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THE EFFECTS OF HUMAN-INDUCED CHANGES ON THE AVIFAUNA OF WESTERN RIPARIAN HABITATS

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Abstract. Western riparian habitats have suffered significant degradation and loss from human activities. I estimate that 95% of the riparian habitats in the west have been either altered, degraded, or destroyed in the past 100 years. Riparian habitats represent about 1% of the total western landscape, yet support avian values equal to or in excess of the richest avian habitats in the continental United States. Many agents have degraded or destroyed riparian habitats but the most important are water management, agriculture, and domestic livestock grazing. The first two have run their course and their future impacts will be minimal. The latter is significant and is the most insidious threat to riparian habitats and their avifauna. Where short stream reaches have been given better management or where livestock have been excluded, the recovery has been phenomenal. Many endangered species and neotropical migrants in the west are only found in riparian habitats. Data are lacking to clearly tie the degradation and loss of these habitats to declining numbers of neotropical migrants except in well-studied examples, e.g., the lower Colorado River. If the western avifauna is to remain intact, public agencies must improve their conservation and land management practices.

Key Words: Agriculture; domestic livestock grazing; riparian degradation; riparian habitats; riparian restoration; water management.

This paper examines avifaunal habitat changes caused by major human-induced environmental modifications of riparian habitats in the 11 western states. By major induced changes, I include water management activities (dams, reservoirs, instream flow reductions, flood control and dewatering of rivers), domestic livestock grazing, and agriculture. Others are recreational activities, mining, and timber harvesting, but because of space limitations they are not considered. Not all of these activities have had equal impacts, but all have been significant. Some losses may be offset with revegetation efforts, some are near or beyond rectification, and, in some cases, reversal is possible with simple management changes. If the western North American avifauna, as we know it, is to be conserved for future generations then wise use of riparian habitats is essential. A minimum of 95% of the riparian habitats in the west have been lost, altered, or degraded by human-induced change. Along the lower Colorado River alone over 95% of the native gallery forest has been extirpated and the existence of many bird species is in jeopardy (Rosenberg et al. 1991).

Riparian habitat refers to the alluvial floodplain along either side of the channel (permanent or intermittent flow) and the vegetation growing there. Arid-adapted upland species are prevented from encroaching into the floodplain because of intermittent flooding, high water table levels, and high available soil moisture. Riparian vegetation is prevented from entering the uplands because of lack of available soil moisture. In arid environments, the transition between riparian and upland habitats is usually less than a meter.

Riparian plant species have their roots located in the capillary fringe just above the water table and generally are confined to floodplain habitats. Mesquites (*Prosopis* spp.) are located on higher or second terraces where flooding does not occur annually, and when it does its duration is less than two weeks. Mesquites may also occur in the upland, where its stature is that of a small shrub. Cottonwoods (*Populus* spp.) and willows (*Salix* spp.) occupy lower or first terraces along the stream. They normally occur along permanent streams but will occasionally grow along intermittent streams, if the water table is near the channel surface, even though the channel is dry. Depth to the water table is critical to the occurrence of a number of riparian trees and shrubs.

Most riparian trees and shrubs do poorly in soil or water where the salinity approaches or exceeds 3 electroconductivity units (ECs). There are some exceptions, and most of those species are in the Chenopodiaceae. Most riparian plants evolved with low salinity water and melting spring snow pack generally producing annual floods.

Annual floods are a key element to healthy, functioning riparian systems. Floods deposit new alluvial soils, cover or wash away organic material, irrigate and bring new soil nutrients onto the floodplain, and leach accumulated salts toward the stream and eventually out of the system. If the flood event is heavy the channel may move by eroding on one side and depositing new materials on the other. Riparian vegetation is adapted to pioneering into new soils with rhizomes, stolons, and wind- and water-disseminated seeds. Seedlings quickly become established on wet soils with high water tables and begin stabilizing newly deposited soils.

