Relating Human Activities and Biological Resources in Riparian Habitats of Western Texas[1]

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Abstract.--This paper discusses the recreational and wildlife values of riparian habitats along the Rio Grande in western Texas (from El Paso to Del Rio). Several human activities have the potential or have in fact impacted on riparian resources in this region. These include: (1) irrigation diversions and stream channelization which greatly alter rates and amounts of water flow; (2) land flooding resulting from reservoir construction; (3) land clearing for purposes of cultivation to increase agriculture production; (4) overgrazing by domestic livestock; (5) introductions of exotic plants and fishes; (6) increases in human recreation activity (floating, camping, hunting, and trapping); and (7) pesticide buildups which have accumulated as a result of drainage and erosion from nearby fields. Contract research with the National Park Service at Big Bend National Park and Amistad Recreation Area focused on outdoor recreation and grazing impacts and findings are reported elsewhere. This paper seeks to place these impacts into broader land use perspective so that riparian resources can be more effectively managed in western Texas.

INTRODUCTION

The most extensive riparian habitats in western Texas exist wherever periodic flooding occurs along the Rio Grande. In the past few years biologists and resource managers have realized that substantial numbers of both game and non-game wildlife species are dependent upon riparian vegetation and that these habitats have remarkably high wildlife potential. At the same time, it has also been demonstrated that riparian communities support a level of outdoor recreation activity that is greatly disproportionate to their limited linear acreage.

Exploitation by man has greatly altered the riparian habitats of the southwest, and, in the last 100 years, the rate of alteration has increased significantly (Davis, 1977). This is due largely to ever-increasing human pressures which include the following: (1) irrigation diversions and stream channelization which greatly alter rates and amounts of water flow; (2) land flooding resulting from reservoir construction; (3) land clearing for purposes of cultivation to increase agriculture production; (4) overgrazing by domestic livestock; (5) introductions of exotic plants and fishes; (6) increases in human recreational activity (floating, camping, hunting, trapping, etc.); and (7) pesticide buildups which have accumulated as a result of drainage and erosion from nearby fields. The Rio Grande of western Texas has been influenced in one way or another by each of these activities. For the most part, basic information about riparian habitats along the Rio Grande has been lacking and this has hindered the development of realistic management plans to effectively conserve this important resource.

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[1]Paper presented at the National Symposium on Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems, Callaway Gardens, Georgia, Dec. 11-13, 1978.

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RESEARCH PROGRAM

In response to the need for additional information concerning riparian habitats in western Texas, the National Park Service (NPS) contracted us to conduct human impact studies in Big Bend National Park (BBNP) and Amistad Recreation Area (ARA) in 1976 and 1977, respectively. Both of these areas are situated in the Rio Grande river system and in recent years both have experienced dramatic increases in recreational and water resource use. Both projects were interdisciplinary in that they involved biological and social scientists and both considered these four elements: the resource, the user, human use impacts, and management alternatives.

The methodology and results of our research projects at BBNP and ARA are presented elsewhere (Boeer, 1977; Boeer and Schmidly, 1977; Ditton and Schmidly, 1977; Ditton et al., 1977; Schmidly and Ditton, 1976, 1979; and Schmidly et al., 1976) and need not be repeated in detail here. Instead, we will summarize the major findings of our research and relate these to other factors impacting riparian ecosystems along the Rio Grande in western Texas (from El Paso to Del Rio) as documented by others.

DESCRIPTION OF THE RIO GRANDE CORRIDOR

Physiography

By the time the Rio Grande reaches Texas, it is nothing but a small stream and most of its waters are diverted to irrigate fields south and east of El Paso. The stream is dry for much of the next 100 miles (mi) between El Paso and Ft. Hancock, but southeast of Ft. Hancock the river valley narrows and ground water surfaces to form a salty stream. The river remains small until just about Presidio where it is rejuvenated by the waters of the Rio Conchos, which is estimated to supply 18% of the Rio Grande's total flow. Granero Dam, constructed in 1964 on the Rio Conchos in Chihuahua (Mexico), greatly restricts water flow into the Rio Grande during certain times of the year.

