Proceedings of a USGS Workshop on Facing Tomorrow's Challenges Along the U.S.-Mexico Border—Monitoring, Modeling, and Forecasting Change Within the Arizona-Sonora Transboundary Watersheds

Circular 1322

U.S. Department of the Interior
U.S. Geological Survey

This page intentionally left blank

Proceedings of a USGS Workshop on Facing Tomorrow's Challenges Along the U.S.-Mexico Border—Monitoring, Modeling, and Forecasting Change Within the Arizona-Sonora Transboundary Watersheds

Edited by Laura M. Norman, Derrick D. Hirsch, and A. Wesley Ward

Circular 1322

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia, 2008

This report and any updates to it are available online at:
http://pubs.usgs.gov/circ/1322/

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod/
Telephone: 1–888–ASK–USGS

For more information on the USGS—the Federal source for science about the Earth,
its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1–888–ASK–USGS

Suggested citation: Norman, L.M., Hirsch, D.D., Ward, A.W., eds., 2008, Proceedings of a USGS Workshop on Facing Tomorrow's Challenges along the U.S.-Mexico Border—Monitoring, Modeling, and Forecasting Change Within the Arizona-Sonora Transboundary Watersheds U.S. Geological Survey Circular 1322, 63 p.

Cataloging-in-Publication data are on file with the Library of Congress

Produced in the Western Region, Menlo Park, California
Manuscript approved for publication, January 23, 2008
Text edited by Tracey L. Suzuki
Layout and design by Stephen L. Scott

FRONT COVER
Images of the U.S.-Mexico border. **Central photo:** Stretch of the Rio Grande drying up in February 2003 in the Big Bend National Park, Texas (USGS photo by John Klein). **Insert photos (clockwise from upper right):** (1) Rangelands looking south into Mexico from the eastern edge of the San Rafael Valley, south of the Huachuca Mountains, Arizona (USGS photo by Bruce Gungle); (2) border fencing at California coast (photo by Chris Lukinbeal, Arizona State University); (3) vehicle barrier, Coronado National Memorial at the International Boundary with Mexico ((USGS photo by Bruce Gungle); (4) artwork on the border wall at Nogales, Sonora, Mexico (photo by Gigi Owen, University of Arizona); (5) view from Castlerock of street and houses in colonia of historic Bisbee, Arizona (USGS photo by Laura Norman). **Banner photo:** Panoramic view of the twin cities of Nogales, Arizona, and Nogales, Sonora, Mexico (photo by Chris Lukinbeal, Arizona State University).

Contents

Introduction to the Workshop Proceedings

By Laura M. Norman[1], Derrick D. Hirsch[2], and A. Wesley Ward[3]

Borderland Setting

The international border between the United States and Mexico runs from the California/Baja California Norte to Texas/Tamaulipas (fig. 1). The length of the border from west to east is almost 2,000 miles. The areas north and south of the border are usually referred to as the "Borderlands"; however, there is no consensus as to the exact area encompassed by the Borderlands. The U.S. Environmental Protection Agency (2006) defines the Borderlands as a zone 100-kilometers wide (approximately 62-miles), the U.S. Department of Housing and Urban Development (2007) defines the Borderlands as a zone 150-miles wide, and Woodward and Durall (1996) describe the Borderlands in terms of watershed boundaries.

The border in the Eastern part, from El Paso, Tex., to the Gulf of Mexico, follows the Rio Grande. The border in the Western part, from the Pacific coast to El Paso, is composed of straight, surveyed line segments that randomly cross watershed boundaries. In the Western region of the Borderlands, water flows north and (or) south across the international border with Mexico into the interior of each country. Therefore, mutual dependencies exist in terms of potential vulnerability, and impacts on natural resources exist on both sides of the border.

Natural Setting

The Borderlands terrain comprises steeply rising mountain ranges separated by broad, wide valleys and desert basins, such as the northern Chihuahuan Desert, the Sonoran Desert, and parts of the Mojave Desert. Deeply cut arroyos (dry rivers), canyons, mesas, and broad alluvial fans are prominent features. Copper, silver, gold, and other metals occur in the region.

The border climate varies from Mediterranean in the coastal areas to hot and arid or semiarid in the inland areas. In the Sonoran Desert of Arizona, climate is characterized by hot summers and cool, mild winters. Droughts are common.

Hydrologically, surface-water features in the Borderlands include springs, ephemeral and intermittent streams, and water pockets. Transborder rivers commonly flow through deep, steep-walled canyons, forming riparian environments that provide a stark comparison to the adjacent desert landscape. Natural hazards, such as flooding, are prominent in the Borderlands. Short, intense, convective thunderstorms are common during the summer monsoon season.

The varieties of precipitation, landscape, and soil types in the Borderlands have led to the development of habitats that support thousands of species of plants and animals with high biodiversity. Vegetation is taller and lusher in riparian areas than in the dryer uplands, and these riparian areas provide important nesting and feeding habitat, as well as corridors for animal movement.

Workshop

Competition for water resources, habitats, and urban areas in the Borderlands has become an international concern. In the United States, Department of Interior Bureaus, Native American Tribes, and other State and Federal partners rely on the U.S. Geological Survey (USGS) to provide unbiased science and leadership in the Borderlands region. Consequently, the USGS hosted a workshop, "Facing Tomorrow's Challenges along the U.S.-Mexico Border," on March 20-22, 2007, in Tucson, Ariz., focused specifically on monitoring, modeling, and forecasting change within the Arizona-Sonora Transboundary Watersheds.

Goals of Workshop

The two-day scientific workshop drew State, university, and Federal scientists together to discuss current and potential interdisciplinary research that would address the complex human and environmental issues that manifest themselves in the Borderlands. The goal of the workshop was to provide a venue to pursue research initiatives and to document science issues and priorities. The workshop was intended to compliment and build on an internal USGS border-strategy meeting held in El Paso, Tex., in spring 2006, at which a small group of scientists from the USGS met to synthesize a collective-science strategy for the USGS to guide U.S.-Mexico border research.

[1]U.S. Geological Survey, 520 N. Park Ave., Suite 355, Tucson, AZ 85719.
[2]U.S. Geological Survey, 2255 N. Gemini Drive, Flagstaff, AZ 86001.
[3]U.S. Geological Survey, 520 N. Park Ave., Suite 106A, Tucson, AZ 85719.

Workshop Themes

The 2007 workshop program was formatted based on USGS research conducted in four topical areas, categorized and presented under the following themes:

- Surficial and Bedrock Materials, MineralResources, and Natural Hazards,
- Populations, Urban Growth, Infrastructure Health, and Land-Use Change,
- Role of Environmental Indicators in Determining Impacts, Ecosystem Preservation, and Climate Change, and
- Quality and Quantity of Water Resources.

Part of the workshop was designed to identify new multi disciplinary scientific-research needs and to develop USGS research priorities in keeping with the Bureau Science Strategy themes of Water Availability, Climate Change, Human Health, Natural Hazards, Energy and Minerals, and Ecosystems. A field trip to Nogales, Ariz., on the day after the workshop introduced participants to some of the environmental issues faced by residents along the border (fig. 2).

Workshop Findings

Environmental and health problems along the U.S.-Mexico border are plentiful, yet identifiable and manageable. Issues of unmanaged urban growth, exponentially growing populations, and rapidly diminishing resources were at the forefront of the workshop. Some of the specific human and environmental issues along the U.S.-Mexico border that were identified as research priorities include:

1. Air Pollution—Among the problems requiring attention is levels of particulate matter that exceed U.S. Federal air-quality standards. Sources of particulate matter include unpaved roads and parking lots, vehicle emissions, burning garbage and wood, and deforested hillsides, all of which contribute to poor air quality and related health effects. Airborne-sediment transport is affected by vehicular traffic, foot traffic, and wind transport; it is in these areas that the highest concentrations of atmospheric particulate matter (dust) are observed (see abstracts by Berry; Chavez and others; Gray and others; Norman and others).

2. Colonias—Urbanization has consequences on infrastructure, erosion, flooding, the airshed, the watershed, and human health. Unplanned colonias and squatter settlements have poor housing conditions and nonexistent or below-adequate levels of services, water supply, sanitation, electricity, roads, and drainage (Norman and others, 2004). Mapping conditions along the border can help local residents to attract earmarked funding to these areas (see abstract by Humberson and Parcher).

3. Endangered Species Habitat—Many species (some endangered) cross the international border frequently as they range within their borderland habitats, for example, the cactus pygmy owl and Sonoran pronghorn in Arizona; flat-

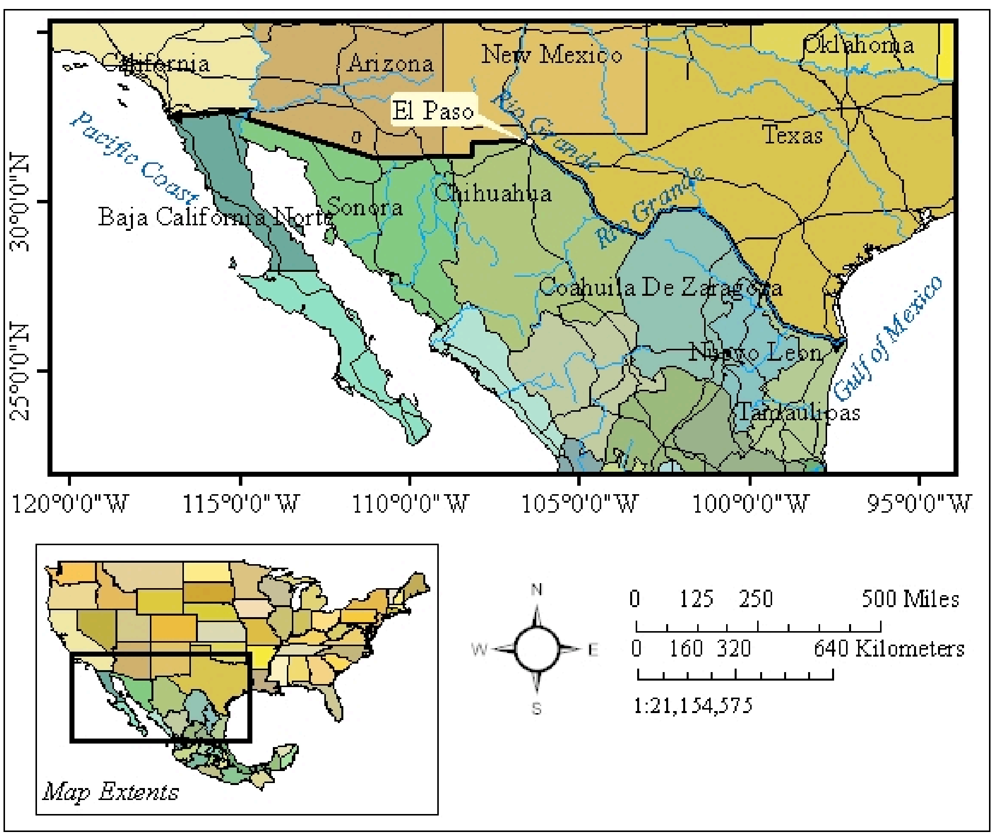

Figure 1. Location map of the U.S.-Mexico Border.

tailed horned lizard and Peninsular Ranges bighorn sheep in California; jaguar and Mexican gray wolves in New Mexico; and ocelot in Texas. Artificial barriers can harm wildlife by blocking critical migration corridors and destroying valuable habitat. Mapping of land use, vegetation, riparian areas, and habitats for monitoring purposes is invaluable to the U.S.-Mexico border (see abstracts by Case and Barnum; Chavez and others; Kepner and others; Lowry and others; Malmon and others; Page and others; Ruhlman and others; Wilson and Parcher; van Riper).

4. Erosion—Arid lands are known for supporting specially adapted vegetation and animal populations. When disturbed, the land and life that it supports takes a long time to return to a fully-natural state. Disturbed land is vulnerable to erosion and landslides. Urbanization, especially, has led to devegetation and erosion of the land. Bare hillslopes have higher rates of surface runoff and lower rates of water infiltration into the soil than hillslopes covered with natural grasses (see abstracts by Berry; Gray and others; Huth and Tinney; Norman and others).

5. Flooding and Natural Disasters—Seasonal monsoon flooding affects low-lying areas throughout the Borderlands. For example, in Ambos Nogales, where many major streets follow the course of natural waterways, landslides caused by rushing waters damage homes and streets. In some cases, these catastrophic floods have destroyed people's livelihoods and homes and have taken lives (see abstracts by Berry; Gray and others; Huth and Tinney; Malmon and others; Norman and others).

6. High Population Growth—Southern Arizona and northern Mexico have high human-population growth rates. There is a need to better understand the short-term and long-term impacts this rapid population growth has on changes in water demand and on patterns of water use in the basins. An ecological strain is created largely by the rapidity of economic and population growth coupled with gaps in the supply and (or) the ability of available economic, technical, and human resources to monitor and protect the environment. Accurate monitoring of resources available to incoming populations in the sensitive Borderlands area is in high demand (see abstracts by Allison and Gunderson; Humberson and Parcher; Kepner and others; Norman and others; Stefanov and others).

7. Human Health—Human health problems in the Borderlands relate in part to air pollution, inadequate water and sewage treatment, or improper management of pesticides, and hazardous wastes. Elderly and children are especially at risk. Waterborne and respiratory diseases are a particular concern to local residents (see abstracts by Chavez and others; Page and others; Stefanov and others).

8. Water Quality—Water-quality data for the Borderlands area are limited, especially where rivers cross the international boundary and along stretches of rivers downstream of the effluent discharge from wastewater-treatment plants. In both in the U.S. and Mexico, potential chemical contaminants from industrial sources and biological contaminants from sewage and wastewater discharges are inadequately monitored. The poor quality of available water supplies increases vulnerability to drought, especially for domestic users (see abstracts by Berry and others; Callegary and others; Gray and others; Guertin and others; Huth and Tinney; Kepner and others; Megdal; Norman and others; Page and others).

9. Water Quantity—A better understanding of the water budget is needed for borderland watersheds, including quantification of water derived from potential snowpack, surface and ground-water flows, evapotranspiration rates, and water lost to pumping. In addition, if mines are reopened due to world market

Figure 2. Photograph taken from Nogales, Ariz., showing the International border fencing (diagonal from northwest to southeast) and adjacent housing, built on a hillslope, in Nogales, Sonora, Mexico (photo by Leslie Gordon).

demands, there could be an additional strain on water supplies that currently are allocated for other uses or are critical to habitat (see abstracts by Callegary and others; Gray and others; Guertin and others; Leenhouts and Gungle; Malmon and others; Megdal).

As a result of the workshop, several new research projects are being developed to address priority issues in the transborder watersheds of the lower Colorado River, the Upper Santa Cruz River, the San Pedro River and Douglas Basin, the lower Rio Grande, the area surrounding El Paso/Juarez, and in Big Bend National Park. The research projects build on the wide array of ongoing USGS activities described in the abstracts in this report. The abstracts are not inclusive of every USGS borderland study, but they are representative of the projects the USGS is conducting in the region.

Acknowledgments

This workshop and publication would not have been possible without the support of Anne E. Kinsinger, USGS Western Regional Director. Extra effort and initiative contributed by the workshop's steering committee, which included not only the editors of this publication, but also dedicated representatives from each of the disciplines at the USGS, including Edwin Pfeifer, Floyd Gray, Charles van Riper, Nick Melcher, and Bruce Gungle, made this workshop a success. Additionally, Jean Parcher's contributions to the organization of the workshop were instrumental in the flow of our sessions.

References Cited

Norman, L.M., Parcher, J.W., and Lam, A.H., 2004, Monitoring colonias along the U.S.-Mexico border: U.S. Geological Survey Fact Sheet, FS 2004-3070, [http://erg.usgs.gov/isb/pubs/factsheets/fs307004.html, last accessed October 17, 2007].

U.S. Department of Housing and Urban Development, 2007, Community development block grant—Colonias, [http://www.hud.gov/offices/cpd/communitydevelopment/programs/colonias/cdbgcolonias.cfm, last accessed October 17, 2007].

U.S. Environmental Protection Agency, 2006, U.S.-Mexico border 2012 framework, [http://www.epa.gov/usmexicoborder/intro.htm, last accessed October 17, 2007].

Woodward , D.G., and Durall, R.A., 1996, United States-Mexico border area, as delineated by a shared-water resources perspective: Department of the Interior Fact Sheet 1, 4 p.

The U.S.-Mexico Field Coordinating Committee—Who We Are and What We Do

By Diana M. Papoulias[1]

The U.S.-Mexico Field Coordinating Committee (FCC) was chartered in 1994. It consists of seven bureaus within the Department of the Interior (DOI)—the Bureau of Indian Affairs, the Bureau of Land Management, Bureau of Reclamation, Minerals Management Service, National Park Service, U.S. Fish and Wildlife Service, and the U.S. Geological Survey. Each bureau has a representative who serves on the FCC leadership team along with the FCC Chair and Vice-Chair. The regional environmental officers of the Office of the Secretary of the Interior and an international-affairs representative from the Secretary's Office in Washington, D.C., are ex officio members. FCC membership is comprised of DOI employees with an interest in, or responsibility for, resource management or resource activities along the U.S.-Mexico border. Participation by bureau personnel is in addition to the other duties of their positions. Expenses are borne by the participating bureaus.

The FCC accomplishes its work on the U.S.-Mexico border through biannual meetings, information sharing, and work groups established to address specific subjects. The FCC also facilitates contacts among those who have an interest in natural- and cultural-resource issues along the border. Important border relationships include those with Federal, Tribal, State, and local governments on both sides of the border concerning programs, projects, and activities affecting the border area. By assisting the member bureaus in building partnerships and enlisting volunteers, the FCC advances its objectives of improved communication, coordinated activity, and implementation of the best conservation practices in the border area.

[1]U.S. Geological Survey, 4200 New Haven Road, Columbia, MO 65201.

This page intentionally left blank

Interdisciplinary Science in Support of Environmental Health along the U.S.-Mexico Border—Using Map Tools to Understand Linkages Between the Environment and Human Health

By Jim Stefanov[1], Diana Papoulias[2], Jean Parcher[3], and Ric Page[4]

The diverse, fragile ecosystems of the borderlands have been pushed beyond sustainable levels due to rapid population growth and land-use changes. Water shortages and pollution, poor air quality, increased soil salinities, residual pesticides, and heavy-metal contaminants are some of the many stressors that are degrading the quality of life in the borderlands. The relationship between human health and environmental quality challenges public officials, medical professionals, and resource managers on both sides of the border in their efforts to provide for and maintain healthy communities.

To better understand the relationship between environmental and human health, the USGS's "Border Environmental Health Initiative" (BEHI; fig. 1) created an Internet Map Service (IMS) with binational-georeferenced data. BEHI's goal is to have seamless integration of borderwide datasets, at regional and local scales, that can lend an understanding of the linkages between the condition of the physical environment and public-health issues.

The Border Environmental Health Initiative Internet Map Service is available at http://borderheath.cr.usgs.gov/.

Collaborative Partnerships

An interdisciplinary USGS team identifies biologic, geologic, hydrologic, environmental, public-health, and demographic datasets for incorporation into the binational IMS. This team works in collaboration with other Federal, State, and local agencies, including nongovernmental and universities in both the United States and Mexico. Project success and the reliability of these binational scientific databases are dependent on these mutually beneficial partnerships.

Examples of cooperative partnerships that utilize the scientific data and research include the following.

Environmental Protection Agency/Secretaría de Medio Ambiente y Recursos Naturales Border 2012—The Border 2012 Environmental Health Indicators Working Group focuses on developing metrics to measure changes in human health as a result of improvements to sanitation, and air and water-quality in the border region. The USGS is cooperating with this group to develop a binational water quality geodatabase for the region and to use geospatial data for reporting environmental activities.

Natural Heritage Institute, University of Texas, and Instituto Mexicano de Technogía del Agua—Through the Rio Grande Physical Assessment Project, the USGS is collaborating with U.S. and Mexican partners to build a water-resources database as the foundation of an advanced hydrologic-planning model of the entire Rio Grande Basin. The USGS is verifying binational land use and surface- and ground-water data, and is validating model results.

Southwest Consortium of Environmental Resources Program (SCERP)— The USGS is partnering with SCERP to further our respective missions and to enhance interaction and cooperation with border research and policy programs. A first joint activity was to co-host a binational GIS summit.

Housing and Urban Development Colonia Database—The goal of this project is to provide the baseline data necessary to identify the need for Federal aid to improve the living conditions for residents of the many unincorporated settlements, known as colonias, found along the U.S.-Mexico border. In conjunction with partners, the USGS is providing geographic and demographic data to facilitate prioritization of community development and infrastructure investment.

Data Assimilation and Integration

USGS scientists strive to preserve the accuracy and associated attributes of the data during production of the IMS. Rigorous efforts have been made to seamlessly integrate U.S. and Mexican geospatial datasets along common themes to analyze environmental issues relative to human health.

The procedures are documented in Federal Geographic Data Committee-compliant metadata files and in procedural papers that define the differences in scale, scope, definition of terms, and methods of data collection between the two countries.

[1]U.S. Geological Survey, 8027 Exchange Dr., Austin, TX 78754.

