The U.S.-Mexican Border Environment

Tribal Environmental Issues of the Border Region

SCERP Monograph Series, no. 9

Paul Ganster, Series Editor

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The Southwest Center for Environmental Research and Policy (SCERP) is a consortium of U.S. and Mexican universities dedicated to addressing environmental issues in the U.S.-Mexican border region through applied research, outreach, and regional capacity building.

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About this volume:
All times are local
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The views of the authors contained herein are not necessarily the views of SCERP, the U.S. Environmental Protection Agency, the Secretaría de Medio Ambiente y Recursos Naturales, or the tribal nations involved. They are presented in the interest of providing a wide range of policy recommendations to prompt discussion and action in the U.S.-Mexican border region.

Contents

Preface

Too often we forget that indigenous people were just that—native to the Americas and living on these lands in established communities long before European contact. Tribes have had subsequent governments impose borders and boundaries on them contrary to their customs, traditions, and cultures. In the Southwestern United States and Northern Mexico because of the international border between the two countries, many once-united tribes now live a bifurcated existence.

While tribes are forced to respect this border, resources and pollution pay it no regard. Water follows topography. Air pollution moves with the wind. Animals migrate in response to needs. Diseases spread without passports or visas.

The intersection of these border phenomena is the topic of this monograph and the result of a several-year effort by the Southwest Center for Environmental Research and Policy (SCERP) to find ways for academia to add cultural and social capital to transboundary tribal environmental needs. Just like the border as a whole, the tribal nations here are growing fast and thus need proactive, informed planning to develop a base of understanding about their human and natural resources. This allows tribes to assess, prioritize, mitigate, manage, and protect them.

With the help of academia, the experiences of the border tribes involved with the SCERP Tribal Environmental Program (STEP) can be generalized and exported to other tribes and translated into value there as well. In essence, the lessons we learned here—specifically those about protocol and cooperation—can be applied in future research projects involving sovereign tribal nations.

I'm pleased to recognize the efforts of a handful of the many individuals who were involved with the production of this book. Guillermo Torres Moye at Universidad Autónoma de Baja California provided the Spanish translation of the Executive Summary; Jenny Carlsson drafted the map that appears in the Executive Summary;

the Ysleta de Sur Pueblo Tribal Council provided the photos that appear on the cover depicting tribal lands and tribal members in the process of constructing their wind anemometer; and Amy Conner, SCERP's managing editor of publications, edited and coordinated the publication of this volume.

Michael Wilken-Robertson, Volume Editor
Instituto de Culturas Nativas de Baja California

Executive Summary

The SCERP Tribal Environmental Program

D. Rick Van Schoik and Amy Conner

Introduction

Nearly 40,000 people and a land base of 3 million acres make up the approximately 60 U.S. and Mexican tribal nations and indigenous communities encompassed by the U.S.-Mexican border zone, defined as the 100 kilometers north and south of the international boundary between the United States and Mexico. The original territories of the tribes in this region—which include California, Baja California, Arizona, Sonora, Texas, and Coahuila—are now bisected by the international boundary.

Despite their long-held and intimate knowledge of their lands and environments, these tribes have been excluded from some conventional environmental programs. Too often in many projects' final reports, native populations were addressed in little more than a generic paragraph outlining a cursory effort to include them. Prior to the 1990s, the involvement of tribal nations in any U.S government initiative was usually limited to activities where tribes clearly needed to be integrated or needed to be present in order to avoid lawsuits. However, the U.S. Environmental Protection Agency (EPA) recognized the intimate relationship among sovereignty, environmental equality, transboundary pollution, and human health and chose to incorporate both state and tribal interests into its border programs. The recent Border XXI and 2012 initiatives are excellent examples of the integration of tribes into local planning and implementation efforts. There is even a special grants program to help tribes deal with pollution prevention. In Mexico, though, the less-formal status of tribal people has diluted their roles in Mexican border environmental programs. The critical problem for the future will be how to integrate the perspectives and needs of these tribal nations (Figure 1) into a shared, multinational vision for the border region.

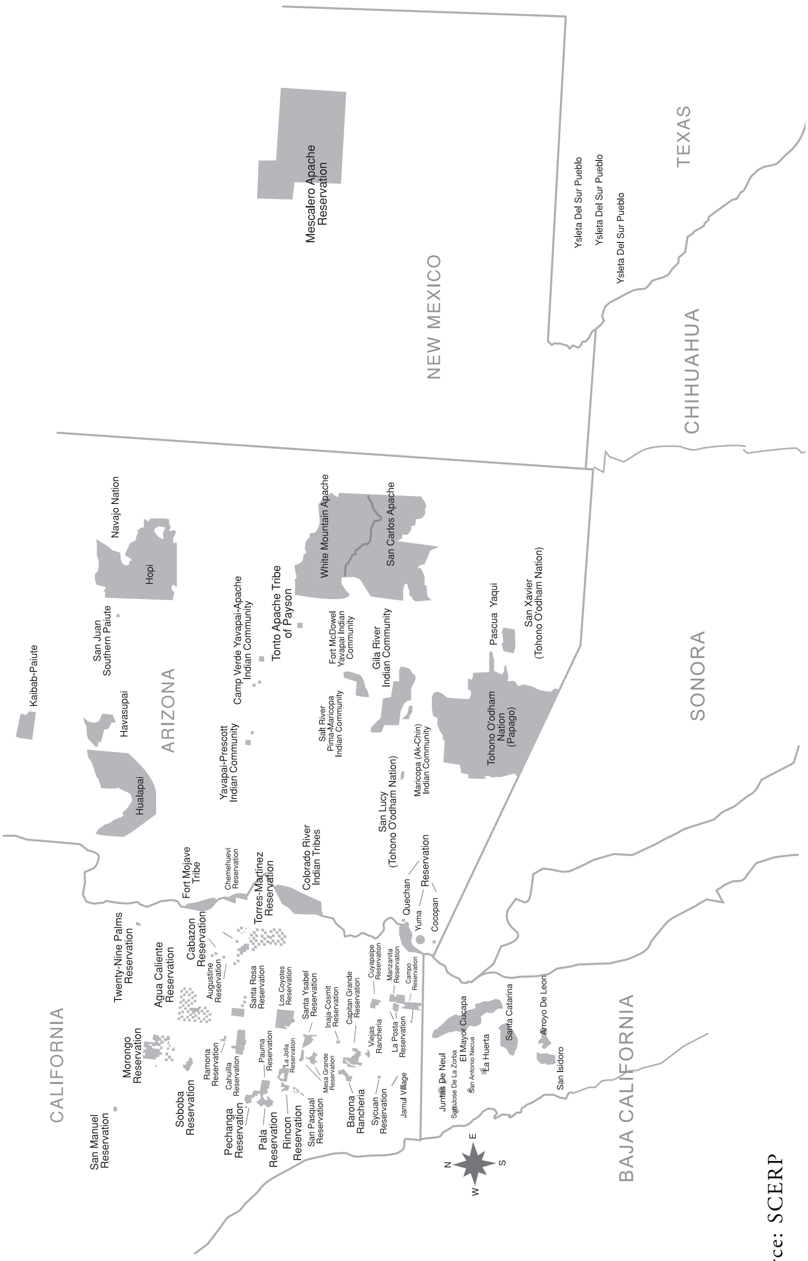
The Southwest Center for Environmental Research and Policy (SCERP) created the SCERP Tribal Environmental Program (STEP) as a binational, multi-university effort to study natural resource development and tribal cooperative planning among interested Native American communities located along the U.S.-Mexican border. This interdisciplinary applied research initiative involved scholars and technical experts from San Diego State University (SDSU), Arizona State University (ASU), the University of Utah (UofU), New Mexico State University (NMSU), and the University of Texas at El Paso (UTEP), as well as colleagues from various Mexican universities. The tribes served by the program include the Paipai of Santa Catarina, Baja California; the Tohono O'odham of Arizona; and the Ysleta del Sur Pueblo Tigua Tribe of El Paso, Texas.

The purpose of this pilot program was to build a critical mass of research about the range of environmental problems, socioeconomic issues, and political issues that challenge tribal efforts to achieve sustainable development in the U.S.-Mexican border region. By offering training and educational opportunities to tribal members, as well as technical expertise in the form of Geographic Information Systems (GIS) development, the program sought to promote productive interactions among academics, government agencies, nonprofit organizations, and the tribal groups themselves.

Tribal Needs

The challenge for all nations is to simultaneously develop all sectors of society—environmental, human health, economic, and entrepreneurial—so none suffers at the expenses of the others. Tribal efforts that aim to meet this challenge are similar to programs in other nations, but tribes need to improve inter- and intra-agency coordination, build overall capacity, and improve science-based decision making to succeed.

Figure 1. Map of Tribal Nations in the U.S.-Mexican Border Region



Source: SCERP

Through their involvement with STEP specifically, tribes needed to be provided with basic information they could present to state and federal governments to obtain financial support and access to programs and services. Mexican tribal nations that have developed natural resource management plans have found that this information often facilitates access to private and public funds to implement portions of those plans. Other general needs included:

- An industry survey that informed tribes about the value of their products for marketing
- A stock of education materials on environmental topics
- GIS tools
- Sampling and analysis of soil, water, and air
- Energy development planning
- Web sites, CD-ROMs, and other electronic materials

Role of Academia

SCERP became involved with this project at the request of the EPA and Mexico's Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). At that time in the late 1990s, both federal environmental agencies were developing binational environmental programs that included tribal nations. Initially, EPA and SEMARNAT, while sensitive to tribal needs and attentive to their capacity, did not have the experience or track record that would allow them to integrate tribal interests from both sides of the border and thus help tribes in environmental endeavors.

SCERP was an ideal organization to spearhead a program to improve tribal nations' capacities for addressing environmental issues. The consortium intended to assist both with developing tribes' abilities to deal with environmental and health issues as well as with improving actual environmental quality, especially in the areas of water, soil, and air pollution.

Tribal nations are an environmental microcosm of the border region. Tribal lands are arid and the nations are plagued by poverty. Many are experiencing significant demographic growth. Importantly, some tribes suffer the fragmentation of an additional political boundary—the international boundary between Mexico and the United States. With its expertise in transborder studies, models of cooperation, and experience with collaboration on binational issues, SCERP can translate scientific or technical findings into meaningful information policymakers can use. The consortium has relationships with tribal researchers on both sides of the U.S.-Mexican border, as well as environmental expertise developed over the last 14 years while researching the border region's environmental issues.

In 1999, SCERP began the STEP program by building on the research of Alan Kilpatrick at SDSU and Diane Peart at ASU. They had examined a handful of tribal issues in Arizona, Sonora, California, and Baja California through research papers. These papers highlighted research topics that needed to be addressed in other geographic areas of the border region. From there, SCERP began identifying researchers. Not only did they need to be technically proficient and have an affinity for working with U.S.-Mexican border region tribal nations, they also had to understand the rules and protocols (ways of conducting business under tribal culture) that must be followed when working with the nations. In addition, they had to be sensitive to the history of the relationship between tribal nations and non-Indians—non-Indian researchers in particular. Many past instances have seen researchers announce their presence on tribal lands, gather data, and disappear without ever presenting their data to the tribe—and more importantly, without recognizing the sovereign tribes' specific protocols for carrying out research and their rights to the proprietary data gathered. This was exactly the situation SCERP did not want to re-create. The process of pairing the right researchers with the right nations took nearly a year.

Research Mission and Objectives

The overall mission of the program was to assist in devising and implementing culturally sensitive and sustainable resources that would aid the nations in making decisions about their lands. SCERP hoped these studies and tools would encompass:

- Economics, such as marketing surveys and ecotourism feasibility studies
- Health care, including establishment of the unique links among environmental exposure, tribal customs, and health effects

- Energy, especially wind energy
- Information technology, especially GIS
- Human resources, including environmental training and education
- Community needs, including tribal boundary definition
- Water, such as sourcing, treatment, and disposal
- Natural resources, such as forestry
- Soils, including laboratory analysis

However, the studies and tools SCERP would ultimately help develop depended upon the needs of the particular tribes. Almost all projects consisted of an initial inventory and accounting of available resources, an evaluation of their current status, and organization of that data or asset. GIS was often used to first collect and conceptualize issues, and then to display data for decision making on issues such as carrying capacities, natural resource yields, and management plans. From there, the specific research approaches for SCERP included:

- Conducting research important to the nations
- Providing tangible results to participating tribes
- Appreciating the nature and protocol of research with tribal nations
- Recruiting a cadre of knowledgeable and culturally sensitive researchers
- Receiving guidance from tribal councils and staff
- Building capacity with the tribes
- Initiating a series of demonstration and pilot projects
- Developing studies and tools that are transferable to other tribes
- Exporting the research to other tribes so they can actually use it

Developing the Program

SCERP's initial contacts with tribal EPA representatives led to a variety of activities, including visits, conversations with other agencies, and tours of tribal lands, all of which culminated in a meeting with tribal council presidents to offer assistance. Native authorities then developed a list of needs and priorities and SCERP selected for action those that could be accomplished.

A key component of the research plan was to maintain an appropriate methodology and respectful interaction with tribal representatives. SCERP researchers did not seek to approach tribes as outside experts but as collaborators seeking active participation in mutually beneficial projects. As a result, these projects were approached with sensitivity toward the collective tribal nation concerns and made every effort to involve the tribes at all stages of the research. The ultimate goal was to foster inter-tribal cooperation on a binational level, an approach geared toward building capacity by using existing tribal strengths.

Obtaining tribal approval for a project sometimes meant finding a sponsoring government agency within the tribe. This entailed meeting with the tribal administrator, obtaining council approval, and then presenting the idea to different departments to find a proper "host." Although SCERP funded the work, SCERP researchers were met with mistrust and skepticism, which resulted in the need for many visits for the important task of simply listening to tribal representatives to understand the decision-making process and use for the research.

Researcher sensitivity involved not only conducting research to support the tribe's needs, but also helping the tribe ask the right research question. Often, a client recognizes a problem that must be addressed, but the solution might not be readily evident. It is incumbent upon the researcher to determine whether the question is appropriate or should be revised. This dialogue occurred between the nations and SCERP and led to stronger research projects.

For example, the Tohono O'odham Nation became involved in two projects: the GIS project with UofU and the mine tailings project with NMSU. The Cyprus-Tohono copper mine had a mine tailings pond left from ore processing during the 1970s. This leftover waste material had a high iron content, and the tribe wondered whether it might be suitable for use as an iron fertilizer for golf courses in the southwestern United States. The first meetings and interactions helped the tribe define and refine its research questions.

The modified research questions ultimately became:

- What were the iron characteristics of the material in the tailings pond?
- Do plants, especially turfgrass, respond to the material in iron-deficient conditions?
- Does the industry—golf courses and recreation areas—have a need for this material?

Other projects began in a similar fashion. Eventually, over a three- to five-year span, SCERP faculty from the five U.S. universities, as well as a number of Mexican universities and NGOs, worked closely with interested native communities and appropriate government agencies to:

- Identify the need for baseline environmental data on the reservation or Indian community
- Analyze the nations' political contexts; assess the effectiveness of various conflict-resolution methodologies; and investigate the impact of international, federal, state, and local government environmental policies on tribal sovereignty
- Provide public outreach by sponsoring conferences and workshops to disseminate the research results

Working with Tribal Nations: Lessons Learned

During this multi-year project, one broad lesson learned was that SCERP researchers were ultimately working for the people in the tribal community, not just for themselves. As well, many researchers learned the true differences between sharing ideas versus imposing ideas, and understanding what it is to see the world from a different perspective versus proselytizing. One outcome of this shift in approach was that, after reviewing the final products, in many cases the tribes discovered a value of the work that had not been apparent to the academic researchers, adding even more value to the end result.

Perhaps the most valuable lesson researchers gleaned—and hope to communicate to others who do research with tribal nations—was that the tribal nations' ways of conducting business must be respected. Tribal governments, traditions, and protocols differ with every nation. There is no way to conduct significant research without first forming a meaningful relationship with the tribe, and that comes only through learning how the tribe operates and how its protocol should be followed.

For instance, research results must first be presented to the tribal council and the tribal administrator should facilitate that process. Tribal councils expect as much respect as do federal and state governments in the United States and Mexico; just as there are pathways to reach the upper echelons of these governments, there are similar pathways in tribal governments. These ideas are explored more fully in the Epilogue of this volume.

Tribal governments are small and there is a tendency to assume they are agile and able to reach quick decisions about research. However, that is not the case. The tribal sense of urgency was not the same as many researchers', and that meant reviews of research and approvals took much longer than expected—perhaps as long as federal or state entities in the United States or Mexico would take. Further complicating matters was the fact that some tribal governments change with elections every two years, so elements of the researchers' relationships with the tribes sometimes needed to be reestablished.

With this in mind, future researchers addressing tribal issues should allow in their plans enough time to learn how the tribe operates and to develop appropriate relationships under those conditions. Building the relationship is an ongoing process where trust is gained over time and, as is often the case when working across cultures, through frequent and extra effort on the part of the parties involved. In an effort to provide new depth to their relationship with the Tohono O'odham, ASU researchers invited tribal members to their campus for a tour and hands-on look at how business and research are conducted at a U.S. university. This helped the tribe better understand the approach of the researcher.

This basis for understanding was also important for non-disclosure agreements between tribes and academia. While the research conducted on tribal lands—which are sovereign nations—is proprietary as far as the tribal nation is concerned, academics need and want to publish their research results. Many STEP researchers faced this dilemma.

For example, during the NMSU mine tailings project, the Tohono O'odham requested, as it did of UofU during its GIS project, that NMSU researchers sign non-disclosure and confidentiality agreements to protect tribal interests. There were several problems with this. First, NMSU has a policy prohibiting signing such agreements. Second, NMSU's College of Agriculture and Home Economics—with which the NMSU researchers are affiliated—discourages this type of proprietary, contract research. Third, the research needed to be published in peer-reviewed journals before the tribe could have any credibility as a supplier of an effective iron fertilizer. The tribal representatives recognized the importance of the third factor and waived the rights to confidentiality. They did, however, request and receive the right to review any manuscripts prior to publication.

Therefore, learning the protocol of providing information should be the first activity of any researcher working with tribes. The next tasks would be to have the tribal members articulate what research they need, then secure the permission to perform it. Researchers should never arrive on a sovereign nation's land and announce what research they believe is needed.

Summary of Specific Project Findings

The specific projects successfully accomplished are listed in Table 1. While more detailed information is presented in the chapters of this volume, summarized here are the various findings of the STEP projects.

During "The Cocopah Indian Tribal Environmental Education Project," (see Epilogue) researcher Richard Meyers learned about the challenges of implementing a project in an indigenous community that is wrestling with the competing interests of environmental preservation and development within its definition of what it means to be a sovereign nation. The working relationship between a tribe and a university requires a delicate approach; it is an ongoing process that must commit to recognizing and allowing the tribal nation to voice and assert its own decisions while at the same time communicating and working with the research community's academic and scientific institutions.

Table 1. Tribal Nations and Projects Accomplished through STEP

U.S. Tribal Name	Mexican Tribal Name	Location	Project	Deliverables
Tohono O'odham	Pápago	Southern Arizona	GIS	Maps, software, and electronic data resources
			Mine tailings evaluation and golf industry market survey	Experimental evaluation and market survey
Cocopah	Cucapá	Southwestern Arizona	Environmental education	Collection of environmental education materials
Paipai	Paipai	Santa Catarina, Baja California	Sustainable economic development activities evaluation	Evaluation of sustainable economic practices
Yselta del Sur Pueblo Tigua Tribe	Tiguas	El Paso, Texas	Wind survey	Anemometer procurement

Source: Authors

Environmental education is not a commodity package that can be delivered to the tribe via academia, Meyers discovered. And conversely, tribal knowledge cannot be extracted from the tribe and put on exhibit for other cultures. A trusting and effective working relationship must exist if a knowledge exchange is to occur and a valuable research project is to succeed. In the same vein, as is evident in Susan Williams' "Indigenous Education: A Literature Review," research has demonstrated that when set in a culturally appropriate framework, knowledge of indigenous plants, animals, and geological features is associated with better learning outcomes and conservation of local resources.

The importance of flexibility was reiterated in Jacob Massoud's and John Peterson's wind potential survey with the Tigua tribe in Texas, as detailed in the chapter titled "Ysleta del Sur Pueblo Tigua Tribe of El Paso, Texas." After determining which areas on the reservation might be appropriate sites for a wind farm, the project was successful in working with the tribe to obtain permanent access to an anemometer to determine seasonal and time-of-day wind availability. The most important lessons learned, however, were that researchers should be open-minded and adaptable to any circumstances that might arise, and how tribal protocol, traditions, and the tribe's proprietary information might affect the timeline for conducting a project.

In their preparation of GIS materials for the Tohono O'odham Nation in Arizona, Phoebe B. McNeally, Barry Biediger, and Daniel McCool, authors of "The Development of a Geographic Information System at Tohono O'odham Nation, Arizona," had expected formal, written answers to a questionnaire they developed at the outset of the process. They were at first disappointed that the answers they received and the way they received them—through conversations with tribal representatives—were so informal. Yet, a closer look proved the answers were still useful, and so then was the development process of the questionnaire. It was clear that the questionnaires brought about a deeper consideration of the nation's data needs than if a detailed questionnaire had not been made.

In evaluating the Tohono O'odham's mine tailings in "Iron-Rich Mine Tailings Fail to Perform as Fertilizer: An Economic Development Model," John G. Mexal and his team yielded several results that could benefit other tribes. The survey of the golf course industry in the southwestern United States revealed that iron nutrition is a serious concern to golf course managers; there is a general dissatisfaction with many current iron fertilizers; an efficacious iron fertilizer would be readily accepted by the industry; and cost would not likely be an issue for application to golf course fairways, roughs, and tees. Also, the study revealed that the tribe's mine tailings failed to improve the growth, color, or mineral content of any of the six plant species tested in two trials. It appears there is little benefit to developing a fertilizer product from the mine tailings on the Tohono O'odham lands, unless it is possible to further refine the product to improve iron availability without greatly increasing production costs.

For the Santa Catarina community of the Paipai in Baja California, Michael Wilken-Robertson created strategies that could help bring about sustainable development practices, both for this community and tribes elsewhere. "Strategies for Sustainable Development of Natural and Cultural Resources in the Paipai Indian Community of Santa Catarina, Baja California" shows that when land use possibilities were evaluated, ecotourism, conservation, and grazing agriculture were determined to be the best uses for the land. An evaluation of cultural resources revealed that increasing handcraft production might be a viable economic activity. Further studies are needed to determine the feasibility and sustainability of these activities to ensure a dynamic, diversified economy for the community. Academia, rather than expensive consultants, is ideally suited to carry out these studies through the continued collaboration of the indigenous community with the Instituto de Culturas Nativas de Baja California (CUNA), Universidad Autónoma de Baja California, SCERP, and other institutions.

The volume also includes two other chapters by Wilken-Robertson. "Indigenous Groups of Mexico's Northern Border Region" examines the impact of the U.S.-Mexican border on the environments of native and migrant groups within the Mexican border region. "Indigenous Groups of Baja California and the Environment" discusses environmental issues faced by tribal groups in the Baja California peninsula. As well, included herein is an abridged version of Kathleen Coates Hedberg's Master's thesis for the SDSU Department of Public Health, "Association of Gastrointestinal Illnesses and Environmental Factors in a Kumiai Indian Community in Baja California, Mexico."

Conclusion

As Tigua tribal member Massoud articulated in his chapter, the SCERP program was hardly a panacea, but it did provide a venue for communication and a chance to develop and cultivate working relationships—processes regarded by both parties as productive. The Indian and academic participants came to know each other and each others' ways, and the program slowly evolved into a fruitful relationship between tribes and academia. As participants come and go within tribal governments and the universities, predicting whether the relationships will survive beyond the parameters of the SCERP Tribal Environmental Program is difficult. But, perhaps the positive history of working together will promote new and varied exchanges, Massoud wrote.

The extended effect of STEP yielded a research approach for academia and other consultants who work with tribal nations. The program developed a number of valued products that provided positive outcomes for the nations involved. In addition, the expertise developed within SCERP allows subsequent research projects to be conducted as sensitively and effectively as possible, and without undue delay. Such liaison enables SCERP researchers to readily assist tribal members, agencies, and councils to apply for and conduct EPA, General Assistance Program (GAP), and SCERP grants and contracts.

Through this endeavor, many tribal nations discovered a wealth of information and assistance available from willing partners within the universities. The schools, in turn, found a new community to serve as part of its academic education and training mission. SCERP can be the vehicle that continues to facilitate these links between academia and tribes.

Resumen Ejecutivo

El Programa Ambiental de CIPAS para les Comunidades Indígenas

D. Rick Van Schoik y Amy Conner

Introducción

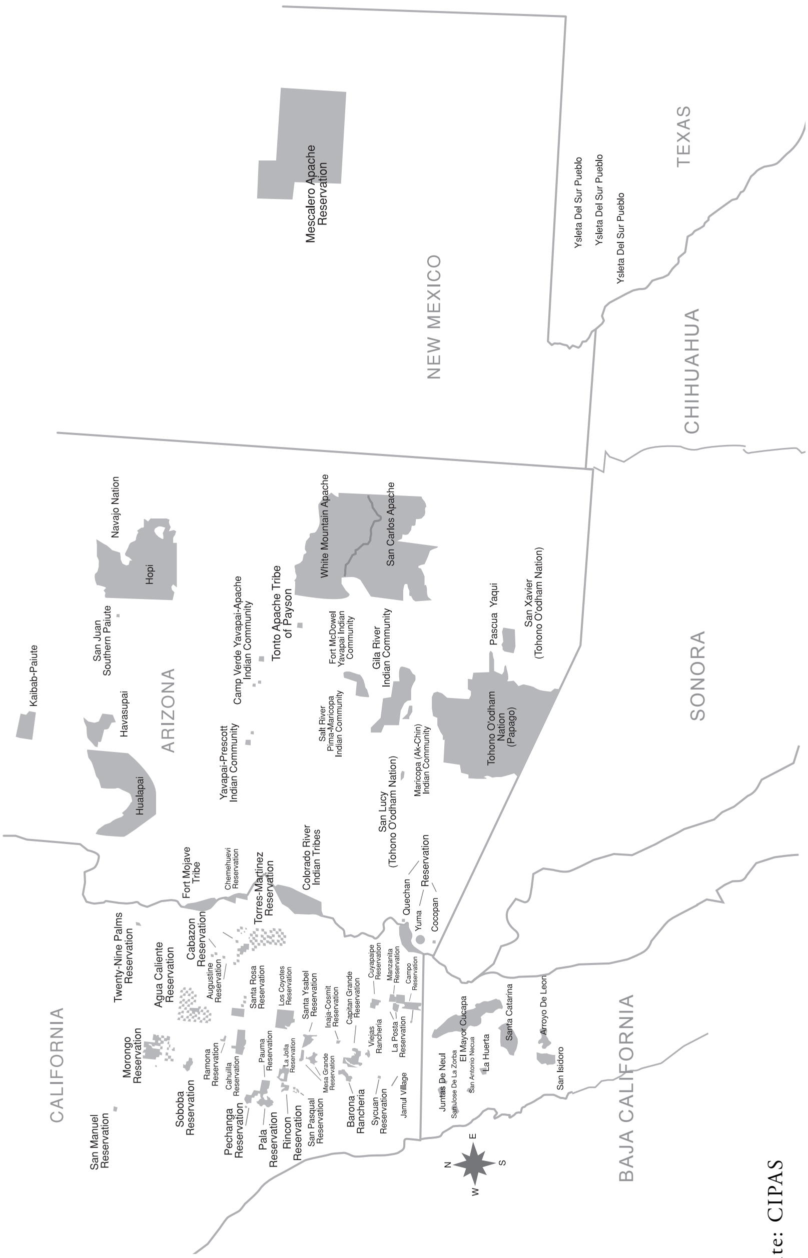
Aproximadamente de 40,000 personas y una base territorial de 3 millones de acres componen alrededer de 60 naciones y comunidades indígenas estadounidenses y mexicanas abarcadas por la zona fronteriza México-E.U., definida como los 100 kilómetros al norte y sur de la frontera internacional entre los Estados Unidos y México. Los territorios originales de las tribus en esta región—los cuales incluyen California, Baja California, Arizona, Sonora, Texas, y Coahuila—están ahora divididos en dos por la frontera internacional.

A pesar del prohendo conocimiento ancestral de sus tierras y entorno, estas tribus han sido excluidas de algunos programas ambientales tradicionales. Muy frecuentemente, en los informes finales de muchos proyectos, las poblaciones nativas apenas fueron mencionadas en un párrafo general denotando un esfuerzo superficial por incluirlas. Previo a los años noventa, la participación de las naciones tribales en cualquier iniciativa de gobierno de los E.U., se limitaba usualmente a las actividades donde las tribus claramente necesitaban ser integradas o estar presentes para evitar demandas legales. Sin embargo, la Agencia de Protección Ambiental de los E.U. (EPA, por sus siglas en inglés) reconoció la relación estrecha entre la soberanía, equidad ambiental, contaminación transfronteriza y la salud humana, decidiendo incorporar a ambos intereses, estatales e indígenas, en sus programas fronterizos. Las iniciativas recientes Frontera XXI y Frontera 2012 son ejemplos excelentes de la integración de las tribus en los esfuerzos locales de planeación e implantación. Incluso existe un programa especial de financiamiento para ayudar a que las tribus hagan frente a la prevención de la contaminación. En México, sin embargo, la condición menos formal de los indígenas ha diluido su función en programas ambientales fronterizos mexicanos. El problema crítico para el futuro será la integración de las perspectivas y necesidades de estas comunidades indígenas (Figura 1) en una visión multinacional compartida para la región fronteriza.

El Centro de Investigación y Política Ambiental del Suroeste (CIPAS) elaboró Programa Ambiental para las comunidades indígenas del (STEP, por sus siglas en inglés) como un esfuerzo binacional, multiuniversitario para estudiar el desarrollo de los recursos naturales y la planificación compartida entre las comunidades indígenas de Americanos Nativos interesadas y localizadas a lo largo de la frontera México-E.U. en esta iniciativa de investigación aplicada interdisciplinaria involucró a estudiantes y espcialistas técnicos de la Universidad Estatal de San Diego (SDSU), la Universidad del Estado de Arizona (ASU), la Universidad de Utah (UofU), la Universidad Estatal de Nuevo México (NMSU), y la Universidad de Texas en El Paso (UTEP) así como colegas de diversas universidades mexicanas. Entre las tribus que el programa atendió se encuentran los Paipai de Santa Catarina, Baja California; los Tohono O'odham de Arizona; y los Ysleta del Sur Tribu Pueblo Tigua de El Paso, Texas.

El propósito de este programa piloto fue construir un conjunto crítico de investigación acerca de la diversidad de los problemas ambientales, y los asuntos socioeconómicos y políticos que desafían los esfuerzos de las comunidades indígenas para lograr un desarrollo sustentable en la región fronteriza México-E.U. Por medio de capacitación y oportunidades educativas para los miembros de las tribus, así como la experiencia técnica especializada en el desarrollo de Sistemas de Información Geográfica (GIS, por sus siglas en inglés), el programa buscó fomentar interacciones productivas entre académicos, organismos gubernamentales, instituciones no lucrativas y los mismos grupos indígenas.

Figura 1. Mapa de Comunidades Indígenas en la Región Fronteriza México-E.U.



Fuente: CIPAS

Necesidades de las Tribus

El desafío para todas las naciones es el desarrollar simultáneamente todos los sectores de la sociedad—ambiental, salud humana, económico, y empresarial—para que ninguno sufra a expensas de los otros. Los esfuerzos indígenas que tienen la intención de cumplir este desafío, son similares a los programas en otras naciones, pero las tribus necesitan mejorar la coordinación inter e intra-agencias, construir su capacidad en general, y mejorar la toma de decisiones basada en la ciencia para tener éxito.

A través de su involucramiento con STEP específicamente, las tribus debieron ser provistas de información básica que pudieran presentar a los gobiernos federal y estatal para obtener apoyo financiero y tener acceso a programas y servicios. Las comunidades indígenas mexicanas que han desarrollado planes de manejo de recursos naturales han encontrado que esta información a menudo facilita el acceso a fondos públicos y privados para la realización de algunas de las acciones de esos planes. Otras necesidades generales incluían:

- Una encuesta de la industria que informe a las tribus acerca del valor de sus productos para la comercialización
- Una remesa de materiales educativos sobre temas ambientales
- Herramientas de GIS
- Muestreo y análisis del suelo, agua, y aire
- Planeación del desarrollo de energía
- Sitios de Red Electrónica, Discos Compactos y otros materiales electrónicos

El Papel de la Academia

CIPAS se involucró con este proyecto a petición de la EPA y la Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) de México. En aquel entonces, a finales de los noventas, ambas agencias ambientales federales estaban desarrollando programas ambientales binacionales que incluían comunidades indígenas. Inicialmente, la EPA y SEMARNAT, aunque eran sensibles a las necesidades tribales y atentos a sus capacidades, no tenían la experiencia o el historial que les permitiera integrar los intereses indígenas de ambos lados de la frontera y así ayudarles en sus esfuerzos ambientalistas.

CIPAS fue una organización ideal para encabezar un programa para mejorar las aptitudes de las naciones indígenas para atender asuntos ambientales. El consorcio tuvo la intención de asesorar en el desarrollo de ambas habilidades de las tribus para ocuparse de asuntos ambientales y de salud así como también en el mejoramiento de la calidad ambiental, especialmente en las áreas de contaminación del agua, tierra y aire.

Las naciones indígenas son un microcosmo ambiental de la región fronteriza. Las tierras tribales son áridas y las comunidades están plagadas por la pobreza. Muchas experimentan crecimiento demográfico significativo. Algunas tribus sufren, de manera importante, la fragmentación de un límite político adicional—la frontera internacional entre México y los E.U. Con sus conocimientos en estudios transfronterizos, modelos de cooperación, y la experiencia de colaboración en asuntos binacionales, CIPAS puede traducir los descubrimientos científicos o técnicos en información significativa que pueden usar los hacedores de políticas. El consorcio tiene relaciones con investigadores de grupos indígenas en ambos lados de la frontera México-E.U., así como la experiencia ambiental desarrollada en los últimos 14 años investigando asuntos ambientales de la región fronteriza.

En 1999, CIPAS empezó el programa de STEP basándose en las investigaciones de Alan Kilpatrick en SDSU y Diane Peart en la ASU. Habían examinado un puñado de asuntos tribales en Arizona, Sonora, California, y Baja California a través de documentos de investigación. Estas publicaciones resaltaban temas de investigación que necesitaban ser atendidos en otras áreas geográficas de la región fronteriza. A partir de allí, CIPAS empezó a identificar investigadores. No sólo necesitaban ser técnicamente diestros y tener una afinidad para trabajar con naciones indígenas de la región México-E.U., también debían entender las reglas y protocolos (o las formas de conducir los asuntos de conformidad con los requisitos tribales) que deben ser seguidos al trabajar con las naciones. Además, tuvieron que ser sensibles a la historia de las relaciones entre las naciones indígenas y no indígenas con investigadores no indígenas en particular. Muchas instancias pasadas han visto a los investigadores anunciar su presencia en tierras tribales, obtener información y desaparecer sin presentar sus datos a las tribus—y más importante aún, sin reconocer los protocolos de soberanía específicos de las tribus para llevar a cabo investigación y sus derechos de propiedad relacionados con los datos colectados. Ésta fue exactamente la situación que CIPAS no quiso repetir. El proceso de juntar a los investigadores indicados con las naciones correctas tomó casi un año.

Misión y Objetivos de la Investigación

La misión global del programa fue el asistir en idear e implantar recursos sostenibles y culturalmente sensitivos que auxiliarían a las comunidades en tomar decisiones acerca de sus tierras. CIPAS albergó la esperanza de que estos estudios y/o herramientas abarcarían:

- Economía, en aspectos tales como encuestas de mercado y estudios de factibilidad ecoturística
- El cuidado de la salud, incluyendo el establecimiento de enlaces únicos entre la exposición ambiental, las costumbres tribales, y los efectos en la salud
- La energía, especialmente la energía del viento
- La tecnología de la información, especialmente GIS
- Los recursos humanos, incluyendo educación y entrenamiento ambiental
- Las necesidades de la comunidad, incluyendo la definición de la delimitación tribal
- Agua, en asuntos tales como fuentes, tratamiento, y desecho
- Recursos naturales, como la silvicultura
- Suelos, incluyendo análisis de laboratorio

Sin embargo, los estudios y las herramientas que CIPAS finalmente ayudaría a desarrollar dependerían de las necesidades de las tribus particulares. Casi todos los proyectos consistían de un inventario inicial y la estimación de los recursos disponibles, una evaluación de su estado actual, y organización de esos datos o activos. GIS fue a menudo utilizado para primero recoger y conceptualizar asuntos, y luego desplegar datos para la toma de decisiones en asuntos tales como capacidades de carga, rendimientos de recursos naturales, y planes de manejo. De allí, los enfoques específicos de investigación para CIPAS incluyeron:

- El realizar investigaciones importantes para las naciones
- El proporcionar resultados tangibles a las tribus participantes
- Apreciar la naturaleza y protocolo de la investigación con naciones indígenas
- Reclutar a un grupo de investigadores conocedores y culturalmente receptivos
- Recibir orientación de concejos indígenas y el cuerpo administrativo
- Construir capacidades de respuesta en las tribus
- Iniciar una serie de demostraciones y proyectos pilotos
- Desarrollar estudios y herramientas que sean transferibles a otras tribus
- Exportar la investigación a otras tribus para que la utilicen realmente

Desarrollando el Programa

Los contactos iniciales de CIPAS con representantes tribales de la EPA condujeron a una variedad de actividades, incluyendo visitas, conversaciones con otras agencias, y excursiones en tierras indígenas, todo lo cual culminaba en una reunión con los presidentes de consejos tribales para ofrecerles apoyo. Las naciones desarrollaron posteriormente una lista de necesidades y prioridades y CIPAS seleccionó para la acción aquellas que pudieran cumplirse.

Un componente clave del plan de investigación fue el mantener una metodología apropiada y una interacción respetuosa con representantes tribales. Los investigadores de CIPAS no buscaban acercarse a las tribus como expertos externos sino como colaboradores buscando soluciones mutuamente beneficiosas. Como consecuencia, estos proyectos fueron abordados con sensibilidad hacia las preocupaciones tribales colectivas de la nación e hicieron todo el esfuerzo para involucrar a las tribus en todas las etapas de la investigación. El objetivo final fue el fomentar la cooperación inter tribal en un nivel binacional, un acercamiento encausado hacia la construcción de capacidad utilizando las fuerzas tribales existentes.

