Associates, the Desert Botanical Garden, and other not-for-profit organizations in the private sector. Many of the accomplishments and contributions that have evolved from these partnerships are presented in these proceedings.

## Milestone Activities

There have been a large number of activities that have resulted in significant contributions to the level of knowledge relative to ecosystem management in the Madrean Archipelago region since publication of the proceedings of the first conference (DeBano and others 1995). While not intended to be complete, some of the more significant of these milestone collaborative activities are summarized below.

### *Symposia, Conferences, and Meetings*

A symposium on the “Desired Future Conditions of Southwestern Riparian Ecosystems: Bringing Interest and Concerns Together” provided another forum for researchers, managers, conservationists, and representatives from the private sector to come together and share their findings, ideas, and visions for managing, conserving, and restoring degraded riparian ecosystems in the Southwestern United States including the Madrean Archipelago region (Shaw and Finch 1996). This symposium, held in Albuquerque, New Mexico, from September 18-22, 1995, addressed a variety of topics on hydrology and ecology; human history, values, and needs; and desired future conditions for these fragile ecosystems. It became evident that people were acknowledging and managing the region’s landscapes in the context of humans being integral and influential components of riparian ecosystems by incorporating their needs, effects, and conflicts into more comprehensive management endeavors.

Researchers, managers, and resource specialists from government agencies, universities, and the private sector came together in a second conference (symposium) focusing specifically on the Madrean Archipelago ecosystems, entitled “Effects of Fire on Madrean Province Ecosystems,” to learn about the effects of fire on ecosystem resources and how fire might be incorporated into a more holistic ecosystem approach to both research and management of these resources (Ffolliott and others 1996). Oral and poster papers on the management implications of the effects of fire on the ecosystems’ resources; the varying socio-political perspectives of fire; and fire management issues of interest to different stakeholders were presented at the conference held in Tucson, Arizona, on March 11-15, 1996. The concluding presentation considered the benefits, concerns, and constraints relative to the future use of fire in the region.

The National Park Service and its cooperators continue to organize biannual conferences on “Research and Resource Management in Southern Arizona Parks and Neighboring Lands,” with this conference on “Connecting the Mountain Islands and Desert Seas” in the Madrean Archipelago representing the fifth in the series. These conferences, all of which have been held in Tucson, Arizona, allow a diversity of attendees to learn about asking the right questions on research and resource management issues; gathering and processing relevant data sets and other information; effectively communicating findings; and guiding the application of results. The first conference, held May 15-17, 1996, sought to highlight and explore the relationships between National Park Service resources and those on neighboring lands and between researchers, resource

managers, and the public (Tibbitts and Maender 1998). The following conferences had more specific themes. The second conference, held May 5-7, 1998, focused mostly on a century of research and resource management in the parks of Arizona and neighboring lands (Benson and Gebow 1999); the third conference, held May 16-18, 2000, reviewed the creativeness of cooperation and collaboration in research endeavors and resources management of these lands (Halverson and Gebow 2000), and the fourth conference, held May 15-17, 2002, addressed the research and resource management information needs of these lands (Halverson and Gebow 2002).

The fragile grassland ecosystems of the Madrean Archipelago region face continuing threats from spreading urbanization; habitat fragmentation resulting from development of rural housing; ecological impacts of invasive plant species; and conflicts over livestock grazing policies. Therefore, a conference on the “Future of Arid Grasslands: Identifying Issues, Seeking Solutions,” was held in Tucson, Arizona, October 9-13, 1996, to provide a platform for private and public stakeholders to thoroughly discuss these problems and their possible resolutions in a non-confrontational manner (Tellman and others 1998). The targeted groups of attendees were ranchers and other private landowners, not-for-profit private organizations; representatives of government agencies with responsibilities for land stewardship in the region; and environmental advocates, researchers, and students.

More than 150 researchers, managers, and food producers were brought together in a symposium on the “Utilization and Conservation of Wild Flora in the Arid Zones of Northwestern Mexico and the Southwestern United States” to review utilization and conservation strategies for the often fragile flora inhabiting the arid and semiarid ecosystems of Northwestern Mexico and the Southwestern United States region (Vasquez del Castillo and others 1999). This symposium was organized by the University of Sonora and held in Hermosillo, March 4-6, 1998. Formal presentations and informal discussions allowed the diverse group of attendees to review and evaluate the status-of-knowledge (at the time) relative to the symposium’s theme and, in doing so, provide a basis to plan for future collaborative efforts that will benefit both countries. Ecosystem conservation, sustainable use of resources, and proper management of the indigenous flora were stressed throughout the symposium.

