Chapter 8. Arizona as a Watershed—Then and Now: Case Studies of Changed Management of Rivers and Habitat in the Lower Colorado River System

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Introduction

Prior to human development in the West, rivers flowed freely. Flows in the Colorado River varied greatly with season, with snowmelt runoff from the Rocky Mountains resulting in annual high flows (Topping et al. 2003). The large sediment loads historically found in the Colorado River, estimated to average 160,000,000 tons passing Yuma annually (LaRue 1916), have since caused Laguna Dam (fig. 23) near Yuma, Arizona, completed in 1905, to silt in almost immediately. Even in a managed system, unpredictable unmeasured tributary inflow into the Colorado River below Hoover Dam accounts for approximately 96,000 acre-ft of water annually, with about 62 percent of that flow from Arizona tributaries, including Sacramento Wash, the Bill Williams River area, Bouse Wash, Tyson Wash, the Dome Rock-Trigo-Chocolate Mountains area, and the Gila River area (Owen-Joyce 1987). Grinnell (1914) provided an account of mammals and birds of the Lower Colorado River Valley, which provides a benchmark from early in the development of the river. Riparian habitat became established following seed deposition on surfaces where sufficient soil moisture maintained the vegetation to maturity. As we see today, large numbers of seeds germinate but few plants survive to maturity to provide seed to repeat the cycle.

Human development of the American West included construction of large dams to retain water from high flow periods for later use and clearing of floodplains for agriculture and urban development, impacting riparian habitat (table 7). Dam construction not only changed the pattern of water flow in rivers, but the pattern of sediment movement as well. Fine textured sediment, such as silt, often drops out of water flow in deltaic deposits at the upper end of reservoirs so that the fine sediment is no longer deposited along rivers to form surfaces where seeds collect and vegetation becomes established as described by Brady et al. (1985).

The effect is that, while the processes that perpetuate riparian vegetation persist, the pattern and location on the landscape have changed in many areas. Vegetation on sediment deposits forming deltas in reservoir pool space is often temporary, depending on water and soil moisture conditions suitable for maintaining the vegetation. Conditions change through time, being suitable—following a high flow—with sufficient groundwater in streamside alluvium that is supported by baseflow in the stream in the upper portions of the delta, or by stable reservoir water levels saturating alluvium in the lower portions of the delta. However, more extreme conditions result from either (1) complete inundation of vegetation, if a reservoir fills to capacity, or (2) contrastingly, drying conditions resulting from inadequate water supply to the vegetation if a reservoir is drawn down, resulting in groundwater levels dropping.

