A Riparian Case History: The Colorado River[1]

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Abstract.--Historically to present cottonwood communities have declined in abundance along the lower Colorado River to the condition that the future of this natural resource is precarious. Avian species showing strong specialization to cottonwood communities may be extirpated should the cottonwood community be lost from the river. Only through the concern and action by responsible agencies can we assure the persistance of this natural resource.

An overview of the ecological changes that have occurred on the lower Colorado River can be obtained by selecting an important plant community and examining its condition through time. To adequately describe the lower Colorado River riparian ecosystem and discuss the ecological changes from our first written records (1539) to the present is not possible within the space constraints of these proceedings. Therefore, we have elected to analyze an important plant association in this ecosystem and examine its distribution from the early 1600's to present. Although we refer to this association as the cottonwood (Populus fremontii) community, it frequently occurs mixed with such species as willow (Salix gooddingii) and/or screwbean mesquite (Prosopis pubescens) and infrequently with such species as arrowweed (Tessaria sericea), honey mesquite (Prosopis juliflora) and recently the introduced salt cedar (Tamarix chinensis).

Some avian species that inhabit this community along the lower river appear to be very specific in their habitat requirements (Anderson and Ohmart 1975). Consequently, as the unit area of this plant community changed, in all probability, so did the abundance of these habitat-specific species. By examining this biotic community from past to present, we gain an appreciation of the areal changes that have occurred and can make better predictions as to the future of this community type. This analysis should be helpful in providing impetus for management decisions relative to the cottonwood community along the river.

It is tempting to speculate that early man lived in harmony with his environment and that the earliest descriptions of the plant communities along the lower Colorado River reflect the natural environment unaltered by man. Because of space constraints, we will assume this is true, but it must be kept in mind that man could have had a strong influence on his environment through burning and other habitat alterations, especially at the local level.

If we assume that the Indians did not drastically modify the environment, we can examine alterations, classed as natural or unnatural, brought about by the Spaniards and later the Anglo-Americans. It has been argued that man is a natural part of his environment and that alterations brought about by his activities are as natural as changes produced by other animal activities (Malin 1956). This is academic when it is considered that natural resources are finite, and regardless of the causes of degradation and loss, if we value these resources, then we must preserve and manage them for their continued existence.

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INDIANS AND SPANIARDS

Long before European man viewed the waters of the lower Colorado River, a variety of Indian cultures evolved and became established along its banks. However, they left no written record, so Spanish documents provide our earliest information about the region. The Spaniards claimed the region of the lower Colorado for over 250 years. Interested in converting the Indians to christianity, discovering a land passage to the South Sea (Gulf of California) and acquiring mineral wealth, their missionary-military expeditions explored the Pimeria Alta. These early explorers left diaries often containing descriptive information on the areas they traveled.

In February of 1699, Father Eusebio Francisco Kino, accompanied by Juan Mathes Manje, an excellent diarist, viewed the junction of the Gila and Colorado rivers from a distance of 15-18 miles. Manje wrote: "...we plainly saw at a distance of six or seven leagues [1 league = 2.5 miles] the banks and junction of the very great Rio Colorado with this one [the Gila], grown with dense groves with new leaves and although we saw it at a long distance the groves appeared to us to be more than a league wide,..." (Bolton MS 203:20).

Kino, a student of both the Faith and geography, spent twenty years in the area known as the Pimeria Alta, delineated on the east by the San Pedro River, the north by the Gila Valley and on the west by the Rio Colorado and the Gulf of California. Two of his major goals were to convert the Indians to christianity and to find a land passage to California to prove it was not an island. In 1700, Kino was again near the junction of the Colorado and Gila rivers. He ascended a hill in hopes of viewing the Gulf of California: "...but looking and sighting toward the south, the west, and the southwest, ...we saw more than thirty leagues of level country, without any sea, and the junction of the Rio Colorado with this Rio Grande..., and their many groves and plains." (Bolton 1919: 1, 249). In the flood plain in 1701, Kino wrote that the Indians: "...showed themselves most affectionate toward us, ...especially in opening for us some good, and straight and short roads through the thickets of the abundant and very dense woods, which were on these most fertile banks." (Bolton 1919: 1, 316).

Cottonwoods are first mentioned specifically by Father Sedelmayr in 1744 during his endeavors along the Colorado at the junction of the Bill Williams River: "The Indians burn the trunks of the alders [willows] and cottonwoods and when they fall they burn the tops of them until they have a pole of the size desired." (Dunne 1955: 31).

Thirty years later, in 1774, Fathers Diaz and Garces accompanied Captain Anza to the Colorado River. After they crossed the river near Yuma, Arizona, Diaz wrote: "On its banks there are many cottonwoods, most of them small." (Bolton 1930: 2, 264). The following day (9 February), Diaz wrote: "...we camped on the bank of this river below its junction with the Gila... Its banks and adjacent lands are very thickly grown with cottonwoods, which would serve for any kind of building." (Bolton 1930: 2, 267-268). On that same day, Captain Anza measured the Colorado River and commented on the plant communities: "...one can see clearly the junction of the rivers and the immense grove of cottonwoods, willows useful for thatching, and other trees, both upstream and down." (Bolton 1930: 2, 169).

