

Landscape Change, Land Use History and Planning for the San Pedro Riparian National Conservation Area, Arizona, U.S.A.

Gordon Nelson
Heritage Resources Centre, University of Waterloo

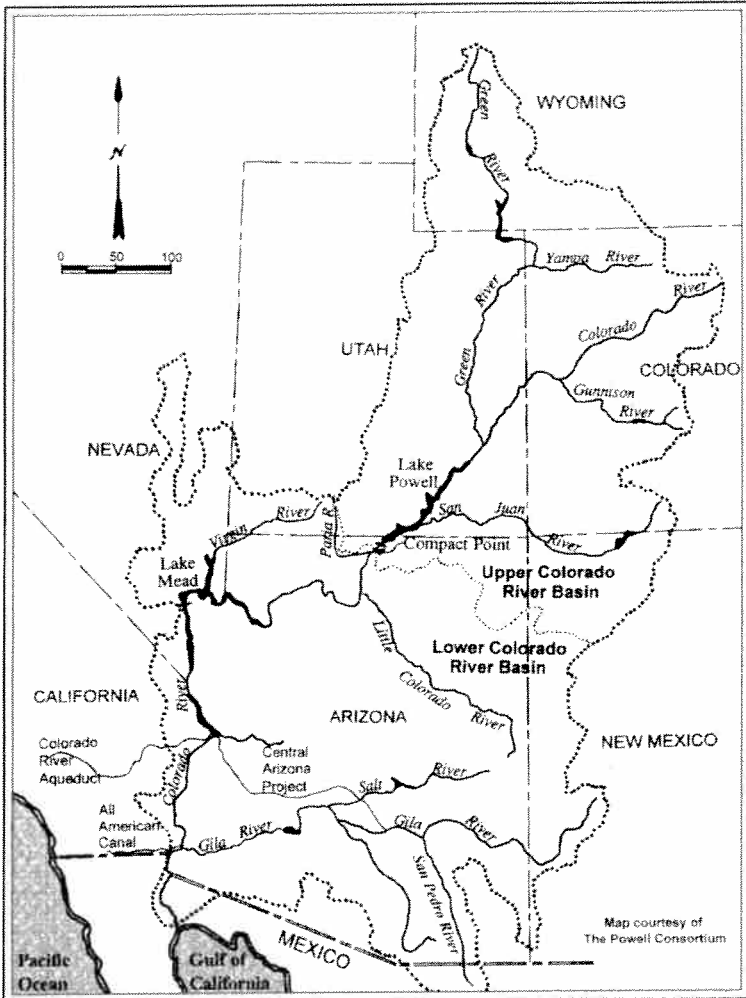
Abstract

This is an overview of landscape and land use history and some planning implications for the San Pedro Riparian National Conservation Area (NCA), Arizona, U.S.A. The overview is organized in terms of an Abiotic, Biotic and Cultural (ABC) approach which integrates the natural and cultural history of the San Pedro Riparian NCA and surrounding country. The overview reveals the highly significant history and character of the San Pedro landscape geologically, biologically and culturally. The unique aspects of the NCA include several Paleo-Indian sites dating from approximately 11,000 BP as well as the rare gallery forest and riparian habitat along the San Pedro. The overview ends with some planning implications of the study including more widely disseminating the success of the NCA in protecting and restoring habitat in the face of grazing, mining and other pressures and in planning for associated water resource conservation in the surrounding region. The success of the San Pedro National Riparian Conservation Area to date merits careful attention in other watersheds elsewhere in North America.

Introduction

River valleys or riparian areas are increasingly recognized as important for the conservation of migratory fauna and flora as well as habitat for many resident wildlife populations. Riparian areas are also increasingly of commercial interest for aggregate mining, irrigation projects, hydroelectric power facilities, livestock grazing and other enterprises. In few places is the conflict between these two broad sets of values and interests more apparent than in the American Southwest, including the State of Arizona. In the close to five centuries since the invasion of the area by Spanish, and later other Caucasians, the river valleys have been subject to growing pressure for development. By the 1980s, few major river valleys in Arizona remained in anything close to what might be called a natural state. One of these was the San Pedro River corridor, which had not been nearly as heavily exploited as other desert stream habitats along the Gila, the Salt and the Santa Cruz (Figure 1).

Figure 1. The San Pedro and the Colorado River watershed (courtesy of Water Resources Research Center, University of Arizona, Hanson, 2001).



Concern about the future of the San Pedro rose sharply in the 1980s as a result of increasing pressure for grazing, gravel mining and housing developments for the growing influx of immigrants and visitors. On November 18, 1988, the U.S. Congress responded to this concern by passing an Act setting up the San Pedro Riparian National Conservation Area (NCA) to be managed by the U.S. Bureau of Land Reclamation (BLM) (Friends of the San Pedro River, San Pedro Riparian National Conservation Area, n.d.). This NCA was established to conserve, protect and enhance the desert riparian ecosystem, a rare remnant of what once was an

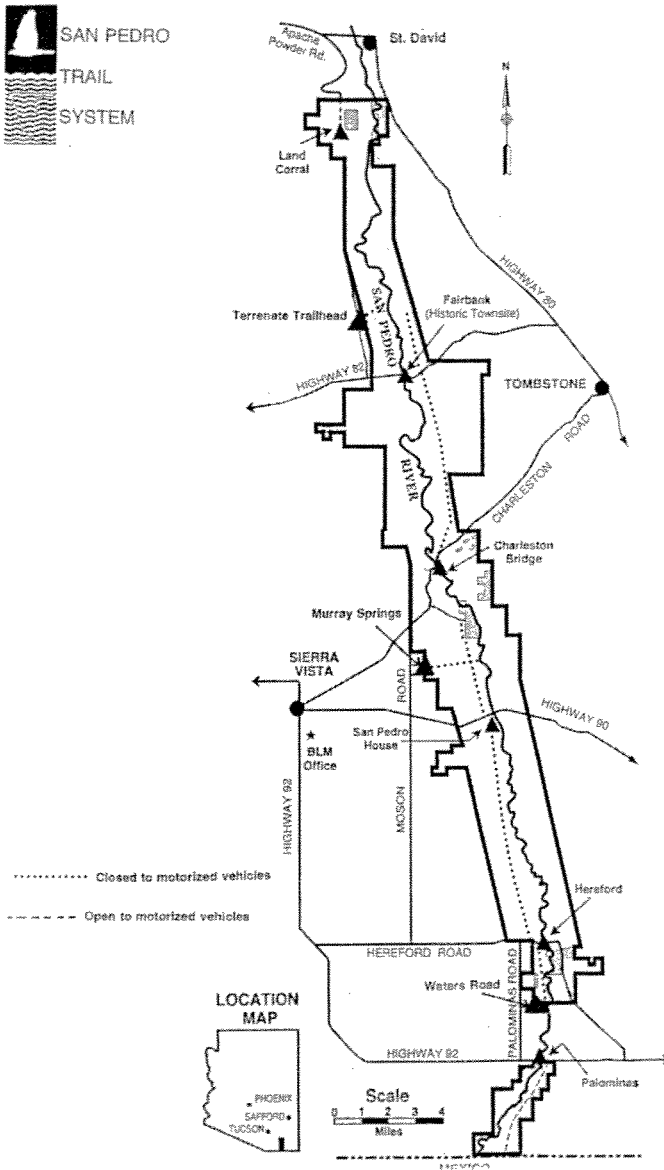
extensive network of similar riparian systems throughout the Southwest. The San Pedro Riparian NCA supports over 350 species of mammals, two indigenous and several introduced species of fish, more than 40 species of reptiles and amphibians, as well as thousands of species of plants (Friends of the San Pedro River, n.d.; BLM, 1989; Hanson, 2000).

