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A Twelve-Year Retrospective of SCERP: 1990 2002

INTRODUCTION

The U.S. Mexican Border Region

Nowhere in the world are the issues of sustainability so crystallized as in the U.S. Mexican border region. The unparalleled growth in population and industrialization over the past 15 years in this binational region has led to a state of environmental crisis. This is one of the rare places where one can see the socioeconomic and environmental impact of the juxtaposition of two vastly different countries on a daily basis. While the prosperity of the United States has been based on the exorbitant consumption of natural resources from both domestic and foreign sources, Mexico barely treads water trying to provide for its people with its dwindling store of resources.

Over the next 25 years, the 2000 population of approximately 12 million people who live in the border region (which is roughly defined as the area within 100 km of the U.S. Mexican border) is expected to double. This population growth is the principal driver behind numerous environmental and ecological concerns. Point and nonpoint source pollution of air, water, and soil, in addition to the disturbance and destruction of natural habitats, threaten environmental quality, ecological integrity, and even human health. The combination of indus-

Overcoming Vulnerability

trial expansion and population growth, without corresponding infrastructure improvements, has led to ever-increasing stresses on border communities, natural resources, and ecosystems and has created environmental problems that pose serious health risks.

In addition to the infrastructure deficit, the border is greatly lacking in regional planning and environmental compliance. Former Vice President Al Gore called the New River, which flows north across the border, perhaps the most polluted river in North America because of the lack of environmental enforcement; while Mexican President Vicente Fox has stated that cross-border conflicts over water may be the harbinger of conflict between the United States and Mexico if we can't work together for common solutions to these socioeconomic and environmental challenges facing us both.

SCERP Providing Solutions to Border Environmental Problems

The Southwest Center for Environmental Research and Policy (SCERP) assists U.S. Mexican border residents and aims to improve their shared environment by applying research, developing environmental and socioeconomic databases, and providing education and training. The U.S. Congress initially created SCERP in 1989 to address the pressing environmental issues along the border. Specifically, the enabling legislation stated that SCERP was to initiate a comprehensive analysis of possible solutions to the acute air quality, water quality, and hazardous waste problems that plague the U.S. Mexican border region. SCERP, as a consortium of ten universities, five in the United States and five in Mexico (Table 1), possesses the collective expertise, the commitment, and the facilities to address the complex and interrelated environmental problems of the border. In addition, SCERP is recognized as one of the major institutions playing a significant role in improving border environmental conditions.

The SCERP consortium works closely with numerous organizations, especially the United States Environmental Protection Agency (EPA) and the Secretaría de Medio Ambiente y

A Twelve-Year Retrospective of SCERP: 1990-2002

Recursos Naturales (Secretary of Environmental Media and Natural Resources, SEMARNAT). SCERP's multifold mission of applied research on the environment, outreach, education, policy development, and regional capacity building is directed at border communities, SCERP's ultimate customers. The primary purpose of SCERP is to address the rapidly deteriorating border environment, protect and enhance the quality of life of border residents, and support the educational mission of its universities.

SCERP envisions a dynamic and prosperous border region with a diverse economy, a fully-developed binational infrastructure, a sustainable environment, intact ecological systems, and a more equitable quality of life. The approach that SCERP takes is to integrate and focus transdisciplinary academic expertise; binational, state, tribal, and local policymaking; nongovernmental organization (NGO) capacity; and private industry attention on transborder issues. A model of binational cooperation and collaboration, SCERP has learned that the United States and Mexico are better able to implement solutions when they collaborate throughout all levels of research, from research design and data collection to the interpretation of results.

Table 1: The SCERP Consortium

U.S. Universities	Mexican Universities
Arizona State University (ASU)	El Colegio de la Frontera Norte (COLEF)
New Mexico State University (NMSU)	Instituto Tecnológico de Ciudad Juárez (ITCJ)
San Diego State University (SDSU)	Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM)
The University of Texas at El Paso (UTEP)	Universidad Autónoma de Baja California (UABC)
The University of Utah (UU)	Universidad Autónoma de Ciudad Juárez (UACJ)

Overcoming Vulnerability

One of SCERP's outstanding achievements has been supporting and developing local capacity to address problems. One clear example is the Agua para Beber (safe drinking water) program designed by SCERP. This program is based on the Ford Foundation's model of using local promotoras (trainers) to show families how to disinfect and store safe drinking water. As part of the project, SCERP worked with community-based organizations to find and prepare trainers who could then recruit and train health professionals based in the colonias (substandard residential communities).

SCERP utilizes a broad, integrated, multidisciplinary approach in addressing the issues of the border region. Since 1990, SCERP has implemented more than 300 projects conducted by researchers and outreach specialists from both sides of the border. Through its policy briefings, SCERP provides data for policy makers, community leaders, public officials, and trade organizations so that these groups may make more informed decisions. Moreover, representatives from different border community sectors participate in SCERP activities (e.g., workshops, education, forums, symposia, and training activities). SCERP's key objective is to build local capacity for solving border environmental problems by pioneering a model of binational cooperation.

SCERP's primary areas for research include:

- 1 air quality improvement
- 1 water quality and quantity improvement
- 1 pollution prevention
- 1 natural resource conservation
- 1 environmental information resources
- 1 energy resource
- 1 contingency planning
- 1 environmental health
- 1 watershed management

These research areas largely coincide with the topical activities of the binational workgroups first established under the 1983 La Paz border environmental agreement. These workgroups continued under subsequent U.S. Mexican border plans. SCERP has specifically developed its ongoing

research activities to support these joint EPA-SEMARNAT border environmental plans.

Other important SCERP programs include environmental policy, binational planning, environmental information management training, field and environmental sampling education, environmental infrastructure development, and emergency management. In addition, during the last five years, SCERP has added a multiuniversity directed research program that addresses the unique needs of the many border tribal communities.

SCERP Structure

SCERP offers research-based services that are innovative, scientifically credible, and culturally appropriate. Policy-driven forums are organized annually on specific border-wide issues. These SCERP Border Institutes are attended by key border region policy makers, heads of public and private organizations, local planners, and advocacy groups. Institute deliberations, background reports, and recommendations are published annually through SCERP's monograph series. Part of the value of SCERP is its bilingualism, its sustainable economic and environmental policy interests, its binational government familiarity, and its dual nation implementation. The unique structure of SCERP facilitates the funding and research implementation on both sides of the border.

SCERP receives congressional support through a cooperative agreement with the EPA, whose program officer ensures accountability, quality assurance, and contract compliance. Specifically, SCERP is

1. governed by a Management Committee that consists of a representative from each U.S. university, and which meets and communicates regularly on policy, management, and scientific issues;
1. advised by an Advisory Council that is made up of members from private industry, government, and advocacy groups who are nominated by each university, and which meets semi-annually on direction, management, and outreach matters; and

Overcoming Vulnerability

1 administered by a centralized staff

With its academic expertise, SCERP identifies and develops appropriate information for environmental decisions, programs, and policies. As a university-based research consortium, SCERP has access to a wealth of databases, analytical skills, laboratories, and interdisciplinary perspectives. The range of services that SCERP provides includes research, education, strategies for environmental and ecological protection (including monitoring and developing technologies and plans), and assistance in urban and rural economic development.

Given its university base, SCERP is in a unique position to be an unbiased nexus among various border interest groups with conflicting agendas. Moreover, SCERP brings an important educational dimension to research and has sponsored joint binational workshops, training programs, and scholar exchanges. It is particularly noteworthy that SCERP has emphasized binational participation in all of its research projects, and that it involves advanced undergraduate and graduate students from both countries on its research teams. Some of the organizations with which SCERP collaborates include:

- 1 The EPA and SEMARNAT on their U.S. Mexican Border programs to address pressing environmental issues
- 1 The Border Environment Cooperation Commission/Comisi n de Cooperaci n Ecol gica Fronteriza (BECC/COCEF) and the North American Development Bank (NADB) to develop and invest in environmental infrastructure
- 1 The International Boundary and Water Commission/Comisi n Internacional de L mites y Aguas (IBWC/CILA) to seek appropriate distribution of limited regional water resources
- 1 The Southwest Border Task Group to encourage prosperity in the region
- 1 The Good Neighbor Environmental Board (GNEB) to recommend sound policies to the president and to Congress

SCERP benefits from over 12 years in operation and has undertaken over 300 basic and applied research projects. The

A Twelve-Year Retrospective of SCERP: 1990-2002

consortium has a mature organizational structure, a strong binational reputation, and a cadre of committed professionals. The individual researchers and the institutional partners who constitute the consortium have proven their ability to work together on hard, cutting-edge issues such as sustainability and appropriate technology transfer. No other organization has such a strong presence in the entire border region. Over the years, SCERP researchers have developed a strong professional and personal respect for one another, as well as fluid working relationships, capitalizing on the diverse expert-

Table 2: SCERP's Research Themes

Coupled Social and Ecological Systems	Ecosystem Services
- the evolution of different social norms regarding the environment - understanding past and modeling future ownership patterns and land-use change - feedback loops in social and ecological systems	- human impacts on ecological structures and the delivery of ecosystem services - valuation of ecosystem services
Uncertainty, Complexity, and Change	Communicating Scientific Information
- indicators of human welfare, quality of life, and environmental change - risk assessment and risk reduction for technology deployment - governance and management of common-pool transboundary resources and assessment of binational impacts	- the effects of disparate access to science and scientists - the impact of information technology and NGOs on the flow of scientific information - stakeholder and local participation in natural resource management and policy formulation - the effectiveness of interdisciplinary training
Environmental Dimensions of Human Welfare, Health, and Security	Systemic and Strategic Policy Values
- environmental change and human health - environmental justice, poverty, and inequity	- precautionary principle - comprehensive: industrial, residential, and urban ecology - inclusive: human, natural, and financial capital

Adapted from Ann P. Kinzig *Bridging Disciplinary Divides to Environmental and Intellectual Challenges*. *Ecosystems* 4 (8): 709-715.

Overcoming Vulnerability

ise of all of its members. Management Committee meetings alternate among the five U.S. consortium universities, capitalizing on the unique strengths and expertise of each institution. SCERP draws on the support and collaboration of NGOs, government agencies, and communities from both sides of the border. Overall, SCERP's capacity is derived from a wealth of cooperative, collaborative partnerships.

Clearly, SCERP was created to fill a niche, which it has done concurrent with other developing programs and organizations, such as the Integrated Border Environmental Plan (IBEP), Border XXI, and BECC/COCEF. However, the academic perspective is unique and is a critical component as it enables SCERP to develop baseline data on the environment, apply spatial dynamic modeling as a decision-support tool, monitor changes in environmental quality, apply geographic information technologies, and establish long-term strategic and management plans. Academia is best suited to provide technical and policy education, practical training in various pollution and geographic information technologies, and decision-support systems.

Research Focus

The consortium strives for an improved and enhanced U.S. Mexican border region through sustainability science and management that is binational, transboundary, interdisciplinary, multimedia, and multiscalar and that integrates the six categories that are listed in Table 2 below.

The issues presented in Table 2 are abstract themes that are woven into SCERP's applied research approach. A description of other characteristics of SCERP's approach follows:

1. Integrates several disciplines: Through this approach, SCERP research reveals comprehensive relationships that support long-term management and policy solutions. What is best for the local economy is also best for the local residents and the local natural biological communities. These relationships, however, are only dis-

covered through interdisciplinary and integrated research.

2. Produces multiscale results: One of the greatest challenges to a regional consortium is aggregating up to the regional scale and disaggregating down to the local or project scale and even to the research pixel scale, which can be as small as a meter square. This issue is further confounded by time when trying to suggest possible future outcomes. Developing regional databases across two countries is certainly a challenge given the different scales at which data are collected, different sampling protocols, and different indicators for similar environmental quality concerns.
3. Informs policy making: Research is only as good as its capacity to support sound policy development. While the intent of SCERP research is to inform management and technical applications, the projects also inform policy making. The Border Institute (BI) series, which is described later in this chapter, is a good example. The BI is an annual, issue-specific border think tank for top-level decision makers in the region. BIs address concrete problems that are analyzed through a number of informative and provocative background papers and through panels and workgroup discussions. The annual think tank brings together academics, professionals, and government and community leaders to tackle pressing border issues and to plan for the future. These institutes have addressed urban growth and sustainability issues, environmental infrastructure needs, and the role of energy development as a basis for regional growth.
4. Integrates education: One way of improving capacity to deal with border problems is to develop a cadre of researchers, teachers, and government personnel who are interested in and informed about the border region. SCERP develops this pool of talent by redirecting academics at some point in their careers. Many master's theses and doctoral dissertations that originated with SCERP funding have resulted in the full-time applica-

Overcoming Vulnerability

tion of a researcher's skills, attention, and energy to the border. SCERP has also sponsored post-doctoral scholarships and provided numerous training workshops.

5. Prevents, minimizes, or mitigates pollution: Because of the pervasive poverty and population pressures, dramatic environmental infrastructure improvements in the border region are gravely needed. These measures would help stem the water-borne and air-borne diseases that are prevalent in the area. However, most current efforts in the region are directed toward clean up and remediation of environmental contamination. SCERP recommends pollution prevention as a more cost effective approach than the current end-of-the-pipe action. The emphasis of many SCERP research projects is to understand the nature of the environmental problem and to address possible solutions through prevention and mitigation strategies. Many of the workshops and outreach programs sponsored by SCERP have been in the areas of hazardous waste minimization, energy conservation, and pollution prevention.
6. Integrates indicators and measures of effectiveness: Improving the quality of life of border residents is the ultimate goal of most SCERP work. Some of SCERP's key projects evaluate existing environmental projects, programs, and plans. Very recent efforts examine the utility of an indicators program for the region and for specific watersheds.
7. Facilitates outreach and transportability: Most applied research that SCERP has conducted has demonstrated applicability beyond the border region to the rest of Mexico and other arid, developing, or remote locations. Some examples include latrines, safe drinking water, energy projects, and artificial wetlands.
8. Focuses on the future: SCERP has received outstanding responses to its two modeling efforts, the Border Institute series on a sustainable border and the Border Plus Twenty/Frontera Más Veinte (B+20/F+20) framework, because they offer policy options for a sustain-

able future with protected natural resources. The two initiatives are described later in this report.

SCERP Accomplishments

Research Projects and the Directed Research Program

Principal investigator (PI)-initiated research projects, which in the past have favored single issue, short-term research projects, are now balanced with longer-term, multidisciplinary research programs called directed research. PI-initiated research proposals are peer-reviewed by a panel of experts, by the EPA headquarters and regional offices, and by the SCERP Management Committee. Directed research program proposals undergo the same scrutiny and, in addition, benefit from more active involvement by the EPA Program Office, the SCERP Management Committee, the SCERP Advisory Council, and by a program-related SCERP Technical Advisory Committee. Directed research program topics develop through an open, highly iterative, year-long process that enables inclusion and consensus building among the larger EPA community; BECC, NADB, and other funding organizations; state and local agencies; Native American tribal nations; and private industry groups such as the Border Trade Alliance (BTA) or the U.S. Mexico Chamber of Commerce. More information about research projects and the directed research program is provided later in this report.

Outreach Data and Training

While the individual research projects and directed research programs are central to SCERP's mission and have clearly provided enormous benefits to the border region, there are important accomplishments that lie outside of these two categories. These projects fall into the following areas: geographic information system development, economic assessment and economic development assistance, environmental and hazardous waste and safety training for border professionals, and educational workshops. Examples of these important contributions include:

Overcoming Vulnerability

1. Borderwide Environmental Geographic Information System (GIS) (1995 1999): GIS is being used by SCERP researchers as a support tool for officials and border communities, and as a key resource for assessing the health of the border environment. One GIS project resulted in the formulation of a sister-city emergency response plan based on the modeling of the vulnerability of the residents of Nogales, Arizona, and Nogales, Sonora, (Ambos Nogales) to a hazardous contaminant release.
2. Review of U.S. Mexican Environmental Infrastructure Needs (2000): This project produced a comprehensive policy report of border environmental infrastructure needs and cost estimates.
3. California Mexico Environmental Trade Mission (1994): The trade mission was cosponsored by SCERP and the California Trade and Commerce Agency's Office of Export Development and brought Baja California and Mexican environmental officials into contact with U.S. companies interested in providing environmental technology and services.
4. Hazardous Waste Training on the U.S. Mexican Border (1997 2000): This program provided training in Spanish and English for personnel engaged in handling hazardous materials/wastes during both routine operations and emergency response situations. The curriculum included hazard awareness, safety, and regulatory requirements for workers engaged in the transportation of hazardous materials/wastes.
5. Environmental Infrastructure Workshops (1995 1997): In conjunction with NMSU, the U.S. Department of Commerce, and others, SCERP cosponsored a series of workshops that were designed to assist border communities in submitting proposals for environmental infrastructure projects to the BECC.
6. Border Community Environmental Forums: SCERP sponsored 12 community forums held throughout the border region in 1992. The forums were designed to inform communities about SCERP and EPA environ-

A Twelve-Year Retrospective of SCERP: 1990-2002

mental programs and activities. These forums were also instrumental in developing SCERP's research agenda because they provided a detailed description of the environmental concerns of border community residents.

The Border Institute (BI) Series

The BIs, which are held in Rio Rico, Arizona, enable senior-level local, state, national, and international planners and decision makers to meet, become informed on current border issues and perspectives, and discuss the best alternatives for the future of the U.S.-Mexican border. The series is organized by SCERP, the EPA, the Border Trade Alliance, and the U.S.-Mexico Chamber of Commerce. BI-I addressed demographic, environmental, and economic characteristics of the border; BI-II analyzed border sustainability issues; BI-III reviewed energy and environmental issues; and BI-IV centered on binational water management planning. A complete description of the BI series is provided toward the end of this chapter.

The Monograph Series

The SCERP monograph series was initiated in 1998. Monograph no. 1, which covered the topics from BI-I, discussed sustainable development; Monograph no. 2 concentrated on water quality and quantity issues; Monograph no. 3, which reported the results and recommendations of BI-II, focused on the economy and the environment; Monograph no. 4 studied the impact of NAFTA on border communities; and Monograph no. 5 is this retrospective. The objective of the series is to publish a selection of the best SCERP-supported research projects, applied research, and outreach activities in a readable format and in nontechnical language in order to make the series accessible to border readers from different backgrounds. Each volume includes four to six essays by leading SCERP researchers. The target audience includes researchers, professionals, national and border policy makers, community members, and advanced students interested in border environmental issues. The subjects for 20 mono-

Overcoming Vulnerability

graphs have been determined and these are in the process of being developed.

RESEARCH PROJECTS

Appendices A H highlight a variety of SCERP supported research projects, which are identified by principal investigator (PI), title, institute, and study. The categories are similar to those listed in the U.S. Mexican Border XXI Program: Framework Document and other U.S. Mexican border programs and include air quality, water quality, hazardous and solid waste, environmental health, natural resources, information resources, and emergency management.

SCERP S Commitment to a Fair and Effective Research Process

The SCERP Management Committee is responsible for the proposal selection process. The first step in this process is to develop a Request for Proposals (RFP) that will generate a pool of project proposals. Each year the consortium has achieved a cohesive program that spans all media types and geographic areas. Although this complexity dilutes the focus of the program, it allows SCERP to align its programs to the strengths of its participating faculty.

In response to suggestions from the EPA and other border environment stakeholders, SCERP implemented policies early on to assure strong linkages with EPA headquarters, Regions 6 and 9, and the border liaison offices. As the primary relationships with the EPA have developed, SCERP has gone on to build ties to state environmental agencies such as the California EPA, the Texas Commission on Environmental Quality (TCEQ), the Arizona Department of Environmental Quality (ADEQ), and the New Mexico Environment Department. One concern for SCERP as it solicits more input from potential clients, such as state regulatory agencies, is that it runs the risk of creating unmet expectations. However, the improved communication with state agencies has served to strengthen SCERP research as well as to make agencies

aware of the strengths and benefits of SCERP as well as the consortium's limitations.

The annual proposal selection begins by screening proposals for border relevance, capacity building, agency needs, and a client-based focus. The objective is to avoid investing time in developing and reviewing faculty proposals that, although technically meritorious, fail to fit the broader goals of SCERP and the EPA. While the original intention of this first phase was to eliminate the nonqualifying proposals, this initial screening process has actually enabled SCERP to provide PIs with valuable feedback to improve their ideas for the next funding cycle. This step has helped to ensure relevant, high quality proposals for future RFPs. Perhaps the most helpful aspect for researchers in this feedback process is SCERP's capacity to match the researchers with potential clients and collaborators, which not only improves the proposal, but also, if eventually funded, enhances the overall effectiveness of the project. The input at the proposal phase has facilitated the development of scientifically significant projects that are directly applied to the border and also meet the needs of border stakeholders. The full proposal review includes an outside peer review component.

The SCERP Management Committee, the EPA Office of Air and Radiation (OAR), and EPA Regions 6 and 9 carefully review preproposals. Final project selection is carried out by the SCERP Management Committee in consultation with the EPA. The program is finalized by screening for certain criteria, such as geographic distribution of the projects. In a typical cycle, nearly 100 preproposals are received and about 30 are carried forward to be developed as full proposals. Some 20 to 30 are finally funded.

Overview of SCERP Research Projects

This section provides an historic overview of the research trends of each category. The studies described in this chapter are part of SCERP's competitive research program and represent the specific, generally small, one-year efforts by one or two researchers. The larger, multiuniversity, multiyear direct-

Overcoming Vulnerability

ed research programs are discussed toward the end of this chapter.