Diaz and Anza journeyed westward to the coast, leaving Garces to continue his missionary work. In his travels north along the river in the vicinity of Ehrenberg, on 28 February 1774, he wrote: "...I arrived at eleven o'clock in the forenoon at the beaches and the groves of the Colorado, halting at a very long and narrow lagoon..." (Bolton 1930: 2, 379). As he traveled north above the Bill Williams River, he viewed the Chemehuevi Mountains and described the area now under the upper end of Lake Havasu: "In the vicinity of the sierra I saw much water, groves and large beaches, which must be those of the Colorado River." (Bolton 1930: 2, 385).

TRANSIENT PIONEERS

The crude Spanish Missions built on the lower river were destroyed in 1781, and most of the inhabitants, including Father Garces, were killed. Spanish activity in the area waned and between the late 1700's and 1850, only a few passing explorers, trappers and pioneers visited the lower Colorado River. One diary, that of Jose Joaquin Arrillaga, contained worthwhile vegetative descriptions where he approached the Colorado near its mouth and then traveled north to Yuma. On 19 September 1796 he wrote: "At half past three in the morning I took up my march to the east,...and at sunrise I was already in sight of the cottonwoods of the Rio Colorado." He crossed the Colorado River near Yuma and continued east: "After one leaves the banks of the river there is not a useful tree to be found, except the mezquite grove where I set out, and this serves for nothing but firewood," (Arrillaga 1796 MS).

A number of trappers were known to have illegally entered the now Mexican territory (Weber 1971) which included the region of the Colorado River. They were tight-lipped and

only one, James Ohio Pattie, in 1827 left records of the Colorado River environment: "The river, below its junction with the Helay, is from 2 to 300 yards wide, with high banks, that have dilapidated by falling in. Its course is west, and its timber chiefly cotton-wood, which in the bottoms is lofty and thick set." (Pattie 1831: 129).

AMERICAN EXPLORERS

The best and most complete records of cottonwood distribution, abundance and size occur from the late 1840's on when soldiers and scientists began working in the area of the lower Colorado River either because of war or to conduct various surveys. The United States boundaries were expanded to the Pacific Ocean in the 1840's and in 1846, the United States went to war with Mexico for land acquisition, the Colorado River being part of this region.

Lt. William H. Emory (1848: 99-100), Topographical Engineer accompanying the "Army of the West" in 1846, recorded his observations in the area of the Colorado-Gila junction: "The banks are low, not more than four feet high, and judging from indications, sometimes, though not frequently, overflowed.... The growth in the river bottom is cotton wood, willow of different kinds,..."

A member of Emory's party, A. R. Johnson, also kept a journal and observed that: "The Colorado disappears from here in a vast bottom; the last we can see of its cotton-woods is in the southwest." (Emory 1848: 609). The following day, after a 10 mile march, they again reached the river and Johnson stated: "...the river here is about ten miles wide, and much of the land could bear cultivation; it is all now overgrown with the most impenetrable thickets of willows, mesquite, Fremontia, etc." (Emory 1848: 609). The term "Fremontia" was frequently used to denote cottonwoods because the species was named in honor of the naturalist J. C. Fremont.

One of the many commissioners of the trouble-plagued boundary survey, John R. Bartlett, published his "Personal Narrative of Explorations" along the Colorado River in 1854. His following description of the Algodones area in 1852 is duplicated by a photograph (plate 1a) some 50 years later and then again in 1976 (plate 1b). In his description of the area (Bartlett 1854: 149-151) he wrote:

> June 9th, 1852 - Our journey was through a bottom filled with mezquit and cotton-woods; ...Our eyes were greeted with a sight of the great Colorado River, twelve miles below its junction with the Gila, at a place called "The Algodones," and soon after, we halted upon its bank. It was much swollen, and rushed by with great velocity, washing away the banks and carrying with it numberless snags and trees. The road ran along the river's bank, which, as well as the bottom-land, was filled with a dense forest of willows, cotton-woods, and mezquit.

Lt. Amiel Weeks Whipple (1856: 3(1), 109) in his exploration of a railroad route along the 35th parallel described the Chemehuevi Valley (79 years after Garces): "On both banks are strips of bottom lands, from half a mile to a mile wide. The soil is alluvial, and seems to contain less sand and more loam than is found in the valley of the Rio del Norte. But here, as there, are occasionally spots white with efflorescent salts. A coarse grass grows luxuriantly upon the bottoms. Bordering the river are cotton-woods, willows, and mezquites, or tornillas." Dr. J. M. Bigelow, surgeon and botanist in Whipple's party, described the same area: "From the mouth of Bill Williams' fork to the point above where we crossed the Rio Colorado, is about sixty miles.... Along the valley of this river, alamo [cottonwood], mezquite, and willow form the principal, and almost entire, kinds of trees." (Bigelow 1856: 4, 13).

The interest in river navigability was so strong in 1857 that a government expedition was organized. Lt. Joseph C. Ives, Corps of Topographical Engineers, was directed to determine how far and to what extent the Colorado River was available for steamer traffic. At Camps 50 and 53, Ives described Cottonwood Valley and Round Island. The latter was commonly called Cottonwood Island because of the heavy forest of large cottonwood trees. Of Cottonwood Valley, Ives (1861: 78) reported: "Groves of cottonwood trees, of a larger growth than any seen before, indicate that there is some alluvial land, but the valley does not appear to be of great extent.... The Cottonwood valley was found to be only five or six miles in length and completely hemmed in by wild-looking mountains. The belt of bottom land is narrow, and dotted with graceful clusters of stately cottonwood in full and brilliant leaf."