RIPARIAN VEGETATIVE COMPONENTS MOST IMPORTANT TO BIRDS

In our studies of riparian habitats along the lower Colorado River in western Arizona, my colleagues and I attempted to determine the vegetative components most important to birds. We hoped to build habitats that possessed all necessary components, yet transpired less water and had less resistance to flow during floods than native or natural communities.

To achieve this we sampled bird species composition and densities along 800-m or 1600-m lines three times each monthly for more than ten years. More than 100 census lines were located in relatively homogeneous plant communities between Davis Dam and the U.S.–Mexico boundary (443 km). We also quantified numerous vegetation variables in each censused area, so that we could test vegetation variables with avian use values. We counted trees and shrubs in belts along each entire census line, including data on height, species, and if parasitized by mistletoe (*Phoradendron californicum*).

We were able to identify the most important plant community components for birds in general, and in many instances specific components for individual species. These components, in approximate order of importance, are tree species and densities, foliage height diversity, foliage volume, patchiness, habitat patch size, shrubs and shrub densities, and mistletoe.

Importance of specific tree species and their densities is a component that has not been examined in other avian community studies. We documented the importance of this variable by comparing tree species' influence on horizontal and vertical patchiness and foliage volume. Bird species responded with greater frequency to number of particular tree species than any other variable (Rice et al. 1984). This is not surprising, since the avifauna evolved with specific tree species, which provide nest sites, forage areas, and cover. Exotic trees such as athel tamarisk (*Tamarix aphylla*) may have similar vertical profiles, foliage volumes, and horizontal patchiness but never attain the same avian values as forests of cottonwoods (*Populus fremontii*) and willows (*Salix gooddingii*). Although I specifically reference desert riparian tree species, other species in the genera *Populus* and *Salix* are also extremely important to birds (Thomas 1989, Winternitz 1980, Winternitz and Cahn 1983).

The vertical foliage profile comprises the horizontal layers of vegetation in a particular plant community. Each layer tends to have a cadre of species associated with it (Ohmart and Anderson 1982), and if that layer is missing ten or more species of birds will generally not be found. In our Colorado River studies we found that birds responded to four layers of vegetation. Nineteen species are associated with the canopy or overstory layer ($\geq$7.6 m), 10 species with the

4.6–7.6 m layer, 13 species with the 1.5–4.6 m layer, and 11 species with the 0.15–1.5 m layer. The overstory was composed of foliage specialists that were generally missing when this layer was absent or poorly represented (Ohmart and Anderson 1982).

Foliage volume is the amount of surface area of vegetation per cubic volume of space. Because it is related to insect abundance (Anderson and Ohmart, unpubl. data) the greater the amount of vegetation in each of the vertical layers, the higher the density of most birds. Some species appear to need dense vegetation to create suitable habitat. This appears to be most critical in the overstory layer in desert riparian habitats, where many of the visiting insectivorous breeding birds nest in the hottest summer months. This dense canopy layer appears to be vital in ameliorating summer temperature extremes (Hunter 1988).

Intracommunity patchiness or the differential height of tree tops in a mixed-tree species forest creates high patchiness values. Exactly why this attracts more bird species is conjecture, but patchy environments support more species than monocultures with low patchiness values (Ohmart and Anderson 1982).

Habitat patch size is an important avian component in continuous forest habitats (Blake and Karr 1984, Temple and Cary 1988, Faaborg et al. 1989) and it appears to be as well in riparian habitats, with large blocks containing higher avian values than those of 0.5 ha or less (Anderson and Ohmart 1985).