Although some in-holdings still exist, the San Pedro Riparian NCA consists of approximately 56,000 acres of public land assembled by the BLM along about 40 miles of the upper river between the Mexican-US border and St. David, a Mormon settlement dating from about the turn of the 19th century (Figure 1). The headwaters of the river are in Mexico where the catchment is exploited for cultivation, grazing, mining and other uses. Efforts have been underway for several years to co-operate with the people of Mexico in introducing more effective conservation measures in their part of the watershed. According to the Friends of the San Pedro River (2002), a group of concerned citizens in Mexico has formed an association similar to the Friends. This group hopes to protect the San Pedro River from its source in Mexico to the US border. The Friends of the San Pedro and BLM have agreed to serve on the Board and act as consultant to the new Association.

The main management measures put in place by BLM since 1988 include controls on grazing, gravel mining and housing developments, as well as roads and other facilities. Various types of recreation are encouraged including hiking and naturalist activities, notably birding. All Terrain Vehicles (ATVs) and other recreation technology are subject to controls. Although birders visit the area from throughout North America, much of the recreational use is local and involves family hikes, picnics and other evening and weekend activities. A hiking trail parallels the full length of the Riparian NCA and seems to be used frequently by locals and visitors alike (Figure 2). An excellent guide to the upper San Pedro has been prepared by the naturalist and Executive Director of the Sky Islands Alliance (Hanson, 2001). The guide is built around a hike from the beginning of the NCA, near the Mexican border, to St. David. No reliable data are available on the number of visitors to the NCA. The collection of data is difficult because of the numerous points of entry to the NCA and also because of the limited staff and other resources available to manage the river.

Thousands of birders visit the area annually as it is renowned for the high population and diversity of its avifauna. The focal point for birders is the San Pedro House, a historic cabin occupied and renovated by the BLM and The Friends of the San Pedro River, a volunteer non-profit, non-political organization providing support for the Bureau in the stewardship of the NCA. The San Pedro Riparian NCA was designated as the first Globally Important Bird Area in North America in 1995, being joined not long thereafter by the Long Point Biosphere in Ontario and a site in southern Mexico.

Figure 2. The San Pedro National Conservation Area trail network (BLM, n.d.).



A wide range of conservation activities has been introduced by the BLM and its supporters to enhance the degraded habitat of the NCA since its creation in 1988. The removal of cattle grazing and hay production has led to the restoration of extensive floodplains and grasslands. Areas disturbed by plowing, surface mining

and other similar activities are returning to grass and other cover. Growth of cottonwood, willow, sycamore and other trees and shrubs along the stream banks and adjoining floodplain areas has been impressive. Such changes have been evident to me since my first visit to the NCA, in 1994. Mesquite has begun to encroach onto the floodplain areas, with some constraints on this as a result of accidental and controlled burning. Water quality is also said to have improved. The difficulty, however, is limited systematic monitoring of the ecosystem changes has been undertaken, largely because of lack of resources by BLM and others. Lack of such data could pose problems when some aspects of the agreement for the San Pedro Riparian NCA come up for review and possible renewal. A key example is the pending review of the prohibition against livestock grazing which ends in 2003.

This leads to the basic reason for presenting this paper, which is to review the land use and landscape history of the valley and assess some of the implications this has for future planning, management and decision making for the San Pedro Riparian NCA. The paper is based on six annual field visits to the area between 1995 and 2002, and interviews and conversations with numerous people from relevant government and non-governmental organizations as well as numerous tourists and local residents encountered during visits. Extensive research was also undertaken in libraries, notably the Bisbee Mining Museum and the Douglas Public Library. The natural and cultural history of the San Pedro is quite complex and cannot be considered in detail here. The San Pedro Riparian NCA is affected not only by activities and processes occurring within its more immediate vicinity, but also by those in more distant parts of the watershed and beyond. It is, however, possible to highlight San Pedro's history by focusing on some key aspects of its evolution from early geologic times to the end of the last field research for this study, in spring, 2002.

The ABC Approach

The San Pedro valley and surrounding area are of outstanding interest for a number of interrelated natural and cultural reasons. From the natural standpoint the area is highly significant in terms of both earth science and biological attributes. From a cultural standpoint the area is highly significant in terms of the great length of human occupancy, the diverse array of changing ethnic and cultural groups, and their frequently profound impacts on vegetation, wildlife, landscapes and ecosystems generally. These ecosystem changes are a result not only of human activity but also post glacial climatic and natural changes and their interaction with human activities.

In organizing this paper to describe, analyze and assess such changes, it has been useful to follow the ABC or Abiotic, Biotic and Cultural method (Bastedo et al., 1984). This method was developed to facilitate comprehensive resource and environmental surveys and assessments for planning purposes. The method provides

a broad framework for organizing, describing, mapping, analyzing, assessing and integrating diverse information from an array of disciplines and sources. The method is useful in dealing with historic as well as current information and ongoing research.

The ABC method can be undertaken in considerable technical detail as well as in a more general way. The latter approach is the one followed here – the aim being to produce an integrated overview of the natural and cultural evolution and current character of the San Pedro area, its significance and challenges, especially in planning from a conservation and sustainable development perspective.

Accordingly, the following text considers salient aspects of the geology, hydrology and climate, or ‘Abiotic’, the plants, animals and habitats or ‘Biotic’, and the human or ‘Cultural’ characteristics of the San Pedro area. In the general sense, the cultural characteristics include land use, economics, social, institutional and other aspects of learned human behaviour and activities. In a brief overview such as this however, some selectivity or judgment is required about what is significant for the purposes at hand. Such selectivity is reflected in the following text. The salient Abiotic and Biotic characteristics are considered first, followed by a general discussion of changing human activities, their interaction with the surrounding environment, and some implications for planning, especially conservation planning.

Abiotic

The San Pedro watershed and surrounding country are located amid the great desert of the U.S. southwest and northern Mexico. The desert lies in the general vicinity of 30° north latitude, a dry zone subject to strong seasonal shifts in atmospheric circulation and storm trends (Shreve and Wiggins, 1946; Larson, 1977). In the winter, storms and weather originating in the west over the Pacific move eastward and inland. These moisture-laden systems encounter and are pushed upward and cooled by the Coast Ranges, the Sierra Nevada and inland mountains. The result is that the western part of the desert receives predominantly winter precipitation.

In the spring the atmospheric circulation and storm trends move north with the sun. The eastward flow from the Pacific becomes weaker. Monsoon-type circulation and storm tracks move into the increasingly hot interior from the southeast and the Gulf of Mexico. In consequence, much of the precipitation in the eastern part of the southwestern desert falls in the summer in contrast to the winter peak in the west.

