Southwestern Riparian Communities: Their Biotic Importance and Management in Arizona[1]

David E. Brown [2]
Charles H. Lowe [3]
Janet F. Hausler [4]

Abstract.--The various riparian communities occuring in Arizona and the Southwest are described and their biotic importance discussed. Recommendations are made concerning the management of streamside environments and their watersheds. These include recommendations pertaining to the classification and inventory of riparian habitats; the determination of limiting factors for key riparian species; the establishment of study areas; the regulation and elimination of livestock grazing; the greater consideration of streamside vegetation in authorizing water management projects; and the more conservative use of our watersheds.

INTRODUCTION

No report on riparian habitats would be complete without a discussion of the characteristics and limiting factors of Southwestern riparian vegetation and its associated fauna. These biotic communities have an importance to wildlife and outdoor recreation greatly disproportionate to their limited linear acreage. While man's various manipulations and alterations have resulted in enormous changes in the riparian vegetation, so have his watershed practices affected riparian environments. The long-term effects of past and present land management practices are imperfectly known, but the current situation for many of our riparian communities cannot be termed less than disastrous when compared to conditions of even a short time ago (Freeman 1930, Phillips et al. 1964, Lowe 1964, Jordan and Maynard 1970, Hubbard 1971, Davis 1973, Minckley 1973, Turner 1974 and others). Some understanding of our remaining riparian communities is therefore necessary if we are to make intelligent judgments about the desirability of future watershed projects in Arizona.

The various riparian communities of Arizona may be represented as formations or vegetation types of forest, woodland, marshland, and even grassland and scrub. A riparian community or association is one that occurs in or adjacent to a drainageway and/or its floodplain and which is further characterized by species and/or life forms different from those of the immediately surrounding non-riparian climax (Lowe 1964). A riparian community may be composed either of constituents peculiar to the riparian situation, or an extension of a higher, climax association fingering downward into the drainageway; the latter type has been termed "pseudo-riparian" (Campbell and Green 1968) to distinguish its faculative nature from the obligate nature of purely riparian species. Examples of pseudo-riparian communities are (1) ponderosa pine (Pinus ponderosa) forests above the Mogollon Rim that follow canyons into the pinyon-juniper woodland, and (2) extensions of some Arizona upland desert scrub species such as palo verde (Cercidium floridum), ironwood (Olneya tesota) and saguaros (Cereus giganteus) in arroyos and along washes within creosote communities in Yuma County. Another regularly observed riparian community of this kind is the extension of encinal or oak woodlands along creeks into plains and desert grasslands in southwestern Arizona.

[1]Paper contributed to the Importance, Preservation and Management of the Riparian Habitat, July 9, 1977, Tucson, Arizona

[2]Arizona Game and Fish Department, Phoenix

[3]University of Arizona, Tucson.

[4]Rocky Mountain Forest and Range Experiment Station, Forestry Sciences Laboratory, Arizona State University, Tempe.

It is the riparian communities proper, commonly with distinctive plant and animal components not found elsewhere, that are of greatest concern here. This concern stems from their unique character and the resulting changes brought about by modern man, who has reduced and eliminated them at an alarmingly rapid rate. Hopefully an increased awareness and enlightened attitude on the part of public-spirited citizens will prevail and many of the more interesting riparian communities remaining will be available for future enjoyment and study. The following discussion and summary of these riparian communities generally follows the classification outlined in Brown and Lowe (1974).

I. Temperate Deciduous Forests and Woodlands

Warm-temperate, winter-deciduous gallery forest and woodlands, where they still occur, are the most interesting and spectacular riparian communities in Arizona. Originally, interior riparian forests occupied most of the major drainages in the Southwest from the Mohave and Sonoran Deserts through submogollon Arizona, northeastern Sonora, southern New Mexico, northern and eastern Chihuahua to the Rio Grande and its tributaries in southwest Texas. Other, cold-temperate deciduous forests occupy streamsides in montane habitats and in the Great Plains and Great Basin. These forests are maintained along perennial or seasonally intermittent streams and springs and can be divided into two major communities: mix broadleaf and cottonwood-willow. Today only a few drainage systems, such as the undammed Rio Magdalena in Sonora and (to a lesser extent) the San Pedro River in Arizona, present extensive linear riparian forest development. Where streamflows are seasonally intermittent, riparian deciduous forests can be expected only where surface runoff occurs from November through March (Zimmerman 1969, Hibbert et al. 1974) and where the advent of the spring growing season can be expected prior to April 15 (warm-temperate). After mid-April increased evapotranspiration and phytotranspiration may result in only subsurface flow, especially during daytime hours. Summer precipitation usually does not result in sustained streamflow (Zimmerman 1969, Hibbert 1971, Hibbert et al. 1974), and riparian deciduous forests in the Southwest are vernal adapted. As such, Arizona's warm-temperate forests require abundant water during March and April, when most species set seed and germinate (Zimmerman 1969). Probably for this reason, these forests are poorly represented or largely absent from the westerm pediments of the Sierra Madres in southeastern Sonora and Sinaloa, where winter-spring precipitation is less than 25 percent of the total.

