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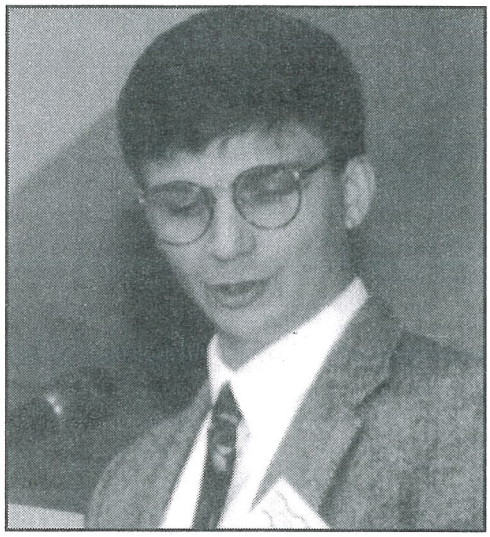

UNITED STATES-MEXICO BORDER GEOGRAPHIC INFORMATION SYSTEM

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Introduction

The United States-Mexico border region, including all the states north and south of the international boundary, is geographically complex and diverse. It is one of the fastest growing regions in both countries. The growth of the region has generated a significant number of positive effects including increased employment, a strong housing industry and an increase in retail sales. Along with the positive aspects of growth, a variety of negative effects have also been identified such as water quality degradation, air pollution, and increased traffic congestion.

The environmental, social and economic problems along this international border are often "transboundary," meaning that the problems cross over the boundary. As a result of the transboundary effect, the positive and negative aspects of growth can be significantly influenced by decisions made by the national governments of the United States and Mexico. One example of an important treaty agreed upon by both countries is the North American Free Trade Agreement (NAFTA). The passage of NAFTA has enhanced trade and expanded local economies. However, a successful NAFTA may also exacerbate many of the negative effects of growth if they are not mitigated in the immediate future.

The international border between the United States and its southern NAFTA partner, Mexico, is approximately 1,600 miles long. A central question for any policy maker working in this region is how to begin addressing problems over such an expansive territory. In order to develop plans and programs that will solve border issues, researchers and policy makers must have a comprehensive and unified vision of the problems' geographic locations and magnitudes.

Anyone who has tried to analyze binational spatial issues has experienced the daunting problem of bringing together dissimilar data sets from both sides of the border. In addition, there are few maps that view the region as a unit.

A desktop geographic information system (GIS) can address many of these problems by providing a decision maker with electronic maps and associated data bases. Using a GIS, a person can view the border region as a unified entity or choose to look at any portion of it. In addition by merging data, located in the GIS' database, specific problems can become the object of study.

Selected Research and GIS Activities along the United States-Mexico Border

There have been numerous studies and data gathering efforts along the U.S.-Mexico border. An excellent example of data gathering is the text *United States-Mexico Border Statistics since 1900* (Lorey 1990). It presents social and economic data on border states, counties and municipios. A second example is the work by Arreola and Curtis (1993), *The Mexican Border Cities*. Even with this impressive amount of work, there have been few attempts to map environmental or socioeconomic data along the international border between the United States and Mexico.

The passage of NAFTA on December 17, 1992, spurred geographic research along the border. Two research topics received immediate attention—transportation and environment. The Federal Highway Administration under the Intermodal Surface Transportation and Efficiency Act of 1991 initiated a detailed analysis of the origins and destinations of freight flows in the report, *An Assessment of Border Crossings and Transportation Corridors for North American Trade* (FHWA 1994). This work included a number of maps identifying corridors of trade as well as maps of specific border crossings.

The Environmental Protection Agency (EPA) funded the Southwest Center for Environmental Research and Policy (SCERP). This consortium of five U.S. universities and Mexico institutions of higher education was given the charge to undertake cooperative environmental applied research along the border. The program has produced a number of applied geographic research reports including some highly detailed mapping efforts. They include *The Tijuana River Basin Study* (Wright 1994) and groundwater GIS-based research in the Nogales, Arizona-Sonora region (Hepner 1995).

