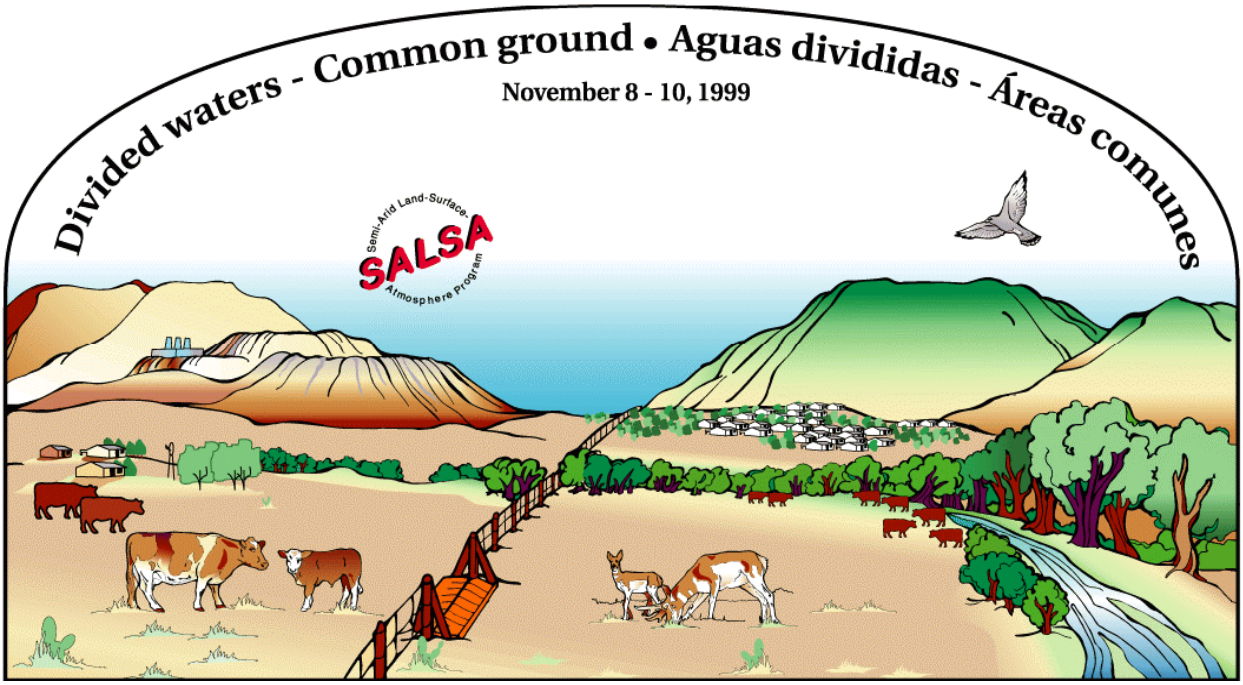
San Pedro Conference Proceedings

Memoria Descriptiva de la Conferencia San Pedro



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SAN PEDRO CONFERENCE PROCEEDINGS

April 27, 2000

One of the primary goals of the binational conference, *Divided Waters, Common Ground: Cooperative Research and Management of Binational Resources in the Upper San Pedro River Basin of Sonora and Arizona*, was to foster knowledge exchange and cooperation among residents, resource users, resource managers, and scientists in the Upper San Pedro River Basin. Without a doubt, we feel that we have obtained this objective. Based on public feedback and press coverage of the event, the San Pedro Conference was a tremendous success. In an effort to share some of the lessons that we learned at the conference, we present this summary document.

We hope that these bilingual proceedings reflect accurately both the breadth of research that has taken place in the Upper San Pedro River Basin and the range of comments made by various resource users in the area. In an effort to provide the reader with the experience of being a conference participant, editing was kept to a minimum and the use of the present tense was retained as much as possible.

The future well-being of the San Pedro River depends on the willingness of all resource users in the basin to continue sharing knowledge and information about the area. Through open dialogue, people on both sides of the Mexico-United States border will be able to reach an equitable means of preserving the unique habitat and the communities of the Upper San Pedro River Basin.

By sharing scientific research results with those at the local level, the conference demonstrated how science can contribute to the formulation of rational resource management strategies.

Stephen A. McElroy
San Pedro Conference Coordinator

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Available on the SALSA website/Disponible en la página electrónica de SALSA en http://www.tucson.ars.ag.gov/salsa/salsahome.html

Background and Context

The San Pedro River begins 30 miles (48 kilometers) south of the U.S.-Mexico border in Sonora and flows north about 149 miles (240 kilometers) to the Gila River in Arizona. The surface-water catchment for the San Pedro River drains an area of 4,487 square miles (11,620 square kilometers), of which approximately sixteen percent, or 695 square miles (1,800 km^2), is located in Mexico. In 1990 the largest urban areas in the watershed were Sierra Vista, Arizona (40,000 population), and Cananea, Sonora (25,000).

The climate of the region is arid to semiarid and is characterized by warm summers and moderate winters. Furthermore, the climate varies in accordance with elevation, with cooler temperatures and greater rainfall at higher elevations.

INSERT MAP OF THE SAN PEDRO RIVER BASIN

Stephen McElroy, San Pedro Conference Coordinator, welcomed everyone to the three-day event. "Welcome to *Divided Waters - Common Ground*, the first conference focused on the Upper San Pedro River Basin. I think that we have organized a very interesting meeting for everyone that is concerned about the management of natural resources in the basin. Over the course of the next three days, we hope to open the dialogue and talk to each other about the key issues related to the San Pedro River. I would like to welcome everyone in attendance, particularly those from nongovernmental organizations and federal, state, and local governmental agencies from both countries. This event will be truly binational, beginning here in Cananea, then onto fieldtrips in Mexico and the United States tomorrow, and terminating on Wednesday in Bisbee, Arizona. The conference dialogue will be simultaneously interpreted and presented in a variety of sessions, among them scientific summaries, poster presentations, talks about decision making, and group discussions about critical issues in the San Pedro River Basin."

David Goodrich (USDA-ARS) and Christopher Watts (IMADES) emphasized the key objectives of the conference in their remarks. "Welcome to *Divided Waters – Common Ground/Aguas Divididas – Áreas Comunes*, the first San Pedro binational watershed conference. The objectives of this conference are to 1) foster knowledge exchange; 2) encourage binational communication and cooperation; and 3) obtain direction for future research activities from managers, decision makers, and the public. In order to encourage both knowledge exchange and binational cooperation, the conference was specifically organized to have public open houses and day-long sessions in both Cananea, Sonora, and Bisbee, Arizona; with a combined travel and field presentations day between the sessions in Mexico and the United States. In both locations, public open houses provide an opportunity for the public to talk to researchers and view posters and computer demonstrations. The formal sessions in Cananea and in Bisbee begin with statements from invited dignitaries and overviews of the historical aspects of the basin and its people. Next, summaries of science and outreach activities conducted in the basin will be presented. This will be followed by a poster and computer demonstration session in which interaction among participants is emphasized. A variety of managers and decision makers in the basin will then provide summaries of critical natural resource issues they must deal with and discuss their information needs to address these issues. The participants will then break into smaller groups to discuss critical issues in the San Pedro River Basin with bilingual facilitators and reconvene to present summaries of the small-group discussions. In addition, we are fortunate to have several engaging speakers who will discuss aspects of water use, binational collaboration, science and public policy, and sustainability of rural areas. Once again, welcome to all of you and I urge each one of you to take the time to introduce yourself to someone from across the border."

There were two significant initiatives to achieve the objectives mentioned in Goodrich’s and Watts' remarks. The first was the production of an interactive, bilingual CD documentary on the San Pedro River Basin, entitled *The Miracle of a Desert River*. Jack Peterson (BLM) compiled the CD and provided demonstrations to conference participants. The second was the production of the *San Pedro Data Browser* that contains all the spatial data for public distribution. Bill Kepner and Dan Heggem (EPA) compiled the CD and provided demonstrations to conference participants.

Historical Perspectives of the Basin

Arturo Rodríguez Agüero
Cananea Historian

Introduction

For the great majority of us, the study of history is an experience that is limited to our school days. When we try to remember historical events, what come to mind are names of important people, significant places, and dates. Against this institutional backdrop, one may view history as a coherent narrative of the past, based on the careful evaluation of experiences contained in important facts. The historian emphasizes the events and characters that he considers relevant and presents history as a process guided by momentous events.

Today we remember back to past millennia, gathered together in the San Pedro River Basin, surrounded by La Mariquita, La Elenita, Los Ajos, San José, Huachuca, El Chivato, Bisbee, El Dragón, and Whestone mountains. From these mountains descends the water, that like a stream of blood formed by small veins and arteries, will spill out on the surface into the main channel of the San Pedro River, and at the same time provide recharge for an abundant underground aquifer. And following the current of a natural divide near Cananea, it begins its journey toward the north, discharging into the Gila River, Colorado River, and the Gulf of California.

The San Pedro Valley, including the municipality of Cananea, by being located in the western Sierra Madre, is identified by the main characteristic of its soils that were formed by extrusive igneous rocks with plains formed by gritty and bitter continental sediments from the Tertiary Period.

It is important to note that the San Pedro Valley is filled with disaggregated soils that extend to a minimum depth of 1509 feet (460 meters). The soils in this whole chain are rich in organic and nutritive material and show a calcareous accumulation. Another soil type is brown alluvium that is characterized by the accumulation of clays.

With respect to the cupriferos porphyries, they are surely the deposits that are best known for the economic interest that they represent. They are associated temporally and spatially with intrusions that took place during the orogeny laramide (fifty to sixty million years ago). The type of minerals found in these deposits is copper-molybdenum. Ores of this type are found at Cananea, La Claridad, El Alacrán, and other locations.

Let us leave the underground aspects of this beautiful area and transport ourselves to cohabitate with the first residents of pre-Hispanic origin. Historically, the forests and prairies were an area of influence for the Opatas and Pimas. And after the white man's arrival, it belonged to the Apaches. It practically became a border point among these groups. The nomadic

character of these ethnicities led them to occupy wide areas of northern Sonora and the southern part of the United States, areas that represented the common lands from which to supply their necessities. There are still vestiges of these groups on both sides of the border. But in some cases, they have been destroyed regrettably, thereby extinguishing a rich potential source of information. In this respect, we are left to appeal to the description made by the conquistadors upon their arrival.

It should be clear that these ethnicities were comprised by several groups. In this way, we see that the Eudeves and Jovas were considered Opatas and that the Pimas are related to the Papagos. All these groups shared the Uto-Aztec language family that was different than the Apache, a group that is divided in Gileños, Mimbreños, Mezcaleros, and others. For example, the fact that the Opatas and Pimas have a very similar language leads us to believe that they share a common origin, even though they inhabited distinct geographic areas. Recall the historical descriptions given by the natives with relationship to their origin. We know that they were part of the Nahuatl family, and that in their journey through Sonora, separated to settle in an area near what today is known as Huepac. From this point forward, it is possible that as the group grew, the resources were insufficient to supply the slowly increasing population. Therefore, it forced the inhabitants or the young people to look for another area in which to settle.

Along with agricultural activities, hunting and gathering were important for subsistence. We can observe that along with the naturally determined division of labor, another division was necessary for agriculture. In the case of the Opatas, women and men occupied the fields in times of cultivation, but the women withdrew during times of gestation to pursue work involving weaving, sewing, and the preparation of food.

The forests in the mountains that surround the San Pedro Valley provided a variety of fauna for hunting, as well as fertile soils that were favorable for agriculture and a great variety of flora.

Arrival of the White Man

On March 1, 1540, Francisco Vázquez de Coronado, under order of the viceroy Antonio de Mendoza, departed from Compostela, Nayarit to explore northern areas and to try to arrive north of Quivira. Coronado was the first military man of importance to walk on Cananean soil. In 1567, Rodrigo de Maldonado arrived in the Cananea Valley on his journey toward Arizona.

In 1680 in Bacoachi, the government of Carlos II granted the gentle Apache Nation title to the Cananea Valley, La Mariquita, Bacanuchi, El Picacho, Cerro del Apache, Las Nutrias, San Lazaro, and Cocospera in exchange for establishing the San Adores mine in Cananea. In 1686, Cananea was a homestead inhabited by Pima Indians that were loyal to the Spanish authorities. From this date, the first mining operations began at "La Cananea." At the time, it did not have much potential, what was important to exploit was gold and silver, however, not much revenue resulted from these efforts.

In 1858, almost 200 years since the mine failed to prosper due to continuous attacks by the Apache, General Ignacio Pesqueira built a barracks in what today is the public land of Cananea Vieja. With the protection of government soldiers, large-scale efforts began anew to exploit the mine at "La Cananea." In 1886, the town of Tombstone, Arizona had a population of 8,000 inhabitants, many of them miners. Many came to work at "La Cananea."

The Indian Geronimo and his people settled around La Mariquita. Already tired of so much fighting and persecution, he surrendered to Don Mariano Avila, who was administrator of the Cuchuta hacienda. Geronimo and his people belonged to the Chiricahua group.

The ethnic inhabitants of these lands were robbed of their lands, receiving in payment abuses, slavery, and death from the Spaniards, Mexicans and North Americans, as a result of the ambition to appropriate these beautiful lands.

Cattle Ranching and Agriculture in the San Pedro River Basin

Accompanied by mining, cattle and horses arrived in these lands. Livestock was used for subsistence and horses as a means of transport.

The first property owners from the period of the viceregal government were members of the "Elías" genealogical tree. The trunk of the family tree was formed when Francisco Elías de Zayas married María Águeda Campoy in Alamos. After becoming a widower, he married for a second time to María Ignacia Díaz de Carpio in Arizpe, Sonora. She was the daughter of the commander of the Presido Terrenate, located in what today is property of Mr. Ignacio Molina Bringas. This property forms part of the San Pedro River Basin.

The properties that were titled to different Elíases, in the basin that we occupy, took the names San Pedro Palominas, San Rafael del Valle, Ciénaga de San José Heredia, San Juan de Boquillas and others that were in Mexican territory at the time. The registers date between 1800 and 1840.

Regarding claims in the Cananea and San Pedro Valley, the Elías family ended up managing 494,211 acres (200,000 hectares). In the Elías' ranches, they ended up raising 300,000 heads of livestock. As a consequence of Apache attacks to ranches, towns, and small mining operations, many places were abandoned by their owners. For this reason, the prairie was recovering again and its wild fauna was increasing again.

At this time William Cornell Greene arrived, king of copper and livestock in the San Pedro River Basin from 1899 until he died in 1911. He created two empires, one in mining and another in ranching. He was born on August 26, 1853, in Duck Creek, Wisconsin. In 1880, at the age of 27, he arrived in Tombstone, Arizona. In this mining town, he had his first dream: to own a mine and to be able to sell it to a large company.

After working in mining for a few years, he lost his belongings to Apache attacks in multiple encounters, mainly with Geronimo. Later, he met Ed Roberts, a local cattleman in Tombstone, who later would become his father-in-law. Accompanied by Roberts, Greene took his first trip to Mexico to buy livestock. In 1899, Greene had his first 300 head of cattle worth $1,000. In future trips to Mexico, Greene was amazed by the richness of the San Pedro Valley and began to establish relationships with descendents of Spaniards that were owners of ranches. Later, Greene bought his first ranch in the area: San Rafael del Valle that had a total area of 14,000 acres (5,666 hectares). In this manner, his property in the San Pedro River Basin and Cananea Valley grew until he possessed 340,000 acres (137,593 hectares) and thousands of cattle and horses.

Greene got the urge to return to mining because he realized the great potential that there was to exploit copper in the Cananea area. He began anew his search for a large mine until he found it. The great company that would buy it brought sufficient economic resources from New York to Cananea. In 1899, the Cananea Consolidated Copper Company was founded.

(I have in my files, the book from the store in Imuris, Sonora that my grandfather Timoteo Agilero owned. It is where Mr. Greene got supplies and provisions in order to be able to continue exploring in Cananea. Upon my grandfather's death, Greene owed $792.00 pesos. My grandmother told me that they had been good friends).

To supply water to the first beneficiaries of mining and to the city of Cananea, Greene, through his general manager, George Mitchel, received a concession from the Mexican government to use water from El Ojo de Agua de Arvayo, the source of the Sonora River on the south side of the divide.

Between 1900 and 1999, the original well had provided water, first for the concentration plant that produced 2,000 tons of mineral per day, and for the population of Cananea. During the Second World War, the American government built for the Anaconda Copper Mines, a new concentration plant that milled 12,000 tons of mineral daily. For this operation, they had to drill eleven new wells in the San Pedro River Basin, as such they were able to support the supply of El Ojo de Agua. Upon constructing the modern concentration plant that is in operation today, fifty-four more wells were drilled to be able to mill 80,000 tons daily, with a usage of 800 liters per second.

In 1907, Greene turned over control of the mine to Anaconda and devoted his attention to his cattle ranching empire. Greene once mentioned to a group of his friends that "the ranch lands of this area are as good as the best in the world." The San Pedro River Basin has the best grasslands in Sonora and they surround Cananea.

Cananea Cattle Company measured forty-two miles (67.6 kilometers) from north to south and sixty-eight miles (109.4 kilometers) from east to west and three rivers crossed the land: San Pedro, Santa Cruz, and Sonora. This cattle ranch was managed with the best techniques of the

time and ended up being one of the best in the world. In 1904, Greene shoed 35,000 animals on his ranches in Mexico.

Between 1908 and 1958, many Mexicans requested expropriation of the land owned by Greene to create public lands in the form of ejidos. But it was not until 1959, by presidential decree, that the "Ranchos de Cananea" were expropriated. In 1959, Mexican President Adolfo Lopez Mateos turned over 253,000 hectares to 853 ejidatarios in seven new population centers, a cattle company that was managed by 150 people and had 23,000 heads of cattle and horses.

Looking back forty years, for multiple motives and reasons, what was a cattle empire has decayed economically, but the most important thing is that its natural resources, (hydrological, flora, and fauna) have suffered even more, due to the main predator of humanity: man himself.