In the central parts of the desert, the two seasonal precipitation patterns overlap. These areas receive both summer and winter precipitation. This is true for the country around the San Pedro watershed. Tucson, about 100 miles west and north of the San Pedro NCA, receives about one half its 275 mm (11 inches) annual average in winter and about half in summer (Larson, 1977: 35). The availability of

this precipitation is reduced by high evapotranspiration rates which result from temperatures often exceeding 40°C (100°F) in summer. Temperatures tend to fluctuate considerably around the mean. Temperatures and precipitation have also varied as a result of past climate changes. Weather and climate also vary in accordance with variations in geology and topography. Some details on the geologic and topographic variations are presented in the following discussions which set the stage for consideration of significant historic and current climatic and biotic patterns in the study area.

The geological history of the southwest U.S. and adjoining parts of Mexico is a very long and convoluted one. About 1600 million years ago, the region was covered by sedimentary and volcanic rocks (Drewes and Thorman, 1978: 291). An array of tectonic episodes included: a Paleozoic period of relative stability; Late Triassic to Late Jurassic magmatic arc activity; an intense period of deformation and magmatic arc activity in the late Cretaceous to Early Tertiary (Laramide); evolution of middle Tertiary calderas and metamorphic core complexes; and Late Tertiary Basin and Range rifting.

Much of the structure of the present landscape arises from the Middle Tertiary and Later Tertiary phases. According to Coney (1978: 288), the mid-Tertiary was "the most bizarre and varied period of tectonic activity in the entire history of the region". The bedrock was deformed, domed, extended and metamorphosed. Of special interest is a Cordilleran-wide sequence of volcanism which extended from the Pacific Northwest to southern Mexico (Sierra Madre Occidental Mountains), leaving a landscape buried in ash and punctured by calderas (Coney, 1978: 288).

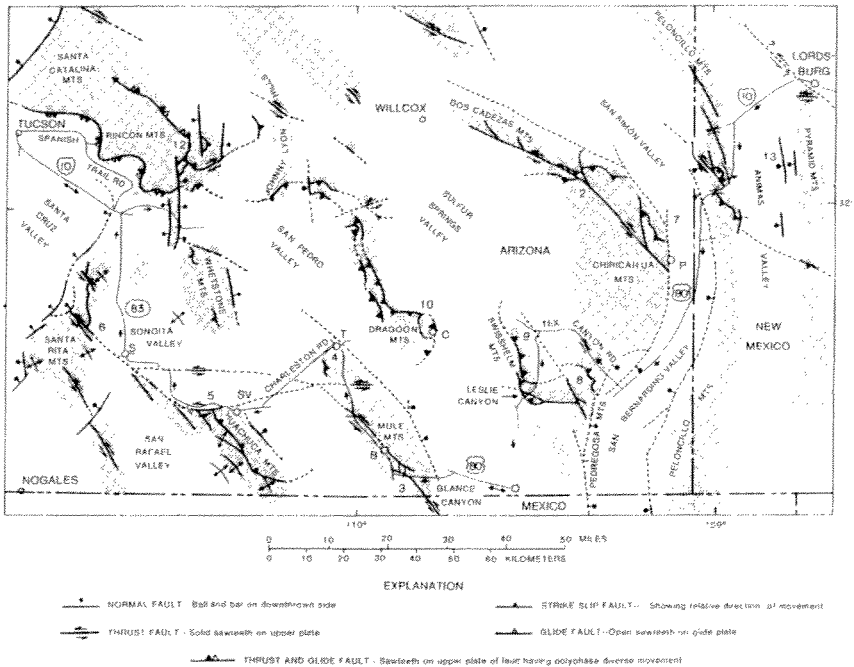
In Late Tertiary, between about 15 million and 6 million years ago, widespread faulting and extensive vulcanism produced the characteristic southern Arizona and northern Mexico landscape of fault-block mountains. These are separated by basins, such as Sulfur Springs and the San Pedro Valley, filled with thousands of feet of sediment (Drewes and Thorman, 1978: 291). Figure 3 is a sketch map showing the major kinds of structured features making up the region (Drewes and Thorman, 1978: 292).

In addition to its location in pronounced Basin and Range topography, the San Pedro area is of unusual interest because of its Quaternary history of the last several million years. Huge ice sheets advanced across Canada and the U.S. a number of times, causing changes in climate throughout the continent. In the southwest U.S., ice advances resulted in alpine cool-wet, or pluvial climates, and ice retreats in interpluvial or semi-arid climates.

Evidence for these changes is found in remnants of formerly extensive lakes in the basins of the region. An example is pluvial Lake Cochise which was located in what is now called The Willcox Playa near the town of that name in the Sulfur Springs Basin on the western fringe of the Chiricahua Mountains (Schreiber, 1978: 277).

Schreiber and some students did research on this former lake between 1962 and 1965. Using core analysis and other field studies, they determined that former Lake Cochise covered about 190 km² around the present smaller and ephemerally flooded playa. Using surrounding old beach ridges as indicators of the extent and elevation of the former lake, they estimated it was about 18 km x 32 km and 11 m (35 ft) deep.

Figure 3. Sketch map of southeastern Arizona and southwestern New Mexico, showing major structural features of the region (Drewes and Thorman, 1978: 292).



A 43 m core from the middle of the former lake was examined by P.S. Martin, a pollen expert. C14 dates were also obtained on carbon from this core. According to Schreiber (1978: 281), Martin interpreted high pine counts in the core as indicating more extensive growth of forest and woodland and a cool-wet climate. He interpreted low pine pollen counts, or poor pollen preservation and oxidized sediment, as indicating drier interglacial or interpluvial climates. Martin placed the upper 23 m (77 ft) of the core in the Wisconsin glacial interval. The pollen in the sediment below 2 m (6 ft) was 99% pine pollen. A C14 date of 22,000 BP was secured at the top of this pine pollen zone. Martin put the lower 23 - 29 m (77-96 ft) section of the core in the drier Sangamon interglacial interval and concluded that the base of the core represented pluvial conditions of the Illinoian glacial interval.

Similar evidence of former lakes has been found elsewhere in the southwest and

has been interpreted as indicating widespread fluctuations in climate, flora and fauna in the Basin and Range region during the Pleistocene (Bezy, 2001: 22). The general picture in the pluvials is one in which upper level Spruce, Fir and Pine forest are seen as moving downslope along with mid and lower level Oak savannah and grasslands. In the drier interpluvials these vegetation zones are interpreted as moving upslope again. Such fluctuations continued until about 12,000 years ago when the ice sheets underwent massive retreat and climates and vegetation patterns generally similar to current ones were established. Today Willcox Playa, the descendant of Lake Cochise is one of only two active Playas in Arizona (Bezy, 2001: 22)

According to Bezy (2001: 22), glacial or pluvial Lake Cochise was present in the Sulfur Springs Basin, which is located immediately east of the San Pedro Valley (Figure 3), as recently as 10,500 years ago. At that time, the basin had open stands of ponderosa pine and herds of mammoth, horse and camel. This interpretation is in line with evidence from the San Pedro basin to the west, where excavations have revealed such early fauna in association with human artifacts. In fact, the lower San Pedro Valley is generally considered to have the highest number of early man or Paleo-Indian sites of any comparable area in North America. Of particular note are the Naco and Double Adobe sites on the east fringe of the San Pedro as well as the Escalupe, Lehner and the Murray Spring sites in the San Pedro Valley NCA, just north the Mexican border. Archaeological excavations at all three sites reveal bones of now extinct Pleistocene animals in association with stone tools and debris interpreted as having been worked by humans. All these sites have also been dated by C14 and other geologic methods as about 11,000 years BP (Bromtzky and Merritt, 1986: 54-55).