Many shrubs play important roles in attracting birds. Quail bush (*Atriplex lentiformis*) attains heights of 3–4 m and a mature plant may cover a 10-m^2 area. The dense evergreen foliage disallows light penetration and drying of the litter accumulated under the shrub. Thrashers, towhees, quail, and other ground-foraging birds feed on the insects in the litter and use the dense foliage as escape cover and shade (Anderson et al. 1978, Anderson and Ohmart 1985). Foliage-gleaning insectivores are heavily attracted to the abundant insect fauna on the leaves, which are retained in winter. The litter and foliage insects are important food resources for wintering birds, while the dense foliage provides roosting cover. Wolfberry (*Lycium* spp.) has similar values to birds except that it is a much smaller plant. The berries produced in the spring are relied on heavily by frugivorous birds. Moderate densities of quail bush and wolfberry greatly enhance riparian values for birds (Anderson and Ohmart 1985).

Infestations of mistletoe in honey mesquite (*Prosopis glandulosa*) communities along the lower Colorado River may add as many as seven or eight species to this community type (Anderson and Ohmart, unpubl. data). Phainopepla (*Phainopepla nitens*), Northern Mockingbird (*Mimus polyglottos*), Cedar Waxwing (*Bombycilla cedrorum*), Western Bluebird (*Sialia mexicana*), American Robin (*Turdus migratorius*), and Sage Thrasher (*Oreoscoptes montanus*) rely on the fruit of this plant during the winter months. Mistletoe and other berries make up ≥90% of the above species' winter diet.

IMPORTANCE OF RIPARIAN HABITATS TO BIRDS

Riparian habitats, though tiny in area, have been reported to support as many breeding pairs of birds/unit area as the best avian habitats in the United States (Carothers et al. 1974, Stamp 1978). Johnson et al. (1977) reported that of 166 breeding species in west Texas, southern New Mexico, and southern Arizona 51% were completely dependent on riparian habitats, while another 20% were partially dependent on it. In California, Gaines (1977) reported that 43% of the species breeding in cottonwood-willow-dominated habitat had "a primary affinity" to this habitat type. The cottonwood-willow habitat along the Verde River in central Arizona provided the only breeding habitat for over 50% of the total species breeding in that riparian environment. Across an altitudinal cline between 1200 m and 2750 m, Knopf (1985) reported in a two-year study which examined over 100 species that 82% of all species were observed in riparian sites. In southeast Oregon riparian areas were of principal importance for 62% of the birds (Kindschy 1978).

More impressive than citing literature is to ask yourself, where have I gone birding in the west and seen the greatest number of species at highest densities? In Arizona that is easily answered with Cave Creek in the Chiricahua Mountains, Sonoita Creek near Patagonia, Ramsey Canyon in the Huachuca Mountains, the San Pedro River in southeastern Arizona, or the Verde River in central Arizona. Flycatchers, trogons, many hawks, hummingbirds, becards, and others are found primarily along our riparian habitats in Arizona.

Has riparian habitat loss and degradation been so severe that the future of this large segment of birds that are dependent on this habitat is in jeopardy? An honest answer is that we are not sure, but many riparian species are in trouble. For example, the Summer Tanager (*Piranga rubra*) and Yellow-billed Cuckoo (*Coccyzus americanus*) have been virtually extirpated from the west coast and the lower Colorado River (Rosenberg et al. 1991), and the latter is declining throughout the west (W. C. Hunter, pers. comm.). The *extimus* race of the Willow Flycatcher (*Empidonax traillii*) is a Candidate 1 Species on the endangered species list and soon to be listed. Most state game and fish agencies have listings of birds they consider endangered (Atwood 1994). In Arizona, 40% of the birds on the list are riparian species (T. Corman, pers. comm.) and in New Mexico over 50% of the species are aquatic or riparian (J. Hubbard, pers. comm.).

Recently, much concern has been expressed over declining populations of neotropical migratory birds (Morton and Greenberg 1989, Askins et al. 1990), which have been linked to human-induced activities such as tropical deforestation, forest fragmentation, and general habitat loss. In the west there are two major habitats that support the main breeding populations of these migrants—riparian habitats and montane forests. Riparian habitats have suffered dramatically from the above activities and continue to do so. Desert riparian forests are tropical deciduous woodlands with subtropical affinities (Lowe and Brown 1982). The Arizona Nature Conservancy (1987) listed the cottonwood-willow forest as the rarest forest community type in North America.