The research and policy-related efforts related to NAFTA and EPA efforts have been place speci-fic. They were intended to address specific problems or set of problems in a constrained geographic loca-tion. Although this type of work is necessary to ad-dress specific problems, there still exists a need to show the region in a larger context.

A Border Atlas

The U.S.-Mexico Border Atlas pilot project was designed to show the big picture along the border. The project also demonstrated that compatible binational data could be identified and mapped. A pre-

liminary atlas and simple GIS were developed in 1993. They focused on environmental and socioeconomic data from the states of New Mexico and Chihuahua. Mapping was accomplished at two scales. First, socioeconomic data was mapped at the county level for the two states. Environmental data was mapped below the county level for the U.S. counties and Mexico municipios along the border. The specific topics in the pilot project atlas were:

- Environment - physiography, water, vegetation, surficial geology, soils
- Economic - major data from the 1990 U.S. census (and updates) and TIGER files and the estimated 1990 census in Mexico, transportation routes, airports, railroads, land use
- Political - cities, municipios, counties

A black and white example (the atlas is printed in color) from each section of the atlas can demonstrate the look and feel of the original document.

Water resources is a critical resource in this region. A general surface hydrology map for the counties and municipios along the border was produced (Figure 1). It shows the major permanent drainages for the eleven-border county equivalent units. Even though this map was little more than a sketch of the surficial water resources, it was one of the first maps of its kind to show the location of linear water features on both sides of the border simultaneously.

To help explain the physical geography of the region, physiography and surficial geology were mapped at the subcounty (submunicipio) level (figures 2 and 3). The larger scale mapping was undertaken for environmental data because small scale mapping for this type of data is not useful for problem solving.

The physiography of the border region clearly shows the basin and range configuration on both sides of the border. The surficial geology demon-