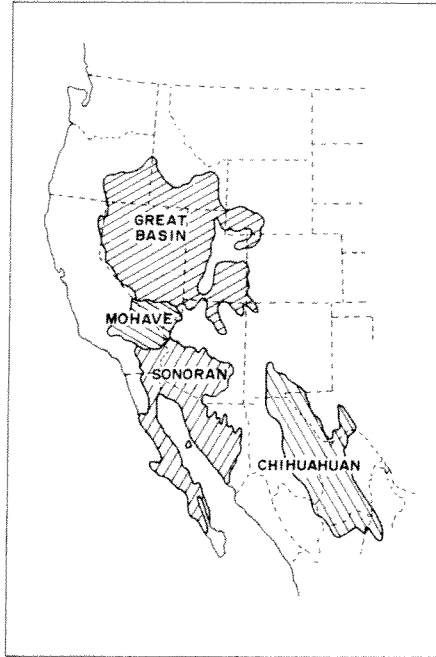
Biotic

Today the western and southwestern deserts of the U.S. can be subdivided into types on the basis of differences in their weather and climate, their geology and land forms and most especially, their vegetation. The four main types of deserts are the Great Basin, the Mohave, the Sonoran and the Chihuahuan, as shown in Figure 4 (Larson, 1977: 31). These in turn, can be divided into various subtypes or subdivisions (MacMahon, 1985: 63). The San Pedro area has been considered to be in the Sonoran zone but also can be seen to occupy an intermediate position among several of these desert types and subtypes. The San Pedro area's location in an upland area close to high fault block mountains such as the Huachucas also adds to its biodiversity potential.

According to MacMahon (1985: 65-69), the San Pedro area lies toward the eastern edge of the Arizona Upland, in the Sonoran desert region. Many shrubs occur at various heights in this upland. In very general terms, one vegetation layer is less than eighteen inches high, another is about three feet, and beyond that is an upper layer of sub-trees. This array of plants includes Creosote Bush, Foothill Palo Verde,

Iron Wood and many species of cacti whose diversity is high. They include Prickly Pear, Barrel Cactus, and various species of Cholla such as Buckthorn, Cane and Jumping Cholla.

Figure 4. North American deserts (Larson, 1977: 31).



This vegetation assemblage is associated with an array of animals, of which birds are of special interest for scientific, recreational and other reasons. According to Nabhan and Holdsworth (1998: 15) at least 500 bird species have been reported in the Sonoran, approximately half the number of birds reported for the continental U.S. or Mexico. In the desert shrub and semidesert grassland habitats, however, the per unit area diversity of breeding birds is not especially noteworthy, approximately 30-150 pairs per 40 ha. According to MacMahon (1985: 76), typical Sonoran desert sites generally have less than 25 breeding species. However, wooded and shrub lined valleys or riparian corridors may play host to as many as 400 species for breeding, overwintering and migrating. This constitutes approximately 75 percent of all the bird species which migrate between the U.S. and Mexico (Nabhan and Holdsworth, 1998: 15).

Nabhan and Holdsworth (1998: 16) note that deciduous riparian gallery forests of the Sonoran, such as those along the San Pedro, harbour 304 to 847 breeding pairs per 40 ha, possibly the highest breeding bird densities on the North American

continent. In terms of breeding bird diversity and productivity, Sonoran riparian habitat such as the San Pedro, appears to be among the richest in North America.

Species diversity and productivity are also high for species other than birds in the Sonoran. Overall, the species richness of mammals known for the San Pedro Riparian National Conservation Area is estimated at 86 species including 12 at risk. This richness is thought to be unsurpassed for any landscape of similar size in the US (Nabhan and Holdsworth, 1998: 13). The Sonoran region's reptile diversity also is high although the same cannot be said for amphibians and fish.

Cultural

Early Humans

Previous discussion of the natural history and character of the San Pedro Valley and surrounding areas included references to archaeological evidence of early human artifacts at Lehner, Murray Springs and other sites. The Lehner and the Murray Springs sites have been carefully excavated and studied by professional archaeologists and other scientists and the results highlight the significance of these finds (Anonymous, 1982; BLM, Lehner Mammoth Kill Site, n.d.; BLM, Murray Springs Clovis Site, n.d.; Bronitsky and Merritt, 1986). In 1952, Ed Lehner, a rancher, discovered extinct mammoth fragments in terrace deposits at a locality on his ranch, now known as the Lehner Mammoth Kill Site. It was excavated in 1955-56 and again in 1974-75. The archaeologists identified 13 worked stone points similar to the Clovis points found earlier in New Mexico. In addition to these points, which were likely used on long lances to kill mammoth, the archaeologists also found stone butchering tools, chips and other stone debris as well as fire hearths (BLM; Lehner Mammoth Kill Site, n.d. and Hanny *et al.*, 1959). These hearths contained carbon, which was dated at about 11,000 BP. Animal bones identified at the site included those of twelve immature mammoths, one horse, one tapir, several bison, one camel, one bear, several rabbits and a small snake. Botanists identified pine, ash and oak in the charcoal from the hearths. From this and other evidence, they deduced that the site was used by humans in the interval between the end of the Pleistocene and the beginning of recent drier times.

The Murray Springs site is located just north of the Lehner site on the edge of a terrace above the San Pedro floodplain. The site was excavated by archaeologists and other scientists from 1966-71 (Kardeka, 1982; BLM, Murray Springs, n.d.; Bronitsky and Merritt, 1986; Amann *et al.*, 1998). The findings were generally similar to those for the Lehner Site. Sixteen projectile or Clovis points were found along with other worked stone and bone tools and debris. Bones of several extinct animals included mammoth, North American horse, camel, bison, lion and dire wolf. The stone artifacts and bones were found several feet below the surface, beneath a dark organic layer or "black mat." This yielded C14 dates of approximately 11,000 BP, similar to those of the Lehner site.

The evidence from the Lehner, Murray Springs and similar sites near and beyond the San Pedro indicates that ancient people, the so-called Paleo-Indians, were big game hunters who moved in pursuit of mammoth and other sources of food. They were successful in killing large Pleistocene animals and are considered by some scholars to have been largely responsible for their extinction (Martin and Klein, 1984; Amann *et al.*, 1998). Others are of the view that the change from a cool-wet or pluvial climate to a drier post-glacial one damaged or destroyed habitat, thereby leading to extinction. Still others have concluded that extinction was due to several causes, including both climate change and over-hunting (Amann *et al.*, 1998). The high number of young or immature mammoth at sites such as the Lehner has been interpreted by some scientists as indicating that extinction likely was caused by these early people preying heavily on more vulnerable, younger animals. On the other hand, faunal extinctions at the end of the Pleistocene included some animals and plants not known to have been used by humans, who do not therefore seem likely causes of their extinction (Amann, 1998: 8).