SCERP's competitive research projects encompass a wide variety of themes. The research projects address the environmental problems for each category that are identified in national and binational reports provided by the EPA, SEMARNAT, and other agencies. This was accomplished in part by requesting that key border organizations participate in SCERP's research development, project selection, and advisory board. SCERP also receives valuable feedback on current and future research directions from its annual technical conference. Moreover, a large number of SCERP research projects represent direct requests for data on specific problems from regional organizations such as the EPA. SCERP's research agenda has not been developed in isolation; rather, it has developed in response to the needs of border communities, NGOs, and governmental regulatory agencies. In doing so, SCERP has changed the culture of its researchers by steering them away from abstract, esoteric research toward applied, multidisciplinary projects.

The research projects reflect the specific needs of the long-neglected border region with particular sensitivity toward the differences in data availability between the two sides of the border. In many cases environmental data are scant, not available, or not current. As a result, SCERP has developed a four-pronged approach to data, which is to (1) identify and develop basic data to guide and inform science, (2) develop or update specific data streams to inform management decisions, (3) develop databases using GIS for local capacity-building, and (4) provide training for border personnel on the databases. A broad look at SCERP's research programs will lead to an appreciation of the fundamental need to improve data availability in the border region. Later in the report, we identify the various databases developed for local capacity building.

A broad, historical look at the consortium's research on the border reveals a strong emphasis on applied research. As suggested by SCERP's criteria for project selection, a high priority is given to projects that focus on the application of

research to specific problem areas. SCERP is proud of the fact that its research projects are recognized in the scientific and environmental literature as contributing to scientific knowledge, but are also seen as important projects that help improve environmental conditions in places where people work, live, and play. Examples of highly applicable projects include a study on the efficacy of constructed wetlands methods for wastewater treatment, alternative structures for brick-making kilns that reduce air emissions, ecosystem data to restore habitats, and an emergency management GIS system for Nogales, Sonora, to help build local public safety and emergency capacity. Showcase projects that reflect research that can be used by local and regional agencies to produce short- and long-term improvements are described later in this chapter.

Air Quality Projects

SCERP has sponsored numerous air quality projects. For example, in 1991 and 1992, SCERP sponsored the development of a computer model to track the regional transport of pollutants, field evaluations and monitoring of air pollutant levels, air pollution monitoring in natural areas of the southwestern United States, and an analysis of particulate matter that is smaller than ten micrometers in diameter (PM_{10}) in the wind field in Nogales, Arizona, to determine how to proceed with a larger study of dispersion in complex terrain. Other efforts later included the investigation of low-cost technologies to reduce toxic hydrocarbon emissions from domestic heating systems and other incineration fire systems that utilize various fuels as well as the characterization of particles in the ambient aerosol in the Arizona Sonora border region.

In the mid-1990s, air research involved database development, training programs, design strategies, and specific air quality problem studies. The following are the three completed database projects: (1) temperature and wind profiles at the upper altitude levels in the El Paso Ciudad Juárez area, (2) identification and characterization of principal sources of air pollution along the U.S. Mexican border, and (3) GIS for locales on the border for modeling the geographic location

Overcoming Vulnerability

and potential movement pathways of industrial and agricultural contaminants and their relationships to human populations. One training program dealt with the effectiveness of permits for pollution control and another involved the development of basic technical courses for the operation of brick kilns. One of the specific air quality studies provided a profile of the exhaust emissions and mechanical condition of border vehicles in the El Paso Ciudad Juárez metropolitan area in order to quantify and identify the reactive organic and related compounds by season and diurnal period. Additional SCERP air projects include investigating the use of alternative fuels in brick manufacturing, designing strategies to incorporate the use of less polluting energy sources and energy-efficiency techniques into the brick making process, developing technology for Mexican wastepaper recycling and pulp/paper plants, and analyzing potential policies that could enhance technology transfer in mitigating air pollution. Additional air projects performed in the mid-1990s include the identification of the most likely source areas of visibility-reducing pollutants in Big Bend National Park and the characterization of the heavy-duty truck fleet that crosses the border into California and the estimation of emissions from these trucks.

SCERP air projects for the 1999-2002 period included the following:

- 1 analysis of air, water, and soil samples by students from NMSU and UACJ;
- 1 identification of urban PM_{10} sources using remote sensing for the Nogales, Arizona, area;
- 1 multi-scale atmospheric analysis of PM_{10} concentration and flow in the Douglas Agua Prieta airshed;
- 1 characterization of transport and fate of atmospheric mercury and other trace element pollutants on surface waters in southern New Mexico;
- 1 analysis of contaminants in PM_{10} filters and health-related impacts of severe, transient PM_{10} episodes at the U.S. Mexican border;
- 1 field and modeling study in Doña Ana County, New Mexico;

A Twelve-Year Retrospective of SCERP: 1990-2002

1. analysis of the air quality in the Imperial Valley Mexican region; and
1. evaluation of the EPA's border environmental indicators that include air quality conditions.

Water Quality Projects

Water quality research funded by SCERP started with 13 projects in 1991 and 1992. The research projects were carried out in the following U.S. Mexican border areas: the Sonoran Desert; the Verde River Basin; the El Paso Ciudad Juárez region; Las Cruces, New Mexico; and the San Diego Tijuana region. At that time, the research focused on the types, amounts, and sources of water pollutants/contaminants; a wetlands resource management plan for the Sea of Cortez area; a study of groundwater and surface water quality in the El Paso region; and ways to access environmental data in the Tijuana River Watershed.

During the last several years, water quality research has emphasized the use of economic and ecological criteria in evaluating water improvement alternatives. The 2000 projects specifically examined linkages between water quality and health, new testing systems for wastewater contamination, and linkages between urban growth and water quality.

In the early years of SCERP, from 1991 to 1994, the majority of the water studies analyzed the types and quantities of water pollutants and ways to remove contaminants to provide safe drinking water for border inhabitants. From 1995 onwards, SCERP funded the development of databases to provide information on water quality to the general public and to promote awareness among education service providers. More recently, research has linked growth to water quality issues, examining the ecosystem dynamics of deteriorating water systems, natural alternatives to wastewater treatment, and the interconnections between health and water quality.

Natural Resources Projects

In 1991 and 1992, one SCERP project undertook database development for the selenium dynamics of the Colorado River Basin and another studied long-term border climatology. In

Overcoming Vulnerability

this same period, a third project utilized GIS to develop the best management practices for water and riparian resources in the Santa Cruz Watershed.

In the mid-1990s, SCERP sponsored several natural resource projects including developing a proposal for the establishment of a binational biosphere reserve for the San Diego Tijuana area, studying regional surface-groundwater interactions and their influence on water quality, and examining changing land patterns along the U.S. Mexican border to understand the effects on ecosystem structure and climatic feedbacks. In the last several years, SCERP has funded demonstration projects related to environmental remediation and the local economic benefits of reforestation and re-vegetation of abandoned farmlands that had been rendered unusable by salt buildup from irrigation water.

Information Resources Projects

The main objective of the projects of this category is to provide the general public, community organizations, public institutions, and policy makers with scientific information on environmental resources, areas of degradation, and sources of pollution to help improve decision making and to provide baseline data for environmental monitoring. The people who make management decisions along the U.S. Mexican border can easily access SCERP databases. SCERP has funded several studies on environmental information resources from 1991 to 2002.

In the early 1990s, SCERP projects included an inventory of environmental training programs in the southwestern United States to determine the availability of environmental training resources for the border. Other studies developed GIS programs for regional ecological characterizations of the border environment. The GIS ecological and training programs are ongoing.

In 1993 and 1994, SCERP funded a database coordination initiative project that entailed the implementation of computerized systems for the management of environmental hazards in Nogales, Sonora, and involved access to information on SCERP's environmental research and training activities.

A Twelve-Year Retrospective of SCERP: 1990 2002

Additional SCERP projects included the following: (1) development of a workshop that promoted private sector participation in the BECC proposal process, (2) creation of short, concise summaries of eight SCERP air pollution and related research projects, (3) creation of outreach activities to enable SCERP institutions to work with the BECC and the EPA border offices, (4) development of a binational database that identifies and characterizes principal sources of air pollution along the border, (5) production of EPA air monitoring training courses into Spanish-language videotapes, and (6) analysis of policies that will enhance technology transfer in mitigating air pollution along the border. The value of developing environmental databases has been augmented with the implementation of corresponding training programs, which involve these databases, for the purpose of building local management capacity in the region.

There were two information resource projects in 1997 and 1998: one targeted border businesses to encourage the establishment of environmentally sound management practices and waste reduction while the second trained workers in hazardous waste and materials management. Other projects that were funded in the late 1990s included the mapping and management of seven wetland communities along the northeastern shore of the Sea of Cortez, the development of an information system to improve community access to environmental data for the Tijuana Watershed, an environmental accounting project for sustainable development in the San Diego Tijuana region, and the development of a public environmental information network for the Texas Mexico border.

The most recent information resources projects consisted of two workshops one that focused on reducing waste solvents in the workplace (solvents pollute air and groundwater, posing significant health risks to human and wildlife populations) and the other on disseminating examples of local maquiladoras that have successfully implemented economically sound and environmentally sustainable programs.

Overcoming Vulnerability

Hazardous and Solid Waste Projects

Twelve hazardous and solid waste studies were conducted from 1991 to 2002. The first four studies included (1) a comparative corrosive materials study, (2) the potential of low-cost biotechnological treatment of wastewater, (3) the identification of large hazardous waste treatment and disposal facilities, and (4) the implementation of two international environmental training workshops on hazardous material incident response and EPA air pollution enforcement.

The first GIS databases were developed for certain local areas to provide information and technology transfer. The database development included the design of a comprehensive expert system for hazardous waste management and the identification of the amount, type, and regional flows of hazardous waste from Mexico to the United States. The latter was done to develop a GIS risk-assessment model that would be used to analyze various management scenarios that affect transportation risks. Several U.S. agencies have adopted this model for use outside of the border region.

The following projects were funded in 1997 and 1998: (1) public safety workshops for workers engaged in manufacturing and transporting hazardous materials/wastes, (2) a study of the energy recovery from scrap tires with the use of advanced boiler technology, (3) a study of the impact of environmental degradation on residents health, and (4) a study of the consequences for border communities of potential on-site or off-site accidents that involve hazardous materials. From 1999 to 2002 two studies were completed. The first entailed training maquiladora (assembly plant) managers in hazardous waste minimization, the second entailed quantifying the amount and type of hazardous waste generated in El Paso so that an appropriate emergency management system could be developed.

Emergency Response Projects

SCERP has worked closely with local planners to develop emergency management programs. SCERP-funded projects include emergency response plan assessments, emergency resource capacity reviews, medical preparedness, and

A Twelve-Year Retrospective of SCERP: 1990-2002

response to hazardous materials incidents. The development of a GIS-emergency response system for Nogales, Sonora, by George Hepner of the University of Utah was path breaking study and an important model that can be used for other border communities. Another important study, which was conducted by Suleiman A. Ashur and K. David Pijawka from Arizona State University, developed a risk model for hazardous waste shipments based on a GIS platform. In the emergency management area, ongoing studies include an emergency response plan for El Paso Ciudad Juárez, and risk reduction/hazard minimization strategies for the maquiladora industry.

Environmental Health Projects

Early SCERP efforts in the environmental health area included short-term training courses in occupational and environmental health, occupational and environmental health education, and several studies of occupational exposure levels. By 1994, two studies were completed that documented lead levels among pregnant women in Ciudad Juárez. The potential users of the information for these studies are health care professionals, environmental health scientists, and policy makers.

In 1995 and 1996, SCERP environmental health research moved toward the development of databases for respiratory health in children in the border area of Laredo Nuevo Laredo and models for training community advisors in the field of environmental health. The health education theme continued into the late 1990s. For example, in 1998, one of the projects conducted was an outreach-educational program that shared information with residents of Arizona Sonora about certain conditions that could pose serious health risks, such as trash burning, residential burns for heating and cooking, and waste disposal practices. Other projects include the identification of environmental and nutritional risk factors for neural tube defects along the California Baja California border and training to develop a model for community advisors in the environmental health field. The project that addressed neural tube defect incidents also helped establish a delivery room survey

Overcoming Vulnerability

and reporting infrastructure that contributes to cooperative binational efforts in surveying all birth defects in Tijuana hospitals as well as developing research tools. Edward Sadalla and his co-researchers at Arizona State University recently completed a two-year study on attitudes, awareness, and perceptions of health risks in a colonia in Nogales, Sonora. This study also investigated the role of diet and lead exposure in birth defects. These data will be used in the development of health education and information programs for other colonias.

THE DIRECTED RESEARCH PROGRAM

SCERP has developed a strategy through its close working relationship with agencies such as the EPA, the BECC, and the NADB that targets complex, region-wide environmental issues through directed research programs that are multidisciplinary, multiyear, and multi-institutional (i.e., involve three or more members of the consortium).

The directed research programs to date have included the following:

- 1 the Paso del Norte Particulate Air Study,
- 1 the SCERP Tribal Environmental Program (STEP),
- 1 the Border Plus Twenty/Frontera Más Veinte (B+20/F+20) decision-support system, and
- 1 the Transborder Watershed Research Program (TWRP).

The Selection of Directed Research Programs

SCERP has developed a number of procedures in selecting directed research programs. The Management Committee follows seven steps in its interactive, yearlong selection process:

- 1 Identify research topics from partner organizations.
- 2 Evaluate the role and benefit of SCERP involvement.

A Twelve-Year Retrospective of SCERP: 1990-2002

3. Prioritize topics to identify the best options.
 4. Develop research objectives and methodologies.
 5. Identify member university expertise and outside players.
 6. Designate research leadership and management mechanisms.
 7. Identify and name scientific or technical advisory group.
- SCERP research and implementation partners are consulted as needed throughout the process. Future directed research programs are expected to address the issues of energy, water, health, and border environmental education.

The Transborder Watershed Research Program (TWRP)

This program focused on the Tijuana and San Pedro watersheds to integrate existing information into a larger land-use model to investigate the interdependencies and feedback mechanisms among ecological, economic, social, and political factors influencing land use. The research characterized

Table 3: Summary of PM Concentrations at Five Paso del Norte Sites

Site Name	PM _{2.5} μg/m ³	PM _{coarse} μg/m ³	PM ₁₀ μg/m ³	PM _{2.5} /PM ₁₀	r ₂ for PM _{2.5} to PM ₁₀	r ₂ for PM _{coarse} to PM ₁₀
	Avg ±S.D.	Avg ±S.D.	Avg ±S.D.	Avg ±S.D.		
Chamizal ¹	12.6 ± 6.5	57.7 ±54.7	70.3 ±57.9	0.22 ±0.118	0.21	0.97
Sun Metro ¹	23.1 ±14.2	90.0 ±71.0	113.0 ±79.2	0.23 ±0.099	0.28	0.97
Mission ²	26.8 ±11.6	142.0 ±50.7	169.0 ±58.2	0.16 ±0.055	0.49	0.97
Club 20-30 ²	20.0 ±11.5	36.0 ±17.0	56.3 ±26.0	0.36 ±0.105	0.73	0.87
Adv. Transformer ²	50.9 ±59.3	146.0 ±68.5	197.0 ±107.0	0.23 ±0.112	0.56	0.67

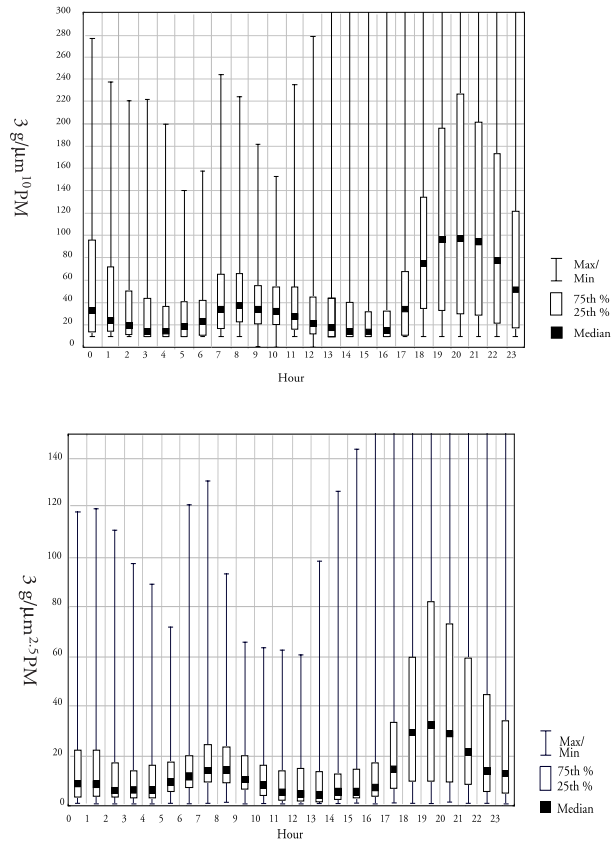
the distribution and intensity of land use in each watershed and developed models to describe the interrelationships

Overcoming Vulnerability

among land-use patterns and ecological and human factors. Patterns of land use were documented using maps, planning documents, aerial photographs, and satellite imagery to generate a GIS-based record of recent land-use change.

Several types of modeling activities have been undertaken. For the San Pedro Watershed, a hierarchically structured, patch dynamic watershed model was developed. This model is spatially explicit and uses grid-based, remotely sensed data as well as ecological and socioeconomic data. For the Tijuana Watershed, a similar GIS-linked model was employed that, when coupled with an empirically-based runoff model, man-

Figure 1: PM_{10} and $PM_{2.5}$ Diurnal Variations at Sun Metro, December 1999 February 2000

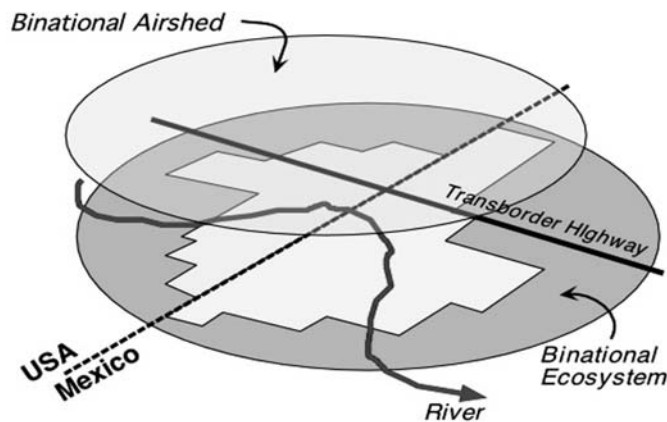


ages the spatial and temporal datasets and predicts pollutant loading to the estuarine ecosystems. For both watersheds, the following land-use characteristics were described for each patch type:

1. social and economic factors
2. surface and subsurface water flow
3. point-source and nonpoint-source pollution
4. biodiversity
5. activities (such as fuel combustion) that give rise to air pollution, which impacts water quality

The Tijuana and San Pedro watersheds, both of which are undergoing explosive population growth, span the international border between the United States and Mexico. Water resource issues greatly influence sustainability in these ecologically fragile, semiarid ecosystems. From an ecological perspective, these watersheds form meaningful landscape units for study and management because of the shared functional relationships that exist within their boundaries. However, very different social, political, and economic influences occur on the two sides of the border. One result is that a sig-

Figure 2: Graphical Representation of B+20 s Approach as a Decision-Support Tool



The B+20 project will develop analytical tools that will assist decision makers in gaining an improved understanding of the interactions between human and natural environments in border region environmental systems.

Overcoming Vulnerability

nificant gap exists between the watershed as an ecological unit and the watershed as a planning and administrative unit.

The overall objective of TWRP was to initiate an integrative research program that explores this gap and identifies barriers to, and opportunities for, bridging the gap. More specifically, the goal of TWRP was to investigate the dynamic inter-relationships between human and natural factors as reflected by land-use patterns. Integrative approaches to watershed research combine ecological, economic, political, and social factors in the study of watershed processes. Land uses are influenced by these factors and, in turn, impact ecosystem dynamics through events that can be identified and monitored.

Characterization of Ambient Particulate Matter in

Figure 3: Timeframe of the B+20 Model

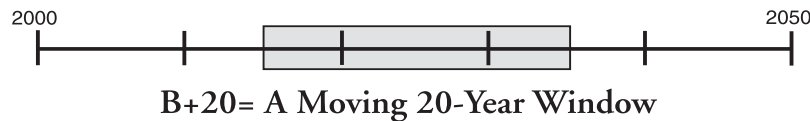
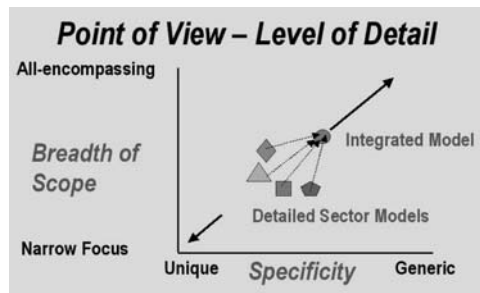


Figure 4: B+20 Perspective



The system dynamics approach involves a point of view that differs from the detailed view typically adopted by experts within their field of expertise. For example, the detailed variation in the time series in the point-of-view figure becomes progressively less detailed as breadth of scope and speci-

the Paso del Norte Region

The Paso del Norte air research program began in December 1998 and continued until 2001. The program was developed by UTEP, UU, NMSU, ASU, and UACJ in collaboration with several U.S. and Mexican agencies.