Interior mixed broadleaf communities are usually found in Arizona between about 3,500 and 6,500 feet along rubble-bottomed perennial and semiperennial streams (fig. 1). They are

Figure 1.--Interior riparian deciduous forest; mixed broadleaf series along Beaver Creek, Coconino National Forest, Yavapai County, Arizona; ca. 3850 ft., July, 1971. Arboreal associates at this locality in this warm-temperate "gallery" forest are alder, walnut, ash, cottonwoods and willows. Note the luxuriant understory and streamside vegetation without the presence of livestock.

represented in the western portions of the state along Trout, Francis and Burro Creeks in Mohave and Yavapai Counties, through the submogollon region to Rucker and Guadalupe Canyons in southeastern Cochise County. Arboreal constituents may be admixtures or stands of a variety of Holarctic genera consisting of sycamore (Platanus wrighti), ash (Fraxinus pennsylvanica velutina), cottonwood (Populus fremontii, P. angustifolia), boxelder (Acer negundo), alder (Alnus oblongifolia), bigtooth maple (Acer grandidentatum), willow (Salix spp.), walnut (Juglans major), mulberry (Morus microphylla), bitter cherry (Prunus emarginata), and other deciduous species intermingled with oaks and, to a lesser extent, conifers from the adjacent mountains. Arizona cypress (Cupressus arizonica) is not infrequent. Characteristic understory species include brackenfern (Pteridium aquilinum), scarlet sumac (Rhus glabra), poison ivy (Rhus radicans) and the deciduous vines, Virginia creeper (Pathenocissus quinquefolia) and canyon grape (Vitus arizonica).

Several species of wildlife are totally or largely dependent on this community. Among these are the Arizona grey squirrel (Sciurus arizonensis), otter (Lutra canadensis), zone-tailed hawk (Buteo albonotatus), black hawk (Buteogallus anthracinus), water ouzel or dipper (Cincius mexicanus), sulphur-bellied flycatcher (Myiodyrcaster luteiventris), summer tanager (Piranga rubra), Bullock oriole (Icterus bullocki), yellow warbler (Dendroica petechial), Arizona alligator lizard (Gerrhonotus kingi), Sonoran mud turtle (Klinosternon sonoriense), and canyon tree frog (Hyla arenicolor). These communities also provide major habitat types for white-tailed deer (Odocoileus virginianus), black bear (Ursus americanus), turkey (Meleagris gallopavo), as well as a myriad of nesting and migrating raptors and songbirds. Unfortunately, intensive investigations of the populations and nesting densities are lacking for most species of wildlife in this habitat type. An important exception is the lower Gila River in New Mexico where the biota has been inventoried by Hubbard (1977). Lowered streamflow has reduced a number of forests to scattered, individual constituents (woodlands), opening the canopy and presumably reducing its desirability to wildlife dependent on this type. Flash floods, such as the notorious Labor Day flood of September, 1970, have affected many miles of this beautiful streamside forest, and grazing by livestock has reduced the quality of the forest understory almost everywhere, curtailing or eliminating reproduction of some forest species.

Excellent examples of mixed broadleaf forests are still found in Arizona along Wet Beaver Creek above Rim Rock, along Oak Creek in Oak Creek Canyon, along Ash, Redfield, Eagle and Aravaipa Creeks and the San Francisco River. A revitalized forest along Rock Creek on the Three Bar Wildlife Area in the Mazatzal Mountains is especially worthy of mention. In 1959, after the elimination of grazing about 15 years before, the majority of the chaparral watershed burned; subsequent herbicide treatment prevented the rejuvenation of the nonriparian, climax chaparral community, and the sparsely forested vegetation along the drainage was transformed into a dense, excellent representative of mixed broadleaf deciduous forest. The area now provides habitats of importance to black bear and turkey, neither of which had utilized the area before the transformation (Gallizioli 1974). Since the streamflow was transformed from ephemeral to almost perennial prior to the application of herbicides (Pase and Ingebo 1965), the determining roles of fire and range restoration need further consideration.

Forests and woodlands in Arizona dominated by cottonwood and willow (Populus fremonti Salix gooddingii, S. bonplandiana and others) are confined primarily to riparian environments below 3,500 feet on clay or other fine soil and rock deposits [1/] (fig. 2). Streamflows are perennial or nearly so. The understory may be a tangle of riparian trees or shrubs or relatively open and parklike. Once extensive, these forests have diminished greatly over the past 100 years with the diversion, interruption and elimination of streamflows. Descriptions taken from accounts telling of the extent of these forests along the Santa Cruz, Gila and Colorado Rivers prior to 1900 are indeed difficult to envision today (Davis 1973). Upstream impoundments, channel cutting, channelization, increased water salinity, irrigation diversions, and ground water pumping have made and continue to make massive inroads on these now relict communities. As in the mixed broadleaf community upstream, cattle grazing has negatively influenced the understory and the quality of remaining stands. Many remaining

Figure 2.--Interior riparian deciduous forest; Cottonwood-willow series along Aravaipa Creek, Pinal County, Arizona; ca. 2800 ft., September, 1968. Willows, principally Salix gooddingii, outnumber cottonwood in this warm-temperate forest and woodland. The principal shrub is seep-willow and because of grazing, the understory vegetation is scant as oppossed to that shown in Figure 1. Photo by Richard L. Todd.