Obtener la aprobación de la tribu para un proyecto algunas veces significó el encontrar a un organismo gubernamental patrocinador. Esto conllevó al encontrarse con el administrador tribal, obteniendo la aprobación del consejo, y luego presentando la idea a diferentes departamentos para encontrar un "anfitrión" correcto. Aunque CIPAS financió el trabajo, los investigadores CIPAS fueron recibidos con desconfianza y escepticismo, lo cual resultó en la necesidad de muchas visitas para cumplir con la importante tarea de escuchar simplemente a representantes tribales para así entender el proceso de decisión y el uso de la investigación.

La sensibilidad del investigador no sólo involucraba el conducir investigaciones para dar soporte a las necesidades del cliente, sino también el ayudar al cliente a hacer la pregunta de investigación correcta. A menudo, el cliente reconoce un problema que debe ser atendido, pero la solución puede no ser fácilmente evidente. Es competencia del investigador el determinar si la pregunta es apropiada o debería ser revisada. Este diálogo ocurrió entre las naciones indígenas y CIPAS y condujo a proyectos de investigación más fortalecidos.

Por ejemplo, la nación Tohono O'odham se involucró en dos proyectos: El proyecto GIS con la Universidad de Utah y el proyecto de residuos mineros con NMSU. La mina de cobre de Cyprus-Tohono dejó un estanque de residuos de la mina que quedo del proceso minero durante los 1970s. Este material de desecho residual tenía un alto contenido de hierro, y la tribu se preguntaba si podría servir como fertilizante de hierro para campos de golf en el sudoeste de los Estados Unidos. Las primeras reuniones e interacciones ayudaron a que la tribu definiera y refinara sus preguntas de investigación. Las preguntas de investigación modificadas finalmente se convirtieron en:

- ¿Cuáles eran las características de hierro del material en el estanque de residuos?
- ¿Responden las plantas, especialmente el pasto de golf, al material en condiciones deficientes en hierro?

- ¿Tiene la industria de campos de golf y áreas de recreación una necesidad para este material?

Otros proyectos comenzaron de manera similar. Eventualmente, en el curso de tres a cinco años, investigadores CIPAS de las cinco universidades de los E.U., así como algunas universidades mexicanas y organizaciones no gubernamentales, trabajaron estrechamente con comunidades nativas interesadas y organismos gubernamentales apropiados para:

- Identificar la necesidad de datos ambientales de base sobre la reserva o comunidad indígena
- Analizar los contextos políticos de las naciones; evaluar la efectividad de diversas metodologías de resolución de conflictos; e investigar el impacto de políticas ambientales internacionales, federales, estatales y locales en la soberanía de las tribus
- Proveer difusión pública patrocinando talleres y conferencias para dar a conocer los resultados de investigación

Trabajando con Naciones Indígenas: Lecciones Aprendidas

Durante este proyecto multi-anual, una lección ampliamente aprendida fue que los investigadores CIPAS estaban trabajando finalmente para la gente en la comunidad indígena, y no sólo para ellos mismos. Igualmente, muchos investigadores aprendieron las verdaderas diferencias entre compartir ideas contra la imposición de ideas, y a entender lo que es ver el mundo desde una perspectiva diferente a la proselitista. Un resultado de este cambio en el acercamiento fue que, después de revisar los productos finales, en muchos casos las tribus descubrieron un valor del trabajo que no había sido aparente para los investigadores académicos, añadiendo aun más valor al resultado final.

Quizá la lección más valiosa que los investigadores recabaron—y esperan comunicar a otros que hacen investigaciones con naciones indígenas—fue que la forma de conducir los asuntos de las naciones tribales debe ser respetada. Los gobiernos tribales, las tradiciones, y los protocolos difieren con cada nación. No hay manera de dirigir una investigación relevante sin primero formar una relación significativa con la tribu, y eso viene sólo a través del aprender cómo funciona la tribu y cómo deberá ser seguido su protocolo.

Por ejemplo, los resultados de investigación primero deben ser presentados ante el consejo tribal y el administrador tribal deberá facilitar ese proceso. Los consejos tribales esperan tanto respeto como hacen los gobiernos federales y estatales en los Estados Unidos y México; así como hay sendas para alcanzar los escalones superiores de estos gobiernos, así mismo hay sendas similares en los gobiernos tribales. Estas ideas son exploradas más completamente en el Epílogo de este volumen.

Los gobiernos de las tribus son pequeños y hay una tendencia a asumir que son ágiles y capaces para cumplir con decisiones rápidas acerca de la investigación. Sin embargo, ese no es el caso. El sentido tribal de urgencia no fue igual que el de muchos investigadores, y eso significó que revisiones de investigación y aprobaciones tomaron mucho más tiempo de lo esperado quizá tanto como el tiempo que las entidades federales o estatales en los Estados Unidos o México pudieran tomarse. Adicionalmente complicando la situación fue el hecho de que algunos gobiernos tribales cambian con las elecciones cada dos años, así que algunas de las relaciones de los investigadores con las tribus necesitaron ser restablecidas.

Con esto en mente, los investigadores futuros ocupándose de asuntos tribales deberían incorporar en sus planes bastante tiempo para aprender cómo opera la tribu y desarrollar relaciones apropiadas bajo esas condiciones. Construir la relación es un proceso continuo, donde la confianza es ganada en el tiempo y, como a menudo es el caso al interactuar entre culturas, a través de esfuerzo frecuente y adicional de parte de las partes involucradas. En un esfuerzo para proveer nueva profundidad a su relación con el Tohono O'odham, los investigadores de ASU invitaron a miembros tribales a su campus para una excursión y una vista de participación activa de cómo los negocios y la investigación son conducidos en la universidad de E.U. Esto ayudó a la tribu a mejor entender el enfoque del investigador.

Este principio básico para el entendimiento fue también importante para los contratos de confidencialidad entre tribus y academia. Mientras la investigación conducida en tierras tribales—

que son naciones soberanas—es de su propiedad según concierne a la nación tribal, los académicos necesitan y desean publicar los resultados de su investigación. Muchos investigadores de STEP confrontaron este dilema. Finalmente, los equipos de investigación firmaron contratos de confidencialidad, trabajaron estrechamente con las agencias de las naciones para conocer acerca de qué necesitaba ser protegido, y cedieron los derechos finales de revisión a la nación.

Por ejemplo, durante el proyecto de residuos mineros de NMSU, los Tohono O'odham pidieron, así como lo hicieron con la Universidad de Utah durante su proyecto GIS, que investigadores de NMSU firmaran contratos de confidencialidad para proteger intereses tribales. Hubo varios problemas con esto. Primeramente, la NMSU tiene una política que prohíbe firmar tales contratos. Segundo, La Escuela de Agricultura y Economía del Hogar de la NMSU—a la cual los investigadores NMSU están afiliados—desalienta la investigación basada en el contrato de propiedad. Tercero, la investigación necesitaba ser publicada en revistas arbitradas antes de que la tribu pudiera tener credibilidad como proveedor de un efectivo fertilizante de hierro. Los representantes de la tribu reconocieron la importancia del tercer factor y renunciaron a los derechos de confidencialidad. Ellos, sin embargo, demandaron y recibieron el derecho a revisar cualquier escrito antes de su publicación.

Por consiguiente, aprender el protocolo de suministro de información deberá ser la primera actividad de cualquier investigador trabajando con tribus. Las siguientes tareas serían el lograr que los miembros tribales logren expresar qué investigación necesitan, luego obtener el permiso para realizarlo. Los investigadores nunca deberán llegar a la tierra de una nación soberana y anunciar qué investigación creen ellos que es necesaria.

Resumen de Hallazgos Específicos del Proyecto

Los proyectos específicos cumplidos exitosamente están listados en la Tabla 1. Mientras que la información más detallada se presenta en los capítulos de este volumen, aquí están resumidos los diversos descubrimientos de los proyectos de STEP.

Durante "El Proyecto de Educación Ambiental de la Tribu Indígena Cocopah", el investigador Richard Meyers aprendió acerca de los desafíos de implantar un proyecto en una comunidad indígena que forcejea con los intereses en pugna de conservación ambiental y desarrollo dentro de su contexto de lo que significa ser una nación soberana. La relación de trabajo entre una tribu y una universidad requiere de un acercamiento delicado. Es un proceso continuo que debe comprometerse a reconocer y permitir a la nación indígena el expresar y tomar sus propias decisiones mientras que al mismo tiempo se comunica y trabaja con la comunidad de investigación e instituciones académicas y científicas.

Tabla 1. Naciones Tribales y Proyectos Concluidos a través de STEP

Nombre Estadounidense de la Tribu	Nombre Mexicano de la Tribu	Ubicación	Proyecto	Entregables
Tohono O'odham	Pápago	El sur de Arizona	GIS	Mapas, software y recursos electrónicos de datos
			Evaluación de residuos mineros y encuesta de mercado para la industria de campos de golf	Evaluación experimental y encuesta de mercado
Cocopah	Cucupá	El sudoeste de Arizona	Educación ambiental	Conjunto de educación ambiental
Paipai	Paipai	Santa Catarina, Baja California	Desarrollo económico sustentable	Evaluación de las costumbres económicas sustentables
Ysleta del Sur Pueblo Tigua Tribe	Tribu Ysleta del Sur Pueblo Tigua	El Paso, Texas	Encuesta del potencial del viento	Compra de un anemómetro

Fuente: Los autores

La educación ambiental no es un paquete que puede entregarse a la tribu por vía de la academia, descubrió Meyers. Y asimismo, el conocimiento indígena no puede ser extraído de la tribu y puesto en exhibición para otras culturas. Una relación de trabajo confiable y efectiva debe existir para que ocurra el intercambio de conocimiento y un proyecto de investigación valioso sea exitoso. Del mismo modo, como es evidente en "Educación Indígena: Una revisión literaria," de Susan Williams, la investigación ha demostrado que cuando el conocimiento de plantas indígenas, animales, y las características geológicas es posicionado en un marco culturalmente apropiado, el conocimiento es asociado con resultados de mejor aprendizaje y conservación de recursos locales.

La importancia de la flexibilidad fue reiterada en la encuesta del potencial de viento de Jacob Massoud y John Peterson con la tribu Tigua en Texas, como se detalla en el capítulo titulado "Tribu Tigua de Ysleta Del Sur Pueblo de El Paso, Texas." Después de determinar cuáles áreas en la reservación podrían ser apropiadas para una granja eólica, el proyecto tuvo éxito en obtener para la tribu acceso permanente a un anemómetro para determinar la disponibilidad estacional del viento y sus variaciones diarias. La lección más importante aprendida, sin embargo, fue el que los investigadores deben mantener su mente abierta y adaptable a cualquier circunstancia que pueda surgir, y cómo el protocolo tribal, las tradiciones, y la información de propiedad exclusiva de la tribu podrían afectar la agenda para llevar a cabo un proyecto.

En su preparación de materiales GIS para la nación Tohono O'odham en Arizona, Phoebe B. McNeally, Barry Biediger y Daniel McCool, autores de "El Desarrollo de un Sistema de Información Geográfico en la Nación Tohono O'odham, Arizona", habían esperado respuestas formales, escritas para un cuestionario que desarrollaron al principio del proceso. Estaban al principio decepcionados de las respuestas que recibieron hayan sido tan informales y la manera en que las recibieron a través de conversaciones con representantes tribales. Sin embargo, una observación más cercana probó que las respuestas todavía fueron útiles, y así bien fue el proceso de desarrollo del cuestionario. Estaba claro que los cuestionarios destacaron una importancia más profunda de las necesidades de datos de la nación a diferencia de lo que hubiese reflejado un cuestionario menos detallado.

Al evaluar los residuos de la mina de Tohono O'odham en "Residuos de Mina rica en hierro fallan en su desempeño como fertilizantes: Un Modelo de Desarrollo Económico", John G. Mexal y su equipo produjeron varios resultados que podrían beneficiar a otras tribus: La encuesta de la industria del campo de golf en el sudoeste de los Estados Unidos reveló que la nutrición de hierro es una preocupación seria para los gerentes de campos de golf; hay un descontento general con muchos fertilizantes de hierro actuales; un fertilizante eficaz de hierro sería fácilmente aceptado por la industria; y el costo probablemente no sería un asunto relevante para su aplicación en los diferentes espacios de los campos de golf. También, el estudio reveló que los residuos de la mina de la tribu fallaron en mejorar el crecimiento, color, o contenido mineral de cualquiera de las seis especies de plantas utilizadas en dos pruebas. Parecía existir poco beneficio en el desarrollo de un producto de fertilizante de los residuos de la mina en las tierras Tohono O'odham, a menos que fuera posible refinar el producto para mejorar la disponibilidad del hierro sin aumentar enormemente los costos de producción.

Para la Comunidad Santa Catarina de los Paipai en Baja California, Michael Wilken-Robertson creó estrategias que podrían ayudar a llevar a cabo prácticas de desarrollo sustentable, tanto como para esta comunidad como para tribus en otros sitios. La publicación "Estrategias para el desarrollo sostenible de recursos naturales y culturales de la comunidad India Paipai de Santa Catarina, Baja California", muestra que cuando las posibilidades de uso del suelo fueron evaluadas, el ecoturismo, la conservación, y la agricultura para pastoreo fueron determinadas como los mejores usos para la tierra. Una evaluación de los recursos culturales reveló que la producción creciente de artesanías podría ser una actividad económica viable. Son necesarios estudios posteriores para determinar la viabilidad y sustentabilidad de estas actividades para asegurar una economía dinámica, y diversificada para la comunidad. La academia, en vez de ser asesoría cara, es idealmente adecuada para llevar a cabo estos estudios a través de la colaboración continua de la comunidad indígena con el Instituto de Culturas Nativas de Baja California (CUNA), la Universidad Autónoma de Baja California, CIPAS, y otras instituciones.

El tomo contiene dos capítulos de Wilken-Robertson también. "Grupos Indígenas de la Región Frontera Norte de México" examina el impacto de la frontera México-E.U. en el medio ambiente de los grupos nativos e itinerantes dentro de la región fronteriza de México. "Grupos Indígenas de Baja California y el Medio Ambiente" trata los asuntos ambientales que las tribus enfrentan en la península Baja California. Además se incluye una versión abreviada de la tesis de maestría de Kathleen Coates Heberg para el Departamento de Salud Pública en la Universidad Estatal de San Diego, la cual lleva el título "La asociación de enfermedades gastrointestinales y factores ambientales en una comunidad indígena de la tribu Kumiai en Baja California, México".

Conclusión

Así como Massoud el miembro de la tribu Tigua lo expresó en su capítulo, el programa CIPAS difícilmente fue una panacea, pero proporcionó una vía para la comunicación y una oportunidad para desarrollar y cultivar relaciones de trabajo y procesos considerados productivos por ambos integrantes. Los participantes indios y académicos llegaron a conocerse el uno al otro y sus formas de interactuar, y el programa lentamente evolucionó hacia una relación provechosa entre tribus y academia. Como los participantes van y vienen dentro de los gobiernos tribales y las universidades, es difícil predecir si las relaciones sobrevivirán más allá de los alcances del Programa Ambiental de Comunidades Indígenas del CIPAS. Pero, quizá la historia favorable de trabajar conjuntamente promoverá nuevos y variados intercambios, escribió Massoud.

El efecto extendido de STEP produjo un acercamiento de investigación para la academia y otros consultores que trabajan con naciones indígenas. El programa desarrolló diversos resultados valiosos que produjeron resultados positivos para las naciones involucradas. Además, la experiencia desarrollada dentro de CIPAS permitirá que futuros proyectos de investigación sean desarrollados tan sensitivamente y eficazmente como sea posible, y sin retraso indebido. Tal alianza faculta a los investigadores CIPAS para ayudar fácilmente a los miembros de las tribus, las agencias, y los consejos para solicitar y llevar a cabo Programas de Asistencia General de EPA (GAP, según sus siglas en Inglés), así como en apoyos y contratos de CIPAS.

A través de este empeño, muchas naciones indígenas descubrieron la disponibilidad de una riqueza de información y asistencia a partir de socios voluntariosos dentro de las universidades. Las escuelas, a su vez, encontraron a una comunidad nueva a quien servir como parte de su misión de educación académica y entrenamiento. CIPAS puede ser el vehículo que continúe facilitando estos vínculos entre la academia y las tribus.

I

Indigenous Groups of Mexico's Northern Border Region

Michael Wilken-Robertson

Introduction

The indigenous cultural heritage of Mexico's northern border region includes native tribes—relatively small, rural populations living on communally held ancestral lands—and migrant indigenous groups—larger populations of indigenous descent living in urban areas or agricultural settlements, usually without a community land base. This chapter examines the impact of the border on the environments of both native and migrant groups within the Mexican border region, which is defined as the 100-kilometer (km) zone south of the U.S.-Mexican international political boundary.

Just as this definition of the border region is problematic when considering ecosystems, watersheds, and other natural configurations, it likewise leads to arbitrary distinctions when discussing the indigenous peoples of the border region. For example, the territory of some groups, such as the Tohono O'odham (referred to as Papago in Mexico), extends beyond the 100 km zone. People in this tribe also maintain constant contact with other closely related indigenous peoples beyond the border region. Other groups, such as the Paipai and the Kiliwa of Baja California, live outside the 100 km range but are closely tied culturally, socially, politically, and economically to indigenous and non-indigenous populations within the range. The

Pai, Yaqui, and Pima are closely related groups on both sides of the border, but their entire territories are north and south of the 100 km designation. For migrant indigenous groups, the concept of the border region is even more problematic, as their residences may range from staying a few hours or days in one place to permanent settlements of transplanted ethnic *colonias* (neighborhoods that sometimes lack access to utility services) in urban areas such as Ciudad Juárez or Tijuana.

In spite of these problems, the 100 km limit has the advantage of bringing into focus a few rural native groups and urban migrant groups whose environments are directly affected by the border. While this chapter should not be construed as a complete vision of the impact of the border on Mexican tribes and their environments, it will examine key issues and indicators of region-wide significance and identify some of the many missing components to guide future research and policy. Perhaps the most consistent finding of this study is the notable lack of published or reliable baseline information—particularly quantitative data such as that used for indicators—for Mexico's border tribes and their environments. The data that exist are dispersed, embedded in databases, or simply unpublished, and would require a major study to compile and synthesize.

Mexican federal government agencies do provide important sources of information, although none offer datasets specific to indigenous people of the border region. The National Commission for the Development of Indigenous Peoples (in Spanish, Comisión Nacional para el Desarrollo de los Pueblos Indígenas, or CDI), until recently known as the National Indian Institute (in Spanish, Instituto Nacional Indigenista, or INI), administers federal programs designed to assist indigenous peoples. The CDI website (http://www.cdi.gob.mx) includes monographs on many tribes, including the Kikapu and Papago, a socioeconomic database, and other useful information. The National Institute of Statistics, Geography, and Information (in Spanish, Instituto Nacional de Estadística, Geografía e Informática, or INEGI) (http://www.inegi.gob.mx) offers statistical and geospacial data. The Secretariat of Environment and Natural Resources (in Spanish, Secretaría de Medio Ambiente y Recursos Naturales, or SEMARNAT) (http://www.semarnat.gob.mx) has an environmental database and information on environmental conditions and programs involving indigenous communities; however, there is no tribal program such as the one administered by the U.S. Environmental Protection Agency (EPA). The Secretariat of Health (in Spanish, Secretaría de Salud) compiles information based on monthly reports from its doctors throughout the nation and synthesizes this information into the National Health Information System (in Spanish, Sistema Nacional de Información en Salud, or SINAIS) (http://www.salud.gob.mx/index.html); this includes information specific to indigenous communities.

Another important source of information is the Southwest Center for Environmental Research and Policy (SCERP) (http://www.scerp.org), which has commissioned specific studies on border tribes, including "Indian Groups of the California-Baja California Border Region and Border Environmental Issues" (Kilpatrick, et al. 1998). The Native Cultures Institute of Baja California (in Spanish, Instituto de Culturas Nativas de Baja California, or CUNA)(http://www.cunabc.org), a Mexican nonprofit association working with the indigenous tribes of the peninsula, has published several studies of baseline environmental information and sustainable development in Baja California's Kumiai, Cucupá, Paipai, and Kiliwa tribes. Back issues of the journal *Borderlines*, which include several articles on issues facing border tribes, can be visited at the Americas Program website (http://www.americaspolicy.org).

Native Tribes of Mexico's Border Region

The four native indigenous groups with a permanent land base living within 100 km of the border, followed here by their U.S. nomenclature, are the Kikapu (Kickapoo), Kumiai (Kumeyaay), Papago (Tohono O'odham), and Cucapá (Cocopah). All these groups are directly related to tribal groups in the United States, some continuing to inhabit ancestral territory that was divided by the U.S.-Mexican border and others having been separated from their U.S. counterparts as a result of migrations and other historic processes subsequent to European contact. These groups are primarily rural and have communal land holdings; in many cases, some tribal members migrate seasonally or permanently to nearby towns. Often, those who remain on communal lands retain indigenous knowledge of traditional environmental management (including hunting, gathering, and fishing strategies), and this increases their possibilities for survival as they adapt to challenging economic, environmental, social, and political changes.

Kikapu

The Kikapu of Coahuila are part of an Algonquin-speaking tribe of northern origin that also inhabits lands in Oklahoma, Kansas, and Texas (Hays 1996a). The Mexican Kikapu live primarily around the town of El Nacimiento de los Kikapúes, located in the municipality of Melchor Múzquiz, Coahuila. According to INI (2003) and the National Council on Population (in Spanish, Consejo Nacional de Población, or CONAPO), there were 339 Kikapu speakers in 1995 and only 138 in 2000 (this may reflect migration patterns when each census was taken; also, many tribal members may not be speakers). They live on approximately 7,022 hectares of *ejido* land, 6,500 hectares of which are used for cattle grazing and 500 of which are used for the cultivation of wheat, oats, corn barley, beans, and squash. Water for drinking and other domestic uses, as well as irrigation, comes from the springs of the Sabinas River; drinking water is brought directly from the source while the rest of the water is channeled into a canal that flanks the community.

Hunting has long been an important economic and ritual activity for the Kikapu. Wild nuts and chilies collected from communally owned wild groves are important natural resources that are gathered for sale. Firewood is the main source of fuel, although natural gas is also brought in tanks from nearby towns. Some families use gasoline-fueled generators or oil lamps (Embriz Osorio 2003). Since 1832, the Kikapu have enjoyed the right to pass freely across the border and although they have had to defend their border crossing rights, they are probably less impacted by the border than any of the other border tribes (Hays 1996a). Telephone, telegraph, mail, and health services are not available in the community; for these the Kikapu must go to the county seat.

Papago

The Papago (known as Tohono O'odham and Hia'ched O'odham in Arizona) have traditionally been agriculturalists. For centuries they have raised beans, corn, teparies, and other plants adapted to the arid desert of northern Sonora and southern Arizona. During the dry season (winter) they focus on hunting and gathering. Even today, the hunting of deer and gathering of saguaro fruit and other wild foods has both economic and ceremonial importance for the Papago. Their traditional territory was bisected as a result of the Treaty of Guadalupe Hidalgo of 1848 and the Gadsden Purchase of 1853. Today, approximately 1,500 tribal members (Taliman 2001) live in a number of villages and towns of Sonora. According to the INI socioeconomic database (2003), there were 142 native-language speakers in 2000. Unlike their northern counterparts who live on the second largest reservation in the United States, the Mexican Papago have lost most of their traditional land base to *mestizo* (non-Indian heritage) ranchers and farmers and have retained less than 729 hectares (Hays 1996a). Many Papago have migrated to nearby towns and cities in search of jobs.

According to INI, in Papago villages, "infrastructure and public services are practically non-existent except in Quitovac where electricity is produced by a small generator. Water is insufficient; it is extracted from hand-dug wells that often show a high level of salinity. The nearest telegraph, telephone and mail services are in Sonoyta, Caborca and Puerto Peñasco" (Ortiz Garay and Saldaña Fernández 2003).

Cucapá

The Cucapá have long lived in the fertile delta region of the Colorado River and the surrounding desert areas, practicing both flood-plain agriculture as well as hunting, gathering, and fishing. Closely related to the Kumiai and other Yuman-speaking groups of Baja California and Arizona, most Cucapá today live in the settlement of El Mayor Cucapá, some 56 km south of Mexicali, and in Pozas de Arvizu and San Luis Río Colorado, Sonora. Their Cocopah relatives live primarily in Somerton, Arizona. INI (2003) census data indicates that in 2000, there were 178 Cucapá speakers in Mexico.

Over the last century, the Cucapá have been drastically affected by the many changes in the upstream uses of the Colorado River's water, which have resulted in floods, drought, salinity, or contamination. The Cucapá land base is the most extensive of all the indigenous communities of Baja California, totaling 143,000 hectares. However, much of it is parched desert without the potential for agricultural or livestock activities. A large part of this land is the usually dry bed of the Laguna Salada, which has been greatly affected by fluctuations in the quantity and quality of water flowing in from the Colorado River. In years when sufficient water is released upstream, the lake fills and the Cucapá are able to practice traditional fishing activities. Yet, contaminants either from the river itself or from toxic waste dumped within the watershed have affected the fish, as has stagnation caused when fresh water no longer flows into the lake. Both of these situations have caused the deaths of large numbers of fish. Some illegal dumping of toxic materials into the lake watershed has been reported by tribal members (Wilken 2001).

El Mayor does have basic water and electric services, but water quantity and quality are serious concerns. Economic activities include fishing, handcraft production (primarily beadwork, bark skirts, and other traditional arts), wage labor in neighboring communities, tourist services, and use of natural resources such as sand and stone (Wilken 2001).

Kumiai

Traditional Kumiai territory originally extended from around Escondido in California to south of Santo Tomás in Baja California. The Kumiai were hunters, gatherers, and fishers who managed a variety of coastal, inland valley, and mountain ecosystems. Like the Papago, the Kumiai of Alta and Baja California saw their lands divided into separate countries after the Treaty of Guadalupe Hidalgo.

Today, Mexico's Kumiai live primarily in four rural communities—Juntas de Nejí, San José de la Zorra, San Antonio Necua, and La Huerta—with a land base of more than 38,500 hectares and a total population of approximately 600 (Wilken, et al. 1998). Several unrecognized traditional Kumiai settlements also exist, including Peña Blanca, Aguaje de la Tuna, and San José Tecate. INI census data indicates that there were 243 Kumiai speakers in Mexico in 2000. The Kumiai have developed diversified economies that include cattle ranching, agriculture, handcraft production, seasonal wage labor, and natural resource use. Although Mexico's Kumiai are economically disadvantaged in comparison with their U.S. Kumeyaay relatives, they are rich in terms of traditional knowledge and are often invited to teach basketry, language, plant uses, and other traditional arts to Kumeyaay students in the United States. Unfortunately, this vital transfer of traditions has been severely limited by the difficulties the Mexican Kumiai have experienced in acquiring the necessary U.S. work permits.

A study of water quality in the Kumiai communities found that most drinking water came from untreated surface water. The wells that exist are usually hand-dug and unsealed. Water is often stored in buckets or drums within homes. (Wilken-Robertson 1996). In San Antonio Necua, a public health study (Coates Hedburg 1999) (See Chapter VII) and a medical anthropological study (Fleuriet 2002) both examined environmental factors in illness among the local population. Rivera Medina (2000) conducted a Master's thesis that examined traditional uses of natural resources.

Only one of the four Kumiai communities has electrical services. None have telephone, telegraph, or mail services. Health facilities exist in three of the four communities; government (in Spanish, Instituto de Servicios de Salud Pública de Baja California, or ISSESalud) and volunteer doctors make occasional visits.

Border Native Indigenous Groups: Clusters and Indicators

Tribal Governance and Representation in Regional Research, Planning, and Policy

Although they are too often overlooked or ignored by federal, state, and local governments, all border tribes have their own governments that may include both traditional and elected authorities. The former have evolved to meet the changing leadership needs of tribes over hundreds or thousands of years; the latter (*comisarios*, or elected chiefs) are often an interface between tribes and non-Indian governments. Most tribes hold regular community *asambleas*, or meetings, to discuss issues and make decisions. Like all political systems, these mechanisms are not without their problems. For example, some tribes may have two opposing groups with two separate governments. Nonetheless, these forms of governance are critical points of articulation between tribes and their authorities and municipal, state, and federal governments. All too often, governments and institutions disregard these mechanisms or give undue authority to self-appointed "representatives." True representatives should be designated by their communities through a town meeting or by an elected chief or traditional authority with the knowledge of the community.

Regional councils exist in some of the border tribal areas. One example is the Baja California Intertribal Council, which includes elected and traditional authorities representing the Kumiai, Paipai, Kiliwa, and Cucapá tribes at a state level. Sonora and Chihuahua also have regional councils that represent all or part of tribal nations in those states.

Appropriate indigenous representation in regional research, planning, and policy development is itself a significant indicator of community involvement. However, this elusive goal is rarely met because there are special circumstances that need to be considered to facilitate tribal participation. Time must be allotted for meeting with the tribe, providing clear information, allowing for internal decision-making processes to take place, and ensuring follow-up. If tribal representation is requested, the time and expense that representation implies should be considered. Since few tribes have telephone or mail service, communication is slower and more costly, usually implying several trips to and from other communities. Tribal funds for travel, communications, computers, and other standard operating expenses of governments are often extremely limited or non-existent. Furthermore, most tribal authorities also work at regular jobs, so a day off to attend a meeting or participate in a planning workshop means a day of lost wages. In spite of these challenges, fostering tribal participation has the potential to strengthen the effectiveness of regional planning and policy processes and avoid many problems in the long term.

Historically, the Mexican federal government's relationship with tribes has been based on the idea that all Mexican citizens share the same rights and, therefore, indigenous groups should not be treated differently. Unfortunately, this policy has meant—among other things—that Mexican tribes have been glaringly unrepresented in the EPA's Border XXI process. This situation is said to be changing under the continuation of that program, Border 2012.

Economy, Biodiversity, and Sustainable Development

Due to the arid climate throughout the border region, most of the original native inhabitants developed hunting and gathering economies, except in areas where rivers provided sufficient water for the development of irrigated agriculture. Traditional indigenous environmental management involved maintaining or propagating flora and fauna beneficial to humans. Political and economic changes have led to the drastic reduction of tribal territories, and consequently, changes in land use, including the abandonment of traditional management practices over wide areas (Shipek 1993).

Because of demographic pressures since European contact, native groups have lost much of their original land base, especially valuable agricultural lands. Native groups have adapted to the regional pastoral cattle ranching economy that has allowed them to extract value from non-agricultural lands. However, extensive cattle raising has a variety of impacts on wide areas, including the reduction of vegetative cover, accelerated soil erosion, and the introduction of invasive species. Mexican government programs have often focused on agricultural projects that involve the total removal of vegetative cover and the establishment of irrigation systems. Many of these projects have failed, leading to desertification. Some groups, such as the Cucapá and the Papago, like other groups of the Southwest, have long cultivated plants adapted to the arid climate, including corn, beans, teparies, squash, and gourds. In some cases, hunting, gathering, and other traditional or innovative uses of natural resources continue as survival strategies in a diversified economic base. The case of the Papago illustrates this diverse adaptive strategy—economic activities include work in the mines and on non-Indian ranches, the sale of wood and handcrafts (basketry and pottery), small-scale commerce, and wage labor in the cotton fields (Ortiz Garay 2003).

Biodiversity values remain fairly high in many native communities. Invasive species, particularly related to cattle ranching and agricultural activities, have been little-studied, and in some cases, such as with mustard, tamarisk, and castor bean, may be perceived as useful by tribal members. In most native communities, natural living resources remain in a fairly good state of conservation due to the remote nature of areas and infrequent access to government programs and capital for economic development projects that result in large-scale changes in land use (Escoto 2000). Demographic pressures from outside and inside the communities are the primary pressure on living resources. Encroachment on tribal lands always involves an interest in appropriating and exploiting land, water, or living resources. Economic pressures from within communities may lead to overexploitation of resources, including overgrazing, unmanaged firewood gathering, and fencepost cutting. Cattle ranching has had the farthest-reaching affect in many communities, resulting in erosion, desertification of riparian areas, and some loss of vegetative cover when not carefully managed (Ahumada Cervantes 1999).

Traditional knowledge of the environment and its natural resources allows many indigenous groups to not only survive, but seek new options for living off the land. These include the harvesting of yucca, jojoba, sage, and basketry plants. Handcraft production—originally used for domestic purposes or traded with other groups—that uses natural resources has been adapted to the modern cash economy (Wilken 1998; Rivera 2000). Hunting of bighorn sheep and deer was traditionally part of indigenous subsistence strategies. But today, expensive permits are required and favor wealthy U.S. and Mexican citizens—there is no benefit for tribes. Poachers also take an unknown amount of game, which affects faunal populations. The impact of undocumented worker migration and drug trafficking activities on the environment of the border region is little understood or documented.

Rather than involving the groups to provide them with new options for sustainable development, biosphere reserves often limit tribes' access to traditional use areas. Hays (1996b) points out that "biosphere reserves and other mechanisms for protecting ecologically sensitive areas have proven to be barriers to indigenous access to traditional homelands, whether in Mexico or the United States. Federal efforts to shield such zones from environmental degradation have also effectively denied Native peoples the rights to collect traditional food and medicinal and ceremonial plants." In the northern Gulf of California, Cucapá fishermen charge that the biosphere reserve has drastically limited their ability to fish in traditional areas (Franco 2003). Authorities, on the other hand, claim that some Cucapá engage in illegal business practices by simply selling their permits to commercial fishermen. Similar problems exist with the Papago (particularly the Hia'ched O'odham) and the Pinacates reserve (Hays 1996b). As a result, the Sonoran Desert Alliance, a non-governmental organization (NGO), has worked to "increase ... indigenous participation in the planning and management of federally protected Native homelands" (Hays 1996b).

An approach that avoids these pitfalls are conservation easements with tribes in which sustainable development activities benefiting communities—including ecotourism, sustainable harvesting of natural resources, and research field stations employing tribal members—are supported in exchange for conservation and traditional management of tracts of tribal lands. Wetlands restoration and reforestation projects, particularly those focused on yucca, plants used in basketry and other plants that can be used for sustainable development, have already been carried out on a small scale through collaborative efforts between tribes, NGOs, and government programs. They should be further explored. Ecotourism offers the opportunity to encourage conservation and stewardship of living resources and the landscapes, habitats, and ecosystems in which they occur, while at the same time providing benefits to communities.

Another important opportunity is the establishment of indigenous environmental management programs. Preliminary efforts in this direction have already been undertaken in Baja California, where indigenous community members have been trained in the use of Global Positioning Systems (GPS), Geographic Information Systems (GIS), and basic environmental management techniques through collaborations between CUNA, SCERP, Universidad Autónoma de Baja California (UABC), and the communities themselves. Centers for indigenous environmental management have the potential to provide tribal members with the technology and technical expertise necessary to drive indigenous sustainable development initiatives in tribal lands.

Air

No indicator data for any of the border native groups could be found on air emissions inventories and ambient monitoring, visibility measurements, cases of asthma as measured by hospital visits, or ambient air concentrations of select criteria air pollutants. Except for the dust raised by the ubiquitous dirt roads that service native settlements, air quality appears to be excellent in most rural indigenous communities of Baja California. Only the Cucapá community has been affected by the ever-expanding air pollution of the Mexicali and Imperial Valleys. Good air quality is one of the valuable resources for ecotourism and conservation projects in native communities. Well-preserved, oxygen-producing forests and vegetative cover provide a valuable environmental service to the greater regions.

Water Quantity and Quality

Data on measurable indicators of water quantity and quality are practically unavailable, except in Baja California. Among rural native communities, agricultural use of water is generally limited to small-scale, traditional agricultural practices adapted to arid conditions. Groups like the Papago and Cucupá have lost access to most of their traditional lands and water for irrigation. Hays (1996a) also cites the example of the Kikapu in the 1940s: "protracted drought and excessive groundwater pumping by the American Smelting and Refining Company (ASARCO) left the Kickapoo unable to support themselves by traditional agriculture." Today, the Kikapu irrigate using channeled water.

Rainfall and natural water production is of great concern to rural native communities as changes in land use—for example, cattle ranching and clearing of natural vegetative cover for intensive agriculture—lead to less rain. Desert tribes such as the Papago have also pointed to the lack of appropriate ceremonials as a factor in drought.

A successful example of a cross-border activity with the potential to increase water supply is the wetlands restoration project carried out by the Campo EPA, CUNA, and the Kumiai community of San José de la Zorra. A sediment retention structure—based on traditional methods of collecting water—works naturally to recharge the community's aquifer.

For native groups living in remote rural locations with small populations, the challenge is to motivate local governments to help develop appropriate infrastructure. Some of the opportunities for communities with low water supplies are traditional agriculture, sustainable use of natural resources based on traditional knowledge (including the harvesting of medicinal and basketry plants), and ecotourism. Given many communities' remote locations, appropriate technology such as solar, wind, and gravity is often cost-effective compared to the expense of connecting to distant municipal systems.

Water quality studies specific to native or migrant communities of the border region have not been carried out, except in Baja California's Kumiai communities. Most communities depend more on surface water than groundwater because the cost of drilling and maintaining wells is prohibitively expensive. Aquifers may not have been tapped due to the high cost of drilling and maintaining wells. Remote native communities tend to have fairly clean sources of surface water or groundwater. Small improvements like fencing surface water collection areas, well seals, backflow valves, and chlorine bleach can make a significant difference. Some communities do not perceive a need for purification because they are accustomed to local flora (Kilpatrick, et al. 1998).

In rural native communities, water is administrated by user groups. Existing infrastructure is often poor due to difficulties in raising funds for repair and maintenance. Old, broken, or leaking PVC pipes are commonly seen wrapped in rags with water leaking from them (Coates Hedberg 1999).

Among native groups, infrastructure varies from simple wells or surface water where people fill buckets and drums to community-wide water systems where water is available all day or periodically. Pressurized and purified water systems and community-wide waste-water systems are non-existent; generally, gray water is discharged into gardens and human waste is disposed of through outhouses.

Water infrastructure projects in Baja California have been promoted through a collaboration between CUNA and Aqualink, a U.S. NGO. The Border 2012 Program's focus on water quality and health (EPA 2002) represent potential opportunities to work with tribes in Mexico, driving further cross-border collaborations. U.S. tribes have also expressed interest in helping Mexican tribes with water systems.

Other Indicators

Quantitative data on solid, hazardous, and toxic waste; health; emergency preparedness; public safety; transportation; quality of life; and other indicators are not available or would require an extensive interdisciplinary, intersectorial study to compile.

