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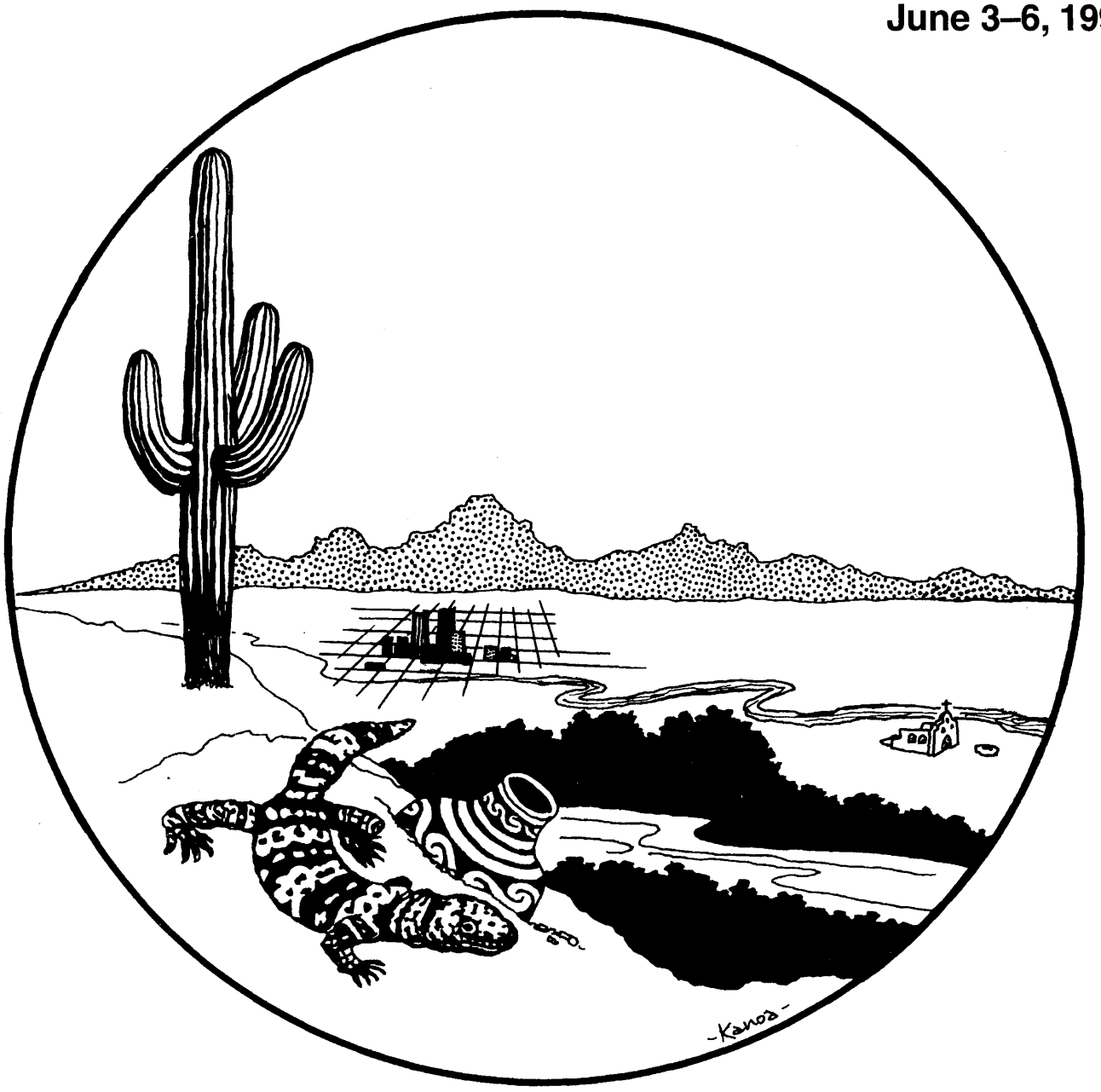
December 1998

Cross Border Waters: Fragile Treasures for the 21st Century

Ninth U.S./Mexico Border States Conference on Recreation, Parks, and Wildlife

Tucson, Arizona

June 3–6, 1998



Abstract

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This conference brought together scientists and resource managers from government, universities, and private organizations in the United States and Mexico. In a continuing international forum, participants exchanged information on existing or potential cooperative projects, agency functions and programs, and issues were concerning natural and cultural resource management in the border states. The sessions addressed: ecotourism, recreation and partnerships, wildlife biology and management, wetlands and watersheds, flora and vegetation, environmental education, cultural resources; water resources, fisheries, and protection and conservation. These proceedings contain 26 papers and abstracts, usually in English and Spanish, for the other presentations.

Keywords: U.S./Mexico border states, recreation, parks, wildlife, natural resources, cultural resources

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Cross Border Waters: Fragile Treasures for the 21st Century

Ninth U.S./Mexico Border States Conference on Recreation, Parks, and Wildlife

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INTRODUCTION

Cross Border Waters: Fragile Treasures for the 21st Century

Ninth U.S./Mexico Border States Conference on Recreation, Parks, and Wildlife:

June 3–6, 1998

Tucson, Arizona

PURPOSE OF CONFERENCE

To provide the continuation of an international forum for the exchange of information, sharing of common concerns, and discussion on the international cooperation for natural and cultural resource management between Mexico and the United States.

CONFERENCE OBJECTIVES

- Identify issues affecting management of wildlife and recreation areas.
- Develop contacts and establish informal networks among public and private resource managers, educational institutions, and policy makers.
- Increase awareness and appreciation of the complex issues facing the border states in the protection of the environment and utilization of recreational resources.
- Provide input to the respective state governors concerning major issues identified by the conference.

ACKNOWLEDGMENTS

The proceedings compilers acknowledge those who contributed to the success of the conference. C. P. Patrick Reid, Director, School of Natural Resources, University of Arizona, served as conference chairperson. Dr. Reid was assisted by Linda Lee, who coordinated administrative arrangements, and Susy Morales, who assisted with coordination and translation services. The conference committee consisted of Francisco Abarca, Peter Bennett, Juan Carlos Barrera, Steve Cornelius, Serge Dedina, Carleton Edminster, Ronald Engel-Wilson, Gil Lusk, O. Eugene Maughan, Beaumont McClure, Howard Ness, Ramon Olivas, Luther Propst, Ann Rasor, Charles Sanchez, Thomas Sheridan, William Shaw, Peggy Weber, and Jay Zieman. We thank Peter Bennett, Gerald Gottfried, O. Eugene Maughan, Beaumont McClure, and Susy Morales for their technical reviews of the manuscripts. The editorial assistance of Madelyn Dillon and Karen Mora is greatly appreciated.

GENERAL SESSION

Planning for "Natural" Disaster: Unsustainable Development of the U.S./Mexico Border

Helen Ingram[1]

Abstract.—Planning is designed to insure that undesirable outcomes do not occur and that decisions are based on knowledge and reason. However, past planning on the border has been insensitive to the environment and sustainability. Planning for agricultural development has been narrowly focused on hydrology and engineering without consideration of impacts on the natural world. Industrial planning has focused on jobs and economic growth, again without real consideration to impacts on natural systems. The consequences have been environmental degradation and threats to human health. More recently NAFTA has promised to avoid these earlier planning limitations by expanding economic activities, correcting environmental problems and focusing on sustainability. It remains to be seen whether the promises made by NAFTA and other planning efforts can be kept. There are real limits to the water available for growth and development along the border. To ignore these limits is to guarantee disaster.

INTRODUCTION

Similar to recent years, the winter of 1997–98 in Southern California was marred by natural disasters. While the earthquakes and fires sometimes threatening human and wildlife and property did not erupt, the winter rainstorms and high seas of El Niño flooded houses, swept away beaches and the parks, playgrounds, and dwellings. High winds felled large eucalyptus trees often upon parked cars and buildings. Once the hillsides in lovely communities like Laguna Beach were thoroughly soaked, the mud slides began, and some uphill residents were horrified to witness the creeping of their front lawn through their downhill neighbors kitchen door. While treated by the media as a freak of nature—national television audiences repeatedly were entertained with scenes of gigantic waves crashing through windows of luxury apartments at Huntington Beach—the reality is that almost every surprise was entirely predictable. As William Cronon observed in his fine essay "In Search of Nature" labeling a

[1] *Warmington Endowed Chair, School of Social Ecology, University of California at Irvine*

disaster "natural" implies there is nothing we can do about it. It is just the way things are, and we'd better resign ourselves to the nasty temper of much maligned Mother Nature. Yet, the worst effects of El Niño were visited on the developments expensively planned with beautiful architecture and landscaping that ignored key features of topography and climate. Beaches are in a constant flux of washing away and rebuilding, often in different locations. The unstable soils of the low hills once held loosely in place by native grasses that thrived on winter rains shift easily under the heavy weight of human dwellings and highways. Most trees in Orange County are exotic, including the fast growing eucalyptus that quickly provides shade and the illusion of solidity, yet shatters when subjected to coastal winds.[2]

Transforming terrain has long been a thriving way of life in the greater American Southwest where since the beginning of the twentieth century applied hydrology and agricultural engineering have diverted the waters of the Colorado River first to make cotton and citrus, and now to make condos cover the deserts of California and Arizona. The accomplishment of such alterations have taken place under the guise of rational planning and created an illusion of human capacity to impose not only order upon the environment but also to alter the environment to conform to human will. For the most part, large investments of energy and capital so far have allowed humans mainly to ignore whatever limits may ultimately be imposed by landform and climate. This is not to be the case, however, in regard to one area, the U.S./Mexico Border, and one resource, water. The argument of this paper is that the growing reliance upon water supplies that simply are not dependably available, even in the relatively near term, is to invite disaster. Ironically, "rational" planning, purposeful policy, and infrastructure development have set the course toward practically certain human and ecological crisis.

GROWTH OF POPULATION ON THE U.S./MEXICO BORDER

The U.S./Mexico border region was home to more than ten million people in 1995, an increase of two million in only five years. Ninety percent of the border population lives in urban areas, and there are 14 major sister city pairs along the border stretching from San Diego-Tijuana to Brownsville/Matamoros. Table 1 provides population growth figures of border states.

[2] *William Cronon, "In Search of Nature:"* in *Cronon ed. Uncommon Ground: Toward Reinventing Nature, New York: W.W. Norton and Co, 1995.*

Table 1. Population Growth on the U.S./Mexico Border

Area	% Change 1980	1990	% Change 1980-90	1990-95	% Change 1990-95	% Change 1980-95
Binational Border States	NA	8,301,000	NA	10,305,000	24%	NA
U.S. States	NA	4,412,000	NA	5,230,000	16%	NA
Mexican States	NA	3,889,000	NA	5,075,000	23%	NA
Sister Cities	5,149,510	6,902,590	25%	8,051,140	14%	56%
U.S. Cities	2,662,810	3,478,490	23%	3,868,540	10%	31%
Mexican Cities	2,486,700	3,424,100	27%	4,182,600	18%	41%

Source: EPA, U.S.-Mexico Border XXI Program Framework Document

As the table indicates, the percentages of population increase in this area is astonishing and growth is even more rapid in Mexico than in the United States. Further there is no indication of growth abatement in recent years since the rate between 1990 and 1995 surpasses that of the previous ten years.

Concentration of population in cities and the attendant problems of urbanization have drawn the most attention, but territorially, most of the border remains rural. The rural economy of much of the border is based upon agriculture which is highly dependent upon irrigation and relatively sophisticated technology. The Imperial and Mexicali Valleys have historically been big producers of cotton, alfalfa, wheat and sorghum.[3] The lower Rio Grande Valley in the United States is a source of pecans on the U.S. side and of alfalfa on the Mexican side. Cattle ranching has been particularly important in the state of Sonora and in recent years the introduction of bufflegrass and the diversion of water to irrigate this exotic fodder has introduced increased water demand for ranching.[4]

In the spaces between cities and the farms there are ecosystems that support more than 450 rare or endemic species. In addition there are 85 threatened or endangered species of plants and animals. More than 700 neotropical migratory species, including birds, mammals and insects use the borderland habitats during their annual migrations. A majority of species in the border area are dependent upon riparian habitats. Within the U.S. there are eight national wildlife refuges within twenty-five miles of the border. In addition there are several national parks and monuments in the United States on or near the border, including Big Bend National Park, Organ Pipe Cactus National Monument, and protected areas in Mexico including El Pinacate, Cañon Santa Elena and Maderas de Carmen adjacent to Big Bend, and Laguna Madre de Tamaulipas.

[3] *Francisco Alba, "Mexico's Northern Border: A Framework of Reference" in* Natural Resources Journal, *October, 1992, Volume 22, No. 4, October, 1982.*

[4] *Luis Vila, "Acaparan ganaderos el agua en Guaymas: miles of campesinos, en las miseria por la Sequia,* El Financiero," *May, 14, 1998, p. 16.*

INCIPIENT WATER WARS

The most salient features of the U.S./Mexico region is aridity. Along most of the border, rainfall is eight inches a year or less. What surface water is available evaporates quickly under the stress of very high summer temperatures. Surface water resources in the border include two major river drainages, the Colorado River and the Rio Grande, both of which flow north to south, and a number of other streams, sometimes intermittent, many of which flow south to north.

In addition to low rainfall, a second notable feature of the desert border region is enormous variability in water supply, with dramatic swings in rainfall and runoff. In prehistory, climatic variability was closely associated with viability of human settlement. Long-term tree ring data in the Rio Grande Basin, for instance, show a pattern in which below average rainfalls have occurred for as long as 200 years at a stretch. The flowering of Native American cultures in the Rio Grande Basin from 200 BC to the nineteenth century took place only during those peak periods of a century or more when rainfall consistently exceeded the long term mean. Further, there are very large year to year and seasonal variations in streamflows on the Rio Grande.[5] There is no reason to believe that the droughts of 1993-96 which were so enormously harmful to Mexican agriculture and precipitated both international conflicts between the states of Texas and Chihuahua and between urban and rural areas in Mexico are unlikely to occur again. The long-term historical record confirms similar variability on the Colorado River. Tree-ring reconstructions suggest that over the last 500 years, the lowest 80 year mean at Lee's Ferry is less than 11 million acre feet which corresponds to a 27% decrease in natural flow compared to the 1906-83 stream gauge record.[6]

A third significant feature of water on the border is the critical importance of groundwater supplies. Uncertain surface water sources are complemented by numerous groundwater basins which feed important wetlands areas that support biodiversity and the region's natural system. In the first part of the nineteenth century the major river systems also were totally allocated and quantification of water rights on minor streams since then have fully apportioned their waters also. As a consequence, more recent users have often turned to groundwater as an alternative source. Prior to 1940, groundwater basins in any areas along the border were in hydrologic equilibrium, that is, water inflow was approximately equal to

[5] *John Hernandez, "Long term climatic and streamflow Records on the Rio Grande" paper presented to bi-national conference, "Coping with Scarcity in the Rio Grande/Rio Grande Drainage Basin: Lessons to be Learned From the Droughts of 1993-1996" Cuernavaca, Morelos, Mexico, October, 1997.*

[6] *Linda Nash and Peter Gleick, "The Colorado River Basin and Climate Change: The Sensitivity of Streamflow and Water Supply to Variations in Temperature and Precipitation," Pacific Institute for Studies in Development, Environment and Security, December, 1993.*

outflow, based on long-term flow conditions.[7] Since then water withdrawal and use has far exceeded recharge and degraded water quality resulting in significant effects upon the resource. There are areas on the border where aquifers have reached critical levels. It is estimated, for example, that the Hueco Bolson, upon which both the cities of El Paso and Juarez depend, has no more than twenty more years of usable supply. Groundwater overdraft each year is nearly two million acre feet in Southern California and the Mexicali Valley.[8] Such overdraft is far from sustainable.

Because of its dependence on only two major water systems with huge drainage basins, the border is acutely at risk from human induced climate change. Looking only at the Colorado River, one widely cited study of general scenarios based on general circulation models of climate suggests that certain aspects of the hydrology and water supply system of the river are extremely sensitive to climate change that could occur over the next several decades. Not only are significant changes of runoff possible, but the ability of existing water supply systems to mitigate the worst effects are limited. Reservoir storage lessens impacts for only a short period of time. An increase in temperature of only 2 degrees, with no change in precipitation would cause mean annual runoff in the Colorado Basin to decline by 4 to 12 percent. Further, under conditions of long-term flow reduction salinity increases dramatically.[9] Such a completely plausible change would dramatically affect water reservoir storage, water deliveries and water quality on the lower Colorado River shared with Mexico and would likely precipitate international tension, not to mention human crises.

Even without considering such a troubling future, there is sufficient current water conflict to signal future problems. Cities are having to look outside their adjacent areas and river basins to find new supplies, and rural farmers are seeing an essential ingredient to their livelihood drained off to quench the thirst of cities. Shared aquifers are being depleted with both nations realizing that what supplies they do not capture will be sucked up and used on the other side. The winners and losers in the struggle vary over time and from place to place, but consistently the natural world of flora and fauna is bearing the brunt of shortages. Riparian areas are disappearing, and with them the loss of many species dependent upon wet habitat. Streams, once flowing much of the year, have dried up with insufficient water to feed the trees and shrubs which once traced them like lifelines through the desert. The largest natural springs in the

[7] *Anderson and others, "Geohydrology and Water Resources of Alluvial Basins in South-Central Arizona and Parts of Adjoining States:" U.S. Geological Survey Professional Paper 1406-B, 1972.*

8 Jason Morrison, Sandra Pastel, Peter Gleick, Sustainable Use of Water in the Colorado Basin, San Francisco: The Pacific Institute, November, 1996.

9 Nash and Gleick.

border region, Quitobaquito, within the Organ Pipe Cactus National Monument, and the endangered desert pupfish found there is at risk. Nearly all the Mexican land adjacent to the Monument is undergoing intensive agricultural development and urbanization. Groundwater pumping from the Sonoyta river basin has resulted in dropping the water table sufficiently to threaten the spring. In addition, biocide drift from aerial spraying of crops are threatening rare plants and insects.[10] Further, the water quality upon which natural species depend has become degraded. For example, high levels of pesticides and increased concentrations of salts and selenium in the Salton Sea are resulting in deaths of ducks and other bird species and the malformation of offspring.

PLANS PAVE THE WAY FOR PROBLEMS

The present water conflict is the direct result of rational, discipline based planning based on narrowly focused goals and instrumental reasoning. Goals changed over time, but in each case water was treated as a property, product or commodity, not an integral part of the natural system in a desert where scarcity is the rule and strategies to limit water use and survive periodic droughts are essential.

Making the Deserts Bloom

Shortly after the turn of the twentieth century both the U.S. and Mexican governments turned their attention to irrigation in deserts with rich soils and long growing seasons. So called reclamation policies accepted legal definitions of water as property of individuals and nations. Large scale engineering works moved water like a raw material through production processes. Prevailing water law and politics ruled that not to use water was to lose it. There was a fierce competition among the two nations and among subnational regions to put water to work through dams, diversions, reservoirs and irrigation projects as rapidly as possible so as to lay claim to it. A 1944 treaty on Colorado and Rio Grande waters divided them like slicing loaves of bread, ignoring the systemic characteristics of water and the many unintended consequences associated with storage and diversion. But once rights were secure, government planners moved quickly to divert water from its natural course to create agricultural wealth.

The development of the Imperial Valley was the largest of many such projects. With less than three inches of rainfall per year and summer temperatures ranging to 120 degrees, the area would seem unsuitable for intensive development were it not for bureaucratic and engineering inge-

[10] *U.S. Department of Interior, National Park Service, Organ Pipe Cactus Statement for Management, September, 1994.*

nuity combined with constituency pressure and Congressional log rolling.[11] While the early diversion of Colorado River water into the valley was private and involved as many as 160,00 acres by 1909, the enterprise might well have gone the way of gold rush miners had it not been for the help of federal reclamation planners and engineers. Beginning with federal emergency rescue help when the project's headgate in Mexico failed resulting in the diversion of the whole river into the Valley, the enterprise was beset by troubles that only large federal subsidies and engineering expertise could resolve. The Bureau of Reclamation accommodated the needs of the Valley through the erection of a series of dams, diversions and canals. Originally intended for small farmers, the 160 acre limitation built into reclamation law was never observed in practice, and later was all but abandoned. For more than a quarter of a century the Imperial Valley has provided bountiful harvest of fodder, food and fiber and not a few great individual and corporate fortunes. Today, like other water users on the border, the Imperial Valley is feeling the pressures of over exploitation. One source of pressure comes from environment. The so called Bono Bill, passed after the death of Congressman Sonny Bono, mandates that the salinity levels in the Salton Sea not be allowed to increase. Since agriculture is the major contributor to salinity increase, it may well have to foot the bill for preventive measures. Another source of pressure comes from urban competition for water resources. The City of San Diego, the last in line for the over appropriated Colorado River, has been pressuring the Imperial Valley to sell irrigation water to the City, agreeing to pay for lining canals and other conservation measures which could keep agriculturalists in business while using less water. Unfortunately, the lining of the All American Canal will put a stop to fugitive flows to groundwater sources upon which farmers in the Mexicali Valley depend. The Mexicali Valley is an irrigated agricultural development in Mexico of approximately the same size but of lesser productivity than the Imperial Valley. It is reasonable to expect the Mexicans to react strongly to the loss of this long established water source even if it is outside the treaty obligations.

Border Industrialization

Just as the spread of agriculture in arid borderlands was the result of purposeful governmental planning and policy, so, too, has been urban development. While the U.S. Government has fueled urban growth through the location of military installations, and funding of water and highway projects throughout the West, the main impetus for urban development on the border has come from the Mexican government. The Border Industrialization Program was the brainchild of economic planners

[11] *Phillip Fradkin, A River No More, Knopf, New York, 1984.*

and experts in international trade. Designed to generate jobs in Mexico Border Cities through the establishment of assembly plants, or maquiladoras, the program initially enjoyed a modest success. Beginning in 1983, stimulated by simplified regulations and lower water costs in dollar terms brought by devalued Mexican currency, the industry saw increases that averaged 14.4% a year in numbers of workers and nearly 11% of numbers of new plants each year for the next ten years. In 1993, there were 2, 170 plants employing 540,930 workers.[12] The economic importance of the Maquila program to Mexico can not be overemphasized. This sector of the economy continued to grow even during the latest economic downturn. As well as providing a source of employment for Mexico's huge population just entering the workforce, the program is a source of hard currency badly needed in repaying the Mexican debt.

The principle driving force for bringing maquilas to the border has been the low cost of Mexican labor, roughly one-eighth of that in the U.S. However, the low costs of plant sites is also important. Maquilas have paid little or nothing for the additional infrastructure burdens upon schools, highways, and water supplies caused by their operations and the workers they attract to the border. Further, up until the passage of the North American Free Trade Agreement, the enforcement of environmental regulations was relatively lax.

Just as reclamation plans and policies have had unintended and very negative side effects particularly adverse to water quantity and quality, border industrialization has resulted in additional serious problems. The population explosion of border cities quickly out paced infrastructure development, particularly that related to water supply and sewerage treatment. The *colonies* that burgeoned particularly on the Mexican side of the border usually had no dependable water service. In many cities almost a third of the residents in 1990 did not have uninterrupted, convenient water supplies. While water was piped to spigots in some neighborhoods, many residents depended on water trucked into houses several times a week where often it was stored in uncovered and unsanitary barrels. Sewerage was handled even more poorly than water. Broken sewer pipes in ancient water systems combined with leaky water supply pipes with low pressure contributed to the contamination of the water supply. Raw sewerage was spilled into streams and ran down roads and streams creating very serious health hazards. Since the direction of flow in a number of urban water courses is south to north, contaminated water flowed across the border to jeopardize U.S. as well as Mexican citizens. Public attention to the poor state of environmental protection was drawn to the border as a

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[12] *Paul Ganster, "The U.S. Border Region" in Paul Ganster, Alan Sweedler, James Scott, Wolf Dieter-eberwein, Borders and Border Regions in Europe and North America, San Diego, San Diego State University Press, 1997, p. 243-44).*

result of the free trade agreement. National newspapers like the Christian Science Monitor and the New York Times ran series of stories labeling the U.S.–Mexico border an environmental war zone.[13]

NAFTA Side Agreement Planning

The border side agreements were the conditions added to NAFTA by the Clinton Administration to make the accord more acceptable to labor and environmentalists. While the agreements have had many beneficial effects for the border, including much larger funding for border projects directed to many federal and state agencies and the initiation of many new environmental programs, my main argument is that their failure to address sustainable water supply questions while encouraging the further expansion of water use on the border is a perpetuation of planning and policy that lead toward environmental disaster.

The environmental side agreements included the creation of a pair of new institutions, the Border Environment Cooperation Commission or BECC and the North American Development Bank or NADBank. The purposes of these institutions is to review, certify and fund border infrastructure projects. While other institutions had previously existed with much of the same mandate including the International Boundary and Water Commission and the Border Environmental Plan put together by the Environmental Protection Agency and Mexican counterparts, the performance of these institutions was clearly inadequate for the new circumstances. In particular, the interests of states and people living on the border were poorly represented, and the funding of projects depended on uncertain national legislative appropriations processes. BECC in particular represents an improvement in openness and representativeness in that it has a bi-national board of directors with ten members, five from each country and decision making procedures to ensure that the views of states, local communities and members of the public are taken into account. NADBank has a bi-national board of six members, and is a good deal less open to public input. However, it is more open than most international development banks to public participation. Both institutions are jointly funded by the U.S. and Mexico.

From the perspective of avoiding unsustainable development, however, the most important innovation of the environmental side agreements and the BECC was the adoption of different evaluation criteria for proposed projects. The BECC and the NADBank must, according to their rules, consider the need to conserve, protect, and enhance the environment and only sustainable projects are supposed to be certified. The economic criteria are also much improved over the politically driven past allocation of monies. Financing of projects is supposed to depend upon "user-pays"

[13] *Helen Ingram, Nancy Laney, and David Guillilan, Divided Water: Bridging the U.S. Mexico Border, Tucson: University of Arizona Press, 1995.*

principles through fees paid by the beneficiaries of the projects. Financing is supposed to come from public and private sectors.

Another improvement of the side agreements is the commitment to community capacity building: Increasingly BECC has realized that an impediment to better water planning and management has been the lack of professional and technical capacity, particularly in smaller border communities. The institution has devoted staff resources and provided loans to secure the necessary technical support for communities to prepare project proposals. The level of such support, however, has by no means been adequate.

The real issue seems to me to be whether BECC and NADBank have been or promise to be effective in bringing level of industrial expansion and population growth more in line with sustainable levels of water use. If the answer to the question is not positive, then the side agreements will turn out to be no more than a rationalization or a half hearted attempt at planning that will lead to disaster. Following is an assessment of accomplishments and shortcomings.

BECC and NADBank have gotten a slow start. Around 20 projects have been certified by BECC and less than a quarter of them have been financed by NADBank. Part of the problem has been staff instability and turn over. Within two years, there was a complete change in leadership at BECC. Another problem has been disagreement on the BECC board about its mission. Not all members have had the same level of commitment to openness and public participation and sustainability. Another problem has been the relationship of BECC to NADBank. It is not yet clear if NADBank can fund projects not certified by BECC and whether NADBank needs under the law to consider environmental as well as financial sustainability.[14]

The commitment to sustainability may be more formal and symbolic than actual. No project has as yet been turned down on the grounds that it is environmentally unsustainable. This is the case even though many projects were planned and designed before the new regulations were put in place and reflect older, "engineering-fix" ideas about water management. Sustainable criteria has not led to projects that specifically encourage water conservation in ways other than water rate increases. BECC has a procedure in place whereby it certifies projects as simply sustainable or highly sustainable. However, there is no connection between this rating system and likelihood or priority of funding by NADBank. NADBank's position has been that BECC's sustainability criteria are important, but for purposes of funding, bank directors are most interested in the ability of users to pay back loans, or financial sustainability. The argument is that the value of scarce water will be signalled to users through high water rates. While there is some logic to this argument, financial sustainability and environmental sustainability may in the long run be at odds. If the pay out of projects

[14] *Mark J. Spalding and John J. Audley, "Promising Potential for the U.S.-Mexico Border and for the Future: An Assessment of the BECC/NADBank Institutions," November, 1997.*

depends upon projected population expansion and economic development, then infrastructure development becomes one of the forces driving growth. New industries and new workers need to be attracted to cities if projects are to be financially successful. Yet, this means increasing water demands pressing close upon very limited supplies. After all, the increase of population on the border has continued unabated since the passage of NAFTA.[15] Border infrastructure planning for sustainability begins to look like wishful thinking.

PERSPECTIVES FOR THE FUTURE

The whole purpose of planning is to avoid the tyranny of the accumulation of many small decisions which may be individually rational but collectively do not serve public welfare. Planning is supposed to guide societies to avoid undesirable outcomes and to reach scenarios which have been chosen on the basis of knowledge and reason. In the past, the planning done on the border has been insensitive to environment and to issues of sustainability. Plans guiding agricultural development were narrowly focused on hydrology and irrigation engineering, and failed to take into account many negative side effects, particularly to the natural world. Industrial planning initiated in Mexico, and implemented with the collaboration of the United States, suffered from similar myopia. Jobs, economic growth and hard currency materialized as planned but at a cost for which the border was unprepared. The consequence of rapid urbanization has been serious environmental degradation and threats to human health and natural systems. In contrast, environmental planning related to NAFTA embraced a more inclusive vision. Not only were economic opportunities to be expanded, but past environmental problems were to be corrected and future developments were to be guided by criteria of sustainability.

Unfortunately plans may function to provide reassurance that things are on the right track when in fact they are moving in a dangerous direction. This paper has argued that unabated urban population growth in an arid region with limited and uncertain water supplies invites disaster. Human populations are particularly vulnerable because there are high proportions of poor, minority and underprivileged people who do not have the resources to take actions to protect themselves. Further, the area has significant ecological resources which will be terribly difficult to protect in trade offs with human health and welfare. Rich areas like Southern California may be able to afford to ignore, at least for the present, basic physical and climatic features of the area and recover from the "disasters" that are the inevitable consequences. The limitation of water resources, however, places a firm boundary on human development and population growth on the U.S./Mexico border going beyond which is to guarantee disaster.

[15] *"Public Citizen, NAFTA's Broken Promises: The Border Betrayed." Washington:* Public Citizen's Global Trade Watch, *January, 1996.*

ECOTOURISM, RECREATION, AND PARTERSHIPS

Valuing Tourism in the Sierra Tarahumara of Chihuahua, Mexico: A Comparison Between Domestic and Foreign Tourists

Lydia Breunig[1] and Evan Mercer[2]

Abstract.—A contingent valuation survey of 264 domestic and foreign tourists was conducted in the Sierra Tarahumara (Copper Canyon Region) of Chihuahua, Mexico in the summer of 1996 to determine the use and preservation values tourists hold for the region. From this survey, it is determined that tourists were willing to pay a per-person entrance fee of US $111-115 to finance a plan to protect this region. Domestic tourists were willing to pay US$124-131, while foreign tourists were only willing to pay US$89-95, despite the fact that the average income for domestic tourists was significantly lower than that of foreign tourists. Results support the concept that tourists highly value the use and preservation of natural areas and also provide economic justification for the protection of the Sierra Tarahumara. Results showing that Mexican tourists have higher use and public preservation values than international tourists supports the theory that tourists value natural areas in their own country more highly than natural areas in other countries.

Resumen.—Una encuesta de valuación contingente de 264 turistas se llevó a cabo en la Sierra Tarahumara (Barranca del Cobre) de Chihuahua, Mexico durante el verano de 1996. Los turistas en general estaban dispuestos a pagar US$111-115 para proteger la región. Los turistas locales estaban dispuestos a pagar US$ US$124-131, mientras que los turistas extranjeros estaban dispuestos a pagar US$89-95, a pesar de que el sueldo promedio de los turistas locales era sumamente inferior al de los turistas extranjeros. Los resultados comprueban el concepto de que los turistas valoran enormemente el uso y preservación de las zonas naturales, proporcionando al mismo tiempo justificación económica para la protección de la Sierra Tarahumara. Los resultados indican que los turistas mexicanos hacen un mayor uso y tienen valores de preservación pública superiores a los de los

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turistas extranjeros, comprueban la idea de que los turistas locales tienen una gran estima por las zonas naturales en su propio país.

INTRODUCTION

Although the benefits of protecting natural areas in less developed countries (LDCs) are often recognized, they are difficult to measure. In contrast, the opportunity costs of preserving natural areas in LDCs are easily measured and often very large. As a result, governments in LDCs have typically underestimated the benefits from preserving natural areas (Dixon and Sherman 1990; Mercer et al. 1995).

As nature tourism becomes increasingly popular, however, LDCs are recognizing the potential of natural areas to attract tourism revenue. Despite this, few studies have estimated the use and preservation values[3] to tourists of natural areas in LDCs (Mercer et al. 1995; Brown et al. 1994; Maille and Mendelsohn 1993; Edwards 1991; Tobias and Mendelsohn 1991). Of the few studies that have been done, the majority have only considered the values to foreign tourists (mostly tourists from "industrialized" counties). We know of no previous studies that have compared the use and preservation values of foreign and domestic tourists for a natural area in an LDC. Because foreign tourists tend to have higher incomes than domestic tourists in LDCs, it is generally assumed that foreign tourists are willing to pay more than domestic tourists for the preservation and use of natural areas. The overall objective of this study is to better understand benefits derived by tourists from the use and protection of natural areas in LDCs. In particular, we use the contingent valuation method (CVM) to examine the difference in benefits derived by domestic and foreign tourists. A CVM survey was administered to 264 tourists visiting a natural area. From the survey responses, an estimate was obtained of the willingness of each visitor to pay and entrance fee to the natural—to finance the area's environmental protection.

The Sierra Tarahumara

The natural area used in this study is the Sierra Tarahumara[4], located in southwestern region of Chihuahua, Mexico (figure 1). The Sierra Tarahumara, distinguished by a network of deep canyons that support a variety of habitats, is recognized by the International Union for the Con-

[3] *Use values are derived from direct benefits of using a natural area for the recreational opportunities it provides. Public preservation values are derived from the indirect benefits an individual receives from the protection of a natural area (e.g. option value, bequest value, and existence value) (Stoll and Johnson 1984; Krutilla 1967).*

[4] *The Sierra Tarahumara is also known as the "Copper Canyon (Barranca del Cobre)" or the "Copper Canyon Region," for the most famous canyon of the region.*

servation of Nature as a "mega-center of biological diversity" (Felger et al. 1997). The Sierra Tarahumara is also home to the Rarámuri people, who have maintained much of their pre-Columbian lifestyle. Given the biological resources and cultural heritage of the region, the Mexican government is considering a proposal to protect the Sierra Tarahumara. Environmental and humanitarian groups are lobbying to have the region designated as a biosphere reserve under UNESCO's Man and Biosphere Reserve Program (Gingrich 1996).

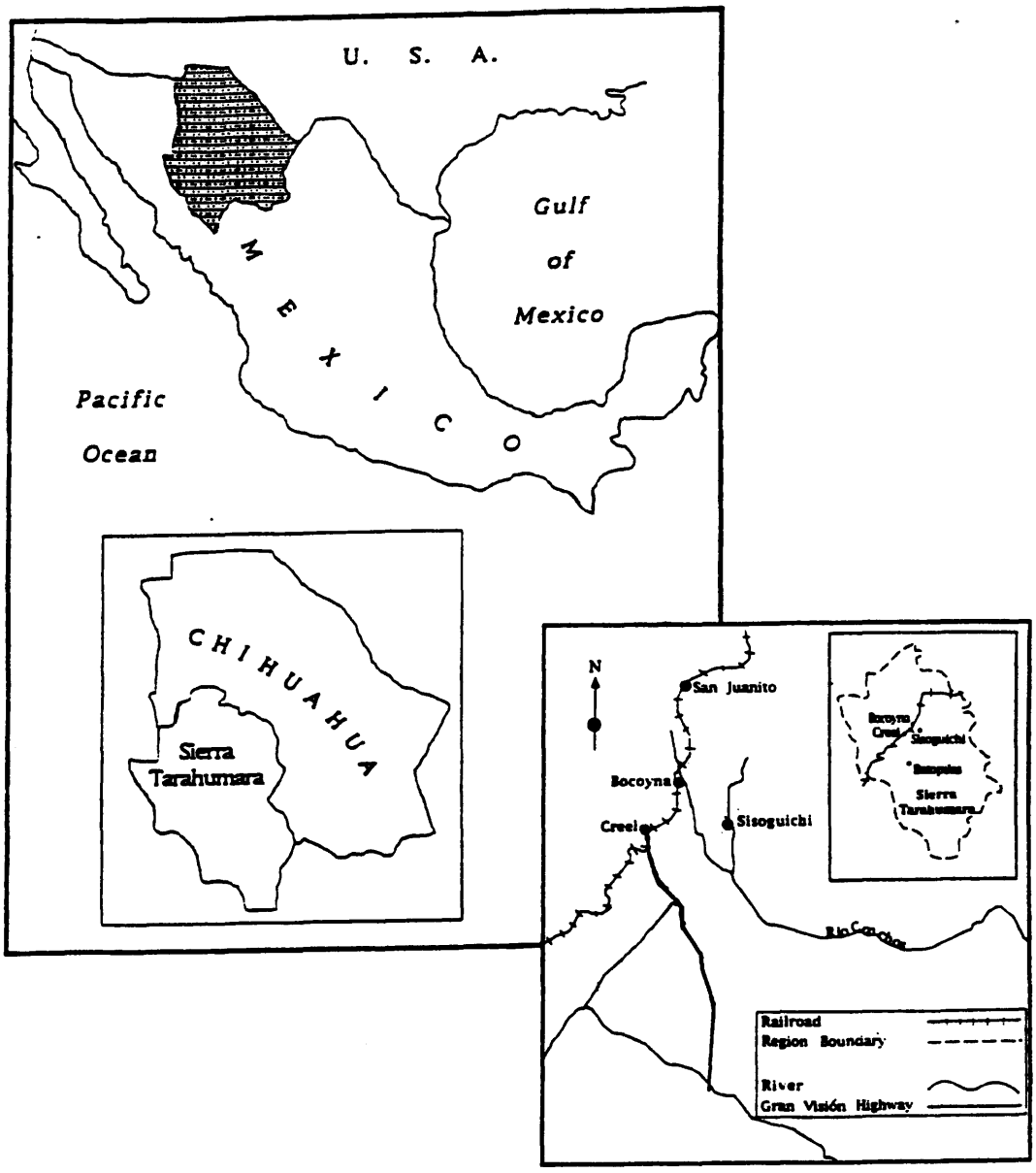


Figure 1. The Sierra Tarahumara of Chihuahua, Mexico.

The natural splendor and cultural heritage of the Sierra Tarahumara have made the region a large tourist attraction. The majority of the 70,000 tourists who visit the region each year arrive by the Chihuahua al Pacífico Train (Coordinación General de Turismo 1996). Although the timber industry dominates the local economy, tourism is becoming an increasing source of income (Programa Turistico 1996). This is particularly true in the town of Creel, which has become the "gateway" to the Sierra Tarahumara for tourists. As a result, the Mexican government and Chihuahua's state government have developed a plan to sustain and encourage future tourism growth within the Sierra Tarahumara (Programa Turistico 1996).

Despite the fact that the Sierra Tarahumara is a major tourist attraction, no studies have been conducted to evaluate the benefits of preserving the Sierra Tarahumara. Thus, the region is a timely and relevant case study for evaluating the use and preservation values tourists hold for natural area protection in LDCs. Because a large proportion of tourists to the Sierra Tarahumara are Mexican[5], the region also provides an excellent opportunity to compare the relative benefits derived by foreign and domestic tourists.

The Contingent Valuation Method

Resource economists originally developed the contingent valuation method (CVM) to measure the demand for an environmental good. Demand describes the linear relationship between the price of the good and the amount purchased:

$$G=f(P,S) \qquad (1)$$

where:

G = the amount of the good purchased
P = the price of the good
S = a vector of socio-economic variables that might affect demand

For normal goods, there is a negative relationship between price and amount purchased. As price increases, amount purchased decreases. When plotted, this relationship is represented by a downward sloping curve. The area under the demand curve represents the value of the good. The same is true of environmental goods. However, because environmental goods are public goods, they cannot be bought or sold. Therefore, the demand or the value of an environmental good cannot be directly observed. For this reason, resource economists have devised methods for indirectly observing demand for an environmental good. One of these methods is the contingent valuation method, in which the researcher uses

[5] *The Office for the General Coordination of Tourism estimates that 36 percent of the visitors to the Sierra Tarahumara are Mexican, but recognizes this is a rough estimate subject to seasonal fluctuation.*

surveys to create "hypothetical" markets for environmental goods. First the researcher describes the good to be valued and then asks the respondents how much they are willing to pay for the environmental good. The researcher also asks respondents about their socioeconomic characteristics (Mitchell and Carson 1989).

A demand curve for the good is constructed from a regression that describes the relationship between the price the individual is willing to pay (WTP) and the individual's socio-economic characteristics. The average value for the good is determined by the area under the demand curve.

The area under the demand curve is determined by using a model described by Hanemann (1984). Hanemann's model is based on utility maximization in which the individual is willing to accept a reduction in her income (I) by the amount of the bid price (P) as long as the utility she receives offsets her loss of income. This concept is demonstrated in the following equation:

$$U(y_0, I; A) \leq U(y_1, I\text{-}P; A) \quad (2)$$

where:

U = an individual's utility and is a function of:
y_0 = current environmental conditions
y_1 = improved environmental conditions
I = income
P = the bid price
A = a vector of attributes that effect the WTP

It is impossible to observe all the components that influence an individual's utility. Therefore, we assume that utility is a random variable with an observable mean and a parametric distribution. Given this assumption, the random utility variable is described by:

$$U = v(i, I; A) + \varepsilon \quad (3)$$

where:

$v(\bullet)$ = the mean value for $U(\bullet)$
ε = the unobservable component of the individual's utility—independently and identically distributed random variables with zero means.

The individual will respond positively to the WTP question when the following condition is met:

$$v_0(y_0, I; A) + \varepsilon_0 \leq v_1(y_1, I\text{-}P; A) + \varepsilon_1 \quad (4)$$

The individual knows when this condition exists, because she is aware of her own utility. To the researcher, however, this condition is unobservable. Therefore, in order for a researcher to determine utility, it must be assumed that for each individual this condition has a probability of being

true. The probability that the individual will respond positively to the WTP question is equal to the probability that the previous condition is met.

$$\Pr(\text{yes}) = \Pr\{ v_0(y_0, I; A) + \varepsilon_0 \leq v_1(y_1, I\text{-}P; A) + \varepsilon_1 \} \quad (5)$$

Following Hanemann's (1984) derivation, if the cumulative density function is assumed to be logistic, the probability that the individual's WTP is less than the bid, is given by:

$$\Pr(\text{yes}) = \frac{1}{1+\exp^{-(v_0 - v_1)}} \quad (6)$$

Ignoring A, assume that $v_0(y_0, I; A) = \alpha_0 + \beta I$ and $v_1(y_1, I\text{-}P; A) = \alpha_1 + \beta(I\text{-}P)$, then $v_0 - v_1 = (\alpha_0 - \alpha_1) + \beta P$. Substituting this into equation (5), the probability that the individual's WTP is less than the bid price is:

$$\Pr(\text{yes}) = \frac{1}{1+\exp^{-((\alpha 0 - \alpha 1) + \beta P)}} \quad (7)$$

With a logit regression model, and P can be estimated. Once and P are plugged back into equation (6), the individuals' probabilities of a negative response to the WTP question are aggregated into one probability function that can be plotted as a curve. The area under the curve represents the total WTP. Total mean WTP can be expressed as the integral of the probability function:

$$E(\text{WTP}) = \int_0^{\infty} [1 - F\varepsilon(\bullet) db] - \int_{-\infty}^{0} F\varepsilon(\bullet) db \quad (8)$$

where:

$F\varepsilon(\bullet)$ = the logistic cumulative probability function.

Simply put, the WTP can be found by dividing the component of the model that is *not* explained by the bid price by the component of the model that *is* explained by the bid price:

$$\text{WTP} = (\alpha_1 - \alpha_0) / \beta \quad (9)$$

By using this method, it is possible to determine how much tourists are willing to pay for an entrance fee that would finance a biosphere reserve in the Sierra Tarahumara.

METHODOLOGY

From July 23 to August 18, 1996, a CVM survey was administered to 264 randomly selected tourists at the train and bus stations in Creel, Chihua-

hua, Mexico while they waited to depart. The self administered surveys were offered in either Spanish or English. Respondents were provided with a survey instrument, clip board, pen, and map of the region with an outline of the proposed boundaries for the protected area.

A focus group of Duke University students and faculty and an on-site pre-test determined the final format of the survey. The five page survey had a total of 25 questions divided into three sections. Section A included questions about the respondent's trip. Section B was the contingent valuation question. The last section asked about the respondent's social and economic background.

The contingent valuation question (presented in figure 2) utilized the referendum format, otherwise known as a "take-it-or-leave-it" approach (Arrow et al. 1993). In the referendum format, a range of prices is selected that encompasses the maximum WTP of most respondents for the good being valued. Each respondent is randomly given one of the prices and asked to either accept or reject the price. If the person responds "yes," the price is considered a lower bound on his/her willingness to pay for the good being valued. Likewise, a "no" response is taken as an upper bound on willingness to pay. The referendum format is preferred to other alternatives because it is believed to eliminate the greatest number of biases that may occur with other formats (Arrow et al. 1993; Mitchell and Carson 1989).

The Copper Canyon region is a unique natural area. The rough terrain of the Copper Canyon region has created many different habitats, which support a wide variety of plants and animals. Some of these habitats, such as old growth forests, are already endangered. Loss of more habitat threatens the survival of species such as the Mexican gray wolf and the thick-billed parrot.

To preserve Copper Canyon's natural habitats and maintain future recreational uses of the region will require some form of environmental protection. One plan for protecting the Copper Canyon is to designate 1,430,000 hectares as a Biosphere Reserve (shown in the yellow lines on the map that is provided). Within this area, development activities such as logging, mining, and dam construction would be regulated. Local residents would still be allowed to use the land — provided their activities did not threaten the habitats of the region. The Biosphere Reserve would not prohibit recreational activities that you have done or plan to do on your current trip.

To finance the Biosphere Reserve plan, it would be necessary to charge a fee per person for all visitors to the region. The fee would be a one time charge per visit for each visitor and would be collected by the Secretary of the Environment, Natural Resources, and Fishing. The fee would be used to conduct ecological studies and manage development activities in the Biosphere Reserve. Assume that you had evidence and knew for certain that the funds from this visitor fee were being used for these purposes.

Consider your current and planned expenses for this trip. If this fee were $_____ New Pesos ($___ U.S. Dollars) per person in addition to your total costs for your current trip to the Copper Canyon and you knew of this fee when your planned you trip — would you come to the Copper Canyon region?

(Fee values assigned randomly from 5, 10, 15, 25, 35, 50, 75, 100, 150, 200, 250, and 300 U.S. Dollars)
_____ Yes _____ No

Figure 2. CVM Question.

By looking at the CVM question in figure 2, it is clear to see how both use and public preservation values are captured. The question asks for

two things: 1) WTP for access to the region given its designation as a biosphere reserve; 2) WTP to finance the biosphere reserve plan. The first component of the question captures on-site use values. The second component captures all other preservation values.

Mexican tourists comprised 49 percent of the sample. The next largest group of respondents was from Europe with 26 percent of the sample (table 1). Other demographic characteristics of the survey respondents are described in table 2. Respondents were evenly distributed between males and females. The respondents' mean household income was US$35,254 and the average age of respondents was 36 years. On average, respondents had completed three years of college. As expected, domestic tourists have a significantly lower average household income than international tourists (table 3). The average household income (1995 before taxes) for domestic (Mexican) tourists was US$11,517 while the average household income for international tourists was US$56,339 (table 3).

Table 1. Nationalities of respondents.

Nationality	Number of respondents	Percentage of respondents
Mexico	116	48.95
U.S.A./Canada	51	21.52
Europe	61	25.74
Australia/New Zealand	6	2.53
Asia (Japan)	1	.42
Middle East / Africa	2	.84
Sum	237**	100.00

***Of the six individuals who rejected the survey, one was French, five were Mexican. Three Japanese, one French, and one German individuals were approached, but could not answer the survey due to language barriers.*

Table 2. Demographic information on respondents.

Respondent character	Median	Mean	Minimum	Maximum
Household income in U.S. dollars in 1995 before taxes	16,556	35,254	16.48*	350,000 +
Years of age	33.5	36.24	18	72
Years of education	16	15.73	5	25
Number of people in respondent's household	3	3.12	1	8
Number of people employed in respondent's household	2	1.75	0	6

**The low income values are probably inaccurate due to problems with the question on individuals' incomes.*

Respondent character	Percentage of respondents
Male	49.33
Chose survey to be in Spanish	57.08
Belong to a environmental or conservation organization	19.56
Subscribe to nature, conservation, wildlife, or natural history magazine	32.89

Table 3. Difference in household income (1995) for domestic and international tourists.

	Mean (US$)	Median (US$)	F-test	T-test
Domestic Tourists	11,517	5,960	1.46489×10^{-11}	4.0467×10^{-36}
International Tourists	56,339	45,000	——	——

The following, linear logistic regression function was used to model the probability of a positive response to the CVM question:

$$\Pr(\text{yes}) = C + P + A + I + E + N + D + T + F \qquad (10)$$

where:

C = Constant
P = Bid price
A = Age
I = Household income before 1995 (before taxes)
E = Years of education
F = Traveling with family (dummy variable)
N = American or Canadian (dummy variable)
D = Proportion of the number of days spent in the Sierra Tarahumara compared to the length of total trip
T = Number of days spent in the Sierra Tarahumara

From the regression, mean and median WTP was estimated using equation (8) from the utility maximization model described by Hanemann (1984). In addition, the Turnbull estimator was applied to WTP responses to determine a distribution-free estimation for the mean WTP (McConnell and Haab 1997). Using WTP estimates, the present value of total benefit to tourists of protecting the Sierra Tarahumara was calculated.

RESULTS

Only 9.1 percent of the survey refused to participate in the survey. Of those who responded to the survey, response rate to the CVM question was 94.17 percent. Of those that responded, only one observation was dropped from the sample for strategic behavior.[5] Figure 3 shows the percentage of respondents from the sample who answered positively to the CV question.

The results of the logistic regression are shown in table 4. Bid price was highly significant as a determinant of responses to the WTP question. As predicted by economic theory, the coefficient for the bid price is negative, indicating that as bid increases the probability of responding "no" to the WTP question increases. Household income was not significant in explaining responses to the WTP question. The reliability of responses to the income question is questionable due to contradictory responses between

questions on household income, occupation, and number of individuals employed in the household. Twenty-five individuals listed annual house-

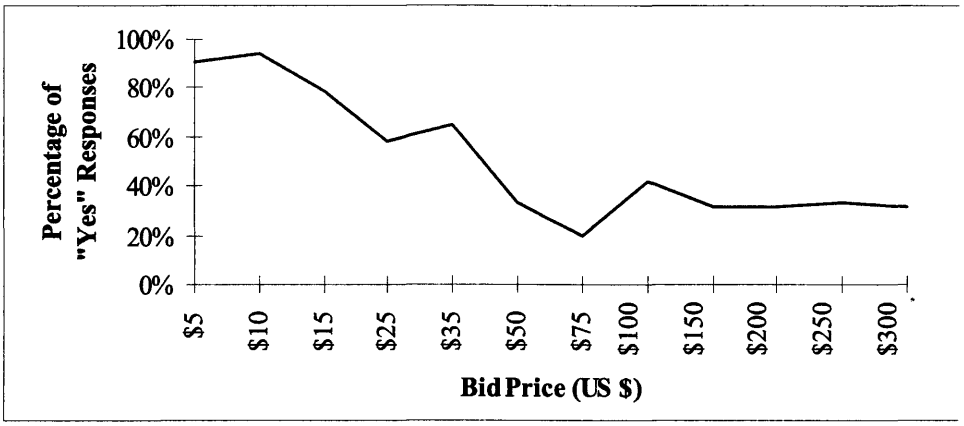


Figure 3. Percentage of "yes" responses to each bid price in the CVM question.

hold income for 1995 less than US$1,000. The information provided by these individuals on their occupation, years of employment, and the number of employed household members is inconsistent with their response to household income. This contradiction indicates that some of these individuals may have intentionally or unintentionally misrepresented their household income. If this sub-sample is an indication of the entire sample then the reliability of all responses to the income question is debatable.

Table 4. Results from the logistic regression used to determine willingness-to-pay.

Variables	Coefficients	Z values
Constant	-1.317247	-1.251
Bid price*	-.0074226	-4.134*
Age*	.0432372	2.499*
Household income for 1995 (before taxes)	-1.02×10^{-6}	-0.271
Years of education	.0637626	1.137
American or Canadian (dummy variable)**	-1.010623	-2.153**
Proportion of the number of days spent in the Sierra Tarahumara compared to the length of total trip	.3854526	.903
Number of days spent in the Sierra Tarahumara	.0144694	.171
Traveling with family (dummy variable)***	-.6045073	-1.602***
Number of Observations = 173		
Pseudo R^2 = .1317		

* *Significant at the .01 level*

** *Significant at the .03 level*

****Significant at the .10 level*

Using equation (9), mean WTP is estimated at US$115.25, and median WTP is US$113.25 (table 6).

DISCUSSION

Few studies exist with which the WTP value from this study can be directly compared. We are aware of only a handful of other valuation studies conducted in LDCs – this being the only study that includes both domestic and foreign visitors. The WTP estimate from this study (US$115.25) lies within the range of values found by similar previous studies (table 5). Despite this fact, the WTP estimate found in this study seems unrealistically high.

Table 5. Willingness to pay (WTP) estimates from previous valuation studies of natural areas in developing countries.

Item being valued	Individuals' average WTP	Valuation method	Sample	Reference
Perinet National Park, Madagascar	45.81 - 268.37 (US$ 1991)	Travel Cost Analysis	International Nature Tourists	Mercer et al. 1995
"	61.39 (US$ 1991)	CVM Referendum Format	"	"
Galapagos Islands, Ecuador	312 (US$ 1986)	Hedonic Demand Analysis	Ecotourists (Mostly International)	Edwards 1991
Beza Mahafaly Special Reserve, Madagascar	349-265 (US$ 1991)	Travel Cost Analysis	Tourists from "Industrialized" Countries	Maille and Mendelsohn 1993
Game Parks and Reserves in Kenya	52 (US$ 1993)	CVM Referendum Format	International Tourists	Brown et al. 1994
"	81-86 (US$ 1993)	CVM Double Bounded Format	"	"
"	77-134 (US$ 1993)	Travel Cost Analysis	"	"
Monteverde Cloud Forest Biological Reserve, Costa Rica	35 (US$ 1988)	Travel Cost Analysis	Domestic Tourists	Tobias and Mendelsohn 1991

There are several explanations for a high value from the WTP estimate. First, high WTP values result from errors in the survey process. Mitchell and Carson (1989) thoroughly discuss potential sources of error in responses to CV questions. Generally, the referendum format that was used in this study is considered the best format for reducing errors in the survey process (Arrow et al. 1993). Despite its preferential use in CV studies there are drawbacks to the referendum format. Ready et al. (1996) found for a split-sample CV study, responses to the referendum format consistently generated higher WTP estimates than responses to an open ended format (Ready et al. 1996). Ready et al. (1996) attributes the higher WTP generated by the referendum format primarily to respondent behavior. In other words, the referendum format might induce "yea saying."

Other drawbacks to the referendum approach emerge in the analysis of responses. For statistical precision in WTP estimates, a large sample is required for a referendum format. WTP estimates from a dichotomous response are more sensitive to the model specification and the assumption of a parametric distribution of responses (Ready 1996, Mitchell and Carson 1989, Hanemann 1984).

A technique developed by Turnbull (1976) provides a distribution-free estimator that can be applied to referendum style CVM responses. Because this estimator is distribution-free, it alleviates biases caused by the distribution of responses (McConnell and Haab 1997). When this technique is applied to the responses, the WTP drops to US$110.74 (table 6). Therefore, if the parametric distribution creates a bias, it is very slight.

Table 6. Mean, median, and Turnbull willingness-to- pay estimates for Mexican and international tourists.

	Median (US$ 1996)	Mean (US$ 1996)	Turnbull WTP estimate (US$ 1996)
Total Sample	113.25	115.25	110.74
International Tourists	88.64	94.34	94.88
Mexican Tourists	130.78	138.67	123.62

Given the slight difference in the WTP estimates, the most conservative WTP estimate is used to calculate total benefits to tourists from the protection of the Sierra Tarahumara. Multiplying the most conservative per person WTP estimate (US$110.74) by the estimated 70,00 tourists that visit the Sierra Tarahumara each year, reveals an annual net benefit for 1996 of US$7.752 million. The present value of the total annual net benefits from 1996 to 2021 (25 year time horizon) is determined using the following equation:

$$PV[B_{1996},\ldots,B_{2021}] = \sum_{i=0}^{i=25} \frac{B_{1996}}{(1+r)^i} \qquad (11)$$

where:

B = Annual net benefits
r = Social discount rate (opportunity cost of capital)
i = Period (*i* for 1996 = 0, *i* for 2021 = 25)

With a social discount rate of 6.5 percent (Giosa 1992) and the average WTP estimate of US$110.74 per tourist, the present value of the total annual net benefits equals US$39.02 million. This calculation conservatively assumes that the number of annual tourists to the Sierra Tarahumara remains constant at 70,000. The Mexican government's tourism development plan projects an 18.42 percent increase in the annual number of visitors (although the plan does not define a time horizon over which this increase will occur). If this increase occurs over 25 years (from 1996 to 2021), at a constant rate of .74 percent/year, the present value of total annual net benefits becomes US$102.4 million. See table 7 for summary of results from alternative scenarios.

Table 7. Present value of total benefits to tourists under different scenarios.

	Scenario	Present value of total benefits to tourists (US$ 1996)
Discount Rate = 6.5%	1996-2021 constant annual number of tourists (70,000)	39,020,946.82
	1996-2021 increasing annual number of tourists (rate .737%/year)	102,361,306.87
	into perpetuity constant annual number of tourists (70,000)	119,258,461.54
Discount Rate = 4%	1996-2021 constant annual number of tourists (70,000)	49,298,512.27
	1996-2021 increasing annual number of tourists (rate .737%/year)	128,906,352.86
	into perpetuity constant annual number of tourists (70,000)	193,795,000.00

CONCLUSIONS

The overall objective of this study is to provide a better understanding of the benefits derived by tourists from the use and protection of natural areas in LDCs. In particular, this study examines the difference in benefits derived by domestic and international tourists. This study supports the

concept that tourists highly value the benefits they receive from the conservation of natural areas in LDCs. Previous studies have found similar WTP values (Mercer et al. 1995; Brown et al. 1994; Maille and Mendelsohn 1993; Edwards 1991; Tobias and Mendelsohn 1991). The reader should keep in mind that *many* benefits exist from the protection of the Sierra Tarahumara as well as other natural areas. Benefits to tourists represent only a portion of the potential gain from protecting the region. This evidence provides an economic justification for the protection of the Sierra Tarahumara.

Results from this study demonstrate that Mexican tourists are willing to pay more than foreign tourists. This is particularly interesting given that the mean annual income of Mexican tourists was significantly less than the annual income of international tourists. In addition, Mercer et al. (1995) found that the country of origin for international tourists also influenced willingness to pay. This observation could have important implications for policy makers in developing countries who want to attract tourists who highly value natural areas. Given that domestic tourists have a higher WTP for the preservation and use of the Sierra Tarahumara, it could be worthwhile for tourism managers in Mexico to focus publicity on the Sierra Tarahumara within their own country. It also indicates that nationality might be a stronger indicator of willingness-to-pay than income.

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BIOGRAPHICAL SKETCH

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Sonoran Desert Ecosystem Partnership: Putting Practice to Commitment

S.E. Cornelius[1] and Carlos Yruretagoyena[2]

Abstract.—The *Sonoran Desert Ecosystem Partnership* is firmly established through formal commitments at state and federal levels in Mexico and the U.S. Technical staffs of border protected areas and representatives of the region's civil society endorse the concept. Conservation scientists recognize the global significance of the Sonoran Desert and endorse the validity of planning at the ecoregional scale. The conservation community in the Sonoran Desert is ahead of similar efforts elsewhere and is poised to take full advantage of the opportunity. Setting a policy framework for the *Partnership*, which includes a common conservation vision, integrated implementation strategies, mutually supporting relationships among partners, and mechanisms for monitoring and evaluation, requires communication. The geographic scope, stakeholder groups, involvement of other interested parties, funding arrangements, limits and extent of authority, and other operational parameters of the *Partnership* are in development.

INTRODUCTION

In October 1997, the International Sonoran Desert Alliance (ISDA), the Sonoran Institute (SI), and the Arizona-Sonora Desert Museum drafted a justification for a cross-sector, transborder coordinating body and proposed a set of principles of operation. As a follow up action, a task force was formed to move the proposed Sonoran Desert Ecosystem Partnership (SDEP) beyond the conceptual stage to an operational level. ISDA and SI offered to facilitate the work of this group, which was composed of land and resource managers from the region, and tribal representatives. A working assumption was that a forum to discuss and resolve large-scale conservation problems shared by residents and protected area managers of the border region was utilitarian. It was also assumed that the characteristics of this forum needed additional definition. For example, a com-

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mon understanding of what the geographic scope of interest would be; who the core stakeholder groups are; what form of representation they would have; how other interested parties would be involved; how often the forum would meet; what the extent of its mandate would be; and how its deliberations and actions would be financed were needed. An overarching question was whether the proposed SDEP duplicated or complicated other coordination efforts ongoing or planned in the borderlands of the Sonoran Desert.

A questionnaire was prepared and sent to 10 federal, state, and tribal government representatives with direct or indirect responsibility for natural and cultural resource management in the borderlands. Responses were collated, returned for review and comment, and discussed at a meeting in April 1998 at Organ Pipe Cactus National Monument. This paper reflects the collective response of the task force to three cardinal aspects in the design of a SDEP: does it have utility?; how would it operate?; and, finally, what are the next steps?

RESULTS

Would a SDEP be useful?

The task force reviewed other coordination efforts in the Sonoran Desert borderlands to determine niche availability and need for a SDEP.

It was concluded that a local forum to address conservation opportunities and needs shared by public land managers and residents of the Sonoran Desert borderlands would be useful. This was based on six observations.

Right-Sized

Geographic scope of the SDEP would be broad enough to encourage ecosystem scale conservation thinking but small enough to be administratively manageable and responsive to local priorities. Other coordination efforts are border-wide and managed at the national or broad regional level with a diffused local impact or relevance (Border XXI; BECC); they do not fully address the international context (Southwest Strategy); or they focus on geographic or stakeholder subsets in the borderlands (BMG Range Partners Working Group; SEMARNAP Biosphere Reserve Advisory Committee). The Department of Interior/SEMARNAP Letter of Intent (LOI) was identified as an important government mechanism to establish, coordinate, and implement specific joint actions between sister reserves along the border. As such, the LOI pilot projects would complement the SDEP's broader function of promoting collaboration among managers,

residents, and NGOs to resolve threats or capture opportunities that are common to the entire target area.

Decentralized approach

SDEP would strive for decentralization of public land management responsibility and authority to the local level, in this case, to reserve managers and directors. Involvement and support from regional and national staff would be help to ensure the success of SDEP.

Participatory focus

SDEP would encourage partnerships between civil society, including residents and non-governmental organizations, and land managers.

Conservation and development linkage

SDEP would promote locally identified social and economic development actions that support conservation objectives.

Leverage support

SDEP would be effective at gaining support from public and private sectors if the need or opportunity were communicated by a collective rather than solitary voice.

Regional responsiveness

A SDEP would respond to Sonoran Desert borderlands conservation issues that cannot easily be addressed by other coordination efforts. Examples include:

- Transportation policies that fragment landscapes and habitats
- Overdraft of ground water and diversion of surface water
- Spread of exotic species across the landscape
- Under-managed visitation and use of public lands and resources
- Cost effective technical training
- Coordinated management of, and joint access to, natural resource data
- Common protocols for monitoring ecosystem health in the borderlands

What does an operational framework for SDEP consider?

The task force clarified their responses to the questionnaire, confirming agreements on certain characteristics of an operational framework, and identifying other areas that warrant more discussion.

Purpose of the Partnership

Through regular dialog of stakeholder groups, the SDEP would seek environmentally sound, economically viable, and culturally sensitive solutions to problems threatening the social fabric and ecological integrity and diversity of the Sonoran Desert. The SDEP may become engaged in three general areas. In order of priority, they are:

Building Capacity, including environmental education (building awareness); resource use (building local sustainable economies); training (building technical know-how); joint funding efforts (building financial wherewith-all), research (building data bases).

Management actions, including habitat, species, visitation, and cultural preservation.

Policy, including law enforcement.

Geographic Scope

The SDEP would focus on the Lower Colorado River and Arizona Uplands subdivisions of the Sonoran Desert including all xeric, riparian and coastal marine habitats within an oval roughly 400 km east to west and 300 km north to south centered at the point the Pinacate, Organ Pipe Cactus and Cabeza Prieta protected areas meet. It would initially focus on the five contiguous units straddling the Arizona-Sonora border including the Alto Golfo y Delta del Rio Colorado, Pinacate y Gran Desierto del Altar, and Organ Pipe Cactus biosphere reserves; Cabeza Prieta National Wildlife Refuge; and Areas of Critical Environmental Concern within the Barry M. Goldwater Air Force Range. Though separated from these lands, the Imperial National Wildlife Refuge would be included because of its reference in the LOI and evolving partnership with the Alto Golfo Biosphere Reserve. The Tohono O'odham Nation and other tribes, ejidos, settlements, and communities located within the circle would be encouraged to participate. The SDEP scope may expand to non-contiguous protected areas and neighboring private lands in the Sonoran Desert borderlands as need and opportunity warrant. It was noted that expanding the geographic scope, however, decreases the number of issues of common concern, and thus the utility of the SDEP. The SDEP would unlikely become involved in complex, on-going management policy issues such as Colorado River water allocation or the BMG Range renewal process.

Approach

The SDEP will be participatory and inclusive in its deliberations, decisions, and actions; it would follow an adaptive process based on biological and cultural information, and institutional and community priorities; it would incorporate regional and national interests in locally-driven conservation and social development initiatives. Initially, it would likely pro-

mote dialog and exchange of perspectives, with the possibility of evolving to a more active advisory and project implementation role. It would not have a direct policy-making function.

Membership

The SDEP would be formed by organizations, agencies, and communities with an expressed interest in the region and something to offer to its conservation and sustained development. It may be useful to allow a one or two-year open enrollment period during which the SDEP mission and the responsibilities of the stakeholders are better defined. Subsequently, qualifying requirements for participation would be established based on ratification of the SDEP objectives and a local presence. If the SDEP remains a discussion and dialog forum, a general membership structure would suffice. If it evolves into a decision-making body with many participating entities, it may be useful to draw a governing council from the recognized stakeholders. Each delegate would have authority to speak and take positions for the stakeholder group they represent, and a responsibility to report back to their constituents or employer on deliberations. All delegates would have equal voice in deliberations and decisions, with positions or decisions reached by consensus. In as much as possible, council delegates would be local staff or officials and have sufficient authority to adequately represent their constituency. Further assessment of legal and structural options to ensure that the SDEP abides by the US Federal Advisory Committee Act and any similar open meetings legislation in Mexico is needed.

Stakeholder Groups

Protected areas within the geographic scope of the partnership, including lands managed by FWS, NPS, and SEMARNAP/INE, would be permanently represented by the unit's senior manager. Wildlife, land and environmental management agencies, and military departments with resource management responsibilities would be permanently represented by local officials. These may include BLM, AGFD, ASLD, ADWR, IMADES, USAF, and USMC. Town and ejido governments would be permanently represented by senior elected or appointed officials. Native peoples within the geographic scope of the partnership would be permanently represented by official delegates from tribal councils. Mexican and US non-governmental and community-based organizations active in conservation, education, or sustainable resource development activities in the region would be represented, either individually or as a group. Other possible council delegates might include binational agencies such as the IBWC/CILA, universities, and research institutes. The total number of council members should not exceed 20.

Limitations of Authority

The SDEP would have no authority over protected areas nor implementation of their management or operational plans. Each participating protected area would continue to be managed according to current enabling legislation and pertinent state and federal laws. Nor would the SDEP have authority over regional land use planning agencies, ejido, or local governments. No new restrictions or mandates could be imposed through the actions of the SDEP on current resource use practices on public, military or private lands.

Financing

Expenses related to meetings of the SDEP general membership would be borne by the participating stakeholders. Common costs of a governing council and general administration of the SDEP would be supported through start-up grants during the initial years from third party donors and through voluntary contributions by participating government agencies. Projects carried out under the auspices of the SDEP would normally be financed and implemented by the promoting agency or organization. Agreement to participate in the SDEP would not obligate an agency or organization to provide funds for projects of the SDEP nor operation of a governing council.

Formation

The SDEP would be grounded on the Letter of Intent signed by US and Mexico federal agencies and operate informally at its inception. Agencies, communities, non-governmental organizations, and other stakeholder groups might formally join the SDEP at any time upon submission of an official declaration of support to the operating principles developed during the start-up period. Should a governing council be established from the SDEP, it would be initially formed through self-selection by those representatives of agencies, tribes, and organizations with expressed interest in the concept. Membership in the Council would be reviewed periodically.

What are the next steps in consolidation of the SDEP?

Discussions on the design of an operational framework for a SDEP have thus far involved land and resource managers. An outreach program to communities in the region is now essential to ensure a broad understanding of the concept, of its potential to resolve shared threats to the natural and economic foundation to the border region, and of the responsibilities associated with participation in the SDEP. Further discussion is needed to determine the qualifications of non-governmental organizations and

community-based groups to participate as stakeholders; how communities can most effectively participate, what financial options are available; and whether an administrative and fiscal agency role is needed.

CONCLUSION

There is a long record of collaboration on broadly defined as well as specific aspects of conservation in the Sonoran Desert (Laird et al. 1998). Cooperation has occurred at different geographic scales, time periods, and levels of formality. Some efforts resulted in official agreements contributing to long-term working relationships between agencies, across borders, and among a broad array of non-governmental stakeholders. Others are smaller in scale, more restricted in time and involve fewer players. The latter experiences, though less formal, are no less important. They have happened because a problem was shared by neighboring managers who had vested interests in its resolution. These experiences serve to encourage cooperation on tasks that are more complex and possibly more significant to the sustained conservation of the Sonoran Desert.

The *Sonoran Desert Ecosystem Partnership* has been firmly established through state and federal commitments. Technical staffs of the protected areas and representatives of the region's civil society are practicing the concept through modest actions. Conservation scientists have recognized the global significance of the Sonoran Desert and endorse the validity of planning at the ecoregional scale. Such a broad base of support for transborder, inter-agency, and cross-sector collaboration in ecosystem management is remarkable and uncommon. The conservation community in the Sonoran Desert is ahead of similar efforts elsewhere but has yet to take full advantage of this opportunity. Essential to this process is the participation of community neighbors of the protected areas. They have more to gain or lose than other stakeholders, as their home is the Sonoran Desert. Few policy decisions and management actions have a neutral impact on their lives. Sustainable communities are needed in the Sonoran Desert, ones with a high quality of life, broad-based economic vitality and a healthy human environment. Successful resource conservation depends on it.

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ENVIRONMENTAL EDUCATION

Jointly Managing a Transboundary Aquifer: A Binational Dialogue through Community Participation and Education

Elaine Moore Hebard[1]

Abstract.—Rapid economic expansion and population growth along the U.S./Mexico border already strain natural resources and basic infrastructure. Continued development, especially in arid regions, will depend on sufficient, uncontaminated water supplies. The absence of a ground water treaty encourages unilateral appropriation and impedes regional management while conservation and protection require transboundary watershed planning. Although efforts are now underway in an attempt to address these issues, the endeavors are often directed by regional or national officials, or academic investigators, rather than by local residents. Information is gathered, and then the public is invited to comment. Problems may arise with this process as the affected persons acquire no ownership with the data, and thus no responsibility to change behavior, much less abide by injunctions to do so, no matter that such are beneficially-and/or factually-based. To be successful, local participation and education must be included as a integral part of the planning process from the onset, right from the initial set of questions being formulated. Benefits include not only identifying local concerns, but also an educated public more willing and able to participate and to utilize the plans they helped to draft. Working together, a transborder dialogue can evolve, enabling the area to ameliorate increasingly negative impacts.

Resumen.—La rapida expansin econmica y crecimiento poblacional a lo largo de la frontera entre Estados Unidos y Mexico ejerce una fuerte presin sobre los recursos naturales y la infraestructura basica. El desarrollo continuo, especialmente en las regiones ridas, va a depender de la disponibilidad de agua sufiente y libre de contaminacin. La ausencia de un tratamiento para las aguas subterrneas crea condiciones para una apropiacin unilateral de las mismas, imposibilitando un manejo regional, mientras que las acciones en conservacin y proteccin requieren necesariamente de una planificacin transfronteriza de la cuenca. A pesar de los esfuerzos encaminado y de los intentos de abordar stas problemticas, stos a menudo son llevados a cabo por oficinas

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regionales o nacionales, o bien por investigadores acadmicos, en lugar de ser iniciativas que surgen a partir de los residentes locales. La informacin es recolectada y luego se invita al publico para que ofrezca sus comentarios. Algunos problemas que pueden surgir de ste procedimiento, puesto que las personas afectadas no se sientcn dueos de la informacin, y por tanto tampoco se sienten responsables del cambio de actitud que requiere, y menos an ejecutar la normative correspondiente, independiente de que stas sean beneficiosas y basadas en datos reales. Para poder tener xito, la participacin y educacin local debe ser incluida como parte del proceso de planificacin, desde la formulacin de la inicial de preguntas, al comienzo del proceso. Los beneficios incluyen no solo una identificacin apropiada de las preocupaciones locales, pero tambien un publico consciente, mas dispuesto y preparado para participar y utilizar los planes que ellos mismos contribuyeron a formular. Trabajando juntos, un dilogo trasnacional puede desenvolverse con mayor xito, permitiendo en el rea un decrecimiento en los impactos negativos que sufre en la actualidad.

INTRODUCTION

Recent population growth and economic development have placed enormous pressures on public services, infrastructure, and natural resources along the US-Mexico border. Continued development, especially in arid regions, will depend on sufficient, uncontaminated ground water supplies. While it is always difficult to balance demands for a finite resource such as water, exploitation becomes even more critical when the resource being depleted is a transboundary aquifer. Its allocation can become a source of conflict. (Hayton & Utton: 663) Moreover, utilization of water is common to both sides, so the border, being a political barrier, cannot bar the negative effects experienced - both sides are affected in terms of health and economic burdens.

Adequate mechanisms to deal with this dilemma are lacking. The international boundary hinders local, state and bioregional management of natural resources. The absence of a ground water treaty encourages unilateral appropriation and impedes regional management. Conservation and protection requires the development of a transboundary watershed management plan.

Watershed planning requires knowledge of water quantity, water quality, economic activities, social characteristics, and a baseline inventory of natural resources--all fundamental to designing a workable management regime. In addition to data collection, the process must include initiating a water dialogue that blends technical analysis with public participation.

Such a dialogue would help local citizens understand what the resource is, including its present condition and potential, and how they may best conserve and preserve it.

If encouraged properly, public participation is a vital part of any planning project. It provides a feedback mechanism both to a technical team and to the public. By engaging the public early on, a team acquires information which otherwise might be missed and can identify local concerns, which in turn can be addressed during the process. Moreover, an educated public will be more willing and able to participate. The information collected will thus be more useful, and will have a better likelihood of being utilized.

COMMUNITY PARTICIPATION AND EDUCATION

Why Public Participation and Education?[2]

Public participation runs from passive to active involvement; a continuum of activity can range from publicity, education, input, interaction, to partnership. A variety of techniques are available to planners to solicit public input in the planning process, from token notification to allowing participants to assume substantive control over the creation and implementation of a plan.

Planners are frequently prone to assume that they know what the public needs and wants. Contrasting with the public participation process is the technocratic approach, defined as the application of technical knowledge, expertise, techniques, and methods to problem solving. Conventional planning tends to be dominated by a technical/analytic style where the planner is a detached value-neutral expert advising decision makers about the best way to accomplish their goals and serve the public interest. Emphasis is placed on data collection and analysis as a means for finding the best solutions to problems and developing a technically sound plan. The implicit assumption is that better information leads to better decisions. Success in conventional planning is measured by the extent to which the objectives of the plan are achieved. On the other hand, interactive planning is based on the assumption that open, participatory processes lead to better decisions, thus incorporates local values and inputs when conceiving, designing and implementing resource policies, programs or projects. Success is measured by the extent to which balance can be achieved among competing interests and consensus is reached on appropriate actions. (Lang, 1986: 39)

In planning, especially where water is concerned, social values are involved. Succinctly stated, "Water is associated with three important

community aspirations - A. Opportunity, B. Security, and C. Control." (Ingram: 1992) Because social goals are often complex, conflicting and unclear, it is difficult to successfully resolve them with a purely technocratic approach. According to Kantrowitz: "The problem for experts is that the issues they most frequently confront when addressing social problems are `mixed decisions'--decisions involving both technical and value judgments". (1975:506)

Any process should provide the opportunity for direct public participation to ensure that it addresses community concerns, so that the public has confidence that water quality programs are implemented in a reasonable manner and result in social, environmental, and economic benefits. It is also more democratic, as those who are affected by a given decision should have the right to participate in the making of that decision. Without public input the researcher may miss information or concerns, as local citizens are an essential source of information, insights, and opinions. If it plays a part in the planning process, the public becomes a repository of support and goodwill for a project. However, if citizens are not engaged from the outset, then it is likely that a plan will not be embraced and utilized.

Many agencies and funding sources promote, if not require, a public participation component. A review of such programs of several agencies involved in natural resource management demonstrates that, although approaches may differ, partly because each is unique to its' constituency, there are certain recommendations and conclusions central to all the programs:

- local residents often lack basic knowledge, much less technical information, about their resources
- to effectively engage in decision making, participants must first be educated and informed
- such education helps participants in locating relevant information and in knowing what to ask for
- information empowers people, allowing them to participate more fully public education programs should present relatively complete and balanced information so that citizens may draw their own conclusions
- children should be involved, both to educate the future population as well as to provide a conduit for information from students to their parents
- creative channels need to be investigated and pursued to include everyone
- available resources need to be sought out and utilized.

What Should a Public Participation Program Contain?

The challenge is to stimulate interest and involvement from the outset and then to manage its integration into the decision-making process. Methods can encompass publicity, workshops, presentations, as well as more intense interaction. Understanding that a variety of citizen participation techniques exist, planners must develop public participation programs that meet the specific goals, objectives, and circumstances of each individual project. The technical team must also agree that public participation needs to be an indispensable part of the decision-making structure.

Then it is necessary to design a process whereby such public participation will help to shape a plan. Fundamental elements include:

- identify concerned groups and individuals
- employ a variety of communication techniques
- provide access to the process to all interested parties
- ensure that materials are easily understood; without too much technical jargon
- consider that the satisfaction of the participants is important and be responsive to them
- furnish adequate funding

Another essential component is the involvement of local and regional officials in a project from the onset. In addition to being courteous, the benefits include:

- assistance in designing and implementing the entire project to mesh with current undertakings
- gaining vital information, whether in the form of data or anecdotes
- obtaining consent for and participation in the project
- reducing distrust of activities
- locating potential sources of further information

Specific activities for watershed planning should include:

- identification of sources of data and information
- exchange of water information of regional and local interest
- assistance in the design and scope of project products
- review of project planning documents and reports

PUBLIC PARTICIPATION AND EDUCATION

Rationale for Binational Watershed Planning[3]

The Mimbres drainage system, a "closed basin", is located in southwestern New Mexico and northwestern Chihuahua. The region is arid, receiving approximately nine inches of rain annually. Lacking surface water, two border communities --Columbus, New Mexico and Palomas, Chihuahua-- depend solely on the aquifer to meet their water needs. Historical, familial and economic ties bind them. Columbus, New Mexico, located in Luna County, has 650 residents. Las Palomas, Chihuahua, situated in the Municipio of Ascensin, has roughly 10,000 residents. During the last twenty years, the population of Luna County has increased by 55% and of the Municipio by 76%. Although agriculture contributes significantly to the social and economic makeup of the area, it also accounts for 95% of the withdrawal and the depletion rates from the aquifer. Projected increases in population as well as agriculture and industrial development will only intensify pressure on the already declining water table.[4]

There are concerns regarding current or potential contamination and alkalization as well as availability. Recent drought conditions in the region have emphasized the need for water conservation. Because of the international border, these communities have found it nearly impossible to jointly manage their resource. And yet the need to develop a joint management plan is critical.

While both the New Mexico State Engineer and the Comisin Nacional de Agua (Mexico's National Water Commission) do plan for their users, rates of withdrawal are formulated without consideration of usage across the border, enabling each side to utilize the resource as deemed best suited to its citizens' needs. Furthermore, there is little systematic data on water characteristics or behavior, and no formal sharing of existing data. Generally, there is no mechanism to assess withdrawal from the aquifer, determine water quality, disseminate water resource and testing information to either community in a consistent format, or to plan for future usage and/or conservation. This lack of information about the aquifer makes it difficult for residents to make rational decisions between proposed uses of water, such as between agriculture and manufacturing; it also makes it difficult for government agencies to predict how many people can be sustained by the aquifer. Not only does this result in inappropriate policies, it renders current unilateral plans useless, hinders impact analysis and impedes the consideration of options. The international boundary has made it even more difficult for residents to acquire germane information on this vital resource, much less share it or adequately plan for the future.

Public Participation Segment

The circumstances call for a transboundary watershed plan. Integral to this process is a binational water dialogue, balancing technical analysis with public participation.[5]

> *In formulating a transboundary plan for the Mimbres, local involvement is crucial. The initial dialogue process would raise awareness of the ecological limitations of the watershed and serve to identify general questions over the quality, availability and control of water. Regional planning provides local residents an opportunity to have a say in issues critical to their future rather than having terms and conditions mandated from above. Building upon current binational informal linkages, an inclusive process would ultimately result in a more responsive solution for managing this precious resource while creating a procedure for conflict mitigation.* Hebard (1994:6-7)

Regional agencies and universities have been gathering data which can be used in the planning process. Some which bear mentioning are: a bilingual resource guide,[6] outlining issues facing the communities and recommendations made by them; a baseline inventory of natural resources[7] — soils, vegetation, water, wildlife and land use—prepared with local participation and formatted into a GIS database; and the creation of a plan to assess water quality, which is nearing completion.[8] Other relevant efforts include water quality testing by the New Mexico Border Health Office, investigations by the Desarrollo Urbano y Ecologa (Urban Development and Ecology Office) in Nuevo Casas Grandes, and urban plans for Columbus and Palomas.