[1]The limited woodlands of cottonwoods (Populus acuminata and others) willows (Salix lasiandra, S. lutea and others) and other deciduous trees north of the Mogollon Rim above 6,000 feet in northeastern Arizona are here considered extreme fasciations of riparian forest other than warm-temperate interior riparian deciduous forest.

mixed broadleaf riparian forests are under the jurisdiction of the U.S. Forest Service, where it is hoped future management of grazing and timber resources will give added consideration to these valuable environments (USFS 1969).

Interrupted examples of cottonwood-willow forests are still found along the Verde, Hassayampa, San Pedro, Bill Williams, Colorado and other rivers. Indications are that these communities are maintained through periodic winter-spring flooding. Stabilized water flows result in decadent stands, in which the dominant species are lacking in reproduction. Cottonwood regenerates itself principally from seed, unlike sycamore and other broadleaf riparian species that reproduce by sprouting, forming clones (Horton et al 1960). Further indications of the subclimax nature of this community are the "new" stands adjacent to portions of the Verde River and Santa Cruz Rivers, which were generated after heavy winter-spring runoffs on these drainages in 1965 and 1967 respectively. The presence of similar fasciations in California also indicates that these forests are vernal-adapted, and that late summer runoff is of little or no benefit to their regeneration.

Studies by Carothers and Johnson (1970) on the Verde River in Arizona have shown the importance of cottonwood-willow forests to breeding birds. More species are recorded as nesting in this vegetation type than any other; in Arizona several species such as the yellow-billed cuckoo (Coccyzus americanus) and blue-throated hummingbird (Lampornis clemenciae) are, for all practical purposes, restricted to it. A comparable study of the nesting birds of a cottonwood-willow community in California showed a similar importance to nesting birdlife (Ingles 1950). The importance of the cottonwood-willow community to avian species including raptors, particularly the black hawk (Buteogallus anthracinus), grey hawk (Buteo nitidus), and bald eagle (Haliaeetus leucocephhalus) is discussed by Todd (1969, 1970, 1971, 1972; Hubbard 1971) and others. The Sonoita Creek Natural Area retained by The Nature Conservancy along Sonoita Creek in Santa Cruz County is an over-mature example of the cottonwood-willow association and a mecca for observers of songbirds and other wildlife. Because of its proximity to Mexico, several peripheral species of birds such as the sub-tropical becard (Pachyramphus agaiae) are regularly observed here. The importance of these communities in maintaining environments for the Southwest's aquatic biota is imperfectly known, but studies by Minckley (1969) on Sonoita Creek and other drainages indicate that they may be of great consequence (also see Miller 1961).

II. Subtropical Deciduous Woodland

The famous mesquite bosques of pre-settlement Arizona are discussed by Brandt (1951), Phillips et al (1964), Lowe (1964), Davis (1973) and others. Unfortunately, the major bosques such as the ones at San Xavier, Komatke (New York Thicket), and Texas Hill are now mostly of historical interest (Brown 1970, 1974; Wigal 1973) (fig. 3). Remnants, some of which are nonetheless excellent examples, still occur along the San Pedro, Santa Maria and Verde Rivers, on the Robbins Butte Wildlife Area adjacent to the Gila River, along the upper middle Gila, and in scattered patches along other Lower Sonoran water courses (fig. 4). While winter deciduous, these bosques are very much subtropical and in Arizona are largely restricted to below 3,500 feet elevation within the Sonoran Desert, where they attain maximum development on the alluvium of old dissected flood plains laid down between the intersection of major watercourses and their larger tributaries (fig. 5).

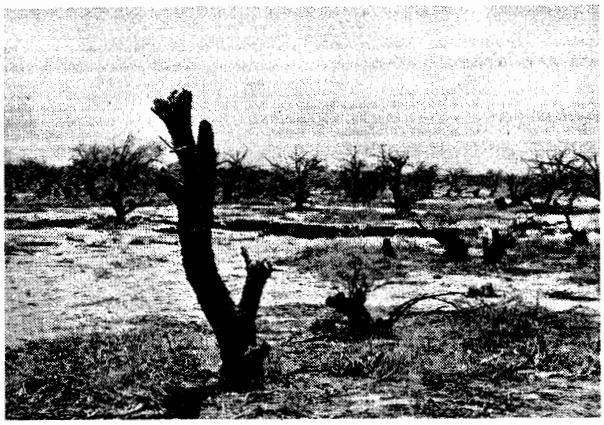

Figure 3.--Subtropical riparian deciduous woodland; remnant of the recently great mesquite bosque at Komatke (New York thicket) near confluence of the Gila and Santa Cruz Rivers, Gila River Indian Reservation, Maricopa County, ca. 1,050 ft., July, 1972. The rapidly dropping ground water table has resulted in this scene of dead and dying mesquites.

Figure 4.--Subtropical riparian deciduous woodland; interior view of mesquite bosque along San Pedro Rivers between Cascabel and Redington, Cochise County, Arizona; May, 1977. The thrifty appearance and abundant reproduction of the mesquites here is in marked contrast to most of the other bosques in Arizona. These bosques are being rapidly cleared for agriculture, however.