[2]U.S. Geological Survey, 4200 New Haven Rd., Columbia, MO 65201.

[3]U.S. Geological Survey, 8027 Exchange Dr., Austin, TX 78754.

[4]U.S. Geological Survey, Box 25046, Denver Federal Center, MS 980, Denver, CO 80225.

Accomplishments to Date

Methods for building binational geospatial data and constructing integrated databases were developed during the BEHI pilot phase for the Lower Rio Grande Valley (Subregion 8), which extends from Falcon Reservoir to the lower part of the Laguna Madre, Tex. The IMS for this data-rich area includes remotely sensed imagery and anthropogenic and environmental datasets at a large scale (1:24,000). A similar suite of datasets at equivalent scales is being integrated for all subregions beginning with Subregion 7, which extends along the Rio Grande from Amistad Reservoir to Falcon Reservoir. Applying similar methodology border-wide, regional datasets at medium- (1:250,000-scale) and low-resolution (1:2M scale) have been integrated to form the basic geospatial framework and to be displayed in the IMS. These border-wide datasets provide the platform upon which the comprehensive and subregion-specific datasets will subsequently be overlaid and will also assure compatibility at temporal and spatial scales.

Web-Site Features

Maps and Data— The IMS provides users with binational datasets and the tools to manipulate them over the Internet by using a browser. The interface allows users to zoom in to areas of interest and select a combination of layers appropriate to their focus. Users can select an initial view of the entire border region or a particular subregion, and use the tools available to customize the view.

Data Layers— Data layers are grouped under the major themes of anthropology, hydrology, transportation, biology, geology, imagery, elevation, land use, and infectious disease. The numerous data layers within these themes are detailed with a description, metadata, and minimum- and maximum-view table extents. By means of the Web mapping-service protocols, users may incorporate available layers into their own geospatial analyses.

Static Map Library— This feature provides users with ready-made maps of common views and themes. These maps can be easily integrated into custom presentations.

Data Tables— Additional information about the specific data used in the layers is provided in tabular form.

Collaborative Opportunities

An anticipated outcome of this project is an increased opportunity to collaborate with scientific researchers in the public health, natural resources, and environmental protection fields to apply the BEHI datasets and the IMS to address specific public- and environmental-health issues. The vision of the USGS is that such collaborations could ultimately expand the breadth and depth of the datasets available and allow more sophisticated analysis of border health issues, ultimately leading to a healthier border environment.

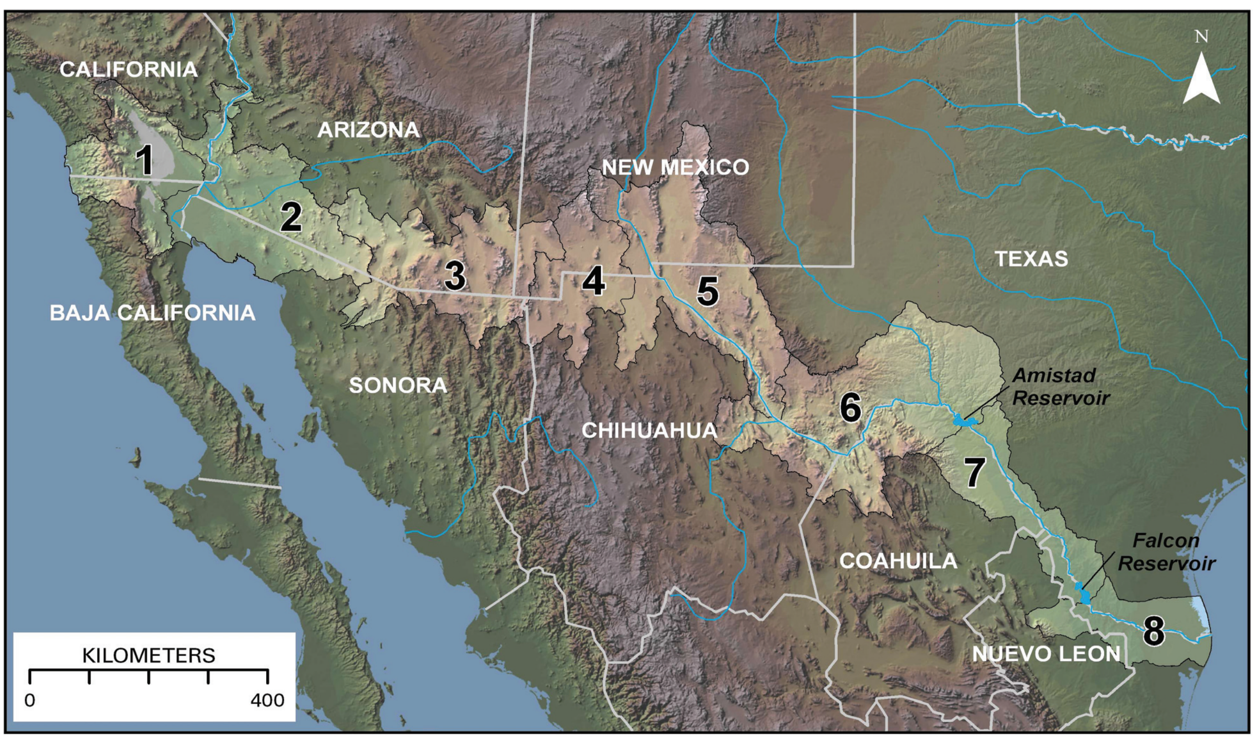

Figure 1. The USGS Border Environmental Health Initiative (BEHI) encompasses the entire U.S.–Mexico border, an area defined as 161,000 square miles; it is partitioned into eight subregions based on watersheds as delineated by Woodward and Duvall (1996).

How an Integrated State-Federal Geoscience Information Network Can Be Applied in the Borderlands

By M. Lee Allison[1] and Linda Gundersen[2]

National Geoscience Information Network

In early 2007, the United States geological surveys agreed to the development of a National Geoscience Information Network that is distributed, interoperable, uses open-source standards and common protocols, respects and acknowledges data ownership, fosters communities of practice to grow, and develops new web services and clients. A common approach enhances the nations geoscience community's ability to coordinate with other countries. Such an approach could greatly facilitate analysis, monitoring, and modeling among disparate agencies and disciplines along the U.S.-Mexico Borderlands region.

Geological surveys have unique resources and mission-specific requirements that include the gathering, archiving, and dissemination of data. Together these data represent one of the largest, most extensive long-term information resources on the geology of the U.S. Currently, however, these data are available in disparate systems, which require time and resources to explore, extract, and reformat. By using modern information technology and a virtual "service-oriented architecture" that provides common discovery tools and standards, the surveys and the general science community will benefit in multiple ways. First, online data and other informational products from each survey will be more readily available to the world audience and will be more valuable because they will be interoperable. Second, data and applications from external sources, such as the USGS' more than 1,000 databases, catalogues, and inventories will be readily accessed and integratable with each participating survey's own data system. Third, a large, federated data network will create inestimable opportunities for the broader community, including academia and the private sector, to build applications utilizing this huge data resource, and to integrate it with other data. The breadth and depth of survey-based data are so large that they constitute one of the largest, if not the largest, data resources in the geosciences, in essence, a national data "backbone."

[1]Arizona Geological Survey, 416 W. Congress St., Ste. 100, Tucson, AZ 85701.

[2]U.S. Geological Survey, 12201 Sunrise Valley Dr., MS 911, Reston, VA 20192.

By demonstrating national cooperation for data access and interoperability among the Federal and State geological surveys, the network also could serve as a model for broader cooperation in geoinformatics across the entire Earth-science community and other scientific disciplines, especially those with a geospatial aspect. We intend to coordinate the development of this network with other efforts, including the National Science Foundation's "Cyberinfrastructure Vision for 21st Century Discovery" and the emerging international efforts in informatics. This "community of practice" approach means that we will learn, develop, evolve, and coordinate the building of the network with each other and our partners. When completed, we envision a scenario where any user may go to a geological survey, or other participating Web site, enter a distributed science-data catalog, (for example, through a simple piece of software served on each geological survey's Web site) and view available data for a specific state and adjacent states if desired. Because all these data will use a common mark-up language, the user can immediately select and download the needed data and load them into any number of applications, including in-house, freeware, and proprietary commercial products. The original data source would be credited with the download.

Vision for a National Geoscience Information Network—To achieve this vision of a coordinated network, the surveys have agreed to the following principles and activities to be undertaken in the next few years.

- Develop a coordinated, national geoscience framework to access and integrate state-survey and USGS-information resources (data bases, maps, publications, methods, applications, and data services).
- Function as a "community of practice" in development of geoinformatics and the geoscience network.
- Develop prototypes (pilots, test beds) to show proof of concept, to determine realistic levels of effort, and to compare costs and benefits while providing immediate benefits in the form of user services.
- Build the network through an iterative and evolutionary process.
- The basic architecture of the network should be distributed and leverage existing systems, map services, and data with local autonomy, by using standards to enable interopera-biity.
- Review, test, and adopt standards and protocols for developing the system (including metadata).

- New and existing systems should communicate with an open source (for example, Open Geospatial Consortium-based) protocol to promote interoperability.
- Test and consider accepting GeoSciML (geoscience mark-up language) as a protocol and consider proposing it as a standard to the Federal Geographic Data Committee (FGDC).
- Recognize that there are priority data for which we have mission requirements and inherent partnerships amongst the geological surveys.
- Encourage Web clients and services to be developed, and facilitate participation and implementation by others in a manner that meets their own business model and needs.
- Reduce philosophical and cultural barriers that impede system development.
- Adhere to a code of conduct that respects and acknowl edges data ownership and the work of others. Respect intellectual property and data provenance, use "branding" in data services to acknowledge data sources. Develop usage measurements and utilize them with Web clients and services.
- Develop a database-citation format.
- Acknowledge that geological surveys need to recognize interoperable, Web-enabled information resources as part their mission. The surveys also must seek partnerships to leverage resources, develop, and implement the vision.

Mapping Surficial Geology in the Border Region of Big Bend National Park, Texas

By Margaret E. Berry[1]

Big Bend National Park lies within the U.S.-Mexico border region of western Texas. Surficial deposits within the park are being mapped as part of a collaborative effort among the USGS, the National Park Service, and academia to produce a new 1:100,000-scale geologic map of the park to use as a framework for land and resource management. Surficial deposits cover a large part of the park, but were not mapped in detail on the existing map (Maxwell and others, 1967, Univ. Texas Pub. 6711; 1:62,500 scale). Our mapping subdivides these deposits by genesis and relative age into active (latest Holocene) tributary wash and river deposits (Qaw); young (Holocene to latest Pleistocene) river deposits (Qyw); young alluvial (fan, pediment, and stream) deposits, undifferentiated (Qya); intermediate (late to middle Pleistocene) river deposits (Qiw); intermediate alluvial (fan, pediment, and stream) deposits, undifferentiated (Qia); old (middle to early Pleistocene) river deposits (Qow); old alluvial (fan, pediment, and stream) deposits, undifferentiated (Qoa); very old (early Pleistocene and Pliocene) alluvium (QTa); slope deposits consisting of colluvium aprons and colluvial-fan deposits (Qc); rock-fall deposits (Qrf); landslide deposits (Qls); eolian sand (Qe); and mixed eolian and alluvial deposits (Qea). Units Qyw, Qya, Qiw, and Qia are further subdivided by age where criteria for division are evident and units are large enough to map separately at a 1:100,000 map scale. River (axial) deposits are differentiated from other types of alluvial deposits mainly along the Rio Grande, where morphological distinctions are pronounced. Terraces along this portion of the Rio Grande typically are underlain by coarse-gravel deposits comprised of subrounded to well-rounded clasts. Soil carbonate accumulation on the terraces tends to be greater than that in corresponding fan and pediment alluvium due to subtle textural differences that may influence the way water moves through the soils.

To expedite mapping over the park's large area (3,242 km^2), surficial geologic units are interpreted from aerial photography, satellite imagery, and topographic data, and are digitally mapped on color-infrared orthophoto images with 1-meter ground resolution. Surface morphology, tone, relative height above modern stream channel, and map pattern are used to interpret surficial geology from the imagery. Maps are printed on a topographic base and field checked, at which time soil, weathering, and pavement characteristics are used to refine interpretation of mapping units.

General characteristics of young alluvial deposits (Qy, Holocene to latest Pleistocene) include some preservation of original morphology (channel, and bar-and-swale or meander-scroll topography), and low relative height above stream channels. Pavement, varnish, and soil carbonate ranges from weak or no development, to densely packed and uniform pavement with well-varnished clasts and stage I soil-carbonate morphology. Intermediate-age alluvial deposits (Qi, late to middle Pleistocene) typically have surfaces that are relatively planar, partly incised, and slightly rounded at the edges at intermediate relative height. Pavement ranges from weakly developed to densely packed and uniform with well-varnished clasts. Soils typically have stage I-II carbonate morphology in the younger-intermediate age deposits and stage III-IV carbonate morphology in the older-intermediate age deposits. Old alluvial deposits (Qo, middle to early Pleistocene) typically have surfaces that are dissected into ridge and ravine topography (thick gravel deposits) or form generally planar remnants (thin gravel deposits) high above adjacent valley floors. Pavement ranges from weakly developed to moderately packed and uniform with moderately-varnished clasts; soils typically have weak to moderately cemented stage IV carbonate morphology. Very old alluvium (QTa, early Pleistocene and Pliocene), typically with the highest relative height, is deeply eroded and dissected. Where preserved, soils have stage III to IV carbonate horizons as much as 2-m thick.

The wide variety of surficial deposits in Big Bend National Park reflect the long and complex Quaternary geologic and climatic history of this border region and provide an important part of the geologic framework for land and resource management.

[1]U.S. Geological Survey, Box 25046, DFC, MS 980, Denver, CO 80225.

This page intentionally left blank

Geologic-Map Compilation of the U.S.-Mexico Border

By Floyd Gray[1], Jaime Castro Escarrega[2], and William R. Page[3]

Introduction

The North American Free Trade Agreement (NAFTA), the Border Environmental Cooperation Commission (BECC) and the U.S.-Mexico Environmental Protection Agency (USEPA) U.S.-México Border XXI through Border XXXII (2012) Program have all focused attention on the environmental, social-cultural, and economic conditions in the U.S.-Mexico frontier and have demonstrated the need for a binational, transborder approach to addressing problems. Currently, state and national government entities, nongovernment organizations, and universities are conducting numerous data-collection and research activities in the border region. Much of the work being done recognizes that the region's physiography, ecological zones, and human phenomena extend uninterrupted across the international boundary and cannot be understood if restricted to one side of the border. Researchers and land managers from both countries need current, accurate, and binationally compatible geospatial information to manage such issues as water availability and pollution, land-cover change, natural-resource sustainability, and human health (Dohrenwend and others, 2001). Toward these ends, a cross-border, geologic-map compilation was cooperatively undertaken by the Servicio Geologico Mexicana and the U.S. Geological Survey (USGS). The compiled map is designed to be utilized as a fundamental part of a geographic information system database to further the understanding of natural-resource availability and the processes involved in urban development, commerce, ecosystem sustainability, protected species, and agriculture (fig. 1). The compilation involved the merger of eighteen 1- by 2-degree quadrangles along the 1,800-kilometer (1,100 miles) extent of the border (fig. 1)

Methodology

In 2004, the USGS and the Servicio Geologico Mexicana signed a Mapping Initiative Memorandum of Understanding (MOU) to jointly produce matching geologic maps across the U.S.-Mexico border. Highlights of the compilation process that developed as a result of the agencies' efforts include:

- Transboundary 1:250,000-scale quadrangle maps were agreed upon as base.
- Compiled maps from several scales—1:250,000 or larger (1:500,000-scale maps used for Texas because of the level of detail in the maps).
- Databases were created with updated paleontological-and isotopic-age compilations.
- Quaternary portion of the geologic database was enhanced where possible with use of Landsat and Digital Elevation Model data in the GIS platform.
- Adjusted line work and age designations within several kilometers of the frontier only—a "border zone".
- Created a parallel but integrated nomenclature in designated zone during the process of merging the stratigraphic column.

Geologic Setting

In general, the U.S.-Mexico border region can be divided into six geologic provinces from east to west (1) the gulf of Mexico Coastal Plain, (2) Paleozoic and Mesozoic platform rocks, (3) an area of terrestrial volcanism and accompanying plutonism, (4) an area of structural extension, (5) a transitional area between platform rocks and the area of extension, and (6) an accreted terrane (Orris and others, 1993).

Utilization of Maps

Utility of a cohesive transboundary geologic map is demonstrated in studies such as the geologic framework and three-dimensional characterization of the Mexican headwaters of the upper San Pedro River project (fig. 1). In this investigation, data on geology and geophysics in the San Pedro River Basin in northern Sonora, Mexico, and southeastern Arizona were combined to develop a three-dimensional conceptual model of the basin-fill aquifer that is being used to construct a regional ground-water-flow model. This work will better constrain a number of significant geohydrologic parameters critical to the modeling calculations and forward simulations of flow regimes in the river system. Likewise, in addition to hydrologic systems,

[1]U.S. Geological Survey, 520 North Park Ave., Tucson, AZ 85719.

[2]Servicio Geológico Mexicano, López del Castillo No. 14, 83180 Hermosillo, Son., Mexico.

[3]U.S. Geological Survey, Box 25046, Denver Federal Center, MS 980, Denver, CO 80225.

mineral tracts, and ecological zones are contiguous across the border region and are more easily understood by using a seamless geologic-map product.

References Cited

Dohrenwend, J.C., Gray, Floyd, and Miller, R.J., 2001, Processed Thematic Mapper satellite imagery for selected areas within the U.S.-Mexico borderlands: U.S. Geological Survey Open-File Report 00-309 (3-CD-ROM set).

Orris, G.J., Page, N.J. Staude, John-Mark G., Bolm, K.S., Carbonaro, M., Gray, Floyd, and Long, K.R., 1993, Nonfuel mineral resources in the United States-Mexico border region—A progress report on information available from the Center for Inter-American Mineral Resource Investigations (CIMI): U.S. Geological Survey Circular 1098, 19 p.

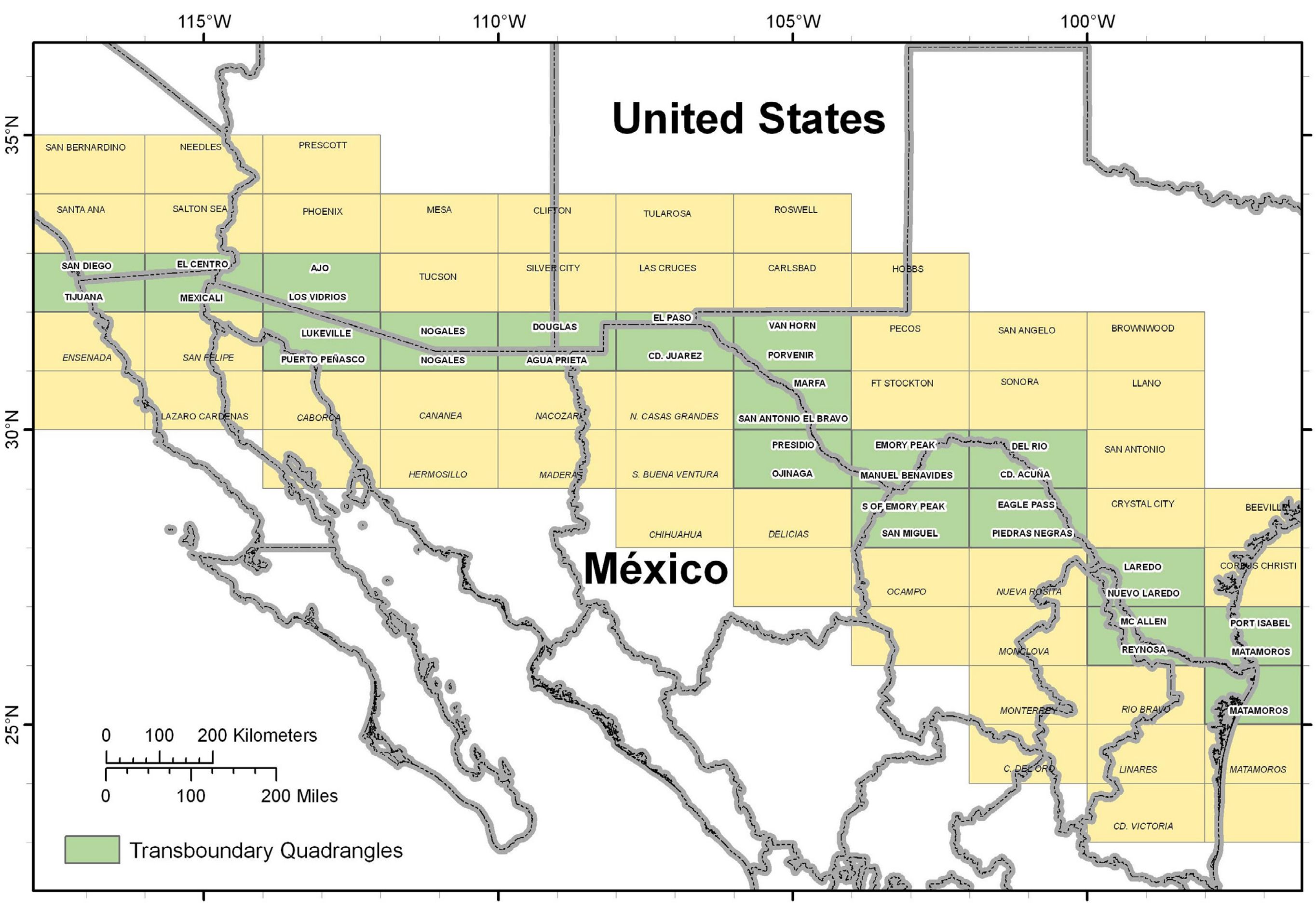

Figure 1. Index map highlighting transboundary quadrangles used in the U.S.-Mexico border geologic-map compilation in red and green.