Using the Southwest Center for Environmental Research and Policy (SCERP) project, to create a water quality assessment plan, as an example, this paper discusses public participation and community education in terms of binational watershed planning. The proposal was to compile data and characterize the aquifer, and to involve local residents, municipalities, and regional planning bodies in the design, coordination and implementation of the project so as to integrate the results of the project into the communities. The proposal envisioned that both team consultations and community meetings would be held, so that the questions raised would help guide the research as well as the formulation of the plan, which in turn would address noted local concerns. The objectives for the community meetings were to "disseminate information about ground water to the public, to involve citizens in the decision-making process concerning ground water and to nurture a transborder dialogue on ground water."

The initial task was to design and implement a public participation program for the two border communities. While the shared aquifer creates a unifying theme, clearly there are enormous differences - be they derived

from different legal and administrative systems, the level of knowledge, available data, sufficient time to participate, experiences, cultures, etc. Most critical is that expectations of what public participation means may vary, thus actual participation is likely to as well.

Process

Giving due consideration to the foregoing principles and observations, an inaugural program was designed. Without an applicable model to follow, identical processes were initially implemented on both sides of the border. These included personal contacts, presentations to officials, informational public meetings and communications with teachers.

Preliminary outcomes can be summarized as follows:

- while concerns regarding the aquifer were substantial, most participants determined that they lacked sufficient knowledge about water in general; hence they could not discuss water quality
- there are at least two embedded communities, which do not necessarily have similar interests; they therefore infrequently attend similar events
- different administrative cultures result in different degrees of participation. Border residents often have knowledge of the workings of both systems. As participants or observers, they have seen public participation at work, which may create problems with a more centralized system.
- working on a different time table, the technical part of the team did not have data available to share with the community.

After the first cycle, taking into consideration the comments and observations, adjustments were made to the program. A revised work plan was necessary to address the lack of knowledge. The focus shifted from providing information from the team to the community to providing knowledge concerning the resource in general. Such modifications also meant that the programs were no longer identical in the two communities.

The revised work plan (a) strove to involve as many people as possible, so certain populations--parents and retirees in Columbus and officials and parents in Palomas--were specifically targeted,[9] and (b) incorporated several suggestions, for example to hold an event, such as an "evening at the library", to draw people not principally involved with the schools; to work with the schools to involve children and their parents, such as producing a binational water fair; and, to encourage agency participation.

Under the new plan, the objectives changed to: present information about potential water quality problems as well as solutions; advise about the function of the different agencies charged with protecting and managing hydrologic resources; and exchange ideas about water between the two communities.

Final activities included:

a) The team conducted ongoing consultations with and presentations of the project to various officials to ensure good communication and cooperation.

b) To increase attendance, ensure diversity and provide notification, flyers were mailed prior to each meeting to public officials and to specific individuals who had either participated or had been recommended. Follow-up telephone calls together with personal visits were also part of this process.

c) Water-related materials were donated to the Columbus Public Library, as well as schools on both sides. (Unfortunately, there is not a similar community repository for information in Palomas.)

d) Presentations were made to the three elementary, junior high and senior high schools. These entailed discussions regarding the hydrologic cycle and the importance of and ways to conserve and preserve water, and then performing some tests using a spectrophotometer.

e) Materials were developed for use in the school and community meetings as it was difficult to find materials suited to this region, i.e. both focused on ground water and bilingual. These materials included bilingual posters and pamphlets on basic hydrology, conservation and preservation.[10]

f) A binational Water Festival/Festival del Agua, was organized and held at the end of the project at the Palomas Elementary School.

g) Display posters were prepared, explaining the project as well as public participation and how it is an integral part of planning.[11]

h) The team gathered comments and suggestions throughout the process. Approximately 90 persons filled out the exit survey at the water festival.[12]

i) Suggestions were made as to various projects which could be pursued including: form a high school Ecological Club (one formed less than a month after the festival); join the local group "Water for Life"; start a Water Advisory Board (Chihuahua) and a Water Planning Group for the Mimbres (New Mexico); and initiate a binational dialogue.

RESULTS

The results thus far have been:

a) A group, *Water for Life/Agua Para la Vida* was formed in Columbus with the goal of learning more about their water resource. The first project was a seminar on xeriscaping, intended as a type of event which would

attract residents by using a less intimidating approach than a purely technical presentation while still being educational.

b) The Water Festival drew over 400 attendees with some 15 U.S. and Mexican agencies participating. Approximately 800 students from the local schools prepared posters, models, skits, dances, and a survey of water knowledge in the community. This forum also provided the team with an excellent vehicle to present the project. It was so well-received that the plan is to make it an annual event.

c) Information about water was disseminated throughout the communities, especially via school handouts and the festival. A video of the event is evolving into a useful teaching tool.

ANALYSIS, LESSONS, RECOMMENDATIONS AND CONCLUSIONS

Analysis

a) Was the design model followed? Was it appropriate?

The team made successful attempts to identify concerned groups and individuals and to provide all interested parties access to the process. Different forums were utilized to foment involvement. A variety of communication means were used, and all materials were prepared to be easily understood. Local participants were recruited to take on various assignments. The educational component was successful, as highlighted by the water festival.

b) Were the articulated goals of the project reached?

In accord with the earlier-stated objectives, both the planning preceding the water festival, as well as the desire to make it an annual event, were steps toward developing a binational discussion. However, little was accomplished as far as enabling residents to discover and share data, to obtain their input on water quality issues, and to be involved in the designing of the plan. To date, the participation component has not been an integral part of the planning process. Specific information regarding the aquifer was not available from the team to present to the public in a timely fashion. Perhaps this was due to conflicting expectations within the team. There was difficulty determining and thus agreeing on what an assessment plan entailed, much less on how various components fit together and within what time frame. The information still to be provided by the team is anticipated to provide state and federal agencies, private citizens, and municipal and regional elected officials with information that can be used for planning and decision-making.

Lessons Learned

In reviewing the public participation and education component of the project, several lessons, both general and specific, can be enumerated:

- be creative[13]
- be flexible and adaptable
- don't try to run the agenda - trust the local people to know what will best work for them
- don't adopt or be adopted - let them take over as soon as possible
- allow sufficient time as this is a slow process
- for the process to continue, local residents have to "pick up the ball"
- small towns tend to have a few "movers and shakers" so don't abuse them
- financial assistance may be necessary to enable everyone to participate
- build upon informal linkages
- handouts need to consider the community's educational level
- handouts, rarer in Mexico, are more likely to be read and are thus useful tools to transmit information
- ensure that materials are available in both languages
- children are often key to reaching the parents
- for effective public involvement, need access to timely and relevant information
- participation should not be merely employed to transmit information or to gain concurrence, but also to foment a public dialogue toward a solution
- public participation keeps a technical team honest
- balance technical analysis and public participation so that any resultant study will be utilized
- be ever vigilant to ensure that delegated work is being accomplished and that team members are coordinated
- work with applicable agencies
- be sensitive to the myriad layers of differences

Recommendations

These lessons can be reduced to a few recommendations:

a. Community

- identify and involve key regional stakeholders

- seek local coordinators to become involved as soon as possible
- create a local committee to announce activities, share information and coordinate efforts, as well as to establish long-term commitment to the process
- build resources into a budget to assist local participants
- share information and address concerns to instill ownership and ensure implementation
- integrate results of a project with local and regional governments
- obtain long-term funding to ensure the continuation of the process

b. Team

- especially when working with a binational, multi-disciplinary team, formalize all work plans rather than considering each member of a team as an independent entity,
- there needs to be ongoing and constant communication, coordination and joint involvement throughout a project
- obtain consensus on all components of a project

Conclusions

Public participation is indispensable when creating a plan. An opportunity is provided for agencies responsible for managing the resource to disseminate information, discover information needs and fill those gaps, and identify additional aspects requiring inquiry and research. Once local citizens become aware of and interested in their watershed, they are more likely to become involved in decision-making as well as hands-on protection and restoration efforts. With local involvement, watershed management builds a sense of community, helps reduce conflicts, and increases the public's commitment to actions required to meet environmental goals.

The most effective means to improving the quality of the water and protecting the health of residents in the border region is through binational coordination and collaboration. The water festival was successful partly because the local community, and particularly the schools, made it its own. Hopefully, it will become a permanent event, which would nourish ongoing educational and binational collaborative efforts. With an educated populace, a binational dialogue concerning the mutually-shared aquifer can occur.

The project began an educational process by creating and distributing information, obtaining comments, and working within the schools. But that is only the beginning of public participation continuum. Without a

commitment to engage citizens from both sides of the border, it is unlikely that cross-border planning efforts will flourish.

The public participation component was successful as a public outreach service, raising the communities' general knowledge of their water resource and promoting awareness of water-related issues, in particular, its limitations and ways to conserve and preserve the resource. Unfortunately, the transmission of information to be incorporated into a plan never occurred. Nevertheless, it is anticipated that there will be future presentations of the technical aspects of the project. How best this information can be integrated with local and regional governments' efforts to manage the resource remains a fundamental, but unfinished, goal.

A single year did not provide sufficient time to develop groups committed to ongoing involvement, particularly where there are no final outcomes in sight nor any proprietary interest in the resultant data. Should further information be forthcoming, thus providing further reason to be involved, participants will likely be more interested in continuing their endeavors. Hopefully, as the communities become better informed, a nascent binational dialogue concerning their mutually-shared aquifer will evolve. Working together, the binational area can create solutions to ameliorate increasingly negative impacts.

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ENDNOTES

[2]*This section draws extensively from Cogan, Sharpe and Hertberg's chapter on "Citizen Participation", in The Practice of State and Regional Planning, and from the Delta Showcase Project: Public Participation Report.*

[3]*Much of this section is drawn from personal knowledge, as the author has worked on a variety of projects related to watershed planning in the region.*

[4]*Over the past several decades, water levels have been declining on both sides due to overdrafting. Between 1950 and 1970, water levels decreased 120 feet in an area of concentrated irrigation east of Columbus. (Harsberger 1978) Blandford's (1987:23) study indicated that a source of water for wells in the Columbus area was the "reduced underflow toward the basin's southern boundary." The 1991 Regional Water Plan underscored this situation, noting that "pumpage on this side of the border has reversed the flow direction across the border and induced flow into New Mexico" (Volume I, 9-3).*

[5]*Public involvement is also consistent with several relevant agencies and institutions goals, such as SEMARNAP (the Mexican environmental agency), EPA, BECC (Border Environmental Cooperation Commission), U.S.- Mexico Border Governors, New Mexico State Engineer, and Comisin Nacional del Agua. Public participation and education are key elements in both the statutorily-created New Mexico Regional Water Planning (72-14-44 NMSA 1978 Comp) and Mexico's Water Advisory Councils (Consejos de Cuencas), mentioned in Article 13 of the National Water Law, enacted in December 1992.*

[6]*Community and Regional Planning Advanced Studio Members at the University of New Mexico, Resource Guide for the Communities of Columbus, New Mexico and Puerto Palomas, Chihuahua, Technical Report #2, Border Research Institute, New Mexico State University, December 1992.*

[7]*Community and Regional Planning Program and Environmental Finance Center at the University of New Mexico, An Ecological Baseline Model for the US-Mexico Border Region, September 1997.*

[8]*Tanski, Janet M., Adrian Hanson, Alfredo Granados Olivas, Mauricio G. Mercado Prez, David Henkel and Elaine Moore Hebard, Water Quality Assessment Plan for Columbus, New Mexico, and Puerto Palomas, Chihuahua, SCERP Project Number: WQ96-5, 1997. Much of this section utilizes experiences gained by the author in taking part in this project, where she, supervised by Dr. Henkel, managed the public participation component together with Ing. Mercado Prez of the Universidad Autnoma de Cd. Jurez.*

[9]*Note that the regional population includes "snowbirds", people in residence during the winter, and agricultural workers, who migrate to the area when there is available work. These two populations, while sizable, were not specifically targeted, as they were thought to be less likely to be involved in community affairs.*

[10]*Extensive use was also made of the USGS posters series, especially the black and white ones which are printed in English or Spanish and can be colored, as well as the Arid Lands, Sacred Waters: Selection of Activities for Students and Tierra Aridas/Aguas Sagradas: Seleccin de Actividades para Estudiantes, produced by the New Mexico Museum of Natural History and Science.*

[11]*The schematics included headings such as "Why a Plan" and the "Purpose of the Project" on one poster board, and "How does Public Participation and Education Fit into a Plan?", "What We've Done", "Objectives", "Potential Outcomes", "What Can You Do" and "Where You Can Obtain More Information" on another. The rest of the team likewise prepared displays highlighting their activities. One of the most useful posters was placed at the end of the exhibition, included several pictures of the region. Viewers were asked whether they recognized the depictions, to consider what their relationship to water might be, and then to fill out the questionnaire located at the table.*

[12]*The survey included questions such as: Is water important to you? Do you think that people use water inadequately? Why? What are your suggestions as to how to conserve water? To protect water? If decisions about the care of water were in your hands, what would you do? and What additional information would you like?*

[13]*For example, to communicate and inform, use various "non-traditional" methods, such as asking the local parish to announce activities, along with using a sound truck, posters, and a call-in radio program in Jurez.*

ACKNOWLEDGEMENTS

Funding for most recent project was provided by the Southwest Center for Environmental Research and Policy (SCERP). Thanks especially to Dr. David Henkel and the teachers and residents of Palomas and Columbus for their invaluable assistance.

BIOGRAPHICAL SKETCH

After practicing law for ten years, and traveling for three, I returned to school, this time focusing on regional planning based upon natural resource conditions. My emphasis has been binational watershed management in a region between New Mexico and Chihuahua, where I have worked on a variety of related projects. I have participated in team efforts

such as An Ecological Baseline Model for the U.S.-Mexico Border Region (1997) and A Design to Assess the Quality of Water in Columbus, New Mexico and Puerto Palomas, Chihuahua (soon to be published). Generally, my policy research interests include: transborder and water issues, bioregional and watershed planning methods, community participation and education, sustainable development criteria and environmental indicators, and techniques to deal with areas of conflict.

Tucson Audubon Society's Borderlands Environmental Education Programs

Erin K. Deely[1]

Abstract.—The Tucson Audubon Society is a private, non-profit environmental organization dedicated to improving the quality of the environment by providing leadership throughout southeastern Arizona through education, conservation and recreation programs and activities. Due to its proximately to the U.S./Mexico border and the bicultural nature of the community, TAS has invested considerable energy into developing and offering activities and projects for children, families and educators on both sides of the border. The bilingual, education programs consist of an afterschool, environmental/arts education program for students in South Tucson, a city primarily consisting of migrants from Mexico; working with a women's group to provide training in urban gardening, first aid and health issues, computer training, sewing, nutrition, and leading afterschool programs; instruction of a Border Ecology course for teachers in training; and leading family groups on a Tidepools Family Institute, weekend, field course, held in Puerto Peñasco, Sonora, Mexico with an emphasis on developing a better understanding and appreciation for the flora, fauna and culture of the area through hands-on activities. The success and increasing demand for these programs demonstrate the ability of a small non-profit organization to positively impact environmental education efforts along the border.

Resuman.—La Sociedad Audubon de Tucson es una organización no lucrativa, privada, ambiental dedicada al mejoramiento de la calidad del ambiente por proveer liderazco en el campo del medio ambiente por el sureste de Arizona. Por ser ubicada cercana a la frontera y el hecho de que la comunidad sea bicultural, ha invertido tiempo y energia para el desarollo y ofrecimiento de actividades y proyectos para ninos, familias y educadores por los dos lados de la frontera. Los programas bilingues, educativas incluyen un programa ambiental, artistica (Nuevos Horizontes), para los alumnos de Sur Tucson, que es una comunidad donde la mayoria de los cuidanos son immigrantes de Mexico; trabajando con un grupo de Mujeres (Mujeres en Progreso) desarollando un programa de entrenamiento en lo siguente: járdines urbanos,

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primarios auxilios y temas de salud, enseñanza de computadores, cocer, nutricion y ofrecer programas especiales despues de las clases regulares; colaboración y enseñanza de un curso de la Ecologia de la Frontera para estudiantes tomando clases para ser maestros, matriculados en la Universidad de Prescott; giuar grupos de familias los fines de semanas para un viaje de historia natural en el campo de Puerto Peñasco, Sonora, Mexico con un emfasis de desarollar un mejor aprecimiento y conocimiento de la vida marina y la cultura encontrada allá; El éxito y aumentación de la demanda para estos programas demuestra la habilidad de un pequeño organización tener una influencia positiva en las esfuerzas de programas ambientales por la frontera.

INTRODUCTION

The Education Department of the Tucson Audubon Society (TAS) has a long-term commitment to develop and offer environmental education programs and activities along the U.S./Mexico Border, for youth, families and educators. This goal reflects the mission statement to serve as a leader in fostering local, grassroots movements to improve the environmental quality of neighborhoods and surrounding communities and work to meet the needs of underserved populations of diverse cultures, ages and backgrounds. The variety of programs also indicates the richness of the many partnerships TAS has formed with other local, educational institutions such as the Tucson Unified School District (T.U.S.D.), Mujeres en Progreso (Women in Progress), Prescott College (Tucson Campus), Tucson Parks and Recreation KIDCO program, the Boys & Girls Clubs of Tucson, the Extended University of Arizona, and the Center for the Studies of Deserts and Oceans (CEDO).

MUJERES EN PROGRESO

Over the past 6 years, TAS and Mujeres en Progreso have worked diligently to provide mothers and their families opportunities for personal growth. Women that once felt "trapped" in their homes due to lack of transportation, childcare options and language barriers, have been exposed to training classes in sewing, nutrition, exercise, computers, floral design, hair styling, gardening, solar oven construction, and CPR & first aid. The training programs help women gain new skills and self esteem. Many women within the community have come forward to share their skills and pass them on to other members. One of the main goals of this group is to participate in their children's education. "Graduates" of the training programs decided to offer classroom presentations to every class

at Ochoa Elementary School. They received funding from a local foundation, PRO Neighborhoods, and offered a variety of "hands-on" presentations to every class, grades K-6th. They named the project "Madres Enseñando" (Mothers Teaching). Urban gardening, tamale making, arts & crafts, sewing, nutrition, and first aid classes have been taught by volunteer moms. They also received a generous grant from the Southern Arizona Women's Fund to continue providing training programs for their members, in addition to the establishment of a community closet for needy families of Ochoa Elementary, that provides clothing, shoes, jackets, dishes, blankets, etc. Through this grant, three women have attended computer classes at Pima Community College and many others have expressed a desire to continue their education. A third mini-grant was awarded by Sueños del Barrio to provide a program for families that addresses the prevention of teenage pregnancy, substance abuse and gang activity. The group decided to offer a series of family workshops designed to strengthen communication between parents and between parents and their children. Children of the families that participated were involved with planning and development of the project and at the family retreat held in the natural setting of Brown Canyon, it was evident that the program proved successful and beneficial to everyone. The groups of families that attended plan the next workshop series and serve as a supportive group in the South Tucson community! It is clear this group serves as a model of how efforts to create positive changes can make a difference. TAS has served as a fiscal agent, provided consultation for grant writing, accounting, and assisted with the development of by-laws and job descriptions of the organization's officers. Tucson Audubon Society's role has changed over the years, slowly diminishing, due to the increasing autonomy of the group.

BORDER ECOLOGY WORKSHOP

The Border Ecology Workshop is one of a series of liberal arts seminars offered through the Culture, Environment and Education Project (CEE), at Prescott College. The seminars on environmental education targeted bilingual, Hispanic Adult Degree students preparing to earn teaching credentials to work in the schools of Nogales, Arizona, where they work as para-professionals. The ultimate goal of CEE was to produce a generation of bilingual, certified teachers aware of the environmental issues facing their community and who are skilled in presenting those issues in a culturally knowledgeable and appropriate way into the curriculum of the public schools where they teach. Nogales, Arizona faces problems such as surface and groundwater contamination due to disposal of untreated

maquiladora toxic waste and untreated human waste. As a result of accumulative exposure to water and air contamination, Nogales residents have the highest rate of lupus and 4.8 times the expected rate of a bone-marrow cancer in Santa Cruz County. Students had opportunities to interview local environmental and education activists discussing topics such as the U.S./Mexico border history, industrialization, NAFTA, cultural and political differences, environmental ethics and policies and the community based movements developed to deal with the issues. Tucson Audubon Society played a critical role in assisting with the coordination, instruction and development of the course and resource materials.

AUDUBON NATURE EXPLORERS

Tucson Audubon Society's partnership with the Tucson Parks and Recreation KIDCO program has continued to develop from its beginnings as a pilot project in the spring of '96. The KIDCO project provides an afterschool and summer program to elementary aged children (6-8 yrs old), free of charge. TAS has developed an environmental education/arts and crafts program that has been integrated into the program at 16 of the 40 KIDCO sites, located throughout the community. The sites have been carefully selected, targeting low income neighborhoods within or bordering South Tucson, serving a large percentage of children that have immigrated from Mexico. A minimum of 450 children have participated in the program since its pilot phase. TAS has developed a series of environmental education workshops and kits with "hands-on" activities for the KIDCO staff, so that representatives from every KIDCO site can offer an environmental education program to the kids they serve. The series of workshops focus on the Sonoran Desert environment, emphasizing the interrelationships between the plants, animals and people of the desert. A long term goal is to reach up to 2,500 children as a result of the training program. Tucson Audubon will continue to monitor and act as a consultant for the program and provide future training sessions and/or coordinate guest speakers and field trips. It is particularly rewarding to be involved with a program offered free of charge to its participants, so that all children have an opportunity to learn about the Sonoran Desert and how it relates to the urban environment.

ULTIMATE JOURNEY

Ultimate Journey is a national program developed by the Boys & Girls Clubs of America. Clubhouse sites are chosen based on neighborhood poverty and crime rates. The Boys & Girls Clubs of Tucson focus their

programs on building self esteem and mentoring for their members. Children ages 6-17 yrs old can join for a nominal fee and have access to a gymnasium, computer lab, arts and crafts room, library, games room and a variety of specialized programs. Two of the clubhouses have a majority of members that are immigrants from Mexico. The Ultimate Journey program encourages local clubhouses to incorporate an environmental education component in their annual programming, by seeking support from a local environmental organization. Tucson Audubon Society is entering its sixth year running the program at all three clubhouses. The Boys & Girls Clubs of Tucson has received a variety of grants from local foundations and state funds to support the program. Current funding is through a private donor, whom is offering long term, year round funding for the program! The Tucson Audubon Society is responsible for the development, administration, instruction and evaluation of the environmental education program. Ultimate Journey has taken many forms. TAS has held intensive ten week summer sessions, two week winter sessions, and six week spring sessions. Ultimate Journey is a combination of environmentally related field trips, community projects addressing environmental issues identified by the kids, and in-house activities, such as guest presentations with live animals or hands-on exhibits. An average of 75-90 kids participate in the summer session and the kids that participate and attend most regularly get to go on the "Ultimate Journey", an overnight camping trip in the mountains! This is one of the most popular programs offered at the clubs and each session has a waiting list of kids that want to join.

TIDEPOOLS FAMILY INSTITUTE

The Tidepools Family Institute is part of a series of retreats offered to parents and children five years and older to experience learning about nature while actually staying in the habitat that is being studied. TAS is one of the few organizations to fulfill the desire families have to experience nature in a learning environment along with other families with similar interests. The institutes are offered in a variety of biomes throughout the year. The program has been made available due to the collaboration between TAS, Extended University of Arizona, and the Center for the Studies of Deserts and Oceans (CEDO), with support from Heritage funds. Participants of the Tidepool Family Institute cross the border, pass through the small fishing village, Puerto Peñasco, on their way to the Sea of Cortez. Families and TAS faculty stay at CEDO, a research and educational facility, bordering a marine sanctuary with a thriving tidepool community. Scheduled events include tidepool investigation and observations, a visit to a local oyster farm (run by a women's cooperative) located

in an estero which contrasts greatly to the intertidal zone, and public aquarium administered by a local vocational college. This program is an excellent way to introduce families to the cultural, environmental and economic issues pressuring a shared resource such as the ocean, which recognizes no borders. Due to the overwhelming response from new and repeating participants, we fill two trips annually.

CONCLUSIONS

Tucson Audubon Society is fortunate to collaborate with such a diversity of organizations with similar goals of providing quality education programs along the U.S./Mexico border for youth, families and educators. We are proud to be involved with such innovative and valuable projects serving a wide range of community members. TAS continues to explore the gaps in environmental education in border communities to fulfill our long term commitment to better serve a much neglected population.

ACKNOWLEDGMENTS

Former Education Director, Lucia Sayre, Institutes Director, Cynthia Lindquist, and Executive Director, David Yetman of the Tucson Audubon Society were the driving force behind initiating programs along the border. Their hard work and vision provided the foundation for a majority of what Tucson Audubon Society stands for and continues to build upon. All three remain closely connected to TAS, contributing greatly to the strength and leadership of the organization. Their personal commitment, talent and enthusiasm are greatly appreciated!

BIOGRAPHICAL SKETCH

Erin K. Deely has been working as the Education Director for the Tucson Audubon Society for the past three and a half years. Prior to that, she worked as a forestry extentionist for the Monteverde Conservation League while serving as a Peace Corps Volunteer in Costa Rica, Central America. She worked as a marine biology instructor for the Catalina Island Marine Institute, following her graduation with a B.A. in Ecology and Evolutionary Biology from the University of Arizona. During her college years she gained experience in field biology as an intern at the Southwestern Research Station. She worked as an undergraduate teaching assistant for the 150 Marine Biology course and as a student research assistant for the Department of Entomology of the University of Arizona. Other skills include fluency in Spanish, S.C.U.B.A. certified, grant writing, and public speaking.

CULTURAL RESOURCES

El Uso Actual de los Monumentos Historicos en la Ciudad Fronteriza de Matamoros

Angelica Ibarra Gonzalez

Resumen.—El objetivo del trabajo es conocer cual es el uso y destino de los bienes inmuebles catalogados como monumentos historicos dentro del primer cuadro de la ciudad fronteriza de H. Matamoros, Tamaulipas. Estas edificaciones forman parte del patrimonio cultural del municipio, interesandonos saber cual es su uso actual, dando por resultado percibir con una vision concreta el nivel real de la concientizacion por parte de sus habitantes, ante la factibilidad y rentabilidad de sus propiedades. Usando para ello el siguiente metodo: mediante el levantamiento de un censo actualizado con el registro de los usos y destinos de los bienes inmuebles, especificar cual es su ubicacion dentro de la manzana. Clasificando esta informacion de acuerdo con el tipo de uso encontrado. Basandose en la lista del Catalogo Nacional de Monumentos Historicos actualizado en 1996 por el Centro INAH Tamaulipas y el Municipio. Con lo anterior sabremos la cantidad de inmuebles demolidos, abandonados por sus propietarios, o utilizados como viviendas particulares o de uso publico. Dandonos esto una vision clara del nivel de conciencia al patrimonio cultural por parte de los habitantes de este Muncipio y sus Autoridades. En la busqueda de la reactivacion y dignificacion del patrimonio edificado en el Centro Historico de la ciudad de Matamoros.

INTRODUCCION

En la ciudad de Matamoros, existen 154 Monumentos Históricos catalogados por el Instituto Nacional de Antropología e Historia como inmuebles con valor patrimonial, siendo estos parte del patrimonio cultural edificado existente en esta ciudad fronteriza. El Centro INAH Tamaulipas realizó la revisión de la Catálogo de Monumentos, conjuntamente con la Coordinación del Centro Histórico de la Dirección de Obras Públicas del Municipio, en junio de 1996, para su actualización. Posteriormente la Coordinación por se dió a la tarea de precisar los datos sobre las construcciones catalogadas, para entender de manera específica cuál es el uso al que se destinan los Monumentos por sus propietarios. De

esta forma se pueden distinguir cuál es la densidad de uso habitacional, equipamiento municipal, comercial, entre otros. Asimismo saber cuál es la cantidad de inmuebles demolidos a la fecha, cuántos Monumentos están abandonados, y cuál es el porcentaje de los monumentos restaurados.

Con lo anterior podemos establecer un panorama real de las acciones realizadas a la fecha dentro de las edificaciones del Centro Histórico. Asimismo se presentarán el trabajo realizado a la fecha para la protección del Patrimonio Edificado por parte de las Autoridades Municipales, Estatales, Federales y de los mismos propietarios para la conservación o destrucción de su patrimonio edificado.

El Centro Historico de Matamoros

A mediados del siglo XIX Matamoros tenia una sociedad cosmopolita que reunia a gente de distintas partes del mundo. En ese periodo en Matamoros se presento un gran auge economico y se dieron sucesos que tuvieron una importancia decisiva en el desarrollo politico del pais. En este contexto, las construcciones tuvieron una riqueza invaluable, con el estilo arquitectonico caracteristico de la epoca, donde se conjuntaron principalmente el neocolonial frances y el estilo Nueva Orleans.

Las construcciones mas importantes de este periodo se localizaron en un area especifica que puede consideranrse como el nucleo de sus actividades economicas, politicas, sociales, recreativas, etc.

Esta area actualmente se define como el Centro Historico de la ciudad. El centro historico mas que cualquier otra parte de la ciudad, por la presencia permanente del tiempo en sus estructuras, sus materiales y sus tradiciones, constituye la identificacion visual del hombre de hoy con sus raices, y en esta presencia viva del pasado es indispensable para su equilibrio tanto individual como social.

Los Usos y Destinos de los Monumentos Historicos

El Centro Historico de Matamoros, alcanza una cobertura de 114 manzanas. En ellas existen de 154 inmuebles catalogados como Monumentos Historicos por el Instituto Nacional de Antropologia e Historia y otros construcciones construidas a principios de este siglo que utilizaron en su estructura y ornamentos tipologias regionales, lo cual aporta un valor contextual de cerca del 40 % .

De los Monumentos revisados al 31 de mayo de 1998, se desprenden los siguientes tipos de utilidad. Lista de los tipos de usos actuales a los que se destinan:

- Casas Habitación.
- Comercios.

- Equipamiento Municipal.
- Sitios Históricos.
- Clubes Nocturnos.
- Demoliciones.
- Abandonados.
- Usos mixtos.

Casas Habitación

En cuanto a las casas habitación se incluyen todos aquellos monumentos históricos que hoy en día son utilizados para vivienda unifamiliar o plurifamiliar. Las personas que en ellas habitan conservan las propiedades por herencia familiar, o por adquisiciones posteriores. Con un promedio de habitantes por inmueble de 3.5. Existen 43 Monumentos utilizados como Casas Habitación.

El estado de conservación de los edificios varía desde unas óptimas condiciones hasta lasque se encuentran en peligro de derrumbarse, en cuanto a su estructura , instalaciones y sistema constructivo en general. Cabe mencionar el buen estado de los patios interiores, en cuanto a sistemas de recolección de agua pluvial y almacenaje para ser recicladas en aljibes o cisternas se refiere. La diversidad de la vegetación y los cuidados que sólo con un mantenimiento constante de las mismas familias se conserva. Ademas de 11 Monumentos usados como en uso mixto con la Casa Habitacion, y van desde los comercios varios hasta demoliciones parciales.

Comercio

Dentro de la actividad comercial en los monumentos historicos se tiene la mas amplia densidad; los problemas mas importantes son la subdivision de los espacios para su renta por varios locatarios dentro de un solo monumento, lo que conlleva a el intento constante de individualizar a sus negocios con colores, grandes anuncios publicitarios, todo con el fin de sobresalir de sus competidores con una publicidad mal entendida. Pues si lograran uniformizar los recursos utilizados dentro de un mismo monumento, resaltarian las virtudes arquitectonicas del espacio y reforzarian su presencia de forma contundente. Existen 60 Monumentos Historicos usados para albergar a la actividad comercial.

Los tipos de comercio registrados van desde las zapaterias, paleterias, tiendas de ropa, restaurantes, mercerias, joyerias, taquerias, oficinas, madererias, mueblerias. Tambien se combinan con el estado de demolicion y abandono.

Demoliciones

Desafortunadamente se ha perdido una parte insustituible del patrimonio edificado las causas son variadas, pero los resultados siguen siendo lamentables. De los 154 Monumentos Historicos son 18 los que ya no existen que representan cerca del 12 porciento de patrimonio destruido. A la fecha existen en su lugar estacionamientos, bancos, ferreterias, imprentas y hoteles; con una arquitectura que dista mucho de semejar el esplendor arquitectonico de sus antecesores.

Clubes Nocturnos

Existen clubes nocturnos albergados en monumentos, son 2. Uno de ellos es un club & dance y el otro es un Table Dance. Cabe hacer el comentario que los contructores o inversionistas en este momento tienen un gran interes en aprovechar este tipo de espacios para ser utilizados como clubes, restaurantes o discotecas. Al ser los costos por concepto de restauracion muy elevados, desisten y prefieren darle rehabilitacion y acondicionamiento a construcciones contemporaneas haciendolas parecer como antiguas.

Abandonadas

Con esto nos referimos a los Monumentos existentes en la actualidad a los que sus propietarios no les dan ni uso ni mantenimiento, y por lo anterior paulatinamente estan en peligro de perderse. Son 12 en total de los 154 existentes.

Sitios Históricos

Son aquellos sitios donde el alguna fecha se encontraban edificios del siglo XIX que eran utilizados para los mismos fines para los que ahora se utilizan, con la diferencia de que no se conserva nada de los materiales de aquel entonces, en su lugar estan inmuebles contemporaneos con estructuras, tipologias y ornamentos semejantes a los anteriores.

CONCLUSIONES

De la informacion de campo registrada, mediante su clasificacion nos podemos dar cuenta de que existe una marcada tendencia a utilizar estos espacios con fines comerciales. En este aspecto podemos planear la distribucion de factibilidad de uso de suelo comercial de acuerdo a una planeacion que corresponda con el caracter y las actividades del Centro Historico. Asimismo se percibe el interes de seguir habitando estos

espacios. Lo que nos refuerza el sentido de arraigo e identidad en correspondencia con sus tradiciones familiares.

Se presenta el fenomeno de demolicion como un tercer uso segun su densidad, y aunado con el abandono de los espacios es el renglon preocupante por mantenerse la postura de indiferencia y falta de preocupacion por conservar su patrimonio. Cabe hacer mencion que en estas demoliciones se efectuaron a lo largo de 12 anos desde la elaboracion del Catalogo de Monumentos en 1984 hasta su revision en 1996. De 1996 a la fecha no se ha realizado ninguna demolicion en el Centro Historico, debido a la compromiso de la autoridad municipal en la proteccion del patrimonio edificado. Mediante la creacion de una Coordinacion del Centro Historico dentro de la Direccion de Obras Publicas, en la que cualquier licencia de construccion dentro del Centro Historica, necesita ser aprobada para su ejecucion. Sin embargo se han presentado 7 licencias para demolicion por los propietarios, de las cuales solo una fue aprobada por sus debiles condiciones estructurales, asi como por ser construccion de este siglo.

Se percibe de igual forma la preocupacion de las autoridades municipales de poner el ejemplo con el mantenimiento constante de los Monumentos de su propiedad. A la vez que atendio una solicitud de demolicion para hacer un estacionamiento, y convertirla en una restauracion completa de un inmueble en el cual el monto de la restauracion sera tomado a cuenta de renta por su propietario para la instalacion de Oficinas de Planeacion Municipal.

Proporcionalmente, el uso de los Monumentos Historicos para ser utilizados como clubes nocturnos o expendios de vinos y licores, es menor, pero no con ello menos preocupante. Por lo que se han dictado ordenes para que el Departamento de Alcoholes no expida licencias para la venta de vinos y licores en las edificaciones catalogadas.

El resultado de esta investigacion permitira a futuros proyectos de planeacion turistica, comercial, historica, de fortalecimiento de vivienda, establecerse siguiendo como fin el equilibrio de las actividades que aqui se desarrollen y con esto fomentar el fortalecimiento de los proyectos para la rectivacion del Centro Historico del Municipio.

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PROTECTION AND CONSERVATION

Areas Protegidas en México ante Proyectos de desarrollo: El Caso de la Laguna San Ignacio en B.C.S., México

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Resumen.—Actualmente la conservación de la naturaleza se encuentra directamente vinculada con la planificación y la utilización de los bienes naturales y las Areas Naturales Protegidas resultan ser un instrumento clave para lograrlo.

En Baja California Sur, existen cinco zonas geográficas protegidas legalmente por decreto presidencial dentro de las cuales se incluye la Laguna San Ignacio decretada en 1979 y la Reserva de la Biósfera El Vizcaíno decretada en 1988.

A mediados de 1994, se propone la creación de un proyecto salinero en una parte del Area Natural Protegida, que generó una controversia que llegaban a demostrar la disyuntiva a la que se enfrentan los tomadores de decisiones frente a proyectos de este tipo. Por un lado se busca promover el desarrollo económico tan necesario en regiones como Baja California Sur, y por el otro se busca promover la conservación de los recursos naturales de la región.

En este trabajo se pretenden resaltar los elementos que fundamentados en la conservación de los recursos naturales presentes en el área, fueron utilizados para detener el proyecto hasta la fecha, así como el de reconocer el papel de los instrumentos de conservación en proyectos de desarrollo que involucran la posible afectación al entorno natural.

Abstract.— The conservation of the natural resources is directly vinculated with the planification process and the utilization of the natures goods, and the Natural Protected Areas seems to be the key instrument to achieve it.

Baja California Sur has five geographic zones that are legally protected by presidential decree, being one of them the San Ignacio Lagoon decreeted in 1979 and also the Biosphere Reserve El Vizcaíno decreeted in 1988, that is the biggest area under protection in the country.

In the middle of 1994, it proposes the creation of a saline project in one part of the Natural Protected Area, it generates a controversy that demonstrate the reality that the decision makers confront when projects like this go public. In one side, they are

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looking to promote an economy development that is so necessary in regions like Baja California Sur, but by the other hand, they are looking forward to promote the regions natural resources conservation.

This paper highlights the main elements according to the basis on natural resources conservation, where used to postponed the project until now, and also it recognizes the function of the conservation instruments in projects where involves the possibly affectation of the natural surroundings.

INTRODUCCION

En México, contamos con una riqueza florística y faunística impresionante, lo que nos ha permitido ocupar el cuarto lugar a nivel internacional en cuanto a biodiversidad se refiere. Sin embargo, la desaparición de los viejos y sencillos estilos de vida y de las prácticas tradicionales de uso de los recursos en las comunidades rurales, han logrado afectar significativamente las condiciones de existencia, salud, acceso a satisfactores mínimos y calidad de vida de las grandes mayorías del pueblo mexicano, que aunado a la falta de planeación integral y espacial para el uso de suelo se ha traducido en un deterioro constante de los recursos naturales.

Ante esta realidad, se busca adaptar algunas de las estrategias emitidas internacionalmente para la conservación y protección de los recursos naturales, siendo una de ellas la relacionada con las declaratorias de las Areas Naturales Protegidas, las cuales se definen como:

"porciones de ecosistemas terrestres o acuáticos sujetas a un régimen especial de protección, cuyo objeto es suprimir o mitigar cualquier influencia negativa del hombre sobre dicha área, así como asegurar la preservación y restauración de los ecosistemas, especialmente los más representativos y aquellos sujetos a procesos de deterioro o degradación" (Alcérreca C., 1988).

Las alternativas de uso de suelo y recursos en estas áreas se consideran mutuamente exclusivas y son las siguientes:

- **Conservación** refleja un costo de oportunidad representado por lo que se deja de obtener al decidirse por no modificar el Area Natural Protegida.
- ***Manejo Sustentable*** donde se manifiestan las opciones de conservar o transformar pero tomando en cuenta a las generaciones futuras (Daly, 1994).
- ***Utilización*** donde la transformación puede llegar a modificar las opciones del futuro.

En 1983 con la creación de la Secretaría de Desarrollo Social (SEDUE) se generó una propuesta de reorganización de todas las ANP en el país, como un primer paso para la creación del Sistema Nacional de Areas Naturales Protegidas (SINAP). Tanto el SINAP como cada una de las ANP en lo particular, han enfrentado una problemática definida y un panorama desalentador.

Hablando particularmente de las Reservas de la Biósfera, cabe destacar que son aquellos espacios que intentan proteger muestras representativas de los ecosistemas naturales, y a la vez abarcar zonas ya alteradas para poder de esta manera monitorear la interrelación Hombre - Ambiente. La conservación se concibe como usar bien y no como prohibir el uso (Alcérreca, *op. cit.*).

Dentro de esta clasificación, se denota unas "zonas núcleo", que son las superficies mejor conservadas o no alteradas; y por "zonas de amortiguamiento", las cuales son las superficies que se consideran necesarias para proteger la zona núcleo.[2]

En este trabajo se pretenden resaltar los elementos que fundamentados en la conservación de los recursos naturales, fueron utilizados para detener hasta la fecha la propuesta de creación de una salinera en las inmediaciones de un Area Natural Protegida en Baja California Sur, así como el de reconocer el papel de los instrumentos de conservación en proyectos de desarrollo que involucran la posible afectación al entorno natural.

En párticular, este proyecto generó una controversia a nivel nacional e internacional que llegaban a demostrar la disyuntiva a la que se enfrentan los tomadores de decisiones frente a proyectos de este tipo. Por un lado se busca promover el desarrollo económico tan necesario en regiones de nuestro país y por el otro se busca promover la conservación de los recursos naturales, con base en los elementos que motivaron a la declaratoria del área bajo protección.

LAS ÁREAS NATURALES PROTEGIDAS EN BAJA CALIFORNIA SUR

El estado de Baja California Sur tiene aproximadamente 2 700 000 Has. bajo algún régimen de protección, lo que corresponde al 36.4% de la superficie estatal. Es el Estado que aporta cerca del 45% de la superficie bajo protección al SINAP. Las categorías incluyen una Reserva de la Biósfera y una serie de refugios y reservas de flora y fauna de la región.

La Reserva de la Biósfera se reconoce bajo el nombre de El Vizcaíno, comprende la mayor parte de la superficie bajo protección en el país con

[2] *En estas sólo pueden autorizarse actividades de preservación de los ecosistemas y sus elementos, y las cuales se limitan a actividades productivas de las comunidades que ahí habiten en el momento de la expedición de la declaración respectiva, así como actividades educativas, recreativas, de investigación y capacitación.*

2'546,790 Has., está ubicada en la parte norte del estado de Baja California Sur en el Municipio de Mulegé. Tiene una población aproximada de 38,000 habitantes y es el área que representa el ecosistema de matorral desértico dentro del Sistema Nacional de Areas Naturales Protegidas (SINAP) (Teja, Servín y Gallina, 1991). Incluye 16 *zonas núcleo* que ocupan en conjunto 363,438 hectáreas y *zonas de amortiguamiento* que constituyen el 86% de toda la región reservada, según lo establecido dentro del Plan de Manejo de la Reserva.[3]

Las características físicas presentes en la Reserva, pertenecen a la región hidrológica Baja California Centro - Oeste (INEGI, 1982a y 1982b)

LA DISPUTA EN LA ZONA

En el año de 1993 la empresa Exportadora de Sal S.A. de C.V. (ESSA) presentó ante las autoridades su inquietud por desarrollar el proyecto denominado Salitrales de San Ignacio el cual consiste en la instalación de una salina para la producción de sal a través de la evaporación de agua de mar con la utilización de energía solar. La zona de ubicación propuesta es la parte norte del estado de B.C.S. colindante con el Océano Pacífico.

El proceso de producción de sal sería el mismo que se ha venido desarrollando por la misma empresa desde hace ya cuarenta años en las instalaciones de Guerrero Negro, con la que se mantiene una producción anual de 6 millones de toneladas de sal, posicionando con ello al país en el segundo lugar a nivel mundial.[4]

En términos de factibilidad económica, la justificación parece aceptable considerando que en la región existen elevados niveles de migración debido a la carencia de empleo, falta de acceso a servicios y una calidad de vida precaria. En términos ambientales el área de ubicación del proyecto forma parte de la zona de amortiguamiento de la Reserva de la Biosfera El Vizcaíno, que como se mencionó anteriormente contiene en sí misma una importancia natural importante.

A manera de respuesta, aparecen declaraciones de organismos como el Instituto Nacional de Pesca y el gobierno estatal y municipal que argumentan la necesidad de fomentar proyectos de desarrollo económico que permitan la inversión en una zona donde las necesidades para elevar la calidad de vida son evidentes.

En febrero el INE emite el resultado del proyecto "Salitrales de San Ignacio como NO PROCEDENTE en los términos establecidos en el Estudio de Impacto Ambiental (EIA)."

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[3] *"Dentro de la zona de amortiguamiento pueden impulsarse actividades productivas que no alteren los principios de preservación y conservación de los diversos ecosistemas existentes en el área."*

[4] *Actualmente Australia ocupa el primer lugar en producción con 6.5 MTon/año, le sigue México con 6 MTon/año.*

En marzo de 1995 ESSA interpone un "Recurso de inconformidad" y manifiesta la voluntad por realizar un nuevo EIA, solicitando al INE establezca los términos de referencia que debe contener el nuevo documento.

En enero de 1996 la SEMARNAP informa sobre la creación de un Comité Científico Internacional, integrado por siete científicos expertos en materia de dinámica de ballenas, sistemas marinos y terrestres y manejo de Recursos Naturales en zonas desérticas.

El Comité inició sus funciones visitando la zona donde se pretende establecer el proyecto y convoca a una Consulta Pública sobre el "Proyecto Salitrales de San Ignacio", con objeto de reconocer la opinión de los afectados directos e indirectos del proyecto.

"Con esto se pretende incorporar la participación social en proyectos de desarrollo" declaró Pedro Alvarez Icaza (Comunicación personal, 1996).

La fecha límite para que el Comité Científico estableciera los términos de referencia que deben incluirse en el nuevo EIA fue el último de mayo. En junio aparece en El Mexicano un informe de la SEMARNAP sobre los resultados de los primeros trabajos del Comité donde se declara que los términos de referencia se darán a conocer públicamente.

Una vez establecidos estos, la empresa encargó la elaboración del estudio a la Universidad Autónoma de Baja California Sur con asesoría directa de empresas consultoras internacionales. Una vez concluido éste, el INE entregará al Comité el nuevo EIA a fin de verificar el cumplimiento de los términos de referencia establecidos y realizar una evaluación ecológica de este proyecto para que la autoridad lleve a cabo la evaluación y dictaminación final del mismo.

El INE manifiesta su firme compromiso de que "este proyecto sólo será autorizado si cumple con la normatividad ambiental vigente" (Comunicación personal, Pedro Alvarez, 1996).

La problemática que se generó a partir de la propuesta "Salitrales de San Ignacio" involucró un proceso que hasta la fecha de culminación de esta investigación, aún no ha llegado a su fin.

REFLEXIONES FINALES

Las diferentes clasificaciones de Areas Naturales Protegidas (ANP) en México están sujetas a cierta normatividad y podríamos afirmar que su aplicación está lejos de ser óptima. El problema inicia desde la declaratoria del área, ya que en el país no se cuenta con un reglamento específico que señale los procedimientos que debe seguirse tanto para su seguimiento como para el manejo y administración de la misma.

Por otro lado, las ANP ya declaradas enfrentan un abandono considerable debido a la falta de infraestructura administrativa para su manejo y

control, por lo que se presenta un deterioro en las funciones del área como instrumento de conservación, además, no existen programas de investigación que reflejen la diversidad de recursos con los que cuenta el ANP, los cuales se consideran necesarios para utilizarlos como base de información para investigaciones futuras que permitan reconocer la relevancia del área como instrumento de conservación.

El seguimiento del conflicto hasta la fecha permitió identificar dos líneas que dieron origen a que la decisión sobre el proyecto de instalación de la nueva salina generara la discusión a la que se enfrentan las autoridades en materia ambiental en el país. La primera corresponde a la falta de incorporación de la participación social en decisiones que involucran proyectos de desarrollo y el segundo se refiere a la falta de claridad en el plan de manejo de las Areas Naturales Protegidas en nuestro país, en este caso de la reserva de la Biósfera El Vizcaíno.

La incorporación de la opinión pública refleja una etapa que hace notar el cambio que emerge en la administración pública cuando se enfrentan a proyectos que involucran el posible impacto sobre el ambiente y se busca incorporar los elementos establecidos a nivel internacional para lograr un Desarrollo Sustentable en nuestro país.

La falta de reglamento explícito de la Reserva de la Biósfera el Vizcaíno, donde se determinen claramente las modalidades de acceso a los recursos existentes, la participación de las comunidades locales en la gestión de esta área y el desarrollo de disposiciones relativas a los usos permitidos dentro de ella, fueron sin duda un determinante importante en el proceso que se manifestó a partir de la propuesta por parte de ESSA.

Esta misma carencia se observa también en cuanto a infraestructura y presupuesto suficiente y la carencia de programas de investigación que proporcionen el conocimiento pleno de los recursos de las Reserva y las técnicas adecuadas tanto para el manejo racional y sostenido de los recursos como para la solución de los problemas sociales ligados a éstos.

Existe además un alto grado de centralización en la toma de decisiones, discrecionalidad de las autoridades en turno, carencia de recursos humanos para la administración y vigilancia, así como una legislación bastante dispersa, lo cual dificulta su aplicación.

Con respecto al derecho de propiedad bajo el cual se sustenta la Reserva, éste puede considerarse eficiente ya que al estar bajo propiedad Estatal, se pueden determinar las reglas de uso de la misma, además todos los involucrados tienen la obligación de observar todo tipo de lineamiento establecido, ya que la Reserva constituye un bien público donde la decisión de los individuos se manifiesta a través del Estado y el interés común es el de mayor peso sobre los intereses individuales, sin embargo, el problema que se presenta con este tipo de derecho de propiedad es que existe una falta de recursos para el buen manejo y administración de la Reserva.

Por otra parte, la participación de la población local en el manejo y conservación de la Reserva ha sido prácticamente nula (MIA, 1994).

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RESUMEN BIOGRÁFICO

Investigadora en el área ambiental de El Colegio de la Frontera Norte en la Dirección Regional de Cd. Juárez desde septiembre de 1996. Con estudios de Maestría en Administración Integral del Ambiente por El Colegio de la Frontera Norte (El COLEF) y Centro de Investigación Científica y Educación Superior de Ensenada (CICESE). Tijuana B.C. (1994-1996). Licenciatura en Químico Industrial Facultad de Ciencias Químicas. Universidad Autónoma de Baja California, cindad Tijuana (1989-1993).

Objetivo profesional es el de prestar servicios en el área ambiental, con el fin de contribuir en la solución de problemas que involucren el manejo de recursos naturales, la aplicación de la normatividad y la evaluación de los posibles impactos sobre el medio. Asistencia a diferentes foros y seminarios organizados en materia ambiental a nivel nacional y binacional.

Environmental researcher in the El Colegio de la Frontera Norte in Ciudad Juárez since September 1996. Master degree in Integrated Environmental Administration by El Colegio de la Frontera Norte (El COLEF) and the Centro de Investigación Científica y Educación Superior de Ensenada (CICESE) in Tijuana B. C. (1994-1996). Bachelors degree on Industrial Chemist by the Chemistry Science Faculty of the Universidad Autónoma de Baja California, in Tijuana (1989-1993).

Professional goal is to work in the environmental area solving problems in natural resource management and the legal application and evaluation of environmental impacts.

Ecological Information Exchange Across the Border: A Bibliography for Planners, Managers, and Research Workers

Peter F. Ffolliott[1], Leonard F. DeBano[1], Diego Valdez-Zamudio[1], Malchus B. Baker, Jr.[2], Carleton B. Edminster[2], Daniel P. Huebner,[2] and Gerald J. Gottfried[2]

Abstract.—The ecology of the Madro-Tertiary of North America is generally poorly known. Furthermore, its scientific literature on ecosystem-based management has been largely uncollected and, therefore, is unknown to many planners, managers, and research workers. To provide this needed informational base, a bibliography of about 5,000 references has been compiled to furnish a basis for the planning and implementing of management activities and research endeavors in this region. The geographical scope of the bibliography is the Madrean Archipelago region of the southwestern United States and northwestern Mexico. Literature from similar ecosystems on adjacent areas has also been included in the bibliography, because of the significant ecological overlap. The large number of citations in the bibliography prevents its publication. However, the bibliography is available on a World Wide Web site.

Resumen.—La ecologia de Norte América en el Madro-Terciario es escasamente conocida. Además, muy poca de la literatura relacionada con el manejo de ecosistemas ha sido colectada y, por consiguiente, desconocida por muchos planificadores, técnicos e investigadores del suroeste de los Estados Unidos y el noroeste de México. Como consecuencia de esta situación, la presente bibliografia de casi 5,000 citas fue compilada para proporcionar una literatura básica relacionada con al implementación de actividades de manejo y planificación de proyectos de investigación en esta región. La extensión geográfica de esta literatura comprende la Provincia Biogeográfica Madrense al norte de los 27° de latitud, incluyendo la región del Archipélago Madrense en el interior de los Estados Unidos. Importante literatura sobre ecosistemas similares pero de áreas adyacentes, se ha incluido en la compilación bibliográfica debido a la similitud ecológica entre áreas. La mayor parte de las referencias en el

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acervo bibliográfico prohibe su publicación. Sin embargo, dicha bibliografía o categorías individuales estan disponibles en una página del sistema World Wide Web.

INTRODUCTION

The ecology of the Madro-Tertiary of North America is generally poorly known. Furthermore, its scientific literature on ecosystem-based management is largely uncollected and, therefore, is unknown to many planners, managers, and research workers. To provide this needed informational base, a comprehensive bibliography of about 5,000 references has been compiled to furnish a base for the planning and implementing of management activities and research endeavors in this region.

The geographical scope of the bibliography is the Madrean Biogeographic Province north of 27° latitude, including the Madrean Archipelago region in the southwestern United States and northwestern Mexico (IUCN Secretariat 1973, Brown 1982, DeBano et al. 1995). Literature from similar ecosystems on adjacent areas has also been included in the bibliography, because of the significant ecological overlap.

The bibliography contains citations of historical and contemporary relevance to the Madrean Biogeographic Province. More general citations have also been included when specific mention has been made of this region in the reference. References relating soley to technologies, methodologies, and procedures have been largely omitted from the bibliography, except in cases when the application illustrated applies directly to the region.

DATA BASES SEARCHED

Computerized and hardcopy data bases were searched for appropriate literature in compiling this bibliography. The computerized data bases interrogated were:

- FS INFO
- CAB Abstracts
- AGRICOLA
- BIO SIF Previews
- Life Science Collections
- Southwestern Center for Biological Diversity: Grazing Abstracts
- Riparian Bibliography for New Mexico and the Southwest: Selected Annotations

Published hardcopy data bases searched in compiling the bibliography included:

- Selected References: The Encinal Woodlands (Ffolliott and Gottfried 1992).
- Livestock Management Effects on Wildlife, Fisheries, and Riparian Areas: A Selected Literature Review (Anderson 1993).
- Annotated Bibliography: Ecological Impacts of Livestock Grazing in Western North America (Fleischner 1993).
- Southwestern Research Station Bibliography (1955-1994) (Sherbrooke 1994).
- A Bibliography for the Northern Madrean Biogeographic Province (Ffolliott et al. 1994).
- Southwest Watershed Research Center: A History of Research for Today and Tomorrow (USDA Agricultural Research Service 1994).
- Land Use History of the San Rafael Valley, Arizona (1540-1960) (Hadley and Sheridan 1995).
- Annotated Bibliography of Reports, Publication, and Thesis on the Appleton-Whittell Research Ranch Sanctuary (National Audubon Society 1995).
- Papers presented at the conference on the 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, are also included in the bibliography, along with the relevant literature cited in these papers (DeBano et al. 1995).
- An annotated bibliography of publications from the Southwest Watershed Research Center (USDA Agricultural Research Service 1995).
- A bibliography for Animas Valley of SW New Mexico (no author).
- A Selected Bibliography: Effects of Fire on the Madrean Province Ecosystems (DeBano and Ffolliott 1996).
- The Santa Rita Experimental Range: History and Annotated Bibliography (1903-1988) (Medina 1996).
- The Role and Importance of Disturbances and Climate Change on Plant Communities in the Borderlands of U.S./Mexico: A State-of-the-Knowledge Review with Recommendations for Future Research (McPherson and Weltzin 1996).
- Literature of Wildlife Research in the Madrean Archipelago: 1800s - 1994 (Morrison et al. 1997).

Thesis and dissertations on topics relevant to the Madrean Biogeographic Province are listed in the bibliography. "Fugitive literature," that is, office reports, field trip summaries, map references, and other unpublished but relevant materials, are also included where appropriate. This latter literature is most commonly found in special collections of large libraries.

ORGANIZATION OF BIBLIOGRAPHY

Citations in the bibliography are listed alphabetically by senior author's last name in selected categories determined by the bibliography's compilers to be most appropriate to the subject-matter of the reference. In cases where a citation could have been placed into two or more categories, it was placed in the one category judged by the compliers to be most appropriate based on the major emphasis of the reference. Categories in the bibliography are:

- Climate and Weather Patterns
- Conservation and Management
- Economics, Policies, Sociology
- Fire and Fire Effects
- History of Land Use
- Human Impacts
- Hydrology and Watershed Management
- Invertebrate Ecology
- Plant Ecology
- Range Management and Livestock Grazing
- Recreation and Tourism
- Riparian Ecosystems
- Soils, Minerals, Geological Features
- Vertebrate Ecology

It can be necessary to search through more than one category to complete a listing of references on a particular topic. For example, references on a topic in Range Management and Livestock Grazing might be found in this category and also in the categories on conservation and management and plant ecology. References on Riparian Ecosystems are found in both this category and the categories on Hydrology And Watershed Man-

agement and Vertebrate Ecology (e.g., birds in riparian habitats). References on Fire And Fire Effects can be found in this category and also in the categories on Conservation And Management and Plant Ecology.

Some of the citations listed are incomplete. Pages of volumes in a series might not always be included, or symposia editors, technical coordinators, or compilers have not always been presented. These instances occurred when a reference itself could not be located in the library and its citation verified. Information presented in the bibliography in these instances represents that contained in the original data base searched for the reference. However, information for the references contained in the bibliography should enable the user to search for the document in a library.

The large number of references comprising the bibliography precludes publication in this paper. However, the bibliography, and individual categories therein, are available to users on a World Wide Web site at

www.rms.nau.edu/publications/madrean/

provides a connection to the bibliography's main menu. Selected background information and topical categories can then be downloaded from the Web site onto computer disks for further analysis.

ACKNOWLEDGEMENTS

Financial support from the Cooperative Park Studies Unit, Geological Survey, U.S. Department of the Interior, enabled the effort to compile this bibliography to begin. This initial work culminated in the publication of a preliminary bibliography of literature pertaining to the Madrean Biogeographic Province (Ffolliott et al. 1994). Subsequent funding was then provided by the Rocky Mountain Research Station, USDA Forest Service, through the Borderlands Ecosystem Management Program, and by the School of Renewable Natural Resources, University of Arizona, to complete collation of the bibliography.

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BIOGRAPHICAL SKETCHES

Peter F. Ffolliott is a Professor with the School of Renewable Natural Resources, University of Arizona, Tucson, Arizona. He graduated with a B.S. in Forestry from the University of Minnesota, with a M.F. in Forestry-Wildlife Management from the University of Minnesota, and with a Ph.D. in Watershed Management from the University of Arizona. Peter teaches and conducts research in forestry and integrated watershed management.

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What to Protect in Chihuahua and Sonora

Rurik List[1], Oscar Moctezuma[2], and Matthew J. Miller[3]

Abstract.—In November 1997, The Wildlands Project and Naturalia A.C. organized a workshop to identify conservation priority areas in the Northern Sierra Madre Occidental and adjacent lowlands of Chihuahua and Sonora as a step towards the creation of a regional network of protected areas. 45 participants representing 25 government institutions, universities and NGOs, outlined on topographic maps areas they worked or knew within northern Chihuahua and Sonora that were considered biologically important using predetermined criteria. Thirty-three areas in northern Chihuahua and northeastern Sonora were identified as important for maintaining high biodiversity and providing many ecosystem services within the region. Participants listed logging, overgrazing, agriculture, overexploitation of natural resources, introduction of exotic species, and development as the major threats to the ecological integrity of the region. Most of the land is either privately owned or ejidal. More information is needed from the selected areas, both biological and social, in order to determine the best strategies for the conservation of each site. The collaboration of people and institutions working within the region is essential for the implementation of conservation actions.

Resumen.—En noviembre de 1997, The Wildlands Project y Naturalia A.C. organizaron un taller de trabajo para identificar áreas prioritarias para la conservación en el norte de la Sierra Madre Occidental y tierras bajas adyacentes de Chihuahua y Sonora, como un paso hacia la creación de una red de áreas protegidas en la región. 45 participantes, representando 25 instituciones de gobierno, Universidades y ONGs, delimitaron en mapas topográficos las áreas en que trabajan o conocen en el norte de Chihuahua y Sonora, y que son consideradas como biológicamente importantes basadas en 16 criterios predeterminados. Treinta y tres áreas fueron identificadas como áreas que son importantes para el mantemiento de la diversidad biológica y de los servicios ecologicos en la región. Los participantes consideraron la tala, sobrepastoreo, agricultura,

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sobre-explotación de recursos naturales, introducción de especies exóticas y desarrollo como las principales amenazas a la integridad ecológica de la región. La mayor parte de la tierra es propiedad privada o ejidal. Se requiere mas información de las áreas seleccionadas, tanto biológica como social, para determinar las mejores estrategias para la conservación de cada sitio. La colaboración de las personas e instituciones que trabajan en la región es esencial para llevar a cabo las acciones de conservación.

INTRODUCTION

A central mission of protected areas worldwide is the preservation of biodiversity and maintenance of ecological and evolutionary processes. In order to accomplish this mission in the northern Sierra Madre Occidental region of northwestern Mexico and the Sky Island region of southwestern United States, cross-border efforts to maintain ecosystem integrity and landscape connectivity must be established. As part of this effort, The Wildlands Project (TWP) and Naturalia A.C., initiated a joint project to design a system of protected areas in the northern Sierra Madre Occidental and adjacent lowlands based on the goals of biodiversity protection and landscape connectivity. This system will be linked to the ongoing reserve design efforts of The Sky Island Alliance, which is creating a similar plan for southwestern New Mexico and southeastern Arizona. Combined, these efforts will result in the design of a regional network of reserves and protected areas for the long-term protection of wide-ranging animals and other spatially sensitive species.

METHODS

Our first step was to identify the areas of biological importance that require protection. In November 1997, TWP and Naturalia organized a workshop in "La Campana Experimental Field" near Chihuahua City. Forty-five participants from 25 state and federal government institutions, universities and non-governmental organizations, including several people from the U.S., participated in the workshop. Table 1 lists the organizations and institutions which participated in the workshop.

Participation by representatives of state and federal agencies was important as it informed them directly of the sponsor organization's conservation interest. As a result, these representatives were able to commit to collaborating and assisting with the future protected areas network design. At the same time, government representatives informed other participants of the different opportunities for conservation efforts available

under current Mexican law. The governmental and non-governmental cooperation established at the meeting will greatly facilitate the development of the project.

Table 1. Agencies and organizations participating in site identification.

Bosque Modelo
Centro de Estudios Biológicos, Universidad Autónoma de Ciudad Juárez
Consejo Internacional para la Preservación de las Aves en México (CIPAMEX)
Comision Nacional para el Conocimiento y el Uso de la Biodiversidad (CONABIO)
Consejo Asesor Sierra Madre
COTECOCA Secretaría de Agricultura y Ganadería
Departamento de Ecología del Gobierno del Estado de Chihuahua
Dirección General de Fauna Silvestre-Instituto Nacional de Ecología, Secretaría de Marina, Recursos Naturales y Pesca (DGVS-INE-SEMARNAP)
Dirección de Investigación, Universidad Autónoma de Chihuahua
Dirección General de Desarrollo Rural, Gobierno del Estado de Chihuahua
Facultad de Biología, Universidad Autónoma del Estado de México
Fauna Silvestre, Universidad Autónoma de Chihuahua
Fondo Mexicano para la Conservación de la Naturaleza
Instituto del Medio Ambiente y Desarrollo de Sonora (IMADES)
Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, Secretaría de Agricultura y Ganadería (INIFAP-SAGAR)
Instituto de Ecología, Universidad Nacional Autónoma de México
Instituto de Estudios Superiores de Monterrey
Museo de Zoología, Universidad de Amsterdam
Naturalia, A.C.
Parque Nacional Cumbres de Majalca
Protección de la Fauna Mexicana, A.C. (PROFAUNA)
Secretaría de Marina, Recursos Naturales y Pesca (SEMARNAP), Chihuahua
Sierra Madre Alliance
Sky Island Alliance
The Wildlands Project

We asked participants who worked in the region to identify those areas that they considered biologically important based on 16 predetermined criteria identified in Table 2. It is important to note that the results of this survey were not intended nor expected to be comprehensive. Rather, results provide an initial insight into the regional ecology, biogeography and conservation status which will be used in further analysis.

Table 2. Criteria used for site selection.

1. High biodiversity (HDIV)	9. Important biological phenomena (BIOL)
2. High endemicity (HEND)	10. Important sites for migratory species (MIGR)
3. Presence of endemic species (ENDM)	11. Low road and human density (WILD)
4. Presence of endangered species (ENDG)	12. River headwaters (HEAD)
5. Climax communities (CLIM)	13. Alternative use of resources (ALTR)
6. Unique habitats (HABT)	14. Diversified cattle ranching (CATT)
7. Nesting sites (NEST)	15. Presence of conservation projects (CONS)
8 Well preserved sites (PRSV)	16. Protected areas (PROT)

Areas were drawn on 1:250,000 scale topographic maps, and the description of each was written in data sheets, and latter entered into an electronic database.

RESULTS

Thirty-three areas were identified during the workshop, however there was overlap between some areas. If the areas with overlap are clustered, the number of separate areas is 27. Table 3 gives the name of sites identified in the workshop. Figure 1 is a map delimiting sites by the number given in Table 3.

Table 3: Sites identified for biodiversity and ecosystem services.

1. Babícora	11. La Gregoria-El Sueco	21. Pastizales en valles centrales
2. Bavispe	12. Laguna Mexicanos	22. Salamayuca
3. Cebadillas	13. Los Reyes	23. Sierra del Nido
4. Cuenca del Río Papigochi	14. Los Reyes	24. Sierra Huachinera (El Tobaco)
	15. Mesa San Agustín	25. Sierra San Antonio
5. El Berrendo	16. Mesa Campanero – **Arroyo El Reparo**	26. Sierra de San Luis
6. El Capulín		27. Tapiecitas
7. El Cuervo	17. Mirador El Caballo	28. Teseachic
8. Janos	18. Mesa de las Guacamayas	29. Los Ajos-Buenos Aires
9. Laguna Bustillos	19. Pastizales Halófitos	30. Mazatán
10. Laguna Encinillas	20. El Poleo-Río Negro – **Mesa Pinoza**	31. Sierra El Tigre-San Diego

Biological highlights

Vegetation types included in the areas identified at the workshop include: different grasslands, oak, pine-oak, pine, mix, and gallery forests, tropical deciduous forest, different types of desert scrubs, sand dunes and riparian vegetation. Some of the biological highlights include:

1. The main breeding grounds for the thick-billed parrot, in Mesa de las Guacamayas and Cebadillas.
2. The largest prairie dog complex in North America in Janos (due to the key role of prairie dogs in the prairie ecosystem, many species, including several at-risk like the golden eagle and kit fox, are abundant in the area).
3. The presence of black bears and pumas. Given the large habitat requirements of large carnivores, the long-term survival of these species in the region depends on the connectivity between the populations;
4. Recent records of jaguars in Bavispe and Janos.

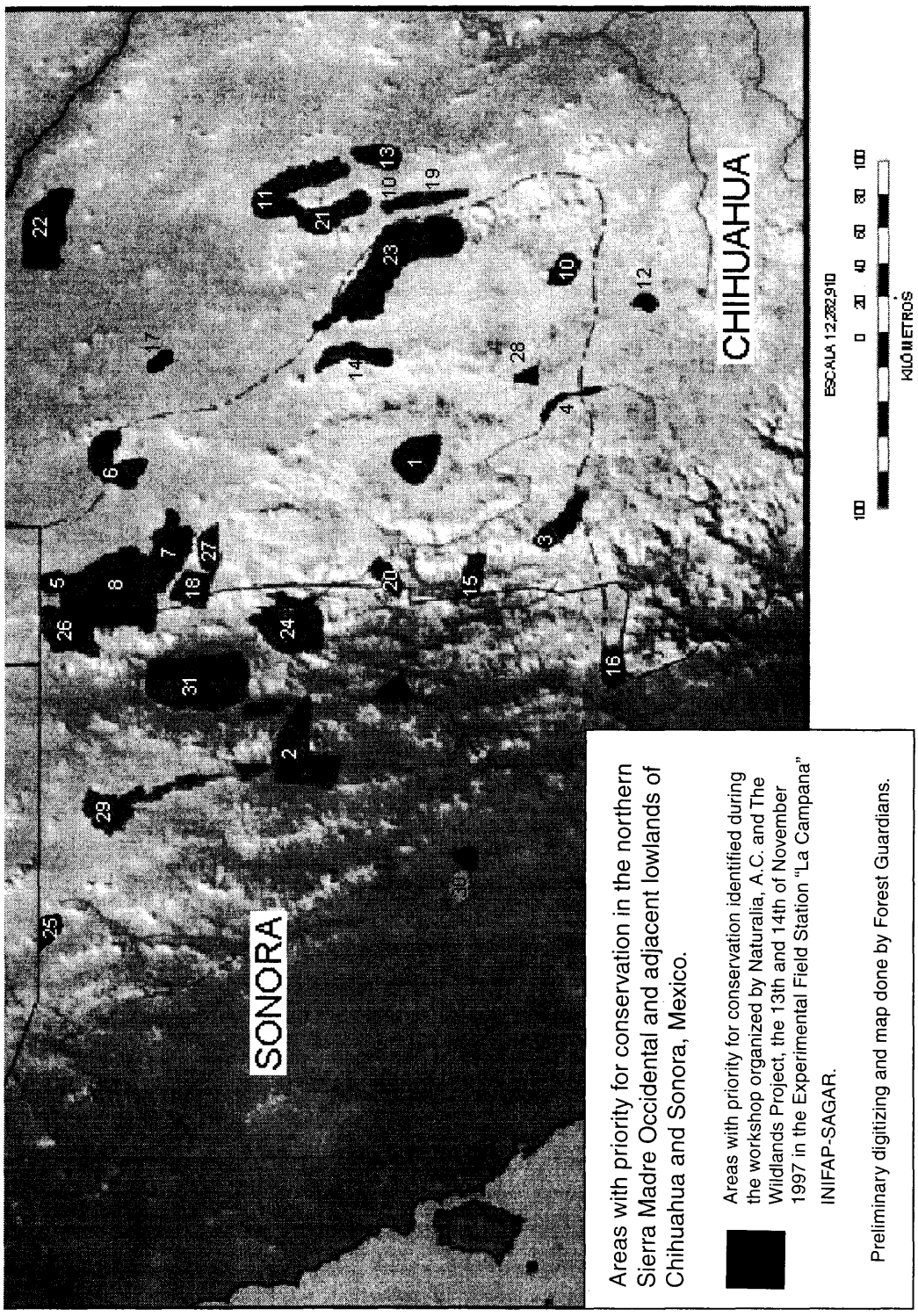


Figure 1. Sites of high biodiversity and/or important ecosystem services in Chihuahua and Sonora, Mexico.

5. The southernmost populations of beavers (in Río Negro, further south than most people think).
6. Patches of *Pseudotzuga menziesi* (Douglas fir) and *Picea chihuahuana* (Chihauhuan spruce) found in the highest elevations of areas like Janos and Cebadillas.
7. The largest (300 ha) remnant of pine-oak old-growth forest in the region, which is found in Sierra Huachinera.

Most areas hold populations of species at risk (28) and endemics (20). About half of the areas are important nesting sites (17), maintain unique habitats (15), and important biological phenomena occurs within them (16). Many areas are well preserved (13), have ongoing conservation projects (12), have a high biodiversity (11) and have a low human and road density (11). In some areas, alternative uses of natural resources is taking place (8), while in only 3 areas diversified cattle ranching are taking place. Only 1 area is officially protected (Table 4).

Regional threats

The main threat to the areas is the overgrazing by cattle. This and illegal hunting affect both lowlands and highlands. Deforestation is a major problem in the highlands. Other threats, like road construction, fires, over-exploitation of natural resources, urban and industrial development, and even nuclear wastes, are currently faced by particular areas.

Status of information, protection and conservation

Some areas, like Bavícora, Bavispe and El Cuervo, have good general biological information such as species list's of flora and fauna, conservation status, land property, etc. Others like Cebadillas, La Gregoria-El Sueco or Samalayuca have in-depth information on some aspects, but require complete inventories, etc. In general, the information available for most sites is fragmentary.

CONCLUSIONS

The workshop provided a first step towards a conservation strategy for northern Sonoran and Chihuahuan ecosystems. Considerable work remains to secure the conservation of the diversity and ecological function of this region. However, our workshop gathered people who previously were working independently to unite in working towards a common goal. The collaboration of such people studying, researching and living in the region is essential to our future conservation success.

Table 4: Identified Ecosystem Services by Site (for headings see Table 2)

SITE	HDIV	HEND	ENDM	ENDG	CLIM	HABT	NEST	PRSV	BIOL	MIGR	WILD	HEAD	ALTR	CATT	CONS	PROT
Babícora			x	x			x			x					x	
Bavispe				x												
Cebadillas	x		x	x	x	x	x	x	x		x	x				
Cananea				x												
Cuenca del Río Papigochic		x	x	x			x		x	x					x	
El Berrendo		x		x		x			x				x			
El Capulín			x	x		x		x								
El Cuervo			x	x												
Janos	x			x		x	x		x	x					x	
Laguna Bustillos	x					x	x		x	x		x			x	
Ciudad Júarez		x	x	x		x			x		x	x				
Laguna Encinillas	x			x		x	x		x	x			x		x	
La Gregoria-El Sueco		x		x	x	x	x	x	x	x				x	x	
Laguna Mexicanos		x	x	x		x	x		x	x			x		x	
Los Reyes			x	x					x				x		x	
Las Tunas			x	x	x	x									x	
Mesa San Agustín	x		x	x	x	x	x	x			x					
Mesa Campanero - Arroyo El Reparo				x					x							
Mirador El Caballo	x		x	x	x	x										
Mesa de las Guacamayas	x			x			x	x			x					
Pastizales Halófitos					x		x	x			x			x		
El Poleo-Río Negro -Mesa Pinoza	x		x	x	x	x	x	x		x	x	x			x	
Pastizales en valles centrales		x		x				x			x			x		
Salamayuca	x		x	x		x	x	x	x		x	x	x			
Sierra del Nido	x		x	x	x	x	x	x	x	x	x	x	x		x	
Sierra Huachinera		x		x			x	x			x					
Sierra San Antonio			x	x										x		
Sierra de San Luis				x				x	x		x					
Tapiecitas	x		x	x			x	x					x			x
Teseachic			x	x		x	x		x				x			
Los Ajos-Buenos Aires		x													x	
Mazatán																
Sierra El Tigre-San Diego																

Our design process for a system of protected areas is on-going: we hope to create a standardized database that provides an objective conservation planning and prioritization tool for the region. We are looking for collaborators and field work is being carried out in the less studied areas. The immediate steps are the setting-up of a GIS and starting the communication with local people.

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FLORA AND VEGETATION

Caracterizacion de la Vegetacion del Desierto Sonorense en una area Del Municipio de Pitiquito, Sonora, Mexico

Cecilia Hernández C.[1], Glafiro Alanís F.[2], Susana Favela L.[2], y Alejandro Ledezma M.[2]

Resumen.—Se evaluó la vegetación en forma cualitativa y cuantitativa y se determinó su similaridad en planicie, lomerío y sierra, considerando como variables la flora, tipo de suelo, altitud, pendiente, temperatura y humedad. Se utilizó el método de intercepción en línea de Canfield, analizando 46 transectos de 100 m^2. Para cada tipo de vegetación se determinó la composición por especies de acuerdo a las fórmulas descritas por Pieper (1978) y la estructura de la comunidad en base a los Indices Ecológicos descritos por Brower y Zar (1977). Se identificaron 3 comunidades : Matorral Desértico Micrófilo, Matorral Micrófilo Sarcocaule y Matorral Alto Espinoso. El Matorral Micrófilo Sarcocaule de acuerdo al Indice de Diversidad de Shannon - Weaver presenta mayor diversidad de especies, con un valor de $H' = 1.3034$ y una mayor equitabilidad en número de individuos por especie con una $J' = 0.2157$; mientras que el Matorral Desértico Micrófilo presenta mayor dominancia de especies con $1 - J = 0.8330$. La presencia de especies como *Olneya tesota* (protección especial; NOM-059, SEMARNAP 1997), *Simmondsia chinensis* y *Carnegiea gigantea*, reflejan la importancia por conservar esta área y por continuar con estudios que nos permitan diagnosticar el estado actual de sus poblaciones y sus posibilidades de conservación y aprovechamiento.

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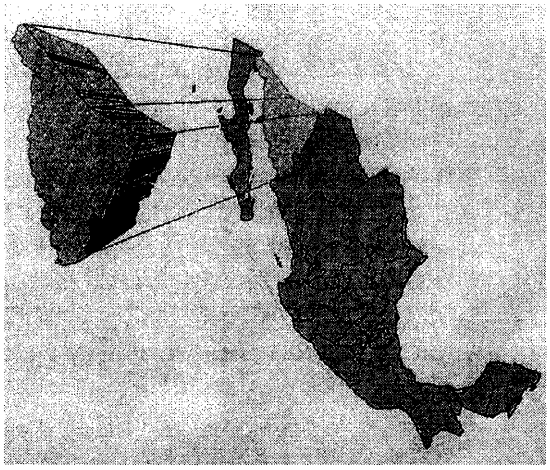
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INTRODUCCION

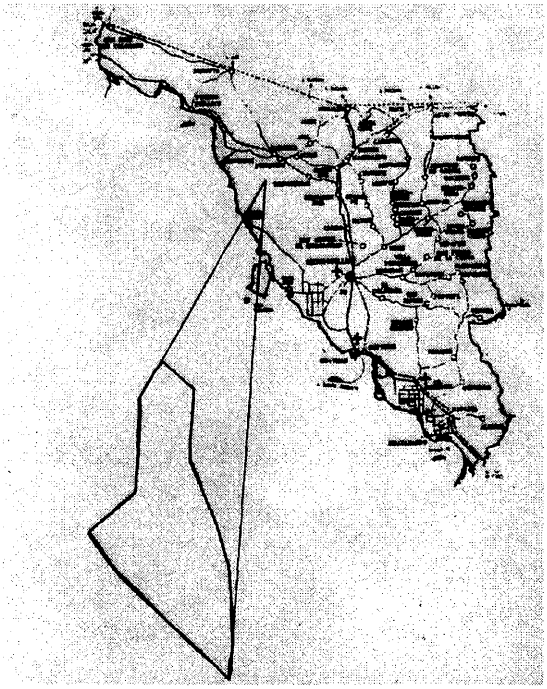
La vegetación del Desierto Sonorense presenta una gran diversidad biológica en cuanto a su estructura y composición florística, encontrando cinco subdivisiones de acuerdo a las especies tipo y sus asociaciones. Su distribución comprende los estados de Sonora, Baja California y Baja California Sur en México y los estados de Arizona y California en Estados Unidos.

El presente trabajo se desarrolla en el municipio de Pitiquito, Sonora el cual corresponde a una pequeña porción de este importante desierto, que ha sido poco estudiado y/o es escasa la información disponible.

Localización del estado de Sonora, "El Plomito", Pitiquito, Sonora, México.



Localización de "El Plomito", Pitiquito, Sonora, México.



Este estudio se realizó con la finalidad de obtener un mayor conocimiento de la vegetación que se desarrolla en el predio el "El Plomito", así como de su relación con el medio abiótico que le rodea. Los resultados generados, a partir de este trabajo permitirán desarrollar estrategias de manejo para incrementar las poblaciones de aquellas plantas tipo más ventajosas para la comunidad y/o la fauna silvestre; así como determinar las posibilidades de aprovechamiento y conservación. De igual forma este estudio contribuirá al incremento de los conocimientos sobre la Vegetación del Desierto Sonorense.

OBJETIVOS

1. Identificar y evaluar las comunidades de vegetación presentes en el predio "El Plomito", Pitiquito, Sonora.
2. Evaluar en forma cualitativa y cuantitativa las especies de plantas de "El Plomito", Pitiquito, Sonora.
3. Comparar la vegetación de "El Plomito" en las diferentes topoformas : planicie, lomerío y sierra.

METODOLOGIA

El presente trabajo consistió de tres fases fundamentales: levantamiento de información en campo, identificación de ejemplares y procesamiento y análisis .

Levantamiento de información en campo

Para obtener la información de campo se ubicaron 22 estaciones de muestreo en las áreas de sierra (500 a 700 metros) y 24 en las áreas de planicie (300 a 500 metros). En las áreas de cañadas, escurrideros y grietas de cañón, no fue posible efectuar transectos por lo accidentado del lugar, por lo que se realizaron observaciones y anotaciones en campo para definir el tipo de vegetación. En cada una de las estaciones se realizó el Método de intercepción en línea de Canfield (1941) modificado. El método consistió en marcar un transecto de 100 m^2 y determinar las especies interceptadas. Para cada planta interceptada se determinó el diámetro de la copa y su altura. En cada una de las estaciones de muestreo se determinó la latitud, longitud, altura, pendiente y tipo de suelo.

Identificación de ejemplares

De las plantas no identificadas en campo se colectaron muestras y se colocaron en prensa botánica para posteriormente identificarlas utilizando las claves taxonómicas de Kearney y Peebles (1951), Stewart y Marshall (1967) , Shreve y Wiggins (1964) y Martínez (1979).