CHANGES INDUCED BY WATER MANAGEMENT TECHNIQUES

A constant supply of water is essential to human survival in the arid west. The most successful settlements have been built along riparian systems that provide a dependable water source. The vegetation along the streams is generally viewed as a nuisance or food for domestic livestock.

Reservoirs

Exploitation of the west began slightly before the turn of the century. Because agriculture expanded on rich alluvial soils, the problems of a constant water supply and the annual threat of floods were resolved with storage reservoirs; virtually every major stream in the west has one or more. Most in the west were built in large bowl-like settings, and have large surface areas that promote high annual evaporative water losses. Fradkin (1984) reports that almost a million acre-feet of water is lost annually from Lake Mead. This water exits as distilled water, leaving the salts behind. The higher salinity water is released for downstream use, impairing the survival of most riparian plants.

Dams create a multitude of problems for riparian habitats and are essentially the death knell for two of the most valuable avian habitat components—cottonwoods and willows and vertical profile. Initially the backed-up water floods and kills all the vegetation and the dam itself stops natural flooding, which is essential to cottonwood and willow reproduction. If floods (now termed controlled-releases from dams) do occur they are usually 1) too late for successful reproduction of trees or 2) of such long duration that native vegetation drowns in the process (Hunter et al. 1987, Rosenberg et al. 1991).

Water releases are generally predicated on downstream needs for irrigation, cities, or power generation. Because floods that watered the alluvial floodplain have been stopped, minimum releases cause the water table to be lowered, which further stresses the downstream vegetation. With time a high vertical profile forest of ≥30 m cottonwoods and willows will be reduced to tree species seldom exceeding 10 m and with lower foliage volumes.

An example of the effects of water management activities can be seen in a number of neotropical migrants on the lower Colorado River. Dams eliminated cottonwood-willow reproduction, increased salinities, reduced instream flows, and allowed many mature tree communities, which were robbed of floods that wash litter away, to succumb to fires. The steamboat era in the late 19th century significantly reduced mature soft-wood species for fuel use, but historical photographs and written testimony demonstrate abundant cottonwood-willow regeneration all along the river up until Hoover Dam was operational in 1936 (Ohmart et al. 1977). Bird census data collected monthly from over 10 years in the 1970s and 1980s spell out the rapid demise of many avian species (Rosenberg et al. 1991).

Swarth (1914) reported the Yellow-billed Cuckoo as fairly common along the Gila and lower Colorado River drainages. The Yellow-billed Cuckoo showed a 93% decline from 242 birds in 1976 to 18 in 1986. The breeding race of the Willow Flycatcher had already been extirpated when our work began. The breeding habitat in which I have observed this species consists of dense and patchy mature willows with very moist, even boggy soil conditions. These habitats probably disappeared from the Colorado River in the 1950s and 1960s, when there was intensive dredging and channel straightening. Vermilion Flycatchers (*Pyrocephalus rubinus*) were reported by Grinnell (1914) as common and he predicted this species would become more common as patches of forest were opened. He failed to realize either the extent to which the forest would be cleared or the drying that would occur from channelization. This species now numbers about ten pairs from Yuma, Arizona, to Needles, California. In 1976, we recorded 203 Bell's Vireos (*Vireo bellii*); in 1988 the population was down to 88. The prolonged water releases in the mid-1980s led to very high water tables, which killed much of the preferred habitat for this species.