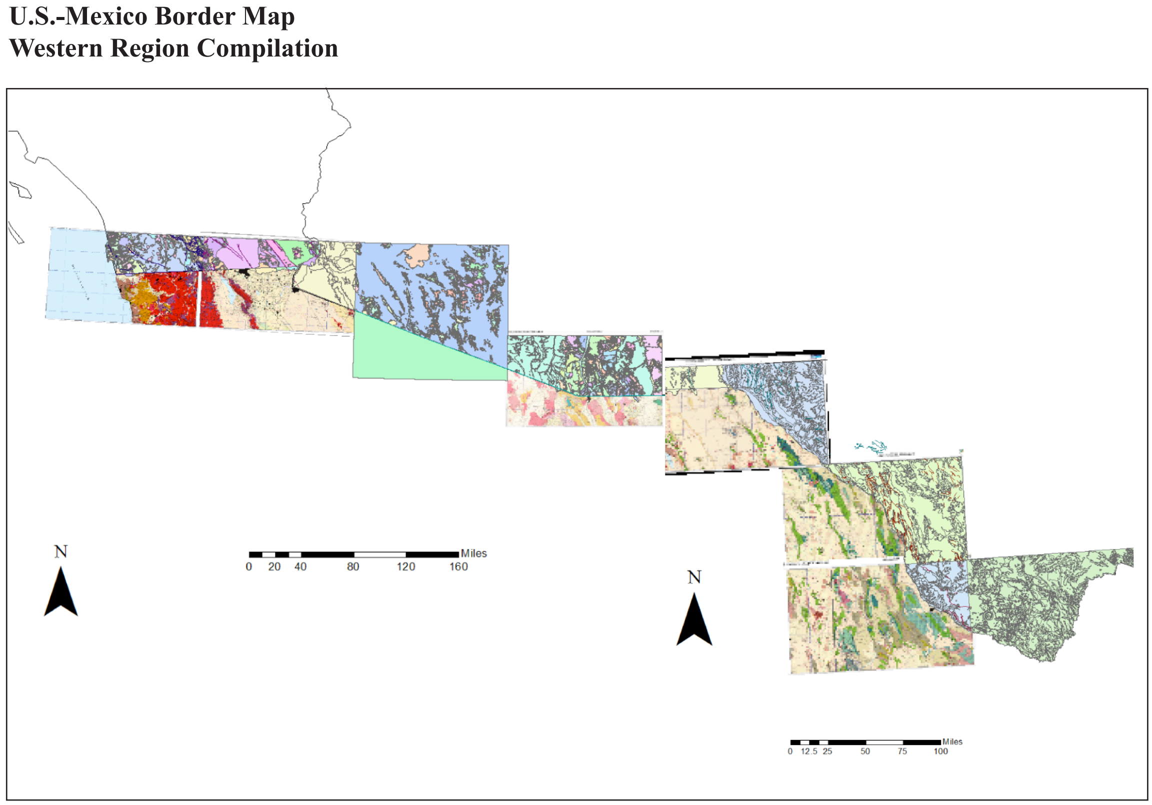

Figure 2. Schematic diagram showing components of the merged geologic data used in the construction of the trans-boundary geologic map.

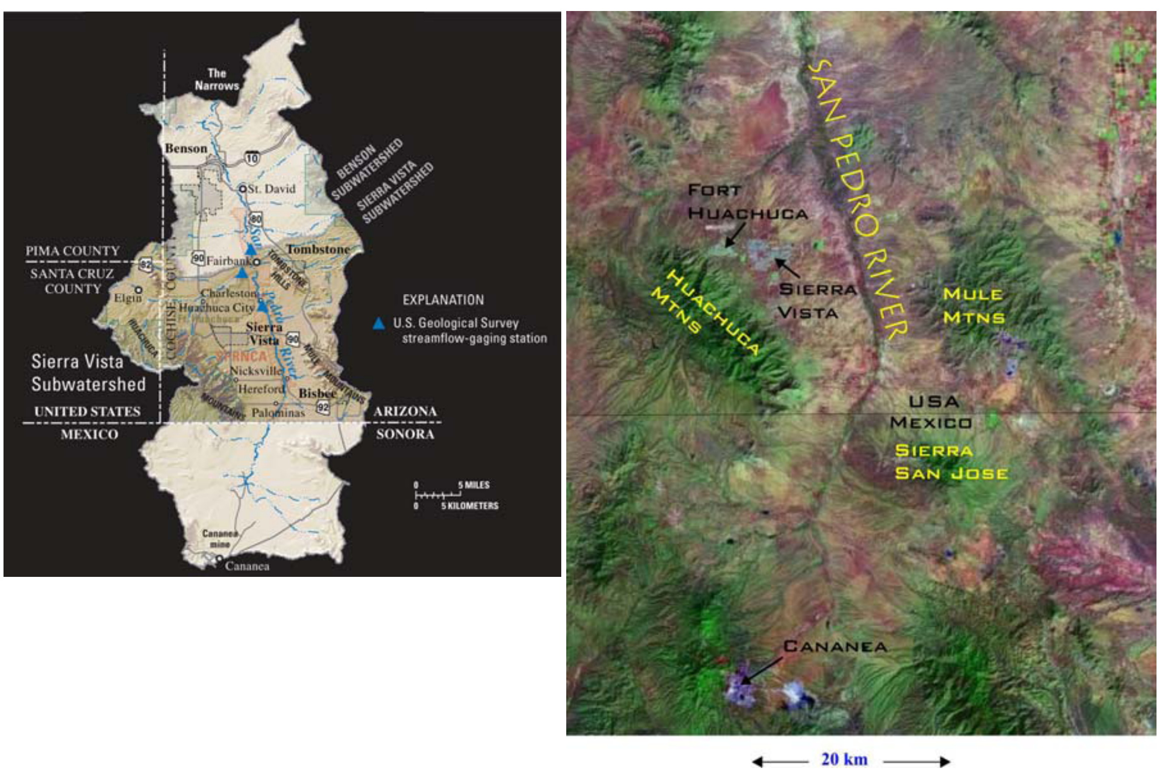

Figure 3. Index map and Landsat Thematic Mapper image of the Upper San Pedro River drainage basin.

This page intentionally left blank

Floodplain Lakes and Their Relation to Alluviation Cycles in the Lower Colorado River

By Daniel V. Malmon[1] , Tracey J. Felger[2] , Keith A. Howard[1]

The broad valleys along the lower Colorado River, Ariz., contain numerous bodies of still water that provide critical habitat for birds, fish, and other wildlife. This chain of floodplain lakes is an important part of the Pacific Flyway—the major north-south route of travel for migratory birds in the western hemisphere—and is also used by many resident-bird species. In addition, isolated floodplain lakes may provide the only viable habitat for endangered native fish, such as the razorback sucker—a fish that is vulnerable to predation by introduced species in the main stem of the Colorado River. Floodplain lakes typically occupy former channel courses of the river and form by river meandering or avulsion.

Persistent fluvial-sediment deposition (aggradation) creates conditions that favor rapid formation and destruction of floodplain lakes, while long-term river downcutting (degradation) inhibits their formation and evolution. New radiocarbon dates from wood recovered from drill cores near Topock, Ariz., indicate that the river aggraded an average of 3 mm/yr during the middle and late Holocene. Aggradational conditions before Hoover Dam was built were associated with rapid channel shifting and frequent lake formation. Lakes had short life spans due to rapid infilling with fine-grained sediment during turbid floods on the unregulated Colorado River. The building of dams and armored banks has impacted floodplain lakes, not only by drowning large portions of the valley beneath reservoirs, but also by preventing new lake formation in some areas and accelerating it in others. GIS analyses of three sets of historical maps show that both the number and total area of isolated (that is, not linked to the main channel by a surface-water connection) lakes in the lower Colorado River valley increased between 1902 and the 1950s, and then decreased through the 1970s. River-bed degradation below dams inhibits channel shifting and floodplain-lake formation, and the capture of fines behind the dams has prevented sediment infilling of the lakes. Bed lowering below dams and in artificially confined reaches could potentially dewater floodplain lakes. This process is occurring at Beal Lake, a natural lake used for native-fish restoration in the Havasu National Wildlife Refuge. Sedimentation near the upstream ends of reservoirs has created large areas of still water. One of the largest, Topock Marsh, is connected to the main channel, restricting its usefulness as a native-fish nursery; other backwater areas are confined by bars that isolate standing water at tributaries.

---

[1]U.S. Geological Survey, 345 Middlefield Road MS 973, Menlo Park, CA 94025.

[2]U.S. Geological Survey, 2255 N. Gemini Drive, Flagstaff, AZ 86001.

This page intentionally left blank

Binational Geologic Mapping in the Lower Rio Grande of Southern Texas, United States, and Northern Tamaulipas, Mexico

By William R. Page[1] , Helen Folger[2] , Bernard Hubbard[2], Jim Stefanov[3] , and Matthew D. Merrill[2]

Geologic maps are a fundamental dataset supporting multidisciplinary studies in the U.S.-Mexico border region. We compiled binational geologic maps in parts of southernmost Texas, and in Tamaulipas, for the U.S.-Mexico Border Environmental Health Initiative. The mapping is based on the integration of geologic, geochemical, and geophysical data, and this synergistic approach provides a template for compiling map datasets in other parts of the border region.

Our research resulted in new mapping of the Pliocene Goliad Formation, Pleistocene Lissie and Beaumont Formations, and Holocene Rio Grande fluvial-deltaic deposits in parts of Tamaulipas. We also refined existing mapping of the Beaumont and Lissie Formations in Texas. Ongoing research includes characterizing the lithology, geochemistry, and mineralogy of these map units to provide baseline data important in assessing human and wildlife health. Other research includes soil-moisture modeling and mapping parts of the Beaumont Formation and the Rio Grande deposits to address issues related to permeability, surface-water ponding, and vector-borne disease potential.

Our binational mapping efforts will provide hydrogeologic-framework data to support ground-water modeling related to the U.S.-Mexico Transboundary Aquifer Assessment Act. Geologic maps show the distribution of hydrostratigraphic units and the location and geometry of faults and fractures that control ground-water flow and also are pathways for contaminant transport. The Beaumont, Lissie, and Goliad Formations, and the Rio Grande deposits are ground-water aquifers in the Lower Rio Grande Valley, and alluvial aquifers in the Rio Grande deposits produce some of the highest quality ground water (less than 1,000 TDS) in the valley. New mapping of these formations in Tamaulipas provides a unified hydrogeologic framework spanning the U.S.-Mexico border.

[1]Arizona Geological Survey, Box 25046, Denver Federal Center, MS 980, Denver, CO 80225.
[2]U.S. Geological Survey, 12201 Sunrise Valley Dr., MS 954, Reston, VA 20192.
[3]U.S. Geological Survey, 8027 Exchange Dr., Austin, TX 78754.

This page intentionally left blank

Lessons Learned from the Salton Sea—Potential Impact of Dust Emission to Both Air Quality and Human Health

By Pat Chavez[1] , Jana Ruhlman[1], Miguel Velasco[1], Rian Bogle[1], John Vogel[2] , and JoAnn Isbrecht[1]

Air quality continues to be an important public health concern within the Salton Sea Air Basin, with areas in both Riverside and Imperial counties having some of the worst air pollution/ PM10 levels in the country during certain times of the year. With a recent agreement between the water stakeholders and the urban areas in southern California some of the water that drains into the Salton Sea will be diverted to the cities. Over time this will cause the water level to drop and up to 80,000 acres of the Salton Sea's bottom will be exposed and become potential new dust sources (fig. 1). Several Federal, State, and local agencies are involved in investigating the possible best methods to restore the Salton Sea to protect the wildlife habitats and minimize the impact to human health caused by new dust sources. The following major issues are being investigated by the United States Geological Survey (USGS) under this project in collaboration with the Bureau of Reclamation and the California Department of Water Resources:

- Use of dual-frequency acoustics to map Salton Sea bottom-sediment characteristics to generate a first-order potential wind-erosion vulnerability map.
- Analysis and study of the wind characteristics within the Salton Sea Air Basin to help predict the potential impact to air quality the lower water levels will have on the area, including identifying the areas that may be impacted the most.
- Identification of some of the current on-land large dust sources in the Salton Sea Air Basin and investigate their current impact on the region's air quality.

To help understand the current wind-erosion vulnerability in the Salton Sea region we used satellite-image data to detect and identify existing on-land dust sources. This information will help with management decisions that are being made on how to best restore the Salton Sea to minimize the impact to both wildlife habitats and human health. Restoration costs are estimated to be in the hundreds of millions to several billions of dollars.

Figure 1. Photo showing an existing exposed playa surface at the edge of the Salton Sea. A concern is the potential dust emission from very large areas that could look like this in the future due to the lowering of the lake's water level.

[1]U.S. Geological Survey, 2255 North Gemini Drive, Flagstaff, AZ 86001.
[2]U.S. Geological Survey, 520 N. Park Ave., Tucson, CA 85719.

This page intentionally left blank

Use of Remote Sensing To Detect and Map Temporal and Spatial Vegetation Dynamics to Help Map Landscape Erosion Vulnerability—Mojave Desert and Moloka'i, Hawai'i

By Pat Chavez[1] , JoAnn Isbrecht[1], Miguel Velasco[1], and Rian Bogle[1]

In many landscapes the potential vulnerability to erosion is important, and vegetation sheltering the soils is a critical component that influences the level of vulnerability. In the Mojave Desert in the southwestern United States, wind erosion and dust emission are concerns with respect to soil loss and its effects on air quality and on human health and safety. In Hawai'i, water erosion and sediment runoff onto coral reefs are major concerns. Methods to detect, map, and monitor both temporal- and spatial-vegetation dynamics within a landscape are critical for mapping and monitoring the degree of vulnerability to erosion. Changes that occur from season to season in annual vegetation and perennial grasses, because of differences in climate/rainfall conditions and the spatial distribution of perennial nongrass vegetation, are critical parameters that influence potential erosion of landscapes.

Change-detection algorithms and procedures were developed to detect and map differences between wet and dry conditions by identifying areas of annual and perennial grasses, and algorithms and procedures for spatial-variability analyses were used to detect and map differences in the spatial coverage and distribution of nongrass perennial vegetation. These types of spatial analyses have been applied in the Mojave Desert and the island of Moloka'i, Hawai'i, for studies of wind erosion and water erosion, respectively. Multitemporal satellite (Landsat TM, IKONOS, and Quickbird) and airborne images (figs. 1 and 2) collected under conditions of high and low antecedent

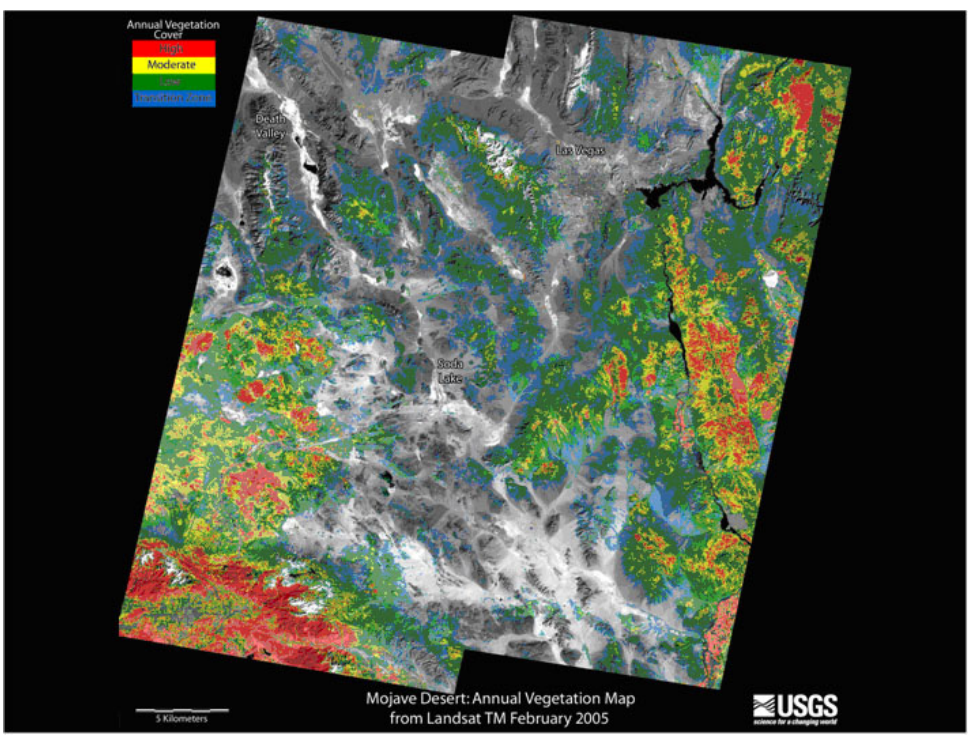

Figure 1. Image map generated by using Landsat TM images to show annual-vegetation dynamics in the Mojave Desert, southwestern United States.

[1]U.S. Geological Survey, 2255 N. Gemini Drive, Flagstaff, AZ 86001.

rainfall for both locations show that (1) dust emission from vegetated landscapes in the Mojave Desert is greatly enhanced following drought and almost completely shut down after only a few months of heavy winter rainfall, and (2) sediment runoff on Moloka'i appears to be effected by the amount of vegetation cover within the watersheds, with the highest amount of vegetation dynamics (greening up and (or) having new growth) occurring within the lower half of the watersheds being studied. From a management perspective, areas identified as having the greatest level of vegetation dynamics (the lower half of the watersheds) might be some of the more promising sites to consider for management efforts.

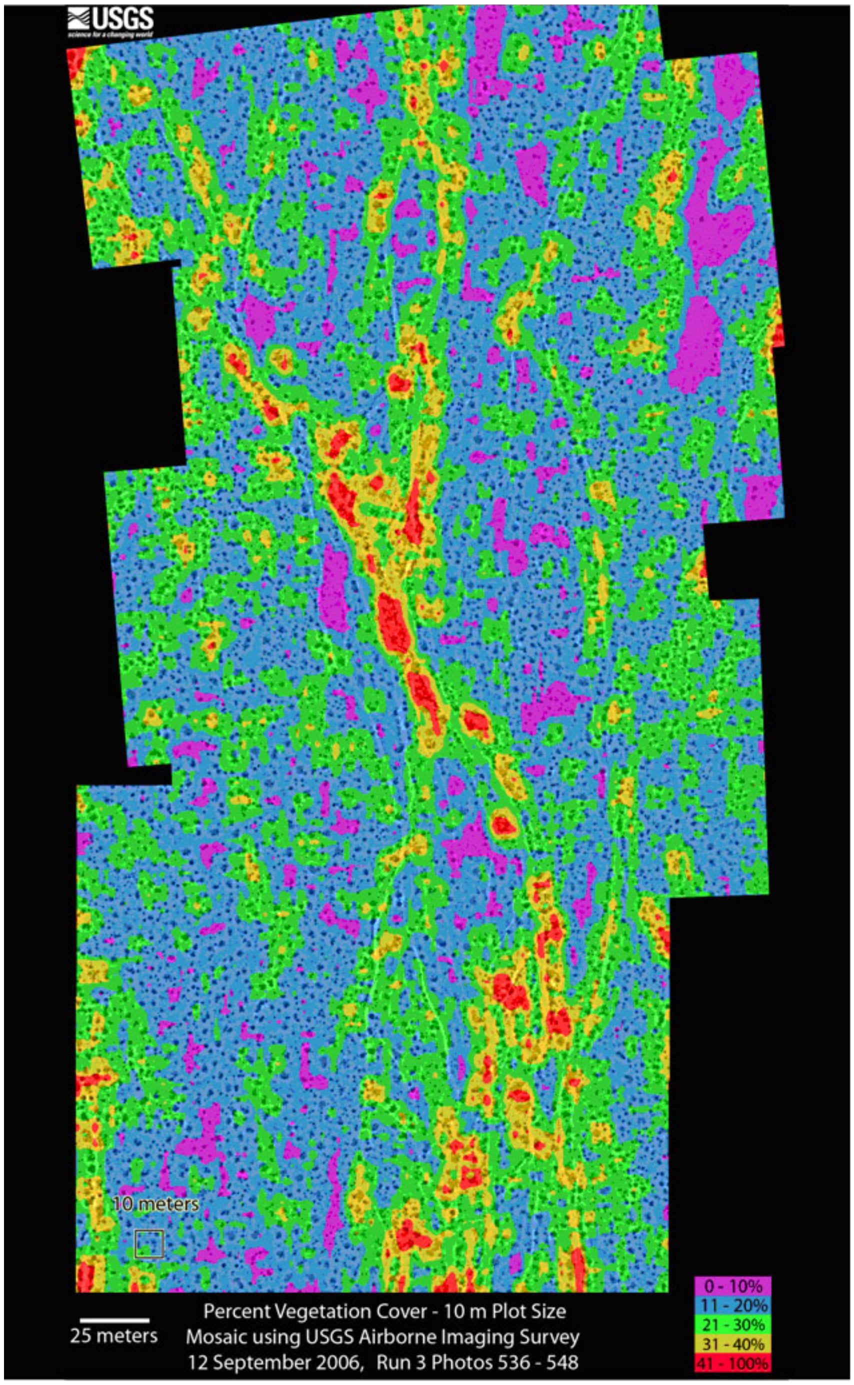

Figure 2. Image map generated by using high-resolution (six-inch pixels) airborne-image data showing percentage of perennial-vegetation cover at a ten-meter field plot size, in the Mojave Desert.