Historical Land Use Context for the Upper San Pedro River Basin, Sonora, Mexico

Diana Hadley
Research Specialist, Arizona State Museum
University of Arizona

A series of culture groups have occupied the Upper San Pedro River Basin for approximately 14,000 years. Not until the past 125 years, however, have human land uses contributed to significant impacts upon soils, vegetation, waterways, and wildlife.

The land use history of the San Pedro River Basin can be roughly divided into five major phases. Two phases fall into the era of prehistory, with the earliest cultures relying on hunting and gathering, while later cultures practiced agriculture. During the Paleolithic period, the area was a cool wet grassland that supported herds of horses, camels, bison, mammoths, and giant sloths. Archaeological finds at the Lehner and Lewis Springs sites indicate that Paleo-Indian Clovis peoples hunted megafauna. Peoples of the Cochise culture occupied the watershed from approximately 5000 BC until the first century AD, living in pit houses, hunting deer, antelope, and rabbits. The gradual transition from hunting and gathering to an economy that relied, in part, on agriculture began at the end of this period.

During the agricultural phase, Archaic period peoples constructed ball courts and raised ceremonial sites. During the first centuries of the Christian era, the Hohokam brought advanced agricultural techniques and irrigation from Mexico. Settlements increased in size and trade took place with groups as distant as central Mexico. Between 1250 and the arrival of the Spaniards in the 1500s, however, human activity in the region declined dramatically.

During the Spanish period (1539-1821), explorers wrote the first descriptions of the San Pedro River Basin. Journals of Fray Marcos de Niza’s 1539 expedition and those describing Francisco Vásquez de Coronado’s expedition two years later agree that many small villages with irrigated farms dotted the "Nexpa River," a river assumed to be the San Pedro River. The inhabitants had the same culture and language as the villagers of other Sonoran river basins. By

the mid-1600s, Athapascan-speaking Apaches established strongholds in the mountains nearby. During the late 1690s, Jesuit missionary Father Eusebio Kino made several trips down the river he called the Río de San Joseph de Terrenate or the Río de Quiburi, where approximately 2,000 Sobaipuri Pimas were living in twelve to fifteen villages. They practiced irrigated agriculture, lived in reed houses, and raised corn, beans, cotton, and squash. Kino established missions and visiting stations at Quiburi, Gaybanipitea, and Cuachuca. Along with the Catholic faith, Kino introduced European crops, livestock, and tools. The missions were short-lived. They were abandoned during the early 1700s because Apaches raided along the river corridor and the missionaries suffered from malarial fevers. By 1762, the Sobipuri Pimas also gave up their settlements on the San Pedro River, and Spanish troops relocated them to less exposed locations along the Santa Cruz River. In the 1770s, Spaniards made another attempt to reoccupy the San Pedro River. They established a garrisoned fort, near the abandoned mission at Quibori, but the beleaguered presidio remained at the site for only a few years. Apaches killed both soldiers and settlers. In 1780 the presidio was moved south to Las Nutrias near the headwaters of the San Pedro River.

During the Mexican period (1821-1854), with diminished funding for defense, Apaches tightened their control of the area. Despite the Apache threat, Mexican citizens petitioned the government for land grants for cattle ranches in the San Pedro River Basin. Large numbers of livestock were introduced to the grants at four sites: the San Rafael del Valle on the San Pedro River near the present international boundary; the San Juan de las Boquillas y Nogales farther north on the San Pedro River; the San Ignacio del Babocómari on Babocómari Creek; and a communal grant at Tres Alamos. By the 1830s, however, Apaches forced the owners to abandon their ranches. The cattle became wild and adobe buildings fell into ruins. All of the grants, situated on permanent water sources, continued to be important to ranches during the Anglo-American period.

In 1854, the Gadsden Purchase transferred approximately 1,700 square miles (4,403 square kilometers) of the Upper San Pedro River watershed to the United States. In 1877, mineral strikes at Tombstone and Bisbee initiated the area’s legendary mining industry, along with a number of subsidiary extractive activities, including ore milling, fuelwood cutting, and lumbering. In 1877, the Church of Latter-day Saints authorized settlement along the San Pedro River, and Mormon farmers began constructing irrigation canals, draining beaver dams, and digging wells. In 1881, the Southern Pacific Railroad was completed across southern Arizona, allowing increased mining development and fast importation of livestock. Within four years, the watershed’s grazing ranges were stocked to capacity. During the open-range cattle boom, three major droughts occurred: the first in 1885, the second in 1892-93, and the third in 1902-03. As early as 1886, the Tombstone newspaper published a plea from cattle ranchers to prohibit introduction of more cattle. In 1893, between fifty and seventy-five percent of the cattle in Cochise County died of starvation on the ranges. During the early years of the twentieth century, a boom in homesteading accompanied the dry-farming craze. The Arizona Agricultural Extension Service instructed farmers in deep-soil tilling and other techniques that facilitated farming without irrigation. Extension bulletins featured articles on gathering and mowing "wild" hay for fodder and the use of cacti as forage.

It is possible to measure the nature and extent of landscape level change through a comparison of early descriptions with conditions present today. Leaders of Spanish military expeditions were required to write journals of their trips that included information on distances between water sources, forage conditions, potential for mineral development, and other important landscape details. Their diaries provide a composite description of the watershed prior to intensive human impacts. The San Pedro was an unincised river with long intermittent perennial reaches, was not downcut, had little erosion, and supported mature riparian forests of cottonwood, willow, sycamore, hackberry, and ash. Beyond the river, there were plains covered with tall stands of native grama grasses.

Subsequent descriptions reinforce this image of abundance in vegetation and wildlife. American trappers led by James Ohio Pattie referred to the San Pedro River as "Beaver River." They collected 1,200 skins between March 3 and 10, 1833. Members of the Mormon Battalion caught "salmon trout" up to eighteen inches (45.7 centimeters) in length near Babacomari. James Tevis noted that the grass in the San Pedro Valley was so tall he could not see the heads of antelope in numerous herds. Lieutenant William Emory referred to the San Pedro River as "Hog River" for its many javelinas and admired its flights of geese and "myriads of blue quail and flocks of turkey." One hundred and fifty years after the first Spanish descriptions were written, Forty-Niners on their way to the Gold Rush still described a winding, nonincised sandy riverbed almost level with the plain, blocked by beaver dams, with at least six major cienegas, many marshes, and thick stands of sacaton grass.

By the mid-1800s, written descriptions began to note changes in the watershed. In 1852, Boundary Survey Commissioner John Russell Bartlett remarked that on his second visit to Ash Creek, a tributary to the San Pedro River, the ash trees were almost gone, cut by travelers to repair wagon wheels and axles. Travelers began to complain that they had to "cut" the banks of the San Pedro River to lower their wagons to cross the channel. Ecological changes resulted from both cultural and natural impacts. Well-intentioned settlers denuded hillsides of timber for sawmills, cut the available fuelwood for ore smelters and household stoves, made head-cuts in riverbanks for irrigation canals, allowed livestock to consume the forage supplies, cut and stacked wild hay for sale to the army at Fort Huachuca, and constructed roadways next to watercourses. Natural impacts compounded the change. In May 1887, a major earthquake left large cracks in the valley floor, causing some springs to dry up while others emerged. Climate variability, with major periods of drought interspersed by wet years, confused newcomers who had no previous experience with arid environments. By the late 1880s, floods in the San Pedro initiated down cutting and channelization. Heavy rains carried topsoil from grassless plains and initiated erosion.

During the decades between 1880 and 1930, the Upper San Pedro River Basin experienced an unprecedented population boom accompanied by the introduction of new land uses. Today, a similar population boom is occurring in the U.S. portion of the basin. In 1955, the tiny community of Fry was renamed Sierra Vista. Since that time, its suburban growth and consumption of resources has rivaled the boom of the late nineteenth and early twentieth

centuries. In both instances, population increases and new land uses have initiated extreme change within the watershed.

Keynote Address

Honorable Bruce Babbitt, Secretary
United States Department of the Interior

This conference is a milestone event in the preservation of the San Pedro River. One of the last intact riparian ecosystems in the Southwest, the San Pedro River remains at risk due to our failure to meet our obligations to the land, its resources, and to the future.

I congratulate the ejidatarios for their exemplary land management practices. And here in Arizona, local governments deserve recognition and praise for their efforts, notably their impressive progress on developing effluent recharge capacity.

We are, however, clearly falling farther behind. We are in danger of losing the opportunity to manage the Arizona San Pedro River in a way that meets our stewardship obligations. We developed a vision and acted on it by putting the San Pedro River into a National Conservation Area. It is now my responsibility as Secretary of the Interior to advocate for—and to defend—the integrity of the San Pedro River. This may ultimately involve taking necessary legal steps, in Congress and in the federal courts, to make certain that we do not repeat the mistakes of the past. We must do what we have to do, to protect this extraordinary resource.

The current level of per capita water consumption is unsustainable, and expansion of irrigated agriculture in the Valley by land speculators is an unimaginable abuse of this resource. Demand management is essential, but there is no mechanism in the Valley to fully manage the water resource. The reason such a mechanism does not exist here is that the state of Arizona has not done enough to lead in the management of this resource in this basin. It must be persuaded to live up to its responsibility to help manage the problem.

The San Pedro Valley is a unique place on the planet. This does not mean that opportunity does not exist, for plenty of space remains for the Valley to grow, develop, and provide jobs. But, in the process, we do not have to destroy the very values that make this place unique.

Looking across the border, the emerging partnership between Arizona and Sonora is a powerful success story. We have come a long way in overcoming the cross-border communication barriers that existed twenty-five years ago when I was governor of Arizona. And it has been one of the great joys of my life to see the emergence of a conservation movement in Mexico that has flowered under the administration of Julia Carabias, Mexico's Secretariat for the Environment, Natural Resources and Fisheries. Secretary Carabias is one of the most powerful leaders I have worked with in a long time, and we work very closely together. Recently, at her

suggestion, we searched for natural areas along the border and zeroed in on the San Pedro River as a landscape where the future is still developing, where we could develop a partnership across the border, and where we could learn from each other. We agreed to do everything possible to facilitate communication between Arizona and Sonora to preserve the river. This is not about compromising sovereignty; rather, about creating a new model, a common landscape where a new binational culture would be created out of the best of both cultures.

Panel Discussion Summaries

During the introductory session on November 10, 1999, several elected officials from nearby communities made brief comments about activities related to the San Pedro River. Lyle Reddy, Mayor of Bisbee, pointed out that although the conference is made up of a diverse group of people, everyone in attendance is concerned about the future of the San Pedro River. Mike Palmer, a member of the Cochise County Board of Supervisors, questioned whether continued study of the San Pedro River is merely avoidance behavior. Currently available information should be used to make decisions. However, local decision making is increasingly difficult due to legislative snags at the state level. Due to these constraints, Cochise County officials are disempowered from taking corrective actions to protect the sub-flow of the river. Palmer closed his remarks by beseeching the participants to use their collective passion to construct remedies that would preserve the river.

Chuck Potucek, City Manager of Sierra Vista, requested that different agencies continue to work together and foster cooperation regarding the San Pedro River Basin. It is a daunting challenge to bring people together in the midst of laws, regulations, and policies that act to create divisive camps of people. Legal barriers and red tape must be eliminated so that solutions can be implemented that are amicable to all organizations involved in the San Pedro River Basin.

Organized panel discussions focused on management and decision-making information needs from a group of nongovernment organizations, and local, state, and federal representatives. Mexican representatives spoke on November 8, 1999, and U.S. representatives spoke on November 10, 1999. Prior to the conference, each panelist prepared a short summary of his or her response to the following questions:

What are the top five natural resource issues that you must deal with in the San Pedro Basin? What information do you need in order to address these issues?

Francisco García Gámez, Mayor of Cananea, cited contamination of the San Pedro River. Although efforts have been made to prevent contamination of the river, more studies are needed regarding wells, aquifers, and sewage reclamation. Furthermore, the mine needs to contribute more to the prevention of contamination. The city of Cananea is concerned with issues of water quality and reliable supply. The citizens want to know if mine activities are contaminating wells and the aquifer and how they are going to be affected. The impacts on Ejido Zapata and Ejido Zaragoza are especially important. Plans and support are needed to prevent contamination.

Another problem is that historically the mining company has provided the city with water and as a result of the last labor strikes and mounting criticisms of a possible water monopoly, they transferred the responsibility to the city. Because of inadequate infrastructure, the existence of a reliable water supply has become a problem in the community. Furthermore, the residents of Cananea are being charged for water for the first time.

José María Guerra Limón, Director of the Ajos-Bavispe Reserve, mentioned that the creation of a natural protected area of the San Pedro River headwaters is needed to protect water resources, control land cover degradation, and conserve the biological resources of the area. When water was thought to be inexhaustible, its rapid consumption was a major problem in the San Pedro River Basin. Water conservation efforts are needed to preserve this resource. Another problem in the basin is loss of land cover that is a result of the reduction in the number of grasses in the area. Efforts to protect the basin's fauna are also needed. The last important problem is conservation and protection of the biological corridor. This is an area that is especially important for migratory birds. Currently, the Secretaría del Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP) through Instituto Nacional de Ecología (INE) is interested in extending the Ajos Bavispe Reserve to include the San Pedro River Basin. The extended Ajos-Bavispe Reserve will encompass the biological corridor.

José Manuel Barcelo, President of Ejido Zapata, listed contamination and extraction of water as the number one issue. He advocated the necessity of continued research projects along the San Pedro River in order to understand drought impacts and declining water levels. One of the most important issues in the San Pedro River Basin is water scarcity during certain times of the year. The recent drought has further aggravated this problem. Ejiditarios are especially concerned about this issue because while the ejidos' wells are dry, the mine has enough water for its activities. The ejidos want to know why this is happening. Another issue that needs further study is whether water is being contaminated and what are the effects of using contaminated water on crops and livestock. There have been reports of water contamination affecting cattle but no direct links have been made. The ejidatarios want to emphasize that they are interested in conserving water but do not have the knowledge or equipment to practice water-efficient agriculture and ranching. We are open to learning new farming and ranching methods. Furthermore, we support continuing projects in the basin.

Juan Francisco Elías González Bojórquez, President of Association of Rural Producers of Cananea, cited extraction of water and reforestation as the primary concerns.

Judy Gignac, Vice President and General Manager of Bella Vista Water Company and Bella Vista Ranches, compiled a list that includes the following: a) adequate groundwater availability; b) drainage flows and control; c) erosion mitigation; d) recharge potential; and e) native plant preservation. I must deal with these concerns within a context that demands attention to adequate financial resources, the existing political climate, and compliance with county and state regulatory laws and requirements. As a water utility, I must show I have the capacity to provide a specific level of management, financial, and technical expertise and I must do all of this at the lowest possible price to the consumer. As a land developer, I must respond to a multitude of

local, state, and federal regulations concerning all of my actions relating to the use of my land. Let's talk about my information and research needs. Adequate groundwater availability requires knowledge of where groundwater is and how to site wells that result in minimal impacts on the flow of the river. Drainage flow and control information related to selective grading of subdivisions would result in less property denudation. Erosion mitigation relates to finding substitues for the channelization of washes. Recharge potential relates to the creation of detention/retention areas that are adequate in size relative to the number of developable parcels. Native plant preservation certainly would benefit from research under the issue of drainage flow and control. Plants will always have a better chance of survival if we don't have to move them at all. I hope that what I have told you is helpful in your search for ways in which information and research can assist in providing good decision making on the part of natural resource users and managers. I want to conclude by saying that most developers do not set out to ravage the land or the environment. I am interested in doing the right thing, the ethical thing, but I am caught in a conundrum. Help me figure out how I can use my lands without destroying the very product I am trying to sell.

James Chambers, Deputy Garrison Commander at Fort Huachuca, noted that being water wise is the most critical aspect. He said that funds allocated for the environment are used by the military installation to ensure that efforts are made to find better, smarter ways to manage natural resources.

Holly Richter, Restoration Ecologist with The Nature Conservancy, listed the promotion of a nature reserve in Mexico as priority number one. She mentioned that collaborative efforts and the use of solid science to make decisions are cornerstones of broad-based vision for such an area. Furthermore, she added that hydrological monitoring and conservation strategies can be used as benchmarks for long-term evaluation of the success of such a reserve.

Gretchen Kent, representative from the Upper San Pedro Partnership, remarked that understanding the dynamics of hydrology is very important and studies of the effects of unauthorized water use are needed. There have been a lot of policy recommendations made regarding water management in the Upper San Pedro River Basin, but feasibility studies of these policy recommendations are needed. The long-term goal of the Partnership is to identify and prioritize water management projects (conservation/recycling, recharge, or preservation projects), and then rely on a democratic process to decide which ones should be undertaken.

Jack Ladd, Rancher, noted that all ranchers are environmentalists. The primary issues for ranchers are restrictions related to water, land, and air. With water, we have to consider surface water, groundwater, and rainfall. Regarding the land, we deal with noxious weed encroachment, grazing management, wildlife management, population growth and human encroachment, and planning and zoning. We also have to think about particulate and chemical air pollution. He identified a need to understand the interactions between the ground-based activities of grazing, wildlife, population growth, and zoning with air-based phenomenon such as pollution and legal burning. Because our area is attracting many new residents, we are losing the rural nature of this area. We have to accept that there will be more and more growth, and more requests for

regulations. I just hope our decision makers will be reasonable when considering the need for more regulations.

Jesse Juen, Office Manager of the Tucson Office of the Bureau of Land Management, mentioned that efforts should focus on determining: 1) the necessary base flows to sustain proper riparian functions, habitat, and diversity; and 2) the effects of human use of the San Pedro Riparian National Conservation Area. Although a natural protected area was established in 1988, the base flow of the San Pedro River in Arizona continues to decline. A strong base flow is needed to sustain the riparian area and maintain the biodiversity of the area. We need to conduct our actions as a community to balance information needs and resource needs—this includes all the cultures within the basin. This portion of the basin is experiencing a 3,000 to 10,000 acre-feet (3.7 to 12.3 million cubic meters) deficit annually. Tucson is looking at a 300,000 to 360,000 acre-feet (370 to 440 million cubic meters) deficit annually. Here in the San Pedro area we have the opportunity and the ability to turn around that deficit—if we act as a whole.

