RIPARIAN HISTORY OF THE SOUTHWEST

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Riparian ecosystems provide ecologically important habitats throughout the Southwest because they possess a unique combination of hydrologic, biologic, and geomorphologic features. Compared to other land forms, riparian areas are characterized by a combination of high levels of species diversity, species densities, and biological productivity (Hoover et al. 1985). These highly sensitive areas support plant communities that are interrelated with the surrounding watershed and provide valuable wildlife habitat, particularly for threatened and endangered plant and animal species.

Riparian areas supported early civilizations in the Southwest for thousands of years by providing drinking water, water for irrigation, wood for house frameworks, game, fish, edible plants, and other amenities. Early European settlers first entering the Southwest in the 1500s did not fully recognize the sensitivity of riparian areas to concentrated use, and as a result, quickly overutilized the water, grass, and wood products available in these attractive riverside environments. The exploitation of riparian areas continued after European settlement, and as late as the 1950s and early 1960s, studies were being conducted to determine the effect of removing riparian vegetation on the amount and duration of streamflow. However, starting in the 1970s, the importance of riparian areas as a critical part of the landscape began to gain attention. Wildlife biologists became aware of the importance of the riparian areas as essential habitat for many animals, including fishes, birds, mammals, and amphibians. Also, in the late 1980s, managers began applying the concept of ecosystem management. As a result, land managers started integrating physical, chemical, and biological processes along with socioeconomic concerns into management strategies for riparian areas. This paper discusses the past uses and evolving philosophies of riparian area management in the Southwest.

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HISTORICAL TIME PERIODS

The history of the Southwest has been classified by scientists studying human ecology and ethnology in the New Mexico Rio Grande Basin into four historical periods: Spanish Colonial (1540–1821), Mexican (1821–1846), Territorial (1846–1912), and Statehood (1912–present; Scurlock 1995). However, for the purpose of discussing riparian history, the following time periods are used instead: the pre-European period (prior to 1500), the period of accelerated use (1528–1950), the period of phreatophyte management (1950–1970), the period of recognition (1970–1985), and the period of scientific understanding (1985–present). This latter historical sequence better represents the periods in which substantial changes in riparian areas have occurred since prehistoric time.

The Pre-European Period

About 11,000 years ago (at the beginning of the Wisconsin Ice Age), the Southwest was occupied by large grazing animals (bison) and small bands of humans (Wildeman and Brock 2000). Following the recession of the ice sheet that covered most of North America, the climate became warmer and drier. The Clovis people were regularly pursuing giant bisons throughout southeastern New Mexico by 10,000 BC (Harbert 1996). As a result, humans, plants, and animals were impacted by numerous shifts in species types and distribution. Human populations were not uniformly distributed over the land surface during these several millennia; instead, these earlier civilizations congregated seasonally in riparian environments (Dobyns 1989). The streams in these areas provided drinking water, wood for buildings and fire, wildlife for food, and edible plants, while the riparian galleries provided shelter during the winter for hunter groups and shade during the summer for gatherer groups.

The Southwest was inhabited by several Native American civilizations between 600 BC and 550 AD. The Anasazi, Mogollon, Sinagua, and Hohokam peoples occupied Arizona during this time period (Tellman et al. 1997). The Mogollon and Mimbres Indians were found in New Mexico (Harbert 1996) and southern California was occupied by a diverse group of small independent tribes (Rice et al. 1988). The Anasazi consisted of mobile groups that moved frequently and camped near water courses, where they planted crops. The Mogollon people were also nomadic and lived mainly in the highlands of the Arizona–New Mexico border. The Sinagua people settled in the area between the Verde Valley and the San Francisco Peaks region north of Flagstaff, where they grew corn on flood plains during the eighth century. Between 700 and 1150 AD the Hohokam people started the first irrigation projects in the Southwest and developed major settlements along the Salt and Gila Rivers, living in small communities extending from what is currently known as Flagstaff to the Santa Cruz River. The Hohokam disappeared about 1450, and the modern-day Tohono O'odham and Pimas consider themselves to be their descendants.

Period of Accelerated Use

The arrival of the early Spanish expeditions in the Southwest starting in 1540 marked the beginning of concentrated human occupancy and intensive use of the rivers throughout this region. These early Spanish explorers established the first European settlements in the Southwest, introducing sheep, goats, horses, mules, burros, oxen, cattle, hogs, and chickens. During these years overgrazing occurred around old settlements and in nearby valleys, and the most heavily impacted areas were those around cienegas and other wetlands.