CHIPS—A New Way to Monitor Colonias Along the U.S.-Mexico Border

By Delbert G. Humberson[1] and Jean W. Parcher[1]

The Handbook of Texas Online defines colonias as unincorporated and unregulated settlements that emerged during the 1960s along the U.S.-Mexico border (Texas State Historical Association, 2003). The majority of colonias are found in Texas (more than 1,400 as of 2001), but they also exist in Arizona (80) and New Mexico (120; Ward, 1999; Norman and others, 2006). The emergence of colonias within the U.S.-Mexico border region can be traced back to the rapid growth associated with the Mexican Border Industrial Program during the 1960s. Increased economic growth on the Mexican side of the border fueled population expansion in sister cities (Parcher, 2002), which are communities where a city in one country borders a city in another country, creating a large urban area separated by administrative boundaries. This rapid population growth in the border region triggered a lack of affordable housing, causing new migrants in the U.S. to purchase rural homestead lots through a contract-for-deed program from land developers. Due to the need to keep prices affordable and the absence of effective land-use controls, these rural subdivisions were built without proper infrastructure (Davies and Holz, 1992). Since the region is binationally interconnected economically, politically, and socially, the phenomenon of colonias is a transborder issue.

With the passing of Senate Bill 827 (SB 827) by the 79th Texas Legislature in 2005, the State was mandated to create a colonia-identification system and to track the progress of State-funded colonia-improvement projects. These efforts were spearheaded by the Office of the Texas Secretary of State (SOS), and the SB 827 workgroup was formed (Office of the Texas Secretary of State, 2006). In order to track the progress of State-funded projects, the SB 827 workgroup created a set of infrastructure, demography, and health-related criteria for ombudsmen in the field to collect. The ombudsmen collected data from a variety of sources, including utility companies, county-appraisal districts, site visits, and the Office of the Attorney General of Texas. Once these data were collected, colonias were assigned a color classification of red, yellow, or green (fig. 1).

[1]U.S. Geological Survey, 8027 Exchange Dr. MS 518, Austin, TX 78754.

Since colonias are not uniquely represented within the census geography, an explicit long-term working database is needed to monitor progress, set infrastructure priorities, and measure quality of life indicators within the colonias. Based on requirements outlined in SB 827, and in cooperation with the SOS, the U.S. Geological Survey (USGS) developed the Colonia Health, Infrastructure, and Platting Status tool (CHIPS). CHIPS is a relational database that uses the criteria created by the SB 827 workgroup as a template for the database schema. This database structure uses a unique key field to link data tables, which results in an open-ended design that can integrate data from new sources. Relational databases also allow the use of Structured Query Language (SQL), which allows users to manipulate how data are displayed without altering the original data tables.

Since SB 827 requires a biennial report to be submitted by December 1 on even years, it is imperative that the data be stored in a format that can be updated easily and used to generate custom reports rapidly. Thus, a graphical user-interface (GUI) was designed to allow rapid and consistent data entry regardless of the user's level of familiarity with the database structure. As colonia data are revised, the GUI within CHIPS provides the capability of updating the color classification of every colonia with a click of a single button. The color classification of a colonia can be red, yellow, or green. Red denotes a colonia that is either unplatted, has an inadequate potable-water supply, or has inadequate wastewater disposal. Yellow denotes a colonia that does not meet the red criteria, but still has inadequate trash collection, unpaved roads, or inadequate drainage. Green denotes a colonia that does not meet red or yellow criteria. The classification procedure is designed to be easily altered if the classification criteria change. Another function of the database is a custom-report generator that is integrated into the GUI, which allows users with little or no knowledge of database queries to extract information with ease. The report generator is flexible, and its output can be tailored to be either broad or specific. For example, a congressperson could use CHIPS to list colonias with wastewater issues in a specific county, while a health researcher could list all colonias without access to healthcare clinics.

The results of the colonia color classifications are shown in figure 1. The ombudsmen populated CHIPs for six counties in Texas (Cameron, El Paso, Hidalgo, Maverick, Starr, and Webb) from July to December 2006. Of the 1,786 colonias identified in CHIPS, 36 percent are identified as green. The percentage of colonias identified as green is higher than the percentage of colonias identified as red (24.2 percent) or yellow (22.5 percent), but still less than the combined percentage of red and yellow colonias (46.7 percent). By using CHIPS we can quickly compare the distribution of colonias among counties (fig. 1). For example, we can see that 10 percent of the total number of colonias are in Cameron County, but Cameron County has 14.5 percent of the total number of green colonias. On the other hand, Maverick County has 4.1 percent of the total number of colonias, but only 2.3 percent of the total number of green colonias.

With CHIPS it is possible to highlight where funds for colonia projects are needed. Hidalgo County accounts for 84.5 percent of the number of unknown colonias in the six counties (fig. 1). This percentage represents 261 colonias

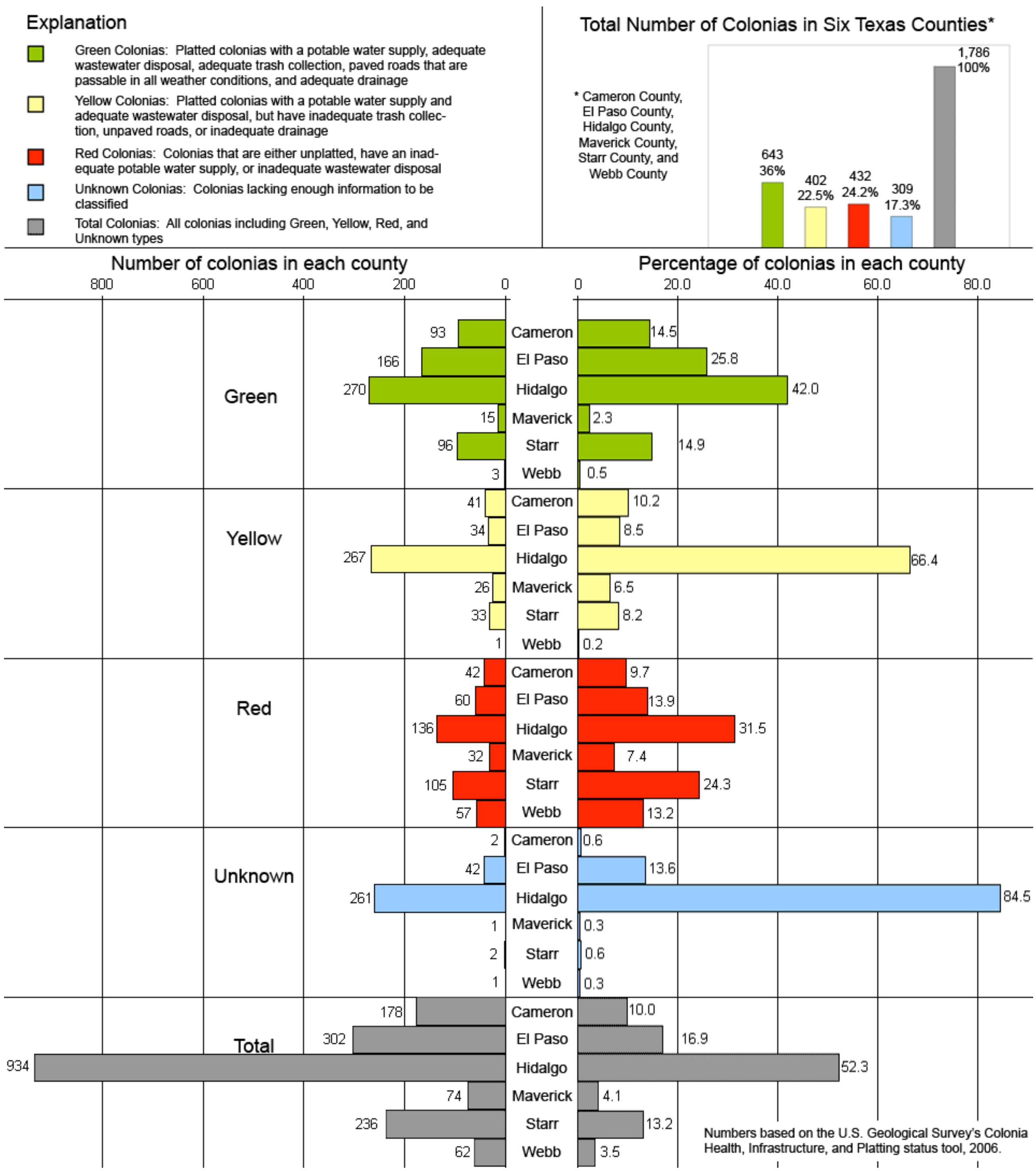

Figure 1. Distribution of green, yellow, and red colonias within the six Texas counties contained in CHIPS, U.S.-Mexico border region.

where funding should be directed in order to obtain a color classification. Once the colonias are classified, a more meaningful distribution can be created and used to direct future funding.

CHIPS is part of a larger project involving scientists from the U.S. and Mexico who are merging landscape and demographic data from both countries into integrated datasets. These datasets are used to assess environmental health issues along the U.S.-Mexico border. To view the interactive Web maps, documentation, and links, visit http://borderhealth.cr.usgs.gov. For more information, contact Delbert Geronimo Humberson at (512) 927-3567 or dghumber@usgs.gov, or Jean W. Parcher at (512) 927-3523 or jwparcher@usgs.gov.

References Cited

Davies, C.S., and Holz, R.K., 1992, Settlement evolution of "colonias" along the US-Mexico border, the case of the Lower Rio Grande Valley of Texas: Habitat International, v. 16, no. 4, p. 119–142.

Norman, L.M., Donelson, A.J., Pfeifer, E.L., and Lam, A.H., 2006, Colonia development and land use change in Ambos Nogales, United States – Mexican Border: U.S. Geological Survey Open-File Report 2006–1112, 121 p.

Office of the Texas Secretary of State, 2006, Tracking the progress of state-funded projects that benefit colonias, [http://www.sos.state.tx.us/border/colonias/reports.shtml, last accessed February 13, 2007].

Parcher, J.W., 2002, Remote sensing method for estimating impervious cover for hydrologic modeling applications—A case study of the Brownsville, Matamoros area: Austin, University of Texas, master's thesis, 158 p.

Texas State Historical Association, 2003, The handbook of Texas online, [http://www. tsha.utexas.edu/handbook/online/, last accessed February 13, 2006].

Ward, P.M., 1999, Colonias and public policy in Texas and Mexico—Urbanization by stealth: Austin, University of Texas Press, 298 p.

This page intentionally left blank

An Approach to Prevent Nonpoint-Source Pollutants and Support Sustainable Development in the Ambos Nogales Transboundary Watershed

By Laura M. Norman[1] , D. Phillip Guertin[2] , and Mark Feller[3]

The twin cities of Nogales, Ariz., and Nogales, Sonora, Mexico, known collectively as Ambos Nogales ("ambos" is the Spanish word for "both"), spanning the Arizona-Sonora section of the border in a shared watershed. Ambos Nogales is the site of one of the larger maquiladora (twin-plant) programs along the U.S.-Mexico border. The improvement in quality of life and environment, along with the promise of better jobs and incomes, has generated a considerable flow of migrants to Ambos Nogales from the south, particularly since the 1970s. Approximately 80 percent of Nogales, Sonora's residents are recent immigrants who find work in the low-wage maquiladoras crowded along the border. This migration to the border and rapid population growth has placed enormaous pressure on the land and produced widespread, unplanned urban development.

Development in this region, with its arid-land sensitivity and rugged terrain, is inevitable. However, the area has limited land available for development, and the mountainous topography makes the cost of site preparation expensive. The population of the Arizona-Sonora border area is predicted to continue growing—potentially doubling by 2030. Although population has been increasing in both cities, growth is most dramatic in Nogales, Sonora, beginning with a trend in the 1940s and leaping again in the 1980s to higher and higher rates. In contrast, rates rose slightly in Nogales, Ariz., in the 1970s, but seem to have plateaued in the 1990s.

Environmental problems in Ambos Nogales are attributable to rapid economic and population growth. Surface activities and discharges to the Nogales Wash are shown to result in the deterioration of water quality. Flooding also affects low-lying areas throughout Ambos Nogales, where many unpaved streets follow the course of natural river washes. Erosion susceptibility increases with soil compaction, devegetation, and land-use changes associated with development. Pollution generated in border colonias (neighborhoods) may impact residents on both sides of the border who share the transboundary watershed and airshed. U.S.-Mexico border residents are affected disproportionately by many environmental health problems, including waterborne and respiratory diseases.

In a study done in cooperation with U.S. Department of Housing and Urban Development (HUD) and the Instituto Nacional de Estadística Geografía e Informática (INEGI), urban changes in Ambos Nogales were documented for 1975, 1983, 1995, and 2002, by using remote-sensing analyses (fig.1). These analyses were used to identify colonia development and settlement patterns along the U.S.-Mexico border.

The urban footprints derived from these data for four time periods were input to the SLEUTH urban-growth model and coupled with erosion and sedimentation models in a geographic information system (GIS) to estimate future nonpoint source (NPS) pollution in this binational watershed (Norman, 2005; 2007). The modeling approach is designed to predict the impacts of increasing urban development on surface erosion and sediment yield. To accomplish this, the model links a hillslope-scale erosion-prediction model, the Universal Soil Loss Equation (USLE), and a spatially derived sediment-delivery model (SEDMOD) within a GIS to estimate erosion, sediment yield, and sediment deposition across the watershed (Norman and others, 2006). The modeling approach will be used to support watershed planning. Potential erosion "hot spots" related to future development and the effect of different management scenarios used to reduce sediment loads in the future will be evaluated (fig. 2).

References Cited

Norman, L.M., 2007, United States-Mexican border watershed assessment—modeling nonpoint source pollution in Ambos Nogales: Journal of Borderland Studies v. 22, no. 1, 20 p.

Norman, L.M., Donelson, Angela, Pfeifer, Edwin, and Lam, A.H., 2006, Colonia development and land use change in Ambos Nogales, United States-Mexican border: U.S.

[1]U.S. Geological Survey, Southwest Geographic Science Team, 520 North Park Ave., Str.355, Tucson, AZ 85719.

[2]The University of Arizona, School of Natural Resources, 325 Biosciences East, Tucson, AZ 85719.

[3]U.S. Geological Survey, Rocky Mountain Geographic Science Center, Box 25046, Denver, CO 80225.

Geological Survey Open-File Report 2006–1112, [http://pubs.usgs.gov/of/2006/1112].

Norman, L.M., 2005, Modeling land use change and associate water quality impacts in the *Ambos* Nogales watershed, U.S.-Mexico border: Tucson, University of Arizona, Ph.D. dissertation, 216 p.

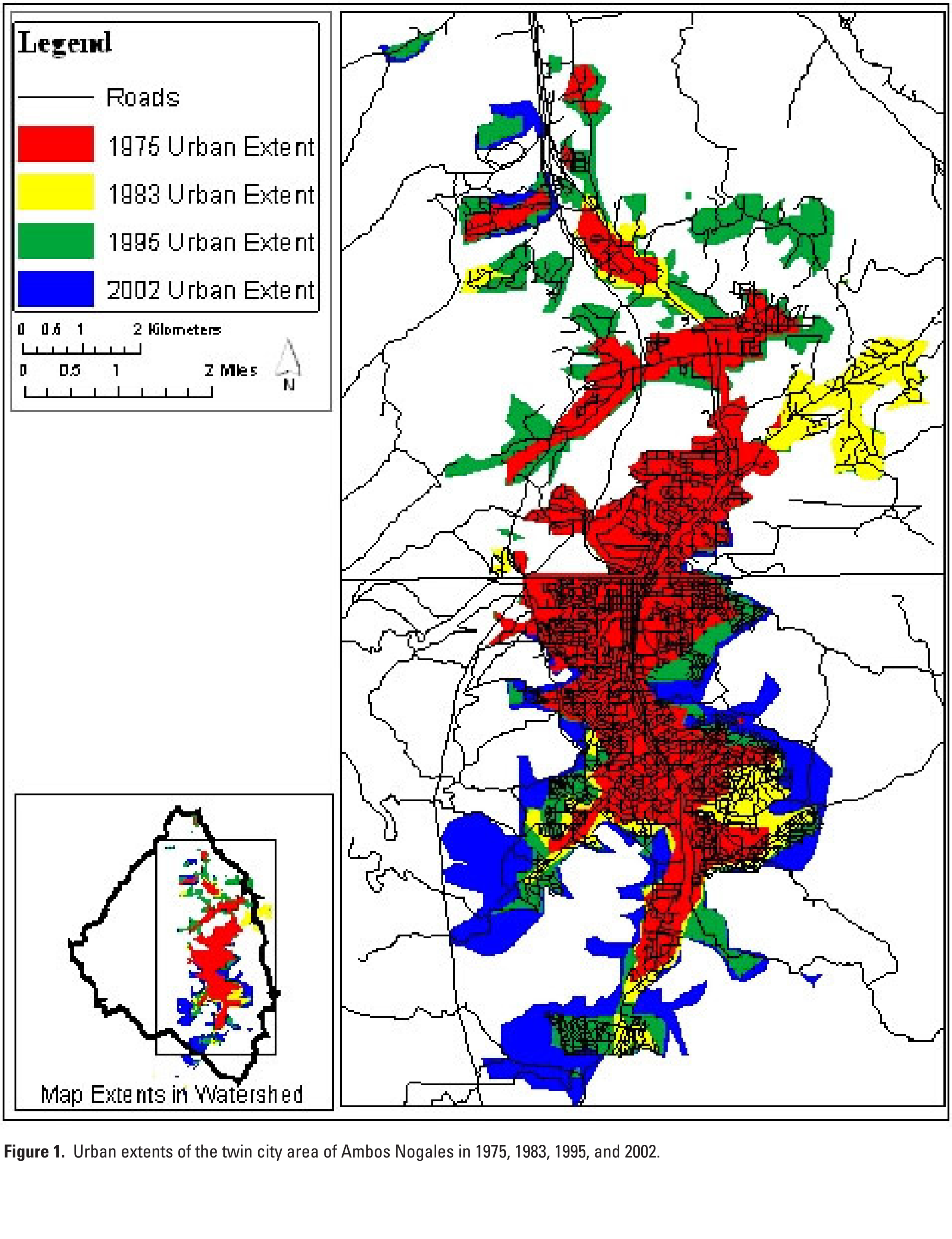

Figure 1. Urban extents of the twin city area of Ambos Nogales in 1975, 1983, 1995, and 2002.