Procesamiento y Análisis

Para conocer la composición por especies de las comunidades, se determinó la abundancia relativa, frecuencia relativa, dominancia relativa y el valor de importancia por especie, utilizando las fórmulas descritas por Pieper (1978).

Para el análisis cualitativo y cuantitativo de las comunidades se utilizaron los índices ecológicos recomendados por Brower y Zar (1977).

La similitud entre las comunidades de vegetación, se probó a través del "Indice de Similitud" de Sörensen, para lo cual se utilizó el programa computacional de estadística multivarial MVSP versión 2.1.

RESULTADOS

Se determinaron tres comunidades de vegetación, las cuales fueron diferenciadas de acuerdo a la fisonomía, la estructura de su composición y las asociaciones que presentan. Así mismo se incluyen características físicas del suelo donde se desarrollan y la topografía dentro de los factores abióticos.

Comunidades de vegetación

Matorral Desértico Micrófilo

Presenta plantas con tallos delgados ramificados desde la base de 0.50 a 2 metros, de hojas pequeñas y simples, compuestas por folíolos, pubescentes, cubiertas por tricomas, y/o armadas en ocasiones por espinas. El 70% de sus componentes son perennes y las especies caducas son por un breve período en la época más seca del año. La especie dominante es *Larrea tridentata.*

Se desarrolla en terrenos planos, planos inclinados o sobre los márgenes de los arroyos intermitentes, con un porcentaje de inclinación del 0 al 2%. El tipo de suelo es el Regosol Calcárico, de textura arcilloso areno - limoso, de color café rojizo y con un 75% de pedregosidad. Se presenta en cotas topográficas que van desde los 300 a 500 metros.

Dentro del Matorral Desértico Micrófilo se presentan dos sitios de vegetación, definidos por su asociación y separados por el tipo de suelo, porcentaje de inclinación e hidrología, como se describe a continuación.

Matorral Desértico Micrófilo de *Larrea tridentata - Franseria deltoidea*

Se presenta en la parte Oeste del predio, y es floristicamente pobre en especies leñosas. Sus componentes son plantas ramificadas desde la base, las cuales presentan hojas pequeñas, simples o compuestas y alturas que van desde los 0.50 - 1.5 metros. Las especies dominantes son *Larrea tridentata* y *Franseria deltoidea* y se encuentran asociadas a especies suculentas cilindropuntias como *Opuntia bigelovii, Opuntia arbuscula, Opuntia fulgida* y *Opuntia violacea,* los cuales se presentan generalmente formando densos stands.

Crece en terrenos planos, de suelo profundo y en las partes inferiores de los abanicos aluviales. El tipo de suelo corresponde al arcilloso - areno limoso, con una coloración café rojizo.

Matorral Desértico Micrófilo de *Larrea tridentata - Simmondsia chinensis*

Se presenta en la parte central del predio, y esta representado por plantas perennifolias, con hojas gruesas altamente cuticularizadas como *Simmondsia chinensis y Sapium biloculare,* así como plantas con hojas más delgadas y menos cuticularizadas como *Celtis pallida, y Cordia parvifolia,* las cuales caducan durante los períodos más secos del año; y plantas de hojas delgadas y compuestas, como *Coursetia glandulosa* y *Olneya tesota,* las cuales retienen sus hojas bajo condiciones favorables.

Crece en terrenos planos con ondulaciones. El tipo de suelo es de textura areno - arcilloso de color café, con un afloramiento de roca del 10% y una pedregosidad del 70 al 90%.

Matorral Micrófilo Sarcocaule

Se caracteriza fisonomicamente por estar formado con plantas leñosas, de hoja pequeña con textura suave. Presenta especies arbustivas con el tallo delgado y especies arbóreas de tallo grueso, corto y muy ramificado , con alturas que van desde los 0.50 a 2 metros. La especie dominante es *Bursera microphylla.*

Se distribuye en lomeríos pedregosos y en la Sierra "El Viejo". El tipo de suelo es el Litosol, con afloramiento de roca del 20% al 80% y un porcentaje de inclinación del 12 al 45%, de color gris o café grisáceo, de textura areno - arcilloso. Se presenta en altitudes que van de los 500 a 700 metros.

Matorral Alto Espinoso de *Cercidium microphyllum - Olneya*

Se caracteriza por presentar individuos de 3 a 6 metros de altura, ramificados desde la base, con diámetros de copas redondeadas. Presenta tres estratos : el alto con *Cercidium microphyllum* y *Olneya tesota*, el mediano con *Sapium biloculare, Bursera microphylla, B. laxiflora, Prosopis glandulosa, Lemairocereus thurberi* y *Carnegiea gigantea* y el bajo con *Encelia farinosa, Opuntia arbuscula* y *Opuntia bigelovii* .

Se distribuye en cañadas, escurrideros y grietas de cañón. El tipo de suelo es el Regosol Calcárico, de textura areno - arcilloso, de color café , café grisáceo y café amarillento. Sin afloramiento rocoso y con el 85% de pedregosidad, con un porcentaje de inclinación del 0 al 2% y con una profundidad de 0 a 50 cm., por lo que se denomina suelo profundo.

Composición por especies de las comunidades

En el Matorral Desértico Micrófilo la especie más abundante es *Encelia farinosa* con 28.6%, ésta, se presenta generalmente en áreas que registran actividades de sobrepastoreo, por lo que se ha incrementado notablemente en número debido a que se observó no presenta predatores y suponemos que su poder germinativo es muy alto, como la mayoría de las especies de la familia Compositae. Otras especies importantes por su abundancia son *Franseria deltoidea* con 8.89% y *Larrea tridentata* con 7.64%, las cuales imprimen como plantas tipo, el carácter fisonómico a esta comunidad vegetal.

Las especies dominantes son *Cercidium microphyllum* con 15.5% y *Fouquieria splendens* con 14.3 %, los cuales corresponden al estrato alto, así como *Larrea tridentata* con 13% y *Encelia farinosa* con 9.89% . Estas especies representan el 52.7 % de la cobertura total del Matorral Desértico Micrófilo.

Dentro del Matorral Micrófilo Sarcocaule las especies más abundantes son *Encelia farinosa* con 21.6%, *Euphorbia polycarpa* con 8.7% , *Bursera microphylla* con 8.3% y *Jatropha cuneata* con 7.3%.

Las especies dominantes son *Bursera microphylla* con 26.6%, *Jatropha cuneata* con 17.3% y *Fouquieria splendens* con 8.6%, las cuales corresponden al 52% de la cobertura total. De lo anterior puede decirse que *Fouquieria splendens* no tiene límites ni en altitud, suelo y exposición y es capaz de adaptarse a diferentes condiciones ecológicas. Mientras que *Bursera microphylla* es la especie dominante y junto con *Jatropha cuneata* imprimen el carácter fisonómico al Matorral Micrófilo Sarcocaule.

Estructura de las comunidades

Diversidad de Especies (Shannon - Weaver)

La diversidad de especies expresada en la ecuación H' = - Spi Log pi, nos indica la diferencia en la riqueza de especies por comunidades. Para el área de estudio, la mayor diversidad de especies se presentó en el Matorral Micrófilo Sarcocaule con una H´=1.3034, producto de la mayor equitabilidad de especies.

Equitabilidad de Especies

La equitabilidad o uniformidad de la distribución por comunidad, se determinó comparando la diversidad observada para la comunidad con la diversidad máxima posible para una comunidad hipotética con el mismo número de especies, expresado en la ecuación : J(H´) = H´/H´máx. La mayor proporción de los individuos entre las especies se presentó en el Matorral Micrófilo Sarcocaule con una J(H´) = 0.2157, mientras que en el Matorral Micrófilo desértico J(H´) fue de 0.1670, lo que significa una menor diversidad de sus especies en abundancia.

Dominancia de Especies

La mayor dominancia de especies se registró en el Matorral Desértico Micrófilo con 1 - J(H´) = 0.8330 , resultado de la baja diversidad y equitabilidad de especies. Este dato también indica que la comunidad del Matorral Desértico Micrófilo presenta un número relativamente pequeño de especies que controla la comunidad y que por ende son las dominantes.

"Indice de Similitud" de Sörensen

La semejanza entre las comunidades se probó a través del "Indice de Similitud" de Sörensen, para lo cual se utilizó el programa computacional de estadística multivarial MVSP, versión 2.1. Para el análisis se consideró el número de especies y su presencia o ausencia en cada una de las partes a comparar.

De acuerdo a las especies encontradas en cada uno de los transectos y siguiendo los criterios de Rzedowski (1988), Turner y Brown (1994) e INEGI (1982), se identificaron dos comunidades vegetales : el Matorral Desértico Micrófilo y el Matorral Micrófilo Sarcocaule. El Matorral Desértico Micrófilo presenta dos sitios de vegetación separados por asociación entre especies : El Matorral de *Larrea tridentata - Franseria deltoidea* y el Matorral de *Larrea tridentata - Simmondsia chinensis* en terrenos planos inclinados.

DISCUSIONES Y CONCLUSIONES

El trabajo aquí presentado, obedece al uso de una metodología que fue adecuada para el lugar; con características muy particulares debido a su posición geográfica y a sus actividades cinegéticas. Para definir las comunidades vegetales, se modificó la línea de Canfield en los levantamientos de campo y para la definición fisonómica se adoptó y modificó la metodología de Miranda y Hernández X. (1963). Los resultados hicieron posible determinar tres tipos de vegetación: Matorral Desértico Micrófilo, Matorral Micrófilo Sarcocaule y Matorral Alto Espinoso de *Cercidium microphyllum - Olneya tesosta.* La comunidad del Matorral Desértico Micrófilo fue necesario dividirla en dos sitios separados por su asociación entre las especies que los forman. El Matorral de *Larrea tridentata - Franseria deltoidea,* en terrenos planos y el Matorral de *Larrea tridentata* y *Simmondsia chinensis* en terrenos planos inclinados.

Otra metodología usada anteriormente es la del INEGI (1982) que marca para esta área, la comunidad de Mezquital, la cual fue imposible de caracterizar debido a que no se encontraron elementos distintivos como individuos o asociaciones. Es importante destacar en este aspecto la presencia del Matorral Alto Espinoso de *Cercidium microphyllum - Olneya tesosta* caracterizado y delimitado en el presente trabajo por primera vez.

Los resultados del análisis estadístico hicieron posible delimitar o definir el valor que representa numéricamente cada especie dentro de la comunidad o del área en cuestión. Es así como podemos citar por ejemplo al Matorral Micrófilo Sarcocaule con la mayor diversidad y equitabilidad de especies, mientras que la mayor dominancia se presenta en el Matorral Desértico Micrófilo y *Encelia farinosa* es la especie más dominante en número de individuos. Esta dominancia indica actividades de sobrepastoreo realizadas en el área hace más de diez años (comunicación personal), ya que *Encelia farinosa* tiende a ocupar lugares con suelo desnudo con facilidad y su poder germinativo y dispersión son muy altos, además de que no es una planta palatable para las especies herbívoros.

El Matorral Alto Espinoso se caracterizó por presentar los individuos de mayor altura y cobertura de sus copas.

La presencia de especies como *Olneya tesota,* árbol endémico del Desierto Sonorense y considerado en la categoría de protección especial en la Norma Oficial Mexicana - 059 (SEMARNAP, 1997); *Simmondsia chinensis,* planta utilizada en la elaboración de lubricantes, cosméticos, jabones y farmacéuticos y de la cual no se tiene un control del aprovechamiento de ejemplares provenientes del medio natural; *y Carnegiea gigantea,* especie característica del Desierto Sonorense, de distribución limitada a los estados de Sonora, Arizona y California y muy utilizada como planta de ornato. Reflejan la importancia por conservar

esta área, dándole especial importancia a la dinámica de población y llevar con esto a cada ecosistema en particular el manejo más adecuado, evitando así que la comunidad madure con el tiempo y consiguiendo incrementar las poblaciones de aquellas plantas tipo más ventajosas para la comunidad y/o la fauna silvestre. Además de continuar con estudios que nos permitan diagnosticar el estado actual de sus poblaciones y sus posibilidades de conservación y aprovechamiento.

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Riparian Vegetation on the Río Santa Cruz, Sonora

Gilberto Solis-Garza[1] and Philip Jenkins[2]

Abstract.—Though riparian areas are infrequent, they have economic, ecological and social significance because they provide useful products; water, forage, firewood, protection to wildlife, increase in water quality and quantity, and erosion control. However, the ability of a given site to provide this range of products is dependent upon the quality of the vegetation present. Studies related to the abiotic factors and biotic factors and to survey the number of species present in the Rio Santa Cruz (RSC) are few. The objectives of this paper is to create a species lists based on existing vegetation in the RSC. The vegetation diversity was obtained from 10 representative sites along the river, each 20 x 50 meters. A total of 149 species in 104 genera and 38 families were found. The most diverse families were Asteraceae, Poaceae and Fabaceae. The largest genera were *Machaeranthera, Eragrostis* and *Ipomea*. Herbaceous species averaged 70.5%, grasses 18.1%, trees 7.4%, and shrubs 4.0%. Cottonwood *(Populus fremontii)* and Goodding willow *(Salix gooddingii)* were the most frequent tree species on the sites. Preliminary investigations indicated that 40.2% of the cottonwood trees are 10 or more decimeters in basal diameter basal (15 cm above the ground). This can be due to perturbations that impact the younger plants. Loss of seed viability, intolerance of lowering of water tables, and livestock grazing are examples.

Resumen.—Las áreas riparias tienen gran importancia económica, ecológica y social ya que proporcionan agua, forraje, leña, protección a la fauna silvestre, incremento en la calidad y cantidad de agua, reducción de erosión, etc. Sin embargo, la calidad de los productos obtenidos dependerá de las especies de la vegetación presente. Estudios relacionados a determinar la vegetación presente en el Río Santa Cruz, Sonora (RSC) son escasos. El objetivo del presente estudio es elaborar un listado de especies basado en la vegetación actual del RSC. La diversidad de la vegetación se obtuvo a través de 10 sitios de 20 x 50 metros localizados a lo largo del cauce del RSC. Se identificaron 149

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especies pertenecientes a 104 géneros y 38 familias. Las familias con mayor número de géneros son: Asteraceae, Poaceae y Leguminosae siendo los mas representativos: *Machaeranthera*, *Eragrostis* e *Ipomea*. Las especies identificadas son herbáceas anuales (70.5%), pastos (18.1%), arboles (7.4%) y arbustos (4.0%) . El álamo y el sauz son las especies arbóreas mas frecuentes. Estudios preliminares indican que el 40.2% de los individuos de la especie alamo son mayores a 10 cm. de dbh. Lo anterior, debido al impacto de las perturbaciones a las plantulas, perdidad de viabilidad de la semilla, y baja tolerancia a la falta de humedad, pastoreo, etc.

INTRODUCTION

Studies of Sonoran riparian areas are scarce. A survey of the literature revealed that no vegetative work has been previously done in Santa Cruz River basin in Sonora. Elsewhere in Sonora, Gentry (1942) discusses riparian vegetation along the Río Mayo, White (1948) surveyed the region of the Río Bavispe, Garza (1985) studied the area of the Sierra de los Ajos, and Solis and collaborators (1993) surveyed the Río de los Ajos. Just north of the border, Stromberg et al. (1993) studied the affects of sewage affluent on vegetation in Nogales, Arizona.

The Santa Cruz River, part of the Colorado River system, arises in the San Rafael Valley of Arizona, taking its water from the Patagonia Mountains on the west, the Canelo hills on the north, and the Huachuca mountains on the east. Miller Peak in the Huachucas is the highest point in the drainage at 2885 m. After it arises in the San Rafael Valley at about 1600 m, the river flows south into Sonora. It continues south as far as the ex-hydrometric station called El Cajon, thence southeast to the town of San Lázaro, where it turns west. It then turns north and reenters Arizona east of the city of Nogales (Sonora and Arizona). The length of its course in Sonora is 56 kilometers. The channel continues northward through Tucson to meet the Gila River southeast of Phoenix, Arizona.

The basin is located in north-central Sonora, between the coordinates 31° 08' and 31° 20' North latitude and 110° 30' and 111° 00' West longitude. The riverbed is localized between 31° 09' and 31° 20' North and 110° 50' West. In Sonora, the valley is delimited by Sierra El Chivato on the east and Sierra El Pinito on the west. Sierra San Antonio lies between the south-flowing and north-flowing parts of the valley in Sonora (Figure 1). The area falls almost entirely within the municipios of Nogales and Santa Cruz.

Through much of its course in Arizona it flows only in time of flood, but in Sonora there are lengths of the stream with enough water to support

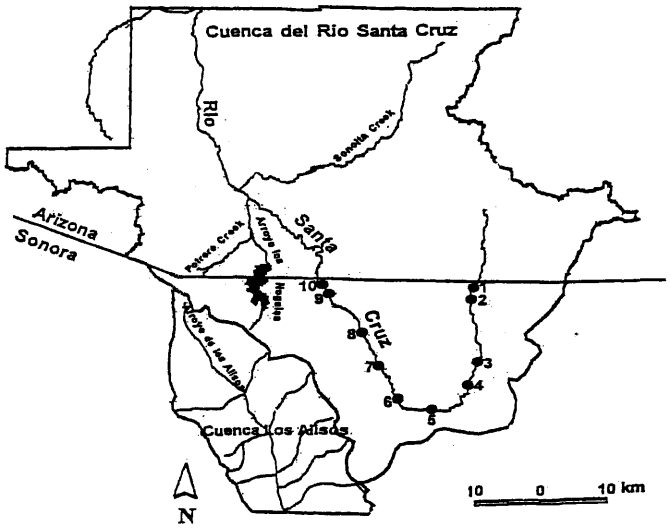


Figure 1. Map of the upper Santa Cruz drainage showing the locations of the ten sites.

riparian vegetation and three species of fish. It is a principle source of water for Nogales. Without doubt, it is an area of great importance for ecological and human resources, and it is a fragile and rare commodity in this arid part of the continent. Among the other functions of the river and the associated vegetation, it sustains life by giving water, plus it controls erosion and purifies the water by filtering contaminants. Riparian areas provide food and shelter for up to 75% of the native wildlife for at least some part of their life cycles (ASU-COLEF 1995).

Materials and Methods

The object of this study was to begin a list of plant species that grow adjacent to the Santa Cruz by creating study plots and collecting voucher specimens from them that could be accurately identified later in a herbarium. In order to sample the changes in vegetation along the gradient of the stream, a number of sites had to be chosen. A preliminary survey of the area was conducted to select the collection sites. The sites were chosen by visual observation based on the criteria of relative homogeneity of the dominant species present and the estimated biomass (the areas with greater biomass were opted for). In addition, the presence trees and shrubs that are considered obligate riparian species (as defined by Dick-Peddie and Hubbard, 1977) was a prerequisite.

Ten sites were chosen, each 20 x 50 meters, running parallel to the course of the river (Figure 1 and Table 1). They were surveyed and collected during the month of October, 1995. A voucher for all of the species of plants encountered at each site were collected (trees, shrubs, herbaceous

annuals and perennials, grasses and vines). The study was originally intended to be resurveyed for winter annuals, but the absence of winter rains in the year of the study made it impossible, as none of those plants appeared.

Table 1. The geographic location of the sampling sites.

Site number	Site name	Latitude	Longitude	Alt. (m)
1	La Faja	31° 19' N	110° 35' W	1250
2	Camino a Cananea	31° 17' N	110° 36' W	1220
3	Poblado Santa Cruz	31° 12' N	110° 35' W	1200
4	El Alamo	31° 10' N	110° 36' W	1180
5	Poblado Miguel Hidalgo	31° 09' N	110° 39' W	1140
6	Paredes	31° 10' N	110° 43' W	1120
7	Ejido Cádenas Valdéz	31° 12' N	110° 44' W	1110
8	Ejido López Mateos	31° 15' N	110° 47' W	1100
9	Estación Máscareña	31° 18' N	110° 49' W	1060
10	Substación	31° 18' N	110° 50' W	1040

The identification of the plants was conducted in coordination with the University of Arizona herbarium and the University of Sonora, and the vouchers were deposited in the herbarium of DICTUS (Departamento de Investigaciones Científicas y Tecnológicas de la Universidad de Sonora) in Hermosillo, Sonora. The nomenclature and identifications were accomplished through the use of Kearney and Peebles (1961), Lehr (1978), Gould (1951), and from the most recent and/or most widely accepted botanical taxonomic literature. The author names and abbreviations follow the standards of Brummet and Powell (1992).

Rather than simply reporting the presence of a species, a second set of data was made to measure the abundance of the species on the sites as a whole. To determine the rate of abundance of species occurrence a scale of 5 classes was used to describe each plants continuity and abundance over the range of the study, described in Table 2 (Oosting, 1956).

Table 2. Abundance classes.

Class	Abundance
1	Rare (1 to 20% of the sites)
2	Present infrequently (21 to 40% of the sites)
3	Present frequently (41 to 60% of the sites)
4	Present consistently (61 to 80% of the sites)
5	Present very consistently (81-100% of the sites)

RESULTS

The basin of the Santa Cruz River has an area of 783 square kilometers in Sonora. The River's total length is approximately 360 kilometers (Swallen and Shaw 1957), 56 kilometers of which is in Sonora. In Sonora, the area's climate is temperate and semi-arid. According to rainfall records of the Comisión Nacional del Agua's Santa Cruz station, the average annual precipitation is 603.8 mm and the station at Nogales averages 428.4 mm. The rainfall is bimodal with the great majority falling during the monsoon season of July to September. The second period of rainfall occurs, with less reliability, from December to February. These winter rains account for 10.2% of the annual total. The average daily maximum temperature in winter varies from 5 to 10° C, while those of summer vary between 25 and 30°C (SPP,1981). The station in Santa Cruz reports an annual median temperature of 18.3°C, and the one in Nogales, 17.3°C.

The Santa Cruz Valley and surrounding mountain ranges lie in the Basin and Range Province (SPP 1981b). Centrally situated the area, with the river making an "end run" around it, the Sierra San Antonio is composed largely of conglomerate rock, but the river valley is composed of intrusive and extrusive igneous formations (SPP, 1981c). The mountains and valleys of the area were formed between 26 and 12 mya, during the Miocene and Pliocene periods, a result of emergent movements caused by declivities and faults. Present day valley fill and alluvium are composed of sands and gravels (USDA 1977).

The higher mountains support Pine-oak and Madrean oak woodlands and forests, but the area near the river's course is Grassland dominated by several species of grama grass (*Bouteloua* spp.). Plains lovegrass (*Eragrostis intermedia)* and Texas beardgrass (*Schizachyrium cirratum*) are other common species, and oak trees (*Quercus emoryi, Q. oblongifolia)* are occasionally present at the higher elevations. Mesquite (*Prosopis velutina*) bosques occur in the south to northwest parts of the valley. Netleaf hackberry (*Celtis reticulata)* and Mexican elderberry (*Sambucus mexicana*) occur in the northwestern section toward the point where the river enters Arizona.

The Riparian communities are principally of groves of cottonwood *(Populus fremontii)* and Goodding willow (*Salix gooddingii*). Commonly associated plants are other willows (*Salix bonplandiana, S. taxifolia*), sacaton (*Sporobolus wrightii*), seep-willow baccharis (*Baccharis salicifolia*), and burrobrush (*Hymenoclea monogyra*) (Solis et al.1996). It was curious that Arizona sycamore (*Platanus wrightii),* a common riparian species of the region, occurred on only one of the plots. The river is said to be perennial, but by the late twentieth century, it is ephemeral for great parts of its length, a victim of human activity. Doubtlessly its riparian vegetation has

suffered, but we can only now begin to measure changes in that vegetation.

Appendix 1 is the list of species observed on the initial survey. The ten sites yielded a flora of 149 species in 104 genera in 38 families. In this flora, 18 species were non-native. A summary of the groupings and numbers of best represented groups are listed in Appendix 2. True to the pattern everywhere on this part of the continent, the families with the greatest number of genera and species were: Asteraceae with 23, Poaceae with 16 and Fabaceae with 14. The genera best represented were: *Machaeranthera, Ipomoea, Eragrostis, Ambrosia, Bidens*, and *Euphorbia.*

Of the species identified, 104 were annuals and herbaceous perennials, 27 were grasses, 11 were trees, and 8 were shrubs. Obligate riparian species were represented by a total of 13 species. With the exception of cottonwood, present on all 10 plots, and Goodding willow, found on 8, the other species were found on a limited number of sites.

There is evidence that the study revealed 2 species not before recorded in Sonora: a lovegrass (*Eragrostis barrelieri*) and honey locust (*Gleditsia triacanthus),* a tree of the eastern United States. The latter is probably spreading south into Mexico from cultivated plants in the tiny border town of Lochiel, Arizona. In addition, desert- willow (*Chilopsis linearis*) was first record in the Santa Cruz area (it occurs elsewhere in northeastern Sonora).

In 1991, the Comisión Técnica Consultiva para la Determinación de los Coeficientes de Agostadero (COTECOCA) published *Gramineas de Sonora,* in which the distribution of grasses in Sonora were described in accordance to their presence or absence in each of the municipios of the state. The Santa Cruz study reports 12 species of grasses in the municipios of Santa Cruz and Nogales not reported in that work. They are *Chloris virgata, Cynodon dactylon, Digitaria sanguinalis, Echinochloa crusgalli, Eragrostis berrelieri, Eragrostis cilianensis, Eragrostis pectinacea, Leptochloa facicularis, Muhlenbergia fragilis, Muhlenbergia rigens, Paspalum dilitatum,* and *Polypogon monspeliensis.*

Saltcedar (*Tamarix ramosissima*), a species that has displaced native vegetation in large tracts at other riparian areas in the arid west, was found on only one site in this study. Future studies should monitor this species and if it is increasing in numbers, it is hoped that management practices would be implemented to control it.

Preliminary investigations indicated that 40.2% of the cottonwood trees are 10 or more decimeters in diameter basal (15 cm above the ground). The lack of the presence of younger plants can be due to recent perturbations that impact them. Loss of seed viability, intolerance of lowering of water tables, and livestock grazing are examples.

Abundance of the Species Present on the Plots

Once the flora of a plant community has been created, it can be useful to know which species are encountered incidentally, which occur only under given conditions, and which are almost always present.

In Appendix 3, all the identified species are listed indicating their presence or absence on a given site, and the rated according to the 5 classifications of abundance listed above. Of the species identified in the ten plots, 48.2% were classified as rare (1), 35% were infrequent (2), 10.5% were frequent (3), 5.6% were present consistently, and only 0.7% were very consistent . As mentioned earlier the cottonwood was the only tree present on all 10 sites (as it was selected for when choosing the plots) and the Goodding willow was on 8. Of the shrubs the seep-willow baccharis and the mistletoe *(Phoradendron californicum)* were seen with major consistency. Seep-willow baccharis is important species for the establishment of cottonwood and other species because it forms a "seedbed" necessary for germination (Fenner et al. 1985). Mistletoe, on the other hand, can tap the vigor from trees if it becomes abundant.

Herbaceous annuals and perennials frequently encountered were a species of Amaranth (*Amaranthus palmeri*), and yellow flowered Asteraceae *Viguiera annua, Xanthocephalum,* and the aster-like *Machaeranthera tanecetifolia.* The most frequent grasses were six-weeks three-awn *(Aristida adscensionis),* feather finger-grass (*Chloris virgata*) and Bermudagrass (*Cynodon dactylon*), species commonly seen in damp soil.

CONCLUSIONS

It is hoped that this preliminary study will be useful in beginning to monitor the vegetation along the river, and to aid in future management policies to maintain and improve the vitality of the riparian vegetation along Sonora's Santa Cruz River. Each return visit to the ten sites (especially during a wet spring) will see the plant list more complete and useful, and eventually patterns of change will emerge.

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Philip Jenkins has been Assistant Curator at the University of Arizona Herbarium for 6 years, is co-author on the forthcoming revision of Howard Scott Gentry's *Rio Mayo Plants*, a floristic work that encompasses southern Sonora, and is a graduate student in the Department of Ecology and Evolutionary Biology, doing taxonomic study in the family Solanaceae. In the past, he worked for the U.S. Forest Service in Washington State and several places in Arizona, and in the Fire Research Project at the Rocky Mountain Forest and Range Experiment Station before coming to the University of Arizona.

Appendix 1

The list of the plants vouchered within the ten study sites. When the plant has a synonym with which the reader may be more familiar, it appears on the right in brackets.

PTERIDOPHYTES
Equisetaceae
Equisetum arvense L.
Equisetum laevigatum A. Brauun.

ANGIOSPERMS
DICOTYLEDONS

Amaranthaceae
Amaranthus palmeri S. Watson
Gomphrena sonorae Torr.
Guillemenea densa Moq. [*Brayulinea densa* (Willd.) Small]

Apiaceae (Umbelliferae)
Berula erecta (Huds.) Coville [*B. pusilla* (Nutt.) Fern.]
+*Coriandrum sativum* L.

Asteraceae (Compositae)
Ambrosia acanthicarpa Hook. [*Franseria acanthicarpa* (Hook.) Coville]
Ambrosia aptera DC.
Ambrosia confertiflora DC. [*Franseria confertiflora* (DC.) Rydb.]
Ambrosia psilostachya DC.
Aster commutatus (Torr. & A.Gray) A. Gray
Aster subulatus Michx.
Baccharis salicifolia (Ruiz.& Pav.) Pers. [*B. glutinosa* Pers.]
Bidens bigelovii A. Gray
Bidens laevis (L.) Britt., Sterns &.Pogg.
Bidens leptocephala Sherff
Bidens pilosa L.
Conyza canadensis (L.) Cronq. [*Erigeron canadensis* L.]
Erigeron divergens Torr. & A. Gray
Gnaphalium leucocephalum A. Gray
Gnaphalium wrightii A. Gray
Helenium thurberi A. Gray
Helianthus petiolaris Nutt.
Heterosperma pinnatum Cav.
Heterotheca subaxillaris (Lam.) Britt. & Rusby [*H. psammophila* Wagenkn.]
Hymenoclea monogyra Torr. & A.Gray
Machaeranthera aff. *parviflora* A. Gray [*Aster parvulus* Blake]
Machaeranthera gracilis (Nutt.) Shinners [*Haplopappus gracilis* (Nutt.) A. Gray]
Machaeranthera pinnatifida (Hook.) Shinners [*Haplopappus spinulosus* (Pursh) DC.]
Machaeranthera tagetina Greene [*Aster tagetinus* (Greene) Blake]
Machaeranthera tanacetifolia (H.B.K.) Ness [*Aster tanacetifolius* (H.B.K.) Nees]

Appendix 1 (Cont'd.)

Asteraceae (Compositae) (Cont'd.)

Melampodium strigosum Steussy	[*M. hispidum* H.B.K.]
Melampodium longicorne A. Gray	
Pectis prostata Cav.	
Senecio douglasii DC.	
Sonchus asper (L.)Hill	
Tagetes lemmoni Cav.	
Viguiera annua (Jones) Blake	
Vigueria longifolia (B.L.Rob. & Greenm.) Blake	
Xanthium strumarium L.	[*X. saccharatum* Wallr.]
Xanthocephalum eradiatum (Lane) G. Nesom	
Zinnia peruviana (L.)L.	

Bignoniaceae

Chilopsis linearis (Cav.) Sweet
Tecoma stans (L.) Juss. ex. H.B.K.

Brassicaceae (Cruciferae)

Lepidium thurberi Wooton	
Rorippa nasturtium-aquaticum (L.) Hayek	[*Nasturtium oficionale* R.Br.]

Caprifoliaceae

Sambucus mexicana Presl.

Chenopodiaceae

Chenopodium neomexicanum Standl.

Cleomaceae

Polanisia dodecandra (L.) DC.

Convolvulaceae

Ipomoea barbatisepala A. Gray	
Ipomoea cardiophylla A. Gray	
Ipomoea cristulata Hallier F.	[*I. coccinea* L. var. *hederifolia* (A. Gray) House]
Ipomoea hederacea (L.) Jacq.	
Ipomoea leptotoma Torr.	

Cucurbitaceae

Cucurbita digitata A. Gray

Euphorbiaceae

Acalypha neomexicana Muell.Arg.	
Acalypha ostryaefolia Riddell	
Croton texensis (Klotzsch) Muell.Arg.	
Euphorbia heterophylla L.	[*Poinsettia heterophylla* Klotzsch & Garcke]
Euphorbia hirta L.	[*Chamaesyce hirta* Millsp.]
Euphorbia hyssopifolia L.	
Euphorbia indivisa (Engelm) Tidestrom	

Appendix 1 (Cont'd.)

Fabaceae (Leguminosae)
Astragalus nothoxys A. Gray
Calliandra humilis Benth.
Chamaecrista nictitans (L.) Moench [*Cassia leptadenia* Greenm.]
Crotalaria pumila Ortega
Dalea leporina (Ait.) Bullock
Desmodium procumbes (Mill.) A.S. Hitch. var. *exiguum*
(A. Gray) Schubert [*D. exiguum* A. Gray]
Gleditsia triacanthus L.
Melilotus albus Desr.
Melilotus indicus (L.) All.
Mimosa aculeaticarpa Ortega var. *biuncifera* (Benth.) Barneby
[*M. biuncifera* Benth.]
Phaseolus vulgaris L.
Prosopis velutina Wooton [*P. juliflora* (Sw)DC. var. *velutina* (Wooton) Sarge]
Psoralea tenuiflora Pursh
Senna hirsuta (L.) Irwin & Barneby [*Cassia leptocarpa* Benth.]
Trifolium sp.

Loasaceae
Mentzelia sp.

Lythraceae
Cuphea wrightii A. Gray

Malvaceae
Anoda cristata (L.)Schltdl.
Sida abutifolia Miller [*S. procumbens* Sw.]
Sphaeralcea fendleri A. Gray

Martyniaceae
Proboscidia parviflora (Wooton) Wooton & Standl.

Molluginaceae
Mollugo verticillata L.

Nyctaginaceae
Boerhaavia coccinea Miller [*B. caribea* Jacq.]
Mirabilis longiflora L.

Oleaceae
Fraxinus velutina Torr.

Onagraceae
Gaura gracilis Wooton & Standl.
Gaura parviflora Duval

Appendix 1 (Cont'd.)

Onagraceae (Cont'd.)

Ludwigia palustris (L.) Ell	[*L. palustris* (L.) Ell. var. *americana* (DC.) Fern. & Griscom]
Oenothera caespitosa Nutt.	

Oxalidaceae

Oxalis corniculata L.	[*O. repens* Thumb.]

Papaveraceae

Argenome pleiacantha Greene subsp. *ambigua* G. B. Ownbey

Platanaceae

Platanus wrightii S.Watson

Polygonaceae

Eriogonum polycladon Benth.
Polygonum lapathifolium L.
Rumex sp.

Portulacaceae

Portulaca suffrutescens Engelm.

Ranunculaceae

Ranunculus sp.

Rubiaceae

Diodia teres Walter

Salicaceae

Populus fremontii S. Watson
Salix bonplandiana H.B.K.
Salix gooddingii Ball
Salix taxifolia H.B.K.

Santalaceae

Comandra umbellata (L.) Nutt. subsp. *pallida* (A.DC.) Plehl

Solanaceae

Calibrachoa parviflora (Juss) D'Arcy	[*Petunia parviflora* Juss.]
Datura discolor Bernh.	
Datura wrightii Regel	[*D. meteloides* DC.]
Physalis acutifolia (Miers) Sandw.	[*P. wrightii* A. Gray]
Solanum nigrescens Martinez & Gal.	
Solanum nodiflorum Jacq.	
Solanum rostratum Dunal	

Tamaricaceae

Tamarix ramosissima Ledeb.	[*T. pentandra* Pallas]

Appendix 1 (Cont'd.)

MONOCOTYLEDONS

Cyperaceae
Cyperus esculentus L.
Cyperus niger Ruiz & Pavon
Cyperus odoratus L.
Eleocharis sp.

Poaceae (Gramineae)
Aristida adscencionis L.
Aristida ternipes Cav.
Bouteloua aristidoides (H.B.K) Griseb
Bouteloua barbata Lag.
Bouteloua curtipendula (Michx.)Torrey
Bouteloua gracilis H.B.K. Lag. ex. Griffith
Cenchrus insertus M.A. Curtis
Chloris virgata Sw.
Cynodon dactylon (L.) Pers.
Digitaria sanguinalis (L.) Scop
Echinochloa crusgalli (L.) P. Beauv.
Eragrostis barrelieri Daveau
Eragrostis cilianensis (All.) Vign.-Lutati ex. Janchen
Eragrostis pectinacea (Michx.) Ness var. *pectinacea*
Eragrostis pectinacea (Michx.) Ness var. *miserrima* (E. Fourn.) J. Reeder
Eriochloa acuminata (Presl) Kunth var. *acuminata*
Eriochloa acuminata (Presl) Kunth var. *minor* (Vasey) R.B. Shaw
Leptochloa fascicularis (Lam.) A. Gray
Muhlenbergia asperifolia (Ness & Mey) L. Parodi
Muhlenbergia fragilis Swallen
Muhlenbergia rigens (Benth.) Hitchc.
Paspalum dilatatum Poir
Paspalum distichum L.
Polypogon monspeliensis (L.) Desv. [*Alopecurus monspeliensis* L.]
Setaria grisebachii E. Fourn.
Sorghum halapense (L.) Pers.

Appendix 2. Summary of plants by classification and the largest families and genera.

Group	No. of families	No. of genera	No. of species	No. of non-native species
Pteridophytes	1	1	2	0
Monocots	2	16	31	6
Dicots	34	85	116	10
Total Groups	37	104	149	16
Families				
Asteraceae		23	36	1
Poaceae		16	27	6
Fabaceae		13	14	4
Euphorbiaceae		3	7	0
Solanaceae		3	7	2
Convolvulaceae		1	5	0
Salicaceae		2	4	0
Cyperaceae		2	4	0
Genera				
Eragrostis			5	0
Ipomea			5	0
Machaeranthera			5	0
Ambrosia			4	0
Bidens			4	0
Bouteloua			4	0
Euphorbia			4	0
Cyperus			3	0
Muhlenbergia			3	0
Salix			3	0
Solanum			3	1

Appendix 3. Distribution of species across the sites and grade of frequency.

Site number	1	2	3	4	5	6	7	8	9	10	F
Trees											
Populus fremontii	1	2	3	4	5	6	7	8	9	10	5
Salix gooddingii	1	2		4	5		7	8	9	10	4
Salix bonplandiana				4	5		7	8	9		3
Prosopis velutina			3			6	7				2
Celtis reticulata								8			1
Chilopsis linearis						6					1
Fraxinus velutina			3								1
Platanus wrightii							7				1
Salix taxifolia					5			8			1
Sambucus mexicanum				4				8			1
Tamarix ramosissima					5						1
Shrubs											
Baccharis salicifolia				4	5			8	9		2
Phoradendron californicum	1								9	10	2
Gleditsia triacanthus	1										1
Hymenoclea monogyra			3								1
Mimosa aculeaticarpa var. *biuncifera*			3		5	6					1
Tecoma stans				4		6					1
Vitis arizonica									9		1
Herbaceous plants											
Amaranthus palmeri	1		3	4	5		7	8	9	10	4
Machaeranthera tanacetifolia	1			4	5	6	7	8	9	10	4
Viguiera annua	1		3	4	5		7	8	9		4
Xanthocephalum eradiatum			3	4	5		7	8	9	10	4
Bidens laevis	1	2	3	4	5		7				3
Aster subulatus		2	3	4		6		8		10	3
Astragalus nothoxys		2	3	4	5		7		9	10	3
Crotalaria pumila		2			5		7	8	9		3
Dalea leporina	1	2	3		5		7	8			3
Gomphrena sonorae	1	2		4	5		7				3
Ipomoea hederacea	1		3		5	6			9	10	3
Machaeranthera pinnatifida		2	3			6		8		10	3
Melampodium strigosum			3		5	6		8	9		3
Oenothera caespitosa		2	3	4	5	6	7				3
Senecio douglasii		2	3	4		6				10	3
Vigueria longifolia	1		3	4	5					10	3
Zinnia peruviana				4	5			8	9	10	3
Bidens bigelovii	1	2	3	4					9		3
Helianthus petiolaris	1			4	5		7				2
Heterotheca subaxillaris				4	5				9		2
Acalypha neomexicana		2				6		8			2
Ambrosia aptera	1					6			9	10	2
Ambrosia psilostachya				4	5					10	2

Appendix 3 (Cont'd.)

Site number	1	2	3	4	5	6	7	8	9	10	F
Herbaceous Plants (Cont'd.)											
Anoda cristata	1						7			10	2
Aster commutatus		2	3			6					2
Bidens leptocephala		2	3	4	5						2
Calibrachoa parviflora			3					8			2
Calliandra humilis			3				7	8			2
Melilotus indicus	1		3					8			2
Comandra umbellata subsp. *pallida*	1			4	5						2
Coriandrum sativum	1	2					7				2
Cyperus niger	1		3	4				8			2
Cyperus esculentus	1		3			6			9		2
Cyperus odoratus	1		3	4				8			2
Datura discolor			3						9	10	2
Datura wrightii							7		9	10	2
Eriogonum polycladon	1			4	5						2
Euphorbia hirta			3		5		7				2
Euphorbia hyssopifolia	1				5	6				10	2
Gaura parviflora					5		7	8			2
Heterosperma pinnatum			3	4	5				9		2
Ipomoea leptotoma	1							8	9	10	2
Ludwigia palustris		2	3	4		6					2
Machaeranthera gracilis				4	5	6					2
Machaeranthera tagetina			3	4	5						2
Melampodium longicorne	1						7	8	9		2
Polanisia dodecandra			3	4				8			2
Polygonum lapathifolium	1			4	5		7				2
Portulaca suffrutescens		2	3				7				2
Rorippa nasturtium-aquaticum	1	2		4							2
Rumex sp.	1			4	5						2
Solanum nigrescens	1	2				6					2
Solanum nodiflorum				4	5	6					2
Solanum rostratum			3			6	7				2
Sphaeralcea fendleri			3		5	6					2
Acalypha ostryaefolia					5		7				1
Ambrosia acanthicarpa						6					1
Ambrosia confertiflora	1					6					1
Argenome pleiacantha subsp. *ambigua*			3			6					1
Berula erecta	1		3								1
Bidens pilosa	1				5						1
Boerhaavia coccinea						6					1
Guilleminea densa		2									1
Cassia leptadenia						6					1
Conyza canadensis		2									1
Croton texensis			3	4							1
Cucurbita digitata									9		1
Cuphea wrightii						6					1
Desmodium procumbes var. *exiguum*					5						1

Appendix 3 (Cont'd.)

Site number	1	2	3	4	5	6	7	8	9	10	F
Herbaceous Plants (Cont'd.)											
Chenopodium neomexicanum							7				1
Diodia teres						6					1
Eleocharis sp.	1										1
Equisetum arvense	1							8			1
Equisetum laevigatum	1										1
Erigeron divergens				4		6					1
Euphorbia heterophylla					5						1
Euphorbia indivisa		2				6					1
Gaura gracilis		2					7				1
Gnaphalium leucocephalum							7				1
Gnaphalium wrightii				4		6					1
Helenium thurberi				4		6					1
Ipomoea barbatisepala						6					1
Ipomoea cardiophylla	1				5						1
Ipomoea cristulata				4			7				1
Lepidium thurberi							7	8			1
Machaeranthera aff. *parviflora*						6					1
Melilotus albus	1							8			1
Mentzelia sp.			3		5						1
Mirabilis longiflora				4	5						1
Mollugo verticillata		2				6					1
Oxalis corniculata					5						1
Pectis prostata									9		1
Phaseolus vulgaris				4							1
Physalis acutifolia		2				6					1
Proboscidia parviflora							7	8			1
Psoralea tenuiflora			3		5						1
Ranunculus sp.	1					6					1
Senna hirsuta						6					1
Sida abutifolia						6					1
Sonchus asper	1										1
Tagetes lemmoni				4							1
Trifolium sp.		2						8			1
Xanthium strumarium	1				5						1
Grasses											
Aristida adscencionis	1			4	5	6				10	3
Chloris virgata	1			4	5				9	10	3
Eragrostis pectinacea		2	3	4			7		9	10	3
Eragrostis pectinacea var. *miserrima*		2	3	4	5			8		10	3
Cynodon dactylon		2	3			6			9	10	3
Digitaria sanguinalis		2	3	4		6					2
Bouteloua aristidoides	1			4	5					10	2
Bouteloua barbata		2				6			9	10	2
Bouteloua gracilis	1					6	7		9		2
Cenchrus insertus			3	4			7				2
Echinochloa crusgalli	1					6				10	2

Appendix 3 (Cont'd.)

Site number	1	2	3	4	5	6	7	8	9	10	F
Grasses (Cont'd.)											
Eragrostis cilianensis				4	5					10	2
Eragrostis pectinacea var. *pectinacea*			3	4		6					2
Eriochloa acuminata var. *acuminata*	1			4	5						2
Eriochloa acuminata var. *minor*		2							9	10	2
Muhlenbergia rigens			3		5		7		9		2
Paspalum distichum			3		5		7		9		2
Polypogon monspeliensis		2	3						9		2
Setaria grisebachii	1							8		10	2
Aristida ternipes						6					1
Bouteloua curtipendula						6					1
Eragrostis barrelieri							7	8			1
Leptochloa facicularis								8			1
Muhlenbergia asperifolia	1									10	1
Muhlenbergia fragilis							7		9		1
Paspalum dilatatum	1				5						1
Sorghum halapense						6					1

Vegetation Classification Field Techniques verses the Arizona GAP Program Vegetation Map

Peter S. Bennett[1] and Michael Kunzmann[1]

Abstract.—The Arizona GAP Program and related Geographical Information Systems (GIS) databases are located within the School of Renewable Natural Resources at the University of Arizona in the Advanced Resources Technology Program (ART). In conjunction with ART, the USGS Cooperative Park Studies Unit have been developing methodologies to assess the accuracy of the Arizona GAP datasets. Under the auspices of the national GAP program, Dr. Lee Graham created a 40-ha minimum mapping unit vegetation map for Arizona. The initial map, derived from 1992-1993 Landsat Thematic Mapper (TM) and other data, contained 58,170 polygons classed into 109 landcover types.

Subsequently Bennett and Kunzmann were asked to refine vegetation classes and develop ground-truth techniques to assess the overall accuracy of the vegetation map. Five major problems we needed to solve were (1) fitting the original TM landcover types into a hierarchical classification classification system of mutually exclusive units, (2) developing adequate vegetation class descriptions that could be used by graduate student field teams to recognize vegetation types and landcover classes, (3) generating adequate "ground-truthed" data to assess the overall attributional accuracy of each vegetation type, (4) delineating differences between the original and new landcover classification classes, and (5) measuring the classification accuracy of each vegetation class.

Field polygon samples were taken by a plotless sampling method using aircraft or automobiles for transportation. Portable computers displaying unattributed polygons were linked to GPS receivers in such a manner that the observers map position was visible and target polygons clearly delineated. In this manner over 7,000 observations were made, each linked to a polygon, and the vegetation type present was electronically documented in a database. The degree of agreement between the original and modified map legend was subsequently determined in the ART lab using GIS and other statistical methods. Binary scores measuring agreement were given to each of the lower levels of the classification hierarchy. We found overall class agreement between the map polygons and the legend 55 % of the time at the basic (finest)

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classification level and 88 % at the coarsest level. However, individual vegetation variances are considerable and prone to many errors classification biases. Suggestions for regional vegetation mapping and improvement of the Arizona GAP map are presented.

Resumen.—El Programa GAP y las bases de datos relacionadas de sistemas de información geográfica (SIG) están localizadas en la Escuela de Recursos Naturales Renovables en la Universidad de Arizona dentro del Programa de Advanced Resource Technology (ART). En conjunción, este programa y la Unidad Cooperativa para el Estudio de los Parques (USGS Cooperative Park Studies UNIT) han desarrollado metodología para evaluar la exactitud de las bases de datos del GAP análisis para Arizona. Bajo el auspicio del Programa Nacional GAP, el Dr. Lee Graham creó un mapa de vegetación para el estado de Arizona, con una unidad mínima cartografiable de 40 hectáreas. El mapa inicial derivado de imágenes Lansat Thematic Mapper (TM) 1992-1993 y de otros datos, contiene 58,170 polígonos clasificados dentro de 109 tipos de cobertura del suelo.

Subsecuentemente, a Bennet y Kunzmann se les solicitó el refinamiento de las clases de vegetación y el desarrollo de técnicas de comprobación en campo para evaluar la exactitud total del mapa de vegetación. Fue necesario resolver cinco problemas principales: 1) el ajuste de coberturas del suelo originales de la imagen TM hacia un sistema jerárquico de clasificación basado en biomas con unidades mutuamente excluyentes, 2) el desarrollo de descriptores de las clases de vegetación que pudieran ser usados por grupos de trabajo en campo para reconocer los tipos de vegetación y las clases de cobertura del suelo, 3) la generación de datos adecuados verificados en campo para la evaluación de la exactitud de los atributos de cada tipo de vegetación, 4) la delineacion de las diferencias entre las clases de clasificación originales y las nuevas, y 5) la medición de la exactitud de la clasificación para cada tipo de vegetación.

Los polígonos muéstrales de campo fueron tomados por un muestreo de area usando una avioneta o un automóvil para la transportación. Computadoras portátiles desplegando los polígonos sin atributos fueron ligadas a un geoposisionador receptor (GPS), de tal manera que la posición observada en el mapa fue visible y los polígonos blanco fueron claramente delineados. De esta forma mas de 7,000 observaciones fueron hechas, cada una ligada a un polígono, y el tipo de vegetación presente fue electrónicamente documentado en la base de datos. El grado de concordancia entre la leyenda original del mapa y la modificada fue subsecuentemente determinada en el laboratorio

ART por medio del uso de un SIG y otros métodos estadísticos. Valores binarios que median la concordancia fueron dados para cada uno de los niveles bajos de la clasificación jerárquica. Encontramos una concordancia del 64% entre los polígonos del mapa y la leyenda para la clasificación básica (mas fina), y de 83% para el nivel mas grueso. Sin embargo, las varianzas individuales de las clases de vegetación son considerables indicando posibles errores y sesgos en la clasificación. Se presentan sugerencias para el mapeo regional de la vegetación y el mejoramiento del mapa del Programa GAP para Arizona.

INTRODUCTION

Vegetation Classification

The Arizona GAP program began in 1991 and is housed within the Advanced Resources Technology Program (ART) in the School of Renewable Natural Resources at the University of Arizona. Initially the program was directed by Dr. Lee Graham from April, 1991 through June, 1995. Dr. Graham utilized airborne video techniques to assist with satellite image classification and in the identification and description of prominent vegetation types. In April, 1996, the USGS Cooperative Park Studies Unit at the University of Arizona was asked to: (1) assess the overall GAP mapping effort; (2) to review the adequacy of ancillary GAP data including the metadata; (3) to update and convert the Graham landcover types to the National Vegetation Classification System (NVCS).

Although the landcover types developed by Graham were roughly modeled on Brown, Lowe, and Pase (1979) she retained many ecotonal units because of their potential value for wildlife habitat description. The distribution of vertebrate species, one of the major products of the GAP Program, was delineated in part by the distribution of such habitats. This created difficulties when we attempted to crosswalk the Graham habitats into NVCS.

Problems with the Graham map legend were previously reported (Bennett 1996). Graham was aware of the Brown, Lowe, and Pase (1979, 1980) vegetation classification system and also knew of Brown (1982). Her nomenclature used the concepts of these authors but did not necessarily apply them consistently to her labels creating some confusion. Aside from this uncertainty, three problems occurred. These were: (1) label ambiguity; (2) mixing of unrelated ecological units within the same type; and (3) unequal classification ranking which created unnecessary categories.

Ambiguity, caused by use of synonymous, vague, or conflicting labels is the first problem. For example, the difference between "Wetland" and

"Riparian" labels was unclear. "Chaparral," " Shrub Oak and Manzanita," and "Evergreen Sclerophyll" are all evergreen chaparral; are they intended to be different—are they of equal rank? Also, encinal (Spanish = a place where oaks grow)" is a localized term applied to Madrean evergreen oak woodlands. Pinyon-Juniper is reserved for a type of coniferous woodland of the Great Basin biome but pinyon pines and junipers (species different than the Great Basin trees) also occur in the Madrean. Thus, the map legends "Encinal Mixed Oak-Pinyon-Juniper" are ambiguous.

The second problem is mixing of vegetation types within a single label. "Pinyon Juniper-Shrub/Ponderosa Pine-Gambel Oak-Juniper" and "Sonoran Paloverde—Mixed Cacti/Sonoran Creosote—Bursage" are examples. These vegetation units apparently represent ecotones; in the first case between biomes and in the second between different series within the same biome. Attempts to classify ecotones can create an enormous number of vegetation types which are not discretely different.

The third problem, unequal classification ranking, is illustrated by the Graham "Madrean Riparian/Wet Meadow" where riparian is a higher or broader category than wet meadow. "Encinal Mixed Oak/Mixed Chaparral/Semidesert Grassland" combines two narrower (series) communities with the Semidesert Grassland biome, obscuring any possible relationships at the landscape level.

Classification ranking problems are remedied by fitting them into an established hierarchical and evolutionary classification system; a procedure that clarifies relationships between units of differing breadth or rank as well as between those of different origin. Obviously, the result is only as good as the classification system employed. We distinguish here between a classification system and a classification: the system is the structure that underlies the classification; the classification is the concrete vegetation units arranged by the system. Even if the classification is incorrect but the system lying behind it is consistent, the resulting classification is coherent and uniform. We used Brown, Lowe, and Pase (1979) and Bailey and Cushwa (1982) because they are hierarchical, show evolutionary relationships, have been critically reviewed, and are analytically described (Brown 1982). Regardless of the system or format used, placing labels in orderly ranks clarifies their intra- and inter-relationship to other systems such as that of GAP program.

Fitting the Graham vegetation legend into the Brown, Lowe, and Pase system (BLP) quickly pointed out hierarchical ranking problems. For example, the diverse mapped Graham pinyon-juniper types have a high degree of geographic adjacency justifying their combination into the larger "Great Basin Conifer Woodland Series" (Brown, Lowe, and Pase 1979, p.7). A series is a community of dominant endemic genera (Takhtajan 1986, Brown, Lowe, and Pase 1979) which approximates the GAP alliance-level classification.

Some other examples are the combination of Graham's "encinal mixed oak—pinyon juniper," "encinal mixed oak—Mexican pine—juniper," "encinal mixed oak/mixed chaparral/semidesert grassland," and "GB juniper" were combined into Madrean Evergreen Forest (Encinal). The "GB juniper" polygons were found to associate with Madrean vegetation not that of the Great Basin. Graham's "ponderosa pine—mixed conifer," "ponderosa pine—gambel oak—juniper/pinyon—juniper," "ponderosa pine/pinyon—juniper," "ponderosa pine -aspen," "ponderosa pine—mixed oak—juniper," and "encinal mixed oak" were combined into Rocky Mountain Conifer Forest (Pine). Here the "encinal mixed oak" polygons were not associated with Rocky Mountain vegetation. Graham's "interior chaparral (mixed)/Sonoran paloverde—mixed cacti," "interior chaparral (mixed)/mixed grass—scrub complex," and "Rocky Mt/gb dry meadow" were combined to Mogollon Chaparral Scrubland (Mixed Evergreen Sclerophyll). Space does not permit a complete exposition of the combinations formed.

Ambiguous or conflicting labels were combined and given single names that best fit our understanding of Arizona's vegetation. Labels with synonymous terms were also combined into a single unit retaining term with the broadest meaning. Labels representing mixtures of vegetation were renamed for first, and presumably most prominant element. The newly combined labels, when added to those that required no change, resulted in a list of 55 cover types; roughly half of the original number. The validity of these changes was later tested and reported in the results section of this paper. The 55 cover types resulting will be used on our map pending their eventual conversion to the National Vegetation Classification System (NVCS) when it is completely defined.

METHODS

Data Collection

The first step toward evaluating the Graham map was development of quantified vegetation descriptions. Species importance, cover, and community physiognomy were developed for common vegetation types. Sources for these data included published reports by Alexander et al. (1984), Bassett, Larsen, & Moir (1987), Brown (1982), Johnson, (1984), Moir & Ludwig (1979), Warren, et al. (1980, 1982) and others. These combined data provided the basis for ground-truthing the Graham map. Three methods were employed: (1) use of traditional relevé plots; (2) automobile-based assessment; and (3) airborne assessment.

Traditional relevé plots. Although rapid data collection methods have been devised (Rowlands 1994, and several others), they are intended for

development of vegetation classifications or mapping limited areas and are too time consuming for extensive surveys. Simply recording the data takes 10 to 15 minutes and traveling to and finding the polygon selected takes considerably longer. On average we were able to record 4 to 6 Graham polygons per day. Evaluation of the entire GAP map by this method may not be economically feasible so the method was reserved for working out difficult communities and for refining quantified vegetation descriptions.

Automobile-based assessment. Data collection while driving is rapid and inexpensive. We carry a GPS receiver coupled to a laptop computer controlled by suitable software. We used a two-person team: a driver familiar with Arizona's vegetation and a computer operator/data logger passenger. The computer screen displays vehicle position, a road map, and the Graham vegetation polygon outlines. Data recorded in the field included: (1) date/time; (2) GPS longitude/latitude/elevation; (3) topographic influence on vegetation distribution; (4) synusia present; (5) eveness of vegetation distribution; (6) type of data collected (paper relivé, electronic relivé, brief description); (7) species present and their prominence; (8) area of polygon where data was collected; (9) field classification; (10) and name of data logger. Each vegetation polygon has an unique serial number and has a vegetation class assigned by Graham. Field personnel did not have access to the Graham vegetation types making the field classification unbiased. The driver/observer does not know the correct answer before the data is logged and is, therefor not biased.

Arizona vegetation was sampled by traversing nearly 10,000 miles of highways, secondary roads, and primitive motor trails. Altogether 5,503 vehicle-borne observations were made. The computer operator was able to tell moment by moment the vehicle's position in relation to the Graham polygon boundaries. When a polygon was entered or left the operator and driver would decide where to take a relevé. We tried to avoid vegetation transitions by taking samples away from polygon edges. Only one sample was taken in small polygons but where possible large polygons were sampled multiple times to capture vegetation variability within the polygon. Speed and low cost are the advantages of this kind of evaluation. Accuracy and precision are commensurate with Dr. Graham's methodology. However, there are several disadvantages: (1) the results are dependent upon the assessment team's ability to recognize the different vegetation classes; (2) roadside vegetation grows taller and sometimes obscures the view and may not be representative of the polygon; (3) sampling is not rigorously random since some roads tend to follow landscape features such as ridges and canyons, and (4) roadless areas cannot be sampled.

Airborne assessment. The use of video/GPS equipped aircraft is rapid and can reach roadless areas. However, data accuracy and precision are an

order of magnitude less than that collected via motor vehicle or by foot. Some formations are easier to work with than others: conifer forests are easy but scrublands and grasslands are difficult because of the difficulty of recognizing and identifying specific plant species. This method has the disadvantages of (1) requiring considerable post processing, (2) increased position uncertainty owing to verticality errors caused by aircraft roll and pitch, (3) post processing personnel must be trained to recognize aerial views of important vegetation species, and (4) difficulty of recognizing desert vegetation where ground reflectance is high. This technique compliments auto-based assessment. Cost of airborne sampling is considerably greater than auto-based sampling.

Evaluation of the Map and Legend

Post Processing. All 6,348 data sets were loaded into a spread sheet. This is the first time that rating personnel were able to view the Graham vegetation classes associated with the individual polygons. The list was sorted by polygon serial number thus bringing multiply sampled polygon data together for evaluation. The classifier in the laboratory can easily view the degree of apparent homogeneity of large polygons. A final classification was given to each polygon based on the preponderance of the data. Large polygons with multiple data sets were classified considering the field assessment classifications, unclassified Graham-based field data, uniformity of distribution, similarity of physiognomic structures, and effect of topography.

The final classification and the prominence of plant species found in the field were used as the standard against which Graham's vegetation assignment, polygon by polygon, was compared. Development of this standard was necessary to test (1) the original Graham vegetation classes; (2) our modifications of the original Graham legends to better fit the BLP and NVC systems, and (3) the assignment of the Graham map to the actual vegetation on the ground, i.e., ground-truthing the map.

The evaluation project was assigned the task of determining the accuracy of the Graham map in terms of its own legend. Beyond this appraisal we have been asked to adjust her vegetation types to fit the NVCS at the alliance level. Thus the accuracy evaluation process does not change the polygonal units as previously defined by Thematic mapper image classification procedures. We designed a sliding numeric scale to reflect various degrees of agreement between the vegetation on the ground and the Graham map legend in proportion to the importance of the element rated. Agreement at the species level received 1 point, at the formation level (i.e. forest, grassland, etc.) 2 points, at the biome (i.e. biogeographic level) 4 points, and at the series level (assemblages of genera) 8 points. A perfect

score is 15 points. This particular nonlinear scale was adopted because any sum can be decomposed into its component parts. For example sum 6 can only come from 2 + 4, sum 11 can only come from 8 + 2 +1 and so on. Series and Biome ratings received the highest point weights to increase the utility and usefulness of the map at the most appropriate resolution level and classification rank.

RESULTS

Comparison of the Graham vegetation map, using her legends, with actual vegetation showed that she was correct 0.66 of the time overall (her actual score divided by the total possible points). Broken down by classification rank the figures are: 0.68 (series); 0.82 (biome); 0.88 (formation); and 0.55 (species). As expected, scores for the higher (broader) classification levels are substantially greater than for the lower ones where identification of plant genera and species are required. Biome and formation identification requires the ability to distinguish texture which satellite imagery does well. Identification of genera or species requires distinguishing of shapes and spectral signatures which are greatly influenced by vegetation moisture content, vegetation destiny, ground signal return, cloud cover, and sun angle. For example, the TM was unable to reliably distinguish between types of junipers and pinyon pines or between Arizona cypress and Douglas-fir.

When the Graham legends are templated to fit BLP, agreement with field data generally improves. Space does not permit full exposition data for combined cover types so we will present a single but complex example. Nine Graham labels were combined to form the Great Basin Pinyon—Juniper Woodland, which was determined to be 68 percent accurate in field tests. However, if the nine elements are considered separately and the results combined, the accuracy is only 62 percent. Combination caused an improvement of 6 percent. The individual accuracy scores are:

Graham No.	Graham Legend Name	Accuracy (%)
6	PJ/Sagebrush/Mixed Grass Scrub	24
7	Pinyon Juniper—Shrub Live Oak—Mixed Shrub	78
8	PJ (mixed)/Mixed Chaparral	2
9	Pinyon Juniper—Mixed Scrub	51
10	Pinyon Juniper—Mixed Grass—Scrub	78
11	Pinyon—Juniper (mixed)	82
12	Douglas-fir—Mixed Conifer	70
27	Int. Chaparral-Scrub Live Oak—Pointleaf Manzanita	46
52	GB Mormon Tea/Pinyon-Juniper	90

Inclusion of these Douglas-fir and Int. Chaparral-Scrub Live Oak—Pointleaf Manzanita communities may seem to be peculiar but in these cases are in reality ecotonal with the Great Basin Woodland. Overall, templating the Graham vegetation classes did not increase error and resulted in a better GAP legend.

CONCLUSIONS AND RECOMMENDATIONS

Graham's mapping effort incorporated innovations subsequently adopted by the GAP program. We were able build upon what she started and find solutions for several problems that she was aware of but did not have the time to solve herself. We do not intend that our criticisms should reflect adversely on Dr. Graham's work, in fact, we admire what she accomplished considering the complexity and ecotonal nature of Arizona's vegetation.

Graham's use of GPS referenced airborne video training plots was brilliant. However, her lack of a documented and quantified vegetation classification created problems that could not be wholly solved. Our foremost recommendation is adoption or construction of a vegetation classification and diagnostic rules prior to field mapping.

Graham's attempt to develop a TM-classification by assembly of raw vegetation data is time consuming and does not adequately address inherent polygon heterogeneity or ecotonal vegetation issues and therefore the map requires further adjustment to correct errors discovered in the assessment process. The use of this data to develop vegetation, vertebrate, and species richness maps was an excellent start despite the inevitable map errors. Reclassification of TM data based on higher resolution ground-based vegetation information would improve the next generation of GAP maps. However, Graham's accuracy level based on her own vegetation classification was nearly 70% at the series level but rose to 88% at the formation level indicating that TM imagery is not adequate for the demand placed upon it. A far better and much more costly product could be obtained by using high resolution, medium elevation, airborne color photography supported by high-resolution ground-based vegetation surveys. In spite of the problems discussed, the Arizona GAP Map is a valuable contribution to conservation biology. It represents an initial approximation employing a difficult technology but is not, perhaps, the ultimate product desired by site-specific or parcel based land managers. It is intended to display and interrelate the biota at a regional landscape level; it is broad-brushed; users who expect detail will be disappointed. We, the creators, must be careful not to oversell the product to the users and the users must in turn remember that this is an initial landscape level

effort. The GAP Program anticipates that future research founded on this product will produce superior and more refined results. It is an excellent start to a complex task.

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Legal and Illegal Trade Between Mexico and the U.S. in Plants and Plant Products Listed Under CITES

Joel P. Floyd[1]

Abstract.—CITES, (Convention on International Trade in Endangered Species of Wild Fauna and Flora) as it applies to plants and its enforcement by the U.S. Department of Agriculture along the U.S./Mexico border, is summarized. Examples of protected taxa are presented along with recent information about the listing of Mexican cactus seed on CITES. Trade data and enforcement activities obtained from our own records, and those of the U.S. Fish & Wildlife Service, are presented with regard to cycads, orchids, cactus, and cactus wood from Mexico and legal trade between the U.S. and Mexico in artificially propagated CITES listed plants. These data show that there is little or no legal trade in wild collected CITES plants, trade in artificially propagated Mexican cacti is just beginning, and there is limited trade in artificially propagated orchid plants. Commercial shipments of cactus wood from Sonora are imported legally into the United States with some smuggling of this material from Mexico.

Resumen.—CITES (Convenci n Sobre El Comercio Internacional de Especies Amenazadas de Fauna y Flora Silvestres) su relaci n a plantas y su ejecuci n en La Frontera Internacional por el U.S. Department of Agriculture (Departamento De Agricultura de Los Estados Unidos) se resume as : Ejemplos de taxa protegida se prestan acompa ados con informaci n reciente indicando la inclusi n de semillas de cactus en el CITES. Datos del comercio, de nuestras actividades reglamentarias y del Servicio de Pesca Fauna Silvestre de los Estados Unidos (U.S. Fish & Wildlife Service), son presentados en respeto al comercio legal entre Los Estados Unidos y Mexico en plants de cactus cifradas en el CITES que han sido propagadas artificialmente. Estos datos demuestran que el comercio legal en plantas silvestres que son incluidas en el CITES apenas empieza a surgir. Igualmente existe comercio minimo o no existente en cactus que ha sido propagado artificialmente y tambien existe comercio limitado en orgu deas que han sido propagadas artificialmente. Cargamentos de cantidades comerciales de madera de cactus del estado de Sonora son importadas legalmente a Los Estados Unidos, pero aun existe el contrabando de este tipo de materia de Mexico.

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INTRODUCTION

An international treaty known as CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) was conceived in 1973 at a United Nations Environmental Program conference in order to protect selected wild animal and plant species from being impacted by excessive commercial world trade. Regulation for listed species under CITES includes live animals and plants, and the products derived from them. CITES seeks to monitor trade for species threatened with extinction through an internationally recognized permitting system (Appendix II species), and prohibits commercial trade in species in danger of extinction (Appendix I species).

The CITES treaty has been signed by over 130 countries worldwide including the U.S. and Mexico. The entity charged with implementation and monitoring CITES world trade for the United Nations is the CITES Secretariat based in Switzerland. In the U.S., laws promulgated to enforce CITES are under the auspices of the U.S. Fish & Wildlife Service (USF&WS). The agency charged with enforcing the plant provisions of the treaty at international borders is the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA, APHIS, PPQ).

Certain ports of entry are considered Designated Ports for the import and export of CITES listed plants. For the U.S.-Mexico border, these ports are Nogales, Arizona, San Diego, California, and the Texas ports of El Paso, Laredo (limited), and Brownsville.

This review of available trade data was conducted to analyze the current status of CITES plant trade between Mexico and the United States since Mexico became signatory to CITES in 1992. Most of this information was obtained from trade data gathered at the Management Authority Office of the USF&WS in Arlington, Virginia where all U.S. CITES Export Permits and Certificates are issued and later used for export at Designated Ports. Other data used comes from CITES Export Permits from Mexico issued by Mexico's Management Authority, Secretaria de Medio Ambiente, Rescursos Naturales Y Pesca (SEMARNAP), which are collected by USDA at Designated Ports at the time of entry and sent to the USF&WS. Trade data up to and including 1996 were the most recent available.

In addition, USF&WS gathers information on the CITES plant material seized by USDA, or returned to country of origin, at ports of entry. Data on enforcement are taken from a variety of sources including the Law Enforcement Division of USF&WS, the USDA, APHIS, Investigative and Enforcement Service, and non-governmental organizations' publications.

Among the many species of plants protected under CITES, with a few exemptions, the entire plant families of cacti (Cactaceae), orchids (Orchidaceae), and cycads (Cycadaceae, Zamiaceae) are listed as CITES Appendix II, except for those species listed in the highest category of protection, Appendix I. This study concentrates on trade between Mexico and the U.S. in Appendix II members of these three plant families because they are the large plant families where significant trade may occur. Other CITES listed taxa are included if they show any measurable trade. Commercial trade is not permitted for Appendix I species.

WILD-COLLECTED PLANT TRADE

CITES plant trade monitoring distinguishes between wild-collected and artificially propagated plants by the issuance of Import or Export Permits for wild collected plants and Certificates of Artificial Propagation for those plants that meet the CITES definition of artificial propagation. Table 1 shows exportations of wild-collected cacti from Mexico has essentially stopped after Mexico signed the CITES treaty and designated a permit issuing Management Authority in April of 1992. In that year, there were 3,484 plants representing 33 taxa of Appendix II wild or unknown source cacti imported in to the U.S. There has been no trade in live wild-collected cacti since that year.

Table 1. Number of plants and taxa exported from Mexico to the U.S. from wild collected or unknown source CITES listed plant families.

Year	Cactus plants/taxa	Orchid plants/taxa	Cycad plants/taxa
1992	3,484/33	unknown*	1223/2
1993	0	0	7/1
1994	0	0	0
1995	0	0	0
1996	0	0	0

**plants imported were from unknown source*

These data compare with the U.S. CITES annual report data analyzed by Fuller (1985) showing U.S. imports from Mexico in 1982 of 73,156 cactus plants of more than 50 taxa, also from wild or unknown sources. Campbell (1984) estimated from APHIS reports that in 1977 there were 1.5 million cactus plants imported into the U.S. from Mexico.

Similar trends occur for wild collected orchid and cycad species in which there were no U.S. importations of wild collected plants from Mexico after 1993 up to 1996. Thousands of orchids from unknown sources were recorded imported from Mexico in 1992, but it appears the vast majority of these were artificially propagated (see Table 2). In 1982

there were 20 taxa representing 10,834 wild orchid plants and 6 taxa of 4,770 wild cycad plants imported into the U.S. from Mexico (Fuller, 1985). There were also no recorded exports of wild collected CITES listed plants from the U.S. to Mexico from 1992-1996.

ARTIFICIALLY PROPAGATED PLANT TRADE

The practice of artificially propagating endangered plants and their subsequent marketing is generally thought to benefit wild plant populations by taking collection pressure from plant hobbyists off of these, often times, rare plants in their native habitat. For many species, techniques for propagating large numbers of plants from seed, cuttings, offshoots, etc., have been perfected to the extent that many plant species that were once difficult to obtain are readily available as high quality nursery grown specimens.

Mexico is actively exporting artificially propagated orchids, and was doing so during the time period prior to 1992. Many of the species propagated are native to Mexico, but also included are popular non-native species and hybrids that have been in trade as propagated varieties for years. Table 2 summarizes the U.S. imports of artificially propagated (and unknown source) orchids from Mexico.

Table 2. U.S. imports of artificially propagated CITES listed plant families from Mexico.

Year	Orchid hybrids	Total Orchid Plants*	Cactus	Cycads
1992	32,100	41,744	0	0
1993	*	5,741	0	0
1994	259	23,362	0	0
1995	10,330	36,664	0	0
1996	6,022	16,754	661	0

**large proportion of plants imported were from unknown sources*

Information on sources of plant material was incomplete. The proportion of imported orchid plant that are hybrids and which are species is not known with certainty. It is evident that artificially propagated orchids have been a significant export of CITES listed plants from Mexico, but these numbers still pale when compared to major orchid exporting countries like the Netherlands and Thailand.

Table 2 shows there were no recorded exports of artificially propagated cacti or cycads from Mexico to the U.S. from 1992 until 1996, when there was one shipment of 662 cactus plants. There is evidently a great demand among hobbyists in the U.S., Europe, and Japan for many rare Mexican endemic cacti as evidenced by increased smuggling activity involving

these plants (Reed, 1997). There are indications that exports of artificially propagated cacti from Mexico are beginning.

Table 3 shows there were exports of artificially propagated orchids from the U.S. to Mexico in 1992 and 1993, but negligible numbers exported in the following years. Exports of artificially propagated cacti during the same time period were sporadic.

Other significant exports of artificially propagated CITES listed plants include 236,501 venus flytrap plants, Dionea miscipula, exported from the U.S. from 1992 to 1995 and 302,272 Aloe vera plants before they were delisted in 1994.

Table 3. U.S. exports to Mexico of artificially propagated CITES listed plants.

Year	Orchids	Cacti	Cycads	Venus flytraps	Aloe vera
1992	3,273	7	0	1,008	93,250
1993	6,384	479	0	43,308	209,026
1994	0	0	0	19,392	*
1995	14	2521	0	7,144	*
1996	24	18	19	0	*

**From CITES appendices*

TRADE IN CITES LISTED WOOD PRODUCTS

Just as there is regulation of international trade in CITES animal products such as elephant ivory and rhinoceros horn, so it is with the products derived from CITES listed plants, i.e., wood and medicinal plant products. The use of cactus wood for decoration in Southwestern-style architecture, furniture, and souvenirs has become more popular in the last ten years. There is an increased demand in the U.S. for the wood of saguaro (Carnegiea gigantea) and cholla (Cylindropuntia), cactus that are native to the Sonoran Desert in Arizona and Sonora, Mexico.

Typically, this wood is collected as dead, drying pieces from the desert floor. In Arizona, collecting cactus wood requires permits from State or Federal land and permission of the landowner from private land. Collecting the sparsely distributed wood of dead saguaros is labor intensive. Its supply is not considered renewable because of the slow rate of growth and the long average life span of these large columnar cacti. Due to the limited supply and high labor costs for collecting, cleaning, and conditioning of this wood in Arizona, there has been an increased demand and price in the U.S. for Mexican origin cactus wood. Mexican sources are more economical, but Mexican CITES and USDA permits must be obtained.

Table 4 summarizes importations of Mexican cactus wood primarily from saguaro, but also cholla (*Opuntia fulgida*), from 1992-1997 through

the designated port of Nogales, Arizona. These numbers represent virtually all commercial cactus wood imports from Mexico to the United States. The volume has varied from year to year, but the demand has been constant. Prior to 1992, there were significant yearly importations through Nogales, indicating that the popularity of cactus wood products continues, which represents a long term trend in the use of this material for Southwestern style decorating.

Table 4. Cactus wood imports from Mexico through the port of Nogales, Arizona.

Year	Total number of shipments	Total number of pieces
1992	4	95,350
1993	6	158,450
1994	2	57,500
1995	11	95,141
1996	4	37,087
1997	6	118,525

The importations listed are only the legal entries made with valid CITES Export Permits issued by SEMARNAP. There is also an unknown volume of cactus wood being smuggled from Mexico. There is anecdotal evidence of this smuggling from competing importers plus evidence by two seizures of commercial quantities that were seized in 1996 by U.S. Customs agents in Arizona as they patrolled an area on the Tohono O'odham Nation that borders Mexico. The saguaro wood pieces, or ribs, in these shipments were cut into 6 foot lengths, cleaned, and tied in bundles of 50 pieces, the standard packaging intended for commercial contractors and furniture makers in Tucson and Phoenix, Arizona.

There is some concern that the wood of saguaro cactus may be in such demand and now in limited supply that live plants are being sacrificed to meet this demand. There have been observations of girdled cacti in Sonora, Mexico similar to a practice used on mesquite and ironwood trees in order to obtain permits for dead wood. (Burquez, 1998, pers. commun.) It is not, however, known how widespread this practice is. Burquez also indicates there are likely dead cacti available for wood harvesting when land is cleared in Sonora to plant grass for cattle grazing.

Other CITES wood products imported from Mexico during the time period examined include 2 or 3 commercial shipments a year for 1992-1994 of Guaiacum sanctum, or lignum-vitae, and 30 shipments of 879 cubic meters of Mexican origin Big-leaf mahogany, Swietenia macrophylla, in 1996, the first year this species was listed as CITES appendix III by Costa Rica. The Mexican origin Big-leaf mahogany, during this time period, is not under CITES but requires a certificate of origin.

TRADE IN CACTUS SEED

Prior to September of 1997, all Appendix II cactus seed were exempt from CITES requirements consistent with the exemption for all Appendix II CITES listed seed and pollen. Due to illegal collecting in Mexico of newly discovered and rare Appendix II cacti, the seed of which was protected by Mexican law but not CITES, the 10th Conference of the Parties to CITES held in Zimbabwe in 1997 listed all Appendix II cactus seed of Mexican species from Mexico. Wild collected Appendix II Mexican cactus seed now requires a CITES Export Permit and seed obtained from propagated cactus in Mexico requires a Certificate of Artificial Propagation. The stricter Appendix I permit requirements remain unchanged.

Commercial, wild collected cactus seed importations from Mexico through the port of Nogales, Arizona were significant prior to this change. This trade includes only abundant species occurring in Sonora, including saguaro cactus (*Carnegiea gigantea*), organpipe cactus (*Stenocereus thurberi*), cardon cactus (*Pachycereus pringlei*, P. *pectin-aboriginum*), barrel cactus (*Ferocactus covillei*), and senita cactus (*Lophocereus schottii;*). Table 5 indicated the number of kilograms of cactus seed imported from Mexico from 1993 to 1997, through Nogales, Arizona. These data show an increase in importations Appendix II wild collected cactus seed until the trade was stopped in September of 1997.

Table 5. Mexican Appendix II wild collected cactus seed imported through Nogales, Arizona.

	Kilograms of seed by species						
Year	C.g.	F.c.	L.s.	P.pr.	P.pe.	S.t.	Total
1993	0	0	0	0	50	25	75
1994	50	34	30	45	5	70	234
1995	47	0	39	16	0	20	122
1996	85	177	154	46	0	90	552
1997	143	326	148	268	0	79	964

C.g.= Carnegiea gigantea; F.c.= Ferocactus covillei; L.s.= Lophocereus schottii; P.pr.= Pachycereus pringlei; P.pe.= P. pectin-aboriginum; S.t.= Stenocereus thurberi

SEIZURES OF CITES LISTED PLANTS FROM MEXICO

Data are recorded on seized and abandoned CITES plants at U.S. ports of entry which are sent to one of 60 Plant Rescue Centers around the country, typically public botanical gardens or zoos. These seizures are made normally because the plants lack CITES Export Permits or Certificates issued by SEMARNAP. Occasionally, seized Mexican plants are sent

back to Mexico if SEMARNAP requests that they be returned to the country of origin.

Table 6 indicates that, year to year, the number of CITES plant seizures from Mexico at U.S. ports of entry has decreased overall since 1992. The number of CITES plants returned to Mexico was high in 1992, but decreased to zero by 1996. In the USF&WS reports, the majority of seized plants are not identified beyond plant family and not designated as wild-collected or artificially propagated.

Cantu, et al.(1997) analyzed some of the same data on seizures and concluded that 56% of the seizures were in lots less than 10 plants and 34% were single specimens. The only commercial quantity seizures recorded are for illegal cactus wood shipments, that are not included in Table 6.

Table 6. CITES listed live plants from Mexico seized or returned to origin

	Cacti		Orchids		Cycads	
Year	Seized	Returned	Seized	Returned	Seized	Returned
1992	1661	423	1217	1701	14	2
1993	1063	160	182	5	5	0
1994	847	70	288	0	29	0
1995	759	16	203	0	0	0
1996	740	0	251	0	0	0

Although the source of most seized or returned CITES listed live plants is not available from the data compiled from USF&WS reports, from personal experience at the port of Nogales, it is evident that the cacti consist of primarily wild collected plants, with some artificially propagated cactus, imported in small lots by individuals in passenger vehicles. A significant portion of the wild collected cactus consists of cuttings of various species of columnar cacti imported by individuals for medicinal purposes. Seized orchids and cycads are usually from wild sources.

CITES PLANT VIOLATIONS

In recent years, many smugglers of foreign origin have been apprehended either in Mexico or Europe often with large numbers of rare, wild collected cactus plants and/or seed from Mexico (Cantu, et al. 1997, Fuller, 1985). In 1986, six individuals from California were convicted for smuggling cactus plants, including several Appendix I listed species, from Mexico. They were assessed combined penalties of $12,000 and probation totaling 14 years. Two of their vehicles were seized along with 234 live plants.

Prior to Mexico becoming signatory to CITES, there were many illegal or unauthorized permits (Cantu, et al. 1997) issued for the export of CITES material to the U.S., but since there was no Management Authority designated by Mexico at that time, these violations went undetected or unprosecuted.

Recently 500 rare cactus plants were smuggled from Mexico to France through Dallas, Texas by a German landscape gardener. The $53,000 worth of plants, many Appendix I and some over 100 years old, were turned over to the Natural History Museum of France (Reed, 1997).

Since violations may be prosecuted by different agencies, obtaining definitive information on the number of cases involving CITES plant material from Mexico is difficult. Enforcement information was not available from USF&WS, the agency with direct jurisdiction, when this report was compiled. Other cases prosecuted by U.S. Customs Service for smuggling, or "failure to declare", are difficult to access for a comprehensive report on CITES plant violations. One such case in Nogales, Arizona in 1991 involved 125 wild collected orchids smuggled in a motor home.

Wild collected Mexican cacti have shown up in the U.S. nursery trade in the past and in recent years. In addition to cactus wood, there is concern that smug- gling of live wild collected cacti may be occurring in certain US/Mexico border areas. There is a current case under investigation by APHIS for wild collected cycads smuggled from Mexico into Southern California. Enforcement over such a large border area is as difficult for plants and wildlife as it is for other contraband.

