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The environmental information system of the USA-Mexico border*

* **Prepared by Jean Parcher, United States Geological Survey (USGS)**

U.S.-Mexico Border Geographic Information System

By Jean Parcher

U.S. Geological Survey

8027 Exchange Dr.

Austin, Tx. 78750

jwparcher@usgs.gov

Summary

Geographic Information Systems (GIS) and the development of extensive geodatabases have become invaluable tools for addressing a variety of contemporary societal issues and for making predictions about the future. The United States-Mexico Border Geographic Information System (USMX-GIS) is based on fundamental datasets that are produced and/or approved by the national geography agency of each country, the U.S. Geological Survey (USGS) and the Instituto Nacional de Estadística y Geografía (INEGI) of Mexico, and the International Boundary and Water Commission (IBWC). The data are available at various scales to allow both regional and local analysis. The USGS and the INEGI have an extensive history of collaboration for transboundary mapping including exchanging digital technology and developing methods for harmonizing seamless national level geospatial datasets for binational environmental monitoring, urban growth analysis, and other scientific applications.

Background

Societal, economic, and environmental issues cross the U.S.-Mexico international border and affect the landscape and quality of life in both countries. Many species are at their northernmost extents, thus changes in climate, water availability, and fragmentation of their habitat greatly affect their ability to survive. Other environmental stressors, such as population growth, industry, agriculture, and mining, are contributing to a rapid rate of species loss through dewatering, habitat destruction, ecosystem fragmentation, and pollution. The growth of several transfrontier metropolitan regions along the 3,000-kilometer border (fig. 1) presents many environmental management and urban planning challenges. Dramatic urban growth, rapid industrialization, and inadequate infrastructure in border cities increase environmental problems and risks associated with human health.

The rapid economic and demographic growth in the border region is attributed to increased manufacturing and binational trade between the two countries. The U.S.-Mexico border has 43 Ports of Entry that facilitate more than 300 million legal crossings a year and almost $650 million a day in binational commerce, including critical energy supplies. In 2007 Mexico was the second largest trading partner of the United States after Canada. Trade between the United States and Mexico has soared over the past 14 years since the signing of the North American Free Trade Agreement (NAFTA) in 1994.

Assessing risks and implementing sustainable growth policies to protect the environment and quality of life greatly increase in complexity along international borders, where social services, environmental regulations, lifestyles, and cultural beliefs are unique for each country. Shared airsheds, water resources, and transportation networks require an integrated binational approach to assess risks and develop binational management strategies. Sustainable planning and

monitoring of the environmental response to anthropogenic changes to the landscape require complex base datasets.

U.S. and Mexican Geographic Information Systems

In both countries, GIS databases are readily available and applied at many levels of government within each country. For studies that cross international borders, the differences in the availability, integrity, spatial and temporal scales, and database standards for both environmental and base data layers complicate the ability to apply geospatial analysis tools. There- fore, the USGS U.S.-Mexico Border Environmental Health Initiative (BEHI) recognized the need for development of transboundary datasets, standards, and Web mapping services under the guidance of multidisciplinary researchers, using documented methodology, for various themes along the U.S.-Mexico border.

The signing of the USGS and INEGI Project Annex Six, which provides the legal framework for public access to the best available harmonized binational geospatial datasets along the U.S.-Mexico border, allowed full public access to the numerous transboundary GIS datasets developed by the BEHI. The USMX-GIS extends the GIS development to include national level cooperation between various agencies in both countries to provide harmonized geospatial and thematic datasets for viewing in an Internet Map Service at

http://borderhealth.cr.usgs.gov/IMS.html

and for public download from a file transfer protocol (FTP) Web site (fig. 2) at

http://borderhealth.cr.usgs.gov/datalayers.html

Data standards include nonpriority open source format, such as shapefiles for vector data, or geotiffs or band interleaf by line for raster data, along with private formats such as Environmental Systems Research Institute Geodatabase and Keyhole Markup Language (fig. 3).

These consistent databases provide a temporal baseline to analyze changes and predict scenarios for the future and to provide needed information to facilitate joint planning activities, sustainable development practices, and conservation of natural resources. Other specific scientific datasets such as water quality, geology, contaminants, and census data are being provided from other environmental or natural resource agencies in each country.

USGS and INEGI Collaborative Activities

Source cartographic information for both countries are based on the topographic maps produced by the USGS and INEGI for their respective countries using similar data layers. Harmonizing the data in digital files requires additional manipulations; for example, the creation of a single, digital, unofficial international boundary required clipping of polygon data such as local governmental-unit boundaries, watersheds, census units, and land use and land cover (LULC) data. The production of a binational geographic names dataset included integration of INEGI's topónimos and USGS Geographic Names Information System (GNIS) data layers into specific classification categories. Display of major population centers is based on population size and density of features. Development of a binational LULC dataset required generalization of data classifications. Harmonizing geologic map datasets required interpretation of aerial photos

and satellite imagery to increase detail along the border. Specific scientific datasets such as water quality require an analysis of laboratory procedures.

