

Closing Remarks:

Biodiversity and Management of the Madrean Archipelago II: Summary of Discussions During the Concluding Session

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Abstract—The first Conference on Biodiversity and Management of the Madrean Archipelago brought together scientists, managers, and other interested parties from the United States and Mexico to share their knowledge about the region and to identify the needs and possible solutions for the future. The 1994 conference ended with an open discussion among the participants. The conference in 2004 had a similar goal and also concluded with an open forum. Participants discussed past and present accomplishments and the need for increased partnerships, especially among parties in the southwestern United States and northwestern Mexico, growing urban populations, and rural and American Indian communities. We recognized the gaps in our knowledge and major issues and opportunities for the future. All interested groups need to increase efforts to exchange information. Some of the major issues concerned the impacts of landscape fragmentation, management of water resources, and the role of fire in ecosystem management. Communications, cooperation, and technology transfers throughout the greater region should make the common goals of sustained biodiversity and ecosystem health more attainable in the Madrean Archipelago.

Resumen—La primera Conferencia sobre Biodiversidad y manejo del Archipiélago Madreño reunió científicos, supervisores, y otros grupos interesados de Estados Unidos y México para compartir sus conocimientos sobre la región y para identificar las necesidades y las posibles soluciones en el futuro. La conferencia de 1994 terminó con una discusión abierta entre los participantes. La conferencia en el 2004 tenía una meta similar y también concluyó con un foro abierto. Los participantes discutieron sobre logros actuales y pasados y sobre la necesidad de incrementar el número de consorcios, especialmente entre grupos en el sudoeste de los Estados Unidos y en el noroeste de México, poblaciones urbanas y comunidades rurales y tribus Norteamericanas. Hemos Reconocido los huecos en nuestro conocimiento, los asuntos principales y oportunidades importantes en el futuro. Todos los grupos interesados necesitan aumentar sus esfuerzos para intercambiar información. Algunos de los temas principales se refirieron a los impactos de la fragmentación del paisaje, al manejo del agua y al papel de los incendios en la manejo de ecosistemas. La comunicación, la cooperación, y las transferencias de tecnología a través de la región mayor deben hacer que las metas comunes de biodiversidad sustentable y salud del ecosistema sean más alcanzables en el Archipiélago Madreño.

Introduction

The Madrean Archipelago or Sky Island region of the Southwestern United States and Northwestern Mexico is recognized for its great biodiversity and natural beauty. The biological diversity of the region arises from its characteristic network of mountain ranges or “islands” separated by valley grassland or desert scrub and to its location between the main Sierra Madre Occidental and Rocky Mountain Biogeographical regions. The uniqueness of the region and the interest in its future has fostered numerous and diverse research projects throughout the years, and required land management to address the needs of maintaining biodiversity and healthy ecosystems. The same regional characteristics have fostered a number of advocacy organizations dedicated to protecting the region’s natural and aesthetic resources.

One objective of the 1994 conference (DeBano and others 1995) was to bring together scientists, managers, and other interested individuals from the United States and Mexico to share their collective knowledge about the region, and to look ahead to the needs and possible solutions for the future. The conference, by assembling a large number of interested and dedicated people, helped shape research in the Madrean Archipelago for the past ten years. A general discussion at its conclusion considered the current state-of-knowledge and possible future directions of research and management in the Madrean Archipelago. These discussions were summarized by DeBano and Ffolliott (1995).

The 2004 conference represented a 10-year update on the Madrean Archipelago. Approximately 160 oral and poster presentations covered many of the critical issues for understanding and managing the region. Sessions covered biogeography, the role of fire, hydrology and water resources, ecology, invasive species, ecosystem monitoring, conservation planning and practice, and global climate change. The proceedings of the conference reflect the present status of knowledge on a large, but not necessarily all-inclusive, variety of relevant ecological and managerial topics.

The closing session in 2004 followed the same open discussion format that was used at the conclusion of the 1994 conference. The session was moderated by Thomas Van Devender and Laura Arriaga who presented overviews of the conference and changes in the state of regional knowledge since 1994. Daniel Neary then facilitated the open forum among the 90 plus attendees. Neary started the discussions by posing several questions including three suggested by Dale Turner of the The Nature Conservancy, Tucson, Arizona:

- “As a land manager, what knowledge would help you do your job better?”
- “As a researcher, what management questions can you help answer?”
- “As an activist, what can you contribute to improving conditions on the land?”