Migrant Communities of the Border Region

The number of migrant indigenous people along Mexico's northern border is often much greater than that of native populations. A case in point is Baja California, where an estimated 92.8% of the state's 37,000 Indians are migrants (INI 2003; INEGI 2003). It is well known that a large part of the swelling population of the border is made up of migrant indigenous people primarily from central and southern Mexico, but specific statistics of migrant indigenous population and breakdowns by ethnolinguistic affiliation—let alone environmental data—are not available. Although many ethnically homogeneous *colonias* exist in the border regions, not all indigenous migrants settle in *colonias* with others of their same ethnic group, further complicating the effort to identify them. The demographic databases that exist provide more generalized information organized by state or language. Furthermore, the criteria used by INEGI, INI, and CONAPO to define indigenous speakers or tribal members differ so significantly that INEGI's national census found 8 million indigenous people in Mexico in 2000 while INI and CONAPO found more than 12 million.

Several academic institutions, including Colegio de la Frontera Norte (COLEF), state universities, Colegio de México (COLMEX), and Colegio de Sonora (COLSON), have been carrying out research on migration and indigenous people of the border region. However, only a few, such as Velasco-Ortiz (2000; 2002) have focused on the combination of these factors.

Migrants often establish their residences in cities or agricultural settlements that are much more densely populated than their places of origin. Migrants' marginal economic status often push them into less-desirable areas or to the margins of cities where they may end up in poorly constructed homes in irregular settlements lacking proper planning for basic services such as electricity or piped water. Often these settlements begin as "invasions" in high-risk areas such as canyons and slopes, eventually leading to problems with floods, landslides, and legal disputes. In most cases, urban migrant Indians face the same problems as other non-Indian, marginalized social groups (Pombo 2000). Indigenous migrants living in agricultural camps are exposed to pesticides and a variety of other toxic chemicals, as well as smoke and dust.

Some researchers believe that ethnic identity may provide opportunities for community organization. Many migrants maintain social and cultural ties with their places of origin, often sending significant percentages of their earnings back to their families and hometowns for traditional fiestas. Where monolinguism is a significant factor, environmental education materials may need to be developed in native languages.

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II

Indigenous Groups of Baja California and the Environment

Michael Wilken-Robertson

TRADITIONAL MANAGEMENT AND CONTEMPORARY PERSPECTIVES[1]

> This I can assure you, the ancient ones never damaged a tree, no, never; they loved them as something very sacred. They would tell us not to go breaking the branches of the pines, not to play there, nor to climb up on any small tree, they said that they were almost just like humans; "They are watching us, they are taking care of us, they give us our food. Don't go around damaging them, don't be shouting, none of that," they would say, "take special care of them," for this reason we know very well that we must take care of these trees. Also the medicinal herbs, those they especially charged us to care for, we shouldn't just go out and cut for no reason, go out and cut them and throw them away to dry up, no. They told us many things, that we should even care for the rocks, just imagine! The rocks, the sand, the springs, the water flowing, all these things they said we must respect (Teodora Cuero, in Wilken 1997).

The words of Teodora Cuero, traditional authority of the Kumiai Indian community of La Huerta, reveal a practical sense of the interrelationships between humans and the environment. Like other members of Baja California's indigenous communities, Cuero has inherited a unique legacy of traditional knowledge about the management of natural resources developed over thousands of years of habitation on the Baja California peninsula. Much of this knowledge has been lost due to the forced acculturation and extinction of most of the native groups of the peninsula. But, a growing focus on the immense and complex body of knowledge that still exists among a few elders of the surviving communities promises to provide new insights into traditional forms of environmental management, as well as to guide current approaches to resource use.

Fortunately, many aspects of traditional indigenous knowledge about natural resources still exist among the surviving groups of the northern peninsula. This profound understanding of the natural world, developed through thousands of years of dynamic interaction with the environment, is perhaps one of the most important cultural resources of the indigenous communities—one that deserves much greater study while it is still possible. Given the growing recognition of the absolute necessity of sustainable resource use, it would be wise to pay attention to those who have already managed the natural resources of the region for thousands of years.

Gatherers-Hunters-Fishers of the Peninsula

> They say that back in the early times there was plenty of manzanita, barrel cactus, chia, pamita seeds, pine nuts, acorns, sweet acorns; all these things produced a lot and that's what people would gather to have food all year long. Certain times they would go down to the coast, to Eréndira, to the coast of Ensenada, and further on, wherever they could go along the shore to gather mussels and abalones, which they would also pack up to carry later for food. They would go down there in winter because it wasn't so cold and once the winter was over, in springtime they would come up this way (La Huerta) since they knew that there would be greens and all kinds of things to eat.

> From here they would head up to the mountains during the hot time of year to pick pine nuts, acorns, pamita seed, chia, and all those things. Once the pine nuts ran out, they would come back here and then back they go to the coast (Cuero, in Wilken 1997).

During the vast majority of the history of human habitation of the peninsula, native people exploited a variety of ecosystems in the course of yearly cycles of movement through specific territories. The pattern for the Kumiai ancestors of Cuero may have been typical for most indigenous groups of the peninsula: Gathering different plant foods represented the most important subsistence activities, while fishing, gathering shellfish, and hunting small and occasionally large game supplemented seasonally available plant foods. These gatherers-hunters-fishers were organized in small, highly mobile extended family bands that traveled in seasonal cycles over specific territory shared with other bands of the same clan, or *shimul*, as they were called in the peninsular Yuman territory (Laylander 1991).

While their exact route would vary from year to year depending on environmental factors—many plant resources are alternate-season bearing and wet or dry years may affect certain resources—the repeated use of specific areas over generations would logically lead to the selection of resource procurement strategies that either allowed those resources to survive or enhanced their populations. Paipai elder Benito Peralta and Kumiai elder Cuero echo the sentiments of many elders of Alta California when they say that in the old days, there were more wild foods (Wilken 1997), possibly a result of the decrease or abandonment of traditional gathering activities.

According to Gregorio Montes, whose mother, grandmother, and aunts are basketmakers in the San José de la Zorra Kumiai community, the harvesting of materials for the elaboration of baskets actually stimulates greater production of the resource:

> The most important of the hand crafted products that we make are the juncus and willow baskets. The juncus material is found in areas where there is water, where the earth is moist, from these places the plant is extracted when the moon is full to give it greater strength and flexibility when it is worked; this benefits the plant because it

> reproduces more. The willow also gets cut and often one thinks that it has been destroyed, but that is not the case because it actually helps it, it is pruned and it develops more within a certain time (Montes, in Wilken 1997).

One management strategy for the harvesting of medicinal herbs is explained by Cuero:

> We want the medicinal plants, the trees and all these things to continue, so, for example, when you pick a plant, you only pick this side, the north side. Not over here or over there, only the northern side. Also if it is the root of the plant you want to cut, you also just take the northern side (Cuero, in Wilken 1997).

It may be hard for many non-natives to understand what it means to live in a place where one's ancestors have lived for thousands of years. For many indigenous people, it is hard to understand why government policies prohibit them from using resources like pine nuts, which have been successfully managed by their people for thousands of years. Native peoples' relationships with the land and its resources have little in common with Western concepts that treat land and its resources as a commodity from which the greatest possible immediate profit should be extracted. The cultural legacy passed on from the ancestors and the expectation that one's offspring will continue to live on the same land create a unique perspective among indigenous groups. Agustin Dominguez, cultural authority of the Kumiai community of San Antonio Necua, expresses this philosophy through the metaphor of gathering honey:

> The mestizo (someone of non-Indian or mixed heritage) comes and since he's not from here he says, "I'll take everything and leave them with nothing." But one who lives here says, "I'll take a little bit and come back another day, next time I'll take a little more." But not the mestizo, he comes and doesn't care since he's not from there, he says, "I'm going to take it, I won't be coming back so I'll take it all." That's the way it is (Dominguez, in Wilken 1997).

Bernabé Meza, commissioner of San Antonio Necua, emphasizes the responsibility to protect the land and its resources for future generations:

> We like for there to be plenty of trees, since they attract the rain, the water, and so on. We only cut what we need for ourselves. For example, if we need one hundred posts, we cut one hundred posts and no more, we don't knock them down just to knock them down, no. That's why we're always taking care of them, we don't allow people from outside to come and cut down all our trees. If we don't take care of them, who will? (Meza, in Wilken 1997).

Native communities often face special difficulties, primarily economic, in obtaining the permits necessary to make legal use of their natural resources, or they lack information and capital for the resources' most advantageous and appropriate use. While many new forms of exploitation of resources may have negative impacts on the environment, traditional forms of harvesting may mitigate that impact, as in the case of juniper post harvesting as explained by Eufemio Sandoval:

> About forty years ago we started to harvest juniper posts, however the government has recently prohibited the exploitation of these resources, arguing that because this is an endemic species protected by law, the Indians must no longer cut posts even if we starve to death. In other words, the reality is that they take away a source of income and give us nothing as an alternative. Let me say that I agree that we must protect nature, but it should be truly protected. If we Indians have exploited juniper posts, we can say that when we began to exploit it we had ten thousand hectares of juniper, and we still have that same amount since we have never cut the plant to the root, but rather it has been a form of pruning that we carry out. We just take what is useful as a post and leave the rest to keep growing and developing. Not so in our neighboring ejido (communal land grant towns) communities; with the pretext that the plants took up space in

> the areas where they wanted to plant crops, they destroyed huge tracts of juniper (Sandoval, in Wilken 1997).

Unfortunately, the urgent necessity for communities to survive in a modern market economy creates new economic pressures that may be directly related to the degradation of the environment. For example, the lack of capital needed to process natural resources and market them as value-added products means most communities end up selling their products as raw materials for low prices. One of the cheapest forms of using available resources is through free-range raising of livestock; however, when not carefully managed, the land used for this purpose has been overburdened and that has resulted in accelerated erosion and other forms of environmental degradation.

There is clearly a need for funding through government agencies, foundations, or U.S. indigenous communities for community-based projects designed to promote value-added forms of sustainable resource use. Baseline studies carried out in conjunction with the communities themselves would help identify the most appropriate and promising activities and would establish important links with universities, governmental agencies, non-governmental organizations, other indigenous communities, and other potential partners. Training and empowerment of indigenous community members in the carrying out of sustainable development projects and the development of the necessary infrastructure for strengthening the role of regional indigenous organizations are critical to the long-term success of this process.

For the anthropology of Baja California, there is a clear need to re-evaluate historical concepts of indigenous populations and cultures of the peninsula through an interdisciplinary approach combining archaeology, ethnography, physical anthropology, linguistics, history, environmental studies, and biology, among other areas. There are also urgent needs to find funding for interdisciplinary projects bringing together indigenous elders with ethnologists, biologists, and linguists to rescue invaluable traditional knowledge about natural resource management while it is still possible, and to apply this information for the benefit of the indigenous communities.

> Let's hope that somehow those who hear these words will pay special attention to our native communities, and look for a way that we can use our natural resources to create sources of employment, so that in this way we Indians can live peacefully (Sandoval, in Wilken 1997).

Environmental Concerns of the Indigenous Communities of Baja California

Juntas de Nejí (and Peña Blanca)

The Kumiai community of Juntas de Nejí is the northernmost of the indigenous communities of Baja California. Located within the municipality of Tecate, Nejí is divided geographically into two separate polygons, both of which lie relatively close to the international border and within the Tijuana River Watershed; they have a combined total of 11,590 hectares. The clans of Nejí have historically shared close familial and linguistic ties with the Kumeyaay (or Tipai) groups of southern San Diego County, such as Campo and Jamul. Bordering on the western polygon of Nejí is the traditional Kumiai settlement of Peña Blanca, an unofficial neighboring settlement to Nejí that is not recognized by the Mexican government. Nejí's mountainous terrain includes wide areas of high chaparral, oak woodlands, granitic outcroppings, and in some areas pines, Tecate cypress, and other flora indicative of the transition to the higher altitudes of the adjacent sierra. Water sources are scarce, usually consisting of small springs or shallow wells; these are used for both drinking water and limited gravity-fed irrigation.

Most of the inhabitants of Nejí have moved to Tecate, Valle de las Palmas, El Testerazo, El Hongo, or the larger urban areas to seek employment. Although, many of them maintain contact with their community and express interest in returning to live if work were available. The few remaining inhabitants make a modest living through subsistence agriculture, cattle ranching, and other seasonal labor in neighboring *mestizo* (non-Indian or mixed heritage) communities.

Erosion is perhaps the most severe environmental problem for Nejí, especially in the eastern polygon where large-scale grazing by animals from neighboring ranches has caused serious soil and foliage depletion within the watershed. Water quality and quantity also represent serious challenges, since none of the existing settlements has any kind of water system more sophisticated than hand-dug water collection basins. A few of these have cemented retaining walls but none have effective lids, seals, or other protection. Residents have been advised to boil or otherwise treat their water, but they usually drink the water untreated because, they claim, they are used to it.

All of the settlements in the community are located far from the highway and are accessible only by dirt roads in poor condition. Acorns are one of the most important natural resources used in the area of Nejí. Residents also depend on other wild foods and medicinal plants in addition to occasional hunting as part of a diversified survival strategy. Although a tradition of juncus and willow basketry production once existed in the area, there are currently only a few women occasionally producing baskets.

Land tenancy is a serious issue for Nejí because of its limited population base, and even more so for Peña Blanca because of the lack of land tenancy documents. Both communities are undergoing invasion by squatters and encroachment by neighboring *ejidos*. One informant of Peña Blanca commented that members of a neighboring *ejido* interested in claiming the land for their own use have tried to destroy archaeological sites and any other cultural resources that might strengthen the Kumiai families' rights to the land. One of the most valuable resources for Nejí is the natural beauty of the landscape and its sense of remoteness, even though it is actually the closest community to the metropolitan areas of Tijuana and San Diego.

San José de la Zorra

This community of 14,440 hectares in the municipality of Playas de Rosarito is centered in San José, a small, remote valley located about halfway between the former mission site of San Miguel on the Pacific Coast and the Valley of Guadalupe, also a former mission site but today Mexico's most important wine-producing region. La Zorra, another traditional settlement now occupied by neighboring ranchers, is another small valley a few miles northwest of San José. As in most communities, residents' ranches are often spread out over a wide area, wherever permanent water sources exist. The lower altitude and relative proximity to the coast combine to create a mild climate where oak woodlands, chaparral, and grasslands come together. A limited amount of agriculture—for the most part dry farming along with some irrigated crops—has been carried out since the early part of the century. However, livestock grazing has also driven the local economy, as evidenced by visible erosion of the main arroyo. Large areas of topsoil adjacent to the arroyo were washed away during the storms of the early 1980s, along with an earthen dam that had been built there. Very few seedling willows, sycamores, or oaks can be observed, probably because of hungry cattle. Those trees that still stand are almost all older. Erosion has also been increased by the clearing of native shrub cover from large tracts of land for planting.

Wetlands plants such as willow, salt willow, and juncus are particularly important in this community, since they are the raw materials from which artisans produce a variety of forms of elegant basketry. The increasing demand for Kumiai basketry has become a major force in the local economy, where a large percentage of the local residents now depend to some degree on the income generated by this traditional activity. Unfortunately, the changes in the main arroyo have affected this emerging cottage industry. Artisan Gloria Castañeda noted that the materials necessary for making baskets are becoming increasingly difficult to acquire. "We have to go further and further away to find our materials," she said. Fortunately, through a collaboration with the Kumeyaay community of Campo, Calif., and the Instituto de Culturas Nativas de Baja California (CUNA), a wetlands restoration project in the main arroyo is currently underway, one goal of which is to reestablish basketry plants.

The existing water infrastructure in the community is the result of different projects carried out over the years, many of which were never completely finished. Water quality testing carried out in five indigenous communities in 1996 found the water in San José's school yard well to be the most highly contaminated of all samples taken. This may be indicative of nearby septic fields or cattle dung residue leaching into the water table, as well as the lack of a well-sealed cover. The San José Valley appears to have great agricultural potential, but groundwater levels and quantities have not been reported.

San Antonio Necua/Cañón de los Encinos

Nestled into a northeastern nook of the Guadalupe Valley, this community of 6,262 hectares lies on the outskirts of Mexico's prime wine-producing region and at the base of a series of mountain ranges, including the prominent Sierra Blanca, which provides an important source of water for the community. The original settlement of San Antonio Necua at the base of the mountain and other traditional settlements, such as Jamatay, were slowly abandoned as residents moved down to the Cañón de los Encinos (Oak Canyon), on the edge of the wide Guadalupe Valley, to be closer to employment opportunities. Necua is the only indigenous community of Baja California to enjoy the benefits of water systems, electricity, and other services. Although its dirt roads are sometimes impassable during the rainy season, Necua is the most accessible of all the communities most of the year.

Necua's main water infrastructure consists of several kilometers of low-quality pipe leading from springs to two water storage tanks just above the community. From these, water is provided by gravity to residents. Many complained of water shortages during dryer times of the year. Because the community's drinking water system and irrigation system currently depend on the same source, the large amounts required for raising alfalfa tend to overtax the system. The community's location near a major watercourse, the Guadalupe River, has little benefit for the community itself because the city of Ensenada maintains a series of wells in the vicinity that displace large amounts of water for municipal use. Local wineries also use large quantities of water for irrigation, resulting in the creek now being dry for most of the year (there have been no studies to measure the combined effects of this large-scale pumping).

Grazing of livestock plays an important economic role in the community, where animals are maintained both in confined areas and on an open range. The impact of this grazing is unknown; however, as in most communities, the evidence of accelerated erosion in areas of intense grazing can be easily observed.

One resident expressed concern about reduced numbers of deer, citing illegal poaching as a cause for concern. As in other communities, local residents wished to be able to monitor their own faunal resources, protecting them from poachers, keeping track of the animals' numbers and movements, issuing any permits, and serving as guides if any hunting should be carried out.

La Huerta

The southernmost of the Kumiai communities, located on the eastern edge of the great Ojos Negros Valley and at the base of the Sierra Juárez, this community's 6,268 hectares include fertile soil and plentiful springs, giving it the rich agricultural potential its name, La Huerta, or the orchard, suggests. In the past, when indigenous groups were more mobile, the site of La Huerta represented an important encampment in the yearly migration from the coast up to the mountains. Many Huerteños also remember the tradition of cultural and economic exchanges with the Cucapá, who came up from the Colorado River Delta region every summer and created a link with other groups of the Colorado River region and beyond.

Several small family orchards currently exist, but most residents' subsistence strategies revolve around livestock ranching or otherwise working as day laborers on neighboring ranches or in the agricultural fields of the Ojos Negros Valley. Some residents also gather local natural resources such as herbs, jojoba, and wildflower seeds for sale to Mexican or U.S. intermediaries. As in other indigenous communities, many traditional foods, such as pine nuts and acorns, have, for the most part, become inaccessible to Huerteños, because the traditional gathering areas have become the property of neighboring *ejidos*. Even when they grant permission to collect, government regulations make it practically impossible for rural Indians to acquire the expensive permits necessary to gather legally.

Although the community has several springs and a major water source—El Barbon River—water distribution systems for both domestic use and irrigation are inadequate and poor water quality is a persistent problem. Existing water infrastructure, including pipes and collection wells, is badly in need of repair and expansion to meet the needs of the growing community. Residents report a worsening situation, with water visibly full of dirt. This same water is currently used for both drinking and irrigation. An unfinished Rotary Club fish pond project has also affected the water situation and the general viability of the project remains to be proved.

Erosion has affected many parts of the community, possibly due to extensive grazing both within the community and further upstream in the same watershed. Logging and other activities upstream in the watershed may also be factors. Parts of La Huerta's land base, and particularly a sacred site including hot springs, are threatened by encroachment from neighboring *ejidos*.

Santa Catarina

The nucleus of this community is centered around the former Dominican mission site of Santa Catarina, with outlying ranches concentrated in the western section of the 67,828 hectares of high plain, mountain, and desert terrain that belong to the Paipai[2]. The community was first formed as a permanent settlement in 1797 when the Dominican order established a mission on a small knoll overlooking a wide valley near a permanent stream. The Dominicans attempted to place members of the southern Kumiai and Paipai groups into a permanent settlement based on an economy of agriculture and livestock. Although the mission system failed and the Santa Catarina mission itself was destroyed in 1840 by an alliance of Indian groups, agriculture and livestock have remained an important part of the Paipai subsistence strategy, as have wage labor and use of natural resources.

Following the destruction of the mission, the community moved several kilometers downstream to San Miguel, where a broad, fertile plain provided excellent farmland until the 1950s. At that time, "floods washed away the topsoil, the plain filled up with sand, and the water went underground," according to Paipai tribal member Benito Peralta.

The community moved back up to the area around the former mission site, where it has remained. A limited number of crops are still planted in the San Miguel area. Many permanent or seasonal ranches are also found around other permanent streams or springs throughout Paipai territory.

Raising livestock has long been an important economic activity for the Paipai, especially since the large amount of territory and its division into higher and lower altitudes conveniently allows for winter and summer grazing. Agriculture has, for the most part, been carried out at individual family ranches or parcels, as well as in sporadic attempts at larger-scale projects at San Miguel and on the wide plain adjacent to the mission site. The clearing of natural vegetation at this latter site has been blamed by residents for the accelerated erosion of the community's main stream, where much vegetation and topsoil has been lost, the stream bed has deepened, and sand has filled the wash.

Other examples of soil erosion were also mentioned by residents. "Nowadays, when it rains hard, it opens up great big cracks in the ground. That didn't used to happen," Peralta said (Wilken 1997). The impact of grazing needs to be carefully studied, since much of the erosion in the community follows the typical pattern of environmental degradation caused by overgrazing.

Elders also commented on long-term climate change. "Winter rains used to come in October, now they might not come until December. The summer heat seems to burn more, we have seen plants like manzanita dried out by the heat. Many of the wild fruits no longer produce like they used to," Peralta said (Wilken 1997).

A growing number of artisans in the community generate a significant amount of income by making traditional paddle and anvil coil pottery. They gather clay from specific deposits, usually locations associated with specific families. Currently, clay is gathered in relatively small quantities by hand.

Natural resource management is a critical issue for the Paipai. Access to resources such as *palmilla (Yucca schidigera)*, juniper, and pine nuts depends on the ability of the Paipai to pay for expensive permits—and the environmental impact study required to obtain the permit alone costs between $10,000 and $20,000. Traditional management techniques often mitigate the impact on resources, but as use shifts from personal consumption to commercialization, studies are needed to determine the expanded impact of larger-scale production.

San Isidoro

The smaller of the two Paipai communities in terms of both population and land base, San Isidoro's 25,718 hectares extend from the western edge of Trinidad Valley down the Río San Antonio watershed toward the coastal lowlands. Most members of the San Isidoro community live outside their boundaries in the area of Los Pocitos (natural hot springs) or in Trinidad Valley, since there is no work within the community. Some Paipai have sold their land rights to non-Indians, resulting in changing demographics and an uncertain future.

Water testing has not been carried out in this community, so water quality and quantity issues cannot be determined. Because the community has had few residents and only minimal agricultural and livestock projects, the environmental impact has also been minimal. There are several areas with wide plains and sufficient water for agricultural development, but major projects have not been carried out for lack of capital and technical assistance.

San Isidoro has a variety of ecozones within its territory and, consequently, a diversity of natural resources. Currently, members of the community are seeking permits to use *palmilla (Yucca schidigera)*.

Ejido Tribu Kiliwas

The southernmost of the surviving indigenous communities of the peninsula, the Kiliwa community is located at the base of the Sierra San Pedro Martyr and east of Trinidad Valley. The 26,910 hectares of Kiliwa territory extend into a low desert region, crossing Mexico Highway 3. Most Kiliwa today live around Arroyo León or in outlying ranches, although some also live in nearby Trinidad Valley, where there are more job opportunities in addition to water, electricity, and other services.

Survival for the Kiliwa requires a diverse subsistence strategy, including such aspects as small-scale agriculture (mostly on individual ranches), raising livestock, harvesting *palmilla* and jojoba seed, collecting honey, producing handcrafts, and working as wage laborers on neighboring cattle ranches or in the fields of Trinidad Valley. As the smallest remaining indigenous group of Baja California, the survival of the Kiliwa is a serious issue for biodiversity in the region, since this population and their traditional knowledge about the uses of their abundant natural resources are the result of thousands of years of adaptation to specific local environments. The disintegration of the community resulting from the lack of economic opportunities within it make the need for sustainable economic development alternatives all the more urgent.

El Mayor Cucapá

The Cucapá originally occupied much of the lower delta of the Colorado River and surrounding desert areas. Today, the Cucapá live primarily in the settlement of El Mayor Cucapá, while their U.S. relatives, the Cocopah, live primarily in Somerton, Arizona. El Mayor is located on Mexican Highway 5 about 56 kilometers south of Mexicali. The Cucapá land base is the most extensive of all the indigenous communities of Baja California, totaling 143,000 hectares, but much of it is parched desert lacking the potential for agricultural or livestock activities. A large part of this land is the usually dry bed of the Laguna Salada, which has been greatly affected by fluctuations in the quantity and quality of water flowing in from the Colorado River. In years when sufficient water is released upstream, the lake fills and the Cucapá are able to practice traditional fishing activities. However, contaminants either from the river itself or from toxic waste dumped within the watershed have affected fish and the degree of stagnation—which is caused when fresh water no longer flows into the lake. These conditions, on occasion, have caused large numbers of fish to die.

Due to the proximity of Mexicali, illegal dumping of toxic waste has been a problem. A site where "the earth was burned and turned spongy" was described by residents as being located in a part of the watershed that feeds into the Laguna Salada. Although the site was reported to authorities, it has never been remediated. There also appears to be no plan for clean up of hazardous materials that might be spilled onto Cucapá land as a result of a highway accident.

El Mayor does have basic water and electric services, but water quantity and quality are serious concerns. Water testing is needed to assess quality issues. Currently, water is provided to homes in the community, but quantities necessary for irrigation are not available without major water infrastructure improvements such as the drilling of wells and installation of pumps and distribution systems.

Economic activities include fishing, handcraft production (primarily beadwork, bark skirts, and other traditional arts), wage labor in neighboring communities, tourist services, and use of natural resources such as sand and stone.

Working with Tribal Governments: Basic Guidelines for Access to the Native Indigenous Communities[3]

While each community may have specific guidelines for appropriate formalities for approaching them or their members, the following guidelines may be a useful orientation for organizations or individuals interested in collaborative projects or providing assistance for the communities. The first recommendation for those who are interested in working with or visiting the communities is to be very clear about intentions in seeking access to the indigenous groups, whether the objective is to collaborate in the building of houses, schools, public buildings, and other infrastructure projects; to propose economic development projects; to suggest a cultural exchange program or offer support through scholarships or language support programs; to learn about cultural traditions; to study techniques of environmental management; or to carry out some other kind of study. It should be noted that there are several organizations already working in many of these areas, some more effectively than others.

Researchers interested in working with tribal governments should begin by finding out which projects are being carried out in the specific area of interest, and learn from those who already have experience working with the communities.

Research Projects

Each discipline of the social sciences (anthropology, ethnography, sociology) or audiovisual media has its own specific methodological recommendations and ethical considerations to be followed in any research project. Any responsible researcher should be thoroughly aware of and follow them. In the case of projects with indigenous communities, specific considerations should also be pointed out. Ethical field work methodology includes having the permission of tribal cultural consultants (and when appropriate, of the community itself) before undertaking research and ensuring that all involved understand the eventual uses of the material to be gathered and/or published; giving credit to all informants and/or granting anonymity when requested; and never publishing photographs, videos, sound recordings, or other cultural resources without the permission of the subjects.

Some researchers have carried out interviews and field research for decades without any direct benefit to individuals or communities. Community members cannot know their own history and culture better through these studies if none of the information is returned to them. Researchers should always be sure to leave copies of their work with those members of the community who participated in the research, as well as with the appropriate tribal political, cultural, and educational authorities. It is also the researcher's responsibility to avoid needless repetition by reviewing the existing literature before undertaking field work. Teachers interested in taking students of any age to communities for purposes of carrying out field work are responsible for ensuring that students understand and follow principles of ethical field work.

Many people have taken photographs and videos of the communities without giving copies to them so that they might have a record of their own history. It is recommended that something be given in exchange for research information, be it economic compensation for interviews, books or other products of research to the schools, or skills or services useful to tribal consultants.

First Steps: Humanitarian Aid or Visits

Researchers should first specify the targeted community. Support is generally scarce, which is why supporting only one community at a time is recommended, as this usually yields the most effective experience. Preference should be given to the communities with the most need, and within these, the families with the fewest resources, taking into special consideration the needs of both children and adults.

Next, make an introductory visit or send a letter to the elected chief of the community explaining the purpose of the project or visit, clearly including the intentions, scope, limitations, proposed dates, number of participants, and who will benefit. This information will allow the chief to offer his opinion and suggestions, and if the proposal seems feasible, it could result in an invitation to the next town meeting for an in-person direct explanation of the proposal for the assembly, where permission to proceed may be broached.

For the meeting, it is recommended that the place, date, and time be clearly specified. Information should be left in order to communicate with the chief in case of some change of scheduling or plans. Only La Huerta and Santa Catarina have rural telephones; the rest depend on the radio network (which is not always working) through the Comisión Nacional para el Desarrollo de los Pueblos Indígenas (CDI). Usually, those who have come from outside the community will be placed at the beginning of the agenda, as a courtesy, so it is important to be punctual. Written information explaining the project should be left in the community and a response should not be required immediately. Usually, community members are hesitant to comment directly in the meeting and need to talk over the proposal in private. Once the visitors have finished their presentation and left, the community will be able to continue their meeting, which may be lengthy and involve internal affairs. Once researchers' participation has finished, they should offer thanks to the community and retire from the assembly. Do not stay in the meeting unless invited to do so.

In general, meetings in the communities are held monthly or bimonthly, usually one of the last weekend days of the month. Since the meetings require the notification of members and may be affected by weather, it is a good idea to try to obtain up-to-date information upon initiating a project from the appropriate public or private agencies.

Visit/Project Begins

Between the time permission is granted and the project begins, reminders should be sent to the community detailing when the project is to be carried out. In some communities, due to internal divisions, only some of the community members may receive information about the visit, resulting in benefits to some and not others. For this reason, it is important to ensure information about the time, place, and purpose of the visit reaches the largest number of people possible.

If the donation for the community is food, it is important to have previously requested a basic census of families from the chief, and to have organized the donation in separate packages for each family. As each family receives its package, they may be asked by a tribal or school official to sign for it. While this process may sound overly complicated, it has been developed by the communities as a way of ensuring equal distribution and avoiding conflicts. It is also recommended that a list of preferred food items be obtained from the tribal authorities, and that the list be respected, rather than substituting foods of one's own preference. In the case of used clothing, it should be organized by age and gender (women's/men's/girl's/boy's); try to make sure it is practical clothing for people living in rural communities.

For student scholarships, the professor or school director of the community should be contacted so they can provide the number, names, and ages of the students and suggest who would be the most appropriate candidates or how the funds should be distributed in the case that the amount is limited. Scholarships for secondary and high school are badly needed. None of the communities has these services—students must travel to nearby towns such as Guadalupe Valley, Ojos Negros, Trinidad Valley, Tecate, or Ensenada.

ENDNOTES

[1] This paper was condensed from the article *Natural Resource Management among Indigenous Groups of Baja California: Traditional Practices and Contemporary Perspectives,* in Baja California Indigena Symposium VI Papers, Instituto de Culturas Nativas de Baja California (CUNA), Ensenada, Baja California, 1997.

[2] Jamau, a large part of Paipai territory to the east of the present community, has been taken over by neighboring ranches that have managed to acquire a presidential proclamation deeding them the title.

[3] This section was excerpted from Kilpatrick, Alan, Michael Wilken, Michael Connolly, Mario Alberto Magaña Mancillas, and Javier Ceseña. 1998. "Indian Groups of the California-Baja California Border Region: Environmental Issues." Southwest Center for Environmental Research and Policy project #IT97-1. http://www.scerp.org.

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III

Strategies for Sustainable Development of Natural and Cultural Resources in the Paipai Indian Community of Santa Catarina, Baja California

Michael Wilken-Robertson

Introduction

Baja California's native communities are among the poorest populations of the peninsula. Living in remote settlements—the few isolated enclaves that remain of the wide territory that was once their land—these groups struggle for daily survival, attempting to make a living raising cattle, farming, making traditional crafts, and occasionally harvesting some of their natural resources such as yucca, acorns, pine nuts, herbs, and flower seeds. Unfortunately, the ability of the communities to use these resources to create sustainable sources of income for tribal members has been severely limited by the lack of access to government permits. The process of carrying out the environmental impact studies, management plans, and paperwork required to acquire permits is prohibitively expensive for these marginalized populations. As a result, the communities continue to depend on economic activities like cattle ranching and marginally successful agricultural projects, which often cause significant environmental degradation.

Ironically, all of the communities are rich in terms of land base and natural, cultural, and human resources. Furthermore, over thousands of years they have developed traditional methods of managing their natural resources, many of which may be applicable to new patterns of resource use. The purpose of the research presented in this chapter was to work with one of these communities—Santa Catarina—to create strategies for long-term management of these resources that will encourage sustainable development within the unique natural, social, and cultural context of rural indigenous communities.

This project required the integration of data from a wide variety of disciplines and sectors to reach the following objectives:

- Compile all the necessary bibliographic and field data
- Create Geographic Information Systems (GIS) to organize geospacial data for the assessment and monitoring of natural and cultural resource inventories
- Design and carry out interviews to identify human resources and community priorities
- Analyze the development potential for proposed activities
- Identify legal configurations for facilitating the permitting process and assist the community in preparing the necessary paperwork
- Create a feedback loop with communities and their leaders throughout the process
- Propose strategies for sustainable development

Methodology

To compile all the information necessary to propose strategies for sustainable development, project investigators funded by the Southwest Center for Environmental Research and Policy (SCERP) worked closely with indigenous community members, students and faculty from Universidad Autónoma de Baja California (UABC), individual researchers, and private consultants.

Perhaps the most important contributions to this effort are the following documents:

- *Ecosystems Management Proposal for the Indigenous Community of Santa Catarina (Propuesta de manejo de ecosistemas de la Comunidad Indigena de Santa Catarina),* produced in 1999 by students from the UABC's Master's Program for Ecosystems Management, in coordination with the author
- "Sustainable Development in the Indigenous Communities of Baja California" (Wilken, et al. 1998)
- "Indian Groups of the California-Baja California Border Region: Environmental Issues" (Kilpatrick, et al. 1998)
- The Master's thesis of Erika Rivera, titled "Traditional utilization of vegetative species in the Kumiai Indian Community of San Jose de la Zorra, B.C., Mexico. Current situation, perspectives and management alternatives" (or "Explotacion artesanal de especies vegetales en la comunidad indígena kumiai de San Jose de la Zorra, BC Mexico. Estado actual, perspectivas y alternativas de manejo")
- The Field Report (Informe de Camp) of Judith Bravo

The creation of the GIS database was carried out through the expertise of Mtro. Martin Escoto, then-adjunct professor of the UABC Sciences Faculty. Escoto trained Paipai tribal members Andrés Albañez and Aracely Castro in the use of a Global Positioning System (GPS) to identify the locations of their community's resources. These technicians were also taught to transfer the data to a computer and work with GIS programs. This information became part of the permanent GIS database of Baja California's indigenous communities and is housed in the offices of Instituto de Culturas Nativas de Baja California (CUNA) for use by the communities themselves and for future research.

Interviews for the identification of human resources and community priorities were designed by Erika Rivera for her thesis work in San José de la Zorra. These were applied by community members trained for this purpose. The same basic format was then applied in the Paipai community of Santa Catarina by community member Carmen Gonzales.

The analysis of development potential for proposed activities—primarily traditional handcraft production and ecotourism—is based on field work carried out by ethnologist Judith Bravo, this chapter author's personal experience promoting these activities on a small scale, and the experience of Lic. Francisco Detrell of Expediciones de Turismo Ecológico y Aventura, S.A. de C.V. A concurrent CUNA project, "Creating the Green Link for Sustainably Produced Indigenous Goods and Services," funded by the North American Fund for Environmental Cooperation, has also allowed CUNA to explore the economic feasibility of handcraft production and ecotourism and create marketing infrastructure that complements the proposals in the present study.

The identification of legal configurations to facilitate the permitting process was carried out by biologist Alfredo Acosta. Based on the recommendations of previous CUNA and UABC documents, the formation of a Conservation, Management and Sustainable Wildlife Utilization Unit (UMA) was proposed as a means of developing greater self-management of resources. Acosta compiled the data necessary to help the communities take that important next step.

Finally, to create a feedback loop with the communities and their leaders throughout the process, project supervisors and researchers met periodically with community leaders, presented preliminary findings for discussion at community meetings, and provided copies of GIS printouts and other information of special interest to the communities. A special day-long exhibit and interactive workshop was also held as part of the KURI KURI 2000 Indigenous Gathering held at San Miguel Village on July 15, 2000, for the purpose of disseminating information and demonstrating the powerful potential of GIS as a tool for environmental management. Indigenous community members who had received GPS and GIS training had the opportunity to share the information and their experiences with members of all of Baja California's indigenous communities and with the public in general. The results of these studies have also been integrated into Spanish and English posters that have been displayed at a variety of conferences and events.

It is the hope of all involved in this important project that the strategies proposed here may soon be put to work for the benefit of the communities themselves. This kind of multi-disciplinary, cross-sector approach can serve as a model and be applied to help other communities in their struggle to gain greater economic self-sufficiency through the sustainable use of natural and cultural resources.

Santa Catarina—Description

The Paipai Indian Community of Santa Catarina is located in the north-central portion of the state of Baja California, approximately 100 kilometers south of the U.S.-Mexican border. The 350-member community holds title to a total of 68,000 hectares, which are comprised of a variety of ecosystems from high plain to sierra to desert. This communally owned territory lies within the municipalities of Ensenada and Mexicali and is accessed from the city of Ensenada first by 92 kilometers along Mexico's Highway 3 (Ensenada-San Felipe) followed by 8 kilometers of dirt road to reach the main settlement of Santa Catarina. This center of population is situated between the coordinates of 31°30'30" latitude north and 115°49'30" longitude west, according to the official 1998 map of the National Agrarian Registry (Ahumada Cervantes, et al. 1999).

The predominant type of rock in the area is igneous with (Ts(B)) basalt of the late tertiary, sedimentary with (Q(al)) quaternary alluvium deposits, metamorphic with (Tpl(cg)) Pliocene conglomerates, and cretaceous (K(Gd)) granodiorite situated at the lower eastern slopes of the sierra (INEGI 1984; Carranza 1997).

The climate of this region is partially dry (Bwhs(e)) according to Koppen's climatic classification, modified by Garcia (1981), with an average temperature of 16°C to 18°C and precipitation levels measuring 200 millimeters (mm) annually. Winter precipitation levels range from 150 mm to 200 mm, with temperature lows of 0°C and highs of 15°C. Both regional and local dominant winds are north to south. In the summer, precipitation is about 50 mm, with low temperatures of 9°C and highs of 27°C. Regional dominant winds are north-to-south and local dominant winds are south-to-north.