Science Summaries

Several of the primary researchers presented summaries from Semi-Arid Land-Surface-Atmosphere (SALSA) initiatives and natural and social science research and outreach. The seven perspectives represent the variety of SALSA research efforts that are being undertaken in the basin. The first three summaries were presented on November 8, 1999, and the rest were presented on November 10, 1999.

Henri Poupon, of IRD/France, noted that the San Pedro Conference is part of the capstone experience related to French participation in the scientific excursion between SALSA and Mexico. Started in 1996, the project involves research teams from France, the United States, and Mexico. Beginning in 2000, French collaborative efforts with SALSA will focus on the arid regions of the Mediterranean.

David Goodrich, from USDA-ARS, and Ghani Chebouni of IRD/France provided a scientific summary of SALSA research activities. The SALSA Research Program is a multiagency, multinational research effort that seeks to evaluate the consequences of natural and human-induced environmental change in semiarid regions. The ultimate goal of SALSA is to advance scientific understanding of the hydrology and ecological diversity of semiarid regions in order to provide reliable information for natural resource decision making. SALSA approaches this goal through a program of long-term, integrated observations, process research, modeling, assessment, and information management that is sustained by cooperation among scientists and information users. Scientists from about twenty American, five European (four French), and three Mexican agencies and institutions have collaborated closely to make the SALSA Research Program a reality.

SALSA grew out of a convergence of several ongoing and proposed semiarid research efforts, including the long-term, intensively instrumented USDA-ARS Walnut Gulch Experimental

Watershed, which is a tributary to the San Pedro near Tombstone, Arizona; 1990 and 1992 land-surface-atmosphere experiments in Walnut Gulch; and "HAPEX-Sahel" experiments conducted in Niger, West Africa between 1991 and 1993. In July 1995, sixty-five scientists from nine federal agencies, eight universities, and six foreign agencies representing a broad spectrum of science disciplines met in Tucson, Arizona to discuss plans for the SALSA effort and formulate its Primary Science Objective: *to understand, model, and predict the consequences of natural and human-induced change on the basinwide water balance and ecological complexity of semiarid basins over a wide range of time scales.*

SALSA operates on the principle of voluntary collaboration whereby researchers interact with one another across disciplinary, institutional, and political boundaries to address particular components of the Primary Science Objective. Collaborators are free to pursue their own lines of scientific inquiry in accordance with their institutional needs and resources, and may join or leave the program as they wish. The purpose of the organized SALSA Research Program is to facilitate these interactions and to serve as a platform for research coordination, data assimilation and synthesis, and information exchange. The role of the SALSA researcher is to collaborate with fellow SALSA researchers to gain maximum benefit from the resources used to address the Primary Science Objective.

The San Pedro River was selected as the initial focus area for SALSA because it has a variety of characteristics that make it an exceptional outdoor laboratory to address a large number of scientific challenges in arid and semiarid hydrology, meteorology, ecology, and social and policy sciences. SALSA efforts from 1996 to1999 are summarized here and relate primarily to the following issues: 1) basinwide landscape change, 2) grassland/mesquite functioning, and 3) riparian water sources and water use. Numerous additional research projects have been undertaken or are underway and time does not permit a thorough discussion of each. A more comprehensive overview of SALSA efforts is available on the SALSA Web page at: http://www.tucson.ars.ag.gov/salsa/salsahome.html

The efforts noted above have enabled significant progress toward achieving the Primary Science Objective through a series of intensive experimental campaigns, long-term monitoring, application of innovative remote sensing techniques, and subsequent analyses. Satellite measurements were successfully used in several instances as a means to integrate the length scales at which models operate and that of the field observations are used for their validation. The assimilation of satellite data with a process model that uses widely available information from surface meteorological stations aids in providing more robust information. In addition, coupling different sensors for a better characterization of surface properties has also been accomplished.

Basinwide landscape change was documented and measured by acquiring Landsat MSS and TM imagery over the Upper San Pedro Basin (USPB) from 1973, 1986, 1992, and 1997. Vegetation and land use within each image was classified into a ten-class system. Using this data, change detection in land cover classes was computed from the time between the successive land cover maps. Results indicate that mesquite woodland has encroached upon the entire watershed with

more than a 400 percent increase in the 1973-1986 period. Its total extent increased five-fold between 1973 and 1986 from 51,428 to 265,228 acres (20,812 to 107,334 hectares). Where grassland was the dominant cover for the San Pedro River Basin landscape for each of the sample periods, its total extent has steadily declined. Over 123,553 acres (50,000 hectares) of vegetative communities dominated by perennial and annual grasses were lost between 1973 and 1992 with the major decrease occurring between 1973 and 1986 (113,730 acres or 46,025 hectares lost). Mesquite woodlands can exploit water sources at greater depths and can therefore outcompete shallow rooted grasses. To reverse this process and replace mesquite with grasses is energy intensive and very difficult to accomplish on a large scale. These dramatic changes at the basin scale are an indication of the urgency needed to provide policy and decision makers of the basin with sound research and data to enhance their ability to manage basin resources for a sustainable future.

Several different models for desert grassland functioning have been developed. These models are able to incorporate remotely sensed data and have been successfully validated over a ten-year period in the Walnut Gulch subwatershed as well as for data collected in the Mexican portion of the San Pedro River Basin from 1996 to 1998. Light has also been shed on the functioning of the mesquite and its ability to effectively compete with grasses for surface water. Over time, the riparian zone in Mexico has undergone significant destruction and a new form of mesquite has invaded the grassland area. Following the degradation of an area, two unique types of mesquite are present. The first is the original species and the second is a modified mesquite blend that can absorb surface water, thereby encroaching upon and competing with grasslands for available water. The mesquite blend is more adaptable than grass because it obtains water through both groundwater sources and via surface water. Additional research is needed to determine the periods and conditions in which vegetation phase (grassland-to-mesquite) transition commenced.

Riparian research resulted in a major advance by providing an effective methodology to directly measure, model, and scale riparian tree transpiration derived from ground water in time and space. Using the tree transpiration model developed and independent measures of all components of the water balance we were able to close the water balance over a 6.2 mile (10 kilometer) river reach from Lewis Springs to Charleston over a ninety day premonsoon period to within five percent. Valuable information on the dependence of riparian tree transpiration on structural and successional forest dynamics was also acquired. Significant progress was made in identification of the water sources used by several riparian tree species, but further research is required to accurately assess the partition between ground water and surface waters during the monsoon season. This is a high priority issue we hope to address in the near future.

The SALSA Research Program has served as a model of cooperation and has broken new ground in the approach to large-scale interdisciplinary science where limited resources are available. Careful planning resulted in the identification of critical and exciting scientific challenges that not only required but also fostered interdisciplinary collaboration. Careful attention to enhancing interdisciplinary communication built the foundation for trustful collaborations. This enabled unselfish sharing of numerous small grants and in-kind resources to accomplish a goal that is much greater than the sum of the disciplinary parts. An additional driving force behind the

SALSA Research Program's success is the knowledge that the results will directly aid land managers and decision makers in the near term. A challenge SALSA researchers hope to address, in part, at this conference, is the translation and communication of SALSA results and information to policy makers, natural resource managers, and concerned citizens of the San Pedro River Basin. In turn, we would like to hear the priorities of these groups for future research that SALSA might undertake.

Ghani Chehbouni, one of the primary SALSA research leaders from IRD/IMADES, remarked about the successful collaboration among the Mexican (IMADES, the University of Sonora, and ITSON), the United States (USDA-ARS/UA/ASU) and the French (IRD/CESBIO) organizations. A primary research objective was to explore the consequences of natural and human induced change on basinwide water balance and ecological diversity at the event, seasonal, interannual and decadal time scales. Over time, the riparian zone has undergone significant destruction and a new form of mesquite has invaded the grassland area. Following the degradation of an area, two unique types of mesquite are present. The first is the original version and the second is a modified mesquite blend that can absorb surface water, thereby encroaching upon and competing with grasslands for available water. The mesquite blend is more adaptable than grass because it obtains water through both groundwater sources and via surface water.

Diana Liverman, Professor at the Latin American Area Center and the Department of Geography and Regional Development at the University of Arizona, spoke about the policy and land use context for conservation strategies within the Mexican San Pedro River Basin. Liverman provided an overview of some key policy changes affecting land use and conservation in Mexico, mentioned implications of climate variability and change, and discussed current land use and land tenure patterns on the Mexican side of the basin. The socioeconomic context includes two aspects. First, land use patterns are driven by the interactions of larger political, economic, and institutional forces (i.e. political ecology) with the decisions and actions of land and water users within the San Pedro River Watershed. Second, major changes in the last ten years relate to the globalization of the Mexican economy, the rapid introduction of neoliberal policies including privatization and reduced subsidies, and the democratization and decentralization of political system.

Together, these changes have dramatically altered the context of individual and government decision making in rural Mexico. For example, the restructuring of agricultural markets and techniques led to three consequences: increase in demand and security of livestock has led to an increase in feed crop production, decline in cotton (synthetics, imports from Asia) and increase in exports of fruit and vegetables, and increase in use of Green Revolution technologies including improved seeds, fertilizer, and pesticides.

In addition, the recurrent economic crises and collapse of the peso have affected Mexican economic and agricultural policies. For example, secondary affects include the decline in crop and input subsidies as a result of debt restructuring and neoliberal policies, changes in the type of subsidies, and privatization of credit and inputs. Furthermore, the reform of Article 27 of the

Mexican Constitution entails the end of revolutionary land redistribution and a provision that allows the ejido sector to sell, rent, and use land as collateral.

The resulting political landscape in Mexico reflects these changes. The changes in the political landscape include more diverse multiparty affiliations, decentralized government functions at state and local levels, rise of nongovernmental organizations and other powers of influence, and emergence of binational institutions such as Border Environment Cooperation Commission (BECC) and Commission for Environmental Cooperation (CEC) that are resolving conflicts and institutionalizing reforms.

Within the Sierra de los Ajos Reserve, 88.5 percent of ejidos are in crop production, while only 40.17 percent of private land is in production. The percentage of agricultural activity is much greater in small landholdings than large land holdings; however, given the relative dominance of large land holdings in term of acreage, overall greater agricultural production occurs on large landholdings. Ejidos tend to be subsistence based with a relative emphasis on maize, beans, and wheat. Privately held land tends to produce monocultures of high yield crops such as alfalfa. Ranching activities have been severely impacted by recent droughts.

The twentieth century causes of vulnerability are attributed to increases in water demand through agricultural intensification (irrigation, forage, vegetables), growth in population and per capita urban consumption, industrial development (hydro-electrical, oil, maquiladoras), and to unequal access to water rights due to poverty and land tenure (ejido and private) considerations.

Barbara Morehouse of the Institute for the Study of Planet Earth (ISPE) at the University of Arizona explained that the Climate Assessment for the Southwest (CLIMAS) project, operating through seed funding from the National Oceanic and Atmospheric Administration (NOAA), was initiated in spring 1998 to investigate climate impacts on human and natural systems in the Southwest, as well as to research the processes and conditions that drive the region's climate and hydrology. Activities funded under CLIMAS include evaluating climate forecasts, improving the dissemination of locally relevant climate information and forecasts, and working with various constituencies to identify and address their climate information needs. Project members have been actively engaged in working with residents of the southwestern region to identify their patterns of climate information use and their climate information needs.

For example, CLIMAS researchers conducted a pilot survey of stakeholders in summer 1998. The survey, which involved seventy-two structured interviews with specific categories of stakeholders in southeastern Arizona, was designed to provide a broad-based profile use of stakeholders' use of, and need for, various kinds of climate information and forecasts. Individuals interviewed included public officials, land managers, utility managers, emergency response personnel, ranchers, farmers, and representatives of the service and mining sectors. Further insights into climate information needs were gained through an ethnographic assessment of an entire community. The Middle San Pedro River Valley, centered on the community of Benson, Arizona, was targeted for in-depth analysis of vulnerability to climate and climate

information needs. Results of the analysis indicate that climate has the greatest impact on farmers, ranchers, electricity providers, and RV park owners.

In another CLIMAS study, it was found that ranching in southeastern Arizona, as elsewhere in the Southwest, is highly dependent upon climatic conditions. Having information about soil moisture, summer and winter precipitation forecasts, and temperature are all important. Specifically, individuals in the ranching and Middle San Pedro River Basin studies identified the following information needs: historical precipitation data, historical vegetation conditions, annual/seasonal drought probability (preferably at least six months in advance), climate conditions in the Midwest, linkage of vegetation condition with rainfall, ranch-level climate forecasts, and training in satellite image interpretation. Research on climate impacts of urban water revealed that droughts similar to the worst one-, five-, and ten-year droughts in historical records would cause significant stress to urban water systems in the Sierra Vista subwatershed as well as in the Tucson and Phoenix Active Management Areas (AMAs). A survey, in progress, of urban water managers' climate information needs has also revealed important areas of climate impact and needed climate services. Extremely high temperatures, drought, and power outages due to heavy winds, electrical storms, and extreme high temperatures are among their greatest concerns. Among their information needs are predictions of mountain-front runoff and aquifer recharge, better forecasts of snowpack and streamflow, more local temperature and precipitation forecasts at seasonal and longer time scales, evapotranspiration forecasts, and forecasts/reports that are more locally specific.

Addressing climate impacts and information needs is a task requiring long-term commitment, determination to maintaining open communications with and among stakeholders, and commitment to producing information that is intelligible, as well as spatially and temporally relevant. Proper linkages across scales must be developed, as must sets of indicators for measuring progress toward achieving these goals.

Ann Moote, Senior Research Specialist at the Udall Center for Studies in Public Policy at the University of Arizona, spoke about the wide array of social science research being conducted in the basin. Students from a variety of disciplines want to study the San Pedro River Basin from one perspective or another. In order to get a handle on the research that is being done in the basin and to avoid duplication, several meetings of social science researchers working in the San Pedro Basin were organized. There are sociologists and anthropologists examining community perceptions of conservation needs as well as approaches to water conservation, mostly using interviews and surveys. Others are studying the history of social movements and historical land use, including Indian and Spanish Colonial land use. Geographers and landscape architects are mapping current land use practices in the basin, exploring the use of geographic information systems in decision making, and preparing a San Pedro atlas. Political scientists are studying water law, water rights, and water policy in the context of the San Pedro Basin and making recommendations for new policy approaches that might work in the basin. Economists are assessing the monetary impacts that ecotourism, and especially birding, is having on communities in the basin.

Some of the concerns and criticisms of social science as it is applied to the Upper San Pedro River Basin were also examined. First, research is not well coordinated. Often researchers do not know about each other's work. This results in redundancy in terms of research questions posed and data collection. Second, residents of the basin complain that they are "under the microscope," being studied and surveyed excessively and without knowledge of the purpose or end results of the studies. Because local people are rarely invited to participate in research design, they have no way of helping researchers identify issues that they would like to have researched. Furthermore, because research results are rarely shared with local residents and decision makers, these groups fail to benefit from research that is being conducted on them.

This conference and the work of the SALSA project in general are good models for sharing research proposals and research results, and to some extent, research design and data collection, among researchers and with local resource managers and decision makers. I hope that it is a model that social scientists will work to emulate.

Holly Richter of The Nature Conservancy described a collaborative effort among a number of different participants (EPA, IMADES, The Nature Conservancy, BLM, National Park Service, City of Sierra Vista, U.S. Army Garrison at Ft. Huachuca, SEMARNAP, and Cochise County) who are trying to develop linkages across boundaries by bringing resource managers into a dialogue with scientists. The project on land cover change involves the use of satellite imagery from 1973, 1986, 1992, and 1997 as a means of interpreting changes over time. The imagery reveals linear linkages between vegetation types that serve as habitat corridors. By examining open spaces between corridors, one can readily identify land parcels that could be added to the conservation areas in order to expand and/or connect the corridors.

Invited Speaker Summaries

Two speakers were invited to give luncheon talks. Dr. Hector Arias spoke the first day of the conference and focused on goals of SALSA and the conference. Dr. George Seperich, the luncheon speaker the second day, was specifically asked to address the concerns of rural populations and economic sustainability. Two additional speakers gave special presentations. In Cananea, Isaac López spoke about the role of the Cananea mine regarding water issues. In Bisbee, Dr. Victor Baker addressed the relationship between science and public policy. Below is a brief synopsis of each of these talks.

The San Pedro River Basin: An Opportunity for Cooperation in a Binational Framework

Hector Manuel Arias Rojo
Gabinete de Estudios Ambientales, A.C.

In 1995, scientists and researchers from Mexico, the United States, France, England, and Holland met to form a scientific consortium to study global climate changes in mountainous and semi-arid areas. This consortium became known as SALSA (Semi-Arid Land-Surface-

Atmosphere). The area for initial studies was the San Pedro River Basin, which originates in Mexico.

SALSA is a virtual institution comprised of several organizations. The leading member organizations in Mexico are the Universidad de Sonora, IMADES, UNAM, and the Instituto Mexicano de Tecnología del Agua. In the United States, the USDA-ARS, US-EPA, US-BLM, Los Alamos National Laboratory, Jet Propulsion Laboratory, University of Arizona, and Arizona State University are the primary participants. In France, the Institut de Recherche pour le Développement (IRD), and the Centre d'Etudes Spatiales de la Biosphere (CESBIO) are involved. The consortium coordinates participant scientists in order to optimize economic and human resources and allows for the sharing of cutting edge technology and information among participant institutions. The individuals responsible for SALSA coordination were David Goodrich of the U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS) in Tucson, Arizona, and Ghani Chehbouni of IRD/France with residence in Hermosillo, Sonora, Mexico.