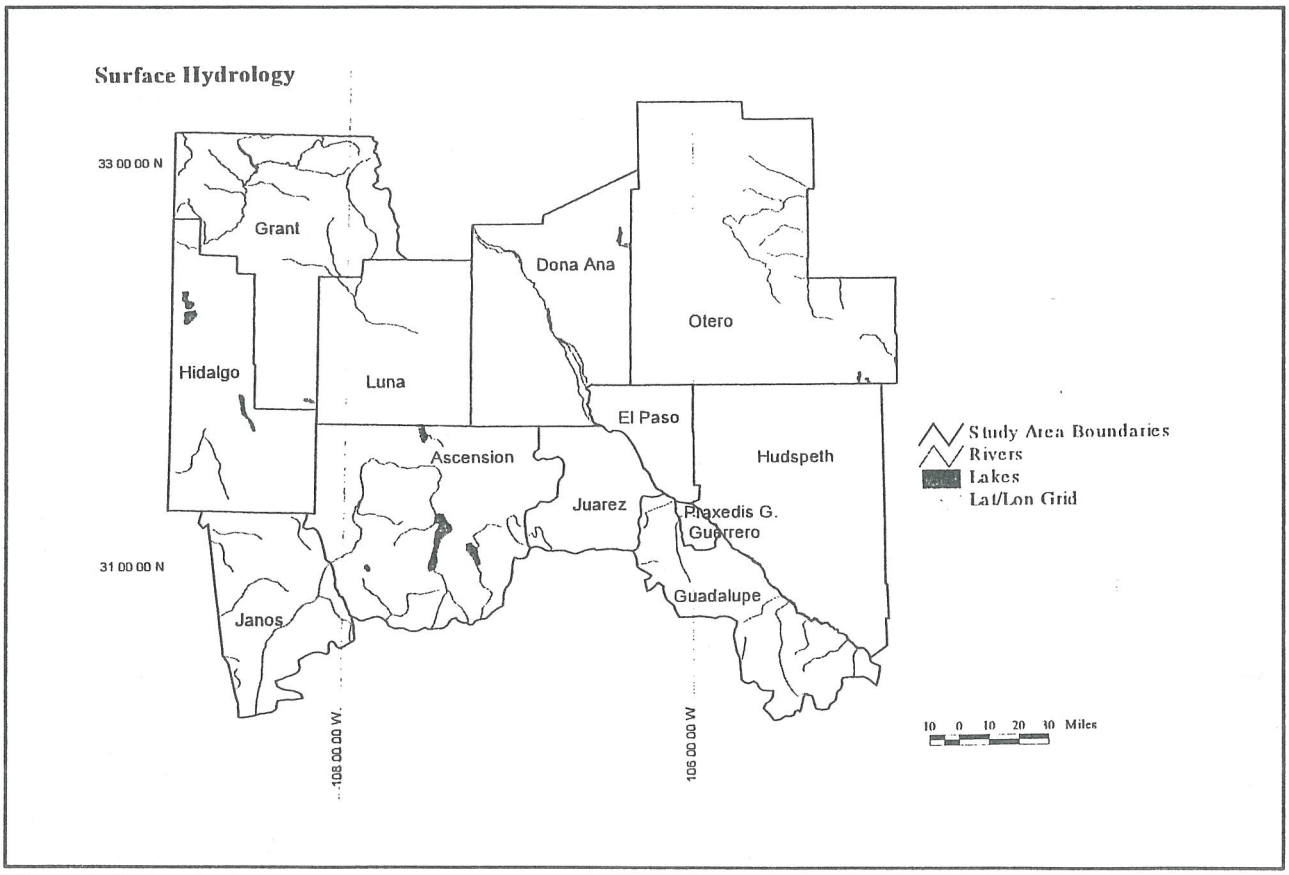

Figure 1. Surface hydrology.