A conference on “Cross Border Waters: Fragile Treasures for the 21<sup>st</sup> Century” held in Tucson, Arizona, June 3-6, 1998, represented the continuation of earlier forums on the exchange of scientific information, sharing of common concerns, and bilateral cooperation between Mexico and the United States for environmentally sound natural and cultural resource management (Gottfried and others 1998). Attendees identified issues affecting the management of wildlife and recreation areas; increased awareness of issues facing the border States on protection of the environment and utilization of valued cultural resources; and developed networks among resource managers, educational institutions, and policy-makers to better manage the binational resources.

A meeting entitled “Toward Integrated Research, Land Management, and Ecosystem Protection in the Malpai Borderlands,” was held in Douglas, Arizona, January 6-8, 1999,

to inform scientific communities, land management agencies, and local stakeholders of the progress made in the research studies and resources inventories of the Rocky Mountain Research Station's partnerships with researchers and managers from universities, public agencies, not-for-profit conservation organizations, and independent investigators in the mentioned "Southwestern Borderlands Ecosystem Management Project" in developing the necessary science base for this purpose (Gottfried and others 1999). Among the topics considered were species ecology and management, resource inventories, landscape changes, and anticipated future directions in the sciences and resource programs Southwestern Borderlands Project and, more generally, the Madrean Archipelago.

The accomplishments and contributions of the Santa Rita Experimental Range, the longest continuously operated research area dedicated to the sustainable management of North American rangelands, were celebrated in a conference held in Tucson, Arizona, October 30-November 1, 2003. The conference proceedings, entitled the "Santa Rita Experimental Range: 100 Years (1903 to 2003) of Accomplishments and Contributions," consist of a series of synthesis papers on significant research findings relative to vegetation and livestock management practices, wildlife ecology and management, hydrology and soil erosion, and historical trends and recent flora on the Santa Rita Experimental Range (McClaran and others 2003). These syntheses were expanded by reporting on recently completed or ongoing research on Santa Rita.

## **Publications**

Ecologically fragile desert grasslands are found in the basins and valleys that skirt the mountain ranges and hills of the Madrean Archipelago. A comprehensive book appropriately entitled "The Desert Grassland" tells the story of the closely tied but also surprisingly independent soil features, landforms, and plants and animals that inhabit this often threatened ecosystem (McClaran and Van Devender 1995). How the frequency and intensity of fire can influence the present flora and fauna and how humans from Amerindians to contemporary ranchers, public land managers, and real estate developers have changed the relative abundance of indigenous species are described. A review of attempts to re-establish native forage plants where overgrazing, drought, farm abandonment, and increased densities of invasive plants have occurred concludes the book.

Interest in the holistic philosophy of ecosystem management led the USDA Forest Service to supported a study of past land use in the San Rafael Valley on the southern slopes of the Huachuca Mountains in southeastern Arizona. To better understand the cumulative impacts of people on the general area, a historical chronology of human occupation of the valley has been presented in a publication on the "Land Use History of the San Rafael Valley, Arizona (1540-1960)." A focus of this publication by Hadley and Sheridan (1995) is placed on natural resources use and an analysis of the impacts of historic land-use practices from Euroamerican contact to the twentieth century. The USDA Forest Service simultaneously sponsored a series of studies on the climatic patterns, soils and hydrology, and vegetation and wildlife in the area to obtain a more complete

ecological picture of this unique setting (see Morrison and others 1997; Ffolliott and others 1996, 1999; McPherson and Weltzin 2000; and others).