CONCLUSIONS

Mexico becoming signatory to CITES has had a decided impact on plant trade. Wild collected CITES listed plant imports from Mexico to the U.S. has all but stopped after that event and after Mexico designated a CITES Management Authority in 1992. During the time period examined, from 1992-1996, imports of artificially propagated orchid plants from Mexico has continued sporadically, while artificially propagated cactus and cycads have shown no significant export activity from Mexico to the U.S. until very recently. Exports of artificially propagated CITES listed plants from the U.S. to Mexico have shown little consistent activity except for yearly exports of venus flytrap plants.

The wood products of saguaro and cholla cactus are legally exported from Mexico to the U.S. in commercial quantities at levels that show no signs of diminishing. The continued demand for these products has resulted in documented smuggling attempts in more isolated border regions of Arizona.

Seizures and return of Mexican CITES listed plants at U.S. ports of entry have decreased slightly since 1992, however the vast majority of this material is not commercial in nature. There have been relatively few documented U.S. violations of CITES plant regulations between Mexico and the U.S. that have resulted in prosecutions or penalties.

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BIOGRAPHICAL SKETCH

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WATER RESOURCES

Ordenamiento Hidrológico de la Cuenca del Río San Juan

Rafael Aranda[1], Rolando Zamarripa[1], Laura Rojas[1], Gabriela Navarro[1], y José Navar[2]

Resumen.— La Cuenca del Río San Juan abarca un área de 33,651 Km^2 distribuidos en los Estados Mexicanos de Coahuila (12,798 Km^2), Nuevo León (20,249 Km^2) y Tamaulipas (604 Km^2). La cuenca presenta severos problemas de distribución y contaminación del agua por descargas y corrientes industriales, municipales y de agricultura, sequías que reducen la descarga de distintos tributarios y el almacenaje de los tres principales embalses (La Boca, El Cuchillo y Marte R. Gómez); y conflictos políticos por el derecho del agua entre usos, usuarios y entidades políticas. El presente estudio resume los principales usos del agua superficial y desarrolla parcialmente un Sistema de Información Geográfica para recomendar el ordenamiento hidrológico de la cuenca.

Abstract.— The watershed of the San Juan River covers an area of 33,651 Km^2 distributed in the Mexican states of Coahuila (12,798 Km^2), Nuevo Leon (20,249 Km^2) and Tamaulipas (604 Km^2). It presents severe problems of distribution and water contamination by industrial, municipal and agricultural outflows and discharges, drought spells which reduce the discharge of several tributaries and the storage of three major reservoirs (La Boca, El Cuchillo and Marte R. Gomez) and political conflicts for water rights between uses, users and states. This project focused on the development of a hydrological zoning of the watershed.

INTRODUCCIÓN

El principal problema en los estados del noreste de México es el abastecimiento de agua potable del Área Metropolitana de Monterrey (AMM), ciudad con 2,988,081 habitantes (INEGI 1995) representando el 84.17% de la población total del estado de Nuevo León y una demanda de 15 m^3/seg. El suministro actual (10 m^3/seg) es cubierto por medio de

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fuentes superficiales y subterráneas (Agua y Drenaje Mty. 1997). Las fuentes principales son las presas La Boca y El Cuchillo (con capacidades de 40 Mm^3 y 1,800 Mm^3 respectivamente).

Además, el embalse Cerro Prieto construido fuera del área de estudio, suministra cerca del 40% de las demandas actuales del AMM, el resto se obtiene de pozos profundos y someros, galerías y manantiales (De León et al 1994). El agua de la Cuenca del Río San Juan también es usada para irrigación del Distrito de riego 026 (con 76,939 has), el cual se alimenta de la presa Marte R. Gómez, construida para tal propósito en 1944 y con una capacidad de almacenamiento de 1,000 Mm^3.

GENERALIDADES DEL SITIO

La cuenca pertenece a la Región Hidrológica El Bravo Conchos. Cubre una superficie de 33,651 Km^2 y comprende parte del territorio de los estados de Coahuila (12,798 Km^2), Nuevo León (20,249 Km^2) y Tamaulipas (604 Km^2) en los provincias denominadas Llanura Costera del Golfo y la Gran Llanura de Norteamérica. En su conjunto la cuenca abarca 34 municipios del estado de Nuevo León, 7 de Coahuila y 2 de Tamaulipas y se divide para su manejo en 8 subcuencas, S. P. Marte R. Gómez, S. R. San Juan, S. R. Pesquería, S. R. Salinas, S. R. San Miguel, S. R. Monterrey, S. R. Ramos y S. R. Pilón (fig. 1).

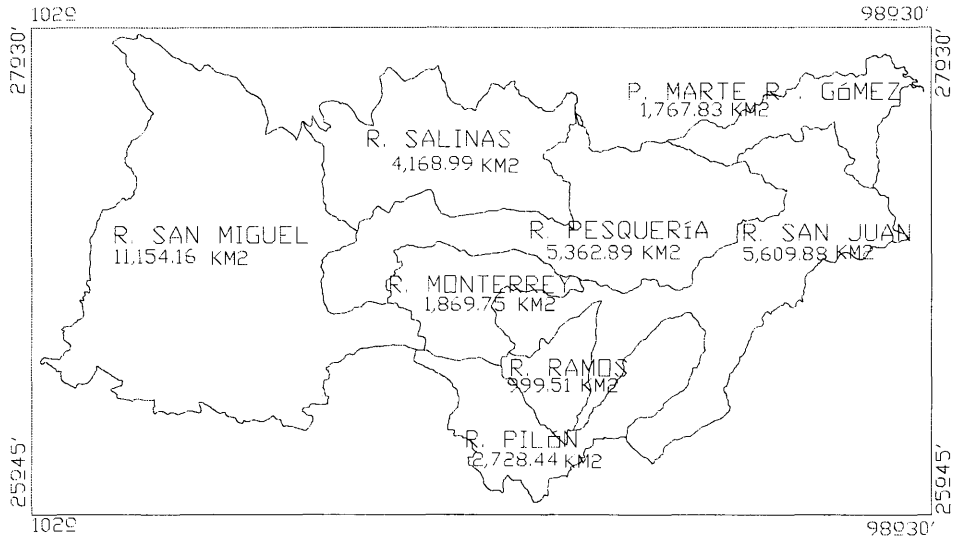


Figura 1. Ubicación y división de la Cuenca del Río San Juan.

El sistema de drenaje está compuesto por los ríos Pesquería, el cual tiene como afluentes el R. Salinas y el Arroyo Ayancual, y los ríos de Monterrey, representados por el Santa Catarina, El Pilón, R. Ramos y el propio San Juan. Todos los ríos nacen en la Sierra Madre Oriental y drenan en dirección este hacia el Río Bravo en la ciudad de Camargo, Tamaulipas (municipio fronterizo con los Estados Unidos de Norteamérica). Los climas dominantes en la cuenca son del tipo muy secos semicálidos en la parte oeste, secos semicálidos y cálidos en la parte este, y desde templados a semicálidos con lluvias en verano en la parte central. La precipitación promedio anual varía desde los 300 mm. en la región oeste hasta los 1,000 mm. en la porción central y las temperaturas promedio anuales varían desde los 16°C hasta los 24°C del oeste árido de la cuenca hasta la región semiárida central (INEGI 1983).

METODOLOGÍA

El Ordenamiento y Manejo de Cuencas se basa en un enfoque geográfico integral que abarca tanto la caracterización geográfica y los regímenes climáticos, como la dinámica demográfica de la cuenca, que permitan definir lo que es posible realizar en ella desde el punto de vista de las prácticas de uso del suelo para la administración de los recursos naturales en la cual el agua se convierte en el elemento integrador del estudio (Gutiérrez et al 1996). Parte de este proyecto se enfoca en la realización de un Sistema de Información Geográfica, incluyendo aspectos de suelos, vegetación, elevación y climas, con temperatura y precipitación promedio anuales. Las determinaciones por métodos electrónicos (Autocad 12 para Windows) son más aplicables en términos de tiempo y economía. Además, el análisis de los principales usos del agua superficial, determina las demandas actuales y los problemas existentes en la administración del recurso en el contexto de la utilización compartida por dos estados.

USOS DEL AGUA SUPERFICIAL

El uso potencial del suelo en la cuenca lo comprenden: 1) los bosques de matorral (M. rosetófilo acaule, M. espinoso tamaulipeco, M. submontano y M. subinerme, que cubren aproximadamente el 56.28% del área total de la cuenca), 2) los bosques de coníferas y latifoliadas (B. de encino, B. de encino-pino y B. de pino, con 6.26%), 3) las tierras de agricultura (11.06% A. de riego y 7.16% A. de temporal), y la zona urbana (Tabla 1). El mapeo de la vegetación debe incluir los tipos de vegetación existentes, determinar qué tipo de especies se tienen y bajo qué densidades; y si son caducas o

perenifolias, esto con la finalidad de producción de agua ya que las especies presentan distintas tasas de evapotranspiración que pueden eliminar volúmenes excesivos de agua a la atmósfera.

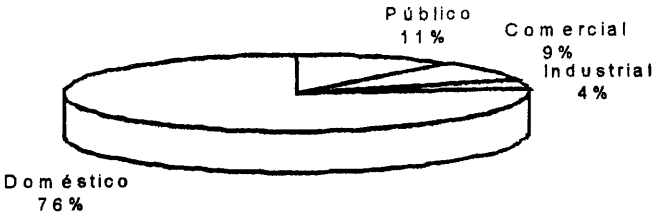
Tabla 1.— Superficie ocupada por los diferentes tipos de vegetación (INEGI, 1980).

Tipo de vegetación	Área en Km^2	Porcentaje (%)
Agricultura de riego	3721.80	11.06
Agricultura de temporal	12409.41	7.16
Bosque de Oyamel	126.92	0.08
Bosque de tascate	10.10	0.03
Bosque de encino-pino	609.08	1.81
Bosque de pino	1204.71	3.58
Bosque de encino	292.76	0.87
Chaparral	1524.39	4.53
Matorral con izotes	124.51	0.37
Matorral rosetófilo acaule	6026.89	17.91
Matorral espinoso tamaulipeco	2120.01	6.30
Matorral espinoso	154.79	0.46
Matorral subinerme	4492.41	13.35
Matorral submontano	6299.47	18.72
Matorral inerme	424.00	1.26
Mezquital	2893.99	8.60
Pastizal cultivado	185.08	0.55
Pastizal inducido	245.65	0.73
Pastizal natural	265.84	0.79
Pastizal halófilo	279.30	0.83
Vegetación secundaria	50.48	0.15
Zona urbana	178.35	0.53
Presas	111.05	0.33
Total:	**33651.00**	**100.00**

Los suelos de la cuenca están constituidos por: a) litosoles, en la región central y oeste de la cuenca, b) yermosoles, en la parte este y c) xerosoles, vertisoles y rendzinas en el lado norte (Tabla 2).

Las demandas actuales comprenden el suministro de agua potable para el Area Metropolitana de Monterrey, con aproximadamente 3 millones de habitantes (en un área de 360 km^2) e integrada por los municipios de Guadalupe, San Nicolás de los Garza, San Pedro Garza García, Santa Catarina, Apodaca, Juárez, General Escobedo y García, población que tiende a duplicarse para el año 2000. Actualmente existe un déficit en el suministro de 5.0 m^3/seg. El AMM es un área totalmente industrializada por lo cual exige gran demanda no sólo para uso doméstico sino también industrial, como se ilustra en la figura 2 (Chávez 1995). Monterrey da tratamiento secundario al 100% del agua utilizada antes de arrojarla a las corrientes superficiales, terminando con la alta tasa de contaminación

Figura 2. Consumo de agua por clase de uso para el AMM (promedio 1990-1996).



Fuente: Atlas de Monterrey

Tabla 2. Superficie ocupada por los diferentes tipos de suelo (INEGI 1980).

Tipo de suelo	Área en Km²	Porcentaje (%)
Cambisol	127.33	0.38
Castañosol	826.78	2.46
Feozem	930.66	2.77
Fluvisol	63.48	0.19
Litosol	10587.00	31.46
Regosol	2294.97	6.82
Rendzina	2902.87	8.63
Solonchak	880.32	2.62
Vertisol	3964.94	11.78
Xerosol	4563.97	13.56
Yermosol	6508.68	19.34
Total:	33651.00	100.00

provocada en la subregión donde se ubica. Actualmente la ciudad cuenta con 3 plantas de tratamiento de aguas residuales (Agua y Drenaje Mty. 1997). El abastecimiento cumple con las normas mexicanas de calidad del agua y mantiene al menos 5 ppm de cloro residual para desinfección .

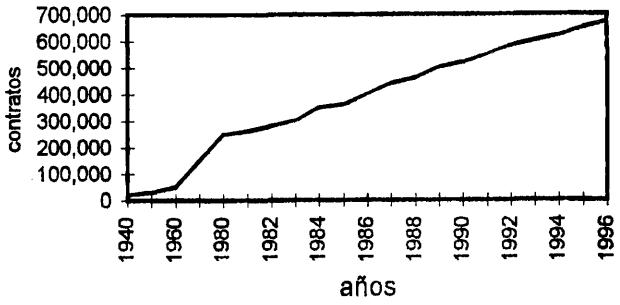
Las fuentes actuales no son suficientes para el crecimiento de la población, encontrándose alejadas de la ciudad, con lo que aumenta la inversión para satisfacer las demandas crecientes día con día. Las lluvias que se presentan en los últimos años no abastecen la recarga de los acuíferos, su beneficio consiste únicamente en la reducción de la evaporación de las presas y las demandas de agua.

Otra forma de estudiar la demanda de agua en el tiempo, se refiere al número de contratos de agua y drenaje en el AMM mediante el transcurso de los años (fig. 3). La problemática en el abastecimiento de agua potable se reduciría por el uso eficiente de la misma, el tratamiento y rehuso de aguas residuales e incrementado la oferta incorporando nuevas fuentes de abastecimiento.

La sequía manifestada en los últimos años ha traído grandes conflictos políticos entre los usuarios del agua del río San Juan. De las 76,939.6 has de riego que comprende el Distrito 026 o Bajo San Juan, solo son irrigadas el 48%. Los agricultores reclaman el suministro de agua pactado en el acuerdo de 1952, donde constaba que todas la aguas del Río San Juan

Figura 3. Contratos totales de Agua y Drenaje para el AMM (1940-1996).

Fuente : Atlas de Monterrey



serían utilizadas con el único propósito de irrigar el distrito, vía presà Marte R. Gómez. Las negociaciones entre los estados de Tamaulipas (Distrito 026) y Nuevo León (AMM) acordaron enviar solo 200 Mm^3 por año para irrigación, mediante el plan Monterrey IV. La presa el Cuchillo capta las aguas provenientes del río San Juan para disminuir el déficit de agua potable que sufre el AMM desde 1989. Cuando dos o más estados utilizan una misma fuente de abastecimiento, cualquier decisión tomada respecto a ésta, afecta directamente a ambas regiones, por lo que se vuelve delicada la administración del recurso.

Gran cantidad de agua se pierde por evaporación en las zonas áridas del este de la cuenca. Particularmente en la estación climatológica el Cuchillo N. L. se tienen registros en los que la evaporación rebasa la precipitación mensual (333.74 mm por 107.35 mm en la época de lluvia máxima). De igual manera existen registros similares para la estación Monterrey. En la región citrícola de Montemorelos, N. L. y en la estación La Boca (Santiago, N. L.), la precipitación excede en la época de verano a la evaporación (fig. 4). Con el fin de analizar ésta situación se establecieron en la cuenca alrededor de 70 estaciones climatológicas (Comisión Internacional de Límites y Aguas 1993), donde se registran parámetros como la evaporación, temperatura y precipitación del área de estudio.

El problema de las entidades del norte de la República es su ubicación geográfica cercana al Trópico de Cáncer, alrededor del cual se extiende la franja desértica a nivel mundial, en la cual las condiciones son sumamente adversas: sus ríos son erráticos e intermitentes, sus caudales bajan de nivel varios meses del año hasta llegar a ser nulos en largos periodos.

Con el aumento de la población y el incremento de las actividades agrícolas e industriales, se intensifica la explotación y el deterioro de los recursos, por lo cual es necesario el uso racional y su conservación para el desarrollo humano (EMC 1980). El manejo integral de las cuencas hidrográficas coordina esfuerzos entre los usuarios con el fin de repartir adecuadamente las riquezas obtenidas de la explotación de los recursos naturales, manteniendo y conservando los renovables indefinidamente si es posible (Arias 1990).

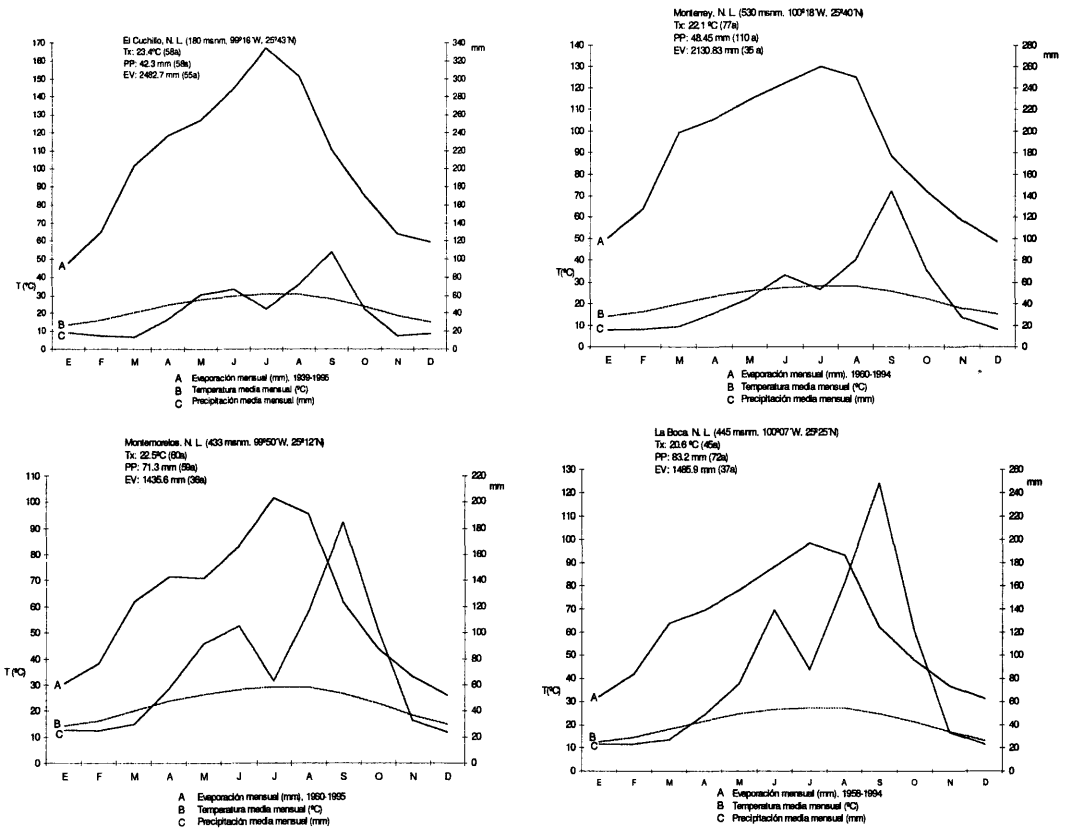


Figura 4.— Diagramas ombrotérmicos correspondientes a 4 estaciones climatológicas ubicadas en la Cuenca del Río San Juan.

DISCUSIÓN

- Deben difundirse planes y programas para un mejor manejo del agua, desarrollados a partir de las demandas de los sectores urbano, industrial y agrícola.
- Es necesario establecer una medida económica que haga conciencia entre los usuarios del recurso agua, ya que debe valorarse para su uso racional y conservarse. El crecimiento de la población y la urbanización son los determinantes actuales en la demanda de agua, como es el caso típico de la ciudad de Monterrey.
- Se requiere de nuevos acuerdos bilaterales que garanticen el mejor aprovechamiento sostenido de los recursos. Se deben evitar los daños ambientales que repercutan en el aprovechamiento por parte de otro estado que lo comparte.
- Es necesario explorar nuevas fuentes de abastecimiento en el estado de Tamaulipas, cuyo volumen se aproveche para irrigar el Distrito 026, ya

que los conflictos por la disputa del agua serán más fuertes conforme las fuentes se agoten -Presa El Cuchillo al 17 % de su capacidad y P. Rodrigo Gómez al 43% (El Diario de Monterrey 1998).

- La calidad de vida de la población se acentúa por el uso de los recursos manejados aisladamente, sin considerar el concepto de integridad, como lo expone el ordenamiento por cuencas hidrográficas.

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ESBOZO BIOGRÁFICO

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El Agua en la Frontera Entre México y Estados Unidos: Una Perspectiva Histórica

Lawrence Douglas Taylor Hansen[1]

Abstract.—La ponencia trata de los cambios en el suministro, el uso y el control del agua por parte de los colonizadores en la región frontera entre México y Estados Unidos, desde los inicios de la colonización europea hasta las décadas más recientes. En particular, se dirige la atención a las semejanzas y diferencias entre las antiguas nociones y prácticas referentes al uso del agua como recurso renovable y las de los políticos y usuarios de hoy en día. Asimismo, se discuten las repercusiones del establecimiento de la frontera internacional en 1848 con respecto a los recursos acuáticos compartidos por los dos países. El estudio concluye con un análisis de la época desde el final de la Segunda Guerra Mundial hasta el presente, durante la cual el gran aumento de las tierras bajo cultivo, junto con un correspondiente incremento en la población y el desarrollo de los centros urbanos, crearon nuevas demandas con respecto a las limitadas reservas de aguas terrestres y subterráneas de la zona.

INTRODUCCIÓN

Desde el comienzo del proceso de la colonización del territorio que hoy en día constituye la región fronteriza entre Estados Unidos y México, el abastecimiento y el uso del agua han sido un factor de importancia decisiva. El agua también representa uno de los elementos claves que podría ser determinante para el desarrollo y crecimiento futuro de la región.

Una comprensión de las actitudes de los antiguos colonizadores de la zona con respecto a este recurso, así como de las diferentes maneras en las cuales intentaron utilizarlo para sus propios usos, sirve para comprender muchos de los aspectos y problemas contemporáneos con respecto al agua en esta región.

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La adaptación de los colonizadores europeos a los métodos hidraúlicos indígenas:

Los reducidos niveles de precipitación en gran parte de la zona motivaron a varios de los grupos indígenas que habitaron la región antes de la llegada de los europeos a desarrollar técnicas de riego con objeto de proporcionar sus cultivos —principalmente el maíz, el frijol y la calabaza—con agua durante los momentos críticos en sus ciclos de crecimiento.

Durante muchos años, se creyó que la agricultura indígena de la zona en cuestión había sido circunscrita a regiones tales como la meseta del Río Colorado (que correspondía aproximadamente a la denominada área de hoy en día de las "Cuatro Esquinas", es decir, donde se unen los estados de Arizona, Nuevo México, Colorado y Utah) y Casas Grandes en Chihuahua. Sin embargo, investigaciones arqueológicas llevadas a cabo a partir de la década de 1960 han mostrado que algunos de los grupos de indios que habitaban otras áreas, por ejemplo, los grandes valles pluviales de Sonora y del sur de Arizona, así como ciertas regiones de California, tales como el valle Owens, no vivían exclusivamente de la caza y la recolección sino que también practicaban la agricultura.[2] Al igual que los pueblos indígenas anteriormente mencionados, construyeron canales, diques y, hasta cierto grado, cisternas o estanques artificialmente construidos, para propósitos de riego.[3]

La cantidad y la disponibilidad del agua también eran determinantes cruciales en el establecimiento de comunidades y el desarrollo de economías locales por los españoles a partir de las últimas décadas del siglo XVI. Debido a la necesidad de preparar los campos con el objeto de producir las cosechas lo más pronto posible, la construcción de un sistema hidraúlico tuvo prioridad sobre la edificación de iglesias, edificios públicos y casas.[4] En sus esfuerzos para obtener agua con el propósito de cultivar alimentos destinados al personal de la misión y a los indios bajo su custodia, los frailes franciscanos, dominicanos y jesuítas, con el apoyo de los mismos indios como fuerza laboral, ampliaron y mejoraron las técnicas indígenas existentes para explotar las reservas limitadas del agua y optimizar su uso.[5] De hecho, los sistemas extensos de acueductos, cisternas, presas y acequías construidos bajo la dirección de los misioneros resultaron en la producción de una diversidad de granos, frutos y verduras, y en cantidades superiores a las que habían podido cosechar los pueblos indígenas de la zona.[6]

Los sistemas hidraúlicos de las misiones de la Alta California, en particular, constituyeron los más desarrollados de las colonias españolas en el Nuevo Mundo. No sólo existía un número mayor de fuentes de agua en la región que podían ser explotadas, sino que las misiones de la zona fueron

construidas durante una época posterior a la de la mayoría de las instituciones de este tipo en Hispanoamérica y, en consecuencia, los frailes pudieron aprovecharse de los avances en la tecnología hidraúlica que había ocurrido en el ínterin. Además, para el período en cuestión había más artesanos y técnicos disponibles para auxiliar a los padres en la construcción de las misiones.

Los dos sistemas hidraúlicos más extensos fueron construidos en las misiones de San Diego de Alcalá y Santa Bárbara. En el caso del primero, los franciscanos construyeron sobre el río San Diego una presa de mampostería de 76 metros de largo, cinco metros de altura y tres metros de grueso, que producía un flujo de agua constante que, a su vez, era conducida a los campos de cultivos por medio de una serie de zanjas. La presa que se construyó en las barrancas situadas al este de Santa Bárbara medía 30 metros de largo y cinco metros de altura, y suministraba agua en cantidades suficientes para satisfacer las necesidades de riego de los jardines, del viñedo y del molino harinero del complejo misional.[7]

Los misioneros españoles no sólo expandieron y mejoraron los sistemas hidraúlicos indígenas de la región, sino que también introdujeron la noción del "control del agua", es decir, el manejo del agua para propósitos que incluían, o eran exclusivos de, su uso para la agricultura. La expansión y el mejoramiento de los sistemas hidraúlicos indígenas, junto con la introducción de las técnicas de los españoles referentes al manejo y al control del agua, comenzaron a producir una transformación en el medio ambiente de los territorios de la región, que sería acelerada grandemente en los siglos XIX y XX.

Hasta cierto punto, esta expansión en la utilización del agua estaba ligada a las diferentes maneras en las cuales los pueblos indígenas y europeos interpretaban la relación entre el agua y el hombre. Mientras que los indios veían el agua, junto con el mundo natural en general, como una unidad de la cual ellos mismos constituían una parte [8], los españoles, en cambio, lo concebían como algo que Dios había dado al hombre para ser explotado con el propósito de beneficiar a la humanidad. Según el pensamiento de los colonizadores europeos, era preciso manipular y controlar la naturaleza con objeto de sacar el máximo provecho de ella en términos de sus productos y su utilidad.[9]

No obstante, al contrario de la noción popular de que el desperdicio de los recursos naturales y la destrucción del ambiente natural en Norteamérica y en otras regiones se inició con la colonización europea, en el caso del agua, hay que señalar que la conservación constituía la función más importante del sistema hidraúlico hispánico. [10] Aunque los sistemas de riego indígenas cumplieron con los propósitos para los cuales fueron diseñados, no constituyeron necesariamente maneras muy eficientes o económicas de utilizar el agua. Los sistemas hidraúlicos introducidos por

los españoles, en cambio, fueron diseñados con el objeto de extraer la máxima cantidad de agua de las reservas limitadas de la región, así como de generar tanta energía como fuera posible de cierta cantidad de agua con la tecnología a su disposición. Los españoles ya tenían considerable experiencia con los problemas relacionados con la extracción y el uso del agua en regiones áridas o semiáridas, dado que el agua no abundaba en su país de origen. Por añadidura, pudieron aprovecharse de la tecnología hidraúlica introducida por los conquistadores árabes a España durante la Edad Media y que, para finales de dicha época, se había mejorado considerablemente en términos de su sofisticación.

Los colonizadores españoles, por ejemplo, hicieron un uso mucho más extendido que los indios de las cisternas o depósitos de agua.[11] La construcción de depósitos de agua cerca de los campos de cultivo significó que estos recipientes pudieran ser llenados durante la noche y su contenido vaciado sobre los campos la mañana siguiente. De esta manera, se evitaba que el agua fluyera en los canales de riego durante el día, cuando ocurrieron las pérdidas más elevadas debido a la evaporación. [12] Los españoles también introdujeron varios aparatos para elevar el agua de un nivel a otro. Uno de tales aparatos utilizados fue la noria, que consistía en una serie de botes ligados en forma de una cadena continua, que se empleaba comúnmente para subir el agua de los pozos y depositarlo en cisternas cercanas. Los españoles también construyeron molinos harineros, que fueron impulsados por ruedas de tipo turbina o de impulsión por abajo.[13] La tecnología de esta naturaleza fue frecuentemente empleada para suministrar el agua para usos domésticos, en vista de que a menudo éste tenía que ser conducido arriba, debajo o alrededor de los edificios, jardines o paredes, para que pudiera ser utilizada para suplir las necesidades de una variedad de funciones u operaciones distintas de la misión, tales como la lavandería, la alferería u otro centro de artesanía, las tinas de curtir, las fuentes, los jarrones de agua potable, etcétera.[14]

De esta manera, el agua era utilizada varias veces antes de ser canalizada a los campos, donde se dejaba que penetrara el suelo o se evaporara. La principal desventaja de tal sistema consistió, como hoy en día, del riesgo de la contaminación, a pesar de que ordenanzas fueron emitidas por parte del gobierno virreinal y de las autoridades locales para evitar este peligro, particularmente con respecto al agua destinada para el consumo humano.[15]

Desde el punto de visto legal, las autoridades españolas consideraban el agua como un recurso que debía ser compartido entre los residentes de un pueblo, los diferentes grupos de comunidades que había—por ejemplo, las misiones, los presidios, los pueblos poblados por blancos o indios, etcétera— , o incluso entre comunidades y terratenientes individuales, tales como los rancheros, aun cuando en las disputas se consideraban de

mayor peso los derechos de la comunidad.[16] Con respecto a los pueblos indígenas, en cambio, sus derechos con respecto a la posesión de tierras o al uso del agua a menudo no fueron respetados en la práctica, con la excepción de aquellos grupos que tenían una larga tradición de ser agricultores, como en el caso de los indios pueblo de Nuevo México.[17]

La fiebre de oro de 1848 y su impacto sobre la región

El principio español del "bien procomunal" con respecto al manejo de los recursos hidraúlicos de sus colonias contrastó con el que se desarrolló en los territorios norteños de México que fueron cedidos a Estados Unidos en 1848 de acuerdo con el Tratado de Guadalupe Hidalgo. Los numerosos buscadores de oro que llegaron a California subsecuente al descubrimiento de oro en aquel año requerían un suministro continuo de agua para el manejo de las gamellas, acueductos y otros aparatos utilizados con objeto de separar el oro de capas de grava y arenas en las cuales se encontraba. Además, la poca precipitación pluvial, así como el pequeño número de ríos existentes en comparación con otras regiones de Estados Unidos, dictó la necesidad de desviar el agua a través de un sistema de canalización desde sus fuentes hasta los lugares en donde se situaban las minas y lavaderos de oro. Varias empresas se formaron con el propósito de llevar a cabo la tarea costosa de construir acueductos de madera o zanjas para proporcionar a los mineros el agua necesaria para el lavado del mineral. Tales demandas de agua se incrementaron considerablemente con la introducción de la minería hidraúlica a partir de 1853.[18]

Al ver la necesidad de imponer algún tipo de control sobre la construcción y operación de los sistemas de desviación del agua en los distritos auríferos, los mineros recurrieron a la antigua tradición entre los colonos pioneros del este de Estados Unidos de respetar los derechos de colonización de las primeras personas de asentarse en una área o región en particular. La mayoría de los inmigrantes, quienes eran demócratas provenientes del sur de Estados Unidos o miembros de minorías étnicas, tales como los irlandeses, eran representantes de una tradición que hacía hincapié en los derechos y la iniciativa individuales, así como una preferencia por la toma de decisiones al nivel local con un mínimo de interferencia por parte del gobierno federal.[19] Esta tradición se había convertido en regla general tanto en California como en la capital de la nación, con la excepción de aquellas ocasiones poco frecuentes cuando los republicanos gobernaban a nivel estatal o federal.[20] La aplicación por parte de los mineros de tales nociones y tradiciones a las denuncias mineras de California, y por extensión, al agua que se requería para trabajarlas, eventualmente se cristalizó en la forma de la doctrina conocida como *arid*

region (región árida) o de *prior appropiation* (apropiación previa).[21] La doctrina recibió reconocimiento oficial con la ratificación por el congreso californiano en 1851 de "las costumbres, usos o regulaciones establecidas y vigentes en el banco de arena, o minas", así como la ley federal promulgada en 1866 con respecto a las tierras baldías en general.[22]

A diferencia del principio hispánico del "bien procomunal", la doctrina de *prior apropiation* estaba basada en la iniciativa personal en lugar de un decreto promulgado por un gobierno central. Además, estableció que la prioridad de uso, en vez de consideraciones de equidad o justicia, sería utilizada como el factor más significativo para determinar cuales personas tendrían el derecho de utilizar el agua y la cantidad que debería ser repartida. Con el tiempo, la doctrina de *prior appropiation* llegó a ser vista como un derecho propietario. Un individuo, por ejemplo, podría acumular derechos con respecto al uso del agua en diferentes puntos a lo largo de un río, o una serie de ríos, de la misma manera en que podría acumular otras formas de propiedad. Tales "propiedades" podrían, en consecuencia, ser vendidas de manera individual o colectivamente, sin tener que vender el terreno o terrenos de los cuales era dueño. La doctrina pronto se extendió a otras regiones de Estados Unidos y no se restringió al uso del agua para la minería, sino que también llegó a ser aplicada a los sectores agrícola y manufacturero.[23]

Otra doctrina respecto al uso y al control del agua que adquirió reconocimiento legal durante este período fue el del derecho ribereño, que, a diferencia de la de *prior appropiation*, hacía hincapié en la posesión legal, es decir, de ser dueño de una parcela de terreno a través de la cual pasaba un arroyo o río. El término *riparian rights* (derecho ribereño), que provino de la palabra latina ripa, o el margen de un río, significaba que el dueño de una parcela de terreno contiguo a un arroyo o río tenía el derecho de utilizar el agua de esta fuente, con la excepción de la que pudiera ser requerida río arriba para satisfacer ciertas necesidades domésticas, incluyendo la provisión de agua para el ganado. Aquellos dueños de terrenos que no estaban contiguos al arroyo o río en cuestión no disfrutaban de tal derecho. La doctrina no permitía, empero, la retención del agua para los propósitos de riego. Debido a que, en teoría, todos los que disfrutaban de este derecho podían utilizar el agua mientras que no perjudicaran los derechos de otros usuarios, ninguno de éstos, en consecuencia, podía acaparar para su propio uso, por medio de canales, presas y otros métodos, todo el agua que quería. La doctrina de *riparian rights* fue reconocida implícitamente por el gobierno de California en 1850, cuando la legislatura del estado adoptó el derecho consuetudinario inglés como el sistema de derecho básico para las cortes estatales, que posteriormente fue modificado por el derecho estatutario y el de precedentes.[24]

Estas dos doctrinas, las de *prior appropiation* y *riparian rights*, junto con la escasez en general del agua en la región fronteriza, eventualmente condujeron al acaparamiento del control de los recursos hidraúlicos en determinadas áreas por parte de individuos y empresas.[25] A pesar de que las cortes estatales y federales pusieron fin a las actividades de los mineros hidraúlicos cuando sus intereses llegaron a afectar a un gran número de californianos a finales del siglo XIX, en los años subsecuentes el descontento provocado por los monopolios sobre los recursos hidraúlicos fue neutralizado por el auge económico de aquella época. La mayoría de los nuevos inmigrantes al estado se mudaron a los grandes centros urbanos de San Francisco, Los Angeles y San Diego en busca de empleo y viviendas en estas regiones, donde se abrían casi diariamente nuevas oportunidades para trabajar en los sectores del transporte y servicios en general, la industria cinematográfica, la del petróleo, la defensa nacional, etcétera. Aunque el gobierno aprobó algunas reformas limitadas referentes a proyectos para el desarrollo de los recursos hidraúlicos del estado, la mayoría de los ciudadanos de California no sintieron ninguna necesidad apremiante para cuestionar el sistema del manejo del agua en la región. A consecuencia de tal indiferencia, los californianos dieron su apoyo para la construcción de una serie de proyectos hidraúlicos de gran magnitud: el acueducto del Río Owens y su extensión hasta la cuenca de drenaje Mono; la construcción de una presa en la barranca de Hetch Hetchy así como un acueducto de allí hasta la región de la Bahía de San Francisco; el acueducto del Río Colorado, diseñado para suministrar agua de esta fuente a las ciudades de San Diego y Los Angeles; el proyecto del valle central, que consistió en una serie de canales con objeto de proporcionar agua en cantidades suficientes a las regiones del interior para ser utilizada para distintos propósitos; y, por último, el State Water Project (Proyecto de Agua Estatal), un proyecto semejante cuya meta consistía en proporcionar agua principalmente a la región sur del estado, con cantidades menores para las aréas de la costa central y del norte.[26]

La creciente privatización y monopolización del control del agua en California y otros estados a lo largo de la frontera con México también produjeron, con el tiempo, daños ambientales muy extensos. Los inmigrantes quienes colonizaron a estas regiones eran herederos de una tradición de explotación que se remontaba al inicio de la expansión europea. No veían ninguna necesidad de conservar el agua u otros recursos, tales como la madera, los minerales, el suelo, etcétera. Para ellos, las reservas de estos materiales eran ilimitadas y siempre habrían reservas más grandes en otras regiones todavía no exploradas o colonizadas.[27] El proceso de la destrucción del medio ambiente de la región, que recibió su primer gran estímulo durante la época de la minería hidraúlica, no se

detuvo hasta mediados del siglo actual, cuando el público comenzó a ejercer presión en las legislaturas estatales y a nivel nacional con objeto de frustrar la realización de otros proyectos hidraúlicos masivos y, en cambio, aprobar una serie de leyes dirigidas hacia la conservación de los recursos naturales de la zona y la protección de su frágil ecosistema.[28]

Otra de las consecuencias adversas del desarrollo de las doctrinas de *prior appropiation* y *riparian rights* consistió en su contribución a la disputa que ocurrió entre los gobiernos de México y Estados Unidos en torno a sus respectivos derechos referentes al uso de los recursos hidraúlicos, incluyendo los depósitos de agua subterránea, a lo largo de la frontera entre los dos países. Durante las primeras seis décadas después de la firma del tratado de 1848, el gobierno estadunidense prosiguió sus reclamaciones referentes al agua en la región fronteriza basadas en estas dos nociones. Al negociar el tratado de 1906, que adjudicó entre los dos países el agua del Alto Río Bravo, el Procurador General Judson Harmon sostuvo que Estados Unidos poseía derechos de soberanía sobre sus ríos internacionales y que no tenía ninguna obligación frente a los usuarios que habitaban las regiones ubicadas río abajo. Durante las décadas posteriores al tratado, sin embargo, la llamada "Doctrina Harmon" cayó en desuso y el gobierno estadunidense gradualmente adoptó la noción de la soberanía territorial limitada en torno a los recursos hidraúlicos compartidos por diferentes países. En el transcurso de las negociaciones subsecuentes referentes a la apropiación entre los dos países de agua en la región fronteriza, el gobierno estadunidense reconoció que no poseía ningún derecho unilateral referente al uso del agua de esta zona, sobre todo uno que no permitía tomar en cuenta sus posibles consecuencias para México. En 1944, como resultado de estas discusiones, se firmó un tratado que dividió las aguas del Río Colorado y del Bajo Río Bravo entre los dos países, y que incluía disposiciones con respecto a la construcción de plantas hidroeléctricas, así como obras para el almacenaje de agua y protección contra las inundaciones.

El gobierno de México, a raíz de que su país se encuentra en la posición de estar "río abajo" con respecto a los Estados Unidos [29], ha utilizado en estas negociaciones bilaterales el principio de derecho internacional sobre agua que mantiene que las cuencas fluviales constituyen unidades indivisibles y que, como consecuencia, los recursos hidraúlicos deberían ser distribuidos de manera equitativa entre los dos países involucrados. Al estar sujeto a presiones nacionalistas que han surgido a consecuencia de la larga historia de relaciones difíciles entre las dos naciones, el gobierno mexicano también ha ligado a las discusiones la necesidad de proteger el patrimonio y los valores nacionales.[30]

Los efectos del auge de la época de posguerra

Después de la Segunda Guerra Mundial, el crecimiento de la industria agrícola, sobre todo la basada en el riego, junto con el aumento de la población y la expansión de las áreas urbanas, crearon nuevas demandas con respecto al abastecimiento de agua en la región fronteriza.

Este problema se ha ido agudizando en las últimas dos décadas a raíz de una migración continua y rápida de población e industria desde las regiones más septentrionales de Estados Unidos al llamado "Sun Belt" del oeste y suroeste, sobre todo en los estados de California, Arizona, Nuevo México, Colorado y Nevada. La población de Arizona, por ejemplo, se incrementó en más del 50 por ciento durante la década de 1970, mientras que la del estado vecino de Nevada se aumentó en un 66 por ciento. La población de California, por su parte, se ha incrementado en un 25 por ciento durante el mismo período. Con la excepción de aquellos años cuando hubo recesión, la población de California se ha incrementado anualmente por más de 800,000 personas por año.[31]

Este incremento poblacional y de las actividades económicas en la región ha impuesto fuertes demandas sobre las fuentes existentes de agua. Los integrantes de las nuevas olas migratorias a la región están poco acostumbrados a los principios y prácticas relacionados con la conservación del agua. El Río Colorado y el Río Bravo, que tradicionalmente suministraban agua a las regiones del sur del estado de California, al norte de Baja California y a las áreas fronterizas entre Texas y el noreste de México, han alcanzado su límite máximo en este sentido.[32] Las demandas de agua para satisfacer los requerimientos de una población que se expande continuamente son particularmente evidentes en California en donde, para el año 2010, se calcula que habrá una carestía de agua anualmente de entre 1.4 y 2.5 mil millones de métros cúbicos.[33]

Durante las últimas dos décadas, México también ha experimentado un auge económico, una gran parte del cual ha sido creado en sus regiones limítrofes con los Estados Unidos. Este auge ha incrementado las exigencias con respecto a los recursos hidraúlicos de la región fronteriza.

A raíz de estas nuevas presiones, los depósitos de agua subterránea se han convertido en el elemento principal con referencia a la distribución de agua en la zona.

Sin embargo, la falta de suficiente agua subterránea para satisfacer las demandas de los consumidores se ha convertido en un problema en las áreas urbanas de crecimiento rápido, tales como el corredor entre Tijuana y San Diego o las ciudades de Phoenix y Prescott, Arizona. Otros grandes centros metropolitanos de la región, tales como Albuquerque, ya se encuentran a punto de experimentar graves crisis a raíz de la extracción

masiva de agua que existe debajo de estas ciudades por medio del gran número de pozos que se han cavado.[34]

Muchas regiones a lo largo del lado mexicano de la frontera también se han vuelto cada vez más dependientes de los recursos de agua subterránea. Aun cuando la mayor parte del agua utilizada ha sido destinada para propósitos agrícolas, existen carencias con respecto al agua en las comunidades urbanas de la zona. Tijuana, Mexicali, Nuevo Laredo y Reynosa padecen de carencias serias para suministrar el agua de acuerdo con las necesidades de sus crecientes poblaciones respectivas.[35] La dependencia es particularmente fuerte a lo largo de la franja fronteriza bajacaliforniana, donde el agua subterránea constituye el 50 por ciento de toda el agua utilizada.[36] Desde principios de la década de 1970, la ciudad de Tijuana, por ejemplo, ha dependido fuertemente de este líquido del subsuelo para suplir sus reservas de agua terrestre.[37]

El TLCAN, que entró en rigor a principios de enero de 1994, ha acentuado todavía más la demanda para el agua en la región fronteriza. El crecimiento de la industria maquiladora, que ha sido estimulada por el tratado, depende de las fuentes de agua disponibles. La expansión del comercio bilateral en la región fronteriza, al provocar el traslado a la zona de gente e industrias, no sólo ha resultado en un incremento en el tamaño de las ciudades de la zona, sino que también ha aumentado los problemas económicos y sociales ya existentes. El principal sector consumidor del agua no es, como se piensa comunmente, el de la industria, sino el de la población que acumula en la región a raíz del crecimiento de las actividades económicas. El aumento continuo de industrias y población en la región ha contribuido a la contaminación en general del sistema del abastecimiento del agua, así como a la reducción continua del nivel de agua en el subsuelo.[38]

El calentamiento global, así como otros efectos relacionados con el cambio de clima, limitarán todavía más los recursos hidraúlicos de la región. Las temperaturas más elevadas acelerarán el proceso de evapotranspiración, que, a su vez, provocará un incremento en la demanda de agua para el riego, los céspedes y jardines urbanos, así como otras actividades que requieren el uso del agua. Las escaseces de agua son cada vez más comunes en el suroeste así como en otras regiones de Estados Unidos, en donde los niveles de lluvia ya no alcanzan sus niveles anteriores.[39]

No existen muchas alterativas para aumentar las fuentes de abastecimiento del agua en la región, ya sea por medio de la conservación, las transferencias de agua o la desalación. El uso del agua con base en la conservación únicamente funciona cuando existe suficiente voluntad política, y ésta existe si otras formas de sumistro están cortadas o

restringidas. La desalación es un proceso caro y también tiene cierto costo ambiental, en las regiones litorales.[40]

La única otra opción son las transferencias masivas de agua desde otras regiones de la América del Norte, tales como los estados del noroeste de Estados Unidos, Canadá o incluso Alaska. Los costos de tales proyectos, empero, serían muy elevados y provocarían grandes daños al ambiente.[41]

CONCLUSIONES

El problema en torno a la obtención de agua en cantidades suficientes para el cumplimiento de sus múltiples usos y necesidades, siempre ha presentado un desafío para los habitantes de la región fronteriza entre México y Estados Unidos. Aunque las actitudes de los varios grupos de colonizadores referentes al agua, junto con los métodos y técnicas empleados para su explotación, han variado á través del tiempo, este recurso vital permanece como uno de los factores más relevantes, si no el más significativo, en términos del desarrollo de esta región en la actualidad.

Por lo tanto, para que continúe el crecimiento y desarrollo de las comunidades de la zona, es necesario que los gobiernos locales y nacionales de los dos países colindantes elaboren planes conjuntamente que traten del agua como un recurso común, uno que no debería ser desperdiciado, sino conservado para futuras generaciones.

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RESUMEN BIOGRÁFICO

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[15] Hundley, *The Great Thirst*, pp. 43-44.

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[28] Hundley, *The Great Thirst*, pp. 299-349.

[29] No en todos los casos se encuentra México en una situación de estar "río abajo" frente a Estados Unidos. Por ejemplo, con respecto a los ríos San Pedro y Santa Cruz, en la región fronteriza entre Arizona y Sonora, los Estados Unidos se encuentra en esta condición.

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[34] Datos proporcionados al autor por algunos de los ciudadanos de Albuquerque, Nuevo México, durante el Encuentro Anual de la Association of Borderlands Scholars, llevado a cabo en aquella ciudad del 20 al 23 de abril de 1994. Véase también Micha Gisser, "The Appropiation Doctrine: A Tool for Continental Water Marketing Along the U.S.-Mexico Border," en Terry L. Anderson, ed., *Continental Water Marketing* (Vancouver, B.C.: The Fraser Institute, 1994), p. 104.

[35] Gisser, "The Appropiation Doctrine"; y Roberto Salinas León, "Water and North American Free Trade: Problems and Prospects for a Viable Water Market in Mexico," ambos en Anderson, *Continental Water Marketing*, pp. 102-105, 124, respectivamente.

[36] México, Comisión del Plan Nacional Hidraúlico, *Inventario regional de aguas subterráneas* (México: Comisión del Plan Nacional Hidraúlico, 1979), p. 29.

[37] Carlos Cabrera Fernández, "El desarrollo económico de Tijuana en relación al suministro de agua y a la contaminación atmosférica, marina, y acuática," en *Natural Resources Journal*, vol. 18, núm. 1 (enero de 1978), pp. 21-23. Tijuana también depende en gran parte de agua suministrada desde el Río Colorado por medio de un acueducto. La Comisión Nacional del Agua estima que sus fuentes actuales durarán hasta el año 2002, cuando será preciso construir otro acueducto entre esta ciudad y el Río Colorado. *El Sol de Tijuana*, 23 de marzo de 1998, pp. A-1, A-6.

[38] Arthur R. Gómez, *Quest for the Golden Circle: The Four Corners and the Metropolitan West, 1945-1970* (Albuuerque, N.M.: University of New Mexico Press, 1994), pp. 17-30.

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FISHERIES

Influence of Low Flows on Abundance of Fish in the Upper San Pedro River, Arizona

Jerome A. Stefferud and Sally E. Stefferud[1]

Abstract.—The relationship between stream discharge and abundance of fish in the upper San Pedro River, Arizona, was examined. Backpack electrofishing equipment was used to capture fish at four sites in a 50-kilometer reach between the International Boundary and Fairbank. Surveys were done annually in the spring, 1990 to 1997. Catch per unit of effort (CPUE: number of individuals per 15 minutes shocking) varied between years (mean = 89.1, range = 32.7 to 167.8). Native desert sucker, *Catostomus clarki*, and longfin dace, *Agosia chrysogaster*, comprised 57 to 85% of the annual catch. In addition to the two native species, black bullhead, *Ameiurus melas*, and fathead minnow, *Pimephales promelas*, were captured in all eight efforts. Seven surveys included western mosquitofish, *Gambusia affinis*, green sunfish, *Lepomis cyanellus*, were in the last six efforts, largemouth bass, *Micropterus salmoides*, were in two, and common carp, *Cyprinus carpio*, was taken once. Fish abundance appeared related to extreme low flow during the previous year, but not peak or mean flows, or total runoff. Lowest daily mean discharges (mean = 25 l/sec, range = 1 to 48) explained 82% of the variation in catch for all species and all sites combined, and 78% and 70% of the variation for native and nonnative species, respectively.

Resumen.—La relación entre descarga de arroyo y la abundancia de peces localizados en la parte arriba del Río San Pedro, Arizona se examino. Equipo electrico para pescado en mochila se uso para capturar peces en cuatro sitios entre 50 kilometros de la Frontera Internacional y Fairbank. Cada año se completaron estudios entre 1990 a 1997 en la primavera. Captura por esfuerzo de unidad (CPEU: cantidad de individuales por cada 15 minutos de choques electricos) variado entre años (medio = 89.1, surtido = 32.7 a 167.8). Peces nativo matalote del desierto, *Catostomus clarki*, y charalito aleta larga, *Agosia chrysogaster*, constar de 57% asta 85% de la captura annual. Ademas de los dos especies nativos, el barge, *Ameiurus melas*, y carpita cabezona, *Pimephales promelas*, se capturaron en todo los ocho esfuerzos. En siete estudios incluido

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el guajacon mosquito, *Gambusia affinis*, pez sol, *Lepomis cyanellus*) fueron en los ultimos seis esfuerzos. La lobina negra, *Micropterus salmoides*, fueron en dos, y la carpa comun, *Cyprinus carpio*, se capturaron en un es fuerzo. Se parese que la abundancia de los peces sera relacionado de las corrientes extremas de agua baja durante el año pasado, pero de medio o al tiempo mas alta de la corriente, o de escurrimento total. Corrientes extremas de agua baja (medio = 25 l/seg, surtido = 1 a 48) se explico al 73% de variación en captura de todo los especies y todo los sitios combinados, y 78% y 70% por los especies nativos o no nativos, respectivo.

INTRODUCTION

Patterns of stream discharge influence population dynamics of fishes in streams of arid southwestern North America, and the retention of a natural hydrograph is vital in sustaining native fishes (Rinne and Minckley, 1991). Extreme floods have been shown to differentially affect native and nonnative fishes (Meffe and Minckley, 1987; Minckley and Meffe, 1987), and during periods of extreme drying of desert watercourses mass mortalities of fishes occur (Minckley and Barber, 1971; Carpenter and Maughan, 1993). In general, high flood flows are beneficial to native fishes (Stefferud and Rinne, 1997; Rinne and Stefferud, 1997), but low flows, particularly as they approach zero, may have serious consequences for sustainability of the native fishery (Jackson et al., 1987; Neary and Rinne, 1998). Most large streams in this region have been dammed or diverted and their natural hydrograph substantially altered, but a few streams persist where surface flows remain continuous and reflect primarily rainfall runoff and ground-water discharge (Rinne and Minckley, 1991).

The upper ca. 100-km of the San Pedro River in south-central Arizona and north-central Sonora (figure 1) is essentially unaffected by diversions and dams. Watershed alterations and increased ground water pumping have reduced mean annual flows during the past century, however, the river remains perennial between Hereford and Fairbank (Jackson et al., 1987). Along this reach, the San Pedro Riparian National Conservation Area (NCA) was established in the mid-1980's for the purposes of protection and management of riparian ecosystems, wildlife, and prehistoric and historic resources (Yuncevich, 1993). Although once accommodating 13 native species of fish, currently only two common and widespread native fishes persist in the mainstem: longfin dace, *Agosia chrysogaster,* and desert

sucker, *Catostomus clarki*; about a dozen nonnative fishes are established (Jackson et al., 1987).

In 1989, we initiated a study to observe changes in fish species abundance and occurrence through time and space, and fish densities relative to aquatic microhabitat types in the perennial reach of the upper San Pedro River. The primary objective of our study was to provide the management agency long-term monitoring information on fisheries to achieve the goals of the NCA's establishment. During our study period record low flows occurred, which appeared to have meaningful consequences on abundance of fish in the river. Here we provide results from eight years of sampling.

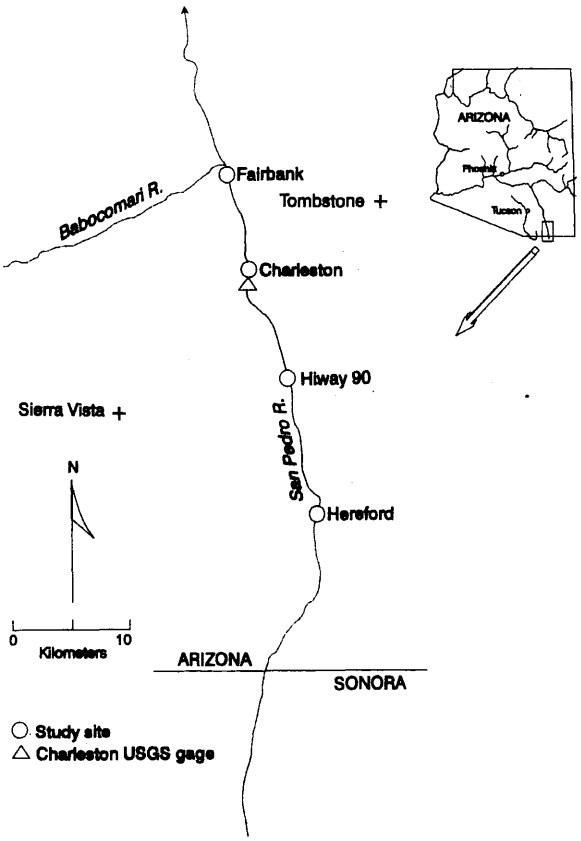


Figure 1. The upper San Pedro River in Arizona and Sonora. Assemblages of fish were sampled at the study sites indicated by closed circles.

STUDY AREA

The San Pedro River arises near Cananea, Sonora, and flows northward about 40 km before entering Arizona. Within Arizona, it continues about 200 km more to its confluence with the Gila River near Winkelman (Minckley, 1985). Our study area encompassed a 40-km reach in the NCA between Hereford and Fairbank, where we established four sample sites (north to south: Fairbank, Charleston, Hiway 90, and Hereford). General location of the study sites was chosen based primarily on reasonable access and linear disposition along the study reach. Specific locations were

selected during a pre-project survey and were based on channel morphology and types of habitat present. We hiked much of the 40-km reach to determine how representative our sites were of the overall stream morphology. Since we had selected sample sites for habitat heterogeneity in order to increase probability of sampling the entire fish assemblage, our sites were more diverse in terms of habitat type sequencing and occurrence than what is characteristic of the stream.

Within the study reach, the river flows in a broad channel lined with cottonwood, willow, salt cedar, and mesquite 2 to 10 m below the former floodplain. Presently, active channel widths range from about 60 m in straight, confined reaches to nearly 500 m in curved reaches with large point bars. Sinuosity ranges between 1.0 and 1.8, becoming straighter in downstream reaches. Gradient is decidedly convex, ranging from roughly 0.19 percent in the southern reaches to roughly 0.38 percent at the northern end of the study area (Jackson et al., 1987). Drainage area at the U. S. Geological Survey (USGS) stream gage at Charleston is 3,196 km^2 (USGS 1997).

The annual precipitation cycle is one of a distinct wet season from July through September followed by occasional rainfall from November to late March. Early April through June is the driest time of the year when drought or near-drought conditions prevail (Hereford, 1992). Discharge has averaged 1.6 m^3/sec over 85 years, and instantaneous flows between 0.0014 and 2,700 m^3/sec have been recorded (USGS 1997). During this century, mean annual discharge at Charleston has steadily decreased (Jackson et al., 1987).

METHODS

We sampled about 250 m of stream at each of four sites, but exact length was dependent on habitat complexity. In general, a riffle-pool sequence was selected, and then the study site expanded to include other significant habitat types present. Habitat types were defined by combinations of gradient, subjective descriptions of channel shape and turbulence, and relative position in the stream channel (Bisson et al., 1982; Aadland, 1993). Sampling was done annually during late April to early May, a time when young-of-year specimens were unlikely to be captured by our methods, thus our catch reflected individuals surviving from the previous year.

Habitat types were sampled for fish in sequence, progressing from downstream to upstream. A backpack, DC, electrofishing unit was used to stun fish for capture with hand-held dipnets. Total seconds of elapsed shocking time were recorded by habitat type. All fish captured within a habitat type were identified to species and enumerated before being

returned to the stream. Measurements of length, width, depth, and ocular evaluations of size of substrate were made at each habitat type. To ensure similarity of effort between years and to document gross changes in channel morphology, each year a map of the entire site was sketched and location of habitat types noted.

Catch per unit effort (CPUE) was determined as number of individuals captured per 15 minutes shocking time. Morisita's index was used to compare similarity of fish assemblages between sites and years (Morisita, 1959). Discharge records were obtained from the continuous recording gage at Charleston (USGS records). Least-squares regression lines were fit to scatter plots to determine the relationships between CPUE and annual mean discharge, instantaneous peak discharge, highest daily mean discharge, and lowest daily mean discharge during the calendar year previous to sampling.

RESULTS

During the study period, daily mean discharges ranged between 0.0014 and 217.8 m^3/sec (table 1), with a median of 0.27 m^3/sec. Annual mean discharges were all below the long-term mean of 1.6 m^3/sec; daily mean discharges of 0.00623 m^3/sec in 1990, and 0.00142 m^3/sec in 1994, were record lows. Daily mean discharges during our annual site visits were between 0.15 (1991) and 0.34 (1993) m^3/sec (USGS records). Peak discharges recorded during our study period had a recurrence interval of about 5 years or less, and the two highest occurred in winter and spring.

Fairbank and Hereford sites were similar in habitats, both being wide and shallow with shifting sand substrates, and with times when flow is at or near zero. Hereford included a few pools, whereas Fairbank was virtually absent of pools. Charleston and Highway 90 sites were more diverse in habitat, with deep pools, swift riffles, and runs and glides. Both were strongly influenced by large ephemeral washes entering immediately upstream of the sample area, which during high flows scoured and deposited large quantities of sand and gravel into the upper portion of each site.

Mean catch at all sites combined was 397 fish per year (range 161 to 794) with longfin dace and desert sucker decreasing from 87% of the total catch the second year of the study to 57% in 1997 (figure 2); CPUE was between 32.7 and 167.8 ($x = 89.1$). The ratio of native to nonnative fishes did not appear influenced by flooding that occurred in 1993 and 1994. In addition to the two native species, black bullhead, *Ameiurus melas*, and fathead minnow, *Pimephales promelas*, were captured in all efforts. Seven surveys included western mosquitofish, *Gambusia affinis*, green sunfish, *Lepomis cyanellus*, were in the last six efforts, largemouth bass, *Micropterus*

salmoides, and common carp, *Cyprinus carpio*, were taken once each. No pattern in longitudinal distribution of any species was apparent, although number of species was higher at Charleston and Highway 90 sites. Overall, longfin dace was predominant at Hereford and Fairbank, and desert sucker at Highway 90 (table 2). No nonnative species comprised greater than 10% of the total 8-yr catch at any site, except fathead minnow at Highway 90, and western mosquitofish at Charleston. The appearance of green sunfish beginning in 1993 is likely the result of that year's flood overtopping gravel ponds near the Highway 90 site and allowing the resident green sunfish there to escape into the river.

Table 1. Discharge data from Charleston USGS gage used in this study.

Calendar year	Lowest daily mean (l/sec)	Highest daily mean (m^3/sec)	Peak discharge (m^3/sec)	Annual mean (m^3/sec)
1989	33.98	9.0	47.6	0.42
1990	6.23	36.8	79.9	0.78
1991	31.15	27.5	55.2	0.56
1992	28.32	20.6	47.6	0.44
1993	48.14	217.8	325.7	1.45
1994	1.42	64.3	276.4	0.99
1995	31.15	38.8	53.4	.78
1996	18.41	22.8	58.6	0.54

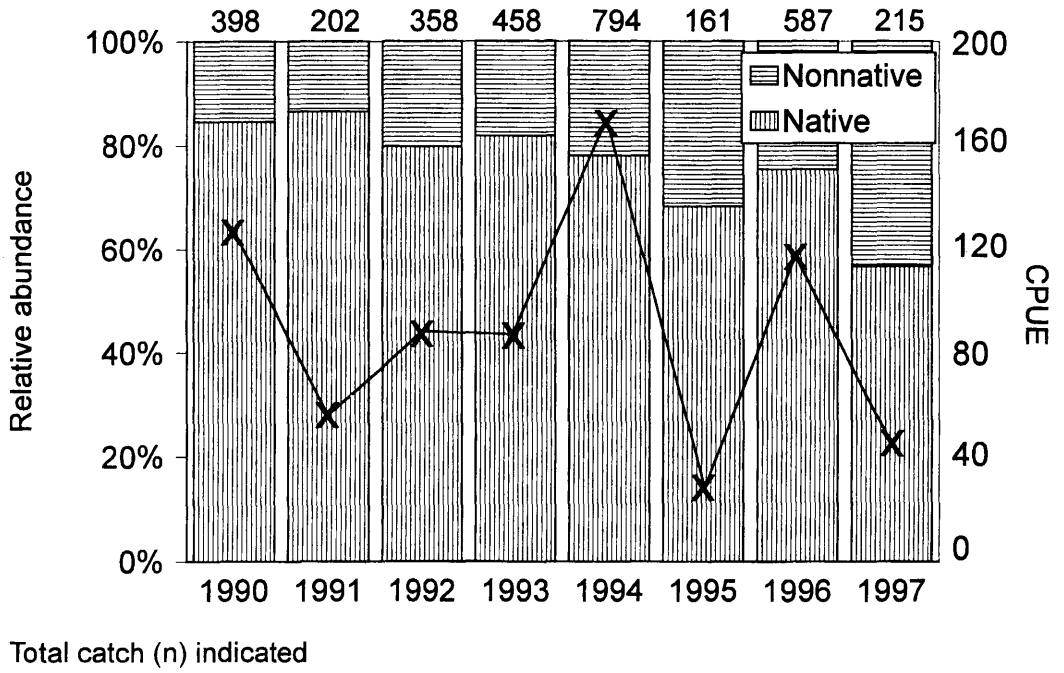


Figure 2. Relative abundance of native and nonnative fishes, and total CPUE of annual catches, 1990 to 1997. Total catch (n) indicated by numbers atop columns.

Table 2. CPUE of fish (number/900 secs) at four sites during 1990 to 1997. AGCH=longfin dace, PACL=desert sucker, AMME=black bullhead, CYCA=common carp, GAAF=western mosquitofish, LECY=green sunfish, MISA=largemouth bass, and PIPR=fathead minnow.

Year	AGCH	PACL	AMME	CYCA	GAAF	LECY	MISA	PIPR	secs
Hereford site									
1990	41.0	61.5			30.8				439
1991	64.6	31.3			3.9				460
1992	13.7	92.1			8.8				919
1993	54.6	5.3	3.5			6.2		0.9	1022
1994	114.6	59.4	1.6		10.6	1.6			1107
1995	3.5	3.5	3.5			6.1			1033
1996	79.3	14.1	3.2		7.7	5.1			1408
1997		4.8	2.9		7.6	1.0			948
Mean	46.4	34.0	1.8		8.7	2.5		0.11	
StDev	40.1	33.4	1.6		9.8	2.8		0.31	
Hiway 90 site									
1990	24.7	35.1	7.2		0.8			4.0	1128
1991	2.7	23.1	2.7		0.9				1012
1992	25.8	40.2	10.1		0.7			13.6	1254
1993	6.1	26.1	3.9		1.7	5.6		2.2	1619
1994	16.7	120.8	3.3		16.7	5.0		30.8	1080
1995	5.8	21.9				4.0		5.2	1561
1996	21.7	57.2	1.5		7.2	10.1	2.2	13.8	1244
1997	5.4	23.5	3.6		7.2	3.6		0.9	996
Mean	13.6	43.5	4.0		4.4	3.5	0.3	8.8	
StDev	9.7	33.5	3.2		5.8	3.5	0.8	10.4	
Charleston site									
1990	148.2	61.2	4.9		26.9			3.7	735
1991	18.7	7.2	3.6	0.7	2.9			5.0	1252
1992	41.1	14.5	1.6		19.3	0.8			1117
1993	15.1	36.5	16.3			6.9		3.8	1432
1994	26.6	35.4	11.1		15.5	8.9		24.4	1219
1995		20.9	4.7			9.3		1.6	1161
1996	2.2	57.1			17.1	11.9	3.7	0.7	1214
1997		10.4	4.9		25.7	2.8		0.7	1298
Mean	31.5	30.4	5.9	0.1	13.4	5.1	0.5	5.0	
StDev	40.3	20.7	5.3	0.3	11.1	4.7	1.3	8.0	
Fairbank site									
1990	70.4	5.6			3.7				486
1991	88.8	4.6	6.1						588
1992	24.9				1.5			1.5	615
1993	154.0		1.8			0.9		0.9	976
1994	115.9	49.5	3.2		3.2	3.2			854
1995	35.8							5.3	679
1996	139.2	9.7			35.8				653
1997	80.2	1.2			14.0			3.5	774
Mean	88.7	8.8	1.4		7.3	0.5		1.4	
StDev	46.0	16.8	2.3		12.4	1.1		2.0	

In terms of similarity of the assemblage between years at each site, Fairbank and Highway 90 were highly consistent, with Morisita index values greater than 0.88 and 0.83, respectively. The assemblage at Charleston showed moderate consistency between years, whereas Hereford had index values below 0.60 in five out of seven comparisons. For the eight-year period, all sites were relatively similar, except Fairbank, which was highly dissimilar to Highway 90. Since all sites were generally similar between years and during the study period, we felt it appropriate to combine data from the four sites by year for analysis of discharge relationships.

Neither annual mean discharge nor annual peak discharge during the year previous to sampling had significant influence on the variation in total CPUE at any site, nor for all sites combined (figures 3a and b). However, with the exception of Charleston, the general trend was an increase in CPUE with increasing annual mean discharge. Trends in CPUE were neutral or slightly positive with increases in annual peak discharge; again Charleston had a slightly negative trend. When CPUE was plotted against highest daily mean discharge (figure 3c), the trend was again positive at three sites and for all sites combined, and neutral at Charleston. Highest daily mean discharge explained 66% of the variation in CPUE at Highway 90. Annual mean, annual peak, and highest daily mean flows studied were not well-distributed across their respective ranges, in each case, six or seven flows were in the lower 25 to 50%-ile of flows, and one or two in the upper quartile.

Lowest daily mean discharges were well-distributed across the range of flows studied, explaining between 38% and 69% of the variation in CPUE at Highway 90, Hereford, and Charleston sites. When all sites were combined, 82% of the variation in CPUE was explained by low discharges during the previous year (figure 3d). Although the relationship between low discharge and CPUE at Fairbank was not significant, that site also showed a positive trend in CPUE with increasing minimum discharges.

Trends of CPUE of individual species at each site generally were positive when plotted against lowest daily mean flow (table 3), although few explained much of the variation or provided significant relationships. Slope of the regression line was generally steeper for the two native species at each site than for the nonnative species. Regression line slopes for the nonnative species were either negative or close to neutral with increasing minimum flows. Common carp and largemouth bass were not considered in this analysis due to their relative rarity in the catch.

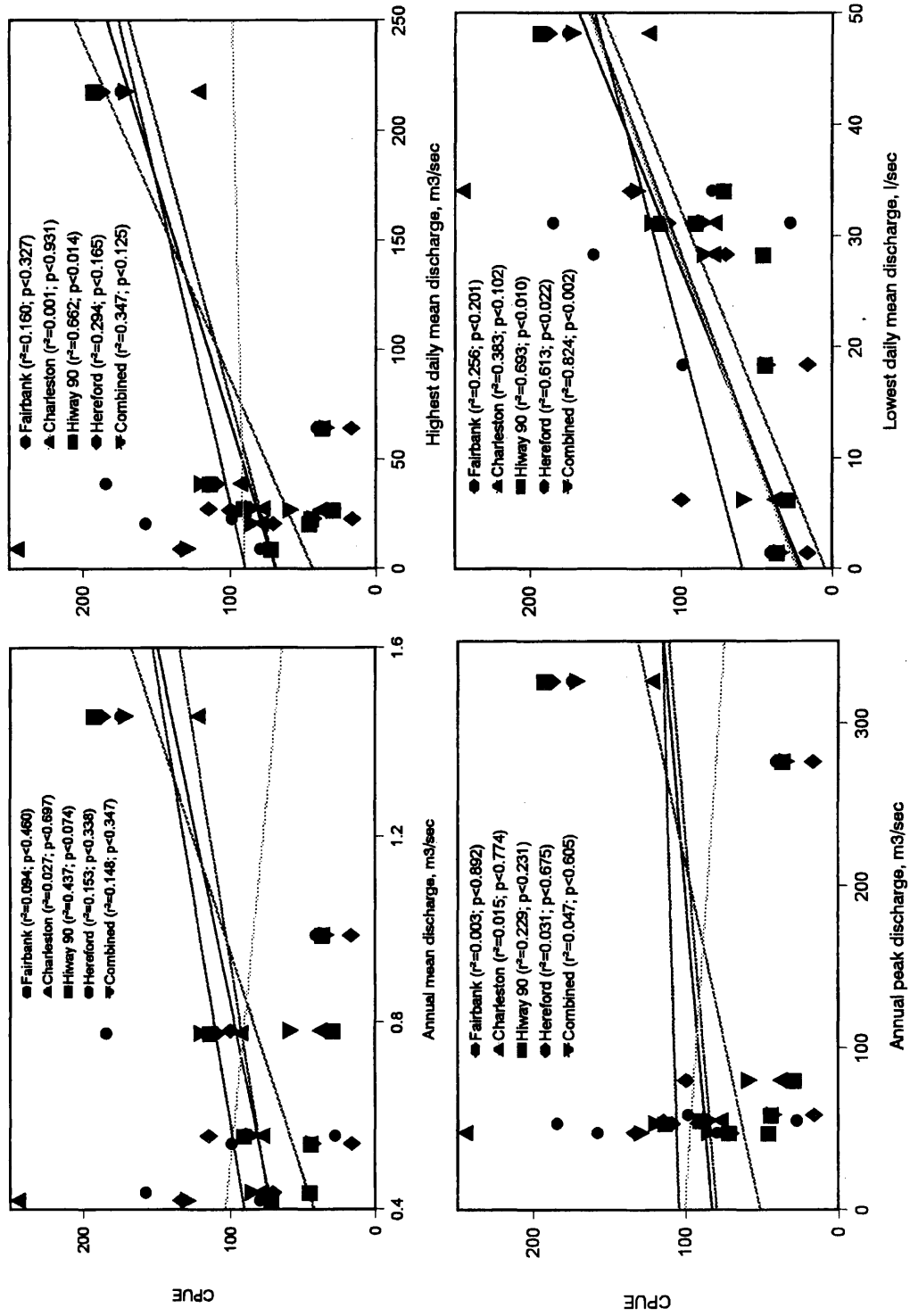


Figure 3. Least-squares relationships between total CPUE and annual mean discharge (a), annual peak discharge (b), highest daily discharge (c), and lowest daily discharge (d).

Table 3. Least-squares regression (Y = a + bX) of lowest daily mean discharge versus CPUE of each species at each site during 1990 to 1997. Acronyms are the same as in table 2.

Species	a	b	r^2	p <
Hereford site				
AGCH	8.324	1.532	0.346	0.125
PACL	4.897	1.170	0.291	0.168
AMME	2.279	-0.018	0.028	0.690
LECY	3.358	-0.035	0.036	0.651
PIPR	0.064	0.002	0.008	0.830
GAAF	1.016	0.308	0.235	0.223
Hiway 90 site				
AGCH	2.876	0.432	0.474	0.059
PACL	2.286	1.658	0.581	0.028
AMME	1.678	0.094	0.206	0.259
LECY	2.316	0.049	0.046	0.610
PIPR	-3.310	0.488	0.524	0.042
GAAF	-1.430	0.235	0.393	0.097
Charleston site				
AGCH	2.202	1.178	0.135	0.370
PACL	1.318	0.768	0.325	0.140
AMME	3.438	0.098	0.081	0.496
LECY	3.947	0.045	0.021	0.730
PIPR	-2.296	0.293	0.314	0.149
GAAF	4.147	0.373	0.269	0.188
Fairbank site				
AGCH	60.078	1.150	0.147	0.348
PACL	-8.794	0.708	0.420	0.082
AMME	1.900	-0.021	0.020	0.740
LECY	-0.643	0.046	0.407	0.089
PIPR	3.413	-0.081	0.394	0.096
GAAF	3.471	0.153	0.036	0.655
All sites combined				
AGCH	11.304	1.135	0.640	0.017
PACL	3.440	1.079	0.766	0.004
AMME	2.454	0.051	0.200	0.266
LECY	2.487	0.263	0.019	0.746
PIPR	-0.472	0.191	0.445	0.071
GAAF	1.850	0.248	0.367	0.112

CONCLUSIONS

The native fishes of the Southwest are adapted to a hydrologic pattern of flood and drought, having high reproductive potential and being stimulated to spawn by flood events (John, 1963; Minckley and Meffe, 1987; Meffe and Minckley, 1987; Rinne and Stefferud, 1997). In the San Pedro River, however, floods during 1993 and 1994 had little apparent effect on total abundance, native:nonnative ratios, or presence/absence of species, as has been found elsewhere. This could be attributed to a number of reasons, including the size of the floods (both <5-year recurrence interval events) not being large enough to displace individuals or species, or occurring at a time of the year when the biology of the fishes was unlikely to be affected. In addition, lack of floods that were capable of mobilizing substrate materials may have resulted in spawning substrate becoming embedded and unsuitable, and nursery habitat being invaded by emergent vegetation. Another explanation could be that the increased channel stability of the San Pedro River as a result of removal of livestock for several years could be ameliorating the effects of floods on the biota.

Whereas floods can significantly affect fish populations, drought conditions may be far more perilous (Jackson et al., 1987; Neary and Rinne, 1998). Effects of drought include crowding into reduced habitats with increased potential for disease or starvation, conditions which may also inhibit spawning and reduce reproductive success. Crowding into low water situations also likely increases predation and competition, particularly when predacious species are present. Low water conditions can also induce changes in water chemistry that may affect fish, including elevated temperatures and lowered dissolved oxygen concentrations (Lowe et al., 1967).

Eight years of regular and consistent sampling of the fish community at four sites in the upper San Pedro River indicated that discharge during the year previous to sampling had an effect on the abundance of fish there. In general, CPUE for all fish and at all sites decreased after years with lower flows and increased after years with higher flows. This general trend was not particularly strong for peak, annual mean, or highest daily mean discharges, but was strong for lowest daily mean flows. This may have reflected the limited range of high flows that occurred during the study period. However, lowest daily mean flows were well-distributed between the extremes, indicating that the elements that contribute to reduced populations during droughts were affecting the populations.

In particular, the native fishes responded more positively to increases in lowest daily discharges than did nonnative fishes. Longfin dace and desert

sucker prefer flowing water habitats (Rinne, 1992), whereas the nonnatives are more pool-oriented (Cross and Collins, 1995). Longfin dace becomes most abundant in hot, shallow, sandy-bottomed desert streams. It rarely occupies deep pools, and uses shallow glide and run habitats with sand substrates for spawning. Although it normally spawns in the spring, it will also spawn in the summer in response to freshets. Desert sucker lives in hard-bottomed, shallow streams, but occupies turbulent water more often than longfin dace, and breeds and feeds on riffles; spawning occurs in the spring (Minckley, 1973; Rinne, 1992). These types of habitats decrease rapidly as flow recedes, thus the amount of habitat available becomes limited during extreme low flow periods (Neary and Rinne, 1998). Extreme low flows, which occurred in June, could have affected survival and recruitment of young-of-year individuals, and may have diminished adult populations of both species, resulting in limited reproductive effort during subsequent spawning efforts. Additionally, during extreme low flow the small-bodied native fishes are forced into sharing habitat with the larger, predacious fishes, and thus are subject to more predation than in years of higher flows.

All of the nonnative species prefer pool or backwater habitats of calm water over soft substrates, and reproduction takes place in these same habitats (Jenkins and Burkhead, 1994; Cross and Collins, 1995). Even during periods of extreme drought, these areas retain habitat characteristics suitable to support the complete life cycles of the nonnative species. The nonnative ictalurid and centrarchids are long-lived species capable of several years of reproductive effort. Thus, even if one or more of their year-classes are lost or diminished due to drought, the adults can survive till conditions for spawning improve.

The upper San Pedro River is a habitat-limited system (Jackson et al., 1987). Where once it was a narrow, unentrenched stream with extensive marshes and beaver ponds characterized by high storage and slow release of water with high habitat heterogeneity, it now has little storage, rapid runoff depletion, and habitats are relatively homogenous. Predominant habitat types are runs, glides, and shallow riffles; deep pools and riffles are limited in extent and occurrence (Velasco, 1993). Some reaches of the study area dry completely during extreme drought, particularly near Hereford and Fairbank (M. Fredlake, Bureau of Land Management, pers. comm.). Jackson et al. (1987) considered that the fishery in the San Pedro River could be maintained under the present flow regime, and likely enhanced for existing fish species if median monthly flows were elevated to long-term norms. They noted that a return to a pre-incision state would permit an increase in diversity of native species, and recommended that higher flows somehow be reestablished. But flows since their study have

continued to decline, a trend that will presumably continue, thus the fate of the fishery there is problematic.

Obviously, a dry streambed will not sustain fish, but one with some reaches of perennial water can. So long as perennial surface flows remain continuous in a few reaches during a substantial portion of the year, and the hydrograph continues to reflect rainfall runoff and ground-water discharge, the species now present should survive. However, potential for the San Pedro River to ever regain its historic fauna is severely limited under the current conditions. Recovery to pre-incisement habitat conditions may also prove disastrous for the native fish so long as nonnative species are present. Before the San Pedro River became incised, habitats were predominantly pools, cienegas, and marshes (Hendrickson and Minckley, 1984), areas that today would harbor nonnative species. Thus management efforts should be focused on removing the nonnative species, or barring that, emphasizing processes that promote formation of riffle and run habitat types, and de-emphasizing those that result in pools.

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BIOGRAPHICAL SKETCH

Jerry and Sally Stefferud voluntarily study fishes in the San Pedro River as a break from their day jobs and a reason to get out of the city and back to reality once a year.

Habitat Use by Three Yaqui Fishes on the San Bernardino and Leslie Canyon National Wildlife Refuges

Ronnie A. Maes[1] and O. Eugene Maughan[1]

Abstract.—Many of the species of fish occupying the Rio Yaqui are considered to be threatened and endangered. Refugia for these species have been established in ponds on the San Bernardino National Wildlife Refuge and in Leslie Creek on the Leslie Canyon National Wildlife Refuge. Although ponds are not the typical habitat for these species, available habitat in streams is often reduced to isolated pools fed by subsurface flow. We studied habitat utilization by Yaqui topminnow (*Poeciliopsis occidentalis sonoriensis*), Yaqui chub (*Gila purpurea*) and beautiful shiner (*Cyprinella formosa*) in ponds. Habitat utilization of Yaqui chub was also studied in Leslie Creek. Adult topminnow where found at all levels in the water column but juveniles were generally closer to the water surface than adults. Juveniles were also closer to the water surface in the winter than in other seasons. Both juveniles and adults used depths in proportion to their availability. Topminnow did not select cover in ponds where they co-occurred with Yaqui chub but they did select cover where they co-occurred with Yaqui chub and beautiful shiner. Beautiful shiner occupied the edges of the pond but avoided water < 40 cm deep. Shiners did not select for substrate or cover and generally occupied the top half-meter of the water column. In both ponds and Leslie Creek, adults and juvenile Yaqui chub were most often at the bottom of the water column. Juveniles and young of year were found in water 1 m deep or less but adults were generally found at depths > 1m. In ponds, adults were generally found over vegetation but subadults (juveniles and young-of year) selected silt substrates. In Leslie Creek all age classes selected silt substrates. Areas near cover (generally vegetation) were selected in the ponds but not in Leslie Creek. Although ponds do not constitute typical habitat for these three species, ponds constitute the majority of the habitat that they occupy within the United States. Knowing the habitats selected by each species in these ponds allows managers to construct or modify existing habitat to facilitate use by these species. In addition, the fact that habitats occupied by Yaqui chub were not greatly different in ponds and Leslie Creek, might suggest that habitats selected in ponds would mimic the pool habitats selected in more typical stream habitat.