SALSA research in the basin has focused on several ecosystems. In the United States, emphasis has been on riparian gallery forests and sacaton vegetation. In Mexico, research has focused on native pastures and mesquite woodlands located on ejido lands. Scientific equipment was installed at Ejido Zapata and Ejido Morelos upon approval of ejido authorities and with support of Mexicana de Cananea. In addition, researchers visited the ejidos within the basin in order to learn about their productive activities and to undertake resource inventories.

The objective of this conference is to promote community awareness and conservation of the valuable shared resources that are found in the San Pedro River Basin. Conservation is the use of resources in a sustainable manner. Currently, proposals exist for the protection of migratory bird habitats along the river. The attainment of these conservation goals requires understanding and cooperation of the property owners of the area. Because the basin is located in both countries, coordination of groups from both sides of the border is necessary to carry out this mission. Each community interested in natural resource issues can accomplish its conservation goals through alliances with the Sonora-Arizona Commission.

The Other 'Eco'-System

George J. Seperich, Associate Dean
Morrison School of Agribusiness and Resource Management
Arizona State University East

Your research through the SALSA program has admirably delineated numerous ecological parameters in the San Pedro River watershed for measurement and study. You are well into developing workable ecosystem models for this area. However, another significant 'eco'-system does not seem to have received the attention it deserves. This is the economic system upon which the residents of the San Pedro River watershed depend.

On January 1, 1000 approximately 250 million people inhabited our planet. One thousand years later there are 6 billion people, but the real concern is, if present trends continue, in eighty years we will become 11 billion people. And these 11 billion people will have a set of economic expectations that exceed mere sustainability. The global satellite communication system has connected most of us to each other and has raised our collective economic expectations. These rising economic expectations will severely tax our abilities to marshal the resources of this planet. We do have a Y2K problem but it does not involve computing systems. It involves four components—People, Land, Food, and Water.

These variables define an economic system as much as an ecological system. Every night when most people retire, each knows exactly how many pesos, dollars, yen, or yuan he or she has. This is their measure of participation in the economic system. They do not have a measure of how they participate in the ecological system. They do not know much about your ecosystem, i.e. the status of species in their realm, and unfortunately they care little to know. This is why your considerations must include their ecosystem involvement.

How does your work impact them? You chose to study a site located in the western United States. This was propitious, because by 2025 one out of every three Americans is expected to be living in the western United States. They will be in or clustered around Phoenix, Tucson and major cities in the other western states. This geographic concentration is merely the United State's manifestation of demographic changes that are occurring globally. While the population is concentrated, their demand for resources is not and in Arizona this demand will reach to the furthest reaches of the San Pedro River Basin. Short of some global catastrophe there will be no stop to this economic and demographic juggernaut.

In this complex mixture of people, land, food, water, ecology, and economics, one component will dominate. It is water. It will become the rate-limiting component of growth and personal economic well-being. Water is the component that joins your ecological system to their economic system, your value system to their value system. Water will become one of our most precious resources and in the future we can expect it to become a commodity traded like oil or gold, only more valuable. Oil and gold sustain an economic system but water can sustain both systems—economic and ecological. The same water needed to sustain your riparian ecosystem is also needed to sustain the economic system of the San Pedro River Basin (or perhaps even the Tucson economic system).

Your task is to define the relationships between people, land, food, and water within this watershed. But you should do it with both 'eco'-systems in mind. One is just as important as the other. While increasing scarcity will force us into making hard choices, the better we understand both systems and their interrelationships, the better equipped we will be to make good choices—good choices for both 'eco'-systems. If you fail to consider both ‘eco’-systems you may force us to choose between the ‘eco’-systems and species of the San Pedro Basin and another endangered species, the rural people of Arizona and Sonora. These people are local representatives of the larger demographics that confront us. Do not forget or ignore them. Time and numbers are on their side.

Water Issues Related to Mining in the San Pedro River Basin

Isaac López, Director of Operations
Mexicana de Cananea

In the Cananea region, organized mining operations date to 1899. Over the course of the past 100 years, numerous social, political, and economic events have changed the panorama and development of mining activities in Cananea. For its industrial operations, the old mining company employed eleven deep wells that were drilled between 1945 and 1950 to tap into the subterranean water from the San Pedro River Basin aquifer. Since then, the development of the mining industry depended on the potential of aquifer water from San Pedro River Basin.

In the early 1900s, the potable water supply for the population of Cananea was derived from Ojo de Agua, located in the Upper Basin of the Sonora River. Later, due to the growth of the city of Cananea, it was necessary to tap wells in the area of the San Pedro River to provide potable water. It is worth mentioning that the mining company provided potable water service to the population of Cananea until 1998. Currently, the state of Sonora manages the service.

The old mining company increased production to 70,000 tons per day with a new concentration plant. At the time, employment opportunities in mining and competitiveness in national and international markets increased. In 1980, geohydrological studies began in the Upper Basin of the San Pedro River. This area contains the most reliable source for the supply of fresh water for the expansion of future mining operations. The Cananea Mining Company began operation of a newer concentration plant in August 1986. At the same time, it began operation of the "los patos" pumping system of wells located in the Upper Basin of the San Pedro River. Simultaneously, a new system of industrial water reclamation was initiated to support the milling operations in the concentration plant. In 1990, Grupo México acquired the assets of Minera de Cananea. Since then, mining activities have been carried out with more concern to environmental and water resource issues. Through various projects and political actions, Grupo México has attempted to achieve its environmental objectives in the San Pedro River Basin and elsewhere.

The concentration plant uses about ninety-three percent of the fresh water that is used in the entire mining process. The consumption index (cubic meters per milled ton) is the most representative measure of water usage. In 1987, the consumption index in the concentradora was 346 gallons (1.31 cubic meters) for milled ton. Following a series of investments aimed at reducing water usage, the index fell to 275 gallons (1.04 cubic meters) in 1990, 188 gallons (0.71 cubic meters) in 1991, 177 gallons (0.67 cubic meters) in 1995, and 127 gallons (0.48 cubic meters) in 1998. The reduction in fresh water usage in the past ten years is significant. In 1990, water extraction for industrial use was approximately 15,400 acre-feet (19 million cubic meters); currently, it is between 9,730 and 10,540 acre-feet (12 and 13 million cubic meters) per year. The operation of the current system of wells in the San Pedro River Basin is undertaken in alternating areas of pumping so as to achieve distributed water extraction from the aquifer.

Recently, Mexicana de Cananea hired a consultant firm to carry out a study of the hydrological resources in the aquifers of the Upper Basin of the San Pedro River and part of the Upper Basin of the Sonora River. The study abides by the terms of the Comisión Nacional del Agua. The objective of the study is to define the aquifer system, determine its behavior and degree of exploitation, and evaluate its potential for exploitation. The study, to be completed in mid-2000, includes an inventory of underground water usage, geology, superficial and subterranean hydrology, hydrological geochemistry of wells, and modeling of the aquifer. Based on partial results, the aquifer in the valley of the Upper Basin of the San Pedro River is developed in a porous environment formed in alluvial and conglomerate deposits of good permeability that fill the valley and that in some instances reaches depths of 1,640 feet (500 meters).

Over time, the original system conditions have remained the same in the northern portion of the aquifer. In the southern portion, where most of the extraction occurs, water levels have tended to stabilize. Preliminary results indicate that system recharge is greater than previously believed, thereby indicating that the aquifer is underexploited. It is important to highlight that the results pertain to only one aquifer and that accurate assessments of evapotranspiration, flow toward the San Pedro River, and underground flow through the divide toward the United States have not been determined. The cost of these geohydrological studies exceeds US$200,000.

In 1994, Mexicana de Cananea elaborated an ambitious project in global hydrological control that deals with several hydrological works such as channels, diversion dams, and pumping systems. In the area to the north of the mine where the San Pedro River Basin begins, three anticontamination diversion dams were built along with a pumping system to avoid industrial water spills. From the old diversion dams toward El Barrilito arroyo, 1.9 miles (3 kilometers) of channels were constructed in the Buenavista zone to divert rainwater toward the San Pedro River Basin. In 1998, a pumping shaft was built in El Barrilito arroyo to recover excess industrial water. Water monitoring in the basin was also instituted. Investments in these important projects in the San Pedro River Basin total nearly US$5 million. Mexicana de Cananea has been taking concrete actions aimed at the optimization of fresh water for use in mining processes. These actions undoubtedly contribute to the further conservation of the aquifer of the San Pedro River Basin and help to maintain water quality. Furthermore, Mexicana de Cananea continues to carry out studies and projects that contribute to a better understanding of the basin and the use of its water resources.

Science and Public Policy

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It is one of the great myths of our time that science constitutes a repository of authoritative knowledge. The corollary to this myth is that action can be confidently based on this authority. The myth is sustained by definitions of science such as the following: "…a branch

of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operations of general laws."

The problem is that this definition applies not only to science, a process of inquiry into the world, but also to a body of knowledge for which claims are made, including claims of truth and law-like operation. There can be no process of scientific inquiry into truth; one merely has it. Scientific inquiry seeks for truths and law-like operations of nature. If these seem to be achieved, the only role left to science is to question them, or seek better ones. Ultimately, science as inquiry eschews authority.

The professional culture of the scientist involves a world of objective facts, proofs, rational methods, measurements and incremental progress. In contrast, the world of policymakers revolves around subjective values, beliefs, emotions, perceptions, and deadlines or crises. The way in which these worlds intersect for achieving policy can be partly understood by reflecting on the following principles: (1) the less the societal consensus on an issue, the greater the scientific certainty required for action, and (2) the higher the societal cost of a policy, the greater the scientific certainty required for action.

Consensus and cost are political issues, so it is natural to claim some level of scientific certainty when consensus is needed or high costs must be justified. The mathematical/predictive sciences produce the highest certainty, so they are preferentially invoked for claims to authority in achieving political requirements in policy matters.

It has long been argued by behavioral scientists that direct perception of phenomena is more important to instilling belief than are abstract concepts. In a democratic process of policy development, these beliefs must be incorporated as societal factors, equal in importance to technical information. Thus, abstract concepts used to provide answers to environmental problems cannot provide authoritative basis for acting on those problems. Instead, the basis for action lies in complex factors that instill belief. This basis for action is more in the realm of percepts than that of concepts. The concepts of science cannot serve as the basis for action; they can only serve as part of the process in which various percepts compel that action. Despite the amazing conceptual capabilities of modern science, what matters to the implementation of policy, is often the popular belief systems, grounded in local realities, that can be perceived by all participants in the policy process. Given present and foreseeable future levels of public scientific literacy, the public is unlikely to abandon its common sense approach to the fixation of belief. Powerful as conceptualizations may be for providing guidance to the potential solutions for environmental problems, they remain idealizations of lesser pragmatic significance in perception-driven environmental policy.

Given the above realities, it is appropriate to consider another role for science in policy, which is to use the results of science to trigger perception-based action by responsible decision makers. The role of science is to call attention to potential problems and promote them into the policy agenda. Thus, science should not be viewed solely as a basis for policy solutions; it should be involved in the process of policy development and appraisal.

Let us consider an illustration of the science/policy dichotomy involving ephemeral alluvial rivers in sedimentary basins of the southwestern United States. Such rivers have long histories of channel change, incision, and aggradation, operating on time scales of several decades to centuries. Many types of human activity, including effects of grazing, water withdrawal, and bank stabilization have also disturbed these rivers. These activities often have severely impacted the plant communities that are developed along such rivers.

The "answer" to environmental problems on such rivers is generally a form of engineering. The engineer applies the best available theory, usually derived from mathematical/predictive sciences, to achieve an accurate representation of the system of interest. From this system, the engineer formulates a design that resolves the problem. The system is the key element. It presumes certain scales of operation to the river sector of interest. Notice that this crucial step defines in advance: (1) what the relevant portion of the river is, and (2) what the relevant time period is. Of course, this must be done because cost considerations prevent one from engineering for all possible portions of the river and all time periods. This step is really the problem definition. It is, in essence, the "question" for which an engineering design will become an eventual "answer." But we have a dilemma: how does one formulate the "question" when one is ignorant of the natural scales of operation and complex behaviors of the specific river, and one does not know the perceptions of those to be impacted by the proposed "answer?"

A pragmatic resolution for the dilemma requires that one not perceive the natural community as an objective system, isolated from humanity and specified in advance in terms of its temporal and spatial scales. The attributes of nature are to be discovered for each specific circumstance. People are to be involved in the natural community, and the interpretative science of that community should influence the thought of its community members. The wise acts that follow will require employing a scientific process that addresses questions appropriate to the problem as well as idealized answers or solutions. This is actually a much broader notion of "experiment" than that applied in mathematical/predictive physical sciences. For the latter, controlled experiments serve to test theories and other conceptual schemes. Pragmatic experiments, however, are broadly conceived as questions put to nature. Science must be conceived more as developing better questions for environmental policy than as providing definitive, authoritative answers for these issues.

Breakout Sessions

Afternoon breakout sessions allowed conference attendees to participate in discussions related to critical issues in the basin. There were five breakout sessions in Cananea and three in Bisbee. In Cananea, the breakout groups discussed the following issues:

1. What are the geographic information systems (GIS) and mapping needs in Mexico?
2. What are the conservation options for the San Pedro River corridor?
3. What needs to be done to assure a satisfactory water supply

in the Upper San Pedro River Basin?
4. What can be done to foster binational, interagency coordination in the San Pedro River Basin?
5. How can we foster binational natural resource information exchange?

In Bisbee, the breakout groups discussed similar questions:

6. How can we foster binational natural resource information exchange and binational, interagency coordination in the Upper San Pedro River Basin?
7. What must be done to assure a satisfactory water supply in the Upper San Pedro River Basin?
8. What are the conservation options for the San Pedro River corridor?

A bilingual facilitator led each discussion. The structure and format of the breakout sessions followed an established methodology. After the topic was introduced, nominal group technique was employed to allow all participants to contribute to brainstorming a list of items for further discussion. Next, the group arrived at consensus on the most important issues. These issues were discussed in the context of the following five questions:

- What is the current state of affairs related to this idea?
- What would be the ideal state of affairs?
- What changes are necessary to achieve the ideal state of affairs?
- What science and information are needed to help implement these changes?
- What are the first steps that need to be taken?

At the end of the breakout session, a final report was provided to the plenary session and facilitators drafted written summaries of the discussions. A number of emergent themes appeared in many of the sessions:

Identify and apply state-of-the art water conservation practices. Breakout group participants said all users, including industry, municipalities, residents, and especially farmers who irrigate, should apply state-of-the-art conservation practices.

Improve binational coordination. Several groups suggested that conferences such as this one should occur regularly, perhaps annually. A couple of groups discussed opportunities for student, researcher, and agency exchange programs. There was considerable interest in creating a binational watershed management plan and organization to oversee it, perhaps taking the Upper San Pedro Partnership as a starting point.

Improve access to information. Although the groups were asked to identify additional science and research needs to address the issues they were discussing, in most cases they said that there is less need for new science than for improved access to existing information and data sharing. Information should be made accessible to and

understandable by local users. There was substantial interest in having a bilingual information center clearinghouse (building and website).

Include local community issues and needs. Several breakout groups said community members and resource users should help design and implement research, management, and policy agendas. Research and policy should take into account local customs and cultures. Scientists and decision makers should listen to and learn from locals.

The written summaries of each breakout session are below. Lists of ideas generated by group brainstorming are in Appendix 2.

1. What are geographic information systems (GIS) and mapping needs in Mexico? (Facilitator: John Trachta)

The purposes of this breakout session were: 1) to ascertain what base maps and remotely sensed products exist and who collected and owns the data; 2) to identify missing areas of mapped information; and 3) to explore the means of establishing a centralized clearinghouse for geographic data. Government and private sector representatives from the United States and Mexico who wish to collaborate and share information concerning the San Pedro River watershed attended the session.

The mapping need in Mexico is pressing because the U.S. Department of the Interior and SEMARNAP have recommended creating a preserve along the river corridor on the Mexican side of the basin. The Department of the Interior offered to assist the Mexican government with funds for redesigning the preserve, but a development plan needs to be created first. In order to move forward in this process, the proposal for the redesign of the conservation area must be completed by March 2000.

Participants in this session noted that the idea of declaring a conservation area is not a priority. Instead, the strengthening of existing reserves is considered to be the best means of natural resource preservation. Mines and landowners are worried about land and water use restrictions.

Current mapping needs in Mexico include the development of a map of the basin that contains vegetation, topography, and parcel ownership. At present, maps at various scales are used. The scales vary depending on the given subject matter. The Mexicans have very little information for the United States; thus the Mexican maps often end at the border. Currently mapped data is in vector format. The most common software employed is ArcView.

The group discussed the format and means of providing data to Mexico. This would involve data standardization and the creation of a spatial data repository. Much of the data collected in the United States overlaps into Mexico. For example, the USGS has had an aggressive mapping campaign of the Mexican border region. Data is available for the entire

border at a one-meter ground sampling resolution in color infrared. In addition, there is some black and white imagery available in Mexico. In general, the imagery includes the area two to three miles (3.2 to 4.8 kilometers) south of the international border. The Mexican mapping agency (Instituto Nacional de Estadística e Informática (INEGI) has the same resolution covering 100 miles (160.9 kilometers) south of the border. Priority areas have infrared imagery and the remaining areas are black and white imagery. Furthermore, Landsat 7 is available for all of Mexico. The 15-meter resolution panchromatic Landsat imagery is taken every eighteen days. Using aerial photography, digital orthophotographs can be developed at 1-meter ground resolution. Products developed by the USGS far outpace efforts by INEGI. INEGI has aerial photographs, but they have not been digitized. A 1997 vegetation map of the entire San Pedro Basin will be available once the accuracy assessment is completed. A 1992 vegetation map, which has been classified and assessed at the 60-meter resolution level, is currently available for planning purposes.

In order to define the extent of a new preserve, a variety of data is necessary. This includes a definition of the study area, a description of the current reserve boundary, and the delimitation of roads, railroads, population centers, land ownership, hydrological aspects such as flow and recharge, watersheds, topography, digital elevation model (DEM), vegetation, soils, political/administrative boundaries, mines, land use, conservation targets, wilderness areas, conservation areas, geology, mineral reserves, mineral rights, at risk areas, and critical habitats.