A summary of these discussions and comments is presented in this paper. The authors have rearranged the contents of the dialogue among participants to provide a logical flow to this paper. This summary is not all encompassing but rather largely reflects the opinions of the participants in the closing session.

Past and Present Accomplishments

The 1994 conference and the resulting proceedings inspired much of the research that was presented at the 2004 meeting. DeBano and Ffolliott (this proceedings) summarized many of the accomplishments during the past 10 years in the opening paper of this conference. A noticeable difference at the current conference was a greater emphasis on conservation in both the United States and Mexico and less on inventory and distribution information. Likewise, important studies concerning ecological phenomena over long temporal and large spatial scales were presented. Databases have developed and are continuing to grow as more information about the region becomes available. Examples of the evolving knowledge about the Madrean Archipelago region in southern Arizona include the floristic studies of Steven McLaughlin of the University of Arizona and Donald Pinkava and his students at Arizona State University, and the herpetological studies of Cecil Schwalbe and his associates from the U.S. Geological Survey and the University of Arizona. Several important books and publications printed since 1994 have contributed to the general knowledge of the region; the botanical and ecological works of Raymond Turner and others (1995, 2003), Felger and others (2000a, b), Paredes and others (2000), and Tellman (2002) are excellent examples. Russell and Monson (1998) have similarly contributed to our knowledge of the birds of Sonora. A number of conferences since 1994 have emphasized specific topics such as the future of arid grasslands and the effects of fire in Madrean ecosystems (DeBano and Ffolliott, this proceedings).

Much more baseline inventory information remains to be collected for Northwestern Mexico. The taxonomic databases compiled by the Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) represent a noteworthy advance to achieve this baseline (Arriaga and others, this proceedings), but more local efforts are needed to complete regional biotas. Although a preliminary list of the flora of the Sierra de los Ajos in Sonora has been published, the distribution of plants and animals in many areas are very poorly known. Increased knowledge of species distributions will help revise the official lists of threatened, endangered, and sensitive (TES) species in Mexico. Collaboration between institutions and individuals in the United States and Mexico is increasing and should contribute to progress in filling information gaps related to the flora and fauna in Sonora. Additional investigation will ensure a larger regional effort for correcting the disparate state of knowledge found on the two sides of the border.

The impression ten years ago was that biodiversity in the Madrean Archipelago was rapidly eroding and that we had to act quickly to protect valuable resources. Regrettably, biodiversity is still declining as deforestation and landscape fragmentation continue. An issue arising during the past ten years is the concern about the spread of non-native invasive plants and animals and their impacts on the biological diversity of the region. Conservation and remediation of degraded or fragile ecosystems would be easier and more successful if adequate baseline information was available to managers in all areas.

Partnerships

It is important to build partnerships among the interested individuals and organizations to achieve the goals of sustained biodiversity in the Madrean Archipelago. An advantage of a conference is that it provides a vehicle for bringing people together for the interchange of ideas. Everyone and everything is tied to the environment, so we need to build bridges that connect all of us—ranchers and other private land owners, governmental agencies, universities, and environmental organizations. Improved and continuous communications among interested parties should result in less duplication of efforts and energy consumed in litigation among agencies, universities, and non-governmental organizations. Increased contacts between scientists and managers are vital so that new information is incorporated into management plans and the research community is aware of management's information needs. A more holistic viewpoint can alleviate the frequently encountered problems between urban and rural social-economic-political-institutional communications. We need to increase outreach and interpretation efforts to inform the growing and politically powerful urban populations in Arizona and elsewhere in the region about the values of maintaining and protecting biodiversity in the region. This population has an obvious impact on the land because of its occupation of the valleys and the need for quality recreation in the nearby mountains.

Outreach activities directed at rural communities should be sensitive to the effects of management decisions on livelihoods and social structure. The American Indian's traditional perspective on land management, resource use, ecology, and historical conditions of the land should be included. Knowledge gained by centuries of observation by indigenous peoples and their cultural histories has much to offer to the discussion of our region's future. Long-time ranchers and rural residents also have insights about natural processes that can contribute to our knowledge of biodiversity. Advocates for the "Sky Islands" must learn to be effective storytellers to reach the diverse populations within the region.

Opportunities for partnerships exist in the Metropolitan Tucson area that could have wide implications throughout the region. Both the Coronado National Forest and the Saguaro National Park will revise their land management plans in the near future, and have invited the public to participate in the process and share their knowledge and concerns with the agencies. The public should take advantage of these opportunities to work within our political, social, and legal systems to protect important resources. The plans will build on the foundations created by the information provided by the 1994 and 2004 conferences. Pima County's Sonoran Desert Conservation Plan and the USDI Bureau of Land Management's planning for the new Ironwood Forest National Monument are other examples of partnerships for land management planning.

