Saving the San
Pedro River

Science, Collaboration, and Water Sustainability in Arizona

by George Saliba and Katharine L. Jacobs

The San Pedro River in southeastern Arizona went dry for the first time in recorded history in the summer of 2005 at the Charleston Gauge and was nearly dry again in 2006. These events raised alarm among conservationists and water managers, who fear for the future of the river. On the other extreme are those who do not support protecting the river, such as the city councilman of Sierra Vista who declared in 1997, “All right, there may be 500 species of wildlife found along the San Pedro. My response is so what? What benefit do these animals have for humans? We are the ones who rule supreme, and if a plant or animal can’t adapt to our needs, then it’s too bad.” However, people are also endangered by a water shortage: if the San Pedro River goes from perennial to intermittent flow, loss of species and biodiversity will occur, as will threats of litigation from environmental groups under the Endangered Species Act. Litigation could lead to a reduction or, in a less likely scenario, closure of the region’s largest economic driver and primary stressor on the area’s groundwater supply, Fort Huachuca, delivering a crushing blow to Sierra Vista.
The effects of increased pressure on water supplies are already visible in the San Pedro River basin. As growth continues, without a successful water importation scheme in place, flows in the San Pedro River could become completely unsustainable. Local and federal initiatives have begun to address unsustainable water use practices in this region through science-based, collaborative decision-making to meet a federally mandated deadline of sustainable yield by 2011. The San Pedro River basin illustrates how protecting socioeconomic and ecological benefits of freshwater systems challenges watershed managers\(^5\) and creates implications for ecosystem sustainability and prevailing governance norms. It also provides an excellent case study for evaluating the role of science in public participation processes.

Residents' reliance on groundwater for their daily needs complicates balancing the interests of growing communities and surrounding wildlife in the San Pedro River basin. While the aquifer contains enough water for human use for an extended period of time, the San Pedro River and the wildlife and ecosystem that rely on it require continuous base flow—groundwater outflow into the river system—which is directly connected to the water table. Groundwater pumping draws down the aquifer, causing base flow to become intermittent or nonexistent and threatening plants and animals. Public acknowledgement that surface water and groundwater are linked and that changes in development policies are required to protect the river was the first step in addressing land-use and water management practices in the Sierra Vista subwatershed.

Demand for groundwater in arid and semi-arid regions of the world is expected to increase over time, not only in response to population pressures but also due to climate change. For the southwestern United States and subtropical regions worldwide, the Intergovernmental Panel on Climate Change (IPCC) projects a decrease in total precipitation as well as an increase in temperatures—both of which will add more stress to riparian systems.\(^3\) For example, the IPCC projects that by 2020, climate change-related water stress will affect between 75 and 250 million people in Africa. The IPCC also anticipates a decrease in available freshwater in central, south, east, and southeast Asia as its population increases.\(^4\) In recent years, portions of the southeastern United States have also faced severe drought, including states with high precipitation relative to Arizona, such as Georgia, Alabama, and Florida. Georgia has been forced to quickly develop and implement statewide drought and conservation plans, including the formation of water basin advisory committees to give a local perspective on resource management options.\(^5\) Humans as well as ecosystems will be greatly impacted. Efforts by groups such as the Upper San Pedro Partnership (USPP) can be helpful in providing lessons to these new initiatives.

The western United States has seen a proliferation in collaborative watershed partnerships over the last three decades.\(^6\) This trend has emerged in an era of mandated public participation via the Clean Water Act (1972), National Environmental Policy Act (1969), Endangered Species Act (1973), and others, and at the same time, shrinking government in terms of budgets for public land management, increased population, and competition for use of natural resources. Collaborative partnerships are now an integral aspect of rural watershed management in Arizona.

The Rural Watershed Initiative, which commenced in 1999, is the state's main policy framework for such endeavors. While partnerships' decisions can have significant ramifications for water management in rural areas, the dynamics influencing these partnerships are not well understood. Major water infrastructure decisions, such as those now being considered in the Upper San Pedro basin, often have unanticipated longer-term environmental and social impacts.\(^7\) The USPP, convened in 1998, is the oldest and most advanced of Arizona's 17 watershed partnerships. Operating within the Sierra Vista subwatershed of the Upper San Pedro River basin in Cochise County, Arizona, the USPP has engaged in water management discussions within a complex sociopolitical environment. Ecology, population growth, politics, economics, and land-use issues all intersect in this portion of the Upper San Pedro basin, providing several lessons about collaborative management of water resources with implications beyond Arizona.