Paleo – Indian Times to Arrival of the Spanish

This long interval extends from the end of the Paleo-Indian times, about 10,000 years ago to the entrance of the Spanish into what later became Mexico and the American Southwest by about 1540. This very lengthy period has been subject to confusing and uncertain interpretations by archaeologists and other scientists (Bronitzky and Merritt, 1986: 100). Hundreds of relevant sites have been excavated in the Southwest and the general region of the San Pedro Valley.

These sites have been interpreted as representing various complexes and stages of what are generally thought of as Archaic or Desert cultures. They developed a range of stone, bone and other tools that permitted a hunting and gathering lifestyle in the Southwest, including the San Pedro Basin. A small amount of evidence indicates that Archaic people (Sulfur Springs) hunted mammoth and may have overlapped to some extent in time with the people identified by archaeologists as Paleo-Indians; although this possibility has been challenged by Waters (1986) on the basis of his excavations in Whitewater Draw just to the east of the San Pedro Basin. For the most part, the Archaic or Desert Cultures pursued a migratory lifestyle, hunting deer, coyote, rabbit, antelope and other currently existing animals, as well as gathering, grinding, and processing mesquite, beans and other plants. They may have moved about in bands of about 20-30, although their overall numbers in the Southwest and the San Pedro area are unknown.

Hundreds of Archaic sites have been identified in the San Pedro area. The sites include ancient hearths showing use of fire for cooking and domestic purposes. Fire may also have been used in burning grass and vegetation to drive deer and other game, as was done in more recent times by people living with similar technology and lifestyles (Cornett, 2000: 26; de Golia, 1993: 6; Hanson, 2001: 84). It has also been suggested that these people might have encouraged the growth of wild plants to collect for food, introducing a kind of incipient or early stage of agriculture

(Bronitzky and Merritt, 1986: 113). Cumulatively through hunting, plant selection and other activities over about 7500 years or approximately 400 generations (10,000 BP - 2,500 BP) these early people probably caused many unappreciated changes in the fauna, flora and ecosystems of the San Pedro and other areas.

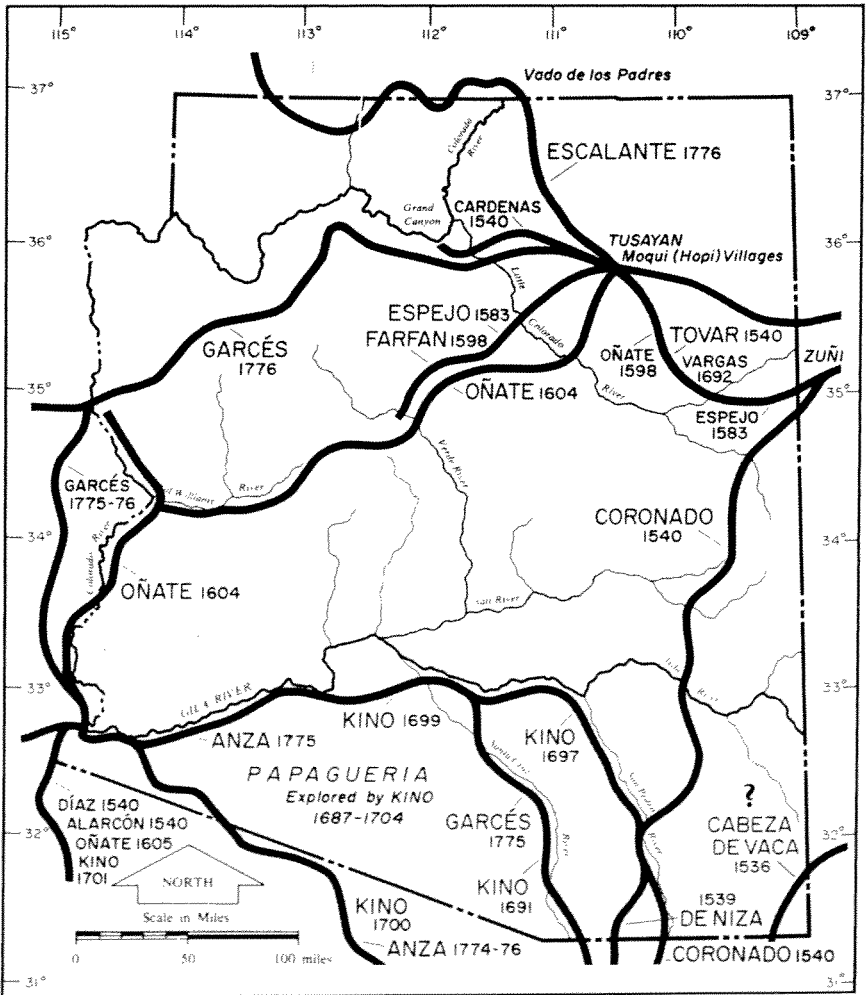
With the development of sedentary agriculture however, the scene was set for major impacts on the environment. The evidence for agriculture revolves around the three relatively well known indigenous crops: maize, squash and beans. C14 dates have been obtained for the earliest occurrences of maize and squash at the Bat Cave, Tularosa Cave and Cienega Creek sites in west central New Mexico and eastern Arizona. These plant remnants are said to be associated with Chiricahua stage artifacts and have been dated at between about 4200 and 3500 BP by C14 analysis. Beans from later San Pedro stage levels at Bat Cave have been dated as early as 3,000 BP. Maize was also recovered from these San Pedro levels. This corn was a crossbreed between early maize and a teosinte form of the plant, likely introduced from antecedents in Mexico. This new form of maize produced larger cobs and was more adapted to arid environments, which probably contributed to its spread through the southwest (Bronitzky and Merritt, 1986: 113). According to Bronitzky and Merritt (1986: 113), before the teosinte introduction and the development of a new hybrid maize, corn may only have been a minor component of an economy which relied heavily on wild plants, some of which might, like maize, have been encouraged to grow through "benign neglect", as was the case with the historic Papago people of early European times.

Slow and gradually increasing use of the new maize and other crops led to a gradual shift to a more sedentary and elaborate lifestyle. Domestic structures, such as storage pits and cooking hearths, as well as human burials, suggest a trend to sedentism. The existence of settled villages in certain parts of the area, by about 1500 years BP or 500 AD, is seen as a result of these trends (Bronitzky and Merritt, 1986: 114). These villages gradually elaborated into those of people known as the Hohokam with their well built mud and stone homes, as well as kivas, other ceremonial areas, ball courts and other architectures. These villages and settlements were associated with the production of corn, beans and squash through irrigation as well as farming based on natural sources of water. In some cases, irrigation canals, sluices, gates and other structures were built. In other cases, the crops were grown on floodplains or through diversion of floods and high waters. Little evidence of Hohokam agriculture and irrigation apparently has not been found in the upper San Pedro or current NCA in comparison with such evidence for the lower valley, towards its junction with the Gila River. Where sedentary indigenous agriculture and irrigation did develop, this began the process of land clearing, soil disturbance, stream and water diversion, salinization and other environmental effects that may have been of considerable significance locally, but only heralded the larger scale changes yet to come with the introduction of elaborate irrigated farming in European times.