During the 410+ years following the first Spanish expeditions, rivers and riparian areas were increasingly impacted by humans engaging in farming, hunting, ranching, mining, logging, stream impoundment, and recreation. These activities coupled with periodic droughts and wildfires resulted in high rates of runoff and active erosion. More subtle impacts occurred as the result of introducing exotic species of plants and animals, diverting water for irrigation, constructing dams, and introducing metal tools such as the axe, which made cutting green wood faster and easier. The effects of human disturbances were accentuated by droughts which occurred throughout the region every 20–25 years on average.

The first Anglo-Americans to enter the Southwest were mainly trappers, military personnel, ranchers, and settlers. Trappers began intensively harvesting beaver pelts in the rivers and streams throughout northern, central, and southwestern New Mexico in the early 1820s (Wildeman and Brock 2000). Beaver populations were quickly decimated throughout the region and even extirpated in most streams. Consequently a moratorium was placed on trapping by the Mexican government in 1838. Currently, beavers occupy only a small percentage of the perennial streams in the Southwest.

The arrival of large numbers of Anglo-American military personnel, ranchers, and settlers, beginning in 1856, was the start of concentrated human occupancy and the intensive use of the riparian areas and associated environment. Early settlers established individual homesteads that developed into small communities, and in some cases grew into today's large metropolitan cities (e.g. Los Angeles, Phoenix, Tucson, Albuquerque, and El Paso).

Widespread grazing by livestock was an important disturbance to both the riparian areas and the surrounding watershed. The cattle industry began to flourish as a result of cattle drives from Texas that started in 1867 (Wildeman and Brock 2000). By 1891, there were an estimated 1.5 million cattle in Arizona alone, in addition to the 700,000 head of sheep. The cattle industry also prospered in New Mexico, and in 1883 it was estimated that there were 4 million sheep and 250,000 cattle in that state. A severe drought in 1891 reduced the number of cattle by 50–75 percent, but overgrazing nevertheless resulted in sparser plant cover. The lack of natural fires and recurring drought allowed many of the native ecosystems to be invaded by early successional plants that were not replaced by native species even following favorable rainfall. Also, severe erosion resulted in an irreversible loss of productivity in many of the smaller valleys throughout the Southwest (Leopold 1946). The effects of this early grazing by domestic livestock are still apparent today and the history of land use needs to be considered by present-day managers when implementing ecosystem recovery programs.

Military forts, mining camps, and railroad construction also made heavy demands on trees for both building and fuel supplies (Wildeman and Brock 2000). The mining boom began in 1863, producing major stream pollution that killed fauna and flora and poisoned water supplies. Many of these mining sites were then abandoned, leaving open pits and shafts and toxic spoil deposits spread throughout the landscape. Railroads, because of their need for gentle terrain, often followed rivers and streams, further damaging the riparian communities and polluting the streams. Train engines also started frequent range or forest fires. Air quality was negatively impacted by both railroads and mine smelters.

Upon early human settlement, surface water was immediately used for irrigation, and consequently was soon fully allocated. During the beginning of the twentieth century, dam and reservoir construction and transbasin water transfers were actively implemented to distribute the available surface water (e.g. water was transferred from the Owens Valley to Los Angeles in early 1900s). Dam construction began with the completion of Roosevelt Dam on the Salt River in Arizona in 1911. The construction of Hoover Dam on the lower Colorado River was started in 1930 (Sheridan 1995); since then numerous other large dams have been constructed throughout the Southwest. After the surface water was all appropriated, groundwater pumping increased, and has continued to do so, a matter of major concern today. Intensified irrigation farming impacted stream hydrology and increased salinization and water logging of soils in the late nineteenth and twentieth centuries.

Another important impact on native riparian systems resulted from the introduction of alien plant and animal species, which competed with and completely dominated sites formerly occupied by more desirable native fauna and flora (Wildeman and Brock 2000).

Period of Phreatophyte Management (1950–1970)

Water-loving plants (phreatophytes) are found throughout the Southwest along perennial streams and ephemeral or intermittent streams where a high water table is maintained throughout the year. There were abundant galleries of native riparian species along most streams when the Spaniards first explored the Southwest. Most native phreatophytes are deep-rooted, woody perennials, with root systems that can extend to shallow water tables. Native species are Fremont cottonwood (*Populus fremontii*), mesquite (*Prosopis juliflora*), ash (*Fraxinus pennsylvanica*), sycamore (*Platanus wrightii*), walnut (*Juglus major*), willow (*Salix* spp.), seepwillow (*Baccharis glutinosa*), and salt grasses (*Sporobolus* and *Distichlis* spp.).