As habitats are modified, the results are negative for some species but positive for others. Grinnell (1914:72–73) observed, "the little open water sometimes attracted a few transient ducks and mudhens, but so far as known no water birds outside the Ardeidae remain to breed anywhere along the Colorado River." From his notes in 1910 and our river census data in 1978 we were able to compare waterfowl changes that occurred in that period. A selected few that Grinnell did not report but that we found in relatively high numbers were 620 American Wigeon (*Anas americana*), 276 Bufflehead (*Bucephala albeola*), 1743 Common Goldeneye (*B. clangula*), and 591 Common Merganser (*Mergus merganser*). Grinnell observed eight species, whereas we observed 19, whose total population was 5238 individuals (Anderson and Ohmart 1988, Ohmart et al. 1988). There are numerous other waterbirds, both wading and deep-water, that are attracted to the reservoirs that now dot the Colorado River (Rosenberg et al. 1991). Also, as marsh habitats developed along canals and in deltas behind dams, a race of Clapper Rail (*Rallus longirostris yumanensis*) spread north from the Colorado River Delta in Mexico (Ohmart and Smith 1973). The secretive Black Rail (*Laterallus jamaicensis*) also found habitat created by water storage seeps near Imperial Dam

(Repking and Ohmart 1977). Unfortunately, the zenith of waterfowl numbers has passed, as recreational and homesite development reduce the habitat availability of these species. The Clapper Rail may be at the beginning of its decline as selenium values approach and exceed safe reproductive levels (Radtke et al. 1988, Kepner, unpubl. data).

Once a dam was in place, more sophisticated water managers sought channelization to straighten the river, which more expeditiously lowered the water table. The next step was stripping the bank of vegetation, then shaping the sloughing banks, and finally riprapping or cementing the soil to reduce dredging costs. Dredge spoil material was generally placed in low wet areas, frequently old oxbows or backwaters that supported emergent vegetation.

In the 1960s, engineers began viewing large trees along rivers as wasting or transpiring large quantities of water. The theory, for which there are no definitive data, was that by removing the tree or wick, water would be saved for beneficial use downstream. For the next 20 years many trees were removed by federal agencies. Even today, thousands of hectares along the Pecos River in New Mexico are cleared of riparian vegetation to conserve or salvage water (Hildebrandt and Ohmart 1982).

Dewatering of rivers very quickly eliminates native trees and favors the shorter-statured exotic saltcedar (*Tamarix chinensis*). Fortunately, this activity has not been widespread, but portions of the Gila River in western Arizona and >443 km of the Rio Grande in west Texas are dewatered. Even in a highly deteriorated state these barely surviving riparian habitats support more species and higher bird populations than adjacent uplands (Engel-Wilson and Ohmart 1978).

Groundwater pumping, which lowers water tables and kills riparian vegetation, has been localized but its effects are quick and dramatic (Minckley and Brown 1982). Large mesquite bosques in Arizona that supported huge breeding colonies of White-winged Doves (*Zenaida asiatica*), large populations of Lucy's Warbler (*Vermivora luciae*), Abert's Towhees (*Pipilo aberti*), and a multitude of other species are now gone (Phillips et al. 1964).

Federal and state flood control dikes are commonplace throughout the west to protect those who built in floodplains. Bulldozers scraped the channel free of vegetation before dirt dams were built. In most of these activities riparian vegetation above the dam has returned, but that below has died as water tables dropped.

DOMESTIC LIVESTOCK GRAZING

Most people do not think of this human-induced change to riparian habitats until they see a stream that has not been grazed. Carothers (1977:3) stated "the most insidious threat to the riparian habitat today is domestic livestock grazing." I concur and the following data illustrate the magnitude of the problem just on public lands in the west, where the Bureau of Land Management (BLM) and the U.S. Forest Service administer vast areas for domestic livestock grazing. BLM reported that on 0.52 million ha of riparian-wetland habitats and 78,400 km of streams from 10 of the 11 state offices, only 7% were meeting management objectives, 8% were not meeting them, and 85% were unknown (GAO 1992). From over 20 years' experience I contend that the 85% unknown can be added to the 8% not meeting objectives. The U.S. Forest Service reported that 93,339 km of riparian habitats within grazing allotments in western rangelands were not meeting forest objectives (GAO 1992).