Specific Examples

LULC data can be used to analyze landscape change, to provide data for hydrologic modeling applications, to statistically analyze landscape fragmentation, and to prepare a base layer for regional maps. The Mexican INEGI Uso de Suelo dataset and the U.S. National Land Cover Dataset were chosen to build the binational LULC datasets because they represent a consistent nationwide classification system for their respective countries. Though each country's classification system is consistent within the country's own borders, the classes defined by the respective classification systems do not represent a one-to-one relation across the border. Integration of the U.S. and Mexican data required the creation of a generalized (modified Anderson Level I) binational classification system to which both countries' LULC data could be reclassified to build temporal datasets for the 1990 and the 2000 decades.

Water availability and water quality are critical issues for the U.S.-Mexico border region. To facilitate hydrologic analysis applications, the USGS and INEGI are collaborating together to harmonize watershed boundaries and build a connected hydrographic network of surface-water features for the border region (fig. 4). Because digital elevation models are a critical data source to delineate watershed boundaries, the USGS is applying specific algorithms to the raster elevation datasets along the border to build a seamless 30-meter resolution digital elevation dataset. Binational watershed boundaries are being harmonized at the U.S. sub-watershed levels to accommodate the development of a networked hydrology layer at the 1:24,000-scale for the

United States and at the 1:50,000-scale for Mexico. To assess water-quality trends, the USGS in collaboration with the IBWC and the Mexican Commission of Water (Comisión Nacional de Agua) are building a digital warehouse database of water-quality data for the region.

Conclusions

Providing public access to these high quality, accurate, and consistent U.S.-Mexico border transboundary geographic information datasets serves several important purposes. Public access increases the value of the data as researchers will have a consistent geographic information database to compare model and analysis results. When the data are harmonized between the two countries, the metadata or corresponding documentation describe the harmonization and sources of the data.

Currently in 2008 the project boundaries of the USMXGIS are the major binational watersheds spanning the international border. Depending on partners, funding, and needs, the project boundaries could be expanded on either side of the border to include the 100 kilometers on either side of the international border per mutual agreement of both parties.

For more information please contact:

Jean Parcher, USGS, *jwparcher@usgs.gov*

Antonio Hernandez, INEGI, *Antonio.hernandez@inegi.org.mx*

For data access and availability:

http://borderhealth.cr.usgs.gov/datalayers.html

For information on other USGS products and services visit the USGS home page at

www.usgs.gov

For information on INEGI products and services visit the INEGI home page at

www.inegi.org.mx

Figure 1. The major watersheds along the U.S.–Mexico border compose the current project area for the U.S.–Mexico Border Geographic Information System.

Figura 1. Las principales cuencas hidrográficas a los largo de la frontera entre Estados Unidos y México constituyen el área actual del proyecto Sistemas de Información Geográfica de la frontera entre Estados Unidos y México.