The most pristine and unchanged portion of the Rio Grande is within a 200 mi strip that lies between the western edge of BBNP and Langtry, Texas. Topography along this stretch of the river includes (1) sheer wall canyons (Santa Elena and Mariscal canyons) with few areas of alluvial deposits; (2) long deep canyons (Boquillas and the "Lower Canyons") where the walls do not rise abruptly and where larger areas of alluvial deposits occur; and (3) areas of broad flat floodplain with extensive alluvial deposits.

The impounded waters of Amistad Reservoir reach their westernmost limits near Langtry. The character of the river between Langtry and Del Rio has been altered considerably since the construction of Amistad Dam. Prior to construction of the dam, the landscape of the region consisted primarily of steep river canyons and dry tributaries characterized by cliff overhangs, scoured canyon floors, and bedrock potholes. Bordering the steep river canyons and tributaries, the landscape was generally hilly to rolling. Since the filling of the lake commenced in 1978, over 100 mi of this limestone canyon country has been inundated. The filling of the reservoir completely inundated many of the shorter cliffs while only partially covering the higher ones so that today an uncalculated surface is under water.

Vegetation

Floodplain or riparian vegetation exists wherever periodic flooding occurs along the Rio Grande except where sheer cliffs rise directly out of the riverbed. These areas may extend from a few feet to one-half mile from the river channel; furthermore, adjacent arroyos and creeks may carry enough surface or ground water to produce a similar floodplain environment.

The bottomlands of the Rio Grande are choked with salt cedar (Tamarix gallica), mesquite (Prosopis sp.), willows (Salix sp.) and an occasional cottonwood (Populus sp.). Much of the water of the Rio Grande below El Paso comes from the Rio Conchos that enters above Ojinaga, Mexico, across from Presidio. As a result of this great river much of the Rio Grande from Presidio to Amistad Dam supports two large grasses (called river cane) on its banks, namely the exotic giant reed (Arundo donax) and the common reed (Phragmites communis). River cane, willow, and mesquite grow so dense in many places along the river that it is often difficult to get out on the banks of the river. Bermuda grass (Cynodon dactylon) is common in protected areas along the river (called vegas) except where dense river cane grows.

Other mesic plants that commonly grow in riparian habitats along the Rio Grande include seepwillow (Baccharis glutinosa), honey mesquite (Prosopis glandulosa), desertwillow (Chilopsis linearis), tree tobacco (Nicotiana glauca), and screwbean (Prosopis pubescens). Occasionally ponds are formed where the river changes its course or where high water has dredged a deep hole or scour. Common plants which occur in the silty soils around these

ponds include seepwillow, salt cedar, cottonwood, and common cattail (Typha latifolia).

Vertebrate Fauna

Riparian ecosystems are of paramount importance in producing and maintaining a large degree of the biotic diversity along the Rio Grande in western Texas. The Rio Grande traverses the Chihuahuan Desert and the mesic riparian situations along the river serve as suitable habitat for many vertebrates, which otherwise could not exist in this region of harsh desert climates. At least 61 species of vertebrates live along the Rio Grande in western Texas and are dependent upon riparian habitats for their existence. These include 35 fishes (see Hubbs et al., 1977 for a complete list), 11 amphibians and reptiles, 13 birds, and 3 mammals. A host of other vertebrate species also live in riparian habitats, but they are not restricted to or dependent on these places for their survival.

Among vertebrates, fishes are the group most dependent upon riparian ecosystems for their survival. Hubbs et al. (1977) documented the fishes of the middle part of the Rio Grande and divided them into three faunal assemblages: the Saline Rio Grande fauna (made up of widely distributed and salt tolerant species) upstream from the Conchos confluence; the Rio Conchos-Rio Grande fauna between the Conchos and Pecos rivers; and the Tributary creek fauna that depend on tributary creeks for all or part of their life history stages. At least two presumed endangered species (Notropis simus and Scaphirhynchus platyrynchus) have already been eliminated from the Tributary creek fauna.