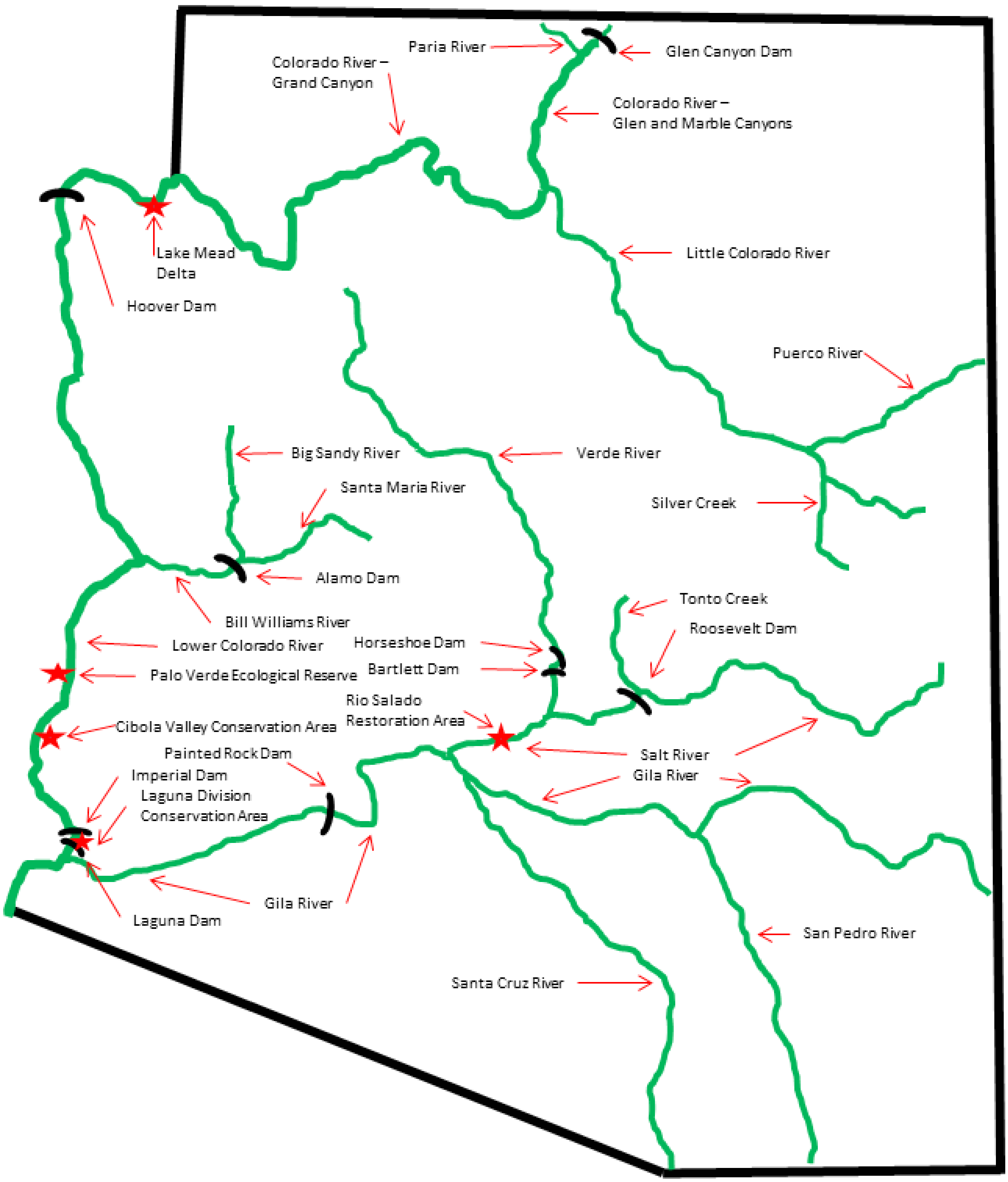

Figure 23—Select Arizona rivers and conservation areas (map by W.E. Werner).

Table 7—Arizona streams and riparian status.

Stream reach	Dams, irrigation project diversions, and flood control	Current status of riparian ecosystems
Summary of Arizona streams and watersheds	Numerous "water projects" throughout Arizona (see below).	Much of riparian habitat at time of Euro-American settlement lost to agriculture, urbanization, and water projects (Dobyns 1981). Cottonwood-willow (*Populus-Salix*) and mesquite (*Prosopis* spp.) replaced by tamarisk (*Tamarix* spp.) along much of perennial reaches.
Colorado River below Glen Canyon Dam and tributaries	None, Grand Canyon National Park most of river length to Lake Mead National Recreation Area.	Prior to Glen Canyon Dam, annual high flows from snowmelt in Rocky Mountains scoured vegetation from sides of the river. After Dam, tamarisk major woody vegetation, with scattered Goodding's willow (*Salix gooddingii*), coyote willow (*S. exigua*), seep willow (*Baccharis* spp.). Willow flycatcher habitat occurs in lower Grand Canyon/Lake Mead Delta area depending on hydrologic conditions and pool elevation at Lake Mead.
Bill Williams River	Alamo Dam, completed in 1969 to reduce flood damage along the lower Colorado River.	Large tamarisk stands; dam releases planned to benefit native trees, e.g., cottonwood-willows. Beaver dams established. Large stands of cottonwood and willow habitat following improved water management. Large numbers of western yellow-billed cuckoo (*Coccyzus americanus occidentalis*) in new habitat.
Salt River in Salt River Valley (Phoenix, AZ)	Corps of Engineers Rio Salado Environmental Restoration Project for flood control and environmental enhancement under authority to address effects of previous federal projects.	Original stands of cottonwood-willow gallery forests killed when Roosevelt Dam constructed upstream. Tamarisk minimal; cottonwood, Goodding's willow, and mesquite. Beavers established; overwintering monarch butterflies (*Danaus plexippus*) in willows.
Gila River below Painted Rock Dam	Storm flows down the Gila River from upstream dams contained in Painted Rock Reservoir, impounded by Corps of Engineers. Wellton-Mohawk Irrigation and Drainage District (WMIDD) located downstream from Painted Rock Dam.	Large tamarisk stands, cattail (*Typha*) marshes; following high flows in 1993, seedling cottonwood and willow trees were observed in the WMIDD area and downstream. Lower reaches of the Gila River have supported habitat used by migrant southwestern willow flycatcher (McLeod 2008).
Colorado River below Hoover Dam	Davis Dam, Parker Dam, Headgate Rock Dam, Palo Verde Weir, Imperial Dam, Morelos Dam; numerous irrigation districts; Havasu, Bill Williams River, Cibola, and Imperial National Wildlife Refuges; diversions by Metropolitan Water District of Southern California and Central Arizona Project.	National Wildlife Refuges created to provide wildlife conservation at the time of dam construction but were not enough to address effects of river operation to habitat. Cottonwood and willow habitat largely lost along the Colorado River, replaced by salt cedar. Lower Colorado River Multi-Species Conservation Program implemented to conserve threatened, endangered, and sensitive species and to provide ongoing Endangered Species Act compliance for operation and maintenance of the river.