AMERICAN EXPANSION

Ives' steamer exploration up the river, and the demonstration that the river was navigable, generated an abundance of steamer travel and allowed shipment of goods to the mining industry. In 1862, placer gold was discovered midway between Fort Yuma and Mohave, and the

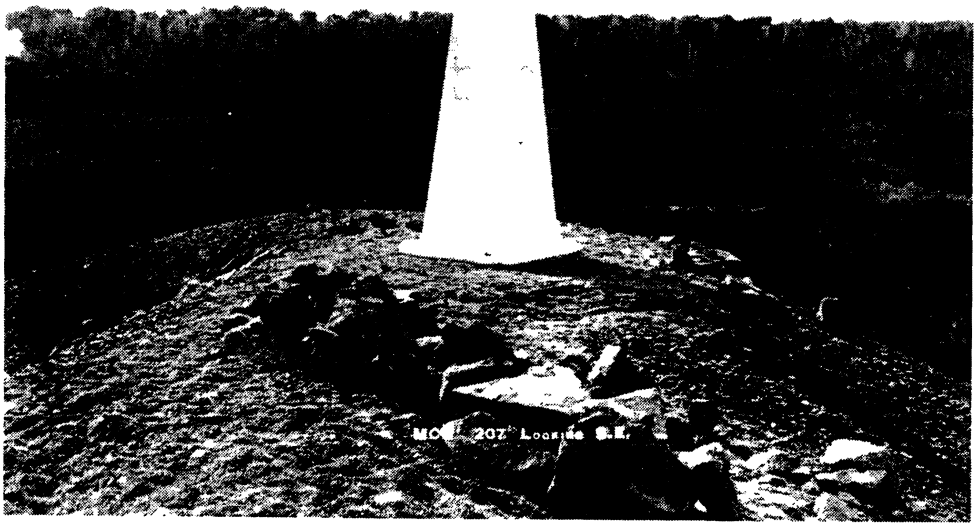

Plate 1a (1894). Looking southeast into Mexico at Mexican-American Boundary Monument 207. Maturing cottonwood community with trees 20 to 30 feet tall can be seen in the background following the cessation of the fuel wood industry for steam boats. A community of arrowweed occurs between the marker and the cottonwoods.

Plate 1b (1976). Looking southeast into Algodones, Mexico.

town of LaPaz was born (Renner 1974). Fuel for steamers was readily available in the form of cottonwood, willow and mesquite, the latter being less desirable because of its slow-burning properties. Large quantities of fuel were needed frequently and fuel stations were established at 25-mile intervals. The Indians, realizing that a profit could be made, cut and corded the wood, selling it at $2.50 a cord (Leavitt 1943).

The continuing search for gold revealed deposits near present-day Oatman and in El Dorado Canyon (Dunning and Peplow 1959; Casebier 1970). The expanding mining activities increased the military presence and businessmen soon realized the potential for development.

G. W. Gilmore, a member of the Colorado Steam Navigation Company, submitted a report on the availability of fuel along the river after having taken a trip on the steamer Esmeralda in 1866 in which he stated: "...bends of the river in the bottom lands, which, as below Fort Yuma, are covered with vegetation and timber; the trees of the varieties already named are suitable for fuel, and are of very rapid growth. It is found that upon new lands formed by the cuttings of the river cottonwood, willow, and mesquite trees will be produced in three years large enough to cut for fuel... Trees are quite abundant for most of the distance, and plenty of fuel to be had."

His statements about Cottonwood Island were as follows: "...about 10 miles long by an average of about three miles wide, is a fine, level island, fertile and covered with grass, and having considerable timber.... An immense quantity of this wood was upon the island, estimated at several thousand cords" (Browne 1869: 462-464).

The need for exploration was almost over and although further expeditions would be sent, they would be of a very different nature. In 1875 and 1876, Lt. Eric Bergland, under the direction of George Wheeler, leader of the United States Surveys West of the 100th Meridian, examined the Colorado River as a potential irrigation source. Describing the vegetation of the Colorado River, he stated: "A most pleasant sight... Cottonwood Island, with its majestic cottonwood trees and rich vegetation, afforded a pleasant relief to the eye.... Along the river there is a rich growth of trees, principally cottonwood, and here the fuel is obtained for the river steamers." (Bergland 1876: 330-333).

In 1877, Lt. A. G. Tassin authored a document entitled "Report on the Forestry, Elevation, Rainfall, and Drainage of the Colorado Valley together with an Apercue of Its Principal Inhabitants the Mahhaos [Mohave] Indians" compiled while he was stationed at Camp Mohave. Never published, the report remains in handwritten manuscript form, often undecipherable. In his discussion of the vegetation, Tassin (1877: 5-6) noted: "Finally along the margin of 'lagunas' the most substantial of the Colorado timber the willow and cottonwood. The largest of these in the entire course of the river, are in what is called 'Cottonwood Island' between Camp Mohave and the Grand Canyon where they have attained a size which may be styled majestic.... The cottonwood, mesquite and willow are the principal, if not the only fuel of the country, the first having a diameter varying from two to twenty inches." In a latter section of his report, Tassin (1877: 30) wrote: "Cottonwood island the sole bottom-land between the Grand Canyon and Camp Mohave, is, as denoted by its appellation, celebrated for its splendid cottonwood trees which here attain their full size. Its area varies between from four to six miles in length and from one to three-fourths of a mile in width.... In a few years, however, its beautiful trees will have disappeared, a large demand being made on them yearly for fuel for the use of the _____ Mormons."