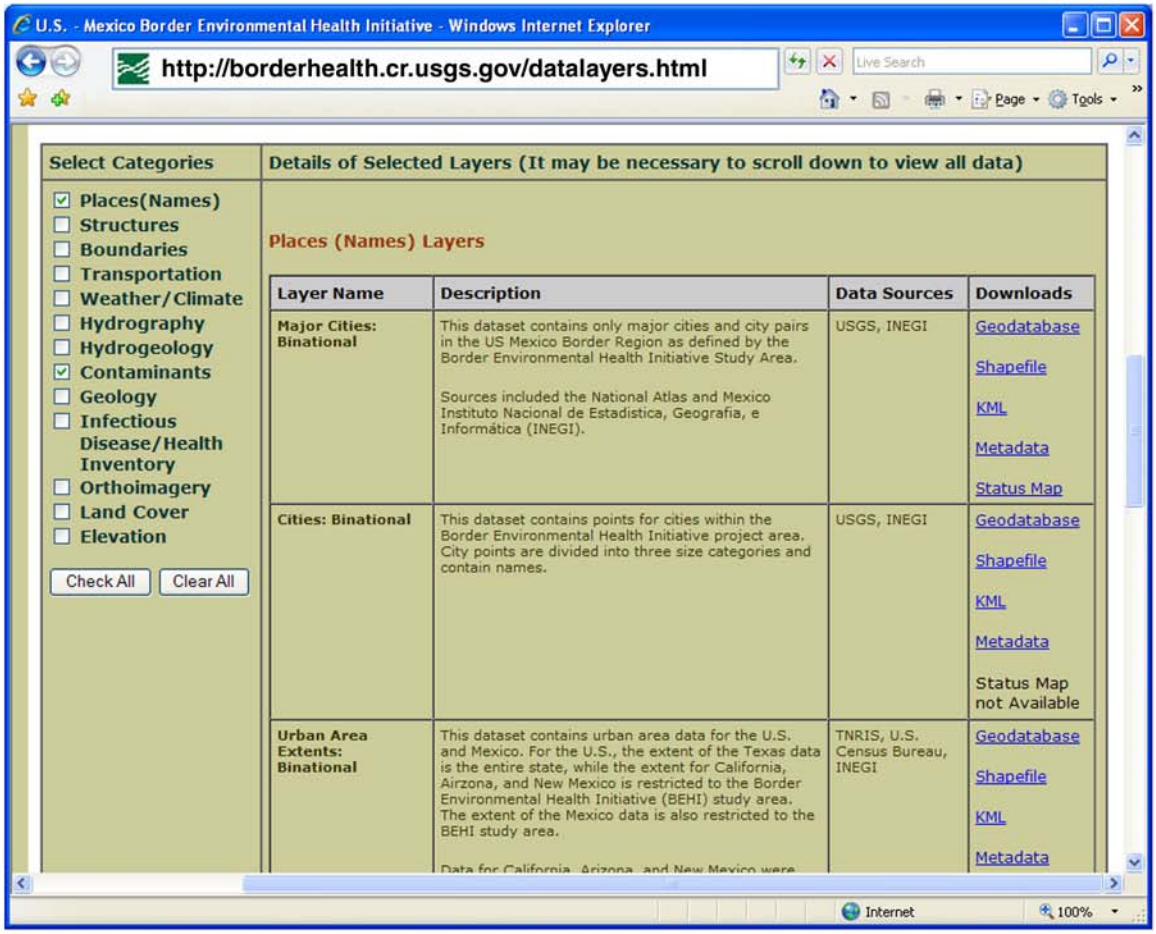

Figure 2. U.S.–Mexico Border Environmental Health Initiative data download Web page at *http://borderhealth.cr.usgs.gov/datalayers.html*

Figura 2. Página de descarga de datos del proyecto La Iniciativa de Salud Ambiental en la Frontera entre México y Estados Unidos. *http://borderhealth.cr.usgs.gov/datalayers.html*

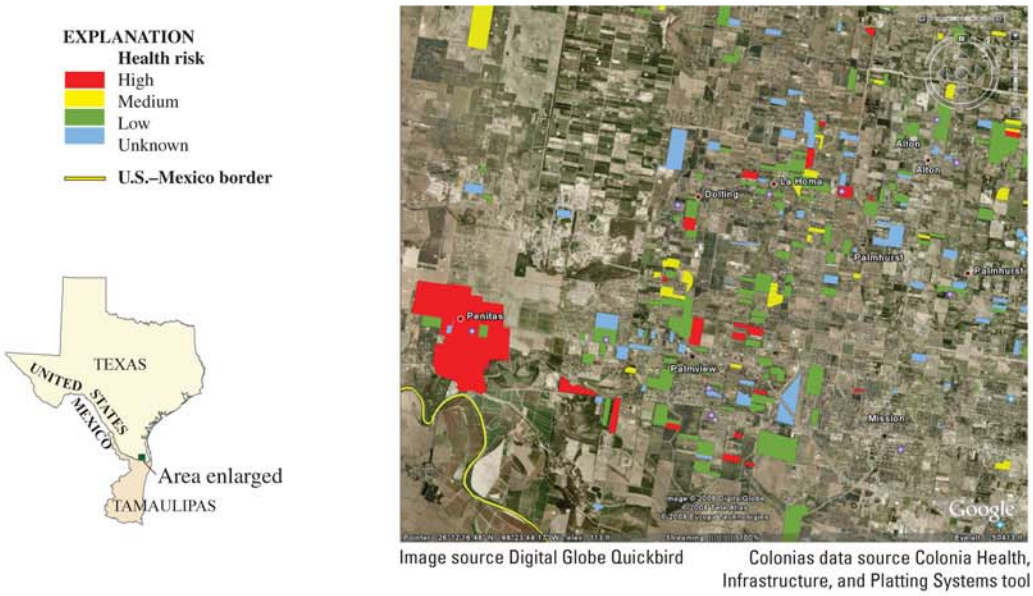

Figure 3. Texas colonias datasets viewed in Google Earth by downloading the data in Keyhole Markup Language from the United States–Mexico Border Geographic Information System.