If the conditions that support riparian vegetation are temporary at many locations in many watersheds without man's intervention, better understanding of those conditions can help us better manage systems to maintain riparian vegetation in managed watersheds. There are opportunities to manage, to a greater or lesser degree, flow of water, sediment, stream morphology, and suitable surfaces for establishment of vegetation in flow-regulated systems. Examples include the Colorado River below Glen Canyon

Dam, the Bill Williams River, the Salt River in the Salt River Valley, the Gila River below Painted Rock Dam, and the Colorado River below Hoover Dam (fig. 23, table 7). Success has been variable. One of the challenges managers face is developing appropriate expectations and objectives in systems with variables beyond their control. It may be possible to maintain, as an example, a patch of cottonwood trees that can provide a seed source downstream when conditions are right to establish cottonwood trees after a large flow event. Whether new seedlings persist is constrained by many variables, but without the seeds from seed bearing trees there is little or no opportunity. The species composition of riparian vegetation on a managed stream below a dam may be quite different from unmanaged streams above the dam (Stromberg et al. 2012).

Colorado River Below Glen Canyon Dam and the Role of Tributaries

Much has been written about riparian vegetation and management of the Colorado River downstream from Glen Canyon Dam (fig. 23; e.g., Carothers and Dolan 1982 and Sankey et al. 2015). Glen Canyon Dam, forming Lake Powell, not only stops and stores snowmelt water from the upper Colorado River watershed, but also traps sediment that once flowed downstream. Downstream from Glen Canyon Dam, the Paria River discharges water and sediment into the Colorado at Lees Ferry, with a mean sediment contribution of approximately 3 million tons/year (Andrews 1991). While surface water flow in the Paria River watershed is not managed to a large degree, the watershed is desert and significant flow of water and sediment depends on episodic storm events. Farther downstream, the Little Colorado River discharges water and sediment from a larger watershed with a mean sediment contribution of approximately 9 million tons/year (Andrews 1991). Many streams in the Little Colorado River watershed have been dammed for consumptive use or recreation, changing the frequency of significant flow events. The Puerco River, a tributary to the Little Colorado River, is largely unregulated and can produce a large volume of sediment under intense runoff conditions (Wirt et al. 1991).

Sediment inflow into the Colorado River from the Paria and Little Colorado Rivers is monitored by the Grand Canyon Monitoring and Research Center as part of the Glen Canyon Dam Adaptive Management Program pursuant to the Grand Canyon Protection Act. When sediment accumulation in the Colorado River has reached an appropriate level, recommendations for higher water releases from Glen Canyon Dam are made to the Secretary of the Interior with goals generally to benefit resources along the river by re-depositing the sediment at higher elevations to benefit riparian vegetation and to create bars to form backwater aquatic habitats (Salazar 2012).

Research into the effects of efforts to manage water and sediment below Glen Canyon Dam conducted by the Grand Canyon Monitoring and Research Center and others in association with the Glen Canyon Dam Adaptive Management Workgroup is ongoing. As described by Johnson and Carothers (1987) and as a former participant in the Workgroup, one of the challenges is identifying management objectives appropriate for the changed system. Water resource development in the watershed above Glen Canyon Dam has resulted in large changes to the pattern and magnitude of movement of both water and sediment. Yet there are opportunities to do the best we can with circumstances as they are today.