The predominant type of soil is medium-textured regosol; in the higher regions it is coarse-textured litosol. The low to moderate terrain has fair agricultural capacity and average possibilities for drainage (INEGI 1984c; Carranza 1997).

Santa Catarina is located between Hydrological Regions RH4 and RH7. The principal stream in the western portion is Jactobojol (translated as "water splashing over rocks"), which flows through the main settlement and down to the agricultural plain and former settlement of San Miguel. This is the main source of water for the

Paipai, although several outlying ranches depend on springs or smaller creeks such as Agua Colorada. This watershed drains west to the Pacific Ocean near the town of San Vicente. On the eastern side of the community, several streams drain off the eastern escarpment of the Sierra Juárez and into the desert creating palm oases, some with hot springs, such as Agua Caliente (Meigs 1935; INEGI 1984).

The community is located in an ecotone between the San Pedro Martir chaparral and the microphile Sonoran desert scrub of San Felipe, which is known as desert or transitional chaparral (Carranza 1997). The desert chaparral is found in zones of highly arid conditions at higher elevations and occurs in places where the vegetation is transitioning to desert. This type of vegetation is characterized by various species of mountain coastal chaparral and elements of the Sonoran desert, and is located at elevations of 1,000 meters to 1,300 meters (Ahumada, et al. 1999).

The vegetation includes both conifer forests and deserts in the eastern section. Some species of chaparral include sugar bush *(Rhus ovata),* greasewood *(Adenostoma fasciculatum),* jojoba *(Simmondsia chinensis),* Mormon tea *(Ephedra californica),* flat-top buckwheat *(Eriogonum fasciculatum),* wild lilac *(Ceonothus greggii),* and two under special conservation status—juniper *(Juniperus californica),* considered rare, and piñon pine *(Pinus monophylla),* under special protection. Examples of the desert species are creosote bush *(Larrea tridentate),* mesquite *(Prosopis juliflora),* Mojave yucca *(Yucca schidigera),* prickly pear *(Opuntia prolifera),* and barrel cactus *(Ferocactus acanthodes* and *Ferocactus peninsulae)* (Delgadillo 1992 and field verified) (Table 1) (Ahumada, et al. 1999).

Table 1. List of Vegetation

Common Name	Scientific Name
Barrel cactus	*Ferocactus acanthodes*
Basin sagebrush	*Artemisia tridentata*
Brickellia	*Brickellia californica*
Broom	*Baccharis brachyphylla*
Carrizo	*Arundo donax*
Cattail	*Scirpus* sp.
Chamizo blanco	*Atriplex canescens*

Table 1. continued

Common Name	Scientific Name
Chia	*Salvia columbariae*
Cholla	*Opuntia acanthocarpa*
Chuchupate	*Tauschia arguta*
Chuparrosa	*Ipomopsis tenuifolia*
Coast live oak	*Quercus agrifolia*
Cottonwood	*Populus fremontii*
Creosote bush	*Larrea tridentata*
Deerweed	*Porophyllum gracile*
Elderberry	*Sambucus mexicana*
Estafiate	*Ambrosia psilostachya*
Flor de concha	*Centaurium venustum*
Golondrina	*Euphorbia micromera*
Gordolobo	*Gnaphalium purpureum*
Greasewood	*Adenostoma fasciculatum*
Heliotrope	*Heliotropium curassavicum*
Hen and chicks	*Dudleya pulverulenta*
Hen and chicks	*Dudleya lanceolata*
Hierba colorada	*Rumex violascens*
Hierba de la víbora	*Daucus pusillus*
Hierba del burro	*Isomeris arborea*
Hierba del empacho	*Mirabilis lavéis*
Hierba del pasmo	*Haplopappus juarezensis*
Hierba santa	*Eriodictyon trichocalix*
Hierba santa	*Eriodictyon angustifolium*
Hierba santa	*Eriodictyon lanatum*
Indian tobacco	*Nicotiana glauca*
Islay or California cherry	*Prunus ilicifolia*
Jimson weed	*Datura inoxia*
Jimson weed	*Datura discolor*
Jiuata	*Lotus scoparius*
Jojoba	*Simmondsia chinensis*
Juncus	*Juncus acutus*
Juncus	*Juncus cooperi*
Juniper	*Juniperus californica*

Table 1. continued

Common Name	Scientific Name
Laurel sumac	*Rhus laurina*
Lizard's tail	*Anemopsis californica*
Llámate	*Asclepias subulata*
Manrrubio	*Marrubium vulgare*
Manzanita	*Arctostaphylos glandulosa*
Mayflower	*Viguieria laciniata*
Mesquite	*Prosopis glandulosa*
Mezquite	*Prosopis juliflora*
Mohave yucca	*Yucca schidigera*
Monkey flower	*Mimulus brevipes*
Mormon tea	*Ephedra californica*
Moronel	*Lonicera subspicata*
Mulefat	*Baccharis glutinosa*
Nettles	*Urtica holosericea*
Nolina	*Nolina palmeri*
Oak	*Quercus chrysolepis*
Our Lord's candle	*Yucca whipplei*
Piñon pine	*Pinus quadrifolia*
Pitaya	*Echinocereus engelmannii*
Prickly pear	*Opuntia engelmannii* and *phaecanta*
Rabbit's pillow	*Baileya pleniradiata*
Romerillo	*Baccharis saratroides*
Romero	*Trichostema lanatum*
Royal sage	*Salvia pachyphylla*
Rush Chaparral-Star	*Haplopappus junceus*
Salvia	*Salvia californica*
Scrub oak	*Quercus dumosa*
Sugar bush	*Rhus ovata*
Sycamore	*Platanus racemosa*
Tofe	*Phoradendron bolleanum*
Water cress	*Nasturtium officinale*
White sage	*Salvia apiana*
Wild ash	*Fraxinus trifoliata*
Wild buckwheat	*Eriogonum fasciculatum*

Table 1. continued

Common Name	Scientific Name
Wild garlic	*Chaenactis tenuifolia*
Wild lilac	*Ceanothus cuneatus*
Wild peony	*Paeonia californica*
Wild tobacco	*Nicotiana atenuatta*
Willow	*Salix hindsiana*
Willow	*Salix laevigata*
Zorrillo	*Chorizante interposita*

Source: Ahumada Cervantes, et al. 1999

As in the rest of the state, this area is composed of a wide variety of vertebrates that do not have exact boundaries in their movements, particularly in this area of transition. Some of the species include squirrel *(Spermophillus bechei),* chipmunk *(Spermophillus* sp.*),* rabbit *(Sylvyllagus audubonii),* and woodrat *(Neotoma* sp.*)*. In some regions, there are occasionally migrant species like deer *(Odocoileus hemionus fuliginata)* and Bighorn sheep *(Ovis canadiensis cremnobates)*. Also, various predator species exist, such as coyote *(Cannis latrans),* fox *(Urocyon cinereoargenteus),* lynx *(Lynx rufus),* and California puma *(Puma concolor californicus)* (Garduño 1994). Bird species include quail *(Callipepla californica),* dove *(Zenaida asiatica),* white-winged dove *(Zenaida macroura),* white owl *(Tito alba),* falcon *(Falco* sp.*),* roadrunner *(Geocoxis californicus),* and five under special conservation status—the golden eagle *(Aquila chrysaetus),* in danger of extinction; the prairie falcon *(Falco mexicanus)* and purple finch *(Carpodacus purpureus),* which are threatened; the red-tail hawk *(Buteo jamaicencis),* under special protection; and the burrowing owl *(Tecolotillo serrano),* a rare species (Table 2).

Before the arrival of non-Indian cultures, the ancestors of the Paipai were semi-nomadic hunters and gatherers who developed a highly mobile way of life based on the use of a diversity of natural resources from a variety of ecosystems. Some aspects of this traditional lifestyle—such as gathering plant foods and medicines; hunting; and the use of soils, plants, and animals for manufacture of traditional arts—are still important in Paipai subsistence strategies.

Table 2. List of Wild Fauna

Common Name	Scientific Name
Aguililla migratoria	*Buteo swainsoni*
Bighorn sheep	*Ovis canadensis*
Black-shouldered kite	*Elanus caeruleus leucurus*
Bolsero parisino	*Icterus parisorum*
Calandria zapotera	*Icterus cuculiatus*
Camea	*Chamea fasciata*
Carbonero oregones	*Junco hyemalis*
Cardenalito	*Pyrocephalus rubinus*
Carpintero aliblanco	*Sphyrapicus thyriodes*
Carpintero alirojo	*Colapter cafer auratus*
Carpintero encinero	*Melanerpes formicivorus*
Carpintero nuttall	*Piccoides nuttallii*
Carpintero saucero	*Sphyrapicus ruber*
Carpodaco de cassin	*Carpodacus cassini*
Cascanueces americano	*Nucifraga columbiana*
Chara pechirrayada	*Aphelocoma coerulences*
Chipe celato	*Vermivora celata*
Chipe negrigris	*Dendroica nigrescens*
Chipmunk	*Ammospermophilus leucurus*
Colorín sietecolores	*Passerina ciris*
Common poorwheel	*Phalaenoptilus nuttaliii*
Contopus de chaleco	*Contopus borealis*
Contopus occidental	*Contopus sordidulus*
Copetón cenizo	*Myiarchus cinerascens*
Coyote	*Canis latrans*
Cuervo grande ronco	*Corvus corax*
Cuitlacoche	*Toxostoma radivivum*
Cuitlacoche ceniciento	*Toxostoma cinereum*
Dove	*Zenaida macroura*
Empidonax de wright	*Enpidonax wrightii*
Gavilán pajarero	*Accipiter striatus*
Gavilán pechirrufo	*Acciper cooperi*
Golden eagle	*Aquila chrysaetus*
Golondrina grande	*Progne subis*
Golondrina verde	*Tachycineta thalassina*

Table 2. continued

Common Name	Scientific Name
Gorrión barbinegro	*Spizella atrogularis*
Gorrión coronirrufo	*Spizella passerina*
Gorrión indefinido	*Spizella breweri*
Gorrión troglodita	*Amphispiza belli*
Gorrión vulpino	*Passerela iliaca fulginosa*
Gray fox	*Urocyon cinereoargenteus*
Gusanero	*Dendroica coronata*
Halcón cernícalo	*Falco sparverius*
Hare	*Lepus californicus*
Hummingbird	*Doricha eliza*
Hummingbird	*Calypte anna*
Hummingbird	*Archilochus alexandri*
Hummingbird	*Stellula calliope*
Jilguero canario	*Carduelis tristis*
Jilguero norteño	*Myadestes towsendi*
Jilguero pinero	*Carduelis pinus*
Lechuza barranquera	*Asio otus*
Lechuza blanca	*Tito alba*
Lesser nighthawk	*Chordeles acutippennis*
Mosquerito barranqueño	*Empidonax difficilis*
Mountain lion (puma)	*Puma concolor*
Mule deer	*Odocoileus hemionus*
Northern harrier	*Circus cyaneus*
Northern pygmy owl	*Glaucidium gnoma*
Northern roadrunner	*Geococcys californicus*
Papamoscas negro	*Sayornis nigricans*
Para cejiblanco	*Parus gambei*
Pelucilla	*Wilsonia pusilla*
Perlita piis	*Polioptila coerulea*
Picocruzado	*Loxia curvirostra*
Piquituerto común	*Coxia curvirrostra*
Prairie falcon	*Falco mexicanus*
Purple finch	*Carpodacus purpureus*
Quail	*Callipepla californica*
Quail	*Oreortyx pictus*

Table 2. continued

Common Name	Scientific Name
Rabbit	*Silvilagus bachmani*
Rabbit	*Sylvilagus audubonii*
Rascador pinto oscuro	*Pipilo erythrophthalmus*
Red-tail hawk	*Buteo jamaicencis*
Rellesuelo de rojo	*Regulus calendula*
Saltapared enano	*Sitta pygmaea*
Sastrecito	*Psaltriparus minimus*
Sharp-shinned hawk	*Accipiter striatus*
Sita pechiblanca	*Sitta carolinemsis*
Skunk	*Spilogale putorius*
Sparrow	*Carpodacus mexicanus*
Squirrel	*Spermophilus bechei*
Swainson's hawk	*Buteo swainsoni*
Tangara aliblanca	*Piranga lodoviciana*
Tecolotito chillón	*Otus kennicottil*
Tigrillo	*Pheucticus melanocephalus*
Tirano gritón	*Tyranus vociferans*
Tordo ojiclaro	*Euphagus cyanocephalus*
Tordo solitario	*Catharus guttatus*
Troglodita continental	*Troglodytes aedon*
Troglodita saltapared	*Catherpes mexicanus*
Urraca piñonera	*Gymnorhinus cyanocephalus*
Ventura azul	*Siala mexicana*
Verdugo cabezón	*Lanius ludovicianus*
Vieja	*Pipilo fuscus*
Vireo anteojillo	*Vireo solitario*
Vireo gris	*Vireo vicinor*
Vulture	*Cathartes aura*
White-wing dove	*Zenaida asiatica*
Wildcat	*Lynx rufus*
Zone-tail hawk	*Buteo albonotatus*
Zorzal pichirrojo	*Tordus migratorius*

Source: Ahumada Cervantes, et al. 1999

However, since the mission period beginning in 1797 and with the establishment of a sedentary way of life, livestock grazing—and to a lesser degree agriculture—have become increasingly important forms of land use. For the last century and a half, many Paipai have made a living outside of the community working as wage laborers for neighboring ranches, in mines (during Baja California's gold rush from 1860 to 1880), and in agricultural projects. Today, along with the these economic activities, many Paipai make a living from the manufacture and sale of traditional handcrafts, by extracting natural resources such as yucca and firewood for sale to outsiders, by working for state-run road maintenance projects, or by teaching in the local school.

A network of dirt roads crisscrosses the western portion of the territory, which is the area of Santa Catarina where most community members live and carry out a variety of economic and social activities. Currently, road improvement programs—a major source of employment for the Paipai—are focused on improving access to the eastern desert area of the community's territory.

Homes and ranches are constructed from a variety of materials, including traditional brush huts, adobe, stone, wood, cinder block, and recycled materials. During 2000, a solar-powered water system servicing the main settled area was installed through a collaboration between the non-governmental organizations AquaLink and CUNA, and the Baja California state government. During the same year, the state also provided small solar energy systems to each home or ranch because the community lacks a central energy system or access to Federal Energy Commission (in Spanish, Comisión Federal de Electricidad, or CFE) lines.

A primary school, cafeteria, and boarding facilities, as well as a "telesecundaria" (a secondary school with televised course components), provide basic education for approximately 50 children. The elusive goal of bilingual education (Spanish and Paipai) has proven difficult to attain, however it continues to be an official priority. Many children are exposed to both Paipai and Kuatl (apparently a hybrid of Kumiai and Paipai), and although these native languages are losing ground to Spanish, fluency is still much higher than in other Pai communities north of the border. Increased funding for expanded language preservation programs is critical and would represent an important investment in this rare and valuable cultural resource. Students who want to study beyond secondary school must move to Trinidad Valley, Ensenada, or other towns with high schools. Currently, CUNA's scholarship program provides basic support for the nine secondary students and 15 high school students from Santa Catarina.

Health services are provided to the community through CUNA's Medical Aid Network and the state health agency, Instituto de Servicios de Salud Pública de Baja California (ISSESalud). Many members of the community retain traditional knowledge of medicinal plants (Cortés 1994) and often prefer to self-diagnose and treat before resorting to biomedicine (Fleuriet 2002). A clinic in the community has recently been renovated by ISSESalud and a doctor has been assigned to make regular visits.

The community has no tribal office or infrastructure to support its elected officials, save a partially constructed meeting hall for monthly *juntas*, or gatherings where issues of interest to the community are discussed and decisions are made.

Environmental Management by Ecosystem Units

To assist the community with long-term environmental planning, students from the Ecosystems Management Masters program at UABC analyzed the possibilities for land use based on ecologically homogenous areas, taking into consideration their current and potential uses. These units were identified as chaparral with juniper, chaparral without juniper, pine forest, riparian vegetation, desert, and populated areas. Students evaluated several activities based on current or potential use, including agriculture, livestock, habitation, ecotourism, and conservation. Traditional use of plants and soils for the manufacture of handcrafts will be treated separately in this chapter. Traditional harvesting of flora and fauna for food, medicine, and other purposes was considered innocuous or beneficial at current levels, however at commercial levels, specific studies would be necessary on a species-by-species basis (Ahumada Cervantes, et al. 1999).

The students assigned values to the different activities in the context of each ecosystem unit depending on whether its impact would be favorable (+1), null (0), or unfavorable (-1). The value assigned represents the importance each factor had for each of the activities, depending on the biotic or abiotic components that the activity required to be carried out successfully. These were classified as very important (3), important (2), and less important (1). To evaluate impact on environmental quality in the community, the students created an environmental impact matrix allowing them to identify specific impacts on water, soils, air, vegetation, fauna, economy, and culture. The results of this system of quantification are presented in Table 3 and are the basis for the Ecological Management Ordinance proposed by the students (Ahumada Cervantes, et al. 1999).

Table 3. Ecosystem Capacity

Ecosystem Unit	Agriculture	Livestock	Settlement	Ecotourism	Conservation
Chaparral with juniper	1	1	23	17	13
Chaparral without juniper	1	1	23	17	13
Pine Forest	-10	-2	5	17	17
Riparian Zone	13	2	7	20	15
Town-habitation areas	7	2	23	2	-9

Source: Ahumada Cervantes, et al. 1999

The Ecological Management Ordinance is a planning tool for local development as articulated by the General Law for Ecological Equilibrium and Environmental Protection (in Spanish, Ley General del Equilibrio Ecológico y la Protección al Ambiente, or LGEEPA). As environmental policy, it is the duty of the federal, state, and local governments to comply with the priorities of established ordinances. Table 3 presents the basis for an ordinance for Santa Catarina based on the land use capacity of each ecosystem unit. Positive values indicate a high capacity for a particular activity, negative values indicate that the ecosystem cannot support a particular activity.

Both types of chaparral (with or without juniper) show similar results. Livestock grazing is not recommended because the soils in these areas are poor and extensive grazing requires fertile soil that regenerates quickly. This land is not recommended for agriculture because of its uneven soils and lack of water. The recommended policy for this ecosystem is that of continued use for habitational, ecotourism, and conservation activities, as well as carrying out traditional activities such as the gathering of seeds, plants, and fruits. The extraction of certain resources such as yucca and juniper—which currently represents an important source of income for the community—should also continue with careful management and seek to add value wherever possible to the raw materials. This area also has a high capacity for ecotourism, as will be discussed later in this chapter.

Pine forest areas are also not suitable for agriculture and grazing due to the steep slopes and lack of water. The steep slopes also impede access for other types of development. These areas are recommended for ecotourism and conservation because they include many attractive landscapes and most of the species with some kind of protected status.

The best uses for riparian areas are ecotourism, conservation, and agriculture; the least appropriate is livestock grazing. Conservation is appropriate because drinking water and many of the most important materials for handcraft production (willow, palm, juncus, cottonwood, and clay) also come from these areas.

The habitational areas, most of which have been established on land that was cleared of chaparral, are best suited for continued use as human settlements. These areas have been most severely impacted environmentally, so reforestation of parts of them is recommended to reverse the impact of increasing soil erosion (Ahumada Cervantes, et al. 1999).

The desert areas in the eastern portion of the community are remote and practically uninhabited by humans, except for occasional cowboys who take cattle down from the mountains during the winter to graze in the warmer desert areas. Because little information is available about the desert ecosystem of the Paipai and the students were not able to visit the remote area, it was not included in this environmental evaluation. However, members of the Paipai community have expressed interest in the potential for ecotourism development of the palm oases and hot springs, as well as the development of mining for flagstone in this section of their land.

Environmental Issues

Water Quantity and Quality

The main stream of Jacotobojol provides the main settlement of Santa Catarina with an adequate drinking water supply through the newly functioning solar water pumping system. Outlying ranches at Jayuacahuatl (Agua Colorada) collect surface water in buckets, storage drums, or gravity-fed hoses. Many other springs throughout the territory provide water for single family ranches such as Rincón de Santa Catarina, Agua Escondida, Jamin, and San Miguel, or for seasonal camps such as Agua Caliente, La Parra, and El Alamito. In many cases, these springs have been dug out and small earthen dams formed to retain water.

Water quality is better than in other indigenous communities of the region, however, high nitrate levels may be the result of waste contamination or fertilizer runoff (Wilken-Robertson 1996). Livestock is often seen grazing in the riparian area upstream from the water system intake and the area has not been fenced to avoid contamination in the immediate area. Washing clothes in the stream and bathing may also affect water quality (Ahumada Cervantes, et al. 1999). The new water system pumps all water up to one central holding tank, offering the possibility of chlorinating or otherwise treating water. This measure has been proposed to the community, but there is resistance to the possible effect on the taste of the water and because the Paipai report they are already accustomed to the local water flora.

Currently, water for irrigation comes primarily from groundwater. An irrigation ditch diverted from the Jacotobojol stream, parts of which date from the mission period, has long been used to irrigate some of the fertile plains along the riparian area near the main settlement. During the last several years, several kilometers of hose have been used to irrigate crops in the former settlement area of San Miguel. The area also has at least two wells that are not currently functioning. According to a local hydrology map, the San Miguel area should have plenty of groundwater for irrigation. The eastern desert areas are also indicated as potential sources of groundwater that could be applied to agricultural projects. The Paipai have expressed interest in developing their land's agricultural potential, but they have also pointed out the failed agricultural projects of neighboring communities where natural species have been cleared and the plots abandoned, leading to an accelerated process of desertification (Wilken 1997). Traditional and contemporary management of already established native plants such as yucca, jojoba, juniper, barrel cactus, and many other species has also been described by some researchers as a form of agriculture (Blackburn 1993) that may be preferable to large-scale irrigated agricultural development for the Paipai.

Air

Although no studies have been carried out in the community, air quality appears to be excellent; there is no visual or pathological evidence to suggest air quality problems. Clean air is itself an important resource that may be an added attraction for ecotourism in the community. According to the UABC study, the only possible sources of air pollution would be dust from wind erosion resulting from changes in land use, such as the loss of vegetative cover due to grazing and new roads, and the occasional burning of trash.

Soils

Contamination of soils does not appear to be a problem in Santa Catarina, but soil erosion appears to be increasing due to extensive livestock grazing, and this increases the volume of dirt roads, vehicular traffic (several major off-road races pass through the community each year), and clearing of land for habitation and agriculture. Much of the fertile soil formerly used for agriculture along the riparian areas has washed away during the floods of the last half century, perhaps due to changes in land use farther up the watershed. A small amount of clay is mined for the manufacture of traditional pottery, a topic broached later in this chapter.

Trash

The community has no centralized infrastructure for waste disposal. Trash often accumulates near living areas until it is burned. The UABC study recommends that the community designate a landfill area to which trash could be removed on a regular basis, possibly with the cooperation of the municipal government (Ahumada Cervantes, et al. 1999).

Cultural Resource Management Proposals

Santa Catarina is blessed with a rich diversity of cultural resources, perhaps more than any other native community of Baja California. Historic sites from ancient, mission, ranch, and modern periods; vast knowledge of the land, its flora, and fauna; living traditions of language and arts; native construction experience, including traditional housing and adobe manufacture; cowboy culture; and many other aspects of Paipai ways of life represent valuable resources for Santa Catarina. Community members often express their interest in preserving these aspects of their culture, especially since they help reinforce their identity as native Baja Californians. A highly effective means of ensuring the transmission of these components of indigenous culture is through revitalization of their value within the Paipai economy.

The revival of traditional handcraft production illustrates how this process can help native artisans preserve, practice, and reinterpret the knowledge passed on from their ancestors while at the same time strengthening and diversifying their tribal economy and self-sufficiency. Ceramics, agave fiber nets, bows and arrows, and other tools—originally indispensable utilitarian components of Paipai material culture and economy—were rapidly falling from use by the middle of the twentieth century due to the introduction of new materials (Michelson 1971). Twenty years ago, only four older women of Santa Catarina occasionally made pottery, mostly for sale to infrequent tourists who happened on the community. Younger women rarely took the time to learn the skills for what seemed to be a dying art. Today, however, this trend has been entirely reversed. Growing interest and emerging markets for their wares has allowed many of the artisans to dedicate all their productive hours to traditional handcraft production. Daughters and granddaughters have learned the skills and become recognized artisans; older and younger men have also become specialists at making bows and arrows, wooden ladders, gathering buckets, rabbit sticks, and leather goods. They also specialize in providing raw materials to ceramicists. New forms like the pine needle and palm basket have been developed and quickly perfected, while traditional wares are also evolving in exciting and dynamic directions.

These developments have been greatly enhanced by the ability of artisans to access markets throughout the original territory of their Yuman ancestors, which includes California, Arizona, and Baja California. Over the last eight years, artisans have been invited to participate in events and gatherings in museums, on Indian reservations, and at schools, historic sites, state parks, and conventions. They are often asked to teach classes to students in related Indian communities of the United States, reinforcing the transmission and preservation of skills in areas where these ancient traditions had been lost. Clearly, both the knowledge and products of these skills have taken on a new value in the Paipai economy. Fortunately, most of the handcraft processes involve sustainable environmental management practices and, even at significantly higher commercial levels, they can continue to provide important economic benefits without sacrificing the integrity of the environment. This is especially useful because these and other culturally based activities allow the Paipai to replace environmentally degrading activities like poorly managed cattle and goat ranching with better-paying, environmentally friendly jobs.

Increasing Handcraft Production

The dramatic increase in quality and quantity of handcraft production reflects a variety of changing dynamics in the Paipai economy:

- Growing appreciation for traditional arts creates new markets
- Younger people choosing to stay in their communities to take advantage of new and more diversified economic opportunities
- The handcraft cottage industry providing better income than non-sustainable activities

- Increased initiative, empowerment, and self-sufficiency, especially for women
- Development of partnerships with outside organizations, communities, and individuals that assist or do business with artisans

Currently, the limits on handcraft production include:

- The need for wider and more consistent markets for products, improved infrastructure for the promotion and distribution of products, and training of apprentices by master artisans to increase quantity and quality of production
- The lack of legal permits for natural resources used in manufacture, long-term environmental management plans for resources used, and tribal members with advanced marketing, business administration, and foreign language skills

Fortunately, there are several concrete steps that can be taken by native community members and tribal governments and non-governmental organizations to overcome these limitations. The widening of markets and assurance of a more consistent income for artisans goes hand-in-hand with the improvement of infrastructure for production, promotion, and distribution of products. At a local level, one recommendation is to encourage the development of outlets for products within the communities themselves. A limited number of buyers occasionally visit the communities now, but many potential retail and wholesale customers might not even know the communities exist or may lack information about how to find them. For this reason, it is important to create a destination such as a community museum—which provides important contextual information about the handcraft traditions—with a marketplace space accessible to all artisans.

Artisans from both Santa Catarina and San José de la Zorra can take advantage of the proximity of a major highway (Mexico 3) with sufficient traffic to guarantee a certain level of sales. A small but highly visible booth with appropriate signs would require a minimal investment and could provide ongoing returns. Wholesale distribution to retail stores in the urban areas of the Baja California border region is a strategy recently explored by enterprising young tribal members. However, the cost of fuel and vehicle maintenance limits the feasibility of this strategy.

The establishment of retail outlets specializing in native handcrafts with promotion through the Internet provides worldwide exposure for indigenous handcrafts. One example of this is Nativa Indian EcoArts in Ensenada, Baja California (http://www.nativa.netfirms.com.mx). This non-profit project of CUNA was designed to assist native artisans through the promotion and distribution of sustainably produced indigenous handcrafts.

Although the lack of legal permits for use of natural resources for handcraft manufacture is currently not a major limitation, it is an issue that will begin to affect artisans as their work becomes more widely distributed. This is because Mexico's Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) requires permits for the commercial use of most natural resources. Permits may also be required for the export and/or certification of handcrafts. Fortunately, the system of UMAs can help communities get the permits they need through the management of their natural resources.

For long-term environmental management planning, communities can benefit from partnerships with academic and research institutions such as UABC and Centro de Investigatión Científica y de Educación Superior de Ensenada (CICESE), and civil associations such as CUNA. These groups can collaborate with the communities to carry out studies of individual species and ecosystems, as well as create natural resource databases through GIS.

For indigenous communities to realize additional economic benefits from handcraft production, tribal members need to develop advanced marketing, business administration, and foreign language skills. Currently, few tribal members have had the opportunity to continue their education beyond the primary level. For this reason, it is imperative to identify and support native students interested in developing careers in these areas. Support is needed for long-term scholarship programs that help students complete their studies.

Programs for the training of apprentices by master artisans may be available through the Mexican government or international foundations and would be an excellent investment to increase the quantity and quality of production. Furthermore, since most artisans are fluent in their native languages, classes could also encourage the transmission of this vital aspect of culture.

Management Design for Sustainable Pottery Production

Potters from Santa Catarina have identified at least two sources of clay in the vicinity of their community. These deposits have been mined for at least half a century and probably much longer, as evidenced by numerous potshards found throughout the area. Because relatively small amounts of clay are needed to support the small level of production, the impact on the deposits is minor; they still appear to contain a large amount of raw material for continued production. A small area of vegetative cover approximately 80 square meters in size appears to have been affected, but this impact is miniscule compared to that of cattle grazing, agricultural projects, and road construction.

As in the past, clay is mined with pick and shovel. One kilogram of raw clay yields approximately 500 grams of fine clay powder, which is hydrated and kneaded to make workable clay. A finished pot weighing 500 grams can be sold for approximately $4.50 (500 pesos)—more than 160 times the price paid for clay sold as adobes. Clearly, the cultural value added makes pottery the best possible use of clay soil resources.

Currently, eight artisans regularly make pottery, and many of their children are also learning the skills of the trade. For many of these ceramicists, pottery represents their primary source of income. Pottery is also a key element in Paipai cultural identity and in recent years has become an important link with other indigenous groups of Baja California, California, and Arizona as Paipai teachers are contracted to teach their skills throughout the Yuman region. Considering that the Paipai have more than 68,000 hectares of land and there are undoubtedly other clay deposits within their community, pottery represents an excellent option for years to come, even at increased levels of commercialization. The GIS developed for Santa Catarina may be useful for detecting potential deposits for mining clay.

Firing

The preferred material for firing pottery is the dead, dried stem of the Mohave yucca *(Yucca Schidigera)*, although cow manure can also be substituted. Yucca does not have a special conservation status. The firing is carried out in shallow pits and appears to generate a minimal amount of smoke. This simple firing process uses no glazes or potentially harmful chemicals.

Mitigation of Impact

Eventually, the mining of clay leaves a shallow depression between 40 centimeters (cm) and 110 cm over an area of about 8 square meters. The potters have pointed out that this is eventually filled in during flood conditions, erasing any signs of impact. As production increases, clay deposits should be inspected twice annually to assess the impact on vegetation. If the impact on large areas of vegetative cover appears to be adverse, other clay deposits should be identified while those that have been affected are allowed to fill in by natural processes.

Ecotourism Proposal

Carefully managed ecotourism can allow the community to use—and at the same time conserve—its most valuable resources: unique landscapes, pristine habitat, biodiversity, historic sites, knowledge of the environment and native peoples' roles in it, traditional indigenous culture, and cowboy culture, among many others. To take advantage of this potential, basic infrastructure needs to be established. Based on interviews with the Paipai tribal council, consultations with the community at their monthly assembly, and the experience of CUNA and EcoTour Adventures, S.A., a special area for ecotourism operations has been designated and the following infrastructure needs identified:

- An adobe or stone principal structure to include an office and registration area, a kitchen and dining area, and restrooms

- 12 traditional houses (six adobe cabins and six brush houses made from juniper, willow, agave stalks, and other local materials) with rustic beds, table, chairs, and chimney
- Camping area
- Shade ramadas
- A solar energy system to provide minimal electricity to the area
- Men's and women's restrooms with environmentally appropriate toilets and showers
- Picnic-type tables
- Campfire facilities
- Access roads
- Parking areas
- Fences
- Signs
- Protection of native flora and carefully planned landscaping with native plants to provide shade and screening of parking, water tanks, and other areas

Mission Santa Catarina

One of the outstanding historic sites in the community is the former mission of Santa Catarina, founded by the Dominicans in 1797. The excavation of this site could help lead to a better understanding of this critical period in the community's history and could provide many years of employment for local community members who could be trained as para-archaeologists. A full-scale excavation of the site, carried out in collaboration with the National Institute of Anthropology and History, could also attract students interested in archaeological field work and provide a basis for the construction of a replica and museum, thereby creating a more attractive destination for ecotourism, all of which would generate income for the community.

Museum

A community museum, possibly housed in or near the replica of the mission, would give the Paipai the opportunity to tell the story of their people and culture, including mythology, native ways of life, evolution of traditional handcrafts, ancient and recent history, language, and whatever else they consider important and appropriate to share. The museum could also include spaces where local artisans could exhibit their wares and demonstrate techniques of manufacture.

Suggestions for Further Study

Many other activities to promote sustainable economic development have been identified by the indigenous community, but further studies are needed to ascertain the feasibility and sustainability of these activities to ensure a dynamic, diversified economy for the community. To avoid the prohibitively high cost of paying private consultants for these studies, many of them can be carried out through the continued collaboration of the indigenous community with CUNA, UABC, the Southwest Center for Environmental Research and Policy (SCERP), and other foundations. Furthermore, the GIS database, which has been created for the community, can be used for and enhanced by future studies. Some priority research topics include:

- Long-term water planning
- Agricultural potential
- Establishment of nurseries for the production of fruit trees, native plants, and others with commercial potential
- Use of specific plant species (juniper, yucca, barrel cactus, cholla, etc.)
- Potential for a processing plant for making finished products from yucca, herbs, and other natural resources
- Production of furniture made from native plants and other local materials
- Collection and/or propagation of native flower seeds
- Development of the Agua Caliente hot springs location
- Addition of a water park to the Paipai EcoVillage
- Livestock management
- Extraction of flagstone

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IV

The Development of a Geographic Information System at Tohono O'odham Nation, Arizona

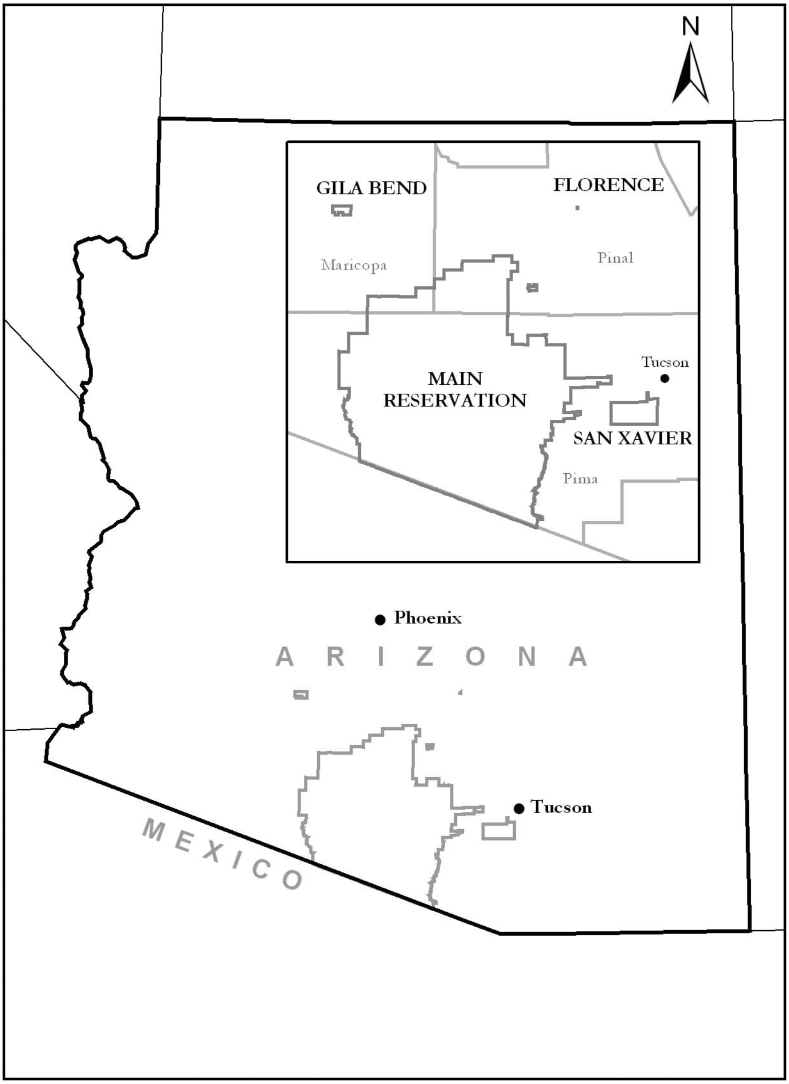
Phoebe B. McNeally, Barry Biediger, and Daniel McCool

Introduction

With the widespread movement among tribal nations to take over management responsibilities from the Bureau of Indian Affairs, developing a Geographic Information System (GIS) is central to facilitating the self-management of their resources. To that end, the University of Utah Department of Geography's DIGIT Lab, in cooperation with the university's American West Center and the Southwest Center for Environmental Research and Policy (SCERP), developed a GIS database for the Tohono O'odham Nation. The goal of this project was to help the nation manage its own resources and enhance its self-determination.

The Tohono O'odham Nation is located on the U.S.-Mexican border in Arizona's Sonoran Desert. It occupies portions of Pima, Pinal, and Maricopa counties (Figure 1). The relatively large nation comprises four separate reservations totaling more than 2.8 million acres with an approximate total population of 20,000. The main reservation covers nearly 1.1 million hectares; the San Xavier and Gila Bend reservations and Florence Village cover 29,100, 4,200, and 8 hectares respectively.

Figure 1. The Tohono O'odham Nation



Source: Authors

Project Development

A research plan was formulated jointly at a meeting in February 2000 with representatives of the nation's major data users. This user group concluded that before the Tohono O'odham Nation can begin to benefit from GIS and spatial information technologies, it must first develop a strategic plan to determine and prioritize the data needs of the nation's agencies. This would help avoid unnecessary duplication of effort and promote opportunities for data sharing and partnering. The user group, coordinated by representatives from the Tohono O'odham Nation Environmental Office and Planning Department, formulated three tasks—first, assess the nation's needs, and second, develop a strategic plan for GIS use. The third task was to compile, organize, and document as many of the priority data sets as feasible within the project's budget to create a data product that can be distributed to end users in the nation.