The Upper San Pedro Partnership in Context

The Upper San Pedro basin is located in southeastern Arizona about 50 miles southeast of Tucson in Cochise County. The headwaters of the San Pedro River
are in Mexico, and the river flows north across the international border 90 miles to the northern boundary of the Upper San Pedro River basin study area. This watershed is about 2,500 square miles bounded by a U.S. Geological Survey (USGS) stream gauge near Benson, Arizona. About 696 square miles of this drainage area are in Mexico (see Figure 1 above). The area of the Upper San Pedro subbasin, one of the few remaining free-flowing streams in Arizona, faces intense development pressure, partially from its close proximity to Fort Huachuca, an army facility in Sierra Vista. Fort Huachuca drives the local economy, not only because of the number of people directly stationed at the base, but also the goods and services it requires and the significant ancillary population it supports. The base provides approximately $1.5 billion annually in economic benefits to Arizona, a majority of them in the Sierra Vista subwatershed. However, Fort Huachuca has faced serious threat of closure under the federal Base Realignment and Closure assessment program largely based on its water use and consequent implications for endangered species in the Sierra Vista subwatershed, as well as external issues surrounding growth and water supply.

The Upper San Pedro River supports 350 bird species and several endangered plants and animals. In recognition of this natural richness and the threat from development pressures from the surrounding community, the U.S. Congress established the San Pedro Riparian National Conservation Area in 1988—the first designation of its kind in the nation. The San Pedro Riparian National Conservation Area depends on surface flows from the Sierra Vista subwatershed. However, the San Pedro River, like most other low elevation rivers in Arizona, could dry up due to groundwater pumping. The U.S. Department of the Interior Bureau of Land Management supervises the San Pedro Riparian National Conservation Area with the legislative directive to conserve, protect, and enhance the resources of this riparian system, which provides significant economic benefits to the region.

**Groundwater in the Sierra Vista Subwatershed**

Groundwater is the primary source of water for the residents of the Sierra Vista subwatershed. Groundwater outflow from the basin, including water withdrawn by pumping, currently exceeds natural inflow to the regional aquifer. As a result, groundwater levels in parts of the aquifer are declining, and groundwater storage is being depleted. While total available water supply for the human population is not an immediate issue because there is substantial storage in the aquifers, maintaining surface flow (which is directly connected to groundwater levels) in the Upper San Pedro River is critical. The city of Sierra Vista, in conjunction with Fort Huachuca, has made strides toward

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**Figure 1. Upper San Pedro River Basin**
increasing the use and recharge of municipal effluent, now 1,500 acre-feet per year (AFY)—approximately 6.9 percent of the annual inflow to the groundwater system within the Sierra Vista subwatershed.¹⁴

A comprehensive water budget analysis study of the Sierra Vista subwatershed by the Arizona Department of Water Resources in 2002 indicated that municipal demand was 14,500 AFY, riparian use was 7,700 AFY, and agricultural demand was 2,500 AFY. These three sectors of water use comprised the majority of the total water use in the subwatershed.¹⁵ The results of this study have been used to set the volumetric requirement—the volume of water that has to be offset through demand reduction or supply enhancement to preserve flows in the river—of meeting sustainable yield. There was an estimated 9,900 AFY deficit in the Sierra Vista subwatershed's water budget in 2002; with anticipated increases in water use, the deficit was projected to increase to 12,000 AFY by 2011 (see Figure 2 on this page). A 2007 study put the deficit at 10,800 AFY, higher than previously thought.¹⁶

The rapidly growing population in the subwatershed increases municipal water use, in turn straining the region's water supply. Sierra Vista, the subwatershed's largest city, has grown from a small town of 6,689 in 1970 to a sizeable city with an estimated population of 56,602 as of 2008.¹⁷ A considerable number of residents live outside municipal areas; water use in such rural areas goes largely unmeasured and is not subject to water companies' conservation measures. In addition, these rural residents do not pay for water use other than the energy cost for pumping. Cochise County as a whole is expected to see a 55 percent increase in population between 2000 and 2050, growing from 117,755 to 212,822.¹⁸ With groundwater being the only viable source of water in the absence of large-scale imported sources, this population growth will lead to increased groundwater pumping.