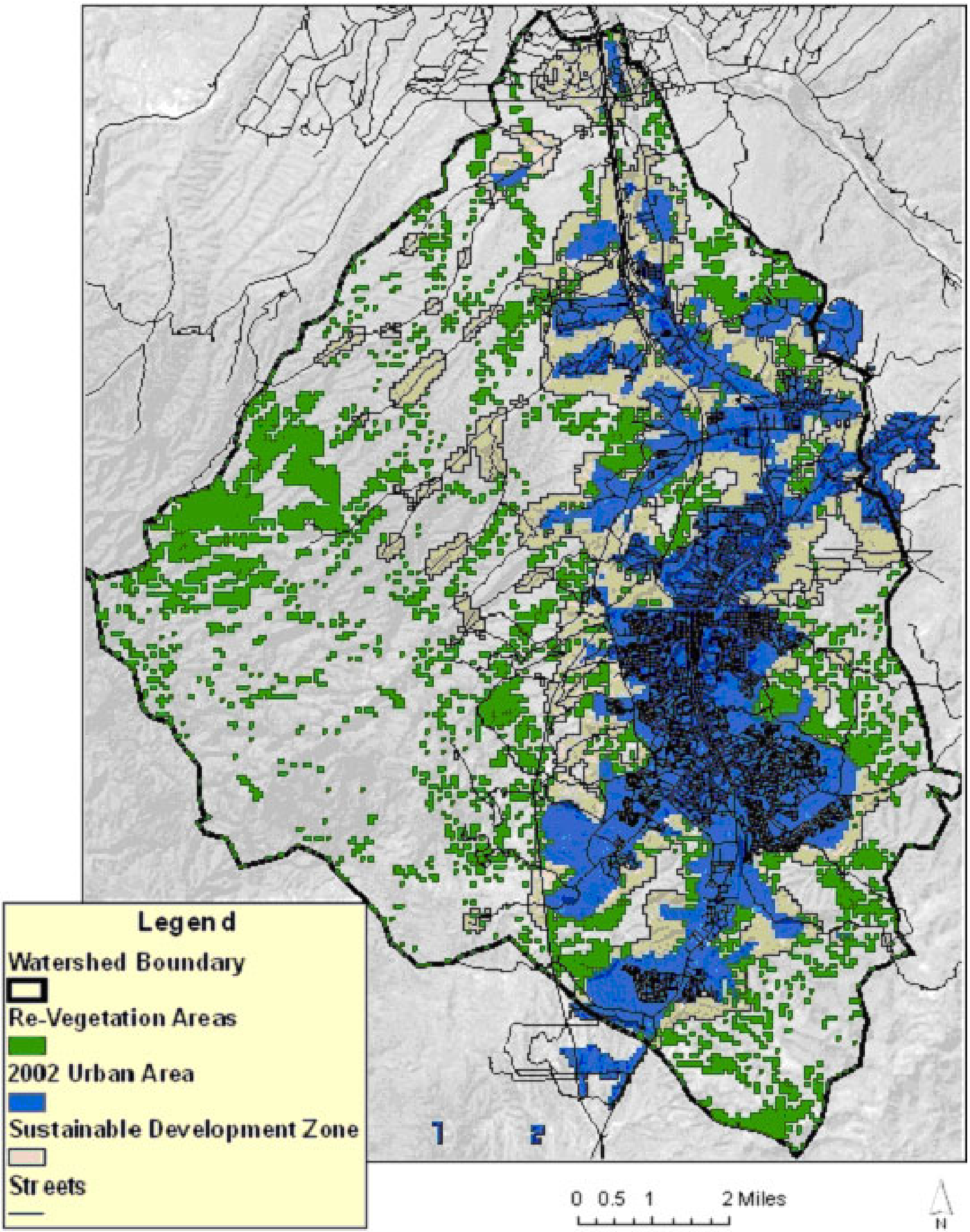

Figure 2. Sustainable development plans for Ambos Nogales Watershed based on curbed urban growth and revegetation.

This page intentionally left blank

The Potential of Binational Land-Cover-Change Detection Procedures for use Along the U.S.-Mexico Border

By Zachary D. Wilson[1] and Jean W. Parcher[1]

Land-cover change datasets provide an important contextual tool for understanding changes in water quality, hydrology, and water use over time (Lillesand and Kiefer, 2000). As important as land-cover change detection might be, the cost of producing these datasets for a large area often is prohibitive. A process developed by Michael Coan and Joyce Fry of the U.S. Geological Survey (USGS) Center for Earth Resources Observation and Science (EROS) has made the production of land-cover change datasets less costly by using aggregated land-cover data from the National Land Cover Dataset (NLCD) 1992 (USGS, 2000) and NLCD 2001 (Homer and others, 2004) as training data. The land-cover change process uses Landsat imagery from 1992 and 2001 classified at Anderson Level I, a generalized land-cover classification scheme, to produce a land-cover change dataset (Anderson and others, 1976). This process eliminates the need to collect training data in the field. The USGS U.S.-Mexico Border Environmental Health Initiative (Buckler and Strom, 2004; Buckler and Stefanov, 2004; Papoulias and others, 2006) is testing this method on one Landsat scene in the lower part of the Rio Grande/Rio Bravo (fig. 1).

Both the United States and Mexico have programs to produce land-use/land-cover (LULC) datasets by using a nationally consistent classification scheme, which can be used to create training data for use in the change-detection process. The USGS NLCD 1992 and the NLCD 2001 are based on the LULC classification system for remotely sensed data described by Anderson and others (1976). Both of these datasets are available in raster format at 30-meter resolution. In Mexico, the Instituto Nacional

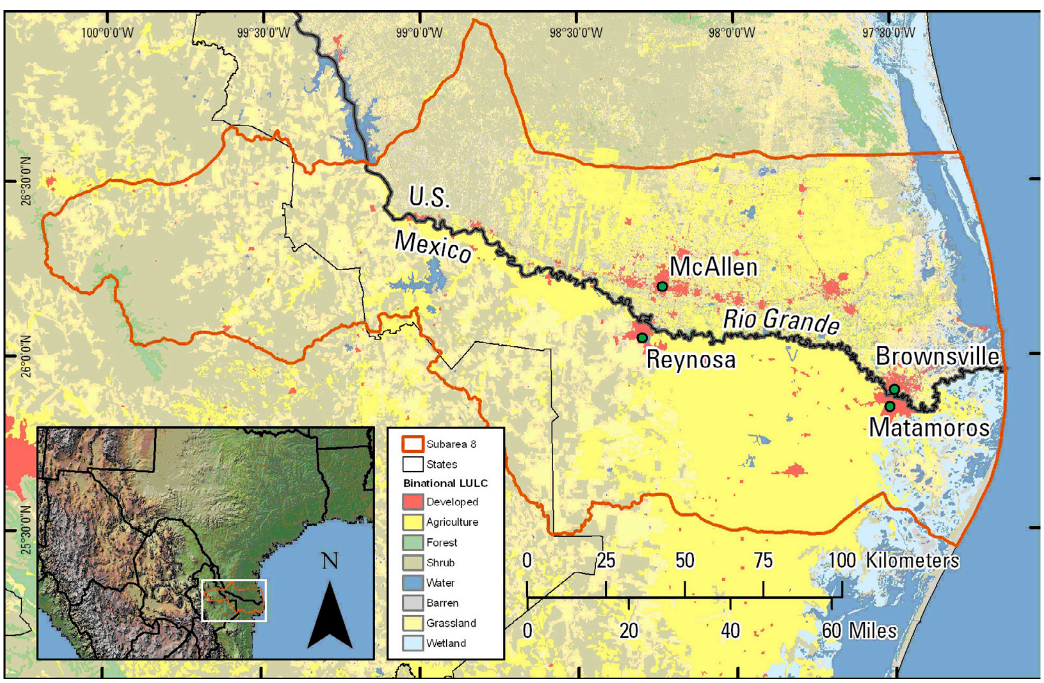

Figure 1. LULC map of the lower Rio Grande/Rio Bravo and USGS U.S.-Mexico Border Environmental Health Initiative Subarea 8.

[1]U.S. Geological Survey, 8027 Exchange Dr. MS 518, Austin, TX 78754.

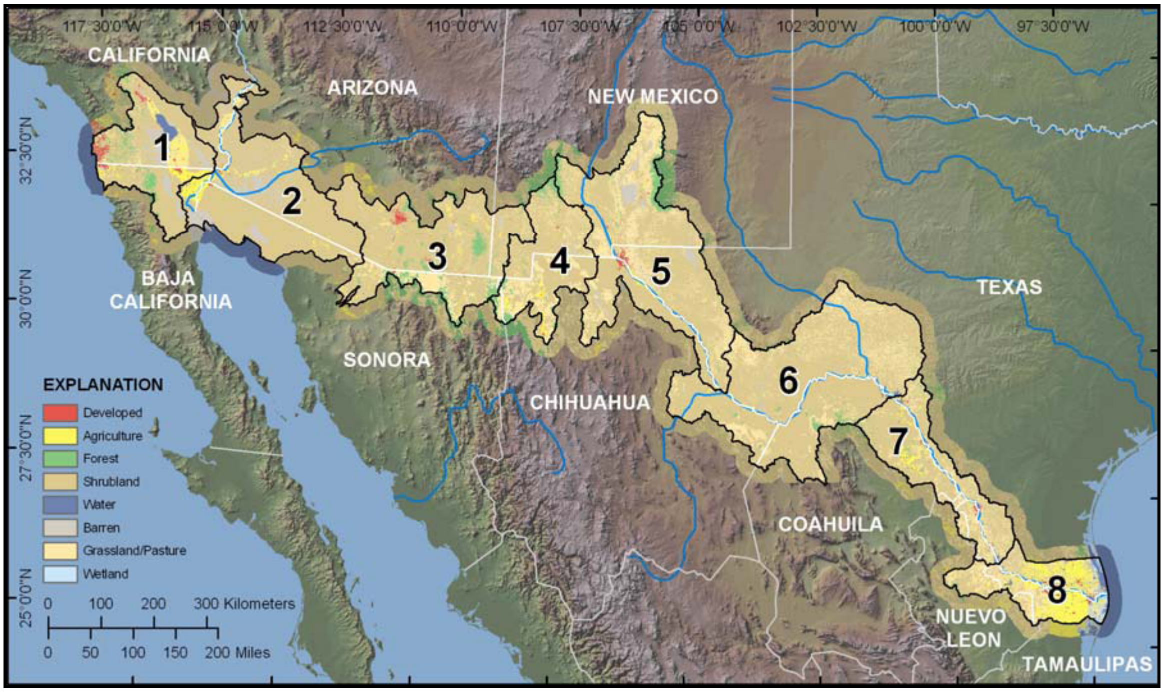

Figure 2. U.S. Geological Survey U.S.-Mexico Border Environmental Health Initiative study area boundary with subareas (Woodward and Durall, 1996) and the binationally integrated LULC dataset used for creating training points.

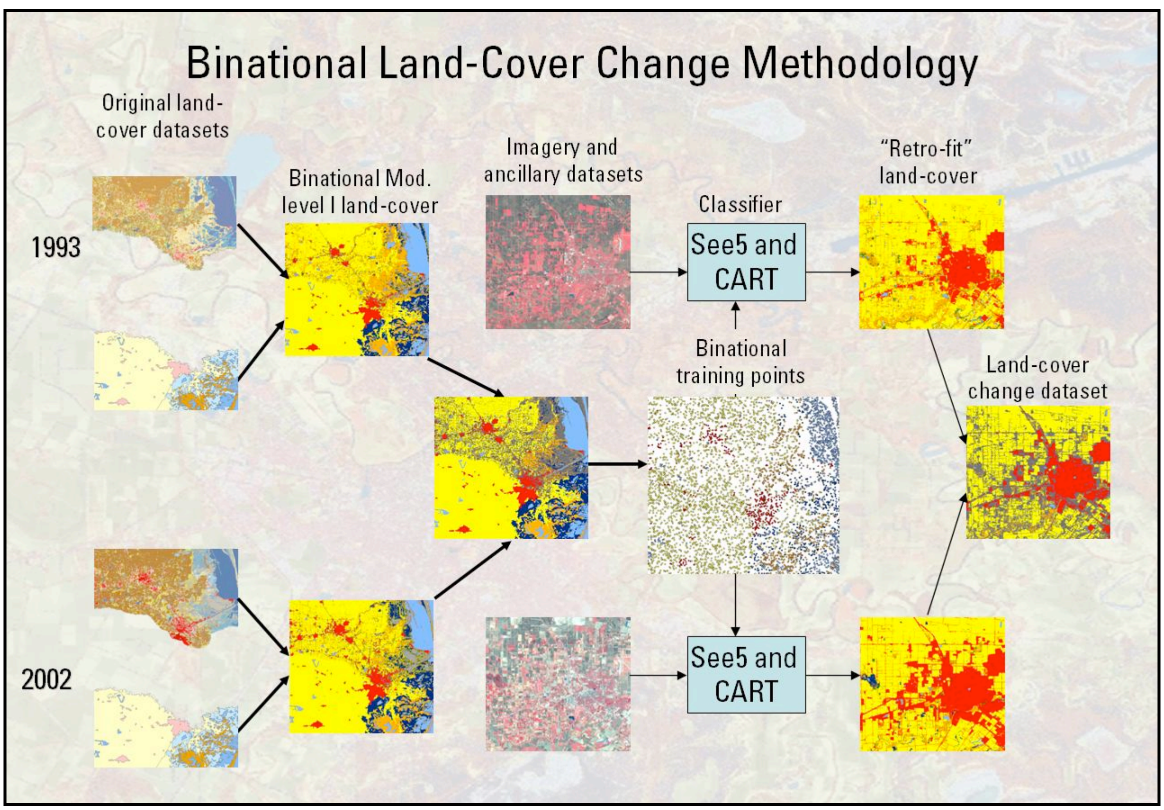

Figure 3. Binational land-cover change detection method modified from Coan and Fry (U.S. Geological Survey, written commun., 2006).

de Geografía, Estadística, e Informática (INEGI), the National Geography, Statistics, and Information Technology Institute, is responsible for mapping LULC. INEGI produces the 1:250,000-scale Mapa de Uso de Suelo y Vegetación (Land Use and Vegetation Map) based on visual interpretation of remotely sensed imagery by using unified regional-vegetation classification systems developed during the last 70 years by many scientists, including Leopold, Muller, and Rzedowski (Instituto Nacional de Estadística, Geografía, e Informática, 1993). The Mexican LULC data are available in digital vector format.

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 (fig. 2). The integrated and reclassified LULC data can then be used to create training data for the change-detection process (fig. 3) developed by Coan and Fry (U.S. Geological Survey, written commun., 2006). Preliminary results indicate that these procedures could be effective in developing binational land-cover change datasets along the entire U.S.-Mexico Border.

References

Anderson, J.R., Hardy, E.E., Roach, J.T., and Witmer, R.E., 1976, A land use and land cover classification system for use with remote sensor data: U.S. Geological Survey Professional Paper 964, [http://landcover.usgs.gov/pdf/anderson.pdf, last accessed April 10, 2007].

Buckler, D., and Stefanov, J., 2004, Internet map service for environmental health in the U.S.-Mexico border region: U.S. Geological Survey Fact Sheet 2004–3140, [http://pubs.usgs.gov/fs/2004/3140, last accessed April 10, 2007].

Buckler, D., and Strom, E., 2004, Science data in support of environmental health studies in the U.S.-Mexico border region: U.S. Geological Survey Fact Sheet 2004–3013, [http://pubs.usgs.gov/fs/2004/3013/, accessed April 10, 2007].

Homer, C., Huang, C., Yang, L., Wylie, B., and Coan, M., 2004, Development of a 2001 National Land-Cover Database for the United States: Photogrammetric Engineering and Remote Sensing v. 70, no. 7, p. 829–840, [http://www.mrlc.gov/pdfs/July_PERS.pdf, last accessed June 2, 2006].

Instituto Nacional de Estadística, Informática, e Geografía (INEGI), 1993, Guía para la interpretación de información cartográfica impresa y digital de uso de suelo: Aguascalientes, 99 p.

Lillesand, T.M, and Kiefer, R.W., 2000, Remote sensing and image interpretation (4th ed.): New York, Wiley and Sons, 724 p.

Papoulias, D., Parcher, J., Stefanov, J., and Page, W., 2006, Interdisciplinary science in support of environmental health along the United States-Mexico border: U.S. Geological Survey Fact Sheet 2006–3054, [http://pubs.usgs.gov/preview/fs/2006/3054/, last accessed April 10, 2007].

U.S. Geological Survey, 2000, National Land Cover Dataset: U.S. Geological Survey Fact Sheet 108–00, [http://erg.usgs.gov/isb/pubs/factsheets/fs10800.html, last accessed April 10, 2007].

Woodward, D.G., and Durall, R.A., 1996, United States-Mexico border area, as delineated by a shared-water resources perspective: U.S. Department of the Interior Field Coordinating Committee Fact Sheet 1, [http://www.cerc.usgs.gov/FCC/pubs/Fact_sheets/Fact_1/DOI_US-MX_Border_FCC_Fact_sheet_1.html, last accessed April 10, 2007].

This page intentionally left blank

Comparison of Contemporary Land-Cover Trends Among the Sonoran Basin and Range, Madrean Archipelago, and Chihuahuan Deserts Ecoregions

By Jana Ruhlman[1] , Leila Gass[2] , Barry Middleton[1]

The Land Cover Trends project, a joint effort between the U.S. Geological Survey and the U.S. Environmental Protection Agency (USEPA), uses satellite imagery to classify land cover and estimate contemporary (1973-2000) changes in land use and land cover in the United States. By using ecoregions defined by Omernik and the USEPA, estimates of land-cover and land-use change are derived from interpretations of a statistical sampling of image blocks from five dates of Landsat imagery. The statistical results, in conjunction with site visits, geographical research, and socioeconomic data, are used to assess regional driving forces of land-use change. The focus of this research examines and compares three adjacent southwestern ecoregions—the Sonoran Basin and Range, the Madrean Archipelago, and the Chihuahuan Deserts. Combined, these ecoregions stretch along the U.S.-Mexico border from south-central California to western Texas. The ecoregions each have their own distinct landscapes, contain high amounts of biological diversity, and share common issues that affect land use. Increased oil and gas extraction, availability of ground-water resources, and reduction of natural grasslands because of overgrazing and other desertification processes are some of the factors affecting contemporary land use in these ecoregions. By using the Land Cover Trends research and interpretation results, the rates and types of land-cover change are being compared to find similarities and contrasts among these three contiguous areas. Initial findings indicate that change is infrequent and occurs mostly within the grass/shrub, agriculture, and mining classes. A closer examination and comparison will provide a look at regional land-cover trends for the border areas of the southwest.

[1]U.S. Geological Survey, 2255 N. Gemini Drive, Flagstaff, AZ 86001.
[2]U.S. Geological Survey, 520 N. Park Ave., Tucson, AZ 85719.

This page intentionally left blank

The San Pedro River—A Case Study for Examining Past Landscape Change and Forecasting Hydrological and Biological Response to Urban Growth and Land-Use Change

William G. Kepner[1] , Kenneth G. Boykin[2] , Darius J. Semmens[1], David C. Goodrich[3] , Christopher J. Watts[4] , and D. Phillip Guertin[5]

Key Words: landscape characterization, remote sensing, geographic information systems, change detection, hydrological process models, habitat models, alternative futures, watershed assessment, San Pedro River (Arizona/Sonora).

It is currently possible to measure landscape change over large areas and determine trends in environmental condition by using advanced space-based technologies accompanied by geospatial data. During the past two decades, important

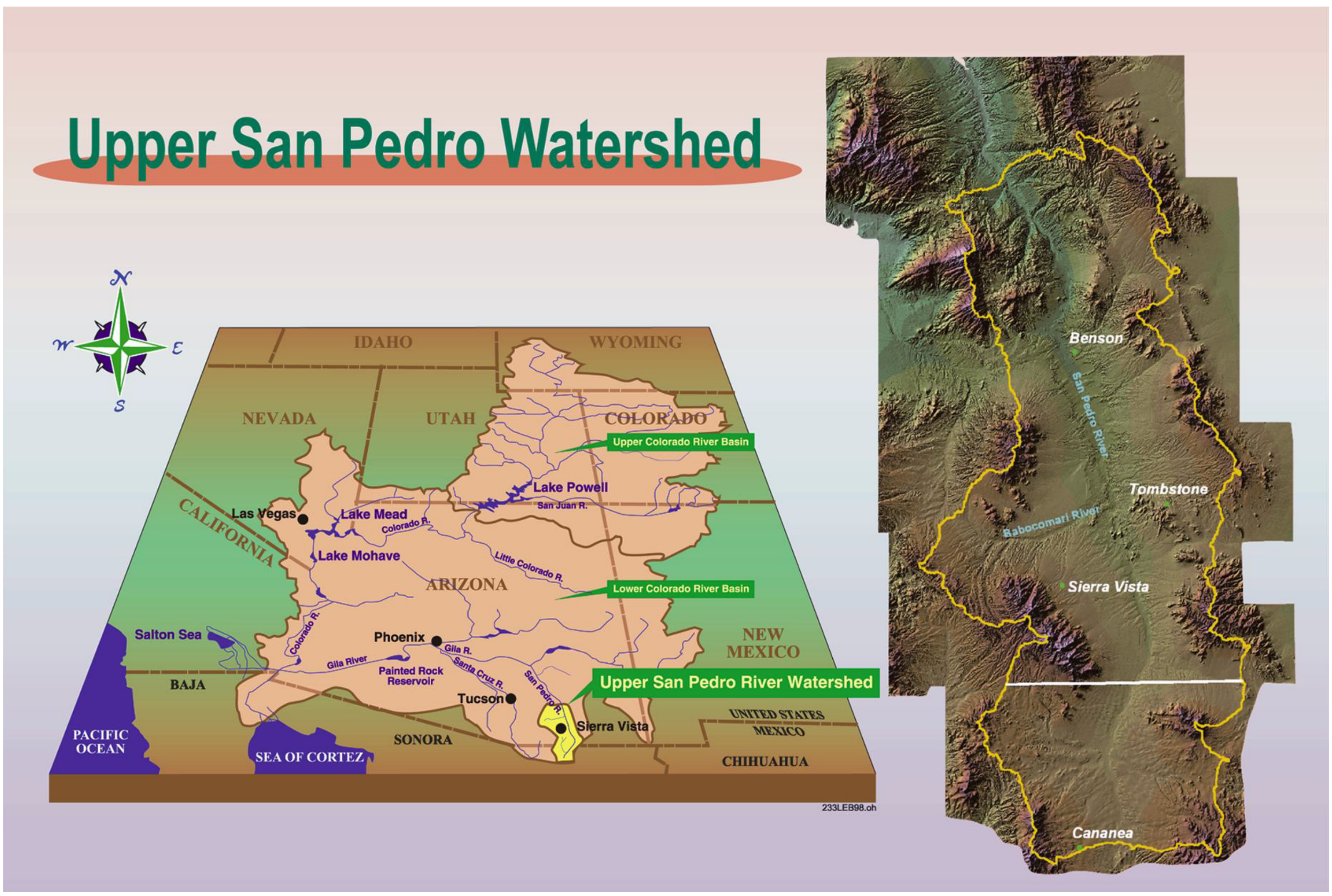

Figure 1. Upper San Pedro Watershed (U.S.-Mexico).