Sediment from the Colorado River below the Grand Canyon has formed deltaic deposits within the reservoir pool area of Lake Mead, providing seed beds suitable for native riparian tree species (McLeod et al. 2008). Depending on reservoir operating conditions, namely the amount of water entering the system versus releases for downstream use, native trees such as Goodding's willow (*Salix gooddingii*) have provided habitat for the southwestern willow flycatcher (*Empidonax traillii extimus*; McLeod et al. 2008) as long as moisture remained to support the trees in a stable or falling reservoir condition and water did not completely inundate them in a rising reservoir condition (1996 condition). Flooded vegetation can apparently provide protective cover for young native fish, including razorback sucker (*Xyrauchen texanus*) increasing survival and recruitment into the adult population (Albrecht et al. 2008). Thus, although within the pool of a reservoir, the natural processes facilitating recruitment of native trees and birds, as well as native fish, can occur in a managed system, although perhaps more accidental than planned.

Alamo Dam and the Bill Williams River

The Bill Williams River is a major tributary of the Colorado River (fig. 23) beginning at the confluence of the Big Sandy and Santa Maria Rivers in west central Arizona. Alamo Dam, completed in 1969, was constructed to manage flood flows from the Bill Williams River that would otherwise cause flooding along the Lower Colorado River in the vicinity of Parker and Yuma, Arizona. Hunter et al. (1987) describe changes in habitat below Alamo Dam following flooding from high-water releases. Beginning in 1989 the Bill Williams River Corridor Steering Committee, a multi-agency effort, began planning for improved management of flows from Alamo Dam. We sought to benefit native tree species and avoid benefitting nonnative saltcedar (*Tamarix* spp.) both downstream of the dam and in the reservoir pool, through recommendations to the Corps of Engineers (Werner 2010). Saltcedar is well established in the Bill Williams River watershed, and shoreline deposition of seeds at high reservoir conditions in the late 1970s and early 1980s resulted in establishment of plants around the shoreline of Alamo Lake and where the lake inundated the lower ends of the Santa Maria and Big Sandy Rivers. In analyzing an optimal operating range for Alamo Lake, working with all existing flow data, we sought to minimize the probability of pushing the "bathtub ring" of saltcedar further up the rivers. In addition we attempted to mimic natural timing of downstream high releases from Alamo Dam to benefit native trees and tried to avoid releases that would favor saltcedar. We also recommended base flow releases that would vary seasonally to sustain trees. This planning was informed by research on the Hassayampa River by Stromberg et al. (1991) who found that recruitment of cottonwood and willow trees occurred approximately every 7 to 10 years on that unmanaged system. The Bill Williams River Corridor Steering Committee was concerned that dam operation and flow recommendations not result in a rigid management regime, as had occurred with previous recommendations responding to a planned drawdown that resulted in management of the reservoir with a fixed target elevation, and included a recommendation for development of a monitoring program and an outline of information and data needs to facilitate improvement of recommendations, or adaptive management, in the future. During the period of planning by the Bill Williams River Corridor Steering Committee, heavy winter rains occurred in 1993 in the Bill Williams River watershed, resulting in a need for high releases from Alamo Dam. The Corps of Engineers was able to incorporate draft recommendations, based on the existing Water Control Manual, into the schedule for high releases in an attempt to avoid detrimental effects documented previously by Hunter et al. (1987). The Corps of Engineers funded aerial photography during the high releases to document the inundated area along the river.

Operating a reservoir to benefit downstream riparian habitat is like using a debit card drawn from a checking account. There is a finite amount of water in the "account" from which to make baseflow releases. If there is inflow, "income," withdrawals can be sustained to the extent that the volume released doesn't exceed the volume available. If withdrawals are larger than income, the balance in volume goes down. If inflows go down due to reduced precipitation in the watershed, releases must be reduced to maintain a "balance" in the system. Reduced baseflow releases may result in a reduction of the total acreage of riparian habitat maintained downstream from the dam, with some reaches more susceptible to change than others based on geology and landform (Wolcott et al. 1956; House et al. 1999). Maintaining releases to maintain the acreage of riparian habitat downstream will reduce the balance available to make future releases, to the eventual point that releases cannot be made until inflow occurs. The quandary is how much releases should be reduced to be able to make any releases in the future or how much downstream habitat acreage we are reluctantly willing to give up, assuming that future inflows will occur in the nick of time. There are no right or wrong answers to these questions. Decisions can be informed, however, by better understanding the variables that control the system and consequences of decisions. Ultimately, we don't control nature, and precipitation may not be as we desire and the acreage of riparian habitat will adjust downward.