One of the major program objectives was to characterize the nature of $PM_{2.5}$ and PM_{10} (particulate matter with diameters less than 2.5 and 10 micrometers, respectively). The goals of the project were to (1) determine the organic and inorganic contents, spatial and temporal distributions, and chemical composition of PM concentrations; (2) identify the fingerprints of major PM sources in the region; (3) determine the sources of emissions and their relative strengths by chemical mass balance/receptor modeling; and (4) establish a regional information center or clearinghouse to coordinate other monitoring and research activities in the region.

Major findings of the first phase of the study are summarized below:

- 1 During the three-day exploratory study of PM concentrations, strong variations in particle concentrations were observed, showing the impact of wind and inversion on recurring or singular events.
- 1 Computer-controlled techniques were employed to determine single-particle sizes, concentrations, and compositions.
- 1 Urban dust, presumably continuously re-aerosolized by traffic and containing a complex mixture of automotive emissions, unpaved road dust, and many other combustion and noncombustion sources, tends to achieve high concentrations under calm and near-calm conditions.
- 1 The $PM_{2.5}/PM_{10}$ ratio for the air basin varied from 0.16 to 0.36, compared to 0.38 in 1990 (two sites for two weeks) and 0.45 in 1997 (one site for 11 months determined with two different types of instrument).
- 1 The study shows that the PM_{coarse} (between 2.5 μg and 10 μg) dominates the PM_{10} mass concentration and the

Overcoming Vulnerability

elemental analysis shows that geologic sources are the major contributors of PM_{coarse}.

- 1 Trace metal concentrations are currently lower than historical values, and evaluation is being done to find out causes of this reduction.

The second phase of Paso del Norte, which began September 1, 2000, utilized the following novel features:

- 1 The combined use of elemental inorganic analysis, organic compound analysis, and electron micrographic single-particle analysis for source attribution
- 1 Combined studies of the episodic and long-range temporal trends as well as the spatial distribution of sources.

Based on the findings of the first phase of the study, several tasks were incorporated into the second phase in order to enhance the results, which include:

- 1 validation of fast thermal desorption techniques for organics analysis
- 1 source proximity gradient sampling for source profiling
- 1 hourly variation of PM concentrations
- 1 diurnal variation of PM concentrations
- 1 spatial variation of PM concentrations
- 1 mesoscale meteorological modeling

The study was designed to address air pollution problems in the El Paso Ciudad Juárez region through a coordinated effort by researchers on both sides of the border. The findings of this research have enabled the border community to identify and control the dominant sources of particulate air pollutants in the region. It has improved visibility in the region and reduced mortality and morbidity due to the decreased concentration of fine particles and particle-borne hazardous air pollutants. This study has led to the establishment of technical capabilities in the region to continue air quality monitoring, evaluation, and control.

Border Plus Twenty/Frontera Más Veinte
(B+20/F+20) Project: Modeling Future Conditions
in the Border Region

There is an increasing awareness of the environment as a system of interdependent variables. Rapid population growth and industrialization in the U.S. Mexican border is causing these interdependent environmental variables to change rapidly. As a result, it is becoming increasingly necessary to regularly update and revise assessments of future conditions in the border region.

The purpose of the B+20 project is to create a systems modeling framework that will allow border stakeholders to accurately project the environmental situation in 20-year increments. This model will evaluate the interactions between human, environmental, and ecological systems.

System dynamics modeling is an effective tool for exploring the implications of interconnectedness within complex systems. For example, evaluating the implications of transborder air quality within the binational region requires a model that recognizes possible differences in the way that air quality protection policies might be implemented and enforced on each side of the border. At the same time, however, policy development must recognize how quality-of-life issues reflect inherent cultural differences and varying aspirations of both individuals and communities in the border region. Though system models cannot show the level of detail embodied in detailed mechanistic models, system models provide a higher-level view of the interdependencies and feedback resulting from interaction between human behavior and natural systems. Thus, system models can provide important clues to determine the most responsive factors for implementing new policies or technologies while maximizing quality of life, ecosystem health, economic health, and community prosperity.

This project will result in a set of prototype system models that will enable stakeholders to better understand the effects of population growth and industrial development on various environmental systems while accounting for the unique chal-

Overcoming Vulnerability

Challenges associated with implementing binational environmental policy. This tool will allow decision makers to access information that had been unavailable and to make more informed decisions. From a research perspective, the model results can be used to identify the consequences of various policy options.

An important element that makes this project unique is its use of both scientific and human elements to produce a model that can be used and understood by a wide-range of people with varying levels of technical understanding. Models based wholly on scientific or technical data often alienate decision makers and other stakeholders who have a vested interest in the environmental systems in question. Lack of understanding, or misunderstanding, often results from inadequate communication between scientists, policy makers, and the public. Worse, such models often miss the underlying causes behind major problems, many times resulting in short-term band-aid solutions with no long-term viable solutions. In order to create a workable, long-term environmental policy it is necessary to examine the system as a whole as well as its separate parts.

Developing a modeling framework for the binational region requires accounting for a wide range of stakeholder concerns that differ from community to community along and across the border. The proven approach to developing a quantitative model for assessing alternate futures is to use a group-based modeling process that directly involves affected stakeholders throughout the binational region. This approach can lead to a consensus-based framework that incorporates the critical interdependencies and feedbacks that underlie efforts to assess possible consequences of alternate plans for the region.

The group-based modeling process proceeds in a series of steps and involves stakeholders, experts, and a core-systems modeling group. The stakeholders comprise principals from decision-making entities within the targeted transborder community. The experts are individuals who have already developed a wealth of experience in identifying, assessing, and planning for alternate futures throughout the border region. The core-modeling group directly supports the model-building

effort with data synthesis by carrying out the simulation work after the model structure is outlined.

While the primary effort is aimed at exploring relationships specific to the border region, the project is first targeting one or two coherent binational communities that will provide a template for expanding the model for other communities.

SCERP Tribal Environmental Program (STEP)

There are approximately 25 Native American tribal nations located on the U.S. side of the 100 km border zone and approximately 25 located on the Mexican side. Collectively, the indigenous populations in this region comprise over 40,000 people and encompass a land base of over three million acres. The original territory of these tribes was the region now bisected by the international boundary. As a result, many of the tribal communities that live on the U.S. side still maintain strong cross-border ties with their Mexican relatives. Others have been isolated from their kin because of border controls.

Despite their long and intimate knowledge of their lands and environment, these tribal nations have indicated that they have been excluded from border consultations with the exception of initiatives and discussions that ensued after Border XXI. The critical challenge will be to incorporate these communities and their present-day territories into a shared, binational vision for the border region.

The SCERP Tribal Environmental Program (STEP) is a binational, multiuniversity effort designed to study natural resource development, tribal planning issues, and environmental education programs among interested Native American communities located along the U.S. Mexican border. This interdisciplinary, applied research initiative involves scholars and technical experts from SDSU, ASU, UU, NMSU, and UTEP; colleagues from various Mexican universities; and personnel from participating tribes. The program was developed after SCERP had supported a number of individual projects in this area and the consortium had developed working relations with a number of border tribes.

Overcoming Vulnerability

The purpose of this pilot tribal program is to build a critical mass of research targeting a range of environmental problems, socioeconomic factors, and environmental education programs that support border area tribal efforts to achieve sustainable development. One aspect of the program is to offer training and educational opportunities to tribal members as well as technical expertise in the form of GIS surveys. The program seeks to promote productive interactions among academics, government agencies, nonprofit organizations, and the tribal groups themselves. Another current project is to create environmental education programs. A third component of the pilot project is to provide data, research, and information on developing natural resources. In all cases the research projects are identified and developed in close consultation with members of the tribes.

STEP is guided by a technical advisory council and is managed collaboratively through a coordinating committee, which consists of tribal representatives, principal investigators from the SCERP universities, a coordinator (the Managing Director of SCERP), and a Management Committee representative.

STEP projects are funded through a two-phase process. First, the Management Committee has to approve the concept

Figure 5: Open Space Public Education,
Cocopah Indian Nation



A Twelve-Year Retrospective of SCERP: 1990 2002

paper and organizational structure for the program. Second, project proposals from PIs are sent to the coordinator who distributes them to the coordinating committee, the technical advisory council, the EPA, and the SCERP Management Committee for expert peer review. In the first year of the STEP program, which has been expanded through 2002, five pilot projects in four tribes were identified. These projects are described below.

Resource Inventories: The Cuyapaipe and Santa Catarina Tribes

Professors Alan Kilpatrick, SDSU and Michael Wilken, Native Cultures Institute of Baja California

Since the summer of 2000, the focus of the project has been to create a GIS inventory of natural resources and archaeological sites on the Cuyapaipe reservation. This project was envisioned to encompass three phases: a detailed GIS field survey of the area, the creation of a large-scale infrared topographical map of the reservation, and a formal survey of the reservation boundaries.

All phases of this project have been completed with the assistance of Professors Richard Carrico and Mark McGinnis

Figure 6: Environmental Field Education, Cocopah Indian Nation

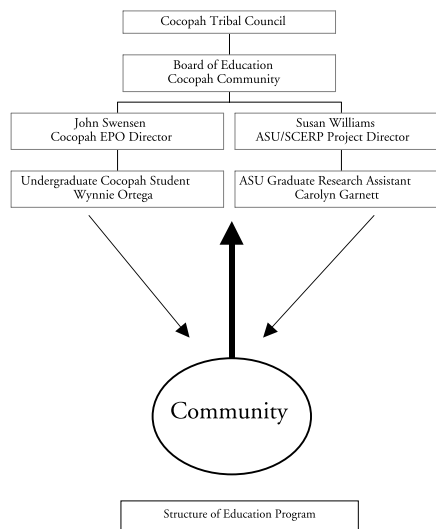


Overcoming Vulnerability

of the SDSU geography department. In 2000, Professor Alan Kilpatrick presented members of the Cuyapaípe tribe with a formal report of the research findings as well as a color infrared composite map of the reservation composed of Digital Ortho Quarter Quad remote sensing imagery.

Michael Wilken has been working in Mexico with graduate students and faculty from the UABC environmental science department to supervise the Global Positioning System fieldwork in the Paipai community of Santa Catarina. Professor Claudia Leyva of UABC worked closely with the graduate students providing technical assistance and revising documents. Alfredo Acosta supervised the process of indigenous community participation in the project, especially related to the

Figure 7: Organization Chart of the Cocopah Environmental Education Program



establishment of environmental monitoring units, a legal configuration that allows communities greater self-management of resources. Judith Bravo carried out extensive field research regarding the sustainability of traditional ceramics and basketry production and Marco Antonio Villavicencio pro-

A Twelve-Year Retrospective of SCERP: 1990-2002

vided administrative and research assistance throughout the project.

A full report of the community-based international research project is now available for public dissemination. As part of the second-year effort, the research team held a regional conference at SDSU to discuss results and to obtain feedback from tribal members, government officials, and other academics about the feasibility of creating natural resource development models for other border tribal nations.

The Development of a Geographic Information System (GIS) at the Tohono O'odham Nation

Professor Dan McCool, UU

The overall goal of this project is to collaborate with the Tohono O'odham Nation Environmental Protection Agency to develop a strategic plan to determine and prioritize the GIS data needs for the tribe. This action will avoid unnecessary duplication and promote opportunities for data sharing and partnering.

Several months were spent developing a GIS database from public information sources about the Tohono O'odham reservation. The research team also developed two questionnaires. The purpose of developing the database (which involved soliciting information from federal, state, and local agencies) was to determine the availability, quality, extent of coverage, and costs of environmental data for the region occupied by the nation. The purpose of the questionnaires was to determine the specific data needs of the Tohono O'odham.

The user group, which was coordinated by representatives from the Tohono O'odham Nation Environmental Protection Agency, formulated several tasks. One initiated the strategic planning while another provided the information needed by the nation to examine needs and establish priorities. 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 data to be distributed to end users in the nation.

Overcoming Vulnerability

Environmental Needs Assessment and Sustainable Resource Development for the Tigua Tribe, Ysleta del Sur

Professor John Peterson, UTEP

The overall goals of the Tigua project are to mitigate adverse environmental impacts and protect cultural resources both in the rural and urban areas owned by the tribe. The team developed a base GIS system to (1) input existing data for these areas, (2) train tribal personnel to monitor ecological changes, and (3) develop a sound management strategy to prioritize issues that need to be addressed now and in the future.

The initial months of the project were spent organizing the research team that includes Jamie Barnes, Agra Earth and Environmental; Julian Chianelli, Center for Environmental Resource Management (CERM) GIS specialist; Steve Cook, CERM Energy Center; Albert Alvidrez and Filbert Candelaria, Tigua Tribal Council; and Linda Cuellar, Tribal Housing Director. The project will continue to assist the tribe in GIS training and data acquisition. Furthermore, Steve Cook will conduct a wind energy assessment of tribal lands.

Mine Tailings Market Survey for the Tohono O odham Nation
Professor John Mexal, NMSU

The overall goal of this project was to evaluate waste materials from Tohono O odham mining operations to see if these could be economically recycled. Professor John Mexal conducted a laboratory analysis of iron content in evaporation ponds and presented the results at the 2001 SCERP conference. Mexal plans to develop a marketing study of the feasibility of recycling these natural by-products.

Environmental Education Project, Cocopah Indian Nation

Professor Susan Williams, Arizona-Sonora Desert Museum

As part of the SCERP tribal initiatives, this study focused on environmental education for students from the Cocopah Indian community near Somerton, Arizona. The community must develop interest, knowledge, and skills in order to restore and preserve the lands and waters of the reservation and surrounding areas. As a result, this project's researchers

focused first on the tribal community and then extended the scope to include the surrounding public schools and community. The tribal council leaders made a commitment to work regionally to develop solutions to land and water concerns. This environmental education project was an important step toward achieving the goal of regional problem-solving because it informed the Cocopah community as well as assisting in developing broad-based community consensus on environmental issues.

The environmental education project, which was designed to encourage students and to impart the desire to continuously build upon previously gained skills and knowledge, was entirely community based; Cocopah elders, parents, students and leaders guided the development of the education program. One of the primary goals was to encourage students to return to their tribal community after college, build upon their past, and encourage them to continue making contributions to environmental enhancement. The program was a collaborative effort among the community, tribal leaders, and personnel from ASU to instill a sense of pride in the rich cultural and environmental heritage of the Cocopah Nation.

The overall objective of the program was to develop an environmental education program on the Cocopah reservation that incorporates tribal culture and values concerning land, air, and water in the region. The program served as a unifying project among many tribal departments. Indeed, the first few months of meetings with each department facilitated dialogue among tribal leaders. The Cocopah Board of Education, for example, has redefined its decision-making role in education as a result of the talks. The following are the key objectives of the various departments for proposed environmental education:

- 1 to develop leadership on tribal environmental issues,
- 1 to raise community-wide awareness on environmental issues and concerns, and
- 1 to implement educational and self-esteem programs for students on the reservation to instill the desire to recover knowledge of tribal values and customs that will support these goals.

Overcoming Vulnerability

A graduate research assistant from ASU and an undergraduate intern from the Cocopah community were hired to help develop a community-based education plan and craft a natural history and science curriculum. The objectives of the curriculum were to familiarize students with various habitats and the watershed on their lands. They studied, collected, and documented plants and animals, as well as sampled water at key sites on the reservation. They learned the use of GIS technology to map and analyze these data under the supervision of the principal investigator and the project's tribal advisory committee. These tasks were accomplished during outdoor community and education activities and during field trips for local school children.

The second phase of the program, which was based on environmental education, brought youth activities to the community. The graduate student and undergraduate intern continued the curriculum development under the direction of Ms. Wanstall (Cocopah Museum director) and Professor Trujillo (director of the Center for Indian Education, ASU). There are many agencies and educational groups that have and will continue to commit their expertise and time to teach ecology and conservation to Cocopah students, including:

- ¹ Environmental Protection Office of the Cocopah Tribal Headquarters

Figure 8: Break-out Session of a Leadership Forum on Border Environmental Issues



- ¹ Yuma Youth Conservation Garden

A Twelve-Year Retrospective of SCERP: 1990-2002

- 1 ASU Center for Environmental Studies
- 1 Arizona Sonora Desert Museum
- 1 Arizona Game and Fish Department

The accomplishment of these objectives through a community-based environmental educational program will continue to help build the capacity of the tribe to move forward on plans to more effectively manage tribal lands and waters. Sustainable development has been a major focus. By training Cocopah students in the habitat enhancement plans, the program encourages them to become leaders with a shared vision of the future. The research program facilitates community awareness about the issues the Cocopah people face as a sovereign nation with respect to water, land, health, and the quality of the environment.

Students hired as graduate and undergraduate interns are given an opportunity to learn from the multifaceted and complex objectives of the project. ASU students learn how to communicate with tribal communities and they learn about the unique set of circumstances of each community. Students from tribal communities gain opportunities to work with tribal leaders and to directly affect conditions in their community. The relationship between the two groups of students in this proposal design fostered a cooperative exchange in both cultures. Their experience in traveling to professional meetings and conferences sharpened their insights and deepened their knowledge about the challenges that tribal communities face and how positive collaboration can help meet these challenges.

SCERP OUTREACH ACTIVITIES AND PRODUCTS

One of SCERP's central goals is to make its research and data accessible to as many people, education centers, governmental agencies, and private organizations as possible. Its research, training, and outreach programs address EPA objectives as outlined in the U.S. Mexico Border XXI Program: Framework Document. Since 1990, SCERP has implemented more than 300 research projects, including specific outreach and training initiatives associated with the projects.

Overcoming Vulnerability

SCERP regularly conducts briefings for policy makers, community leaders, public officials, and business and trade organizations involved in border issues, providing data needed to make informed decisions. SCERP's website, conferences, and forums serve to make the results of completed research projects accessible. They also update and provide status reports on ongoing efforts, as well as foster discussion on border issues.

Databases

Local natural and environmental resource managers, regional decision makers and regulatory personnel, and national and binational policy makers are making more effective decisions with the aid of science-based data developed by SCERP researchers. SCERP has developed environmental, economic, and quality-of-life databases in addition to GIS-decision-support systems to aid policymaking and resource management on such diverse issues as:

- 1 Imperial Valley agricultural nutrient loading
- 1 human impacts on and management options for the Tijuana River Watershed
- 1 San Pedro River natural habitats
- 1 Sea of Cortez wetlands
- 1 various tribal natural resource development projects
- 1 epidemiology of birth defects and contamination hazards
- 1 near-shore marine environment planning
- 1 particulate air quality in El Paso Ciudad Juárez
- 1 transportation risk assessments in Nogales and El Paso Ciudad Juárez
- 1 emergency management in Nogales, Sonora

Publications in Professional and Scientific Journals

SCERP researchers, staff, and management disseminate the results of the research programs to various publications. These publications include journals in environmental science,

land management, ecological sciences, natural resource management and planning, and SCERP environmental response reports. A comprehensive report of SCERP publications and papers in scientific journals is currently available.

SCERP Border Environment Research Reports

SCERP publishes occasional research reports that are designed to be available to a wide range of border stakeholders and written in nontechnical language. These reports are published in a booklet format and are distributed nationally and throughout the border region in both the United States and Mexico. Although most of the reports are out of print they are available on the SCERP website at <www.scerp.org>.

1) Environmental Issues of the California Baja California Border Region

This report provides a brief overview of the important environmental issues of the California Baja California border region within the social, economic, political, and administrative framework of the transborder zone. Key border environmental issues are presented and briefly detailed.

2) Reducing Emissions from Brick Kilns in Ciudad Juárez: Three Approaches

This report discusses the issues of brick kiln emissions, which are a major source of pollution in the El Paso Ciudad Juárez area. Three SCERP projects address ways to reduce these emissions; other SCERP projects have addressed these issues in the past.

3) Improving the Quality of Drinking Water in Colonias in the Ciudad Juárez El Paso Area

The lack of access to potable water, a problem in many low-income neighborhoods along the U.S. Mexican border, contributes to the spread of illnesses related to water contamination. This publication discusses how researchers from UTEP developed an educational model to serve as a short-term approach to this grave problem. This model was later adopted broadly along the border region.

Overcoming Vulnerability

4) The Santa Cruz River Basin: Best Practices for Maintaining its Health

This report discusses the factors that negatively affect the Santa Cruz River such as pollutants, declining vegetation along its banks, and decreased water levels due to excessive groundwater pumping.

5) The U.S. Mexican Border Environment: A Road Map to a Sustainable 2020

This publication presents a summary of Border Institute I, which was organized by SCERP and the EPA in collaboration with BTA. Border Institute I initiated the process of determining how to ensure adequate environmental quality for border residents by 2020.

Final Reports and Publicly Available Literature

Final reports from SCERP applied research projects are available on SCERP's website <www.scerp.org>. These concise reports, often technical in nature, provide a description of the project and its results. The reports are an excellent source of information on numerous critical border environmental issues. Additional information about specific research projects may be obtained by contacting the author or authors.

In order to facilitate the dissemination of research results to nontechnical personnel, one project, for example, was designed to develop short, concise summaries of eight SCERP research projects dealing with air pollution and related topics. These allowed SCERP to communicate with a larger, nontechnical audience. Other educational outreach efforts include the construction of a long-term border synoptic climatology database, an integrated cross-border GIS for the San Diego Tijuana interface, a database coordination initiative project that provides the public and private sector with access to information on SCERP's environmental research and training activities, a binational database that identifies and characterizes principal sources of air pollution along the U.S. Mexican border, and a GIS-based program to assist emergency response planners in the Ambos Nogales.