The Spanish

The next phase of San Pedro Valley history is the Spanish period from about the 1530s to the 1850s (Bannon, 1974; Meyer, 1984; Walker and Baukin, 1979). For our purposes, this three-century span includes the time of Mexican independence from 1821 to 1856, when the U.S. Congress completed its acquisition of the current state of Arizona and other parts of the U.S. Southwest through the Gadsden Purchase. The Spanish discovered and invaded current Mexico in 1521. By the 1530s and 1540s, expeditions in search of gold, silver and other metals were underway in the present state of Arizona, as well as New Mexico and Texas. The best known of these expeditions was that of Coronado in the early 1840s (Figure 5).

Figure 5. Routes of Spanish explorers (Walker and Butkin, 1979).



A wave of Spanish invasion was religious in nature. The Jesuits, and later the Franciscans and other orders of the Roman Catholic Church, moved into the study area to convert the natives to Christianity. Serious attempts to establish missions were made from northern Mexico in the mid-to-late 1600s. Some of these efforts were successful, for example in the Santa Cruz Valley west of the San Pedro. These successes included well known sites such as Tubac, San Xavier de Bac and later Tucson. The military also increased its presence in southern Arizona and other parts of the current southwest to defend the Missions as well as other migrants moving into the region for trade and commerce (BLM, Presidio Santa Cruz De Terrenate, n.d.).

Efforts to establish Missions and Presidios, or military posts, in the San Pedro Watershed were largely unsuccessful, particularly in the southern or upper parts of the valley. Some success was achieved for a few years at Quibari (Quivari) and the nearby Terrenate Mission. However these posts were eventually abandoned because of the hostility of invading nomadic hunting groups such as the Apache and the withdrawal of the Sobraipuri and other previous collecting and gathering people, whose cultures are thought to resemble those of the archaeological Archaic.

The Spanish introduced many exotic plants and animals into the San Pedro area and the Southwest (Bronitsky and Merritt, 1986; Bahre, 1991; Bennet *et al.*, 1996). Expeditions such as Coronado's in the 1540s included hundreds of horses, cattle and other stock, some of which were lost. Such animals also were taken to Missions like those along the Santa Cruz, for use by the Spanish as well as natives. Wheat and European crops were introduced for similar purposes. Over the decades and the centuries, many of these animals and plants went wild or spread domestically through southwestern ecosystems. Water diversion and irrigation systems were expanded by the Spanish. The invaders also introduced new germs and diseases to the natives, causing epidemics that killed thousands over the years. The development of Missions, Presidios and silver and other mining camps brought larger populations and settlements, and accelerated ecosystem and landscape changes.

The Americans

The next phase of interest, the American, grew sharply with the 1849 California gold rush. Explorers and traders from the US had been active in Arizona decades earlier. James Battie, an American Mountain Man, explored and worked the Gila River for beaver and other furs in the 1820's, following the river to the vicinity of the Gulf of California (Bronitsky and Merritt, 1986: 273-276; Walker and Bufkin, 1979). He is known to have been active in the lower San Pedro Valley, close to its entrance to the Gila. Neither he, nor other American trappers, seem to have reached the upper San Pedro and the vicinity of the current NCA.

Traders, prospectors and other invaders from the US came in increasing numbers to Tucson area and other parts of current Arizona, New Mexico and California in the 1840s. War with Mexico led to US acquisition of much of the American Southwest

in 1848 and the rest through the Gadsden purchase of 1856. Some predecessors of the California Gold seekers of 1849 passed through the upper San Pedro Valley, but travel increased greatly with the rush of prospectors and others from the east. These travelers used a number of routes through Mexico and the southwest, including one that ran more or less along the current border and up the San Pedro valley to the Gila, Tucson and beyond (Bronitsky and Merritt, 1986: 283-284).

After 1856, an array of US economic activities began to boom in the Southwest and the San Pedro valley watershed. Prospectors swept the region looking for gold, silver, lead, copper and other minerals. Some were found, often in short-lived deposits, lasting only a few years. Some rich finds were eventually made including Tombstone, Bisbee and a number of sites in the mountains on the fringe of the San Pedro Valley (Schwantes, 1992; Leaming, 1998). These sites lasted into the 20th century and spawned mills and settlements at now abandoned sites such as Fairbanks and Charleston, in the upper San Pedro, in what is now the NCA.

Other settlers moved in to ranch and raise cattle, horses and other stock for the mining settlements (Bronitsky and Merritt, 1986: 283-284). Some of these outfits were in place in the 1860's, including the Kitchen Ranch on the lower Santa Cruz, the Slaughter Ranch in the San Bernardino Valley, and the Hooker Ranch in the lower or northern San Pedro valley, closer to the Gila (Stewart, n.d.: 9-12). Other ranching operations began in the upper San Pedro in the vicinity of the NCA, for example on the Babocomari Creek, a tributary of the San Pedro just north of the present town of Sierra Vista and the large military post of Fort Huachuca. The Babocomari and other ranches developed on land grants made to settlers and ranchers from Mexico by the Mexican governments prior to the 1840s (Walker and Bufkin, 1979). These ranches were generally ill-defined outfits whose cattle ranged over many square miles.

The incursions of travelers, miners and ranchers, led to increasing conflicts with the Apache. One major result was an increasing number of US troops and military posts. These troops numbered in the tens of thousands and had to be fed and housed. This provided big opportunities for cattle and stockmen as well as irrigators and agriculturalists. The extent and intensity of ranching, grazing and other activities placed rising pressures on the desert environment. In his remarkable book, *A Legacy of Change*, which deals with the historic human impact on vegetation in the Arizona borderlands, Conrad Bahre (1991) describes the effects of grazing, mining and other activities in detail, with support from historic photographs.

Exploration and development activity took on new vigor in the 20th century. One major reason was the growth of recreation and tourism. Another was the entrance of rising numbers of retirees from other parts of the US. In addition, the Southwest and the San Pedro watershed, became increasingly important for military installations and activities. Recreation and tourism have been growing since the late 19th century through hunting and related outdoor activities. Guided hunts for lions,

jaguars and other large animals rose after WWI. Aldo Leopold and his family described hunts for deer, turkey and other animals along the Gila and the Sierra Madre of northern Mexico in the 1920s and 1930s (Leopold, 1953).

Recreation and tourism boomed after WWII with the arrival of the entertainment industry. This involved the establishment of gambling casinos, large hotels and convention centres, as well as filmmaking and family automobile tourism to the deserts and the great mountains of the Southwest. These developments in turn, led to rapid increases in urbanization and rising demand for water and other resources over much of southern Arizona, including the upper San Pedro Valley.

A large and growing military base, Fort Huachuca, was originally established in about 1885 in efforts to quell the Apache who resisted both Spanish and American control for more than 200 years. Today Fort Huachuca specializes in electronic systems and houses thousands of troops with more planned for the future. Fort Huachuca borders on the rapidly growing city of Sierra Vista on the western side of the San Pedro valley. Sierra Vista was almost non-existent in 1958 and exceeds 40,000 today. Other nearby growing areas include the town of Benson which is close to the north border of the San Pedro NCA. Its damaging impacts on the floodplain, the riparian habitat and other parts of the valley stand in strong contrast to the protected areas in the NCA to the south.