One introduced phreatophyte is Old World tamarisk or saltcedar (*Tamarix chinensis*), which has spread vigorously in the reservoir deltas and along major rivers in the southwestern United States (Horton and Campbell 1974). Saltcedar was introduced in the eastern United States as an ornamental as early as 1823. By 1856, it was being sold in nurseries in California. In 1901, it was a naturalized shrub along the Salt River in Tempe and by 1940 it had covered many of the river floodplains along the Gila, Salt, Pecos, and Colorado Rivers. Saltcedar has physiological characteristics (e.g. higher leaf gas exchange rates, faster growth when moisture is abundant, and higher drought tolerance) that make it a successful invader of riparian ecosystems containing Gooding willow (*Salix goodingii*) and Fremont cottonwood (Horton et al. 2001). Consequently, saltcedar has replaced many of the native riparian species. Russian olive (*Elaeagnus angustifolia*), a native of Europe and western Asia first introduced to the United States around 1900, is also found widely distributed in riparian areas throughout the Southwest (Obedzinski et al. 2001).

A comprehensive watershed program was initiated in Arizona in the late 1950s (Fox et al. 2000). Its overall objective was to explore vegetation management techniques that could be used to increase streamflow; this was in response to the increasing awareness of the need for additional water to support the economic growth of Arizona. Part of this program involved installing numerous experimental watersheds to evaluate the effects of vegetation manipulation on streamflow in mixed conifer and ponderosa pine forests, pinyon-juniper woodlands, and chaparral shrublands (Baker 1999).

An interest in the large amounts of water that were lost by evapotranspiration from streamside vegetation stimulated efforts to determine the amount of water use by riparian vegetation. It was recognized that streamside vegetation such as trees, shrubs, and grasses could effectively tap the water table and transpire large amounts of water that would otherwise be available for streamflow. Studies done in Arizona estimated that these species can lose up to 2500 m^3 of water per hectare per year by evapotranspiration, depending upon the individual species and depth to the water table (Horton and Campbell 1974). The complete removal of woodland-riparian vegetation from a watershed in southern California confirmed this increase in water yield during the first year following treatment (Rowe 1963). The initial increase, however, was found to decrease to less that one-half that amount during the second year.

The response of hillslope vegetation (e.g. mixed conifer, ponderosa pine, pinyon-juniper, and chaparral) to different amounts and patterns of removal showed that mixed conifer forests and chaparral produced the greatest streamflow responses (Hibbert 1979). It is interesting that the conversion of dense stands of chaparral to grass in areas receiving 25 or more inches of annual precipitation increased the amount and duration of streamflow to near perennial streamflow. This change in streamflow regime on treated chaparral areas enhanced the reestablishment of riparian vegetation along the banks of previously dry chaparral streams on an experimental watershed near Lake Roosevelt, Arizona (DeBano et al. 1984).

Period of Recognition (1970–1985)

Starting in the late 1960s and early 1970s, environmental awareness led to the enactment of laws designed to protect the environment. As a result, both state and national legislation was passed to enhance the well-being of specific species and the environment in general. Examples of the legislation included the National Environmental Policy Act of 1969, the Endangered Species Act of 1973, the Forest and Rangeland Renewable Resources Planning Act of 1974, the National Forest Management Act of 1976, and the Clean Water Act of 1972, which was amended in 1987 to include non-point pollution (Jacobs 1991).

Biologists began focusing on the management of riparian areas as habitats for many species of fish, birds, mammals, and plants, particularly those that are threatened and endangered; the Endangered Species Act of 1973 reflected this increasing concern. Interest also appeared on the regional level and one of the first conferences on the importance, preservation, and management of riparian habitats was held in Tucson, Arizona in July of 1977 (Johnson and Jones 1977). Within a decade, the first North American Riparian Conference was also held in Tucson in April of 1985 (Johnson et al. 1985). Organizations such as the Arizona Riparian Council, formed in 1986, were also created to focus attention on the alarming rate of loss of the state's riparian ecosystems and to provide for the exchange of information on the status, protection, and management of Arizona's riparian resource.

At the end of this era, traditional watershed management and riparian ecology had begun merging. Overall, it was being recognized that healthy riparian areas reduce floods, improve water quality, store water, and provide cool, shady areas for birds, animals, and fish.

Period of Scientific Understanding (1986–Present)

When the importance of riparian habitat had been established, the general awareness and interest in the complex physical, chemical, and biological processes began gaining momentum, starting in about 1985. As a result, many of the management teams dealing with riparian areas consisted of multi-disciplinary teams with expertise in fisheries and wildlife biology, surface and groundwater hydrology, limnology, entomology, aquatic biology, geomorphology, and geology, rather than consisting of only a single discipline as had been the case earlier. This approach combined the emerging principles of watershed, range, and forest management to address specific riparian issues and concerns.