A Twelve-Year Retrospective of SCERP: 1990 2002

Table 4: SCERP Agency Coordination

Agency	Interaction
Agency for International Development	Discuss joint implementation and carbon sequestration in Mexico to offset carbon emission in the United States. Invited to Border Institutes.
U.S. Agriculture Department	Share GIS resources, consult on local issues, and provide support to GNEB. SCERP is especially close to Resource Control Districts.
Arizona–Sonora Commission	Briefed on SCERP past, present, and future research. Consulted on Border Institute participation from Arizona.
Border County Commissioners' Coalition	Provide briefing on environmental issues during their seminal meetings. Provide comment on strategic plans and local issues.
Border Environment Cooperation Commission	Provide contractual services including electronic project management system, water use model, environmental infrastructure needs assessment capabilities, and invited on field trips.
Border Governors' Association	Provide annual briefing on priority topics and progress.
Border Health Initiative	Consult when environment and health intersect.
Border Trade Association	Coordinate for policy and advocacy. Co-sponsor Border Institute series. Serve on committees and working groups.
Bureau of Land Management	Coordinate with field coordinating committee on natural resource work.
California Energy Commission	Inform their agenda on border issues. Comment on international energy program plan.
Commission for Environmental Cooperation	Provide comments on strategic plans, local issues, and workshops. Act as respondent at trinalational conventions. Nominated a SCERP member to public advisory board.
U.S. Congress	Provide products, progress reports, and annual updates on activities. Address issues raised.
U.S. Energy Department	Coordinate border infrastructure corridor, technology transfer, and material projects. Provide biannual briefings on advisory council.
Environmental Education Council of the Californias	Serve on the steering committee for binational initiatives to inform residents and students of the region about threats and solutions. Reviewed binational proposals.
U.S. Environmental Protection Agency	Coordinate with the Office of International Activities, Border XXI Program, and Border Institute issues. Work closely with program officer at Office of Air and Radiation. Recruit modelers for research programs.
U.S. Fish and Wildlife Service	Coordinate endangered species, fire management, and protected areas.
Foundations	Consult on priorities, seek funding, and include in special events.
Fundación Estados Unidos y México para la Ciencia	Collaborate on meetings, research project prioritization, modeling work, and publications. Established <i>Memorandum of Understanding</i> .
Good Neighbor Environmental Board	In addition to annual update of SCERP work, provide comments on their annual reports, especially as they pertain to watersheds. Nominated SCERP members to board.
U.S. Government Accounting Office	Provide insights to personnel regarding border issues for reports and hearings.

Overcoming Vulnerability

Table 4 continued

Agency	Interaction
U.S. Department of the Interior	Collaborate on binational planning of areas protected by joint letters of intent.
International Boundary and Water Commission	Coordinate filed ecological surveys. Review environmental impact statements. Brief U.S. and Mexican Commissioners biannually as members of advisory council.
Mexico	Coordinate with universities, government agencies, advocates, state EPAs, and citizens to improve quality of life.
Municipalities	Provide briefings on accomplishments, plans, and partners.
National Science Foundation	Brief annually on progress, and propose work through them.
Native American Tribes (border area)	Work with a few nations on resource development protocols.
Nongovernmental Organizations	Support common interest projects and studies. For example, developed a biodiversity hot spot paper with the National Wildlife Federation.
North American Development Bank	Collaborate on papers, meetings, and Border Institute reports. SCERP seeks NADB support of traditional technology projects. Provide data for their reports.
Pan American Health Organization	Coordinate health research in Mexico.
Salton Sea Authority	Provide binational perspective to their plans and projects.
Southwest Border Task Force	Chair session on environmental infrastructure and planning during strategic development plan.
U.S. Department of State	Provide data as requested on demographics and economics.
Ten State EPAs	Coordinate research priorities, progress, and plans. Ten State Coordinator co-sponsor.
U.S. and Mexican Universities	Provide support to binational and border proposals.
U.S.-Mexico Chamber of Commerce	Support meetings and provide briefings.
Western Governors' Association	Coordinate border state issue development.

SCERP Sponsored Workshops and Forums

SCERP has sponsored numerous workshops and forums as part of its outreach program, which include a certification course on hazardous material incident response operations, an EPA air pollution enforcement course, a workshop on GIS training, environmental health training, and several on hazardous waste minimization in the maquiladora industry.

A Twelve-Year Retrospective of SCERP: 1990 2002

SCERP has also sponsored numerous public outreach events, some of which have produced printed summaries and working papers. In 1992, SCERP sponsored public forums in a number of border communities in order to obtain information from residents about their environmental concerns. The forums were also designed as a mechanism to improve communication between SCERP and border communities. The results of the community forums were compiled and issued in 1992 by SCERP.

The SCERP technical conferences started in 1995 and have become annual events. The primary objective of the technical conferences is to organize a public forum to report the findings of the applied environmental research conducted by SCERP researchers to academia; industries; local, state, and federal organizations; and community leaders from both sides of the border. The technical conferences are bilingual and include field trips to key border environmental project sites. The proceedings are compiled and disseminated at the end of each conference. Special reports issued by SCERP have received national recognition such as the Environmental Issues of the California Baja California Border Region and a report that examines the scientific and policy issues in managing the San Pedro Watershed.

Education and Training

Among a large set, some of the training programs and target audiences associated with SCERP include hazardous material storage, transport, and disposal training for industry; corporate environmental citizenship for corporate managers; business environmental videos for maquiladora managers; environmental health advisories for practitioners; community-based promotoras for drinking water training; water and air pollution training for teachers; birth defect classification for delivery room nurses; and teacher enhancement and community awareness in air and water quality education.

Monograph Series

In 1998, SCERP initiated a monograph series, which is based on the selection of key SCERP supported research projects. Each volume includes research results by the leading SCERP researchers. The target audience includes researchers, professionals, and advanced students interested in border environmental issues. Each volume addresses key border issues including sustainability, water quality and quantity, the relationship between environmental infrastructure and sustainability, and the impact of NAFTA on border communities. This current monograph is a retrospective of SCERP research and activities. Volumes from the monograph series, which are described below, may be obtained through the SCERP directorate.

Monograph no.1

The first monograph, *The U.S. Mexican Border Environment: A Road Map to a Sustainable 2020*, brings together background papers and ancillary materials prepared for Border Institute I, which was held in December 1998. The Border Institute I briefing papers, which were revised for the monograph, provide basic information and analysis about the population, economy, environment, and governance of the border region.

The background reports provide the context for discussions on environmental sustainability objectives for the region over the next 20 years. The purpose of Border Institute I was to encourage stakeholders in the region and elsewhere to redirect their focus from immediate and urgent border environmental issues to the steps that must be implemented if we are to achieve a healthy and sustainable environment by 2020.

Monograph no. 2

The U.S. Mexican Border Environment: Water Issues along the U.S. Mexican Border is the second volume of the monograph series. It addresses the critical environmental issues of water quality and quantity in the border region. The five chapters that follow the overview and introduction are the results

A Twelve-Year Retrospective of SCERP: 1990-2002

of important studies in water resources funded by SCERP. These studies aid in understanding the complexity of this resource base and offer strategies for its improvement and development.

The chapters cover issues such as water availability, regional imbalances, relationships between water use and aquifer water quality, and alternative low-cost natural systems for treating wastewater. The papers range from addressing fundamental scientific questions regarding the linkages of land use and water quality, the ecological impacts of excessive water consumption, and the feasibility of applying alternative treatment options.

Monograph no. 3

The third monograph in the series, *The U.S. Mexican Border Environment: Economy and Environment for a Sustainable Border Region: Now and in 2020*, is based on the papers and recommendations from Border Institute II. The overview and the seven papers investigate specific ways to reinvent and reinvigorate the economy to bring both prosperity and sustainable development to the region. Some of these recommendations include supporting infrastructure construction, integrating natural capitalism to support sustainable economic development, and developing new finance mechanisms for border communities.

Monograph no. 4

The U.S. Mexican Border Environment: U.S. Mexican Border Communities in the NAFTA Era is actually the final report that was carried out by the Network of Border Economics/Red de la Economía Fronteriza, a network of researchers from universities and public institutions in the border region. As the title suggests, this monograph addresses the impact that NAFTA has had on the economic, demographic, environmental, and infrastructure situations of numerous U.S. Mexican border communities. The monograph begins with a general overview of the economic dynamics of the border region followed by excellent state-by-state profiles of various border communities. The findings of two major binational surveys are

Overcoming Vulnerability

reported and analyzed. In the conclusion the authors pull together their findings into seven hypotheses that connect such issues as immigration and maquiladoras; infrastructure, environment, and employment in trade-related sectors; employment, retail sales, and manufacturing plants; and poverty and prosperity.

Subsequent monographs are planned on the topics of Border Institutes III V (see page 46), border air pollution in general, and particulate matter pollution in the Paso del Norte region.

Briefings

Over the years, SCERP has participated in and organized briefings for policy makers, communities, NGOs, and agencies. Some of these briefings include:

- 1 The Mexican Congress, SEMARNAT, researchers, and U.S. embassy personnel in Mexico City
- 1 EPA Region 6, EPA Region 9, and EPA headquarters in Washington, D.C.
- 1 The U.S. Mexico Chamber of Commerce's annual congressional briefings in Washington, D.C.
- 1 The World Environment Center, Washington, D.C.

Presentations at meetings include:

- 1 The EPA Office of International Activities and the Office of Air and Radiation. This involves coordination with the Office of International Activities Border XXI Program and Border Institute briefings. SCERP also works closely with the Program Officer at the Office of Air and Radiation.
- 1 The Border Trade Alliance (BTA). SCERP coordinates with this group to inform grassroots trade organizations on environmental and sustainable development. SCERP believes that the private sector should be part of the solutions for border environmental problems. One SCERP member chairs the BTA Environmental Committee and another is a member of its Strategic Planning Committee. The BTA also co-sponsors the Border Institute series.

A Twelve-Year Retrospective of SCERP: 1990-2002

- 1 The Western Governors Association. This organization coordinates with SCERP on the development of border state issues.
- 1 The U.S. Commission on Ocean Policy. SCERP staff presented on border water issues.
- 1 The Association for Borderland Studies. SCERP staff provided a ten-year overview in Albuquerque, New Mexico.

Examples of SCERP coordination with agencies are listed in Table 4.

Border Institute Series

The annual Border Institute enables senior level local, state, national, and international planners and decision makers to meet, become informed of issues and options, and discuss the best alternatives for the future of the U.S. Mexican border. SCERP organizes the Border Institute series with support from the EPA, the BTA, and the U.S. Mexico Chamber of Commerce. The executive summaries of the Border Institutes may be obtained through the SCERP directorate and website.

Border Institute I: Demographics and economic development asymmetry across the border

Border Institute II: Environmental infrastructure, natural capitalism, and environmental accounting

Border Institute III: Energy and its interdependencies in the border region

Border Institute IV: Binational water management planning

Border Institute I

Border Institute I, held in Rio Rico, Arizona, in April 1998, brought together 60 community leaders; members of the private sector; representatives of nonprofit organizations; university researchers; and local, state, and federal government officials from the United States and Mexico to discuss how to ensure the future environmental quality and economic development of the border by the year 2020. Basic border issues that came out of Border Institute I include:

Overcoming Vulnerability

Population: Border counties and municipalities now have 10.6 million residents. If migration were to decline significantly, the border would naturally grow by some five million residents by 2020. If current growth rates continue, which is the most likely scenario, the border will increase by an additional 14 million people and the populations of most twin-city regions will more than double. Most of the population is concentrated in binational twin cities, contributing to significant environmental, economic, and social spillover across the international boundary.

Economy: NAFTA has brought a major increase in bilateral trade, most of which is carried across the border by trucks. NAFTA, coupled with national and global economic growth, has created more jobs in the border region. However, wages on both sides of the border have remained low and unemployment has remained high, with the exception of San Diego.

Environment: The border environment, which is currently at risk, will continue to deteriorate significantly if population and economic growth continue at present rates without significant changes in regional development. By 2020, business-as-usual will bring greater traffic congestion, poorer air quality and its attendant human health effects, water shortages, increasing numbers of endangered and threatened habitats and species, hazardous and solid waste disposal crises, sewage infrastructure shortfall, and contaminated beaches and oceans.

A vision for the border's environment in 2020: The following is a two-part vision for 2020 that Border Institute participants crafted as a goal that all stakeholders in border communities are encouraged to embrace:

- 1 A healthy, sustainable natural environment with an involved binational community, ensuring proper resource management as a basis for a secure and adequate quality of life for all border inhabitants

A Twelve-Year Retrospective of SCERP: 1990-2002

- 1 A sustainable and responsible border economy that provides all residents with a satisfactory quality of life through enhanced employment, education, and business opportunities.

Achieving the vision: The steps that Border Institute participants identified that are necessary to achieve this vision include:

- 1 Binational solutions for binational problems must be formulated with increasing transboundary effects and transborder coordination of land-use planning.
- 1 Border communities must address the issues of smart economic growth that increase the standard of living rather than simply expand the economy.
- 1 Communities must focus on long-term issues of growth and environment.
- 1 Federal, local, and state agencies must address long-term issues now.
- 1 The BECC, the NADB, and Border XXI are key institutions that need to be strengthened.
- 1 SCERP, the EPA, and the BTA must continue to work with border stakeholders to achieve this vision.

Border Institute II

Border Institute II, which took place in April of 2000 in Rio Rico, Arizona, investigated the following issues:

- 1 reinventing and reinvigorating the economy in order to bring prosperity and to support infrastructure construction
- 1 integrating natural capitalism to support sustainable economic development
- 1 investing in environmental infrastructure
- 1 developing new finance mechanisms for border communities

A summary of the major topics and recommendations from Border Institute II is provided below.

The Current Border Economic Situation: The economic situation of the border includes persistent asymmetries across the

Overcoming Vulnerability

border, periodic peso devaluations and inflation, and increasing economic linkages and integration between Mexican and U.S. border communities.

Figure 9: SCERP's Environmental Kiln in Front of the Museum of Natural History



Recommendation: Economic and environmental indicators and monitoring systems are needed to inform and motivate new investments and improvements

Reinventing the Economy and Natural Capitalism: The border economies need to be reinvented to increase prosperity, improve competitiveness, and to sup-

Figure 10: SCERP's Environmental Kiln



SCERP's environmental kiln dries in the sun during the Smithsonian Institute's annual Folklife Festival, held in June 2000, on the National Mall in Washington, D.C. The arched doorway to the kiln was designed with the

Figure 11: A Brickmaker from Ciudad Juárez



A brickmaker from Ciudad Juárez, pours stucco from a bucket onto the surface of the kiln. The stucco was made from the red clay that was donated for bricks.

treatment, and disposal; solid and hazardous waste handling, storage, and safe elimination; and air quality monitoring equipment and emissions reduction programs).

Recommendation: Alternative and sustainable technologies provide cost-effective options for many border communities and have significantly lower capital costs and operating costs, including energy efficiencies.

Inadequate Water Supply: Many border communities have inadequate potable water supplies, water quality, and wastewater treatment capacities and face significant deficits in the future.

port environmentally sustainable development.

Recommendation: Economic development in the future is urged to address long-ignored needs such as raising real incomes in all sectors and to value ecological services, the community, and individual health, which lie at the base of any economic potential.

Inadequate Border Environmental Infrastructure: Sustainable economic development is seriously limited by a deficit in environmental infrastructure (water supply, treatment, and distribution; wastewater collection,

Recommendation: Demand-side management, conservation, and reuse are priorities.

Municipal Water and Wastewater System Reorganization: In many border communities, functions relating to supply, treatment, and distribution of water as well as the collection, treatment, and disposal of wastewater are often managed independently.

Recommendation: BECC and NADB are the appropriate institutions to encourage reorganization of environmental management administrative structures in border communities.

Efforts of the BECC and the NADB: The BECC and the NADB play critical roles in helping border communities address environmental infrastructure problems.

Recommendation: Expand the funding and scope of the BECC and the NADB to include other needs and media, more assistance to professional management of utility operations is critical, and an expanded emphasis on sustainable technologies and methods is important.

Environmental Infrastructure Financing Mechanism: It was clear to Border Institute II participants that planned and anticipated transfers from the two federal governments will not be adequate to meet the environmental infrastructure needs for the region.

Recommendation: User fees for environmental services need to be implemented more widely in border communities, and structural bottlenecks for financing infrastructure should be addressed, particularly for Mexican border communities.

Environmental Accounting: Environmental accounting, which considers both the positive and negative contribution of economic activities to environmental health and ecological services, can be used by jurisdictions to help evaluate the long-term environmental costs of new industry and other economic

I

SCERP's Showcase Projects

INTRODUCTION

The editors of this report requested that the SCERP Management Committee and personnel from several environmental agencies interested in the border environment identify SCERP projects that not only reflect the goals of the consortium, but are also examples of outstanding science or applied environmental research. Nine projects were identified and are showcased in this chapter. The principal investigators (PIs) of each project were asked to describe the project in terms of its objectives, findings, and importance to the border region.

These showcase projects were chosen based upon their immediate efficacy, region-wide applicability, regional and national recognition, return-on-cost ratio, partnering potential, and policy connections. The criteria as they relate to SCERP projects are defined below:

- 1 Efficacy: Immediate application to problems signifies that the recommended remedies and management strategies are technically available, affordable, and culturally appropriate. Ideally, organizations at the community level are involved in planning and conducting research.
- 1 Application: The solutions, answers, or means to address a variety of local problems often have implications and transferability to other locations along the border region or elsewhere in Mexico or the United

Overcoming Vulnerability

States. Since many SCERP projects have exportability designed into them, they may even be applied to developing nations elsewhere in the world.

- 1 Return: Although most SCERP projects show little quantifiable return on investment in the short-term, the medium- and long-term value of all SCERP projects significantly outweighs the cost of the work. Health-related projects, however, tend to exhibit the highest return.
- 1 Partnering: The most effective SCERP projects link students with professionals, Mexican researchers with their U.S. counterparts, government agencies with industry, and advocates with practitioners.
- 1 Policy: Even the best science has limited value unless it affects policy making. Research is most effectively disseminated by informing the decision-making process at all levels.

A LOW-TECH STRATEGY TO TREAT AND REUSE WASTEWATER ON THE U.S. MEXICAN BORDER

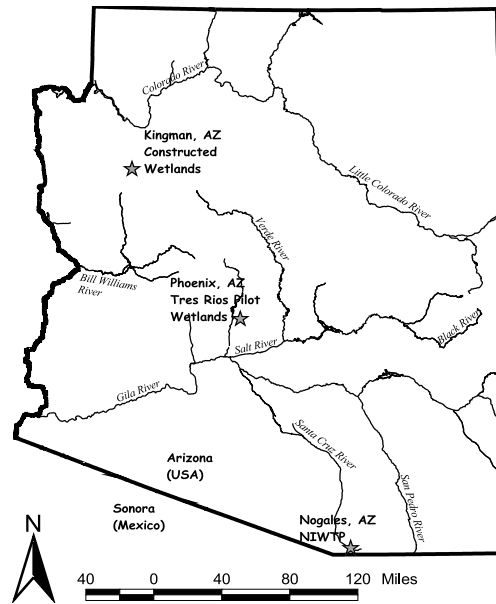
Paul Westerhoff
Arizona State University

Many cities with limited renewable surface water or groundwater supplies will need to consider reusing treated municipal wastewater for long-term sustainability. In the arid U.S. Mexican border region, a low-tech treatment system composed of aerated lagoons, constructed wetlands, and aquifer treatment was evaluated as a method to treat and store wastewater for later reuse. Field and laboratory experiments, as well as literature reviews, demonstrated that such a system could provide water with low nitrate levels that might only require disinfection prior to municipal use. The results were used to develop operational and design guidelines for a low-cost, low-tech treatment system. The potential impact of recharging the water that is now being discharged directly into the Santa Cruz River at Nogales was also evaluated (Figure 1).

The first step in this study was to identify treatment objectives and related goals for a low-tech treatment system. The

SCERP s Showcase Projects

Figure 1: Location of Study Sites

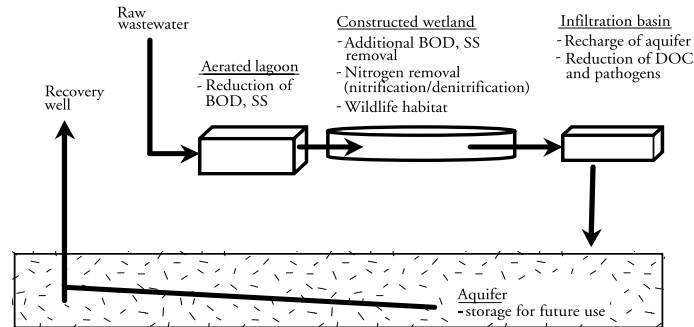


second step was to review literature on treatment processes to formulate a series of research questions for further study. In reviewing water quality data, three key constituents appeared to be of greatest concern: nitrogen (several species), dissolved organic material, and pathogens. A low-tech system to augment or replace the existing lagoon system would probably have to meet both discharge standards and recharge standards. Two other considerations in designing a low-tech treatment system would include habitat quality (particularly for the wetland component) and the impact of water reuse on the ecological status of the Santa Cruz River.

The working hypothesis was that low-tech treatment systems could provide a level of treatment sufficient to meet municipal drinking water requirements with minimal additional treatment, i.e., chlorination. The research focused on key treatment objectives including nitrogen removal, minimization of disinfection by-products precursors, reduction of pathogens, and ecological sustainability. One treatment sys-

Overcoming Vulnerability

Figure 2: Schematic Representation of a Low-Tech, Low Cost System to Treat and Reuse Wastewater



tem that would probably meet these treatment requirements consists of a combination of aerated lagoons, constructed wetlands, and infiltration basins (Figure 2).