The General Land Office, now known as the Bureau of Land Management, initiated the original township surveys or cadastral mapping along the river in 1855. Not all the land was surveyed during the same time period. Figure 1 shows a reconstruction of the general vegetative types below Blythe, California in 1879 derived by interpreting floral descriptions contained in original field notebooks and then transferring these to the original field plats. The field notes contain exact measurements from section corners to points where the vegetation or topography changed. At each change notes were taken on soil, vegetation and general character of the land. Once a section (1 square mile) was chained, the surveyors took random walks (giving specific localities) through the section and again took notes at various places on vegetation, etc. Insight into the maturity of the community was also indicated when tree diameter values at breast height were noted and when trees were used as section corners. Although these data are semi-quantitative and highly time consuming to obtain, they yield the earliest aerial view of plant community extent, abundance and placement along the lower river. They further support previous and subsequent written descriptions in the historical record.

By about 1890, the use of and need for steamboats had declined, as had the fuel supply. Some steamer traffic ran north of Yuma, but to insure adequate amounts of fuel, they had to travel into the delta area (Sykes 1937: 37). The decreased need for steamers was in part due

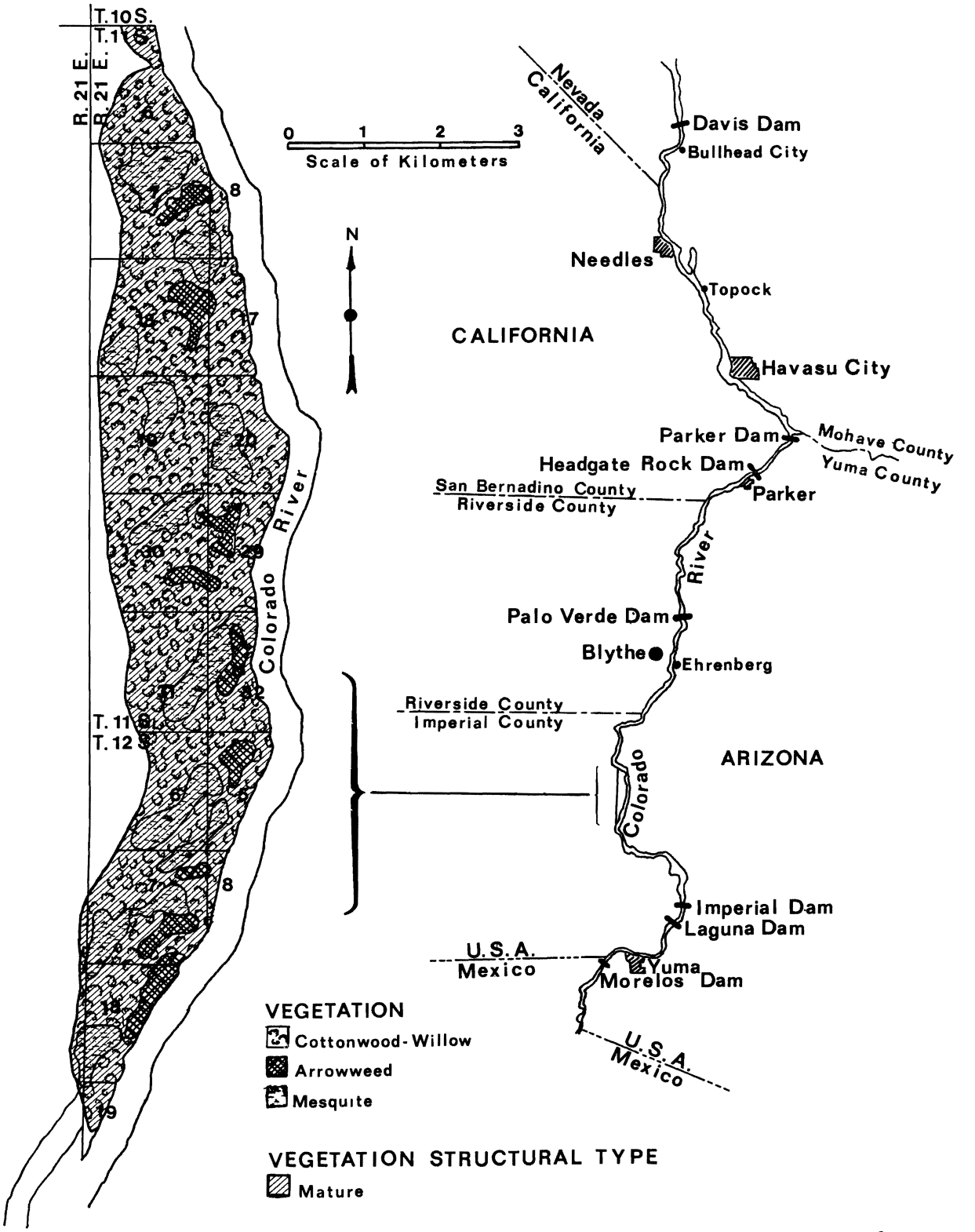

Figure 1.--Reconstruction of native plant community placement and species composition from original surveyor notes and plats along the lower Colorado River in 1879. Area surveyed by Benson.

to the completion of the railroad to Yuma (1877) and Needles, California (1883).