Water Management in Arizona

Arizona has a bifurcated water management system, with one set of legal standards based on “prior appropriation,” or “first in time, first in right,” for surface water, and a separate, permit-based system for groundwater that applies only within specific areas called “active management areas.” The only standard for groundwater withdrawals outside of active management areas is “reasonable use,” meaning use that serves a beneficial purpose without waste.¹⁹

Although Arizona is widely recognized for its innovative groundwater management efforts, these efforts are largely concentrated within the five active management areas that encompass the central urbanized core of the state. Only about one-fifth of the state's land area is within these active management areas, which were formed under Arizona’s 1980 Groundwater Management Act with a management goal of eliminating the overuse of groundwater by 2025. Although the goals for specific active management areas vary, the overall focus is “safe yield,” a long-term balance between groundwater withdrawals and natural and artificial recharge of the aquifers. These goals are to be achieved through a series of five management plans, including demand management requirements and supply enhancement activities, from 1980 to 2025, in theory moving iteratively toward the 2025 goal. All large users of water are regulated, no new agriculture is allowed, and all new developments are required to have an assured water supply—a 100-year supply of water primarily from renewable sources—before subdivision plans are approved. The management plans,
Arizona’s rapidly growing communities raise questions about how to balance interests of human development and water conservation, an issue facing the Upper San Pedro Partnership.

Adopted through administrative law, are enforced by the Arizona Department of Water Resources, which can levy fines of up to $10,000 per day for those who deliberately violate water use restrictions such as maximum annual allotments for golf courses and conservation requirements for municipal utilities, among other regulations.

By contrast, in places such as the San Pedro watershed that lie outside of active management areas, there are few limitations on groundwater withdrawal: drilling new wells, expanding agricultural acreage, or, until recently, subdividing in areas with inadequate water supplies have all proceeded without regulation. Pursuant to new regulations adopted in 2007 by the Arizona legislature, counties and jurisdictions can require developers to show 100-year water adequacy for the proposed use—a less stringent standard than the “assured water supply” standard within active management areas—prior to approving new land for development. There is strong opposition to the highly regulatory active management area concept in rural parts of Arizona, which explains why the active management area approach to water management is not widely supported throughout the entire state. Local water management efforts seem to garner more support, but to date, such efforts have been limited in their effectiveness.

Developing the Partnership

In the early and mid-1990s, the fight over water use in the Sierra Vista subwatershed involved single-issue interest groups. Bringing these interests together required comprehensive conflict resolution efforts in the community, and the Udall Foundation’s Center for Environmental Dispute Resolution greatly facilitated these efforts in the late 1990s. However, these various stakeholder groups initially failed to develop a consensus solution. In 1998, the USPP, a consortium of 21 agencies and organizations, was convened under Arizona’s Rural Watershed Initiative. The USPP’s original stated purpose was “to coordinate and cooperate in the identification, prioritization, and implementation of comprehensive policies and projects to assist in meeting water needs” in the Sierra Vista subwatershed. This purpose has subsequently been expanded by federal legislation to include achieving sustainable yield by 2011, preserving the San Pedro Riparian National Conservation Area, and maintaining the viability of Fort Huachuca. The USPP defines sustainable yield as “the development and use of groundwater in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences.”

There is no statutory penalty if the goal is not achieved, though not meeting the federally mandated timeline may negatively affect critical federal decisions, such as the future of Fort Huachuca.

Over the last decade, the USPP has emerged as a highly structured stakeholder group that controls substantial monetary resources and political clout. In 2006, the partnership completed a $35 million five-year funding cycle that pooled the resources of several agencies. Recently retired U.S. Congressman Jim Kolbe (R-AZ) and partnership efforts with state and federal agencies such as the U.S. Bureau of Reclamation brought federal funding to the basin, a feat largely made possible by the pragmatic front presented by this broad-based consortium (see Tables 1 and 2 on pages 36 and 37, respectively, for the 21 agencies that comprise the USPP and their roles and its organizational structure as of 2007).

The city of Sierra Vista and Cochise County each have three commission members on the Partnership Advisory Commission (PAC) and therefore possess more votes and sway in the decision-making process than other interests. This is a significant factor in the power structure of the USPP and a point of frustration for some who see it as a bias toward economic growth. However, the opposing view is that these members are elected officials representing the people of the region. There have not been many instances where the elected officials have not agreed with each other, and most, but not all, decisions are made by consensus. Also, all partnership meetings are public, and decisions are open to public participation and comment.