[1]U.S. Environmental Protection Agency, Office of Research and Development, P.O. Box 93478, Las Vegas, NV 89193.
[2]New Mexico State University, Cooperative Fish and Wildlife Research Unit, P.O. Box 30003, MSC 4901, Las Cruces, NM 88003.
[3]U.S. Department of Agriculture, Agricultural Research Service, Southwest Watershed Research Center, 2000 E. Allen Road, Tucson, AZ 85719.
[4]University of Sonora, Physics Department, Blvd., Encinas y Rosales, Hermosillo, Sonora, Mexico 83000.
[5]University of Arizona, School of Natural Resources, 325 Biological Sciences East, Tucson, AZ 85721.

advances in the integration of remote imagery, computer processing, and spatial analysis technologies have been used to develop landscape information that can be integrated within hydrologic and habitat models to determine long-term change and make predictive inferences about the future. These technologies provide the basis for developing landscape composition and pattern indicators as sensitive measures of large-scale environmental change and, thus, may provide an effective and economical method for evaluating watershed conditions related to disturbance from human and natural stresses. This case study for the upper San Pedro River (fig. 1) employs a system of land-cover maps generated from a multidate satellite-imagery database, which incorporates Landsat Multi-Spectral Scanner (MSS) imagery from the early 1970s, mid 1980s, and early 1990s and Landsat Thematic Mapper (TM) imagery from 1997 to examine change during approximately a 25-year period. Future environments were examined relative to their impact on wildlife habitat and surface-water conditions, for example, sediment yield and surface runoff. Both habitat and hydrological outputs were estimated for a baseline year (2000) and predicted twenty years into the future by using hydrological- and habitat-process models and spatially oriented land-use models based on stakeholder preferences and historical growth.

Contemporary Digital Land-Cover Mapping for the American Southwest—The Southwest Regional Gap Analysis Project

By John Lowry[1] , William G. Kepner[2] , Kenneth G. Boykin[3] , Kathryn A. Thomas[4] , Donald L. Schrupp[5] , and Pat Comer[6]

Key Words: digital land cover, remote sensing, Geographic Information Systems, CART analysis, Gap Analysis, National Vegetation Classification System, Arizona, Colorado, Nevada, New Mexico, and Utah.

The Gap Analysis Program (GAP) is a national interagency program that maps the distribution of plant communities and selected animal species and compares these distributions with land stewardship to identify "gaps" in biodiversity protec-

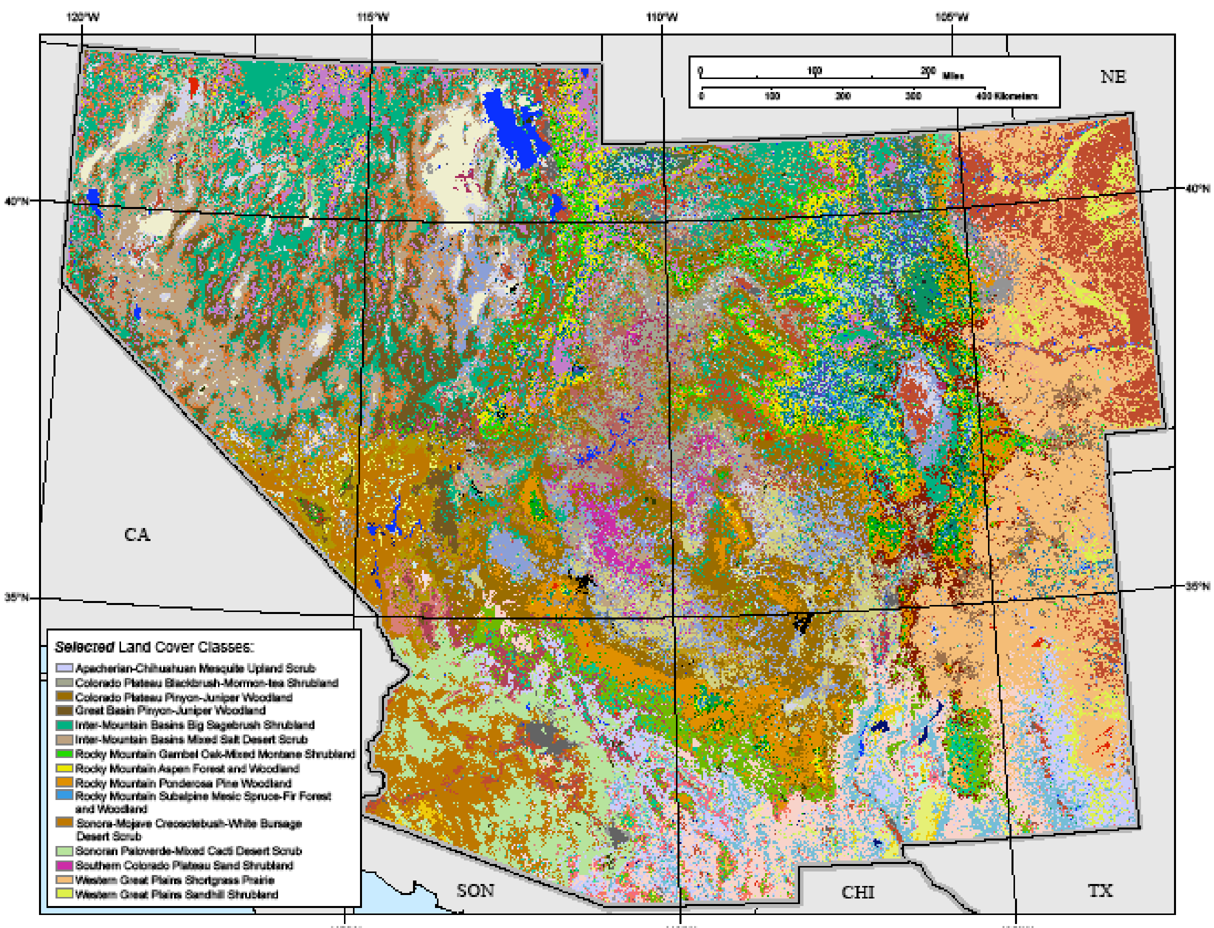

Figure 1. Southwest Regional Gap Analysis Project five-state digital land-cover map. The final map product contains 125 land-cover classes with a minimum mapping unit of 0.40 ha; only the 15 most abundant land-cover classes are depicted in the map legend.

---

[1]Utah State University, College of Natural Resources, Remote Sensing/GIS Laboratory, UMC 5275, Logan, UT 84322.
[2]U.S. Environmental Protection Agency, Office of Research and Development, P.O. Box 93478, Las Vegas, NV 89193.
[3]New Mexico State University, Cooperative Fish and Wildlife Research Unit, P.O. Box 30003, MSC 4901, Las Cruces, NM 88003.
[4]U.S. Geological Survey, Sonoran Desert Research Station, 125 Biological Sciences East, Bldg. 43, University of Arizona, Tucson, AZ 85721.
[5]Colorado Division of Wildlife, 6060 Broadway, Denver, CO 80216.
[6]NatureServe, 2060 Broadway, Ste. 230, Boulder, CO 80320.

tion. GAP uses remote satellite imagery (Landsat 7) and Geographic Information System (GIS) technology to assemble and view large amounts of biological and land-management data to identify areas where conservation efforts may not be sufficient to maintain diversity of living natural resources. Historically, GAP has been conducted by individual states. However, this has resulted in inconsistencies in mapped distributions of vegetation types and animal habitat across state lines because of differences in mapping and modeling protocols. This was further compounded from the lack of a national vegetation classification nomenclature. In response to these limitations, GAP embarked on a second-generation effort to conduct the program at a regional scale by using (1) a vegetation-classification scheme applicable across the U.S., (2) ecoregional units as the basis for segmenting the landscape into manageable units, and (3) inter-agency investigator teams with land-cover analysis and environmental-protection expertise. The program's first formalized multistate effort includes five Southwestern states (Arizona, Colorado, Nevada, New Mexico, and Utah), which comprise 535,175 square miles, or nearly one-fifth of the conterminous United States.

Multiseason satellite imagery (Landsat ETM+) from 1999 to 2001 were used in conjunction with digital elevation model (DEM) derived datasets (for example, elevation, landform, and aspect) to model natural and seminatural vegetation. Land-cover classes are drawn from NatureServe's Ecological System concept, with 109 of the 125 total classes mapped at the ecological systems level. For the majority of classes, a decision tree classifier was used to discriminate land cover types, while a minority of classes (for example, urban classes, sand dunes, and burn scars) were mapped by using other techniques. Twenty mapping areas, each characterized by similar ecological and spectral characteristics, were modeled independently of one another. These mapping areas, which included a 4-km overlap, were subsequently mosaicked to create the regional dataset (fig. 1).

This map was generated by using data from the land-cover mapping portion of the Southwest Regional Gap Analysis Project (SWReGAP). These data and related datasets are made available to the public by the SWReGAP consortium of institutions responsible for their development, and they can be obtained via download at http://earth.gis.usu.edu/swgap/landcover.html.

Stopover Ecology and Habitat Utilization of Migrating Land Birds in Colorado River Riparian Forests of Mexico and the Southwestern United States

By Charles van Riper III[1]

In western North America, migration patterns of neotropical land birds evolved within a landscape of a heterogeneous and patchy environments with no political boundaries. Western migrant land birds appear to assess migrant routes and stopover habitats at four major scales (1) genetically influenced corridor selection, (2) large-scale landscape features, (3) vegetation patches, and (4) microhabitat selection within the vegetation patch. Along the lower Colorado River in Mexico, Calif., and Ariz., these four scales are variously influenced by weather, vegetative species, structure, plant-phenology patterns, and insect-prey base. In migrating, neotropical migrant warblers that we have examined in Sonora, Mexico and Ariz., species arrival dates and numbers were variable and largely influenced by large-scale weather patterns and plant-phenology cycles. Once a microhabitat was selected, there was little movement by individual birds over the landscape during the stopover period. Therefore, stopover and bird foraging patterns were greatly influenced by plant species and phenological patterns of the selected microhabitat. Warbler species partitioned foraging habitat relative to foraging height, and they preferred native to introduced vegetation. Influences on location of warbler foraging within vegetative strata were related to abundances of foliage invertebrates that were significantly different among tree species and between native and introduced plants. Thus, it appears that large-scale landscape features, along with vegetation species, structure, phenology, abundance, and insect prey base, all play a role in structuring spring warbler migration patterns in northwest Sonora, Mexico and the southwestern U.S. along the lower Colorado River corridor.

[1]U.S. Geological Survey, SBSC Sonoron Desert Research Station, University of Arizona, Tucson, AZ 85721.

This page intentionally left blank

Salton Sea Ecosystem—Issues and Status of Restoration Planning

By Harvey L. Case, III[1] and Douglas A. Barnum[1]

Water transfers from Imperial Valley, Calif., agricultural users to urban Southern California users, and changes in flows from the Mexicali Valley, Mexico, are expected to decrease inflows to the Salton Sea. These water transfers and changes in flow will result in increased salinity and a lower lake level for the Salton Sea. The increased salinity will soon be greater than the biological tolerance of most fish and some invertebrate species and, therefore, will effect the food base for many species of migratory birds. A lowering of the lake level will also expose up to 81,000 acres of lake-bed sediments creating a potential for air-quality impacts. The State of California has prepared a draft Programmatic Environmental Report assessing eight alternative and two no-action scenarios for restoration of the Salton Sea Ecosystem ranging in cost from about $0.8 to $5.8 billion. A preferred alternative is expected to be recommended to the Legislature in 2007, and major construction is anticipated to be initiated by 2014. The Salton Sea Authority has developed a 5-year Work Plan proposing pilot projects addressing early start habitat, controlled eutrophication, preparation of a site-specific environmental impact statement, development of preliminary designs, and implementation of environmental monitoring. The U.S. Geological Survey has begun development of an integrated monitoring and assessment plan that includes objectives and metrics; retrospective analysis; data collection; data management; data analysis and assessment; reporting; and quality assurance.

[1]U.S. Geological Survey, 78401 Highway 111, Suite R, La Quinta, CA 92253.

This page intentionally left blank

Geologic Framework, Hydrologic Monitoring, and Land-Use Change in the Willcox and Douglas Basins, Southeastern Arizona

By James Callegary[1] , Kurt Schonauer[1], and Alice Konieczki[1]

The combined Willcox and Douglas Basins of southeastern Arizona along the border with Mexico are being studied as part of the Arizona Rural Watershed Initiative Program funded by the State of Arizona and managed by the Arizona Department of Water Resources. The fundamental goal of this program is to improve our understanding of the available water supply in

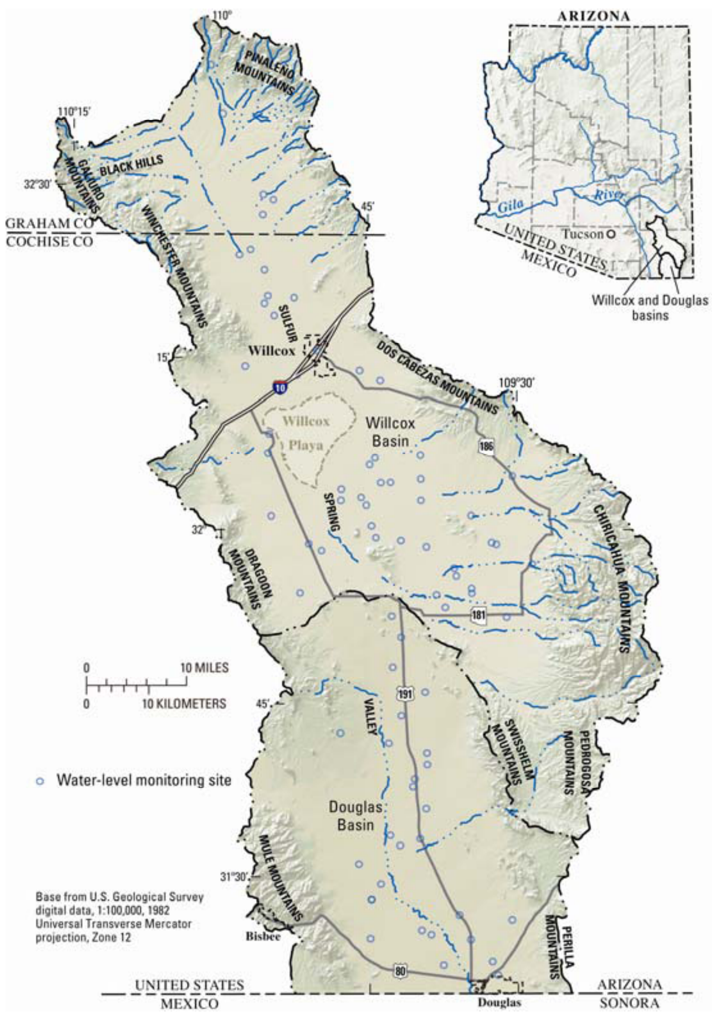

Figure 1. Map showing physiography and location of water-level monitoring sites in the Willcox and Douglas Basins, Southeastern Arizona.

---

[1]U.S. Geological Survey, Arizona Water Science Center, 520 N. Park Ave., Ste. 221, Tucson, AZ 85719.

rural Arizona. The Rural Watershed Initiative was passed by the Arizona legislature in response to increasing pressure on rural water managers to provide sustainable supplies of water despite rapid population growth and demands for environmental protection.

There are four specific objectives for the Willcox-Douglas portion of the initiative. The first objective is to assess the state of knowledge of the ground-water conditions in this region; this includes an evaluation of the existing water-level monitoring network and recommendations for improvement. The second objective is to improve knowledge of the hydrogeologic framework of the basins, including an assessment of depth to crystalline basement and an estimation of the distribution and permeability of hydrostratigraphic units. The third objective is to establish networks for monitoring subsidence and changes in ground-water storage. The fourth objective of the project is to estimate changes in the amount and distribution of water use through time.

The Willcox (4,947 km^2) and Douglas (1,942 km^2) Basins (fig. 1) are northwest-to-southeast trending basins in southeastern Arizona, stretching from southern Graham County to the U.S.-Mexico border in southern Cochise County. These basins lie within the southeastern portion of the Basin and Range geologic province.

Elevations range from about 3,300 m in the Pinaleño Mountains to about 1,190 m at the international boundary with Mexico. The basins consist of alluvial fill underlain by sedimentary and crystalline bedrock bounded by fault-block mountains. The primary aquifers are in the recent stream alluvium and basin-fill deposits. The Willcox Basin is closed, with no interbasin inflow or outflow. Historically, ground-water flow in the Willcox Basin was toward the Willcox Playa; in the Douglas Basin ground-water flow was from north to south toward the international boundary. However, ground-water flow directions have been altered by pumping, which was greater than 12 million acre-feet between 1915 and 2000 in the two basins.

The water-level monitoring network consists of 46 wells in the Willcox Basin and 27 wells in the Douglas Basin. The hydrogeologic framework of the basins is being investigated by using borehole data, gravity measurements, and ground- and air-based electromagnetic surveys. The electromagnetic surveys were done during the summer of 2006 and indicate higher electrical conductivities centering on the Willcox Playa with the subsurface becoming more electrically resistive north and south of this area. Modeling and calibration of the airborne data by using the ground-based surveys is currently being carried out. At present, gravity monuments are being installed, and a survey to study basin structure will probably be done during summer 2007. The initial gravity survey will serve as a baseline for subsequent measurements used to monitor ground-water-storage change. Earth fissures are being mapped by using both ground reconnaissance and aerial photos. Subsidence is being monitored with INSAR images. Land use and water use in the study area are primarily for agricultural purposes. Irrigated acreage has decreased by about 40 percent since 1960 (from about 28,000 to 17,400 hectares in 2006). Irrigated acreage was at a minimum during the 1980s, but increased by 25 percent between 1992 and 2002. Pumpage peaked in 1974 in both basins and then declined through the late 1980s, however, pumpage has risen since then, particularly in the Willcox Basin, from a low of 82,000 acre-ft in 1987 to 193,000 acre-ft in 2003. Pumping in the Douglas Basin has remained more stable because legislation in 1980 created the Douglas Irrigation Non-Expansion Area.

Automated Geospatial Watershed Assessment (AGWA)—A GIS-Based Hydrologic Modeling Tool for Watershed Assessment and Analysis

By D. Phillip Guertin[1] , David C. Goodrich[2] , William G. Kepner[3] , Darius J. Semmens[3], Mariano Hernandez[2], Shea Burns[2], Averill Cate[2], Lainie Levick[2], and Scott N. Miller[2]

The Automated Geospatial Watershed Assessment tool (AGWA) is a GIS interface jointly developed by the U.S. Department of Agriculture's Agricultural Research Service, the U.S. Environmental Protection Agency, the University of Arizona, and the University of Wyoming to automate the parameterization and execution of the Soil Water Assessment Tool (SWAT) and KINEmatic Runoff and EROSion (KINEROS2) hydrologic models. The application of these two models allows AGWA to conduct hydrologic modeling and watershed assessments at multiple temporal and spatial scales. AGWA's current outputs are runoff (volumes and peaks) and sediment yield from KINEROS2, and from SWAT, these runoff and sediment yield outputs and several water-quality measurements. AGWA uses commonly available GIS data layers to fully parameterize, execute, and visualize results from both SWAT and KINEROS2. Through an intuitive interface, the user selects an outlet from which AGWA delineates and discretizes the watershed by using a digital elevation model (DEM) based on the individual model requirements. The watershed model elements are then intersected with soils and land-cover data layers to derive the requisite model input parameters (fig. 1). AGWA can currently use STATSGO, SURRGO, and FAO soils and nationally available NLCD, NALC and GAP land-cover/land-use data. Users also are provided the capability to use their own land-cover/land-use data (Miller et al., 2007). The chosen model is then executed, and the results are imported back into AGWA for visualization. This allows managers to identify potential problem areas where additional monitoring can be undertaken, mitigation activities can be focused, or alternative management can be recommended. AGWA can difference results from multiple simulations to examine relative change from alternative of input scenarios (for example, climate/storm change, land-cover change, present conditions and alternative futures). The AGWA tool, originally constructed in ArcView 3.X, is being migrated to ArcGIS 9.X and an Internet-based service (Cate and others, 2006) to provide environmental decision-makers, resource managers, researchers, and user groups ready access to the applications. A variety of new capabilities have recently been incorporated into AGWA. They include handling FAO soils for international application; pre- and post-fire watershed assessments (Goodrich and others, 2005); options for user-defined land-cover change; implementation of stream-buffer zones, simulation of nitrogen and phosphorus movement; and installation of retention and detention structures. AGWA is currently being used for watershed assessment and to support watershed planning. Applications include watershed-based planning for the Arizona Department of Environmental Quality; assessing the impact of energy development in Wyoming; assessing the impacts of landscape change in New York, Arizona, Oregon and Virginia (Miller and others, 2004); and analysis of alternative futures in the San Pedro River, Arizona (Kepner and others, 2005). For more information on AGWA visit the AGWA Web site at: http://www.tucson.ars.ag.gov/agwa/.