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Resumen.—Muchas de las especies de peces que ocurren en el Rio Yaqui son consideradas como amenazadas y en peligro. Se han establecido refugios para estas especies en dos refugios para fauna silvestre, los refugios, San Bernardino y Canon Leslie. Aunque los estanques no son habitat típico para estas especies, el habitat disponible en corrientes es frecuentemente reducido a charcas naturales aisladas alimentadas por corrientes sub-superficiales. Nosotros estudiamos utilización del habitat por Yaqui topminnow (*Poeciliopsis occidentalis sonoriensis*), Yaqui chub (*Gila purpurea*) y beautiful shiner (*Cyprinella formosa*) en estanques. Utilización del habitat del Yaqui chub también fue estudiado en Leslie Creek. Los adultos topminnow fueron encontrados en todos los nivels de la columna de agua, pero los juveniles se encontraron generalmente mas cercanos a la superficie del agua que los adultos. Los juveniles también fueron encontrados cerca de la superficie del agua durante el invierno mas que en las otras estaciones. Ambos, juveniles y adultos, usaron las profundidaes en proporción a su disponibilidad. Topminnow no seleccionaron cobertura en los estanques cuando ellos co-occurrieron con Yaqui chub, tampoco cuando co-ocurrieron con Yaqui chub y beautiful shiner. Beautiful shiner ocuparon las orillas de los estanques pero evitaron aquellos lugares donde la profundidad del agua fue menor que 40 cm. Shiners no seleccionaron sustratos o cobertura y generalmente ocuparon los primeros 50 cm de la columna de agua. En ambos estanques y en Leslie Creek, los adultos y juveniles Yaqui chub ocuparon la parte baja de la columna de agua. Los juveniles y jovenes del año fueron encontrados en areas con profunidades de 1 metro o menos pero los adultos usaron areas de mayor profundidad, de >1 metro. En estanques, los adultos fueron encontrados encima de vegetación pero sub-adultos (los juveniles y jovenes del año) seleccionaron sustratos de limo. Las areas cerca de cobertura (generalmente vegetación) fueron seleccionadas en los estanques peron no fueron seleccionadas en Leslie Creek. Aunque estanques no constituyen habitat típico por estas tres especies, estanques constituyen la mayor parte del habitat que ocupan dentro de los Estados Unidos. Teniendo conocimiento de habitat seleccionados por cada especie en estos estanques permite que directores de manejo puedan construir o modificar habitat que existe para facilitar el uso por estas especies. Además, el hecho de que los habitat ocupados por Yaqui chub no fueron diferentes en estanques y Leslie Creek, podría indicar que los habitat seleccionados en estanques mímicarian los habitat de charcas naturales seleccionados en corrientes de habitat típico.

INTRODUCTION

Many of the fish native to the Rio Yaqui drainage live in streams that flow during certain seasons but are reduced to isolated pools maintained by subsurface flow during others. Prior to the 19th Century, a perennial stream, fed by many springs, flowed through the San Bernardino Valley in Arizona (USFWS 1987) and south into the Rio Yaqui of Mexico. However, by the 1960's intensive pumping from the undeground aquifer and diversion of water for irrigation had decreased output from springs. Surface flow had been eliminated (USDI 1984, USFWS 1987, Williams 1991) and only remnant populations of native fish species remained.

The San Bernardino National Wildlife Refuge was established in 1986 to serve as a refugium for six threatened or endangered species of fish native to streams in the Rio Yaqui drainage (Arizona and Mexico). These species were Yaqui chub, *Gila purpurea,* Yaqui topminnow *(Poeciliopsis occidentalis sonoriensis),* beautiful shiner, *Cyprinella formosa,* Yaqui catfish, *Ictalurus pricei,* Yaqui sucker, *Catostomus bernardini,* and Mexican Stoneroller, *Campostoma ornatum.* Yaqui chub, Yaqui topminnow and beautiful shiner were introduced on to the refuge shortly after it was established (USDI 1984, USFWS 1987, Williams 1991).

The absence of flowing streams on the San Bernardino National Wildlife Refuge precluded the possibility of introducing these species into stream habitat on the refuge. Therefore, they were introduced into ponds fed by wells. Although ponds are not typical habitat for these species, they do resemble the isolated pools to which Rio Yaqui fishes are restricted during drought.

Despite the fact that these ponds do not represent typical habitat for Rio Yaqui fishes, we undertook a study to determine how habitat was utilized by three species (Yaqui topminnow, Yaqui Chub and beautiful shiner) in three ponds (figure 1) on the refuge. The objective of this study was to identify what elements of habitat were selected so that ponds could be managed to maximize the availability of these habitat elements. We also studied habitat use by Yaqui Chub in Leslie Creek on Leslie Canyon National Wildlife Refuge (figure 2) so we could compare habitat use in ponds with that in more typical stream habitat.

At the time of the establishment of the San Bernardino National Wildlife Refuge, beautiful shiner had been extirpated in the United States (USDI 1984). However, the species was widespread, and locally (Rinne and Minckley 1991), but not generally abundant over most of the Rio Yaqui drainage in Mexico (Hendrickson et al. 1980). Therefore, stocks obtained in Mexico and maintained at Dexter National Fish Hatchery and Technology

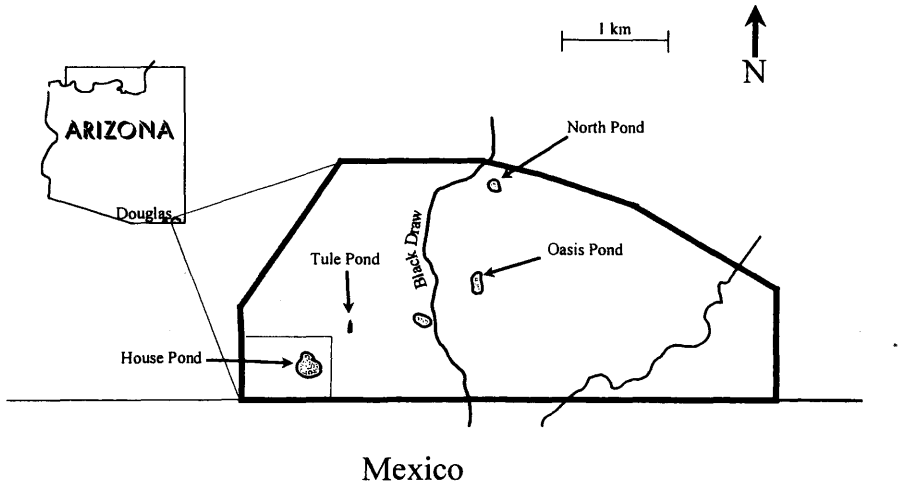


Figure 1. Main portion of the San Bernardino National Wildlife Refuge, southeastern Arizona.

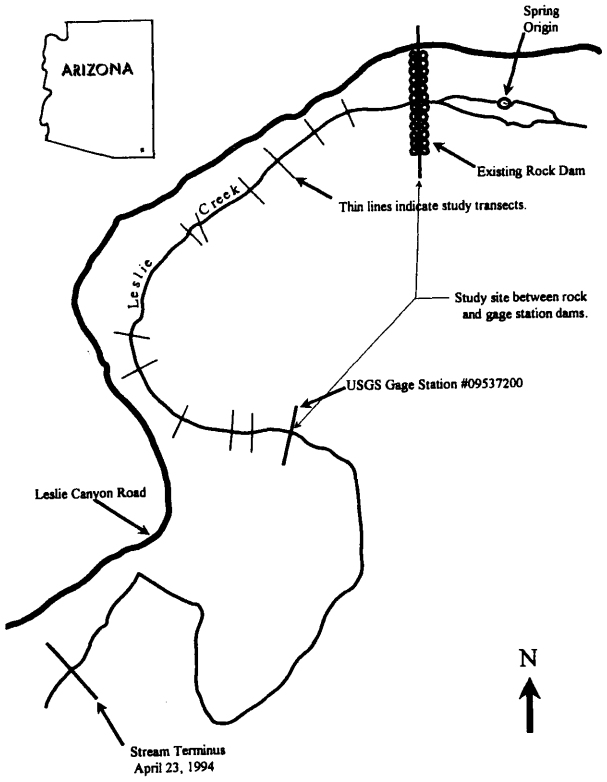


Figure 2. Leslie Creek Canyon in the southern extension of the Swisshelm Mtns., San Bernardino National Wildlife Refuge, southeastern Arizona (25 km north of Douglas).

Center in New Mexico were used to establish the populations on the refuge (U. S. Fish and Wildlife Service 1990).

Beautiful shiner are primarily found in small streams in Mexico, but they do occur in large rivers. In small streams, the species occupies riffles, runs, and mid-water areas in pools. In large rivers, beautiful shiner are found along the shoreline (Hendrickson et al. 1980, USDI 1984, Rinne and Minckley 1991). Despite the fact that beautiful shiner typically inhabit streams, they survive and reproduce relatively well in ponds (McNatt 1974, Hendrickson et al. 1980).

In Mexico, Yaqui topminnow were recently abundant in lower elevation habitats along stream margins, or in thermal waters fed by artesian sources at higher elevations (Hedrickson et al. 1980). The current status of this subspecies in Mexico is not well documented. In the U.S. a small number of populations (about 15), have been maintained (U. S. Fish and Wildlife Service 1994). Yaqui topminnow typically occupy vegetated springs, small streams, and the margins and backwaters of larger waters (Minckley 1973)..

Yaqui chub (*Gila purpurea*) were originally described as inhabiting the headwaters of the Rio Yaqui including the Rio Sonora and the Rio Matape (Minckley 1980, Cobble 1995). However, DeMarais (1991) recently recognized all populations except those in San Bernardino Creek (Rio San Bernardino in Mexico) as a new species (*Gila eremica,* Desert chub*)*. Prior to the recognition of this new species, the Yaqui chub was considered to be endangered (USFWS 1984). With the recognition of the Desert chub, the Yaqui chub became even more imperilled.

In the U.S., Yaqui chub are restricted to Black Draw (San Bernardino Creek), and various ponds on the San Bernardino National Wildlife Refuge, Leslie Creek on the Leslie Creek National Wildlife Refuge, House Pond on the Slaughter Ranch Historic Site and West Turkey Creek in the Chiricahua Mountains (DeMarais and Minckley 1993). In Mexico, the species is known (historically and currently) only from the Rio San Bernardino (Black Draw) just south of the border (Varela-Romero et al. 1992).

Yaqui chub occupy deep pools in creeks, scoured areas of cienegas and other quiet waters (Minckley 1973, McNatt 1974, Cobble 1995). Chub seek cover in deep water, debris, aquatic vegetation or under cut-banks in the day (Hendrickson et al. 1980, Rinne and Minckley 1991). Young fish are generally found near shore. Yaqui chub are opportunistic feeders, taking algae, insects and detritus (Galat and Gerhardt 1987). Adults spawn throughout the summer and fry often reach maturity in the first summer of life. Prolonged spawning and rapid maturity allow large populations to develop quickly (DeMarais and Minckley 1993).

DESCRIPTION OF THE STUDY AREA

The San Bernardino National Wildlife Refuge is located in the San Bernardino Valley near Douglas Arizona. Leslie Canyon National Wildlife Refuge lies to the north and west of San Bernardino National Wildlife Refuge. Yaqui topminnow were studied in three ponds on the San Bernardino refuge: Tule Pond, North Pond and Oasis Pond. Beautiful Shiner were studied in Oasis Pond. Yaqui chub were studied in North and Oasis ponds and Leslie Creek on the Leslie Canyon National Wildlife Refuge. Leslie Creek generally has only a short reach (800-1000 meters) of permanent water. This short reach contains shallow riffles and runs interspersed with pools. Tule Pond has a surface area of about 0.03 ha and is fed by a seep within the pond basin. Maximum pond depth is about 1.5 m. Without vegetation control in the summer, the pond is soon covered with *Carex*, *Typha* and *Potomogeton*. Low levels of dissolved oxygen are common. Yaqui topminnow is the only species that occurs in this pond. North Pond has a surface area of about 0.10 ha and a maximum depth of 2.0 m. Water for the pond comes from an artesian well. Without vegetation control in the summer, the pond is soon covered with the emergent *Typha* and submergents *Najas* and *Potomogeton*. Yaqui topminnow and Yaqui chub co-occur in North Pond. Oasis Pond has a surface area of about 0.12 ha and has a maximum depth of 2.1 m. The water source for this pond is an artesian well. There is little emergent vegetation in Oasis pond. Yaqui topminnow co-occur with Yaqui chub and beautiful shiner in Oasis Pond (USFWS 1987).

METHODS AND MATERIALS

The three ponds differed in physical-chemical characteristics and species of fish that occurred. Therefore, they could not be considered replicates. However, by comparing the habitats utilized across the range of conditions available, we distinquished factors that were always selected from those that were selected only under certain conditions.

Habitats used were identified by snorkeling at a constant rate along transects and recording the location of each fish, approximate fish size (Griffith and Fuller 1979, Griffith 1981, Platts et al. 1983, Springer 1983, Helfman 1985) and life stage, frequency of occurrence, substrate, cover type, distance from cover (Fausch and White 1981, Heggens et al 1990), activity and position in the water column (focal point elevation of Moyle and Baltz 1985). The location of each fish was marked with a weighted buoy and habitat conditions such as water temperature, water depth and relative depth (Moyle and Baltz 1985, Gorman 1987, Gorman 1988), were measured. Data from fish that were fleeing from or attracted to the diver

were not used in the analysis (Fausch and White 1981, Heggens et al. 1990). Bias associated with differences in visibility (Keenylside 1962) were avoided by discontinuing when the view of the bottom became obscured. Habitat avialibility was estimated by measuring physical variables (depth, substrate) at 1-m intervals along transects (Jones et al 1984, Bovee 1986).

A Kolmogorov-Smirnov two-sample test (0.001 significance level) was used to test for differences in vertical position and depth occupied. The Mann-Whitney-Wilcoxon test (0.05 significance level) was used to test for difference in habitat use within sites. The Bonferroni correction factor was used to determine the appropriate significance level. Spearman's Rank Correlation Coefficiants were used to determine if there were significant (0.001) linear relationships between relative depth, total water column deph, species size, distance to cover and frequency of occurrence. The Kruskal-Wallis one way analysis of variance (0.05 significance level) was used to test for seasonal differences. Dunn's multiple comparisons test (0.05) was used to test for pair-wise differences. A chi-square test of independence was use to determine if use of substrates and cover types differed between sites and life stages (Cunjack and Green 1983). A chi square test of homogeniety was used to compare availability and use of depths, substrates, velocities, and relative depths (Ordway and Krausman 1986, Carson and Peak 1987, Thomas and Taylor 1990. Bonferroni Z-tests with simultaneous confidence intervals were used to determine if there was selection for individual habitat categories (Marcum and Loftsgaarden 1980). A Chi-square goodness of fit test was used to compare use and availability of relative depths.

We had insufficient numbers of observations of beautiful shiner to analyze for seasonal or age class differences. Therefore, data from all seasons and age classes were combined.

RESULTS

Yaqui Topminnow (figures 3-8)

Tule Pond

There were significant differences between the vertical position (relative depth) in the water column used by adults and juveniles in Tule Pond. Juveniles preferred the top portion of the water column but adults showed no preference for any vertical position. Vertical position in the water column did not differ by season for adults but juveniles were higher in the water column in the winter than in other seasons. The actual depth of the water used was the same for juveniles and adults in all seasons and was proportional to availability. Adults selected open substrates (inorganic and detrital) but did not select cover. Juveniles selected neither substrate nor cover.

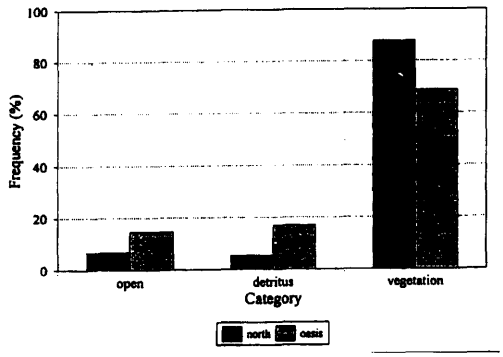


Figure 3. Distribution of available substrates for North Pond versus Oasis Pond, SBNWR, Arizona.

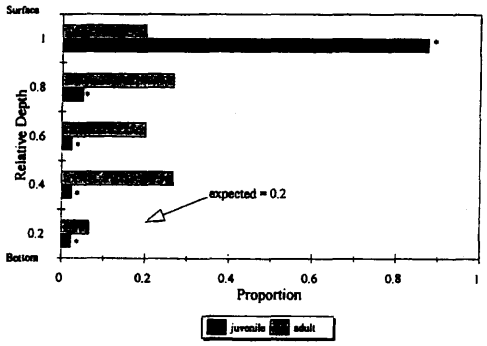


Figure 4. Distribution of relative depths used by Yaqui topminnows in Tule Pond. *, significant difference using Bonferroni Z-test simultaneous confidence intervals. If horizontal bar extends beyond expected proportions and contains an asterisk it indicates a preference. If the bar does not extend beyond expected proportion and an asterisk is present, an avoidance is indicated.

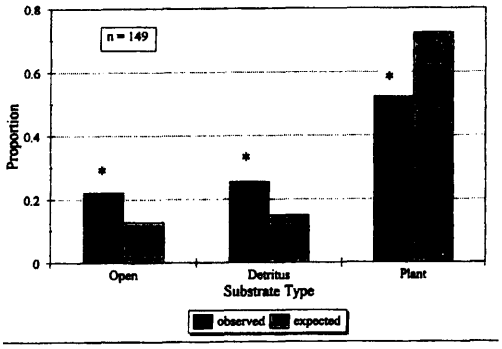


Figure 5. Substrates used versus available to topminnows in Tule, North, and Oasis Ponds. Asterisks denote a significant difference between use and availability using the Bonferroni Z-test simultaneous confidence intervals.

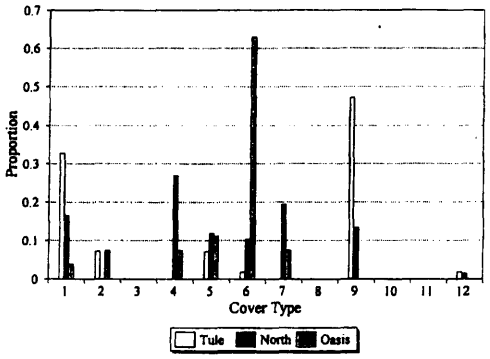


Figure 6. Cover types used by topminnows in Tule, North, and Oasis Ponds. Cover types are as follows: 1) cattail, 2) sedge, 3) watercress, 4) flooded terrestrial vegetation, 5) pondweed, 6) *Chara*, 7) spiny naiad, 8) woody material, 9) floating organics, 10) undercut banks, 11) substrate, 12) root wads.

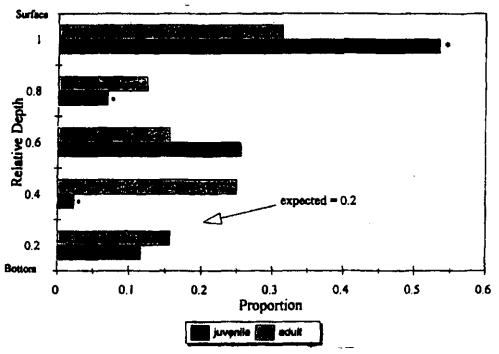


Figure 7. Relative depths used by Yaqui topminnows in Oasis and North Ponds. Asterisks denote significant difference between use and expected proportions.

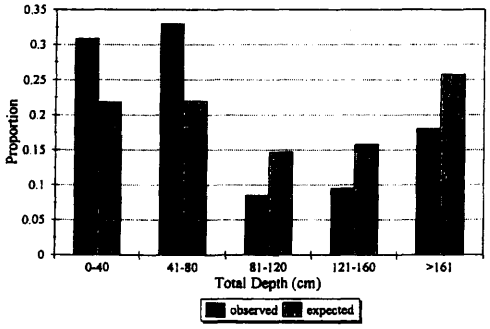


Figure 8. Depths used by topminnows in North and Oasis Ponds.

Oasis and North Pond

In Oasis and North pond, vertical position in the water column used by topminnow were generally the same as in Tule Pond. Although juveniles preferred water near the surface they also selected mid water areas in these ponds. Both juveniles and adults were generally found in water < 80 cm deep over open substrates in North and Oasis ponds. Topminnow did not select cover in North Pond but they did in Oasis Pond. Distance to cover was more than three times greater in Tule and North ponds than in Oasis Pond.

Beautiful Shiner (figures 9-12)

Relative depth used by beautiful shiners was most often between 0.6 and 0.8 of the relative depth in water 40-100 cm deep. Fish generally remained in the top half-meter of the water column regardless of the

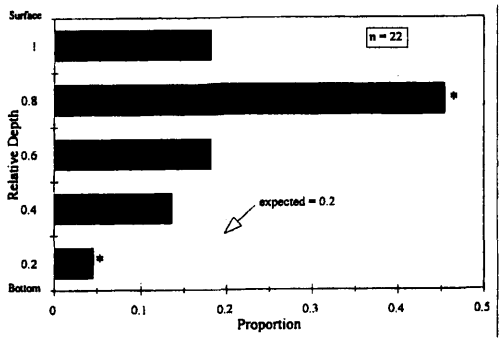


Figure 9. Relative depths used by beautiful shiners in Oasis Pond. Asterisks denote a significant difference between observed and expected value for individual depth zones.

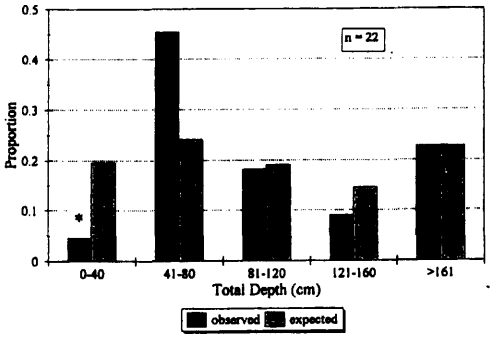


Figure 10. Depths used by beautiful shiners in Oasis Pond. Asterisk denotes a significant difference between observed and available proportions for individual depths categories.

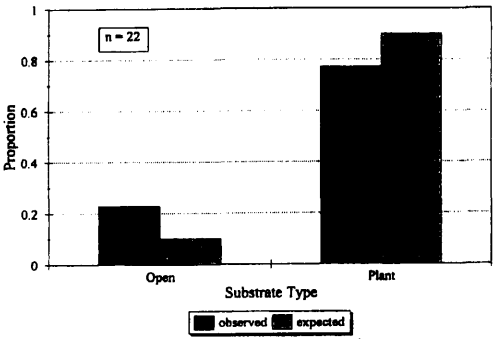


Figure 11. Substrates used by beautiful shiners in Oasis Pond.

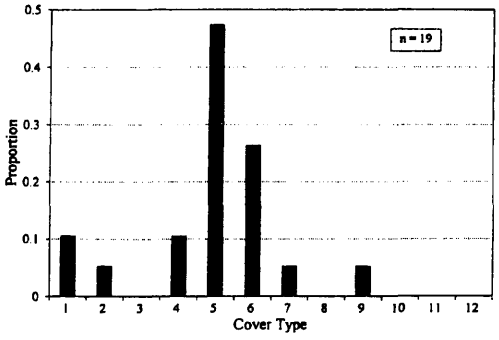


Figure 12. Cover types used by beautiful shiners in Oasis Pond. Cover types are: 1) cattail, 2) sedge, 3) watercress, 4) flooded terrestrial vegetation, 5) pondweed, 6) *Chara*, 7) spiny naiad, 8) woody material, 9) floating organics, 10) undercut bank, 11) substrate, 12) root wad.

overall depth but avoided water < 40 cm deep. There was no selection for substrate or cover. Beautiful shiners occupied waters between 18 and 28 C but temperatures in the pond ranged from 17 to 31 C. They also occupied the edges of the pond and were seldom found away from these areas.

Yaqui Chub (figures 13-22)

The relative depth used by chub did not differ between the ponds and Leslie Creek. However, relative depth used differed between juveniles and adults. Adults and juveniles were found most often at the bottom of the water column. Juveniles and young-of-year were found in water 1 m deep or less but adults were found at depths > 1 m. There were no seasonal differences in the actual depth used by juveniles and adults, but the relative depths used differed for juveniles during summer versus other seasons and adults during winter versus other seasons.

Chub selected substrates in both the ponds and in Leslie Creek. The substrates used in the ponds differed by life stage but they did not differ by life stage in Leslie Creek. In the ponds, juveniles selected silt substrates but adults were generally in or over vegetation. Both juveniles and adults selected silt substrates in Leslie Creek.

All life stages selected areas close to cover in the ponds but did not select areas close to cover in Leslie Creek. Cover type selected in the ponds differed by live stage. Adults selected *Chara* and pond weed beds, juveniles selected spiny naiad, and young-of-year selected cattail and flooded terrestrial vegetation. In Leslie Creek, adult chub avoided velocities >0.04 m/sec, but juveniles used velocity in proportion to its availability. There was no velocity in the ponds.

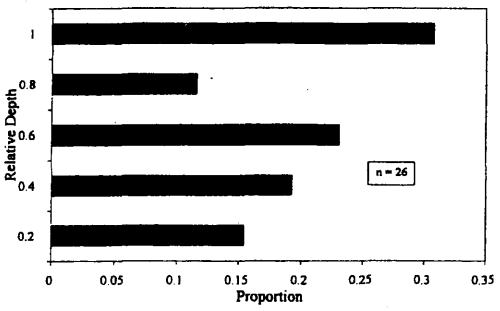


Figure 13. Relative depths used by young-of-year chubs (YOY) at all sites.

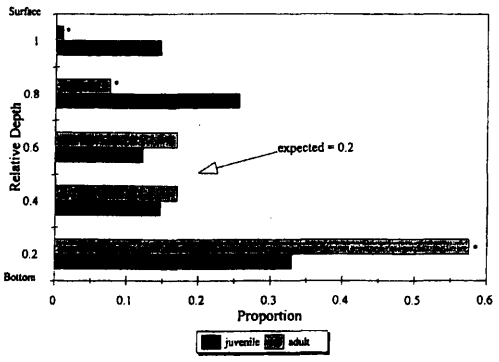


Figure 14. Relative depths used by Yaqui chubs (excluding YOY) at all sites.

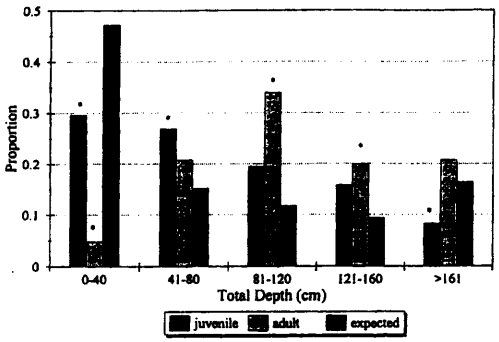


Figure 15. Depths used by Yaqui chubs at all sites. Asterisks denote a significant difference between use and expected proportions based on availability.

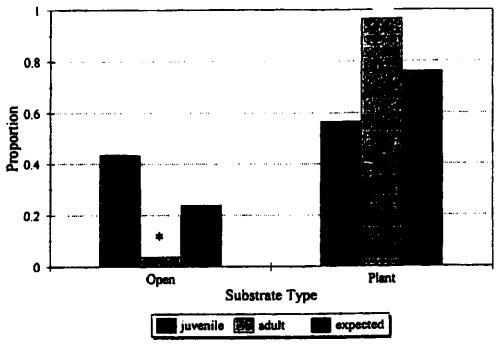


Figure 16. Substrates used by Yaqui chubs in North and Oasis Ponds. Asterisk denotes a significant difference between use and availability.

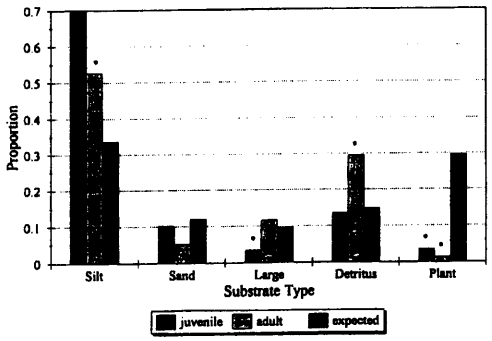


Figure 17. Substrates used by Yaqui chubs in Leslie Creek. Asterisks denote a significant difference between use and availability.

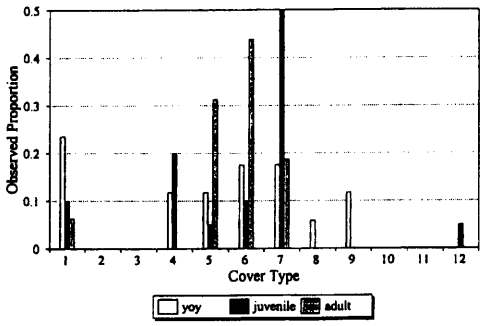


Figure 18. Cover types used by different life stages of Yaqui chubs in North Pond. Cover types are: 1) cattail, 2) sedge, 3) watercress, 4) flooded terrestrial vegetation, 5) pondweed, 6) *Chara*, 7) spiny naiad, 8) woody material, 9) floating organics, 10) undercut bank, 11) substrate, 12) root wad.

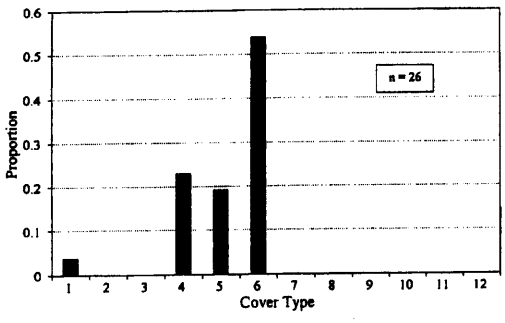


Figure 19. Cover types used by Yaqui chubs in Oasis Pond. Cover types are: 1) cattail, 2) sedge, 3) watercress, 4) flooded terrestrial vegetation, 5) pondweed, 6) *Chara*, 7) spiny naiad, 8) woody material, 9) floating organics, 10) undercut bank, 11) substrate, 12) root wad.

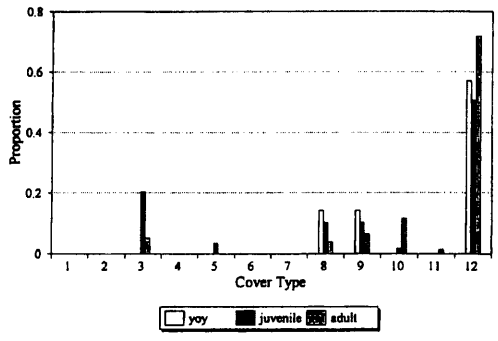


Figure 20. Cover types used by different life stages of Yaqui chubs in Leslie Creek. Cover types are: 1) cattail, 2) sedge, 3) watercress, 4) flooded terrestrial vegetation, 5) pondweed, 6) *Chara*, 7) spiny naiad, 8) woody material, 9) floating organics, 10) undercut bank, 11) substrate, 12) root wad.

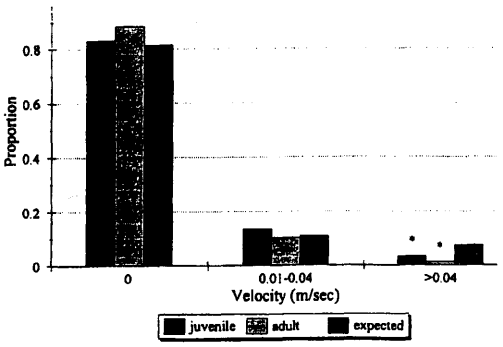


Figure 21. Mean water column velocity for Yaqui chub observations in Leslie Creek. Asterisks denote a significant difference between observed and expected proportions for that individual category.

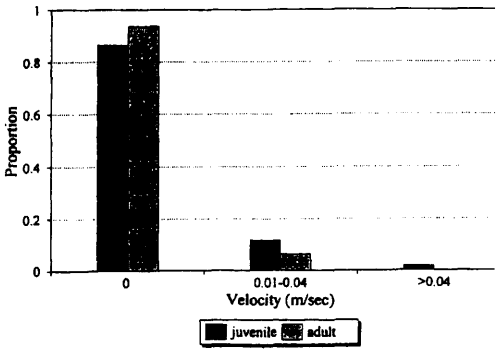


Figure 22. Note velocity for Yaqui chubs in Leslie Creek.

DISCUSSION

Yaqui Topminnow

Tule Pond

The position in the water column and the depth of water used by Yaqui topminnow were not exactly the same in Tule Pond as in Oasis or North ponds. We might have expected fish to select positions higher in the water column in Tule Pond because of the low sunmer oxygen levels. Low summer oxygen levels could force fish to occupy positions higher in the water column to allow access to the oxygen rich surface layer of water. However, despite the availability of oxygen at all depths in Oasis and North ponds, juvenile topminnow still selected areas near the water surface. In addition, they occupied the middle portion of the water column in North and Oasis ponds. Adult fish occupied all depths in all three ponds. However, adult fish were not visable during low oxygen conditions in Tule Pond. Topminnows evolved under conditions of periodic low oxygen, and can utilize the O_2 rich surface water layer to insure survival. However, since ponds on the San Bernardino National Wildlife Refuge are the only refugia for this species in the United States, it would seem prudent to eliminate low oxygen episodes.

Minckley et al. (1977) reported that Gila topminnow prefer water < 25 cm deep. However, other authors have reported that the Sonoron topminnow (*Poeciliopsis occidentalis* including both the Gila and Yaqui forms) occupy depths from1 cm to 1 m (Stefferud 1984, Forrest 1992). In these study areas, Yaqui topminnow occurred in water < 80 cm deep about 63% of the time but occurred at depths up to 2 m. Meffe and Snelson (1989) have suggested that poeciliid fishes select shallow areas to escape preda-

tion from larger fish. However, in these study areas, juvenile topminnow selected shallow areas even when there were no fish predators in the pond. Bullfrogs were another predator present in the area but moving into shallow areas might enhance rather than reduce the amount of predation from bullfrogs. Occupation of shallow areas has also been reported to result from selection for warmer waters (Meffe and Snelson 1989, Forrest 1992). However, topminnows congregate around inlet pipes into the pond in the winter even though the temperatures in these areas were lower than in the surrounding pond.

The substrates at the depths selected were generally silt or detitus. Minckley (1973) and Brooks (1985) reported that detritus was the major food source for topminnows. However, in this study topminnow seldom fed from detritus, but fed instead from epiphytic algae on the plants and particulates suspended in the water column. Sometimes substrates are important for spawning. However, topminnow breed and bare young at mid column water depths. Therefore, the apparent preference for silt substrates may be a by product of the selection for shallow depths. Topminnow did not select cover in Tule pond or North ponds but they did in Oasis Pond. Absence of fish predators might have made the selection of cover unnecessary in Tule Pond. Iin North pond topminnow co-occurred with Yaqui Chub, while in Oasis Pond topminnow co-occurred with Yaqui chub and beautiful shiner. Minckley (1980) has reported that adult Yaqui chub feed on topminnow. Where topminnow are exposed to predation pressure we might expect some selection for cover. However, we found no selection for cover where topminnow co-occurred with only Yaqui chub. Topminnow did select cover where they co-occurred with beautiful shiner and Yaqui chub. Selection of cover by topminnow only in the pond where they co-occurred with beautiful shiner might suggest some sort of an interaction, perhaps predation or aggression, between these two species. Beautiful shiner are stocked with Yaqui topminnow in several ponds on the refuge. However, it might be desireable to discontinue stocking these two species together until there is a better resolution of the interactions that occur between them.

Beautiful Shiner

Beautiful shiner tended to avoid shallow waters. Fish might avoid shallow waters to minimize the probability of stranding during droughts, to lessen the contact with predators or to maintain thermal stability (Matthews and Hill 1979). The riffles and pools that constitute the primary habitat of this species periodically dry up. Therefore, being stranded would be a real risk. However, it is unlikely that predator avoidance is the reason that beautiful shiner avoid shallow waters. Most predators would

probably be larger fish. It is unlikely that these larger fish would venture into shallow waters. Beautiful shiner concentrate in the warmer waters in the pond during the winter. However, they do not require access to these warmer waters to survive.

Beautiful shiner concentrated at the margins of the pond. When disturbed, they did not seek cover nor did they escape into deeper water. Instead they generally escaped by swimming laterally. Avoidance of deeper areas of the pond may minimize contact with large fish predators. Beautiful shiner co-occurred with Yaqui chub in Oasis Pond and it is possible that there was a predatory interaction between the two species or an avoidance of deep water due to a ghost predator e.g. Yaqui Catfish. It is unknown whether beautiful shiner would have been more uniformly distributed throughout the pond if Yaqui chub had been absent. Although there is no direct evidence of predation on beautiful shiner by Yaqui chub, the fact that shiners restricted their activity to a relatively small portion of the pond, might suggest some sort of interaction between the species. Stocking beautiful shiner alone in a pond and evaluating their distribution in the absence of other species would be a simple way to determine whether the areas selected in Oasis Pond would be the same as those selected in the absence of potential predators.

There is no way to determine whether the observations made in Oasis Pond illuminate real habitat preferences of beautiful shiner. Ponds are not typical habitat, although the species can survive in them (Hendrickson et al. 1980). However, the data are important for the management of the species in the refugial ponds on the refuge. Periodic vegetation control would be required to maintain the habitats selected in Oasis Pond. In addition, interactions between Yaqui chub and beautiful shiner should be investigated under more rigorous conditions than were possible in this study. Should it be found that Yaqui chub prey on beautiful shiner it may be necessary to curtail stocking the two species together in refugial ponds.

Beautiful shiners do not select cover. However, they do form schools and schooling may reduce the need for cover (Moyle and Cech 1988). The relatively shallow areas that beautiful shiner select, around the margins of the ponds, are the areas that are the most susceptible to being overgrown with aquatic vegetation. To maintain the conditions that seem to be preferred by this species would require periodic vegetation control around the pond margins.

Yaqui Chub

Adults, juveniles, and young-of-year chub all used different depths and occupied different positions in the water column. Generally the juveniles were in shallower water than adults and young-of-year were in shallower

water than juveniles. Young-of-year were also closer to the surface of the water column than adults and juveniles. The selection of different positions in the water column and different depths by each life stage limits their degree of contact and lessens the probability for intraspecific predation or competition. Partitioning the available habitat areas between life stages also helps insure a more efficient utilization of resources.

The conditions selected by chub in Leslie Creek were the same as those selected in Oasis and North ponds. Streams such as Leslie Creek are typical habitat, whereas ponds are seldom occupied by this species. The fact that the same factors were selected in both Leslie Creek and the two ponds would seem to indicate that the conditions selected represent real preferences. The presence of co-occurring species (beautiful shiner and Yaqui topminnow) did not alter the habitats selected by Yaqui chub. Nor did the presence of Yaqui chub appear to alter the habitats selected by these co-occurring species. Knowing the real preferences of the species becomes important for establishing design criteria for habitat management and for developing stocking protocols for ponds on the San Bernardino National Wildlife Refuge.

Yaqui chub strongly selected areas near cover in the ponds but did not select areas near cover in Leslie Creek. We do not interpret these data to mean that cover is not important in streams. Leslie Creek had a thick riparian overstory that reduced light penetration. The reduction of light penetration and the associated creation of shade and shadows on the water surface may have reduced the necessity for Yaqui Chub to seek proximity to cover. Another factor perhaps, reducing the necessity for proximity to cover might be the relatively low density of potential predators in Leslie Creek compared to the ponds. There were no potential fish predators on adult or juvenile chub in either the ponds or Leslie Creek. However, there were fish eating birds and bullfrogs that could prey upon Yaqui Chub in the ponds. In Leslie Creek, fish eating birds were present but rare and bullfrogs did not occur. Fish eating birds were probably less common in Leslie Creek than in the ponds because the stream flowed for only a short distance.

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El pez Pupo del Desierto (*Cyprinodon macularius*) en la reserva de la biosfera El Pinacate y Gran Desierto de Altar, Sonora, México.

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Resumen.—La mayor parte del cauce del Río Sonoyta es intermitente con una zona perenne dentro de la reserva donde existe una población de Pupo del Desierto (*Cyprinodon macularius*), especie endémica en peligro de extinción. Miller y Fuiman (1987) consideran esta forma del Río Sonoyta un eslabón intermedio entre *C. m. macularius* y *C. m. eremus*. La especie esta amenazada por la sobreexplotación de agua para abrevaderos de ganado, riego agrícola, abastecimiento de agua para pobladores, contaminación e introducción de especies exóticas. En mayo de 1997 se realizó una prospección del sitio comprobando la presencia de Pupo. Un mes después, se denunció la drástica disminución de agua del Río por la apertura ilegal de pozos para abrevar ganado y la extracción de agua para reparar la carretera federal No. 2. La consecuencia fue la mortalidad masiva de Pupos y la modificación del habitat. Los pozos fueron cerrados, pero el cauce del Río no ha logrado reestablecerse completamente. El reto de la reserva es proteger la especie proponiendo derechos de propiedad, buen suministro de agua de calidad, control de especies exóticas y contaminación, búsqueda de financiamiento para manejo del sitio, monitoreo, programas educativos y alternativas económicas con bajos requerimientos de agua para la población residente.

Abstract.—Most of the Sonoyta River is intermittent, however, it has a perennial zone inside the reserve where a Desert Pupfish (*Cyprinodon macularius*) population exists, an endangered and endemic specie. Miller and Fuiman (1987) considered the form from the Sonoyta River an intermediate link between *C. m. macularius* and *C. m. eremus*. The species is threatened because of water over exploitation for cattle, agricultural irrigation, popula-

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tion water supply, contamination and introduction of exotic. In May 1997 we made a site examination to prove the presence of Desert Pupfish. One month later the drastic decrease of water in the River was reported due to illegal opening of wells for cattle and because of extraction of water to repair Highway 2. The consequence of it was the mortality of Pupfishes and habitat modification. Wells were closed, but the river beds have not recovered completely. The challenge is to protect this species and its important habitat by proposing land rights, ensuring a water supply (quantity and quality), improving protection and management of the species, controlling exotic species, avoiding contamination, searching for funds for the appropriate management of the site, continuing surveys, improving educational programs, and developing economic alternatives with low requirements of water for the resident population.

INTRODUCCION

La reserva de la biosfera El Pinacate y Gran Desierto de Altar se ubica en el extremo noroeste del Estado de Sonora, México y su declaratoria se sustentó en la necesidad de conservar la biodiversidad representada por especies únicas en el mundo, algunas de las cuales están bajo alguna categoría de protección federal, los valores paisajísticos y los prehistóricos e histórico-culturales de la región.

La declaratoria de la reserva incluye una porción del Río Sonoyta, cuyo cauce es un afluente deltaíco del Río Colorado con un cambio en su desembocadura hacia el sur por los flujos de lava de los campos cercanos a la Sierra de El Pinacate (Ives, 1936).

La mayor parte del cauce del Río es intermitente, sin embargo se encuentran zonas perennes dentro del cauce. La ictiofauna esta conformada por dos especies nativas, el Pupo del Desierto (*Cyprinodon macularius*) y el Charal de Aleta Larga (*Agosia chrysogaster*) mas dos especies introducidas: el Pez Mosquito (*Gambusia affinis*) y el Bagre Amarillo (*Ameiurus melas*) (Juárez *et al*, 1988).

El Pupo del Desierto (*Cyprinodon macularius*) es un pequeño pez cyprinodonte que fue abundante en algunos lugares al sur de Arizona y al sureste de California, en los Estados Unidos y al norte de Baja California y Sonora en México (Miller, 1943). Históricamente, su habitat era variado en tamaño y complejidad e incluía ciénegas, manantiales, arroyos y las márgenes de grandes ríos y lagos (Minckley, 1973).

A pesar de su gran tolerancia a las condiciones ambientales extremas, la especie, además de ser endémica, esta bajo la categoría de peligro de extinción debido a la modificación parcial o pérdida total de su habitat, a

la contaminación y a la introducción de peces exóticos (U.S.F.W.S., 1986 y SEDESOL, 1994).

Descripción de la Especie

El Pupo del Desierto fue descrito por primera vez de especímenes colectados en el Río San Pedro, Arizona en el año de 1853 por Baird y Girard. El taxa actualmente incluye dos subespecies reconocidas, *Cyprinodon macularius macularius* y *Cyprinodon macularius eremus*, además de una forma no diagnosticada que ocurre en el Río Sonoyta, Sonora, México (McMahon and Miller, 1985). *Cyprinodon macularius eremus*, es una especie endémica de los manantiales de Quitobaquito, en la reserva de Organ Pipe Cactus National Monument, Arizona (Miller and Fuiman, 1987). Las otras poblaciones de Pupo del Desierto en California y en el Delta del Río Colorado, Baja California, se han identificado como la subespecie *Cyprinodon macularius macularius* (Minckley 1973, Miller and Fuiman 1987).

La descripción de este pez de acuerdo a Baird y Girard (1853), ratificada porteriormente por otros autores como Miller (1943), Minckley (1973) y Moyle (1976) es la siguiente:

> "El cuerpo es grueso, abultado o marcadamente comprimido lateralmente en los machos adultos. La boca tiene posición superior, es altamente protráctil y esta equipada con una mandíbula tricúspide dentada. Las proyecciones dorsales presentan características escamas circulares. El perfil dorsal es suavemente redondeado. La coloración del pez es plateada en hembras y juveniles. Los costados presentan barras obscuras angostas verticales. Las aletas no presentan coloración, excepto por un oscuro ocelo en la aleta dorsal y (raramente) un punto oscuro en la aleta anal. Los machos maduros en condición reproductiva son brillantemente coloridos en la aleta caudal y la porción posterior del pedúnculo caudal. El color del cuerpo va de azul iridiscente a azul cielo, especialmente en la superficie dorsal de la cabeza y en la región predorsal".

De la subespecie de Pupo del Desierto de Quitobaquito, Arizona, fueron descritas por Miller y Fuiman en 1987, algunas diferencias del resto de la población de *Cyprinodon Macularius*. Ademas, ambos notaron diferencias distintivas en la población de peces del Río Sonoyta comparadas con la de los Pupos de Quitobaquito y consideraron a esta forma un eslabón entre *Cyprinodon macularius macularius* y *Cyprinodon macularius eremus*.

DISMINUCION DE LA POBLACION

Existen muchas razones para la disminución de las poblaciones de Pupo del Desierto dentro de las que se incluyen: pérdida de habitat (utilización de manantiales como abrevaderos o para riego, disminución de corrientes de agua de grandes cauces) modificación de habitat (arroyos confiscados, canalización, regulación de la cantidad de agua), contaminación e interacción con especies no nativas (competencia por alimento y espacio, además de depredación) (Miller y Fuiman, 1987).

Muchas localidades históricas en donde se distribuía el Pupo del Desierto, se han secado por el bombeo de agua subterránea, afectando tanto las reservas de manantiales como las de cauces superficiales (Fradkin 1981, Rea 1983); tal es el caso de la problemática del habitat de esta especie dentro de la reserva.

El 27 de junio de 1997 el propietario del rancho El Refugio-Agua Dulce (ubicado dentro de la zona de amortiguamiento de la reserva) (figura 1), denunció a los guardaparques que la porción del Río Sonoyta que atraviesa su propiedad, la cual siempre había tenido agua permanente, se estaba secando, lo cual trajo como consecuencia la mortalidad y la modificación del habitat de los Pupos del Desierto y de los Charalitos de Aleta Larga; ambas especies protegidas por ley.

Problemática

Para un país con tantas carencias como México, conservar se ha convertido en todo un lujo, sin embargo, es menester entender que de la conservación de los valiosos recursos con los que contamos depende el futuro del país.

Conservar a las especies de flora y fauna, incluída la subespecie de Pupo del Desierto que habita en una pequeña porción del Río Sonoyta, es uno de los objetivos primordiales por los cuales la reserva fué decretada.

Sin embargo el caracter de biosfera que se le dió, implica un sentido mas amplio y profundo de lo que la conservación debe ser: *el equilibrio inminente entre la cuestión social y la natural para el aprovechamiento sustentable de los recursos que nos rodean.*

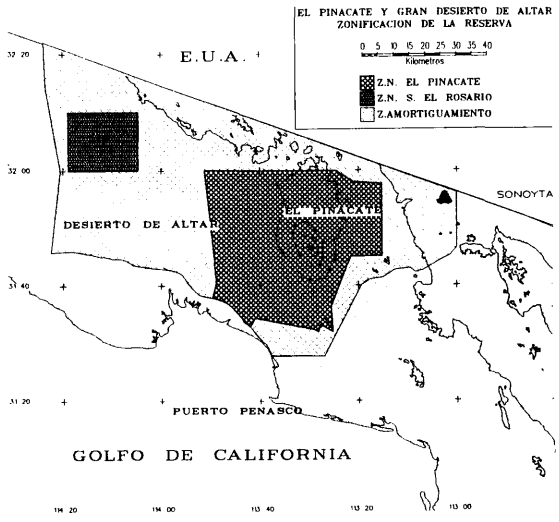


Figura 1. Ubicación del rancho El Refugio-Agua Dulce

La imperiosa necesidad de agua de todos los seres vivos, hace de aquellos ambientes que la poseen sitios mágicos; imanes naturales que no recuperaremos mientras carezcamos de una firme conciencia del agua y de lo que significa, sobre todo en un desierto como el Sonorense.

Asi pues, la extracción de arena y agua de los cauces de los rios como el Río Sonoyta, ubicado en uno de los desiertos mas áridos del mundo, provoca impactos que dificilmente serán mitigados, pues se pierden un recurso no renovable, y otro muy escaso, modificando ecosistemas vitales dentro del equilibrio natural.

En este caso, el problema va mas allá de una área protegida y los recursos que en ella se conservan: se trata también del medio de vida de comunidades locales y del desarrollo económico de todo un país.

En el primer caso, la pobre vocación de la tierra aunada a la escasez de agua obliga a los ejidatarios y pequeños propietarios de tierras dentro y fuera de la reserva, a consecionar los recursos de sus propiedades a cambio de recursos económicos y trabajo temporal, tal fué el caso de la comunidad del ejido Santo Domingo, a quienes una empresa privada contrató como mano de obra para extraer arena del cauce del Río y reparar la carretera Sonoyta-San Luis Río Colorado. Además las altas temperaturas del verano y la falta de agua fueron un buen pretexto para abrir pozos en los cuales pudiera abrevar el ganado. En el segundo caso resulta que la carretera federal No. 2 es la única vía que comunica el centro de la república mexicana con Tijuana, una de las ciudades mas transitadas del mundo y la principal en cuanto a importación y exportación se refiere, razón por la cual resulta de vital importancia la constante reparación de dicha vía de comunicación.

Las preguntas son pues: ¿Cuál es el punto medio entre la conservación de los recursos y el desarrollo? ¿Cuál sacrificar? ¿Cómo desarrollar uno sin perjuicio del otro? ¿Cómo pueden ser compatibles la forma de vida de los ejidatarios y los recursos naturales que los rodean? ¿Qué alternativas propone la reserva? ¿Cuáles las empresas que aprovechan los recursos? ¿Cuáles el gobierno que los regula? ¿Cuántas especies de plantas y animales estamos dispuestos a perder para siempre? Estas son algunas de las preguntas que constantemente debemos hacernos para no perder la compleja perspectiva existente entre la conservación, el desarrollo y lo que deseamos sea un verdadero aprovechamiento sustentable de los recursos naturales.

La conservación tiene un precio implícito, un precio que tenemos que pagar por seguir viendo nadar a los Pupos en su habitat, pero ¿Cuál es el precio? ¿Cuánto estamos dispuestos a pagar? Tal vez este precio sea permitir a mediano plazo la presencia en el sitio de especies introducidas como el ganado y el pino salado (*Tamarix Ramosissima*), pero ciertamente el

precio a pagar no será la irreversible modificación del habitat, la extracción desordenada e ilegal de agua o en el peor de los casos, la extinción de alguna especie.

La reserva dió seguimiento a la problemática dirigiendose oficialmente a dependencias como la Comisión Nacional del Agua y la Procuraduría Federal de Protección al Ambiente, la empresa privada, responsable de los daños ambientales ocasionados, dejó de extraer agua, los pozos hechos como abrevaderos para el ganado fueron cerrados y las lluvias llegaron, con lo cual la corriente de agua del cauce del Río logró restablecerse. Sin embargo, con la extracción de arena se modificó parte del cauce del Río Sonoyta, y con la de agua sobrevino la mortalidad de especies de peces bajo protección federal, impactos dificilmente reparables.

Propuestas

La protección de las especies es posible porque su distribución geográfica comprende los límites de una área natural protegida con decreto federal y por tratarse de una especie en peligro de extinción y además endémica. Pero las especificaciones de conservación en papel no son suficiente garantía para proteger a esta especie y su habitat, para ello es menester considerar los siguientes puntos:

1. El Pupo del Desierto y su habitat no pueden conservarse ni protegerse adecuadamente mientras los derechos de propiedad de la localidad donde se distribuye no estén bajo la responsabilidad de entidades responsables que aseguren la protección de la especie y su ambiente. Lo ideal sería que los derechos de propiedad estuvieran en manos de la federación, pero mientras esto sucede, se propone un acuerdo de colaboración entre la reserva y el propietario del rancho El Refugio-Agua Dulce (en donde se distribuye la especie), por medio del cual el propietario se comprometa a conservar a la especie en peligro y la reserva a buscar alternativas benéficas para ambas partes dentro de las que se incluyen el aprovechamiento de la madera del pino salado (*Tamarix ramosissima*), una especie introducida y distribuída en los márgenes del Río con altos requerimientos de agua que puede ser sustituída paulatinamente por especies nativas como el mezquite. El beneficio para el propietario sería el aprovechamiento de madera, y para la reserva la erradicación de una especie no nativa, la conservación del recurso hidrológico y la creación de habitats propios de la zona. El acuerdo también incluiría el manejo apropiado del ganado existentes en el rancho, el cual compite. Una alternativa podría ser buscar financiamiento para la construcción de abrevaderos de ganado y cercos que mantengan al ganado alejado del habitat del Pupo.

2. Al igual que en el caso de los derechos de propiedad, asegurar el suministro de agua al cauce del Río es una acción prioritaria. La corriente de agua superficial permanente del Río Sonoyta puede ser afectada por causas como desvío o interrupción de su cauce por aprovechamientos de arena para construcción, sobreexplotación de agua superficial y subterránea para ganado, riego de cultivos y aprovechamiento doméstico, o factores de caracter internacional como la retención de agua en presas por el gobierno estadounidense. Lo primero que procede es asegurar el suministro adecuado de agua para conservar el habitat del Pupo mediante mecanismos legales y derechos sobre el recurso. Estos son factibles y están contemplados en la Ley de Aguas Nacionales, la cual establece en el artículo 38 la posibilidad de establecer una zona de veda o declarar la reserva de aguas para proteger o restaurar un ecosistema. Por otro lado no puede perderse de vista la cercanía del poblado de Sonoyta y sus requerimientos de agua, así como los medios de subsistencia de los ejidatarios que incluyen agricultura tradicional y ganadería. En el caso del poblado de Sonoyta, la conservación del agua puede hacerse mediante campañas de concientisación para evitar su contaminación y despilfarro, en el caso de la agricultura y ganadería, la falta natural de agua en la zona hace poco redituables estas actividades que pueden remplazarse a mediano plazo con las alternativas de reconversión económica propuestas por la reserva.
3. Implementar la protección y el manejo de la especie a largo plazo a través de la reserva, garantizar la cantidad y calidad suficiente de agua, proteger la degradación del habitat, controlar y remover plantas y animales no nativos, prevenir la introducción de especies de peces no nativos, proteger el habitat contra la contaminación y modificar las prácticas de manejo de la tierra que deterioren o afecten el habitat del Pupo. Además se requieren estudios socioeconómicos de las comunidades que viven de los recursos relacionados con el habitat que queremos proteger (agricultura, ganadería, aprovechamiento de bagre, etc.).
4. La conservación de la especie solo se dará si existe el apoyo adecuado y disponible que incluya suficiente personal, equipo y financiamiento. Para ello la reserva deberá buscar el apoyo de instituciones nacionales e internacionales.
5. Se requiere información confiable que determine que el Pupo del Desierto que habita el Río Sonoyta es realmente una subespecie. Al respecto, un investigador del Centro de Investigaciones Científicas y

Tecnológicas de la Universidad de Sonora informó que pronto estarán los resultados de la investigación al respecto.

6. Se propone un programa de monitoreo mensual escrito y fotográfico para estimar el numero de organismos, sexo y talla, así como las condiciones del agua que incluyen cantidad y calidad de la misma mediante variables como temperatura, salinidad, oxígeno disuelto, materia orgánica, profundidad, área superficial, diversidad y abundancia de plantas, sustrato, especies de peces asociadas, etc.
7. La elaboración de programas informativos y educativos es necesaria para informar a los ejidatarios residentes, a los pobladores de Sonoyta y al público en general de la importancia y la fragilidad de la especie y su habitat. Estos programas pueden realizarse con el apoyo del Area de Educación de la reserva e incluir presentaciones con diapositivas y videos, elaboración de trípticos, sesiones escolares, pláticas con investigadores y conservacionistas, programas de radio, seminarios a empresas interesadas en extracción de arena y agua del cauce del Río y entrenamientos especiales a los comunitarios. La educación ambiental en este aspecto brinda la oportunidad al público en general de conocer mas sobre la especie, por qué está en peligro de extinción, su nivel dentro de un ecosistema y las implicaciones que causaría su extinción. Además el público puede apoyar activamente en la conservación si realmente llega a entender y a apreciar el valor de la especie.
8. Se propone también el establecimiento de un acuario en la Estación Biológica de la reserva con un doble objetivo: para cuestiones de educación y difusión y para investigación y monitoreo.

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RESEÑA BIOGRAFICA

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WILDLIFE MANAGEMENT

Wildlife as an Economic Staple: An Example from the San Carlos Apache Reservation

Brian Czech[1] and Luis A. Tarango[2]

Abstract.—The San Carlos Apache Reservation consists of 730,000 hectares in eastern Arizona, the majority of which is ecologically similar to portions of northern Sonora and, to a lesser extent, Chihauhau. To preserve, protect, and enhance wildlife populations, the San Carlos Recreation and Wildlife Department has found that it is very important to demonstrate the economic value of wildlife, and to capitalize thereon. Prior to construction of a casino on the reservation, approximately 15% of the general fund of the Tribe came from hunting, fishing, and recreation permits. Permit sales totaled about $1.1 million in 1994, including about $435,000 from big game tags. The Recreation and Wildlife Department was more profitable than the tribal cattle associations and ranches, suggesting that Mexican ranchers in some areas may profit by converting from cattle operations to wildlife or wildlife/cattle operations. Conversion entails a series of inventories, cattle carrying capacity adjustments, marketing, and sound wildlife harvesting principles. A higher ratio of plant:animal biomass is required for trophy wildlife production than for beef production. Converting from cattle to large mammal operations may result in improved range conditions, greater profit, and less work.

Resumen.—La Reservación Apache San Carlos localizada en la parte Este de Arizona consiste de una area de 730,000 hectareas. Para preservar, proteger y promover las poblaciones de fauna silvestre, El Departamento de Recreación y Fauna Silvestre ha encontrado que es muy importante demostrar el valor económico de la fauna silvestre y lograr una capitalización a partir de ésta. Antes de la construcción de un casino en la reservación, aproximadamente 15% de los ingresos de la tribu se originaban de la venta de permisos de caza, pesca y recreación. La venta de permisos en 1994 alcanzó $1.1 millones, de los cuáles $440,075 fueron de permisos de caza mayor. El Departmento de Recreación y Fauna Silvestre fue mas productivo que todas las asociaciones ganaderas y ranchos en la reservación. Estos datos

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indican que los ganaderos en el suroeste podrían obtener mas ganancias convirtiendo sus ranchos de una economía netamente ganadera a una donde se incluya la participación de la fauna silvestre. Dicha conversión incluiría una serie de inventarios, ajustes en la capacidad de carga, mercadeo y la aplicación de buenos principios de manejo y cosecha de las especies de fauna. Se requiere una relacíon de biomasa mas alta de plantas y animales para la producción de trofeos que para la producción de carne. La conversión de una economía netamente ganadera a una economía donde se incluyan especies mayores de fauna podría traducirse en mejores condiciones del rancho, mayor ganancia y menos trabajo.

INTRODUCTION

The San Carlos Apache Reservation consists of 730,000 hectares in eastern Arizona. Elevations on the reservation range from 580 meters to 2,500 meters above sea level, corresponding with plant communities from Sonoran Desert to mixed conifer forest. Extensive plains, rolling hills, rugged mountains, and deep canyons are found at all elevations. Therefore, the reservation has some of the most biodiversity of any contiguous landholding in the United States. Many of the plant communities found on the reservation are also found on ranches in northern Mexico, especially Sonora, and to a lesser extent, Chihauhau.

Approximately 250 species of birds and 75 species of mammals inhabit the reservation. Of primary economic importance are the 10 big game and 8 small game species (not including waterfowl). In addition to this variety, big game populations on the reservation are noted for high quality, as judged by horn, antler, and body sizes. The largest antlers ever recorded for elk (*Cervus elaphus)* were shed and found on the reservation in 1987, and the pending Boone and Crockett world record non-typical bull was taken in 1997. A state record desert bighorn sheep (*Ovis canadensis mexicana*) was taken in 1988, but the world record was taken in 1989 about a mile south of the reservation boundary. The Pope and Young world record Coues deer (*Odocoileus virginianus Couesii*) was taken on the reservation in 1988. Other record class animals that are taken on the reservation include pronghorn (*Antilocapra americana*), black bear (*Ursus americanus*), and mountain lion (*Felis concolor*).

Wildlife populations on the reservation are managed by the San Carlos Apache Tribe's Recreation and Wildlife Department (Czech 1990). The policies of this department are formulated by a Recreation and Wildlife Commission, consisting of five tribal members. Management via Commission has been recognized as a key to successful wildlife management on Indian reservations in the United States (Pearson 1989).

The San Carlos Recreation and Wildlife Department consists of a Law Enforcement Division, a Wildlife Management Program, an Information Branch, and a Planning Branch (Czech 1993). The goal of the Department is to preserve, protect, and enhance wildlife populations and their habitat on the reservation, for the benefit of the Tribe and for the benefit of the ecosystem itself.

ECONOMIC CHARACTERISTICS OF SAN CARLOS WILDLIFE MANAGEMENT

To preserve, protect, and enhance wildlife populations, the Recreation and Wildlife Department has found it very important to demonstrate the economic value of wildlife, and to capitalize on some of this value. Otherwise, the tribal government cannot justify adequate financial support for wildlife management activities on the reservation. The Recreation and Wildlife Department is one of the few profitable tribal enterprises. In 1994, approximately 15% (i.e., 1.1 million dollars) of the general fund of the Tribe came from the hunting, fishing, and other camping permits sold by the Department.

The most important revenue source is fishing, which brought in close to $550,000 in 1994. Most of the fishing occurs on the 2,300 hectare San Carlos Lake. The tribe is assisted in fisheries management by the U.S. Fish and Wildlife Service.

Almost as important to tribal revenue is big game, which accounted for approximately $440,000 of revenue in 1994 (Table 1). In 1993 the Department sold the three highest-priced elk tags in the United States, for $43,000 each. The demand for San Carlos elk hunts is due primarily to the records mentioned above. Other important game species include javelina (*Tayassu tajacu*) and turkey (*Meleagris gallopavo*). Mule deer (*Odocoileus hemionus*), potentially one of the most valuable big game species at San Carlos, are reserved entirely for tribal member hunting.

Small game permits bring in about $100,000 per year, with quail (*Callipepla* spp.) being the most popular. Trapping brings in $4,000 per year, and other types of outdoor recreation permit sales amount to $20,000.

ECOLOGICAL IMPLICATIONS OF MANAGING WILDLIFE FOR REVENUE; ELK AS A CASE STUDY

To grow trophy-sized animals of any species, every factor contributing to size must be present in an adequate amount. In the case of San Carlos elk, the basic mineral requirements are present in the soils and waters. San

Carlos winters are mild relative to those of other North American elk ranges (Thomas and Toweill 1982). Perhaps most importantly, the San Carlos Recreation and Wildlife Department manages for the optimum antler-producing social structure. The bull:cow ratio used is 70:100 as recommended by Bubenik (1988). Management for high quality is common among American Indian tribes (Eskew 1994, Czech 1995).

Elk and cattle are grazers and therefore direct competitors for feed. All else equal, the more elk desired, the less cattle can be grown. Assuming that the market for elk hunting is as stable as it appears, the replacement of a domestic cow with an elk cow is an economically wise move.

With cattle, the product is beef. With elk, the product is antlers. To produce beef, grass is required. To produce antlers, grass is required, and then muscle tissue. Antlers are analogous to a higher trophic level. They could be considered an ecosystem "luxury." A steer in lean condition can be sold, but the bull elk in lean condition will not grow a set of trophy antlers and will have little economic value. Therefore, the successful game rancher cannot allow the range to be overgrazed into as poor a condition as the cattle rancher can. The same principle applies to most big game animals. Having trophy wildlife as the primary product from a rangeland, then, will result in better range conditions and the corresponding ecological benefits.

Table 1. Revenue from big game permits sold on the San Carlos Apache Reservation in 1994.

Species	Revenue in dollars
Bear	40,325
Elk	160,000
Pronghorn antelope	5,000
Turkey	35,000
Coues deer	71,750
Javelina	107 ,500
Mountain lion	20,500

MARKETING HUNTS

Many hunting and fishing conventions, shows, and meetings are held in the United States. Examples include annual conventions of the Rocky Mountain Elk Foundation, the Foundation for North American Wild Sheep, and Safari Club International. These conventions commonly get 5,000 visitors in one weekend. Many of the booths are represented by

American outfitters who come to sell hunts. Some of these outfitters are ranchers as well. There are usually a few representatives from Mexico.

Annual conventions have auctions at which hunts are sold to the highest bidder. The most expensive hunting permits in the United States are sold at these auctions. For example, at the 1993 Convention of the Foundation for North American Wild Sheep, held in Reno, Nevada, a desert bighorn sheep tag was auctioned for $303,000. Four bighorn tags were sold at the auction for over $100,000 each.

ECONOMIC FRINGE BENEFITS OF CONVERTING A CATTLE OPERATION INTO WILDLIFE PRODUCTION

In addition to permit sales, other revenue opportunities exist in the production of wildlife that do not exist with the production of cattle. For example, the privilege of going into a rutting herd of elk with a camera is easier to sell than the privilege of going into a herd of cattle with a camera.

For every dollar spent on permit sales on the San Carlos Apache Reservation, about as much is spent on other items related to the outdoor experience. Many of the services that are purchased by outdoorsmen are not available on the reservation. If these services were available, tribal revenue would be higher.

Some of the most important goods and services that are purchased by outdoorsmen on the reservation include groceries, gasoline, guiding services, maps, and souvenirs. Unavailable goods and services in high demand include sporting goods such as binoculars, fishing poles, guns and ammunition, bait and tackle, and boat storage facilities.

Usually the traveling sportsman, especially the international trophy hunter, is wealthy enough to purchase expensive goods and services. The San Carlos Recreation and Wildlife Department has considered expanding its line of low-inventory, high-priced types of souvenirs such as paintings, sculptures, etc.

SUGGESTIONS FOR THE SONORAN RANCHER

As a prerequisite to converting cattle forage to wildlife production, the rancher should check on the availability of hunting licenses and tags for the area encompassing the ranch. The rancher will be selling access to the ranch, and perhaps services related to the hunt, but only the Secretaría del Medio Ambiente Recursos Naturales y Pesca (Secretary of the Environment, Natural Resources, and Fisheries) has the authority to sell hunting licenses and tags. If there is a closed or highly restrictive hunting regime,

then it may not be economically feasible to convert from cattle to wildlife production. Normally it will be feasible, however, and we recommend the following steps to diversify a typical Sonoran ranch to include the marketing of hunts:

1. Make a rough inventory of the big game and small game populations on the ranch.
2. Make a rough inventory of the carrying capacity for game species. Ranchers who find this task implausible may request assistance from a government biologist, or hire a wildlife consultant.
3. Estimate how much competition each game species will have with cattle, and adjust stocking rates according to the ratio of cattle:wildlife desired. For example, the culling of one adult cow may increase carrying capacity by 6-7 mule deer (Holechek 1988). When range is overgrazed, however, more than the equivalent share of cattle should be culled, because better range conditions are needed to make money from wildlife.
4. Determine what portion of the hunting market is to be targeted. Examples include "world class trophy hunter," "record book trophy hunter," "mixed bag hunter," "Mexican experience hunter," etc.
5. Estimate the sustained annual yield for each of the species, given the market targeted. For those beginning a hunting operation, a greater number of good quality hunts may be more effective at building a clientele than a slight number of top quality hunts.
6. Market the hunts using the technique most appropriate for that portion of the market targeted. For example, to sell a small number of highly priced hunts, conventions of elite hunting groups should be visited. To sell a greater number of lesser-priced hunts, conventions that cater to blue collar hunters are more productive. The rancher will not be selling hunting licenses or tags, but access or opportunities to hunt.
7. Sell hunting opportunities according to the sustained annual yield estimate derived in step #5. Ranchers who hunt may want to guide the hunts and therefore obtain more of the profits.

SOME AMERICAN ORGANIZATIONS THAT MAY OFFER HELP

Large outdoor groups such as the National Wildlife Federation, Rocky Mountain Elk Foundation, and Ducks Unlimited offer financial assistance for landowners that are going to conduct habitat improvement projects for wildlife. These groups may provide assistance to ranchers who intend to

convert cattle forage to wildlife production. Gordon (1997) provided a directory of conservation organizations in the United States.

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BIOGRAPHICAL SKETCH

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Densidad y Diversidad Estacional de una Comunidad de Roedores en la Provincia Biótica Tamaulipeca, Nuevo León, México

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Abstract.—The lack of ecological knowledge of the Mexican Tamaulipan Province encouraged us to determine the composition, diversity, and density of the rodent community in a desert schrub habitat in Northeastern Mexico. During 1997, small mammals were captured with Sherman traps. We selected two study sites, one fenced with deer proof mesh. Density was calculated using NOREMARK software. Diversity was estimated using the inverse of Simpson´s index (N2). We used two quadrants with one replica to quantify the community structure. To date we have recorded 8 species: *Chaetodipus hispidus, Dipodomys merriami, Perognathus flavus, Neotoma albigula, Onychomys leucogaster, Peromyscus eremicus, Sigmodon hispidus*, and *Spermophilus mexicanus*. The dominant species were *Sigmodon hispidus* (13 ind/ha), *Dipodomys merriami* (11 ind/ha), and *Peromyscus* sp. (9.9 ind/ha). Rare species were *Neotoma albigula* (1.81 ind/ha) and *Spermophilus mexicanus* (1.43 ind /ha). Seven species were nocturnal, one diurnal (*S. mexicanus*) and one active through day and night (*Sigmodon hispidus*). Overall diversity was higher for the dry season (N2=6.60) than the wet one (N2=5.28). Density for most species (n=7) is increased during the wet season, only *Sigmodon hispidus* shows variation along the year.

Resumen.—La escasez de conocimiento ecológico sobre el ecosistema de la Provincia Biótica Tamaulipeca nos motivó a determinar la composición, diversidad y densidad de la comunidad de roedores en un matorral xerófilo en el Noreste de México. Durante 1997 realizamos trampeos en dos sitios seleccionados, uno de ellos protegido con cerca venadera. La densidad de roedores fue calculada con el programa NOREMARK. La diversidad fue estimada usando el inverso del índice de Simpson (N2). Se muestrearon dos cuadrantes con una replica cada uno para determinar la estructura de la comunidad. Hemos registrado 8 especies: *Chaetodipus hispidus, Dipodomys*

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merriami, Perognathus flavus, Neotoma albigula, Onychomys leucogaster, Peromyscus eremicus, Sigmodon hispidus y *Spermophilus mexicanus*. Las especies dominantes fueron *Sigmodon hispidus* (13 ind/ha), *Dipodomys merriami* (11 ind/ha) y *Peromyscus* sp (9.9 ind/ha). Las especies raras fueron *Neotoma albigula* (1.81 ind/ha) y *Spermophilus mexicanus* (1.43 ind/ha). Siete de las especies son nocturnas, una diurna (*S. mexicanus*) y otra es activa día y noche (*Sigmodon hispidus*). La diversidad fue mayor en la época seca (N2= 6.60) que en la de lluvias (N2=5.28). Para la mayoría de las especies, la densidad aumenta durante la época de lluvias, y solamente *Sigmodon hispidus* mostró variación a lo largo del año.

INTRODUCCION

El grupo de los roedores es el mas numeroso y diverso de los vertebrados terrestres y se encuentra distribuido en todo el mundo. Los estudios ecológicos y evolutivos que se han realizado sobre roedores en zonas áridas de México y Norteamérica se han enfocado en la selección de semillas por *Dipodomys merriami* y *Perognathus penicillatus* (Smigel y Rosenzweig, 1974) y estudios generales sobre la comunidad de roedores desertícolas del Bolsón de Mapimí (Serrano, 1987). Además de los estudios de Brown (1975), Rogovin y Surov (1992), Rogovin *et al.* (1992a., 1992b), Sokolov *et al.* (1992), Lomolino (1993) y González-Romero (1986, 1995) que analizaron aspectos de la estructuración de las comunidades de roedores desertícolas. En México se han realizado relativamente pocos estudios orientados a conocer y entender la dinámica de las comunidades de roedores en zonas áridas y semiáridas, por lo que el presente estudio esta enfocado a conocer como se comportan las poblaciones de roedores en un área localizada en una zona de transición de las provincias Bióticas Tamaulipeca y desierto Chihuahuense.

Area de estudio

El presente estudio se realizó durante el año de 1997 en el rancho San Francisco, que pertenece a Ducks Unlimited de México, A.C, ubicado en el Noreste de México. El área se localiza entre los limites de los municipios de Lampazos, Nuevo León y Progreso, Coahuila, dentro de las coordenadas 27° 19' 36" y 27° 22' 24" latitud Norte y 100° 36' 23" y 100° 39' 01" longitud Oeste (Herrera, 1993), con una altitud promedio de 430 m (Stewart, 1992). El rancho tiene una superficie de 1500 ha. Del área total, 1000 ha están delimitadas por cerca venadera y están dedicadas al estudio y conservación del venado cola blanca texano. La vegetación de la zona esta representada por matorral xerófilo (Rzedowski, 1978). Briones (1984)

identificó siete tipos de comunidades vegetales para el municipio de Lampazos, de los cuales seis se presentan en la zona de estudio: pastizal de zacate toboso (*Hilaria mutica*), matorral bajo inerme de *Fluorensia cernua*, Matorral mediano subinerme de *Leucophyllum frutescens- Acacia rigidula*, matorral mediano subinerme de *Acacia-Prosopis-Fluorensia Larrea*, matorral mediano espinoso de *Prosopis glandulosa-Acacia farnesiana* y matorral alto espinoso de *Prosopis glandulosa-Acacia farnesiana*.

METODOLOGIA

Los muestreos de roedores se realizaron en 4 áreas de una hectárea y fueron establecidos en la comunidad vegetal de *Prosopis glandulosa-Acacia farnesiana* que es la asociación vegetal que ocupa la mayor superficie dentro del rancho (546 ha). Dos de los cuadrado se establecieron dentro del cercado de 1000 ha dedicadas al manejo del venado cola blanca y los dos cuadrados restantes se colocaron fuera de éste cercado. En cada cuadrado se marcó una rejilla colocando una trampa Sherman cada 20 metros, quedando 6 trampas Sherman por línea y 6 por columna, haciendo un total de 36 trampas en cada área de muestreo. El establecer los cuadrados dentro y fuera de la malla, fue con el propósito de comparar ambas áreas ya que, en el área fuera del cercado además de venados, existe un pastoreo por ganado vacuno y es de suponer que las características del sitio tendrían que ser diferentes a las de la zona dentro del cercado en donde el pastoreo lo realiza solamente el venado. El objetivo de establecer estas áreas fue el determinar si existen diferencias en la estructura y densidades poblacionales de roedores debido al pastoreo de los diferentes herbívoros y predecir que es lo que causa estas diferencias en caso de que existan.

Cada muestreo fue realizado por un periodo de 3 noches consecutivas por cuadrado, los individuos se capturaron vivos utilizando trampas Sherman. Se realizó un total de 432 noches trampa/sitio/salida. Los animales capturados se identificaron, pesaron, sexaron y marcaron de manera temporal (con tinta indeleble para facilitar el manejo de los animales durante el muestreo) y permanente para llevar un registro de los individuos en el tiempo. Después de registrar la información de cada individuo, estos fueron liberados *in situ*.

La densidad de roedores fue calculada con ayuda del programa Noremark (White, 1996) y la diversidad de la comunidad de roedores fue estimada mediante el inverso del índice de Simpson usando el paquete estadístico Statistical Ecology (Ludwig y Reynolds, 1988).

RESULTADOS

En los cuadrados se capturaron 8 (50 %) de las 16 especies con registros en el área (González-Romero, 1997), un sciúrido: la ardilla de tierra mexicana (*Spermophilus mexicanus*), tres heterómidos: la rata canguro (*Dipodomys merriami*), el ratón de bolsas (*Chaetodipus hispidus*), el ratón de bolsas enano (*Perognathus flavus*) y cuatro múridos: la rata nopalera (*Neotoma albigula*), el ratón chapulinero (*Onychomys leucogaster*), el ratón de los cactos (*Peromyscus eremicus*), la rata jabalina (*Sigmodon hispidus*).

Con un total de 2592 noches/trampa capturamos 592 roedores y tuvimos 763 recapturas durante el año de 1997. De este total el 55.74% de las capturas estuvo representado por especies de la familia Muridae (4 especies), el 40.37% por la familia Heteromyidae (3 especies), y el 3.88 restante correspondió a la familia Sciuridae (1 especie).

De los registros de capturas totales, *Sigmodon hispidus* y *Peromyscus eremicus* fueron las especies que presentaron un mayor porcentaje de los individuos capturados (22.80% y 19.59% respectivamente). En orden decreciente *Chaetodipus hispidus* y *Dipodomys merriami* presentaron valores similares (16.21% y 14.35%). *Perognathus flavus* y *Onychomys leucogaster* fueron de las especies con bajas capturas (9.79% y 8.44%), aunque las especies que registraron las capturas mas bajas del muestreo total anual fueron *Neotoma albigula* (4.89%) y *Spermophilus mexicanus* (3.88%).

En cuanto a las épocas seca y de lluvias no hubo variación en la diversidad de especies dentro y fuera de la malla. En general la densidad para las distintas especies se mantuvo estable tanto dentro como fuera de la malla en la época de secas, y se presentó poca variación en la densidad dentro y fuera de la malla para la época lluviosa. En la comparación anual, *Dipodomys merriami* mostró una densidad mayor fuera de la malla y *Sigmodon hispidus* mostró mayor densidad dentro, las especies restantes mostraron muy poca variación.

Densidad poblacional

Entre las especies dominantes a lo largo del año, destacó la presencia de *Sigmodon hispidus* (13.0 ind/ha). Es interesante mencionar que en los dos primeros muestreos que fueron realizados en la zona durante la época seca, esta especie estaba prácticamente ausente en las áreas de muestreo. Por lo menos durante los meses de febrero y abril las capturas de individuos de la especie fueron bajas. Para el mes de junio la población se vio incrementada, alcanzando un máximo de 23 ind/ha en el mes de agosto. *Dipodomys merriami* que es una especie característica de las zonas áridas, también tuvo cierta dominancia, aunque menor que la rata jabalina. Para esta especie se registró una densidad promedio de 11 ind/ha a lo largo del año. Esta especie mostró poca variación poblacional a lo largo del periodo de estudio. Al comparar las densidades de esta especie dentro y fuera de la malla, se esperaba que la densidad fuera mayor dentro del cercado que fuera del mismo, pero contrario a

esto, la densidad fue ligeramente mayor fuera del cercado que dentro (fuera= 13.2 ind/ha, dentro= 8.91 ind/ha).

El ratón de los cactos (*Peromyscus eremicus*) estuvo presente en todos los muestreos y en las cuatro áreas establecidas y las densidades variaron poco a lo largo del año. La densidad para esta especie fue en promedio de 9.9 ind/ha. *Chaetodipus hispidus* tuvo una densidad promedio de 7.4 ind/ha a lo largo del año., y las especies que mostraron densidades mas bajas fueron *Perognathus flavus* (2.9 ind/ha), *Neotoma albigula* (1.81 ind/ha) y *Spermophilus mexicanus* (1.43 ind/ha).

Los patrones reproductivos de las especies son importantes para entender los cambios en la densidad y la composición de las comunidades. La mayoría de las especies mostró actividad reproductiva a lo largo del estudio, se sabe que algunas de las especies están activas durante todo el año (*Chaetodipus hispidus*, *Peromyscus eremicus*) (Davis y Schmidly, 1994). Los periodos en que encontramos actividad reproductiva de las especies fue en los muestreos de febrero, abril, junio y agosto. Durante la temporada de lluvias también registramos actividad reproductiva para casi todas las especies, excepto para *Neotoma albigula*. Fue en el mes posterior a las lluvias que encontramos hembras lactantes de esta especie..

La densidad poblacional para la mayoría de las especies se ve incrementada durante la temporada de lluvias y decrece cuando la estación seca progresa. Así algunas de las especies como *Chaetodipus hispidus* y *Sigmodon hispidus* mostraron picos poblacionales durante las lluvias pero otras se mantuvieron casi estables a lo largo del ciclo anual (*D. merriami*, *P. flavus*, *O. leucogaster*). La mayoría de las especies (*D. merriami, P. flavus*, *N. albigula, O. leucogaster*, *S. hispidus*) no mostraron diferencias significativas en cuanto a densidades a lo largo del tiempo. Pero las tres especies restantes (*C. hispidus*, *P. eremicus* y *S. mexicanus*) si mostraron diferencias significativas en sus densidades a lo largo del año (F= 2.787, P= 0.049., F= 3.612, P= 0.019., H= 17.29, P= 0.004 respectivamente).

Al comparar las densidades de las especies dentro y fuera de la malla, no se encontraron diferencias significativas para 6 de las especies. Solamente dos de ellas: *D. merriami* y *S. hispidus* mostraron diferencias significativas en cuanto a las densidades a lo largo del año. En general la densidad para las distintas especies se mantuvo estable tanto dentro como fuera de la malla a lo largo de la época de secas y se presentó poca variación dentro y fuera de la malla para la época lluviosa. En la comparación anual, *Dipodomys merriami* mostró una densidad mayor fuera de la malla y *Sigmodon hispidus* mostró mayor densidad dentro, las especies restantes mostraron muy poca variación en cuanto a la presencia de la cerca.