In ongoing conversations between 2005 and 2008, multiple USPP participants indicated that coming to consensus on the goals and objectives of the USPP was difficult at first. The initial goal of the partnership was broadly defined as meeting the water needs of the Sierra Vista subwatershed,
<table>
<thead>
<tr>
<th>Agency</th>
<th>Affiliation</th>
<th>Role(s)</th>
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</thead>
<tbody>
<tr>
<td>Fort Huachuca</td>
<td>U.S. Department of Defense (DOD)</td>
<td>Secures funding from the DOD; invests significantly in conservation projects; executive committee member</td>
</tr>
<tr>
<td>Bureau of Land Management</td>
<td>U.S. Department of the Interior</td>
<td>Monitors and manages San Pedro Riparian National Conservation Area; executive committee member</td>
</tr>
<tr>
<td>Forest Service</td>
<td>U.S. Department of Agriculture</td>
<td>Land manager</td>
</tr>
<tr>
<td>National Park Service</td>
<td>U.S. Department of the Interior</td>
<td>Land manager</td>
</tr>
<tr>
<td>Bureau of Reclamation</td>
<td>U.S. Department of the Interior</td>
<td>Evaluates water supply alternatives; provides funding</td>
</tr>
<tr>
<td>U.S. Geological Survey</td>
<td>U.S. Department of the Interior</td>
<td>Generates science through monitoring, research activities, and groundwater modeling</td>
</tr>
<tr>
<td>Agricultural Research Service</td>
<td>U.S. Department of Agriculture</td>
<td>Generates science through monitoring, research activities, and runoff modeling</td>
</tr>
<tr>
<td>Fish and Wildlife Service</td>
<td>U.S. Department of the Interior</td>
<td>Administers Endangered Species Act</td>
</tr>
<tr>
<td>State Land Department</td>
<td>State of Arizona</td>
<td>Land manager</td>
</tr>
<tr>
<td>Arizona Department of Water Resources</td>
<td>State of Arizona</td>
<td>Generates science; helps with policy at state level</td>
</tr>
<tr>
<td>Arizona Department of Environmental Quality</td>
<td>State of Arizona</td>
<td>Generates science and funding; influences policy at state level</td>
</tr>
<tr>
<td>Arizona Association of Conservation Districts</td>
<td>State of Arizona</td>
<td>State land manager</td>
</tr>
<tr>
<td>Cochise County</td>
<td>Local jurisdiction</td>
<td>Funds projects; determines policy; holds three partnership advisory commission (PAC) seats; executive committee member</td>
</tr>
<tr>
<td>City of Sierra Vista</td>
<td>Local jurisdiction</td>
<td>Acts as fiscal agent; determines policy; funds projects; holds three PAC seats and chair; executive committee member</td>
</tr>
<tr>
<td>City of Bisbee</td>
<td>Local jurisdiction</td>
<td>Determines policy</td>
</tr>
<tr>
<td>City of Tombstone</td>
<td>Local jurisdiction</td>
<td>Determines policy</td>
</tr>
<tr>
<td>Huachuca City</td>
<td>Local jurisdiction</td>
<td>Determines policy</td>
</tr>
<tr>
<td>The Nature Conservancy</td>
<td>Environmental nongovernmental organization</td>
<td>Heads technical committee; land owner; executive committee member</td>
</tr>
<tr>
<td>The Audubon Society</td>
<td>Environmental nongovernmental organization</td>
<td>Land owner</td>
</tr>
<tr>
<td>Bella Vista Ranches</td>
<td>Private land-owning entity</td>
<td>Land developer and owner; former water manager; executive committee chair and member</td>
</tr>
<tr>
<td>Hereford Natural Resource Conservation District</td>
<td>Elected board nonprofit, administered through state land department</td>
<td>Provides local land education</td>
</tr>
</tbody>
</table>
but competing interests struggled to define issues and agree on how to move forward. Environmental interests sought to protect the river and its riparian habitat, while other stakeholders were determined to advance economic growth and development in the growing region. Though these interests continue to conflict, the federal government strongly clarified the USPP’s goals through the Defense Authorization Act of 2004, Public Law 108–136, Section 321. Section 321 states,

The Secretary of [the] Interior shall prepare, in consultation with the Secretary of Agriculture and the Secretary of Defense and in cooperation with the other members of the [Upper San Pedro] Partnership, a report on water use management and conservation measures that have been implemented and are needed to restore and maintain the sustainable yield of the regional aquifer by and after September 30, 2011. The Secretary of the Interior shall submit the report to Congress no later than December 31, 2004.24