Figure 5.--Subtropical riparian deciduous woodland: mesquite bosque community along Gila River below its confluence with Bonita Creek, Graham County, ca. 3,100 ft., December, 1970. Note the sharp contrast between the riparian bosque and the nonriparian Sonoran desert-scrub.

In the past these subtropic woodlands were almost completely dominated by mesquite (Prosopis juliflora velutina), once containing individuals of great size (see e.g., Brandt 1951). Hackberry (Celtis reticulata), screwbean (Prosopis pubescens), and increasingly the deciduous saltcedar or tamarisk (Tamarix chinensis) may now share dominance in local situations (Bowser 1957, Robinson 1965, Turner 1974). As in areas of former cottonwood-willow forest, riparian scrub and marshland, the introduced saltcedar now often exclusively constitutes a disclimax community (fig. 6) at the expense of native plant and animal diversity (see e.g., Phillips et al. 1964, Ohmart 1973).

Figure 6.--Riparian deciduous scrubland; a subtropical disclimax consociation along the Salt River in south-central Arizona; September 1958. Scrublands and woodlands of the hybrid saltcedar (Tamarix chinensis) now occupy hundreds of miles of stream channels in the Southwest where they provide important nesting habitats for mourning doves, and in subtropical areas, mourning and white-winged doves.

Historically, saltbushes (Atriplex polycarpa, A. lentiformis), or annual and perennial grasses and forbs formed the ground cover in mature mesquite bosques; the understory was relatively open. Today, introduced annual forbs such as filaree (Erodium cicutartium), mustards (Cruciferae) and grasses, e.g. Cynadon dactylon, Bromis rubens, Schismus barbatus and others, are frequently encountered as understory species. Vines such as janusia (Janusia gracilis), canyon grape (Vitis arizonica), gourds (Cucurbita palmata) and others were, and still may be, conspicuous constituents. Individual cottonwoods, velvet ash and Goodding willow may be interspersed in more mesic sites within the bosque. Greythorn (Condalia lycioides) or a blue palo verde (Cercidium floridum) may occupy an occasional opening or sunny place.

The importance of this woodland type to colonial nesting white-winged (Zenaida asiatica) and mourning (Zenaidura macroura) doves is well documented (Neff 1940, Arnold 1943, Wigal 1973, Carr 1960 and others). Its importance to other avian species is discussed by Brandt (1951), Phillips et al. (1964), Gavin (1972) and others. This community too has suffered greatly from a variety of man-related causes including water diversion, flood control, agricultural clearing programs, and, principally, dropping water tables. This llast factor, including interrupted subsurface flow, has been responsible for the almost total destruction of the mesquite "forests" at San Xavier, Casa Grande Ruins National Monument, Komatke and Texas Hill (Phillips et al. 1964, Brown 1970, Judd et al. 1971).

The continued clearing of other bosques along the Gila and Colorado Rivers has resulted in their replacement by agricultural crops and other type conversions. It has been noted that where intermittent flooding and/or slowly receeding summer surface flow occurs, saltcedar tends to replace mesquite. This is particularly prevalent after the woodlands have been cleared or burned and ground water is close to the surface and water storage facilities and agricultural tracts are present upstream. Whether this replacement is partially due to irreversible changes in water quality and soil chemistry, or is entirely due to the inherent ability of tamarisk to repopulate floodplains rapidly, is a matter for some discussion.[2]

Saltcedar in Arizona has hybridized; it sets seed and germinates throughout the long Southwestern growing season (Horton 1960, Horton et al. 1960), and it is hypothesized that storage facilities which hold back winter-spring runoff and release water irregularly during the summer months favor the establishment of this adventive at the expense of native riparian communties. The aggressive ability of saltcedar to outcompete native riparian species after summer flooding has been well demonstrated by Turner (1974) and Warren and Turner (1975). Nonetheless, saltcedar now provides satisfactory and important nesting sites for mourning and white-winged doves (Carr 1960, Shaw 1961, Wigal 1973 and others). Several thousand acres of federal land along the Gila River, much of which is saltcedar and mesquite, have been withdrawn for these species under Public Law 1015 as the "Fred Weiler Greenbelt". Other areas receiving some degree of protection include the mesquite bosques on the Black Butte Wildlife Management Area, maintained by the Arizona Game and Fish Department, and Tonto National Forest lands along the Verde River. The high demands placed on both mesquite wood and ground water, however threaten all remaining bosques (see e.g., Lacey et al. 1975).

[2]For a discussion of the salt secretion abilities of saltcedar see Decker 1961.