Task 1—Agency Questionnaire and Needs Assessment

The DIGIT Lab is an auxiliary facility that operates within the University of Utah's research infrastructure and provides support for both theoretical and applied geographical information analysis and application development. Based on its expertise in designing GIS for clients, the lab prepared a questionnaire to solicit information from federal, state, and local agencies (see Appendix A). The purpose of the questionnaire was to determine the availability, quality, extent of coverage, and costs of environmental data in the region occupied by the nation. The questionnaire contained a brief statement of the proposed objectives for the data; that helped give respondents an idea of what data would be most useful to the nation. A slightly different questionnaire was used to solicit information from the agencies of the Tohono O'odham Nation. This questionnaire contained supplemental questions about mapping and spatial analysis needs, as well as questions designed to determine the specific data needs of end users and how that data would be used. Some basic information explaining GIS and spatial analysis concepts was included in this internal questionnaire because it was a technology unfamiliar to many of the tribal personnel. Both questionnaires were submitted to the appropriate officials at Tohono O'odham for their approval.

Responses to the internal questionnaire came in large part in the form of informal communications with many of the nation's potential data users. The informal communications took place in a series of meetings among tribal members and administrators and staff from the University of Utah. The objective of the meetings was to ensure that the data compiled accurately matched the needs of the nation. While the responses were not written, nor were they as formal as expected, it is clear that the questionnaires brought about a deeper consideration of the nation's data needs than if a detailed questionnaire had not been created.

The responses received from the internal questionnaire were compiled and analyzed by DIGIT Lab. A matrix was prepared to summarize data availability, data quality, extent of coverage, and costs (if any). Based on these responses, DIGIT Lab assessed the needs reported by the nation's data creators and users to prepare a report. At a series of meetings, the report and matrix were presented to the user group at the nation for review. The user group then determined priorities for data acquisition.

Tribal members were especially interested in data that would help them develop natural resources on the reservation in a manner that protected the natural environment and served the larger goal of the reservation, which is to provide a homeland for the Tohono O'odham people. When non-Indians conduct research on Indian reservations, it is imperative to get permission and approval from tribal officials at every step of the research process. Tribal members are sensitive to being exploited merely for the sake of non-Indian research, thus, the objective of the research must always be to serve the needs and interests of tribal members. This requires an iterative process that may seem redundant to the researcher, but is imperative to ensure a complete understanding of tribal interests.

Using the information about available data and the relative priority of needs identified in the needs assessment, the user group made specific data requests from agencies that minimized the burden on them while providing the nation with data to meet their needs. Data requests to agencies were submitted with a cover letter from the chairman of the Tohono O'odham Nation.

Task 2—GIS Strategic Plan

Based on the results of the needs assessment and responses to the questionnaires, DIGIT Lab prepared a plan to guide the ongoing implementation of GIS at the Tohono O'odham Nation. The intent of the strategic plan was to provide initial guidance for the nation's agencies in their efforts to accomplish their missions by making better use of available data resources, reducing data costs, and improving the quality and utility of GIS data.

Central to the plan was the procurement of GIS software for the potential users in the nation's district offices. It was decided that most users would need only limited functionality, such as data query and simple map output. Taking this into account, DIGIT Lab selected ESRI's ArcExplorer, a GIS data viewer distributed for free. Along with this software, a basic "getting started" help document created by the DIGIT Lab was included to enable the beginning user to start working with the data layers quickly.

Task 3—Data Compilation

DIGIT Lab obtained some baseline data sets that were clipped to the boundaries of the nation. These included:

- USGS 1:100,000 digital line graphs of roads, hypsography (contours), surface hydrology (streams, washes, water bodies, springs, etc.), and boundaries (nation, county, city, and other jurisdictions)
- USGS 30-meter digital elevation model (topography, shaded relief)
- USGS digital orthophoto quads (aerial photographic coverage)
- Arizona GAP data (vegetation and land cover)
- Natural Resources Conservation Service soils data (classifications and attributes)

Additional data sets were obtained based on the results of the data availability questionnaire and needs assessment. Table 1 lists the data layers obtained from various agencies.

Table 1. Existing GIS Data Sets Obtained for the Tohono O'odham Nation

Tohono O'odham Solid Waste Regulatory Office	Hazardous storage tanks
Tohono O'odham Utilities Authority	Utilities
Arizona Department of Water Resources	Well location points
	AMA and INA boundary
	Central Arizona Project
	Certificates of Convenience and Necessity
	County polygons
	Groundwater basins
	Surface watersheds
	Surface water filing locations
	Grandfathered Groundwater Rights in the Active Management Areas
	Grandfathered Groundwater Rights in the Irrigation Non-expansion Areas
	Irrigation districts
	Groundwater sub-basins
	Arizona township polygons
	Arizona section polygons
National Biological Information Infrastructure	Census boundaries and data
	Brown, Lowe & Pase Vegetation Classification 1980
	City boundaries
	Geologic formations 1:1,000,000
	Lakes, reservoirs, ponds, etc.
	Mines
	Major land resources areas and resources units
	USGS 7.5 minute quad boundaries
	General soil map 1:1,000,000
	Springs
	Voting districts
	TIGER power lines
Indian Health Service	Community wells
	District boundaries
	Hospitals and clinics
	Sewage lagoons
	Monuments
	Dumpsites
	Schools
	Villages
	Streets

Source: Authors

Aside from these existing data layers, DIGIT Lab created or digitized other layers, such as a current land cover classification, a vegetation classification, range management ecological units, a composite development suitability analysis, and a shaded relief image.

The land cover classification was created using Landsat ETM data from 2000 and 2001. Using the Anderson land cover classification scheme (Anderson 1976), the ETM data was classified into six categories: built-up area, agricultural, rangeland, forest, water, and barren land. A ground-truth survey was conducted on the classified images.

Multi-season imagery was available for a portion of the nation's land. This allowed a further classification of the vegetated areas into the following categories:

- Mesquite dominated, or mesquite and palo verde mixed
- Mesquite and sage mixed, mesquite and creosote mixed, or palo verde and creosote mixed
- Creosote
- Soil or bone land

Range management ecological units were provided by the National Resources Conservation Service in the form of hand-drawn ecological unit boundaries on USGS 1:24,000-scale topographic paper maps. DIGIT Lab digitized and geo-referenced these areas into shapefiles and attributed them with the appropriate values as labeled on the maps.

The composite development suitability analysis was prepared based on the criteria provided by Greg Saxe of the Tohono O'odham Nation's planning department. Based on these criteria, the areas suitable for development were defined as areas no closer than 50 feet to streams, on soil without severe limitations to septic systems, and within 1,000 feet of existing paved roads and utilities. The layers needed for this analysis were all included in the data compiled by DIGIT Lab. Using standard GIS buffer, intersection, and union operations, the composite development suitability analysis was created in the form of a shapefile representing areas suitable for development.

After the data were compiled or created, all data layers were converted to the ESRI shapefile format. They were then clipped to an area that included the entire nation and 1 mile outside its boundaries. Then, all shapefiles were projected into the UTM zone 12 projection NAD 83 (meters) datum. It had been determined that all data should also be provided in the NAD 27 (feet) datum to meet the needs of some users in the nation. In addition to the shapefiles, a shaded relief image was created in both NAD 83 and NAD 27 to serve as a topographic map background.

The data sets obtained during the project were organized into a library, along with metadata that documented the source and other characteristics of each data set. In addition, a complete set of data was clipped out to the boundaries of each of the 13 districts in the nation. The compiled data sets were written to a CD-ROM for distribution to the nation's agencies.

Figures 2 through 6 show samples of some of the data layers gathered and created for this project.

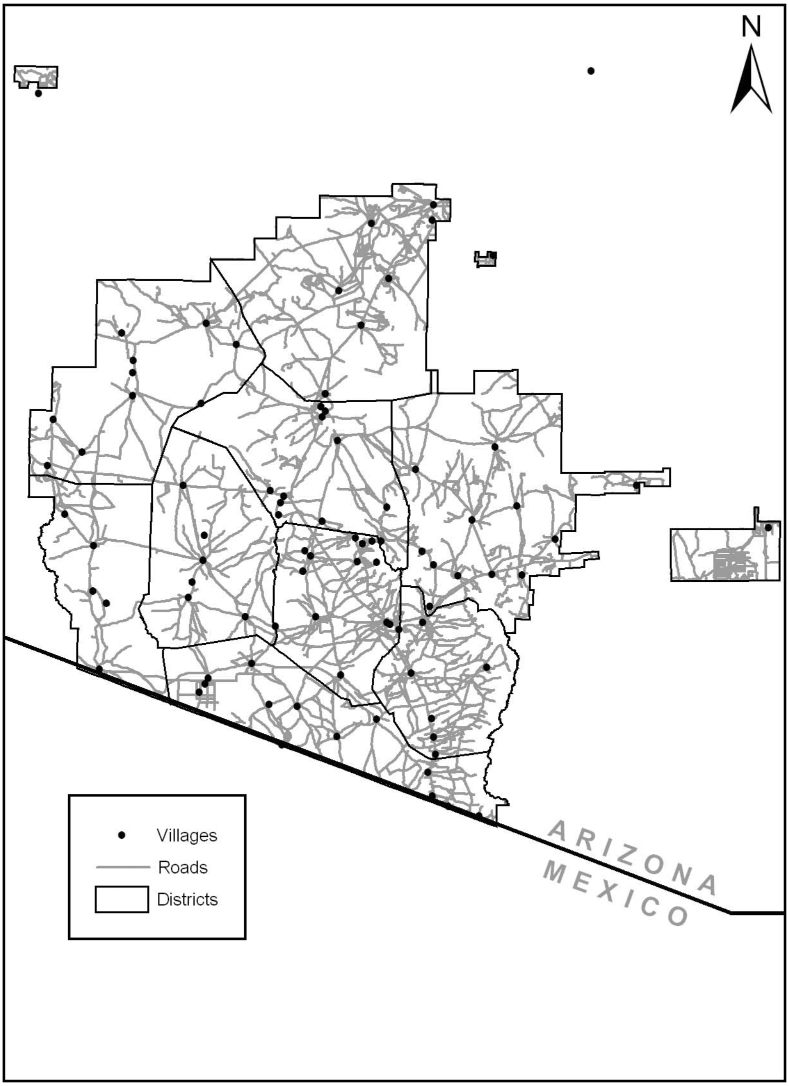
Product Delivery

In May 2002, the researchers delivered to the Tohono O'odham Nation the following:

1. A full set of Digital Ortho Quarter Quads (DOQQs). These are aerial photos that cover the entire nation.
2. A data CD for each of the 13 districts with the data covering their respective districts, and three CDs with data covering the entire nation (16 CDs total). There were a total of 64 data layers for the entire nation.
3. A large mounted and laminated paper map of each of the 13 districts and three of the entire nation (16 maps total). These maps included shaded relief, roads, villages, dumpsites, underground storage tanks, and composite development suitability.

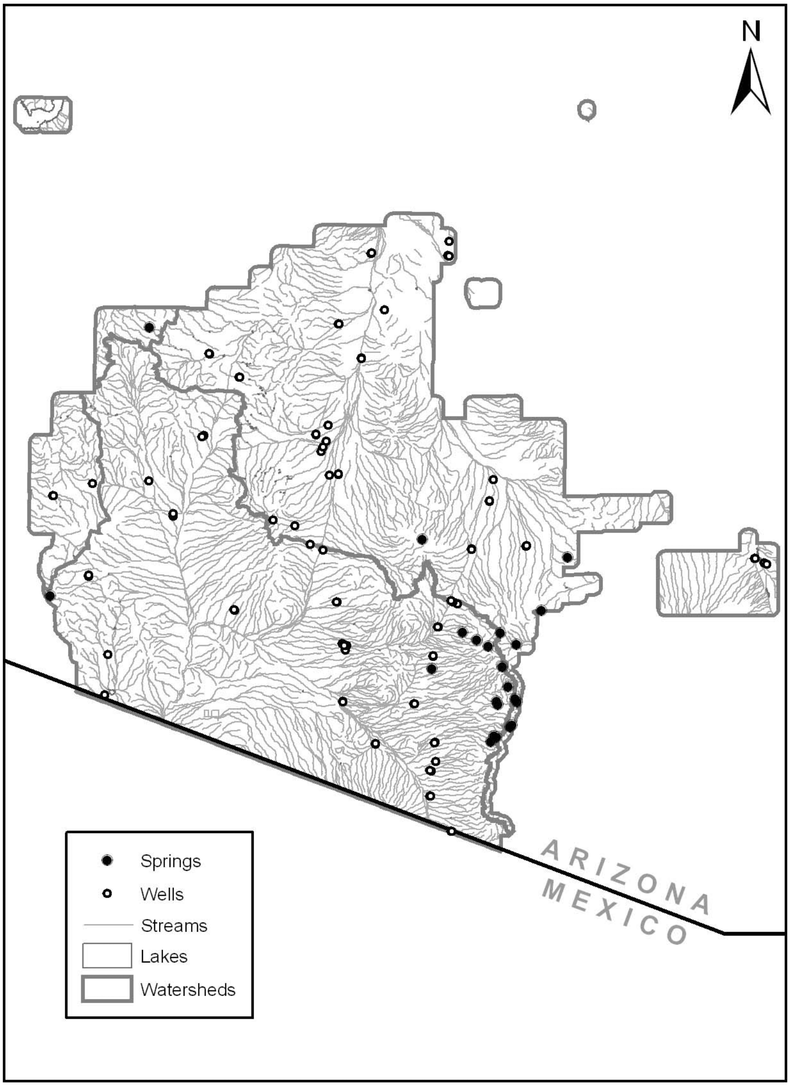
Also provided was a CD for each district that included ArcExplorer and basic instructions to get the new users started.

Figure 2. Roads, Villages, and Districts of the Tohono O'odham Nation



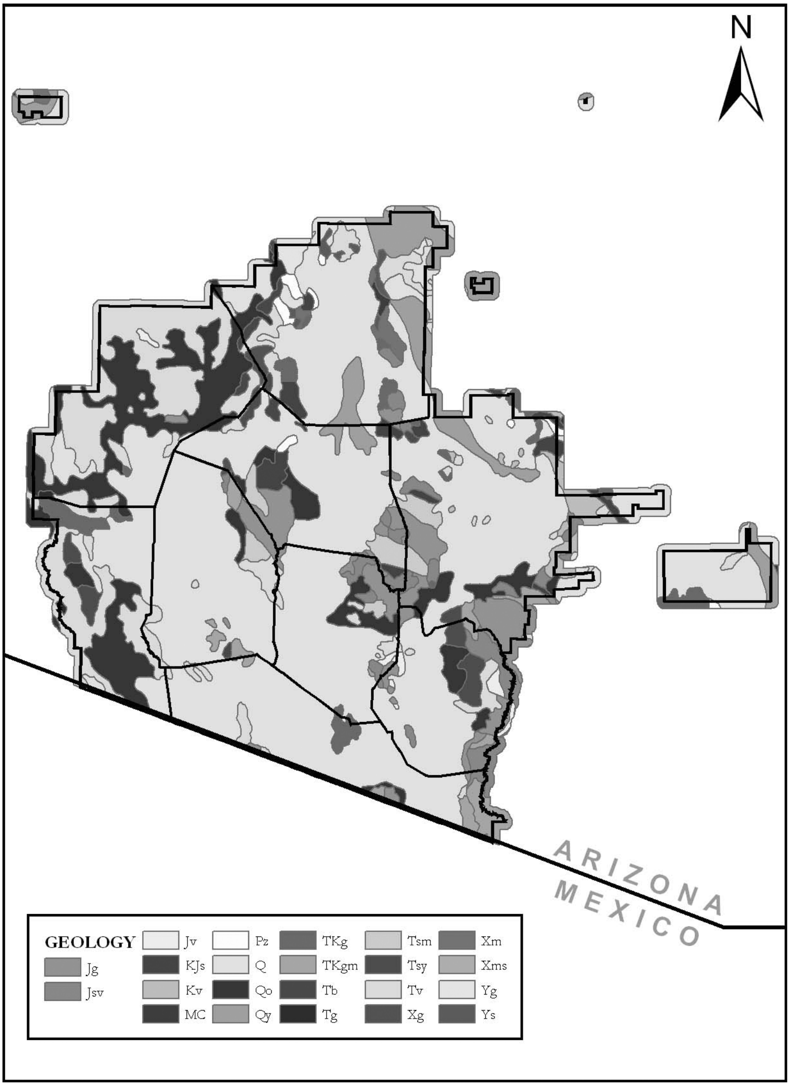
Source: Authors

Figure 3. Water Features of the Tohono O'odham Nation



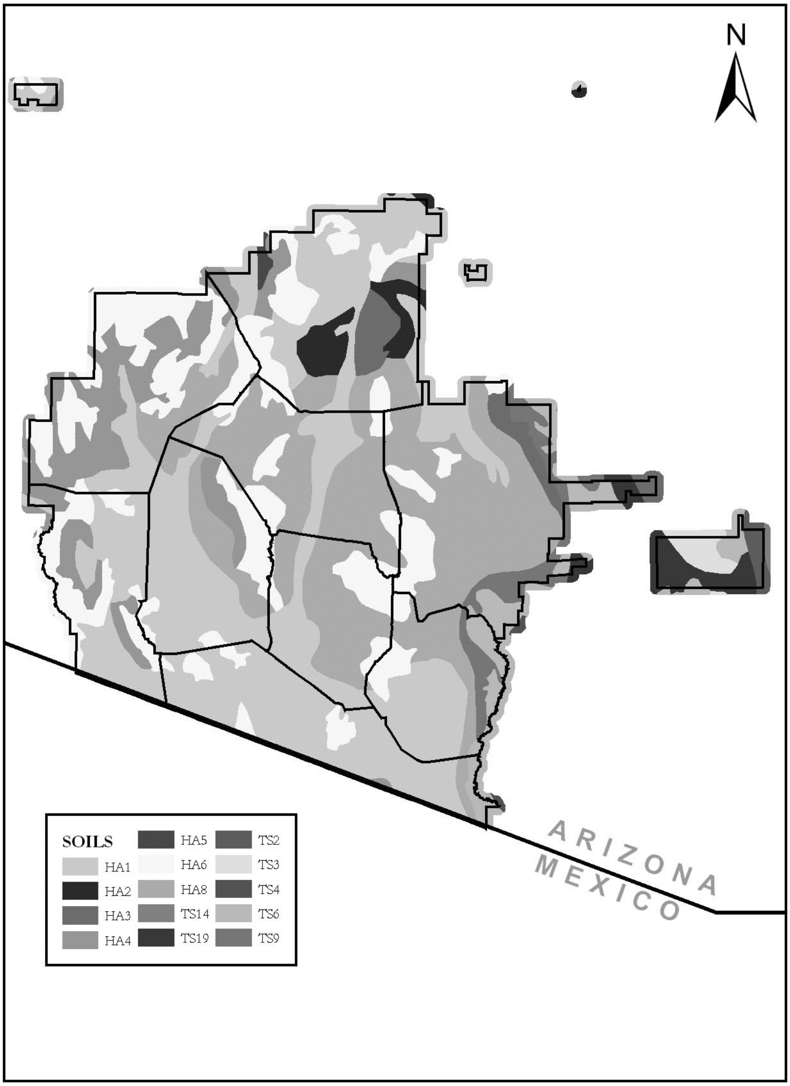
Source: Authors

Figure 4. Geology of the Tohono O'odham Nation



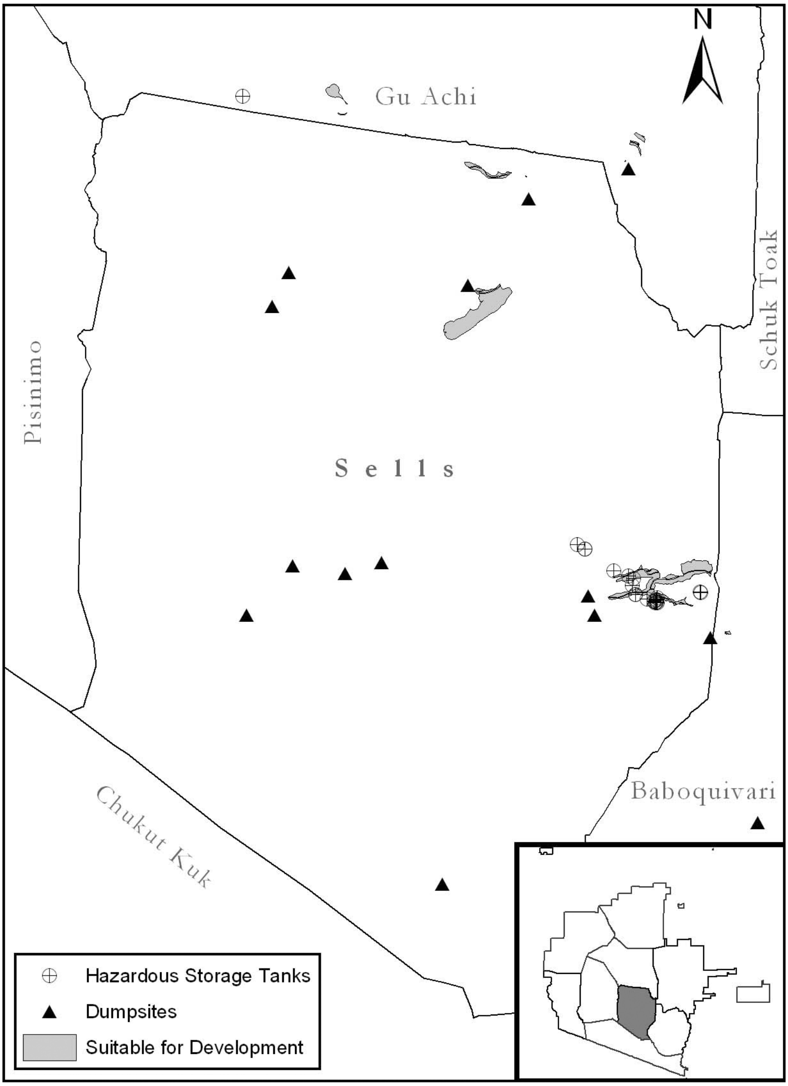
Source: Authors

Figure 5. Soils of the Tohono O'odham Nation



Source: Authors

Figure 6. Sells District* Composite Development Suitability and Hazards



*Note: The reservation is divided into districts. The Sells District is the location of the tribal headquarters.

Source: Authors

Conclusion

The common thread in all the SCERP Tribal Environmental Program research is helping tribes manage their own resources, primarily through GIS and other forms of data collection. This, in turn, improves tribal management. There is a widespread movement among tribes to take over management responsibilities from the Bureau of Indian Affairs—this research will be especially useful in assisting the Tohono O'odham Nation in this process, and thus helping them achieve self-determination.

Reference

Anderson, J. R., E. Hardy, J. Roach, and R. Witmer. 1976. "A Land Use and Land Cover Classification System for Use with Remote Sensor Data." U.S. Geological Survey Professional Paper 964. Washington D.C.: U.S. Government Printing Office.

Appendix A

GIS and Spatial Analysis Background Information

Introduction

A Geographic Information System (GIS) is a digital database that enables users to capture, model, manipulate, retrieve, and analyze geographically referenced data. In addition, GIS is used to display and present geographic data in charts, tables, and maps. These capabilities are achieved through a combination of hardware, software, geographic data, and skilled users. For a GIS to be successful, the users must assess what their current and future GIS needs are. First, users should identify the areas in which GIS use would be beneficial, and then the data that would be necessary to achieve that use.

Examples of Potential GIS Uses

GIS is being used in a wide range of application areas. The following are just a few examples of the many potential uses of GIS.

Land Use/Administration: Land information systems contain the parcel boundaries, owner, easements, right-of-ways, etc., and identify designated land use/zoning (residential, commercial, agriculture, etc.), boundaries, and information about census blocks/tracts.

Infrastructure: These systems contain utility (sewer, gas, water, electric, etc.) locations, descriptions, and maintenance; road location, classification, and maintenance; and the extent of utilities availability.

Natural Resource Management: The location, extent, and amount of available resources (timber, mining, water, etc); the location of endangered/threatened species habitats; and the geology of an area (soils, land cover, hazards, etc.) can be identified.

Spatial Analysis Operations

Powerful analysis tools can be performed in GIS by using a set of spatial operations that manipulate the data to achieve the desired outcome. The basic set of GIS spatial operations are summary, reclassify, overlay, proximity, connectivity, and neighborhood analysis.

Summary: Classify range land quality based on a scale and calculate the number of acres in each category. The summary operation provides the statistical (sum, average, mean, minimum, maximum) information about the data set.

Reclassify: Create a data layer that displays areas of high and low population. Reclassify is used to assign new values to an existing data set.

Overlay: Combine the soils, precipitation, and land use layers to determine where the most suitable land for agriculture is located. "Overlay" refers to the process of placing a layer map over another layer to form a composite layer.

Proximity: Calculate the average and maximum drive time from residences to a local hospital or average distance from structures to fire hydrants to best locate new facilities. Proximity is used to determine a distance from a feature. The distance does not have to be a ground distance, instead the distance could be based on time, travel speed, cost, etc.

Connectivity: Determine which houses will be effected by a water shut-off. Connectivity analyzes how features are connected in a network to determine how the different features effect each other.

Neighborhood: Create a data layer predicting precipitation at any location based on samples taken at rain gauge stations. Neighborhood operations use the values in the surrounding area to calculate a new value at a given point.

Data

For a GIS to meet the needs of the users, the appropriate data must be collected. There are many different sources for data including, but not limited to, digitized data, scanned data, surveying, satellite imagery, aerial photography, census, and recording stations. When outlining potential GIS uses, users must carefully consider the data that will be needed to support each particular use.

All GIS data sets use geographic coordinates to describe the location and shape of the objects represented. Data can be created and/or obtained in a variety of coordinate systems. While it is possible to translate data from one coordinate system to another, it is easiest to choose a single coordinate system with which to work. A common coordinate system allows the GIS to display many different data sets on the same map and to perform spatial analysis functions.

For more information on GIS, visit this Internet site:
http://www.esri.com/library/gis/index.html

Tohono O'odham Nation Internal GIS Survey

Project Objective:
The University of Utah DIGIT Lab is currently working with the Tohono O'odham Nation to expand its Geographic Information System (GIS) data library. The goal of this effort is to compile a comprehensive set of GIS base map layers that contain and describe the topographic, geologic, infrastructural, ownership, and resource-related features within and in proximity to the Tohono O'odham Nation.

Mapping and Spatial Analysis:
Spatial analysis involves the examination of features (e.g., soil type, buildings, roads, springs, etc.) with known geographic locations and the relationships between these features.

What mapping applications and/or spatial analysis would be of interest to you in your office/agency?

Data:
For a GIS to meet the needs of the users, the appropriate data must be collected. There are many different sources for data including, but not limited to, digitized data, scanned data, surveying, satellite imagery, aerial photography, census, and recording stations.

Below is a list of potential GIS data layers. For each layer, please indicate whether or not the data would be useful in your operations. Briefly describe your potential use of that data (refer to the GIS information section). Please feel free to include additional information on the back side of this survey.

Land Use/Administration: (answer Yes or No and provide Potential Uses and Comments for each query)
Land ownership
Land use (agricultural/mining/etc.)
Jurisdictions (federal/state)

Parcel or cadastral
Zoning
State, county, municipal boundary
Tribal boundaries
School districts
Census blocks/tracts
Legislative districts
Other

Infrastructure:
Roads
Railroads
Utility
Sewer
Water
Electric
Gas
Telephone
Pipelines
Trails
Other

Housing/Building Types:
Residential
Commercial
Industrial
Other

Geodetic Control:
Public Land Survey System
Control points
Benchmarks
Reference points
Other

Natural Hazards:
Floodplain
Earthquake faults
Earthquake epicenters
Liquefaction potential
Other

Environmental:
Topography (elevation)
Soils
Geologic formations
Land cover
GAP analysis (vegetation)
Landfills/waste sites
Hazardous storage/tanks
Other

Hydrology:
Lakes/reservoirs
Streams
Watersheds
Wells
Springs
Water tanks/towers
Livestock ponds
Groundwater
Gauging stations
Aquifers
Aqueducts/canals
Irrigation
Other

Designated Areas:
Wilderness
Protected species/habitats
Sacred grounds
Archaeological sites
Other

Resources:
Mines
Claims/permits
Recreation
Other

Imagery/Photography:
Digital elevation models
Digital ortho quads
Digital raster graphics
Digital line graphics
Other satellite imagery
Other photography

Other Data of Interest: (Please list in the space below other data that would be of use to you)

Contact and Information:
Name:
Office/Agency:
Position:
Address:
Telephone:
E-mail:
Current level of GIS or CAD use (if any):
Please describe the content of any databases that your agency maintains (e.g., telephone directory, well locations, building permits)
What GIS software is available in your office:
What hardware is used in your office:
What computer processor (e.g., 486, or Pentium 233):
What operating system (Unix, Win 95/98/NT, etc.) is being used:
Describe your current Internet access:

V

Ysleta del Sur Pueblo Tigua Tribe of El Paso, Texas

Jacob A. Massoud and John A. Peterson

Introduction

The Tigua Tribe of El Paso has the distinction of being the only recognized Puebloan community in Texas, and one of only three federally recognized tribes in the state with established tribal lands. The modern Tigua are descendents of Pueblo peoples who settled in El Paso following the Pueblo Revolt of 1680. They have more than 300 years of cultural continuity as a tribal or pueblo community in El Paso, and several hundred or a thousand more in their ancestral lands, located less than 100 miles to the north along the Rio Grande, near what is now the area of Socorro, New Mexico.

Their own cultural history avers that they were captives of the Spanish and forced to leave their homelands; there is well-documented support of this in the archival and academic literature. For the last several centuries they have endured taunts from other Puebloans of being complicit with the Spanish. Mexican-Americans in the borderlands have, for at least the last 150 years, accused them of being "Mexican" Indians. Current Anglo and Mexican-Americans in El Paso criticize them for being a "re-invented" tribe. The state of Texas recognized the tribe in the late 1960s, but has yet to fully accept its right to sovereignty, as witnessed by the recent closing of their profitable casino enterprise.

The Tigua live on an urban reservation consisting of the remnants of lands in the El Paso suburb of Ysleta, Texas. These lands were once hundreds of square miles of Spanish land grant. At one time, the tribe had access to a vast hinterland conveyed to them as the Rancho de Ysleta grant. This area of the desert in West Texas included the Hueco Mountains and its sacred rock art site, the salt flats west of the Guadalupe Mountains, and hunting and gathering rights in the desert floor and mountains of the Chihuahuan Desert. All that survives of this, due in large part to the theft of title in the mid-nineteenth century, is a few square miles in Ysleta surrounding the Ysleta Mission complex. The nearly deserted casino complex adjoins the historic mission. Newly acquired property for housing and community use downriver along Socorro Road, along with a 70,000-acre ranch property south of Van Horn, are the fruits of casino profits from the few years it was in operation. The tribe is nurturing these assets as a platform for economic security and development in lieu of the casino.

The Tigua are not the stereotypical image of the Pueblo Indian still presented to tourists in New Mexico. They are urban, they are educated, they are employed in jobs throughout the local El Paso economy, and they live in modern, comfortable housing in the semi-rural and suburban landscapes of the Lower Valley of El Paso. At the same time, they maintain their culture, community practice, and beliefs, and participate in tribal governance, most of which is shielded from external eyes. The tribe is not hiding from the outside world, in fact, it has published several volumes of research about its own customs and history; rather, it is protective of its identity and culture. Many of the tribe attend or have graduated from the University of Texas at El Paso (UTEP), where they have pursued degrees in several fields—even anthropology, which is often viewed skeptically by Native Americans. In recent years, the ranks of the discipline have swelled with native peoples from around the world, and the current critique of colonialism and cultural hegemony is informed by many voices from many places.

It was in this context that the university and the tribe became connected through yet another nexus. Dr. John Peterson, an anthropologist at UTEP, wrote a proposal to the Southwest Center for Environmental Research and Policy (SCERP) to fund an ethnographic survey of Indian communities in the El Paso and Ciudad Juárez region. He suspected that there were many peoples from most of the Indian ethnicities in Mexico and the United States who lived informally in the region. Friends and students among the Tigua Tribe agreed, and offered to recommend collaboration at the Tigua Tribal Council if the funding was approved. A year later, it was. Peterson and Albert Alvidrez, a student and friend who had by then been voted onto the Tigua Tribal Council, was supportive and they forged ahead.

What emerged from this inchoate beginning was a five-year project that ultimately provided not only a few technical contributions to the tribe, but more importantly, a relationship between the tribe and academia. Over the five years of the SCERP Tribal Environmental Program (STEP), UTEP supported the tribe's interest in and development of Geographic Information System (GIS) technology; wind power assessment at their Valentine, Texas, ranch; and contributed moral support to the tribe's initiative to obtain EPA General Assistance Program (GAP) funding to establish a tribal environmental office.

Tigua Environmental Concerns

Many issues have shaped the natural environment for the tribe. The Pueblo's biotic cultural landscape along the Rio Grande and in the Hueco Mountains, located just outside the El Paso city limits, has become increasingly degraded as a result of a variety of anthropogenic factors (Greenberg 2000). Along the Rio Grande, urbanization and hydrologic modification, such as water impoundment and diversion, have had a significant impact on the water quality and riparian habitat of the area (Daniel B. Stephens & Associates 2000; Greenberg 2000). Cattle grazing and limited development of the Hueco Tanks State Historical Park and surrounding lands are sources of degradation in the Hueco Mountains region (Greenberg and Esber 2000; Raba-Kistner Consultants, Inc. 2000). These once-ecologically healthy areas still possess religious, historical, and cultural significance to the tribe.

The people of the Ysleta del Sur Pueblo have for many generations used plants and other resources along the Rio Grande and in the Hueco Mountains for food, pottery, shelter, medicine, clothing, hunting, and religious ceremonies (Greenberg 2000; Greenberg and Esber 2000). Certain plants are vital for the preservation and persistence of cultural traditions and thus, the Tigua people. However, the portion of the Rio Grande currently used by tribal members borders agricultural lands and industrial sites in both the United States and Mexico, leaving it susceptible to urban and agricultural runoff as well as exposure to pesticides from crop dusting. It is also heavily degraded—the result of invasive species, habitat modification, and erosion.

In general, the ambient air in El Paso is of poor quality and water is scarce. More importantly, air pollution and groundwater do not follow political boundaries. As a U.S.-Mexican border tribe, the Ysleta del Sur Pueblo is confronted with many environmental problems that are difficult to address due to complex social, political, and economic issues. In recent years, the EPA's U.S.-Mexico Border XXI Program, and now its successor program, the U.S.-Mexico Border 2012 Environmental Program, and their diversity-of-stakeholders approach have been empowering border communities to mitigate environmental problems. Some progress is being made; however, there is still a long way to go. Aside from the need for agencies to be educated on tribal sovereignty and cultural awareness issues, environmental problems abound. For example, as of 2003 El Paso County was still designated as a nonattainment area for three of the six criteria pollutants, including ozone, carbon monoxide, and PM_{10} (EPA 2003a). It was within this context of degradation and environmental inequity that the tribe looked to its Chilicote Ranch in Valentine, Texas, as an escape to an undeveloped natural setting. The tribal council decided it should find ways to care for and capitalize on the ranch's natural resources in a role as stewards.

The SCERP Program

The SCERP program was no panacea, but it provided a venue for one channel of communication and a relationship to develop and flourish. It was personalistic because tribes are typically so, as opposed to bureaucratic; it was slow and often non-productive from the eyes of the university administrators; and it was hegemonic and paternalistic in the eyes of tribal participants. Nonetheless, the relationship that developed and the process of engagement between the university and the tribe on environmental needs has been mutually regarded as productive. As participants in the summative meeting of STEP related in June 2003, they themselves—Indian and academic alike—are the products of the process. And as the two have learned about each other and each others' ways, the program has slowly evolved into a fruitful rapprochement between tribes and academia. Will the tribes or the universities survive this success? As participants come and go from within tribal government or within the university, the relationships change and cannot be predicted. But perhaps the positive history of working together will promote new and varied exchanges.

The process between UTEP and the Tigua Tribe began fitfully. An initial organizational meeting was proposed for October 1999 at San Diego State University. The tribe's Albert Alvidrez could not attend because of his many tribal council responsibilities. However, representatives from the SCERP institutions attended, and in the absence of tribal participation, the groundwork was established for the program. The group met a month later in San Francisco, at the invitation of EPA Region 9, to present the outline of the program at its annual meeting; Alvidrez was able to attend this meeting. It proved to be a post-modern moment: One of the tribal representatives from California intoned, "We find these meetings to be a big waste of time, kind of a governmental guilt trip, but then, the food's always pretty good." Academics and tribal representatives (at least one participant was both an academic and a Native American) agreed heartily, and much progress was made toward finding common ground.

Teams at UTEP and on the tribal council formed around the task of identifying specific projects that the program could support. EPA had requested that the effort at least be capacity-building for the tribes, and so the initial focus was on contributing to the tribe's interest in GIS for environmental risk assessment and sustainable management of the Chilicote ranch's resources. In December, Alvidrez was elected governor and Filbert Candelaria became lieutenant governor of the tribe. This was positive for generating tribal interest in the program, but deadly as far as scheduling meetings and travel for the program. No tribal representative was available for the STEP gathering in March 2000, but Alvidrez persisted and was able to attend the following SCERP technical conference in Ciudad Juárez in the fall of 2000. A presentation was made on the GIS training and development that had progressed through the summer, and Alvidrez was warmly supportive while at the same time advising of the difficulties of tribal and governmental coordination. There has been too long a history of mistrust, miscommunication, or missed communication between tribes and the government, and all those in attendance would have to not only learn Indian ways, but also learn to respect Indian ways. That, in fact, is at least a two-way street—environmental sustainability is not something the government needs to teach the tribes; rather, the tribes can lead the learning process with their own wisdom.

Perspectives on Resources

The UTEP team supported the tribal initiative to obtain GAP funding for their own environmental office, something they would have accomplished without any help from the university. But, it was a positive outgrowth of the process and it allowed the tribe to hire an environmental administrator. UTEP contributed some training opportunities for Jacob Massoud, whom the tribe hired for this position. From there, the idea was nurtured to assess wind energy at the Chilicote ranch, and Massoud volunteered to facilitate the acquisition and siting of an anemometer on the ranch. He gathered a group, which traveled together, along with tribal councilmember Jesus Padilla, to Denver to a meeting of the Council of Energy Resource Tribes (CERT). CERT is a means for tribes throughout the United States to access information and obtain technical assistance for energy resource endeavors. The organization also conducts public policy research, advocacy, and education on behalf of its member tribes (CERT 2003). It was exhilarating to see how a purely Indian initiative was succeeding toward sustainable economic development in the context of tribal respect for land and resources.