The section 321 report requirement has had significant ramifications for water management in the Sierra Vista subwatershed. First, the act formally recognized the USPP as a water management entity. Second, it laid out the specific task—achieving sustainable yield—with which the partnership was charged. The USPP collectively decides which approaches are acceptable to achieve this goal. Based on its own definition, the USPP determined outflow from the Sierra Vista subwatershed, including via withdrawals or pumping from the regional aquifer, would need to be less than the amount of inflow through both natural and effluent recharge to sustain the riparian ecosystem along the San Pedro River.

**Science-Based and Policy Innovations**

The USPP deliberately has built an extensive science-based knowledge system to inform water management decisions. While uncertainty about water availability and use still exists and will

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**Table 2. Structure and roles of the Upper San Pedro Partnership (USPP)**

<table>
<thead>
<tr>
<th>Committees as of 2007</th>
<th>Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partnership advisory commission (PAC)</td>
<td>Provides leadership and direction; oversees the work products of its committees, including the 321 Report to Congress; approves the organization’s long-range strategic plan; approves and executes the organization’s legislative agenda, organization and staff changes, and the partnership’s annual budget; possesses final decision-making authority through a voting process in instances when consensus cannot be reached</td>
</tr>
<tr>
<td>Technical committee</td>
<td>Provides review and analysis of data and research by the USPP to PAC; oversees the distribution of the USPP’s scientific outreach information to the general public</td>
</tr>
<tr>
<td>Executive committee</td>
<td>Functions as the administrative arm of the partnership; represents member agencies that make financial contributions to the operations and projects of the partnership; reports to PAC</td>
</tr>
<tr>
<td>Executive director</td>
<td>Coordinates work among committees, work groups, and member agencies to achieve PAC-approved goals and objectives</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Committees dissolved as of 2007</th>
<th>Former roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative committee</td>
<td>Managed the expenditure of partnership funds; provided administrative and policy advice to PAC</td>
</tr>
<tr>
<td>Staff working group</td>
<td>Coordinated activities and advised PAC on the development and implementation of the annual Upper San Pedro Conservation Plan</td>
</tr>
<tr>
<td>Government affairs committee</td>
<td>Coordinated the development of legislative initiatives; advised PAC on partnership endorsement projects and policies; advised PAC on potential political impacts of partnership activities</td>
</tr>
<tr>
<td>Public outreach committee</td>
<td>Acts as a liaison to the public about issues and projects</td>
</tr>
</tbody>
</table>

likely always exist due to the complex nature of science itself, the efforts of the USPP have produced a number of key science products, including hydrologic modeling data; an evaluation of the temporal and spatial water needs of riparian vegetation in the San Pedro Riparian National Conservation Area; a determination of the sources of water supporting surface flows in the river by key riparian plant species in the same location; sophisticated water budgets and decision-support models; numerous reports on augmentation and importation; well impact assessments; studies on the expected results of proposed and implemented conservation efforts; and an assessment of how groundwater pumping from different zones within the basin affects the river.

A science-based approach has been vital to the success of the USPP. Strong ideological as well as political differences existed at the inception of the USPP and remain to a certain degree. However, by using science as a “boundary object” (an object shared between communities and used as a focus for building mutual understanding) and agreeing to base decisions on scientific data, the USPP was able to find common ground and begin overcoming political differences and making decisions collaboratively.

Capacity building among participants in this consensus-based process is critical since many participants do not have backgrounds in natural or physical science. Within the USPP, designing and carrying out scientific studies is an iterative process, building on past studies as well as opening a dialogue between members. The USPP, which has long-standing relationships with scientists from government agencies (such as the USGS), and academia (primarily the University of Arizona and Arizona State University) has been particularly careful to make sure that all members understand the complex scientific studies that have been conducted, hosting question and answer sessions after studies are presented.