III. Subtropical Evergreen Forest

This complex tropic-subtropic formation has its northern terminus in moist canyons and warm springs in and adjacent to the Sonoran Desert in Arizona and California, where it is represented by stands of California fan palm (Washingtonia filifera). In Arizona native groves--but not all individuals--are limited to two canyons in the Kofa Mountains (Benson and Darrow 1954, Smith 1974), to three sites at end near Alkali Springs in the Hieroglyphic Mountains (Brown et al. 1976) and possibly Cienega Springs near Parker (fig. 7). Because of their miniscule acreage and disjunct occurrence, these communities lack the characteristic vegetational and faunal associates of more southerly subtropic evergreen forests and possess instead distinctive Sonoran oasis associates (Vogl and McHargue 1966, Brown et al. 1976). That these relics of the Miocene and Pliocene remained at all in Arizona was due to the continual presence of abundant subsurface waters in favored tropic-subtropic microenvironments. One also suspects that the adaptibility of this species to alkaline waters may have been a competitive advantage with certain warm temperate forms.

Figure 7.--Subtropical riparian evergreen forest; California fan palm series at Cienega Springs, Yuma County, Arizona. Abundant reproduction frequently characterizes native palm groves in Arizona; the fan palms, tolerant of alkaline waters, have outcompeted their cottonwood-willow competitors over the years at this and other sites.

California fan palms are attractive trees, and their adaptibility to cultivation has made them an ubiquitous ornamental landscape feature throughout the Southwest. The few native communities are considered botantical phenomena to be maintained with a minimum of disturbance. The palms in Palm Canyon, Hidden Canyon and elsewhere have had their shag of dead fronds burned but otherwise appear in good condition, with some reproduction noted. Palm groves and individuals in the Kofa Mountains are within the Kofa Game Range and are under the jurisdiction of the United States Fish and Wildlife Service. The palms at Alkali Springs and Cienega Springs are privately owned.

IV. Riparian Scrublands

While riparian scrub communities cover extensive areas of stream channels and flood plains, scientific investigations and resource managers have generally ignored them and concentrated on the more interesting and diverse communities upstream and downstream. They are, nonetheless, both interesting and important.

Above 8500 feet, a boreal riparian scrub is usually present along subalpine streams and in some wetlands. These scrublands are dominated by scrub willows (Salix bebbiana, S. scouleriana), although red-osier dogwood (Cornus stolonifera), blueberry elder (Sambucus glauca), rocky mountain maple (Acer glabrum) and thin-leaf alder (Alnus tenuifolia) may be locally important, particularly downstream as one approaches and enters more cold temperate conditions (fig. 8). Occasional trees such as blue spruce (Picea pungens) and aspen (Populus tremuloides) may stand out within the scrub. These streamside scrublands are nesting habitat for dusky flycatchers (Empidonax oberholseri), MacGillivary warblers (Oporornis tolmiei), orange-crowned warblers (Helminthophila celata), broad-tailed hummingbirds (Selasphorus platycercus), white-crowned sparrows (Zonotrichia leucophrys) and Lincoln sparrows (Melospiza lincolni). The perennial streams are themselves the habitat of the native Arizona trout (Salmo apache) and the now ubiquitous rainbow (Salmo gairdneri). These stream habitats are subject during the summer months to extensive and intensive livestock grazing, including use by sheep. Stream quality has also been altered by logging activity on adjacent watersheds, a situation which can be expected to increase with the demand for timber resources.

In temperate and subtropic situations in intermittent and perennial stream channels and in and along flood channels one also encounters riparian scrublands (fig. 9). Stream flows in these types are irregular and often occur in the form of flash floods. Dominant species are frequently but not necessarily seepwillow or batamote (Baccharis glutinosa), broom (Baccharis sarothroides or B. emoryi), arroweed (Pluchea sericea), and, increasingly, saltcedar. The reasons for the increase in saltcedar at the expense of the native seepwillow since 1940 have been discussed earlier and are well documented by Horton et al. 1960, Zimmerman 1969, Turner 1974, and Warren and Turner 1975. Riparian scrub may exhibit a dense "chaparral" aspect--scrubland--or present a very open one--desertscrub. Desert willow (Chilopsis linearis), mesquite, catclaw (Acacia greggi) and other arboreal species are frequent associates and may share aspect dominance. These trees as well as those of the riparian deciduous forest, if present, provide less than 15 percent of the ground cover. Faunal relationships within these riparian communities are poorly investigated, but there appears to be a considerable interaction with greater or lesser populations of adjacent or upslope nonriparian species. Bird species particularly well represented in riparian scrub include the Say's phoebe (Sayornis saya), crissal thrasher (Toxostoma dorsale), black-tailed gnatcatcher (Polioptila melanura), phainopepla (Phainopepla nitens) and the brown towhee (Pipilo fuscus). To date, little attempt has been made to "manage" these habitats.

Figure 8.--Montane riparian deciduous scrubland; Mixed series along the North Fort of White River, Fort Apache Indian Reservation; ca. 7500 ft., July, 1977. Prevalent and dominant plants here include two willows, thin-leaf alder, blueberry elder, and hawthorn (Crataegus erythropoda).

Figure 9.--Evergreen riparian scrubland in the channel of the San Carlos River, San Carlos Indian Reservation; ca. 3200 ft., March, 1975. The thick "Chaparral" in foreground is largely seep-willow or batamote. The deciduous scrub is mostly saltcedar. Note the decadent stand of cottonwood along the bank in the distance.