Conant (1977) has studied the distributions of semiaquatic reptiles and amphibians in the Chihuahuan Desert and the following list of Rio Grande species is taken from his paper. Many of these species are common in more mesic habitats outside of the desert and exist only as relict populations in the riparian habitats of the Rio Grande. Two toads (Woodhouse's toad, Bufo woodhousei, and the Gulf Coast toad, B. valliceps) are common, although the former species has a wider distribution than the latter. Turtles which have been recorded along the Rio Grande include the slider turtle (Chrysemys concinna), painted turtle (Chrysemys picta), pond slider (Chrysemys scripta), spiny softshell turtle (Trionyx spiniferus), and the Big Bend mud turtle (Kinosternon hirtipes). Common snakes include the common garter snake (Thamnophis sirtalis), the western ribbon snake (Thamnophis proximus), the diamondback water snake (Natrix rhombifera), and the plain-bellied water snake (Natrix erythrogaster). All of these riparian herptiles would be profoundly affected by any marked dimunition or interruption of stream flow or elimination of the gallery forest as a result of subnormal rainfall or the activities of man (Conant, 1977).

Birds also exhibit a strong riparian dependence and this relationship has been well quantified. The Rio Grande corridor serves as a significant migratory and emigration route for avifauna, and 38 species are known to nest within the riparian habitat (Wauer, 1977). The Rio Grande also provides suitable habitat for 40% of the 94 birds known to breed within riparian systems within the American southwest. Several breeding birds known to occur within the Big Bend country appear to owe their presence there to the river corridor (Wauer, 1977). These include the orchard oriole (Icterus spurius), hooded oriole (I. cucullatus), great-tailed grackle (Quiscalus mexicanus), green kingfisher (Chloroceryle americana), great-crested flycatcher (Myiarchus crinitus), great blue heron (Ardea herodias), green heron (Butorides striatus), peregrine falcon (Falco peregrinus), white-winged dove (Zenaida asiatica), screech owl (Otus asio), Bell's vireo (Vireo bellii), yellow warble (Dendroica petechia), and the bronzed cowbird (Molothrus aeneus). The Rio Grande canyons serve as a significant refugium for one highly endangered species, the peregrine falcon, which nests on high canyon walls and hunts for food along the riverway.

Fewer mammals than birds show a strong riparian dependence. Boeer and Schmidly (1977) documented 30 species of terrestrial mammals in riparian habitats in BBNP, but only one species (the beaver, Castor canadensis) is restricted to these areas. Major changes in the vegetation during the past 30 years, involving an increase in basal and canopy cover, have resulted in the elimination of at least one species (Dipodomys ordii) from the river corridor as well as increased abundance and distribution for two other species (Sigmodon hispidus and Peromyscus leucopus). Other mammals with a strong riparian dependence along the Rio Grande include the Pecos River muskrat (Ondatra zibethicus ripensis) and the raccoon (Procyon lotor).

HUMAN ACTIVITIES AND IMPACTS

Recreational Impact

As leisure time, personal income, mobility and population levels have increased, public agencies have sought to acquire more park and recreation areas. In addition, the private sector has created many other recreation

attractions in the Rio Grande Valley. This increase in recreation areas and their increasing use has created a complex array of problems for the various state and federal agencies entrusted with managing these resources. BBNP and ARA were acquired in 1944 and 1968, respectively. Figures provided by the NPS show that park use has increased steadily each year except during the 1974 oil embargo. During 1977, for example, total visitation to BBNP and ARA was 402,433 and 993,577, respectively. Breaking this visitation data down, we can determine how much is related to the river (or reservoir) and riparian habitats. For example, in 1975 the Rio Grande accounted for 49% of the total backcountry use (in man-days) in BBNP; 25% of this use was float trips on the Rio Grande and 24% involved camping at primitive sites along the River Road (Ditton et al., 1976). Additionally, we find that two of the three developed camping areas maintained by the NPS are located in the riparian zone. Although visitation at Amistad exceeds BBNP visitation as reported by the NPS, we found that much of this visitation at Amistad was of an overnight or "pass through" variety. Also we found that visitation to private facilities like motels and campgrounds greatly exceeded public campground visitation in the area. Camping activity at ARA is concentrated, however, at one major campground called Governor's Landing.