A low-tech system to treat and reuse wastewater is feasible, at least with respect to treatment of biological oxygen demand (BOD), nitrogen, dissolved organic carbon (DOC), and pathogens. Traditional aerated lagoons provide good BOD and suspended solids removal. Although wetlands provide additional removal of these constituents, the primary role of wetlands is to remove nitrogen.

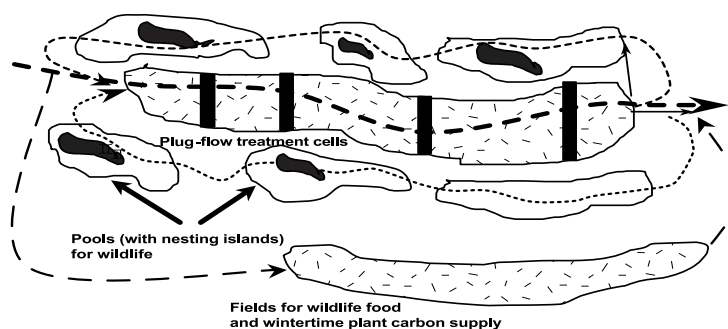
A sequential model of nitrogen transformation for wetlands, calibrated for a Kingman, Arizona, wetland, is more appropriate for sizing wetlands in this region than single-parameter models calibrated in other regions. Increasing the rate of oxygen transfer to the water would increase nitrification rates and would therefore increase overall nitrogen removal rates in the summer. In the winter, increasing the supply of organic carbon would increase denitrification rates. Although pathogen reduction occurs in lagoon wetlands, the soil-aquifer treatment (SAT) system is necessary to reduce pathogen concentrations to very low levels. Mechanisms of pathogen removal include filtration, adsorption, and predation. The SAT system would also reduce DOC to acceptable levels via long-term sustainable biodegradation processes.

SCERP s Showcase Projects

Recovered water would have to be disinfected upon withdrawal for municipal use.

An integrated approach for providing wetland treatment and wildlife habitat was developed. A wetland complex such as illustrated in Figure 3, located in a region where wetland and riparian habitats have largely been destroyed, may have sub-

Figure 3: Schematic of a Wetland Complex to Treat Wastewater and Provide Wildlife Habitat.



stantial ecological and economic benefits that should be evaluated further.

Hydrologic analysis should be incorporated into feasibility analysis of any effluent recharge system. Hydrologic modeling indicated that recharge of effluent would not affect groundwater levels in wells below the Santa Cruz River, suggesting that flows would not be seriously altered. The use of hydrologic modeling would be very useful for a wide range of water management issues along the border. The key limiting factors are data inputs for these models.

USE OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN AMBOS NOGALES FOR HAZARDOUS CONTAMINANT MODELING AND EMERGENCY RESPONSE

George Hepner
The University of Utah

The study of human vulnerability to hazardous contaminant releases requires tracking contaminant movement across the landscape from sources to people. GIS is information management software specifically focused on organizing, analyzing, modeling, and visualizing geographic spatial data. The GIS provides a means to analyze and portray contaminant movement using sequential maps correlated with maps of the locations of people at risk.

The region of Nogales, Arizona, and Nogales, Sonora, (Ambos Nogales) is home to over 80 industrial facilities, known as maquiladoras, that are largely owned by transnational corporations. Most of the maquiladoras, as well as several Mexican national firms, are located in industrial zones at the southern end of the Nogales, Sonora, urbanized area. These manufacturing sites utilize chemicals such as mono- and poly-halogenated solvents and refrigerants (e.g., carbon tetrachloride, perchloroethylene, and freon) as well as various aromatic compounds (e.g., alkylated benzenes, halogenated benzenes, and phenols).

The region consists of complex terrain as well as channeling and valley topography. Most of the industrial areas are located primarily upslope from the densely settled residential and commercial areas that straddle the U.S. Mexican border.

In many places such as Ambos Nogales, the terrain surface is the controlling factor in defining movement pathways for dense gaseous contaminants. This research focused explicitly on the characteristics of the terrain and surface roughness to delineate pathways for dense gas dispersion using an impedance or cost-surface modeling approach within a GIS. The results of this research are maps that correlate these

SCERP s Showcase Projects

pathways to population centers and critical facilities, such as hospitals and schools, in Ambos Nogales. To be prepared for a contaminant release from an industrial plant, a preliminary emergency response plan was developed based on the maps produced from this research.

This research project accomplished the following:

1. Created and coordinated GIS databases for Ambos Nogales that include maps of transportation, soil, terrain, industrial locations, and land use. These maps incorporate the location of critical sites such as hospitals and schools.
2. Modeled the geographic location and potential movement pathways of urban industrial contaminants and their relationships to human populations. The basic models present maps of likely pathways that chemical contaminants would take in the event of release. These pathways were correlated with the locations of people, schools, hospitals, and other important features in order to assess the most vulnerable areas in Ambos Nogales.
3. Utilized the models as a basis for emergency response. Working with the city of Nogales, Arizona, many conditional situations of emergency response were identified. The outcome was integrated into an emergency response system that is based on certain criteria such as the transportation system and demographic characteristics.
4. Provided information and technology transfer to other investigators, agencies, local officials, and other SCERP GIS projects

PILOT STUDY FOR AN INTEGRATED WASTE
TREATMENT AND DISPOSAL SYSTEM ALONG THE
U.S. MEXICAN BORDER: OJINAGA COMMUNITY
AS A PROTOTYPE

John Mexal
New Mexico State University

The test site for this project was Ojinaga, Chihuahua, a small village at the confluence of the R o Conchos and the R o Bravo/Rio Grande in the Big Bend region of Mexico. The overall goal was to develop an effective, low-tech waste treatment and disposal project design suitable for various small communities along the U.S. Mexican border.

In Ojinaga, the slightly saline water that is used to irrigate cotton, which represents almost half of the productive farmland, has raised the salt level in the soil to the extent that the land has been rendered unusable for growing cotton. As a result, jobs have been lost and native people have had little choice but to migrate to other areas in search of agricultural opportunities. Ojinaga was an especially suitable site for this project since it was the only village in the entire border that had experienced a decrease in population due to job losses, which has had a devastating effect on the community.

A proposed solution was to use partially treated wastewater to leach out the salt and reclaim the land. The challenge, however, was to find and cultivate species of plants that could tolerate the high levels of salt, utilize the high levels of nitrates in the wastewater within a few centimeters of the surface so that the groundwater and aquifer do not become contaminated, and provide a sustainable form of income for the laborers and community.

SCERP researchers rose to the challenge. They created a full-scale design integrating wastewater treatment and disposal with simultaneous biomass production for energy and fiber by identifying several fast-growing trees (including Eucalyptus, Populous, and native Robinia) for the paper mill 100 km south that was running out of quality pulp. Local municipal wastewater and irrigation water were subsequently applied to the woody areas with a three-fold effect: the growth

SCERP s Showcase Projects

of the biomass species was greatly enhanced due to the plentiful and nutrient-loaded water, the water quality discharged to the Rio Grande was vastly improved because the trees utilized the nutrients, and the aquifer was recharged.

The three years of SCERP funding laid the foundation for continuing research on the application of tree plantations for municipal wastewater treatment in arid climates. SCERP researchers continue to study the recharge of the aquifer, long-term effects of using wastewater, and the potential to export the model to other arid and land-rich areas. Similar research to date has been conducted primarily in humid areas or in semi-arid areas, where the management challenges of salty water and soil are less severe or are nonexistent.

The establishment of the experimental site in Ojinaga gives this community a tangible demonstration site to point to something that adds credibility to the idea of a sustainable approach to wastewater treatment as an authentic alternative to the more expensive conventional systems. The establishment of this site also benefits other communities in the border region and elsewhere because there is a specific research site with scientific data to support this approach to wastewater treatment. The challenge today is for this approach to be recognized by stakeholders and policy makers as truly leading-edge technology, so that expensive, unwieldy, conventional systems can be replaced by sustainable methods such as the one being researched in Ojinaga.

SUSTAINABLE MANAGEMENT OF WATER IN THE OJOS NEGROS VALLEY, BAJA CALIFORNIA, MEXICO

Victor Ponce
San Diego State University

The Ojos Negros Valley is located in the Real del Castillo delegation, municipality of Ensenada, Baja California, Mexico, 40 km east of the city of Ensenada and 80 km south of the U.S. Mexican border. The valley has a surface area of about

Overcoming Vulnerability

100 km² and is completely surrounded by mountains, particularly the Sierra Juárez to the north and east.

The watershed of the Ojos Negros Wash comprises 173 km² and is a tributary of El Barbón Wash, which in turn is a tributary of the Río Guadalupe. The latter flows into the Pacific Ocean at La Misión de San Miguel Arcángel (La Misión), 42 km north of Ensenada.

The history of the Ojos Negros Valley goes back to 1870 when gold was discovered in the area. This caused an influx of people from other regions, most of whom eventually settled in the area. Later, cattle ranching became the principal economic activity, primarily due to the extensive prairies associated with dryland farming. At one time there were more than 40,000 head of cattle in the valley. In the past 30 years the exploitation of groundwater supplies has allowed irrigated

Figure 4: Main Plaza of the Town of Ojos Negros



agriculture to develop in earnest. Originally, the main crop was fodder for cattle, principally alfalfa, and the most important local actors were the ejido (communal farm) proprietors. However, in the past ten years, there has been a tendency to replace fodder with vegetables, particularly green onions, watermelons, and onions. This shift is directly related to the reduced availability of water, since fodder uses up significantly more water than vegetables. In fact, in the past few

SCERP s Showcase Projects

years the amount of land rented to Tijuana and Mexicali agroindustrial packing companies has greatly increased. These companies, which are of mixed Mexican and foreign capital, grow green onions for export to the United States and Europe.

Irrigation by pumping groundwater is gradually depleting the water table. In 1997, Mexico s Comisi n Nacional del Agua (CNA, National Water Commission) estimated that the mean annual water table had decreased by 0.3 m over the past ten years. Currently, the water table lies at a depth of approximately 30 m in some places. By contrast, the water table was close to the surface in the 1960s, feeding wetlands and riparian vegetation, which have all but disappeared. The valley s landscape, which once consisted of isolated trees and chaparral shrubs, is now intensively irrigated fields. The water table drop continues to date. As the water table descends, the costs associated with pumping increase in proportion to the depth, until the pumping costs become prohibitive for the local ejido proprietors. As a result, the ejido proprietors have little choice but to rent their lands to large packing companies, which operate with more capital, or to sell their land, which changes the traditional structure of land ownership.

The objectives of the research were as follows:

1. Document the effect of water table depletion on the climatic, ecological, economic, and social changes that are occurring in the Ojos Negros Valley.
2. Develop an agricultural database that reflects the ejido proprietors and agroindustrial packing companies and their corresponding profit margins.
4. Develop a hydrogeological model that simulates present and future conditions associated with the exploitation of groundwater in the valley.
5. Couple the hydrogeological model with the agricultural database to determine the increasing cost of pumping water and the subsequent effect on the profits of agricultural operations.
6. Formulate strategies and solutions to redirect the Ojos Negros Valley toward a sustainable use of water.

Overcoming Vulnerability

The water table is gradually being lowered in the Ojos Negros Valley due to the exploitation of the aquifer for economic purposes. The exploitation of groundwater has caused a change in the principal economic activity of the valley from livestock (based on dryland farming) to irrigated agriculture, mainly cattle fodder (until 1990) and, most recently, to vegetables. The increasing cost of pumping at greater depths has produced a shift from fodder to vegetables, which are less water-intensive and now constitute 53 percent of the irrigated area. In the past six years, some ejido proprietors have opted to rent their land to packing companies, which operate with greater capital and concentrate on one crop, namely green onions. In general, these packing companies use a large quantity of fertilizers, pesticides, and herbicides, which not only enable them to increase their yield, but their profits as well. Some ejido proprietors operate with very small profit margins, a situation that makes them susceptible to renting their land to the packing companies.

TIJUANA ESTUARY HYDROLOGIC EVALUATION

Kathryn Thorbjarnarson
San Diego State University

The Tijuana Estuary contains some of the most valued salt marsh habitat remaining in Southern California. It is both a national estuarine research reserve and a national wildlife refuge for endangered species. Located in southern San Diego County, the estuary receives waters from a 1,700 square-mile watershed, three-quarters of which is located within Mexico. The natural balance of fresh and saltwater flows into the Tijuana Estuary has been dramatically altered by the damming of approximately 80 percent of the runoff from Mexico, U.S. water importation and release, wastewater discharges, groundwater extraction, and extensive urbanization (i.e., increased runoff and wastewater discharge). These watershed changes not only have the potential to increase the frequency, extent, and duration of brackish water condi-

SCERP s Showcase Projects

tions within the estuary, but have a substantial impact on estuarine biota, including some endangered species.

The purpose of this study was to simultaneously monitor the estuary, river, and groundwater to provide more definitive information about the causes and factors that contribute to both long- and short-term salinity fluctuations within the estuary. By monitoring over different time scales (daily, weekly, and monthly) the relationships between the fluctuations in water level and salinity due to tidal influences, storm events, seasonal changes, and pulses in the basin could be elucidated.

The need for characterization of groundwater influences in the Tijuana Estuary was identified in previous monitoring and modeling studies. Salinity monitoring in the less-tidally-dominated southern arm of the estuary has shown a 3 1/2-month time period in which salinities declined from approximately 30 parts per trillion to as low as 10 parts per trillion. A similar lowering of salinities in other regions of the estuary was not observed during that time period. In this study, the monitoring of groundwater within the estuary was concentrated within this southern area of the estuary. Five surface water monitoring points and nine groundwater wells were installed within the estuarine region. Monitoring probes and loggers were installed within the surface points and groundwater wells over the time period of October 1998 to June 1999.

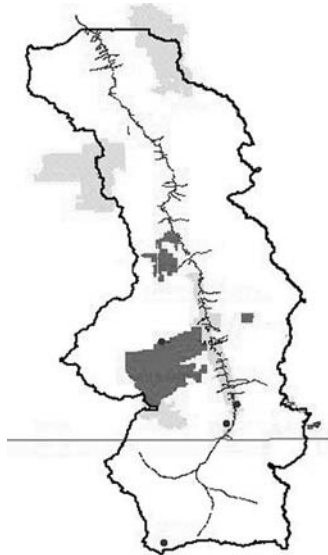
As expected, the water levels of all surface monitoring points were influenced by oceanic tides. Furthermore, all points exhibited a time lag in rising water levels relative to the oceanic tide. The amplitude of the estuarine water level variations was less than the oceanic water level variations. In particular, the low estuarine water levels were always greater than the low oceanic water levels. The results demonstrated a more gradual decline in estuarine water levels during ebb flows and subsequent incoming high tide flows. The Monument Bridge point, located in the southern portion of the estuary, was isolated from the estuary mouth during a period of low water due to a topographic high in between the mouth and this monitoring point. The resulting isolated ponded water maintained a high elevation of 0.5 m.

Overcoming Vulnerability

Contours of groundwater elevation and salinity for the entire Tijuana River Valley and Estuary indicated little variation over the monitoring period. The groundwater hydraulic gradient indicated westward flow down the valley with an overall gradient of 0.0016 to 0.0020. The contour pattern was similar to those previously published in earlier reports but extended groundwater elevation information to the west. The hydraulic gradient in the vicinity of the estuarine channels decreased but the elevations are still above the mean sea level. As expected, salinities were generally higher in wells closer to the ocean. Salinities in the inland wells were typically less than 3 parts per thousand with the exception of two wells. These two wells exhibit anomalously high salinities of 5.8 to 6.5 parts per thousand and are probably impacted by local irrigation and fertilizer application.

This study's intensive monitoring demonstrated a different pattern of salinities than prior monthly monitoring in the southern estuary. Monthly monitoring in 1996 indicated possible long-term lowering of salinities from two monthly data

Figure 5: Regional
Location of the San
Pedro River Basin



points (January and February). Monitoring during 1999 indicated lowering of salinities for several days at the most. The differences among the studies could be due to the increase in monitoring frequency or differences in yearly rainfalls. Rainfall in 1996 was less than the precipitation in 1999 and would not be expected to produce long-term salinity decreases. The two monthly monitoring points, however, may have been sampled within two days of a rainfall event and would not have been representative of the salinity over a longer time period.

This study represents the first intensive monitoring of multiple surface and groundwater points in the Tijuana Estuary. The Tijuana River

Figure 6: San Pedro Watershed



monitoring point exhibited extreme fluctuations in salinities, which were controlled by tides. Tidal fluctuations in salinities were less extreme in the three monitoring points off of the main channel (Oneonta Slough, South Channel, and Monument Bridge Channel). These adjacent channels, however, had significant decreases in salinity several days after rainfall. The southernmost channels (Monument Bridge and Kiosk) were hydraulically isolated from the main estuary during low tides and became hypersaline due to evaporative effects.

Groundwater salinities showed little temporal variation and, with the exception of hot spots, showed a gradual transition or seawater-freshwater mixing zone over a distance of 2,000 m. Within the 2,000 m long mixing zone, the groundwater hydraulic gradient was much lower than the hydraulic gradient inland. The presence of extensive lagoonal muds and low hydraulic gradients produced stagnant groundwater, which was hypersaline. These high salinity groundwaters were found south along the border and in salt panne sites.

Groundwater salinities and levels exhibited little or no effects from rainfall. The groundwater flows and salinities,

Overcoming Vulnerability

however, were found to play an important part in the overall long-term water levels and salinities in the estuary. The amount of groundwater flow and the salinity control the position of the saltwater-freshwater mixing zone. The position of the mixing zone also affects the occurrence of hypersaline salt pannes. These areas tend to occur within the mixing zone with its lower hydraulic gradients. Long-term flow within the Tijuana River downstream is most likely maintained by groundwater.

Short-term (several days) extreme salinity variations in estuarine channels resulted from inflow of storm water runoff. Differences in salinity changes with rainfalls of similar magnitude indicated possible variations in runoff source to the southern estuary. Some rainfall events produced extreme salinity reductions in the northern estuary and more subdued salinity decreases in the southern estuary. This pattern could be produced by river flows into the southern channels of the estuary. Other rainfall events showed small decreases in the vicinity of the Tijuana River but produced extreme salinity reductions in the southern estuary. The integrated study of the groundwater and surface water salinities and fluxes into

Figure 7: The San Pedro Riparian National Conservation Area



SCERP's Showcase Projects

the Tijuana Estuary, through projects like this one, is critical to balancing the protection of the estuary's valuable habitat with the increasing need to utilize water resources within the basin.

THE UPPER SAN PEDRO WATERSHED: STRATEGIES FOR SUSTAINABILITY

Frederick Steiner, Subhrajit Guhathakurta, and
Laurel McSherry
Arizona State University

The objective of this study was to design watershed-level strategies to attain sustainability for the upper San Pedro River Watershed. This region includes the southern portion of Cochise County, Arizona, and parts of the municipalities of Naco, Cananea, and Santa Cruz in Sonora, Mexico. The mostly rural watershed faces significant development pressure resulting from rapid urbanization and exurban sprawl in Arizona as well as cattle ranching and mining in Sonora. The research consisted of a series of watershed-level studies including chorography; identification of environmentally sensitive areas (ESAs); analysis of population, economic, and land tenure characteristics; and identification of the drivers of growth and possible management tools.

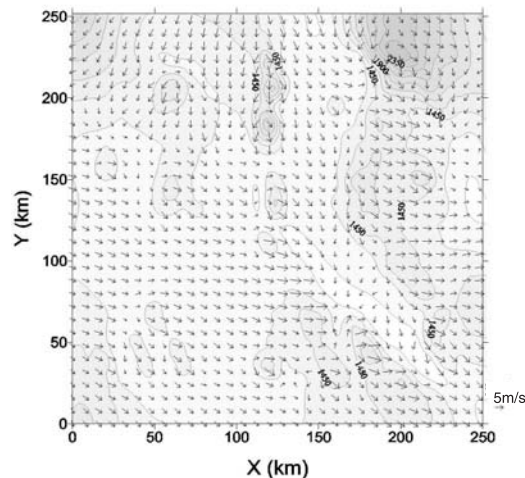
The chorography involved the systematic, iterative study of the watershed. One particular aspect of these studies was to understand the drainage systems. Water quality and water quantity are essential elements for sustaining any watershed. In the case of the San Pedro Watershed, the U.S. Bureau of Land Management established a Riparian National Conservation Area to address water-related issues on the U.S. side of the border. This conservation area has been invaluable in the preservation of a dramatic corridor of cottonwoods and other riparian plant species. This ribbon of green provides valuable habitat for mammals, birds, and reptiles. This water flow is being threatened, however, by the ongoing development on the U.S. side of the border while both Mexican and U.S. sources are degrading water quality.

Overcoming Vulnerability

Watershed-level chorographies are important because they diagnose the state of a watershed. In comparison to a physical examination of a person, where the watershed represents the body and the chorography the elements to monitor, the analysis of water leaving a watershed yields insights about the health of a landscape as a urine analysis would for the health of an individual.

Although much about the landscape and its health is already known because it has been the subject of considerable study, the value of this particular project lies in the organizing framework that enables the ESAs in the watershed to be better understood. The first step of the project was to analyze the effect of ESA protection efforts in the U.S. portion of the watershed. The analysis revealed that, despite the fact that several jurisdictions had initiated protection measures, habitat fragmentation, which contributes to declines in biodiversity, was still prevalent. The ESA framework created in this study suggests that areas should be organized in four categories: ecologically critical areas, perceptually and culturally critical areas, natural resource critical areas, and natural hazard critical areas.