En cuanto a la biomasa, la mayoría de las especies no mostró una variación significativa durante el año de muestreo. Solamente dos de las especies, un múrido (*Peromyscus eremicus*) y un sciúrido (*Spermophilus mexicanus*) mostraron variación significativa en cuanto a la biomasa a través del tiempo (F= 4.107, P= 0.012., H= 17.167, P= 0.004 respectivamente). En cuanto a la comparación de la biomasa dentro y fuera del cercado, no se encontraron diferencias significativas durante el periodo

de estudio. La especie que aportó mayor biomasa a la comunidad a lo largo del año fue *Sigmodon hispidus*, la especie con menor aporte de biomasa fue *Perognathus flavus*. Al examinar los porcentajes de densidad y biomasa de las especies que componen la comunidad de roedores en la zona, puede notarse que *Sigmodon hispidus* y *Dipodomys merriami* contribuyen de manera importante en cuanto a densidad y biomasa. Podemos apreciar que a pesar de que *Neotoma albigula* y *Spermophilus mexicanus* presentan densidades bajas, su aporte de biomasa es importante para la comunidad. Por otra parte, *Peromyscus eremicus* y *Chaetodipus hispidus* son especies que presentan densidades no tan bajas pero el aporte en biomasa es bajo debido a su poco peso.

Riqueza y diversidad

A nivel de comunidad, la riqueza de especies en el área de estudio se mantuvo constante durante el año (ocho especies). Solamente en los primeros muestreos (febrero, abril) la riqueza fue de siete especies. Respecto a la diversidad de especies, esta fue mayor en la época seca (N2= 6.60) que en la época de lluvias (N2= 5.28).

En cuanto a que tan similares o diferentes se comportaban los grupos faunísticos a lo largo del año, se determinó que los grupos a lo largo del tiempo fueron muy similares de acuerdo al índice de disimilitud de Bray-Curtis (Cuadro 1). Respecto a si existían diferencias en cuanto a época seca y lluviosa, dentro y fuera del cercado, la composición de especies fue muy similar en ambas épocas y dentro y fuera del cercado (secas dentro/fuera PD= 0.20, lluvias dentro/fuera PD= 0.13). Respecto a la composición anual dentro y fuera tampoco hubo diferencias marcadas (dentro/fuera PD= 0.16).

Tabla 1. Matriz de disimilitud de las especies de roedores a lo largo de un año.

	Abril	Junio	Agosto	Octubre	Diciembre
Febrero	0.30	0.30	0.46	0.36	0.34
Abril		0.35	0.36	0.40	0.33
Junio			0.25	0.23	0.17
Agosto				0.28	0.25
Octubre					0.13
Diciembre					0

DISCUSION

La temporada de secas en la zona comúnmente inicia en el mes de mayo, pero el año de 1997 se presentó un cambio poco común en el clima. De manera inesperada se presentaron algunas lluvias fuertes en la zona durante el mes de abril, lo que ocasionó que hubiese cambios en la composición vegetal de la zona y por lo tanto en los patrones de distribución de los recursos y en la actividad de los animales.

El aumento en la densidad de población de *Sigmodon hispidus* coincidió con la llegada de las lluvias y a la vez con el aumento de la cobertura de pastos en el área. En la zona esta especie está muy relacionada con áreas de pastos altos (*Hilaria mutica*), que son abundantes en la época lluviosa, pero que en la época de secas son poco comunes. Al llegar las lluvias se incrementa la cobertura y biomasa de pastos, entonces *Sigmodon* tiene disponible el recurso alimentario en gran cantidad, ademas de refugio y área para anidamiento; por lo que las condiciones de esa época del año fueron propicias para que esta especie fuera mas abundante y a la vez mostrara cierta dominancia sobre las especies restantes.

Con respecto a la familia Heteromyidae, se sabe que las especies de esta familia tienen hábitos de almacenamiento de semillas de plantas anuales y que son muy dependientes del banco de semillas favorecido por las lluvias (Bowers, 1990., Kotler y Brown, 1990., Reichman y Price, 1993). *Dipodomys merriami* mostró dominancia sobre las otras especies, debido quizás a la capacidad de esta especie para sobrevivir por largos periodos a base de semillas secas sin consumir agua en forma directa, por lo que sus densidades aparentemente no son dependientes de la lluvia. Aunque *Perognathus flavus* tiene esta misma capacidad, las densidades de esta especie fueron bajas, posiblemente esto se deba a que esta especie consume menos semillas de anuales y más de las plantas perennes como se ha observado en otras partes, y también puede ser debido a que es una especie que hiberna por varias semanas o meses (Brown, 1989). *Chaetodipus hispidus* mostró cierta variación a lo largo del año, la cual se vio incrementada ligeramente durante las lluvias, mostrando quizás cierta dependencia de las semillas de plantas anuales.

Las altas densidades registradas durante la temporada de lluvias pueden estar relacionadas con el aspecto reproductivo de las especies, varias de las especies de la comunidad de roedores tienen actividad reproductiva, por lo que la población se ve incrementada con el nacimiento de las crías y con el reclutamiento de los juveniles. *Sigmodon hispidus*, fue una de las especies con densidades mas altas durante la época lluviosa, debido quizás no solo a que es una especie prolífica (en promedio 5 crías por camada) sino a que sus crías son precoces (Davis y Schmidly, 1994). Esta especie puede presentar fluctuaciones drásticas ya que depende de un hábitat adecuado el cual a su vez depende de la cantidad de lluvia, como pudo apreciarse en este estudio la densidad de esta especie durante la época seca es baja.

Al comparar el presente estudio con los realizados por Brown (1989) y Rogovin *et al* (1992) en Mapimí y Arizona, se encontró que los sitios comparados compartieron algunas especies y que las densidades registradas en Nuevo León, son en general mayores que las reportadas para Mapimí y Arizona. Quizás esto sea debido a que las condiciones climáticas en Nuevo León son menos extremosas que en los otros sitios comparados., ya que aun cuando la sequía se prolongó, algunas especies de plantas se encontraban floreciendo. A pesar de que podría decirse que las características de las áreas dentro y fuera del cercado son distintas, esto parece no afectar de manera drástica a la comunidad de roedores ahí presente. Solamente

Sigmodon hispidus registró una densidad mayor dentro del cercado, pero esto puede deberse a que la cobertura de pastos dentro es mayor que en los cuadrantes fuera del cercado.

En general la biomasa de especies de la comunidad se mantuvo estable a lo largo del año, sin embargo dos de las especies registradas (*Peromyscus eremicus* y *Spermophilus mexicanus*) mostraron una variación significativa en cuanto a la biomasa que representaron (F= 4.107, P= 0.012., H= 17.167, P= 0.004). La diferencia que existe respecto a *Spermophilus* puede ser debida mas a un efecto de muestreo que a razones propias de la especie o de las condiciones del ambiente. Los primeros muestreos realizados en la zona no se capturaron individuos de esta especie debido a que por razones practicas las trampas fueron dejadas cerradas durante el día que es cuando tiene actividad esta especie, esto se hizo debido a que las temperaturas en la zona eran demasiado altas y en algunas ocasiones se encontraron a los animales muertos, debido a que tanto el suelo como la trampa se calentaban demasiado lo que ocasionaba la muerte del animal.

Sigmodon hispidus fue una especie con un aporte importante de biomasa y también fue la que presentó mayor densidad a lo largo del año, la presencia de esta especie dentro de la comunidad como una presa potencial para los depredadores parece ser de gran importancia debido a su biomasa. Otra especie con aporte de biomasa importante fue *Dipodomys merriami.* Aunque las densidades registradas para *Neotoma albigula* y *Spermophilus mexicanus* no fueron muy altas en el presente estudio, se considera que la biomasa que pueden aportar es importante. El que estas especies no hayan tenido densidades altas no indica que no seas abundantes en la zona, es posible que debido al shock que les produce el caer en las trampas les haya provocado trampofobia, contrario a lo que ocurrió con otras especies como *Dipodomys merriami* que presentaron trampofilia.

CONCLUSIONES

No se presentaron fluctuaciones poblacionales drásticas a lo largo del periodo de estudio.

La comunidad de roedores no mostró cambios a lo largo del año, y parece no ser afectada por las practicas de manejo del ganado y del venado. Al parecer las diferencias en cuanto a las características entre el área cercada y abierta no son tan distintas como para provocar cambios en las poblaciones de roedores.

La lluvia parece ser un factor que causa cambios en las densidad poblacional de las especies de roedores. Esto puede verse especialmente en las especies que dependen en gran parte de la vegetación verde y las disponibilidad de plántulas para su alimentación como *Sigmodon hispidus*.

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SKETCH BIOGRAFICO

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Survival of Gould's Turkey Transplanted into the Galiuro Mountains, Arizona

Brian F. Wakeling[1]

Abstract.—Gould's turkeys (*Meleagris gallopavo mexicana*) were captured near Yecora, Sonora, Mexico, radio-marked, disease tested, and free-released into the Galiuro Mountains, Arizona, during the winter of 1994 and 1997. No diseases were detected. I examined the survival rates of turkeys following these releases to determine if age, gender, or holding time influenced survival. Survival rates did not differ among age and gender classes, but were lower for all age and gender classes within the first 2-3 months following release. No age, gender, or holding time class survived at rates superior to any others. I recommend that turkey transplants into habitats that expect high initial mortality should have even age and gender ratios to maximize probability of success. Translocation time should be reasonable and prudent so that periods of captivity in which turkeys lack food and water are minimized. The number of turkeys released into a habitat should be large enough so that a substantial number will survive the period of initial high mortality. Additional releases may be needed in subsequent years to establish self-sustaining turkey populations.

Resumen.—Guajolotes Silvestres (Gould) (*Meleagris gallopavo mexicana*) fueron capturados cerca de Yecora, Sonora, México, marcados con radios transmisores, examinados para enfermedades y liberados en las montañas Galiuro, Arizona durante los inviernos de 1994 y 1997. No se detectaron enfermedades. Examiné tasas de supervivencia despues de liberar Guajolotes para determinar si edad, sexo, ó tiempo de detención en captividad influyeron la supervivencia de los Guajolotes. Tasas de supervivencia no se distinguieron entre edad y sexo pero si fueron mas bajas para todas las edades y ambos sexos durante los primeros 2-3 meses despues de ser liberados. No hubo diferencias en supervivencia entre edades, sexo o tiempo de detención. Yo recomiendo que transplantes de Guajolotes a hábitats donde se anticipa alta mortalidad inicial deben tener Guajolotes con proporciones similares de edad y sexo para asegurar alta probabilidad de éxito. Tiempo de detención y transporte debe ser razonable y prudente para reducir el período que los Guajolotes

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pasan sin agua y alimento. El número de Guajolotes liberados debe ser suficientemente grande para asegurar que un número substancial sobrevive el período inicial de alta mortalidad. En años subsecuentes, es posible que mas transplantes de Guajolotes tendrán que ocurrir para establecer poblaciones que se bastan a si mismas.

INTRODUCTION

Multiple efforts have been made to reestablish Gould's turkey to its former range in southern Arizona. Initial efforts in 1983 and 1985 to reestablish a population of Gould's turkey within the Huachuca Mountains along the U.S.-Mexican border met with obstacles when >55% of the birds died during a mandatory 30-day quarantine period following their translocation from Chihuahua, Mexico (Breland 1988). This quarantine was substantially longer than time periods which turkeys are held for most trap-and-transplant programs. As a result of the high mortality during quarantine, only 21 turkeys were released (9 in 1983, 12 in 1985) (Breland 1988). This reestablishment effort was further exacerbated when suspicions of the continued presence of Merriam's turkeys (*M. g. merriami*), from a prior release, arose following release of the surviving Gould's turkeys into the Huachuca Mountains. Current population estimates for the Huachuca Mountains are 50-90 birds (J. Millican, Ariz. Game and Fish Dep., pers. commun., S. Stone, Fort Huachuca Army Garrison, pers. commun.). Despite the limited success of the reestablishment effort, concerns about high mortality during the quarantine period halted further efforts at trap-and-transplant activities to reestablish Gould's turkey into Arizona from Mexico (R. Engel-Wilson, Ariz. Game and Fish Dep., pers. commun.).

Trap-and-transplant programs have contributed substantially to the recovery of the nation-wide turkey population from a low during the 1920s to its current status of huntable populations in 49 states today (Kennamer et al. 1992). Trap-and-transplant techniques employ the capture of free-ranging turkeys via drug consumption, funnel-entrance traps, box traps, drop nets, or rocket or cannon nets (Baldwin 1947, Glazener et al. 1964, Williams 1966, Bailey et al. 1980), and rapid translocation of captured turkeys to a suitable release site where they are free-released into the wild. This technique has proved far more successful in establishing and augmenting turkey populations than has efforts to do so with pen-reared turkeys (Bailey and Putnam 1979).

In 1994, a plan to temporarily eliminate the need for the mandatory quarantine period when crossing the U.S.-Mexican border with turkeys was implemented. Efforts to reestablish Gould's turkeys into Arizona

were reinitiated. Free-ranging Gould's turkeys were captured near Yecora, Sonora, Mexico, and free-released into the Galiuro Mountains in south-central Arizona. Twenty-one turkeys were released in February 1994, and 46 more were released in January and February 1997.

Because several factors differed between the 1994 and 1997 releases, I evaluated the survival of Gould's turkeys post-release to determine if those factors influenced survival rates. My objective in this study was to examine survival rates following release and determine if age, gender, or holding time influenced those rates. My ultimate objective was to recommend suitable changes to future trap-and-transplant procedures to maximize the probability of success.

STUDY AREA

Gould's turkeys were released near High Creek (at Knob Tank) in the Galiuro Mountains, in south-central Arizona, during February 1994 and January and February 1997. The Galiuro Mountains are steep and broken, containing narrow, deep canyons and rugged cliffs at higher elevations. The area turkeys explored following release encompassed about 1,100 km^2. Elevations ranged from 750 to 2,300 m. The study area was composed of madrean evergreen woodland (49.3% of area), semidesert grassland (39.4%), interior chaparral (6.3%), plains and great basin grassland (3.2%), and petran montane conifer forest (1.7%) (Brown et al. 1979). Ponderosa (*Pinus ponderosa*) and Chihuahuan pine (*P. leiophylla*) are common in higher elevations and canyons, as are Douglas-fir (*Pseudotsuga menziesii*). Aspen (*Populus tremuloides*) occurred, but only within Ash Creek. Numerous oaks (*Quercus gambelii, Q. turbinella, Q. emoryi, Q. oblongifolia*) were common throughout the mountain range, as was juniper (*Juniperus deppeana, J. monosperma*). Pinyon pine (*Pinus edulis*) occurred only in the northern portion of the mountain range. Grasslands occurred mainly in lower elevations between mountain ridges.

METHODS

I radio-marked each turkey with a motion-sensing telemetry unit (Model LB-400, Telonics, Inc., Mesa, Ariz.) prior to release. A cloacal swab was taken from each turkey and used to test for the presence of avian influenza and Newcastles' disease. Fecal samples were tested for salmonella. During 1994, all turkeys were free-released after translocation (about 95 hrs after capture) at the Knob Tank-High Creek release site. All 21 turkeys (12 adult female, 9 subadult male) were free-released on February

2, 1994. In 1997, turkeys were free-released in 8 separate events (Table 1) at the Knob Tank-High Creek release site (<48 hrs after capture).

Table 1. Date, age and gender composition, and approximate holding time for Gould's turkeys released into the Galiuro Mountains, Arizona, 1997.

Release date	Age and gender composition	Approximate holding time
Jan 10, 1997	2 adult female	48 hrs
Jan 23, 1997	4 subadult male, 1 adult female	24 hrs
Jan 24, 1997	2 adult male	24 hrs
Jan 27, 1997	2 subadult male, 4 subadult female, 6 adult female	24 hrs
Jan 30, 1997	1 adult female	48 hrs
Feb 5, 1997	11 adult male	24 hrs
Feb 11, 1997	5 adult female	24 hrs
Feb 12, 1997	2 subadult female, 6 adult female	24 hrs

I aerially monitored radio-marked turkeys >1X monthly to document their survival following release. I visually monitored females during June through September at infrequent intervals to determine if they had successfully nested and brooded young. Survival data was evaluated using MICROMORT (Heisey and Fuller 1985). I evaluated survival rates by monthly time intervals and combined those months with survival rates that did not differ ($P \leq 0.05$) using a Z test (Heisey and Fuller 1985). I used Z tests to conduct pairwise comparisons to determine if survival rates differed by age and gender.

RESULTS

Disease tests isolated no positive cultures for any of the pathogens tested for. All turkeys captured and tested from the Yecora, Sonora, Mexico population during 1994 and 1997 showed no exposure to avian influenza, Newcastles' disease, or salmonella.

Following the first release effort in 1994, turkeys suffered substantial mortality before reproduction could occur. All subadult male turkeys released during 1994 died within the first 2 months following release. I was unable to detect any nesting attempts by adult females during spring 1994. By the end of August 1994, only 7 female turkeys remained alive. By June 1995, 4 females remained alive. The last female died in October 1996.

The second release effort in 1997 suffered similarly high initial mortality. By June 1997, 9 turkeys (1 adult male, 2 subadult males, 5 adult females, and 1 subadult female) remained alive. Although I was again unable to detect any nesting attempts during spring of 1997, frequency of turkey mortalities declined. By January 1998, only 1 additional adult female died.

When evaluating survival rates, I detected no differences ($P > 0.10$) between the first and second release efforts. Consequently, I pooled monthly survival rates across years. Monthly survival rates for all age and gender classes exhibited similar trends during monthly time intervals

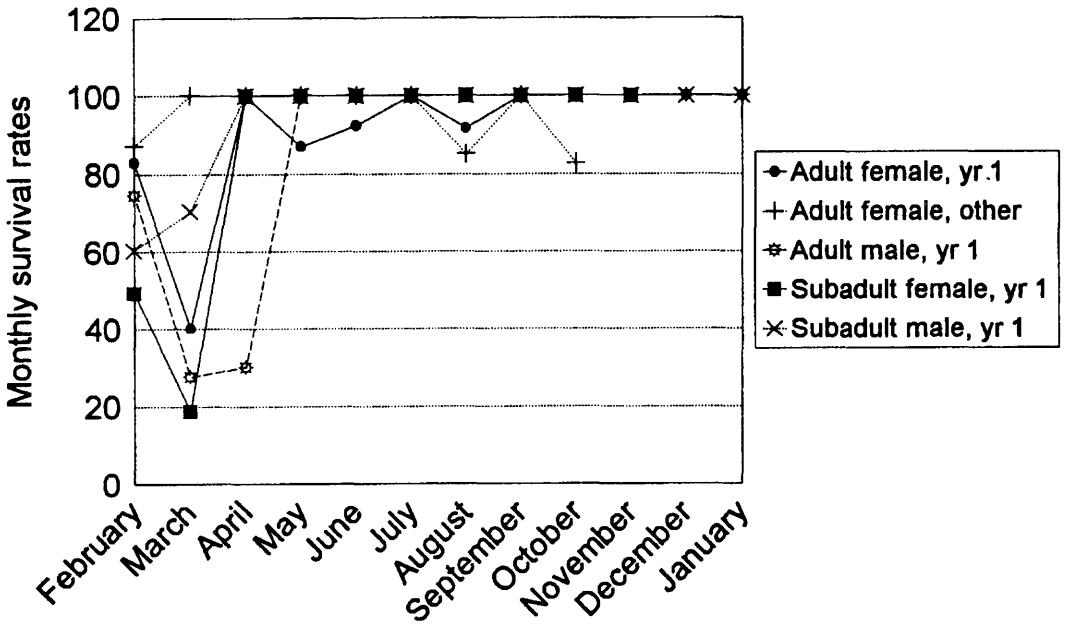


Figure 1. Monthly survival rates for age, gender, and time since release classes in the Galiuro Mountains, Arizona, 1994-1997.

following release (Figure 1). Only adult females during years following the first year of release exhibited elevated survival rates during the February through March time period ($Z = 2.326$, $P = 0.019$).

Gould's turkeys suffered lower survival rates during the first 2-3 months following release than they did in the remainder of their first year (Table 2). Adult male turkey survival rates during the first 3 months after release differed from the remaining 9 months during the first year ($Z = 12.756$, $P < 0.001$). Adult female survival rates differed between the first 2 months and the latter 10 months during the first year ($Z = 6.686$, $P < 0.001$), although there was no difference between survival rates during these time periods in subsequent years for adult female turkeys ($Z = 0.679$, $P = 0.542$). Subadult male ($Z = 3.056$, $P = 0.002$) and females ($Z = 7.139$, $P < 0.001$) also differed between the first 2 months following release and the latter 10 months during the first year. I detected no difference in survival between age and gender classes during either the first 2-3 months or the latter 9-10 months of the first year ($P > 0.145$).

Table 2. Age and gender-specific survival rates (variance) by time period following release for Gould's turkeys transplanted during winter 1994 and 1997 in the Galiuro Mountains, Arizona.

Period	Adult male, first year	Adult female, first year	Subadult male, first year	Subadult female, first year	Adult female, subsequent years
Feb-Mar	0.098 (0.005)	0.408 (0.013)	0.359 (0.044)	0.097 (0.016)	0.859 (0.015)
Apr-Jan	1.000 (0.000)	0.707 (0.014)	1.000 (0.000)	1.000 (0.000)	0.682 (0.030)

[a] *Periods for adult male, first year: Feb-Apr and May-Jan.*

DISCUSSION

Turkeys suffered high initial mortality rates for 2-3 months following release regardless of time held prior to release, age, or gender. There did not seem to be any superior class that survived better than another. This depressed initial survival might be used to encourage resource managers to investigate predator removal or release acclimation pens to improve initial survival. Because of the topography and vegetative cover of the Galiuro Mountains and the large-scale movements exhibited by the turkeys after release, I believe that predator removal could not affect a sufficiently large area and temporary holding birds within acclimation pens might only postpone high mortality during exploration of available habitat. Differential survival rates at different release sites may depend on predator densities and structural characteristics of transplant sites. Because survival rates improve 2-3 months following release, I recommend that future releases contain sufficient numbers of turkeys to ensure that a substantial number will survive through the exploration period. Multiple releases in subsequent years may be necessary to establish a self-sustaining population.

Survival rates of Gould's turkeys in the Galiuro Mountains following the period of initial high mortality were comparable to those of other established turkey populations. Annual mean mortality rates of 30% seem common in stable or increasing turkey populations (Kurzejeski et al. 1987, Wakeling 1991). Nest success seems to be the factor that most affects turkey populations (Roberts et al. 1995, Roberts and Porter 1996). Although in southwestern turkey populations, enhancing the propensity for yearling females to nest has the greatest probability of increasing turkey population size (Wakeling and Rogers 1998).

I believe that there is little evidence to suggest that time held in captivity or age and gender ratios have limited reestablishment efforts. I speculate that once the turkeys become familiar with the habitats that they have been released in, their survival rates increase. Certainly, translocation efforts should occur in the shortest period of time possible to minimize

stresses associated with the lack of food and water during translocation. But differences of 24-95 hrs in transport time had no discernable effect on turkey survival rates.

Age and gender did not influence survival rates. Consequently, sufficient numbers are necessary to ensure that enough of each age and gender will survive to successfully breed. In a habitat where high initial mortality may occur, an even sex ratio may be superior to the 1 male to 4 females recommended by Hoffman et al. (1993). In this type of habitat, approaching an even ratio of subadult and adult birds in the release group is also desirable because turkeys may not breed during the first year following transplant. Breeding during the year of release has been documented in southwestern ranges (S. Albert, Zuni Wildl. Dep., pers. commun.) and should not be universally discounted. However, yearling females may not breed in the Southwest (Wakeling 1991) and may not contribute reproductively during the first year. Alternately, adult birds, with a mean life expectancy of 3 years (Wakeling 1991), may not have sufficient longevity to breed in subsequent years if they do not breed the first year. An even age ratio may best prepare transplanted populations to take advantage of habitat and climatic conditions at the release site.

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BIOGRAPHICAL SKETCH

Brian F. Wakeling received a B.S. in Wildlife Management and an M.S. in Environmental Resources from Arizona State University. He has been conducting research on Arizona's Merriam's and Gould's turkeys for the past 10 years. Prior to working on turkeys, Brian was involved in desert bighorn sheep and black bear research in Arizona. Brian serves as a Technical Representative from Arizona to the National Wild Turkey Federation and is a Past-President of the Arizona Chapter of The Wildlife Society.

Coyotes in Urban Areas: Conflicts and Solutions

Martha Grinder[1] and Paul R. Krausman[2]

Abstract.—Coyotes (*Canis latrans*) are well-adapted to diverse environments throughout North America, including the increasing urban areas. In urban areas, coyotes come into conflict with humans. We discuss these conflicts, investigate how governments deal with the conflicts, and describe our research on coyotes in Tucson. Few humans have been attacked by coyotes in recent years, but small pets are in danger from attacks by coyotes. We conducted a survey at 22 veterinary clinics throughout Tucson, and found that small dogs are most often treated for coyote attacks. The Arizona Game and Fish Department has issued a brochure recommending ways that urban-dwellers can deter coyotes from an area; the primary way is to eliminate all sources of food and water. Tucson, Arizona and other cities have adopted policies to deal with coyote-human conflicts; these policies emphasize education, with trapping and removing individual coyotes being considered only as a last resort. Further education is needed to more effectively teach people about coyotes. Studies are also necessary of the habits of urban coyotes. We are currently conducting research on radiocollared coyotes in Tucson, and have found that coyotes do not tend to become habituated to humans if they are not encouraged to do so.

INTRODUCTION

Coyotes (*Canis latrans*) are one of the least specialized, most primitive living members of their genus (Nowak 1978). As such, they have adapted to diverse environments throughout North America (Bekoff 1982). Coyotes were originally confined to the great plains, but now inhabit all of North America, and are being seen in areas as far south as the Yucatan peninsula, Mexico (Gier 1975, Nowak 1978, Sosa-Escalante et al. 1997).

Concurrent with the expansion of the coyote's range has been the expansion of urban areas throughout North America, including the Southwest. Coyotes have adapted to life in the city (Howell 1982, Quinn 1991), and their expanding distribution has been the subject of newspaper ar-

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ticles in cities such as Mahwah, New Jersey, Chicago, Illinois, Los Angeles, California, Tucson, Arizona, and Langley Washington. Their presence in these urban centers has met with mixed reactions from the human residents of these areas. We discuss the conflicts that surround the presence of coyotes in urban areas, investigate how city and county governments are dealing with these conflicts, and describe our research on coyotes in Tucson.

HOW DOES THE PUBLIC FEEL ABOUT COYOTES?

The public's view of coyotes has recently changed. Once considered by most people to be vermin, the coyote now receives our respect and aide. A resident of a New Jersey county that initiated a bounty hunt on coyotes fasted to lose 11.25 kg in protest of the hunt (Tedeschi 1997). Phoenix wildlife rehabilitator Linda Searles especially loves coyotes, seeing in them the spirit of the southwestern deserts (Aleshire 1997). Michael Soule, renowned conservation biologist, comments that coyotes are a part of the healthy ecosystem and that removing them from an area will have serious deleterious consequences (Soule 1996).

Other urban dwellers fear and distrust the coyote. A resident of Sun City Phoenix recently was followed to her doorstep by a coyote and says that she "...was never more terrified in my life..." (Ellison 1994). She wonders how long it will be before coyotes discover that they can attack and bring down one of her frail, elderly neighbors. A Tucson resident, after losing her cat of 15 years, wrote to the Arizona Daily Star to complain that city officials have more sympathy for urban coyotes than for domestic pets. Residents of Tucson's northwest side have complained of numerous occasions when they have been followed and/or attacked by coyotes in Holy Hope Cemetery.[3] A north-Phoenix resident has only recently become unnerved by the presence of coyotes, stating that "...they are getting braver and they're starting to come up under our bedroom window at night" (O'Grady 1996).

RECORDS OF RECENT COYOTE ATTACKS ON HUMANS

Urban dwellers' fears of coyotes are not unfounded. Within the last year, 2 boys in Scottsdale, Arizona were bit by coyotes. The boys were 3 and 7 years old; both boys were playing outside near their homes when they were bitten (Jackson and Askari 1997). In Tucson, Arizona an 18-month-old girl was bitten in a west-side city park by a coyote. In 1994, an 11-year-old girl in Bagdad, Arizona, was playing in her backyard with a

[3] Unpublished letters to The Arizona Game and Fish Department

dog when a coyote came out of a nearby wash and bit her. In 1990, a 5-year-old girl was bitten in the head by a coyote while sleeping in her sleeping bag on a campout in southern California. In 1988, 3 children were bitten by coyotes in San Diego County, in southern California. All of the children were playing outside in their neighborhoods when they were attacked. Finally, in 1981, a 3-year-old girl was attacked and killed by a coyote while playing in her driveway in Glendale, California. California officials report that coyote attacks are rare, and are usually on small children.[4]

CAUSES OF ATTACKS

Coyotes are not habitually aggressive toward humans and attacks on humans are usually provoked. The small girl in California who was killed by a coyote had been encouraged in the past by her father to feed coyotes.[5] The girl who was attacked in her sleeping bag had vomited earlier in the night, probably attracting the coyote that attacked her. The 2 boys in Phoenix who were bit by a coyote last year had been playing near a coyote den. Scott Richardson, the Arizona Game and Fish Department (AGFD) urban wildlife biologist in Tucson, states that "...almost without exception, when a coyote is causing problems, there is someone in that area feeding those coyotes - either intentionally or unintentionally" (Associated Press 1997). Wildlife officials agree that in almost all coyote-human conflict cases where they are able to make a determination about the cause of the conflict, humans are the primary cause.[6]

RECORDS OF COYOTE ATTACKS ON PETS

Small pets are also vulnerable to attack by coyotes. The Tucson Citizen ran a headline story and color picture of a man with his terrier that has survived 3 coyote attacks (Copenhaver 1996). Numerous pet owners, mostly of small dogs and cats, contact the AGFD each year to complain of coyotes attacking their pets, or harassing them from the other side of fences.[7]

We conducted a survey of 22 veterinary clinics throughout Tucson to try to establish an index of coyote attacks on pets in Tucson. The clinics were selected in a stratified random fashion, to cover all areas in Tucson. We gave a survey to each of the selected clinics and asked them record any pets they treated for coyote-induced injuries. After a year, we consolidated our results. Of the 22 clinics surveyed, 9 had treated pets for coyote-re-

[4] *R. A. Thompson, California State Director, USDA, unpublished report*

[5] *R. A. Thompson, California State Director, USDA, unpublished report*

[6] *R. Aikens, AGDF, unpublished report*

[7] *S. Richardson, Arizona Game and Fish Department urban wildlife biologist, Tucson, Personal communication*

lated injuries. Another 5 clinics had treated pets but had lost the information on these treatments. Twenty pets were treated at the 9 clinics from which we received information (Table 1).

Table 1. Results of survey of Tucson veterinary clinics, January 1997 – April 1998.

Clinic	Clinic Location	Pet	Location of Attack	Type of Injuries
Bear Canyon Pet Clinic	Northeast Tucson	Small dog	Bear Canyon Road Area	Superficial leg wounds
Bear Canyon Pet Clinic	Northeast Tucson	Small dog	Bear Canyon Road Area	Scratches
Bear Canyon Pet Clinic	Northeast Tucson	Small dog	Bear Canyon Road Area	Emotional
University Pet Hospital	Central Tucson	Poodle	Central Tucson	Bites and lacerations to chest
University Pet Hospital	Central Tucson	Cat	Central Tucson	Lacerations to thigh
University Pet Hospital	Central Tucson	Yorkie	Central Tucson	Carried away
University Pet Hospital	Central Tucson	Schnauzer	Northcentral Tucson	Lacerations to back and neck
Animal Emergency West	West Tucson	Chihuahua	Northwest Tucson	Punctured left thorax
Animal Emergency West	West Tucson	Small dog	Northwest Tucson	Unknown
Animal Emergency West	West Tucson	Chihuahua	Southwest Tucson	Puncture under leg
Tucson Small Animal Hospital	Southeast Tucson	2 Shih-tzus	Northeast Tucson	Picked up by coyote
Tucson Small Animal Hospital	Southeast Tucson	Lhasa-apso	Northeast Tucson	Bites and punctures
Catalina Pet Hospital	Central	Poodle/ Chihuahua mix	Foothills, north Tucson	Punctures in abdomen
Catalina Pet Hospital	Central	Small dog	Foothills, north Tucson	Unknown
Tanque Verde Pet Hospital	Northeast	Small dog	East Tucson	Lacerations to chest chest and abdomen
Unknown[8]		Bishon Frise	Central Tucson	Lacerations to neck and thorax
Unknown[8]		Himalayan mix	Northeast Tucson	Wounds to neck and chest
Unknown[8]		Bishon Frise	Northwest Tucson	Wounds to neck and chest
Unknown[8]		Shepherd cross	Foothills, north Tucson	Bite in hind thigh

[8] *Information from these clinics was received in the mail or by fax, with no identification*

Seventeen pets were small dogs under 6.75 kg; one cat was also treated. Most pets sustained lacerations or bites to the back, neck, or head (Table 1). Two medium-sized dogs were also treated for bites to the legs and chest. Our survey uncovered fewer treatments to pets attacked by coyotes than we expected; however, many pets probably either do not survive being attacked by a coyote, or the attack is interrupted by the owner in time for the pet to escape without injuries.

WAYS TO DISCOURAGE COYOTES AND COYOTE ATTACKS

The AGFD has issued a brochure to help urban-dwellers discourage coyotes (Table 2).

Table 2. Steps recommended in the Arizona Game and Fish Department brochure to discourage coyotes, issued 1993.

Steps Recommended by the Arizona Game and Fish Department
• Do not feed coyotes
• Eliminate any source of water
• Eliminate the availability of bird seed
• Do not discard edible garbage where coyotes can get to it
• Remove any pet food from outside
• Trim and clean to ground level any shrubbery that provides cover for coyotes
• Fence the yard
• Install a battery-operated electric fence 30 inches high
• Do not leave small children outside unattended
• Do not allow pets to run free, especially at night
• Assertively discourage coyotes by making loud noises and throwing rocks when they appear
• Ask neighbors to follow the same steps

The AGFD distributes this brochure to citizens in response to complaints about coyotes. Periodically, complainants ask for a large number of brochures and distribute them to their neighbors. On the rare occasions that a complainant writes to the Tucson Mayor's office, that office does a mailing of at least 500 brochures to the area where the complainant lives. The brochures are not generally given out to citizens who have not contacted the AGFD or another city agency about problem coyotes.

COYOTE MANAGEMENT POLICY

In addition to brochure produced by AGFD, the City of Tucson has devised the "Tucson Urban Coyote Response Procedures." These procedures focus on educating people about coyotes, and how they can deter them (Table 3).

Table 3. City of Tucson policy on responding to calls about nuisance coyotes, as of June 1993.

Tucson Urban Coyote Response Procedures
Refer all calls to the Arizona Game and Fish Department
First complaint:
Contact the person who filed the complaint and assess the situation
Determine if the coyote has been aggressive and poses a threat to public safety
If the coyote poses no threat to humans:
Determine if household members are feeding coyotes and discourage this
Recommend removing all sources of food, water, cover
Suggest fencing the yard
Encourage complainant to be assertive in discouraging coyotes (see Table 2)
Encourage parents of small children to teach them about coyotes
Advise that the complainant may not discharge a gun inside the city limits
Send complainant pertinent literature about coyote safety
Request a call back if the problem continues
Second complaint:
Visit the site of the complaint
Interview the complainant
Determine if coyotes pose a threat to public safety
If public safety is threatened, initiate steps to eliminate coyotes in the area
Determine if coyotes are a threat to pets
Provide the same advise as with first complaint
Suggest the services of a licensed wildlife service permittee to assist with coyote removal
Request a call back if the problem continues
Further complaints:
Initiate a neighborhood education program
Issue a limited number of cage traps
Monitor the situation

Capturing problem individuals is only considered as a last resort. Similar policies have been adopted by many southern California communities. In 1993, Los Angeles banned coyote trapping but the city still struggles with the question of whether trapping and killing coyotes can end the urban coyote problem, or if public education about co-existing with coyotes is more effective. Trapping and removal has been an ineffective, short-

term solution that rarely works because when 1 coyote is removed without altering the suitability of the habitat, other coyotes will quickly replace it (Martin 1994).

The Tucson solution to the coyote problem has met with mixed reactions from its citizens. Citizens who believe that their right to live in a city like Tucson without fear for their pets or small children are frustrated at what they see as the lack of action and responsibility on the part of the city and other animal control agencies. This controversy is echoed in Los Angeles, California and Langley, Washington, cities that have adopted policies similar to those of Tucson (Martin 1994, Raamat 1997).

NEED FOR FUTURE RESEARCH

There are 2 areas in which more research is necessary, relative to the human-coyote controversy. First, educators and policy makers must determine the educational methods that will be most effective in teaching urban-dwellers to live with coyotes. This is an important facet of coyote management in urban areas because without proper education about the habits and ecology of coyotes, people will continue to misunderstand these animals. This misunderstanding causes intelligent, rational people to demand that wildlife managers take irrational actions such as initiating intense coyote sterilization programs and eliminating populations of ground squirrels and rabbits.[9] A lack of understanding about the situation also causes people to overestimate the possibility of disease transmission and attacks on pets and children. Because trapping and removing coyotes is an almost impossible option for effective coyote management, education that addresses the above issues is a mandatory part of the urban wildlife manager's solution to the coyote controversy.

The second type of research that is needed in urban areas deals with the coyotes themselves. Almost everything that wildlife managers know about coyotes comes from studies of coyotes in rural areas. We have little information about the kinds of habitats used by coyotes in cities, and how they are used. To address these issues, we are conducting research on 19 radiocollared coyotes in Tucson. We relocate coyotes numerous times per week to characterize their use of Tucson. We have discovered that, although there is much individual variation in the way coyotes use Tucson, they do, in general, act like their rural counterparts if they are not induced to change their behavior by humans. We have found mainly native rodents and rabbits in the stomachs of coyotes killed in Tucson, which indicates that coyotes do not tend to search out garbage or dog food if given other opportunities for food. Two of our collared coyotes are fed by Tuc-

[9] *S. Seigal, Tucson resident, unpublished letter to the AGFD*

son residents on a regular basis; the home ranges of these 2 animals are small compared to the home ranges of other collared coyotes. This indicates that coyotes will become habituated to being fed, and will cease to search for other sources of food. Thus, humans have the power to promote the continued existence of wild, self-sustaining coyotes in urban areas, or to turn them into partly-domesticated animals that may eventually pose a threat to those who feed them and their neighbors.

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Analysis of a Publicly Operated Pheasant Hunt in Southern California

Erick Burres[1], David Fischer[2], and Daniel Wegner[3]

Abstract.—The purpose of this study was to provide information about the wild pheasant hunts and hunters of southern California. Characteristics of southern California pheasant hunters, public demands regarding opportunity, access and participation regarding pheasant hunts, and hunt quality were studied. All hunters participating in the 1994 and 1995 hunts held at San Jacinto Wildlife Area (SJWA) were asked to participate in the study. Survey forms were returned by 467 hunters (256 in 1994 and 211 in 1995). The 1994 hunt was sampled using a questionnaire developed by Pheasants Forever. In 1995 an expanded version of the 1994 questionnaire was used. Every aspect of demand (opportunity to participate, access, number of potential and actual participation) increased. Both the 1994 and 1995 hunts recorded high quality and willingness to return ratings, and the 1994 hunt was shown to have provided for a higher quality hunt. The majority of the hunters surveyed were 24-45 years of age, have hunted pheasants before, and have an annual income of $25,000 to $59,000. Public managers are able to plan and use resources best when they have information on the products being offered, the potential or actual customers receiving that product, and environmental elements. It is hoped that this study has provided such information.

Resumen[4].—El propósito de este estudio es el de proveer información acerca la caza de faisánes salvajes en el sur del estado de California (EEUU). En el estudio se revisan las características de los cazadores, la demanda de acuerdo al acceso, y la participación por parte de los cazadores, como asi tambien la calidad de las piezas cobradas. El estudio comprende datos collectados en el area de vida silvestre de San Jacinto (San Jacinto Wildlife Area - SJWA) durante las temporadas de caza de 1994 y

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1995. El estudio comprende el analisis de datos censuales de cazadores. Un total de 467 cazadores fueron c ensados, 256 en 1994 y 211 en 1995. Para el censo de la temporada de 1994 se utilizó un questionario elaborado por Pheasant Forever. En 1995 se utilizó una versión mas extensa que la utilizada en 1994. El estudio muestra que todos los aspectos de la demanda (oportunidad de participación, acceso, número potencial y número real de participantes) aumentó durante las temporadas censadas. Las dos temporadas de caza analizadas muestran un aumento record en la calidad de las presas y en el deseo de participar nuevamente en cacerías por parte de los cazadores. La temporada de caza de 1994 muestra la mayor calidad de piezas cobradas. La edad de los cazadores muestreados esta comprendida entre los 24 y 45 años, todos los cazadores entrevistados participaron de cacerías de faisánes anteriormente, y poseen un ingreso de entre 25,000 a 59,000 dolares anuales. Los administradores pueden planear el uso de los recursos cuando poseen información sobre el mismo, sus posible usuários y usuários actuales, y los elementos del medio ambiente. Este estudio provee la información mencionada con la esperanza de facilitar el manejo de los cotos de caza.

INTRODUCTION

Since 1972 there has been a dramatic decline in the numbers of Californians buying hunting licenses. In 1990 half as many hunting licenses were purchased as there were in 1972 (DFG 1993) and from 1992/93 to 1993/94 hunting licence sales decreased by nearly 3,900. If this trend is to stop several things should occur. The demands and opportunities for the increased use of hunting programs must be determined and the programs should also be evaluated for the overall quality of the hunting experiences they offer. Where ever possible public entities should promote management activities that will increase public hunting access and participation. Continued analysis of these programs will offer information that can be used to adaptively manage these programs so that over time they will continue to meet their goals.

The model for this study was a public wild pheasant hunting program located in southern California. Within California pheasant hunt programs are a possible recreational activity that could be used to increase hunter participation. Nationally 47% of small game hunters hunt pheasant and 38% of all time spent hunting small game is spent hunting pheasants (USDI). This translates to 2.3 million pheasant hunters who spent 16 million days hunting. In California 446,000 hunters participated in that activity during 1991 and 5,211,000 days were spent hunting (USDI).

Ninety-eight percent of California's hunters are residents, most hunters use public land and generally take trips of less than 49 miles (USDI). Within southern California wild pheasant hunting opportunity is scarce and publicly offered hunts are limited to two sites. As pheasant hunting is important there should be significant management concerns on how this recreational activity is managed. This descriptive study looked at southern California wild pheasant hunts to determine current recreational demands, opportunity, participation and quality.

METHODS

Study Area

This study was conducted at San Jacinto Wildlife Area (SJWA). SJWA is a 6,198 acre complex of upland and wetland habitats actively managed by the State of California, Department of Fish and Game (CDFG) in Riverside County.

Treatments

The study period covered the 1994 and 1995 hunting seasons. Each season's hunting program was conducted under different management prescriptions. During the 1994 pheasant hunting season, hunts were held on each Monday of the pheasant season (November 12 through December 11) for a total of 4 hunt days. Entry into this hunt was through a random drawing. Potential participants mailed in postcards, one postcard per hunter with a maximum of two hunters per postcard. After a specified entry deadline, 100 hunters were selected for each hunt-day. Selected hunters were randomly assigned to a field which they could hunt until a specified time, after which they were allowed access to the entire area open for hunting.

In 1995 the hunts were held each Wednesday and Saturday during the peasant season (November 11 through December 10) for a total of 9 hunt days. Entry for this hunt was through the use of the CDFG reservation card system for Type A wildlife areas. One reservation card with a validation stamp could be sent in by a potential participant for each hunt day. Only those cards which were received at least 10 days prior to the selected hunt day, and were filled out correctly, were allowed into the drawing. From this pool 25 reservation cards were randomly selected for a maximum total of 225 reservations to hunt pheasant at SJWA. Each reservation card allowed up to 2 adult and 2 junior hunters. The waterfowl season was concurrent with the entire pheasant season and both hunts were conducted on the same days. Hunters were randomly assigned to fields

but due to the concurrent waterfowl hunt, pheasant hunters were prohibited from hunting until noon that portion of the wildlife area where waterfowl hunting occurred. From noon until the close of the hunt day the hunters were free to hunt all open areas.

Instrument Development

A survey tool was developed by Pheasants Forever Chapter #466. This questionnaire was used to collect data during the 1994 pheasant season hunts at SJWA. In 1995 the questionnaire was expanded to address other questions, using a Leichter scale when possible, to provide information on hunter demographics, recreational demands, and possible satisfaction factors or indicators (personal communication with Tom Paulek, Associate Wildlife Biologist/ Manager SJWA, John Massie, Senior Biologist). Basic questions asked in the 1994 form were kept as to allow for a comparison between the two public hunt management prescriptions.

Sampling Protocol/Implementation

During a mandatory pre-hunt orientation all pheasant hunters were informed of the survey and asked to voluntarily complete the questionnaire at the conclusion of their hunt. The questionnaire was distributed at this time on the reverse side of the wildlife area map. It was mandatory that all hunters check-out before leaving the wildlife area, it was at this time surveys were collected.

RESULTS

Hunt accessibility from 1994 to 1995 increased due to elements that changed in the management prescriptions. Firstly the number of hunt days increased and a potential participant was able to apply for entry of each of nine hunt days whereas previously the potential participant could only apply once for a chance at one of four hunt days . In addition the total number of possible participants also increased which allowed for greater possible participation.

Accessibility of the public hunts went from a maximum of 400 potential hunters in 1994 to possible participation of up to 900 hunters (225 reservations each allowing up to two adult and two junior hunters) in 1995. In 1994 72% of the applicants (288 hunters) selected participated and surveys were returned by 256 hunters (89%). In 1995 159 reservation cards (71%) were submitted as entry passes for 312 participants and surveys were returned by 211 of these hunters (67%). The pheasant population was about the same for the two seasons (1995 Paulek) but there was no habitat

information The hunts will be discussed in terms of those hunters that returned survey forms.

The 1995 pheasant season saw a 37% decrease in pheasants bagged than from the prior as well as a decrease in the average number of pheasants bagged. Actual annual bag averages have varied but suggest a moderate upward trend.

The 1994 pheasant hunt averaged 72 hunters per day for its 4 hunt-day season and 35 hunters per day for the 9 hunt-day season in 1995. The surveys returned from the 1994 season hunters had a mean of 5.17 roosters and 6.44 hens observed per hunter and in 1995 3.26 roosters and 5.07 hens observed per hunter. The mean for shots taken per hunter of 4.55 and 2.63 respectively for the 1994 and 1995 seasons.

Hunters in 1994 reportedly bagged 253 pheasants (.99 birds/hunter) and 137 pheasants (.65 birds/hunter) ere bagged in 1995. Hunters surveyed also reported loosing .34 pheasants per hunter in 1994 and .27 pheasants per hunter in 1995.

The public hunts overall were rated as "good" for 1994 and "fair" for 1995 respectively. There was a statistically significant difference of the ratings distribution between both the public hunts (t=4.54, a=.05). Since the 1995 hunt-days were held on Wednesdays and Saturdays a comparison of the quality ratings was made. No statistical difference between the two was observed (t=.56, alpha=.05).

When asked whether or not the hunter would like to return for another hunt 99% of those surveyed in 1994 and 96% in 1995 responded with a yes. Additionally, in the 1995 surveys 63% of the public hunters said that they would return if they had not taken a pheasant and 63% would return if they had not seen any pheasant.

When asked whether or not the hunter would be willing to pay more that the $12.00 fee, 46% said yes while 52% said no. From those that would pay more 78% said how much. The average amount that this group would pay was $20.55.

Hunters on Type A wildlife areas must have a permit for that days hunt. One-day Hunting Area Permits are $12.00, Two-day Hunting Area Permits are $17.60 ($8.80/day) and junior hunters are free. Seventy-five percent of the participants paid the 12.00 fee, 19% used the Two-day Hunting Area Permit and 6% had free entry (junior hunters).

When asked to state the average amount spent per hunting trip (gas/food/lodging/fees) for wild pheasant hunts and licensed pheasant club hunts, 81% of the surveys returned had a response to this question. The hunter spent an average of $53.39 per wild pheasant hunt and $76.21 per pheasant club hunt.

Seventy percent of the participants hunted pheasant within the last three years but only 51% hunted them last year. Fifty-eight percent of

those that had not hunted pheasant within the last three years responded that it was due to little or no opportunity. When the hunters were asked if they were to not hunt at SJWA that day, 38% would not have hunted and 48% would have hunted elsewhere. But 87% of those that would have hunted elsewhere would have done so on public land.

Distance from the hunters' residences to SJWA was calculated from data obtained from the reservation cards returned at the check station. Ninety-one percent of the cards were returned by hunters living within 120 miles of SJWA and 91% of these hunters lived within 60 miles.

Demographically the survey revealed that 61% of the hunters were between the ages of 24 and 45. Sixty-one percent reported an annual income between $25,000-59,999 band only 5% had an annual income of less than $25,000. The majority of respondents have hunted pheasants before (77%). Sixty-four percent of all respondents have hunted on a licensed pheasant club but only 7% of the respondents were members.

DISCUSSION AND CONCLUSIONS

The pheasant hunting program at SJWA is fairly new. Over its 5 seasons the program has expanded in the number of hunters able to apply, access and participation in its hunts. The managerial perception has been that the public pheasant hunts held at this site are well received by the hunting public. The two public hunts both received high ratings in terms of quality which support that perception.

Although defining satisfying factors was not the scope of this study, it was successful in describing the hunters that participated and in determining the hunts' quality. The rates at which the public hunters would like to return, even if they did not take a bird or if they did not see birds, suggests that the hunts largely do provide a satisfying hunt for the hunters surveyed. There are several levels or types of hunters and many factors related to what is a satisfying experience and/or why a hunter may no longer hunt. There are many studies that have been conducted on hunter desertion, dissatisfaction, satisfaction (Duda 1993, Schole 1973, Siemer et al 1995) and while this survey did not attempt to specifically address the issue of hunter desertion, the questions asked might be of importance to that issue. If some reasons that hunters did not hunt were due to opportunity, lack of experience or low success it is possible that appropriate management steps could be taken which could eliminate these possible dissatisfiers. For those hunting a public hunt whom had not hunted in the past 3 years, their responses said that it was due either to "little or no opportunity" or a " lack of experience." These elements could both be

easily dealt with in expanding opportunities for participation and by offering hunting education opportunities.

Demand can be thought of in various ways. It can be defined by the opportunity to participate, accessability of participating, or the actual participation of a given activity (Clawson and Knetsch 1996, Miles and Seabrooke, Searle 1972). SJWA draws from a very populous community and the rural area surrounding it is also becoming more developed. A national survey has shown that 64% of hunters travel less than 49 miles (USDI 1991). This study has shown a similar tendency, 82% of all reservations were filled by participants that lived within a 60 mile radius.

As this hunting program has developed, more hunters have attempted to obtain access to its hunts but both hunts experienced around 20% of the available entry slots not being filled. This might show that the demand for this type of activity is not as high as management expected. Yet for half of those surveyed, if they had not participated at that particular hunt, would not have hunted at all which does identify this program's importance.

The 1995 season at SJWA produced more hunters but fewer pheasants were observed (flushed) or bagged, and both hunts had similar rates of hunter/dog use. Although this season received an overall "fair" quality rating it was still significantly lower in quality than the 1994 hunt which had more hunters. The pheasant population sex ratio (roosters:hens) prior to the hunting season should approximate a ratio of 1:1 and at the end of the season it should be significantly less than 1:1 if properly exploited (Hart 1993, personal communication with Massie). The ratio of hunter observed roosters:hens at the conclusion of the 1995 season suggests that more pressure, both an increase in hunters and pheasants taken, could have been placed on the pheasant population. A detriment to 1995 hunters was the overlapping of waterfowl and pheasant season. This excluded prime pheasant hunting areas until afternoon when waterfowl hunting for the day had ended.

Hunter opportunity, access, participation and use of the resources at SJWA could be improved in several ways. Increasing hunter participation could be gained through an increase in the number of reservations drawn, allowing vacant reservations to be filled with other hunters (i.e. "sweat-line"), or exiting hunters may be replaced with new hunters (i.e. "refill-line"). The 1994 season, if used as an example, indicates that more hunters can safely hunt at SJWA, have quality hunts and potentially harvest more pheasant.

The CDFG relies on the sale of sport license sales and its share of federal excise taxes on hunting and fishing equipment for up to 64% of its operating budget. The revenue structure acts to both support the CDFG and programs must be constructed that will generate revenue but not at the detriment of financially excluding citizens from participating in those

activities (Anderson and Reiling 1985) When asked if they would be willing to pay more than the $12.00 permit fee to hunt, 52 % answered no. Those that said yes and indicated how much more, averaged around $20.00 per hunt. If a raise in the cost of permits were to occur it is doubtful that there would be a decline in participation. Statewide the average amount spent per hunt is $102.00 spent per trip (USDI) which is more than the amount reported by those surveyed (mean of $53.39).

It must also be brought to mind that SJWA is a multiple use wildland and that the management decisions that have positive effects on one program may have an additional impact elsewhere which could be negative (Johnson and Johnson 1990). This may have been the case in 1995 with the waterfowl and pheasant hunts. An important part of managing public wildlands involves accessing the various demands that are placed on an area. As more non-consumptive demands rise that benefit wildlife through wildlife management policy it is possible that the overflow effect could be beneficial to hunting opportunity (Arther and Wilson 1979). Public hunting opportunity is important and it is hoped that as various wildland/wildlife programs are developed in southern California, public pheasant hunting will programs continue to prosper. The goal of this study was not to design a pheasant hunt but to provide information that should be helpful to manage public pheasant hunts in southern California and accomplish related Departmental goals such as creating more hunting opportunities and improved license sales.

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Rainfall and Masked Bobwhites in Sonora, Mexico

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Abstract.—We analyzed rainfall records (1956-94) from Rancho El Carrizo, Sonora, Mexico, and related rainfall to population behavior of masked bobwhites (*Colinus virginianus ridgwayi*). Annual rainfall averaged 37.1 ± 11.77 cm (SD) and ranged between 17.1 and 68.7 cm during the 39 years of record. Drought periods (<37.1 cm annual rainfall) averaged 2.2 ± 2.05 years in duration, whereas rainy periods averaged 2.1 ± 1.45 years. Masked bobwhites persisted through a 7-year drought during 1970-76, when annual rainfall averaged 24.6 ± 6.71 cm and ranged between 17.1 and 34.6 cm. These birds are particularly dependent on July (9.5 ± 13.89 cm) and August precipitation (10.4 ± 15.96 cm) for nesting and brood-rearing activities. Populations declined in 13 of 14 years when the 3-point moving average for June-August precipitation was <20 cm. Conversely, populations increased in 11 of 13 years when the moving average was >20 cm. Although rainfall is beyond management control, management can take steps to minimize the impact of drought on masked bobwhite populations.

Resumen.—Analizamos registros de lluvia de plazos largos mantenidos en el Rancho El Carrizo, Sonora, Mexico, y lluvia en relación con la conducta de la población de codorniz mascarita (*Colinus virginianus ridgwayi*). Lluvia anual por regla general fue 37.1 ± 11.77 cm (SD) y extendio entre 17.1 y 68.7 cm durante 39 años de registro. Plazos de sequía (<37.1 cm lluvia anual) promedio 2.2 ± 2.05 años en duración nientras plazos de lluvia promedio 2.1 ± 1.45 años. Poblaciones de codorniz mascarita persistieron durante una sequía de 7 años durante 1970-76, cuando lluvia anual premedio 24.6 ± 6.71 cm y extendio entre 17.1 y 34.6 cm. Estas aves dependen de la lluvia particularmente en Julio (9.5 ± 13.89 cm) y Agosto (10.4 ±15.96 cm) para actividades de nido y cria. Poblaciones de codorniz mascarita declinaron en 13 de 14 años cuando el 3-punto promedio móvil para la lluvia de Junio-Agosto fue <20 cm. Al contrario, las poblaciones aumentaron en 11 de 13 años cuando el promedio móvil fue >20 cm. Aunque lluvia anual esta fuera del control de manejo, el manejo puede tomar pasos para minimizar los impactos de sequía en las poblaciones de codorniz mascarita.

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INTRODUCTION

The recruitment rate of quails in semiarid, subtropical environments is governed to a large degree by the pattern (timing) and amount of precipitation in a particular year. Precipitation influences the productivity of Gambel's quail (*Callipepla gambelii*) (Swank and Galliziol 1954, Smith and Gallizioli 1965, Heffelfinger et al. 1998), California quail (*C. californica*) (Francis 1970, Bottsford and Brittnacher 1992), scaled quail (*C. squamata*) (Wallmo 1956, Campbell et al. 1973), Mearns quail (*Cyrtonyx montezumae*) (Brown 1979), and northern bobwhites (Lehmann 1953, Kiel 1976, Rice et al. 1993). Rainfall also influences annual production of the endangered masked bobwhite (Tomlinson 1972). Our purpose is to analyze the properties of rainfall on Rancho El Carrizo, Sonora, Mexico, based on long-term records maintained by ranch management. This ranch supports one of the few remaining populations of masked bobwhites in the wild. We relate these rainfall properties to long-term records of masked bobwhite dynamics on the ranch. Our goal is to provide information that might be useful in continuing efforts to preserve masked bobwhites for future generations.

METHODS

Rancho El Carrizo is located about 25 km south of Benjamin Hill, Sonora. The plant community on the ranch is classified as summer-active savanna grassland (Shreves 1951, U.S. Fish and Wildlife Service 1975). The owners of Rancho El Carrizo began maintaining daily rainfall records in 1956. A rain gauge at ranch headquarters was checked after each rainfall event and the quantity of rain was recorded in a logbook. We summarized these data by month and year using simple descriptive statistics.

Since 1968, biologists from various agencies, with assistance from ranch personnel and private individuals, have followed population trends of bobwhites on Rancho El Carrizo with call-counts of breeding males. Calling activity starts between 25 June and 15 July, peaks between 10 and 24 August, and ends between 14 and 20 September (Tomlinson 1972). Biologists attempted to conduct call-count surveys during the peak calling period. The standard 32-km call-count route (1.6 km between listening stops) was used when possible. In some years, rainfall made all or portions of the call-count routes inaccessible. Observers listened for 3 minutes at each stop and recorded the number of different males calling and the total number of calls. Although sampling intensity varied somewhat among years, we regard the number of different males heard calling as the known-minimum population of calling males. We take this known minimum as an index of population abundance, subject to qualifications dis-

cussed later. We used 3-point moving averages of summer (June-August) rainfall and the abundance index to analyze comparative trends in rainfall and populations. The moving averages assisted in identifying patterns in the data. We interpolated missing values (n = 5) for counts during 1968-97 as the average of the preceding and subsequent count.

RESULTS

Rainfall Patterns and Trends

During 1956-94, annual precipitation averaged 37. 1 cm (SD = 11.77 cm) and ranged between 17.1 and 68.7 cm. No temporal trend in the quantity of annual rainfall was apparent (figure 1). Mean monthly rainfall showed distinct trends with peaks occurring in July and August (53.5% of average annual precipitation occurred during these months). A second, lower peak occurred in December- January (16.8% of average annual precipitation). Months with higher averages were associated with higher absolute variability in the average. For example, the standard deviation was 13.89 cm for the July mean (9.5 cm) and 15.96 cm for the August mean (10.4 cm). All months except April and May showed considerable variability in rainfall

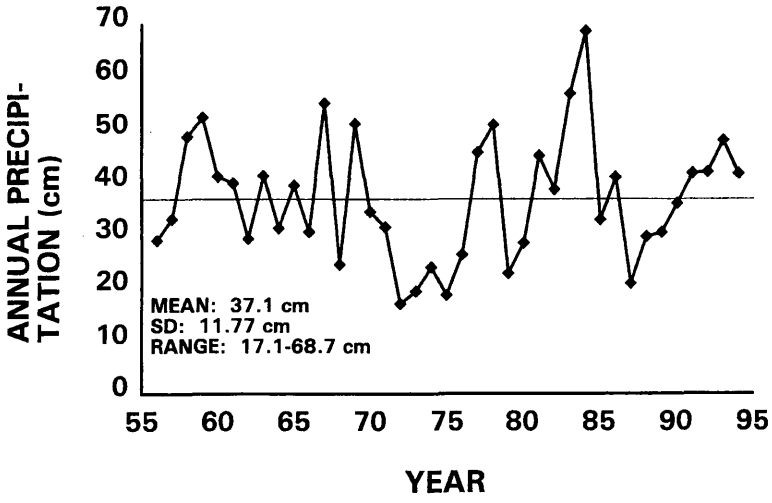


Figure 1. Trend in total annual precipitation, Rancho El Carrizo, Sonora, Mexico, 1956-1994.

among years. Extremely low rainfall characterized these 2 months for the period of record.

Droughts (years with <37.1 cm of precipitation) averaged 2.2 $\pm$ 2.05 years in duration, whereas rainy years averaged 2.1 $\pm$ 1.45 years. The probability of drought (as defined) was 0.51 $\pm$ 0.081. The longest drought

recorded lasted 7 years (1970-76), whereas the longest rainy periods lasted 4 years (figure 1).

Quail Behavior and Dynamics

The known minimum population of calling males ranged between 0 and 77 and averaged 23.3 $\pm$ 22.10 (n = 25). Calling behavior was associated with monthly rainfall peaks in July and August. Based on our analysis of data collected during 1968-71 (Tomlinson 1972), intensity of calling (y = different males heard/ 20-stop route) could be described as a cubic polynomial function of Julian day (figure 2) (n = 14, r^2 = 0.84, $P < 0.01$). The estimated equation was

$$y = 1966.03 - 29.965x + 0.1501x^2 - 0.000246x^3$$

where x = Julian day. This equation indicated the peak calling rate occurred on 19 August (Julian day 231) and that >90% of peak calling intensity would be observed during 9-28 August inclusive. The empirical records showed peak calling (3 highest rates) during 8 August through 22 August. In general, then, the second, third, and fourth weeks of August seem to contain the period of peak calling activity; call-counts should be conducted during this time. Counts conducted before or after this period could be adjusted to the peak standard based on the equation we derived. The process would involve estimating maximum predicted calling for Julian day 231 (21.3 calling males/20-stop route). Then one would calculate calling rate (y_i) for the Julian day (i) in question, find the ratio (21.3/

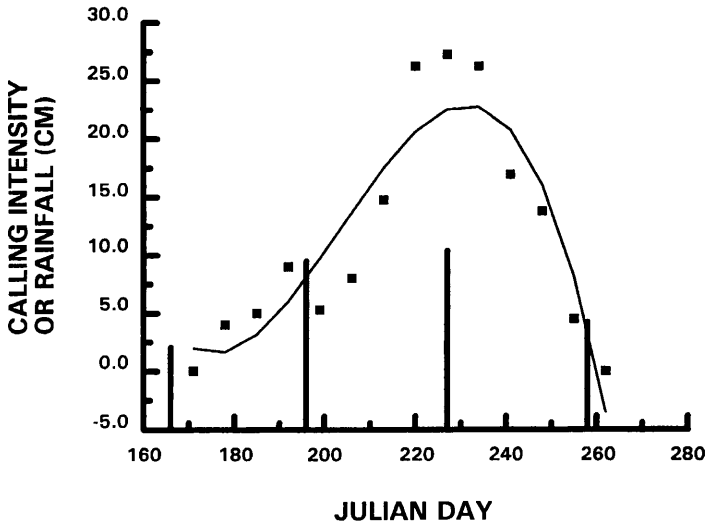


Figure 2. Temporal trends in calling intensity (no./20-stop route) of male masked bobwhites, Rancho El Carrizo, Sonora, Mexico, 1968-71, based on our analysis of data collected by Tomlinson (1972). The vertical bars represent mean rainfall for June, July, August, and September.

y_i), and multiply this ratio times the number of different males heard calling. For example, if a count indicated 10 calling males on 1 August

(Julian day 213), we would have y_i = 16.1. The count would project to (21.3/16.1)(10 calling males) = 13.2 calling males on the date of peak calling activity. Projections such as this probably should be limited to the period 1 August through 5 September, because calling rates are low (figure 2) and probably unreliable before and after these dates. The expansion ratio would

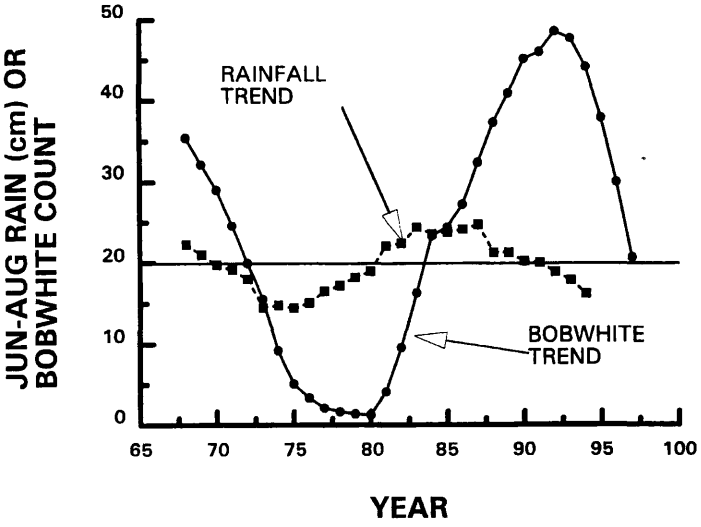


Figure 3. Smoothed trends (3-point moving average) of summer (June-August) rainfall and the known minimum number of masked bobwhite males on Rancho El Carrizo, Sonora, Mexico, 1968-1997.

apply to any type of call-count; i.e., the ratio is not limited to 20-stop routes.

Smoothed trends for June-August rainfall and the known-minimum index revealed a complicated relation between the variables. The population index seemed to show a lagged response to summer rainfall (figure 3). For example, a low in the rainfall trend observed in 1975 was not reflected by a low in the quail population until about 1980. Likewise, a peak in the rainfall trend in 1987 was reflected by a peak in the quail population trend about 1992.

DISCUSSION

Rainfall in the occupied range of masked bobwhites in Sonora shows considerable variability among years and within seasons among years. Annual variability can be gauged by noting that 2 SD's from the mean encompass 13.6-60.6 cm, a span of 47 cm. The quantity and variability of annual rainfall are beyond management control, so management must apply practices that stabilize the near-ground environment among years, especially during the critical July-August-September period of reproduction.

We recognize that the lag-effect between smoothed trends in masked bobwhite abundance and summer rainfall (figure 3) remains hypothetical.

For the effect to occur, declining populations would need sufficient momentum to continue declining for 5 years after a rainfall trough; likewise, expanding populations would need sufficient momentum to continue expanding for 5 years after a rainfall peak. Perhaps a better way to consider the rainfall-population trends is to examine the absolute quantity of the 3-year moving averages for rainfall. Such an analysis reveals that populations declined in 13 of 14 years when the moving average for summer precipitation was <20 cm. Conversely, populations expanded in 11 of 13 years when the moving average was ≥20 cm. Thus, quail population trends may reflect trends associated with a rainfall threshold of 20 cm (figure 3). A threshold effect of rainfall has been observed for northern bobwhites in Kansas (Robinson and Baker 1955). Threshold averages of rainfall (≥20 cm) may permit a level of production in masked bobwhites that leads to expanding populations (births exceed deaths).

Masked bobwhites have evolved so that their breeding season coincides with expected seasonal peaks in rainfall (Brown 1989). The correlation between quail production and rainfall in semiarid environments is thought to be associated with increases in the availability of nesting cover, invertebrates essential to laying hens and chicks, and possibly vitamins and minerals during years with more rainfall. The correlation may also arise because of the cooling effects of rainfall and vegetation, which would permit longer laying seasons (Klimstra and Roseberry 1975) and higher production. Masked bobwhites are particularly vulnerable to shortened laying seasons, because these birds are limited to about a 70-day reproduction season (Tomlinson 1972), given ideal quantities of summer rainfall. The reproduction season may be 2-3 months longer for other races of bobwhites (Roseberry and Klimstra 1984, Guthery et al. 1988).

Habitat management for the masked bobwhite probably should focus on conserving rainfall prior to and during the reproduction season. Mechanical brush management should be practiced to reduce the height and density of brush and to fracture the soil surface; the latter outcome promotes infiltration instead of runoff on soils that have been grazed over the long term. We have seen striking increases in the production of herbaceous plants in association with rangeland discing or aerating in Sonora. The herbaceous plant communities that develop after rangeland renovation need to be grazed at light rates because of the low rainfall typical of masked bobwhite range. We have observed satisfactory maintenance of herbaceous cover through use of a base herd of mother cows grazed in a rapid rotation format. The base herd may be supplemented with stockers to take advantage of the forage produced during years with high rainfall during the growing season. Such a plan permits revenue from livestock while maintaining rangeland vegetation in a condition that fosters the production and survival of masked bobwhites.

ACKNOWLEDGMENTS

A diverse group of individuals, organizations, and agencies has contributed to the preservation of masked bobwhites since a wild population was rediscovered in Sonora in 1964. This group has maintained independent observations and records on masked bobwhites, or environmental features important to these birds, for more than 4 decades. We thank R. Tomlinson, S. Dobrott, W. Shifflett, S. Gall, M. Goddard, R. Engel-Wilson, S. Gallizioli, J. Levy, S. Levy, D. Ellis, J Goodwin, F. Salazar-Garza, O. Camou-Cubillas, O. Camou-Lourdes, C. Camou-Cubillas, A. Camou-Cubillas, and D. Brown for contributions to the biology and management of masked bobwhites. A. Hirales provided Spanish translations.

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POSTER PAPERS

Digital Geographic Data to Support Long-Term Ecosystem Management for the Fort Huachuca Region

Robert Lozar[1], John Wickizer[2], Sheridan Stone[3], David Mouat[4], Carl Steinitz[5], Gretchen Kent[6], Winifred Hodge[7], and Robert Anderson[8]

Abstract.—Fort Huachuca, AZ resides within the Upper San Pedro River Basin. The basin is experiencing a number of challenges with respect to natural resources management issues both on and off the installation. These issues have prompted the Army to take a close look at the interaction between the Army and its regional neighbors over the next several decades. This will include identifying a broad range of alternative future scenarios that are possible within the basin. Through a Geographical Information System (GIS) evaluation effort, possible land use distributions which are most likely to develop as a result of each stated guiding scenario will be predicted. One of the tasks at this initial stage of the project is the assemblage of the GIS database to support the study.

INTRODUCTION

The Upper San Pedro River Basin, within which Fort Huachuca, AZ resides is recognized for its globally-significant biodiversity value, its aesthetic and recreational value, the presence of a concentration of endangered species, as well as the aquifer which is the sole water source for the region. It is experiencing a number of interrelated challenges with respect to natural resources and natural resource management issues both on and off the installation. The issues of water usage, military mission, urban growth, rural economy and unique natural values have prompted the Army to take a close look at its role relative to these complex issues over

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the next several decades. Therefore the Department of Defense's Legacy Resource Management Program (Legacy), with the support of the U.S. Army Training and Doctrine Command (TRADOC) Headquarters, is funding a multi-year project to identify alternative futures for the Upper San Pedro River region under different projections of change over the next few decades.

GIS BACKGROUND DATA EFFORT

The study area (figure 1) is the Upper San Pedro River basin (probably including the Sonoita Planning Area).

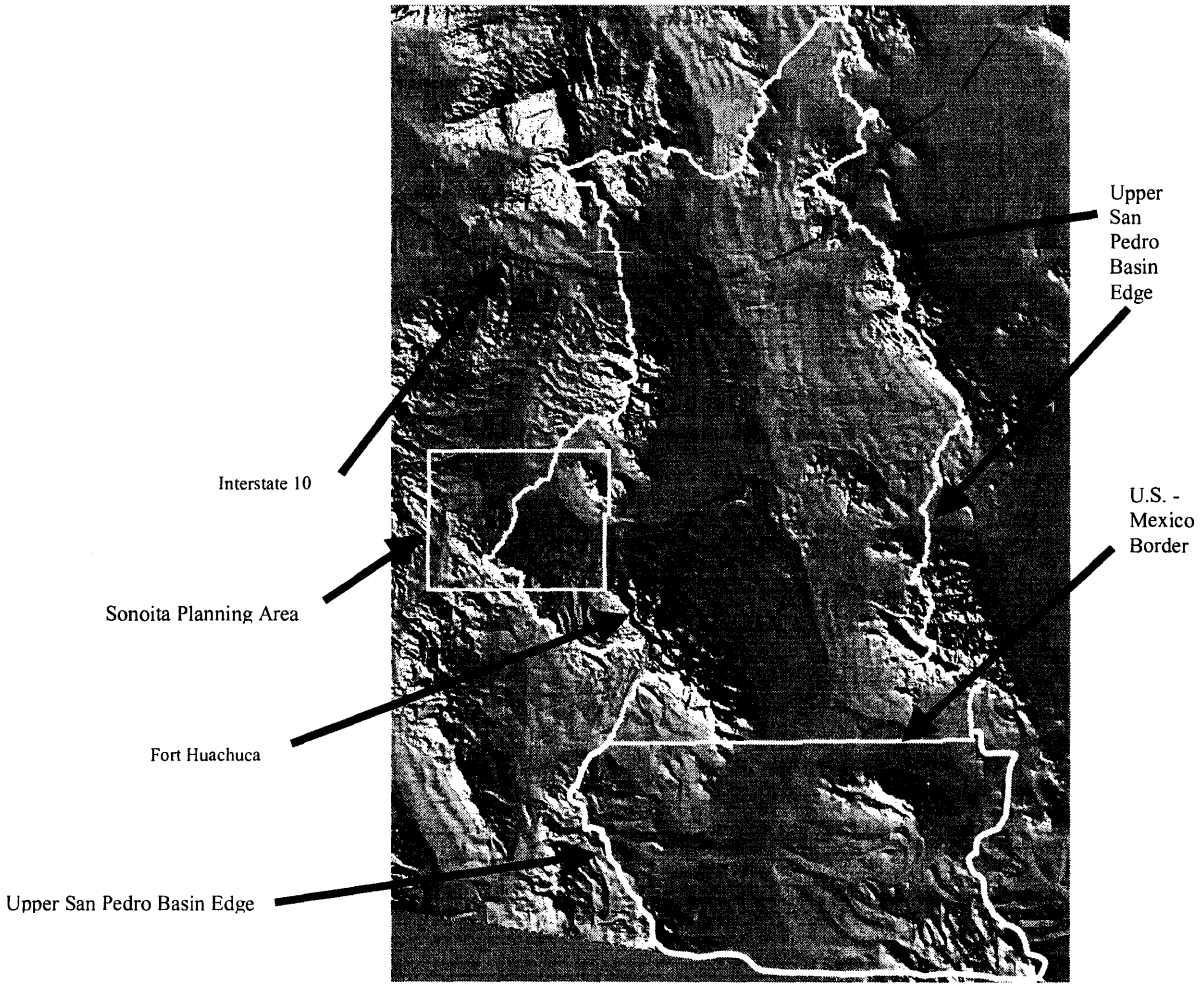


Figure 1. Alternative Futures Study Area.

One of the initial tasks of the project, is the assembling of a Geographical Information System (GIS) database to support the study. Data from many sources, in both the U.S. and Mexico, are being assembled from cooperating agencies and organizations.

The team has identified several critical data types. The data set being assembled will include spatial information about the existing human environment as well as historical satellite imagery, which is intended to provide a temporal context (figure 2.) for the identification of regional trends. The data being collected will focus on four major themes:

- Topography,
- Land Use/Land Cover,
- Soils, and
- Population and Demographic characteristics.

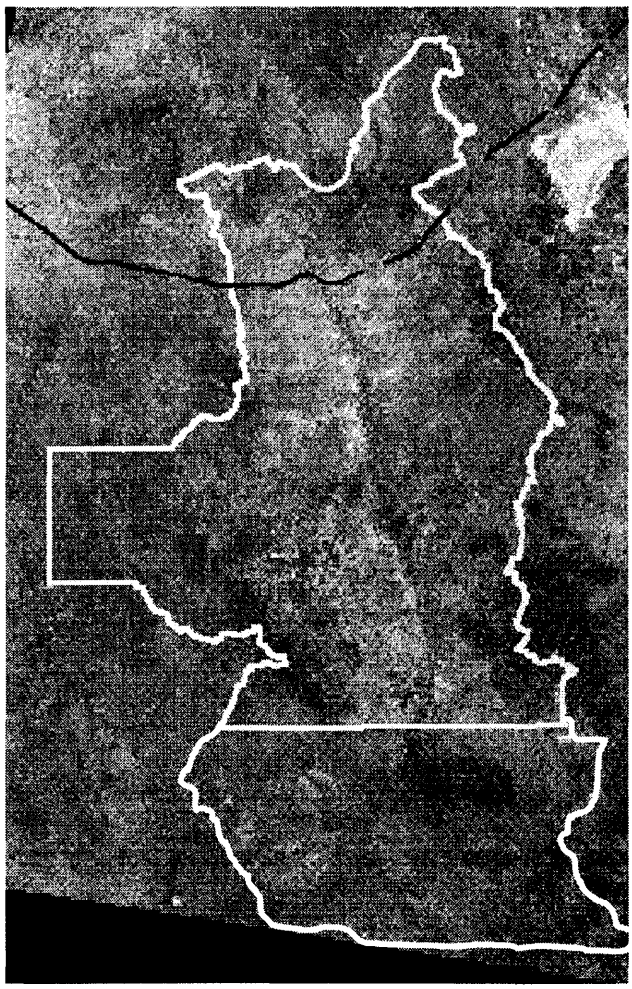


Figure 2. Upper San Pedro River Basin over a June 1986 satellite image.

Progress in the development of this supporting data set has been made. An initial survey of desirable sources has been developed and is presented in table 1. Table 1 can be expected to change as progress is made in the assemblage of the final theme data base.

Table 1. Initial data themes to support Alternative Futures study.

	Upper San Pedro River Basin Projected Data Themes		
Area	**Data Layer Name**	**Type**	**Source**
Hydrology	Streams & Rivers		ALRIS/Counties
	Basin Boundaries		ALRIS
	Springs		GNIS
Boundaries	Grazing	BLM Grazing Allotments	BLM
	Landownership		ALRIS
	Land bounds	Land Boundaries	BLM
Demographic	Counties		ALRIS
	Urban Areas		ALRIS
	Populated Places		GNIS
	Census Tracts	Tiger Files	Cochise/Santa Cruz County
	Tiger Data	Tiger Files	attributes from counties
	Power Network		ALRIS
Topography	DEM	30meter	USGS
	DEM	50meter (mexico)	IMADES
	Slope		modeling
	Aspect		modeling
	Shaded Relief		modeling
Land Cover	MSS images	70, 80, 90 - 60 meter resolution	USGS NALC Triplicates
	Land cover		USGS LUDA land cover
	Land cover	70, 80, 90	USGS NALC
	NDVI	80, 90	USGS NALC
	Land cover Change	70-80,80-90	Modeling
Soils	Soils		ALRIS/GAP
Scanned	1:24,000 maps	USGS maps	USGS/Scanner?
Points	Named Locations		
Lines of Communcation			
	Roads, Rails etc		ALRIS
	Roads, Piplines etc	TIGER 1:00K	DOC
Vegetation	GAP Vegetation		ALRIS
	Riparian		ALRIS

ALRIS-Arizona Land Resources Information Systems
BLM-Bureau of Land Management DEM-Digital Elevation Model
DOC-Department of Census
GNIS-Geographical Names Information System
LUDA-Land Use/Land Cover Digital Analysis
MSS-Multispectral Scanner
NALC-North American Land Characterization
NVDI-Normalized Difference Vegetation Index
USGS-U.S. Geological Survey

We are interested in identifying additional agencies which also are involved in the future of the Upper San Pedro River Basin and who are willing to share some of the digital GIS data in support of this effort.

RESOURCES AND CONSTRAINTS FOR THE REGION

The Upper San Pedro has an interesting set of regional dynamics. If we develop a listing of the known unique resources of the region it would probably include:

- High Biodiversity
- Attractive Climate
- San Pedro River National Conservation Area
- Fort Huachuca
- Sonoita Upland Areas

Similarly, a listing of known potential constraints of the region is likely to include:

- Arid Land
- Limits of Subsurface Water Availability
- Impacts to Biodiversity
- Desirability for Development, Recreation and Retirement.
- Erosion Potential
- Stream System Stabilization

Clearly there is a high relationship between these two listings. One is tempted to conclude that the area's benefits are also its constraints. It is within this somewhat contrasting environment that the Alternative Futures project must be carried out.

POSSIBLE RANGE OF FUTURES AND PROJECT SCHEDULE

The study activities will:

- Include the development of several alternative futures for the Upper San Pedro Region.
- Generate the distribution of land uses that are likely to result from each alternative over a time horizon of several decades. It is not possible to predict exactly what land use will develop at a specific location, but it is reasonable to expect the mix or proportions of land

uses within the region to be relatively predictable based on the planning imperative (i.e. the alternative future) followed through time. It is expected that these alternatives will serve as a basis for regional land management decision-making.

- Include the development of a web-based tool and data access for future regional planning. The data and techniques developed will be made available to local planning agencies.
- Allow local stakeholders to more clearly see the ramifications of their proposals and actions.
- Provide an outline, not a plan, of the region's options for change and their likely effects. This outline will be publicly available.

This project is part of a three year effort. The first year (fiscal 1998) identifies stakeholders and GIS data availability. One of the purposes of this paper is to encourage such groups to identify themselves. In the second year, the data will be used to generate the effects of the alternatives into the future. During the third year final reports will be produced including the Internet website. The website and supporting tools will be transferred to regional users.

CONCLUSIONS

We are in the initial phases of a three-year planning process to generate possible outcomes of various alternative planning imperatives for the Upper San Pedro Watershed. This project represents the first time the Department of the Army will look at long term regional questions which might arise within the sphere of influence of one of its important training installations, Fort Huachuca. Currently, the authors are in the process of identifying sources of base-line GIS data and cooperating agencies that will collaborate in this work.