Schmidly, et al. (1976) used correlation analysis to investigate the relationships among human use, impacts, and biological parameters (rodent fauna and vegetation) at 18 riparian sites in BBNP. Their results revealed a positive and significant relationship between total subjective human impact ratings and annual camping use by site (in man-days). Similarly, they noted that human impacts were more pronounced in those riparian areas where access was most convenient. The extent of human impact, however, did not correlate significantly with rodent densities at 18 sampling sites. Thus, correlation analysis revealed that the sites have been impacted as a result of recreational use, but not to the point where ecological conditions, as indicated by the biological health of the rodent fauna, were in jeopardy (Schmidly et al., 1976). At ARA rodent faunas were compared between an overnight campground (Governor's Landing), and an unused control site (Schmidly and Ditton, 1979). Results revealed that total rodent densities were higher at the campground than at the unused control site, although some differences in the densities of individual species were apparent between the two study sites. These differences were probably related to microhabitat differences at the two study sites rather than any component of human impact.

Some possible recreational impacts on vegetation in riparian habitats include the following (after Settergren, 1977): (1) mechanical injury to trees on heavily used areas; (2) total elimination of trees in the younger age classes (seedlings and saplings) which results in a reduction in understory vegetation; and (3) trampling which results in the reduction in the native ground cover both in amount and the number of species represented. Examples of a few kinds of these impacts were observed in our studies at BBNP and ARA. Mechanical injury to trees (such as wood cutting) was observed at several camping sites in BBNP. Furthermore, the occurrence of trees was negatively and significantly correlated with human impact, indicating that as impact increases the frequency of trees (especially the smaller seedlings and saplings) decreases (Schmidly et al., 1976). Our observations at an overnight campground at ARA indicated that recreationists did not use the entire site uniformly. Rather, they tended to congregate at and move along specific sites and routes, such as picnic benches, sanitary facilities, and the straight-line paths between. The impact of use on the vegetation was almost exclusively limited to these obviously impacted locations. Assessment of vegetation at random points throughout the campground did not reveal any significant differences in ground cover (grasses, forbs, and shrubs) between the campground and an unimpacted control site.

Another aspect of recreational use which potentially could impact some vertebrates living in riparian habitats is hunting and trapping. Several game or fur-bearing animals exist along the Rio Grande in western Texas and their preferred habitats include riparian vegetation. These include the white-winged dove (Zenaida asiatica), Pecos River muskrat (Ondatra zibethicus ripensis), and the white-tailed deer (Odocoileus virginianus).

The riparian zones along the Rio Grande provide some of the most stable known remaining habitat for white-winged dove, and it is important that hunting be carefully regulated in these habitats to insure that these birds are not seriously depleted. The drainage ditches along the Rio Grande near El Paso represent the last stronghold of the Pecos River muskrat in western Texas. This subspecies is now extinct from other areas along the Rio Grande and the Pecos River where it formerly occurred. The following is the muskrat catch by year during a five-year period for one trapper in El Paso County: 1970, 1200 muskrats; 1971, 1200; 1972, 1400; 1973, 700; and 1974, 936 (Schmidly, 1977).

High trapping pressure could eventually threaten the existence of the muskrat in the riparian habitats around El Paso.

White-tailed deer are the most common and important game animal at ARA. Evidence suggests that these deer have increased in numbers with the development of a weed-infested, flood-zone type of riparian vegetation which has developed since the construction of Amistad Dam. The population size of white-tails in this habitat is comparable to other areas in Val Verde County and hunting pressures presently are not seriously depleting the population (Ditton and Schmidly, 1977).

Livestock Impacts

The implications of our research at BBNP and ARA are that overgrazing by domestic livestock (particularly cattle) have had a much more devastating effect on vegetation and vertebrate populations than have recreational impacts. Cattle are attracted to these riparian zones because they prefer the quality and variety of forage available which, because of its moisture content, is higher in palatability (Ames, 1977). The behavior of livestock as compared to that of human users also must be considered. As mentioned earlier, people do not use a campsite uniformly but tend to restrict their activities to well defined trails, showing an obvious reluctance to pioneer new routes through unknown territory. Cattle, on the other hand, do not restrict their movements to predefined paths, and they tend to exert a more generalized disturbance on the ecosystem.