Similar to Lake Mead, deltaic sediment deposits at the upper end of Alamo Lake have provided suitable surfaces and conditions for establishment of native riparian vegetation. Goodding's willow trees in that area have provided nesting habitat for southwestern willow flycatcher (McLeod and Pelligrini 2013). While conditions may remain to support this vegetation, suitable nesting habitat conditions may change through time as vegetation matures and stands thin. The stands of cottonwood and willow trees that became established (fig. 24) following implementation of management recommendations for Alamo Dam downstream from Alamo Dam on the Bill Williams River have supported large numbers of western yellow-billed cuckoo (*Coccyzus americanus occidentalis*) with 139 detections in 2007 (Johnson et al. 2008).

Subsequent to the original recommendations of the Bill Williams River Corridor Steering Committee, changes to the authorizing legislation for Alamo Dam, and formal revision of the dam Water Control Manual, there has been additional analysis of flow recommendations and research and monitoring of flow effects. Monitoring and evaluation of flow prescriptions is reported by Konrad (2010). Flow effects to vegetation have been studied by Shafroth et al. (2006, 2010) and Wilcox and Shafroth (2013). Reynolds et al. (2014) report changes to vegetation on abandoned floodplain surfaces. Stromberg et al. (2012) describe vegetation on the lower Santa Maria River, above Alamo Dam, compared to vegetation below Alamo Dam on the Bill Williams River, finding the latter less diverse. Vegetation response to water table changes was the subject of research by Shafroth et al. (2000). Anderson et al. (2010, 2011) researched beaver dams and effects

Figure 24—Riparian vegetation on Bill Williams River near Narrows on Bill Williams River NWR (photo by W.E. Werner).

associated with controlled flooding. Anderson et al. (2016) researched wood decay on the Bill Williams River. Ellington and Anderson (2002) researched spatial correlation of *Apache cicada* (*Diceroprocta apache*), and *Tamarix* on the Bill Williams River. Nelson and Anderson (1999) researched butterfly assemblages in natural and restored habitats, including on the Bill Williams River. Wilson and Owen-Joyce (2002) describe hydrologic conditions on the lower Bill Williams River. Wiele et al. (2009, 2011) report on sediment discharge from the Bill Williams River and sediment concentration in downstream Lake Havasu associated with high flow releases designed to benefit riparian vegetation.

Salt River in Salt River Valley

Following flooding on the Salt River in 1993, the U.S. Army Corps of Engineers conducted studies at the request of local sponsors to determine if a Federal project was justified to address flood control, water conservation, recreation, and environmental restoration on the Salt River in the vicinity of Tempe and Phoenix (fig. 23). Review of environmental restoration was based on authority in the Water Resources Development Act of 1986 to address environmental effects of existing projects, in this case upstream dams. As a result of these studies, the Congress of the United States authorized the Corps of Engineers Rio Salado Environmental Restoration Project on the Salt River between Interstate 10 and 19th Avenue to address flood control, environmental restoration, and incidental recreation with the City of Phoenix as the non-Federal sponsor.

In designing the cross section for the Rio Salado Environmental Restoration Project, the Corps of Engineers created a “channel within a channel” with dimensions such that flows that would be expected every 7 to 10 years would overtop the low-flow channel, based on research on the Hassayampa River of the flood frequency maintaining riparian trees (Stromberg et al. 1991), but would be contained within dimensions of a flood channel designed to protect adjacent infrastructure. The watershed above the Rio Salado Environmental Restoration Project includes the Salt and Verde River watersheds. There are four large dams on the Salt River, and flood flows are much less likely to completely fill the Salt River reservoir system than to fill the two reservoirs on the Verde formed by two relatively smaller dams. Because of this, flood flows on the Salt River through Phoenix typically originate in the Verde River watershed.