By the late 1800's, the importance of mining and other uses of the river had slowly declined and agriculture along the river was precarious because of the annual floods and constant shifting of the channel. In 1892 Imperial Valley was rediscovered by the Arizona and Sonora Land and Development Company. George Chaffey was instrumental in bringing water into the basin, and by 1904 the California Development Company claimed seven hundred miles of irrigation ditches and seventy-five thousand acres were under cultivation.

The winter of 1905 was one not to be forgotten. Unlike other years, the river began to rise in February and "the condition continued...until February of 1907" (Sykes 1937: 57). Despite attempts to control the flooding waters, by August 1905 the entire river was flowing into the intake of the Imperial Valley canal. Thus, the Salton Sink became the Salton Sea (Cory 1915; Tout 1931; Sykes 1937; Hundley 1973).

The flood of 1905 brought heavy public pressure for river management in the form of flood control and water storage. The Reclamation Act had been passed in 1902, the settlers were having continual problems with the development company, there were difficulties with the Mexican government, and the disastrous floods of 1905 and 1907 increased pressures to evict the promoters and have the Reclamation Service assume responsibility for the river. From about this period on, the Reclamation Service, now U. S. Bureau of Reclamation, played the most important role in developing the river as a utility, although lesser agencies such as the Imperial Irrigation District also played important parts.

One of the major roles in development was the installation of dams for flood control; the first, Laguna Dam, became operational in 1909. A flood in the fall of that same year "...was instrumental in completing the filling of the basin above Laguna Dam with detrital material within six months after the completion of the dam itself." (Sykes 1937:152). Floods continued and levees were raised until the big flood of 1922 which convinced people in Washington that larger dams were needed. In 1935 Hoover was operational. In 1943 Davis Dam, 1938 Parker Dam and Imperial Dam were completed. Lesser dams for water diversion also were constructed.

Concomitant with and following dam construction, engineers began to examine water movement rates, channel siltation and bank erosion. Many of these problems can best be solved by channelization, riprapping of banks and removal of sedimentation through dragline or dredge. All of these methods were employed to straighten and open channels to expedite flows. New and old eroding banks were fortified with riprap to increase bank stability.

Once the dangers of floods were reduced and flows were controlled by Hoover Dam, this allowed for agricultural expansion throughout the floodplain. Settlers claimed new lands and removed large and continuous tracts of natural vegetation for agricultural purposes. These activities, along with city and rural development, continue to claim numerous acreages once vegetated with natural communities. Much of this land, especially near the river, once supported cottonwood communities.

In the 1950's through the 1960's, two plans were formulated by the Bureau of Reclamation to remove riparian vegetation for the purpose of water salvage. Only one of these was ever implemented and this was in the Yuma flood plain area (Curtis W. Bowser, USBR, pers. com.). Van Hylckama (1970 and in press) has pointed out that water losses from a plant varies considerably during the year and past measurements have not taken this into consideration, possibly resulting in large errors.

In the late 1960's and early 1970's, a small flame of environmental concern was beginning to burn throughout the nation. In 1969 the National Environmental Policy Act was passed and federal agencies began to review policies and action decisions more closely. During this period the Regional Director of the Bureau of Reclamation, Mr. Edward A. Lundberg, established an environmental office headed by Mr. F. Phillip Sharpe. Efforts by these individuals in 1972 resulted in an extensive assessment of the little known flora and fauna of the lower river and a comprehensive and long-termed study was begun which was entitled "Vegetation Management for the Enhancement of Wildlife." These studies are still in progress and the legacy of environmental concern generated in the early 1970's is strongly supported by the current Regional Director, Mr. Manuel Lopez, Jr.

DISCUSSION

How extensive was the cottonwood community in historical times? As we swim through a sea of qualitative data, there is little quantitative information available to help answer this question. We know from historical records that cottonwoods were primarily restricted to the river's edge where seedlings became established in newly deposited soils. The following is an attempt to give some quantification to the

extent of cottonwood communities in historical times. If we assume that cottonwoods were absent in areas where the river cuts through canyons and thus remove 75 miles of the 275 miles of river between Davis Dam and the Mexican boundary, this leaves approximately 200 miles of potentially suitable habitat for cottonwoods. If the mean width of the cottonwood community along the river was 100 feet on each side of the river, we can compute a minimum area of 5,000 acres of cottonwood habitat. This figure is conservative, but it yields a value which will be instructive in later discussion.

The Indians exerted some influence on the ecology of the cottonwood community, especially by using fire to fall and size timbers. Cottonwoods cannot tolerate much heat and do not resprout from the roots following a hot fire. But to expedite discussion, in this report we will assume the Indians' influence on the cottonwood community along the river was minimal and capricious.