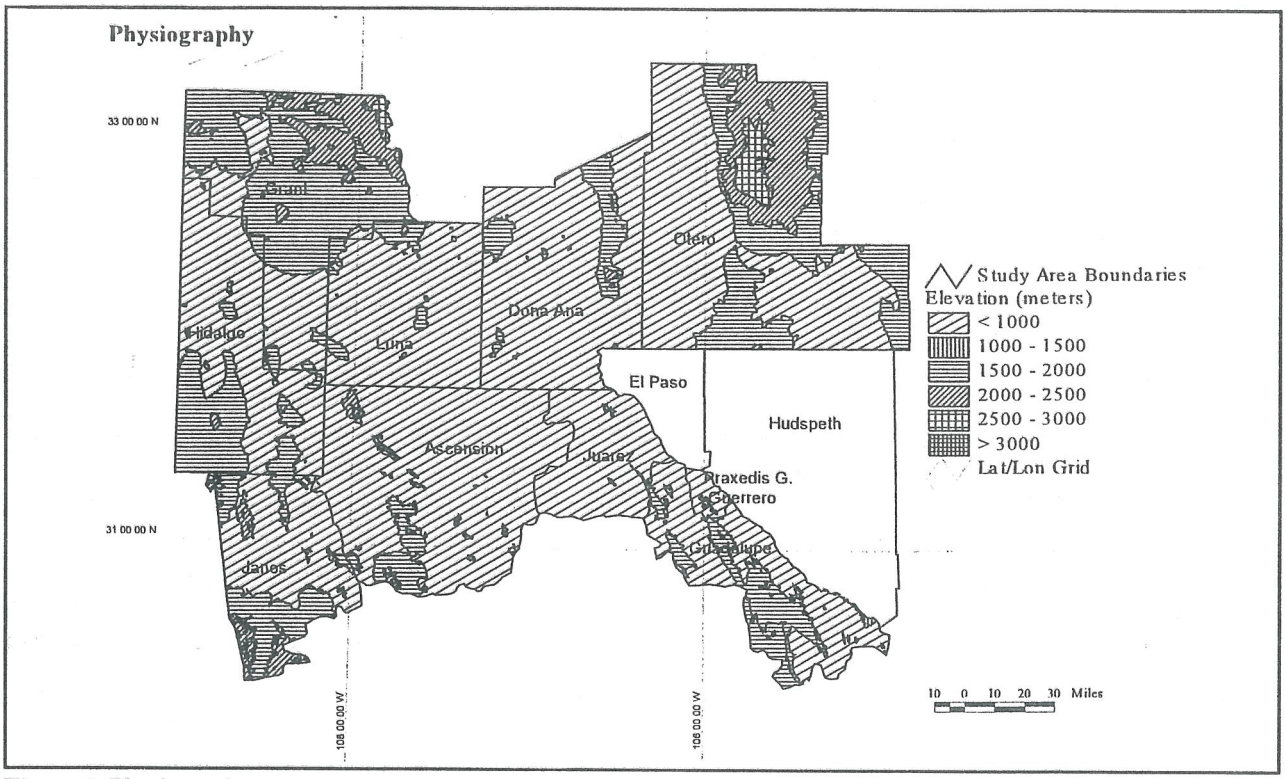

Figure 2. Physiography.

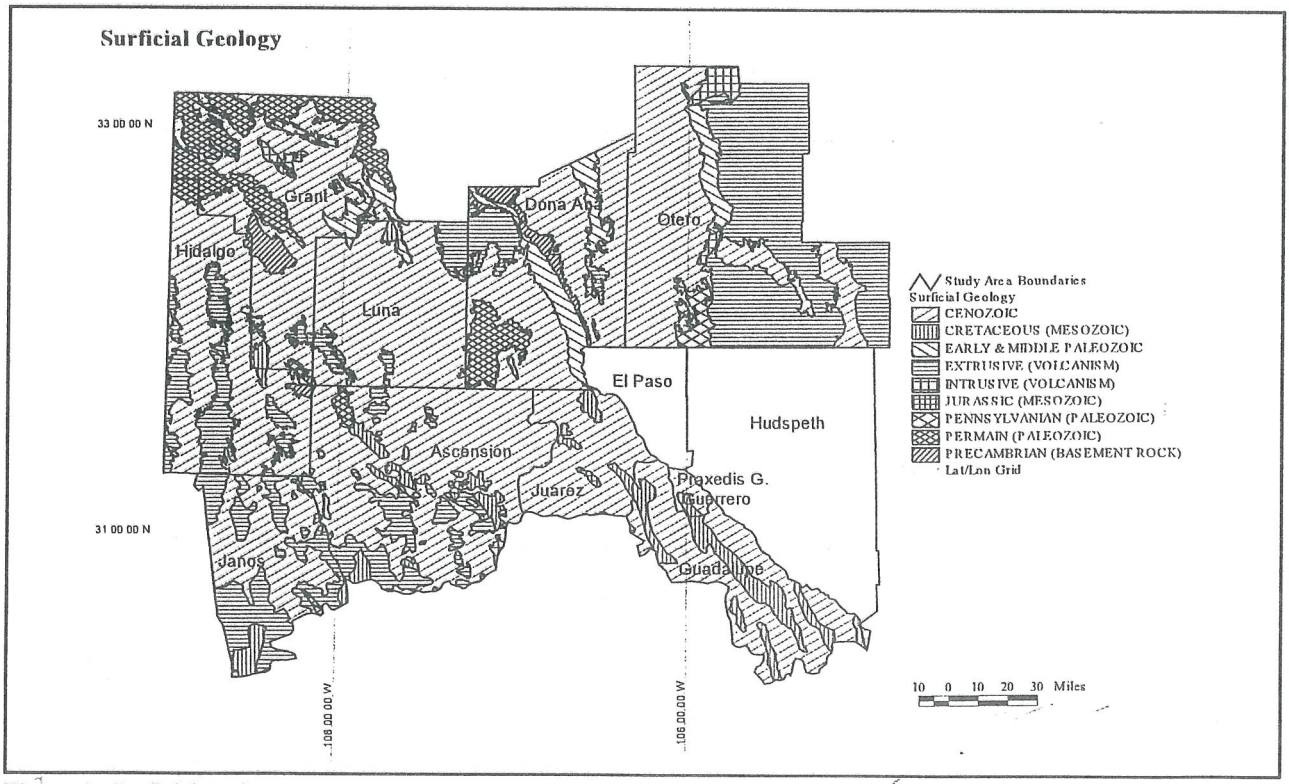

Figure 3. Surficial geology.

strates the widespread influence of the Cenozoic. It also shows the number and variety of contributing geologic periods to the region's surficial geologic structure.