The situation relative to grazing in BBNP has changed since the establishement of the park in 1942. Early accounts (Taylor et al., 1944; Sperry, 1938) describe the vegetation along the river as open and severely overgrazed. However, since ranching activities ceased at the inception of the park, plant densities have increased greatly so that mesquite forests now occur where the river bottom was once open and sparsely vegetated. Extensive fields of grass also occur today at sites which formerly were cultivated and farmed. The increase of grasses in BBNP over the last 30 years has provided forage that is not available in the same quantity or quality across the river in Mexico. As a result, trespass livestock from Mexico have been invading the riparian corridor in increasing numbers during recent years. Unlike recreational usage, grazing by trespass livestock is a constant feature of almost all riparian sites and it not confined to one particular region or section of the river. Should this grazing activity continue to increase, it could have dangerous repercussions on the existing vegetation of the riparian corridor. Hence, dealing with the livestock problem may prove more difficult for park managers than dealing with recreational use and impacts which tend to be concentrated in some areas and virtually absent in others.

Overgrazing by domestic livestock has been prevalent in the Amistad region for the past 100 years, and only with the establishment of the recreation area in 1968 have federal lands been protected from overuse by grazing cattle. This protection is not complete, however, as fences commonly are destroyed and livestock wander onto federally protected lands. We evaluated livestock impacts in the lakeshore habitats of ARA by comparing the results of mammalian and vegetation studies at two study sites, only one of which has not been grazed for over 10 years and other which has received continuous grazing pressure (Schmidly and Ditton, 1979).

In comparing the grazed and ungrazed study sites, some marked differences were noted in the mammalian faunas, especially of rodents. These differences in species composition as well as density. The rodent fauna on the grazed site was composed primarily of heteromyid rodents (65.8% of the total catch), whereas this kind of rodents was rare on the ungrazed site (1.4% of the total catch). Cricetid rodents (primarily Peromyscus) dominated the total catch on the ungrazed site. Capture frequencies were over four times greater on the ungrazed than the grazed site, reflecting the higher density of rodents on the former area. Jackrabbits were commonly observed on the grazed site but only rarely seen on the ungrazed area. The situation was just the opposite with respect to cottontail rabbits; these lagomorphs were commonly seen on the ungrazed grid but they were rare on the grazed grid.

The differences in species composition and density of mammals between the grazed and ungrazed sites at ARA are understandable in light of differences in vegetative cover between the two study areas. In general, heteromyid rodents prefer habitats with sparse ground cover in contrast to cricetid rodents which favor situations with thicker and denser vegetation. The amount of vegetative cover available on the grazed site was was less than on the ungrazed site and average total cover between the two areas differed by almost seven percent. Thus, the more open terrain on the grazed site was suitable for hetermyid rather than cricetid rodents. Similarly, cottontails prefer areas

with a thicker, grassy vegetation, and this habitat preference ecologically separates them from jackrabbits.

Impact of Amistad Dam

Amistad Recreation Area was created in 1968 and is located in Val Verde County in southwest Texas. The lake on which ARA is located was formed by the construction of Amistad Dam on the Rio Grande by the International Boundary and Water Commisssion as a cooperative undertaking between the United States and Mexico. The dam is located 12 mi upstream (northwest) of Del Rio, Texas; it is situated on the Rio Grande about 1 mi below the mouth of the Devils River and 33 mi below the mouth of the Pecos River. At the 1117 ft contour elevation, which is considered conservation level, the impounded water extends 74 mi up the Rio Grande, 25 mi up the Devils, and 14 mi up the Pecos River. The dam was constructed for flood control, water conservation, future electric energy production, and for recreation. The reservoir has a storage capacity of 5,666,000 acre ft, and it is the third largest man-made international lake in the world.

Environmental changes attributable to water inundation have been manifold and will take years of intensive research to completely analyze. LoBello (1976) summarized many of the obvious changes in the flora and fauna of ARA since construction of the dam in 1968 and the following discussion is a compilation of information presented by him as well as data from our research at ARA (Ditton and Schmidly, 1977).