Figura 3. Conjuntos de datos de las colonias de Texas vistos en Google Earth. Los datos han sido descargados en KML del Sistema de Información Geográfica de la frontera entre Estados Unidos y México.

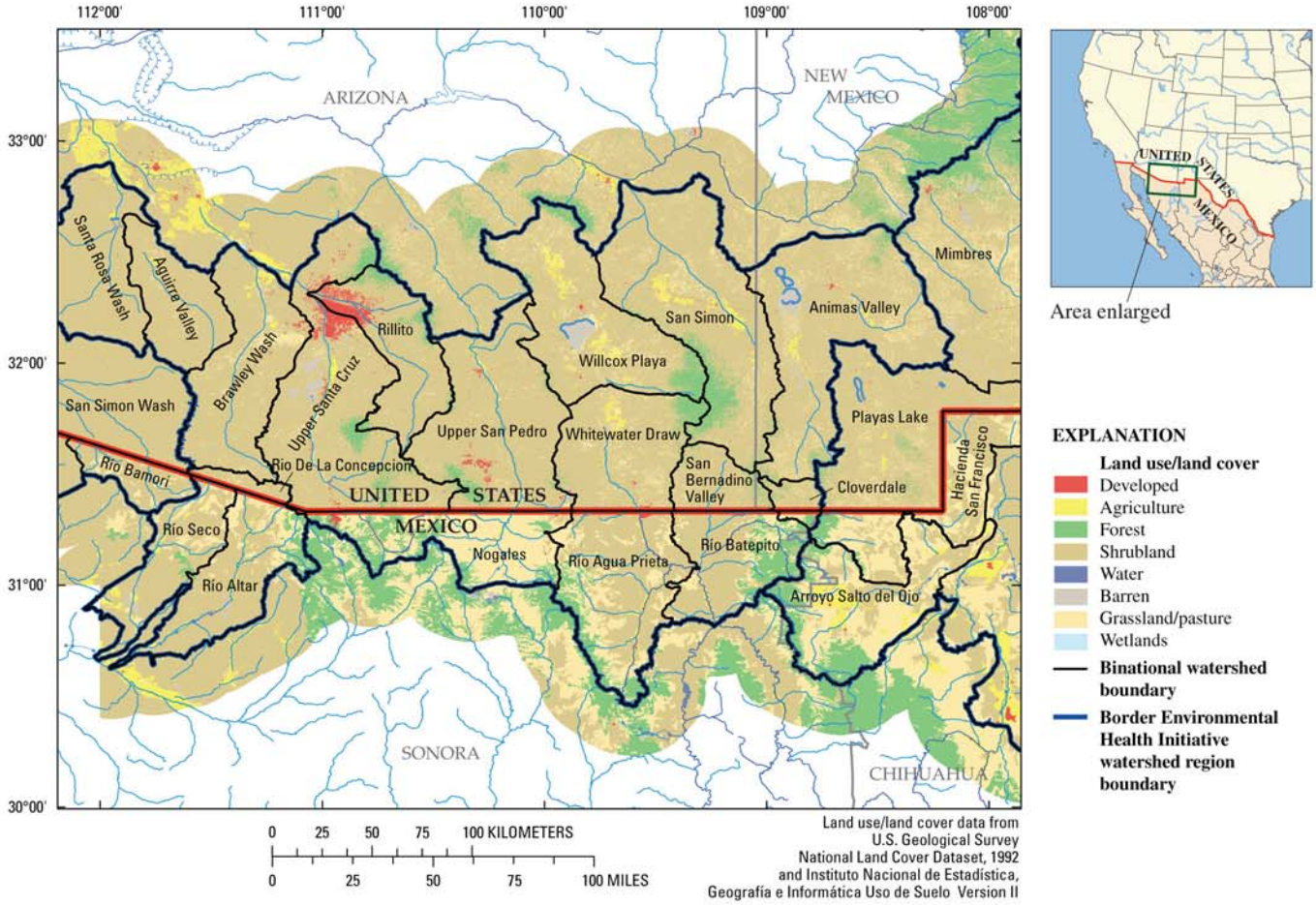

Figure 4. Pilot area to develop binational watershed boundaries and networked hydrography for the border region. The geographic area is along the Arizona and Sonora state borders, using the binational land use and land cover dataset as the background information.

Figura 4. Area piloto para el desarrollo de cuencas hidrográficas binacionales y redes hidrográficas de la región fronteriza. El área geográfica mostrada estáa lo largo de los estados fronterizos de Arizona y Sonora. Los conjuntos de datos binacionales de cobertura y uso de la tierra se usan como información de fondo.