The information that is needed most urgently for the Ajos-Bavispe forest preserve includes the delimitation of the boundary of the current preserve. Decreed in 1936, the boundaries of the preserve have never been precisely defined in map format. The boundaries can be digitized relatively accurately through the use of aerial photography and refined through ground-truthing techniques. In the past sixty-three years, people have encroached upon the boundaries. Land ownership records need to be verified in order to determine the extent of illegal occupation of preserve lands. In addition, infrastructure such as roads and wells needs to be mapped. Furthermore, the hydrological aspects of the area are important because the proposed preserve is considered to be a riparian area and the water balance is very important to the viability of the area. Water usage by the mine and per capita water usage estimates are also required.

With respect to topography, Mexican maps at a scale of 1:50,000 for the boundary and land ownership estimates exist. The use of satellite imagery to identify undisturbed areas within the estimated area of the preserve and to infer boundaries is a possibility. Most participants in this breakout group agreed that determining the exact boundary of the existing preserve is not critical to presenting a proposal for the new preserve area. U.S. scientists involved in SALSA are collecting much of the needed information. In cooperation with leaders in Mexico, a prioritized list of needs should be formulated within the next six months. The issue of data sharing was raised. Which Mexican agency would receive data collected by U.S. agencies? The SALSA group may or may not agree to undertake the data collection of information necessary for the preserve proposal.

2. What are the conservation options for the San Pedro River corridor?
(Facilitator: Bryce Appleton)

The ideas for conserving the San Pedro River corridor can be grouped into five areas:

- Purchase land or conservation easements.
- Establish a conservation reserve of the entire Upper San Pedro River Basin.
- Improve or eliminate agricultural practices.
- Eliminate sewage and mine drainage into Cananea's water source.
- Implement water conservation practices in urban areas.

Purchase land or conservation easements. A priority for this group is purchasing land or conservation easements on both sides of the border, and especially in Mexico. The objective is to halt high water use activities or subdivisions in significant areas. The ideal, according to this group, would be a continuous, protected corridor along the river, extending the length of the river in the U.S. portion of the upper basin and from the U.S.-Mexico border to sky islands in Mexico. Land would be protected to avoid habitat fragmentation and protect the river.

The group noted that currently, most land in Mexico is ejido land, and there is no federal land except the streambed itself. However, participants said, there is no money available to buy land and there are no entities existing that can hold land or easements. Nevertheless, the group thought purchase of land or easements can be done in Mexico, and noted that while it hasn't been done in the San Pedro River Basin in Mexico, it has been done elsewhere. On the U.S. side of the border, the Bureau of Land Management both owns land in fee and has purchased conservation easements. The Ajos-Bavispe reserve has expressed interest in purchasing land or easements.

What it will take to achieve their ideal, the group said, is money. They suggested finding an institution or creating a corporation that could hold land and easements; two possibilities are the Ajos-Bavispe reserve and Amigos de Ajos corporation. In addition to money, creating a conservation corridor through land purchase and conservation easements would require lobbying, public education, landowner education, economic incentives, and identification of a reserve boundary in both countries. The science needed to achieve a protected corridor includes accurate maps of current land ownership, an inventory of land ranked by ecological value, a study of the species to be conserved and their habitat needs, and a baseline biophysical inventory so that changes can be monitored.

Immediate actions recommended by the group included fund-raising, developing GIS maps that incorporate most previous research in order to rank potential purchase areas, providing training on private land conservation mechanisms, and working with the community to gain its support for this effort.

Establish a conservation reserve of the entire Upper San Pedro River Basin. Some participants felt that the entire basin should be declared a biosphere reserve and added to the existing Ajos-Bavispe forest reserve. This, they noted, would require modifying the legislation

for the Ajos-Bavispe reserve, fund-raising, and baseline studies of biological, physiological, legal and socioeconomic conditions. The group recommended the following for immediate action: conduct baseline studies, hold community meetings about the proposed conservation area, develop economic alternatives for landowners and conduct a community needs assessment.

Improve or eliminate agricultural practices. A third conservation option this group discussed was eliminating agriculture on the U.S. side of the Upper San Pedro River corridor and improving conservation practices on agricultural land on the Mexican side of the basin. The group thought improving agricultural practices and retiring some agricultural lands would best be achieved through cost sharing. Currently, the group said there are no incentives for land users to plan and apply needed conservation practices in the Upper San Pedro River Basin. Therefore, the group recommended developing and implementing a natural resource and environmental education program at all levels of the community. This education should be based on sound, accessibly scientific research. Research findings should be shared with all decision makers and available to anyone. Initial actions that could be taken include legal action to provide significant economic incentives that would result in high land-user participation and extensive application of conservation practices throughout the Upper San Pedro River Basin.

Eliminate sewage and mine drainage into Cananea's water source. Group participants also recommended protecting the spring at the river's source that also supplies drinking water to the city of Cananea. Protecting the spring would require protecting the spring and river tributaries from sewage and mine waste that drain into them. The group recommended that to do this, Grupo Mexico, who owns the mine, should improve the mine's system of surface water runoff collection and improve the dam system in the area of Cananea Vieja and Ejido de Cananea. The group also recommended establishing a wastewater treatment plant, cleaning out the pond, and authorizing improving and rerouting the sewage system. Additional information gathering is needed, including sampling water at its source and in the pond, and mapping water movement and water quality in the entire area. Immediate actions that could be taken include declaring El Aguajito and the source of the San Pedro River as a primary protected zone within the city of Cananea, mitigating the environmental damage by stopping the flow of polluted water, and removing contaminated soil.

Implement water conservation practices in urban areas. The group noted that, currently, there are very few voluntary and no mandatory water conservation measures in the urban areas. The group's ideal for this item would be rigorous water conservation by Upper San Pedro River Basin residents, including businesses, homes, building developments, agriculture, and ranching. To improve conservation practices, the group recommended developing and implementing new water conservation strategies, such as low-flow toilets and showers, xeriscaping, and reduced irrigation. They also recommended education to inform the public of various water conservation options. Demographic data, quantifying water use per capita, and research that shows the benefits of conservation would all help this effort. A first step that could be taken is to collaborate with local governments to develop and implement a conservation practices plan.

3. What needs to be done to assure a satisfactory water supply in the Upper San Pedro River Basin? (Facilitator: Pamela Hale Trachta)

The group generated nearly thirty ideas, ranging from increasing water supplies through water harvesting to reducing water use by agricultural and urban users. Three main ideas were selected for discussion:

- Create a binational legal entity to coordinate collaboration on water conservation strategies.
- Implement water conservation practices, techniques and technologies in agriculture.
- Ensure equitable water allocation between rural/urban and residential/industrial uses.

Create a binational legal entity for collaboration on water conservation strategies. The first issue of focus was establishing a binational agreement and watershed plan to ensure the continuation of the river base flow and habitat on both sides of the border. Participants in this breakout group said that as far as they know, the status quo is that there is no plan, no legal entity, and no binational collaboration. To establish binational collaboration, funding, conservation, and a management plan are needed. The plan should be arrived at through binational public participation, and should include monitoring and technology sharing. The plan should address growth issues.

Implement water conservation practices, techniques and technologies in agriculture. The second issue addressed was looking for a better way to administer water. Farmers and ranchers on both sides of the border are looking for best management practices and conservation techniques that they can apply. The work group members believe farmers and ranchers do not have the technical knowledge they need. Ideally there should be adequate funding for conservation technology and a sharing of that technology. Improving communication would be a first step in that direction. The group also recommended a liaison be provided to make existing technology available to farmers and ranchers.

Ensure equitable water allocation between rural/urban and residential/industrial uses. The third issue discussed was how to equalize responsibility for conservation on both sides of the border. The group also noted that now there is no limit on growth in Cochise County. They asked two questions: what will be the role of Fort Huachuca and Sierra Vista, two of the more powerful players in the basin, and who in the basin could enforce an equitable apportionment of water if needed. Some group participants thought the International Boundary and Water Commission might fill the regulatory role for water apportionment. Ideally, the group said, the watershed should be in balance, with no more water withdrawn from the aquifer than is replenished. Achieving this balance will require less water use. Additional science will be needed to determine how much water currently is being used.

4. What can be done to foster binational, interagency coordination in the San Pedro River Basin? (Facilitator: Carlos Nagel)

The group generated several ideas that are organized into five categories:

- Increase stakeholder representation at the binational level.
- Ensure that the issues and problems drive research and ensure community members help set the agenda.
- Encourage alternative funding sources.
- Build trust between public and private binational agencies and personnel at all levels.
- Establish a standardized monitoring system to eliminate data disputes.

Increase stakeholder representation at the binational level. This breakout group identified the ideal as participatory coordination. This would require improved cross-cultural understanding and communication. It would also be helpful to develop a binational outreach process to provide educational materials for communities and local groups. This could be achieved through a bilingual information center clearinghouse, including a bilingual website. Another idea raised was the creation of regional subgroups of the Border XXI water and natural resources work groups. The group recommended activating stakeholders as a first step to be taken.

Ensure that issues and problems drive the research and ensure that community members help set the agenda. This group's ideal is applied research and science translated for better access by nontechnical people. Community members should help set the research agenda, this group said, to ensure that the communities' issues and problems are addressed. The group recommended reward mechanisms for researchers who involve communities in setting their research agendas.

Build trust between public and private binational agencies and personnel at all levels. According to the group, currently, there is fair trust among agencies and personnel, but the ideal would be complete trust. Social scientists and physical scientists should work together, for instance. It would be helpful if border crossings could be simplified for federal employees and researchers. Achieving trust requires honesty, opportunities to work together, and time to work with others. A good first step would be to simplify research language. Some group participants recommended advocating increased cross-border cooperation at the highest levels of government; some also recommended developing a functional liaison process for cross-border government activities.

Establish a standardized monitoring system to eliminate data disputes. Currently, monitoring systems vary considerably. The ideal would be common monitoring standards so that all data are comparable. Agencies should agree on a common nomenclature and standardize their data collection and analysis methods. This should include management information as well as scientific information.

5. How can we foster binational natural resource information exchange?
(Facilitator: Thelma Butts Griggs)

Six main ideas were derived from the preliminary discussion:

- Ensure that the information that is being gathered, interpreted, prepared, and presented takes into consideration the needs, traditions, customs, culture, and ways of using information of the final end user. Have the scientific information translated to the appropriate format taking into account the cultural and social considerations of the user of the information.
- Have more bilingual materials published. Information should be published in both languages.
- Continue to have binational conferences and opportunities to have information exchange, in both countries if possible.
- Establish binational bisectoral work groups (federal, state, NGO, etc) with specific tasks to complete by the next conference.
- Publish a directory of databases so everyone has access.
- Create international exchange programs for ejidatarios, ranchers, and users in general to understand each other's environmental, cultural, and technical issues.

The first priority item was selected for discussion in detail.

Ensure that the information that is being gathered, interpreted, prepared, and presented takes into consideration the needs, traditions, customs, culture, and ways of using information of the final end user. Have the scientific information translated to the appropriate format, taking into account the cultural and social considerations of the user of the information. When discussing the current state of affairs, group participants noted three general problems: many people do not have access to the information they need, information is not available in nontechnical form, and users are not consulted before studies and policy agendas are set. First, many individuals and groups do not receive the information they need, while other, more powerful entities, such as the power companies, do receive the information they need. There is much disparity on who has access to information.

Second, information is available but not in a user-friendly form in some cases. In the United States, extension agencies can provide access to information and training. In Mexico there are some mechanisms at the universities for dissemination of information but it is not as accessible as through the extension services in the United States. In general, however, there currently is no mechanism to change/translate scientific information into practical, user-friendly form. There is no clearinghouse where all the information is collected and interpreted. Special efforts are needed to reach the targeted groups, because many people are not getting information.

Third, researchers don’t ask the end users what they want before the studies happen. Similarly, individual citizens are often not considered during policy-making agendas.

In the ideal, this group said, every user would have the capacity to research, interpret and make use of all the data that he or she needs. Financial resources would be available to every

user; researchers and users would not be denied access to information because of lack of money. The city of Cananea and Grupo Mexico would set aside funds and resources for conservation. Input would be sought from final users at the beginning of research projects, and the basin would be seen as a whole entity in which borders do not exist. In this ideal situation, there would be a coordinated approach to conducting research, gathering, and preparing needed information for all end users.

To achieve the ideal, the group recommended improving cooperation among all users, researchers and resource managers. Agencies, institutions, and organizations should share cooperatively instead of competing. Ongoing relationships need to be developed among all the users. Researchers and agencies, such as Comisión Nacional de Agua (CNA), Comisión Internacional de Límites y Aguas (CILA), and International Boundary and Water Commission (IBWC) should ask for input from user groups, especially the ejidatarios. Social science as well as technical information needs to be collected and made available to all. Financial resources as well as information need to be available to all users.

Group participants said they need additional information to understand the process of relationships for tribal groups and others. Social science research is needed to understand who all the stakeholders are and to understand the reality of everyday life and needs of all the stakeholders. Finally, there is a need for social science research to help people understand what truly are the realistic alternatives for stakeholders—what they are willing to do.

First steps should be taken at the individual level, the group said. As individuals, we can be catalysts in our own work and that of our agencies. We can talk to the end users. We can explain scientific research in a more simplified manner so that everyone understands the applications of the research. We should ask the locals what they need and honestly listen to them.

6. How can we foster binational natural resource information exchange and binational, interagency coordination in the Upper San Pedro River Basin? (Facilitators: Thelma Butts Griggs and Carlos Nagel)

Five main ideas were derived from the preliminary discussion:

- Learn how each country functions internally by exchange of users and agency personnel for six months to one year.
- Each binational conference should have at least one high school class from each side of the border. These students would report back to their school, to the media and the community about the experience.
- Develop and establish an interactive bilingual Internet clearinghouse in order to share and disseminate information about the San Pedro River Basin.
- After a project is completed, results should be translated and published in a bilingual format that the end user can apply.
- Schedule semiannual visits to management areas on both sides of the border.

The first two items were selected for discussion in detail.

Promote resource user and agency personnel exchanges. The group noted that the Arizona-Sonora Commission already has some student exchange programs, the Bureau of Land Management has a one-week training course for Mexican agency staff, and the National Park Service, U.S. Forest Service, and SEMARNAP have agreements for occasional exchanges. However, under these existing agreements, exchanges happen one at a time and there is very little going on. In terms of other exchange programs, breakout group participants said that the sister city agreement between Sierra Vista and Cananea is not taken seriously by Cananea, and that although Sierra Vista says they are a Sister City with Naco, Naco does not take it seriously.

The ideal state of affairs for exchanges would be to establish a common vocabulary for those working on similar or joint projects, maintain consistent, frequent, and broad ranging communication, and provide for personnel on a regular basis, with salaries to be paid by the providing agency.

The group noted several changes needed to implement exchange programs. There is a need to improve communication between agencies. Someone would have to generate funding for the exchange program by selling the people in power on the idea and promoting the concept so as to get recognition of the value of the exchanges. Group participants recommended communicating the values of the exchange programs so the community can lobby and pressure for the exchange programs. Language training would help overcome the language barrier.

To facilitate development of an exchange program, the group recommended researching other exchange programs and use them as models for what does and does not work, and identifying transportation and housing that can be used for an exchange program. Participants also recommended working with local communities to allow them to design the structures that will create the exchange programs. All science and information prepared for and by the exchange program should be written in an understandable, nontechnical manner. Finally, the group said, exchange program participants should be required to submit a final report so that others can learn from their experience.

First steps that could be taken include contacting the Presidente Municipal of Cananea and agency managers to propose the idea of an exchange program, identifying potential exchange program participants, and establishing a binational fund for the exchange program.

Promote a student exchange program. Group participants noted that although there were no provisions for high school students to attend this conference, three students from Naco came with their teacher to attend. There are cases in which high school students are involved in exchange programs, such as the ecological club for high school students in Cananea. The city of Bisbee has funds for students to attend conferences.

Ideally, the group said, youth participation should be built into the conference planning. Students should be included in all future annual conferences. As this breakout group envisioned

it, all youth would have access to the conference, not just high school students. A conference coordinating committee member would brief the students on the issues to be discussed at the conference, and students would be prepared and aware of the issues to be discussed in the conference well in advance. The conference planners, municipal government and/or private institution should cover the cost of attendance. To encourage participation, students would be given school credit for attending. Students would participate by making posters for the conference. Before the conference, organizers should identify the means of communication (audio/video) to be employed in the sharing of information with fellow students, identify the type of reports to be completed by the students, and arrange for media interviews.

Achieving binational student participation in a San Pedro conference would require advance planning, so that curriculum, display space, and transportation issues can be resolved. The group recommended eliciting the cosponsorship of NGOs that already have youth education programs.

First steps that this group recommended were to include schools as full partners in the incipient stages of conference planning, establish institutional contacts on both sides of the border to work out details related to insurance, travel, and visa issues, and share information with teachers, principals, and school administrators.

7. What must be done to assure a satisfactory water supply in the Upper San Pedro River Basin? (Facilitators: Pamela Hale Trachta and Jon Trachta)

Two main ideas were derived from the preliminary discussion:

- Initiate communication, advocating the creation of a natural and national protected area, to promote the integral management of the basin.
- Develop an upland watershed management strategy in all ownership types that identifies valuable practices, land uses, and projects for the maximization of water conservation and recharge, and the maintenance and increase of the base flow in the San Pedro River.

Initiate communication that advocates the creation of a natural and national protected area in order to promote the integral management of the basin. The group recommended continuing some of the existing conservation efforts already underway in the basin, and expanding others. For instance, current cattle rotation on the ejidos should be continued, as should the current conservation efforts at the mine. In addition, the group recommended expanding the U.S. federal land and water conservation fund initiative to acquire conservation easements in the United States and purchasing land in the area between Highway 92 and the border and in the area known as The Gap. They recommended supporting fund-raising efforts for the Mexican conservation preserve and noted that the structure of the ejido allows for a natural evolution of cooperation and community.