For the most part, the original shoreline with its riparian vegetation is gone as a result of water impoundment. In a few places riparian plants such as cattails and willows are making a slow comeback. However, without the floodplain soils, complete recovery of the riparian vegetation seems unlikely.

Local disjunct populations of two trees (the Texas pistacia, Pistacia texana, and the Chisos Oak, Quercus gravesii) have been severly impacted, if not extirpated, by reservoir inundation (D. Riskund, personal communication). Riparian habitat is still evident below the dam and along the Rio Grande just south of Langtry (where the impounded water of the reservoir reaches its western-most limits), and it serves as a dramatic contrast to the rest of the reservoir. The most common plants of the pre-reservoir riparian association include scattered stands of common reed (Phragmites communis), an abundance of common cattail (Typha latifolia), a great abundance of tobacco tree (Nicotiana glauca), and some mesquite (Prosopis glandulosa), willow (Salix sp.) and salt cedar (Tamarix gallica).

A distinct flood-zone vegetation area has developed along the shoreline of the reservoir as a result of periodic water level fluctuations. Because the water level of the reservoir is always fluctuating, the size of this flood-zone also fluctuates. The flood zone vegetation includes: willow, scattered stands of cattail, dead brush (Acacia rigidula, Leucophyllum frutescens, Prosopis glandulosa), dead cacti (Opuntia engelmannii, O. grahamii), and a variety of annual weeds (Conyza canadensis, Croton sp., Cyperus sp., Pluchea sp., Henelium sp., Polygonum sp., and Cenchrus sp.). These annuals and other weeds quickly cover the flood-zone areas, showing dense development from mid-summer to fall.

The impacts of land flooding have been catastrophic to many vertebrates occurring in the Amistad region. Sixty-five species of fish were known to occur historically in this region and, of these, 16 may now be displaced or eliminated in the area due to changes in vegetation and water depth resulting from inundation. At least one fish species Gambusia amistadensis, is now extinct in the wild as a direct result of the filling of the reservoir. The other 15 species are known only from surveys conducted in the early 1950's and 1960's.

Among reptiles and amphibians, only those species directly associated with sandy riparian areas have been seriously affected by the reservoirs inundation. Examples of species which have suffered as a result of inundation of their preferred habitat and which now are either absent or rare in the Amistad region include the following: barking frog (Hylactophryne augusti), two species of aquatic turtles (Chrysemys scripta and Trionyx spiniferus), the marbled whiptailed lizard (Cnemidophoris tigris), the Texas spiny lizard (Sceloprus olivaceus), rough green snake (Opheodrys aestivous), and the copperhead (Agkistrodon contortrix).

The loss of riparian vegetation undoubtedly has had a profound effect on bird populations which use this vegetative zone for nesting, foraging, roosting and cover during migration. At least two small mammals, the muskrat (Ondatra zibethicus ripensis) and the

Texas pocket gopher (Geomys personatus), have become extinct in the Amistad area since reservoir inundation was initiated. Bailey (1905) reported the Texas pocket gopher from sandy soils along the Rio Grande at Del Rio and at the mouth of Sycamore Creek. Flooding of the reservoir undoubtedly destroyed the deep sandy soils along the river systems which constitute the favored habitat for this gopher. Similarly, it is doubtful that the muskrat still occurs at ARA. Bailey (1905) found it "in suitable places along the whole length of the Pecos River and on some of the tributaries and along the Rio Grande near the mouth of the Pecos." Since muskrats are directly associated with marsh areas, it would seem that the inundated water of Amistad would have largely eliminated this rodent from the area. Three other mammals (the beaver, Castor canadensis; fox squirrel, Sciurus niger; and opossum, Didelphis virgiana) have declined drastically in numbers since construction of the dam.

Reservoir inundation has not had a totally negative impact on the vertebrate fauna of the Amistad region. A variety of vertebrates living along the river and stream courses during pre-reservoir days have survived in the altered flood-zone type of riparian vegetation, and many of these species are seemingly more abundant today than they were prior to construction of the dam. Populations of the cotton rat (Sigmodon hispidus), and the white-tailed deer (Odocoileus virginianus) have increased with the establishment of a weed infested flood-zone habitat. Other mammals which should benefit from the increase in shoreline and general change in water character include the nutria (Myocaster coypus) and the raccoon (Procyon lotor).