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BIOGRAPHICAL SKETCHES

Robert C. Lozar is a Community Planner and Principal Investigator with the Army Corps of Engineer's Construction Engineering Research Laboratory in Champaign IL. He graduated from Harvard University with a Master's Degree in Landscape Architecture in 1974. He does research in spatial analysis and applications for land and natural resources management. Readers may contact him at r-lozar@cecer.army.mil.

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David Mouat is a Senior Environmental Scientist at the US EPA Environmental Research Laboratory, Corvallis, Oregon, USA, (on loan from the State of Nevada's Desert Research Institute). He received his Ph.D. from Oregon State University in 1974 for examining the relationships between terrain and vegetation landscape variables. His research focuses on remote sensing and other techniques for assessing landscape dynamics, including desertification in arid and semi-arid areas.

Carl Steinitz is the Alexander and Victoria Wiley Professor of Landscape Architecture and Planning, Graduate School of Design, Harvard University. He graduated with a Ph.D. in City and Regional Planning, with a major in Urban Design, from the Massachusetts Institute of Technology, 1967. Professor Steinitz' teaching and research activities concern landscape

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The Possibility for Establishment of the Clam (*Chione gnidia*) in the Estuary of La Cruz, Sonora, Mexico

Hernan Aubert[1] and O. Eugene Maughan[1]

Abstract.—There is some evidence that *C. gnidia* historically occurred in the estuary of La Cruz. However, *C. gnidia* has not occurred in any numbers in that estuary for at least thirty years and current habitat conditions do not appear suited to this species.

Resumen.—Hay alguna evidencia que *C. gnidia* ocurrio historicamente en el estuario de La Cruz. Sin embargo, *C. gnidia* no ha ocurrido en numeros altos en el estuario por lo menos de treinta años y condiciones del habitat actual no parecen ser adecuados para esta especie.

INTRODUCTION

Clams are abundant along the coasts of Mexico and are highly prized food items (Manzi & Castagna 1989). One of the most sought after species of clams along the western coast of Mexico is *Chione gnidia* (Broderip & Sowerby). In spite of the demand for this species, little has been published about its' distribution or basic ecology (Aquilera & Mathews 1974, Baqueiro & Masso 1983). *C. gnidia* is harvested in large numbers from the estuary of Huivuilai, 100 km southwest of Ciudad Obregon, Sonora, Mexico. The species may have also once occurred in harvestable numbers in the estuary of La Cruz further north (Martinez 1986). Martinez (1986) suggested the possible reintroduction or culture of this species in the estuary of La Cruz, in an effort to reestablish this fishery.

We undertook an evaluation of the feasability of reintroduction of *C. gnidia* to the estuary of La Cruz. We also compared the habitats occupied by *C. gnidia* in the estuary of Huivuilai with those available in the estuary of La Cruz.

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DESCRIPTION OF THE STUDY AREA

The estuary of La Cruz is located about 100 km southwest of Hermosillo, Sonora (figure 1). It is about 52 square km in area. The nearest town (1500 inhabitants) is Kino Viejo about 1 km west of the estuary. Water enters and leaves the estuary through a single 300 meter opening.

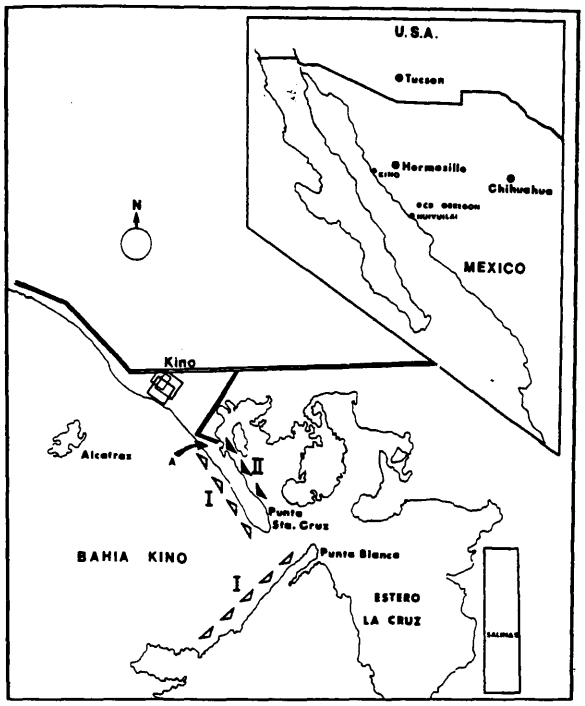


Figure 1. Map of Kino Bay. Region I composed of fine and coarse sand and II sand mud mixtures. A) location of C.I.C.T.U.S. research station.

The estuary of Huivuilai is located about 100 km southwest of Ciudad Obregon (figure 2). The estuary is formed by the mainland on the west and Huivuilai island on the east. Water enters and leaves the estuary (also called Paradon Bay) through a 500 meter wide opening at either end of Huivuilai island. The villages (combined population about 2500) of Paredon Colorado and El Paredoncito are located along the coastal side of the estuary. A non-functional bridge between the mainland and the island has three 150 meter openings through which water can flow.

MATERIAL AND METHODS

We surveyed transects across the estuary of La Cruz and the estuary of Huivuilui to determine the macrohabitats present and the presence or absence and density (rare, common, abundant) of *C. gnidia* in each habitat. Simultaneously, we surveyed the families that have historically fished for clams in the estuaries of La Cruz and Huivuilui to define the oral traditions concerning the occurrence and harvest of *C. gnidia* from each location. We determined the availability of "optimal habitats" (those where *C. gnidia* was abundant) in both estuaries.

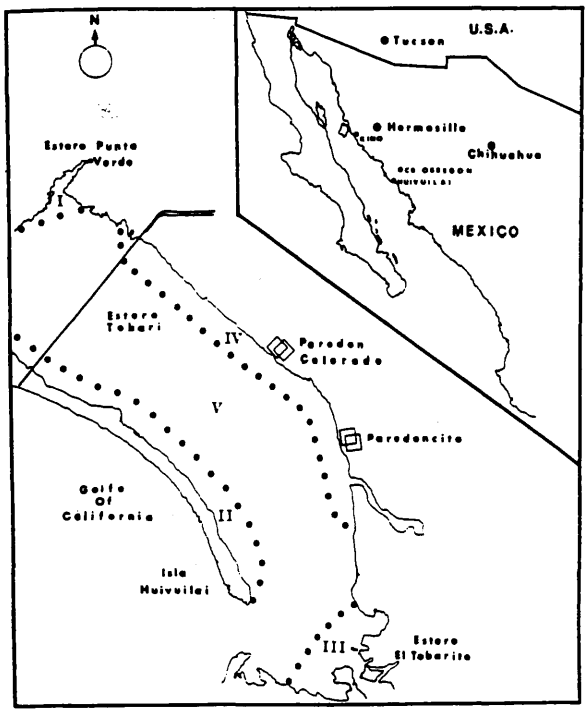


Figure 2. Map of Huivuilai coast. I) Northern estuary, II) Eastern coast of Huivuilai Island, III) Southern estuary, IV) Bay's coastal region, and V) Central Fringe.

RESULTS

There are only two types of macrohabitats in the estuary of La Cruz. Along the shore north from Punta Santa Cruz there is a narrow band of sediments composed of a mixture of mud and sand. The sediment in the rest of the estuary is nutrient rich anaerobic mud.

There are five distinct macrohabitats in the estuary of Huivuilui. Habitat 1 has sediments composed of nutrient rich anaerobic mud comparable to those in the estuary of La Cruz. Several species of clams inhabit these areas but *C. gnidia* is rare. Habitat 2 is an area of predominantly sandy substrates with a few areas of mud and gravel. *C. californiensis* (Broderip) is the primary clam present; *C. gnidia* is rare. Habitat 3 is geographically seperated from Habitat 1 but is similar physically and biologically. Habitat 4 is a shallow intertidal area that has a substrate of mostly mud and mud/sand. Few clams are present. Habitat five is the largest (5 square kilometers surface area) and has a highly aerobic mud substrate with little aquatic vegetation. *C. gnidia* is abundant; an individual fisher can harvest about 600 clams per day.

Oral Traditions Concerning the Occurrence and Harvest of *C. gnidia* from the Estuary of La Cruz and the Estuary of Huivuilui

About six families are traditionally involved in seasonal clam harvest from the estuary of La Cruz. No one surveyed ever remembered a time when *C. gnidia* had been either abundant or commercially harvested from this area. Conversly, *C. gnidia* is regularly harvested from the estuary of Huivuilui. Daily harvest averages about 600 clams per individual, and between 10 and 15 individuals harvest clams each day. This rate of harvest has continued for at least the last 30 years.

DISCUSSION

Although *C. gnidia* may have once been present within the estuary of La Cruz, there is no recent evidence that the species has ever been abundant. The oral traditions of the local fishers suggest that the species has not been present in the estuary in any numbers for at least the last thirty years. In addition the habitats currently available in the estuary of La Cruz are not suitable for this species; highly aerated mud substrates with little aquatic vegetation are absent. Attempts to culture or to augment the population of *C. gnidia* within the estuary of La Cruz do not appear feasible given their current low numbers and the absence of suitable habitat.

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Desert Tortoise Research and Management Conducted by the Arizona Game and Fish Department

Programa de Manejo e Investigacion del Departmento de Caza y Pesca de Arizona para la Tortuga del Desierto

Roy C. Averill-Murray

The Arizona Game and Fish Department is currently involved in several management activities and research projects involving the desert tortoise (*Gopherus agassizii*), whose distribution is divided almost equally by the U.S.-Mexico boundary. The Department is a member of the Desert Tortoise Management Oversight Group, which is primarily involved in management issues regarding the threatened Mojave population. The Department and U.S. Fish and Wildlife Service co-chair the Arizona Interagency Desert Tortoise Team (AIDTT), which focusses on management of desert tortoises in the Sonoran Desert. The AIDTT recently released its Management Plan for the Sonoran Desert population of the desert tortoise in Arizona. In cooperation with the Service and the Bureau of Land Management, the Department manages a monitoring program of tortoise populations in Arizona. To date, 16 study plots up to 1.5 square miles have been surveyed at least twice, with all tortoises found receiving individual marks; several additional plots are scheduled to be surveyed a second time in the near future. This monitoring effort will require a long-term commitment to provide definitive evidence of local population status and trends, but data gathered so far indicate that Sonoran Desert populations are stable at present. Finally, the Department is conducting an ecological study of desert tortoises at a more intensive radio-telemetry study site. This study is collecting data to quantify reproductive output and determine relationships with environmental variables so that local and regional population viability may be estimated.

El Departamento de Caza y Pesca de Arizona está llevando a cabo varios proyectos sobre manejo e investigación de la tortuga del desierto (*Gopherus agassizii*), cuya distribución geográfica está dividida casi por la mitad por la frontera México-Estados Unidos. El Departamento es miembro del Grupo de Trabajo para el Manejo de la Tortuga del Desierto, el cual está enfocado al manejo de la población de tortuga deMohave. El Departamento, junto con el Servicio de Pesca y Vida Silvestre de los Estados Unidos, encabezan el Equipo de Trabajo para la Tortuga de Desierto en Arizona (AIDTT, por sus siglas en Inglés), el cual está enfocado al manejo de tortugas de desierto en el Desierto Sonorense. El AIDTT acaba de publicar su "Plan de Manejo para la Población del Desierto de Sonora". El Departamento, en cooperación con el Servicio y el Buró de Manejo de Tierras, implementa un programa de monitoreo de las poblaciones de tortuga en Arizona. Hasta la fecha, se han muestreado 16 cuadrantes de estudio (de 1.5 millas cuadradas cada uno, visitando al menos dos veces cada uno), marcando individualmente todas las tortugas que se han encontrado. Algunos cuadrantes adicionales están programados para ser muestreados una segunda

vez, en un futuro cercano. Este esfuerzo de monitoreo requerirá de un compromiso a largo plazo para demostrar el estatus poblacional y sus tendencias, aunque la información colectada hasta la fecha indica que las poblaciones en el Desierto Sonorense estan estables. Finalmente, el Departamento está llevando a cabo un estudio ecológico mas intenso sobre radio-telemetría, con el propósito de obtener información para cuantificar el éxito reproductivo y determinar las relaciones con variables medioambientales, de tal manera que la viabilidad poblacional local y regional pueda ser estimada.

A Community-Based Effort to Repair Damaged Riparian Ecosystems Along the Santa Cruz River in Sonora, México

Un Esfuerzo Comunitario para el Mejoramiento de los Ecosistemas Ribereños del Río Santa Cruz en Sonora, México

Mark K. Briggs and Joaquin S. Murrieta

Natural resource practitioners in Sonora, México and Arizona have embarked on a community-based effort to repair damaged riparian ecosystems along the Santa Cruz River in Sonora. In comparison to most other major rivers that cross the U.S.-México border, the reach of the Santa Cruz River in Sonora has received little attention. Although portions of this reach are in good ecological condition, other parts have been heavily damaged by a variety of human-related activities including agriculture, gravel pit operations, and livestock grazing. In addition, this region has suffered from a drought that has lasted over 15 years. Ecological decline along this reach includes loss of riparian plant communities, deterioration of water quality, increased channel instability, and a decline in groundwater levels. These changes impair the well-being of many species of wildlife as well as undermine the economic vitality and overall community health of riverside communities. In close cooperation with universities, federal and state agencies, and conservation organizations from both sides of the Arizona-Sonora border, the Sonoran Institute is working at the community level to design and implement practical, hands-on recovery projects that focus on improving the overall ecological condition of the river and its riparian ecosystems, as well as enhancing the overall health and economic vitality of towns along the Santa Cruz River. Specifically, three activities are being carried out: (1) a series of livestock management workshops that will provide local ranchers with a variety of strategies for improving the management of livestock along the river; (2) the development of a river park that will reduce damage from recreation activities as well as enhance the protection of intact riparian communities; and (3) the continuation of a water quality monitoring program.

Los administradores de los recursos naturales en Sonora, México y Arizona, E.E.U.U. han empezado un esfuerzo comunitario para mejorar la condición de los ecosistemas ribereños que han sido dañados a lo largo del Río Santa Cruz en

Sonora. En comparación con muchos otros ríos que cruzan la frontera, esta parte del Río Santa Cruz ha recibido poca atención. Aunque partes del río están en buena condición ecológica, otras partes han sido dañados profundamente por actividades humanas, incluyendo agricultura, funciones de las minas arenarias, y ganado. Además, esta región ha sufrido 15 años de sequía. El daño ecológico a esta parte del Río Santa Cruz incluye la pérdida de los ecosistemas ribereños, el deterioro en la calidad de agua, un aumento en la inestabilidad del canal del río, y disminución en el nivel del agua subterránea. Estos cambios perjudican el bienestar de la fauna silvestre y compromete la vitalidad económica y la salud comunitaria de los pueblos a lo largo del río. En cooperación con las universidades, agencias federales y estatales, y organizaciones particulares de los dos lados de la frontera, el Sonoran Institute está trabajando con las comunidades a lo largo del río para diseñar y realizar estrategias prácticas que mejorarán la condición ecológica del río y sus ecosistemas ribereños. También, este proyecto aumentará la condición económica y la salud comunitaria de los pueblos a lo largo del Río Santa Cruz. Específicamente, este esfuerzo tiene tres actividades principales: (1) la implementacion de una serie de talleres con los rancheros sobre el manejo de ganado; (2) el desarrollo de un parque al lado del río que reducirá los impactos de las actividades recreativas y protegerá partes del río que tienen ecosistemas ribereños intactos; y (3) la continuación de un proyecto de monitoreo sobre la calidad del agua en esta parte del Río Santa Cruz.

Insectos Defoliadores Asociados a 4 Especies de Encinos (*Quercus L.*) en el Parque Nacional Cumbres de Monterre

Insect Leafeaters Associated with Four Oak Species (*Quercus L.*) in the National Park Cumbres De Monterrey

Florentino Caldera Hinojosa and Jaime Flores Lara

Fueron seleccionados dos sitios de estudio comprendidos dentro del Parque Nacional Cumbres de Monterrey el primero Chipinque en el municipio de San Pedro Garza García N.L. Méx., el segundo en el Cercado y Puerto Genovevo en Santiago N.L. Méx. Para la evaluación de la defoliación, determinación y diagnostico de los insectos, se utilizó el Método de Cuadrante con Punto Central modificado se realizaron 5 transectos con 200m de longitud en cada una de las áreas de estudio (1% de intensidad de muestreo). De la defoliación se obtuvo un 23.02% de defoliación en Chipinque y 23.55% en Santiago N.L. Ambos porcentajes están considerados como condición de foliación ligera según Camacho 1982, Carvajal y Vera 1988 y Cibrian et al 1994. De los resultados sobre las especies de defoliadores se obtuvo un total de 19 familias de insectos representado en 3 ordenes, destacando el orden Lepidoptera con 14 familias, El orden Coleoptera con 3 familias y en menor proporción el orden Orthoptera e Hymenoptera con una familia cada una.

The general objective of this paper is to describe the different species of defoliators associated with four oak species. The study was done on two areas of the national park. Parque Chepinque is located in the municipalities of San Pedro Garza Garcia, N.L. and Santiago N.L. The oak species involved in the study were: *Q. polimorpha, lacey, rysophylla* and *Q. camby*. The collection of data was carried out using a variation of the point centered quarter method; the 5 transects were 200m long in each of the areas (1 % of sampling intensity). Evaluation of defoliation was estimated and the percentage of defoliation was 23.02% in Chepinque and 23.55% in Santiago N.L. Both percentages are considered small according to Camacho (1982), Carbajal and Vera (1988) and Cibrian et. al (1994). From results obtained for leaf eater species, the total family of insects was obtained. They were represented in 3 orders where lepidoptera showed 14 families and this was followed by Coleptera with 3 families and Orthopthera and Hymenophera had only 1 family each.

Extendiendo el Concepto de Corredores Binacionales a Distritos: Dos Áreas Culturales y Naturales a lo Largo de la Frontera Entre San Diego y Tijuana

Extending the Concept of Binational Corridors to Districts: Two Cultural and Natural Areas Along the San Diego and Tijuana Border

María E. Castillo-Curry

A lo largo de la frontera entre México y los Estados Unidos, existen áreas culturales y naturales compartidas por ambas naciones. Algunas de éstas han sido en el proyecto binacional "Los Caminos del Río" en el lado este de la frontera y están relacionadas al río que divide a ambos países. En el oeste, los Estados Unidos y México están separados en una porción por una barda, la cual aunque controversial, se ha convertido en un símbolo de las relaciones entre las dos sociedades. Los mexicanos y estadounidenses ven esta barda como un lugar de división, pero también de encuentro entre las dos culturas. A cada lado de la barda existen recursos culturales y naturales, algunos de los cuales se concentran en nodos o distritos en puntos específicos. Estos nodos están formados por la intersección de la barda la cual corre horizontalmente con otras áreas o corredores culturales que lo atraviesan en la dirección norte-sur. Este artículo analiza las características culturales y naturales únicas de dos áreas o distritos binacionales en la frontera entre Tijuana y San Diego, utilizando mapas, fotografías e investigación histórica. La primera esta localizada en el punto de cruce de la barda divisoria y el Océano Pacífico e incluye un área urbana en Tijuana y una reserva natural en los Estados Unidos. La otra esta formada por la intersección de la misma barda y el ferrocarril binacional San Diego y Arizona.

Along the Mexico/U.S. border, there are cultural and natural resources shared by both nations. Some of these have already been identified in "Los Caminos del Río" binational heritage project on the east side of the border and are related to the river that divides both countries. On the west, the U.S. and México are separated by a fence which although controversial, has become a symbol on the relations of both societies. Mexicans and Americans look at the fence as the dividing but also as the encounter place of their cultures. On each side of the fence there are natural and cultural resources some of which concentrate in nodes or districts at specific points. These nodes are formed by the intersection of the fence which runs horizontally and other natural or cultural areas or corridors that traverse on the north-south direction. This paper analyzes the cultural and natural unique characteristics of two binational node areas in the Tijuana and San Diego border utilizing maps, photographs and historical research. The first one is located in the crossing point of the fence and the Pacific Ocean and includes an urban area in Tijuana and a natural reserve in the U.S. The other is formed by the intersection of the fence and the San Diego and Arizona binational railroad. The purpose of the work is to discuss the possibilities of expanding the binational corridor concept to districts and to call the attention on the importance of preserving the valuable characteristics of them in order to improve the understanding of both nations, their natural and built environments and the quality of life in the border.

Agua y Desarrollo Sustentable en la Cuenca del Rio Bravo/Rio Grande: El Caso de la Cuenca Baja

Water and Sustainable Development in the Binational Lower Rio Grande/Rio Bravo Basin: The Case of the Lower Rio Bravo Watershed

José de Jesús Návar Cháidez

La cuenca baja del río Bravo, desde aguas abajo del embalse Falcón hasta el Golfo de México esta experimentando un rápido crecimiento en población, industria y servicios. La cuenca está también presentando un crónico déficit de agua. La presencia de la sequía de los 1990´s ha evidenciado la capacidad de almacenamiento de los embalses de la cuenca para satisfacer la creciente demanda por el agua. Los conflictos históricos por los derechos por el agua se han profundizado. Este proyecto busca entender la oferta y demanda por el agua superficial de la cuenca baja para especular sobre los posibles escenarios para el año 2030, con los siguientes objetivos: 1) observar la oferta del agua, 2) observar la demanda para uso: 2.1) agrícola y 2.2) municipal e industrial y 3) observar los cambios temporales en la superficies irrigadas y 4) especular sobre los escenarios futuros para los años 2010, 2020 y 2030.

Los resultados preliminares han mostrado que las descargas del complejo 'La Amistad – Falcón' están programadas para la agricultura del distrito de riego

025 y las unidades de la parte americana. Los descargas para usos municipales son menores al 5 % y no se consideran los servicios ambientales de los caudales. Las tomas de agua para usos municipales están incrementando a una tasa anual aproximada del 1-2 % y las superficies irrigadas están reduciéndose a una tasa del 0.4 %. La urbanización, el traspaso de los derechos por el agua y sobre todo la reducción en la disponibilidad de agua para la agricultura son los factores que explican este comportamiento. Escenarios preliminares han evidenciado la potencial reducción de las superficies agrícolas bajo riego en aproximadamente un 30 % por la potencial reducción de los caudales disponibles durante sequías extremas con densidades poblacionales esperadas para el año 2030. Estas nuevas superficies no se han registrado en la historia de los distritos de riego en Mĕxico.

The lower watershed of the Rio Bravo/Rio Grande, from the reservoir Falcon to the Gulf of Mexico, is experiencing a fast growth in population, industry, and services. The watershed is also facing a chronic water deficit, deteriorating the quality of surface water and evidencing the storage capacity of its reservoirs to cope with increased water demands in drought spells. These sets of issues are deepening historic conflicts of water rights. This project focused on understanding the surface water supply and demand of the lower watershed to speculate on scenarios for the year 2030, with the following objectives: 1) to observe the water supply along the lower Rio Bravo, 2) to observe outflows, considered demands, for: 2.1) agriculture and 2.2) municipal use, 3) to observe temporal changes on irrigated areas, and 4) to speculate on future irrigated areas for the years 2010, 2020 and 2030. The main source of information was provided by IBWC.

Preliminary results showed that discharges from La Amistad - Falcon are programmed for agriculture (98%) and municipal use (2%) and do not consider the riparian ecosystems of the lower Rio Bravo. Outflows for municipal use are increasing at an annual rate of 1% to 2% and irrigated lands are shrinking and were statistically related to time and discharges from Falcon. Urbanization and transferal of water rights may explain this behavior. Scenarios indicated that irrigated land would shrink in the future considering a drought spell because it showed that reduction of 30% of the releases from Falcon diminished 10 and 4 % irrigated area in the Mexican and American parties, respectively. Considering exclusively time, the irrigated lands would shrink for the years 2010, 2020 and 2030 in 25,590 and 80,830; 33,490 and 95,040; and 41,240 and 109,240 has for the American and Mexican sides, respectively. These areas have not been previously recorded in the watershed. Future work include the operational scenarios based on more important drought spells and the development of indexes based on increased population and water use for agriculture.

Agua y Desarrollo Sustentable en la Cuenca Baja del Rio Bravo: El Caso Del/Rio San Juan

Water and Sustainable Development in the Binational Lower Rio Grande/Rio Bravo Basin: The Case of the San Juan River

José de Jesús Návar Cháidez

El río San Juan es de fundamental importancia para la hidrología de la cuenca baja del río Bravo/río Grande. Las aguas superficiales han sido un elemento clave para el agua municipal del Area Metropolitana de Monterrey. Embalsès como 'La Boca,' y 'El Cuchillo' suministran cerca del 30 % de las aguas municipales. Las aguas del río son también la única fuente para la agricultura de los distritos de riego 026 y 'Las Lajas'. La presente sequía de los 1990's ha causado una reducción en los caudales del río, estresando las relaciones entre usos, usuarios y fronteras políticas. Esta problemática podría empeorar en el futuro por el incremento en la demanda y la potencial reducción en la oferta del agua por las recurrentes sequías en la región.

Este proyecto busca como objetivos entender los escenarios futuros sobre la oferta y demanda del agua en la cuenca del río San Juan para los años 2010, 2020, y 2030 por las variables: 1) sequías, y 2) incremento en la demanda municipal de agua. Esta información es un componente clave para manejar sustentablemente los recursos hidrológicos de la cuenca del río San Juan. Parte del proyecto por ahora se ha concentrado en modelar los balances hidrológicos de los embalses: 1) La Boca, 2) El Cuchillo, 3) Marte R. Gómez, y 4) Cerro Prieto. Los balances hidrológicos incluyeron la predicción de: 1) la evaporación mensual, 2) las relaciones volumen - área, y 3) las relaciones entre caudales observados y predichos. Los trabajos pro desarrollar incluyen: el desarrollo de un modelo para explicar el manejo conjunto de los embalses El Cuchillo - Marte R Gómez e imponer los cambios en la oferta y demanda para establecer los escenarios de este proyecto. Estos trabajos estan en proceso y se espera completarlos a finales del presente año.

The San Juan river is critical to the hydrology of the lower Rio Grande/Rio Bravo Basin. Its water resources have been a key element to the municipal water supply of the Metropolitan Area of Monterrey (MAM). Reservoirs such as "La Boca," and "El Cuchillo" supply about 30% of all municipal water. It is also the main water supply for agriculture of the irrigation district 026. The current drought has caused below normal stream discharge in several tributaries of the San Juan watershed, placing increased stress on the political relationships between water users, users, and political boundaries. This set of affairs would probably worsen in the future because of the increment on water demand for municipal use in the Metropolis of the watershed.

This project seeks to understand the scenarios on the water resources of the San Juan watershed by the years 2010, 2020, and 2030 because of: 1) drought spells, and 2) increased municipal water use. This information is a key compo-

nent to sustainable manage the water resources of the San Juan river. Part of the project has been already accomplished by modeling water balances of the reservoirs 1) La Boca, 2) El Cuchillo, 3) Marte R. Gomez, and 4) Cerro Prieto. Water balances included modeling: 1) monthly evaporation, 2) volume-area relationships, and 3) regressing observed or gauged inflows. Immediate future tasks include: the development of an underlying model to explain the joint management of the El Cuchillo-Marte R Gómez reservoirs and to input the scenarios detailed in this project. To accomplish this, the following goals should be met: 1) to estimate backwards the water balance for the El Cuchillo reservoir and 2) to understand the joint hydrology of both reservoirs, and development of the underlying model. These tasks would be conducted this year and thet are expected to provide information to sustainable manage the San Juan Watershed.

Cattle Points: Migratory and Native Waterfowl Conservation Areas in Northern Mexico

Presones Ganaderos: Áreas De Conservación para las Aves Acuáticas Migratorias y Nativas, en el Norte de Mexico

Enrique Cisneros Tello, Alberto Lafón Terrazas, and Patricio Tavizon García

The points, watering holes, and ponds are the available water sources not just for the economic interest pecuary species in Northern Mexico, but also for a great number of other species of wildlife such as the Mexican Duck (*Anas diazi*), a native species that nests in the cattle ponds where the water availability and coverage during its nesting season is a determinant factor for its duckling production.

The objective of this program is to develop a conservation culture with the land owners, protecting the surrounding areas of the points, and reserving some areas for the cattle to drink water. Also, this program helps to create an awareness of the importance of these areas and about the benefits that represent conservation. Other objectives of this program are to establish a non formal educative program about native and migratory waterfowl and to create a conservation tool for the Mexican Duck. This program is being developed in coordination with the Universidad Autonoma de Chihuahua and the Ecology Department of the Mexican State of Zacatecas, and is directly involving the land owners. Recently we worked with 25 points, benefiting 3000 acres in northern Mexico.

Los abrevaderos, bordos y represas ganaderas son la fuente de agua disponible, no solo para las especies pecuarias de interés económico, en el Norte de México, sino para un gran número de especies de fauna silvestre y especialmente para el Pato Mexicano (*Anas diazi*), especie nativa que anida en los presones ganaderos donde la disponibilidad de agua y cobertura durante la temporada de anidación es un factor determinante para la producción de sus crías.

El objetivo del programa es desarrollar una cultura de conservación con los dueños de los predios, protegiendo las área circundantes de los presones dejando espacios para que el ganado pueda tomar agua. Concientizarlos de la importancia de estas áreas y de los beneficios que representa conservarla adecuadamente. Establecer un programa educativo no formal en torno a las aves acuáticas migratorias y nativas. Brindar una herramienta de conservación para las poblaciones de Pato Mexicano (*Anas diazi*). El programa se esta desarrollando en coordinación con la Universidad Autónoma de Chihuahua y la Dirección de Ecología del Estado de Zacatecas, involucrando directamente a los dueños de los predios. Actualmente trabajamos con 25 presones , beneficiando a 3000 acres, en el Norte de México.

Distribucion de la Avifauan del Cerro el Potosi, Galeana, Nuevo Leon, Mexico

Distribution of the Avifauna from Cerro el Potosi, Galeana, Nuevo Leon, Mexico

Antonio Guzmán-V., Armando J. Contreras-B., Juan A. García-S., y José I. González-R.

El Cerro del Potosí se encuentra localizado en la Sierra Madre Oriental, en el estado de Nuevo León, al NE de México. Tiene una altura de 3715 msnm y presenta 6 tipos de vegetación; lo que da como resultado que sea una formación con características fisiográficas, climáticas y faunísticas muy particulares. Los objetivos del trabajo fueron: elaborar el inventario avifaunístico; establecer la afinidad zoogeográfica familiar y específica; determinar la residencia temporal y estacional de las especies y describir la distribución altitudinal de la avifauna en el Cerro del Potosí. Se hicieron visitas preliminares y 12 transectos mensuales de 30 km cada uno en 1995. Las observaciones se realizaron desde la hora de la salida del sol a una velocidad de 3.3 km/h. La identificación fué por registros visuales. El arreglo y ordenamiento filogenético se hizo de acuerdo al criterio de la AOU (1983), y el análisis zoogeográfico de acuerdo a Darlington (1957), AOU (1983) y Howell y Webb (1995). Se observaron un total de 4115 individuos que se agruparon de la siguiente forma: 6 Ordenes: 22 Familias: 63 Géneros y 81 especies. Biogeográficamente las familias se agrupan en: 3 Holárticas, 1 Neártica, 6 Continentales americanas, 10 Cosmopolitas y 2 Pantropicales; las especies se agrupan en: 1 Holártica, 28 Neárticas y 52 Continentales americanas. De acuerdo a su residencia las especies son: 38 Residentes permanentes, 13 residentes veraniegas, 25 Migratorias, 3 Ocasionales y 2 Inciertas. Ecológicamente, de acuerdo a la distribución por tipos de vegetación, las especies se distribuyen en: 52 en comunidad de encinos *Quercus imbricata* (2000-2200m) ; en las comunidades de pinos: 34 en *Pinus cembroides* (2200-2800m) , 40 en P. ayacahuite (2800-3500m), 18 en P. hartwegii (2900-3000m), 24 en P. culminicola (3500-3650m), y en la Pradera alpina (3600-3715m) 18.

The Cerro El Potosí, is a high peak (3715 meters above sea level) in the Sierra Madre Oriental in Nuevo Leon, northeast of Mexico.The objective of this work is to identify the avifauna and their altitudinal distributions, also biogeographic affinities (families and species), and seasonal residences. We visited the area during different years and months, and in 1995, monthly. A transect of 30 km was covered in 3.3 km/h. The arrangement was follow to AOU (1983), and biogeographically to Darlington (1957), AOU (1983), and Howell and Webb (1995). We found 4115 individuals, in 81 species, 63 geneus, 22 families and 6 orders. Biogeographicaly the families are: 3 Holarctic, 1 Nearctic, 6 American continental, 10 Cosmopolitan and 2 Pantropical; the species are: 1 Holarctic, 28 Nearctic and 52 American continental. For seasonal residents: 38 Permanent resident, 13 summer resident, 25 migrant, 3 occasional and 2 unknown. Ecologically, the species are distributed for vegetational types as follow: Oak community *Quercus imbicata* (2000-2200masl) 52; Pine communities: *Pinus cembroides* (2200-2800masl) 34; P. *ayacahuite* (2800-3500masl) 40; P. *hartwegii* (2900-3000masl) 18; P. *culminicola* (3500-3650masl) 24, and alpine prairie (3600-3715masl) 18.

Cambios de Biodiversidad Ictica del Bajo Rio Bravo/Rio Grande, Tamaulipas (Mexico)/Texas (USA)

Fish Biodiversity Changes in the Lower Rio Grande/Rio Bravo, Tamaulipas (Mexico)/Texas (USA)

Salvador Contreras Balderas, Ma. de Lourdes Lozano Vilano, Ma. Elena García Ramírez, y Robert J. Edwards

El Río Bravo es el mas importante en el Noreste de México. La parte baja está altamente impactada por los desechos industriales, agropecuarios y domésticos, así como por la reducción del flujo de agua. En el presente estudio se intenta interpretar y evaluar los cambios ambientales a través del tiempo, utilizando a los peces como indicadores ecológicos. Se utilizó la información publicada y la acumulada en las colecciónes ictiológicas de la Facultad de Ciencias Biológicas, Universidad Autónoma de Nuevo León, México y University of Texas Pan American, Edinburg, Tx., USA. Un total de 17 localidades desde El Río Bravo en Colombia, N.L., hasta la Boca del Río Bravo, Tamps. y Texas, monitoreadas de 1954 a 1996. Se observó entre 75 y 100% de desaparición de especies nativas, las cuales en su mayoría requieren de aguas limpias y corredizas para su subsistencia; se encontraron entre 1-9 especies exóticas, las cuales en su mayoría también desaparecieron, a pesar de tener alta tolerancia a los cambios ambientales; tambien se encontraron hasta 40 especies periféricas invasoras en colectas de 1989 en la Boca del Bravo, con un total acumulado de 94 invasoras o salobres, algunas con penetración 600 km río arriba, lo cual indica salinización y pérdida de disponibilidad (cantidad/calidad) de agua en la parte baja del río Bravo. El futuro de la región depende de una fuerte racionalización del uso del

agua con bases ecológicas y de manejo de cuencas para el manejo integral y una posible restauración ambiental, dentro del Plan Integral Ambiental Fronterizo derivado del Tratado Americano de Libre Comercio, particularmente importante en considerar que nosotros, como los peces requerimos alta calidad de agua, y dependemos del ciclo del agua, que es indispensable para el ambiente y las actividades humanas y para los recursos naturales vivos mismos.

The Rio Grande is the largest river in Northeastern Mexico and the US border. The Lower Rio Grande is highly impacted by industrial, agricultural and municipal residual waters, and reduced water flow. This study interprets and evaluates environmental changes through time, using fish as ecological indicators. It summarizes published data and fish collection holdings at Universidad Autonoma de Nuevo Leon, and University of Texas at Pan American (Edinburg, TX,). A total of 17 localities from Rio Grande at Colombia to the Rio Grande mouth, Tamps./Texas, were monitored from 1954 to 1996. We recorded between 75 and 100% disappearance of native species, where a majority require clean running waters; 1-9 introduced species, the majority also disappearing, in spite of their tolerance to environmental changes; a high incremental trend of perypheral species was detected, up to 40 per collection until 1989, and 94 invader or brackish water species accumulated to 1996, some of them penetrating up to 600 km. Together these findings indicate high salinization and loss of water availability (quantity/quality) in the Lower Rio Grande Valley. The future of the region depends on a strong rationalization of water uses, applying ecological and basin management criteria, towards a really holistic management and a possible environmental restoration, considering the Integrated Border Environmental Plan, derived from the North American Free Trade Agreement, particularly important when we consider that we, as most native fishes, require high water quality, and depend on the hydrological cycle, both are natural resources, basic to human environment and activities.

Estudio de la Diversidad y Abundancia de Macrophytas en el Municipio de Nuevo Laredo, Tamaulipas, México

Gustavo Córdova Bojórquez

Se presentan los resultados del trabajo de campo realizado en cinco sitios con diferente manejo del agostadero por la actividad ganadera local. El objetivo de este trabajo es determinar la diversidad y abundancia de plantas vasculares en estos sitios y ver el comportamiento de las poblaciones de las diferentes especies por sitio. Para ello se sigue la metodología de "Cuadros típicos" (cuadrantes). En este método los lotes cuadrados o rectangulos están distribuidos en toda el área de estudio y todos los individuos dentro de cada lote están numerados, de aquí se obtiene la densidad de la especie x, asimismo se asume que los doseles de las plantas son circulares y se computa la cobertura relativa de cada especie. Los

resultados muestran que en los cinco sitios de muestreo se pudieron detectar a 134 especies, de las cuales 33 son árboles o arbustos, 16 pastos, 9 cactáceas y 76 herbáceas. En cuanto a la abundancia y cobertura de especies se distingue el Mezquite (*Prosopis glandulosa*), huizache (*Acacia farnesiana*), oreganillo (*Lipia graveolens*), Guayacán (*Porlieria angustifolia*), tasajillo (*Opuntia leptocaulis*) y nopal (*Opuntia* spp.). La conclusion principal es que existen marcados cambios en la diversidad y abundancia de ciertas especies de macrophytas en cada sitio. Las hipótesis que surgen están relacionadas con el tipo de manejo que se da para cada sitio o de algún elemento físico como el suelo que pueda estar influyendo en el comportamiento de las poblaciones.

This study shows the results of field work in five sites with different management for local cattle raising activity. The goal is to determine the diversity and abundance of vascular plants on these sites and to see the behaviour of the population of different species for sitie. That's why the "Typical square" methodology is applied. In this method, the square o rectangular portion are distributed all around study area and all individual inside of each portion are numered to get the density of "x" species. In the same way is supposed that plant canopy is circular and the relative coverage of each species is counted. The results show that in the five sample sites were detected 134 species: 33 tree and shrub, 16 grass, 9 cactaceae and 76 herb. With respect to abundance and coverage of species, the mesquite (*Prosopis glandulosa*), huizache (*Acacia farnesiana*), oreganillo (*Lipia graveolens*), Guayacán (*Porlieria angustifolia*), tasajillo (*Opuntia leptocaulis*) y nopal (*Opuntia* spp.) stood out. The main conclusion is that there are important changes in the diversity and abundance of macrophytes species in each site. Hypotheticaly those changes bear relations to type of management of each sitie or physical elements (soil) can influence the population behaviour.

Cacería Responsable: Alcances y Compromisos en el Estado de Nuevo Leon

Responsible Hunting: Far Reaching Statement and Commitments in Nuevo Leon

Marco A. Corti Veláquez, Marco A. Gonzalez Galindo, Jorge G. Villarreal Gonzalez, and Modesto Alanis v d Meden

Preocupados por el futuro de la cacería en México y ante la iniciativa de asociaciones civiles se implementó este programa. Con el objetivo de capacitar a 500 cazadores en 1998 dentro de los cuáles saldrán los futuros instructores. Los cursos se ofrecerán a todos los interesados siendo llevados a cabo cada 15 días con el apoyo de los clubes de caza y de organizaciones no gubernamentales, bajo las normas de instrucción de la International Hunter Education Association. Hasta la fecha se han llevado a cabo 6 cursos (73 cazadores), los problemas mas

comunes es la falta de instructores, la difusión de dicho programa, los recursos económicos y la apatía de los cazadores. Se ha propuesto el curso obligatorio para todas las personas nacidas de 1972 en adelante en este Estado, además de todas aquellas personas que lleven a cabo el ejercicio de la caza para la temporada 1999-2000 en este Estado. Se tiene un tiempo muy restringido, la solución va a ser el apoyo de los mismos cazadores los cuáles serán instructores voluntarios del programa después de tomar un curso para instructores. Es el esfuerzo mas serio de educación para cazadores en México.

Concerned about the future of hunting in México and because of the initiative of the hunting organized groups, this program was implemented. With the objective of training 500 hunters in 1998 where new instructors will emerge. This courses will be offered to the those who are interested and will be programmed every 15 days in coordination with huntings clubs & NGO's under the quality specifications of the International Hunter Education Association. Up to date 6 courses have been held (73 trained hunters). The common problems associated with this program are the lack of instructors, program promotion, economic resources and lack interested hunters. We have proposed that this program should be obligatory in Nuevo León to those people born after 1972, also those who want to practice the hunting sport by the 1999-2000 season. If we take this into account, we have a very short time. The solution of this program will come from the hunters who will become volunteer intructors after taking instructor training. This is the most serious education effort for hunters in México.

Food Habits of the Kit Fox in Nuevo Leon, Mexico

Mauricio Cotera Correa

The food habits of the kit fox are apparently very different in their distribution area. The goal of this study is to determine the kit fox diet. Between 1990 and 1992 scats were collected and analyzed. The diet of the kit fox was essentially dominated by rodents (52%) and lagomorphs (16%), and it did not show a dependence on a single species.

Los habitos alimenticios de la zorra norteña son aparentemente muy diferentes en su área de distribución. La meta de este estudio fur determinar la dieta de la zorra norteña. Entre 1990 y 1992 se colectaron y analizaron heces fecales de esta especie. La dieta de la zorra norteña fue dominada esencialmente por roedores (52%) y lagomorfos (16%) y no mostró una dependencia a una sóla especie.

Implicaciones de las Caracteristicas de Zonas de Anidación y Los Nidos de la Cotorra Serrana Occidental (*R. Pachyrhyncha)* para su Conservación

Conservation Implications of the Characteristics of Nesting Areas and Nest Sites of the Thick-Billed Parrot (*R. Pachyrhyncha*)

Miguel Angel Cruz Niet, Ernesto C. Enkerlin Hoeflich, Tiberio Monterrubio, Diana Venegas Holguín, and Noel Snyder

Las poblaciones de R. pachyrhyncha han declinado como consecuencia de la remoción de los bosques sobremaduros y la captura de mascotas en la Sierra Madre Occidental. Evaluamos 3 variables de ubicación de los nidos (coordenadas, altitud y exposición de ladera) y 10 variables físicas de cavidades y de árboles (n = 102 nidos) localizados durante tres temporadas reproductivas (1995 a 1997). Los nidos se localizaron en un rango altitudinal superior a los 2 300 m.s.n.m. mostrando una preferencia por laderas expuestas al norte, las cuales mantienen condiciones ecológicas diferentes a las otras exposiciones. Existe una aparente agregación de nidos pero esta no pudo evaluarse estadísticamente. Las características de los árboles y cavidades refleja la dependencia de R. pachyrhyncha por los bosques sobremaduros. Las áreas de anidación importantes han sido propuestas para su protección al gobierno Mexicano a través de mecanismos participativos innovadores, así como algunas recomendaciones sobre aprovechamiento forestal. Aunque permanece la amenaza de explotaciones forestales que ven en estos bosques maduros un rápido y rentable negocio. Cebadillas de Tosanachic reviste singular importancia por contener la mayor concentración de nidos de la especie y muchos otros valores de biodiversidad y servicios ecológicos.

The thick-billed parrot is a conspicuos and endemic specie of the Sierra Madre Occidental. Its populations have decreased precipitously due to the elimination of old-growth forests and its capture for the pet trade. We compared three site variables (location, altitude and exposure) and 10 characteristics of cavities and trees for 102 nests during three nesting seasons (1995 to 1997). Over 98% of nests were located above 2300 masl. Spatial distribution shows a significant preference for sites on slopes with north, northeast and northwest orientation, which have different ecological conditions and structure that other slopes. A trend toward aggregated nesting was noted but could not be tested statistically. Six tree species are used for nesting and its characteristics, indicate that old-growth forest or functional equivalent is needed by thick-billed parrots. The most important nesting areas have been proposed for protection through innovative community based mechanisms to Mexican authorities, and we have made recommendations for forestry practices that protect biodiversity. The area of Cebadillas de Tosanachic is especially important because it has the largest known breeding aggregation of thick-billed parrots and additional important biodiversity values and ecosystem services.

Upper Gulf of California and Colorado River Delta Biosphere Reserve: Response of the Small-Scale Fishermen Three Years After its Declaration

Reserva de la Biósfera Alto Golfo de California y Delta del Río Colorado: Respuesta de los Pescadores de la Flota Menor Tres Años Después de su Declaratoria

John R. Cudney

In June 1993, the upper Gulf of California and Colorado River delta region, in Mexico, was declared a Biosphere Reserve (BR). Although the vast majority of users of the marine area of the BR are "small-scale" or "artisanal" fishermen, fishing dynamics of this sector are poorly understood and little has been done to actively incorporate fishermen's opinions and proposals for a better management of their fishing resources.

Considering this, between June 1996 and December 1997, ethnographic work was conducted in the region. As part of this work, 117 structured interviews were applied randomly to small-scale fishermen of the three principal fishing communities that make use of the Reserve: El Golfo de Santa Clara, San Felipe, and Puerto Peñasco. Only captains of vessels were considered in the samples to ensure results were based on years of fishing experience in the upper gulf region. This work focuses on the interviews' assessment of current spatial organization of fishing activities, some of the fishermen's opinions about the BR, and gives a general perspective of their fishery management priorities. Results suggest fishing activity has not increased significantly in the limits of the BR since its establishment. The majority of fishermen believe the Reserve has neither affected nor benefited them in any way and considerable variations exist between communities regarding fishermen's management priorities and their believes as to why the BR was decreed. Suggestions for fishery management are presented based on these results.

En junio 1993, la región del alto Golfo de California y delta del Río Colorado, en México, fue declarada una Reserva de la Biósfera (RB). Aunque la mayoría de los usuarios de la parte marina de la RB son pescadores de la flota menor o "artesanales", la dinámica pesquera de este sector es poco comprendida y se ha hecho poco por incorporar de forma activa las opiniones y propuestas de los pescadores para un mejor manejo de sus recursos pesqueros. Considerando lo anterior, entre junio 1996 y diciembre 1997, se llevó a cabo un estudio etnográfico en la región. Como parte de éste, 117 entrevistas estructuradas fueron aplicadas en forma azarosa a pescadores artesanales de las tres principales comunidades pesqueras que hacen uso de la Reserva: El Golfo de Santa Clara, San Felipe y Puerto Peñasco. Dentro del marco muestral, sólo los patrones motoristas (capitanes) de las embarcaciones menores fueron considerados para asegurar que los resultados fueran basados en años de experiencia de pesca en la región del alto golfo. Este trabajo presenta una evaluación de la actual organización

espacial de las actividades pesqueras, algunas opiniones de los pescadores sobre la RB, y muestra una perspectiva general sobre sus prioridades de manejo pesquero. Los resultados sugieren que la pesca no ha incrementado significativamente en los límites de la RB desde que ésta fue declarada. La mayoría de los pescadores opinan que la Reserva no los ha ni beneficiado ni perjudicado en ninguna forma y existen variaciones considerables entre una comunidad y otra respecto a las prioridades de manejo pesquero de los pescadores y sus creencias sobre las razones por las cuales la RB fue decretada. Se presentan sugerencias de manejo pesquero basadas en estos resultados.

Identificacion de Prioridades para las Areas Naturales Protegidas en la Peninsula de Baja California

Identification of Priorities for the Natural Protected Areas in the Baja California Peninsula

Gustavo D. Danemann y Roberto Enríquez Andrade

Durante 1997 Pronatura Península de Baja California desarrolló el proyecto titulado "Identificación y establecimiento de prioridades para las acciones de conservación y oportunidades de uso sustentable de los recursos marinos en la Península de Baja California". El propósito general de este proyecto fue identificar acciones y establecer prioridades para la promoción del uso sustentable de los recursos marinos y costeros de la península. Considerando el número de áreas naturales protegidas (ANPs) en la región y su importancia, parte de esta investigación estuvo dedicada a explorar posibilidades de acción en las mismas. Los resultados de este componente del proyecto se discuten en esta presentación. Todas las acciones consideradas involucran un trabajo coordinado con el personal que administra cada área. La metodología empleada constó de tres etapas principales: 1) recopilación de información sobre la problemática general de las ANP´s en la península; 2) realización de un taller multisectorial de consulta, en el cual se elaboró un listado de las acciones que se podrían implementar para contribuir a la solución de dichos problemas; y 3) priorización de las acciones propuestas, a través de la aplicación de un modelo de evaluación multicriterio. Se identificaron diez acciones que podrían incidir sobre los problemas detectados. Estas incluyen redefinición de las políticas de las ANP´s, análisis de sistemas de financiamiento, integración de información y capacitación para usuarios y funcionarios. Este modelo aporta bases sólidas para la planeación de actividades de conservación a mediano y largo plazo en las áreas naturales protegidas, presentando además gran flexibilidad para ser utilizado a diferentes escalas y detalle.

During 1997 Pronatura Península de Baja California carried out the project entitled "Identification and determination of priorities for the conservation

actions and opportunities for sustainable use of the marine resources in the Baja California Península". The general goal of this project was to identify the most important actions to promote the sustainable use of the marine and coastal resources of the peninsula. Considering the number and relevance of the natural protected areas (NPAs) in the region, an important part of this research focused on the conservation opportunities in these areas. The results of this component of the project are described in this paper. In all cases the actions considered involve coordinated work with the authorities in charge of the administration of each NPA. The research was carried out in three stages: 1) information gathering regarding the general problems of the NPA´s in the peninsula and the tourism activities carried out there; 2) a multi-sector consultation workshop, where a list of feasible actions for the solution of the problems detected was prepared; and 3) prioritization of the proposed actions by means of a multicriteria evaluation model. Ten actions that could have an influence on the detected problems were identified. These actions include the redefinition of the national and regional policies regarding NPA´s, the development of practical financing schemes, integration of information, and education and training for users and administrators. The evaluation model developed and its results provide basis for conservation planning, and has great flexibility to be used in different scales and detail

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Remocion de Particulas Suspendidas Totales (PST) y Plomo (Pb) Asociado por Especies Vegetales Presentes en el Area Metropolitana de Monterrey (AMM)

Removal of Total Suspended Particulate Matter (TSP) and Associated Lead (Pb) by Vegetal Species in the Monterrey Metropolitan Area (MMA)

Hector F. Duarte-Tagles and Raul A. Garza-Cuevas

De acuerdo a los reportes del Banco Mundial, los mayores riesgos a la salud de la poblacion de paises en desarrollo expuesta a un aire contaminado son aquellos producidos por particulas y plomo. Monterrey es la ciudad industrializada mas grande de Mexico y esta ubicada en la parte Noreste del pais, en una region basicamente semiarida. Por lo tanto, actualmente enfrenta este problema ambiental debido sobretodo al crecimiento de la actividad industrial y del trafico vehicular que han impactado la calidad del aire por un lado, mientras que por el otro tambien se ha visto afectada esta calidad debido a la escasez de areas verdes urbanas dentro del AMM. El trabajo realizado consistio en comparar el comportamiento de cuatro especies de arboles comunmente presentes en el AMM para remover y acumular PST sobre la superficie foliar. El periodo de muestreo se extendio por espacio de siete meses, ubicando cuatro sitios de muestreo que contuvieran a ejemplares de las especies consideradas: dos nativas (Ehretia anacua y Prosopis glandulosa) y dos introducidas

(Ligustrum lucidum y Fraxinus americana). Los resultados indicaron que hubo diferencias significativas en la capacidad de remocion de particulas entre las especies en unidades de mg/cm^2, mostrando mayor capacidad las especies nativas. Se recomienda incrementar la reforestacion urbana con especies que ademas de ser ecologicamente adaptables a la region, contribuyan al saneamiento de la calidad del aire en el AMM.

According to the World Bank, the major health risks of people exposed to polluted air in developing countries, are those caused by particulate matter and lead. Monterrey is the largest industrialized city in Mexico, and is located in the Northeast part of the country, in a basically semi-arid region. Therefore it is actually facing this environmental problem in part due to the rising of industrial activity and vehicle traffic that has impacted the air quality on one hand, while the lack of green urban areas in the MMA also affects such quality on the other. The present research work compared four tree species commonly seen in the MMA to remove and accumulate TSP on the leaf surfaces. The samples were taken for seven months in four specific sites that contained the species' individuals: two native trees (*Ehretia anacua* and *Prosopis glandulosa*) and two non-native ones (*Ligustrum lucidum* and *Fraxinus americana*). According to the results, there were significant differences among the species in removing particles from the air in mg/cm^2, being the natives trees the best. It is recommended to reforest urban areas with trees not only ecologically adaptable, but with those that contribute to improved air quality as well.

Naco Constructed Wetlands Microenterprise Project: A Model for Effluent Treatment in Latin America

Proyecto de Tratamientos Naturales de Aguas Negras en Naco, Sonora

Eric D. Ellman and Michael F. Wilson

Wastewater treatment is of top concern for the U.S./México border region. Inadequate sewage treatment affects human health and the environment and has economic and political ramifications that can adversely affect the lives of residents on both sides of the international boundary. Seldom has the construction of sewage treatment facilities been combined with the development of effluent-using enterprises, an endeavor that can generate income and—by raising the stakes on the success of the sewage treatment facility—increase the likelihood of success. Drylands Institute, Environmental Compliance International, Border Ecology Project, and Enlace Ecologico are designing and installing a small constructed wetlands wastewater treatment demonstration project on the periphery of Naco, Sonora's sewage treatment facility. These organizations are incorporating various micro-enterprise projects in conjunction with the local ejido to demonstrate the ecological, social and economic benefits of wetland treatments. An overview and history of the project is to be presented.

El tratamiento de "Aguas Negras" es la mayor preocupación de la región fronteriza Mexicana y Estado Unidense. Tratammientos de aguas negras inadequados afectan la salud humana y el medio ambiente, y tambien tienen consequencias negativas económicas que afectan las vidas de los ciudadanos en ambos lados de la frontera. Raramente se ha combinado la construción de plantas tratamiento de aguas negras con esfuerzos empresarios que puedan generar fondos y, por medio de usar la actividad económica de las plantas de tratamiento, aumentar el promedio de su exito. Drylands Institute, Environmental Compliance International, Border Ecology Project, y Enlace Ecologico, estan diseñando e instalando un pequeño proyecto demostratativo de tratamiento de aguas negras en el periférico de la planta de tratamiento de Naco, Sonora. Èstas organizaciones estan incorporando varios proyectos micro-empresarios con conjunto con el ejido local para demostrar los beneficios económicos y sociales de tratamientos naturales. Un recorrido e história del proyecto será presentado.

Flora of the Central Part of the State of Chihuahua

Flora del Centro del Estado de Chihuahua

Andres Eduardo Estrada Castillon Carmen Yen Mendez and Alberto Lafon Terrazas

Objectives: To determine and quantify floristic diversity in the central part of the state of Chihuahua. Methodolgy: 70 sites were located in different vegetal communities to sample, on each site, 5 line transects were done, on each site arboreal, shrubby and herbaceous cover were measured, intensive plant collecting was done on each site. Results: 750 species, 280 genera and 75 families of vascular plants were recorded and determined on the three main vegetation types; grassland, shrubland and forest. Conclusions: the central part of Chihuahua is a very rich area in vegetal diversity because of the contrast and variation of its physical and environmental features. The most diversified plant familes in this area are Asteraceae, Poaceae and Fabaceae, respectivally.

Objetivos, determinar y cuantificar la diversidad florística en el centro del estado de Chihuahua. Metodología, se seleccionaron 70 sitios de muestreo en las diferentes asociaciones vegetales, en cada sitio se realizaron 5 transectos de linea de 50 m, se tomaron mediciones de cobertura vegetal herbácea, arbustiva y arbórea, se realizaron colectas intensivas de material botánico en cada sitio. Resultados, se determinaron aproximadamente 750 especies, 280 géneros y 75 familias de plantas vasculares en los tres principales tipos de vegetación, matorral, pastizal y bosque. Conclusiones, el centro de Chihuahua es una área rica en diversidad vegetal por lo contrastante y variado de sus caraterísticas fisicas y ambientales. Las familias más diversificadas en esta área son Asteraceae, Poaceae y Fabaceae respectivamente.

Hidden Forests: The Trees of Sonora, Mexico

Bosques Escondidos: Los Arboles de Sonora, Mexico

Richard S. Felger and Matthew B. Johnson

Drive down the highways and most of the forests are hidden, going or gone. The State of Sonora (182,500 km^2) has a total tree flora of about 275 species in 153 genera and 66 families —less than 6 percent of the total state flora. As many as 70 of these tree species are typically shrubs and only rarely become trees, are rare in Sonora, or are non-native. Only 5 non-native trees pecies are well-established. This leaves 205 native keystone tree species. This presentation is based on our forthcoming book, The Trees of Sonora, which is the first comprehensive tree flora of the state. Sonora is a meeting place of the temperate North American and Neotropical tree floras with intrusions of Sonoran including Baja California, and Chihuahuan desert species elements at lower elevations. Moisture as well as freezing for the more tropical species are the overall limiting factors restricting tree distributions. Extensive areas of tropical deciduous forest cover much of the southern and eastern parts of the state and harbor the greatest diversity of trees. Oak woodland and pine-oak woodland occur at higher elevations and mixed-conifer forest at the highest elevations. The legume (Fabaceae), oak (Fagaceae), and pine (Pinaceae) families are the most diverse. The most diverse genera are the oaks (Quercus), pines (Pinus), burseras (Bursera), acacias (Acacia), and figs (Ficus). Trees to 30 m tall were commonplace from the great desert river deltas to the highest mountains. Madrean and tropical deciduous forest once stretched unbroken into the American tropics but accelerating deforestation is leading to fragmentattion of the keystone species populations.

Viajando por las carreteras, la mayoría de los bosques estan escondidos, desapareciendo o ya desaparecieron. El estado de Sonora (182,500 km^2) tiene una flora de árboles con un total de alrededor de 275 especies, en 153 géneros y 66 familias — menos del 6% de la flora del estado. Estos datos son basados en el próximo libro, "The Trees of Sonora", el cual es la primera flora de árboles comprendida para el estado. Cerca de 70 de estos árboles son típicamente arbustos, escazas en Sonora o no son nativos, restando 205 especies importantes en el estado. Solamente 5 especies de árboles introducidos están bien establecidos. Sonora es el lugar de reunión de las floras de árboles de las zonas templadas de Norte América y Neotropicales con intrusiones de los Desiertos Sonorense, incluyendo Baja California, y Chihuahuense en elevaciones bajas. La húmedad así como las heladas son los principales factores limitantes que restringen la distribución de las especies más tropicales. Extensivas áreas de bosques tropicales deciduos cubren grandes superficies del Sur y Este del estado y albergan la mayor diversidad de árboles. Bosques de encinos se encuentran en elevaciones altas y bosques mixtos de coníferas en las elevaciones más altas. Las familias de las legumbres (Fabaceae), encinos (Fagaceae) y pinos (Pinaceae) son las más diversas. Los géneros más diversos son los encinos (Quercus), pinos

(Pinus), torotes (Bursera), acacias (Acacia) e higueras (Ficus). Arboles de 30 m. de altura fueron comunes desde los magníficos deltas de los ríos del desierto a las más altas montañas. Bosques tropicales deciduos y bosques madrean se extendían contínuos en los trópicos americanos pero los acelerados desmontes están llevando a la fragmentación de las claves en estas poblaciones de especies.

Economic Impact of Protected Areas and Outdoor Recreation in the U.S./Mexico Border States Region

Impacto Economico de Areas Protegidas y Recreacion Al Aire Libre en la Region Fronteriza de Los Estados Unidos y Mexico

Angela West and L. Joyce Fierro

The direct and indirect economic impacts and value of protected areas and outdoor recreation related tourism will be presented. The biological and social implications will be discussed as they are inevitably linked to economic benefits and costs. The regional trends, outdoor assests, recreation demand, customer profiles and future strategies will be explored. Information is derived from existing and readily available data and research from the national, regional and local levels.

El impacto ecomomico directo y indirecto y el valor de areas protegidas y recreación al aire libre relacionado al turismo será presentado. Las implicaciones biologicas y sociales seran discutidos como son inevitablemente relacionadas a beneficios y costos. Las tendencias regionales, demanda para recreación, profiles de clientes y strategias futuras seran exploradas. Información ha sido obtenido de existentes y disponibles datos a niveles national, regional y local.

Wild Flora of the State of Sonora, Mexico: A Photografic Catalog of the Herbario (Uson)

Flora Silvestre del Estado de Sonora, Exico: Un Catalogo Fotografico del Herbario (Uson)

Agustín Flores Macias and Jesus Sanchez Escalante

The diversity of the State of Sonora is very rich in species and types of vegetation. This is an unimaginable situation for those who do not know the Sonoran territory. In spite of being covered by 70 % desertic bushes, it contains with important areas of forest occupied by conifers and latifoliar species that are mainly located in high hills. Besides, it counts with comunities of halophites, pastures and areas with aquatic and subaquatic vegetatión. All of this conforms

a gamma of multiple contrast among the plant areas of this important State of the Northwest of Mexico, Sonora has the second place in extention with 184,934 square Kilometers. In regard of the richness of the knowledge of the flora of Sonora, there is research with precise information about the existing species in certain areas. However, there is still a lack of information about the flora of other areas. From the botanic point of view there are unexplored areas with a high number of endemic and rare species, threatened or in danger of extintión. These species in many occassions are difficult to find or to sample adequately to be able to identify them. The herbarium of the University of Sonora has computarized informatión and a botanical collectión available to be used for those who intend to research the flora of Sonora or the flora from adjacent regions whenever the objective of this research is to increase the knowledge of our natural resources.

Objectives:

1. To contribute to create a culture to take care of the natural resources of Sonora and Mexico for the sake of future generations.
2. To contribute to the knowledge and publishing of the richness of the sonoran flora.
3. To motivate the fulfilment of collections that ilustrate the beauty of the natural resources.

The herbarium accounts with a collection of 260 images of wild plant species identified adequately by family and species. This information will be available in a CD-ROM and in a web site on the internet (Http://148:225.52.2/herbario.htm).

La diversidad floristica del estado de Sonora es muy rica en especies y tipos de vegetación. Situación no imaginable por quienes no conocen el territotio sonorense, el cual, apesar de estar cubierto en un 70 % por matorral desértico, cuenta con importantes áreas de bosques. Estos conformados por especies de coníferas y latifoliadas que se ubican principalmente en las zonas montañosas. Cuenta además con comunidades de plantas halófitas, pastizales y áreas con vegetación acuática y suacuática, lo cual, conforma una gama de multiples constrastes en la cubierta vegetal de este importante estado del Noroeste de México; el cual, con sus 184,934 Km^2 ocupa el segundo lugar nacional en extención. En lo que corresponde a la riqueza florística de Sonora; existen algunos trabajos florísticos que muestran la riqueza de especies de algunas regiones del estado, pero falta mucho por conocer. Sobre todo si se toma en cuenta las áreas no exploradas botánicamente, el alto número de endemismos, las especies raras, amenazadas o en peligro de extinción, las cuales, en muchas ocasiones es dificil localizarlas o muestrearlas para poder identificarlas y reportarlas. Actualmente el Herbario de la Universida de Sonora, cuenta con un acervo de información computarisada y una colección botánica disponible para ser usada por quienes quieran realizar investigaciones sobre la flora de Sonora o de regiones adyacentes; el único proposito de esto es el de incrementar el conocimiento de nuestros recursos naturales.

Objetivos:

1. Contribuir a fomentar la cultura para el cuidado de los recursos naturales de Sonora y en general de México, en bien de las generaciones futuras.
2. Contribuir al conocimiento y difusión de la riqueza florística de Sonora y el trabajo del Herbario de la Universidad de Sonora.
3. Motivar la realización de colecciones que ilustren la belleza natural de los recursos naturales con que contamos en la actualidad.

Hasta la fecha el Herbario USON, cuenta con una colección de 260 imágenes de especies vegetales silvestres, todas debidamente identificadas por familia, género y especie. Con este mismo material se ha logrado conformar un catálogo de imagenes visible en CD.-ROM y en web por internet. Http://148:225.52.2/herbario.htm

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Pinos Endimicos del Noreste de Mexico

Endemic Pines for Northeast Mexico

Glafiro J. Alanis Flores and Susana Favela Lara

El Noreste de Mexico representado por los estados de Coahuila, Nuevo Leon y Tamaulipas,. cuyas caracteristicas fisiograficas estan determinadas por la Sierra Madre Oriental. Las comunidades de bosques compuestas por Pinus o combinaciones de Quercus-Pinus en el NE de Mexico se localizan en la formacion orografica de la Sierra Madre Oriental, se localizan alrededor de 26 taxa dentro del genero Pinus. Segun Rzedowski 1991, la amplia permanancia de una region en forma emergida y no sujeta a cambios ambientales catastroficos y la diversidad fisiografica presente, como es el caso de la Sierra Madre Oriental, son factores que se conjugan para favorecer endemismos dentro de la flora regional. Uno de los aspectos puntuales para determinar flora endemica es encontrar las correlaciones existentes en la distribucion de las especies con los factores del medio fisico.

Northeast Mexico is represented by the states of Coahuila, Nuevo Leon and Tamaulipas, their physiographic characteristics are determinated by the Sierra Madre Oriental. In Northeast Mexico the woodland comunities of pure Pinus or combinations with Quercus, are localizated in the Sierra Madre Oriental orographic complex; there are about 26 taxa included in the genus Pinus. According to Rzedowsky (1991), the factors that combine to help create endemic taxa in the regional flora are: the long permanence of a region over sea level, not being subject to very dramatic climatic changes, and the physiographic diversity a region, which is the case for the Sierra Madre Oriental. One of the principal points to determine endemic flora is to find existing correlations between species distribution and abiotic factors.

Conservacion en el Cerro "El Potosi", Galeana, N. L., Mexico

Conservation on the "El Potosi" Hill, Galeana N. L. Mexico

A. M. Garcia, E. G. Treviño, A. C. Cantú, y S. F. Gonzalez,

El cerro "El Potosi", en el municipio de Galeana, N. L., es uno de los sitios de mayor altitud (3,650 msnm) en la Sierra Madre Oriental, sus caracteristicas fisiograficas, pendientes abruptas, sus exposiciones hacia el este con la Sierra Madre y al oeste con el altiplano mexicano ademas de su aislamiento con otras sierras de similar altitud, determinan que esta region posea caracteristicas de biodiversidad y endemismo unicas en el pais. Por tal motivo, esta region de 7,389.5 ha desde su base a 2,000 msnm se propone como area natural susceptible de conservacion ecologica. Se hizo un analisis de los tipos de comunidades vegetales utilizando una imagen de satelite Landsat TM de 1993, resultando un mapa de vegetacion y un analisis faunistico basado principalmente en observaciones hechas en campo, generando asi una propuesta de zonificacion ecologica para esta importante region. De acuerdo al mapa de vegetacion de 1993 destacan los siguientes tipos de vegetacion: bosque mixto de Pseudotsuga menziesii, Abies vejarii, y Pinus ayacahuite; bosque de Pinus cembroides, bosque de Pinus hartwegii, bosque de Quercus spp., chaparral, matorral de Pinus culminicola y pradera alpina. Para la region se enlista un total de 45 especies consideradas bajo estatus especial de conservacion, de las cuales 19 son plantas y 26 de animales. En el mapa de zonificacion se propone una zona nucleo donde se incluye un area para la Conservacion del Matorral de coniferas (*P. culminicola) y* conservacion de los bosques de Quercus spp. Una zona de recuperacion ecologica que incluye el bosque de Pinus arizonica y bosque mixto de Pinus cembroides - Pinus arizonica asi como una zona de amortiguamiento que incluye el area de aprovechamiento de los bosques de Pinus cembroides. Manejo silvicola para el bosque de Pinus hartwegii en el area de La Joya y manejo y aprovechamiento en las areas con chaparral.

The "El Potosi" hill, in the municipality of Galeana, N. L., is one of the greater altitude sites (3,650 msnm) in the East Sierra Madre, its physiographic characteristics, abrupt slopes, its expositions toward the east with the Sierra Madre and to the west with the Mexican plateau in addition to its isolation with other hills with similar altitude, determine that this region possess special characteristics of biodiversity and endemism in the country. For that reason, this region with a surface of 7,389.5 ha from its base at 2,000 msnm is proposed as a potential natural area for ecological conservation. An analysis of the types of vegetation communities was made using a satellite image Landsat TM of 1993, resulting a vegetation map and a faunistic analysis based mainly on observations made in field, generating thus an ecological zoning proposal for this important region. Of agreement to the vegetation map of 1993 emphasize the following types of vegetation: *Pseudotsuga menziesii, Abies vejarii* and *Pinus ayacahuite; Pinus cembroides* forest, *Pinus hartwegii* forest, *Quercus* spp. forest, chaparral, scrub of

Pinus culminicola, Alpine and subalpine meadow. For the region is listed a total of 45 species considered under special conservation status, of those which 19 are of plants and 26 of animals. In the zoning map is proposed a nucleus zone where is included an area for the conservation of the scrub of coniferous (*P. culminicola)* and conservation of Quercus spp. forests. An ecological recovery zone that includes the Pinus arizonica forests, mixed forest of Pinus cembroides -Pinus arizonica; and a damping zone that includes the utilization area of the Pinus cembroides forests, silvicultural management for the Pinus hartwegii forests in the area of La Joya, management and utilization in the chaparral areas.

Bioaccumulation of Seleniumin the Cienega de Santa Clara; A Remnant Marsh in the Colorado River Delta

Bioacumulación de Selen en la Ciénega de Santa Clara, Estero Remanente del Delta del Río Colorado

Jaqueline García Hernandez and Edward P. Glenn

The Cienega de Santa Clara is the largest wetland in the Colorado River delta, Sonora, Mexico. It is probably the most important habitat left for the endangered desert pupfish (*Cyprinodon macularius)* and the Yuma clapper rail (*Rallus longirostris yumanensis*). The Cienega is the terminus of a canal that transports irrigation drainage water from the United States. The bioaccumulation of selenium (Se) has created toxicity problems for wildlife in similar wetlands in the U.S. In this study we determined the levels of selenium in water, sediments, plants, and fish collected from ten sites in the Cienega de Santa Clara from October, 1996 to March, 1997. All samples were analyzed by graphite furnace atomic absorption. Selenium was detected in all samples. Concentrations in water ranged from 5-19 mg/L, increasing along a salinity gradient. Although water levels of selenium exceeded the 85 th percentile national baseline and are in the high-risk category for wetland ecosystems, selenium levels in sediment (0.8-1.8 mg/g), plants (0.03-0.17 mg/g) and fish (2.5-6.4 mg/g) are not at hazardous levels for wildlife or humans. However, further monitoring in the Cienega de Santa Clara as well as in the rest of the Colorado River delta wetlands, is recommended from this study.

La Ciénega de Santa Clara es el humedal mas grande del delta del Río Colorado, Sonora, México, y es probablemente el hábitat mas importante para el pupo del desierto (*Cyprinodon macularius*) y el palmoteador de Yuma (*Rallus longirostris yumanensis*) ambos en peligro de extinción. La Ciénega recibe su flujo de drenes agrícolas de los Estados Unidos. La bioacumulación de selenio (Se) ha creado problemas de toxicidad en la vida acuática de humedales similares en los E.U. En esta investigación determinamos los niveles de selenio en agua, sedimentos, plantas y peces colectados en diez estaciones de la Ciénega de Santa

Clara de octubre de 1996 a marzo de 1997. Todas las muestras se analizaron usando absorción atómica en horno de grafito. Selenio fue detectado en todas las muestras. Los niveles de selenio en agua variaron de 5-19 mg/L, incrementándose con el gradiente de salinidad. A pesar de que los niveles de selenio en agua excedieron el 85 % de los niveles en Estados Unidos y de estar en la categoría de alto riesgo para el ecosistema, las concentraciones en sedimento (0.8-1.8 mg/g), plantas (0.03-0.17 mg/g) y peces (2.5-6.4 mg/g) no exceden los límites tóxicos que pudieran causar daño a el ecosistema o a los seres humanos. Sin embargo, se recomienda un mayor monitoreo tanto en la Ciénega de Santa Clara como en el resto de los humedales del delta del Río Colorado.

Evaluacion de la Calidad de Agua en la Region Noreste del Estado de Sonora, Mexico

Assessment of the Water Quality of the Northeast Region of the State of Sonora, Mexico

Arturo Villalba A., Agustín Gómez A. Gilberto Solís G., y Margarita de la O. V.

Se presenta un avance general del proyecto de monitoreo de la calidad de agua en las cuencas de los Ríos San Pedro y Sonora, así como en los municipios de Naco y Agua Prieta, Sonora, México, durante el período enero - diciembre de 1997. Dicho proyecto es realizado por el D.I.C.T.U.S., en convenio con Enlace Ecológico, A.C. (EECO) y la International City/Council Management Association (ICMA). Actualmente se han realizado cuatro muestreos con periodicidad trimestral en agua superficial y sedimento en las cuencas de los Ríos San Pedro y Sonora, así como en algunos pozos para evaluar la condición de las aguas subterráneas en esta región. Asimismo, se han estado colectando muestras de agua del subsuelo en Naco, Sonora, para obtener información para caracterizar los impactos de las operaciones mineras de los EEUU en los pozos de agua potable del municipio. Adicionalmente se estudia el agua superficial y subterránea (incluyendo sedimento) en la región de Agua Prieta, Sonora, para estudiar la posible influencia de los escurrimientos provenientes de los jales de la fundidora de Douglas, localizada en el Estado de Arizona, EEUU. El estudio contempla parámetros de campo (pH, oxígeno disuelto, etc.), análisis de cationes y aniones mayores y metales pesados totales; incluyendo compuestos orgánicos volátiles y plaguicidas. La información que se obtenga en esta investigación constituirá una base inicial de información de referencia para conocer la calidad del agua en la región correspondiente a la franja fronteriza noreste del Estado de Sonora, México.

A preliminary report is presented about the project Water Quality of the Rio San Pedro Basin, Upper Rio Sonora Basin, and Naco and Agua Prieta municipalities in Sonora, Mexico. The study was conducted through January-December of

1997. This project is carried out by D.I.C.T.U.S. in agreement with Enlace Ecologico, A.C. (EECO) and the International Council/Council Management Association (ICMA). Four sampling collections have been done on a quarterly basis on surface water and sediment in Rio San Pedro Basin and Upper Rio Sonora Basin. To evaluate the groundwater samples were taken from wells in that region. Also, samples from groundwater in Naco, Sonora have been collected to get some information in order to characterize the impact of mining operations from the American side in wells of potable water at this municipal. In Agua Prieta, Sonora region samples of surface and groundwater (sediment included) were taken to analyze the possible contamination of possible floods coming from dumps located at the Douglas smelter in the state of Arizona, USA. The field parameters analyzed were pH, dissolved oxygen, etc, major cation and anion analysis, total heavy metals analysis, including organic and volatile components and plaguicides. The information from this research will serve as data base information for future water quality evaluation and management recommendations for the region on the border strip of northeast Sonora, Mexico.

Caracterización de la Vegetación en el Parque Nacional Big Bend en Funcion del Factor Altitudinal y Sistemas de Información Geográfica

Vegetation Characterization in Big Bend National Park Using Altitude Factor and Geographic Information System

Armando González Palma, Soraya Puga Terrazas, y Manuel Sosa Cerecedo

El Big Bend National Park es una área protegida por más de 50 años, localizada en el desierto Chihuahuense, en el sur del estado de Texas. Ocupa una superficie de 328,531 hectáreas, con altitudes que varian de los 580 a los 2,385 msnm. El objetivo general de este estudio es la utilización de metodologías estadísticas y Sistemas de Información Geográfica, para evaluar grandes extenciónes de vegetación de manera eficiente, rápida y con un bajo costo. Los objetivos son: predecir la composición botánica y la cobertura aérea de la vegetación, en función de la altitud como variable fisiográfica y la utilización de SIG, a través de los Modelos Digitales de Elevación (MDE) para formar las diferentes clases de comunidades vegetales y poder generar los mapas respectivos. La metodología fué: se utilizaron 5 transectos de linea de 50 m de largo con 100 puntos, para la determinación de composición botánica y cobertura de la vegetación, por cada 100 m de cambio de altitud; en análisis estadístico se usó el SAS con análisis de conglomerados y la técnica de Ward para las clases de vegetación, y los MDE para generar los mapas. Los resultados fueron la obtención de 9 grupos de vegetación por composición botánica y 7 grupos de vegetación para cobertura aérea. Se elaboraron los mapas definiendo dichas clases así como la superficie que ocupan cada una. Se concluye que el análisis multivariado y los SIG son una herramienta útil para caracterizar en forma precisa en grandes extensiónes los tipos de vegetación.

Big Bend National Park has been a protected for more than 50 years. It is located in the Chihuahuan desert, at the southern portion of the state of Texas, occupying a land area of about 328,531 ha, with the altitude varying from 580 to 2,385 meters above sea level. The general objective of this study is to make use of statistic methods together with Geographic Information System to evaluate big extentions of vegetation in an efficient and rapid way under a low cost. The specific objectives are: to predict the botanical compostion and the vegetation aerial cover as function of the altitude (physiographic variable) and the use of GIS, through Elevation Digital Model EDM) to form the different vegetation classes and to generate thereby the respective maps. The methodology used was: five 50 meters long line transects, each with 100 points, to determine vegetàtion composition and aerial cover, for every 100 meters change in altitude; SAS was used for the statistical analysis with the cluster analysis and the Ward Technique for the vegetation classes, and the EDM to generate maps. As the results, 9 vegetation groups were obtained for the botanical composition an 7 groups according to the aerial cover. Maps were elaborated by defining such vegetaion classes together with the land area that they occupy. It is concluded that the multivariate analysis and GIS are useful tools to characterize in a precise manner big extentions of vegetation types.

Source Chemistry and Characteristics of Stream Waters having Low pH and Elevated Metal Concentrations, Patagonia and Southern Santa Rita Mountains, Santa Cruz County, Arizona: Implications for Impacts into Sonoita Creek and Upper Santa Cruz River Basins

Floyd Gray, Laurie Wirt, Kerry Caruthers, Karen Bolm, and Maurice Chaffee

Porphyry copper deposits are important point sources of potentially toxic trace metals in surface waters, both in areas where there has been mining and also as naturally-occurring geologic entities. Perennial seeps and intermittent streams draining mineralized slopes in the Patagonia and Southern Santa Rita Mountains were sampled as part of a study to develop data on regional geochemical baselines and backgrounds, to predict the source, transport and fate of toxic elements, and to develop a geoenvironment model for porphyry copper deposits in a semi-arid climatic setting. Numerous mines and prospects, waste dumps, and tailings piles are abandoned within individual watersheds, but large parts of the region are mineralized and remain largely undisturbed.

Both mined and unmined areas produce surface waters with pH values as low as 2.68, and elevated concentrations of metals. Preliminary values of dissolved trace metals in streamflow range from 0.4 to 60.4 mg L^{-1} of Cu, 0.0002 to 0.067 mg L^{-1} As, 0.00005 to 0.42 mg L^{-1} Pb, and 0.001 to 73.0 mg L^{-1} of Zn. Mine tailings and waste dumps are significant sources of suspended sediment during infrequent storms and contain potentially acid-generating materials; however, springs and seeps related to faults and fractures in the mineralized outcrops may also con-

tribute to the acid chemistry and surface flow. High conductivity, total dissolved solids (TDS), and low pH, typically beyond EPA primary and secondary drinking water standards, correlate well with the modal pyrite mineralogy of the bedrock units.

During conditions of low flow, perennial seeps in the stream bed at higher elevations are intermittent, and do not connect surficially to larger drainages downstream, such as Sonoita Creek, a tributary of the Santa Cruz River. Neutral to slightly alkaline conditions are prevalent in perennial seeps in lower elevations downstream and can be attributed to 1) chemical reactions along the flow path, such as buffering from carbonated, 2)dilution from other groundwater sources, or 3) possibly that water moving down gradient from the upper to lower reaches is not hydrologically connected except during periods of higher precipitation and runoff. During runoff season, the influence of acid waters is widely extended via surface flow. Findings of this study will be useful for developing and prioritizing mitigation and restoration strategies, and formulating regulatory policy.

La Reserva Forestal Nacional y Refugio de Fauna Silvestre "Ajos-Bavispe" : Un Tesoro de Sonora, México

The Reserva Forestal Nacional and Refugio de Fauna Silvestre "Ajos-Bavispe": A Treasure of Sonora, México

José María Guerra Limón, Juan Mario Cirett Galán, Florentino Garza Salazar, José Martín Haro Rodríguez, y Mirella Hernández Almada

La Reserva Forestal Nacional "Sierras Los Ajos, Buenos Aires y La Púrica" , se localiza en el noreste del estado de Sonora, fue decretada en 1936, dotándola con una extensión de 21,494 hectáreas, siendo ratificada en otro decreto presidencial de 1939 con el nombre de Bavispe, junto con otras cuatro fracciones de terrenos nacionales, con la denominación de "Lote 4", agregando la categoría de Refugio de Fauna Silvestre. El objetivo de su establecimiento incluye la protección de la parte superior de importantes cuencas hidrológicas, la conservación y buen manejo de los bosques, y la protección de la fauna silvestre en beneficio de la población en general. En 1996 la Secretaría de Medio Ambiente Recursos Naturales y Pesca a través del Instituto Nacional de Ecología asigna fondos y personal para el manejo del Área. La Reserva es una isla biogeográfica de montañas con bosques de pinos y encinos, rodeada por pastizal natural y matorrales desérticos, en las que se encuentran registros únicos para México y Sonora de plantas vasculares, y numerosas especies de vertebrados listados por la Federación como especies raras, amenazadas y en peligro de extinción, además de que es un laboratorio natural en el que pueden estudiarse numerosos aspectos de la ecología de estos bosques.

