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GIS Mapping of Areas of Critical Ecological Concern on the U.S.-Mexican Border: Selected Binational Watersheds

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Abstract

Contemporary urbanization and economic development patterns in the U.S.-Mexican borderlands are generating increasing pressures on the viability of important ecosystems. Binational watersheds in the U.S.-Mexican border region are especially important and interesting areas of concern. In this research, the authors employ the use of geographic information systems (GIS) to map the physical geography of five target basins in the U.S.-Mexican borderlands, to introduce specific topics of concern to the ecosystems involved, and to provide some initial ideas about protecting regional areas of ecological concern in the face of mounting development pressures. The outcomes of the project include a GIS-based poster that highlights the five study areas, a website hosted at http://www.scerp.org that provides an overview of the project, and this monograph chapter that describes the project in greater detail.

Mapeo SIG de Zonas de Preocupación Ecológica Crítica en la Frontera México-E.U.: Cuencas Binacionales Seleccionadas

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Resumen

La urbanización contemporánea y los patrones de desarrollo económico en tierras de la frontera México-E.U. están aumentando las presiones sobre la viabilidad de ecosistemas importantes. Las cuencas hidrográficas binacionales en la región entre México y los Estados Unidos representan zonas de especial importancia e interés. En esta investigación, los autores utilizan sistemas de información geográfica (SIG) con miras a: trazar un mapa de la geografía física de cinco cuencas seleccionadas de la zona fronteriza México-E.U.; introducir temas específicos de interés dentro de los ecosistemas en cuestión; y ofrecer algunas ideas iniciales sobre la protección de zonas regionales de preocupación ecológica ante las crecientes presiones del desarrollo. Los resultados del proyecto incluyen: un póster basado en SIG resaltando las cinco zonas de estudio; un sitio de Internet en www.scerp.org donde se presenta un panorama general del proyecto; y el presente capítulo monográfico que describe el proyecto con más detalles.

Introduction

Contemporary urbanization and economic development patterns in the U.S.-Mexican borderlands are generating increasing pressures on the viability of important ecosystems. Binational watersheds are especially important and interesting areas of concern (Brown 2003; Brown, et al. 2003; GNEB 2000; and EPA and SEMARNAT 2003). Because of the importance of water to ecosystem health in the region, Southwest Consortium for Environmental Research and Policy (SCERP) researchers in the Department of Geography at New Mexico State University (NMSU) have undertaken a geographic information system (GIS) mapping project that highlights several binational watersheds on the U.S.-Mexican border, details the physical geography of these basins, introduces relevant issues of ecological concern, and provides some preliminary ideas for how to meet the challenges of retaining ecological integrity in the face of the contemporary development pressures that these regions face. The five areas that this project investigates are:

- The Colorado River Delta that lies in the lowermost portion of the Colorado Basin and empties into the Sea of Cortez
- The confluence of the Río Conchos and the main stem of the Río Bravo/Rio Grande near Ojinaga, Chih.
- The Upper San Pedro Basin that lies within the Sonoran Desert along the Arizona-Sonora segment of the border
- The Tijuana River Watershed that lies on the California-Baja California segment of the westernmost U.S.-Mexican border
- The Upper Santa Cruz Basin that lies within the Sonoran Desert along the Arizona-Sonora segment of the border

The outcome of this project is threefold. Working with a variety of U.S.-Mexican border water and environmental researchers, project staff at NMSU produced a large-format GIS poster that highlights the GIS maps at the heart of this work. This poster was presented and distributed at Border Institute VI in Rio Rico, Ariz., in April 2004. Project staff also developed a website that features various elements of the mapping poster (see http://www.scerp.org). The website provides an alternative vehicle by which the data and related products of the research project can be accessed. Specifically,

this website serves the digital map products involved in the poster, discusses each region and the related ecosystem management challenges in some detail, serves the underlying GIS data and related metadata, serves the large-format poster in various digital graphic formats, and provides details on the sources of data and the contributing partners whose generous efforts made this project possible. Lastly, this chapter serves as a hard-copy companion product to the poster and website and describes the project in greater detail.