The influence of the Spaniards on the cottonwood community appears more minimal than that of the Indians except for the introduction of livestock in the early 1700's (Forbes 1965). Spanish activity was concentrated primarily around the Yuma area. The spread and extent of use of domestic livestock by the Indians is not well known, but Forbes (1965:287) reported from hearsay evidence in 1842 that the Quechan and Mohave Indians "...own large numbers of horses and cattle..." Not all the Indians owned or had access to livestock or Browne (1864) would not have observed them starving and eating rodents and reptiles. The primary damage of livestock to cottonwood communities would have been to seedling or sapling stands which would have been important foraging areas for domestic livestock. More mature communities were sometimes cut if livestock forage was scarce; Pattie (1905:188), for example, stated, "Our horses also fared well, for we cut plenty of cotton-wood trees, the bark of which serves them for food nearly as well as corn."

The first and most widespread reduction of cottonwood communities appears to have taken place during the period of steamboat use on the lower river (1855 to 1890). Cottonwoods and willows, fast burning woods, were located nearest to the river and were one of the primary fuels for powering the vessels. The extent of reduction of the cottonwood community is supported by Tassin (1877:30) who predicted the denuding of cottonwoods from Cottonwood Island, which came to pass. Another indication of the reduction of maturing cottonwood communities is exemplified by the necessity for steamers planning long trips up river from Yuma to go into the delta for wood to insure an adequate fuel supply (Sykes 1937). As fuel demands abated in the late 1880's, cottonwood communities began returning; and the photograph (plate 1a) taken in April 1894 by Mearns shows redeveloping cottonwood communities at the Mexican-United States boundary.

The floods which occurred during the years of 1905 and 1907 were of a greater magnitude and longer duration than any described in historical accounts. The destruction and removal of natural communities must have been far greater and more widespread than the 1852 flood which washed away banks and carried in its waters "numberless snags and trees" (Bartlett 1854:50). Presumably, the newly deposited and moist soils again would have provided the basic habitat for cottonwood seed germination and the repetitious reforestation process. Accounts by Grinnell (1914) in 1910 indicate that the cottonwood communities were returning and the 1945 photograph (plate 2a) provides pictorial testimony. Aerial photographs taken every three to five years, beginning in 1942, show that the majority of the trees were gone by 1967 and plate 2b, taken in 1976, revealed only four or five isolated trees in the bottom right. Dense stands of salt cedar presently cover areas previously supporting cottonwoods.

Salt cedar was introduced in the New World in the early 1800's both as a soil stabilizer and as an ornamental (Horton these proceedings). Its entry to the lower Colorado River must have been sometime after 1910 when Grinnell (1914) made extensive museum collections of plants and animals. He makes no mention of it in his publication or field notes, and had it been at all common, he would have found and collected it. The species appears to have become established between 1910 and 1920 and began to spread rapidly in the 1930's and 1940's. By the 1940's it dominated large areas along the Gila (Marks 1950; Haase 1972; Turner 1974) and Colorado (Robinson 1965) rivers.

Horton (these proceedings) discusses the biology of salt cedar but a brief discussion is necessary to gain insight into the events that transpired between 1945 and 1976. The species produces seeds over a long period of time and seeds are both wind and water disseminated. They germinate vigorously in newly deposited alluvial soils. The species is deciduous and when in relatively dense stands (periphery of adjacent trees touching), the annual litter accumulation after 10 to 12 years produces a highly flammable condition. The above ground portions are killed following a fire, but suckers from the root stock reappear in one to two weeks, the burn cycle repeats itself every 10 to 20 years (Anderson and Ohmart MS).

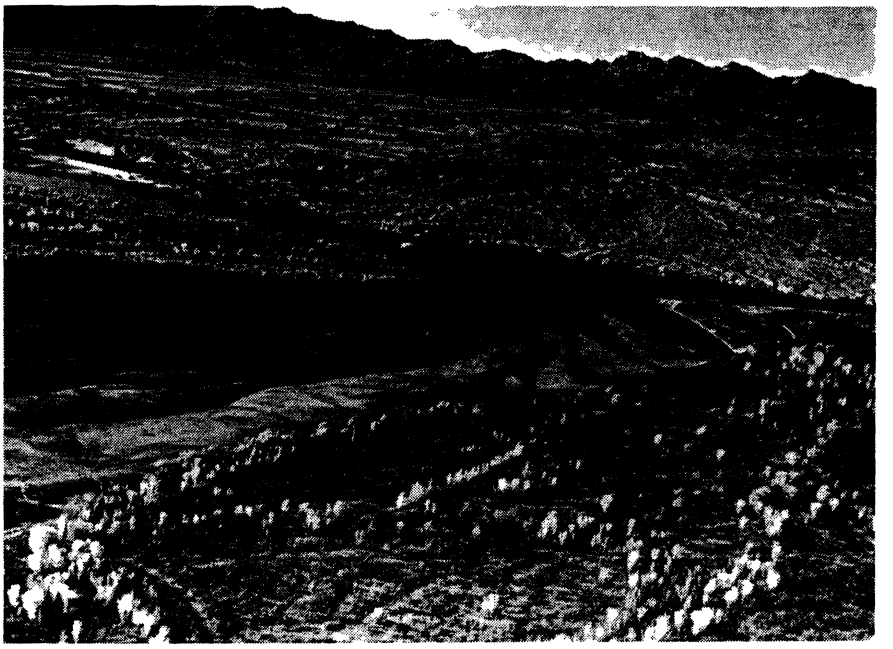

Plate 2a (1945). Aerial oblique looking west into California about 25 miles north of Blythe. The river is flowing in the foreground to the right and then to the left. In bottom right, cottonwoods can be seen along the old braided stream channels on the cut bank. Understory is primarily sparse arrowweed with taller willows or salt cedar near the cottonwoods. The peninsula supports many cottonwoods, willows and arrowweed.