Population counts for New Mexico and Chihuahua were mapped for the years 1980 and 1990 at the county level. Population mapping is one of the most straightforward ways to demonstrate the differences and similarities of border states.

The 1990 map shows the higher density clusters in New Mexico and Chihuahua (Figure 4). The two clusters in New Mexico cover four counties in the southeast and six counties in the northwest, while the higher population municipios in Chihuahua are isolated from one another. Even Ciudad Chihuahua and Ciudad Juárez stand alone as higher density locations. El Paso, Doña Ana and Otero counties and municipio of Juárez are joined together in the largest urban cluster in the region representing more than two million people.

A second type of population data was also mapped. Using the GIS population data base, the 1980 population numbers were subtracted from the 1990 numbers to obtain a map of percent population increase or decline (Figure 5). Mapping of this type gives a dynamic element to the atlas, that is, demonstrating patterns of change.

The population change map clearly shows the highest category of percent increase occurring in the Rio Grande corridor. The pattern extends from the northern border of New Mexico through El Paso and into four of the northerly border municipios in Chihuahua. A corridor of positive population increase is over 325 miles long. The locations of most significant negative growth are scattered throughout New Mexico and Chihuahua. Nine counties in New Mexico and forty municipios in Chihuahua registered negative growth. The wide extent of depopulation in Chihuahua may be evidence of migration to the urban centers of Ciudad Chihuahua, Ciudad Juárez, Delicias, Jimenez, and Creel, which all experienced high growth levels.

With the completion of the initial version of the atlas, the concept of a map set using data from both sides of the border had been proven. Next, it was necessary to improve the atlas by increasing the geographic coverage, adding data layers, and improving the quality of the maps and text.

Second Iteration of the Atlas

With funding from the SCERP program in 1996, a second edition of the border atlas is under development. The geographic coverage of the new version of the atlas again includes both New Mexico and Chihuahua. It adds El Paso and Hudspeth counties in Texas as elements in the socioeconomic and environmental sections (as some of the maps in this article demonstrate).

With El Paso being the major United States urban center in the region, its addition greatly enhances the usability of the atlas (Figure 4). Additional data are added to all sections of the atlas including satellite imagery, more detailed hydrology, groundwater basins and increased detail on the vegetation map. In the socioeconomic section, a more detailed road map of the border region is under development as well as more economic data. The new version of the atlas also includes longer textual descriptions of each map.

GIS and the "Electronic Atlas"

All information presented in the second iteration of the border atlas will be available on a GIS system —ARCVIEW2 (a registered product name of ESRI). While the printed atlas presents static maps, the GIS allows the user to zoom in on specific places along the border study area or zoom out to view the study area as a unified whole. In addition, if someone wants to know an actual value from a mapped unit, for example a county population count, it will be accessible through the GIS data base. One of the unique advantages of a GIS is that data can be viewed in mapped or data base form.

The Ultimate Goal

Through a series of unique efforts on the part of border universities and state governments, there will exist a geographic information system, available in English and Spanish, representing the entire border region between the United States and Mexico.* Perhaps for the first-time, decision makers, planners, engineers, academics and concerned citizens will be able to view the region as a unit divided by a thin geographic boundary.