Mapping Elements

Working with colleagues at various SCERP institutions, governmental agencies, and non-governmental organizations (NGOs) in the United States and Mexico, as well as with a private-sector mapping firm in the United States, project staff developed a series of GIS maps that feature the basic foundational mapping layers of elevation, the major water bodies, the relevant jurisdictional and administrative boundaries, and the key protected natural resource areas. These maps provide a "snapshot" of the physical geographies of each of these basins. Details of the data employed and the numerous individuals and organizations that have collaborated on the project are provided in the poster and on the website. These mapping elements provide an overview of the larger border region and feature key locational elements to "paint the picture" of the borderlands. The website developed for the project also features these map elements and it provides access to select GIS data.

Key Issues of Ecological Concern

This chapter identifies several issues of concern that face each of the five regions that were investigated. These issues are not presented as the only or the most critical issues of concern, rather, these issues are introduced as points of discussion on which further research and discourse can be built. This chapter provides a regional view of these areas and issues of concern and focuses on the challenges that face each watershed, not on the general issues that can be more applicable throughout the entire border region. Based on preliminary research, the maps highlight ideas about how the underlying chal-

lenges may be met, and they focus on regional and watershed approaches that have been introduced or explored through previous research by the NMSU project team, through collaborators that have provided data for the project, and through researchers at other institutions. Each of these areas of investigation is discussed in detail below.

The Lower Colorado River Delta

Covering nearly 1 million hectares, the Colorado River Delta once extended from just north of the U.S.-Mexican border to the confluence of the Colorado River and the Gulf of California. Prior to the damming of the Colorado River, the delta was tremendously important for more than 300 species of resident and migratory birds, which depended on the delta for food and shelter. The plentiful fish and wildlife prompted the native Cocopah Indians to settle the area more than 1,000 years ago, where they lived off the bounty of flora and fauna and farmed the fertile soils. Sixty-five years of vigorous water management that was meant to satisfy agricultural, industrial, and urban needs in the United States and Mexico has reduced the delta to 10% of its original size (Sonoran Institute 2004; Cornelius, et al. 2004).

Specific Issues of Concern

The aggressive anthropocentric use of the river's waters over the last 65 years has transformed this ecosystem from a lush riparian delta into a region wholly altered by humans. Long-term drought in the Colorado River Basin is greatly reducing lower basin supplies to the point that maintaining flood flows that native forests need for survival along the river channel is increasingly unlikely. Increased demand for water among upper basin users threatens to exacerbate the general deterioration in ecosystem health.

Possible Solutions for Ecological Problems

The Sonoran Institute's Colorado River Delta Project is attempting to conserve and restore crucial stretches of the Colorado River and Delta, thus increasing riparian, wetland, and intertidal habitat while enhancing human livelihoods (Sonoran Institute 2004). The International Boundary and Water Commission (IBWC) has advanced the Binational Technical Task Force, which serves as a binational forum for U.S. and Mexican agencies and other stakeholders to cooperate in a formal framework (IBWC 2000). The Pacific Institute's Colorado River Delta-Upper Gulf Restoration Project seeks to apply the key concepts and criteria for sustainable water use developed in "California Water 2020: A Sustainable Vision" to the Colorado River Basin (Pacific Institute 2004).

The Confluence of the Río Conchos and Río Grande Rivers

The region defined by the confluence of the Río Conchos and the Río Grande is called La Junta de los Ríos in Spanish (Morgenthaler 2004). The Río Conchos is the largest of the Rio Grande's tributaries that flows in Mexico, and the Río Conchos Basin covers approximately 66,000 square kilometers, or 14%, of the total drainage area of the Río Grande Basin. Several large urban areas lie within the basin, and more than 1 million people rely on the waters of the Río Conchos. Several surface water impoundments have been built on the Río Conchos; these have a combined capacity of approximately 3.4 million acre-feet and meet a range of irrigation, hydro-electric, municipal/industrial, and flood control demands (Kelly 2001).