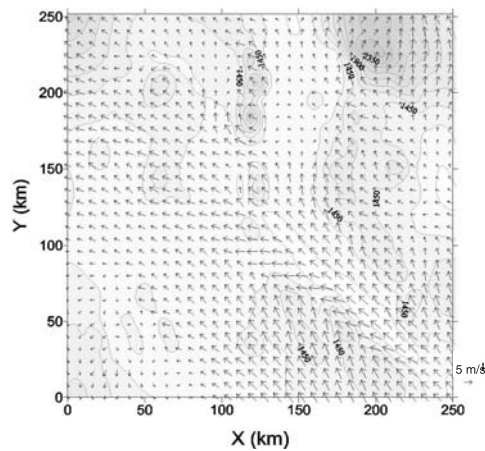
Figure 8: The Distribution of Horizontal Wind at Approximately 10 m Above Ground Level at 0500 LST November 30, 1998



Note: Shading represents terrain heights

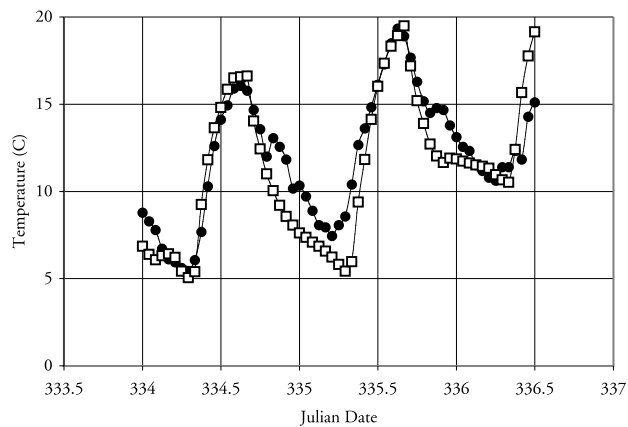
SCERP s Showcase Projects

Figure 9: Same as Figure 8, Except 1400 LST,
December 1, 1998



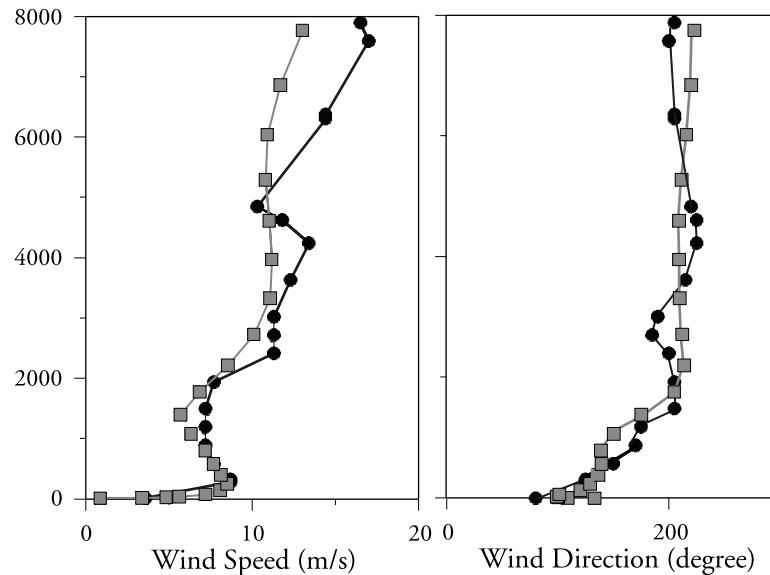
Since growth and development are neither consistent nor uniform across the watershed, it was necessary to conduct an analysis of the population and economic characteristics within the watershed. The analysis included population, housing, employment, and economic trends; the population distribution across the watershed; the projected population growth; and the demographic composition. These socioeconomic trends

Figure 10: A Comparison between the Time Series
Measurement of Temperature and MM5 Predictions



Note: Measurement taken in downtown El Paso, Texas.

Figure 11: Comparisons of Vertical Profiles Taken at the Sante Teresa NWS Station and those Computed by MM5 for 1200 UTC December 1, 1998



are important to understand because of their associated environmental and social impacts. An analysis of present trends revealed that the stresses on the San Pedro River will continue to worsen given the increased rate of housing and population growth within the watershed.

Land tenure, which is especially complicated in binational regions, is perhaps the most vexing issue that proponents of smarter growth in the watershed have to deal with. The analysis conducted in this study indicated that while the San Pedro watershed is particularly complex in this regard, it is also typical of other rural landscapes along the U.S. Mexican border region. In Arizona, as in other western U.S. states, much of the land is publicly owned. Agencies such as the U.S. Forest Service, the U.S. Army, the U.S. Bureau of Land Management, the U.S. National Park Service, and the Arizona Land Department will continue to play crucial roles in the future of the watershed. In Mexico, land tenure is equally complex. Ejidos, a cooperative form of ownership unlike anything found

SCERP s Showcase Projects

north of the border, are currently being reformed and modernized by the Mexican government. These changes could have profound consequences for the San Pedro Watershed. Already in the United States, NGOs, such as the Nature Conservancy, are active in conservation efforts. Likewise, this study revealed the potential that Mexican NGOs could have in regard to conservation efforts.

Every community faces choices about its future. Growing communities have designed tools to manage change more effectively to encourage smarter, more sustainable growth. Growth management has three essential components: first, understanding the drivers influencing growth; second, identifying where growth or decline is occurring; and, third, identifying techniques that may be useful to plan for growth. After identifying the socioeconomic trends and the factors that influence environmental degradation in the watershed, this study explored several tools that local decision makers and the public might find helpful when formulating growth policy.

NUMERICAL SIMULATION OF THE SYNOPTICALLY INFLUENCED LOCAL WIND IN THE EL PASO AIRSHED

H.J.S. Fernando and Sang-Mi Lee
Arizona State University

In this study, the synoptically influenced local wind circulation in the El Paso Airshed was simulated using the mesoscale meteorological model 5 (MM5). The simulation results were compared with measurements taken at the Santa Teresa upper air sounding station at the National Weather Service and air quality monitoring sites located in downtown El Paso, Texas.

MM5 is a nonhydrostatic primitive equation model based on terrain, following a coordinate system. Three nested grids were used for the MM5 simulation, using horizontal grid resolutions of 16 km, 4 km, and 1 km, respectively, for the three domains of interest. The outermost domain covered approxi-

Overcoming Vulnerability

mately 600 km in both the east-west and south-north directions, and included parts of New Mexico, Texas, and Mexico. The innermost domain of the MM5 spanned only the El Paso area. The analysis output of the National Center for Environmental Prediction model was used as the initial and boundary values of the outermost domain. The number of vertical layers of all three domains was 28, and enhanced vertical resolution near the ground was adapted to resolve the detailed structure of the boundary layer. The simulation was begun at 0000 coordinated universal time (UTC) on November 30, 1998 and ended at 0000 UTC on December 3, 1998. This period coincided with the first half of the field experiments conducted in the El Paso Ciudad Juárez area. The field study investigated aerosol characteristics and transport as well as atmospheric chemistry in the highly populated border area.

The diurnal variation of the mountain-valley breeze was reasonably resolved by MM5. Because of the cloudy weather during the period, synoptic forcing as well as topographically driven thermodynamic forcing were dominant features. Therefore, daytime valley winds were not as noticeable in the simulations. The horizontal distribution of simulated wind fields at approximately 10 m above ground level is shown in Figures 8 and 9, corresponding to nighttime down-slope winds and daytime up-slope winds, respectively. In Figure 8, a homogeneous northwesterly wind field was predicted in the basin located to the west of the Rio Grande valley. This is because the momentum of northwesterly wind on 850 hPa level was directly transported to the surface levels of the basin, wherein the topographic forcing was not as dominant as in the vicinity of steep mountains and valleys. Due to the southerly wind in the upper atmosphere, a southerly wind component was dominant in Figure 8, except near mountains and valleys where topographic winds were prevalent. Predicted surface temperature exhibited good agreement with the observations, although slight differences in the minimum temperature on the second day and at the end of simulation could be discerned (Figure 10). The predicted vector quantities exhibited reasonable agreement with the measurements throughout the simulation (not shown). A comparison of measured and calculated

vertical profiles is presented in Figure 11. In general, the vertical profiles of simulated wind speed and direction were in good agreement with the measurements.

Evaluations based on both the time evolution and the vertical spatial structure of the atmosphere clearly illustrated the capabilities of MM5 in simulating microscale as well as synoptic-scale circulations. Encouraged by the success of the mesoscale numerical modeling based on MM5, the researchers have embarked on a program to simulate transport and air pollution chemistry of the border region between El Paso and Ciudad Juárez.

THE BORDER BASKET PROJECT

Maria Amaya and Nick Pingitore
University of Texas at El Paso

The purpose of the Border Basket project was to address consumer product health and safety issues along the U.S. Mexican border. The goals were to analyze consumer products for toxic metals and elements and to develop a culturally relevant consumer information program to address public health risks. A list of foods that might be found in the shopping basket of a typical border consumer was developed by examining food retail and wholesale velocity reports in El Paso, and by conducting interviews in Ciudad Juárez. Other consumer items targeted were cosmetics, utensils, ceramics, and folk medicines. Special attention was given to identify products used by low-income residents. Consumer items were purchased, processed, and analyzed for more than 60 elements. Three funding cycles supported the project from 1995 to 2000.

Over 800 products were analyzed in approximately 2000 separate laboratory tests. Primary and confirmatory analyses were done using x-ray microfluorescence, inductively coupled plasma mass spectrometry (ICP-MS), and/or directly coupled plasma atomic emission spectroscopy. Selected samples

Overcoming Vulnerability

were also sent to a certified laboratory for independent confirmatory testing. The investigators were among the first to use the ICP-MS to test food products for hazardous substances.

The study found unsafe lead levels in various products from Mexico, including the labels on plastic produce bags and candy wrappers, decorations and labels on children's erasers, and in the glazes of ceramics. Lead is especially dangerous to unborn babies, infants, and children. An equally hazardous long-term problem occurs if these products are incinerated or disposed of in landfills. Approximately 1.6 million residents on both sides of the El Paso and Ciudad Juárez international border, and especially low-income people, rely on affordable and readily available Mexican products. U.S. federal regulatory agencies cannot effectively monitor products that are brought across the international border by individual consumers. Mexican regulatory and enforcement agencies, in turn, also cannot provide sufficient product monitoring to protect residents of Ciudad Juárez. As the population swells, and transborder consumerism increases, environmental health and safety issues can be expected to escalate.

Low-income Latino children along the U.S. Mexican border are the highest risk group to lead exposure. A substantial body of scientific evidence suggests that children's ability to learn, memorize, behave, and concentrate is adversely affected by ongoing exposure to even low levels of lead. Children chronically exposed to lead have other health problems, such as short stature, anemia, and hyperactivity disorders. It is well known that children can come into contact with lead by living close to contaminated waste, or living in a home with chipping paint or old plumbing. Additionally, border residents may be exposed to lead by the presence of lead-bearing inks on Mexican consumer products. U.S. manufacturers no longer use lead-bearing inks in consumer products.

The Border Basket consumer information program was designed to explain to parents the risks to their children's health from erasers, food packaging, candy wrappers, and ceramics. Information to reduce the risk of exposure was delivered to the public using the local mass media and a web-

SCERP s Showcase Projects

site. Border Basket s website <<http://borderbasket.utep.edu>> was designed to supplement the outreach program and to provide the public with an opportunity to give feedback. This program resulted in a high degree of public awareness about the problem because of the widespread media coverage. The story was reported on August 13, 2000, in the Sunday edition of El Diario; the El Paso Times followed with a frontpage headline story on September 11, 2000; the Associated Press distributed the story on September 12, 2000; and the New York Times ran a separate story on September 19, 2000.

POLLUTION PREVENTION FOR WASTE SOLVENT GENERATORS IN THE ARIZONA SONORA BORDER CITIES

Harold Berkowitz
Arizona State University

The quantities of hazardous waste generated by the maquiladoras located in the state of Sonora, Mexico, which borders the state of Arizona, have a negative impact on the environment and on border residents. Although a significant amount of these wastes are transported back to the United States for treatment and disposal, it is the handling of hazardous wastes that presents the greatest potential danger to the environment and to the general safety and health of the population. As a result, the reduction of wastes at the source is the only long-term solution to reduce the volume of hazardous wastes that are handled. Although increased efforts of recycling and treatment have resulted in a reduction of hazardous wastes in the air, water, and soil, the overall quantity of waste that is being generated, as well as the actual handling of waste, has actually increased. In fact, it is the handling of these wastes in the Mexican border cities along the Arizona Sonora border that is cause for great concern. Considerable efforts are underway by the state of Arizona, the state of Sonora, and the Mexican government to implement pollution prevention programs.

III

The Next Steps: A Research Agenda for the Next Decade

INTRODUCTION

As part of the effort to develop a research agenda for the border region for the next five to ten years, two surveys were conducted: the Principal Investigator Survey and the Key Informant Survey. This chapter provides a brief explanation of the surveys and summarizes the results.

INTRODUCTION TO THE PRINCIPAL INVESTIGATOR (PI) SURVEY

The purpose of the Principal Investigator Survey was two-fold: to assess current SCERP projects and to direct future SCERP research. As such, this survey was sent to the PIs who were employed at SCERP institutions at the time the survey was conducted. The survey asked the respondents to identify potential follow-ups to their own research, research needs in specific locations along the border, and research projects or programs that would benefit the entire border region. Additionally, because environmental data in the region were not only inconsistent but also difficult to find, the respondents were asked to identify relevant data gaps in their areas of expertise. Table 1 lists the PIs who responded to the survey.

Overcoming Vulnerability

Table 1: List of Survey Respondents

Respondents	Project Title	University
John Horel	Air Pollution Transport Dispersion & Scavenging	UU
H. J. Fernando	Physical Modeling of Drainage in the Rio Grande River Basin	ASU
David Pershing	Control of Pollutant Emissions from Low Rank Fuel Combustion	UU
Peter Buseck	Airborne Particles along the Arizona–Sonora Border	ASU
Julie Stromberg	Effects of Surface & Subsurface Water Decline on Sonoran Riparian Forests	ASU
Chris Martin	Mycorrhizae & Transplant Establishment of Trees in Dry Urban Landscapes	ASU
Peter Fox	Biotechnological Treatment of Hazardous Wastewater	ASU
Hector Balcazar	Occupational Health Profile of Maquiladora Workers: Nogales	ASU
Ray Beckett	Database Coordination Initiative	UU
Soumen Ghosh	Decision Support System for Analysis of Institutions for Environmental Policy	NMSU
Maria Amaya	An Analysis of Lead Exposure During Pregnancy & the Neonatal Period among Indigent Hispanic Women	UTEP
Richard Wright	An Integrated Cross-Border GIS for the San Diego–Tijuana Interface	SDSU
Octavio Chávez	Development of Technical Courses for the Brick Makers Training Center	UTEP
Geoffrey Silcox	Selection and Analysis of the Use of Alternative Fuels in Brick Manufacturing	UU
Jan Miller	Advanced Process Technology for Mexican Wastepaper Recycling Plants & Pulp/Paper Plants	UU
Geraido Mejia	Characterization & Dynamics of Air Pollutants	UU
Nicholas Pingitore	Border Basket	UTEP
Larry Baker	Low Cost Strategy to Treat and Reuse Wastewater on the U.S.–Mexican Border (continuation)	ASU
Harold Berkowitz	Hazardous Waste Training on the U.S.–Mexican Border	ASU
Richard Gersberg	Predictive Modeling of the Interactions between Land Use and Storm Water Quality in the Tijuana River Watershed	SDSU
John Walton	Interactive Teaching of El Paso Air and Water Quality Concerns	UTEP
Ann Torrence	SCERP Data & Information Outreach	UU
Richard Gordon	Border Woodland Recovery Project	ASU

The Next Steps: A Research Agenda for the Next Decade

Table 1 continued

Respondents	Project Title	University
Frederick Steiner	Sustainable Model for Watershed Planning: Ecological Suitability and Growth Management Strategies	ASU
Alan Kilpatrick	Indian Groups of the California–Baja California Border Region and Border Environmental Issues	SDSU
Edward Sadalla	Residential Behavior & Environmental Hazards in Arizona–Sonora <i>Colonias</i>	ASU
Dennis Soden	Analysis of Issues in the Development of a Public Environmental Information Network	UTEP
Elsa Villa	Teacher Enhancement & Community Awareness in Air & Water Quality	UTEP
Victor Ponce	Analysis and Documentation of the Desertification Process in the Valley of Ojos Negros, Baja California (Pilot Study)	SDSU
Ryan Wicker	Hybrid Electrical Power System Using Wind Turbine & Spark Ignited Engine for Air Pollution Mitigation	UTEP
Alan Sweedler	Transborder Trucking and Air Quality	SDSU
Charles Turner	The Rio Grande River as a Potable Water Source	UTEP
Henk Meuzelaar	Field Evaluation & Monitoring of Air Pollutant Levels	UU
Richard Okrasinski	Trajectory and Model Analysis of Wind Flow into Big Bend National Park	NMSU

SURVEY RESULTS

The survey recommended the following actions by environmental media:

Air

1. Develop urban airshed models for binational cities, relating emissions inventories to ambient air quality measurements.
2. Identify the effects of air pollution on human health and explore the potential impacts of air quality controls.
3. Develop specific policy-oriented guidelines to reduce emissions of ozone precursors and particulates, including guidelines for light-duty vehicles.

Overcoming Vulnerability

4. Institute emission permit trading throughout the border region.
5. Identify important applied aspects of border pollution by constructing meteorological and chemical transport models of border pollutants; emphasis should be placed on the sources of heavy metals and carcinogens.
6. Improve techniques to monitor atmospheric motions, analyze wind flow patterns that contribute to cross-border pollution, and map cross-border fluxes of pollutants.
7. Conduct an economic analysis of preheating brick kilns with propane or natural gas before the kilns are filled with waste fuels.
8. Apply the SCERP air initiative in Paso del Norte to other border regions.

Water

1. Develop an integrated water management concept for the border region, recognizing the physical limits for population expansion. Water reuse, drought scenarios, sustainability of aquatic systems, and modifications of water quality regulations should be highlighted.
2. Conduct a border-wide GIS watershed analysis.
3. Determine the potential impacts of climate change on water resources and water use; assess the associated economic implications.
4. Design a full-scale wetland treatment/reuse system.
5. Assess environmental flow needs, including in-stream and flood flows.
6. Identify the potential of wetlands systems to remove nitrogen.
7. Determine the ecological consequences of dams and small tributary impoundments; assess the efficacy of these techniques as water conservation measures.
8. Develop and refine techniques to assess and restore riparian and grassland ecosystems. Institute research-based urban vegetation programs, placing particular emphasis on water-cycling issues.
9. Identify appropriate landscape types throughout the bor-

The Next Steps: A Research Agenda for the Next Decade

- der region to monitor landscape changes and to use detailed studies such as suitability analyses.
10. Identify disposal locations that will safely accommodate wastewater resources but not contaminate groundwater resources.
 11. Develop advanced separation processes to treat contaminated water and wastes and adopt appropriate strategies to recycle industrial and municipal wastes.
 12. Implement advanced process technology to minimize current pollution and place priority on new wastewater treatment systems.
 13. Investigate the human health impacts of casual contact with treated wastewater and determine the health effects of utilizing treated wastewater for irrigation.
 14. Perform human-health and ecological-risk assessments for border watersheds and the near-shore environment, particularly the Tijuana River.
 15. Extend and verify the EPA BASINS (Better Assessment Science Integrating Point and Nonpoint Sources) modeling efforts for coliforms and pathogens; specifically include hepatitis A.
 16. Construct GIS-based hydrological and pollution-load modeling.
 17. Create a comprehensive, interactive atlas of the upper San Pedro basin with multiple scales.
 18. Assess the resource impacts of urbanization of desert land versus irrigated lands along the Rio Grande in the El Paso Las Cruces region.
 19. Carry out additional studies on surface and groundwater interactions in the Rio Grande and San Pedro Rivers; determine how much longer the San Pedro River will flow freely if the present rate of groundwater pumping continues.
 20. Conduct desalination research.
 21. Carry out prototype suitability analyses of the upper San Pedro and Santa Cruz basins.

Overcoming Vulnerability

Hazardous and Solid Wastes

1. Conduct train-the-trainer courses, or emergency response and pollution prevention training, for municipal and maquiladora workers.
2. Coordinate research programs to identify potential and actual exposure pathways of hazardous environmental substances such as heavy metals, pesticides, and polychlorinated biphenyls (PCBs). Special emphasis should be placed on schools and homes to reduce the risk of exposure of these hazardous substances to children.
3. Investigate the potential for waste-to-energy plants to resolve the scrap tire problem.
4. Extend waste-reduction efforts to wastes other than solvents.
5. Develop an effective waste-exchange program.
6. Identify or design prototypes for latrine and septic systems; organize workshops and outreach programs to teach residents how to construct them.

Environmental Policy

1. Organize workshops and conferences to gain input from public and private border organizations in order to determine the major environmental issues that affect these organizations.
2. Conduct a detailed analysis of local, state, and federal plans for the border region.
3. Devise quality-of-life indicators for the San Diego Tijuana area.
4. Examine soil contamination by mining and smelting operations.
5. Carry out an in-depth analysis of energy needs and resources for the next two decades.
6. Conduct an urban forestry/re-vegetation research program.
7. Explore opportunities that exist for expanding cooperation between local groups and international NGOs.
8. Determine the ecological role of fire in riparian ecosystems.