For tribes, "resources" is not a consumer term as it is with the outside world. Resources are interactive elements of the native world within which people relate to them. They are known through the relationship. The categories of earth, water, and air are not perceived and constructed in the same ways by all people. Tribal narratives, as well as current theory in anthropology, affirm this way of living in and seeing the world. STEP has provided all involved a way to envision the world anew and to find points of contact where disparate worldviews can engage each other on themes of common interest and sustainable practice. The hope is that this chapter will communicate some of that value, which is, after all, the real product of this recent dialogue among tribes and academia.

Initiatives in renewable energy resources allow tribes to "harvest the sky" by developing wind and solar energy projects. To do so, however, requires planning and foresight, as well as potential renewable energy resources. Peterson had begun an explorative process prior to the CERT conference in Denver by contracting a local GIS consulting firm to assess wind and solar resources at the ranch. The results were promising, so he presented them to the tribal council and the project moved forward.

Capacity Building

Concomitantly, the tribal environmental office was quickly establishing a foundation to address pertinent environmental issues affecting the Tigua community. The primary purpose of GAP is to establish a core environmental protection program for Indian tribes. In order to do so, tribes use funds to build capacity through a number of activities, including training, developing media-specific programs (air, water, etc.), planning, procuring relevant equipment and supplies, and administering an environmental office. The key to success is that the program be community-driven, based on the needs specific to each tribe.

Through networks established during the CERT conference, Peterson encouraged the tribe to apply for an anemometer. The group's new directive became that of obtaining the instrument to measure wind velocity at the ranch. The National Renewable Energy Laboratory (NREL) and the Western Area Power Administration

(WAPA) administer a Native American Anemometer Loan Program, for which the tribe had already expressed some interest. The loan program required a topographic map illustrating the location of existing substations, electrical lines, and potential wind turbines; the wind assessment maps created earlier satisfied part of this prerequisite. In July 2002, the tribe provided NREL with maps depicting the electrical lines and topography of the ranch. However, the tribe had not afforded NREL with a list of potential sites. This necessitated reconnaissance to the ranch.

Fortunately, the GIS capacity-building phase funded by SCERP had a synergistic relationship with the activities outlined in the GAP work plan. As with most grants, GAP requires deliverables to be submitted to EPA on a periodic basis. One goal was to strengthen the ability of the tribe's environmental management office to conduct spatial analyses and mapping. So, Massoud had the opportunity to attend advanced GIS training with SCERP resources, which provided the tribal environmental office the basic capacity to produce maps of potential wind project sites, as well as conduct future GIS and Global Positioning System (GPS) activities outlined in the GAP work plan. The mapping activities then served two purposes: fulfilling the application requirements for a NREL anemometer loan and establishing GIS/GPS capacity for the tribe's environmental management office.

Challenges and Cultural Considerations

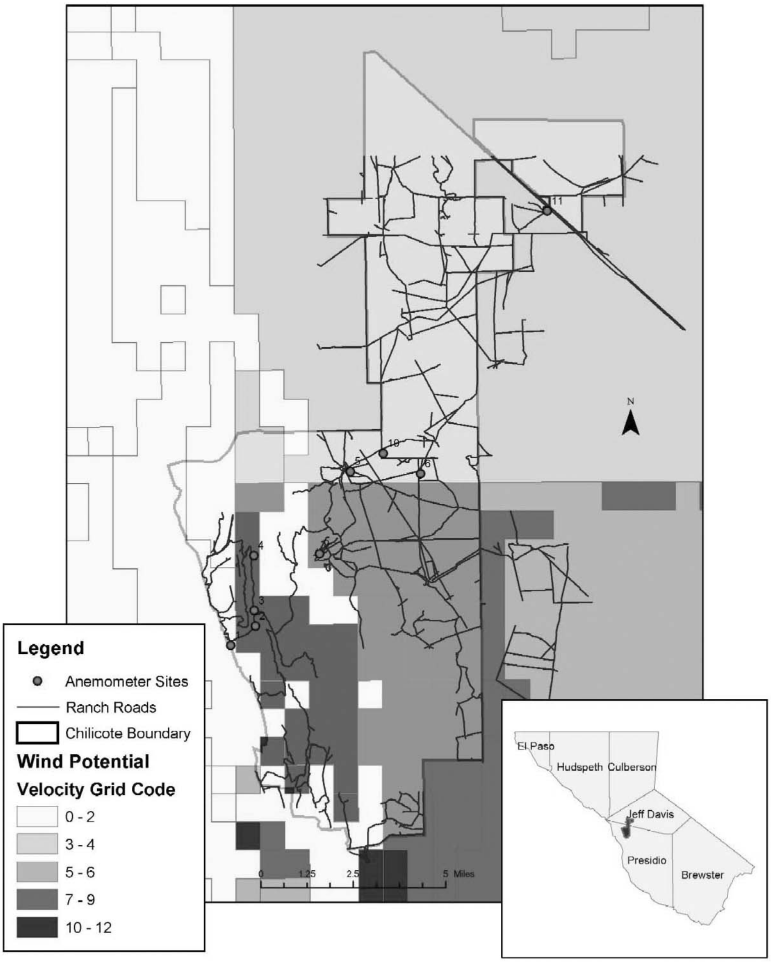
In recent years, one of the many challenges for the Tigua Tribe has been to pursue sustainable economic development in the absence of a casino. Since the closure of its casino, the tribal council has begun exploring economic development opportunities in ranching, nature-based tourism, and entertainment. Incentives for the tribe to focus on wind energy included the creation of a wind farm for financial gain, or increasing tribal self-sufficiency by generating electricity from wind turbines. According to the Texas State Energy Conservation Office, the mountainous regions of West Texas are capable of electric power generation (Texas State Energy Conservation Office 2003). Additionally, portions of Texas may have enough wind potential to meet between 10% and 25% of the state's electricity needs (EPA 2003b). Therefore, the tribe sought a legitimate opportunity to tap into the renewable energy market.

From a sustainability standpoint, wind turbines have long been viewed as an environmentally clean and safe way to generate electricity. Some authors cite the noise produced by the propellers as a disturbance to breeding birds and wildlife (Heathcote 1997; EPA 2003b). Additional adverse effects to the environment include aesthetic degradation of the landscape, as well as obstacles for birds, which may inadvertently fly into or rest on moving propellers, resulting in their deaths (Heathcote 1997; EPA 2003b). However, EPA contends that environmental impacts are minuscule—air emissions are negligible, water discharges typically do not occur, and solid waste is not generated (2003b).

Environmental impacts to Mother Earth are a major concern to the Tigua people. Not only do negative impacts distress living organisms, but they have an effect on one's relationship with the environment. For example, the concept of the sacred landscape or viewshed is present in many earth-based religions. Large wind turbines protruding from the ranch topography could easily obscure this viewshed (Greenberg 2002). This idea corresponds to arguments against the detrimental affects to aesthetics; however, it penetrates much deeper and is often difficult for a non-Indian to comprehend. It was definitely an issue that needed to be addressed before pursuing the wind project any further. Massoud discussed this potential concern with War Captain Rick Quezada, who is a tribal councilman and spiritual leader. Quezada agreed to accompany Massoud to the ranch to locate culturally appropriate sites for wind turbines. Ranch Foreman Mike Miranda and Tribal Councilman Arturo Loera also provided local knowledge about the most suitable sites for a wind farm. Thus, the site evaluation relied on both tribal traditional knowledge and local knowledge. It involved a somewhat non-systematic, yet efficient approach. Factors such as elevation, land area, levelness of the terrain, site access, and distance to transmission lines and substations were considered.

During the site visit, Massoud collected waypoints with a GPS unit, then created maps of potential anemometer sites (Figure 1) for NREL upon his return to El Paso. However, a problem arose in that the nearest transmission lines were approximately 60 miles away from the ranch. According to NREL, a substation or transmission line should be within several miles to establish a viable wind farm. Given the significant distance to the closest transmission lines, a wind farm would not be economically feasible using the current

Figure 1. Ysleta del Sur Pueblo Potential Chilicote Ranch Anemometer Sites



Source: Authors

infrastructure in Presidio County, Texas. To generate enough electricity to realize a profit, the tribe would need to invest more than $100 million in a wind farm project (NREL 2002). Clearly, the costs outweighed the benefits, but all was not lost. The tribal council was still eager to forge ahead, knowing that someday the local infrastructure might improve. More importantly, they perceived an alternative justification to evaluate the ranch's wind resources. Anemometer data could be used for the purpose of developing a self-sufficient ranch. That is, a ranch that could operate using its own electricity generated from wind turbines. Such a project would not only enable the tribe to carry out ranch activities without relying on the local electric utility, but it would also serve as an environmentally friendly substitute for non-renewable resource depletion. Eventually, an anemometer was obtained and constructed (Figures 2 and 3).

Figure 2. Tribal Members Assembling the Anemometer

Source: Ysleta del Sur Pueblo Environmental Management Office

Figure 3. The Assembled Anemometer

Source: Ysleta del Sur Pueblo Environmental Management Office

Conclusions

Much more work is still to be done on anemometer data collection; the group is only in the infancy stages. The anemometer loan will allow the tribe to monitor wind velocity for a 12-month period. Data collection began in July 2003, but the project hit a minor obstacle in August 2003 when the anemometer's wind vane was damaged (hopefully, that event was also an indication that the ranch possesses high-quality wind resources). It took another masterful effort to coordinate a team to lower the tower and replace the wind vane, and it was then revealed that the anemometer had apparently been struck by lightning, which fried the wiring in the data logger as well. Thus, a second visit was made to the ranch in November 2003 to install a new data logger. As of December 2003, the tribe did not yet have any substantive data on average wind velocity. However, the anemometer program appears to be back on track. The tribe will continue to mail a data plug each month to NREL staff for analysis, which takes the burden away from the tribe and its limited resources. In due course, the results will identify the quality of wind resources and lead to alternative action strategies.

This entire process, including the setbacks faced, was a lesson learned. Certain commonalities exist among tribal communities, and those who work for tribes should know and appreciate the following: Each tribe has its own unique traditions, governmental and political structures, and beliefs. Thus, personnel, academics, and contractors who work for tribes must be flexible, respect tribal traditions and beliefs, and make an effort to understand a tribe's culture within appropriate boundaries. As well, sensitive information about a community often exists and an outsider should not be privy to it. Finally, depending on a tribe's political organization, it is also possible that tribal leadership and priorities could differ from year to year. Thus, one should be open-minded and adapt to whatever circumstances might arise.

What are the next steps for the Ysleta del Sur Pueblo? After the anemometer loan expires, the tribe may opt to reapply for it and transfer it to a different location at the ranch. This would enable the tribe to assess its wind resources at another site, given the reality that one site is not representative of the entire 70,000-acre ranch. A priority is to conduct a load assessment to determine the average number of kilowatt (kW) hours used by the ranch headquarters on a per-day or per-month basis. A several-hundred kilowatt wind project would cost approximately $2,000/kW (NREL 2002). It may be possible to offset some of the utility costs at the ranch headquarters, but its practicality is dependent on the cost factors associated with implementing a project. The Tribal Energy Program, under the Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy, offers tribes unique funding opportunities (DOE 2003). DOE funds feasibility studies and energy resource development projects on an annual basis. These could be viable options for the Ysleta del Sur Pueblo in the future.

The researchers and the tribe hope this chapter not only offers insight into tribal issues, but also presents opportunities and ideas for other American Indian tribes. Each of these opportunities and resources should be made more available to tribes through increased funding and promotion. It is each tribe's sovereign right to decide whether it should participate in one of the above-mentioned programs and to determine what programs are relevant to meet its needs. Nonetheless, many of the programs offered by EPA (including GAP and SCERP), NREL, and DOE should be advertised more readily to create a renewed awareness among tribes. Despite the fact that many tribes might hesitate to work with federal agencies due to the historical maltreatment of Indian peoples in the United States, opportunities do exist for federally recognized tribes to develop new initiatives and create intriguing partnerships. Although the federal government may still have quite a bit to learn about tribes, it is making positive strides with these programs.

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VI

Iron-Rich Mine Tailings Fail to Perform as Fertilizer: An Economic Development Model

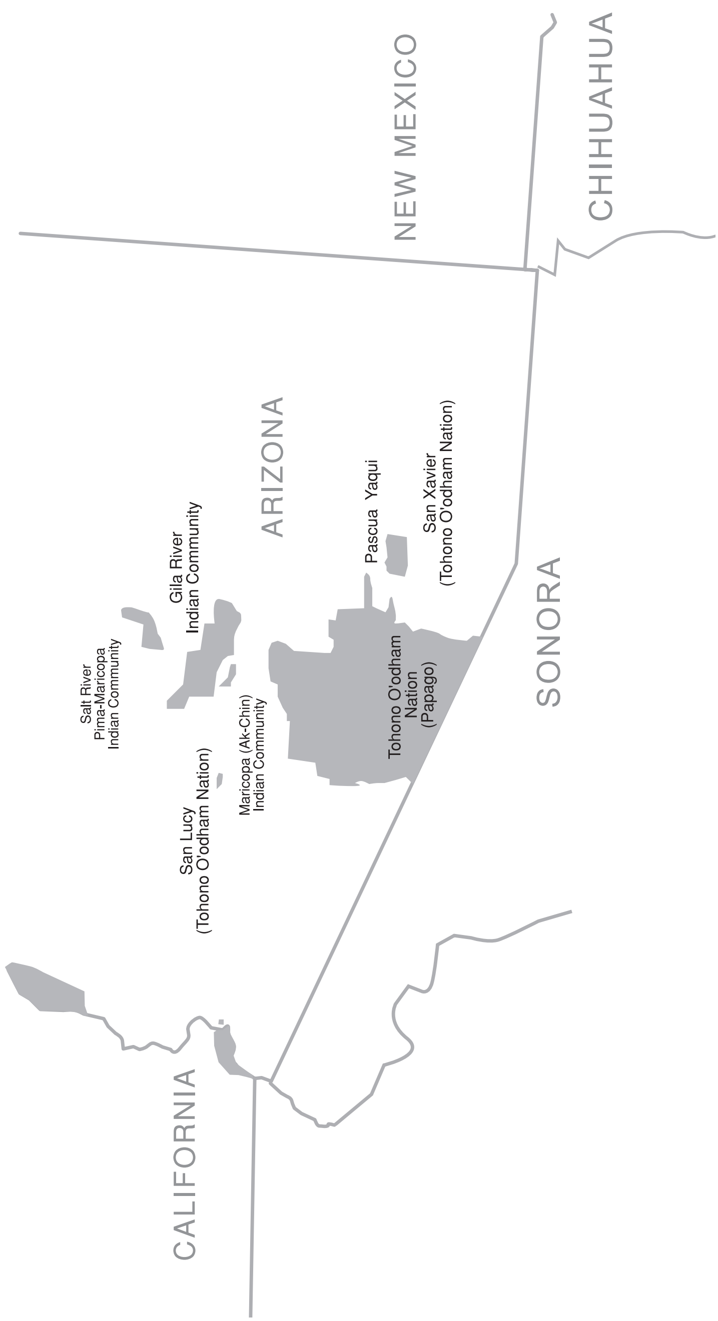
John G. Mexal, Constance L. Falk, April Ulery, Geno Picchioni, Richard Ng, Carolyn Taylor, and Ashley Hagen

Introduction

The Tohono O'odham (T-O) Nation has the largest reservation in the Southwest, occupying 1.2 million hectares (ha) (Figure 1). The reservation is part of the Sonoran Desert ecosystem and receives about 120 millimeters (mm) of precipitation annually.

Part of the landscape has been severely disturbed by copper mine operations. The Cyprus-Tohono mine near Casa Grande, Arizona, opened in the 1970s and closed in 1998. In 2000, the mine was purchased by Phelps Dodge Co. The mining system used during the 1970s created a 40 ha tailings settling lagoon that contains more than 5 million tons of material. The material is about 60% silt, 32% sand, and 8% clay. It contains negligible amounts—considerably below the EPA limit for loading to agricultural soil—of heavy metals such as arsenic (3 milligrams per kilogram [mg/kg]) and lead (126 mg/kg). The loading limit is 41 milligrams of arsenic per kilogram and 300 milligrams of lead per kilogram. Neither cadmium, chromium, nor mercury are present. Thus, these materials would be suitable for land application if a beneficial use were found.

Figure 1. Tohono O’odham Tribal Lands in Southeastern Arizona



Source: SCERP

While these tailings contain negligible amounts of hazardous materials, they do have high amounts of iron (8%) and small amounts of other plant nutrients (2% sulfur, 4% magnesium, 2% potassium, and 0.8% copper). This material may have potential applicability as an amendment to soils with high pH where iron is often limiting. The material from the Cyprus-Tohono mine may have potential as an amendment to calcareous soils in residences or public landscapes.

The objectives of this project were to evaluate the response of crop plants to different iron sources in a greenhouse environment and survey the fertilizer use (especially the use of iron fertilizers) of the golf course industry in the southwestern United States to determine the marketability of such an "indigenous" product. The species used in these experiments are known to suffer from iron deficiency in southwestern soils and should readily illustrate the benefit of alternative iron sources for potential use in the turfgrass industry.

Materials and Methods

Mine Tailings Sampling

Ninety samples were collected from 23 trenches in the tailings pond on April 19, 2000. Samples were analyzed for total digest (U.S. Environmental Protection Agency [EPA] Method 305) and diethylenetriamine pentaacetic acid (DTPA)-extractable iron, copper, and heavy metals. These samples were used as the T-O iron source in the greenhouse studies.

Greenhouse Experiment 1

The study was conducted in a greenhouse using a Reagan Series fine silty loam (fine-silty, mixed, thermic ustollic calciorthid) with a 7.8 pH. This soil is an Aridisol with a calcic (calcium-rich) horizon. Sources of iron were incorporated into the growing medium at high, medium, and low rates based on recommended fertilizer application rates (Table 1). In addition to the T-O spoil material, commercially available Ironite®, Ionate®, Milorganite®, and Sequestrene 338® were evaluated as iron sources.

Table 1. Iron Content and Application Rates (milligrams per pot [mg/pot] or kilograms per hectare [kg/ha]) of the Five Iron Sources Used in the Study

Treatments		Application Rate (mg/pot or kg/ha)		
Iron Source	% Fe	Low	Medium	High
T-O tailings	4.5	315	630	945
Ironite	4.5	315	630	945
Ionate (iron sulfate)	10.0	378	756	1,134
Milorganite	4.0	10	20	30
Sequestrene 338	3.0	42	84	126
Control (no iron)	0.0	--	--	--

Source: Authors

Sorghum *(Sorghum bicolor),* willow (*Salix* sp.)*,* and bermuda grass *(Cynodon dactylon)* were grown in pots (10 centimeters [cm] x 10 cm x 25 cm) filled with Reagan Series fine silty loam soil. A plastic mesh filter lined the bottom of the pot overlain by about 5 cm of perlite. The pots were then filled with soil to a dry weight of 3.2 kg. On July 27, one-third of the pots were planted with 7 cm x 7 cm plugs of bermuda grass sod that had been washed free of adhering soil. One-third of the pots were seeded with nine sorghum seeds, and on August 10, 2000, the remaining third were planted with 30 cm willow cuttings previously dipped in rooting hormone.

Pots were irrigated with tap water as needed for about two weeks to allow plant establishment. Iron treatments were surface applied to bermuda grass and sorghum on August 27, and to the willow cuttings on September 16. Beginning September 5, pots were irrigated with 1/8 strength Hoagland's solution (minus iron), receiving about 0.2 liter (L) at each irrigation. Field capacity was estimated at 4.25 kg, and pots were over-irrigated by about 20% to leach excess salts from the soil profile.

The study consisted of 83 pots of each species, including 75 with iron treatments (5 iron sources x 3 rates x 5 replications), five controls (no iron source), and three pots for Day 0 destructive harvesting. Rates of iron application were based on the medium level recommended on the manufacturer's label. The low rate was 50% of the recommended rate, and the high rate was 150% of the recommended rate. The T-O mine tailings were applied at the same rate as the Ironite material. The Ironite was finely ground with mortar and pestle to match the consistency of the T-O mine tailings. The treatments were arranged in a 5 x 3 x 1 factorial (5 iron sources, 3 rates, and 1 frequency). The treatments were distributed in a randomized complete block design with five replications.

Plants were visually evaluated on October 19, October 31, and November 2, on a 1 to 10 scale, with 1 being chlorotic (having an absence or deficiency of green pigment) and 10 being dark green. The plants also were evaluated for hue, value, and chroma in December using a Minolta Colorimeter.

Greenhouse Experiment 2

The response of fescue (*Festuca ovina* K-31), rye grass *(Lolium perene),* and geranium (*Geranium* sp. var, "Maverick") to iron sources was measured in the second experiment to evaluate the efficacy of potential iron sources. The growing medium in this experiment was a 2:1 mixture of Reagan Series fine silty loam (fine-silty, mixed, thermic ustollic calciorthid) soil and medium grade horticultural sand. The sand was added to improve the drainage of the growing medium. Plants were grown in circular pots (15 cm in diameter x 15 cm tall). Two fiberglass screen filters were placed at the bottom of the pot and covered with 4.5 cm of perlite. Pots were then filled with the soil mixture to an overall pot dry weight of 2.25 kg. Geranium was seeded in flats May 21 and 25, 2001, and transplanted to the pots on June 21. K-31 fescue was seeded directly on May 22, and perennial rye was seeded on May 29.

Plants were watered with tap water until established. Beginning June 10, pots were fertigated with 1/4 strength Hoagland's nutrient solution (without iron) using a drip irrigation system. Two pots per treatment were weighed and approximately 375 milliliters (ml) of nutrient solution was added when the pot weight decreased from 2.93 kg (field capacity) to about 2.59 kg. This allowed a leach factor of approximately 10%.

Treatments consisted of T-O spoil, Ironite, Sequestrene 338, and an acidified T-O treatment. To acidify the mine tailings, 50 ml of concentrated (18 mole [M]) sulphuric acid was gradually added to 180 grams (g) of mine tailings. The mixture was allowed to sit for one hour and then rinsed with 1.6 L of deionized water. The final leachate had an acidity of 3.5 (pH). The acidified tailings were air-dried overnight, lightly ground, and applied to the plants.

The iron sources were applied at the end of June at the rates listed in Table 2. The study consisted of 39 pots of each species (4 iron sources x 3 rates x 3 replications) and three controls (no iron source) arranged in a randomized complete block design. Rates of iron application were based on the medium level recommended on the manufacturer's label. The low rate was 50% of the recommended rate, and the high rate was 150% of the recommended rate. The T-O mine tailings were applied at the same rate as the Ironite material. The Ironite was finely ground with mortar and pestle to match the consistency of the T-O mine tailings. The treatments were arranged in a 4 x 3 x 1 factorial (4 iron sources, 3 rates, and 1 frequency). The treatments were distributed in a randomized complete block design with three replications.

Table 2. Iron Content and Application Rates of the Four Iron Sources Used in the Second Study

Treatments		Application Rate (mg/pot)		
Iron Source	% Fe	Low	Medium	High
T-O tailings	4.5	1360	2720	5440
T-O tailings (acidified)	4.5	1360	2720	5440
Ironite	4.5	1360	2720	5440
Sequestrene 338	6.0	150	300	600
Control (no iron)	0.0	--	--	--

Source: Authors

The fescue and rye were clipped to a height of 2 cm on July 25, August 2, August 9, August 21, and September 2. Clippings were dried and weighed. Visual assessment of the leaf color was made with the Minolta Colorimeter on September 23. Plants were separated into roots and shoots, oven-dried, and weighed. Nutrient concentration was determined on leaf tissue of the three species.

Industry Survey

A survey was conducted to investigate fertilizer use, particularly iron, in Southwest golf courses. The states of Arizona, California, Colorado, New Mexico, Nevada, and Utah were included in the survey. These states and regions were selected because they have soil conditions that most likely require iron applications. At the time of the survey, there were 336 golf courses in Arizona, 1,058 in southern California, 246 in Colorado, 100 in New Mexico, 116 in Nevada, and 118 in Utah (Golfcourse.com 2001). Although there are 1,058 in southern California, only 88 from one golf course association were surveyed.

A list of members of the Associations of Golf Course Superintendents (AGCS) was obtained. The associations in the target states and regions were contacted to request their member mailing lists. A list of members from Utah was obtained from the Internet through its website. A representative from Arizona sent its member list on May 23, 2001. The Colorado list was received on May 25.

The California chapter did not approve of sending its list of members. Thus, the surveys were sent directly to the golf course addresses. The same was done for New Mexico and Nevada. Golf course addresses for southern California, New Mexico, and Nevada were obtained using an Internet yellow pages search. Letters were addressed to the superintendent in charge of the golf course; their names were not included.

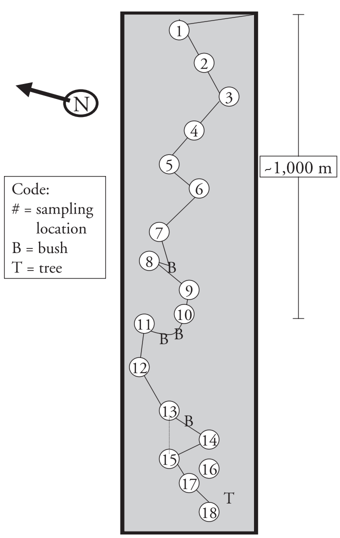
The questionnaire (Appendix A) was mailed in the summer and fall of 2001. Following the Dillman method (Dillman 1978), the surveys were mailed on Tuesday and Wednesday to avoid mail confusion due to weekend mail back-up and lost mail or clerical errors in handling. Postcard reminders were sent to all subjects who had not returned the survey form. Reminders containing a second survey form were also sent.

Results

Mine Tailings Sampling

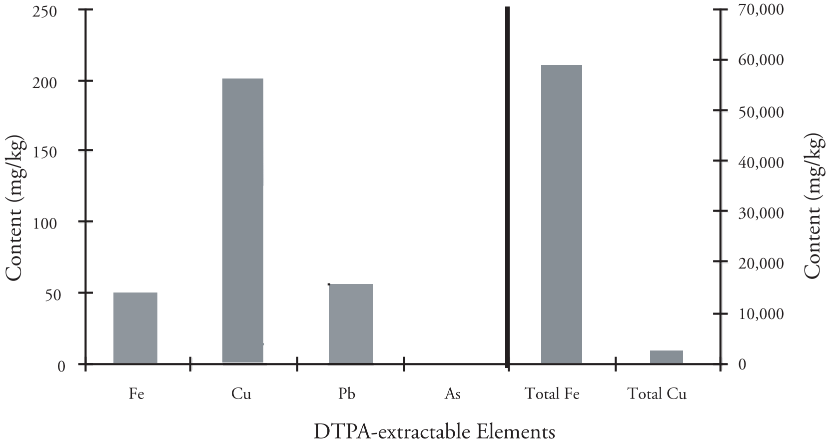
Ninety samples were collected from 23 trenches in the tailings pond on April 19, 2000 (Figure 2). Samples were analyzed for total-digest and DTPA-extractable iron. Total iron content averaged 57,132 mg/kg (S.E. = 2,320 mg/kg), while total copper averaged 1,368 mg/kg (S.E. = 89 mg/kg). Total lead content was less than 60 mg/kg and arsenic was below detection limits (<0.3 mg/kg). Unfortunately, the DTPA-extractable iron content was less than 50 mg/kg (S.E. = 5.4 mg/kg), while the DTPA-extractable copper content was nearly 200 mg/kg (Figure 3). The high extractable copper content may pose potential toxicity problems for some plants.

Figure 2. Sampling Locations at the Tohono O'odham Mine Site



Source: Authors

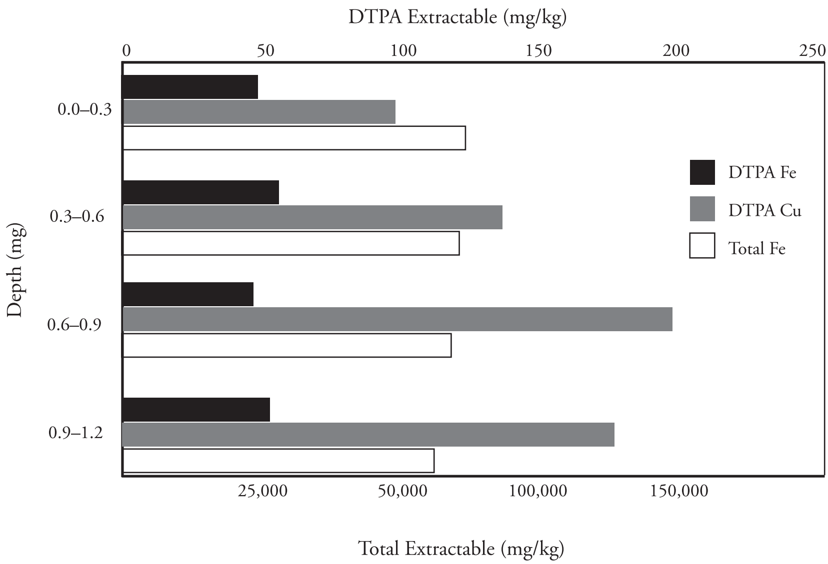
Figure 3. DTPA Extractable Iron and Copper, and Total Lead, Arsenic, Iron, and Copper*



*The scale at right for iron (Fe) and copper (Cu) is averaged across four sampling depths (0 m–1.2 m).
Source: Authors

The settling lagoon containing the mine tailings ranged in depth from 1.2 m to 1.5 m and there was little variation in either extractable or total iron with depth (Figure 4). However, there did appear to be evidence of increasing extractable copper content with depth, which may be an indication of extraction process efficiency over time; later extractions (upper depths) were more efficient. There were insufficient total copper determinations to examine the effect of depth on total copper content. Furthermore, while there was considerable variation among sampling points, there was no discernible trend in this variation (data not shown).

Figure 4. Iron and Copper Content of Tailings by Depth

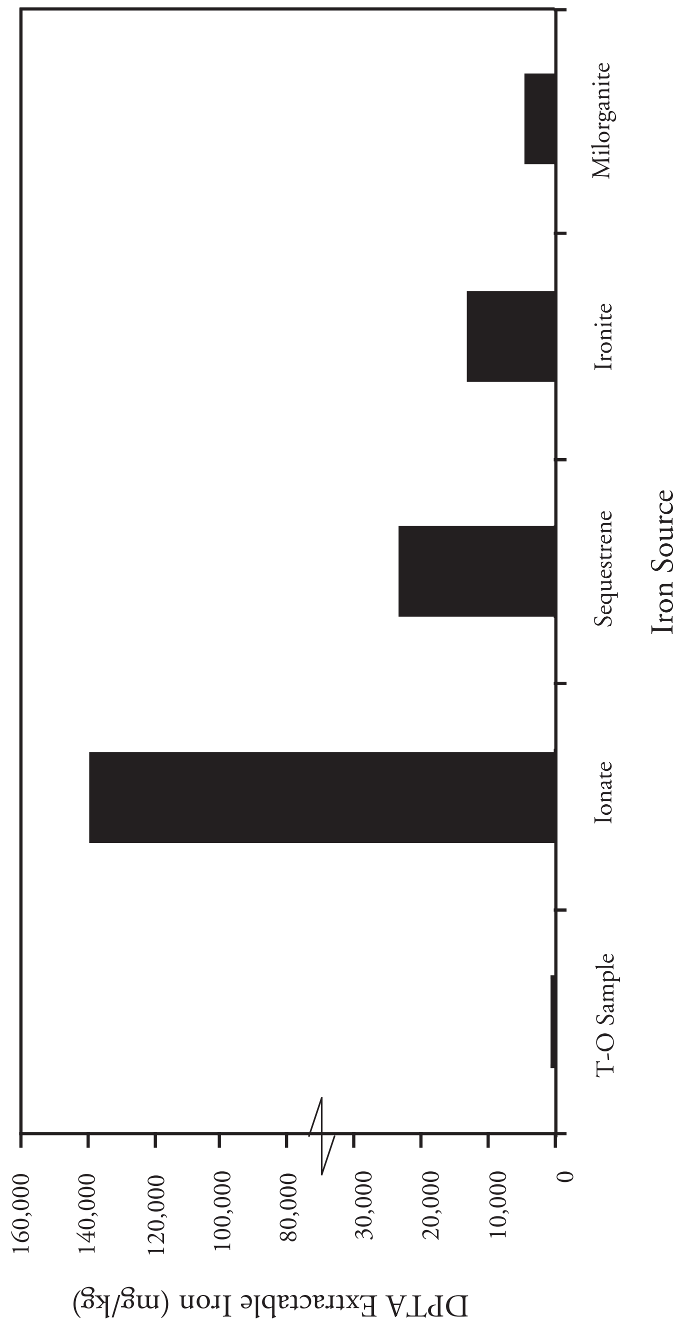


Source: Authors

Greenhouse Experiment 1

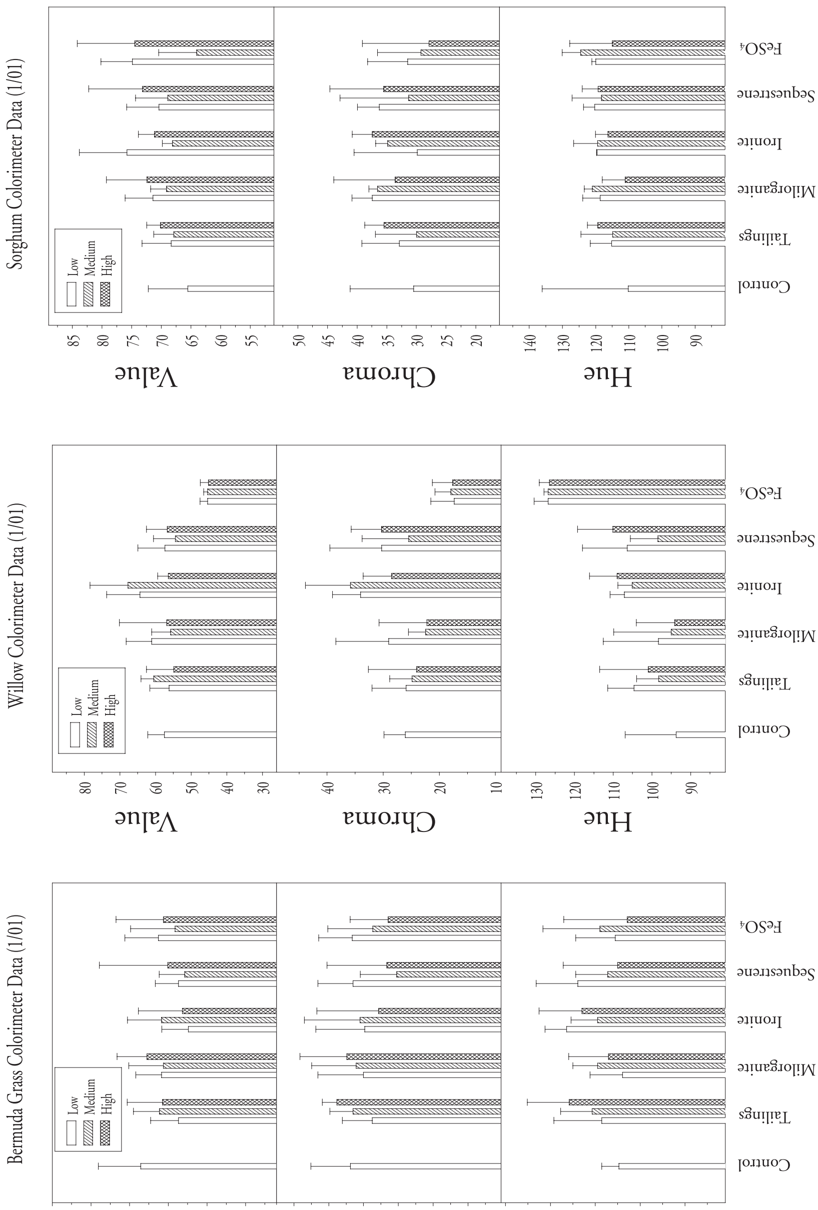
The T-O tailings had much less extractable iron than the other iron sources (Figure 5). Ionate, which was ferrous sulfate, had 140,000 mg/kg, Sequestrene 338 had 23,000 mg/kg, Ironite measured 12,000 mg/kg, Milorganite had nearly 4,000 mg/kg, and the T-O product had only 50 mg/kg. Ironite also has 1% nitrogen (Ironite.com 2003) and Milorganite is composted sewage sludge. In spite of a nearly 3,000-fold difference in iron content, none of the iron products proved beneficial in increasing iron content or color readings in any species evaluated (Figure 6). Furthermore, only Sequestrene applied to the willow cuttings increased the visual color rating of the leaves (Table 3).

Figure 5. Iron Content of Potential Iron Sources



Source: Authors

Figure 6. From Experiment 1, Bermuda Grass, Willow Cuttings, and Sorghum Colorimeter Readings after Receiving Various Sources of Iron



Source: Authors

Table 3. Visual Color Rating, Value, Chroma, and Hue for Sorghum, Willow, and Bermuda Grass Using Colorimeter*

	Sorghum				Willow				Bermuda Grass			
Iron Source	Visual	Value	Chroma	Hue	Visual	Value	Chroma	Hue	Visual	Value	Chroma	Hue
T-O	3.5	70	35	119	3.6	60	25	98	6.3	46	14	116
Ironite	2.7	71	37	116	3.1	56	29	109	6.8	43	11	113
Ionate	5.8	73	36	119	4.4	57	30	110	6.6	45	11	105
Milorganite	4.4	72	34	111	2.9	57	22	94	5.9	48	13	107
Sequestrene	5.9	74	28	115	9.3	45	18	126	6.6	46	11	103
Control	5.2	66	30	110	3.6	57	26	94	4.8	49	13	105

*The visual ratings are based on a 1 to 10 scale and averaged over three dates. There were no significant differences among treatments or among dates.

Source: Authors

Greenhouse Experiment 2

Geranium did not respond to any iron sources in this test. However, Sequestrene increased nitrogen, potassium, sulfur, and iron content relative to the control plants (Table 4). Obviously the greatest effect was on iron content (Figure 7), but improved iron nutrition seemed to increase the other nutrient concentrations. None of the other nutrients seemed to be affected. Surprisingly, Ironite with 1% nitrogen did not increase foliar nitrogen content of geranium leaf tissue.