Specific Issues of Concern

From a water balance perspective, meeting the competing demands of irrigation, hydro-electric, municipal/industrial, and flood control is challenging, and the most recent period of severe drought has intensified these challenges. Crossborder issues are related to this set of challenges. The above-referenced drought and the manner in which Mexico has used the waters of the Río Conchos have caused

the country to amass a major water debt to the United States under the 1944 water treaty. Texas farmers allege that Mexico should be operating its reservoirs to meet international demand, while Mexican interests argue that these demands cannot be met during this period, which they argue is an "extraordinary drought." The larger issues in this binational basin concern how to balance the needs of regional economic development, traditional agricultural activities (both ranching and farming), and ecological preservation for water resources and management in a transboundary context.

Possible Solutions to Ecological Problems

Environmental Defense and World Wildlife Fund's Chihuahuan Desert Ecoregion Project have published analyses of current and future water use trends, worked to increase awareness of environmental water needs, and are working with local interests to identify specific options for the enhanced management and protection of the Río Conchos and the upstream portion of the Río Grande, which is often referred to as the Forgotten River (Kelly 2004).

The Upper San Pedro River Basin

The Upper San Pedro River is one of the last free-flowing rivers in the desert borderlands region. It supports a rich riparian corridor that is critical to local and regional biodiversity. The land contained within the San Pedro Riparian National Conservation Area is of particular biological value. The Conservation Area comprises approximately 18,000 hectares, which many migratory birds rely upon for habitat. The groundwater aquifer that supports the San Pedro River also sustains the municipal, agricultural, and industrial land uses that exist in the basin. Since the early 1990s, resource managers have recognized that the Upper San Pedro Basin and its natural resources are indeed binational in nature, which means the basin is of critical concern for this research project (Browning-Aiken, et al. 2002).

Specific Issues of Concern (Browning-Aiken, et al. 2002)

Land use changes in the last 30 years have seen major grassland areas become mesquite shrub lands. The extraction of groundwater to meet urban and industrial demands is raising questions about the long term viability of the region's aquifers. This extraction of groundwater is also creating a negative effect on surface water hydrology and it is reducing the viability of the riparian areas in the basin. Poorly treated municipal wastewater and effluent from mines, which both flow from upstream areas, are decreasing groundwater quality.

Possible Solutions to Ecological Problems

Researchers in both the United States and Mexico recognize that the management needs of the river transcend the cultural, political, and economic differences that exist across the international border (Browning-Aiken, et al. 2002). The San Pedro Partnership is a consortium of 20 U.S. agencies and organizations that work together to meet the water needs of area residents while they protect the San Pedro River (San Pedro Partnership 2004). The Sonora-Arizona Regional Environmental Association is a group of teachers, doctors, mining engineers, attorneys, and citizens from the United States and Mexico who have come together to address the regional environmental issues in the basin (Browning-Aiken, et al. 2002).

The Tijuana River Watershed

The Tijuana River Watershed (TRW) is a binational river basin that lies on the westernmost section of the U.S.-Mexican border; approximately 30% of the basin lies in the United States and 70% lies in Mexico. The drainage basin of the river covers nearly 4,450 square kilometers and encompasses portions of the City and County of San Diego in the United States and portions of the municipios of Tijuana and Tecate in Mexico. Elevation in the basin ranges from mountainous areas that rise more than 2,000 meters to the coastal areas that lie at sea level (Brown 1998). The Tijuana River Estuary

is of particular interest in this hydrology. The estuary is a wetland-dominated coastal plain estuary that lies in the lowest reaches of the basin (Zedler, Nordby, and Kus 1992).

Specific Issues of Concern

Lack of adequate wastewater collection and treatment facilities in the Tijuana portion of the basin causes renegade sewage flows to negatively impact the lower reaches, the Tijuana River Estuary, and the health of the region's human inhabitants (Brown 1998). Uncontrolled and unmitigated urban sprawl that covers the area from Otay Mountain through the corridor between Tijuana and Tecate and south again to Rosarito causes many of the region's residents great concern (Comer 2004). The plan to further channelize portions of the river in Mexico is one specific impact of urbanization. This plan prevents these areas from being developed as urban river park corridors (Michel and Graizbord 2002).