Over the years large numbers of cattle and other stock have competed directly for range with antelope, deer and other animals. Ranching resulted in extremely hard times for the grizzly bear, the puma, jaguar, bob-cat and other predators for they have been seen as threats to domestic stock. Extensive campaigns to eliminate them were undertaken beginning in the 19th century. These led to government hunting, poisoning and other efforts in the 1920's and 1930's. Animals such as the wolf, grizzly and the jaguar have been completely or nearly eliminated from the area. As recently as 1996 a jaguar was photographed by hunting guides in one major mountain range east of the San Pedro watershed, the Peloncillo Mountains on the New Mexico-Arizona border just north of the Mexican line (Brown and Gonzales, 2001: 1). Whether such occasional jaguars are permanent residents or visitors to southeast Arizona from northern Mexico, is a question.

Other exploitive activities such as lumbering and clearing of vegetation were wide-ranging by the mid to late 19th century because of the need for wood for mining, railroad and other construction, as well as for use in making charcoal and other fuel for mining, industrial and domestic purposes. Extensive areas were cut-over, although in this case considerable reforestation has taken place as a result of measures such as the creation of National Forests and other protected areas to conserve trees, control run-off and protect water supply. The establishment of the San Pedro NCA itself is a recent expression of attempts to protect the environment, reduce destructive exploitation and develop more sustainably. Much has been done through the NCA to protect and restore plant and animal habitat within its

borders.

What is known today as “active conservation management” is practiced in the NCA. This includes for example, allowing wild fires to burn to some extent without attempts to extinguish them. Certain indigenous animals are also being re-introduced, including the beaver. The fur trapper James Battie reported that, as a result of trapping by himself and others, this animal has been removed from the lower part of the San Pedro near its entrance to the Gila, by the late 1830’s (Bronitsky and Merritt, 1986: 273). He probably was referring to the commercial extinction of the animal in the sense that it no longer paid to hunt it in terms of the costs and benefits of Battie’s time. As a result of long continued trapping, drainage of wetlands, dynamiting of dams and habitat, the beaver had virtually disappeared from the lower San Pedro NCA by the early 1900s (Hanson, 2001: 123). It has been re-introduced in recent years.

Such restoration measures are controversial, even within the conservation community. For example, to allow wild fire and take the risk of the escape of a burn, could lead to damage or destruction of riparian forests and shrub communities which have increased along the river since the creation of the NCA in 1988. The re-introduction of the beaver also poses a threat to this riparian community and especially to cottonwood and sycamore because beaver tend to fell such trees in large numbers for use in building dams, houses and food.

To restore fire or beaver under such circumstances is risky. Such situations seem to call for an adaptive management approach of the type advocated by Holling and his associates (Gunderson, Holling and Light, 1995). In such an approach selected policies and practices are pursued on an experimental basis and carefully monitored and assessed for their effects before any final decisions are made. To follow such an approach in the San Pedro NCA may however, be difficult because of staff and budget shortages. Collaborative efforts involving the universities, colleges, schools and volunteers from the Friends of the NCA or other volunteer organizations would seem promising here and some of this has begun to occur.

Growing use of ground water as well as drainage and other activities, have reportedly led to reductions in the water table as well as changes in surface runoff (Anonymous, 2000). These changes have contributed to the loss of cienegas. Few of these formerly extensive wetlands now remain, one being a Research Area established by the BLM in the NCA near St David. Interest in conserving and restoring the cienegas as “natural sponges,” in order to reduce the rates of run-off and other hazards such as floods, encounters challenges. A major challenge is the downcutting that has occurred in many stream valleys of the San Pedro and other parts of the Southwest, apparently mainly since the late 19th century. Prior to that time, relatively few arroyos seem to have been found in the study area. Vegetation patterns also seem to have been quite different than now, with much less mesquite or scrub desert, fewer trees along the streams including the main stem of the San Pedro, and

more grassland and open country. Considerable evidence is available to suggest that such changes have largely occurred in the region since the 1880's (Bahre, 1991).

Various causes have been put forward for these changes, including overgrazing of the ranges, removal of tree cover for fuel and other purposes, climate changes, drainage, reduction in wild fires, and elimination of beaver. Another possible cause that does not appear to have received much attention is earthquakes and tectonic activity. A major quake is known to have occurred in 1887, exceeding 7.5 on the Richter scale, and apparently causing uplift and earth movement over a large area. Overall, however, it seems unlikely that any one of these changes is alone responsible for downcutting and other changes in stream patterns in the study area. More likely, the changes interact with one another in some poorly understood way.

Two fundamental points should be made before concluding this paper. The first involves the basic assumptions and strategy upon which ecosystem or landscape management of the San Pedro Riparian NCA is to be based, particularly with regard to vegetation. The current riparian forest and shrub vegetation has developed to a considerable degree since the creation of the NCA in 1988, and is different than an earlier 19th century landscape dominated by grasslands, and related plant communities along the main stream (Hanson, 2001; Bahre, 1991). As noted previously, to introduce active conservation management based on the idea of a return to that earlier landscape would mean modifying the protectionist policy that has led to the growth of the present gallery forest as well as the rich habitat for resident and migratory birds and other fauna so valued by local people and visitors today. At least one prominent conservationist in the area has raised this problem and has argued for conservation of the present landscape while cautioning about the effects of burning and beaver restoration (Hanson, 2001).

The second fundamental point is that a major if not the major threat to the health of the San Pedro Riparian NCA and surrounding areas today is urban and military development in the Sierra Vista – Fort Huachuca area along the west side of the river, as well as growing settlements in other parts of the valley. These developments will continue to consume large amounts of groundwater since precipitation and runoff in the area are insufficient to meet the demand. Continued development poses a risk to the flow of ground water to the San Pedro River and so to the maintenance of the riparian ecosystem. With leadership from the BLM, the Upper San Pedro Partnership, a committee of regional interests, has been working for a conservation and sustainable approach to this ultimate water challenge. Commitment to growth continues to be very strong however, for example, the Garrison commander at Fort Huachuca outlined plans for large scale growth at the military over a seven year period beginning in 2002 (Spinks, 2002: 1). On the other hand, the military has become sensitive to criticism of its growth and large scale impacts on water. The military is now introducing water use conservation methods on and assisting with conservation outside the base. Numerous new housing projects also

are planned for Sierra Vista and surrounding lands along the eastern flank of the Huachuca Mountains and conflict over these is ongoing.