Partnerships between the United States and Mexico are particularly important and, indeed, critical for the sound management of the diverse ecosystems of the Madrean Archipelago. Our diverse ecosystems are not separated by fences. It is necessary to think on a regional and where appropriate, larger scale in planning management and scientific

efforts. Excellent examples of cross-border cooperation are the partnership between The Nature Conservancy and the Instituto del Medio Ambiente y el Desarrollo Sustentable del Estado de Sonora to identify conservation priorities and strategies for the Apache Highlands Ecoregion (D. Turner and others, this proceedings) and the partnership between the Comisión Nacional de Áreas Naturales Protegidas and the Sonoran Institute to monitor changes in biodiversity in the Sonoran Desert on both sides of the border. The Desert Southwest Cooperative Ecosystem Studies Unit is another example of a cooperative effort. The Unit was established to facilitate collaborative research, education, and technical assistance to address desert resource issues, and includes representatives from several Federal agencies with land management or research responsibilities, seven universities from the United States and northern Mexico, and nongovernmental organizations.

Increased information and technology transfers and exchanges among scientists and managers in both countries would benefit all parties. A recurring problem is the expense for Mexican colleagues to travel to meetings in the United States; holding a future conference at the Universidad de Sonora in Hermosillo would benefit the exchange process.

This conference brought to light much of the work that is underway on both sides of the border. However, workers in both countries remain unaware of research being conducted in their own backyards. A directory of people working on both sides of the international border and their areas of interest would facilitate cooperation. Scientists should also be more aggressive in identifying funding opportunities and in submitting proposals for joint U.S./Mexico research endeavors. We could work together to complete the inventories of the fauna and flora of Sonora and adjacent Chihuahua that can be used in making wise management decisions. Data and other information about TES species in Mexico would aid the understanding of species habitat requirements, the consequences of land management practices, and formulating of management decisions in the United States and Mexico.

Participants from the United States expressed concerns about the process of acquiring permits for research in Mexico and interest in the feasibility of developing a structure to make the permit process easier. However, others viewed the permit process as a way to enhance cooperation since required data sharing and collaboration may make the project results worthwhile for everyone. The permit issue is a legal question, not a scientific one. A booklet on Mexican laws, regulations, and permit procedures could provide guidelines for success. Participants must be sensitive to the fact that conservation and research must consider culture; the framework for working in Mexico is different from that in the United States. Science should be holistic, considering people and their institutions clearly within an ecosystem framework. Technologies developed in the United States cannot be blindly transferred to Mexico without considering the biophysical and socioeconomic environment of Mexico (DeBano and Ffolliott 1995).

There are 20 Sky Island complexes that occur on every continent throughout the world except Australia (Warshall 1995). Ecosystems in the Sky Islands of the adjacent Great

Basin in the Western United States, for example, have been impacted by other sets of dynamics over time. Scientists and managers who work in similar regions throughout the world might have insights and knowledge that could benefit their colleagues working in the Madrean Archipelago. Hence, an international Sky Island conference would bring interested parties together to compare and contrast their respective knowledge and perspectives.

Gaps in Knowledge

Information Technology

While the knowledge about the many faceted resources of the Madrean Archipelago has increased over the past ten years (DeBano and Ffolliott, this proceedings), many gaps still remain. Conference participants identified many concerns about improving access to information relevant to the Madrean Archipelago. A suggestion was made to develop a web site for those working in the region that includes a link to existing Sky Island literature. The Rocky Mountain Research Station developed an annotated bibliography for the Madrean Archipelago (Ffolliott and others 1999) that is posted on one of the Station's Web sites (www.rmrs.nau.edu/publications/madrean/). However, the bibliography requires regular updating with current literature, and its existence should be advertised to potential users. A common framework for inventory and monitoring activities and data acquisition and storage protocols would enhance research and management across agency and university entities. Such a clearinghouse could prevent expensive duplications of efforts within the region. Another method to reduce duplication and to enhance cooperation is to develop an atlas of sites where researchers are conducting projects or where research has been conducted in the past with the appropriate literature citations. A "chat room" to exchange information and to discuss questions and answers also would help facilitate contacts among interested parties.