The geographic information system will provide numeric, textual and geographic information. The maps and data will be printed in a hard copy or transferred electronically to a wide range of users. Most

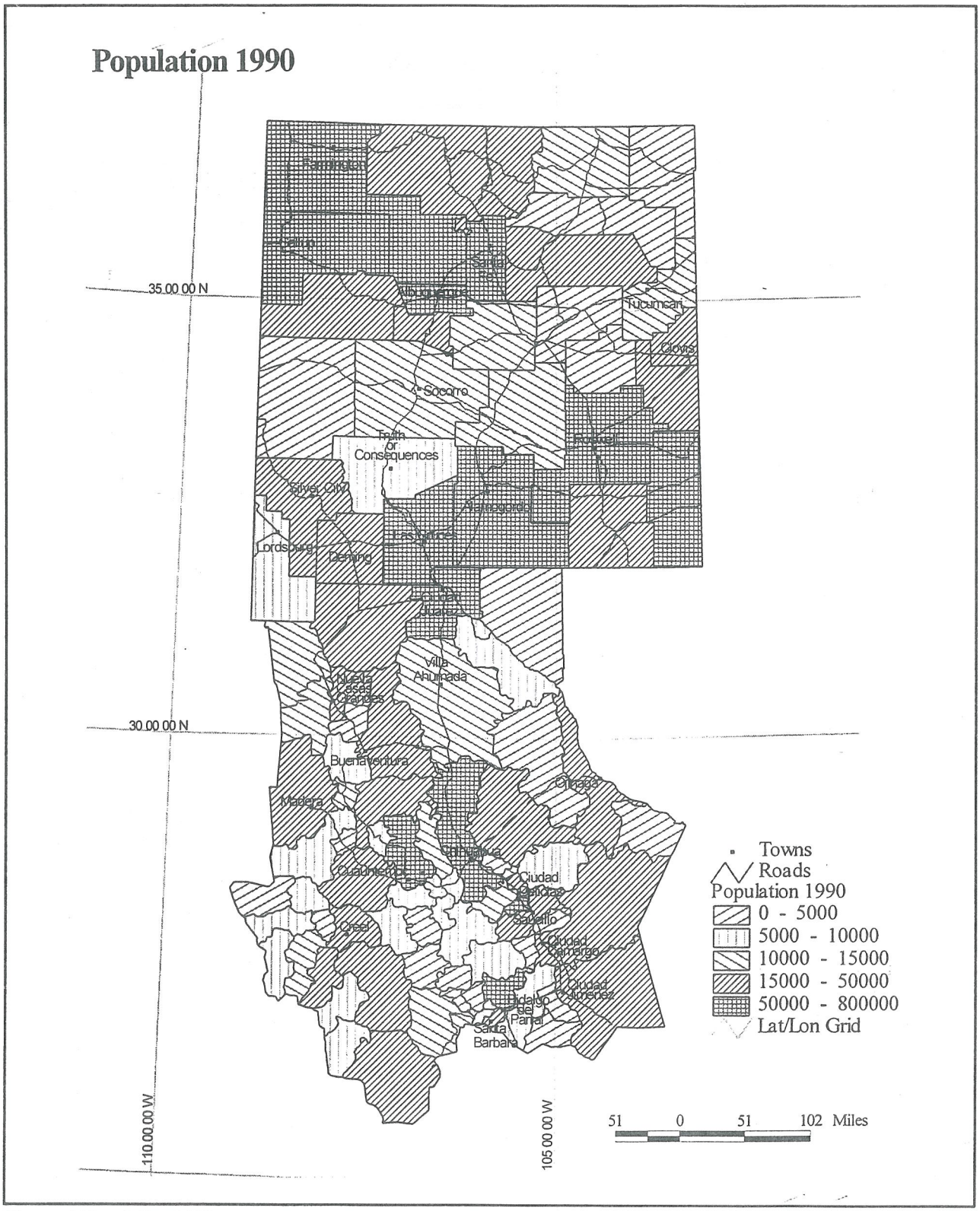

Figure 4. Population 1990.