[1]University of Arizona, School of Natural Resources, 325 Biological Sciences East, Tucson, AZ 85721.

[2] U.S. Department of Agricultural Research Service, Southwest Watershed Research Center, 2000 E. Allen Road, Tucson, AZ 85719.

[3] U.S. Environmental Protection Agency, Office of Research and Development, P.O. Box 93478, Las Vegas, NV 89193.

References

Cate, A., Jr., Goodrich, D.C., and Guertin, D.P., 2006, Integrating hydrologic models and spatial data in a distributed Internet application, in proceedings of the 3rd Federal Interagency Hydrologic Modeling Conference, Reno, NV, April 2-6, 2006, 6 p. CD ROM

Goodrich, D.C., Canfield, H.E., Burns, I.S., Semmens, D.J., Miller, S.N., Hernandez, M.,

Levick, L.R., Guertin, D.P., and Kepner, W.G., 2005, Rapid post-fire hydrologic watershed assessment using the AGWA GIS-based hydrologic modeling tool, in Moglen, G.E., ed., Proceedings of the 2005 ASCE Watershed Management Conference, July 19-22, Williamsburg, VA., 12 p., CD-ROM.

Kepner, W.G., Semmens, D.J., Bassett, S.D., Mouat, D.A., and Goodrich, D.C., 2004, Scenario analysis for the San Pedro

River, analyzing hydrological consequences of a future environment: Journal of Environmental Monitoring and Assessment v. 94, p. 115-127.

Miller, S.N., Kepner, W.G., Mehaffey, M.H., Hernandez, M., Miller, R.C., Goodrich, D.C., Devonald, F.K., Heggem, D.T., and Miller, W.P., 2002, Integrating landscape assessment and hydrologic modeling for land cover change analysis, Journal of the American Water Resources Association, v. 38, no. 4, p. 915-929.

Miller, S.N., Semmens, D.J., Goodrich, D.C., Hernandez, M., Miller, R.C., Kepner, W.G., and Guertin, D.P., 2007, The automated geospatial watershed assessment tool: Environmental Modeling and Software, v. 22, no. 3, p. 365-377.

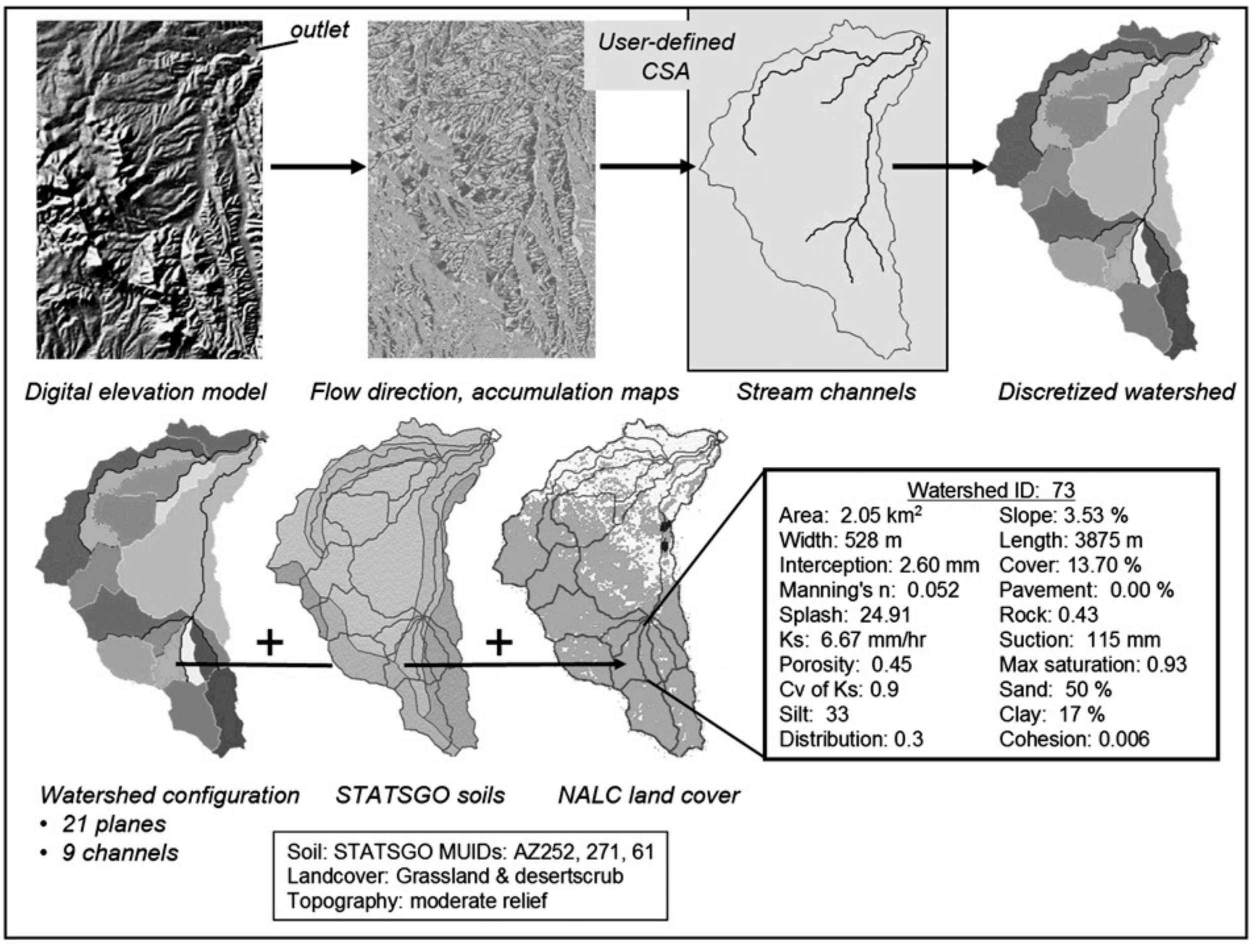

Figure 1. The transformation of topography, soils, and land-cover GIS data into KINEROS2 input parameters. A DEM is used to subdivide the watershed into upland and channel model elements, each of which are parameterized according to their soil, topographic, and land-cover characteristics.

Causes and Consequences of Monsoonal Flooding in Nogales, Sonora

By Hans Huth[1] and Dr. Craig Tinney[1]

Abstract

The effects of flooding cause premature physical deterioration to border infrastructure projects in Ambos [both] Nogales. The U.S. and Mexican communities, which make up Ambos Nogales, are in the Upper Santa Cruz River Watershed approximately 65 miles south of Tucson. Within Nogales, Sonora, the 2000 census recorded a population of 159,787 with an annual growth rate of 4.9 percent. In 2007, unofficial estimates suggest the population is closer to 300,000. The rapid growth of industry and population in Mexico's northern-border region has put increased pressures on State and municipal governments to provide effective and efficient public services, particularly in the area of potable water and wastewater infrastructure. Capacity issues are further compounded by encroachment of population and transportation routes on the floodplains and drainages of Nogales Wash and its tributaries. The resulting channelization concentrates flows during periods of heavy monsoonal precipitation. These flows erode loose alluvial sediments and disturbed soils along the banks of washes. Entrainment of alluvial sediments impacts wastewater infrastructure buried within washes with excessive infiltration. Impacted infrastructure generates sanitary-sewer overflows and potential disease vectors for the populations of Ambos Nogales. The U.S. Environmental Protection Agency (USEPA) has awarded Border Environment (BEIF) grants to Ambos Nogales for projects that include the rehabilitation, upgrade, and construction of wastewater-infrastructure facilities in these communities. For the projects to be successful and sustainable, Nogales, Sonora, needs to consider appropriate watershed management and land-use practices. The EPA Border 2012 Program is one venue that may provide funding to assist with this recommendation.

Hydrologic Setting

Nogales Wash is the main drainage conveyance for Ambos Nogales watershed. Based on data collected from the Mexican Federal Department of Geography and Statistics (INEGI), the Sonoran half of the Nogales Wash watershed encompasses an area of 68 km^2; an average slope of 13 percent; and a min/max elevation of 3,800 and 5,400 ft. The upper end of Nogales Wash is in Mexico and is fed by lateral tributaries, with the most significant being El Tecnologico on the west. Nogales Wash runs perennially from Sonora to Arizona with a baseflow of 2-3 cfs, much of which is supplemented by potable- and wastewater-infrastructure leaks in Sonora.

Consequences of Monsoonal Flooding

The main wastewater interceptor serving Nogales, Sonora, is constructed in the Nogales Wash streambed without anchoring structures. Large runoff events caused by monsoonal precipitation dislodge pipe joints, and the pipes fill with sand. Most of the broken pipelines are in the main interceptor within Nogales Wash; discharges are caused by breaks in the interceptor and subsequent downstream sand obstructions. Finer sediments impact the operation and maintenance of the Nogales International Wastewater Treatment Plant in Rio Rico, Ariz.

Wastewater infrastructure follows a pattern of unplanned development in the upper watershed. During periods of heavy precipitation, sand and other obstructions may be introduced into subcollectors, which run along streets and lateral washes. Heavier sediments settle out in the conveyance where slopes flatten usually near or within the main interceptor. Obstructions manifest as sanitary-sewer overflows (SSOs) which introduce raw sewage into washes and streets. The Nogales, Sonora Wastewater Utility (OOMAPAS-NS) works throughout the city to implement repairs to impacted infrastructure (fig. 1).

OOMAPAS-NS also disinfects SSOs that enter the wash with chlorine provided by the U.S. International Boundary and Water Commission (US-IBWC). The US-IBWC claims to have spent more than $90,000 during FY05-06 for disinfection of the wash by OOMAPAS-NS staff. Records collected by the Arizona Department of Environmental Quality (ADEQ) Border Team Hydrologist suggest that Nogales Wash was dosed with 29 tons of chlorine in 2005.

During September 2006, Nogales Wash experienced extreme runoff contaminated with raw wastewater. There were many small breaks in the collection system, but the most significant concern is the Ruiz Cortinez subcollector that conveys wastewater for the entire east side of the city. During a visit by

[1]Arizona Department of Environmental Quality, 400 W. Congress, Ste. 433, Tucson, AZ 85701.

ADEQ on September 11, 2006, the ADEQ Border Team Engineer witnessed more than 1,000 ft of this collector impacted by sediment (fig. 2). The specific site was 5 km south of the border within Nogales Wash. Although this site does not sustain flow to the border, it does add to the contaminate loading of the wash. In September 2006, the US-IBWC reported flow rates within the wash ranging from 9 to 11 ft^3/s, or 5.8 to 7.1 million gal/d. Fecal coliform contamination ranged from nondetect to a high of more than 2.2 million cfu. The most frequent fecal coliform contamination level is in the 200–2000 cfu range. In ADEQ's draft 2006 section 303-d report, Nogales Wash, just north of the border, is listed as impaired for fecal coliform and copper.

Mitigation of Monsoonal Flooding

Binational plans made in the late 1990s relied on Nogales, Sonora, wastewater projects to alleviate the large uncontrolled, raw-wastewater flows that cross the border into Arizona via Nogales Wash. The projects are funded through BEIF grants on a 50-50 percent match of U.S. and Mexican funds. Although the U.S.-funded projects do remove some of the wastewater lines from precarious areas, the Mexican-funded portions of the rehabilitation may not in many cases. Consequently, the integrity of the BEIF projects as a solution to the long-term contamination of transboundary water flows may be compromised through weak-link areas in the wash that are impacted by high stream-flow events. For this reason, development of appropriate land-use, watershed-management, and flood-attenuation plans are critical.

In September 2006, the USEPA suggested that the Border 2012 Water Task Force solicit proposals for physical projects that might assist Nogales, Sonora, in mitigating monsoonal flooding. One proposal involves healing the slopes of washes through engineered sediment-check dams or Rosgen water-retention features. In order to better understand where projects might be realized, ADEQ initiated a photographic survey of Nogales Wash and its tributaries. Site selection for the survey was based on the extraction of stream-order vectors and subwatershed polygons by using INEGI elevation data (fig. 3). These data were converted to a Google Earth KMZ file so that hydrography might be superimposed on aerial photographs. Sites were then selected for photo documentation based on the locations of major tributaries, disturbed soils, and the ranking of subwatershed areas. Respective locations were exported to a global positioning system (GPS) for navigation in the field.

Between September 23, 2006 and March 21, 2007, the Border Team Hydrologist collected more than 200 photographs tied to more than 50 locations throughout the watershed. Photograph attributes were then exported to a geodatabase for analysis. The survey documented significant encroachment of populations on the floodplain of Nogales Wash and its major tributaries at lower elevations (fig. 4), and the conversion of tributaries to paved and unpaved roads. This has encouraged downcutting and channelization of drainage features. During periods of heavy rainfall, channelization results in concentrated flows which erode loose sediments along the banks of washes (fig. 5). Given the political challenges posed by established populations and transportation vectors within these areas, stabilization of loose alluvial materials appears to be the best alternative along Nogales Wash and the lower elevations of its tributaries.

Floodplain encroachment is not as significant at higher elevations. One example is the large subwatershed on the western side of the basin (fig. 3, subwatershed 17). This subwatershed has an average slope of 15 percent and drains an area of 7.29 km^2 into a large stock tank known as "La Represa". The stock tank frequently overflows into El Tecnologico Wash, an important tributary to Nogales Wash. Similar to Nogales Wash, El Tecnologico suffers from sediment deposition in wastewater infrastructure (fig. 5). Given the lack of development within this subwatershed, this area offers unique opportunities to pursue flow-attenuation projects (for example, check dams and/or Rosgen features) to help offset flooding and increase infiltration.

The EPA Border 2012 Water Task Force has identified Nogales Wash as a priority and is seeking proposals for physical projects that can help offset impacts of monsoonal flooding and sediment deposition within the infrastructure. If you'd like more information, please contact the USEPA liaison for the Water Task Force, Doug Liden (Liden.Douglas@epamail.epa.gov), or the ADEQ liaison, Hans Huth (huth.hans@azdeq.gov). Additional information on the EPA Border 2012 Program can be found at http://www.epa.gov/usmexicoborder/.

Figure 1. OOMAPAS-NS maintenance crew addressing impacted infrastructure in Nogales Wash.

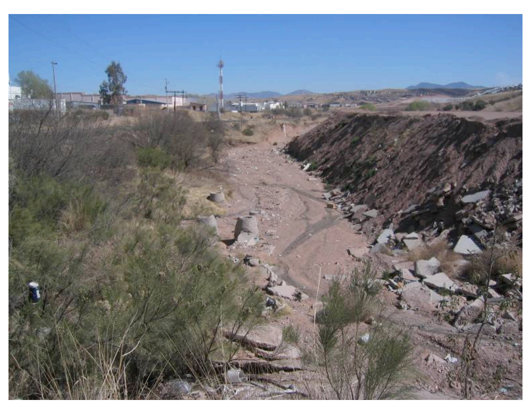

Figure 2. Nogales Wash showing sediment source on right bank and manholes in the channel bottom.

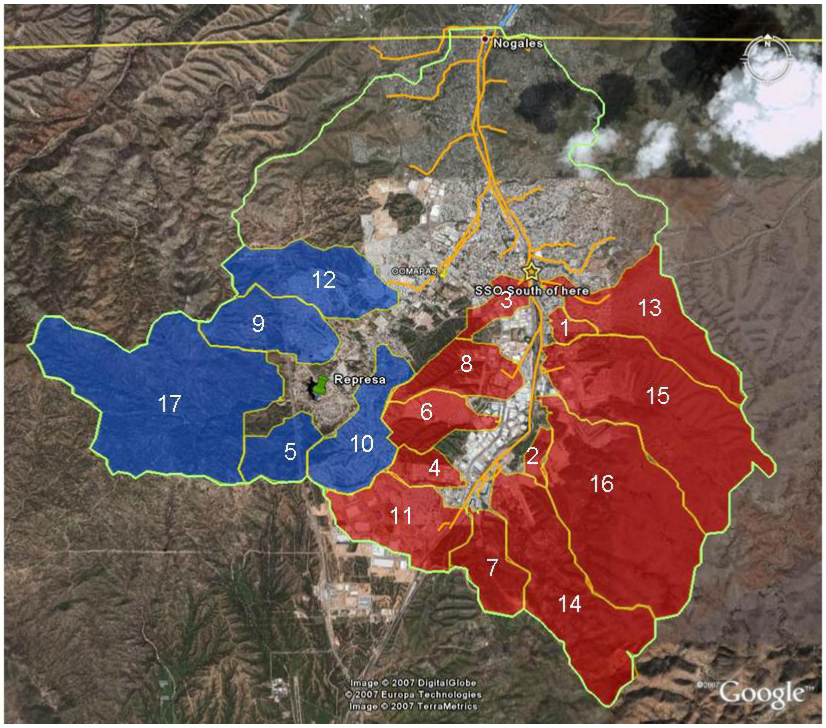

Figure 3. Subwatershed delineations extracted from Mexican Federal Department of Geography and Statistics (INEGI) elevation data. Numbers represent drainage area rankings. Red and blue indicate east and west subwatersheds, respectively.

Figure 4. Floodplain encroachment and channelization (Colonia Virreyes).

Figure 5. Overflow from La Represa erodes soft sediments which impact El Tecnologico wash.

This page intentionally left blank

Sustainability of Water Resources in the Sierra Vista Subwatershed, Arizona—Implications of a Cross-Boundary Aquifer

By James M. Leenhouts[1] and Bruce Gungle[1]

The Upper San Pedro Basin (USPB) is a ground-water system that extends approximately from the Sierra Mariquita and Sierra Los Ajos mountains in Mexico through the U.S.-Mexico international boundary to a bedrock constriction called "the Narrows" about 11 miles north of Benson, Ariz. The Sierra Vista subwatershed is a surface-water unit within the USPB that is bounded on the west by the Huachuca Mountains and on the east by the Mule Mountains and Tombstone Hills. The southern boundary of the Sierra Vista subwatershed is the international boundary with Mexico, and the northern boundary is a watershed divide across the USPB which intersects the river at the gaging station near Tombstone, about 1.5 miles downstream from the town of Fairbank. The area within these bounds includes an alluvium-filled valley with primarily erosional surfaces that slope from the base of the mountains to the San Pedro River, which flows north out of Mexico through the center of the valley. The basin's alluvial sediments constitute the Sierra Vista subwatershed's regional aquifer.

Ground water is the primary source of water for the residents of the Sierra Vista subwatershed, which includes Fort Huachuca, Bisbee, Sierra Vista, Huachuca City, and Tombstone, Ariz., and for the rural residents of the subwatershed. Ground water also sustains the base flow of the San Pedro River and supplies an important component of use by the associated riparian ecosystem, formally protected through an act of Congress as the San Pedro Riparian National Conservation Area (SPRNCA). Water outflow from the Sierra Vista subwatershed, including water withdrawn by pumping, exceeds natural inflow to the regional aquifer within the Sierra Vista subwatershed (U.S. Department of Interior, 2005). As a result, ground-water levels in parts of the Sierra Vista subwatershed are declining, and ground-water storage is being depleted. In the absence of effective management measures, the continued decline of water levels and associated depletion of storage will eventually diminish ground-water flow to the San Pedro River and to riparian vegetation.

Historically, the USPB has been treated as though a hydrologic boundary existed at the U.S.-Mexico boundary; ground-water models and management plans generally have a boundary near the border. The portion of the basin in Mexico was treated as a "black box", about which little was known, and from which an estimated and invariant volume of water crossed into the U.S. Recent efforts, including a recently completed USGS flow model, have extended the upstream boundary to hydrologically significant locations in Mexico.

Inclusion of the Mexican portion of the system into hydrologic analysis has resulted in an improved understanding of the available data and of what information is lacking. Most of the information used to construct the extent and distribution of hydrologic units in the Mexican portion of the system came from three sources (1) a hydrologic report (Consultores en Agua Subterranea S.A. por Mexicana de Cananea, S.A. de C.V., 2000) that provided ground-water hydrographs, well logs, and general hydrogeologic information, (2) a model published as a thesis (Esparza, 2002) that provided the best information available regarding ground-water withdrawals, and (3) a variety of geological and geophysical investigations by USGS scientists that provided information to better delineate the hydrogeologic framework. These documents allowed delineation of the aquifer and hydraulic properties; however, the part of the aquifer on the Mexican side of the USPB is less well defined than in the U.S. For example, well logs helped define the subsurface lithology, but were insufficient for subdividing the aquifer into the multiple units that are defined in the U.S. As a result of these and other uncertainties, the new ground-water model included 5 layers on the U.S. side, but only two layers on the Mexico side. Additional data in the form of well logs and further geophysical analysis would help to better describe the hydrogeology of the portion of the basin on the Mexican side. Even certain basic issues, such as where mine water is pumped and released in Mexico, are not fully understood. In addition, little information is available regarding the status of the San Pedro River and riparian system in Mexico.