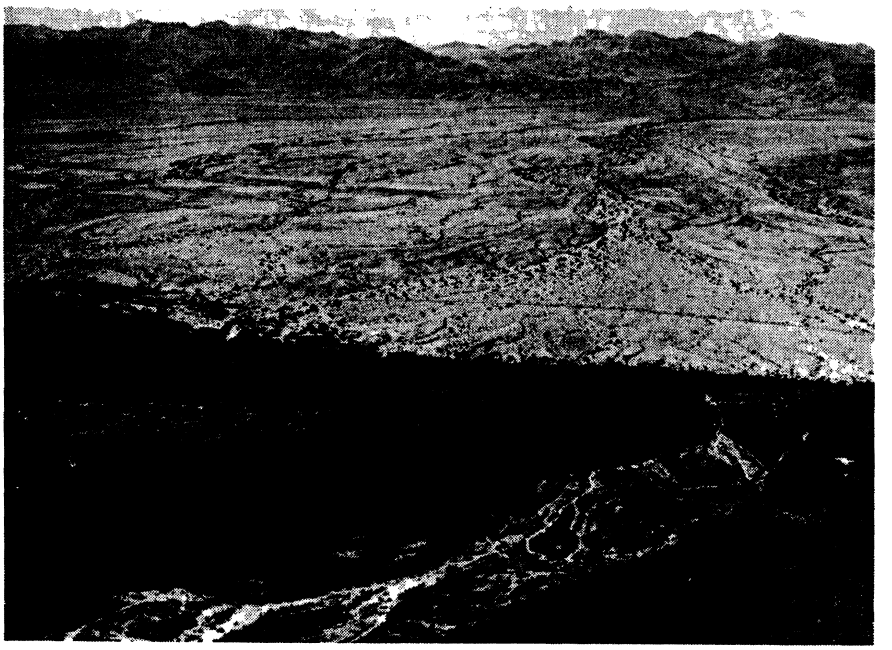

Plate 2b (1976). The camera station is higher and closer than in the previous photograph. Dense salt cedar and arrowweed have invaded the areas previously occupied by cottonwoods. Isolated cottonwoods persist in the lower right. On site remnant blackened tree stumps are persistent testimonials of past fires. Mesquites have become established along the peninsula on the higher and better drained soils.

Cottonwood communities were in the process of returning following the floods; but when salt cedar began invading the lower river, it must have started mixing with the maturing cottonwoods. The proximal location of the cottonwood communities to the river and on soils only inches above the water table provided the type of habitat that salt cedar does best on and aggressively spreads over. Some individual cottonwoods were probably removed for firewood by man and for food by beavers. Today remaining cottonwoods occur as isolated trees or as irregular rows with little understory, mixed with sparse willow communities, in pure stands or temporarily mixed with salt cedar. The latter being temporary as exemplified by the area around Hunters Hole in the Limitrophe Division which burned two years ago and killed all the mature cottonwoods. Many of the remaining cottonwoods along the lower river are mixed with sparse willows and these willows may have served as a buffer which prevented or slowed the invasion of salt cedar by shading out seedlings. Anderson and Ohmart (MS), in studying rodent succession in fire altered salt cedar communities along the lower river, have only found two salt cedar communities of 50 acres or more that have survived fire for more than 20 years.

Many cottonwood communities have been lost to expanding agriculture channelization projects, inundation of lakes behind dams and possibly the placement of dredge spoil materials. Agriculture only poses a minor threat to remaining cottonwood communities since there are only so few left, and they occur primarily on lands between the levees which are not farmed. River management activities tempered by environmental concern, require an Environmental Impact Statement and mitigation for project losses.

The demise of cottonwoods on the lower Colorado River has been related to implementation of dams, and the data indicates that dams expedited the natural loss by stopping annual overflow. This periodic flooding and water movement through the communities covered or washed away litter accumulations. Litter covered with sediment during overflow rapidly decomposed to release nutrients and add humus to the soil. River management stopped these natural overflows and allowed litter accumulation which in turn has resulted in the increased frequency of communities being burned. This has led to the loss of many cottonwood communities from fire.

Cessation of annual overflows and natural channel movements also curtailed the formation of the basic cottonwood seedling habitat, bare sandy soils with high water tables, which appears essential for cottonwood seed germination. The rapid spread of salt cedar and slow demise of cottonwoods began about the time major dams were implemented, the mid 1930's. It is somewhat of a moot point whether major dams tipped the ecological balance to favor dominance of salt cedar over cottonwoods or if cottonwoods could have retained their dominance over the invading salt cedar on the lower Colorado River. Currently the success of cottonwood regeneration has not been stopped, but it has been lowered to the point where it is negligible. Campbell and Dick-Peddie (1964) reported that cottonwoods could maintain their dominance over salt cedar in natural conditions on the upper Rio Grande in New Mexico, but it is doubtful this would be valid along the lower Colorado River. Even without dams it appears highly unlikely that cottonwood communities could have maintained their dominance along the lower Colorado River over the aggressive and fire adapted salt cedar.