Figure 10.--Saltwater marshland; Saltgrass series at Obed Meadows, Navajo County, Arizona. Saltgrass occupies wetland and riparian areas throughout Arizona's subtropic and temperate zones wherever alkaline habitats exist. The deciduous trees in background are the now ubiquitous saltcedar.

V. Marshlands

These wetland formations may be comprised if any of several boreal, temperate or subtropical emergent communities and are defined as aquatic communities, the principal plant constituents of which are emergents not trees, woody shrubs, or nonhalophytic grasses [3], and which normally or regularly have their basal portions annually, periodically or continually submerged. In the Southwest these include communities in both fresh or brackish water environments. They range from the more xeric and alkali communities of salt grass (Distichlis stricta), and alkali bulrush (Scirpus paludosus) through the carrizo or reed communities (Phragmites communis) of the Colorado River and elsewhere to mesic freshwater communities of rushes (Juncus spp.), sedges (Carex spp.). bulrushes (Scirpus spp.) and cattail (Typha spp.) (fig. 10, 11).

Figure 11.--Freshwater marshland; Topock Marsh looking north from north dike, Mohave County, ca. 550 ft. Bullrush and cattail are the principal vegetational constituents in foreground. This famous marsh is one of the few remaining on the Colorado River and is an important breeding area for the Yuma clapper rail. Photo by Richard L. Todd

[3] Riparian grasslands of sacaton (Sporobolus wrightii), tobosa (Hilaria mutica) and other communities, while not discussed, occur in Arizona and the Southwest. See Lowe (1964) for a discussion of tobosa swales. Saltgrass communities are treated here as part of the marshland formation.

These rapidly disappearing communities are found in riparian and littoral situations only where streamflow is turgid, shallow and dependable enough to permit their establishment. Since they are the most mesic of Arizona's vegetational and biotic communities, they have suffered most from the resultant desiccation of the state's natural environment through water diversions and water "management" projects (see e.g., Ohmart ca. 1974). The few riparian marshland communities that remain are habitats for a number of species of Arizona's rare and vanishing wildlife, such as the Yuma clapper rail (Rallus longirostris), black rail (Laterallus jamaicensis), bitterns (Ixobrychus exilis, Botaurus lentiginosus), and Mexican duck (Anas diazi) (Todd 1972a). Numerous other rails, shorebirds, and waterfowl are highly dependent on these diverse environments, both during nesting and migration (Todd 1972a). These marshland oases are now frequently dependent on stored and/or recycled argricultural and industrail waste waters from diverted upstream flow. Examples in Arizona are Picacho Lake in Pinal County and Quigley Pond on the Gila River in Yuma County (see also Brown et al. 1977). Exceptions are a few sloughs and old oxbows of the San Pedro, lower Salt, Verde and Colorado Rivers, almost all of which are threatened by existing or planned projects. It is also an ironic fact that Arizona's most valuable wildlife habitats are too frequently subjected to trampling and grazing by livestock, in addition to hydrological limitations.

VI. Recommendations

It has become increasingly evident that the most valuable and interesting of Arizona's streamside environments are greatly in need of more enlightened management of both the actual riparian communities and the watersheds upon which they depend. Their present limited acreage and importance to endangered, threatened, and peripheral wildlife species have prompted a growing concern by wildlife-oriented groups and individuals in addition to the concern long voiced by professional biologists. This concern has now manifested itself in the political arena and requires that our riparian environments receive greater consideration from resource management agencies.

The following recommendations are suggested to perpetuate and enhance those riparian communities of greatest value to wildlife and public interest:

1. Identify and classify Arizona's riparian environments. Identification and mapping of streamside vegetation is presently either being considered or in the process of inventory by land management agencies, other public agencies, academic groups and ad hoc consultants. These efforts should be coordinated and classifications of the various types determined. A statewide inventory, including maps, of remaining habitats should be prepared and published.

2. Investigate factors determining the limiting specific riparian constituents and communities. The environmental requisities and limits of many of the major riparian plant species must be determined, at least in part. These would of necessity be long-range and continuous studies to provide an understanding of the factors controlling the various communities and their constituents. Only then can we hope to preserve and manage our riparian constituents through regulated discharges of water from reservoirs, selective cutting and other techniques.

3. Establish representative study areas containing all major riparian communities and their surface and groundwater requirements. In addition, as reserves these areas would provide "bench marks" and controls for comparison with "managed" or other "modified" ecosystems.

4. Grazing and other distruptive influences should be eliminated or controlled in riparian forests, woodlands and marshlands. Many of these have had their public values compromised through the degradation of their flora and fauna. Areas presently supporting little or no understory and showing no reproduction of major riparian constituents should be restored where still possible.

5. Riparian and watershed management project planners should reconsider the values both actual and potential of streamside vegetation before irreversible alterations. Several "phreatophyte clearing" projects have resulted in unwarranted destruction of native riparian associations with little or no documented water "salvage" or other claimed conservation measures accomplished (Campbell 1970, Horton 1972, Patrick 1971).