Within the Rio Salado Environmental Restoration Project water to sustain riparian vegetation (fig. 25) is either pumped to higher areas or is drainage water entering the Salt River from the local storm drain system. While storm drain flow isn't predictable it has been consistent and supports habitat in the low-flow channel. Apparently sump pumps pumping high groundwater from the basement levels of some high rise buildings in downtown Phoenix discharge into the storm drain system, providing some of the consistent flow. Efficacy of managing channel size to benefit riparian resources through time will depend on the frequency of flood flows and availability of water to sustain vegetation. An unanticipated high flow through the Rio Salado Environmental Restoration Project occurred in July 2010 when one of the bladders of the inflatable dam at the downstream end of Tempe Town Lake failed, releasing a flood down the Salt River. The low-flow channel through the Rio Salado reach appeared to perform as intended based on high-water marks and flood deposits.

Vegetation within the Rio Salado Environmental Restoration Project includes native Fremont cottonwood (*Populus fremontii*), Goodding's willow, and mesquite (*Prosopis* spp). Overwintering of monarch butterflies (*Danaus plexippus*) has been

Figure 25—Riparian vegetation on Salt River at Central Avenue, Phoenix Arizona (photo by W.E. Werner).

documented in a dense stand of Goodding's willow in the Rio Salado Environmental Restoration Project area (Morris et al. 2015) although suitability of conditions may depend on water management in areas higher in elevation than the low-flow channel (Gail Morris, Southwest Monarch Study, Chandler, AZ, personal communication, October 15, 2016). Beavers have become established in the area with evidence of tree gnawing and dam construction.

Gila River Below Painted Rock Dam

Flow events in central Arizona that exceed the storage capacity of the Salt River Project system on the Salt and Verde Rivers—Lake Pleasant on the Agua Fria River, or San Carlos Reservoir on the Gila River—flow down the Gila River into Painted Rock Reservoir, impounded by the Corps of Engineers Painted Rock Dam. As indicated in the discussion of the Salt River, many of these events are associated with flows on the Verde River but can also result from storm flows from southeastern Arizona flowing into the Gila from the Santa Cruz or San Pedro Rivers. Downstream from Painted Rock Dam, the Wellton-Mohawk Irrigation and Drainage District (WMIDD) was developed as an element of the Gila Project by the Bureau of Reclamation to irrigate floodplain farmland. Irrigation water is diverted from the Colorado River at Imperial Dam and is delivered to the WMIDD area along the lower Gila River through a canal system and pump plants. Flood flows past Painted Rock Dam exceeded the capacity of the Gila River channel through the WMIDD in 1993.

Following high flows in 1993, seedling cottonwood and willow trees were observed in the WMIDD area and downstream. Trees that became established typically were on first terrace silty soils that would retain soil moisture more than river bottom sandy soils. Efforts to restore a channel after the high flows included plans to maintain cutoff meander bends and low-lying areas. In addition, the invert elevation of the channel was raised one foot to increase the probability that future flood flows would overtop the low-flow channel every 7 to 10 years, again based on research on the Hassayampa (Stromberg et al. 1991) to facilitate regeneration of native riparian trees, including cottonwood and willow. This is an example of attempting to shape the channel such that natural processes will maintain riparian habitat.

Groundwater or soil moisture to support riparian habitat along the Gila River downstream from Texas Hill, the upstream end of the WMIDD, is either high groundwater resulting from irrigation with imported Colorado River water or from lateral movement of irrigation water toward lower elevations in the river channel. The first circumstance can change with groundwater pumping patterns and the second can change with cropping patterns and irrigation of agricultural fields adjacent to riparian habitat. Another complicating variable is that groundwater in the WMIDD is often saline, which can vary with mixing with irrigation water from above or less saline water from the river channel during flow events.

Following flood flows in 1993 cottonwood and willow seedlings were observed downstream from mature trees that were apparently supported by water released at ends of the canal system or wasteways. Since a canal system operates on gravity, excess water that is not diverted as planned by a farmer must go somewhere and is sometimes dumped from the canal system into the river floodplain. Sometimes water is flushed into the river to clean wind borne sand from the canal system. In addition, in some systems, leaky gates account for additional water into the river. This results in areas that support mature native trees that can provide seeds during high-flow events on the otherwise dry river. There were flood flows on the Gila downstream from Painted Rock Dam in 1993-1995, and smaller high flows in 2005 and 2010. In many areas cottonwood trees that became established following the 1993-1995 high flows have died back. Survival of cottonwood and willow trees appears to have been better on silty soils of the Gila River floodplain than in coarser texture sands in the river channel itself. The silty floodplain soils are also desirable for agriculture as water is better retained to provide moisture to plants. Lower reaches of the Gila River have supported habitat used by migrant southwestern willow flycatcher (McLeod 2008).