This conclusion is supported by examining the loss and persistence of cottonwoods in natural communities along other southwestern streams. A reach of the Gila River in Arizona between Kearny and Florence is still intermittently flooded but contains few lone cottonwoods and no gallery forest. Conversely, the Verde River in Arizona above and below the dams possesses good cottonwood gallery forest and salt cedar appears to be having more difficulty invading this riparian system than it has had on the Salt or Gila rivers. Another factor appears to be important--total dissolved solids (TDS). Further support of the importance of TDS is indicated by the return of native vegetation along the Salt River below the Flushing Meadows sewage treatment plant in west Phoenix, Arizona. In this area, salty native ground water is being displaced by secondary sewage water and following the flood conditions in the 1960's which scoured away much of the salt cedar in that area, native communities are rapidly returning. It is highly improbable that these native communities would have returned in competition with salt cedar if salt cedar removal by flood waters was the only cause. Many areas have been cleared of salt cedar only to have it promptly return. Observations along the Rio Grande in New Mexico and Texas further support the importance of low TDS and cottonwood dominance over salt cedar. Along the upper portion, around Albuquerque, New Mexico, cottonwoods appear to be thriving and maintaining their dominance. But between Las Cruces, New Mexico, and El Paso, Texas, the frequency of extensive gallery forests declines and individual trees show heavy plant parasite infestations; to the extent that they are dying. Further down river in Texas between Presidio and Fort Quitman there are no gallery forests remaining; only lone cottonwoods remain isolated along ditches or canals from the tall and dense salt cedar

forests. All along the river from Albuquerque to El Paso extensive agricultural and industrial effluent enters the river to slowly work its way down stream. Salts from these and natural sources can be seen covering many acres between Fort Quitman and Presidio following the subsidence of sluggish and intermittent winter floods. Dams have stopped the once rapid moving floods which once flushed and leached salts into the gulf, leaving rejuvenated soils.

Other factors, both man caused and natural, may or may not be involved in each case and should be examined in depth before reaching a final conclusion as to the reasons for cottonwood disappearances. We know that domestic livestock concentrate in riparian communities and heavily utilize young cottonwoods, but we know nothing about possible climatic changes and their effects postulated by Hastings and Turner (1965). What effects have these changes had on cottonwood communities, if their thesis is correct? Much remains to be learned about the ecology of riparian communities and unfortunately there is little information available on the natural history of most of these plant species.

Cottonwood communities have declined from high abundance (5,000 acres plus) along the lower Colorado River in the 1600's to scattered groves containing a few mature individuals today. Anderson and Ohmart (1976) have estimated that only 2,800 acres of cottonwood-willow community remain along the lower river. If one was to consider pure cottonwood communities, it would be less than 500 acres.

In conjunction with the loss of the cottonwood resource, we must have experienced population reductions in bird species which show a strong preference for cottonwood habitats. Summer Tanagers (Piranga rubra), Yellow-billed Cuckoos (Coccyzus americanus), Wied Crested Flycatchers (Myiarchus tyrannulus), Brown Creepers (Certhia familiaris), and many small insectivorous birds (mostly warblers) breed or winter in these habitats. Numbers of some of these species are very low (Anderson and Ohmart 1975) and for all practical purposes some species would be extirpated from the lower river if cottonwood communities were eliminated.

Can anything be done and is anything being done to prevent the further loss of this resource? The U.S. Fish and Wildlife Service has recently bought the remaining cottonwood gallery forest that was not previously part of the Havasu Wildlife Refuge on the Bill Williams River and incorporated it into the refuge. Although adjacent to the Colorado, along the lower end of the Bill Williams River, there is a young gallery forest of about 700-800 acres. If this area is properly managed and prevented from burning, it should survive. Willow Valley Estates, a private housing development in the Mohave Valley was designed with open space areas and has planted natural vegetation (especially native cottonwoods). It is a small area, but some of the habitat specific bird species are found in this community. Recently, the Bureau of Reclamation has begun experimenting with the redevelopment of cottonwood-willow communities for operational enhancement and mitigational measures. Currently 25 acres of dredge spoil in the Cibola Division are being revegetated with cuttings or seedlings of native cottonwoods, willows and honey mesquite, the results look promising. A smaller area below Parker Dam also is being revegetated with cottonwoods and the young trees are doing well.

A look at the past allows us to examine changes and postulate causes. Hopefully we can then turn to the future, with the knowledge of the past, and formulate management plans so we can ultimately move with dispatch to manage and expand the availability of a valuable resource that is rapidly disappearing. To insure the preservation and perpetuation of this resource, all responsible agencies must make special efforts to preserve what cottonwood communities remain on their public trust lands and even attempt to reestablish new communities through transplants of native stock. It is expensive and requires a lot of manpower and attention but if this biotic community is to be preserved for future generations the effort must be undertaken soon.

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