While violent thunderstorms often sweep over the mountains of the Madrean Archipelago, no storm has ever been as fierce as that expressed by the opposition to the telescope installations on Mt. Graham. These installations roused little interest when first proposed in the early 1980s, but they came to represent a threat to many environmentalists and the desecration of sacred land to some Native Americans. Controversy aside, a book entitled "Storm Over a Mountain: Conservation Biology and the Mt. Graham Affair," represents a significant contribution to the knowledge of conservation biology on Mt. Graham and, more generally, throughout the Pinaleno Mountains (Istock and Hoffmann 1995). Contributors in the fields of astronomy, botany, biogeography, and genetics examined the purpose and promise of the ground-based observatories; the forest structure of the Pinalenos and its history; the past and present biogeographical basis for conservation of the Pinalenos; and the vulnerability to extinction of isolated species such as the Mt. Graham red squirrel.

Information on the taxonomic affiliations, geographic distributions, natural history and ecology, conservation and management, and ongoing studies on birds, mammals, and amphibians and reptiles is presented in a review of the "Literature on Wildlife Research in the Madrean Archipelago: 1800s-1994" by Morrison and others (1997). The references contained in this comprehensive literature search have furnished a key input to the development and subsequent prioritization of research plans that integrate the environmental factors that influence wildlife resources in the region. Early investigative works (1800s to 1960) concentrated on determining what species occurred in the borderlands. The majority of more current literature concerns varying aspects of ecology without particular emphasis on any specific topic. Abstracts and comments by the compilers are included with the cited references.

A literature base for planning broadly structured, ecosystem-based research and management activities in the Madrean Archipelago has been compiled online in "A Bibliography for the Northern Madrean Biogeographic Province" by Ffolliott and others (1999). Citations in the bibliography are listed by author(s) in the subject-matter headings of conservation and management, fire and fire effects, history of land use, human impacts, hydrology and watershed management, range management and livestock grazing, recreation and tourism, and plant, vertebrate, and invertebrate ecology. A listing of the over 5,000 items is available on the Web site <http://ag.arizona.edu/OALS/watershed/index.html> maintained by the Office of Arid Land Studies at the University of Arizona and the USDA Forest Service.

Contributors to a book on the "Ecology and Management of Forests, Woodlands, and Shrublands in the Dry Regions of the United States and Mexico: Perspectives for the 21<sup>st</sup> Century" examined the ecological relationships, historical and present-day land-use patterns, and natural resources management practices in the forests, woodlands, and shrublands of this arid and semiarid region (Ffolliott and Ortega-Rubio 1999). Many of the ecosystems of interest and concern to people on

both sides of the border area are considered in this review, including montane forests, pinyon-juniper and encinal (oak) woodlands, sclerophyllous communities, and mesquite ecosystems. This book presents the available knowledge (at the time) in a perspective that furnishes a basis for the conservation and sustainable use of the natural resources in the region into the 21<sup>st</sup> century.

The main effects of disturbance factors and climate change on plant communities in the borderlands region have been evaluated in a literature review by McPherson and Weltzin (2000) entitled "Disturbance and Climate Change in United States-Mexico Borderland Plant Communities." A focus of this review is placed on the physiognomic-level changes of the woodlands and grasslands of southeastern Arizona and southwestern New Mexico. It is apparent that the observed changes in vegetation physiognomy have broad implications for management and land use in the borderlands. Much of this knowledge is derived from descriptive research having value for documenting changes in vegetation and identifying explanations for these changes.

As a follow-up to the keystone book on "The Changing Mile" by Hastings and Turner (1965), Turner and others (2003) have recently authored a sequel entitled "The Changing Mile Revisited" that contains repeat photography of earlier reference sites and accompanying descriptions. The sub-title of this book, "an ecological study of vegetation change with time in the lower mile of an arid and semi-arid region," is indicative of its main contribution to the status of ecological knowledge on both sides of the border of the Madrean Archipelago region. Both of these books contain baseline information to further people's understanding of desert ecology and their appreciation of vegetation dynamics of the Arizona-Mexico borderlands.

## Conclusions

Much of what has been accomplished relative to ecosystem management in the Madrean Archipelago region in the past 10 years forms a sound basis for continuing the collaborative investigations necessary to achieve effective, efficient, and responsible ecosystem management. The partnerships and other relationships that have been forged among researchers, managers, ranchers, and environmentalists in tackling the challenges put forth in the early 1990s to ensure that diverse, healthy, and productive ecosystems are largely responsible for the successes achieved to date. There is every reason to believe that these partnerships and other collaborative efforts will also be sustained in the future to the benefit of the people of the region.

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