While the availability and technology of computerized databases have improved over the past ten years, more needs to be done. These databases still lack information about keystone subject matter areas. An important example is the scarcity of general ecological information about indigenous and invasive herpetofauna. It is difficult to manage for ecosystem diversity without baseline information (DeBano and Ffolliott 1995). Current databases are also incomplete with respect to expressions of ecosystem degradation and fragmentation, conservation of key genetic flows, structural gap analyses, large-scale watershed conditions and hydrologic changes attributed to land use, market and non-market resource responses, and ecosystem management actions. Improved computerized databases containing information from well-studied sites in the United States can be transferred to facilitate cost-effective efforts to solve problems on less studied sites in both the United States and Mexico, although such transfers must recognize the inherent differences and similarities among sites.

Major Issues and Opportunities for the Future

The forest, woodland, and grassland vegetation on the mountains and plateaus throughout the Western United States and Northwestern Mexico are at risk because of the combined forces of extended drought and climate change, insects, fire, diseases, and non-native invasive species, and the impacts of past management and human development. Major ecosystem shifts will result if the current conditions persist, with the possible regional extinctions of some species and communities (Lynch, this proceedings; Swetnam, this proceedings). How should managers respond to the situation? What is the balance between management for natural resource commodities and sustaining ecosystem health? Can the scientific community provide ecological and climatological data for necessary adaptive management? Will adaptive management practices work? What are the effects of changes on adjacent regions and how do they affect the Madrean Archipelago? Can we extrapolate regionally from how people respond to local changes or vice versa? We need to summarize and analyze the historical weather and hydrological records in the region to establish a baseline for evaluating the current changes and predicting future changes. Historic information on vegetation changes during similar periods of drought and insects could help us plan for the current challenges.

The population of the region is growing and spreading into the valleys and mountains. These developments fragment open landscapes, provide conduits for non-native invasive species, block traditional animal migration routes, influence the diversity of animals on the land, increase the demands on often limited water resources, and influence the socio-economic patterns of rural communities. What can be done to mitigate this undermining of so many of the region's desirable attributes? It can be difficult for ranchers to refuse to sell their land when their economic sustainability is in question. There is a need for research to evaluate the impacts of fragmentation on the region's resources and to evaluate potential ecological and political compromises that would reduce its impacts.

Watershed hydrology and condition, riparian ecosystems, and water resources are critical issues in the region and will grow in importance as the population continues to increase in the face of periodic and often prolonged droughts. The climate in the region is variable and extended periods of drought have occurred over pre-historic and historic times (Betancourt, this proceedings). Some critical questions are:

- How will the scientific community respond and contribute to issues related to global climatic change in the region?
- How will possible water diversions and aquifer mining affect the fauna and flora, especially in important riparian communities?
- Is the reuse of water feasible on a large scale and how will this affect native ecosystems?
- How many people can the region support?
- Can scientists assist government with the related political and economic considerations?
- Should there be active management areas (AMA) or compatible delineations for water resources in rural areas?

- How will human activities and the climate variability modify our natural environment?
- What are the trade-offs in ecosystem management and how can the system be modified to adjust to change?

Fire was a natural force in many of the forest, woodland, and grassland communities of the Madrean Archipelago prior to Euro-American settlement (Swetnam, this proceedings). However, fire frequencies and characteristics have been altered because of past livestock grazing practices that removed a significant portion of the fire-carrying herbaceous vegetation and by past aggressive fire suppression policies of governmental agencies. Moratoriums on harvesting and thinning in the mountain forests and fire suppression activities have resulted in overcrowded stands of trees that are susceptible to insects and diseases and to stand-replacing wildfires. Mountain communities, which are at risk during wildfires, have expanded as the regional population continues to grow. Managers are faced with problems of protecting the growing wildland-urban-interface areas around these communities and the limited access routes to them. Agencies, often with support of private organizations, are attempting to reintroduce fire into many of the ecosystems in the Madrean Archipelago. We need to refine the knowledge of how to use fire wisely, how to speed up the approval process, and how the reintroduction of fire affects the ecosystems. A related issue is how should the region's forests and woodlands be managed to reduce the threats of destructive natural forces and still maintain biological diversity and healthy conditions within the ecosystems?

More collaboration with evolutionary biologists and managers will improve restoration efforts. We need to take a longer term view relative to genetic diversity, gene flows, and effective population size and their dynamics. There should be a greater emphasis on species interactions with their environments and less on the study of single species.