In the early 1990s interest in the concept of ecosystem management broadened. The ecosystem approach fostered the philosophy of considering ecosystems not only from the physical, chemical, and biological dimensions but also from the socioeconomic and political perspective. The general interest in ecosystems introduced a concept in river and riparian ecosystem management called "river health." This term incorporates both ecological values and human values into a general philosophical framework for managing rivers and their associated resources (Boulton 2000). Ecological values consist of ecological integrity (capacity to support and maintain natural and balanced, integrative adaptive biological systems) and resilience to stress (ability to recover following disturbance). Human values consist of goods (water supplies for irrigation and industry, clean water for domestic use, and an environment for recreation and spiritual renewal) and services (cleansing and detoxifying water, producing fish, providing aesthetic pleasure, maintaining water supply, and storing and regenerating essential elements).

The interrelationship between the riparian corridors and the surrounding watershed began to be recognized by natural resource managers and scientists attending the riparian conferences held in the 1970s and 1980s (Johnson and Jones 1977; Johnson et al. 1985). During this time, watershed managers were becoming increasingly aware that the health of riparian areas was closely interrelated to the condition of the surrounding watershed (DeBano and Schmidt 1989). Furthermore, linkages among runoff, erosion, streamflow, and groundwater were being identified and quantified. This concept fit well within the framework of landscape dynamics that was gaining importance at this time. More important, however, was that it initiated a concerted effort of scientific inquiry into the host of complex but less obvious linkages existing on the watershed, in the riparian vegetation zone, and in the aquatic environment of the stream. There are many physical, biological, and chemical linkages (Baker et al. 1998) involving numerous processes that are responsible for the continual flux of water, air masses, dissolved particulate matter, organisms, and energy both within and among these three components. Specific processes involved in these linkages include runoff, erosion, sedimentation, groundwater recharge and movement, nutrient cycling, food webs, streamflow, and nutrient enrichment of water, water and nutrient exchanges in the hyporheic zone.

In-depth studies on the functioning of riparian zones began to highlight major differences in some hydrologic processes between arid and humid riparian ecosystems. For example, streamflow routing was now seen as being different in the case of intermittent and ephemeral channels than for perennial streams. The routing model for streamflow in the more mesic environments (e.g. the eastern United States) depicted precipitation as infiltrating into the soil and then being delivered downslope as groundwater into and through the riparian zone before contributing to streamflow. This routing of water flow permitted the riparian vegetation to act as a buffer zone that removed contaminants (source and non-source pollutants) that were released from the watershed during precipitation events. However, in arid environments, surface runoff processes are important because the sparser vegetation cover on the watershed does not protect the soil surface from high-intensity convectional rainstorms. As a result, surface runoff quickly reaches dry ephemeral and intermittent stream channels where it becomes streamflow without moving through the groundwater route common in perennial streams (Martí et al. 2000). The water in the streamside riparian zones bordering intermittent and ephemeral streams is frequently replenished by streambank recharge rather than via the groundwater route that is more characteristic of mesic environments. Direct streambank recharge circumvents the buffering capacity of the on-site riparian vegetation and may deliver upstream contaminants large distances downstream before being immobilized by riparian vegetation.

Since 1985, the interest in riparian areas by managers, scientists, interested citizens, and governmental agencies (local, state, and federal) has increased dramatically. The explosion in literature concerned with riparian area management includes manager guidelines, information pamphlets, news releases, symposium and conference proceedings, books, and papers in a wide range of professional journals.

THE FUTURE OF RIPARIAN AREAS IN THE SOUTHWEST

Urban growth will continue in the Southwest into the future. This increase will intensify the land planning activities that are necessary to accommodate the influx of people associated with this anticipated population growth. The demand and competition for water will likewise intensify (Guilin 1989). Competition for water between riparian areas (in-stream use) and off-site consumptive use of water (e.g. irrigation, industry, urban) will also intensify. As a consequence, in-stream flow rights will continue to be an emerging issue in the future as the competition for water grows (Kulakowski and Tellman 1990). In-stream flow has important biologic, geomorphologic, and legal implications when managing streamflow for fisheries, wildlife, vegetation, and particularly threatened and endangered plant and animal species. In-stream flow requirements not only affect streamflow regimes, but also are related to the various important linkages among the stream, floodplain, riparian, and upland zones, and watershed geomorphology.

All of these factors combine to intensify the need not only to preserve existing riparian ecosystems, but also to develop an aggressive program to enhance and rehabilitate areas that have been badly depleted in the past. The past loss of this unique resource emphasizes the need for a closely coordinated effort among land planners, land managers, scientists, developers, local, state, and federal governments, and an informed public so that present and future generations can share in the many diverse benefits provided by these unique riparian ecosystems found throughout the Southwest.

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