Another tool to connect scientific data to decisionmaking is the Decision Support System (DSS) developed by the Center for Sustainability of Semi-Arid Hydrology and Riparian Areas, a National Science Foundation Science and Technology Center located at the University of Arizona. While people can directly observe land-use change, they cannot directly observe subsurface flow of groundwater, a problem noted by the DSS developers. Many decisionmakers and stakeholders are unaware that surface water and groundwater are linked, and groundwater flow processes are a large, unseen part of the hydrological system, contributing to unsustainable water use practices. The DSS, using linked water management choices and groundwater modeling, can demonstrate the impacts of certain policy decisions on the aquifer by translating policy changes into pumping pattern changes. The impacts on groundwater of specific conservation and augmentation options are generated from a regional USGS groundwater model to demonstrate impacts on groundwater elevations and base flow in the river (see Figure 3 above). For USPP members, comprehending the scientific facts behind their decisions has been crucial in understanding the inherent complexities of water use in the region and building trust over time. Whereas initially, environmental issues often were misunderstood and/or disregarded, decisionmakers now have a
more robust scientific understanding of the human-environment dynamic at play in the Sierra Vista subwatershed. The joint learning between scientists and stakeholders has resulted in major shifts in understanding the region’s ability to sustain additional growth and the impacts of groundwater pumping on the river. For instance, one key change in understanding occurred as a result of calculating the magnitude of pumping in excess of recharge; another resulted from isotope studies, which demonstrated that summer streamflows are dominated by monsoon rainstorms rather than groundwater base flow.

However, generation of the scientific information and maintenance of a consensus-based process has come at a literal and figurative price: substantial federal resources have supported these efforts, and thousands of hours (multiplied by scores of participants) have been spent in partnership meetings. Further, the partnership benefits from both a “carrot” in the form of federal funding and a “stick” in the form of threats emanating from Endangered Species Act requirements, the need to preserve the flows in the San Pedro Riparian National Conservation Area, and the Base Realignment and Closure review process of Fort Huachuca. Some participants’ patience for continuing to engage in the process is wearing thin as fears for the future of the San Pedro River increase; some participants complain that the focus should be on management actions that could fix the problems rather than on long-term scientific studies. Others cite the lack of federal resources to resolve what many view as a federal mandate.

Support of local government officials in the process has proved crucial to the viability of the partnership, a finding consistent with others’ examination of collaborative resource management. Unlike in the past, when local officials often refused to consider scientific data in implementing water management and growth policies, the process of scientific inquiry that the USPP has pursued has led to clear accomplishments connecting science and decisionmaking. To date, the USPP along with local governments, Fort Huachuca, and local citizens have succeeded in reducing the 10,800 AFY deficit by approximately two-thirds—a reduction directly facilitated by the USPP’s scientific collaboration.

Another example of integrating scientific tools into policy and evolving spatially based watershed management is a zoning ordinance implemented by Cochise County. The Cochise County Board of Supervisors adopted a water conservation and policy plan in March 2006, marking significant progress toward more sustainable water and land-use policies. The county has an opportunity to discourage growth near the San Pedro River and help limit further reduction of streamflow. The county can use overlay zoning districts, strategically zoned areas where increased water conservation regulations are implemented, as a tool to carry out water conservation and management policies applicable to all residential and nonresidential development. The new policies move growth toward water company service (which tends to reduce total water use because of better monitoring and increased cost per unit) and away from the river, allow for transfer of development rights, and require design features that conserve water for new developments. The overlay conservation zoning district encompasses some of the more sensitive areas of recharge along the river and includes a provision that does not allow well drilling. All new developments within the overlay district that have an average lot size of less than 5 acres are required to have hot water on demand, drip irrigation, graywater plumbing, low-water-use commercial washing machines, installation of rain or humidity sensors on irrigation systems, connections to a municipal water company, and fewer outdoor water features. These policies will buy time protecting the flows in the river, though they do not resolve the overall problem of water use exceeding sustainable supplies. However, this ordinance would not have been possible without the USPP’s scientific-based decisionmaking approach, and it represents a success for its collaborative-knowledge system, including the DSS.

Further policy changes emerged from the state government not long after the Cochise County board passed its plan. In 2006, Governor Janet Napolitano appointed the Statewide Water Advisory Group to investigate rural water issues. The results of the advisory group convinced the Arizona legislature of the challenges of significant growth pressure that local governments and communities, including those in the Sierra Vista subwatershed, regularly face. As a result, the legislature adopted changes in the water adequacy program for subdivisions: during the 2007 session, Senate Bill 1575 was passed, marking the first time Arizona has allowed counties, cities, and towns outside of active management areas to require subdivisions to meet “adequate water supply” requirements before plan approval, though it requires a unanimous vote of the county board of supervisors if adopted at that level. Cochise County officials were first to seek this authority under the new statute.