Ideally, this group said, communities would be provided with sustainable alternatives such as cottage industries. To achieve this, they recommended initiating training programs to implement these sustainable business activities. The group also recommended developing state-of-the-art mining, industry, and ranching in Mexico, creating a binational organization that supports conservation efforts in the watershed, creating a common database, carrying out research, and obtaining reliable information from mining operations.

The group noted that incentives and resource support for nongovernmental groups and ejidatarios are needed if a natural protected area is to be created, and satellite imagery is important for establishing the reserve.

The group recommended several first steps that could be taken toward advocating for the creation of a natural protected area: establish a binational resource center and library for technological transfer, create an outreach program for resource users, educate the public via the use of a mobile traveling show, initiate a binational education program in the schools through the use of the Sister City concept that includes a student exchange component, and promote bilingual education.

Develop an upland watershed management strategy in all ownership types that identifies valuable practices, land uses, and projects for the maximization of water conservation and recharge and the maintenance and increase of the base flow in the San Pedro River. The group noted that the Natural Resource Conservation Districts and the Upper San Pedro Partnership have already initiated coordinated watershed management and recommended that their work be continued. In addition, more efficient coordination needs to take place on both sides of the border.

It is important to understand that on the Mexican side of the basin, the mine owns as much as ninety percent of the water rights in the area, including those on ejido lands. The city of Cananea now owns water rights for urban use. It is also important to understand that Mexico has 160 federally protected natural areas of which only thirty-four have budgets. Currently, $5 million is the total budget for all of Mexico. Prior to the current president, the budget was less than five percent of this year's budget. It is also important to understand that at the federal level in the United States, there are between forty and fifty natural areas that have priority over the San Pedro River Basin.

Ideally, the amount of water allocated to the mine would be reduced, and everyone would practice sustainable use under an upland watershed management strategy. To work toward this ideal, the group recommended funding initiatives for the protection of the San Pedro River and continuing SALSA research in the basin. First steps that could be taken toward implementing an upland watershed management strategy include formulating a binational agreement that protects the national sovereignty of both countries and advocating a presidential decree that is based on SALSA information and supported by the ejidatarios.

8. What are the conservation options for the San Pedro River Corridor? (Facilitator: Bryce Appleton)

Three main ideas were derived from the preliminary discussion:

- Promote binational watershed councils as a conservation framework.
- Price water appropriately as a scarce and valuable commodity.
- Recharge.

Promote binational watershed councils as a conservation framework. Currently, no such council exists in the San Pedro Basin. The ideal, would be a functioning, respectful, respected, participatory, nonregulatory council. This could possibly be achieved by adapting the existing Upper San Pedro Partnership to make it binational and by adding a public advisory council such as BECC. One challenge would be overcoming hundreds of years of distrust by the Mexicans. The information needed for this effort is social science research into watershed councils. Recommended actions by this group include developing a bilingual database of water data for water users and obtaining $100,000 for implementation. Participants recommended implementing a water override charge to fund the council.

Price water appropriately as a scare and valuable commodity. Currently water is priced as cheaply as possible, i.e., subsidized. It should be reasonably priced for normal use, but expensive for overuse. The ideal would be an affordable base quantity. Overuse could then be charged punitively, and punitive receipts are used to fund projects. Achieving this new market would require a change in state law to allow regulation of private wells. It would also require studies of market economics and social research to help advance this concept. A first step that could be taken immediately is grassroots education.

Recharge. Although there are recharge efforts underway in the basin, presently, only five percent is recharge. The ideal for this group would be twenty percent recharge. Achieving this ideal would require public works projects as well as private incentives for market-based recharge projects. Building code changes would be needed to require recharge in new subdivisions. Considerable scientific information is needed for recharge efforts, including data on soil infiltration and percolation, engineering to determine locations for recharge sites, hydrologic data (both surface and groundwater), and research on prescribed flooding and potential impacts on flood regimes. Immediate actions that could be taken include pilot recharge projects and letters to municipalities supporting recharge efforts.

Appendix 1: Poster Summaries

There were 32 poster presentations at the conference. The following nontechnical summaries capture the primary ideas from each poster. Full abstracts are available on the SALSA website.

Management Plan for the San Pedro River, Sonora, Mexico

Héctor M. Arias R., Gabinete de Estudios Ambientales
Christopher Watts T. and David Peña H., IMADES
Iván E. Parra S., World Wildlife Fund
Alma A. Haro M. and Héctor A. Licón G., CECARENA

The San Pedro River begins in Mexico and flows north into the United States. The watershed is an area of international interest due to the presence of two semiarid ecosystems: gallery forest and grasslands. Both ecosystems provide habitat for migratory birds. A natural resource geographic information systems (GIS) database was created with the objective of providing a tool to support decision makers in the communities of the basin. The protection and restoration of riparian habitats is a primary concern. Upon recommendation of the Commission for Environmental Cooperation, irrigated agriculture should be reduced on a voluntary and compensatory basis. There is also a need to diversify the economy to compensate for potential loss of jobs should a reserve for habitat preservation be established.

The Transborder Watershed Research Program

Ward Brady, Gary Whysong, Subhro Guhathakurta, and Bill Miller, Arizona State University East
Richard Wright, Department of Geography, San Diego State University

The Tijuana and San Pedro River watersheds span the international border between the United States and Mexico. Water resource issues are critical factors influencing sustainability in these ecologically fragile, semiarid ecosystems. From an ecological perspective, these watersheds form meaningful landscape units for study and management because of shared functional relationships that exist within their boundaries. The overall objective of the Transboundary Watershed Research Program is to initiate an integrative program of research that explores the gap between the view of the watershed as an ecological unit and the watershed as a planning and administrative unit. Integrative approaches to watershed research combine ecological, economic, political, and social factors. Land uses are influenced by these factors and, in turn, impact ecosystem dynamics through events that can be identified and monitored. The principal objective of this research is to investigate the dynamic interrelationships between human and natural factors as reflected by land use patterns in the Tijuana and San Pedro River watersheds.

Visions of the Past and Dreams for the Future: Resource Use and Management of the Upper San Pedro Watershed in Sonora

Anne Browning, Department of Anthropology, University of Arizona

This poster represents an attempt to understand the nature of past and present human use of the Upper San Pedro Reserve in Sonora; identify the industrial, agricultural, ranching, government, scientific, and domestic stakeholders in the regional watershed; present potential uses according to the views of these stakeholders; and describe the nature of initial collaborative efforts in regional watershed problem solving. The goal is to familiarize conference participants and community members from both sides of the border with the range of stakeholders' interests and concerns regarding the condition and use of the watershed.

The Cultural Imperative of Shared Waters: An Analysis of Agency, Science and Community Efforts to Develop a Water Culture in the Upper San Pedro Basin of Arizona and Sonora

Manuela Casselmann, Department of Educational Geography, Johann Wolfgang Goethe University Frankfurt

The poster addresses the concept of culture and its meanings, and the role of science in the context of environmental conflict and conflict resolution in the San Pedro River Basin. By focusing on aspects such as culture of choice, rationality of choice, and water culture, the presentation expresses the idea that sound science and culture are critical aspects of environmental conflict and its resolution. The development of a shared understanding that there are opportunities to reconcile the objectivity of science with its social and cultural construction could be useful for managers, decision makers and people in the basin. This understanding would be reflected in public discourse, information exchange, communication, and an examination of culture and science as social endeavors.

Introduction to the Analytical Tools Interface for Landscape Assessments (ATtILA) ArcView Extension: An Example in the San Pedro River Basin

Donald W. Ebert and Timothy G. Wade, U.S. Environmental Protection Agency, Las Vegas, NV
James E. Harrison, U.S. Environmental Protection Agency, Atlanta, GA
Dennis H. Yankee, Tennessee Valley Authority, Environmental Research Center

A common application of geographic information systems (GIS) is the generation of landscape indicators that are quantitative measurements of the status or potential health of an area. The Landscape Ecology Branch, in cooperation with U.S. EPA Region 4 and the Tennessee Valley Authority (TVA), are developing a user-friendly interface to facilitate this process. ATtILA is an easy to use ArcView extension that calculates many commonly used landscape indicators. Four groups of indicators are included in the extension: landscape characteristics, human stresses, physical characteristics, and riparian characteristics. Each group has the ability to accept user input. Once indicator values have been calculated, the output can be displayed as areas ranked by individual indicator values, indexed ranked areas using multiple indicator values, or presented in bar chart format based on selected areas and indicators. This demonstration uses spatial data from the San Pedro River Basin developed as part of a web-based data browser.

Measuring Change in the San Pedro Riparian Ecosystem: A Comparison of Two Methods

Curtis M. Edmonds, William G. Kepner, Daniel T. Heggem, and Lee A. Bice
U.S. Environmental Protection Agency, Las Vegas, NV

Riparian ecosystems in the Southwest make up less that one percent of total land cover and are generally in poorer condition compared to their extent and condition prior to settlement of the West. Riparian areas play a major part in filtering sediment that would otherwise result in reduced water quality, aid in the control of floods, and prevent soil erosion. The San Pedro Riparian National Conservation Area (NCA) was established in 1988 by the Bureau of Land Management to protect and enhance this riparian ecosystem. Using historical satellite imagery from the North American Landscape Characterization (NALC) database, change in this southwestern riparian ecosystem is documented. Two methods of analysis are employed and implications for monitoring riparian ecosystems in the southwestern United States are presented.

Estimates of Riparian Vegetation Evapotranspiration using Remote and In-Situ Measurements

David C. Goodrich, B. Goff, C. Unkrich and R. Marsett, USDA-ARS, Tucson, AZ
R. Scott, D. Williams, S. Schaeffer and R. Mac Nish, University of Arizona
J. Qi, Michigan State University
M.S. Moran, USDA-ARS, Phoenix, AZ
D. Pool, U.S. Geological Survey, Tucson, AZ
A. Chehbouni, IRD/IMADES
C. Watts, IMADES
Y. Kerr, CESBIO, Toulouse, France

In many semiarid basins groundwater resources constitute the primary water source that sustains human habitation, agriculture and riparian systems during extended periods when surface snowmelt or storm runoff is not present. To utilize regional groundwater models to aid in management of these water resources requires accurate estimates of the basin boundary conditions. A critical groundwater boundary condition that is closely coupled to atmospheric processes is seasonal riparian evapotranspiration (ET). The vegetation types of the riparian system in this basin consist primarily of mesquite, grasses, and cottonwood/willow forest. Measurement techniques were used to estimate ET from these vegetation types to provide seasonal riparian vegetation water use estimates for the riparian corridor.

Ecological Change in the San Pedro Watershed: An Inventory of Baseline Environmental Information from Spanish Colonial Documents

Diana Hadley and Dale Bernneman, Arizona State Museum, University of Arizona

The Ecological Change in the Greater Southwest project aims to bring baseline environmental information contained in Spanish colonial documents to a wider group of researchers and land managers through a computerized index on the Internet. Our pilot study begins with the Pimería Alta, which includes the San Pedro River drainage. In addition to summarizing the ecological content of relevant documents, the Ecological Index provides information on climate, streamflow, drought, fire, native plants and animals, agricultural practices, and crop yields as an indication of soil fertility and climatic conditions at particular periods in history.

Predicting Animal Responses to Ecological Changes on the San Pedro River: A Spatial Model Incorporating Edge Effects

Haydee M. Hampton, Leslie Ries, and Thomas D. Sisk
Center for Environmental Sciences and Education, Northern Arizona University
Barry R. Noon, Department of Fisheries and Wildlife Biology, Colorado State University

One consequence of increased human activity along southwestern river ecosystems is an increase in habitat fragmentation. Fragmentation causes once continuous habitat to be broken into "islands," greatly increasing the amount of edge. Many animals are known to avoid or be attracted to edges. The spatial model incorporates field data on animal responses to habitat edges in order to predict animal abundance under various land management scenarios. Using butterfly data from the San Pedro River Basin, the results indicate that incorporating edge effects gave a substantially different outcome to a hypothetical change in habitat. Managers will be able to use this model to more accurately project the consequences of different land-use plans.

A Guide to Weather, Climate and Hydrologic Forecasts for the U.S. Southwest

Holly C. Hartmann, Roger Bales, and Soroosh Sorooshian
Department of Hydrology and Water Resources, University of Arizona

Whether recognized explicitly or not, most decisions related to natural resource management make use of some sort of meteorological forecast. Forecasting techniques range from complex and objective techniques that employ many types of data and mathematical representations of complex physical processes, to simple and subjective approaches. Through the Climate Assessment Project for the Southwest (CLIMAS), this presentation provides a guide to weather, climate and hydrologic forecasts relevant to the Southwest, with an emphasis on operational products. Information is provided on sources of forecasts, proper interpretation of forecasts, techniques used in generating forecasts, strengths and limitations of those techniques, and past evaluations of forecast performance.

A Data Browser for the San Pedro River Watershed

Daniel T. Heggem, William G. Kepner, Curtis M. Edmonds, Edward J. Evanson, and Lee A. Bice
U.S. Environmental Protection Agency, Las Vegas, NV

In an effort to compile and organize available data for the public and scientists interested in the San Pedro River Watershed, the San Pedro Data Browser was created. This data, gathered from many different agencies, is unique because it represents landscape patterns and biological and physical processes that occur within the watershed. The San Pedro Data Browser provides spatial data in a user-friendly and accessible on-line format to other researchers, public agencies, resource managers, nongovernmental organizations, decision makers, and user groups. The Data Browser features easy data download and includes data documentation to assure data usability. This product provides for long-term record keeping and easy access to an exceptional assemblage of spatial data for this internationally significant watershed.

Sharing Grazing Management Information Across the U.S.-Mexico Border

Philip Heilman, Jefrey Stone, and Alicia Melgoza Castillo, U.S. Department of Agriculture, Tucson, AZ

Proper grazing management has an important role to play in maintaining the stability of rangeland watersheds and the health of riparian systems. Different rangeland classification systems to facilitate management exist in the U.S. and Mexico. However, there has been little effort to correlate the two systems across the border. These classifications cannot be applied blindly across the border. Rangeland managers should be aware that information exists for the development of ranch management plans that will conserve natural resources, increase ranch income, and reduce income variability. Preliminary investigations indicate that soils and vegetation in a transition zone between the Sonoran and Chihuahua Deserts are similar enough to share management information between southeastern Arizona, northeastern Sonora, and northwestern Chihuahua.

Fort Huachuca Water Resource Management

Gretchen R. Kent, Fort Huachuca

For more than 100 years, Fort Huachuca has maintained environmental stewardship over more than 73,000 acres (29,542 hectares) in the Upper San Pedro River Basin. During the last decade, Fort Huachuca had reduced annual water pumpage by a third. This dramatic decrease in withdrawal from the aquifer has been accomplished through a multifaceted approach that includes both technology and policy based initiatives. Future initiatives to continue reductions in groundwater withdrawals are in various phases of planning and implementation. The poster presentation illustrates the components of water use reduction and their approximate contribution to overall savings.

A Landscape Approach to Monitoring and Assessing Environmental Condition in the Upper San Pedro River Basin

William Kepner and Curtis Edmonds, U.S. Environmental Protection Agency, Las Vegas, NV
Christopher Watts and Gonzalo Luna, IMADES, Hermosillo, Sonora
Holly Richter, The Nature Conservancy, Hereford, AZ
William Childress, U.S. Bureau of Land Management, Sierra Vista, AZ
Barbara Alberti, U.S. National Park Service, Coronado National Memorial, Hereford, AZ
Robert Blanchard, City of Sierra Vista, Sierra Vista, AZ
Sheridan Stone, U.S. Army Garrison, Ft. Huachuca, AZ
José Guerra, SEMARNAP, Hermosillo, Sonora
Rick Koehler, Cochise County, Highway and Floodplain Department, Bisbee, AZ
David Goodrich, USDA-ARS, Tucson, AZ

Assessment of land use and land cover is an extremely important activity for contemporary land management. Current literature suggests that human land-use management practices are the most important factor influencing ecosystem structure and functioning at local, regional, and global scales. During the past two decades, important advances in the integration of remote imagery, computer processing, and spatial analysis technologies have been used to better understand the distribution of natural communities and ecosystems, and the ecological processes that affect these patterns. These technologies provide the basis for developing landscape measurements that can document large-scale, long-term ecological change and facilitate conservation decision-making processes within the Upper San Pedro River Basin.

The Changing Watershed: A 25-year History of Land Cover Change in the San Pedro River

William Kepner y Curtis Edmonds, U.S. Environmental Protection Agency, Las Vegas, NV
Christopher Watts, IMADES, Hermosillo, Sonora
John Maingi y Stuart Marsh, Arizona Remote Sensing Center, University of Arizona, Tucson, AZ
Beaumont McClure, U.S. Bureau of Land Management, Phoenix, AZ
Jesse Juen, U.S. Bureau of Land Management, Tucson, AZ

It is now practical to measure vegetation change over large geographic areas and determine trends in ecological and hydrological condition by integrating advanced technologies. This has been tested over a 25-year period in the Upper San Pedro River Watershed using a system of landscape pattern measurements derived from Landsat remote sensing, spatial statistics, process modeling and geographic information systems technology. 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 condition related to disturbance from human and natural stresses.

Landuse and Vegetation Change in the San Pedro River Basin Using Landsat Satellite Images from 1973-1992

Gonzalo Luna Salazar and María Luisa Fernández Ruiz, IMADES

At present, the San Pedro River Basin is suffering serious vegetation change provoked mainly by population growth and the productive activities of man, such as mining, agriculture, cattle ranching, and water extraction. According to Landsat image analysis for the period 1973 to 1992, serious vegetation changes occurred to the encino pine forest and natural grasslands. Both habitats were affected by increases in agriculture, cattle ranching, nonvegetated areas, water bodies and urban areas. These changes contributed to the substitution of secondary vegetation for native, natural vegetation.