The Next Steps: A Research Agenda for the Next Decade

tens and the utilization of fire as a desert grassland restoration technique.

9. Design low-cost, environmentally sound housing for colonias.
10. Conduct research on residential behavior in colonias, particularly concentrating on regional variation.

Database Improvements

1. Expand access to databases and create a border-wide databank. This databank should be organized, standardized, and continuously updated. The ultimate goal is for data to be consistent between and within nations. Data insufficiencies should also be addressed. The effectiveness and usefulness of such data in regard to addressing environmental problems along the border should be determined. These data should then be disseminated to the research community and to the general public with a request for feedback. Based upon the feedback, the data should be improved and disseminated once again.
2. Create a comprehensive and integrated GIS database of the border region, ensuring that data are multi-scale, interactive, and dynamic.
3. Develop and maintain a joint U.S. Mexican air quality index; establish a meteorology and air quality monitoring network.
4. Create automotive emission inventories and record the health effects of transient particulate matter episodes on vulnerable population groups.
5. Complete a light-duty vehicle emissions profile and develop a website where real-time data from on-the-road vehicular air can be posted. A framework for emission permit trading from various sources (point source and nonpoint sources) should be developed.
6. Create comprehensive, time- and space-resolved air pollution receptors and source emission records.
7. Improve and increase the monitoring of wind, temperature, and relative humidity in the border region.
8. Create an equivalent to the Toxic Release Inventory that

Overcoming Vulnerability

Table 2: Key Professional Respondents

Respondent	Title	Agency/Organization
Andrea Abel	NAFTA Program Specialist	National Wildlife Federation
John Bernal (by Jim Stefanov)	U.S. Commissioner	International Boundary and Water Commission
Greg Block	Director of Programs	The Commission for Environmental Cooperation
Gary King	Director	U.S. DOE Office of Worker and Community Transition
Russell Knocke	Special Assistant for Mexico Policy	Office of Governor Jane D. Hull (Arizona)
Susan Leiberman Goodwin	U.S.–Mexico Coordinator	U.S. Department of the Interior
Mark Spalding	Professor and Consultant-Attorney	International Environmental Policy and Law (University of California, San Diego)
Arturo Herrera Solis	Mexican Commissioner	International Boundary and Water Commission

displays quantitative data of the amount of hazardous chemicals released near colonias along the border, placing a special emphasis on demonstrating regional pollution variation. Research should focus on effective interventions such as education and appropriate technology.

9. Break down an energy-related database by specific regions.
10. Create a population-based database to document childhood levels of hazardous substances like heavy metals, pesticides, and PCBs in Ciudad Juárez.
11. Conduct floristic surveys (by creating a baseline species list s).
12. Collect groundwater data that includes elevations and nitrate concentrations.

INTRODUCTION TO THE KEY INFORMANT SURVEY

The purpose of the Key Informant Survey was to seek the opinion of key professionals at agencies involved with the U.S. Mexican border environment. The respondents were asked to make specific, programmatic research recommendations, comment on their agency's specific role in the border environment, identify significant research conducted by the agency, and recommend relevant publications. Table 2 contains the list of respondents followed by the results of the survey. A copy of the cover letter and survey may be found in Appendices I and J, respectively, and the full text of the responses may be found in Appendix K.

KEY INFORMANT SURVEY RESULTS

Summary of Recommendations

1. Develop a consistent, region-wide environmental education program.
2. Conduct a detailed, border-wide analysis of watersheds, including water quantity, water quality, groundwater, desalinization, urban and agricultural runoff, and seawater.
3. Create water supply and demand models for border communities.
4. Carry out a comprehensive analysis of the water supply including industrial, urban, and agricultural users. Utilize the resulting information to recommend ways to increase water use efficiency by all users.
5. Explore alternative sources of water including methods to reuse treated wastewater.
6. Assess environmental infrastructure water needs.
7. Establish erosion and sediment controls.
8. Establish measures to protect and conserve cross-border aquifers.
9. Standardize pollutant release data for both countries.
10. Conduct a detailed, quantifiable analysis of the relationship between human environmental impacts and chil-

Overcoming Vulnerability

dren s health.

11. Create a climate variability model that incorporates droughts and floods so that future regional climate variability may be reasonably predicted.
12. Institute non-native species controls.
13. Analyze the implications of habitat fragmentation in the region.
14. Identify and recommend locations for protected wildlife corridors.
15. Conduct genetic and population diversity studies of threatened and endangered species.
16. Conduct species surveys in the riparian habitat along the Rio Grande from Fort Quitman to Amistad.
17. Identify and recommend key habitat areas that should be protected.
18. Determine the impact that NAFTA has had on the border region, especially in regard to maquiladoras.
19. Research alternative energy technologies.

INTRODUCTION TO AGENCY REPORTS

In addition, SCERP researchers asked border agencies to select key reports that identify future border research needs. Ten of these reports are listed below:

The U.S. General Accounting Office

- March 2000. U.S. Mexico Border: Better Planning, Coordination Needed to Handle Growing Commercial Traffic.
- March 2000. U.S. Mexico Border: Despite Some Progress, Environmental Infrastructure Challenges Remain.
- July 1999. Air Pollution: The Border Smog Reduction Act's Impact on Ozone Levels.
- August 5, 1999. Letter and Report to Senator Dianne Feinstein. Water Quality: Problems in the New River and Imperial County, California.

Binational Conference on Environmental Research

The Next Steps: A Research Agenda for the Next Decade

and Policy

Varady, Robert G., Robert G. Arnold, Dean E. Carter, Roberto Guzmán, Carlos Peña, and William A. Suk. June 2000. Hazardous Waste and the U.S. Mexico Border Region: Toward a Binational, University-based Institution.

The Commission for Environmental Cooperation

North American Agenda for Action 2000-2002: A Three-Year Program for the Commission for Environmental Cooperation.

The Demand for Environmental Training in Mexico.

The North American Development Bank

Summer 1999. U.S. Mexico Border Ten Year Outlook: Environmental Infrastructure Funding Projections.

The Good Neighbor Environmental Board

September 2000. Fourth Report of the Good Neighbor Environmental Board to the President and Congress of the United States.

The U.S. Mexico Foundation for Science

June 1997. Water and Health at the U.S. Mexico Border: Science, Technology and Policy Issues.

ABSTRACTS OF EXTERNAL AGENCY REPORTS

The U.S. General Accounting Office

U.S. Mexico Border: Better Planning, Coordination Needed to Handle Growing Commercial Traffic (March 2000)

Overcoming Vulnerability

In this report the General Accounting Office (GAO) offers specific recommendations to improve port-of-entry planning, enhance coordination with Mexico, and streamline U.S. inspection agencies' port-of-entry operations. These recommendations are based on a study of the binational process associated with facilitating northbound commercial truck traffic entering the United States from Mexico. The GAO found that commercial truck traffic and the associated congestion at some border crossings have taxed border community infrastructure.

The GAO points out that there is a lack of empirical data on wait times and traffic delays at and leading to ports of entry. This lack of data impedes the U.S. inspection agencies efforts to more effectively plan and target resources to alleviate congestion. This study recommends a thorough assessment of infrastructure requirements that would allow for more integrated port-of-entry and transportation corridor planning. This study also recommends that information on existing equipment and resources at ports of entry should be collected and analyzed to ensure that technology scheduled to be deployed fits into existing compounds and is optimally utilized. Many of the recommendations are not included here as they are targeted at specific government agencies to improve their internal procedures.

U.S. Mexico Border: Despite Some Progress, Environmental Infrastructure Challenges Remain (March 2000)

This report focuses primarily on three environmental infrastructure issues: water, wastewater, and solid waste. According to the GAO and SCERP, in 1999, 12 percent of the border population did not have access to potable water, 30 percent lacked access to wastewater treatment facilities, and 25 percent needed access to solid waste disposal facilities. It was estimated that \$3.2 billion is needed to correct existing water, wastewater, and solid waste infrastructure shortfalls on both sides of the border. Seventy-seven percent of this amount is needed for wastewater treatment.

The GAO notes that there are several impediments to border infrastructure development which include: (1) the lack of

The Next Steps: A Research Agenda for the Next Decade

human capital, which they define as the technical capacity of communities on both sides of the border to plan, implement, and maintain environmental infrastructure; (2) NADB's loan rates, which they state have been unattractive or unaffordable for many of the border communities; (3) the limited availability of grant funds for solid waste disposal projects; and (4) the absence of a plan that identifies total environmental infrastructure needs and a strategy for meeting these infrastructure deficits.

In conclusion, the GAO emphasizes the notable progress to date in developing and constructing border environmental infrastructure projects. GAO also points out, however, that as currently structured and implemented, existing programs and activities are not likely to close the gap between what is needed and what exists for the foreseeable future, especially considering the realistically projected population growth.

The GAO recommends changes in the NADB's loan rates to make their funds more available to the people who need them. The GAO is mindful of the difficulty in achieving that goal since it would require Congress to amend their charter in a manner that would increase the United States obligation in the border region. Additionally, the GAO recommends that the U.S. and Mexican governments work together to develop a Border Infrastructure Strategic Plan that would

- 1 assess the needs of the border,
- 1 address impediments to infrastructure development, and
- 1 establish measurable goals by which progress can be assessed.

Air Pollution: The Border Smog Reduction Act's Impact on Ozone Levels (July 1999)

This act, initiated in 1998, seeks to reduce ozone-causing chemicals from certain foreign-registered vehicles. The act, which only applies in San Diego, prohibits certain foreign-registered noncommercial vehicles from entering the United States more than twice a month and authorizes fines up to \$400 to get people to bring their vehicles up to California standards. The act does not cover commercial trucks.

Overcoming Vulnerability

According to GAO research, the act's impact is difficult to estimate because data are not available on the number and conditions of vehicles crossing the border. Further, there are a variety of different factors that contribute to ozone. The GAO recommends that a study should be conducted that measures the impact of this act.

Letter and Report to Senator Dianne Feinstein. Water Quality: Problems in the New River and Imperial County, California (August 5, 1999)

In this report the GAO is responding to a request by Senator Feinstein that the GAO examine the issues surrounding water quality in the New River and Imperial County, California.

According to the GAO, the New River in Southern California has been polluted for decades. A major source of this pollution has been untreated and underrated municipal and industrial wastewater discharged into the river in Mexico. Drainage from agricultural lands in the United States constitutes the majority of the water in the river and is also a major source of pollution. Bacteria from sewage as well as a number of pollutants have been identified in sufficient quantities to prevent the New River from supporting its designated uses, such as fishing and swimming.

These pollutants, the untreated and underrated wastewater in particular, can pose a major risk to the environment and cause serious illness, such as typhoid and hepatitis. However, the GAO notes that the Imperial County Health Department has not reported and documented cases of adverse health effects from exposure to the river. The Imperial County Health Department is concerned however, for the safety of persons who are forced to enter the river (i.e., border patrol agents who have to dive into the river to conduct a rescue of the many illegal aliens who attempt to enter the United States via the river on unfit rafts).

The effects of the sewage on the environment are also severe. The GAO notes that the wastewater has virtually eliminated aquatic habitat in the first 20 miles of the river in the United States because the wastewater lowers oxygen con-

centrations in the water to levels that are unsuitable for most aquatic life. This report makes no recommendations.

Binational Conference on Environmental Research and Policy

Hazardous Waste and the U.S. Mexico Border Region: Toward a Binational, University-based Institution (June 2000). By Robert G. Varady, Robert G. Arnold, Dean E. Carter, Robert Guzmán, Carlos Peña, and William A. Suk. This report summarizes the findings of the steering committee of the Binational Conference on Environmental Research and Policy. The steering committee commented on (1) the adequacy of information and human resources in the southwestern United States and northern Mexico for supporting hazardous waste management activities, (2) the need for applied research leading to the solution of hazardous waste problems specific to the region, (3) institutional formats that would facilitate or best serve regional needs for the management of hazardous waste, and (4) funding for centralized, binational institutions for the management of regional hazardous waste problems. The steering committee further agreed that (1) there exists no central repository for environmental data or central responsibility for data dissemination in the region, (2) efforts to collect environmental data in northern Mexico remain handicapped by inadequate numbers of trained personnel and limited funds, and (3) university participation is either missing or inadequate in regional institutions addressing environmental quality, infrastructure, public health, and hazardous waste issues.

To begin to solve these problems the steering committee reached the following conclusion: "There is a clear need for a binational, university-based center to manage environmental and hazardous-waste information, promote training and education in hazardous-waste management, and establish research ties between U.S. and Mexican investigators in environmental science, health, engineering, and policy." The committee also recommended that the center's responsibilities and membership should be designed to avoid redundancy

Overcoming Vulnerability

with those external institutions; U.S. Mexican collaboration would offer a mechanism to help solve hazardous-waste problems, noting that collaboration is not a primary function of any existing international institution in this area; and that a carefully configured, academically rooted binational center with organizational and leadership responsibilities would be useful to both countries. The responsibilities of such a center might include data management, information dissemination, training and education, and research.

The Commission for Environmental Cooperation

North American Agenda for Action 2000 2002: A Three-Year Program Plan for the Commission for Environmental Cooperation

This publication is a strategic document published by the CEC to guide the evolution of environmental programs and initiatives by the CEC across North America. The CEC is an international organization that was created through an accord between the United States, Mexico, and Canada called the North American Agreement on Environmental Cooperation (NAAEC). This accord was part of the NAFTA agreement and reflected the desire of the three nations to have environmental safeguards incorporated into the trade liberalization pact.

The CEC states that the 2000 2002 program is centered around four core program areas:

- 1 Environment, Economy, and Trade
- 1 Conservation of Biodiversity
- 1 Pollutants and Health
- 1 Law and Policy

Environment, Economy, and Trade

In this area the CEC describes its role as the only intergovernmental environmental organization that has its roots in expanded economic integration brought about by a trade liberalization agreement. Therefore, advancing the understanding of the relationship between the environment, the economy, and trade is one of the core objectives of the CEC. The

The Next Steps: A Research Agenda for the Next Decade

following are the specific goals of the Environment, Economy, and Trade program:

- 1 promote sustainable development based on cooperation and mutually supportive environmental and economic policies,
- 1 support the environmental goals and objectives of NAFTA,
- 1 avoid creating trade distortions or new trade barriers,
- 1 promote economically efficient and effective environmental measures, and
- 1 promote "win-win" opportunities for achieving environmental and economic development objectives.

According to the CEC, an enhanced understanding of the relationship among the environment, economy, and trade will assist governments and nongovernmental actors in identifying ways to support environmental protection during trade liberalization and economic growth, develop mechanisms to facilitate environmental protection in a competitive environment, and help avoid environmental and trade conflicts

Conservation of Biodiversity

The mission of the Conservation of Biodiversity program is to promote cooperation between Canada, Mexico, and the United States in fostering conservation, sound management, and sustainable use of North American biodiversity. Their general objectives are as follows:

- 1 Identify and evaluate the most promising ways of conserving, fostering, and restoring biodiversity and ecological process in the region.
- 1 Identify and promote instruments and mechanisms for the conservation of regions, areas, and corridors used by transboundary and migratory species.
- 1 Establish an ecosystems monitoring initiative for North American priority regions that will provide early warning of environmental contingencies and emergencies, allow for a continuous evaluation of conservation actions in ecological regions through the use of performance indicators, and help identify trends related to conservation and utilization of natural resources.

Overcoming Vulnerability

- 1 Create networks of experts to analyze threats to biodiversity and then recommend strategies to address these threats
- 1 Promote sustainable use of the products and services afforded by biodiversity.
- 1 Improve information, understanding, and awareness of biodiversity in order to foster better decision making and to increase quantitative and qualitative public participation, which should lead to actions that maintain, conserve, restore, and sustainably use biodiversity.

Pollutants and Health

The mission of this program is to establish cooperative initiatives to prevent or correct diverse effects in North America from pollution to human and ecosystem health. This program area pursues the following objectives:

- 1 facilitating coordination and cooperation between the three countries to protect the environment;
- 1 enhancing comparability between the three environmental protection systems;
- 1 improving the knowledge base on issues of environmental pollution;
- 1 developing technical and strategic tools to avoid, eliminate, reduce, or manage environmental pollutants; and
- 1 improving the scientific, technical, and strategic capabilities of North American environmental protection agencies.

Law and Policy

According to the CEC, the goal of their Law and Policy program area is to address regional priorities regarding obligations and commitments in the NAAEC related to environmental standards and their implementation. Program initiatives monitor and report regional trends in implementing and enforcing environmental standards, including innovations in regulation, economic instruments, and voluntary initiatives. They also address NAAEC commitments to public participation in processes for establishing and enforcing environmental standards.

The Next Steps: A Research Agenda for the Next Decade

The Demand for Environmental Education and Training in Mexico (1997)

The body of this report summarizes a survey conducted for the CEC that intended to define the need for environmental education and training in the Mexican industrial sector. The survey further sought to assess the long-term trends in the delivery mechanisms for these services and analyze opportunities for the promotion of environmental education and training, primarily through regional cooperation.

The survey was sent to 3,000 private and state-owned businesses of various sizes in the Mexican industrial sector. A total of 528 responses were received for a response rate of 17 percent. The respondents' priorities varied depending upon the size of their company, with larger companies placing a higher priority on the areas surveyed. The survey found that there is much interest in environmental education and training. The following are the areas of greatest priority:

- 1 environmental standards and legislation
- 1 management to prevent pollution
- 1 water pollution and treatment
- 1 hazardous and solid waste management
- 1 energy efficiency
- 1 health, hygiene, and security
- 1 air pollution
- 1 waste reduction, reuse, and recycling

The areas of least priority are:

- 1 biodiversity
- 1 sustainable resource management
- 1 environmental impact
- 1 environmental management systems (ISO 14001)
- 1 risk management

It is noted that the desire for training programs did not fully agree with the programs of highest priority, rather they varied as a function of company size. In all cases the strongest preferences were for courses in pollution prevention management, energy efficiency, and regulatory and legislative policies.

The CEC makes the following short-term recommendations:

Overcoming Vulnerability

1. Reinforce existing programs and institutions while continuing to support new programs, especially in areas that currently lack them.
2. Give priority to the training of persons possessing many skills who can be rapidly integrated into the labor market.
3. Expand the dissemination of environmental awareness information through bulletins, posters, and general training programs given at low cost or free of charge.
4. Give priority to the establishment of basic training programs for smaller companies with the support of industrial and labor groups.
5. Continue the emphasis on audits and inspections to keep the focus on environmental protection in the industrial sector.
6. Emphasize train the trainer programs.
7. Encourage greater participation of both national and foreign-based institutions in the environmental training sector in Mexico.
8. Use regional cooperation programs to help train educators and instructors develop training materials, train auditors and inspectors, and exchange relevant information.
9. Continue and promulgate multinational cooperative programs between academic institutions, including the use of regional and international events to promote such cooperation.
10. Develop and implement an electronic system for the dissemination of information to specialists, particularly in areas of clean technologies and pollution prevention techniques.

Over the long-term, CEC recommends the implementation of skill-based training to ensure that Mexico has the executives, technical staff, and workers with the appropriate environmental skills to execute their respective job functions.

North American Development Bank

U.S. Mexico Border Ten Year Outlook: Environmental Infrastructure Funding Projections (Summer 1999)

In this report the NADB sought to define and project environmental infrastructure needs over the next ten years. According to the NADB, the border environmental infrastructure needs identified to date amount to approximately \$1.7 billion.

According to the NADB, the strategic goals of U.S. and Mexican border-related institutions are far reaching. They point to the need of both countries to construct environmental infrastructure in the border region that is consistent with BECC certification criteria.

The NADB encourages communities to fully utilize the bank's capital and advisory capabilities as well as other available financial resources to assure continual building of local credit capacity.

The NADB gives the following strategies to realize these goals:

- 1 extensive local and state participation in project development, design, construction, and operation;
- 1 close coordination among the principal border-related institutions including the BECC, EPA, IBWC, NADB, and SEMARNAT;
- 1 leverage all capital;
- 1 combine project grants with loans;
- 1 continue project planning and design and construction subsidies, as necessary, until border communities are able to carry larger credit components;
- 1 continue institutional support to develop and maintain higher payment capacity and debt service reserves through better management capabilities;
- 1 focus on long-term sustainable solutions with reserves for effective operation and maintenance of infrastructure;
- 1 continue project technical and cost reviews to ensure cost-effective solutions;
- 1 implement system reforms, such as ongoing user rate adjustments;

Overcoming Vulnerability

- 1 invest in human capital development; and
- 1 link all grant funding to strategic objectives.

The NADB points out that while many of these strategies can be partially carried out by border-related institutions, given the high projected population growth and poverty rates in the border area, a crucial factor in carrying out these strategies will be the financial support of the U.S. and Mexican governments for at least another \$1 billion over the next ten years. This money is needed for project planning and design and construction subsidies.

The Good Neighbor Environmental Board (GNEB)

Fourth Report of the Good Neighbor Environmental Board to the President and Congress of the United States (September 2000)

The GNEB is an independent federal advisory committee whose mission is to advise the president and Congress on good neighbor practices with regard to environmental and infrastructure needs along the U.S. Mexican border.