6. Increase the effort to avoid torrential summer and fall flooding through more conservative use of grazing and timbering watershed resources. Shrub invasions of Southwestern watersheds, due to livestock grazing pressures and suppression of fire, have long been documented (see e.g., Leopold 1924, Humphrey 1958). Through proper management, streamflows can be stabilized and increased to the benefit of our riparian resources. These management techniques should be applied now throughout our rapidly deteriorating Southwest riparian wonderland.

LITERATURE CITED

Arnold, L.W. 1943. A study of the factors influencing the management of and a suggested management plan for the western white-winged dove in Arizona. Ariz. Game and Fish Comm. 103 p.

Benson, L. and R. A. Darrow. 1954. The trees and shrubs of the Southwestern Deserts. 2nd ed. Univ. of Ariz. Press, Tucson, and Univ. New Mexico Press, Albuquerque. 437 p.

Brandt, H. 1951. Arizona and its birdlife. Bird Research Foundation, Cleveland, Ohio. 723 p.

Brown, D.E. 1970. Summary of white-winged dove banding and hunt information. Proj. W-53-R-20: WP3, J2. Spec. Rep. 1961-1969. Ariz. Game and Fish Dep. 28 p.

Brown, D.E. and G.C. Sanderson. 1974. White-winged dove (Zenaida asiatica) In Management of Migratory Shore and Upland Game Brids in North America. The Intern. Assoc. of Fish and Wildl. Agencies, Washington, D.C. p. 246-272.

Brown, D.E. and C.H. Lowe. 1974. A proposed classification for natural and potential vegetation in the Southwest with particular reference to Arizona. J. Ariz. Acad. Sci. 9(2). 11 p.

Brown, D.E., N.B. Carmony, C.H. Lowe, and R.M. Turner. 1976. A second locality for native California fan palms (Washintonia filifera) in Arizona. J. Ariz. Acad. Sci. 11(1): 37-41.

Brown, D.E., N.B. Carmony, and R.M. Turner. 1977. Drainage map of Arizona showing perennial streams and some important wetlands. Map. Proj. W-53-R, Ariz. Game and Fish Dep.

Bowser, C.W. 1957. Introduction and spread of the undesirable tamarisks in the Pacific southwestern section of the United States and comments concerning the plants influence upon the indigenous vegetation. Trans. of Amer. Geophy. Union. 38(3). 7 p.

Campbell, C.J. 1970. Ecological implications of riparian vegetation management. J. of Soil and Water Conserv. 25(2):49-52.

Campbell, C.J., and W. Green. 1968. Perpetual succession of stream-channel vegetation in a semi-arid region. J. Ariz. Acad. Sci. 5(2) 96-98.

Carothers, S.W. and R.R. Johnson. 1970. A summary of the Verde Valley breeding bird survey, 1970. Mus. of Northern Ariz. 13 p.

Carr, J.N. 1960. Mourning dove whitewinged dove nest surveys during the summer of 1960. Proj. W-53-R-11; WP3, J2. 6 p.

Davis, G.P. 1973. Man and wildlife in Arizona: the pre-settlement era, 1823-1864. Master of Sci. Thesis, Univ. of Ariz.

Decker, J.P. 1961. Salt secretion by Tamarix pentandra Pall. Forest Sci. 7;214-217.

Freeman, L.R. 1930. Down the Grand Canyon. Dodd, Mead and Co., N.Y. 371 p.

Gallizioli, S. 1974. Personal communication. Ariz. Game and Fish Dep.

Gavin, T.A. 1972. Avian and mammalian species composition in a mesquite bosque. Proj. 73, Quart. Rep. Ariz. Coop. Wildl. Res. Unit, Univ. of Ariz. unpubl.

Hibbert, A. R. 1971. Increases in streamflow after converting chaparral to grass. Water Resour. Res. 7(1):71-80.

Hibbert, A.R., E.A. Davis and D.G. Scholl. 1974. Chaparral coversion potential in Arizona, Part 1:water yield response and effects on other resources. USDA For. Serv. Res. Pap. RM-126, Rocky Mt. For. and rAnge Exp. Sta., Fort Collins. 36 p.

Horton, J.S. 1960. Ecology of salt cedar. In Watershed and Related Water Management Problems. Proc. 4th An. Ariz. Watershed Symp., Phoenix.

Horton, J.S., F.C. Mounts and J.M. Kraft. 1960. Seed germination and seedling establishment of phreatophyte species. USDA For. Serv. Sta. Pap. 48. Rocky Mt. For. and Range Exp. Sta., Fort Collins. 26 p.

Horton, J.S. 1972. Management problems in the phreatophyte and riparian zones of the Southwest. J. of Soil and Water Conserv. 27(2):57-61.

Horton, J.S. and C.J. Campbell. 1974. Management of phreatophyte and riparian vegetation for maximum multiple use values. USDA For. Serv. Res. Pap. RM-117. Rocky Mt. For. and Range Exp. Sta., Fort Collins. 23 p.

Hubbard, J.P. 1971. The summer birds of the Gila Valley, N.M. Occa. Pap. of the Delaware Mus. of Nat. His., Nemouria 2:1-35.

Hubbard, J.P. 1977. A biological inventory of the lower Gila River, N.M. Bur. of Land Manage. Bur. of Rec., New Mexico Dep. Game and Fish, Soil Conserv. Serv., U.S. Fish and Wildl. Serv. and U.S. For. Serv. 56 p.