Arizona Department of Water Resources – Partnership in the Upper San Pedro Basin

Dale Mason, Arizona Department of Water Resources

Climatic variations and development of groundwater resources in the Upper San Pedro River Basin have altered the regional groundwater and surface water flow regimes. Periods of drought, high surface water flow events, changes in land use patterns, and groundwater pumping for irrigation and public supply have combined to adversely impact the interaction between the regional groundwater aquifer and the surface water system. This has resulted in changes in riparian areas and surface water flow characteristics, entrenchment of the San Pedro River channel, and localized changes in the regional water system. In addition to annual water level and basic water quality data collection and analysis, the ADWR also fosters cooperation among interested groups within the basin by participating in the Upper San Pedro Partnership.

The Naco Constructed Wetlands and Microenterprise Project (NACWEMP): Clean Money from Dirty Water

Luís Miranda, Eric Ellman, and Michael Wilson, Drylands Institute

Located just south of the international boundary in Sonora, Mexico, the Naco Constructed Wetlands and Microenterprise Project (NACWEMP) is an important demonstration project. Four organizations (Border Ecology Project, Drylands Institute, Environmental Compliance International, and Enlace Ecológico) cooperated with the Municipio de Naco and Ejido Naco to build a small subsurface flow wetland that handles about 10,000 liters per day of effluent from Naco's sewage lagoons. The treated effluent flows to a reuse area where it is used to irrigate crops such as timber, bamboo, gourds and other crops. NACWEMP-style operations are inexpensive, easily maintained and encourage communities to view safe, treated water as an income-generating resource. Business ventures such as the decoration of dry gourds as birdhouses has already begun. NACWEMP provides lessons not only on technical aspects, but also on the political, social, and economic logistics of maintaining this type of project on a long-term basis.

Optical and Radar Imagery for Mapping Resource Management Units in Southeast Arizona

Wanmei Ni, Susan Moran, Ross Bryant, and Yann Nouvellon, U.S. Department of Agriculture, Tucson, AZ

Spatial distributions of surface soil moisture and vegetation type and cover are important for rangeland management in the arid southwest. An economic way to map the regional distribution of surface conditions is through the use of spectral images obtained from satellite sensors. Using this remotely sensed data, a variety of techniques were employed to derive information on topography, vegetation density and surface soil moisture. The topographic patterns observed were similar to USGS digital map elevations; the classified vegetation patterns were similar to a regional map of vegetation types; and soil moisture patterns observed were related to regional soil types and the river network. This approach offers a simple means for characterizing regional information about vegetation and soil conditions that could be used to map management units for improved resource allocation.

Morphoedaphological Study of the San Pedro River Basin, Sonora, Mexico: A Regional Analysis

David Peña Hernández, IMADES

This poster provides an analysis of available information on soils in the San Pedro River Basin, Sonora, Mexico. Spatial information on soils was analyzed and processed by using ERDAS and IDRISI software. The GIS database includes the distribution and general characteristics of soils. Located primarily in the piedmont and alluvial zones (plain and channel), Pheozems soils (Mollisols) occupy more than fifty percent of the river basin. In addition, approximately seventy-five percent of the soils in the basin have different physical phases that could represent varying degrees to which the soils are used for agriculture.

Hydrogeologic Investigations in the Sierra Vista Subwatershed of the Upper San Pedro Basin, Cochise County, Southeast Arizona

Don R. Pool, U.S. Geological Survey, Tucson, AZ

This subwatershed was studied in order to understand the effects of groundwater withdrawals on base flow of the San Pedro River. Groundwater withdrawals result in reduced base flow and evapotranspiration, but the rate and location of these effects are poorly known because of a lack of hydrogeologic information. Below-average winter precipitation between 1943 and 1977 resulted in below average recharge and a regional water level decline of 0.2 to 0.5 feet (6.1 to 15.2 centimeters) per year. Hydrochemical and streamflow data, however, suggest that base-flow decline may be related to reduced summer runoff and recharge near the river. Possible causes of reduced runoff include reduced summer precipitation, increased interception of runoff by vegetation and artificial retention of runoff. Enhanced recharge may occur locally, however, as a result of increased seasonal ground-water withdrawals near the river.

Vegetation Change in the San Pedro River Basin in Cananea, Sonora, Mexico

Martín Reyes Juárez, IMADES

The objective of this study is to determine the main factors that contributed to vegetation change in the San Pedro River Basin, with emphasis on man-induced and climatic agents. Using satellite images from 1970, areas will be selected that represent changes in vegetation cover. These areas will be located on the public property register in order to determine ownership of the given parcel. Vegetation sampling will be undertaken. Data from climatological stations in Cananea, Naco, and Agua Prieta will be used to correlate climatic events with vegetation changes observed in satellite images. A literature search will be done to acquire information to interpret incidence of man-induced factors on modification of vegetation and historical land use changes. Expected results include a vegetation change map, a map with vegetation change and landuse related to management practices, and assessments of climatic elements and their association with vegetation changes and the effects of vegetation change on residents of the basin.

The San Pedro Community Monitoring Network: Community-Based Science

Holly Richter, The Nature Conservancy

The Upper San Pedro Community Monitoring Network is a collaborative effort between dozens of local citizens, landowners, decision makers and scientists to provide unbiased information to the public regarding the status and trends of surface flows in the Upper San Pedro River. The initial goal of the Network is to document the spatial extent of pre-monsoon surface flow in the 43 miles (69.2 kilometers) of river between the Mexican border and the northern end of the San Pedro River National Conservation Area. If this information is collected on an annual basis, it can play an essential role in determining where the river remains perennial and in helping to define the long-term cumulative effects of both water conservation efforts and water use. From an ecological standpoint, the presence of perennial streamflow serves as an important indicator of ecosystem integrity because the structure and composition of riparian communities is strongly dependent upon perennial flows.

Study of Vegetation Present in the Riverbed of the San Pedro River, Sonora

Gilberto Solis-Garza, Rigoberto Lopez-Estudillo, Ramses Rodríguez-Ramírez, and Martha Gomez
DICTUS-UNISON / SCERP-ASU

Vegetation of the San Pedro River is of great importance because it is one of the most extensive areas of wide leaf riparian forest in the United States and Mexico. It constitutes a corridor for a great variety of birds. In addition, it provides water, forage, firewood, and protection for wild fauna; increases the quality and quantity of water; and reduces erosion. The objective of this study is to develop a list of species based on current vegetation and its degree of presence in the riverbed of the San Pedro River. A measure of vegetation diversity was obtained by locating eight representative points along the riverbed between Ejido Morelos and Los Corrales Ranch during the months of February, March, June, and September 1999. The 107 species identified belong to eighty genera and forty-two families. Eighteen species are not native to the region.

Ecology of *Sporobolus Wrightii* (Big Sacaton): Implications for Restoration and Management of Riparian Grasslands in Southwestern North America

Ron L. Tiller, B.E. Spakes, J.C. Stromberg, J.C. Stutz, and D.T. Patten
Department of Plant Biology, Arizona State University
Linda J. Kennedy, National Audubon Society, Appleton-Whittel Research Ranch

Grasslands dominated by big sacaton, a warm-season perennial bunchgrass, were abundant in the Southwest before 1900. These grasslands once occupied millions of acres within alluvial floodplain environments where they served important ecological functions such as controlling soil erosion, intercepting and retaining sediments, improving water quality, and facilitating groundwater recharge. In southeastern Arizona, big sacaton occupies an estimated five percent of its former range. A multiyear study is being undertaken to acquire the ecological information necessary to understand the processes and factors that allow for regeneration and maintenance of these grasslands. As part of this endeavor, relationships between big sacaton and environmental factors are being assessed via field observations of plant distributions under natural conditions at thirty-one sites along six streams, including the San Pedro River.

Sensitivity of Water Resources in the Upper San Pedro Basin to Climatic Variability

Petra Tschakert, Rebecca Carter, and Barbara J. Morehouse
Institute for the Study of Planet Earth, University of Arizona

This research was undertaken as part of the Climate Assessment Project for the Southwest (CLIMAS). The poster illustrates impacts of climate and population growth on water budgets in the Benson and Sierra Vista subwatersheds. Assuming a return of the driest one- and ten-year droughts in historical records of southeastern Arizona, and population growth projected for the year 2025, water supply and demand budgets show significant imbalances. Persistence of such imbalances over time may generate conflicts over how groundwater and surface water resources should be allocated to urban, agricultural, and ecosystem needs. The purpose of this poster is to stimulate discussion among water providers and users about how climate information and forecasts might be used in the Upper San Pedro River Basin to improve water resource management on both sides of the border.

Water Quality Monitoring in the San Pedro River, Sonora, Mexico

Arturo I. Villalba-Atondo, Agustín Gómez-Alvarez, Gilberto Solis-Garza, and Margarita de la O-Villanueva
Department of Scientific and Technological Investigations (DICTUS), University of Sonora

During 1997, water quality monitoring in the San Pedro River, Sonora, Mexico was undertaken. The study involved the sampling of water and sediments at four sites along the San Pedro River. In addition, three underground water samples were taken from areas adjacent to the river. The measurements considered in the study are pH, dissolved oxygen, temperature, dissolved solids, suspended solids, cations, anions, volatile organics, metals, and pesticides. At Ejido Morelos, values that exceeded regulation (CE-CCA-001-89.2 /.) were detected. Total phosphorus concentrations also exceeded maximum permissible levels at Pozo Sauceda, Ejido Morelos, and Los Corrales (both superficial and underground). Presence of lead and zinc in samples from Terreros and Arroyo Cananea Vieja exceeded regulation (NOM 001-ECOL-96.1/). In water samples collected between Pozo Sauceda station and Los Corrales, concentrations of metals such as magnesium, nickel, sodium, copper, iron, chromium, and manganese exceeded the maximum permissible levels allowed by regulation (CE-001-89.2/).

The Importance of the San Pedro River Basin for Wildlife

Andrés Villarreal Lizárraga, Marine Biologist, IMADES and CDC-SONORA

The wildlife in San Pedro River region is often unique to the area due to climatic conditions in the isolated Los Ajos, San Jose, and La Mariquita mountain ranges. Although the river region is located in a well-conserved area, potentially threatening activities include mining, cattle ranching, and agriculture. Overall, the people of the region are willing to cooperate with current conservation efforts to protect this region of diverse wildlife.

Save Dixie Canyon

Joan Werner

The Mule Mountain Biological Corridor, connecting the San Pedro River Basin with the Whitewater Basin, includes a forty-five square mile area of public and private property in southeastern Cochise County, Arizona. The heart of this area, in Dixie Canyon, is presently being subdivided for residential development. The area supports cottonwoods, sycamores, and over 100 wetland plant species. It is habitat for bears, mountain lions, eagles, and many other species. On a positive environmental note, the developer, Bisbee Ranch Company, is willing to sell or trade this property to the BLM. Save Dixie Canyon, a citizen's group, has proposed official designation of the corridor in order to preserve the biodiversity and scenic beauty of the area. Private property owners within the corridor, the City of Bisbee, and the Cochise County Board of Supervisors have voiced support of this proposal.

Who is Vulnerable to Climate Change in the Middle San Pedro River Valley?

Colin West and Patrick Barabe, Bureau of Applied Research in Anthropology, University of Arizona

This study involves an assessment of climate variability in the Middle San Pedro River Valley (MSPRV). The principal findings identify the groups of people in the area that are most vulnerable to climate impacts, the location of these groups within the MSPRV, and the nature of climate vulnerability to which they are exposed.

Seasonal Forecasts for Water Resources in the U.S.: Southwest Applications and Evaluations

Paul Whitaker, Holly C. Hartmann, Thomas C. Pagano, Roger Bales, and Soroosh Sorooshian
Department of Hydrology and Water Resources, University of Arizona

This poster presents several measures of forecast quality for water supply outlooks, as well as for seasonal climate outlooks issued by the National Weather Service (NWS) Climate Prediction Center. A review was conducted of current use and past performance of seasonal climate and water supply forecasts for the Southwest. A newly constructed comprehensive database of seasonal water supply outlooks, developed in conjunction with the Natural Resources Conservation Service and NWS Colorado Basin River Forecast Center, enables detailed assessments of performance. This seasonal water supply forecast database includes forecasts of the most probable, reasonable maximum, and reasonable minimum seasonal supplies, beginning in the 1940s, for all forecast locations in the Colorado River Basin.

Vegetation and Flora in the San Pedro River Basin, Sonora, Mexico

Gertrudis Yanes Arvayo and Teresa Solís, IMADES

The San Pedro River Basin is located in the northwestern part of the State of Sonora, within the municipalities of Cananea, Naco and Santa Cruz. This region, although small in area (1,833 km^2), is of great biological diversity. This presentation includes analyses of plant diversity, dominant species, vegetation types, and presence of rare, endemic, and/or threatened species. According to COTECOCA, S.A.R.H. (1974), the San Pedro River Basin included about 190 species distributed in ten vegetation types. For 1995, according to a study by CES (1995), seventy-seven species distributed in twenty-seven families were reported. Within the basin, the following types of vegetation are found: natural pasture, natural pasture with secondary arbustiva vegetation, small areas of induced pasture, encino forest, encino pine forest, and táscate forest (INEGI, 1970).

Appendix 2: Breakout Session Brainstorming

Lists of ideas were generated during small-group discussions at the conference. The first five topics were discussed on November 8, 1999, in Cananea and the final three topics were discussed on November 10, 1999, in Bisbee.

Topic 1: What are the geographical information system (GIS) and mapping needs in Mexico?

No list of ideas was developed.

Topic 2: What are the conservation options for the San Pedro River Corridor?

- Land tenure/ownership mix
- Land management
- Go beyond sustainability to habitat rehabilitation and restoration
- Remove sewer drains in Cananea
- Eliminate mine runoff and reinforce the mine dam to ensure that it is not breached
- Use management plan for a reserve in the Mariquita and Elenita Mountains (headwaters)
- Establish international core team to discuss issues, common projects and research needs
- Buy land and conservation easements in Mexico and the U.S.
- Respect residents by providing for a balance between people and environment
- Maintain communication and continue to collaborate
- Fund conservation in Mexico and provide directed technology transfer
- Maintain agriculture in Mexico and eliminate it in the U.S.
- Eliminate livestock grazing in the riparian areas and cienegas
- Introduce more efficient agriculture practices and better crops in Mexico
- Create a very specific vision in which agriculture is viable
- Encourage and promote environmentally sensitive practices
- Organize the users of the resources so we can reach consensus
- Reintroduce beavers in the lower reaches and gabion dams in the sierra
- Control erosion
- Obtain funds from public and private sources to clean wastewater
- Make the entire San Pedro a reserve
- Provide economic alternatives to users that would allow detrimental land uses to be stopped
- List the characteristics of the river that we wish to preserve
- Prioritize and plan development based on a binational vision of the future
- Enact water conservation practices in all of the urban areas of the watershed
- Legislate changes in building codes that conserve water
- Bring current laws up to date and enforce them at the state and local level
- Study hydrology and explore the possibility of importing water from other areas
- Introduce and fund education programs
- Create advisory committees for the San Pedro Basin
- Make an inventory of flora and fauna for the entire basin and publish it in a bilingual format
- Create an information center that would share and publish data

Topic 3: What needs to be done to assure a satisfactory water supply in the Upper San Pedro River Basin?

- Define a satisfactory water supply
- Implement water harvesting
- Increase the supply of water
- Reduce the use of irrigated water

- Establish a water conservation monetary credit system
- Establish a binational watershed plan for habitat preservation
- Use climate forecasts and predictions to aid in the optimized use of the water supply
- Reduce per capita urban water consumption
- Limit the total water budget
- Relocate well pumping away from the river
- Develop a strong monitoring program to assess conservation strategies
- Make better water management decisions
- Develop a broad binational education policy on conservation issues for adults and children
- Administer the water so that everyone has access
- Employ water conservation techniques in agriculture
- Temporarily prohibit new well permits until adequate water supply can be insured
- Control runoff and soil erosion
- Reduce water usage and reuse wastewater
- Identify all water users
- Determine the water balance for the use of water in the cities
- Control urban development
- Through the BECC, help the city of Cananea fund a treatment and effluent recharge plant
- Create accurate and credible data
- Coordinate binational water conservation strategies
- Involve children in environmental issues and teach them about the measurement and monitoring of water quality, habitat destruction, and water pollution
- Publish bilingual water quality information
- Implement water saving irrigation techniques
- Amend Arizona water law to recognize the connection between groundwater and surface water
- Enact a moratorium on building permits until the water deficit declines

Topic 4: What can be done to foster binational, interagency coordination in the San Pedro River Basin?

- Continue annual interagency conference where information sharing can occur
- Identify and prioritize specific areas of collaboration and evaluate them on a regular basis
- Develop trust between the cross border agencies
- Provide stakeholder representation at a binational level
- Create regional subgroups of the Border XXI water and natural resources work groups
- Create a binational list of agencies and their responsibilities
- Formulate a commonly accepted mission for cross border communication
- Formulate a standardized monitoring system to eliminate data disputes
- Increase understanding, respect, and appreciation between the public and regional agencies
- Recognize that watersheds do not conform to international boundaries
- Ensure that social science and physical science work together
- Simplify cross border scientific research travel
- Simplify border crossings for federal employees (both directions)
- Continue working relationships on binational projects
- Advocate increased cross border cooperation at the highest levels of government
- Publicize agency expertise
- Create linkages between cross border agencies with similar missions
- Advocate truly binational participation
- Develop a functional liaison process for cross border governmental activities
- Develop national level agreements along with local level implementation
- Develop binational outreach process to provide education materials for communities/groups
- Ensure that issues/problems drive research and ensure that communities help set the agenda
- Clarify the benefits to each nation of binational collaboration

- Enforce CILA/IBWC mandates
- Involve more stakeholders in addition to decision makers
- Encourage alternative funding sources
- Ensure that information exchange contains management, not just scientific information
- Establish bilingual information center clearinghouse (building and website)
- Create a binational information center
- Develop and maintain a cross border web site

Topic 5: How can we foster binational natural resource information exchange?