When examined in the context of Cochise County and the Upper San Pedro basin, this new policy is a tool to limit growth in areas with limited water supplies. During interviews, USPP members cited the inability to curtail “irresponsible” growth as a primary obstacle to achieving sustainable yield by 2011. In addition, the legislation allows for local input on defining “adequacy.” Bob Strain, Sierra Vista City Mayor and USPP Chairman, said of the bill, “... Senate Bill 1575 set up the process by which cities and counties in rural Arizona are able to make their own rules as to what can be defined as adequate.” Since the Cochise County Board of Supervisors is represented on the USPP advisory and executive committees, where decisions are formally approved, it will be interesting to see what impact this new adequacy requirement will have on growth in the county and if the scientific research produced through the partnership will continue to guide the county’s decisions on growth.

After years of working to achieve sustainable yield, the partnership recognized the need for a local water manag-
ment authority with the ability to generate revenue to support conservation and augmentation projects. A second significant bill that was passed in 2007, House Bill 2300, allows voters in the subbasin to create the Upper San Pedro Water District, a public improvement district of the state with the associated privileges (tax exemptions and judicial review for board decisions). An organizing board develops a plan for the district and presents its plan to the voters: the county board of supervisors, with permission from the organizing board, places the issue of water district formation on the ballot. If the voters approve the formation of the proposed water district, they will then decide whether the water district will have the authority to levy a tax for water delivery not to exceed 50 cents for every 1,000 gallons of water delivered on a separate ballot initiative. The district would also be able to sell water and water rights, issue revenue bonds, accept gifts, grants, and donations, and apply for financial assistance from public and private sources from a newly created Water Supply Development Revolving Fund. The board will have the authority to acquire water supplies and operate augmentation projects, but the law prohibits the board from regulating water or land use within the district. While it is unclear whether the district will be established, authorization is a major achievement in moving toward a local management entity and funding source.

**Lessons Learned**

Land-use planning and water supply are inextricably linked, and this connection has now been formally acknowledged in both the USPP decision processes and new regulatory options. Growth and development are crucial parts of the Sierra Vista subwatershed’s economic viability, and their potential impacts on the water supply and riparian ecological system are significant. The DSS and several other science-based products are making these critical linkages. From a policy standpoint, USPP members have cited the inability to manage growth outside of incorporated areas as one of their most problematic issues. The recently passed legislation gives local officials the ability to connect future growth to water availability, if the political will exists to establish the district and take the necessary but potentially unpopular or expensive steps.

In the long-term view, the real issue is the total renewable supply in relation to the total demand, not the specifics of what type of development is involved. But in the shorter term, it is clear that a key part of the solution is to shift pumping patterns away from vulnerable stretches of river and stretch finite supplies to insure new users are as efficient as possible. Within the USPP itself and between the
multiple levels of government, there is no consensus on the contentious issue of growth control, and these issues will be the most difficult to resolve.

Time and perception of progress are crucial in the Sierra Vista subwatershed. The knowledge system created by the USPP—the ability to engage in adaptive management and incorporate a changing understanding of science into management and policy—has been a significant accomplishment. Currently the USPP is strongly focused on building an accurate groundwater model linked to the DSS. However, to date, there have been multiple renditions of groundwater models produced for the Sierra Vista subwatershed, and models will continually require modification.

Uncertainty regarding the exact nature of the interactions between groundwater pumping, surface water flow, and aquifer conditions has been used as an excuse for inaction in the past. However, the consequences of withdrawing more water from the aquifer each year than is replenished are now widely understood. The need for lengthy model development and analysis of more hydrologic information is still occasionally used as an excuse for inaction but no longer appears to be a significant stumbling block for USPP participants. It would be valuable for the USPP to explicitly categorize the remaining uncertainties and develop procedures for dealing with specific sources of uncertainty over time to avoid unexpected pitfalls in the process. Robust management strategies, including conservation, which work toward sustainable yield without producing unintended consequences and perform over a range of plausible future scenarios, can produce quicker results and tackle the perception that scientific studies are smoke screens for inaction. These types of “no regret” strategies can provide both the appearance and reality of progress and bridge lengthy and frustrating gaps while scientific data is pending.