The Reserva Forestal Nacional and Refugio de Fauna Silvestre "Ajos - Bavispe" is located at northeast Sonora, México. This protected area was decreed in 1936 with the category of National Forest Reserve and with a surface to protect of 21,494 hectares. Later, in 1939, another presidential decree was signed with the name of "Bavispe", with the same category and adding the category of wildlife refuge. This second decree includes the first area and includes another four areas. The objectives of creation include the protection of the watersheds, conservation and management of the forests, and the protection of wildlife in these ecosystems. In 1996, la Secretaría de Medio Ambiente Recursos Naturales y Pesca through the Instituto Nacional de Ecología assign financial funds and personnel to manage the area. This protected area is a biogeographic island of isolated mountains with pine-oak forests, surrounded by natural grasslands and desert scrub. In this area there are unique records for México and Sonora of vascular plants; also, there are many vertebrate species listed by the Mexican Federal Goverment under a category of protection, such as rares, threatened and endangered species. As a protected area, "Ajos - Bavispe" could be considered as a natural laboratory, where many ecology, wildlife and forestry studies could be developed.

Distribution of the Avifauna from Cerro el Potosi, Galeana, Nuevo Leon, Mexico

Antonio Guzmán-V., Armando J. Contreras-B., Juan A. García-S., y José I. González. R

The Cerro El Potosí, is a high peak (3715 meters above sea level) in the Sierra Madre Oriental in Nuevo Leon, NE of Mexico. This work have as objectives, to know the avifauna and their altitudinal distribution, also biogeographic affinities (families and species), and seasonal residence. We visited the area during different years and months, and in 1995, monthly. A transect of 30 km was to cover to 3.3 km/h. The arrangement was follow to AOU (1983), and biogeographicaly to Darlington (1957), AOU (1983), and Howell and Webb (1995). Was found 4115 individuals, on 81 species, 63 geneus, 22 families and 6 orders. Biogeographicaly the families are: 3 Holarctic, 1 Nearctic, 6 American continental, 10 Cosmopolitan and 2 Pantropical, the species: 1 Holarctic, 28 Nearctic and 52 American continental. For seasonal residence: 38 Permanent resident, 13 summer resident, 25 migrant, 3 occasional and 2 unknown. Ecologically, the species are distributed for vegetational types as follow: Oak community *Quercus imbicata* (2000-2200masl) 52; on Pine communities: *Pinus cembroides* (2200-2800masl) 34; *P. ayacahuite* (2800-3500masl) 40; *P. hartwegii* (2900-3000masl) 18; *P. culminicola* (3500-3650masl) 24, and alpine prairie (3600-3715masl) 18.

El Cerro del Potosí se encuentra localizado en la Sierra Madre Oriental, en el estado de Nuevo León, al NE de México. Tiene una altura de 3715 msnm y

presenta 6 tipos de vegetación; lo que da como resultado que sea una formación con características fisiográficas, climáticas y faunísticas muy particulares. Los objetivos del trabajo fueron: elaborar el inventario avifaunístico; establecer la afinidad zoogeográfica familiar y específica; determinar la residencia temporal y estacional de las especies y describir la distribución altitudinal de la avifauna en el Cerro del Potosí. Se hicieron visitas preliminares y 12 transectos mensuales de 30 km cada uno en 1995. Las observaciones se realizaron desde la hora de la salida del sol a una velocidad de 3.3 km/h. La identificación fué por registros visuales. El arreglo y ordenamiento filogenético se hizo de acuerdo al criterio de la AOU (1983), y el análisis zoogeográfico de acuerdo a Darlington (1957), AOU (1983) y Howell y Webb (1995). Se observaron un total de 4115 individuos que se agruparon de la siguiente forma: 6 Ordenes: 22 Familias: 63 Géneros y 81 especies. Biogeográficamente las familias se agrupan en: 3 Holárticas, 1 Neártica, 6 Continentales americanas, 10 Cosmopolitas y 2 Pantropicales; las especies se agrupan en: 1 Holártica, 28 Neárticas y 52 Continentales americanas. De acuerdo a su residencia las especies son: 38 Residentes permanentes, 13 residentes veraniegas, 25 Migratorias, 3 Ocasionales y 2 Inciertas. Ecológicamente, de acuerdo a la distribución por tipos de vegetación, las especies se distribuyen en: 52 en comunidad de encinos Quercus imbricata (2000-2200m) ; en las comunidades de pinos: 34 en Pinus cembroides (2200-2800m) , 40 en P. ayacahuite (2800-3500m), 18 en P. hartwegii (2900-3000m), 24 en P. culminicola (3500-3650m), y en la Pradera alpina (3600-3715m) 18.

The Name *Odocoileus Hemionus Crooki* is Invalid

El Nombre *Odocoileus Hemionus Crooki* ya no es Valido

James R. Heffelfinger

White-tailed deer (*Odocoileus virginianus*) and mule deer (*O. hemionus)* have been shown to hybridize in areas they are sympatric. The type specimen for desert mule deer (*O. h. crooki),* collected in southwestern New Mexico in 1892, was originally described as a new species of black-tailed deer, but is clearly a whitetail × mule deer hybrid based on a reassessment of morphological characteristics. Article 23(h) of the International Code of Zoological Nomenclature states that a name assigned to a hybrid type specimen is invalid and cannot be used for either parental species. According to the rules of nomenclature, *O. h. canus* is the next available scientific name. The desert mule deer inhabiting the formerly described ranges of *O. h. canus* and *O. h. crooki* should be referred to as *O. h. canus* (=crooki).

Se ha demostrado que el venado cola blanca (*Odocoileus virginianus)* y el venado bura (*O. hemionus)* se hibridizan en áreas en donde son simpátricos. El ejemplar tipo del venado bura del desierto *(O. h. crooki),* colectado en el suroeste

de Nuevo México en 1892, fue descrito originalmente como una nueva especie de venado bura, pero la revaluación de sus características morfológicas muestra claramente que es un híbrido. El artículo 23(h) de la Código Internacional de Nomenclatura Zoológica establece que un nombre asignado a un ejemplar tipo que es híbrido no se puede utilizar para ninguna de las especies que lo originan. De acuerdo a las reglas de nomenclatura, *O. h. canus* es el siguiente nombre científico disponible que corresponde. Se deberá aludir al venado bura del desierto que ocupa las distribuciones descritas anteriormente para *O. h. canus* y *O. h. crooki*, como *O. h. canus* (=crooki).

Risk Assessment of Groundwater Contamination in the El Paso/Ciudad Juarez Region

Aguas Subterráneas en la Región El Paso/Ciudad Juárez

Roberto Hurtado and Hilda S. Taylor

For the past 100 years, El Paso/Ciudad Juarez have been sharing surface water from the Rio Grande/Rio Bravo river, and ground water from the Hueco and Mesilla Bolsons. The geologic structures of these vast aquifers are characterized by non-consolidated sediments such as sand, gravel, and clay; therefore, ground water is highly susceptible to contamination by the infiltration of polluted surface water from the river. The primary sources of ground water contamination are the result of anthropogenic (agricultural, commercial, industrial and residential) activities due to the rapid population growth in this region, which already exceeds two million people. In order to meet the needs of the population, it has been necessary to pump ground water at a faster rate than it is being recharged by the hydrological cycle. This has not only led to the rapid depletion of ground water, but also to increased contamination of ground water. Results of ground water chemical analysis show that the total of dissolved solids is extremely high and has led to the closure of several fresh water wells due to contamination. The objective of this project is to present a summary of the potential sources of ground water contamination and to discuss possible solutions to reduce the risks for contamination and to reduce the consumption of water per capita, which is extremely high for this region.

Las Ciudades de El Paso, Texas y Cd. Juárez, Chihuahua han compartido, en los últimos 100 años, tanto las aguas superficiales del Río Grande/Río Bravo, como también las agua subterráneas de los bolsones de El Hueco y La Mesilla. Las estructuras geológicas de estos enormes acuíferos se caracterizan por estar constituidas de sedimentos no consolidados en los que predominan las arenas y gravas, además de escasos lentes de arcillas, por lo que dichos acuíferos están expuestos a la contaminación por infiltración de aguas superficiales de menor calidad provenientes de actividades antropogénicas tales como los desechos

agrícolas, industriales, comerciales, militares y residenciales. El rápido crecimiento de demográfico en la región, cuya población actual rebasa los dos millones de habitantes, ha ocasionado una sobre-explotación de las reservas subterráneas, lo que ha ocasionado un rápido abatimiento de los niveles friáticos, lo que ha favorecido la contaminación de las aguas profundas. Los análisis químicos de algunas muestras de agua tomadas ligeramente abajo del nivel friático indican concentraciones de sólidos totales disueltos mayores, en un orden de magnitud, que las del agua descargada por los pozos. En los últimos años se han tenido que cerrar pozos, que anteriormente producían agua de calidad potable, porque han sido contaminados. En el presente trabajo se presenta un inventarios de las fuentes de contaminación y se discute algunas alternativas para reducir los riesgos de contaminación, así como también para reducir el consumo per cápita, que es demasiado alta para esta región.

Distribution and Abundance of the Texas Hornshell Mussel, *Popenaias Popeii* (Bivalvia: Unionoidea), of the Rio Grande Basin of New Mexico and Texas

Distribucion and Abundancia del Texas Hornshell Mussel, *Popenaias Popeii* (Bivalvia: Unionoidea), del Bolson del Rio Grande New Mexico and Texas

Brian K. Lang, Mark E. Gordon, and Robert G. Howells

Popenaias popeii, a federal (USA) Species of Concern, and 6 other unionoid freshwater mussels endemic to the Río Grande drainage have experienced significant population declines in recent decades. Approximately 83% (5 of 6 species) of the unionoid fauna native to the Pecos River, New Mexico has been extirpated. Numerous unionoids of the lower Río Grande (Texas) have not been reported live since the early 1970's. Recent collection of live *Popenaias* in the Black River, New Mexico (1996) confirm the species is not extirpated in the United States, as implied by contemporaneous collection records. In New Mexico, *Popenaias* appears restricted to approximately 15-20% of its historic range, where a single extant population exists in the Black River; Pecos River mainstem populations appear extirpated. Live *P. popenaias* colonize sand to gravel-cobble substrates that collect in travertine bedrock cracks and at the base of large boulders in shallow (0.25-1.38 m), low velocity waters (0.02-0.75 m/sec.) at the head and terminus of narrow travertine runs. Population densities were typically <1.0 mussel/m^2, but locally abundant (27 live *Popenaias* were collected beneath a travertine boulder). Thirty-five live specimens have been tagged and released for mark-recapture and life history studies. In Texas, 64 collections from 50 inventory sites in the Río Grande drainage (1992-present) yielded a single fresh *Popenaias* valve. Continued development of water resources throughout the Río Grande basin, including México, will cause future losses in range and abundance of this species.

Popenaias popeii, una Especies de Concernir federal (USA), y 6 otros mariscos unionoidos de agua dulce que son especies endémicas del bolsón del Río Grande han sufrido disminuciones poblacionales significantes durante decenios recientes. Aproximadamente 83% (5 de 6 especies) de la fauna unionoido nativa del Pecos River, New Mexico ha sido extirpado. Varios unionoidos de las aguas bajas del Río Grande (Texas) no han sido recogidos vivos desde los años 1970's. Colectas receintes de *Popenaias* vivos del Black River, New Mexico (1996-98) aseguran que la especie no ha sido extirpada en los Estados Unidos, como se implicaba el registro contemporaneo de colectas. *Popenaias* se aparece restringuido a aproximadamente 15-20% de su rango de distribución histórico en New Mexico, donde que da una sola población en el Black River; poblaciones del Pecos River estén extirpados. *Popenaias* vivos del Black River habitan substratos finos a bastos que se depositan en las rendijas de roca sólida de caliza en el incipiente y el terminus de corrientes angostos del río. Densidades poblacionales tipicas medieron <1.0 marisco/m^2, pero fueron abundante localmente (27 *Popenaias* vivos fueron colectados en la base de una roca grande). Treinta y cinco especimenes han sido marcados para estudios poblacionales y ecologicos. En Texas, 64 colectas desde 50 sitios de muestreo en el bolsón del Río Grande (1992-presente) solo produjo una valvula fresca de *Popenaias*. La contiunuación del desarrollo de recursos del agua através del bolsón del Río Grande, incluyendoMèxico, resultará en perdidas futuras en la distribución y abundancia de la especie.

The Endangered Socorro Isopod: Conservation Efforts and Population Viability

El Isopodo De Socorro, una Sepcies en Peligro de Extincion: Conservacion y Viabilidad Poblacional

Brian K. Lang

The state and federally (USA) endangered Socorro isopod, *Thermosphaeroma thermophilum* (Peracarida: Isopoda), is 1 of 7 freshwater sphaeromatid crustaceans known from small, isolated thermal springs of the Chihuahua Desert in New Mexico, Texas, and México (Chihuahua, Durango and, Aguascalientes). This endemic isopod inhabits vestigial habitats of Sedillo Spring (Socorro County, New Mexico), which was altered earlier this century to serv as a municipal water supply for the City of Socorro, and to provide thermal waters for the defunct Evergreen Spa. Habitat conditions consist of a small ($3m^2$) concrete-walled pool with a short (25m) piped out-flow. The native isopod population of Sedillo Spring went extinct in 1988 due to habitat dessication, and was repatriated with genetic stock from research populations housed at the University of New Mexico. Despite 16 years of significant state (NM) and federal (USFWS) conservation efforts, including the establishment of isolated refuge populations,

construction of a propagational facility, monthly population monitoring and ecological studies, genetic research, and cooperative private landowner-agency liaisons, long-term viability of T. thermophilum remains uncertain. Primary population threats include direct habitat alterations and disruption of Sedillo Spring discharge from human vandalism, adventitious woody root growth, local surface mining practices, and military sub-surface explosive tests. Ultimately, delisting this species will require acquisition of a conservation easement, including water rights for Sedillo Spring, to ensure population viability in perpetuity.

El isopodo de Socorro, *Thermosphaeroma thermophilum* (Peracarida: Isopoda), una especie en peligro de extinción del gobierno del estado (NM) y federal (USA), es 1 de 7 crustaceos sphaeromtidos de agua dulce conocidos de pequeños manantiales térmicos aislados del Desierto de Chihuahua en New Mexico, Texas, y México (Chihuahua, Durango, and Aguascalientes). Este isopodo endemico inhabita vestigos del habitat de manantial de Sedillo (Sedillo Spring), Socorro County, New Mexico; lo cual fue modificado mas temprano este siglo para servicios de agua por la municipio de Socorro, New Mexico, y para proveer agua al difunto baño térmico, Evergreen Spa. Condiciones extantas del habitat consiste de un pozito del agua ($3m^2$) con paredes concretas de poco profunidad y un corto corriente de agua (25m) que descarga flujo por un caño. La población nativa del isopodo de Sedillo Spring fue extinguida en 1988 debido a una sequia del habitat, y fue repatriado con stock genético de poblaciones cautivas de la University of New Mexico. A pesar de diez e seis años de esfuerzos significativos de conservación por la parte de los gobiernos del estado y federal, incluyendo establecimiento de poblaciones en refugios aislados, desarrollo de facilidades para criar la especie, monitreo mensual de las poblaciones, estudios ecologicos, investigaciones genéticas, y relaciones cooperativas entre el terratienente y las agencias, la viabilidad del largo plazo de T. thermophilum queda incierto. Amenazas principales a la población nativa incluye pertubaciones directos al habitat y la disrupción de flujo del agua de Sedillo Spring por vandalismo de ser humano, oclusión del caño debido a crecimiento de razas adventicias de arbustos, actividades locales de minera, y experimentos explosivos subterraneos por el militar. ltimamente, la pertenencia de la especie requiere adquisición de un acuerdo de conservación, inclyendo derechos del agua de Sedillo Spring, para asegurar la viabilidád poblacional en perpetuidad.

Estudios de Borrego Cimarrón, Berrendo y Puma en la Reserva de la Biosfera del Pinacate y Gran Desierto de Altar

Bighorn Sheep, Pronghorn and Mountain Lion Studies in the Pinacate and Great Altar Desert Biosphere Reserve

Eduardo E. Lopez-Saavedra, Rafaela Paredes, Raymond M. Lee, Ray Schweinsburg, y James C. De Vos

Este proyecto consiste en llevar a cabo el monitoreo y evaluación de la calidad del hábitat del borrego cimarrón (*Ovis canadensis mexicana*) y el berrendo sonorense (*Antilocapra americana sonoriensis*) y el Puma (*Felis concolor*) (para éste último, solo se contempla el monitoreo y evaluación de su estatus actual) en la Reserva de la Biosfera el Pinacate y Gran Desierto de Altar.

Tomando en cuenta la situación actual de las tres especies anteriormente mencionadas, en cuanto a su estatus poblacional y los cambios de uso del suelo sobre su área de distribución actual y potencial, así como la ausencia de información básica para su manejo. Este proyecto se propone como objetivos primordiales los siguientes:

1. Dar continuidad a los programas de monitoreo (usando equipo de telemetría y por observaciones directas) de la tres especies anteriormente mencionadas.
2. Generar información cualitativa y cuantitativa con respecto a las tres especies y sus hábitats así como, desarrollar e implementar metodología y modelos de carácter aplicativo para el manejo más adecuado de éstas
3. Participar y contribuir en el programa de manejo de un área natural protegida, tomando en cuenta que una de las funciones principales de la reserva es generar información aplicada para el manejo de los recursos silvestres, así como el transferir esta información fuera de la reserva.

El trabajo se pretende llevar a cabo en forma coordinada entre el IMADES, AG&FD , y La Reserva de la Biosfera el Pinacate y Gran Desierto de Altar.

This project, consists, in the evaluation and the monitoring of wild populations and the habitat quality of desert bighorn sheep (*Ovis canadensis mexicana*), sonoran pronghorn (*Antilocapra americana sonoriensis*) and mountain lion (*Felis concolor*) (for the last one, only direct and indirect observations will be registered on the field and by using historical reports) in the Biosphere Reserve of the Pinacate and Grand Altar Desert.

Thus, taking on account the actual situation of the three species mentioned before, in the sense of their population status and changes in land use in their actual, historical and potential habitat, and on the lack of information regarding management activities, this project is proposed.

Three main objectives conform this project:

1. To monitor and evaluate populations and habitat use of three important species.
2. To generate basic and applied information for management purposes.
3. To contribute to the management program of a natural protected area in a wildlife management and research chapter.

Estudio Preliminar de los Mamiferos del Valle de Cuatrocienegas, Coahuila, Mexico

Preliminary Study on Mammals from Cuatro Cienegas Valley, Coahuila, Mexico

Juan H. López-Soto, Armando J. Contreras-Balderas, José Ma. Torres-Ayala, y Salvador Contreras-Arquieta

El presente estudio se llevo a cabo de diciembre de 1996 a noviembre de 1997 en el Valle de Cuatro Ciénegas, en la porción central del estado de Coahuila, México. El Valle de Cuatro Ciénegas, es un valle intermontano que se caracteriza por presentar un clima arido con menos de 200 mm de precipitación promedio anual, con una vegetación típica del desierto. Se caracteriza asi mismo por su alta riqueza biológica y sus altos indices de endemismos, principalmente en organismos acuaticos. Con el presente estudio, se establece el primer trabajo sobre los mamíferos delValle mencionado. Pocos trabajo en mamiferos refieren el Valle, sin embargo la mayoría de los registros son de areas aledañas y corresponden a huesos encontrados en egargópilas de lechuza, y de registros fosiles recientes como lo mencionan Gilmore (1947), Baker (1953) y Hall (1981), este ultimo solo adiciona una especie de murcielago a las especies reportadas en el Valle. Se encontraron 34 especies (solo 3 registros son visuales), de las cuales 27 vienen a ser nuevos regsitros para el Valle.

The present study, was conducted from December 1996 to November 1997 on the Cuatro Ciénegas Valley. The Cuatro Ciénegas Valley is a small (less 1500 km) intermontane valley in the eastern Sierra Madre Oriental in central Coahuila, northern México. This desert region is extremely arid, with an average annual precipitation of less 200 mm. The objective of this study was to identify the mammals that inhabit this valley. The mammals of Cuatro Cienegas Valley, are poorly studied, in some cases, mentioned the species of this group for pellets of Owls, from near areas, or fossils, as mentioned Gilmore (1947), Baker (1953) and Hall (1981). We found 34 species (31 collected and 3 only observed), 3 species not confirmed and 27 are new records for the Valley.

Rare and Threatened Plant Species of Big Bend National Park, Texas

Las Especies de Plantas Raras y Amenazadas del Parque Nacional Big Bend, Texas

Denise A. Louie

As wildland habitats continue to face global degradation and private lands become increasingly inaccessible to scientific interests, Big Bend National Park

and the Mexican reserves of Santa Elena and Maderas del Carmen stand as critical reserves for the preservation and investigation of biological diversity in the Chihuahuan Desert region. A number of plant species in this region are endemic, relictual, rare, and represent disjunct populations. According to the U.S. Fish and Wildlife Service and the Texas Organization for Endangered Species, there are at least 31 plant species suspected to be within the boundaries of Big Bend National Park warranting attention. However, the current biological status is unknown for most of these species. Although a wealth of outside research, status reports, and recovery plans have been completed on selected rare species, no readily accessible compilation of rare plant information is available for the Big Bend region of the U.S./Mexico border. The purpose of this study was to outline the current knowledge of the rare plant species of Big Bend National Park with the following objectives: (1) retrieve rare plant information from field studies, literature reviews, herbaria, government agencies, natural heritage programs, and knowledgeable individuals; (2) create a field guide and data base of rare taxa; and (3) outline conservation priorities and research needs. This study can provide a baseline of information for expanded studies in Big Bend National Park and in adjacent protected areas in Texas and Mexico.

Conforme los ambientes de areas silvestres encaran el deterioro global y los terrenos de propiedad privada se vuelven inaccesibles a los intereses cientificos, el Parque Nacional Big Bend y las reservas mexicanas de Santa Elena y Maderas del Carmen se mantienen como reservas criticas para la preservacion y la investigacion de la diversidad biologica de la region del desierto de Chihuahua. Un numero de especies de plantas de esta region son endemicas, relictas, raras y representan poblaciones dispersas. De acuerdo con el U. S. Fish and Wildlife Service y la Texas Organization for Endangered Species, se calcula que hay por lo menos 31 especies de plantas dentro del area del Parque Nacional Big Bend que merecen atencion. Sin embargo, el estado biologico presente es desconocido para la mayor parte de estas especies. Aunque se han acabado varias investigaciones externas, informes sobre el estado y planes de recuperacion sobre especies raras seleccionadas, no hay una compilacion accesible que da informacion sobre plantas raras para la region de Big Bend de la frontera entre Estados Unidos y Mexico. El proposito de este estudio fue de hacer un esquema sobre el conocimiento actual de las especies de plantas raras del Parque Nacional Big Bend con los siguientes objetivos: (1) recuperar la informacion sobre plantas raras de los estudios de campo, la literatura que existe, herbaria, agencias gubernamentales, programas sobre la herencia natural e individuos que estan bien informados; (2) crear una guia de campo y una base de datos de taxa rara y (3) hacer un esquema de las prioridades para la conservacion y las necesidades de investigacion. Este estudio puede ofrecer una base de informacion para estudios amplios en el Parque Nacional Big Bend y en areas contiguas protegidas de Texas y Mexico.

Educadores Ambientales: Socios Acercandose a la Frontera

Environmental Educators: Partners Approaching the Border

Neil B. Markowitz and Mariana Lazcano Ferrat

El Intercambio de Educación Ambiental (El Intercambio) es una organización no lucrativa ubicada en Tucson, Arizona; la cual se encuentra trabajando en cooperación con la Oficina de Enlace en San Diego de la Agencia de Protección Ambiental de Estados Unidos (EPA) en el Programa de Planeación de Educación Ambiental que cumple con los objetivos del Programa Frontera XXI México - Estados Unidos. Estos objetivos se llevan realizan mediante una serie de Talleres de entrenamiento para promover y expandir la educación ambiental en las comunidades fronterizas. Aunada a la EPA, la Secretaría de Educación y Cultura del Estado de Sonora ha apoyado este proceso binacional. Este proyecto, basado en talleres, reúne a los educadores de la región fronteriza de Arizona y Sonora para crear nuevos planes de programas comunitarios. Este esfuerzo, con un año de duración, est destinado a identificar y fortalecer a educadores de diversos sectores que deseen planear nuevas iniciativas de educación ambiental, apoyar alianzas internacionales e impulsar mecanismos de comunicación binacionales. Simultaneamente la Fundación Ford-México apoya al Programa Juntos: Maestros y Jóvenes de la Frontera que busca motivar y guiar a muchachos de bachillerato y a sus maestros para aprender acerca del ambiente local y desarrollar planes de acción comunitarios. El objetivo incluye reforzar su programa de estudio e involucrar a maestros, jóvenes y agencias locales en un proceso cooperativo de extensión binacional. Se realizaran Talleres de Planeación y una Guía de Actividades Comunitarias para Escuelas.

The Environmental Education Exchange is cooperating with Border XXI to promote sustainable development in the border region by seeking a balance among social and economic factors and the protection of the environment in the border communities and natural areas. The US Environmental Protection Agency and the Education and Culture Secretariat of Sonora actively support The Environmental Education Planning Workshops Project. This project aims to bring people from the border region of Arizona and Sonora to work together in environmental education on a regional basis. It is a one-year effort to recognize and empower local leaders -educators from diverse sectors- willing to acquire social responsibilities, plan environmental education initiatives, support international alliances and enhance communication mechanisms. Simultaneously, the Ford Foundation in Mexico is supporting the Program Juntos: Teachers and Youth of the Border. This program aims to motivate and guide high school students and teachers to learn about their local environments and to develop community action plans. Objectives include strengthening their school curriculum and enhancing extension bi-national collaboration. Planning workshops will be held and an Activity Guide for Schools will be developed.

Proyecto de las Aves del Coahuila, Mexico

El Proyecto de las Aves de Coahuila, Mexico

Bonnie Reynolds McKinney and Elizabeth Spence de Sellers

Proyecto de las Aves de Coahuila, Mexico was a five year cooperative project between private ranches and Texas Parks and Wildlife Department. The study was conducted in a very remote area of northern Coahuila. Field work began in March 1993 and concluded in July 1997. Northern Coahuila has very little ornithological data available, previous works have concentrated mainly in the frontera area and southward in the Saltillo and Cuatro Cienegas area. The objectives of our study was to document the birdlife, fill in gaps in range and distribution, conduct specific surveys on selected species and to promote an appreciation of the birdlife through education and outreach. Two study sites were selected, a pine-oak woodland habitat in the Serranias del Burro on Rancho La Escondida and a Tamaulipan thorn-scrub habitat on Rancho El Pato, 25 miles north of Melchor Muzquiz. Results of our field work was the documentation of 197 species of birds for the Serranias del Burro and 137 species for the Tamaulipan thorn-scrub area. Nine new species were documented for the state of Coahuila from these two localities and one additional state record was documented outside the study area. Combining our records with other available data from Coahuila produced a total of 382 species for the state. Results of our work will be published in both Spanish and English and future plans include the publication of a book on the birdlife of Coahuila, Mexico.

El Proyecto de las Aves de Coahuila, Mexico es un proyecto de la cooperativa del termino largo entre rancheros privado y El Tejas Parques y Departmento de Fauna Silvestre. Se conducir el estudia en una area remota de Coahuila del norte. Campo trabaja empezo en el Marzo de 1993 y concluyo en Julio 1997. Coahuila del norte tiene muy poco ornithologio datos disponible, previo trabaja ha concentrado principalmente en el frontera area y mas alla sur hacia el Saltillo y Cuatro Cinegas area. Los objectivos de nuestra esdudio, el documentar las aves en esta area del remota, llenar boquetes en distribucion del rango, conducir estudias especificos en selecciono especie y promover una appreciacion del aves por educacion. Dos estudian se escogieron sitios, un sitio que se localiza en el Serranias del Burro, en Rancho La Escondida y contienne bosques mixtos de pino-encino habitat. El sitio del segundo en Rancho El Pato, 25 millas norte de Municipo Melchor Muzquiz, y situo en Tamaulipan matorrales espinosos y mezquitales habitat. Como un resultado de nuestra estudios su documento 197 especies de aves por el area de Serranias del Burro y 137 especies en ara de habitat matorral. Se documento nueve especies pajaros nueva de estado de Coahuila de estos dos estudio sitios. Uno exteriores de la especie adicionales se documento como un primer registro por el estado el area del estudio. Combinar

nuestro archivo con otro disponible ornithologio datos ahora tracen el total especies por el estado de Coahuila a 382 especies.

The Use of Artificial Nest Sites by Elf Owls in Western Texas

El Uso de Sitos Artificiales de Nido por Tecolotito - Colicorto en el Oeste Tejas

Bonnie Reynolds McKinney

The elf owl (*Micrathene whitneyi*) is the smallest owl in the world. Their range includes the hot, arid lands of the desert southwest. In the lower Chihuahuan Desert Region of west Texas the elf owl is almost totally dependent on the ladder-backed woodpecker (*Picoides scalaris*) for nest sites. Due to the scarcity of trees in the region power poles are heavily utilized for nest sites. Advancements modern technology is resulting in many power and telephone lines being placed underground. The loss of significant numbers of wooden power poles may impact the nesting populations of elf owls as well as other cavity nesters. The objectives of the four year research project was to determine if elf owls would use wooden nest boxes, as a complement to the habitat enhancement portion of the study, the ecology of this species was also studied to further knowledge on the ecology by banding and color marking to determine longevity, pair fidelity, site fidelity, food habits and migration information.

La tecolotito colicorto (*Micrathene whitneyi*) es mas pequena en el mundo. Su gama incluye las tierras aridas calientes del sudoeste de desierto. En el Chihuahuan mas inferior region de desierto de oeste Tejas la tecolotito colicorto es muy dependiente de el carpinterillo mexicano (*Picoides scalaris*) para sitos de nido. Debido a la escasez de arboles en la region, los polos de energia se utilizan como anidados lost sitios. A causa de adelantos en la tecnologia moderna el mundo de communicaciones muchos energia de linea siendo puesto el subterraneo, signigicaante la perdida en el numero polos de energia puede impacto las populaciones anidar de tecolotito colicorto. La estudiar es conducir en el Black Gap Wildlife Management Area esta en la suerste de el condado de Brewster, Tejas. Los objectivios del estudio estan para proveer el aumento de habitat mediante las cajas artificales de nido a el conocimiento adicional de la ecologia de estas especies y por marca y color que marca para obtener informacion sobre la longevidad, datos de migracion, par y fidelidad de sito fidelidad y habitos alimentarios.

Winter Ecology of the Bald Eagle (*Haliaeetus Leucocephalus*) in the Babicora Region, Chihuahua

Ecologia Invernal del Aguila Cabeza Blanca (*Haliaeetus Leucocephalus*) en la Region de la Babicora, Chihuahua

Cesar Ernesto Mendez Gonzalez y Ricardo Abel Soto Cruz

The study was carried out during winters of 1994-95 and 1996-97. The objectives were: to describe the population attributes, intra and interspecific relations, habitat use patterns, to determine the feeding behaviors, to determine and describe the main limiting factors of the species. The results were: during the 1994-95 winter, 30 individuals were identified (22 adults and 8 juveniles), making this the highest record of the whole study. The eagles stay in the Babicora area from November until April, with the highest population concentration in the month of January. Commensalism was detected between the eagles and the common crows (*Corvus corax*), competition with other depredators. The white geese (*Chen* spp.) had the most noticeable interspecific relation during the study, due to the fact that most of the eagles movements were influenced by these birds. The diet composition was made up by: waterfowl with the white geese in the first place (57.12%), sandhill cranes (*Grus canadensis*) representing 24.4% of the diet, and diverse species of ducks (*Anas* spp.), the remaining 18.37%. The variables in feed available, the scarce perching sites and the human pressure on the population seem to be the main limiting factors encountered in this study.

El estudio se realizo durante los inviernos de 1994-95, 1995-96 y 1996-97. Los objetivos fueron describir los atributos de la poblacion, relaciones intraspecificas e interpecificas, patrones de uso de habitat, determinacion de los habitos alimenticos, determinar y describir los principales factores limitantes de esta especie. Los resultados son: durante el invierno 1994-95 se lograron identificar 30 individuos (22 adultos y 8 inmaduros), este reistro fue el mas alto de todo el estudio. La presencia de las aguilas en el area de Babicora estuvo comprendidad desde principios de noviembre hasta principios de abril, teniendo sus concentraciones mas altas en enero. Se detecto comensalismo entre las aguilas y los cuervos comunes (*Corvus corax*), competencia con otros depredadores e incluso con los mismos cuervos cuando las condiciones de habitat fueron mas severas. Los gansos blancos (*Chen* spp.), tuvieron la relacion interspecifica mas marcada durante el estudio, ya que muchos de los movimientos de las aguilas estuvieron influenciados por estos. La composicion del alimento estuvo formada por aves acuaticas, siendo los gansos blancos quienes ocuparon el primer lugar de los restos colectados con un 57.12%, las grullas grises (*Grus canadensis*) representaron el 24.49% y los patos de diversas especies (*Anas* spp.) el 18.37%. De los principales factores limitantes resaltan las variaciones en la disponibilidad de alimento, la escasez de sitios de percha diurna adecuados y la presion ejercida en forma directa por el ser humano.

Ecotourism at the Edge: La Ruta De Sonora

La Ruta de Sonora: Ecoturismo de Frontera

Joaquin Murrieta-Saldivar

Ecotourism is an activity for sustainable development that has been identified by communities of the borderlands of the Sonoran Desert Bioregion. It is also mentioned in protected areas management plans' as an economic alternative along the Arizona-Sonora border. Well preserved and managed desert and ocean ecosystems in the U.S. and Mexico that include biosphere reserves and rich and varied cultural and archeological sites in the region offer a special opportunity for conservation and sustainable development. La Ruta de Sonora Ecotourism Association is incorporating business interests, land managers, institutions, and private citizens with interest in promoting the development of ecotourism activities that benefit conservation and economic opportunities for local communities. These advocates have identified that successful ecotourism requires careful definition and compliance with a set of environmental, cultural and socio-economic criteria that establish standards for ecotourism. The final goal of this effort is to foster a better understanding, dialog and cooperation towards the natural and cultural resources of this tri-national Bioregion by linking communities, biosphere reserves and protected areas, business owners and citizens of the borderlands of the Sonoran Desert. This present work describes the experience to date in establishing La Ruta de Sonora Ecotourism Association.

El ecoturismo es una actividad para el desarrollo sustentable que ha sido identificada por varias comunidades de la Bioregion Fronteriza del Desierto Sonorense. Tambien se menciona en los planes de manejo de areas protegidas, como una alternativa economica a lo largo de la frontera entre Sonora y Arizona. Terrenos publicos bien manejados para su conservacion tanto en Mexico como en los Estados Unidos donde encontramos reservas de la biosfera y sitios con una variada riqueza natural, cultural y arqueologica distribuidos en ecosistemas deserticos y oceanicos, ofrecen una oportunidad especial para la conservacion y el desarrollo sustentable. La Asociacion Ecoturistica del La Ruta de Sonora esta incorporando varias organizaciones, instituciones y ciudadanos con interos en promover el desarrollo e implementacion de actividades ecoturisticas para el beneficio de la conservacion y de oportunidades economicas para las comunidades locales. Estos promotores han identificado que para un ecoturismo exitoso a nivel regional se requiere de una cuidadosa definicion y cumplimiento con una serie de criterios ambientales, culturales y socio-economicos que son el estandar para la actividad ecoturistica. La meta final de este esfuerzo es el de vincular comunidades, reservas de la biosfera y areas protegidas, iniciativa privada y ciudadanos de la zona fronteriza del Desierto Sonorense, para asi alentar un mejor entendimiento, dialogo y cooperacion hacia los recursos naturales y culturales de esta Bioregion tri-nacional. La experiencia hasta hoy en el establecimiento de La Asociacion Ecoturistica de La Ruta de Sonora es el proposito de este presente trabajo.

Collaborating with Indigenous Communities on Wildlife Conservation and Sense of Place Education

Gary Paul Nabhan and Kim Buck

Few conservation organizations and natural history have sufficient valued the traditional ecological knowledge in indigenous communities relating to threatened wildlife species and natural habitats. In this case study, we demonstrate the kinds of ecological, behavioral and environmental history information commonly found within indigenous communities of the Seri or Comcaac of the Sonoran coast of the Sea of Cortez. In particular, their knowledge of sea turtles, desert tortoises and chuckwallas have significant implications for regional biological conservation efforts. Next, we show how the devaluation of such knowledge is contributing to its loss from the youngest generation, as verified by interviews with 29 adults over age 25, and 23 youth under the age of 25. Finally we show how the Arizona-Sonora Desert Museum's Transboundry Sense of Place Project has afforded elders new venues for transmitting such traditional ecological knowledge to their communities' youth through hosting joint field trips, preparing culturally-adapted environmental education materials and cassette tapes of traditional animal songs, constructing ethnobotany trails and chuckwalla captive breeding enclosures.

United States/ Mexico Cooperation in Protected Area Management Along the Arizona/Sonora and Upper Baja California Borderlands Region: A National Park Service Program

Estados Unidos/Mexico: Cooperacion en el Manejo de Areas Protejidas a lo Largo Dentro las Fronteras de Arizona, Sonora y Baja California Norte: Una Programa de Servicio de Parques Nacionales

Gina A. Pearson

Four National Park Service units in Arizona are currently working cooperatively on management efforts. Since 1979 cooperative efforts have taken place between Organ Pipe Cactus National Monument and El Pinacate y Gran Desierto de Altar Biosphere Reserve in Sonora. These efforts include, but are not limited to: natural resource monitoring, environmental education and interpretation, establishment of resource management committees, visitor use and resource protection program development, donations of various types of ranger and resource management equipment, and a number of trainings in ranger operations, interpretation, and resource management. Tumacacori National Historical Park has worked with Sonora, Mexico for approximately 28 years regarding the Tumacacori Festival. The fairly recent establishment, 1991, of the US/Mexico Affairs Office for the National Park Service has allowed border park

units to further develop their international cooperative efforts with Mexico. Organ Pipe's program is expanding to include San Pedro Martir National Park and Constitution de 1857 National Park in Baja. Work is to include assistance in the development of the park's management plans, and operational program areas. Program expansion also has helped initiate cooperative management efforts between Chiricahua National Monument and Sierra de los Ajos, Buenos Aires y la Purica Forest Reserve. These efforts have concentrated on infrastructure development and fire ecology research. Tumacacori has expanded their border states program to include stabilization and restoration projects on San Ignacio, Cocospera and Arizpe missions. The future of the Arizona National Park Service International Affairs Program will continue to be a success and an aid for sister parks, forests and reserves in Mexico. Formal agreements and directives by State Governments and Department of Interior level agencies will ensure that established programs continue, and new relationships are strengthened for the protection of the greater Sonora and Northern Baja Borderlands Protected Areas.

Cuatro unidades del Servicio de Parques Nacionales en Arizona en esfuerzos del manejo. Desde 1979 esfuerzos cooperativos se han producido entre Monumento Nacional Organ Pipe Cactus y La Reserva Biosfera El Pinacate y Gran Desierto de Altar en Sonora. Estos esfuerzos incluyen, pero no se limita a: monitoreo de recursos naturales, educacion medioambiental y interpretacion, establecimiento de comites del manejo de recursos, uso de visitantes y desarrollo del programa de la proteccion del recursos, donaciones de varios tipos de equipo de manejo de recursos, y varios entrenamientos en funcionamientos del guardaparque, interpretacion, y manejo del recurso. Parque Nacional Historico Tumacacori ha trabajado con Sonora, Mexico por aproximadamente 28 años con respecto a la Fiesta de Tumacacori. El establecimiento de la Oficina de los Asuntos Internacionales de Mexico por el Servicio de Parques Nacionales en 1991 ayudo ciertos parques de la frontera desarrollar mas sus esfuerzos internacionales cooperativos con Mexico. La programa de Organ Pipe extiende incluir Parques Nacionales San Pedro Martir y Constitucion 1857 en Baja. Trabajo inclue ayuda en el desarrollo sobre plans de manejo, y areas de programa operacionales. Expansion del programa internacional tambien ha ayudado iniciar esfuerzos del manejo cooperativos entre Monumento Nacional Chiricahua y Reserva Forestal Sierra de los Ajos, Buenos Aires y la Purica. Estos esfuerzos han concentrado en desarrollo de la infraestructura y investigacion de ecologia del fuego. Tumacacori ha extendido su programa de los estados de la frontera a incluir estabilizacion y restauracion proyectos en las missiones San Ignacio, Cocospera y Arizpe. El futuro de la Programa de Asuntos Internacionales/ Servicio de Parques continuara ser un exito y un ejemplo de programa de hermanas . Convenios y directivos formal por Gobiernos Estatales y Federales aseguraran que las programas continuaran, y se fortalecen nuevas relaciones por el proteccion de las tierras Sonorense y Baja Norte.

Rangeland Ecosystems: Managing the Information Holistically - The Arizona AgNIC Project

Barbara Hutchinson and Jeanne Pfander

For nearly three years, an alliance of land-grant universities, in cooperation with the National Agricultural Library (NAL), has worked together to develop an Agriculture Network Information Center (AgNIC) on the World Wide Web. This virtual Center offers access to subject-based, distributed, electronic agricultural information and services in selected disciplines. As part of this initiative, the University of Arizona (UA) has followed the AgNIC framework using the topic of rangeland management as a model for creating innovative applications in the dissemination of electronic information.

Partners in this effort include three units in the UA's College of Agriculture and the UA Library, with support from NAL and the Society for Range Management. Together, these partners are developing a comprehensive Web site on rangeland management (http://ag.arizona.edu/OALS/agnic/range.html) including text, images, interactive programs, links to other sites, and public policy issues. The site also offers a variety of applications including geographic information systems (GIS), full-text journal articles, and an online reference service. This unique resource is thus improving access to rangeland information across vast distances and fostering communication among the widely dispersed populations typical of rural areas. To facilitate the development of the site and to ensure its usefulness to a broad range of users, an Advisory Group of practicing range managers and agricultural support group representatives provides periodic web site evaluations. In addition, online evaluation forms are included to give users an opportunity to provide feedback.

Now that the initial phase of the site's development is nearing completion, plans are underway for building a dynamic front-end interface that will allow the user to search for information not only across Arizona AgNIC, but throughout the AgNIC system. Recently, the AgNIC Alliance received a Center Planning Grant from USDA's Fund for Rural America to design this overall system capability. In addition, Arizona AgNIC partners are currently creating tools to assist users in using site resources for decision-making and planning purposes. This presentation will provide an overview to the AgNIC project and demonstrate specific applications of the Arizona AgNIC Rangeland Management Web site.

A lo largo de casi tres anos, una alianza de universidades de agricultura, junto con la Biblioteca Nacional de Agricultura (NAL), ha trabajado para desarrollar un Centro Electronico de Informacion Agricola (AgNIC) para la World Wide Web. Este centro virtual ofrece acceso a informacion y servicios agriculturales, en formatos electronicos, tematicos, y distribuidos, en disciplinas seleccionadas. Como parte de esta iniciativa, la Universidad de Arizona (UA) ha seguido el marco de referencia de AgNIC usando el tema del manejo de praderas como modelo para crear aplicaciones innovadoras en la diseminacion de informacion electronica.

Los socios en este iniciativa incluyen tres partes del Colegio de Agricultura de la UA y la Biblioteca de la UA, con el apoyo de la NAL y la Sociedad del Manejo de Praderas. Juntas, estas organizaciones desarrollan una pagina Web detallada sobre el tema del manejo de praderas que incluye texto, imagenes, programas interactivos, enlazes a otros paginas, y asuntos politica (http://ag.arizona.edu/OALS/agnic/range.html). La pagina tambien ofrece varias aplicaciones como sistemas de informacion geografica (GIS), articulos completos de revistas, y un servicio de referencia electronica. Este recurso unico asi mejora el acceso a informacion sobre praderas tras largas distancias, y establece comunicacion entre las poblaciones tipicas de las areas rurales. Para facilitar el desarrollo de esta pagina y asegurar su utilidad a un amplio espectro de usuarios, un Grupo Consejero de administradores de praderas y de representantes de grupos de apoyo agricola, provee evaluaciones periodicas de la pagina. Ademas se incluyen formularios electronicos de evaluacion para dar a los usuarios la oportunidad de hacer comentarios.

Ahora que la fase inicial del desarrollo de la pagina Web esta a punto de completarse, se esta planeando construir una interface dinamica que permitira al usuario buscar informacion, no solamente en Arizona AgNIC, sino en todo el sistema AgNIC. Recientemente, la alianza AgNIC recibio una concesion de planificacion del Fondo para la America Rural de la USDA para disenar esta capacidad. Ademas, los socios de Arizona AgNIC estan creando aplicaciones para permitir a los usuarios usar recursos de la pagina para tomar decisiones y planes. Esta presentacion consistira en un panorama del proyecto AgNIC y mostrara algunas aplicaciones especificas de la pagina Web "Arizona AgNIC Rangeland Management."

Caracterizacion Fisiografica de la Cuenca Baja del Rio Bravo con Fines de Ordenamiento Territorial

María de Lourdes Romo Aguilar

El objetivo de este trabajo es describir los aspectos físicos del paisaje en la cuenca baja del Río Bravo para la compilación y colección de información espacial adecuada para el ordenamiento territorial. Conceptualizando este último como la herramienta que promueve y regulariza a través de los instrumentos de planeación, a las actividades humanas en el espacio terrestre. La metodología utilizada se basa en la aplicación del enfoque geomorfológico que permitió delimitar unidades ambientales físicas, manejando y analizando la información dentro del contexto de un Sistema de Información Geográfica. Se utilizaron estas unidades como el principal marco de referencia geográfica para definir posteriormente sus aptitudes de uso del suelo. En los resultados las principales unidades morfológicas encontradas en el área de estudio son: llanuras, lomeríos, sierras bajas y mesetas. Estas topoformas asociadas con la hidrología y la edafología permiten delimitar áreas específicas para visualizar

los ajustes en la organización espacial humana actual y para proponer las asignaciones en el uso de recursos naturales disponibles, guardando los principios de conservación de la naturaleza. Por ello se requiere información permanentemente actualizada sobre el estado del medio ambiente y sobre todo de su potencial disponible.

The purpose of this study is to describe physical elements of Río Bravo/ Grande low watershed landscape to collect adequate spatial information for territorial order. Territorial order is conceptualized as the tool to promote and regularize human activities in terrestrial space. The methodology used is focused on applied geomorphology. This permitted to delimit physical envïronmental units through handling and analyzing information in an Geographical Information System. The delimited units were used as geographical reference to define suitability land use. The results show five mainly morphological units in study area: plains, hills, low mountains and plateus. These surface forms related with hydrology and edaphology are important to delimit specifical areas to visualize adjusts human spatial organization and to propose allocations in the use of available natural resources, keeping on mind always the principles of nature conservation. Present-day permanent information about the environment and its potential is necessary.

The Agua Prieta Animal Project

Proyecto con Animales en Agua Prieta

Silke Schneider

Domestic animal genetic diversity is critically endangered on a global scale. Conserving this diversity in a "museum" style farm collection, however, is neither realistic nor practical and neglects the reason for the existence of these breeds. It is clear that rare breeds should be placed in productive environments that not only make use of their unique traits but expose the public to the urgency of conservation of these animals. This presentation describes such a project—an animal farm for a childrens' and senior citizens' home in Agua Prieta, Sonora, Mexico. Besides conserving genetic diversity of rare breeds of domestic animals, the goals of the project are to produce healthy organic products while fostering a sense of responsibility and companionship that domestic animal husbandry can provide. Rare breeds of domestic animals provide a link to appreciating wild animal or habitat conservation and the animal farm will enable chidren and seniors to study and learn about conservation issues. Through this project, both young and old will be able to make a contribution and be rewarded with a sense of meaning in their lives. The Agua Prieta Project, a collaboration between professionals on both sides of the border, is a prototype for self-sufficient, economically viable animal farms using rare breeds adapted to local conditions.

La diversidad genética en animales domésticos se encuentra en peligro crítico a una escala global. Conservar esta diversidad en una colecta de granja al estilo "museo", no es realístico ó práctico y descuida la razón de la existencia de estas razas. Es claro que razas raras deberían estar en ambientes productivos que además de aprovechar sus características únicas, muestran al público la urgencia en la conservación de estos animales. Esta presentación describe este tipo de proyecto: Una granja de animales para un albergue de niños y ancianos en Agua Prieta, Sonora, México. Además de conservar la diversidad genética de razas raras en animales domésticos, las metas del proyecto son producir alimentos orgánicos saludables, mientras se promueve un sentido de responsabilidad y compañerismo con el cuidado de animales domésticos. Las razas raras de animales domésticos son un eslabón en la apreciación de animales silvestres o conservación de habitats y la granja de animales permitirá a niños y ancianos estudiar y aprender acerca de temas de conservación. Por medio de este proyecto jóvenes y mayores serán capaces de hacer una contribución y esto los recompensará dandóles significado a sus vidas. El Proyecto Agua Prieta, una colaboración entre profesionales en ambos lados de la frontera, es un prototipo para autosuficiencia, granjas de animales económicamente viables usando razas raras adaptadas a las condiciones locales.

Monitoring an Endangered Species, the Lesser Long-nosed Bat, on the Ft. Huachuca Army Installation

Monitoreo de una Especie en Peligro de Extinción el Murciélago Magueyero Pequeño,len las Instalaciones Militares de Ft. Huachuca

Ronnie Sidner

Two species of nectar-feeding bats, *Leptonycteris curasoae* and *Choeronycteris mexicana*, were recorded from roosts on Ft. Huachuca prior to the listing of *L. curasoae* as an endangered species in 1988. No information was available concerning numbers of bats or period of occupation by these species on the Fort. The Department of Defense required such information in order to protect the endangered species and its potential food supply during military operations. An inventory and monitoring program for *L. curasoae* was initiated in 1990 to ascertain baseline information. The program continued through 1997, using low-disturbance techniques, to determine comparative patterns of roost use, seasonal presence, and population size. The annual maximum number of individuals counted for any date during the year from 1990-1992 was approximately 50-100 bats, from 1993-1996 was 525-1439 bats, and in 1997 was 93 bats. Banding of a small number of individuals showed movement from a nightroost to a dayroost on the Fort, and movement of 28 km one night from the nightroost to a major dayroost off the Fort. In 1996, the first documentation (in photographs) of *L. curasoae* feeding at Agave palmeri was obtained in August and September while

workers used night-vision devices to observe 31 flowering agaves at 16 localities across the Fort and while sampling during all hours of the night. In 1996, 61 fifteen-minute observation periods yielded counts of bat foraging strikes on individual agaves at an average rate of 53 foraging strikes per 15- minute period, and all but one observation period showed foraging bats. In 1997, the average feeding rate was < 1 foraging strike per 15-minute period of observation.

Dos especies de murciélagos que se alimentan de néctar, *Leptonycteris curasoae* and *Choeronycteris mexicana*, fueron registrados de los refugios en Fort Huachuca (Arizona, USA) antes de incluir en la lista de especies en peligro de extinción a *L. curasoae en* 1988. No existia ninguna información acerca del número de murciélagos o período de ocupación de estas especies en Fort Huachuca, información que el Departamento de Defensa requeria para proteger esta especie en peligro de extinción y su potencial fuente alimenticia durante operaciones militares. Un programa de monitoreo e inventario para *L. curasoae* fue iniciado en 1990 para obtener datos de base de esta especie. El programa continuo hasta 1997, utilizando técnicas de bajo disturbio para determinar patrones comparativos del uso de refugios, presencia estacional y tamaño de la población. El número anual máximo de individuos contados desde 1990 hasta 1992 fue aproximadamente entre 50 y 100 murciélagos. Desde 1993 a 1996 el número de murciélagos fue entre 525 y 1439, y finalmente en 1997 fueron 93 murciélagos. El bandeo de un pequeño número de individuos mostro un movimiento entre un refugio nocturno a un refugio diurno en Fort Huachuca, y el movimiento en una noche de 28 Km del refugio nocturno a un refugio principal fuera de las instalaciones. La primera documentación fotográfica de L. curasoae alimentandose de Agave palmeri fue obtenida en Agosto y Septiembre de 1996, cuando trabajadores utilizando aparatos de visión nocturna observaron 31 agaves en flor en 16 localidades de Fort Huachuca y durante el trabajo de muestreo realizado en cada hora de la noche. En 1996, 61 períodos de observación de 15 minutos dieron un contaje del número de eventos de forrajeo en agaves individuales con una tasa promedio de 53 eventos en cada periodo de 15 minutos de observación. Todos con excepción de un período de observación mostraron murciélagos en forrajeo. En 1997, la tasa promedio de eventos de forrajeo fue menor a un evento por cada período de 15 minutos de observación.

Binational Watershed and Beyond Student Exchange

Represo Binacional e Intercambio con Estudiantes

Karen Sondak, Monica Madrid, and Dagaberto Lopez

Students from Rio Rico High School (RRHS) have been partnering with Friends of the Santa Cruz River (FOSCR) for three years. Applied Biological Systems classes make monthly trips to three sites along the Santa Cruz River at

the same time as FOSCR, to collect information on water quality, aquatic flora, and streamflow. Students compile, review, evaluate, and interpret the data they collect.. Trends of higher levels of ammonia and reduction in fish populations are being analyzed. During an Arizona-Sonora Desert Museum and Pronatura Sonora "Places of the Heart" Workshop, held in San Ignacio, Sonora, in the winter of 1997, members of FOSCR heard of the water quality crisis facing at the people who live along the Rio Magdalena. This sense of place project donated a water test kit, identitical to the ones being used at RRHS, and demonstrated its use. Since this first meeting, two student exchanges have occurred. In May of 1997 RRHS students visited the Rio Magdalena and further demonstrate the use of the water quality test kit to students from Colegio de Bachilleres del Estado de Sonora Plantel Magdalena (COBASH). In December of 1997, RRHS hosted a two day environmental exchange with students from COBASH. Students tested the water and hiked along the Santa Cruz River, toured the Nogales International Wastewater Treatment Plant, and attended an Environmental Theater performance written, directed, and performed by RRHS students. Students will present hypotheses with data of their river quality monitoring as well as their experiences participation in a binational environmental cooperative learning experience.

Los estudiantes de la preparatoria en Rio Rico (RRHS) han tenido una relacion con "Amigos del Rio Santa Cruz" por tres anos. Las clases de Systemas Biologicas junto con "Amigos del Rio Santa Cruz" (ARSC), han llevado acabo el programa de colectar informacion sobre la calidad del agua, la flora y fauna acuatica y la corriente del rio. Los estudiantes comparan, revisan , evaluan e interpretan la informacion colectada. Los altos niveles de amonia y la reduccion de la poblacion de los peces han sido analisada. El museo Arizona-Sonora Desert Museum en Tucson, y Pronatura Sonora " Lugares del corazon" almacen, situada en San Ignacio Sonora, han tenido una relacion durante el invierno de 1997. Miembros de ARSC, prestaron atencion a los problemas ocasionados a la gente que vive alrededor del Rio Magdalena causados por la calidad que tiene el agua del rio. Este problema motivo a los estudiantes de RRHS y ARSC , a donar el Probador de agua utilizado por los estudiantes. Tambien les ensenaron como usarlo. Desde la primera reunion, han occurido dos intercambios de estudiantes. En mayo de 1997, estudiantes de RRHS visitaron el Rio de Magdalena , con el proposito de ensenar a los estudiantes del Colegio de Bachilleres del Estado de Sonora (Plantel Magdalena) COBASH como usar el equipo y tambien para entregarles el Probador de agua. En diciembre de 1997, RRHS hospedo, por dos dias, a estudiantes del Colegio de Bachilleres del Estado de Sonora, en el Intercambio de Medio ambiente. Los estudiantes examinaron el agua del Rio Santa Cruz. Tambien fueron a una excursion a la Planta Intenacional del tratamiento de las aguas sucias de Nogales. Por ultimo asistieron una obra sobre el medio ambiente, escrita, dirigida y actuada por estudiantes de RRHS. Estudiantes presentaran una hypotesis con una grafica de los resultados adquiridos sobre las pruebas hechas al Rio. Tambien tendran muestras de las experiencias de los estudiantes que han participado en el apredisage coperativo sobre el medioamiente binacional.

A Different Approach to Managing Desert Bighorn Sheep in Mexico

Un Enfoque Diferente en el Manejo del Borrego del Desierto en Mexico

Luis A. Tarango, Paul R. Krausman, Raul Valdez, Carlos Alcala, and Sergio Jimenez

Numbers and distribution of bighorn sheep throughout the southwestern United States have been enhanced with concentrated translocation efforts. However, management of sheep in Mexico has not been as aggressive. In Mexico, management of bighorn sheep has been hindered by the lack of basic biological data and lack of sufficient federal and state personnel to enforce laws. In 1995 the National Association of Diversified Ranchers (ANGADI) initiated a management plan in cooperation with the Mexican Government and private land owners. This program consists of enclosures with desert bighorns captured from areas with high wild sheep densities. In these enclosures sheep are fed and protected from poachers, and predators. The main goal is to repopulate areas where sheep have been reduced or extirpated within the state. In 1995 and 1996 Organization for wildlife (OVIS A.C.) in cooperation with local ejidos of Baja California, Sur, trasplanted sheep from the mainland of southern Baja California to El Carmen Island in the Sea of Cortes. These programs need to be monitored to measure their success.

Los números y distribución del borrego del desierto en el suroeste de los Estados Unidos han sido apoyados con programas de traslocación. Sin embargo, el manejo del borrego en México no ha sido tan agresivo. En México, el manejo del borrego se ha visto obstaculizado por la falta de adquisición de datos biológicos básicos de la especie y por la falta de personal estatal y federal para la aplicación de leyes. En 1995, la Asociación Nacional de Ganaderos Diversificados (ANGADI) inició un plan de manejo en cooperación con el Gobierno Mexicano y propietarios privados. Este programa, consiste en el establecimiento de encierros semi-intensivos y extensivos con borregos capturados en areas con alta densidad de borregos. En estos encierros, los borregos son alimentados, protegidos de furtivos y de depredadores. El principal objetivo de este programa es el de repoblar areas en donde el borrego ha sido reducido en número o extirpado dentro del estado. En 1995 y 1996, la Organización Vida Silvestre (OVIS A.C.) en cooperación con ejidos de Baja California, Sur, trasplantó borregos del continente dentro de la Isla del Carmen en del Mar de Cortes. Estos programas, necesitan ser monitoreados para medir su efectividad.

The Impact of El Niño Phenomena on Natural Resources in North America

Impacto del Fenómeno El Niño en los Recursos Naturales de Norte América

Mario Tiscareno-Lopez, Norm J. Rosenberg, Robert Brown, Cesar Izaurralde, Raghavan Srinivasan, and David Legler

Desertification can be the result of large interannual climatic. The presence of extreme weather conditions, such as droughts, floods, are common to affect the hydrologic regime of natural ecosystems with strong impacts on available water resources required in urban and agricultural areas. Places subjected to large interannual climatic variability frequently result in severe socioeconomic consequences on food supply, amount of abandon land, and ultimately, people migration to large urban areas. For most part of North America, this interannual variability has been proved to be driven, or at least influenced, by EL NIÑO Southern Oscillation (ENSO) phenomena, a state of unusual weather patterns (i.e., departures from their trend of means in rainfall amount and temperature) associated to an increase of sea surface temperature in the tropical Pacific Ocean, suppression of up welling nutrient-rich waters along the cost of South America, and disruption of the trade of winds. Because the large spatial variability in climatic conditions in North America, agroecological regions tend to exhibit a wide range of environmental stresses when ENSO events occur. This research assessed the impacts of EL NIÑO-driven climatic phenomena on non-point source pollution and regional-scale water resources of North America. A process-based modeling scheme was applied to simulate climatic ENSO scenarios for 392 locations distributed in Canada, USA and Mexico and taking the systems externalities, such as soil erosion, as surrogates of the systems sustainability under extreme weather variability. Results indicate that the continental sensitivity to ENSO phenomena is highly variable, in both time and space. The ENSO anomalies on precipitation and temperature resulted from El Niño or El Viejo events have been mapped using a GIS scheme, to provide elements of alternative land to reduce the phenomena impact. Although annual rainfall is commonly to decrease in semiarid lands during El Niño years, soil erosion tend to increase due to few high-intensity, short-duration storms developed during the Pacific warming stages.

En la actualidad el procesos de la desertificación puede ser el resultado de la gran variabilidad interanual del clima. La presencia de condiciones climáticas extremas, tal como sequías e inudaciones, frecuentemente afectan el regimen hidrológico que predomina de manera regular en los ecosistemas con fuertes consecuencias en los suministros de agua para consumo urbano y agrícola. Los lugares sujetos a esta gran variabilidad interanual dek clima frecuentemente resultan en severos desastres socioeconómicos debido a la escases en la producción de alimentos, terrenos abandonados, y la emigración de los

productores rurales a los grandes centros urbanos. Para una basta extensión de Norte América, esta variabilidad interanual es el resultado, o al menos influenciada, por el fenómeno El Niño Oscilación del Sur (ENSO), un estado poco usual de patrón climático (p.e. desviaciones de la temperatura y la precipitación de la tendencia de la media) asociada a un incremento de la temperatura del agua superficial del Oceano Pacífico tropical, un descenso abrupto de las aguas ricas en plancton a lo largo de las costas de América del Sur y un debilitamiento de los vientos Alicios. Debido a la gran variabilidad espacial del clima que prevalece en Norte América, las diferentes regiones agroecológicas tienden a exhibir un amplio rango de estres climático bajo eventos ENSO. Esta investigación realizó una estimación del impacto hidrológicos resultantes de eventos ENSO en relación a efectos de contaminación difusa (p.e. erosión) y los recursos hidráulicos de Norte América. Se aplico un esquema basado en modelos de simulación para detectar las externalidades resultantes en 392 localidades distribuidas en Canadá, Estados Unidos y México como consecuencia de eventos climáticos extremos debido al ENSO. Los resultados indican que el continente exhibe una gran variabilidad en la sensibilidad a causa del fenómeno, esto es en el tiempo y en el espacio. Las anomalías en preciptación y temperatura debido a eventos El Niño o El Viejo han sido graficados en mapas utilizando los Sistemas de Información Geográfico, con la finalidad de proveer elementos de toma de decision al publico interesado en el fenómeno. Aunque la preipitación total annual tiende a disminuir en las regiones áridas y semiáridas durante años El Niño, la erosión tiende a incrementar debido a unos pocoa eventos lluviosos caracterizados por ser de alta intensidad, poca duración y limitados en extensión que se desarrollan durante los periodos de calentamiento del Ocenano Pacífico tropical.

Renewing the River Forests: A Rapid Riparian Assessment Method as an Applied Educational Tool

James A. Tolisano

Riparian ecosystems sustain the most diverse biological communities in southwestern North America. Unfortunately, few data exist to indicate existing conditions and trends in these critically important ecosystems, and public agencies lack the funding or personnel to adequately inventory the thousands of miles of river systems in the region. In an effort to respond to this need a rapid riparian assessment (RRA) methodology has been developed which includes and expands beyond the approach developed by the public land agencies. The methodology includes nine parameters which address channel and geomorphic characteristics; instream habitat suitability for invertebrates and fish; vegetation composition, frequency, and diversity; and habitat suitability for small mammals and birds. Each parameter is scored based on the analysis of conditions within a specified reach of riparian area. A cumulative score then defines the quality and

functionability of the reach measured. Demonstration projects involving teachers and students from rural and urban schools throughout New Mexico have shown that the RRA methodology can be quickly learned and used as an educational tool to enable schools and local communities to participate in the inventory and evaluation of riparian area conditions throughout the region. This community participation could accelerate improved management responses that may stimulate the recovery and renewal of these critically important biological systems. The presentation will examine the parameters inventoried, field measurement techniques, and potential applications of the RRA methodology as an educational and research tool.

Los ecosistemas de los bosques riberenos sostienen las comunidades más diversas biológicas en el sudoeste de Norte America. Desgraciadamente, pocos datos existen indicar las condiciones actuales y tendencias en estas ecosistemas, y agencias públicas faltan los fondos y personal a adecuadamente inventario los ríos en la región. En un esfuerzo por responder a esta necesidad se ha desarrollado una metodología de evaluacion rápido de bosques riberenos (RRA). La metodología incluye nueve parámetros que responder a la dirección y características del cauce y geomorfologia; la potencial del habitat en el rio por invertebrados y pez; composición, frecuencia, y diversidad de la vegetación; y la potencial del habitat por micro-mamíferos y pájaros. Se calificar cada parámetro basado en el análisis de condiciones dentro de un especificó alcance de área evaluado. Una cuenta cumulativa entonces define la calidad y "funcionabilidad" del alcance midió. Proyectos involucrando a maestros y estudiantes de escuelas rústico y urbanas en todo Nuevo Mexico han mostrado que los participantes se puede aprender y aplicar la metodología rápidamente y la usa como una herramienta educativa habilitar escuelas y comunidades locales participar en el inventario y evaluación de las condiciones ecologicas de bosque ribereno en todo la región. Esta participación de la comunidad podría acelerar el mejoramiento del manejo que estimularían la recuperación y renovación de estos sistemas extremamente importantes biológicos. La presentación examinará los parámetros de inventarió, técnicas de la medida del campo, y aplicaciones potenciales del RRA metodología como un educativo y herramienta de la investigación.

Conservation Partnerships: The Role of Private Land Owners in Effective Watershed Management

Asociaciónes de la Conservación del Ambiente: Papel del Participante para los Propietario a Su Tierra en el Manejo Efectivo de las Cuencas

Rebecca S. Toupal

Public/private conservation partnerships throughout the United States realize varied success in addressing natural resource problems in local watersheds.

Success guides developed from agency and organization perspectives are available, however, partnerships are often locally led. The guides, consequently, are potentially more useful to public managers than private landowners. This study compared a thirteen-characteristic success model, created from agency and organization sources, with three locally led partnerships. The results indicate that private landowner values play an important role in conservation partnership success. Differences between public and private responses are determined statistically. Measurement of the degree of difference for each characteristic, determined through a quartile division of the model, results in only eight of the characteristics contributing conclusively to partnership success. These eight characteristics are proposed as the basis of a more broadly applicable guide to successful partnerships.

Asociaciónes Estadounidenses púlbicas y/o privadas, dedicadas a la conservación del ambiente, desarrollan usu objectivos de manera exitosa durante la gestion de los problemas de recuros naturales en cuencas locales. Aunque se cuenta con manuales desrrollados desde una perspectiva oficial e instituciónal, las asociaciónes son dirigidas de manera local. Consecuentemente, los manuales son mas utiles a ciertas instituciónes que a los propietarios de la tierra. Este estudio comparó trece características de un modelo desarrollado pro instituciónes con tres asociaciónes dirigidas de manera local. Los resultados del estudio indicaron que el aprecio del propietario a su tierra jugaba un papel importante para la conservación de la misma. Las diferncias entre respuestas públicas y privadas son estadisticamente determinadas. Dividiendo el modelo en quartas partes, cierto grado de diferencia fue identificado en cada característica. Esta estrategia lanzó solamente ocho características que guiaban al exito a diferentes asociaciónes. Estas ocho características son propuestas como guía de aplicación más amplia para llevar a diferentes asociaciónes a su exito en la conservación del ambiente.

Comparison of Density and Activity of Gould's Turkey in Relation to Habitat Type in the Region of Yecora, Sonora, Mexico

Comparación de Densidad y Actividad de Guajolote Silvestre (Meleagris Gallopavo Mexicana) en Relación al Tipo de Habitat, en la Región de Yecora, Sonora, Mexico

Gabriel Valencia-Ortega, Ron Engel-Wilson, and Brian Wakeling

Gould's turkey (*Melleagris gallopavo mexicana*) is the largest and most important game bird of Norteamerica and Mexico. In Mexico is considered as a game resource of the IV type. However, the actual situation of the population in the state of Sonora, is unknown, but recent evaluation suggest that is abundant in several areas of the Sierra Madre Occidental.The project has the objective of

obtaining basic information about the abundance of the Wild Turkey, and about the characteristics and use of the habitat by this subspecies in Yecora. The study area is located in eastern Sonora (28°12´ N : 109°19´W) between 1200 - 2000msnm, covered by Madrean Woodlands and tropical deciduos forest riparian areas and others. The land use is cattle grazing, season agriculture, and logging activities.The Methodology utilized to obtain the abundance of Wild Turkey, is the Transect Method with 74 transect of 500m each one. This to test the hypothesis that differences exist for abundance between each habitat type. Also it is characterized and compared, the habitat used by the Gould's Turkey for several activities like feeding, roosting, loafing; the purpose is to test the null hypothesis that wild turkey do not select certain habitat components for the biological activities mentioned before.

El Guajolote Silvestre es de las mas grandes y principales aves de caza de Norteamerica. En México, es considerado como un recurso de IV tipo. La situación actual de las poblaciones de Guajolote Silvestre en Sonora no son bien conocidas, no obstante recientes evaluaciones sugieren que las poblaciones son abundantes en ciertas zonas de la Sierra Madre Occiental. Este proyecto tiene como objetivo obtener información sobre la abundancia del Guajolote Silvestre y conocer las caracteristicas del habitat de esta subespecie en Yecora. El área de estudio esta ubicada en el Este del Estado de Sonora (28°12´N:109°19' W), entre los 1200 a 2000 msnm. Las principales asociaciones vegetales son Bosque Madrense, pastizales, selva baja caducifolia y vegetación riparia. Los terrenos son utilizados para pastoreo, agricultura y extracción de madera. La metodologia utilizada para obtener la abundancia del Guajolote silvestre contempla el establecimiento de 74 transectos de 500m cada uno, para probar la hipotesis que sí existen diferencias de densidad en cada tipo de vegetación. Se caracteriza y compara el habitat usado por el Guajolote para dormideros, echaderos y comederos, con el proposito de probar que los sitios elegidos para realizar sus actividades no son tomados al azar.

Replicating the Naco Constructed Wetlands Microenterprise Project (NACWEMP): Plant Selections for Nacwemp-Style Wetlands Projects Along the U.S./Mexico Border

Michael F. Wilson

Drylands Institute, Environmental Compliance International, Border Ecology Project, and Enlace Ecologico are designing and installing a small constructed wetlands wastewater treatment demonstration project on the periphery of Naco, Sonora's sewage treatment facility. This project is coupling effluent treatment with the development of wastewater-using agricultural microenterprise. Reviewing site-specific selection criteria of agronomic subjects is instructive to those who would replicate high-sustainability wetlands treatment systems in

other locations. Climate, soils, economic utility, environmental concerns, labor intensity vs. profit indices and social setting greatly influenced the selection of agronomic subjects for the Naco Project, but other considerations such as the quantity and quality of sewage and installation design and size are equally important. To illustrate a selection procedure for wetland and agricultural microenterprise subjects, the process was applied to five communities along the U.S.A./Mexico border with varying climatic regimes (xeric cool, xeric warm, Mediterranean, and humid subtropical) and varying social and economic settings to produce lists of crop/wetland plants for consideration.

Recreation Resources in the Arizona-Sonora Border Region

Recursos Sobre Recreacion en la Region Fronteriza Arizona-Sonora

Ervin H. Zube

This paper explores the tourism/recreation resources and the travel patterns within the Arizona/Sonora border region of the United States and Mexico. This region is defined as a zone that extends approximately one hundred miles/one hundred and sixty kilometers on either side of the international boundaries. It spans a distance of approximately 450 miles/750 kilometers from west to east. The primary objectives of the paper are : first, identify key natural and cultural recreation/tourism attractions; second, assess the flow of traffic across the border and the probable recreation destinations of persons crossing at each of the six international stations; and third, compare and contrast the potential resource attractions on both sides of the border. Primary data sources include tourist guide books, resource field guides, maps, and governmental publications. These sources span the time period of 1940 to 1998 and thus also provide a temporal perspective. Other sources include telephone interviews with United States Border Crossing Agents and, where possible, representatives of Chamber of Commerce offices. Analyses of these data suggest that, in reference to recreation attractions, the emphasis in Sonora is primarily on cultural resources. A notable exception is the access points that provide entry to the Sea of California. Conversely, a strong emphasis tends to be placed on natural resources in Arizona, with the exception of the eastern part of the region where there is a seemingly equal mix of cultural and natural attractions.

Este trabajo explora los recursos sobre turismo y recreación así como los patrones para viajar dentro de la región fronteriza Arizona/Sonora en los Estados Unidos y México. Esta región esta definida como una zona que se extiende 100 millas (160 kilómetros) en cada lado de las fronteras internacionales. Tiene una longitud de aproximadamente 450 millas (725 kilómetros) de Oeste a Este. Los objetivos principales del presente trabajo son: primero, identificar las atracciones clave de tipo natural y cultural sobre

recreación/turismo; segundo, determinar el flujo de tráfico a través de la frontera y los probables sitios de recreación de las personas que cruzan por cada una de las seis estaciones internacionales; tercero, comparar y contrastar los recursos potenciales de atracción en ambos lados de la frontera. Como fuentes principales de información estan las guías turísticas, las guías de campo, los mapas y las publicaciones gubernamentales. Estos recursos cubren un período de tiempo desde 1940 hasta 1998 proporcionando una perspectiva temporal. Otros recursos incluyen entrevistas telefónicas con agentes de Estados Unidos encargados del tráfico através de la frontera (United States Border Crossing Agents) y, donde es posible, con representantes de las oficinas de la Cámara de Comercio. Los análisis de esta información sugieren que, en referencia a las atracciones para recreación, el énfasis en Sonora se hace básicamente sobre los recursos culturales. Una excepción notable son los puntos de acceso a los mares del Golfo de California. Por el contrario, en Arizona un fuerte énfasis es puesto en los recursos naturales, con excepción de la parte Este de la región donde existe una mezcla equitativa de atracciones en los recursos culturales y naturales.

Effect of Range Condition on the Presence of Bird Population in the North-Central Region of State of Chihuahua, Mexico

Efecto de la Condicion del Pasiizal Sobre la Presencia de Aves en la Region Ceni'ro-Norte del, Estado de Chihuahua

Ricardo Abel Soto Cruz, Toutcba Lebgue, y Manuel Sosa Cerecedo

This study was carried out on a short grass rangeland of about 38,686 ha, located in the north-central portion of Chihuahua state. The objectives were to evaluate the effect of the range conditions on the presence of birds; to do an inventory of birds taking into account whether they are permanent residents, wintering or temporal; and to determine the frequency and abundance, throughout the year. The results obtained were: in good condition rangeland dominated by Bouteloua gracilis (51% of vegetation cover) 533 birds were detected; in regular condition areas dominated by Aristida adscencionis, A. divaricata and Chloris virgata (making up 46.8% of aerial cover), 262 birds were counted; and in poor conditions range areas with the presence of Erioneuron pulchellum, Hilaria mutica and A. adscencionis (37.5% of vegetation cover) 201 birds were registered. All together, 996 birds were found, distributed among 11 orders and 25 families and representing 52 species, where the most common orders were: Passeriforme with 12 families (48%), Falconiforme with 3 families (12%), and Charadriiforme with 2 families (8%). The Passeriforme order has the greatest nuniber of species (29) making up 55.79% of the birds, followed by the Faconiforme with 11 species (21.15%). It is concluded that the range condition is an important factor determining the birds abundance, and that this abundance decreases with the deterioration of the rangeland.

El estudio se realizó en una superficie de 38,686 has, en áreas de pastizal mediano abierto, los objetivos fueron evaluar el efecto de la condición del pastizal sobre la presencia de aves, asi como, realizar un inventario de aves de acuerdo a las caracteristicas de residentes permanentes, invernantes y temporales, así como la frecuencia y abundancia a través del año. Los resultados son: en el pastizal en condición buena con una dominancia de Bouteloua gracilis con un 51 % de cobertura aérea se detectaron 533 aves, en condición regular con dominancia de Aristida adscencionis, A. divaricata y Chloris virgata con 46.8% de cobertura aérea 262 aves y en condición pobre dominada por Eryoneurum pulchellum, Hilaria mutica y A. adscencionis con 37.5% de cobertura aérea 201 aves.. El total de aves detectadas fué de 996, comprendidas en 11 órdenes y 25 familias. destacando las órdenes Passeriforme con 12 familias (48%), Falconiformes 3 familias (12%) y C,haradriiformes con 2 familias (8%). Se detectaron 52 especies, sobrosaliendo las del órdon Passeriforme con 29 (55.79%), y las Falconiforme con 11 (21.15%). Se concluye que la condición del pastizal es un factor importante para la abundancia de aves y que su presencia disminuye cuando el pastizal se deteriora y por consiguiente el alimento de las aves disminuye.

Como parte de las alternativas de recuperación del berrendo en México, y promovidas por SEMARNAP, se tiene entre otros objetivos el determinar la cantidad de área y las características de hábitat de la especie Antilocapra americana. El presente trabajo muestra las características de las cuatro principales áreas donde el berrendo concentra su distribución on el estado de Chihuahua. En términos generales estas zonas de distribución se carcaterizan por presentar topografía plana a ondulada, dominada por pastizales medianos abiertos, pastizales halófitos y matorral bajo subinerme. Se pretende continuar la caracterización a fin de observar la distribución y fenología de las especies vegetales mismas que influyen en el rrovimiento del berrendo. Este estudio está apoyado por la SEMARNAP, Universidad Autónoma de Chihuahua, Unidos para la Conservación y PROFAUNA, A.C.

Characterization of the Habitat at of the Pronghorn (*Antilcapra Americans*) in the State of Chihuahua

A. Lafón, E. Estrada, and C. Yen

As part of the alternatives of pronghom recovery in Mexico, promoted by SEMARNAP, the main objectives are to determine area quantity as well as habitat characteristics of the species Antilocapra americana. The present work shows the main features of the 4 principal areas were pronghorn concentrate its distribution in the state of Chihuahua. In general terms, those areas of distribution are characterized by flat and ondulate topography, dominated by medium open grassland, halophytic grassland, and semithorny scrub. It is pretended to continue the characterization of the vegetation to observe the distribution and

fenology of the vegetal species which influence the pronghorn movements. This work is supported by SEMARNAP, Universidad Autónoma de Chihuahua, Unidos para la Consetvación and PROFAUNA, A.C.

Ecologia del Halcón Aplomado (*Falco Femoralls*) en el Estado de Chihuahua

R. F. Piñon, G. Quintana M., A. Lafon T., y A. Montoya

The aplomado falcon (*Falco femoralis*) was studied in the northern portion of the state of Chihuahua, during the period of January through October of 1997. The objectives were to survey the reproductive success of the bird in the state, measure characteristics of the habitat and to compare them with nesting and non-nesting falcons. Two nesting areas were located, one in the county of Coyame with 4 nests and the other in Villa Ahumada, with 13 nests. In the same areas, 26 transacts were established to measure the vegetation. The results were: in the Coyame area, 3 nests succeeded with 6 chicks, in Villa Ahumaga, 12 nests succeeded with 27 chicks; 24 were banded. The plant species dominant in Coyame area were *Bouteloua* spp. with 76.2% cover and *Ephedra trifurca* with 22.8% cover; and *Bouteloua* spp. with 50.8% cover and *Ephedra trifurca* with 55.7% in Villa Ahumada. The most found birds in the areas were: *Zenaida macroura* (30.8%), *Sturnella* spp. (17.9%) and *Zenaida asiatica* (10.3%). Therefore, it is concluded that the habitat in both areas was in an adequate state for the reproduction of the falcons in Chihuahua.

El halcón aplomado (*Falco femoralis*) fue estudiado en el Norte de Chihuahua, en el período comprendido de enero a octubre de 1997. Los objetivos del estudio fueron: monitorear el éxito reproductivo del halcón aplomado en Chihuahua durante 1997, asi como medir las características de su hábitat y comparar las caracteristicas entre los aplomados anidados y los no anidados. So localizaron dos áreas de nidación, una en el Municipio de Coyamo con 4 nidos y otra en Villa Ahumada con 13. En las mismas áreas se establecieron 26 transectos para medir vegetación y recolectar restos y pellets de aves para presa, y determinar la alimentación del halcón. Los resultados fueron: en Coyame 3 nidos tuvieron éxito (6 pollos y en Villa Ahumada 12 nidos tuvieron éxito (27 pollos), siendo anillados solo 24 pollos en 1as dos áreas. Vegetación, las gramineas (*Bouteloua* spp.) con 76.2% y una leñosa. *Ephedra trifurca* con 22.8% en Coyame Y (*Bouteloua* spp.) 50.8% Y (*Ephedra trifurca*) 55.7% en Villa Ahumada, fueron las mas representativas. Aves (*Zenaidz macroura*) 30.8%, (*Sturnella* spp.) 17.9% y (*Zenaida asiatica*) 10.3% fueron las mas abundantes en ambas areas. Conclusiones: el éxito reproductivo fue aceptable, el hábitat resulto adecuado para los halcones

El Sacramento: El campo de Batalla

R. B. Brown and Aaron Mahr

La única batalla que sucedió sobre el Camino Real es la Batalla de Sacramento, Chihuahua, que se llevó a cabo el 28 de febrero de 1847. La fuerzas mexicanas dirigidas por generales Heredia, Trías y Garcia-Conde levantaron una línea de fortificaciones compuesta de tricheras y fortines para impedir la penetración de las fuerzas invasoras dirigidas por el coronel Alejandro Doniphan. Aunque la mayoría de estas f ortificaciones sobreviven en buenas condiciones, se encuentran amenazadas por el desarrollo urbano que ya ocupa la mitad del campo de batalla donde se realizaron los movimientos de la caballería. Despues, se enteraban los caídos en las trincheras y fortines.

Esta ponencia presentara los antecedentes y los acontecimientos pr icipales de la batalla y una primera propuesta para salvaguardar el campo de batalla y conservar dichos trincheras y fortines.

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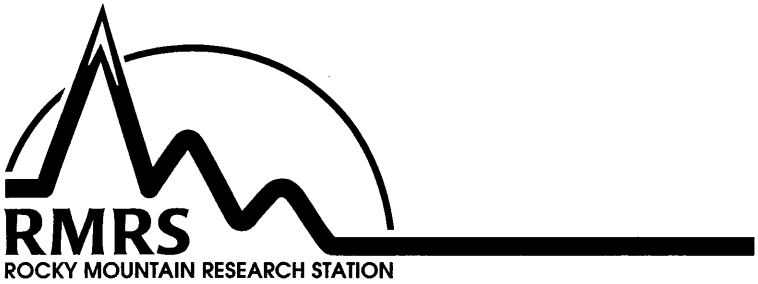
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