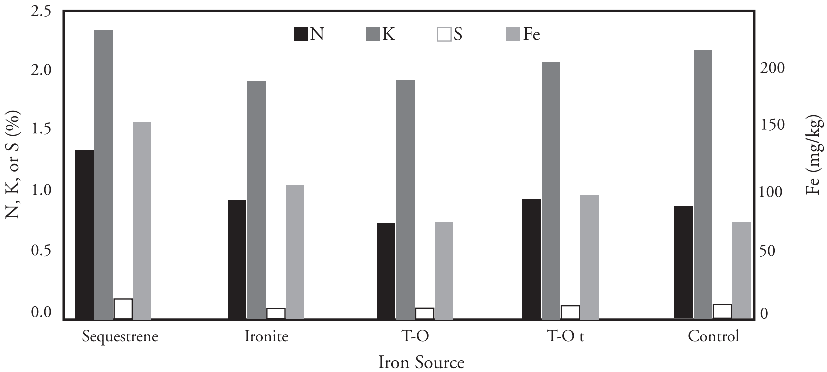
Table 4. Average Nutrient Content Following Fertilization with Different Iron Sources*

Nutrient	Geranium	Rye	Fescue
Nitrogen (%)	0.90	3.60	4.10
Phosphorus (%)	↑ 0.13	0.30	0.27
Potassium (%)	1.95	2.85	3.67
Calcium (%)	↑ 1.70	0.80	0.63
Magnesium (%)	0.41	0.70	0.78
Sulfur (%)	0.10	↓ 0.60	↓ 0.40
Iron (mg/kg)	↑ 90.00	727.00	495.00
Manganese (mg/kg)	↑ 21.00	190.00	170.00
Zinc (mg/kg)	23.00	106.00	↑ 104.00

*The arrow indicates the direction of affect Sequestrene had on plant nutrient; no arrow indicates a neutral effect.

Source: Authors

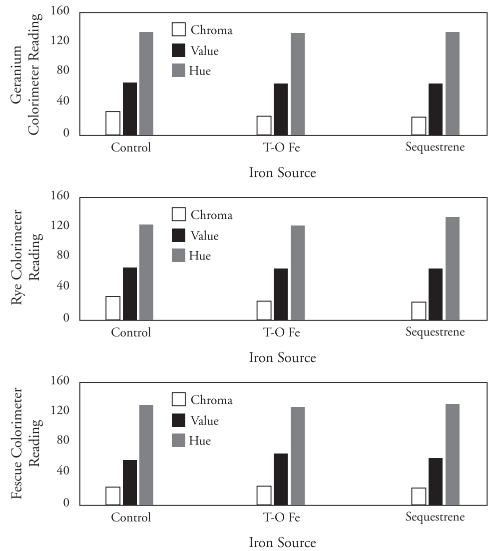
Figure 7. Geranium Nutrient Content Following Fertilization with Different Iron Sources



Source: Authors

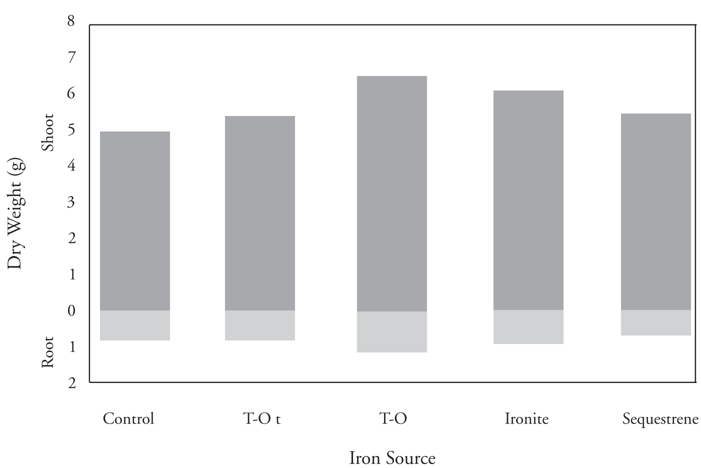
Sequestrene 338 also was the only iron source to affect leaf color visually, but these differences were not detected in the colorimeter readings (Figure 8). Furthermore, improved nutrition did not increase geranium dry matter production (Figure 9). In fact, the Sequestrene-treated plants exhibited foliar spotting and were no different from the controls in total dry weight.

Figure 8. Geranium, Rye, and Fescue Colorimeter Readings at Termination of the Study



Source: Authors

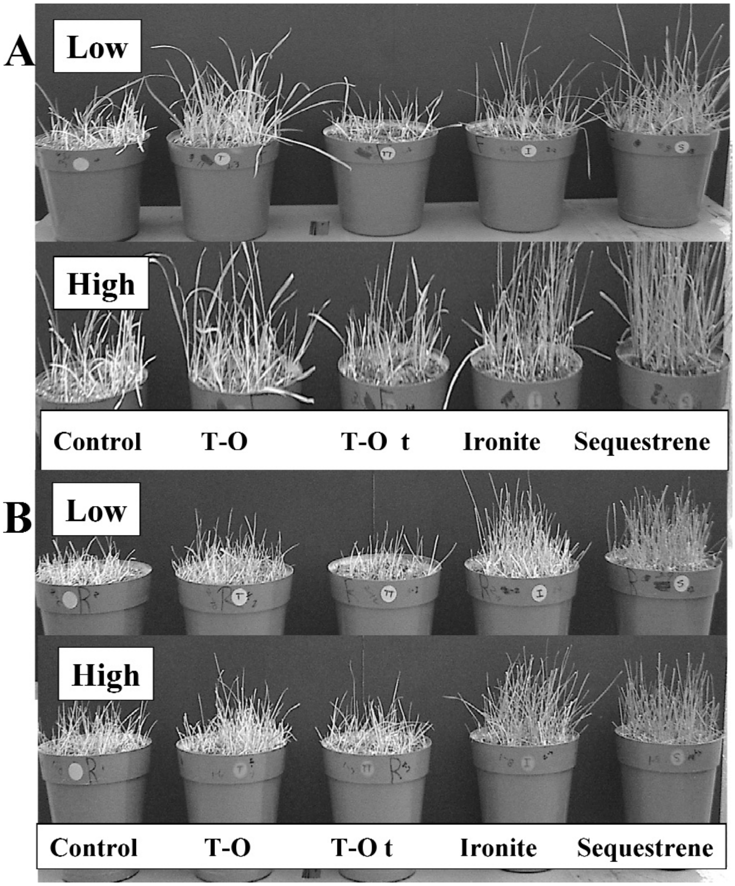
Figure 9. From Experiment 2, Geranium Dry Weight in Response to Iron Sources



Source: Authors

Only Sequestrene caused any differences in nutrient content of either the perennial rye grass or fescue, and that was a decrease in the manganese content of both grass species and an increase in the iron content of the fescue (Table 4). Furthermore, there were no significant differences in colorimeter readings (Figure 8) or in visual appearance among any of the treatments (Figure 10).

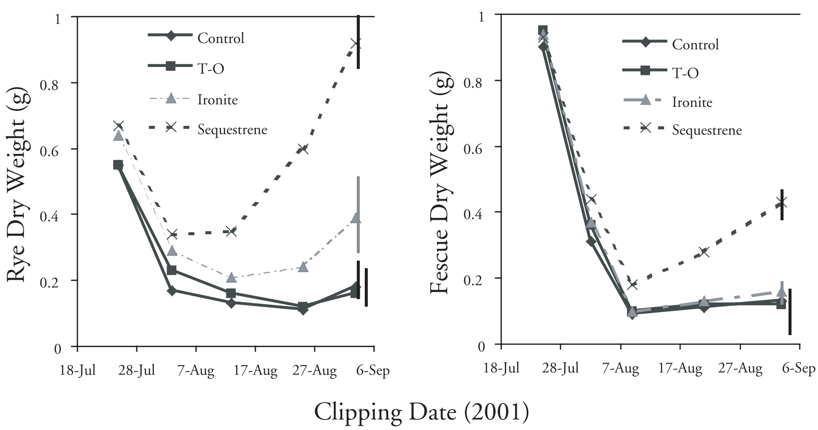
Figure 10. From Experiment 2, Final Fescue (A) and Rye (B) Response to Low and High Rates of Iron Sources



Source: Authors

Sequestrene 338 was also the only iron source that increased clipping dry weight in the study. However, there were no significant differences in clipping weight until the last two cuttings (Figure 11). The results indicate that response to iron fertilization requires at least two months to appear. While none of the other iron sources increased clipping weight, it appeared that perennial rye may have benefited from Ironite if the study had continued. While the differences were not significant, the clipping dry weight was beginning to diverge from the control treatment.

Figure 11. From Experiment 2, Clipping Dry Weight in Response to Iron Sources*

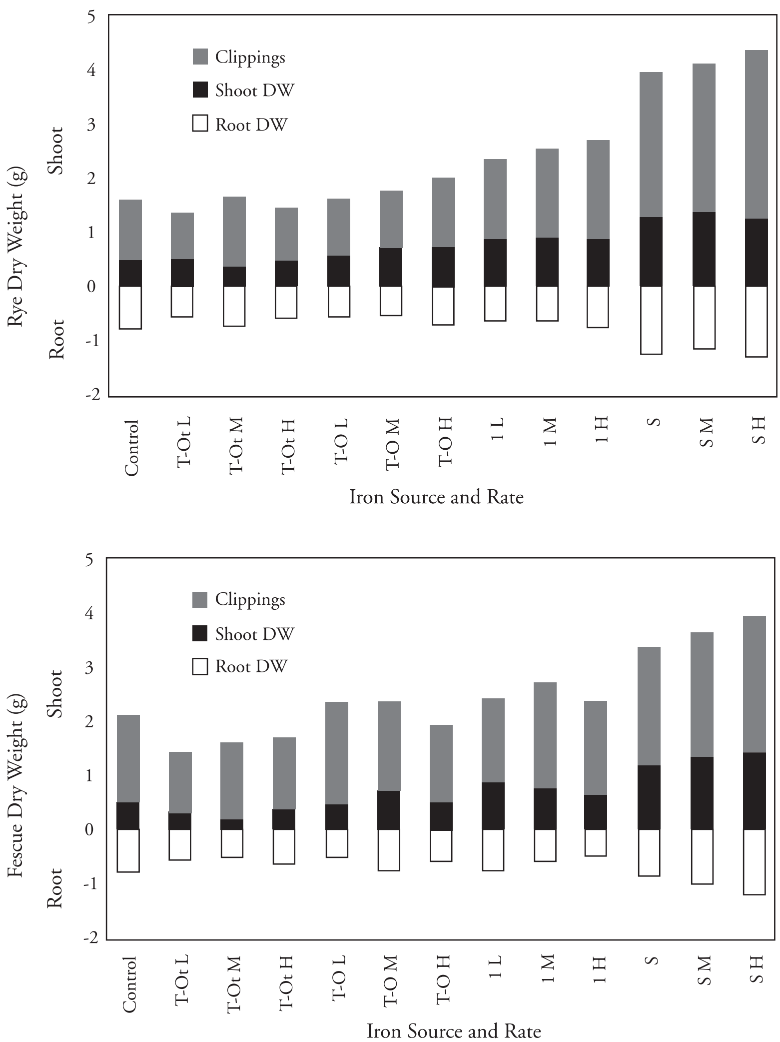


*Vertical bar = 1 S.E.

Source: Authors

Total plant dry weight (shoot, root, plus cumulative clippings) was also strongly affected by fertilization with Sequestrene 338 (Figure 12). Both rye and fescue growth was improved by this iron source, and the highest rates may have been best, although the differences among rates were not significant in this study. Several of the Ironite rates also increased total plant dry weight, although there was no consistent trend. Finally, the acidified T-O tailings iron source appeared to be toxic. Several treatments had significantly reduced growth compared to the control. This is likely due to the low pH of the material rather than any toxic substances.

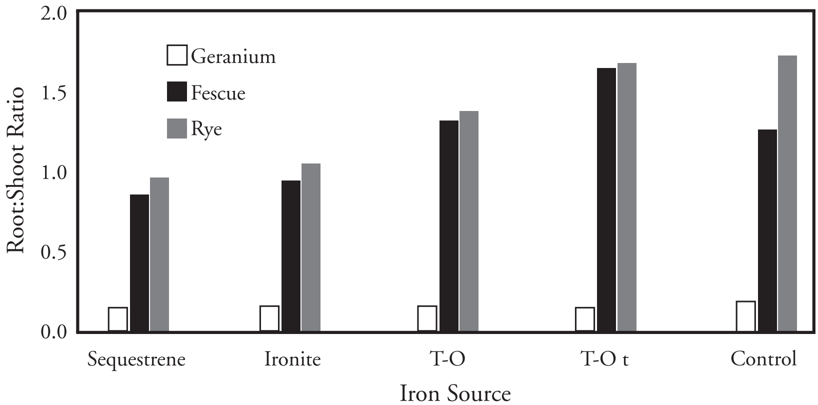
Figure 12. From Experiment 2, Total Dry Weight in Response to Iron Sources



Source: Authors

The final measurement of plant vigor was the root:shoot (R:S) ratio (Figure 13). Generally, the higher the R:S ratio the more photosynthetic energy is put into root growth to supply necessary nutrients. Geranium, in general, had low R:S ratios (~0.15), which would indicate there was little difficulty in obtaining required nutrients. However, the rye and fescue had high R:S ratios when iron was limiting (R:S >1.0). Only the Sequestrene 338 and Ironite treatments resulted in R:S ratios below 1.0.

Figure 13. From Experiment 2, R:S Ratio of Three Species Fertilized with Different Iron Sources



Source: Authors

Industry Survey

Of the nearly 900 surveys mailed to golf courses in the Southwest, 166, or 18.95%, were returned (Table 5). The lowest return rates were from California and New Mexico (8%), followed by Nevada and Utah (13%). The highest percentage returns were from Arizona and Colorado (25%). The typical golf course was about 50 ha (121 acres) in size with an alkaline soil reaction (pH = 7.5). However, the courses ranged from acidic (pH = 5.5) to very alkaline (pH = 9.0). The average respondent had 10.8 years of experience as a golf course superintendent, the last 4.5 years of which were at the current course.

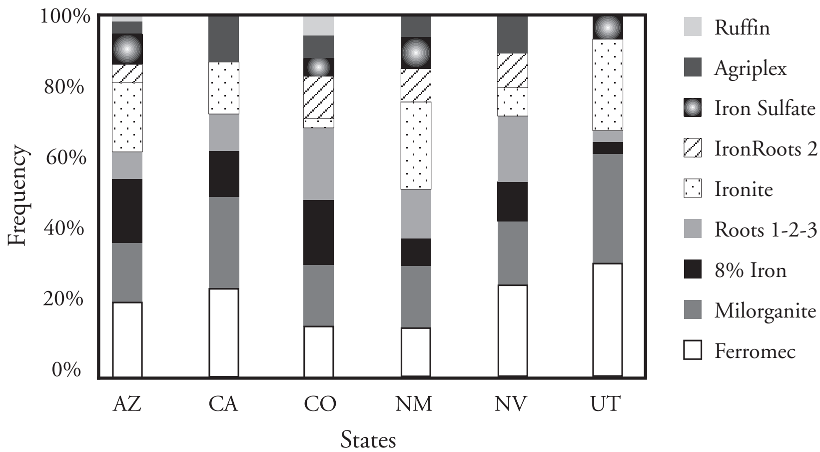
Table 5. Number of Surveys Mailed and Returned

States	Surveys Sent	Surveys Returned	Return Rate (%)
Arizona	238	56	23.50
California	88	7	7.90
Colorado	232	66	28.40
New Mexico	100	8	8.00
Nevada	100	14	14.00
Utah	118	15	12.70
Total	876	166	18.95

Source: Authors

More than 90% (155 of 166) of the courses responding use some sort of iron supplement. Furthermore, most of the courses, with the exception of the Colorado courses, apply iron throughout the year. Colorado courses and some Utah courses do not apply iron during the winter months. The respondents use a number of iron products, the most common of which are illustrated in Figure 14. Ferromec and Milorganite were the most popular iron sources. Use of these two products ranged from 29% (N.M.) to 65% (Utah) of the respondents. However, only 50% of all respondents stated they were "very satisfied" with the performance of the iron product. Furthermore, the preponderance of the "very satisfied" responses were for four products: Agriplex 2, Roots 1-2-3, IronRoots 2, and Iron Sulfate. Of note, the first three of these products are manufactured by Roots, Inc., in Independence, Mo.

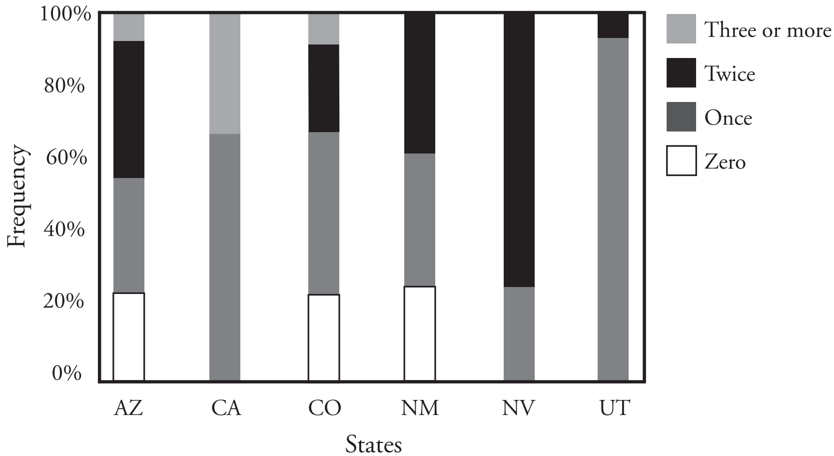
Figure 14. Most Commonly Used Iron Products, According to Responding Golf Course Superintendents



Source: Authors

The general dissatisfaction with iron products may explain the frequency of adopting new fertilizer products (Figure 15). Less than 20% of the respondents will not make any fertilizer changes over the course of a year, 38% will change products at least once, 36% will adopt at least two new fertilizer products over the course of a year, and less than 4% will adopt at least four new products. While the rate of change in fertilizer products is relatively infrequent, there is always an interest in a more effective product. Not surprisingly, the primary reason for either buying or switching to a particular iron source is efficacy (score = 1.0 on a five-point scale). Ingredients were a distant second (2.83 on a five-point scale), and price (3.33) and availability (3.67) were almost inconsequential. Cost was a more important issue on fairways, roughs, and tees, which cover larger areas.

Figure 15. Frequency of Adopting New Fertilizer Products over the Course of a Year



Source: Ng 2002

The obvious reason for efficacy being much more important than cost is that golf course appearance is important both to the superintendent and the users (Table 6). Furthermore, fertilizer costs are a relatively minor component of the total operation budget and are easily recovered in green fees and user goodwill.

Table 6. Importance of Golf Course Appearance in Decisions about Iron Fertilizer Management

State	n	Very Important (%)	Somewhat Important (%)	Not Important (%)	No Answer (%)
AZ	56	37 (66)	14 (25)	0 (0)	5 (9)
CA	7	3 (43)	3 (43)	1 (14)	0 (0)
CO	66	42 (64)	16 (24)	3 (5)	5 (8)
NM	8	7 (8)	1 (13)	0 (0)	0 (0)
NV	14	8 (57)	5 (36)	0 (0)	1 (7)
UT	15	10 (67)	4 (27)	0 (0)	1 (7)
Total	166	107(64)	43 (28)	4 (3)	12 (5)

Source: Authors

Conclusions

The T-O tailings failed to improve the growth, color, or mineral content of any of the six plant species tested in the two trials. Furthermore, these results indicate that all the iron products from mine tailings tested in this trial are ineffectual in improving plant growth. Only Sequestrene 338, a very expensive iron chelate, consistently proved beneficial. It appears there is little benefit to developing a fertilizer product from the mine tailings on the Tohono-O'odham lands, unless it is possible to further refine the product to improve iron availability without greatly increasing production costs.

The survey of the golf course industry in the southwestern United States indicates iron nutrition is a serious concern to golf course managers. However, there is a general dissatisfaction with many current iron fertilizers. An efficacious iron fertilizer would be readily accepted by the industry, and cost would not likely be an issue for application to fairways, roughs, and tees.

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Appendix A

MEMORANDUM

TO: Survey respondents

FROM: Constance L. Falk, Professor and Richard Ng, Graduate research assistant

DATE: May 22, 2001

SUBJECT: Objectives of survey

The enclosed survey has been sent to you so that we may learn more about potential demand for a new fertilizer product containing iron. This fertilizer will be produced using copper mine slag, which is on the land that the Tohono O'odham tribe in Arizona owns. The tribe would like to find an economic use for this material and has asked for laboratory analysis, tests of efficacy, and market research to determine the viability of developing a new product. Your participation in this survey is highly valued. The anonymity of your response will be maintained. If you have additional comments to make or questions to ask, you can contact Connie Falk at cfalk@nmsu.edu or 505-646-4731 or Richard Ng at cheeng@zianet.com or 505-646-2714.

When you have completed the survey, could you please enclose it in the self-addressed stamped envelope and return it to us? Thank you.

Survey of Golf Course Fertilizer Use

1. How many years have you been superintendent at this golf course?

2. How many years have you been a golf course superintendent?

3. How many years has this golf course been in business?

4. How many acres of turf does this golf course cover?

5. What is the average pH of the soil on your golf course?

6. Do you apply any fertilizers on this golf course that contain iron? (If your answer to question 6 is "No," you have completed this survey. Thank you for filling out and returning the survey.)

7. How important are fertilizers that contain iron to maintaining the appearance of the golf course? Circle your answer.
   (a) Very important
   (b) Somewhat important
   (c) Not important

8. From which distributors or wholesalers do you buy your fertilizers? Please write full name.

9. Which month(s) do you apply iron supplement fertilizers? Please write out the month(s).

10. Which month(s) do you apply the highest rates of iron supplement fertilizers? Please write out the month(s).

11. Would you be interested in using an iron supplement that contains organic matter? Circle your answer.
    (a) Very interested
    (b) Interested
    (c) Not interested
    (d) Not sure

12. What brand(s) of iron supplements do you use? Circle all that you currently use. After each brand that you use, please indicate the level of satisfaction you have with the performance of each brand in addressing chlorosis problems, using the following rating system:
    1—Very Satisfied
    2—Somewhat satisfied

3—Somewhat dissatisfied
4—Very dissatisfied
Write number below: 1, 2, 3, or 4

(a) Agriplex 2™ micro-mix
(b) BioGain™ WSP®(FE)
(c) Fe 8% iron chelate
(d) Frit 50
(e) Ferromec
(f) LAWNplex® 2-2-0
(g) Lebanon Country Club® 27-3-5 Controlled-Release Fertilizer
(h) Lebanon Pro 25-5-15 Meth-Ex 40® fertilizer
(i) Librel 13.4%
(j) Ironite™
(k) IronRoots 2™ concentrate
(l) IronRoots 2™ soluble/injectable concentrate
(m) Milorganite®
(n) Rayplex™
(o) Ruffin dry™
(p) Ruffin liquid™
(q) Sequestrene™
(r) Roots® 1-2-3™
(s) Perk Lebanon
(t) Professional Turf™ Products 14-7-7 with Nutralene
(u) Professional Turf™ Products 28-3-10 with PCSCU & Iron
(v) Professional Turf™ Products Fertilizer 25-5-12
(w) Sprint® 138
(x) Sprint® 330
(y) Tee Time® 0-0-30
(z) VigaRoot™

For brands we have not named that you use, please indicate the brand and number satisfaction rating:

13. For each of the following products, indicate total ton, lbs. or gal. used each year.
    (a) Agriplex 2™ micro-mix
    (b) BioGain™ WSP®(FE)
    (c) Fe 8% iron chelate
    (d) Frit 50
    (e) Ferromec
    (f) LAWNplex® 2-2-0
    (g) Lebanon Country Club® 27-3-5 Controlled-Release Fertilizer
    (h) Lebanon Pro 25-5-15 Meth-Ex 40® fertilizer
    (i) Librel 13.4%
    (j) Ironite™
    (k) IronRoots 2™ concentrate
    (l) IronRoots 2™ soluble/injectable concentrate
    (m) Milorganite®
    (n) Rayplex™
    (o) Ruffin dry™
    (p) Ruffin liquid™
    (q) Sequestrene™
    (r) Roots® 1-2-3™
    (s) Perk Lebanon
    (t) Professional Turf™ Products 14-7-7 with Nutralene
    (u) Professional Turf™ Products 28-3-10 with PCSCU & Iron
    (v) Professional Turf™ Products Fertilizer 25-5-12
    (w) Sprint® 138
    (x) Sprint® 330
    (y) Tee Time® 0-0-30
    (z) VigaRoot™

For others, please specify fertilizer brand name and ton, lbs., or gal.

14. Are you concerned about the metal content of the fertilizers you currently use? Indicate your level of concern for each metal.
    Lead
    Arsenic
    Copper
    (a) Very concerned
    (b) Concerned
    (c) Not concerned
    (d) Unaware of the issue

15. What criteria are most important in your iron supplement fertilizer choice? Rank the following in order of importance, starting with 1 being the most important. Provide separate answers for greens, and for fairways, roughs, and tees. If a few items are of the same importance, you can give it the same number. Please try to fill out all blanks.
    Greens, Fairways, Roughs, and Tees
    (a) Advertising
    (b) Availability
    (c) Effectiveness (Availability to plant)
    (d) Ingredients
    (e) Price
    (f) Size of package
    (g) Solubility
    (h) Other (specify)

16. What is/are the reasons you tend to switch brands? Rank greens separately from fairways, roughs, and tees. Rank the most important reason.
    Greens, Fairways, Roughs, and Tees
    (a) Market availability
    (b) Company recommendation
    (c) Effectiveness (Availability to plant)
    (d) Ingredients
    (e) Price
    (f) Size of package
    (g) Solubility
    (h) Other (specify)

17. How price-sensitive are you when purchasing iron supplement fertilizers for your greens and your fairways, roughs, and tees? Circle a separate answer for greens and for fairways, roughs, and tees.

    Greens
    (a) Very price-sensitive
    (b) Moderately price-sensitive
    (c) Somewhat price-sensitive
    (d) Not price-sensitive

    Fairways, Roughs, and Tees
    (a) Very price-sensitive
    (b) Moderately price-sensitive
    (c) Somewhat price-sensitive
    (d) Not price-sensitive

18. How many times per year do you adopt new fertilizer products on average? Do not include products that you try out and did not use.

VII

Association of Gastrointestinal Illnesses and Environmental Factors in a Kumiai Indian Community in Baja California, Mexico[1]

Kathleen Coates Hedberg and Richard M. Gersberg

Introduction

Every country must make choices about how best to use economic resources for health. The severe limitations in developing countries require that resource allocation choices lead to the most health for the money (Evans, Hall, and Warford 1981). The present study was conducted to assess the morbidity status in the Kumiai Indian community of San Antonio Necua, located south of Tecate in Baja California, Mexico, and to determine whether there is an association with environmental health factors.

The planning and evaluation of public health activities and health facilities require knowledge of the extent of morbidity in the population. Morbidity data are essential to attempt to control disease. The most important issues in less-developed countries often involve control of known hazards, such as air pollution, drinking water contamination, sewage and solid waste disposal, vectors, and diet.

In 1996, "Building a Kumiai Environmental Strategy: A Border 21 Project" (Wilken-Robertson 1996) identified the water quality needs of the Kumiai communities of Baja California. The report identified water quality concerns in five different communities and suggested that improvements be made to water used for domestic purposes in San Antonio Necua. Many members of the community had stated that the water tastes like manure and urine and that the water quality was causing illnesses in newborns (Wilken-Robertson 1996).

Instituto de Culturas Nativas de Baja California (CUNA) made efforts to contact non-governmental organizations (NGOs) to assist in providing technical expertise to help this community. Among those NGOs was Aqualink Water Systems, a volunteer group dedicated to providing technical assistance to villages in Baja California that are developing small water and wastewater treatment systems. The group was asked to help San Antonio Necua assess its needs for water system improvements, and in March 1997 it began working with the community.

San Antonio Necua obtains its drinking water from a stream whose water is piped approximately 3 kilometers from the mountains to two concrete storage reservoirs. The water is then distributed to homes. Data on the quality of water used for domestic purposes obtained since January 1996 had consistently shown the presence of fecal coliform bacteria (Wilken-Robertson 1996). The presence of total and fecal coliform bacteria in untreated surface water is common and an indicator of disease-causing organisms in the water (Salvato 1992). This type of contaminated water must be treated before consumption.

After an evaluation of the water system, Aqualink Water Systems made the following suggestions to improve the community's water supply (Coates Hedberg 1998):

- Treat source water with filtration and disinfection
- Rehabilitate an existing abandoned well
- Drill a new well

It was suggested that the best alternative was to rehabilitate an existing abandoned well. However, the community was concerned about changing their water supply from its current source to well water that has a high level of total dissolved solids. When the alternative was suggested to treat the source water with chlorine for disinfection, community members became concerned this might also change the water's taste. Thus, the community opted not to make improvements or changes to the current water system, discounting the fact that it may be a cause of illness. This dilemma prompted the idea of evaluating the community's overall gastrointestinal illnesses and their association with drinking water.

The study examined the association of the community's gastrointestinal illnesses with a number of environmental health factors. The project was intended to answer the following question directly and empirically: Is there an excessive number of gastrointestinal illnesses related to environmental factors in the community?

The process began with an initial visit with the president of the community to discuss the plans for the study. The president was given information on the purpose and basis for the study, what the process consisted of, and what type of questions the researchers hoped to answer. The president consented to the study. The next step was to attend a meeting and propose the study to the community for its approval. After fielding questions, the majority of the community agreed to participate for a small stipend. Upon the researchers' request, the president selected five community members *(promotors)* to assist in gathering data for the study and they were introduced to the community. A meeting with the *promotors* explained their roles and provided training on gathering the data. Data collection began soon after. Each participant in the study was read an informed consent form, which they signed.

The study was carried out for four weeks during the months of September and October 1998 on the San Antonio Necua reservation, which is located in the northeastern part of Valle de Guadalupe. Approximately 42 families live there and the total population is 164.

After the study was completed, the results were presented to the community and additional information was provided to assess the need for environmental health improvements. It is hoped that the study will also assist public health workers in implementing future environmental health evaluations of communities in less-developed countries.

Methodology

This project was an observational prospective study in which participating individuals were followed for a period of four weeks. The information obtained was focused on environmental health aspects, including drinking water supply, sewage waste disposal, solid waste disposal, the presence of rodents in the home, where food was purchased, as well as personal characteristics such as gender, age, occupation, and illness.

Data Collection

Two sets of data were collected from participating families. One set of data was obtained from an initial Environmental Health Assessment Enrollment Questionnaire, which included questions about each household and personal data about the individual participant. The second set of data was collected from Daily Illness Questionnaires, which were administered over four weeks. These questionnaires are variations of those that had been used previously in three studies by the U.S. Environmental Protection Agency (EPA), one study by the Centers for Disease Control and Prevention, and one by an EPA-funded study in Quebec, Canada (Payment, et al. 1991; EPA 1998a).

In order to collect the data, a *promotor* method was implemented. A *promotor* is a person within a community recruited to assist participation in health programs. Using the contracted *promotors* provided consistency of data collection and ease of participation.

Data Analysis

All participating households were initially visited on September 12 or 13, 1998. An interview with the adults (18 years of age and older) in each household was carried out to complete the initial Environmental Health Assessment Enrollment Questionnaire and explain how the daily illness health data would be collected. Illness data was gathered from September 13, 1998, through October 10, 1998.

For the purpose of statistical analyses, an episode of highly credible gastrointestinal illness (HCGI) involved at least one of the following combinations (Payment, et al. 1991):

- Vomiting or diarrhea with or without confinement to bed, consultation with a doctor, or hospitalization
- Nausea or diarrhea combined with abdominal cramps with or without absence from school or work, confinement to bed, consultation with a doctor, or hospitalization

An incident of diarrhea is classified as three or more bowel movements in a 24-hour period. Episodes with plausible etiologies apart from the one under study, such as pregnancy, were excluded from data analysis.

Results

Community Participants

All 42 families living in San Antonio Necua during the month of September 1998 were asked to participate in this study. Of these, 29 families, for a total study population of 114 people or 70% of the community, participated. When requesting participation, a geographical factor was observed within the community for those families who live primarily in the north section of the community—those families declined to participate.

Characteristics of the Families

Table 1 provides the general characteristics of the families within the study group. The mean age of the population studied is 24. When residents of the community reach the age of 14, they typically stop attending school and begin working. More than three quarters of the population (76.3%) had lived in the community all their life. Of the women surveyed, only two (3.6%) were pregnant. None of the participants use day care facilities to watch their children; family members are used when needed. Most of the married women do not work and stay home. Just less than half (44.1%) the population has a job. Only 27% of those who work do so outside the community. The average workweek is Monday through Saturday.

Table 1. Personal Information from Data Obtained during the Survey of Community Participants on September 12 and 13, 1998 (N = 114 Persons)

Variable	Number of People	Percent of People
Age in years		
0–5	19	16.7
6–14	21	18.4
15–44	56	49.1
45+	18	15.8
Gender		
Male	58	50.9
Female	56	49.1
Years lived in community		
Life	87	76.3
1 to 3	12	10.5
4 or more	15	13.2
Occupation		
Housewife	23	20.2
Student	20	17.5
Children at home	18	15.8
Rancher	15	13.2
Fish cannery	14	12.3
Road construction work	11	9.6
Teacher	4	3.5
No work	3	2.6
Winery worker	2	1.8
Janitor	1	0.9
Pump mechanic	1	0.9
Store manager	1	0.9
Truck driver	1	0.9
Work location		
Inside community (includes students)	42	36.8
Outside community	31	27.2
Don't work (includes children at home and housewives)	41	36.0

Source: Authors

Less than 25% of participants indicated that they drink alcohol and less than 20% smoke tobacco (from data obtained from those who are older than age 13). More than 80% use herbal remedies, which are typically made into teas.

The community has a central local health clinic where a doctor provides clinical services once per week. The most common illnesses in the community are diabetes, tuberculosis, and gastrointestinal illness. At the time of the survey, 10% of the participants had been diagnosed with an existing illness. More than 5% were diagnosed with diabetes—a great concern among the community's elders.

Characteristics of the Households

There are 26 homes in the community that house the 29 families who participated in the study. The community is spread out into four different clusters over 15,474 acres. The mean number of people living in the home is 4.9 with a standard deviation of 1.6. The mean number of rooms in the houses within the community is 3.7 with a standard deviation of 1.5.

All participants claim to drink the water supplied in the community and do not purchase bottled or hauled water. None of the participants treat their water prior to consumption. However, at times they need to pick out dirt, debris, and worms (mosquito larvae). The median number of glasses of water consumed per person is 5.0 per day, the mean is 6.1 glasses with a standard deviation of 4.3.

Water is delivered via gravity (there are no water pumps) to San Antonio Necua by pipeline. The community has a water distribution system that allows accessibility to all households. Some households do not have water plumbed into their homes and may instead have a hose tap on site or use a nearby hose tap. However, during warmer times of the year due to increased water use or decreased availability of source water, only 28% of the community receives a constant flow of water. Those who reside on the south side of the community have a constant water supply in comparison to other locations of the community. The homes on the south side of the community are first to receive water from the water source.

Approximately 50% of the community has home water storage in buckets or has water piped to their kitchen sink. Some residents have a water supply piped to their homes' kitchen sinks while others haul water via buckets to store in 55-gallon containers within their house. Storage of drinking water is not related to water availability. Of those who have water available sometimes, 58.5% have water supplied to their kitchen faucet. Of those who have water available all the time, only 37.5% have water supplied to their kitchen faucet.

Containers stored inside the house are sometimes covered; some homes have a scoop to dip into the water to collect for use. Some households have smaller containers with special taps on covered buckets for drinking water. Used water from the homes' sinks and showers is drained by pipe to the outside of the home for washing and cleaning.

Seven homes have septic tanks servicing 28.9% of the participating population. The outhouses are typically used for a year, then the waste is covered and the housing is moved over a new hole. It was observed during the survey that none of the outhouse vent pipes were screened. None of those surveyed indicated that they use lime or any other covering material or mechanism to prevent odor and control vectors in the outhouses.

Twenty-nine percent of the population, or eight homes, indicated that they have problems with rats entering their dwellings. Most indicated that the rats enter through the roof and scavenge for food and water. The majority of the community (89%) indicated that they burn their garbage on a daily basis as a method of trash elimination. The remaining population, 11%, discard their trash near the river that flows adjacent to the community.

Crowding in households was determined by dividing the number of people by the total number of rooms in the household (Olaiz 1987). Overcrowding is defined as more than two individuals per room. By this criteria, overcrowding is present in five households (24%), affecting 27 people. Only two of the houses in the community do not have electricity, affecting 5% of the population. Three households (12%) do not have refrigeration, affecting 7.9% of the population. Those who do not have refrigeration indicated that they shop for food on a daily basis.

Forty-one percent of the participants are the primary cook in the household. The cook is usually a woman who is either the wife or an elder in the household. More than 75% of meat and dairy products are purchased at the community's local store, which participants use because of its convenience and the belief that the prices are discounted. Forty-eight percent of the population purchases produce outside the community; some of the residents grow some fruits and vegetables at their homes. The most common foods for typical daily meals are eggs, beans, tortillas, potatoes, chicken soup, and rice. Some of the interviewees mentioned that they reuse food cooked in the morning for another meal later in the day.

Health Problems in San Antonio Necua

The *promotors* gathered the four-week daily illness questionnaires from the participating families. These questionnaires (given to all participants) requested information about their health and symptoms related to acute gastrointestinal diseases, as well as other illness symptoms such as fever, headache, and cough. The data in Table 2 show the number of days of symptoms experienced by the population during the four-week study. Thirty-seven percent of the community had at least one day of diarrhea during the study. Additionally, 45 people (39.5%) indicated they visually observed worms in their stool.

Table 3 indicates the number of days of highly credible gastrointestinal illness (HCGI). During weeks one, two, and four, more than 17% of the population had at least one day of HCGI. During week one, four people had HCGI for more than four days. In week three, only 13% of the population had one day of HCGI.

During the entire four weeks of the study, 44.6% of the population had one case of HCGI. Only one person had a case of HCGI every week. Tuesday showed the highest average number of cases of HCGI—7.5 people—during the four-week period. Saturday and Sunday had the lowest percent of ongoing HCGI cases on average.

Table 4 and Figure 1 depict the number of cases of onset of HCGI by days of the week. Tuesday showed the highest average number of cases of onset of HCGI (25.0%) during the four-week period. The end of the week, Friday and Saturday, had the lowest percent of HCGI case onset.