Birds are the vertebrate group which have probably benefited most from usage of the lake. Waterfowl, shorebirds, and wading birds undoubtedly use these areas for drinking and feeding purposes. Predatory birds, including hawks and owls, use the flood-zone areas for interim feeding purposes. At least one species, the cliff swallow (Petrochelidon pyrrhonota) definitely uses the flood-zone as a nesting aid by gathering mud along the shoreline.

Water Diversion and Stream Channelization

Some of the most extensively impacted regions of the Rio Grande occur between Fort Quitman and Presidio, Texas, where much of the stream is dry and contains water only during periods of severe flooding. The channel of the river in this region has seriously deteriorated since the late 1940's because most of the water flow has been diverted due to regulation by upstream reservoirs or water diversion for irrigation around El Paso. Consequently, the river has not been able to naturally maintain its channel clear of sediments and vegetation. Ecological studies have shown that the quality of the floodplain habitat for wildlife and native plants has been declining in recent years with the deteriorating channel. Salt cedar continues to spread rapidly over the floodplain and replace the natural vegetation (cottonwoods and willows). This is causing a continuing serious reduction in the food and cover for wildlife so that the river is becoming poor habitat for riparian organisms, as the following examples illustrate. The Mexican beaver (Castor canadensis mexicanus), which is morphologically and behaviorally distinct from other Texas beavers (Schmidly, 1977), was once common along this stretch of the river with specimens having been recorded throughout El Paso and Hudspeth counties. However, a recent survey turned up evidence of beaver sign at only three localities, indicating that this mammal is less common today than it was in the past (Engel-Wilson and Ohmart, 1978). The density and diversity of fish is low along this stretch of the Rio Grande and Hubbs et al. (1977) attribute this to the high salinity of the water and to periodic drought conditions which restrict the aquatic fauna to pools.

The United States and Mexico in 1970 signed a treaty agreeing to resolve their pending boundary location differences by restoring and preserving the character of the Rio Grande as the international boundary. In the same treaty, the two governments agreed to reduce to a minimum the shifting of the channel of the River. As part of the implimentation of this treaty, the United States section of the International Boundary and Water Commission has proposed to channelize and restore a 200 mi reach of the international boundary from a point 10 mi downstream from Fort Quitman to a point about 6 mi upstream from Presidio, Texas (Draft Environmental Impact Statement, DEIS, 1978). Further, as a part of the restoration, it has been recommended that a cleared passageway be provided along each side of the channel to facilitate the flow of floodwaters along the alignment of the channel and to further minimize shifting of the river. No channel excavation work is planned for the narrow canyon sections where the river is naturally confined and will not change its course. Materials excavated from the

channel will be spoiled on mounds of debris in areas of little or no wildlife value, and these spoil areas will be seeded with native plants. No concrete works will be constructed in or along the channel. A 25 foot wide fringe of existing trees will be maintained between each side of the river and the passageway. This fringe will be left along the channel bank to retain its wildlife benefits and to help stabilize the channel. Also, cottonwoods and other select mature trees will not be removed from the passageway.

Extensive surveys of the flora and fauna have shown this proposal to be beneficial to most riparian wildlife (Engel-Wilson and Ohmart, 1978). The trend towards increased soil salinity and spread of salt cedars would be generally curtailed, and, in some areas, improvements in soil salinity should occur incident to better drainage of floodwaters from the floodplain of the channel. This would improve the habitat for wildlife and should provide improved water areas for wildlife (DEIS, 1978).

Other Impacts

Included in this category are localized human activities which create indirect impacts not characteristic of the entire river system. The introduction of exotic plants and fishes is one such activity which, in the long run, could have serious ramifications for the native flora and fauna of the Rio Grande. Significant vegetation changes have occurred in the riparian habitats of the Rio Grande over the past 30 years. The major change is associated with the tremendous increase of salt cedar (Tamarix) which appears to be replacing native cottonwood and willow trees at many places along the river. Research at other riparian habitats (i.e., lower Colorado River) has demonstrated that the salt cedar community supports fewer birds than native communities and that the breeding populations of many birds may be reduced or extirpated as a result of the loss of native vegetation (Anderson et al., 1977).