Colorado River Below Hoover Dam

The Lower Colorado River Multi-Species Conservation Program (LCRMSCP) is designed to create habitat and support programs for the benefit of native fish and wildlife affected by operation and maintenance of the Lower Colorado River Dam system from the upper end of Lake Mead above Hoover Dam to the Southerly International Border with Mexico at San Luis, Arizona (Werner 2006). State and Federal water, power, and fish and wildlife agencies worked together to develop the program with a focus on ensuring long-term compliance with the Endangered Species Act and to avoid listing of additional species (a total of 26 covered species). The program includes creation and management of 8,132 acres of habitat, including 5,940 acres of cottonwood-willow habitat with characteristics suitable for southwestern willow flycatcher and western yellow-billed cuckoo, 1,320 acres of honey mesquite, 512 acres of marsh, and 360 acres of backwater, plus specific measures for certain species (LCR MSCP 2004).

Along the Colorado River below Hoover Dam efforts to maintain riparian habitat include channel shaping and water management at the Laguna Division Project between Imperial and Laguna Dams (LCR MSCP 2012) and planting on silty floodplain soils. Water supporting trees at planting sites is either: (1) surface flow irrigation from the Colorado River either by diversion at Palo Verde Diversion Dam for Palo Verde Ecological Reserve (fig. 23) in California or (2) pumping from the river at Cibola Valley Conservation Area (fig. 23) and Cibola National Wildlife Refuge in Arizona. Because of post-dam changes to the Colorado River, the water surface elevation is too low to overtop the banks to flood silty floodplain soils.

Opportunities to take advantage of natural flooding of low-lying areas have been investigated, but the acreage that can be accomplished through this means is limited, often because sediment in the Colorado River is trapped in reservoirs and is no longer available for building bars that provide sites for seed germination. In addition, the channel of the Colorado River has been simplified through human development of the area such that water does not spread across the floodplain.

Habitat creation targeting western yellow-billed cuckoo and southwestern willow flycatcher has included creation of large blocks of intermixed cottonwood, willow, and mesquite habitat. Hunter et al. (1987) reported that the yellow-billed cuckoo was declining and the willow flycatcher had disappeared from most of its historical range in Arizona. There is an extensive monitoring program associated with the LCRMSCP.

Western yellow-billed cuckoo began nesting in new stands of vegetation within a few years of establishment (Johnson et al. 2008) and there may be bird response and interaction between blocks of mainstem and tributary habitat, including recent habitat on the Bill Williams River discussed earlier, as well as response to decrease in irrigation once trees are established (Tracy and McNeil 2016), a pattern similar to patterns reported by Wallace et al. (2013).

Discussion

Riparian ecosystems are dynamic by their nature and riparian habitat is dynamic as stands of vegetation progress through natural succession and mature. Maintaining sufficient habitat on the landscape involves more than simply maintaining stands of vegetation. Maintaining conditions suitable to support an adequate prey base for birds, for example, is an element of maintaining habitat. Doing so may require more water than is needed simply for survival of trees. In some circumstances, our ability to control variables limits our ability to manage for riparian habitat. In other circumstances, we can set the stage, to the best of our ability, within constraints, such as on the Salt River in Phoenix where we can manage the landform and can create baseflows but have little control on high flows. In further circumstances, such as the operation of Alamo Dam, we can manage flow constraint by managing both high flows and baseflows, to a greater or lesser degree, within physical constraints of dam design and available water upstream in the system.

In the case of operating Alamo Dam to benefit riparian habitat on the Bill Williams River, we can develop contingency plans to exploit opportunities, if and when those opportunities arise. On the lower Gila River below Painted Rock Dam, we can set the stage by creating suitable landform but have no control on the frequency of high flows, which were more frequent during our planning efforts than since. On the Lower Colorado River, we can create functional habitat in floodplain settings where it once occurred naturally although our ability to manage river flows and sediment movement is very low. By doing the best we can in a variety of circumstances in managed systems, we can create a patchwork quilt of habitat.

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