Humphrey, R.R. 1958. The desert grassland. A history of vegetational change and an analysis of causes. Bot. Rev. 24(4):193-252.

Ingles, L.G. 1950. Nesting birds of the willow-cottonwood community in California. Auk 67(3).

Jordan, G.L. and M.L. Maynard. 1970. The San Simon watershed, historical review. Prog. Agric. in Ariz. 22(4):6-9.

Judd, I.B., J.M. Laughlin, H.R. Guenther and R. Handegarde. 1971. The lethal decline of mesquite on the Casa Grande Ruins National Monument. Great Basin Nat. 31(3).

Leopold, A. 1924. Grass, brush, timber and fire in southern Arizona. J. of For. 22(6):1-10.

Lacy, J.R., P.R. Ogden and K.E. Foster. 1975. Southern Arizona riparian habitat:spatial distribution and analysis. School of Renew. Nat. Resour. and Office of Arid Lands Studies. OALS Bull. 8:1-148.

Lowe, C.H. 1964. Arizona's natural environment; landscape and habitats. Univ. of Ariz. Press, Tucson. 270 p.

Miller, R.R. 1961. Man and the changing fish fauna of the American Southwest. Papers Michigan Acad. Sci., Art. Lett. 46:365-404.

Minckley, W.L. 1969. Aquatic biota of the Sonoita Creek Basin, Santa Cruz County, Ariz. Ecol. Studies Leaflet, No. 15. The Nature Conservancy. 8 p.

Minckley, W.L. 1973. Fishes of Arizona. Ariz. Game and Fish Dep., Phoenix. 293 p.

Neff, J.A. 1940. Range, population and game status of the western whitewinged dove in Arizona. J. Wildl. Manage. 4(2):117-127.

Ohmart, R.D. 1973. Observations on the wintering birds and mammals in the proposed Buttes Dam site, Central Ariz. Proj. Bur. Reclam., Boulder City, Nev. 16 p.

Ohmart, R.D. 1974 (ca.) Dynamics of marsh land formation and succession along the lower Colorado River and their importance and management problems as related to wildlife in the arid Southwest. Bur. of Reclam. Preprint 1-21.

Pase, C.P. and P.A. Ingebo. 1965. Burned chaparral to grass: early effects on water and sediment yields from two granite soil watershed in Arizona. Proc. Ariz. Watershed Symp. 9.

Patrick, R. 1971. The effects of channelization on the aquatic life of streams. Acad. of Nat. Sci. of Philadelphia. 12 p.

Phillips, A., J. Marshall and G. Monson. 1964. The birds of Arizona. Univ. of Ariz. Press, Tucson 212 p.

Robinson, T.W. 1965. Introduction, spread and areal extent of salt cedar (Tamarix) in the western states. Studies of Evapotranspiration Geol. Surv. Prof. Pap. 491-A.

Shaw, H. 1961. Influence of salt cedar on whitewinged doves in the Gila Valley. Spec. Rep., Ariz. Game and Fish Dep. 9 p.

Smith, E.L. 1974. Established natural areas in Arizona--A Guidebook for scientists and educators. Office of Econ. Plan. and Develop. Phoenix, 300 p.

Todd, R.L. 1969. Nongame investigations. Proj. W-53-R-19; WP5, J1. Prog. Rep. Ariz. Game and Fish Dep. 26 p.

Todd, R.L. 1970. Nongame investigations. Proj. W-53-R-20; WP5, J1. Prog. Rep., Ariz. Game and Fish Dep. 16 p.

Todd, R.L. 1971. Nongame investigations. Proj. W-53-R-21; WP5, J1. Prog. Rep., Ariz. Game and Fish Dep. 11 p.

Todd, R.L. 1972. Nongame investigations. Proj. W-53-R-22; WP5, J1. Prog. Rep. Ariz. Game and Fish Dep. 22 p.

Todd, R.L. 1972a. Biological report on a marsh near Tuzigoot National Monument. Proj. W-53-R-23; WP5, J1. Spe. Rep., Ariz. Game and Fish Dep. 4 p.

Turner, R.M. 1974. Quantitative and historical evidence of vegetation changes along the upper Gila River, Arizona. U.S. Geol. Surv. Prof. Pap. 655-H. 20 p.

U.S. Forest Service. 1969. Wildlife Habitat improvment handbook. USDA For. Serv.

Vogl, R.J. and L.T. McHargue. 1966. Vegetation of California fan palm oases on the San Andreas fault. Ecol. 47:532-540.

Warren, D.K. and R.M. Turner. 1975. Saltcedar (Tamarix chinensis) seed production, seedling establishment, and response to inundation. J. Ariz. Acad. Sci. 10(3):117-119.

Wigal, D.D. 1973. A survey of the nesting habitats of the whitewinged dove in Arizona. Spec. Rep. No. 2, Ariz. Game and Fish Dep. 37 p.

Zimmerman, R.C. 1969. Plant ecology of an arid basin Tres Alamos--Redington areas. U.S. Geol. Surv. Prof. Pap. 485-D. 51 p.