A brief history will give the reader a feel for the evolution of domestic livestock grazing on public lands. Early in the 1700s the Spanish brought all classes of domestic livestock to the arid southwest, but cattle and horses were most important. Their presence ensured transportation, a food supply, and leather in a harsh, unpredictable environment. In the 1860s and well into the 1900s there was no management of public lands and everything was there for the taking. Grass was free and those who controlled the water controlled the forage. The cattle industry expanded rapidly in the 1880s as new railroads carried beef east to a new market. A $5 calf brought $60 a few months later after running on free pasture. In Arizona, by 1833–1884 the Governor wrote "every running stream and permanent spring were settled upon, ranch houses built, and adjacent ranges stocked" (Report of the Governor 1896:21). By 1891, it was estimated that 1.5 million head were on Arizona ranges (Report of the Governor 1896:22).

Three years of drought then ensued. Cattle began dying in the hot dry months of May and June of 1892 and by late spring 1893 losses were "staggering" (Report of the Governor 1896:22). Land (1934) stated, "Dead cattle lay everywhere. You could actually throw a rock from one carcass to another." Arizona rangelands were left barren and unprotected to wind and water erosion (Hastings and Turner 1965). The timing and consequences of such resource damage was similar in all 11 western states (Adams 1975, Behnke 1978, Meehan and Platts 1978, GAO 1988). Overgrazing continued into the 20th century and although better management was begun in the 1930s, many grazing allotments are overstocked today (GAO 1988).

Cattle are strongly attracted to riparian areas, where water, forage, and shade are all close at hand, and will spend 5 to 30 times longer there than in adjacent uplands of similar areal extent (Skovlin 1984). They congregate in riparian habitats during the summer months or plant growing season (Severson and Boldt 1978). In a study with light-to-moderate stocking rates, cattle removed 20% of the vegetation in the upland compared to almost 45% of the vegetation along the stream (Goodman et al. 1989). Where ranges are overstocked, herbage removal approached 100% in riparian habitats (Platts and Nelson 1985). Cottam and Evans (1945) examined vegetational differences between Red Butte and Emigration canyons near Salt Lake City, Utah. Both were privately owned and grazing began shortly after 1847. The U.S. Government purchased Red Butte in 1888 and began protecting it from grazing to insure a clean water supply. In 1945, total density of vegetation in Red Butte Canyon was twice that in Emigration Canyon. Ten native perennial grasses were found in Red Butte and not in Emigration Canyon. "These facts would seem to emphasize the danger of complete extermination of rare and highly palatable species in overgrazed areas" (Cottam and Evans 1945:178).

The effects of unmanaged cattle grazing on riparian habitats that have never been grazed before are very perceptible within ±5 years. Subsequent changes are hardly noticeable until about a century later, when the last overmature forest begins dying and falling. When cattle first graze a system they trample the banks which, when combined with erosion, widens the stream. (A stream protected from grazing for 50 years showed a 94% reduction in channel width [Clifton 1989]). All palatable vegetation from the ground to about 1.5 m is consumed, and this occurs annually, encouraging the spread of vegetation less valuable to cattle and wildlife. As the channel widens it carries more of the floodwater, whose increased scouring force further widens the banks, as well as deepening the channel bottom, which can be scoured away until the stream flows over either bedrock or large cobble. The lowered channel bottom reduces the water table level in the floodplain, and upland species such as juniper (*Juniperus* spp.) and big sage (*Artemisia tridentata*) begin extending into the floodplain terrace. Upper Black Canyon in the Aldo Leopold Wilderness Area, Gila National Forest, New Mexico, typifies many streams at mid-elevations in the west (Fig. 1).