The analysis of the USPB as a continuous hydrologic system has had the effect of increasing the awareness of decision makers in the Sierra Vista subwatershed about the interconnectedness of the hydrologic system and how upstream changes in Mexico might affect management decisions in the U.S. Key to that appreciation was the realization of the significant magnitude of pumping that is occurring in the Mexican portion of the basin, owing in large part to mining near Cananea. Net ground-water withdrawal in 2002 was 37,400 acre-feet, of which 21,800 acre-feet was in Mexico and 15,500 acre-feet was in the United States.

[1]U.S. Geological Survey, Arizona Water Science Center, 520 N. Park Ave., Ste. 221, Tucson, AZ 85719.

References Cited

Consultores en Agua Subterranea S.A. por Mexicana de Cananea, S.A. de C.V., 2000, Actualizacion del estudio geohidrologico de las cuencas del Rio San Pedro y norte del Rio Sonora en Cananea, Son., 136 p., 5 appendixes.

Esparza, Jose Guillermo De Aguinaga Ruiz, 2002, Modelacion geohydrologica del aquifero del Rio San Pedro: Sonora, Mexico, Universidad De Sonora, Hermisillo, Professional thesis in Geology.

U.S. Department of Interior, 2005, Water management of the regional aquifer in the Sierra Vista Subwatershed, Arizona—2004 Report to Congress, 41 p.

Front-Row View of Federal Water Lawmaking Shows Process Works—U.S.-Mexico Transboundary Aquifer Assessment Act Pondered, Passed, and Signed

By Sharon B. Megdal[1]

Otto von Bismarck reportedly once said, “Laws are like sausages, it is better not to see them being made.” I am not sure what to make of this remark since law making, not sausage making, is my interest. It is an interest that recently broadened when I had the privilege of testifying before the Water and Power Subcommittee of the House Resources Committee on the United States-Mexico Transboundary Aquifer Assessment Act. This bill, numbered S 214 in the Senate and HR 469 in the House, gained final approval in the wee hours of the 109th Congress and was signed by the President on December 22, 2006. My previous involvement in law making had been at the state level.

The program’s purpose is to provide State, National and local officials with information to address pressing water-resource challenges in the U.S.-Mexico border region. As finalized, the act authorizes the Secretary of the Interior, through the U.S. Geologic Survey (USGS), to collaborate with the states of Arizona, New Mexico, and Texas, the country of Mexico, and others to conduct hydrologic characterization, mapping, and assessments of priority transboundary aquifers. For Arizona, the two priority transboundary aquifers established in the legislation are the Santa Cruz River Valley and San Pedro aquifers. The program is authorized for ten years.

Working on obtaining Congressional approval of this bill was a learning experience. I had once provided written testimony to a Congressional subcommittee, but I had not previously had the opportunity to provide oral testimony.

Acting USGS director Patrick Lahey and I were the only witnesses. Some unexpected, tough questions came up at the hearing regarding the bill’s connection to the Colorado River and the treaty with Mexico. The Subcommittee chairman held the bill to allow additional comments. Through the assistance of staff to Senators Kyl and Bingaman amendments to address multiple concerns with the bill’s language were developed.

In contrast to sausage making, which must be a very messy business, I was participating in a carefully crafted lawmaking process involving compromise and clarification to achieve agreement and support.

As a witness on the bill, I first provided written testimony and then was given a few minutes to present oral remarks at the hearing. The oral remarks were not expected to be the same as the written testimony. I emphasized the importance of the bill by making the following points.

I testified that the transboundary aquifer assessment program will assist Federal, State, and local officials address critical water-resource challenges in the U.S.-Mexico border region. The act will build the scientific foundation for addressing daunting and acute water-resource issues. The program also will serve as a catalyst, bringing together the human capital and financial resources necessary to characterize transboundary aquifers. The resulting increased understanding should help resolve many of the currently unquantified and, therefore, unresolved water-resource issues.

I emphasized the importance of water to the growing, arid Southwest, especially along the border where population continues to grow rapidly on both sides. Water-resource issues become more complex and acute along the shared border where understanding aquifer characteristics is critical to the human health and economic vitality of this region. Along the border many and varied interests need to cooperate and participate to address water issues.

I told how the modeling and data base developed as part of the program will address important water-quantity questions including those associated with salinity and toxins. Further complicating border water issues are the different water-quality standards and the physical relationship between surface water and subsurface flows associated with transboundary aquifers that raise special challenges.

I informed the committee that the need for additional scientific information on water resources is well recognized. For example, in fall 2004, the 85th Arizona Town Hall concluded that “[to] avoid crisis management, Arizona must engage in long-term planning based on good science and data collection that should be made widely available throughout the state.” Town Hall participants called for sound science and data, as well as the dissemination of the information to avoid crisis. The program authorized by the bill envisions the partnerships necessary to accomplish these tasks.

[1]The Water Resources Research Center, The University of Arizona, 350 North Campbell Ave., Tucson, AZ 85719.

I noted the widespread support for the bill from governmental and non-governmental entities. In addition, a 2005 U.S.-Mexico Border Governors Conference declaration emphasized the importance of the program by calling for a collaborative work program that includes "the permanent exchange of data and information regarding surface and ground water along the border…".

Passage of the act demonstrated once again that water-policy making is a bi-partisan exercise. All recognize the need for sound information to develop good water policies to ensure needed water supplies to accommodate the rapid growth of the border regions. Funding for this newly authorized program is needed, and the hard work of obtaining Federal appropriations now begins.

The University of Arizona's Water Resources Research Center and its sister centers in New Mexico and Texas are expected to work closely with the USGS and collaborators on developing this program. I thank those who helped us get this far and look forward to working on implementing this legislation .

More information on the history of the act and its final language can be found at the Library of Congress Web site, http://www.thomas.loc.gov.

The above is based on Sharon Megdal's column that appeared in the Water Resource Research Center's bi-monthly newsletter, Arizona Water Resource, January-February 2007.

Appendixes

Appendix 1—List of Participants

- Aggers, Lee, U.S. Geological Survey, Denver, Colo.
- Allison, Lee, Director, Arizona Geological Survey, Tucson, Ariz.
- Austin, Diane, University of Arizona, Bureau of Applied Research in Anthropology, Tucson, Ariz.
- Benjamin, Susan, Chief, U.S. Geological Survey, Western Geographic Science Center, Menlo Park, Calif.
- Berry, Margaret E., Geologist, U.S. Geological Survey, Lakewood, Colo.
- Betancourt, Julio, U.S. Geological Survey, Tucson, Ariz.
- Browning, Dawn, University of Arizona, School of Natural Resources, Tucson, Ariz.
- Callegary, James B., Hydrologist, U.S. Geological Survey, Arizona Water Science Center, Tucson, Ariz.
- Case, Harvey Lee, Biologist, U.S. Geological Survey, La Quinta, Calif.
- Chavez, Pat, Physical Scientist, U.S. Geological Survey, Southwest Geographic Science Team, Flagstaff, Ariz.
- Chesley, John, University of Arizona, Department of Geosciences, Tucson, Ariz.
- Crow, Michelle, Representative, Office of Congressman Grijalva, Tucson, Ariz.
- Donelson, Angela, University of Arizona, Department of Geography, Tucson, Ariz.
- Dos Santos, Plácido, Arizona Water Institute–Arizona Department of Water Resources (ADWR), Phoenix, Ariz.
- Eastoe, Chris, University of Arizona, Department Geosciences, Tucson, Ariz.
- Felger, Tracey J., U.S. Geological Survey, Flagstaff, Ariz.
- Folger, Helen W., Geologist, U.S. Geological Survey, Reston, Va.
- Garate, Don, Tumacacori National Historical Park, Tubac, Ariz.
- Gass, Leila, Physical Scientist, U.S. Geological Survey, Southwest Geographic Science Team, Tucson, Ariz.
- Gordon, Leslie C., Geologist/Public Affairs Specialist, U.S. Geological Survey, Menlo Park, Calif.
- Gray, Floyd, Geologist, U.S. Geological Survey, Tucson, Ariz.
- Guertin, D. Phillip, University of Arizona, School of Natural Resources, Tucson, Ariz.
- Gungle, Bruce, Hydrologist, U.S. Geological Survey, Arizona Water Science Center, Tucson, Ariz.
- Heist, Bruce, National Park Service, Colo.
- Hirsch, Derrick D., Staff Scientist, U.S. Geological Survey, Office of the Western Regional Geologist, Flagstaff, Ariz.
- Hoffmann, John P., Assistant Director, U.S. Geological Survey, Arizona Water Science Center, Tucson, Ariz.
- Huth, Hans, Border Programs Coordinator, Arizona Department of Environmental Quality (ADEQ), Tucson, Ariz.
- Joseph, Bob, Director, U.S. Geological Survey, Texas Water Science Center, Austin, Tex.
- Kepner, William G., U.S. Environmental Protection Agency, Las Vegas, Nev.
- Leenhouts, James M., Hydrologist, U.S. Geological Survey, Arizona Water Science Center, Tucson, Ariz.
- Light, John, U.S. International Boundary Water Commission Nogales Project, Rio Rico, Ariz.
- Little, Tamarack, Representative, Congresswoman Gabrielle Giffords, Tucson, Ariz.
- Malmon, Daniel V., Geologist, U.S. Geological Survey, Menlo Park, Calif.
- Megdal, Sharon, Director, University of Arizona, Water Resources Research Center, Tucson, Ariz.
- Melchler, Nick, Director, U.S. Geological Survey, Arizona Water Science Center, Tucson, Ariz.
- Menges, Chris, Geologist, U.S. Geological Survey, Tucson, Ariz.
- Moring, J. Bruce, Biologist, U.S. Geological Survey, Austin, Tex.
- Norman, Laura M., Physical Scientist, U.S. Geological Survey, Southwest Geographic Science Team, Tucson, Ariz.
- Page, Ric, Geologist, U.S. Geological Survey, Denver, Colo.
- Papoulias, Diana, Biologist, U.S. Geological Survey, Columbia, Mo.
- Parcher, Jean, Geographer, U.S. Geological Survey, US-Mexico Border Research, Austin, Tex.
- Pfeifer, Edwin, Chief, U.S. Geological Survey, Southwest Geographic Science Team, Tucson, Ariz.
- Ruhlman, Jana, Geographer, U.S. Geological Survey, Southwest Geographic Science Team, Flagstaff, Ariz.
- Sass, Sherry, Friends of the Santa Cruz River, Tubac, Ariz.
- Schwalbe, Cecil, Biologist, U.S. Geological Survey, Tucson, Ariz.
- Stefanov, Jim, Deputy Director, U.S. Geological Survey, Texas Water Science Center, Austin, Tex.
- Updike, Randy, Central Regional Geologist, U.S. Geological Survey, Denver, Colo.
- van Riper, Charles, Biologist, U.S. Geological Survey, Tucson, Ariz.
- Varady, Bob, University of Arizona, Udall Center, Tucson, Ariz.
- Ward, A. Wesley, Western Regional Geologist, U.S. Geological Survey, Tucson, Ariz.
- Woosley, Lloyd, Chief Supv. Hydrologist, U.S. Geological Survey, Reston, Va.

Appendix 2—Workshop Agenda

Facing Tomorrow's Challenges Along the U.S.-Mexico Border:

Monitoring, Modeling, and Forecasting Change within the Arizona-Sonora Transboundary Watersheds

A Workshop to Develop a Research Pilot Project in Earth and Life Science

March 20-22, 2007

JW Marriott Starr Pass Resort & Spa, 3800 W Starr Pass Blvd, Tucson, Arizona

Tuesday, March 20, 2007
08:00 a.m. **Registration/Poster Session Set up**

09:00 – 09:45 a.m. **Introductions, Overview, and Objectives: Accomplishments, Desires, Internal/External perspectives**

- "Welcome"—Wes Ward, Western Regional Geologist, US Geological Survey
- "Overview of the DOI US-Mexico Field Coordinating Committee" –Diana Papoulias, FCC Chairperson, Fish Biologist, Research, US Geological Survey
- "Status of the U.S.-Mexico Border Health Initiative" –Jim Stefanov, Deputy Director, Investigations and Research, USGS Texas Water Science Center

09:45 – 10:30 a.m. **Theme Session I: Surficial and Bedrock Materials, Resources, and Hazards**

1. "Geologic Framework, Hydrologic Monitoring and Land-Use Change in the Willcox and Douglas Basins, Southeast Arizona"—James B Callegary, US Geological Survey
2. "Sources of groundwater in the Hueco Bolson, Texas and Chihuahua: implications of an isotope (O, H, tritium, C-14) study in El Paso and the Valle de Juarez"—C.J. Eastoe, University of Arizona; B.J.Hibbs, A. Granados O.
3. "Biogeochemical Monitoring of Heavy Metals in SE Arizona Food Webs: Sources, Pathways, Deposition, and Bioaccumulation" –John T. Chesley, Floyd Gray, Peter Reinthal, Joaquin Ruiz, Ailiang Gu, and Chris Eastoe

10:30 – 10:45 a.m. **Break**

10:45 – 12:00 p.m. **Theme Session I *continued***

4. "Transboundary Cooperative digital geologic map compilation project along the US-Mexico border" by Floyd Gray, U.S. Geological Survey and Jesus Jaime Castro Escarrega
5. "Binational geologic map datasets in the Lower Rio Grande area, Texas, Tamaulipas, and Nuevo Leon"—Ric Page, Geologist, U.S. Geological Survey
6. " Techniques of regional-scale mapping of surficial deposits in the border region of southeastern Arizona and southwestern New Mexico, with applications to fluvial interconnectivity and Quaternary drainage history of cross-border hydrologic basins"—Chris Menges, U.S. Geological Survey
7. "The National Park Service Geologic Resource Evaluation - Opportunities for mapping in park units along the U.S./Mexico Border"—Bruce Heise, Geologist, National Park Service
8. "How An Integrated State-Federal Geoscience Information Network Can be Applied in the Borderlands."—Lee Allison, State Geologist, Arizona Geological Survey
9. "Floodplain lakes and their relation to alluvial cycles in the lower Colorado River"—Daniel Malmon, Geologist, U.S. Geological Survey

12:00 p.m. **Lunch Break**

1:00 p.m. – 3:00 p.m. **Theme Session II: Populations, Urban Growth, Infrastructure Health, and Land Use Change**

1. "An Approach to Prevent Nonpoint-Source Pollutants and Support Sustainable Development in the Ambos Nogales Transboundary Watershed"—Laura M. Norman, South west Geographic Science Center, U.S. Geological Survey
2. "CHIPS - A New Way to Monitor Colonias along the Texas-Mexico Border" –Jean Parcher, Geographer, U.S.-Mexico Border Research, U.S. Geological Survey
3. "Transboundary Land Cover Change Detection Methods - A Consistent Approach" –Jean Parcher, Geographer, U.S.-Mexico Border Research, U.S. Geological Survey
4. "Constructing and Maintaining Social Infrastructure for the Development of Environmental Projects and Programs in Border Urban Communities: The Case of Ambos Nogales" –Diane Austin, Bureau of Applied Research Anthropology, University of Arizona
5. "Immigration Reform and Quality of Life in Arizona and New Mexico Colonias" —Angela Donelson and Adrian Esparza, University of Arizona
6. "Comparison of contemporary land-cover trends among the Sonoran Basin and Range, Madrean Archipelago, and Chihuahuan Deserts Ecoregions." –Jana Ruhlman, U.S. Geological Survey
7. "The detection and mapping of the spatial and temporal dynamics of vegetation in arid lands (Mojave and the southwest examples)" —Pat Chavez, Southwest Geographic Science Center, U.S. Geological Survey
8. "US Mexico Border"—Joaquin Ruiz, Dean, college of Science, University of Arizona

3:00 – 3:15 p.m. **Afternoon Break**

3:15 – 5:00 p.m. **Theme Session III: The Role of Environmental Indicators in Determining Impacts, Ecosystem Preservation, andClimate Change**

1. "Stopover ecology and habitat utilization of migrating land birds in Colorado River riparian forests of Mexico and the southwestern United States."—Charles van Riper III,

USGS/SBSC Sonoran Desert Research Station

2. "Lessons learned from the Salton Sea: potential impact of dust emission to both air quality and human health" — Pat Chavez, Southwest Geographic Science Center, U.S. Geological Survey
3. "Buffelgrass invasion in the Sonoran Desert with and with out climate change"—Julio L. Betancourt, Desert Labora tory, U.S. Geological Survey
4. "Status and issues associated with the restoration of the Salton Sea Ecosystem"— Harvey Lee Case, U.S. Geological Survey
5. "Mapping vegetation and endangered species habitat across national borders: Insights and perspectives." Dawn M. Browning, Kendal Young, Julie Lanser, and Bruce Thompson, University of Arizona
6. "The San Pedro River, a Case Study for Examining Past Landscape Change and Forecasting Hydrological and Biological Response to Urban Growth and Land Use Change"—William G. Kepner; U.S. Environmental Protection Agency, Ken Boykin, Darius J. Semmens, David C. Goodrich, Christopher J. Watts, and D. Phillip Guertin
7. William G. Kepner, continued

Wednesday, March 21, 2007

0830 – 1030 a.m. **Theme Session IV: The Quality and Quantity of Water Resources**

1. "Causes and Consequences of Monsoonal Flooding in Nogales, Sonora"—Hans Huth, Arizona Department of Environmental Quality (ADEQ) Border Programs Hydrologist
2. "Defining A Range of Ecologically Relevant Flows for the Rio Grande in Big Bend Natl. Park and the Rio Grande Wild and Scenic River" –J. Bruce Moring, Biology Specialist, Texas Water Science Center, U.S. Geological Survey
3. "Application of the Automated Geospatial Watershed Assessment tool (AGWA) on the San Pedro River Watershed" –D. Phillip Guertin, Professor, Watershed Management, School of Natural Resources, University of Arizona
4. "Sustainability of Water Resources in the Sierra Vista Subwatershed, Arizona - Implications of a Cross-Boundary Aquifer", James Leenhouts, U.S. Geological Survey
5. "Navigating Institutional Challenges to Cross-border Environmental Policy Research."—Robert G. Varady, Udall Center for Studies in Public Policy, University of Arizona
6. "US NORTHERN COMMAND efforts along the Border and with Mexican counterparts"—Lee Aggers, U.S. Geological Survey
7. "USGS Hydrologic Investigations along the Arizona-Sonora Border" –Nick Melcher, Director, USGS Arizona Water Science Center
8. "United States-Mexico Transboundary Aquifer Assessment Act" –Sharon B. Megdal, Director,Water Resources Research Center, The University of Arizona and Jim Stefanov, Deputy Director, Investigations and Research, USGS Texas Water Science Center

10:30 – 10:45 a.m. **Break**

10:45 – 12:00 p.m. **Internal USGS Workshop: Develop an "Action Plan"**

12:00 p.m. **Lunch Break**

1:00 – 3:00 p.m. **Workshop continues –** identify smaller steps we need to take in order to accomplish goals (Specific, Performance-related (reflect actions that need to be taken), Involving (involve many people's actions), Realistic, and Observable (how will we know when we've reached it?)

Action plans should answer the questions:

1. What needs to be done?
2. How should it be done?
3. Who will do it?
4. By when?
5. What are the desired results?
6. How will you know when you've succeeded?

3:00 – 3::30 p.m. **Afternoon Break**

3:30 – 5:00 p.m. **Presentations on proposal ideas and commitment**

5:00 p.m. **End**

Thursday, March 22, 2007
Field Trip to Nogales, Arizona

8:00 a.m. **Meet at USGS facility on University of Arizona Campus and leave Tucson**

8:45 a.m. **Stop #1—Nogales International Wastewater Treatment Plant, (NIWTP)**

Introduction by John M. Light, USIBWC Nogales Project, Nogales Project Manager, Rio Rico, Ariz.

9:45 a.m. **Stop #2—The Southeast Arizona Area Health Education Center (SEAHEC)**

A. Keynote Speaker: Alberto Suàrez Barnett -- City Historian for the Municipal de Nogales (Sonora) "A Brief History of Nogales, Sonora and its environmental issues"
B. Estela-Maria Diaz of SEAHEC and students from the Nogales High talk about an air quality biodiesel project they are involved in.
C. Mexican students working with Diane Austin at the Bureau of Applied Research in Anthropology from University of Arizona will present following on a water harvesting project they are working on with the Asociación de Reforestación en Ambos Nogales (ARAN: Ambos Nogales Revegetation Partnership).

11:30 a.m. **Stop #3—"The Wall"**

Floyd Gray identifies surface water crossing point, rail road, and automotive crossings

12:00 p.m. **Stop #4—Papachoris' Zulas Restaurant Lunch**

1:30 p.m. **Stop #5—United Musical Instruments Factory**
Floyd Gray presents work done with students from Desert View High School to collect water samples around this facility in remediation of hazardous substances

2:30 p.m. **Stop #6—Tumacácori National Historical Park**

A. "Tour and Orientation"—Don Garate, Interpretative Ranger
B. "Life Along the Santa Cruz River"—Sherry Sass, Treasurer and co-founder of Friends of the Santa Cruz River (FOSCR)

4:00 p.m. **Head back to Tucson.** (1/2 hour-45 minute drive)

Norman, Hirsch, and Ward—Proceedings of a USGS Workshop on Facing Tomorrow's Challenges Along the U.S.-Mexico Border—U.S. Geological Survey Circular 1322