Summary and Implications for Planning

The San Pedro Riparian National Conservation Area is highly significant for national and cultural heritage and related conservation, education, research, recreation, tourism and other purposes. Some of the major reasons for this significance are:

1. The highly complex geologic history and diversity of sedimentary, metamorphic and volcanic rocks and associated land forms, notably the highly faulted and pronounced basin and range topography.
2. A series of recent sediments, terraces, playas and other landforms which provide an unusual record of geologic, climatic, vegetation, animal and other changes resulting from the advance and retreat of northern and alpine glaciers during the last several million years.
3. A complex desert flora and fauna exhibiting high diversity on at least a national scale, as well as breeding, migratory and wintering habitat vital to the survival of some 400 species of birds, numerous species of reptiles and other life. In terms of species richness of mammals, the San Pedro Riparian National Conservation Area is considered to be unsurpassed for any landscape of similar size in the U.S.
4. The San Pedro Valley is possibly the most significant archaeological area in North America, with at least four Paleo-Indian sites dating from approximately 11,000 BP in or close to the NCA. The archaeological and historic record reveals traces of many indigenous cultures and peoples up to the Spanish, Mexicans and Americans of more recent centuries. The NCA and nearby areas are very rich in cultural diversity.
5. The San Pedro Riparian National Conservation Area and surrounding country contain an unusually comprehensive historical record of the Post-Pleistocene evolution of a changing natural landscape and the complex array of effects that humans appear to have had on that landscape. Early changes include the extinction of the mammoth and other Pleistocene fauna, as well as vegetation changes through climate change, human use of fire, collecting and gathering, incipient agriculture, and the introduction of exotic plants such as maize. Later changes and effects include: accelerated erosion and gullying; changes in sedimentation and landforms through flood farming, irrigation and water

diversion; introduction of numerous European plants and animals; heavy livestock grazing and associated vegetation change; lumbering and deforestation; drainage of wetlands; gravel and other mining and habitat disturbance. Recent increases in recreation, tourism, retirement and military facilities, and urbanization, have led to habitat fragmentation and rising pressures on surface and groundwater.

6. Some attempts have been made to counteract these changes and effects, a recent example being the San Pedro Riparian National Conservation Area. The NCA was established in 1988 to protect rare riparian habitat by controlling livestock grazing, gravel mining, housing developments, and other exploitive uses of the San Pedro floodplain and adjoining terraces while principally providing for hiking, birding and other forms of low-tech recreation and tourism. A principal goal was nature conservation and some success has been achieved through protection of riparian forests and other vegetation as well as bird and other habitat. The planning implications of these changes and associated conservation efforts are very significant and include:
 - a) Undertaking more detailed monitoring, assessment and reporting of the effects of the NCA and disseminating the results on a widespread regional, national and international basis. The success of the NCA to date makes it a useful example for conservation programs in other riparian areas and in both dry and humid regions.
 - b) Reviewing and strengthening the NCA and extending the concept to other rare and threatened riparian systems in Arizona and other parts of the southwestern deserts in the U.S. and Mexico.
 - c) Dealing with current issues associated with active conservation planning and management, such as fire and beaver re-introduction, through an adaptive management approach and close interaction and consultation with citizens who can supplement the knowledge, values, and resources of the BLM.
 - d) Building natural corridors and linkages with significant surrounding habitats such as the Huachuca Mountains and continuing efforts to extend principles and programs associated with the NCA across the border into Mexico.
 - e) Working to have the NCA designated as a World Heritage Site because of its uniqueness and diverse geological, biological and cultural heritage.

Some moves have already been made in these directions. In 1989, a San Pedro Riparian Management Plan was introduced by BLM. The Plan involved some consultation with the public about the selection of one of four major alternatives. These alternatives were very general, ranging from relatively strict conservation management to heavy emphasis on recreation and tourism. The selected alternatives involved balancing resource protection and public use of the San Pedro NCA area. The Environmental Impact Statement (EIS) prepared for the proposed planning alternatives contains numerous comments and criticisms of the plan and the preferred alternatives, mainly from citizens.

The preferred alternative included a number of actions aimed at areas of major concern such as recreation, water, wildlife, soils, and the watershed. These actions were preparatory in nature or put in the form of guidelines or statements of principle. For example, the wildlife actions included inventory of terrestrial and aquatic plants and monitoring to determine the condition and status of wildlife and their habitat (BLM, 1989: 2). The planned actions also included: allowing commercial uses only if compatible with conservation management of the San Pedro; developing interpretative displays and facilities; restricting campfires to designated locations; and developing a limited number of campgrounds. It has not been possible to assess the implementation and effects of such actions for this study. To do so would be difficult in any event because of their general nature, which leaves considerable discretion with the management agency, BLM.

Of considerable interest in planning for the conservation and use of the San Pedro NCA from its outset in the late 1980s, has been a growing emphasis on water. In the 1989 Management Plan, actions included closing and stopping unnecessary irrigation and non-irrigation wells and using one well on a short term basis in one field for an experimental revegetation trial. These actions and others were intended to address the objectives of conserving the groundwater resource while providing necessary support for other programs (BLM, 1989: 2)

Since the creation of the NCA and the beginning of planning, water conservation and use have become major, if not the major issues in the NCA and surrounding areas. In this context, it is clear that the growth of military activities, urbanization and settlement pose significant threats to availability of water for use not only by humans, but all life in the region. It has also become obvious that the future of water as a resource and as an essential element in maintaining ecosystems, is outside of the control of BLM, any other management agency, or landowners. Much of the water needed to maintain the San Pedro River and the NCA originates via surficial or ground water flows from surrounding areas. And agencies and owners of these surrounding areas are also affected by the use of water by their neighbours.

Such interrelationships led to the formation of the Upper San Pedro Partnership in the late 1990s. The Partnership was formed to facilitate and implement sound water

resource management and conservation strategies in the Sierra Vista Sub-Watershed of the San Pedro River. The Partnership is a consortium of agencies that own land or control land or water use in this Sub-Watershed. It also includes agencies that can provide significant resources to help the Partnership attain its purposes. Fourteen agencies are part of the Partnership and include Cochise County, Sierra Vista and other local organizations, the Arizona Department of Water Resources and other state agencies, the federal Bureau of Land Management, Fort Huachuca, and The Nature Conservancy, an NGO. The Partnership reflects the interests of a range of organizations operating at local to national scales. The Partnership is said to involve a combined top-down-bottom-up approach, with a focus on community and citizen involvement.

The Partnership has only existed for a few years and it is early to evaluate its progress. The first priority of the Partnership is the development of what at times is called a Water Resources Plan and at other times an Upper San Pedro Conservation Plan. The Conservation Plan involves three broad strategies: reducing human and natural water consumption to the minimum necessary to meet the needs of people and nature; reclaiming used water or effluent; and improved rainfall harvesting techniques (Anonymous, 2000). An approach of growing importance to the Partnership is the use of easements to purchase water rights from heavy users, notably agriculturists. A prominent participant in the easement program is the military operation at Fort Huachuca, which has contributed in the neighbourhood of one million dollars to purchase such easements. Further research is needed to determine how well this and other initiatives of the Partnership are working.

Another potentially very significant aspect of the Partnership's approach is linking water conservation and use with wildlife conservation, principally through the work of an Open Space Sub-Committee. An Open Space program is seen as contributing both by conserving water resources and by providing essential natural links or corridors between the nearby mountains and the San Pedro River. Such linkages are seen as facilitating wildlife migration, conserving habitat and preserving the social values in the area (Anonymous, n.d.: 11). In adopting this approach, the Partnership is explicitly linking the traditional field of water resources management with the traditional field of wildlife management in the context of a broad ecosystem approach. The Partnership is also attempting to link traditional engineering approaches to water with the land use and planning approaches of the environmental planners. The "technical fix" is being extended to include spatial and regional planning. It will be especially interesting to follow the implications of this combined approach. It seems to be a major current example of a broad civic watershed approach to resource and environmental management that is needed in many other parts of North America.

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