Table 2. Daily Illness Data Gathered during the Survey of the Community Participants between September 13, 1998, and October 10, 1998, (N = 112 persons; data do not include those pregnant)

Variable	Number of people and percent by number of days of illness									
	None		One day		Two days		Three days		More than four days	
	#	%	#	%	#	%	#	%	#	%
Cold or flu with cough present	48	42.9	13	11.6	7	6.3	10	8.9	34	30.5
Headache	66	58.9	18	16.1	8	7.1	9	8.0	11	9.9
Diarrhea	71	63.4	16	14.3	11	9.8	6	5.4	8	7.2
Abdominal cramps	81	72.3	13	11.6	7	6.3	8	7.1	3	2.7
Nausea	93	83.0	10	8.9	2	1.8	4	3.6	3	2.7
Fever	94	83.9	9	8.0	6	5.4	2	1.8	1	0.9
Vomiting	97	86.6	10	8.9	1	0.9	2	1.8	2	1.8

Source: Authors

Table 3. Daily Illness Data on Number of Days of HCGI by Week from Data Gathered during Survey of the Community Participants between September 13, 1998, and October 10, 1998, (N = 112 persons; data do not include those pregnant)

Week no.	Number of people and percent with HCGI by number of days of illness									
	None		One day		Two days		Three days		More than four days	
	#	%	#	%	#	%	#	%	#	%
1	92	82.1	8	7.1	3	2.7	5	4.5	4	3.6
2	92	82.1	13	11.6	5	4.5	1	0.9	1	0.9
3	98	87.5	7	6.3	4	3.6	2	1.8	1	0.9
4	93	83.0	15	13.4	2	1.8	1	0.9	1	0.9
Mean	94	83.7	11	9.6	4	3.2	2	2.0	2	1.6

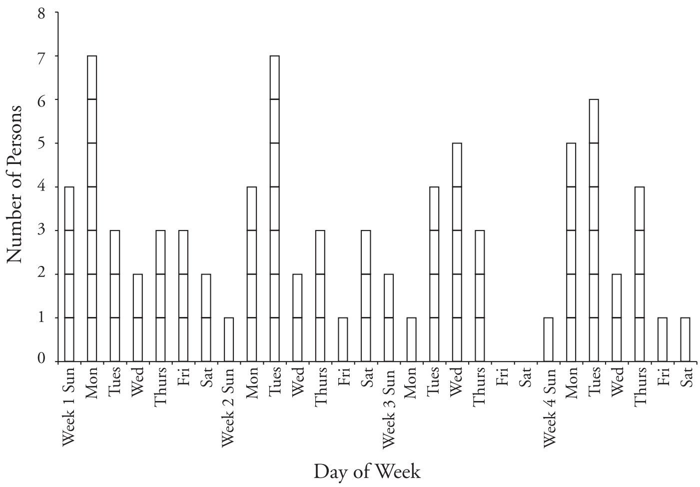
Source: Authors

Table 4. New Cases of HCGI By Onset Day and Week from Data Gathered during Survey of the Community Participants between September 13, 1998, and October 10, 1998, (N = 112 persons; data do not include those pregnant)

	Number of people and percent with new cases of HCGI by onset day and week													
	Sun.		Mon.		Tues.		Wed.		Thurs.		Fri.		Sat.	
Week no.	#	%	#	%	#	%	#	%	#	%	#	%	#	%
1	4	16.7	7	29.2	3	13	2	8.33	3	12.5	3	12.5	2	8.33
2	1	4.8	4	19.0	7	33	2	9.52	3	14.3	1	4.76	3	14.30
3	2	13.3	1	6.7	4	27	5	33.30	3	20.0	0	0.00	0	0.00
4	1	5.0	5	25.0	6	30	2	10.00	4	20.0	1	5.00	1	5.00
Daily total number	8	10.0	17	21.3	20	25	11	13.80	13	16.3	5	6.25	6	7.50
Daily mean	2.0		4.25		5.00		2.75		3.25		1.25		1.50	

Source: Authors

Figure 1. Day of Onset of HCGI illness



Source: Authors

Table 5 depicts the length of HCGI cases per person. More than 35% of HCGI cases occurred for more than one day. Approximately 8% had an HCGI case for more than four days. More than 40% of those who had an HCGI case for three days had a fever.

Table 5. Length of HCGI Cases By Week and Day from Data Gathered during Survey of the Community Participants between September 13, 1998, and October 10, 1998, (N = 112 persons; data do not include those pregnant)

Variable	Number of people and percent by length of HGCI cases							
	One day		Two days		Three days		More than four days	
	#	%	#	%	#	%	#	%
All HCGI cases	50	64.90	14	18.20	7	9.09	6	7.79
HCGI cases with fever	5	45.50	1	9.10	3	27.30	2	1.82
Percent of HCGI with fever of all cases		10.00		7.14		42.90		33.30

Source: Authors

Twenty-three percent of the people who had an illness visited a doctor. Most of the community indicated that when they are sick with diarrhea they visit the local community clinic for antidiarrheal medicine.

Personal Information and HCGI Cases

Table 6 depicts the univariate analysis of personal information and cases of HCGI. Those older than 13 who indicated they were smokers showed a statistically significant inverse relationship to cases of HCGI compared to those who did not smoke ($\chi^2 = 5.121$, $p = 0.024$, Odds Ratio = 0.223). According to the data obtained, there was a decrease in the number of HCGI cases in the age group 6 through 14 in comparison to the other age groups.

Those who had not lived in the community all their lives had a significantly higher number of HCGI cases compared to those who had ($\chi^2 = 3.911$, $p = 0.048$, Odds Ratio = 2.447). Of those who had not lived in the community all their lives, there was no significant difference in how many years they had been there and cases of HCGI. Those who work within the community did not have a significant difference in HCGI compared to those who work outside the community.

Although no statistical significance was shown between drinking less than eight and more than eight glasses of water per day, there was an increase in HCGI cases for those who drank more glasses of water ($\chi^2 = 1.360$, $p = 0.243$, Odds Ratio = 0.618).

Household Information and HCGI Cases

Table 7 shows the univariate analysis of water supply and cases of HCGI. Tap water availability and storage showed no significant difference relative to HCGI cases.

Table 8 shows the univariate analysis of household sanitation characteristics and cases of HCGI. No significant relationship was shown between the type of sewage facility used, garbage disposal, crowding, location of the home within the community, electricity, or refrigeration. Significance was shown between those who live in homes with reported rodent problems and cases of HCGI

Table 6. Univariate Analysis of HCGI from Data Gathered during Survey of the Community Participants between September 13, 1998, and October 10, 1998, and Personal Information (N = 112 persons; data do not include those pregnant)

Variable	Cases of HCGI				χ^2	*p* value	Odds ratio	95% Cl
	At least one case		None					
	#	%	#	%				
Drink alcohol (>13 years)					0.022	0.881	0.921	0.311–2.724
Yes	8	47.1	9	52.9				
No	28	49.1	29	50.9				
Smoke (>13 years)					5.121	0.024	0.223	0.311–2.724
Yes	3	21.4	11	78.6				
No	33	55.0	27	45.0				
Age in groups in years					2.879	0.411	N/A	N/A
0–5	9	47.4	10	52.6				
6–14	6	28.6	15	71.4				
15–44	27	50.0	27	50.0				
45+	8	44.4	10	55.6				
Gender					1.211	0.271	1.522	0.719–3.219
Female	27	50.0	27	50.0				
Male	23	39.7	35	60.3				
Use herbal remedies					0.212	0.645	1.260	0.471–3.371
Yes	42	45.7	50	54.3				
No	8	40.0	12	60.0				

Source: Authors

Table 7. Univariate Analysis of HCGI from Data Gathered during Survey of the Community Participants between September 13, 1998, and October 10, 1998, and Water Supply (N = 112 persons; data do not include those pregnant)

Variable	Cases of HCGI				χ^2	*p* value	Odds ratio	95% Cl
	At least one case		None					
	#	%	#	%				
Tap water available 100% of time					0.127	0.721	0.859	0.372–1.983
Yes	13	41.9	18	58.1				
No	37	45.7	44	54.3				
Water storage					0.002	0.967	1.016	0.482–2.141
Kitchen tap	26	44.8	32	55.2				
Bucket	24	44.4	30	55.6				

Source: Authors

Table 8. Univariate Analysis of HCGI from Data Gathered during Survey of the Community between September 13, 1998, and October 10, 1998, and Household Sanitation Characteristics (N = 112 persons; data do not include those pregnant)

Variable	Cases of HCGI: At least one case #	Cases of HCGI: At least one case %	Cases of HCGI: None #	Cases of HCGI: None %	χ^2	*p* value	Odds ratio	95% Cl
Sewage facility					0.014	0.904	1.052	0.461–2.402
Outhouse	36	45.0	44	55.0				
Septic	14	43.8	18	55.3				
Garbage disposal					1.781	0.182	2.360	0.117–1.539
Do not burn	7	63.6	4	36.4				
Burn	43	42.6	58	57.4				
Rodent problem in home					6.830	0.009	3.017	1.297–7.017
Yes	21	63.6	12	36.4				
No	29	36.7	50	63.3				
Crowded (>1 person/room)					1.841	0.175	0.537	0.217–1.328
Yes	9	33.3	18	66.7				
No	41	48.2	44	51.8				
Location of home					0.109	0.947	N/A[a]	N/A
South side	11	42.3	15	57.7				
East side	15	44.1	19	55.9				
West side	24	46.2	28	53.8				
Electricity in home					0.074	0.786	0.797	0.154–4.129
Yes	47	44.3	59	55.7				
No	3	50.0	3	50.0				
Refrigeration available					0.507	0.477	1.679	0.398–7.078
Yes	47	45.6	56	54.4				
No	3	33.3	6	66.7				

[a] N/A = not applicable

Source: Authors

(χ^2 = 6.830, p = 0.009, Odds Ratio = 3.017, 95% CI = 1.297–7.017). Although no significant relationship was shown, those who did not burn their garbage had an increase in numbers of HCGI cases (χ^2 = 1.781, p = 0.182, Odds Ratio = 2.36, 95% CI = 0.117–1.539). In addition, although no significance was found based on the location of the homes, HCGI cases increased in increments of 2% from south side to east side to west side.

The homes that had at least two people with a case of HCGI had a higher incidence of rodent problems; however, this was determined to be statistically insignificant. Those who have rodent problems and stay within the community during the day also had increased HCGI incidence; this too, though, was determined to be statistically insignificant. It was further shown that for those who have rodent problems and at least one case of HCGI, drinking water storage was not statistically significant. Forty-six percent of those who live on the west side of the community have rodent problems. One south-side home indicated rodent problems, as did one east side home. All those who indicated they had rodent problems on the south and east sides of the community had at least one case of HCGI (100%). Of those who live on the west side of the community and indicated they had rodent problems, 46.2% had at least one case of HCGI; the comparable figure for the east side was 44.1%, and for the south side it was 42.3%.

There was no significant relationship found between cases of HCGI and where dairy products, meat, and produce were purchased, or who cooks the food for the household.

Characteristics of the Water Supply

Samples of water for laboratory analysis were taken from one location within the distribution system. Table 9 indicates the water quality results of these samples.

Table 9. Water Quality Characteristics Gathered during Survey of the Community between September 13, 1998, and October 10, 1998

Date	Total coliform	Fecal coliform	HPC	Turbidity	TDS	Color
9/13/98	900	17	540	0.37	315.0	<20
9/20/98	900	30	Lab error	0.73	337.5	<25
9/27/98	500	8	170	0.76	346.0	<15
10/4/98	110	30	460	0.88	359.0	<15
10/11/98	140	8	125	0.82	249.0	<10

Source: Authors

Discussion

Gastrointestinal Illnesses

During the study of San Antonio Necua, 50 people of the 112-person study population (44.6%) had at least one case of HCGI. The number of gastrointestinal illnesses in the community was present at a frequency high enough to test statistically the postulated hypotheses.

The incidence of diarrheal cases in the community from September 13, 1998, to October 10, 1998, was 366 per 1,000 people and the incidence of HCGI cases was 446 per 1,000. The reported incidence for diarrheal diseases found in Latin America in 1990, according to the Global Health Statistics, was 978 per 1,000 for all ages, and for ages older than 14, the rate was 300 per 1,000 (Murray and Lopez 1996). A study by Olaiz (1987) showed the prevalence rate (new cases over a two-week period) of diarrhea in communities in Tijuana, Mexico, to be 298 per 1,000 in 1987. The Olaiz study was carried out in rural communities within Mexico with a similarly high risk of gastrointestinal illnesses.

The incidence rate of diarrheal diseases in 35 established market economies surveyed in 1990 was 209 per 1,000 for all ages, and for those older than 4 years, the rate was 100 per 1,000. San Antonio Necua has a rate similar to those of developing communities.

Personal Information and HCGI Cases

Those older than 13 who indicated they smoke had a statistically significant inverse relationship with cases of HCGI (Table 6). This relationship may be consistent with recent findings from studies being performed in the United States. Since 1982, studies have shown a strong negative association between smoking and colitis (Thomas, et al. 1996), which has led to a search for the active ingredient responsible for the relationship. Nicotine is currently under investigation to determine whether it has a therapeutic role in the treatment of ulcerative colitis (Thomas, et al. 1996), a gastrointestinal condition that is a form of inflammatory bowel disease.

More than three quarters of the community's population (76.3%) have lived there all their lives, as is common within Indian groups. Most of the children marry outside San Antonio Necua and bring their spouses into the community. Those who indicated they have not lived in the community all their lives had a significant increase in number of cases of HCGI. An evaluation was performed to determine whether there was an association with newer community residents being more susceptible to illnesses. Since the range of years living in the community was from 1 to 32, further analysis was performed and concluded that length of time living in the community had no statistical significance in incidence of HCGI. Thus, a person who was not born in the community was determined to be more likely to incur gastrointestinal illnesses regardless of how long he or she had lived in the community.

During each of the four weeks, Tuesday was found to have the highest percent of onset HCGI cases and Monday ranked second highest, with ratings of 25.0% and 21.3% respectively (Table 4). The most common gastrointestinal illnesses have an incubation period of 24 hours to 48 hours (Seenland and Savitz 1997). Most of the families are home on Sundays all day because of the six-day workweek. Based on a 24-hour to 48-hour incubation period, an

HCGI case exposed on Sunday most likely had a day of onset of Monday or Tuesday. This indicates that the source of the gastrointestinal illness may be coming from the home.

Sixty-five percent of all HCGI cases had a duration period of one day (Table 3). The most common food-borne illnesses last 24 hours. Seventeen percent of all HCGI cases had a duration of more than three days, and of those, 38 percent were associated with fever (Table 5). The presence of fever is common in longer-duration food-borne illnesses.

Household Sanitation Characteristics and HCGI Cases

Those who indicated they had rodent problems had a significant increase in cases of HCGI ($p < 0.05$), as shown in Table 8. This finding was reinforced by the consistency of the effect across different ages, sexes, home locations, and occupations. This study suggests there is a significant association with the presence of rodents in the homes and gastrointestinal illness among the residents.

Water Quality Characteristics

The criteria for filtration avoidance in the United States requires that fecal coliform bacteria number be less than 20 per 100 milliliter (ml) and that turbidity is less than 1 Nephelometric Turbidity Unit. It also requires implementation of a watershed control program. The water supplied to the community met the criteria for filtration avoidance for turbidity; however, two samples showed fecal coliform bacteria at 30 per 100 ml. Although the source water on average met the qualifications for filtration avoidance, disinfection is necessary to achieve 99.9% inactivation of *Giardia lamblia*. The regulations are based on the assumption that all water systems that use surface water sources may be at risk, at least to some degree, from contamination by protozoan cysts and enteric viruses. *Giardia lamblia* is a protozoan that causes gastrointestinal illnesses and is most resistant to disinfection, thereby making it difficult to inactivate (Fulton, et. al 1992). When steps are taken to assure *Giardia* removal, a more complete level of control is thought to be achieved over the full range of waterborne pathogens. In order to meet a 99.9% inactivation (3 Log Inactivation), a certain amount of disinfection and time in contact before consumption is required. Filtration should be considered if fecal coliform bacteria levels continue to be greater than 20 per 100 ml. Chlorination provides an inexpensive method of ensuring the bacteriological quality of water.

According to this study, no significant association was found between the consumption, availability, or storage of drinking water and gastrointestinal illnesses in the community. However, because community members all consumed the same water, the study was not able to determine specifically whether the drinking water was causing gastrointestinal illnesses.

Sources of Bias

Possible sources of bias need to be considered, the main one being reporting bias. Although the data was gathered from each household by the same person and training was provided, there is the possibility that the *promotors* misrecorded information. However, there was no significant increase in reporting of HCGI from any one *promotor*.

The participants who were aware of the study objectives and perceive that there is a problem within the community may have exaggerated their morbidity. Also, underreporting may have occurred for school children between the ages of 6 and 13 due to lack of communication and oversight between child and parent.

However, symptoms such as vomiting, diarrhea, and abdominal cramping are not subjective nor open to interpretation. Over the four-week study period the reported gastrointestinal illnesses were fairly constant, arguing against any such bias.

Recommendations

The intent of this study was to gather gastrointestinal illness and household information from the community and evaluate the association with existing environmental health factors. It was determined that there was a significant association of gastrointestinal illnesses with the presence of rodents (p=0.009). Food in the home may become contaminated by rodent feces and urine, or by the rodent mechanically carrying and transferring disease organisms.

It was recommended that the community make efforts to reduce the number of rodents by eliminating the rodents' supply of food and water. Storage of food and water inside homes should be in tightly covered containers. The community should also implement control measures for breeding outside the home, such as minimizing access to garbage by using a sealed container and eliminating standing water near homes (Salvato 1992).

Although there was no significant association between gastrointestinal illness and the community drinking water, based on the presence of the low levels of fecal coliform bacteria, it is recommended that the community chlorinate their drinking water supply. Disinfection of the source water will assist in inactivation of pathogenic microorganisms.

Endnote

[1] This chapter is an abridged version of Kathleen Coates Hedberg's Master's thesis for the Department of Public Health at San Diego State University in San Diego, California.

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VIII

Indigenous Education: A Literature Review

Susan L. Williams

The Southwest Center for Environmental Research and Policy (SCERP), the Center for Environmental Studies at Arizona State University, and the Cocopah Indian Tribe in Somerton, Arizona, entered into a cooperative agreement to develop an environmental education program for youth at the Cocopah Indian Reservation. The Cocopah Tribal Council and Education Department decided to establish a project that engages and involves Cocopah youth in learning about and helping restore natural communities of the Lower Colorado River region. This approach best addressed the long-term goal of sustainable management of tribal lands. A literature review conducted in 2000 and updated in 2002 provided the basis for a discussion of possible projects and approaches to a community-based project.

Articles on indigenous education, K-12 curricula designed for Indian students, and research on the human relationship to nature are reviewed in this chapter. These sources share common themes and objectives, including:

- Integration of native ways of knowing with Western science ways of knowing
- Successful models that improve science and math skills
- The role of culturally rich curricula in promoting self-knowledge and pride in one's community

- The importance of locally developed curriculum
- The inclusion of natural resource management education as a career path for students

As a whole, this review supports the integrating of local ecology in overall learning. Programs that incorporate learning about indigenous plants and animals and the geologic history of one's homeland are associated with better learning outcomes and contribute to the development of a conservation ethic in students.

Cox (2000) highlights the critical connection between preservation of native flora and the presence of a vibrant, intact local culture. Conservation of plant biodiversity is linked to the survival of cultures that value native flora for medicinal and nutritional uses. The importance of preservation of cultural knowledge and local plant conservation is becoming a focus for botanists working to conserve native flora. A disturbing trend is the loss of indigenous culture worldwide. More than half of 6,000 languages documented worldwide in the beginning of the twentieth century have disappeared along with their cultures. The 1992 Convention on Biodiversity encourages the wide application of traditional knowledge as a means of preserving the world's shrinking biodiversity. Survival of indigenous languages is critical to the survival of cultural values and thus native habitat.

The use of oral histories as a method for documenting ecological diversity over time is presented as a more comprehensive method for understanding ecosystems than scientific surveys alone can provide. Oral histories present a range of cultural perspectives. Raffan (1993) lists four components that emerge from narrative descriptive methods of ecosystem study. They include interesting cognitive features such as naming places as ways of knowing that place; telling how the land came to be; personal experience narratives; and finally, numinous aspects that transcend purely rational ways of knowing. Each of these components allows deeper observations of plants and animals over time. Features like subtle weather changes, events like insect infestations, or tales of the people who lived on the land all offer data not evident from more objective methods of surveying plant and animal life. Thus, elders are important in programs that restore knowledge of how habitat and climate occurred in the past. Students will not understand what is lost and needs to be restored without the collective memory of elders and adult mentors.

Harris and Cox (1997) describe a curriculum for natural resource management education for Indian resource workers. They integrate scientific concepts with values that the authors assert are critically needed in natural resource management today. These values provide a moral and ethical basis for protections of land and natural resources. They demonstrate that traditional understanding of the natural world provides a moral and ethical basis to guide the management of the earth's resources and the living communities they support. The six-week course includes the following topics: People in Ecosystems; Basic Ecology; The Environment; Organisms and Communities; Ecosystems Planning and Regulation of Uses; and Ecological Management. In their article, Harris and Cox compare a Western science food pyramid with a Pomo Indian subsistence diagram as an example of the need to reconcile the two perspectives and find their complementary natures.

Quinn (1993) describes development of an outdoor education program based on hunting traditions. His rationale is that traditional hunters' relationships to land, plants, and animals is one of co-fulfillment—a relationship of marked contrast to the Western producer-consumer relationship. The traditional hunter views "progress" as the turning of seasons, or the renewing of Earth processes through cycles rather than upwardly moving and linear processes.

Cajete (1994) presents a comprehensive study of the elements and goals of indigenous education. He demonstrates the transformative aspects of traditional education that support individuals on a path of lifelong learning. He suggests elements for learning goals and content area in planning effective indigenous educational programs.

Finally, Wendt (1995a, 1995b, 1996) describes a Mohawk math and science project that emphasizes the need for each community to develop its own curriculum based on values and history. The Akwesahsne Science and Math Pilot Project uses the Thanksgiving Address read before every meeting to bring about the use of the Good Mind, an Iroquois set of principles for living. Reading of the address brings respect and gratitude for each component of the earth's ecosystems and describes relationships with all living beings and natural resources. This cultural viewpoint infuses science concepts with land and resource ethics. The program is designed for middle school (7th and 8th grades). Themes include the power of symbols (the importance of manipulating and understanding symbols to live effectively and participate in culture) and dealing with diversity (harmony and respect for other viewpoints). Seventh graders study earth themes, animals and birds, medicine, agriculture, and food. Eighth graders study water, cosmos, and energy themes.

Zwick and Miller (1996) report on a formal study of two methodologies for teaching science and math to American Indian students. Results indicate students do best with outdoor education activities. Scientific Knowledge for Indian Learning and Leadership (SKILL)—an application of hands-on, context-oriented curriculum—has resulted in 100% retention of students through its program. The project is a partnership between government agencies, private foundations, and schools in Rapid City, South Dakota, where the public school student population is 50% American Indian. Before the project began, most Indian students dropped out of science and math classes and rarely went on to higher education opportunities.

SKILL is a comprehensive approach with programs for each age group: 4th through 6th graders participate in hands-on activities, 7th and 8th graders create science fair projects; and high school students can take advantage of a tutoring program that uses mentors from the American Indian Science and Engineering Society Student Chapter. There is also a one-week summer college science camp for 4th through 6th graders with college faculty, undergraduate, and graduate student mentors. The project has teamed with the National Aeronautical and Space Administration to sponsor a one-month residential program for 7th graders to explore careers in science, math, and engineering, and one for 8th graders to study physics principles and prepare science fair projects for state and national competition. Representatives of top projects attend the national science fair sponsored by the American Indian Science and Engineering Society.

Hamilton, from the Pine Ridge Reservation, describes a project based on Lakota cultural traditions (Hamilton 1992). The movement of stars is important in Lakota culture. Where a person lives and when ceremonies take place is determined by celestial movement. One group of teachers and students built an observatory to study constellations. Activities include photographing stars and general astronomy. This project also holds a two-week Outdoor Summer Science Camp. The camp curriculum covers geology and ecology and includes crafts. Hamilton reports that teachers and students of different age groups sit at long tables and enjoy working on projects with the local geology in view. Young students build a butte with peanut butter, jelly, and bread. Older students use chalk to layer the history of life forms on the same butte. A retired geologist from the United States Geological Survey volunteers to teach the geologic history of the butte to students and teachers on site. He brings molds of fossils from the area and students make and paint plaster casts. The activities thus relate to the place where the community lives. The local environment provides a rich, living context involving individual and group memory. These kinds of activities promoted improved learning outcomes for their youth.

The Turtle Mountain College for Kids is another successful model (Davis and Jerome 1992). The one-week program is held at a nearby college campus. Goals are focused: Students learn about indigenous plants, the local aquifer, and insect populations in the region. Two unique features are the daily activity of fishing and the creation of a Nature Notebook for the 3rd, 4th, and 5th graders as a language arts project.

Successful program designs include these important common features:

- Keeping the number of outside experts to a minimum and allowing teachers to work out their own units and curriculum
- Allowing the same amount of time for training the teaching team as for teaching the students
- Working intensively with small groups of students
- Including student mentors who are successful role models
- Establishing a success culture

Whirlwind Soldier (1997) presents recommendations for curriculum from elders. These statements represent the resurgence of indigenous wisdom emerging from a renaissance of tribal culture in

Native American communities. The movement is creating an important influence on modern tribal education programs. Whirlwind Soldier's recommendations include:

- Uphold the value of biculturalism and bilingualism
- Reinforce pride in group achievement
- Encourage students to participate in group problem-solving
- Promote peer tutoring
- Consider the affective growth of students as equally important as cognitive growth
- Always remember the tribal philosophy of helping and supporting one another and never giving up

Finally, Rowland and Adkins (1995) describe a science education program for teachers of Navajo children. They follow two lines of inquiry: How science instruction can be improved and augmented, and how science education can be connected to native science. Their summary is instructive.

The major recommendations for improving science education for Native Americans include the general improvement of science education, which has been recommended for all students. Changes in curriculum and teaching strategies such as the use of cooperative learning; active, hands-on learning; integration of science with other subjects; making connections to the world of the learner; and special attention to teaching the language of science have all been advocated. A second set of recommendations called for making connections to the students' cultural knowledge of science by including the contributions made by native people in science education, viewing science broadly to include native ways of knowing the world, and centering native science education on the study of the environment and relating that study to the native beliefs that connect them to the earth.

From these examples, the Cocopah Indian Tribal Environmental Education Project gleaned the need to foster a locally derived project design and the incorporation of the local ecology of the Lower Colorado River and Delta region as a program theme. Resources within the tribe that can contribute to the program's success are:

- The presence of a program, led by elders, at the Cocopah Cultural Center to recover and revitalize Cocopah language

- A partnership between the tribe and several agencies to restore a natural area along the Colorado River at the West Cocopah Reservation that could become a site for youth to learn about and help restore native habitat
- A tribal council and administrator supportive of a youth project
- Funding from SCERP at Arizona State University for a graduate student from the university and an undergraduate student from the Cocopah community to work on a project design

Challenges will be to form a collaborative team with mutual trust between tribal members and university members, and one that creates opportunities for local ownership of the program and ample time for the conceptual basis of the project to emerge. The integration of tribal knowledge and Western science concepts in outdoor education programs is a good model to support youth in learning how to uphold tribal values while using Western science knowledge to restore and sustain natural environments. Mentorship within the Cocopah community itself between the Cocopah youth and university students, and the participation of Cocopah elders in the program can all facilitate the project's ultimate success.

Additional Resources for Indigenous Education Programs in Arizona

The following institutions provide support to organizations developing or administering Indian education programs in Arizona.

Institute for Tribal Environmental Professionals at Northern Arizona University in Flagstaff

The Environmental Education Outreach Program is designed to interest Native American students in environmental careers and to assist schools in improving environmental science literacy. The institute offers a full program of services for students, teachers, and environmental education projects. It currently works with 400 educators in four states. It attracts Indian students to encourage them to pursue a college education in one of several environmental career paths that relate to tribal community environmental issues: integrity of reservation water and land resources, natural resource management, and environmental law. Information about the program is available at http://www.4.nau.edu/itep.

The American Indian Institute at Arizona State University in Tempe

The institute supports American Indian students in pursuing higher education degrees and retains students through their college education until graduation. It is a comprehensive student support service program offering peer tutoring, career counseling, and cultural activities for American Indian students at the university. Information about the program is available at http://www.asu.edu/aii/.

The Center for Indian Education at Arizona State University in Tempe

The center publishes the *Journal of American Indian Education* and acts as a clearinghouse of pedagogy, programs, and research in Indian education. It also receives multi-partner grants with Indian tribes and agencies working to improve education in tribal communities and at universities and community colleges. The staff acts as a resource and advisor to projects in all phases of development. They also evaluate curriculum. Information about the program is available at http://www.ed.asu.edu/cie/.

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Epilogue

Challenges: Collaborating with Tribal Nations

Richard Meyers

Introduction

If scientific research is to be conducted successfully in collaboration with American Indian tribal nations, some essential cultural obstacles must be recognized. Too often, research projects start with *a priori* judgments, theories, or biases about the importance of their specific agendas and do not take into consideration the lived realities of American Indian communities. It is crucial for researchers to first understand some of the larger cultural contexts if they truly want to include tribal nations' concerns in the construction of meaningful data on environmental issues that are beneficial to both tribes and the scientific and academic communities at large.

This epilogue was based on ethnographic data and the collaboration between the Cocopah Indian Tribal Nation and Arizona State University's (ASU) Center for Indian Education (CIE). The project was titled "The Cocopah Indian Tribal Environmental Education Project."

Of the projects under the umbrella of the Southwest Center for Environmental Research and Policy's (SCERP) Tribal Environmental Program (STEP), "The Cocopah Indian Tribal Environmental Education Project" was unique: It was the only project not specifically seeking scientific data in the form of a study. Rather, it was intended to construct and develop an environmental education program for the entire Cocopah community. The largely ambiguous parameters involved in constructing this environmental education program were both frustrating and rewarding. The frustration of not having a definitive research agenda was offset by the freedom to construct a collaborative relationship that could actually adjust to dynamic obstacles.

Over the course of approximately three years, this project successfully accomplished its main objective: To construct a viable project that will continue into the future as a meaningful and permanent structure useful to both the Cocopah Tribal Nation and SCERP, ASU, and CIE. It also successfully acknowledges tribal self-determination. The end result of SCERP's collaboration with the Cocopah Nation was the bridging of applied research that achieved a legitimate intercultural bond between a university and a tribal nation—a research project that did not circumscribe or perpetuate historical paternalism toward a sovereign nation's ability to voice its own concerns within the United States. This point of recognition is the project's greatest achievement.

In addition to establishing a meaningful working relationship, ASU was able to provide the tribe with invaluable assistance in developing a means to communicate and expand its own ability to educate its community using its own voice. The university provided the Cocopah Museum with various technological information and equipment that staff there use in the production of their community newsletter, which is received by their tribal members and distributed to various allies and friends of the tribe. The working relationship between ASU and the tribe has resulted in the matriculation of one of the tribe's members to a Native Teacher Training Program at the university. The collaboration between the university and the tribe has constructed a line of communication that can be used by both academia and the tribe.

Cocopah Historical Background

The Cocopah Indian Reservation is located in southwestern Arizona's Yuma County on the Colorado River border with Sonora and California. The Cocopah Tribe has 879 enrolled members, roughly 475 of whom live on the reservation.

The ancient Cocopah homeland was divided by the 1848 Treaty of Guadalupe Hidalgo, which created a distinction between American Cocopah and Mexican Cucapá. The American Cocopah received an allotment of 446 acres in 1917 and were left virtually alone for the next 39 years. In 1986, the Cocopah acquired 4,500 acres by an act of Congress and purchased an additional 78 acres. Currently, reservation lands consist of 6,156 acres in three separate locations about 10 miles apart: the East Reservation (1,641 acres), the North Reservation (634 acres), and the West Reservation (3,881 acres). The area around the reservation is rural and agriculture is the main industry.

Through the 1960s, Cocopah families lived in traditional arroweed thatched huts or in automobile shells abandoned on their land. In 1968, there were a few houses and roads, but no utilities. The 1970s and 1980s were a time of expansion and progress. In addition to land acquisition, U.S. Department of Housing and Urban Development (HUD) homes were constructed, utilities and infrastructure installed, and economic development initiated. The tribe improved agricultural lands for lease to area farmers, established business enterprises (an RV park and resort, a convenience store, and a landfill), and operated a successful bingo parlor and casino.

In 1964, the Cocopah ratified their constitution, which established the five-member Tribal Council as the governing body. The council consists of the chairperson, vice-chairperson, and three council members elected by popular vote every two years. The council is supported by the tribal administrator, 20 department directors, and 120 staff and other employees.

Beginning Stages

"The Cocopah Environmental Education Project" began with positive ideals that appeared to be tangible and achievable goals on paper. The initial research agenda involved the implementation of an environmental education curriculum for the community. However, the actual logistical agenda of who was to oversee and coordinate the project was not fully conceptualized.

Some of the initial plans for the environmental education curriculum involved camping out on tribal lands with children from the community who could be immersed in their tribe's actual natural environment. The motivation behind immersion sounded logical and meaningful—it would provide a holistic learning activity incorporating multiple sensory perceptions and make for a greater cognitive experience when learning about the environment. The goals were to learn about the traditional flora, fauna, and habitat from both a contemporary and traditional perspective. The concepts and strategies were innovative and ambitious, but lacked one crucial element—knowledge of the day-to-day lived reality of the community.[1]

The present-day reality of the international border with Mexico, including drug trafficking, illegal border crossings, and policing by the Immigration and Naturalization Service made the immersion experience impossible. The tribal members already knew it would be, although the researcher believed otherwise. This situation awakened an old frustration with non-Indian society: They have negated the voices of tribal people. This frustration is legitimized by history as well as the findings of this project during this initial phase.

This denial of voice in participating in the process of producing knowledge in research situations has been equated to the Marxist term alienation:

> [alienation] ... has emerged as one of the most important themes in the analysis of knowledge production in the context of late imperialism in Indian/non-Indian relations. Marx's concept of alienation applies—metaphorically, if not technically—to the experience of Indian peoples in the scholarly modes of knowledge production. Alienation for Marx involved the process by which the product of labor became an external thing, existing independently of the producer and even confronting the producer as a hostile force (Deloria Jr. 1997).

One of the last research experiences the Cocopah had was with an anthropologist involved in the construction of the tribal museum who had extracted tribal oral histories that she promised to leave with the tribe. Copyright issues and cultural differences over the role and purpose of knowledge somehow soured this relationship, further perpetuating the tension between tribal communities and the world of academia and research. Given this experience, the tribe proceeds with caution when implementing any new community initiative.

During the course of ethnographic work with the Cocopah, there was additional exposure to ecological anthropological literature that helps ground some of the issues experienced. Two terms help circumscribe some of the obstacles confronted while working with the Cocopah—environmentalism and developmentalism. Environmentalism is best defined as a political and social concern about the depletion of natural resources. This concern is the polar opposite of developmentalism, which is best described as the ideals of industrialism, progress, and (over)consumption. Both of these concerns are problematic when dealing with indigenous people, including the Cocopah. As much literature in various anthropological studies demonstrates, "countries and cultures may resist interventionist philosophies aimed at either development or globally oriented environmentalism" (Kottak 1993). In this same article, Kottak (1993) captures one of the main initiatives: "One research-and-development role for today's ecological anthropologist is to assess the extent and nature of ecological awareness and activity in various groups and to harness parts of native ethnoecological models to enhance environmental preservation and amelioration."

Bridging Reality to Good Intentions

Implementing this project in an indigenous community wrestling with the larger constructs of environmentalism and developmentalism within its own definitions of what it means to be a sovereign nation is a challenging endeavor. In other words, to see groundbreaking results and progress in a project like "The Cocopah Environmental Education Project" is often not easy. The working relationship between the tribe and university requires a delicate approach. It is an ongoing process that requires a commitment between recognizing and allowing the tribal nation to voice and assert its own decisions, while simultaneously trying to communicate and work with the dominant culture's institutions of academic and scientific research.

Environmental education is not a commodity package that can be distributed to the tribe via academia. And conversely, the traditional knowledge embedded within a tribe cannot be extracted and put on display for other cultures. Trust and an effective working relationship must exist if a knowledge exchange is to occur and a valuable research project is to succeed. In the anthropological world, this recognition of indigenous property rights has arisen in an attempt to conserve each society's cultural base—its core beliefs and principles, including its ethnoecological knowledge of the environment. The history of the dominant culture intervening and imposing its cultural values and assumptions onto the lives and cultures of tribal people is no longer a viable option in a globalized world that seeks to move beyond imperialism and colonialism.

Findings

As a tribal nation, the Cocopah are well aware of the myriad problems that exist in their environment. They demonstrated in discussions the day-to-day realities of how their lives and culture have transformed since the time when they used the Colorado River as a subsistence mechanism. They also spoke of the current state of defining their status as a sovereign nation within the United States.

One of the tribal museum workers described the pollution and some of the realities of living along the international border today. Billy White told how he used to fish and walk the river as a boy. He mentioned how Cocopah relatives from the Mexican side of the border used to visit, but now it is too big a hassle. One day he showed a restaurant's plumbing emptying directly into the river on the Mexican side. He spoke of his patrolling tribal lands and finding garbage dumped by various agricultural companies' workers. The tribe is not ignorant of the need for environmental education and intervention. However, mitigating the multiple environmental problems is one of the many dilemmas—all of which are intertwined with complex economic and political realities—that confront the tribe.

The acknowledgement and understanding of some fundamental issues must occur within academia if it is to truly establish a viable relationship with American Indian nations. To be an American Indian is to be a member of a collective entity first and an American individual second. The notions of tribal identity and politics are inseparable when trying to work with a tribal nation. To enter an indigenous community and try to extract data or information from community members as though they conceptualize themselves as American individuals is to not recognize tribal identity. The tribal identity and culture takes primacy in such situations.

In Cocopah, one simply has to enter the museum and ask a question about culture or traditions. The immediate response will be something to the extent of, "Why are you asking, what do you want?" The history of being exploited for research is visible in these responses from tribal members, as is the recognition of the positive value of reconstructing traditional concepts for the younger generations. The elders see the need to preserve and pass on their knowledge of the environment and language to the youth. However, governmental policies and historical realities that have affected all indigenous groups globally and within the United States provide a large obstacle to overcome. To address the multitude of cultural problems and issues is an almost overwhelming task, and resolving them will take time. The expectations of universities and the dominant culture, which devote partial time to what communities and entire cultures have been forced to deal with as a result of cultural domination and colonization, is something that must factor into the complex sociopolitical and historical realities of tribal nations.

Endnote

[1] For a good discussion and further inquiry into this notion of the gap between research and tribal communities, see Vine Deloria Jr.'s and Elizabeth Grobsmith's chapters in *Indians and Anthropologists* (1997, University of Arizona Press). The following passage speaks to this gap while citing the specific goals and intentions of anthropology as "...an entire genre of social science that dealt extensively with community planning, community review of outsiders' research, principles of bottom-up (rather than top-down) grass-roots development, conflicts between priorities of funding agencies and of the local community, the uselessness of model building for its own sake, tribal autonomy, and the development of legal codes governing review of researchers' proposals" (Grobsmith 1997).

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