Additional information from the Mexican portion of the region will fill gaps in our knowledge of the floras and faunas of the Madrean Archipelago. The classic work by Marshall (1957) provided valuable information about the bird species and plant community composition in the pine-oak woodlands of southern Arizona and adjacent Mexico. Similar research is needed to increase the understanding of vertebrate and invertebrate community structures. Migration dynamics of indigenous and non-native species throughout the region have not been thoroughly studied.

Conclusions

A wide range of new and relevant information on the biodiversity and management of the Madrean Archipelago of the Southwestern United States and northern Mexico was presented at this conference. The conference has the potential of playing a similar role as the 1994 conference by providing a basis for planning future research and management agendas in the region. The conference provided a medium for communications among a diverse group of interested individuals, representing a variety of institutions from within the Southwest United States and neighboring Mexico. A follow-up conference on common ecological and managerial issues held in Mexico

would enhance the opportunities for a wider group of stakeholders to participate in the established dialogue.

The Madrean Archipelago faces problems that are linked to natural events related to climate variability and some that are related to the consequences of past and present human activities. In 1995, DeBano and Ffolliott stated that building a consensus on the central goals and priorities of research and management will be necessary to confront region's challenges. The need for consensus holds today. Communications, cooperation, and technology transfers throughout the greater region should make the common goals of sustained biodiversity and ecosystem health more attainable in the Madrean Archipelago.

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References

- DeBano, Leonard F.; Ffolliott, Peter F. 1995. The Sky Island conference: looking back, looking forward. In: DeBano, Leonard F.; Ffolliott, Peter F.; Ortega-Rubio, Alfredo; Gottfried, Gerald J.; Hamre, Robert H.; Edminster, Carleton B., tech. cords. 1995. Biodiversity and management of the Madrean Archipelago: the Sky Islands of the Southwestern United States and Northwestern Mexico. Gen. Tech. Rep. RM-GTR-264. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 1-5.
- DeBano, Leonard F.; Ffolliott, Peter F.; Ortega-Rubio, Alfredo; Gottfried, Gerald J.; Hamre, Robert H.; Edminster, Carleton B., tech. cords. 1995. Biodiversity and management of the Madrean Archipelago: the Sky Islands of the Southwestern United States and Northwestern Mexico. Gen. Tech. Rep. RM-GTR-264. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 669 p.
- Felger, Richard S. 2001. Flora of the Gran Desierto and the Rio Colorado of Northwestern Mexico. Tucson: University of Arizona Press.
- Felger, Richard S.; Johnson, Matthew B.; Wilson, Michael F. 2000. The trees of Sonora. New York: Oxford University Press.
- Ffolliott, Peter F.; DeBano, Leonard F.; Gottfried, Gerald J.; Huebner, Daniel P.; Edminster, Carleton B., comps. 1999. A bibliography for the northern Madrean Biogeographic Province. Res. Note RMRS-RN-7. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 3 p.
- Marshall, Joseph T., Jr. 1957 Birds of the pine-oak woodland in southern Arizona and adjacent Mexico. Pacific Coast Avifauna 22. Berkeley, CA: Cooper Ornithological Society.
- Paredes A.; Rafaela Thomas; R. Van Devender; Richard Felger. 2000. Cactáceas de Sonora: su Diversidad, Uso y Conservación. Tucson: Arizona-Sonora Desert Museum Press.
- Russell, S. M.; G. Monson. 1998. The birds of Sonora. Tucson: University of Arizona Press.
- Tellman, Barbara, ed. 2002. Invasive exotic species in the Sonoran Desert Region. Tucson: University of Arizona Press.
- Turner, Raymond M.; Janice E. Bowers; Tony L. Burgess. 1995. Sonoran Desert plants. An ecological atlas. Tucson: University of Arizona Press.

- Turner, Raymond M.; Webb, Robert H.; Bowers, Janice E.; Hastings, James Rodney. 2003. The changing mile revisited. Tucson: University of Arizona Press. 334 p.
- Warshall, Peter. 1995. The Madrean Sky Island Archipelago: a planetary overview. In: DeBano, Leonard F.; Ffolliott, Peter F.; Ortega-Rubio, Alfredo; Gottfried, Gerald J.; Hamre, Robert H.; Edminster, Carleton B., tech. cords. 1995. Biodiversity and management of the Madrean Archipelago: the Sky Islands of the Southwestern United States and Northwestern Mexico. Gen. Tech. Rep. RM-GTR-264. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 6-18.