The process of riparian degradation exceeds a human life span and, to my knowledge, there are no pristine areas to use as yardsticks. Little concern was expressed for

FIGURE 1. Upper Black Canyon in the Aldo Leopold Wilderness Area in the Gila National Forest in New Mexico. Note the size and degraded condition of the channel, the lack of herbaceous ground cover, down cottonwoods, the few live cottonwoods remaining, and the invasion of upland conifers onto the dry floodplain. Photograph by R. D. Ohmart on August 30, 1992.

riparian habitats until about 15 years ago (Johnson and Jones 1977). Since then numerous symposia have highlighted these habitats, and conservation groups have begun to pressure legislators for stricter laws. Better management must come soon or the next 20 years will show the accelerated collapse of the last forest trees. Elmore (1992) reports the elimination of extensive willow stands in Oregon from grazing, and the same holds true in much of Arizona and New Mexico (Ohmart, pers. obs.).

Much research has been conducted on western riparian habitats in the past 10–15 years (Skovlin 1984), and agencies have been forced into protecting stream reaches for endangered native trout. The resiliency of riparian habitats is remarkable after only eight years of cattle exclusion (see examples in GAO 1988, Chaney et al. 1991). In Grand Gulch, southeastern Utah, prior to 20 years of rest, the stream was entrenched to bedrock (in places over 20 m), the floodplain terraces were covered with annuals, and the stream was dominated by saltcedar. Today, the stream is agrading, coyote willow (*Salix exigua*) stems equal or exceed 30/m^2, sedges and grasses mat the alluvial soils preventing erosion and trapping sediment, and all age classes of cottonwoods abound (Ohmart, pers. obs.).

Elmore (1992) argues that riparian habitats can heal with better management of cattle in riparian systems and, in general, that is true. Yet, in experience the healing process is extended at least three or four times what it would be with total exclusion. For example, on Mahogany Creek in Nevada bank stabilization with narrowing of the channel, return of the understory, and the proliferation of young cottonwoods and willows has been amazing in ten years. Stream flow after recovery was increased by 400% (GAO 1988). Such a rapid response would never have occurred with any cattle use, regardless of the season. Along Date

FIGURE 2. Date Creek near Wickenburg, Arizona. Cattle graze year-round in the foreground and only in the nongrowing season on the other side of the fence. Photograph by J. Feller on October 3, 1992.

Creek in Arizona, where the growing season is eight months or longer, stream gradient is moderate and the sediment loads are high for bank building; after 24 years of only winter grazing this reach is just now in the stage of rapid recovery (cf. Figs. 2 and 3). Vegetative conditions along Date Creek and other streams under grazing protection by The Nature Conservancy are far superior to most Arizona streams.

A time of crisis is rapidly approaching for most riparian habitats. This could have been prevented if permittees and federal agencies had used better management as little as a decade ago. We now know that unless heavily degraded streams receive total rest for eight to ten years the seed source for riparian trees may be eliminated (GAO 1988). Unfortunately, permittees and agencies are reluctant to change and this, in many instances, has slowed or stopped management improvement. Ironically, where riparian management has been improved, permittees have reported reduced feed costs, the regeneration of permanent water supplies where streams were intermittent, better use of upland forage by cattle, and generally better livestock health and higher calving rates (GAO 1988, Ohmart, pers. obs.).

A classic example of how dramatically some neotropical species can respond with

FIGURE 3. Date Creek near Wickenburg, Arizona. Stream grazed only in the nongrowing season for 24 years. At flood stage the alluvial soils are covered by the grasses and sedges to disallow erosion and trap sediment. Photograph by J. Feller on October 3, 1992.

the exclusion of cattle comes from the San Pedro River in southeastern Arizona. Approximately 64 km of grazed riparian habitat were obtained by BLM in the 1980s and cattle were removed by 1 January 1987, when the river supported good mature stands of cottonwood-willow forests. Census lines (see Riparian Vegetative Components Most Important to Birds), were established in 1985 and data were collected three times monthly each year to present. The birds listed in Table 1 demonstrate how a rapid response is possible as the understory returns.