The introduction of exotic fishes, especially bait minnows, is a serious problem at certain areas along the Rio Grande where exotics seem to be increasing in numbers and replacing native fishes. For example, Hubbs and Wauer (1973) record that introduced Fundulus kansae may compete with and reduce population densities of native Campostoma ornatum in Tornillo Creek in BBNP. The latter species is known in the United States only from a few scattered tributaries along the Rio Grande.

Land clearing in riparian habitat for purposes of cultivation has been extensive around El Paso and Presidio, which are the main agricultural centers along the Rio Grande in western Texas. At both of these places, pesticide applications have been used extensively to control insect pests, and there is some concern that pesticide buildups could detrimentally affect organisms living in these areas.

Applegate et al. (1971) studied the effects of distribution of DDT and methyl parathion from cotton fields to the surrounding area within a 30 mi radius of Presidio, Texas. Although most of their sampling sites were located in cotton fields or desert habitats around Presidio, at least two of their sites were situated in riparian areas. Therefore, their conclusions are applicable to riparian as well as desert habitats. These authors determined the concentrations and distributions of the insecticides in birds, lizards, rodents, and jackrabbits as well as several kinds of plants. Although there did not appear to be any direct insecticide-mortality relationship, there may have been an indirect relationship. Most insecticides entered the fauna via the food and were transported to muscle tissue and fat, including lipid materials in the brain. The insecticides in the brain may have led either to impaired motor ability or to behavioral change. Rodents carrying high body burdens of methyl parathion were recaptured more often than rodents carrying less residue. The jackrabbit population did not have normally distributed age-classes, and juveniles with high insecticide concentrations died. Insecticide uptake by plants was closely correlated with rainfall and showed little correlation with insecticide applications to cotton plants. Fortunately, Applegate, et al. (1971) found that pesticides break down very rapidly in the Chihuahuan Desert habitat. They attributed this rapid break down to high soil temperature, high ultraviolet radiation, and the alkaline nature of the soil.

Holmes (1970) found dangerously high levels of chlorinated hydrocarbons in fat samples of muskrat from El Paso County. During irrigation seasons, canal water is used to flood cultivated fields with the excess water flowing into the drains. This excess runoff contains in solution remnants of the chemicals, defoliants, and pesticides used to treat crops. Human households in the area also have sewage systems which dump into the drainage ditches. According to Holmes (1970), the situation caused by chemical pollution plus high trapping pressure

(discussed earlier) could seriously threaten the existence of muskrat around El Paso.

SUMMARY

The riparian zone of the Rio Grande in west Texas (from El Paso to Del Rio) is a very important area influencing the habitat of many vertebrates. Several vertebrate species are present that are absent or rare elsewhere, and numerous species utilize the river corridor as routes through inhospitable habitat. Many of man's activities affect the riparian zone to varying degrees. We consider reservoir inundation, water diversion, and livestock grazing to be among the most severe disturbances. As a result of these activities, the character of the river in west Texas has changed drastically during the past 100 years. The pattern of change is reminescent of that occurring along other rivers in the Southwest, as for example the Colorado River (discussed by Ohmart et al., 1977).

There are virtually no gallery forests remaining between El Paso and Presidio; a few isolated cottonwoods remain along ditches or canals apart from the tall and dense salt cedar forets. The most pristine and unaltered section of the river begins at the confluence of the Rio Conchos (near Presidio) and continues downstream to BBNP and through the "lower canyons" to Langtry. Below Langtry the river has been completely altered by the construction of Amistad reservoir and the attenuate ecological changes have been catastrophic.

Can anything be done and is anything being done to prevent the further loss of the riparian resource along the Rio Grande? Just recently the portion of the river from BBNP to Langtry has been designated as a wild and scenic river which should prevent future habitat alterations. A project is currently being initiated to channelize and restore segments of the river from Fort Quitman to Presidio. Although stream channelization is often ecologically detrimental, in the case of the Rio Grande in west Texas it could have positive effects for riparian vegetation and wildlife.

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