- Continue to have binational conferences and opportunities to have information exchange
- Maintain a positive attitude and open environment for information exchange
- Form personnel exchange programs between people of similar disciplines
- Publish more bilingual materials
- Work through universities instead of via government agencies regarding data exchange
- Establish binational bisectoral work groups (federal, state, local, NGO) with specific tasks to complete by the next conference
- Establish international exchange programs for high school juniors and have each participating organization or agency sponsor an entire class
- Map the natural resources of the basin and publish a bilingual document that explains the effects of alternative management systems
- Prepare a nontechnical, San Pedro River Basin pamphlet for local community members
- Ensure that the information that is being gathered, interpreted, prepared, and presented takes into consideration the needs, traditions, customs, culture, and ways of using information of the final end user
- Simplify scientific information into an appropriate format for use at the local level
- Ensure that funding for information exchange occurs on both sides of the border
- Identify binational funding sources, implement binational education programs for children
- Increase diversity at conferences by facilitating attendance by students and rural participants through the provision of transportation and registration waivers
- Publish a directory of databases so that everyone has access to information
- Develop a mechanism for reporting data or reporting errors in data
- Create international exchange programs for ejidatarios and ranchers so that they may understand each other's environmental, cultural and technical issues
- Share information among groups doing similar projects on both sides of the border in order to ensure a stable institutional knowledge base
- Encourage researchers or agency workers to stay and work in the area, rather than move them on to a new site after relatively short stints
- Invite the media to the conference to better understand the issues, to report on the natural resources issues, and to let the public know what is going on
- Identify all the key decision makers (federal, state, ejidos, industry, municipios, etc.) for the
- Upper San Pedro River Basin and provide them the information necessary so that all stakeholders can make decisions about the basin together
- Collect all data in a compatible, bilingual manner

Topic 6: How can we foster binational natural resource information exchange and binational, interagency coordination in the Upper San Pedro River Basin?

- Develop a language and cultural immersion program on both sides of the border for those involved in the San Pedro issue
- Get more computers with Internet access in communities
- Promote smaller scale binational community meetings along the border

- Promote good relations between institutions and researchers
- Develop personal contacts
- Invite one high school class from Mexico and the U.S. to binational conferences and have the
- students provide reports to the school, media and community about the experience
- Include school programs or community education programs in binational projects
- Speed the exchange of information by having agency directors streamline the process
- Disseminate information from conferences and meetings to the community
- Learn about internal country politics by establishing personnel exchange programs between countries
- Schedule semi-annual visits to management areas on both sides of the border
- Reinforce the exchange of human resources and fund these exchange programs
- Establish clearly defined objectives and have good directorship
- Get involved in a cross-border project
- Recognize that there are multiple voices and institutions for each issue and that there are stakeholders that may not be comfortable talking about the issues
- Increase the number of publications
- Create a widespread conviction that a river in the desert should be declared a national treasure
- Encourage politicians to act on a local level
- Ensure that all projects are sensitive to the values, cultures, beliefs and concerns of the communities on both sides of the border
- Take into consideration the needs of the end user
- Encourage all to learn about Mexican and U.S. politics, history and natural resources
- Continue to have this type of conference
- Create a database of researchers and studies that is accessible by everyone
- Develop and establish an interactive, bilingual Internet clearinghouse to share and disseminate information about the San Pedro
- Publish research results in a nontechnical, bilingual format that the end user can apply

Topic 7: What must be done to assure a satisfactory water supply in the Upper San Pedro River Basin?

- Determine the multiple causes and influences on declining base flow
- Ensure water supply for river and biodiversity
- Increase respect and appreciation for the cultures, values, and needs of watershed residents
- Create a foundation for action
- Practice climatic modification such cloud seeding and aggressive surface revegetation
- Account for seasonal, annual and decadal climate variation in the research that is undertaken
- Buy land or slow or stop development and/or initiate land swapping in the Sierra Vista area
- because population growth is the primary problem
- Recycle water in mining operations
- Create a natural and national protected area to promote the integral management of basin
- Make the connection between upstream protection and downstream flow
- Dispel the belief that there is a conspiracy to depopulate the area along the river for the preserve
- Demonstrate the economic benefits of preservation
- Implement more flexible and responsive state water policies
- Change popular perception to one that embraces and values the river and its potential wealth rather than one that favors economic gain from urban growth
- Develop a hydrologic/ecological monitoring program capable of long-term human and natural change detection
- Develop an upland watershed management strategy in all ownership types that identifies valuable practices, land uses and projects for the maximization of water conservation and recharge and the maintenance and increase of the base flow in the San Pedro River
- Relocate well pumping locations away from the river
- Implement aggressive applied research on alternative water sources and conservation for industrial use
- Price water to reflect sustainable usage

- Emphasize more action instead of more research
- Promote alternatives to current human activity in the basin
- Promote environmental education
- Establish county parks to preserve non-federal lands, watersheds and riparian areas
- Define the resource values that are worth preserving and for those values define minimal and optimal base flow and flood flow requirements necessary for their long term maintenance
- Improve grazing management techniques
- Reduce the number of livestock
- Allow more forage for drought years by creating grass banks for all ranches in the basin

Topic 8: What are the conservation options for the San Pedro River Corridor?

- Provide a management mechanism for the control of fire hazards such as forest floor litter
- Decrease runoff erosion
- Prohibit golf courses from using ground water
- Fund the expansion of the water wise program
- Create incentives or tax breaks for water conservation
- Find sources of financial support for watershed restoration efforts in Mexico
- Begin a campaign to devolve power back to the counties
- Increase public awareness of the connection between aquifer pumping and streamflow
- Request that the government be more responsive to public opinion
- Recharge water
- Encourage ranching and dry-land farming instead of irrigated agriculture
- Offer free perma-culture workshops to homeowners
- Change public perception from one of "leave me alone" to "pride and perpetuity of the river"
- Establish a protected area in Mexico and extend the protected area in the U.S.
- Implement a legitimate "Growing Smarter" campaign in the San Pedro River Valley
- Reintroduce fire in to the ecosystem
- Manage growth
- Price water so it reflects its true market value as a scare and valuable commodity
- Promote native plant landscaping
- Implement upland restoration through mechanical means and catchments
- Determine the difference between a healthy community and unrestrained growth
- Increase cienega areas along the stream to slow river flow
- Institute conservation requirements for new urban developments
- Limit new irrigated agricultural lands
- Establish appropriate zoning throughout the county
- Promote a binational watershed council as a conservation framework

Appendix 3: San Pedro Conference Attendees/Apéndice 3: Participantes de la Conferencia de San Pedro

Elsa Aguilar de Cordova	Cananea Teacher
Al Anderson	Huachuca Audubon Society
Sue Anderson	USDA-ARS, Southwest Watershed Research Center
Sandy Anderson	San Pedro Alliance
Susan Anderson	The Nature Conservancy
Bryce Appleton	Facilitator
Hector Arias Rojo	Gabinete de Estudios Ambientales
Olivia Armenta	Latin American Area Center, University of Arizona
Valer Austin	El Coronado Ranch
Bruce Babbitt	United States Department of the Interior
Ken Bagstad	Department of Plant Biology, Arizona State University
Victor Baker	Department of Hydrology and Water Resources, University of Arizona
Jose Manuel Barcelo	Ejido Zapata
Fernando Barra	INIFAP
Scott Bassett	Department of Landscape Architecture, Harvard University, GSD
Jason Batchelor	Department of Geography, San Diego State University
Gary Bauer	Bureau of Land Management
Jim Bellamy	National Park Service
Robert Blanchard	City of Sierra Vista
Ward Brady	Morrison School of Agriculture and Resource Management, Arizona State University East
Dale Brenneman	Arizona State Museum
Christopher Brown	Udall Center for Studies in Public Policy
Anne Browning	Department of Anthropology, University of Arizona
Don Brush	City of Sierra Vista
Ross Bryant	USDA-ARS, Southwest Watershed Research Center
Thelma Butts-Griggs	Facilitator, Griggs Velazquez
Ignacio Cabrera Fernández	IMADES
Juan Caicedo	Prescott College
Amy Carlson	Udall Center for Studies in Public Policy
Manuela Casselmann	Johann Wolfgang Goethe University
Mario Castañeda	Arizona Department of Environmental Quality
Alejandro Castellanos Villegas	DICTUS, Universidad de Sonora
Víctor del Castillo Alarcón	Grupo Mexico, Mexicana de Cananea
James Chambers	US Army Garrison, Ft. Huachuca
Gabriela Chavarría	National Fish and Wildlife Foundation
Ghani Chehbouni	IRD/IMADES
William Childress	Bureau of Land Management
Tom Cochran	US Army Garrison, Ft. Huachuca
Manuel Contreras	Grupo Mexico, Mexicana de Cananea
Elisa Corcuera	Sonoran Institute
Steve Cornelius	Sonoran Institute
Alan Cox	Fort Bowie National Historic Site, Chiricahua National Monument
James Crawford	City of Benson
Mario Cesar Cuen Aranda	Municipio de Cananea
Erin Deely	Tucson Audubon Society
Paul DePrey	Southwest Strategy Coordination Office
Alva D'Orgeix	City of Bisbee
Laura Dupee	United States Forest Service
Curt Edmonds	United States Environmental Protection Agency
Robert Emanuel	Department of Anthropology, University of Arizona
Delfina Falcon	IMADES
Tina Faulkner	Interhemispheric Resource Center
María Luisa Fernandez Ruiz	IMADES
Luis Alonso Flores Molina	Los Campitos Comité Municipal Forestal y de Ecología
Lisa Force	Center for Biological Diversity
Marina Galaz	IMADES
Francisco García Gamez	Municipio de Cananea
Florentino Garza S.	Refugio de Fauna Silvestre Ajos- Bavispe, Reserva Forestal Nacional
Heather Gates	Prescott College
Tricia Gerrodette	Huachuca Audubon Society
Judy Gignac	Bella Vista Water Company and Bella Vista Ranches
Bruce Goff	Jason Associates
Eduardo Gomez Limón	Southeastern Arizona Bird Observatory
Carlos González	COAPAES

Gerardo González	USDA, National Resources Conservation Service
Oscar Gonzalez Rocha	Grupo Mexico, Mexicana de Cananea
David Goodrich	USDA-ARS, Southwest Watershed Research Center
Dave Gori	The Nature Conservancy
María Gracia Ruiz de Olais	IMADES
Guillermo Guerra Limón	Refugio de Fauna Silvestre Ajos-Bavispe, Reserva Forestal Nacional
José María Guerra Limón	Refugio de Fauna Silvestre Ajos-Bavispe, Reserva Forestal Nacional
María Gutiérrez	Udall Center for Studies in Public Policy
Diana Hadley	Arizona State Museum
Haydee Hampton	Center for Environmental Sciences and Education, Northern Arizona University
Jeanmarie Haney	University of Arizona
Alma Haro	CECARENA
Holly Hartmann	Department of Hydrology and Water Resources, University of Arizona
Scott Heckman	Cochise County Resident
Dan Heggem	United States Environmental Protection Agency
Phil Heilman	USDA-ARS, Southwest Watershed Research Center
Mariano Hernández	USDA-ARS, Southwest Watershed Research Center
Tony Herrell	Bureau of Land Management
Bret Herres	Morrison School of Agriculture and Resource Management, Arizona State University East
Jim Herrewig	City of Sierra Vista
Bill Hess	Sierra Vista Herald
Kali Holtschlag	Adams Ranch
Ron Hummel	Teacher/Naturalist
Ignacio Ibarra	The Arizona Daily Star
Mario Jauri	Instituto Tecnológico de Sonora
Ida Johnson	City of Bisbee
Noelle Jue	Southwest Center for Environmental Research and Policy
Jesse Juen	Bureau of Land Management
Dick Kamp	Border Ecology Project
Linda Kennedy	Appleton-Whittell Research Ranch
Gretchen Kent	US Army Garrison, Ft. Huachuca
William Kepner	United States Environmental Protection Agency
Rick Koehler	Cochise County
David Krueper	Bureau of Land Management
Richard Kruse	Morrison School of Agriculture and Resource Management, Arizona State University East
Jack Ladd	Hereford Natural Resource Conservation District
Yadir Lazcaro	IMADES
Stan Leake	United States Geological Survey
Hector Licón	CECARENA
Susan Lieberman Goodwin	United States Department of the Interior
Guanghui Lin	Biosphere 2 Center, Columbia University
Cynthia Lindquist	Tucson Audubon Society
Diana Liverman	Latin American Area Center, University of Arizona
Isaac López	Grupo Mexico, Mexicana de Cananea
Robert Lozar	United States Army Corps of Engineers
Gonzalo Luna Salazar	IMADES
Claudia Martinez Peralta	IMADES
Dale Mason	Arizona Department of Water Resources
Beaumont McClure	Bureau of Land Management
Stephen McElroy	Udall Center for Studies in Public Policy/ USDA-ARS
Enrique Medina	Presa Comaquito
Francisco Mendoza	Bureau of Land Management
Robert Merideth	Udall Center for Studies in Public Policy
Ryan Miller	Morrison School of Agriculture and Resource Management, Arizona State University East
W.L. Minckley	Department of Biology, Arizona State University
Luis Alonso Miranda	Naco Constructed Wetlands
Xavier Montoya	USDA, Natural Resources Conservation Service
Ann Moote	Udall Center for Studies in Public Policy
Susan Moran	USDA-ARS, Southwest Watershed Research Center
Barbara Morehouse	Institute for the Study of the Planet Earth, University of Arizona
Margarita Moreno Ozuna	Los Campitos Comité Municipal Forestal y de Ecología
Carlos Mosqueira	International Boundary and Water Commission
David Mouat	Desert Research Institute
Joaquin Murrieta	Sonoran Institute
Carlos Nagel	Facilitator, Cultural Exchange Service
Wanmei Ni	USDA-ARS, Southwest Watershed Research Center

Yann Nouvellon	USDA-ARS, Southwest Watershed Research Center
Febe Ortiz	USDA, Natural Resources Conservation Service
Margarita Otis Lagarda	Environmental Activist in Cananea
Allon Owen	Cochise County
Mike Palmer	Cochise County
Rafaela Paredes	IMADES
Ivan Parra	CECARENA
David Peña Hernandez	IMADES
Joan Perry	USDA, Natural Resources Conservation Service
Jack Peterson	Bureau of Land Management
Jane Pike Childress	Bureau of Land Management
Bernadette Polley	Office of 5th District Representative Jim Kolbe
Dale Pontius	United States Department of the Interior
Donald Pool	United States Geological Survey
Chuck Potucek	City of Sierra Vista
Henri Poupon	IRD/France
Jackie Power Watkins	Hereford Natural Resource Conservation District
Frank Putnam	Arizona Department of Water Resources
Dean Radtke	Department of Agriculture, University of Arizona
Lyle Reddy	City of Bisbee
James Renthal	Bureau of Land Management
Martín Reyes Juárez	IMADES
Holly Richter	The Nature Conservancy
Brian Richter	The Nature Conservancy
Leslie Ries	Center for Environmental Sciences and Education, Northern Arizona University
John Roberts	US Army Garrison, Ft. Huachuca
Arturo Rodríguez	Municipio de Cananea
Julio Rodríguez	IMADES
Debra Rose	Interhemispheric Resource Center
Art Rotstein	Associated Press
Fausto Santiago	IMADES
Jason Scott	Prescott College
Andrew Seiger	International Boundary and Water Commission
George Seperich	Morrison School of Agriculture and Resource Management, Arizona State University East
Jeff Simms	Bureau of Land Management
Duane Smith	Resident of Cochise County
María Teresa Solis	IMADES
Gilberto Solis-Garza	DICTUS, Universidad de Sonora
Michael Somerville	USDA, National Resources Conservation Service
Lee Spinks	The Bisbee News
Terry Sprouse	Arizona Department of Water Resources
Bob Strain	City of Sierra Vista
Ronald Tiller	Department of Plant Biology, Arizona State University
Rebecca de la Torre	USDA, National Resources Conservation Service
Jon Trachta	Facilitator
Pamela Trachta	Facilitator
Petra Tschakert	Institute for the Study of the Planet Earth, University of Arizona
Carl Unkrich	USDA-ARS, Southwest Watershed Research Center
Gabriela Vales	SEMARNAP
Robert Varady	Udall Center for Studies in Public Policy
Alberto Vargas	Land Tenure Center, University of Wisconsin-Madison
Martin Villa	IMADES
Arturo Villalba Atondo	DICTUS, Universidad de Sonora
Andrés Villarreal Lizárraga	IMADES
Tim Wade	United States Environmental Protection Agency
Christopher Watts	IMADES
Cathy Wertz	Save Dixie Canyon
Colin West	Institute for the Study of the Planet Earth, University of Arizona
Jack Whetstone	Bureau of Land Management
Paul Whitaker	Department of Hydrology and Water Resources, University of Arizona
Mary White	USDA-ARS, Southwest Watershed Research Center
Jeff Whitney	United States Fish and Wildlife Service
David Williams	School of Renewable Natural Resources, University of Arizona
Edward Williams	Department of Political Science, University of Arizona
Gertrudis Yanes Arvayo	IMADES
Robert Yantes	Resident of Cochise County

Appendix 4: San Pedro River Basin Related Websites
Apéndice 4: Páginas Electrónicas Relacionadas con la Cuenca del Río San Pedro

Semi-Arid Land-Surface-Atmosphere (SALSA) Program
http://www.tucson.ars.ag.gov/salsa/salsahome.html

SALSA-related Organizations
http://www.tucson.ars.ag.gov/salsa/contacts/contacts.html

Bureau of Land Management (BLM)
http://tucson.az.blm.gov/tfo.html

Climate Assessment for the Southwest (CLIMAS)
http://www.ispe.arizona.edu/swclimate

Environmental Protection Agency (EPA)
http://www.epa.gov/crdlvweb/land-sci/san-pedro.htm

Instituto del Medio Ambiente y Desarrollo Sustentable del Estado de Sonora (IMADES)
http://www.cideson.mx/imades.html

Water Issues in the San Pedro
http://www.rz.uni-frankfurt.de/FB/fb18/didaktik/xprojekt/Water/sanpedr.htm