RIPARIAN HABITAT RESTORATION

Revegetation

Because of the high value of riparian habitats to all forms of wildlife and especially

TABLE 1. INCREASES IN AVIAN DENSITIES/40 HA AFTER CESSATION OF DOMESTIC LIVESTOCK GRAZING IN JANUARY 1987 (D. KRUEPER, UNPUBL. DATA)

Species (densities are birds/40 ha)	Years 1986	1987	1988	1989	1990	1991	Increase
Western Wood-Pewee (*Contopus sordidulus*)	8	16	22	38	28	29	3.6×
Yellow Warbler (*Dendroica petechia*)	29	84	99	227	131	176	6.1×
Common Yellowthroat (*Geothlypis trichas*)	7	24	39	115	110	149	21.0×
Yellow-breasted Chat (*Icteria virens*)	26	44	47	95	100	110	4.1×
Summer Tanager (*Piranga rubra*)	44	84	73	167	94	108	2.4×
Song Sparrow (*Melospiza melodia*)	Trace	11	14	38	36	61	50.0×

birds, there have been numerous efforts to revegetate portions of rivers either as mitigation or enhancement. Anderson and Ohmart (1982) designed the first such effort on the lower Colorado River in 1978, and have since attempted numerous others.

In our efforts we have always planted those species with the highest value to wildlife. Prior to any revegetation effort, which is expensive, a number of biotic factors must be examined if the effort is to succeed. Soil salinity should be sampled throughout the site, not only on the soil surface but at 0.5 m deep; salinity of the groundwater should be sampled as well. Many native trees cannot tolerate high salinity levels and will only grow to about 10–12 m tall at maturity should they survive at all.

Depth to groundwater is also important, since most native riparian trees are normally shallow rooted. If the roots are not established just above the water table when irrigation is terminated the tree cannot survive. Augering of large holes and back filling these for planting sites is also important. This loosens the soil and destroys any clay or silt layers that would prevent the roots from reaching water. Unless large holes are augered to the water table the probability of success is low.

There is a high risk element in attempting revegetation efforts on large rivers below dams. Most dams have the function of water storage and in periods of exceptionally high rainfall, engineers attempt to maintain the reservoir at maximum storage. Subsequent heavy rains and runoff into the reservoir must be control-released to avoid spilling, which could destroy property and lives. These controlled releases may last for weeks or months. Long releases raise water tables, drown native plant communities, and also elevate the salts near the soil surface. The last two actions are highly detrimental to survival of revegetated communities.

Shallow reservoirs in arid climates evaporate large quantities of water annually. Salts are left behind, and water drained from agricultural crops increases the salt load as well. Two years of high controlled releases on the lower Colorado River in the mid-1980s drowned much of the little remaining native vegetation highly important to birds, and increased salt concentrations near the soil surface has rendered about 75% of the floodplain unsuitable for cottonwood and willow revegetation (Anderson 1988).

Agriculture

This habitat change is primarily manifested along larger rivers with rich alluvial soils. Reservoirs provide a constant water supply and seemingly never ending canals, which allow agriculture to expand over the entire floodplain. The lower Colorado River is the pinnacle of this industry in the west. Cottonwood-willow, honey mesquite, and all other represented communities are root plowed and the dead vegetation is piled and later burned. Hectare after hectare of riparian habitat is treated in this fashion until available land or water becomes a limiting factor. Not only is avian habitat destroyed, but this farming practice has consequences on the vegetation that was not cleared. For example, the water used in irrigation drains from the field carrying leached salts, pesticides, and herbicides, and returns to the river—and eventually the water table—to become the supply for the remaining vegetation.

With this habitat conversion a breeding passerine fauna is eliminated and waterfowl, shorebirds, and other mostly nonpasserine species are attracted to this more open habitat. Virtually all of the species enhanced by the habitat change on the lower Colorado River were wintering birds, with few remaining in the valley to breed. For details of these changes see Anderson and Ohmart (1982), Ohmart et al. (1985), and Rosenberg et al. (1991).

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