Possible Solutions to Ecological Problems

Universities and public agencies from both sides of the border have combined their efforts to help address environmental problems in the TRW with a binational GIS database and with a water resource management program. Researchers at San Diego State University and Colegio de la Frontera Norte initiated this program, and the combined efforts of SCERP, the National Oceanic and Atmospheric Administration, and other regional and national agencies funded the program (Department of Geography, San Diego State University 2004). The Bight of the Californias Program encourages countries to develop or strengthen programs to address land-based sources of pollution to the marine environment, and the overall goal of this project is to establish the information and methodological bases for protecting the nearshore marine environment in the Bight of the Californias from land-based sources of pollution (SANDAG and CEC 2000). The TRW Visioning Program is an effort of a binational team of researchers and practitioners to develop baseline information for the watershed and to identify key stakeholders. The stakeholders are participating in the development of a binational vision,

or ideal state, for the Tijuana River Watershed and are helping devise strategies and options for achieving that vision (Tijuana River Watershed Binational Visioning Project 2004).

The Upper Santa Cruz River Basin

The Upper Santa Cruz Basin is a transboundary watershed that is located along the Sonora-Arizona section of the U.S.-Mexican border, and that houses the binational twin cities of Ambos Nogales (Nogales, Son., and Nogales, Ariz.) and the large urban area of Tucson, Ariz. (Brown 2002). Ambos Nogales has an estimated population of 200,000 people (INEGI 2001), making this binational conurbation a third to a quarter the size of Tucson and an urban region of increasing importance for regional water resource management. The Santa Cruz River originates in the San Rafael Valley, and from these headwaters the river flows in a southerly direction until it crosses the border just east of Lochiel, Ariz., and into Mexico. After flowing through agricultural regions in Mexico, the river crosses back into the United States, eventually flowing through largely channelized reaches in the Tucson urban area (Brown 2002).

Specific Issues of Concern

The largely unpopulated San Rafael Valley has experienced land fragmentation pressures as large areas of ranchland are sold for "ranchette" development, thus splintering this viable and stable grasslands region. Given the limited water resources and financial and human capital, as well as the increasing urban demands for water, the Mexican ranching areas face the mounting challenges inherent in maintaining the viability of agricultural activities. Reaches of the river that are downstream from the International Wastewater Treatment Plant in Nogales have wrestled with water quality issues because of the quality of the treated effluent that enters the river, even though this effluent is a major supply input into the regional water balance in this part of the river. Regional aquifer resources are experiencing increasing demands while Tucson and the Ambos Nogales region continue to extract fossil groundwater to meet urban water demands.

Possible Solutions to Ecological Problems

A range of stakeholders with an interest in preserving and promoting the cultural and natural heritage and landscapes of the valley are united by the vision of a congressionally designated Santa Cruz Valley National Heritage Area (Center for Desert Archeology 2004). The Center for Desert Archaeology, under collaboration with Western Mapping, Inc., and regional environmental educators and researchers, is leading the effort on the National Heritage Area. This work is based on a watershed approach to ecological and historical preservation (Center for Desert Archeology 2004). The Friends of the Santa Cruz River, the Santa Cruz River Alliance, the San Rafael Valley Association, and the San Rafael Valley Land Trust are also working in various parts of the basin to advance preservation and conservation efforts (Brown 2002).

Future Work

The overall goal of this project was to introduce the regions and the topics of concern in each, to demonstrate the usefulness of a watershed approach to these issues through a GIS framework, to explore the usefulness of GIS tools and data in examining these issues, and to stimulate a wider discussion among SCERP researchers and participants at Border Institute VI on the potential ways to meet the challenges these regions face. Out of this dialogue, specific future areas of research emerged and interested parties that can work together in collaborative research efforts were identified. This project stimulated efforts by which interested parties can collaborate on the development and sharing of geo-spatial data in these areas of investigation, on which future research can be conducted.

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