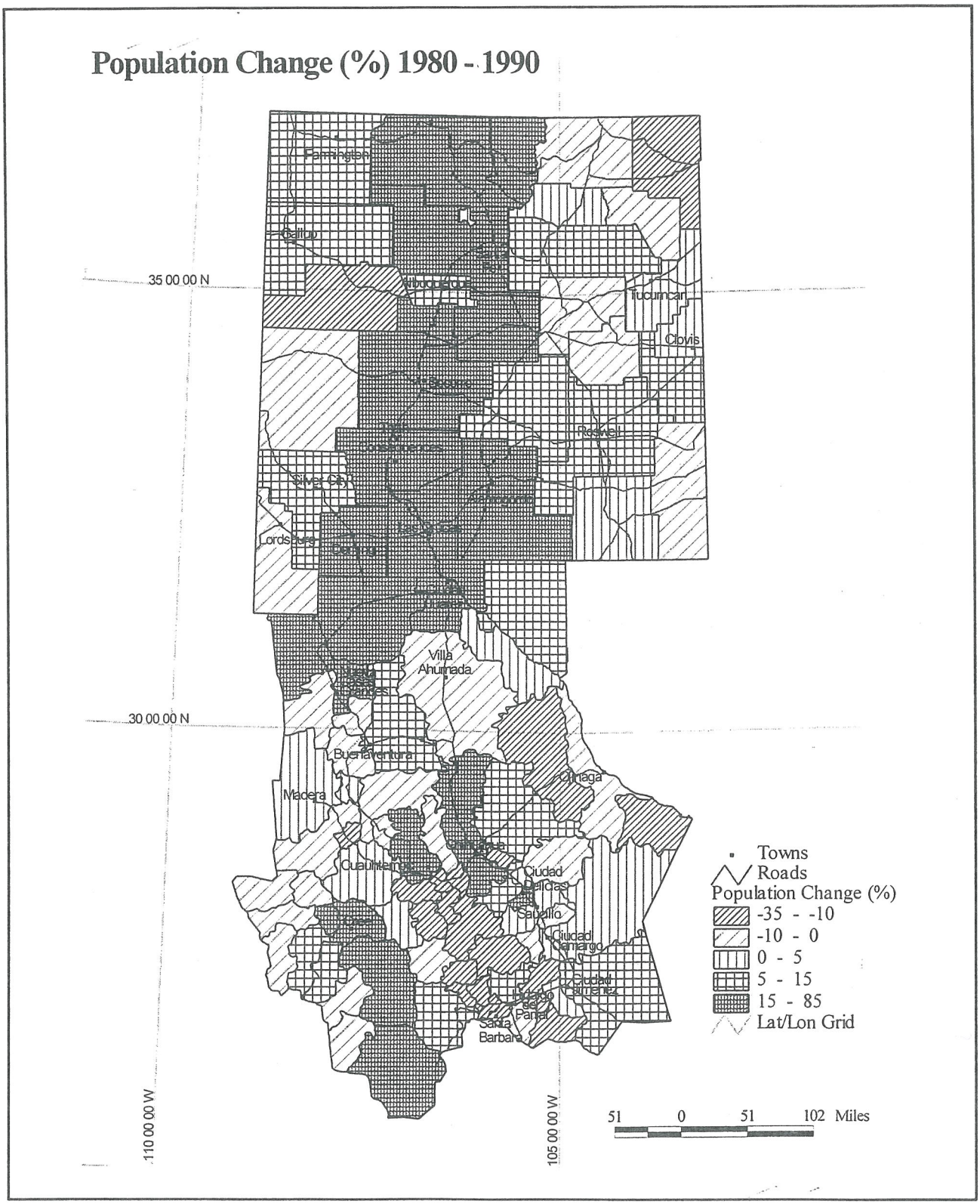

Figure 5. Population change (percent) 1980-1990.

likely the maps and data within a border GIS will be distributed to a variety of locations, contributing to the maintenance and improvement of the system. New Mexico State University has taken the first steps in the actual development of such a system.

* An example of the type of group it will take to coordinate and develop such a GIS is the Transboundary Resource Inventory Project (TRIP). This four-state effort is being led by the Texas General Land Office with support from the United States and Mexican governments and universities along the border.

Acknowledgments

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