Each year the GNEB has targeted their recommendations to a particular and pressing issue along the border. In this report, the GNEB focused on water. The GNEB states that the border region does not have the infrastructure, policy, or institutions required to address the public's water needs in terms of quantity or quality. The board calls for a strategic solution to the border region's water problems to maintain the economic vitality of the region, the health of the 12 million border residents, and the sustainability of its fragile ecosystem. To achieve this goal the GNEB makes five key recommendations:

- 1 Institutionalize a border-wide watershed approach. Enable the institution of a watershed approach as the underlying standard operating procedure for all projects that deal with water resource management along the U.S. Mexican border. Concentrate initially on key priority watersheds and then expand the effort.
- 2 Support data-gathering and analysis that generates a clear picture of border watersheds. Using, initially, a

The Next Steps: A Research Agenda for the Next Decade

subset of priority watersheds, strengthen current efforts to collect, integrate, and analyze the data needed to flesh out watershed-based planning frameworks and fully understand both existing conditions and potential future scenarios in them. Expand this effort until sufficient data is gathered and available for all border-region watersheds so that a watershed approach can be fully implemented.

3. Highlight and support water resource management practices along the border that are based on a watershed approach. Develop a strategic water plan for the border-region to be used as an operational tool for the day-to-day management of individual watersheds by U.S. federal, state, county, municipal and tribal decision makers. Make this plan available to other interested groups. The plan should identify key transboundary watershed analysis, include preliminary options for addressing these issues, and complement existing state, local, and tribal government watershed-based plans and programs.
4. Encourage the full participation of tribal governments, along with binational organizations, federal, state, and local governments and other border groups, in developing and implementing a watershed approach. Ensure that the training, funding, and physical infrastructure needs of all tribal governments, along with other border governmental agencies and population groups, are fully addressed when developing and implementing a watershed management approach.
5. Provide continued federal budgetary support for actions and programs consistent with the themes and purposes of a watershed approach for the border region. The GNEB especially wishes to emphasize the importance and urgency of continued and full budgetary support for binational commitments to address border environmental issues within the context of a watershed approach.

The U.S. Mexico Foundation for Science

Water and Health at the U.S. Mexico Border: Science, Technology and Policy Issues (June 1997)

The U.S. Mexico Foundation for Science was launched in 1992 as a nongovernmental organization to promote and support binational cooperation in research training and capacity building in science, technology, engineering, and public health. This report summarizes the findings of the foundation's June 1997 workshop at El Colegio de la Frontera Norte in Tijuana, Baja California.

The workshop, titled Science and Technology Issues Related to the Environmental and Public Health Effects of Water in the U.S. Mexico Border Region, was attended by 163 U.S. and Mexican experts from various fields and provided an open forum for the discussion of common concerns.

From these discussions, five overarching themes emerged: (1) the need for infrastructure, (2) the need for data and research, (3) the need for training, (4) the need for collaboration, and (5) the need for information systems. These points are expanded upon below:

Infrastructure

- 1 There is a need for a regional master plan for water management in the border region that incorporates reuse and coordinated groundwater and biosolids management policies. Rehabilitation and modernization of existing hydraulic systems must be taken into account as well as the need for appropriate and sustainable technology and public and political participation.
- 1 A long-range binational policy agenda should be formed that guides regulation, fiscal incentives, technical development, employment options, relations, water resource use, infrastructure and information development, and education.
- 1 A binational wastewater research and development center is needed that would include research activities and technology development and transfer as well as the

The Next Steps: A Research Agenda for the Next Decade

training and certification of operators and laboratory and extension services.

- 1 There is a need to generate new service options for adequate drinking water treatment and sanitation in new and low-income communities.
- 1 There is a need to develop new flexible and creative financing mechanisms and strengthen current ones to better address regional needs.

Data and Research

- 1 To enhance decision making and planning, there is need for sufficient data to describe accessible water resources, distribution and treatment systems, and potential pollution sources and to identify and characterize users.
- 1 Current methods for monitoring drinking water sources, treatment, and wastewater disposal must be assessed.
- 1 Agricultural biosolids demonstration projects should be established that include cost-benefit analysis and sampling programs to determine the characteristics and types of sludge in the border area.
- 1 A regional pilot project should be developed to study the efficient use of water along the U.S. Mexican border.
- 1 There is a need to promote toxicological research and improve disease surveillance.
- 1 There is a need for ethnographic data related to household water use, storage and treatment, excreta disposal, and hygiene behaviors.
- 1 There is a need for studies that determine the relative costs of water development, maintenance, and operation projects on both sides of the border.

Training

- 1 There is a need to develop comprehensive, multi-cultural, collaborative training and certification programs of all levels to enhance the region's human capacity to address technical, management, and economic issues that arise. At each level, human resource capacity

Overcoming Vulnerability

building must be done in such a way to facilitate the implementation of appropriate technology.

- 1 Experiences similar to that of the Texas Manufacturing Assistance Center program of UTEP should be considered as a basis for establishing services to help industries in the optimization of their wastewater pretreatment technologies.
- 1 Water management and conservation training must be oriented to meet regional needs and to encourage the involvement of policy makers and the community in the development and management of water treatment projects
- 1 Studies regarding the public's demand for information and water supply should be conducted to gather sufficient information for the design and implementation of water policies.
- 1 An environmental information center should be created to provide environmental and public health information to border communities.

Collaboration

- 1 Binational coordination is necessary in applying methodologies for more useful water planning, operation, management, and monitoring.
- 1 It is necessary to create alliances between industry, commerce, government and nongovernmental organizations and the community in order to promote the sustainable management of water.
- 1 There is a need to promote existing networks and create new networks of practitioners and scientists in the border region. Annual scientific seminars can be used for technology transfer.
- 1 Norms, regulations, and standards need to be equalized throughout the border region over the next five to ten years so that there is limited conflict between them.
- 1 The programs of the Mexican and U.S. academic institutions should be integrated to enhance training and educational collaboration.

The Next Steps: A Research Agenda for the Next Decade

Information Systems

- 1 There is a need to strengthen systematic information gathering and dissemination regarding surface water availability and demand for use, wastewater treatment plant design and operation parameters, appropriate technologies, ongoing monitoring programs, dischargers and users of reclaimed water, and toxic chemicals and sources.
- 1 A catalog of human resources with experience in the management and implementation of industrial discharges should be created.
- 1 There is a need to establish internet-based mechanisms for information sharing that would allow researchers to easily provide known data and results to a centralized database. It should include access to the above information as well as facts about researchers, ongoing research projects, environmental education, research institution, available educational materials, and funding agencies. It should also provide public access to information on key environmental issues.

Follow Up

Some of the projects analyzed and suggested by the participants can be supported through existing programs at various Mexican and U.S. institutions, for example, Consejo Nacional de Ciencia y Tecnología (National Council on Science and Technology) in Mexico and the EPA, the National Science Foundation, and other private and public organizations in the United States.

The U.S. Mexico Foundation for Science achieved an agreement with the EPA to establish a fund supporting the creation of information systems for research, studies, and educational projects on water at the border, as proposed in the Workshop. This will be done according to priorities determined by the CNA, the BECC, the NADB, and the IBWC.

THE FUTURE RESEARCH AGENDA

SCERP has played an important role in addressing U.S. Mexican border environmental problems as an academic consortium focused on applied medium- and long-term solutions. Yet, as with all organizations that must evolve in changing and often very challenging circumstances, the consortium has learned many important lessons through its work.

The consortium has been on the vanguard of developing and implementing applied research on sustainable development, though this effort has not been without its challenges. SCERP has certainly contributed to the evolving science of sustainability, not only through research but also through implementation. Yet, to date, the need for sustainable solutions overwhelms the success of these projects. Awaiting the consortium's current and future researchers are the numerous challenges involved in applying the principles of eco-agriculture, industrial ecology, corporate citizenship in environmental and quality-of-life issues, and binational emissions trading. These principles will undoubtedly influence research that will have a significant impact on the region and, therefore, constitutes an important next step for the consortium.

Over the years, SCERP has come to value environmental education in general. More specifically, SCERP has seen great potential in the implementation of our findings and has found a particular need for water education and energy education for policy makers and citizens alike. An important challenge before SCERP is essentially to make SCERP research findings and policy recommendations more accessible to the public in both the United States and Mexico, where the general population is demanding more and better information on the environmental issues that affect their daily lives.

SCERP was on the forefront of evaluating the impacts of international trade. Increased trade along the U.S. Mexican border brought about by the implementation of NAFTA in 1994 was one of the contributors to the most prolonged period of economic growth in U.S. history. However, with the arguable exception of San Diego County, the region has yet to witness the full benefits of this growth. Many of the economic benefits

The Next Steps: A Research Agenda for the Next Decade

of NAFTA have accrued to other areas of the United States. With this imbalance (some would say great regional economic injustice) firmly in mind, Border Institute II challenged participants to formulate recommendations toward a more sustainable economy along the U.S. Mexican border. Specifically, decision makers were asked to focus on reinventing what has traditionally been a low-wage economy on a regional scale. Future economic development must address long-ignored needs such as raising the real incomes of all employment sectors and placing a higher value on ecological services, the community, and individual health, all of which lie at the base of any economic potential. However, there have been significant challenges to the consortium's vision of a dynamic and diverse regional economy coupled with a more equitable quality of life as stated in SCERP's mission, including a rather steep learning curve on the concept of sustainability for the region's policy makers and citizens.

Finally, it is very important to reiterate that SCERP research holds quality of life as its ultimate objective. Of course, in order to better achieve this objective SCERP needs to devise an effective and objective method to measure quality of life. While the EPA and SEMARNAT have been working to formulate a set of environmental health and quality-of-life indicators, much work remains to be done in this area.

THE LAST FIVE YEARS: THE KEYS TO SCERP'S FUTURE

A sense of what shape SCERP's work should take over the next ten years can be derived from looking back at the consortium's progress over the last five years. In 1998, the SCERP Management Committee decided that it would be most beneficial to direct a body of research that takes fuller advantage of SCERP's multidisciplinary expertise, to capitalize upon economies in the use of expensive and sophisticated equipment, and to focus the consortium's interest in a more regional manner. These directed research programs are complex, yet necessary, undertakings that incorporate multiple institutions and multiple researchers, are decidedly binational, and

Overcoming Vulnerability

result in important new research findings that allow SCERP to formulate policy alternatives grounded in thorough, cutting-edge scientific research. In conjunction with the directed research programs, SCERP made the decision to initiate a series of informed discussions with policy makers that eventually evolved into the Border Institute series (discussed in more detail in Chapter 1). The complementary relationship among the various SCERP programs is seen as a major plus from both inside and outside of the consortium. The interconnect- edness among environments, problems, and potential solu- tions is one of the great underlying themes of SCERP's work.

The first two directed research programs were a study on particulate matter in the Paso del Norte and a set of compara- tive studies of anthropocentric effects and management options for watersheds in the western half of the border. The air quality study, together with the local joint advisory commit- tee in the El Paso Ciudad Juárez region, characterized a par- ticularly nagging environmental problem (the region experi- ences some of the worst air quality in North America) and revealed important opportunities to harness market forces to help clean the air. Taking its momentum from SCERP's work in the Paso del Norte, a study to examine the mechanisms and advantages of binational air emission permit trading was even- tually expanded (given the insights of Border Institute III) to include carbon reduction trades and renewable energy credit trades. SCERP's Transborder Watersheds Research Program (TWRP) focused on the Tijuana Watershed and the Upper San Pedro River Watershed and led to the development of a water transfer, balance, and budget program in late 2001 (imple- mented in 2002).

Together, the air and water programs prompted transmedia modeling of conditions in the border region in the future and the development of SCERP's B+20 decision-support system, thereby successfully meeting a challenge delivered to the consortium at the first Border Institute. Border Institute I also directly led to the focus on infrastructure and finance mecha- nisms at Border Institute II, and inspired the BECC to request an assessment of border environmental infrastructure needs and a system to manage BECC-certified projects. Border

The Next Steps: A Research Agenda for the Next Decade

Institute III stimulated work by the Commission for Environmental Cooperation on demand-side management of electricity loads.

CHALLENGES FOR THE FUTURE

SCERP remains the only regional environmental research organization in the border area, and its interests and influence continue to expand. Now that SCERP has completed over 12 years of work, the time is appropriate to articulate what work should follow. For SCERP's environmental research to remain relevant it must meet the following criteria:

- 1 Maintain a policy context
- 1 Remain contemporary
- 1 Engage significant involvement by the community
- 1 Inform and interest the general population
- 1 Support more informed decision making

SCERP did do work in areas parallel to the Border XXI work groups (all except enforcement) and also did work in energy, economics, and tribal issues above and beyond Border XXI, yet the majority of SCERP's work was in water, air, natural resources, and environmental information. Further work in water and air is recommended; water, in particular, will undoubtedly remain a very important and contentious issue for the border region for years to come.

Toward these ends, SCERP, in its role as the regional and binational environmental research consortium, strives to plan, coordinate, conduct, and report on research that incorporates the following process and content areas that we feel are essential for high-quality applied environmental research along the U.S. Mexican border. Prioritizing these areas is dependent upon the objectives and characteristics of the various SCERP projects or programs. For this reason, these SCERP research topics are listed below in alphabetical order.

Process

Anticipatory Research

Due to the need for more and better long-range planning along the U.S. Mexican border, SCERP research has become more predictive in nature. As described in greater detail in Chapter 1, SCERP has sponsored a series of Border Institutes with support from the EPA Office of International Activities, the Border Trade Alliance, and the U.S. Mexico Chamber of Commerce. The purpose of this series is to develop and examine projections for the region, to discuss sustainable development strategies and options, and to involve and integrate a broader stakeholder constituency. Border Institute I was held in December 1998 and focused on the demographic momentum in the border region and the persisting economic asymmetry across the border. The forum was the source of some research topics that were developed in 1999. Border Institute II looked at reinventing the border economy. Participants estimated the water, wastewater, and solid waste deficit and suggested innovative means to spark investment in border environmental infrastructure. Border Institute III investigated trade, energy, and the environment and presented challenges and opportunities in the border region for sustainable energy security. Border Institute IV focused on binational water management planning. Border Institute V will examine the state of the border environment and develop measures of progress with regard to human and environmental health.

The second predictive and back-casting effort that has had an outstanding response is the B+20 framework, which offers policy options for moving away from a status quo future to a sustainable future with protected natural resources. The program is a unifying framework that connects certain policy decisions to their many intentional and unintentional consequences. SCERP's ability to anticipate future problems, to forecast issues, and to urge the back-casting necessary to avoid the worst outcomes adds tremendous value to the border work currently being done by SCERP and its partners.

The Next Steps: A Research Agenda for the Next Decade

Binational Context

Clearly, the most successful future SCERP projects and programs will be fully binational efforts. Collaborative joint research means many things, including the ability to look across boundaries, translate across languages and cultures, reconcile disparate data sets, jointly design experiments, collect data, analyze, coordinate, conduct, and implement strategies. Cross-border collaboration by SCERP should continue to be intensified.

Local Capacity Building

SCERP expends increasing amounts on outreach, education, and training to develop the abilities of local organizations and programs to best react to the needs of their constituency. Beginning with a survey of nongovernmental organizations, SCERP has tried to tailor and distribute products to grassroots organizations, especially binational ones, that provide information and interpretation to local residents.

Participation at local conferences and regional workshops (the South Texas Regional Environmental Conference and the Encuentro Fronterizo, for example) is another way to provide scientific value to local initiatives. The prioritization of issues and solutions and the promotion of agendas to bring about change are two of the next steps for SCERP. Regional planning around such resource management issues as water, energy, air, and biodiversity continues to make a difference at the local level. Examples include the Joint Advisory Council, the Border Air Quality Alliance, the Border Energy Strategy Committee, and the Environmental Education Council for the Californias. Finally, SCERP researchers regularly testify at local hearings on environmental quality and ecological processes. Dedication to these efforts will continue into the foreseeable future.

Multiplicities

SCERP has learned how to conduct and apply research that addresses multiple facets at once: multidisciplinary expertise, multiscale regimes, multimedia foci, and multitask objectives. Finally, to be truly effective, SCERP's work must be

Overcoming Vulnerability

interdisciplinary, cross-media, interscalar, and multitasking in design and implementation. Innovative solutions that address several problems through one process can be devised. For example, research that explores the benefits of linked energy and water conservation are extremely valuable in the arid and energy-poor U.S. Mexican border region.

SCERP has developed research questions and processes that integrate across disciplines to reveal comprehensive relationships and develop long-term and inclusive answers. What is best for the local economy is best for the local residents and the local natural communities, but those relationships are only discovered through cross-disciplinary research.

Outreach and Transferability

Effective research can be transferred to a larger community than the local one first identified, such as to the rest of Mexico, other arid regions, developing nations, or other border settings. Most applied research that SCERP has accomplished provides value outside academia and has applicability not only elsewhere in the border region and throughout Mexico but to many arid, developing, or simply remote locations. Latrines, safe drinking water, energy projects, and artificial wetlands and woodlands are examples. However, one of the greatest challenges to a regional consortium is aggregating up to the regional scale and disaggregating down to the local or project scale and even to the research pixel scale, which is sometimes as small as a square meter. The issue of scale is confounded by time when we try to make predictions, and remains a significant challenge for SCERP researchers.

Policy-focus

Research is only as good as its ability to support sound policy decision making. SCERP should articulate its policy recommendations in a manner that best informs those involved in the fields of health, security, economic development, and trade. Several SCERP projects inform policy-making; one clear example is the Border Institute series because it is an issue-specific border think tank for top-level decision makers

The Next Steps: A Research Agenda for the Next Decade

in the region. It focuses on concrete problem and commissions a number of informative and provocative papers and participants of panels. Another long-term policy project is the B+20 decision-support tool, which addresses policy questions to a back-casting model.

Scale

Scale includes spatial elements and temporal elements. For instance, research that is landscape in scale considers sources of threats, effects and resolutions in watersheds, air basins, ecosystems, and other similarly scaled challenges. On an even larger scale, SCERP is able to determine effects from and influences to global phenomena like globalization, global climate change, global markets, global trade, and macroeconomics. The range of temporal scales is seen in studies that are mid- to long-term in scope and that predict and avoid unintended effects through back-casting and redirected planning. Long-term research involves assigning local effects from global phenomena and making linkages among the consequences of local effects. For example, initial indications are that the effects of global climate change will be exacerbated in the arid regions and exceed those in other locations. Already persistent and serious drought patterns could get worse, having direct, substantial, and long-term implications for the U.S. Mexican border region.

Strategic Effort

The need to develop a border environmental infrastructure needs assessment and prioritization system is paramount. The BECC and the NADB will spend tens of millions of dollars in a less-than-optimal manner if an effective way to judge and address the most urgent priorities and the most cost-effective solutions are not developed. SCERP is well positioned to conduct such a study.

Sustainability

SCERP tailors all of its research and policy toward developing a sustainable society in the border region. Sustainability implies the use of resources (human, natural, economic, etc.)

Overcoming Vulnerability

and waste processes (disposal of waste streams, reuse of wastewater, and neutralization and storage of hazardous materials) so that future generations may use the same resources and waste processes to enjoy the same quality of life as the present generation.

Precisely because sustainability requires a delicate balance among various interrelated processes, SCERP projects tend to address several issues at once. SCERP's study of salinated soils at Ojinaga illustrates this concept, as it identified a solution that benefited all sectors and resources. Using wastewater to leach the soils of salts accomplishes the following:

- 1 reduces the nutrient load into the Rio Grande
- 1 provides nutrients to grow biomass in the form of trees that are a salable product
- 1 prevents other natural areas from being used for fuel or as biomass for pulp plants
- 1 provides jobs for the local farmers who can no longer cultivate the salinated soils
- 1 recharges the groundwater

Research projects such as SCERP's Ojinaga study are highly beneficial for their ability to address the complexities that are usually present with U.S. Mexican border environmental problems.

Content Areas

Air

While SCERP has conducted extensive research on air pollution in specific areas (for example, particulate matter in the Paso del Norte) it has also recognized that each border twin-city pair has its own air pollution issues. A forthcoming monograph outlines conditions in five twin-city pairs. Different sources, offspring, transport, fate, and risk make air research and policy work difficult. SCERP will continue to develop comprehensive understanding and study border-specific problems such as idling trucks and cars at border ports of entry.

In addition, now that SCERP has completed its analysis of binational air emissions permit trading, this strategy can be

The Next Steps: A Research Agenda for the Next Decade

promoted to benefit the most residents in the quickest manner possible.

Biodiversity

As is the case with environmental health issues, SCERP has done extensive work in this area, but not in a comprehensive way. One way of making the consortium's work more responsive to border needs is by conducting a border-wide biological diversity survey that will give SCERP a sense of the priority in problems and strategies. Other natural resource issues revolve around biodiversity and its relative vulnerability to the many environmental threats. Biodiversity needs include:

- 1 basic information gathering such as surveys and census of transboundary species and habitats
- 1 natural community and corridor fragmentation studies
- 1 assessments of the collocation of biodiversity key hot spots with joint protected areas
- 1 identification of additional protection and preservation needs
- 1 threat analysis (including binational fire management efforts)
- 1 understanding bio-invasion by nonnative species
- 1 avenues for the introduction of more exotic species
- 1 control and eradication strategies specific to the border region
- 1 research to support transborder protected areas

Economics

Economic studies to account for environmental values and impacts (environmental accounting) and ways to integrate principles of natural capitalism are sorely needed in the border region. SCERP researchers must build on the accomplishments of Border Institute II, whose participants recommended greater attention to these issues in order to support a sustainable economic and environmental future for the region.