The USPP has had success in planning and implementing small-scale conservation projects, and Fort Huachuca itself has made major contributions in this area, yet the partnership has had difficulty plan-

ning and implementing high-yield projects and engaging in politically sensitive decisions.33 Perhaps the largest criticism leveled against the USPP is its inability to make difficult decisions regarding growth, though most players recognize that the USPP does not have legal authority to regulate growth. The politics and economics of growth in Arizona make this conversation very difficult.

However, the collaborative learning process has been successful in many ways. The knowledge system that the USPP has formed in the eight years since its inception has produced an impressive array of information for decisionmakers, explicitly focused on the decisions that need to be made. Landmark state policies have been designed and implemented based in part on the efforts of the partnership. This evolution of state water and land-use policy can at least in part be credited to the successful integration of the collaborative science-based work of the USPP. This connection of science informing decisionmaking that has emanated from a broad-based collaborative group is in itself a remarkable feat. The real issue is the degree to which politicians and the general public are motivated to work toward environmental sustainability even if it means the potential economic sacrifice of regulating growth or paying for extremely expensive importation options; balancing social perceptions and will with scientific knowledge is truly challenging.

The collaborative efforts of the USPP are clearly advancing incrementally toward connecting water and land-use management. Whether it is enough to protect perennial flow in the San Pedro River remains uncertain. The future of the USPP and its role in achieving sustainable yield amidst the evolving policy discussed in this article is also unclear. Notable collaborative resource management organizations, including the Quincy Library Group, have seen their role diminish following significant policy changes.36

Examination of the USPP yielded a number of insights that can be useful in other watersheds throughout the world, where citizen participation in environmen-

tal decisionmaking continues to expand. Although there is no current evidence of USPP outcomes being translated into basins other than the Verde Basin in Arizona, the science-policy interface and knowledge network that the USPP built are clearly good platforms for other watershed efforts. The formation of a collaborative group representing diverse interests has allowed the USPP to secure significant funding, and form relationships with government and academic partners. This, in turn, has led to an impressive array of scientific data and tools that can be applied to watershed management. The knowledge system created through collaboration can be adapted at an institutional level and substantively in the science that is produced—as evidenced by the USPP’s restructuring and recent scientific production of tools and knowledge that allow for spatially based land-use and water management. An agreed-upon volumetric goal of water to conserve or replace is extremely useful in clarifying objectives, even if complete agreement on how to reach the goal is difficult to achieve.

As in other similar efforts, USPP participants appear more likely to accept scientific information if they are included in the project planning and design, continually informed of results, and able to discuss and ask questions regarding data, projects, and results. The collaborative process has created a knowledge system capable of spatially based watershed management; however, politics can and do impede the use of knowledge and science for sustainability. Collaborative resource management groups and efforts must adapt to changing political and regulatory contexts and evolving scientific understanding. This implies that successfully designed science-policy interfaces must also incorporate adaptive management. Most importantly, institutions, which sponsor these activities, need to be “learning organizations”37 and evolve in response to changes in science, institutions, and perceptions.

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NOTES


6. D. Kenney, Arguing About Consensus: Examining the Case Against Western Watered Initiatives and Other Collaborative Groups Active in Natural Resources (Boulder, CO: National Resources Law Center, University of Colorado, 2000).


20. The current memorandum of understanding that the Upper San Pedro Partnership operates under can be found at http://www.ussppartnership.org/about/docs_mou.htm (accessed 7 September 2008).


22. Criteria for membership in the Upper San Pedro Partnership (USPP) include “agencies and organizations that (1) own or control land or water, and/or (2) make policy with regard to land or water use in the Sierra Vista subwatershed of the Upper San Pedro River Basin, and will provide significant resources to help the partnership accomplish its purpose; or agencies and organizations that will provide significant technical or financial resources to help the Partnership accomplish its purpose.” Upper San Pedro Partnership, History, http://www.ussppartnership.org/about/history.htm (accessed 7 September 2008).

23. The primary data for this article was collected through a research study spanning nearly two years. Initial data were obtained through 15 semi-structured interviews conducted with USPP members along with numerous informal follow-up interviews; document analysis of newspaper articles, official USPP publications and scientific studies, minutes of USPP meetings, and other written material generated by the USPP; attendance at meetings and workshops involving USPP members and field visits; and policy analysis and examination of policy and management strategies in the larger context of water management in Arizona. The purpose of the case study was to gain insight into the collaborative process from individuals and organizations, who had been long-term members; how decisions were made; and how scientific data was both understood and used in the decision-making process.


