Appendix I.

Implications of Water and River Management for the Southwestern Willow Flycatcher: The Fluvial, Hydrologic, and Geomorphologic Context for Recovery

A. Introduction

The rivers of the Southwestern United States create and maintain most of the riparian habitat that hosts the remaining population of the endangered southwestern willow flycatcher (Figure 1). For breeding habitat the bird relies on riparian forests composed primarily of willow and tamarisk, an ecological niche that in turn depends on the operation of the region's rivers to provide a substrate of water and near-channel landforms. Any policy seeking to enhance the recovery of the southwestern willow flycatcher population must therefore take into account the geographic distribution, hydrologic behavior, and geomorphologic processes associated with the host rivers. The purpose of the following review is to identify the impacts that water management has had on the fluvial system of the region, outline the recent history of changes in hydrology and geomorphology, and provide recommendations for the recovery of the southwestern flycatcher population.

This review concerns hydrography, hydrology, and geomorphology. *Hydrography* is the science of measuring, describing, mapping, and explaining the distribution of surface water. *Hydrology* addresses the physical and chemical processes related to water in the environment, including precipitation, surface runoff, channel flow, and groundwater. The primary focus of any review of hydrology related to the southwestern willow flycatcher is on channel flow because of the preference by the bird for riparian (or stream-side) habitats, but the connections with other parts of the hydrologic system such as groundwater cannot be ignored. *Fluvial geomorphology* addresses river processes and forms related to earth materials and surfaces, particularly the sediment that is eroded, transported, and deposited by channel flow in streams and rivers. The geomorphic work of sediment erosion and deposition creates the landforms, surfaces, and soils that support the riparian forests critical for southwestern willow flycatcher survival. The ultimate fate of the bird population rests in large part on successful creation and management of these physical systems. No matter what other measures are employed to encourage the recovery of the population, none will be successful without insuring that the physical basis exists to support the appropriate habitat.

The southwestern willow flycatcher population depends on breeding habitat in the southwestern United States with particular characteristics (Marshall, 1995). The birds prefer riparian forests with a dense understory of shrub-like vegetation where they typically construct their nests, with a more open canopy of larger trees, all situated near still or slow-moving open water. Commonly, the dense understory consists of willow (*Salix* sp.), seep-willow *(Baccharis sp.)*, arrowweed (*Pluchea* sp.), tamarisk (*Tamarix* sp.), or Russian olive (*Eleagnus* sp.). The scattered overstory often consists of cottonwood (*Populus* sp.). Flycatchers are most abundant in these habitats when they are located adjacent to slack water, also known as lentic water. These riparian habitats were once much more common and spatially continuous, but human intervention in the southwestern river systems has now produced a geography of willow flycatcher habitat that is widely scattered, with small linear patches separated by dryland conditions. This habitat is the product of particular hydrologic and geomorphic conditions that are the subject of this appendix. The following sections of the appendix begin by establishing the general large-scale geographic framework of the issue of southwestern willow flycatcher recovery by describing the region's watersheds and river basins. Next, this appendix describes how humans have altered the hydrologic and geomorphic components of rivers through water and land management. A final section offers recommendations for management of water and water-related resources to enhance the probability of success for southwestern willow flycatcher recovery.

B. Fluvial Systems Components of Flycatcher Habitat

The hydrography of the Southwestern rivers is a geography of watersheds and water courses created by the interaction of the regional geologic and climatic systems. These systems form the physical foundation of the habitat for the southwestern willow flycatcher. Annual precipitation exceeds 50 cm (20 in) only in coastal California or at higher elevations in the interior mountains and high plateaus. California coastal streams have enough precipitation in their headwaters to maintain perennial flow in most of their lengths, potentially supporting southwestern willow flycatcher habitat. In the interior, the arrangement of high terrain with intervening lowlands creates a river system with dichotomous characteristics. The small streams of the region are either at higher elevations and are perennial, or they are ephemeral lowland channels without southwestern willow flycatcher habitat.

The large rivers of the region, the Green, Colorado, San Juan, Little Colorado, Gila, and Rio Grande, accumulate water in their headwaters areas and loose water in their low elevation watercourses (Figure 2). This reflects the elevational and geomorphic forces on in-channel water balance factors. The net water balance in the channel goes from positive (or gaining) in the headwaters to negative (losing) in the lowlands. Natural factors that affect the balance include precipitation, evaporation, transpiration, and groundwater dynamics. The consequences of removal vary over the elevational/temporal gradient. For example, the withdrawal of water from lowland streams for agricultural, industrial, and urban uses causes depletions that are not replaced by natural runoff and the remaining water is lost to evaporation and groundwater recharge. On the other hand, a river's discharge may still increase downstream of the point of water removed from high elevation, water-source areas due to runoff, subsurface seepage, and precipitation. Southwestern willow flycatcher habitat occurs mostly in water deficit areas of the region. Intermediate scale streams such as the Virgin, Escalante, upper portions of the Little Colorado, and San Pedro have mostly perennial flow and support some willow flycatcher habitat, the habitat is of lesser extent than that found in association with the large regional streams.

C. River Basins and Watersheds

Because the southwestern willow flycatcher is a riparian bird, its population depends directly on water and water-related resources. From the standpoint of resources related to water, the American Southwest divides itself into watersheds which serve as obvious regions for analysis, decision-making, and management. Watersheds are drainage basins, portions of the surface that collect runoff from the surface, concentrate it into channels, and conduct the resulting flow to a definable outlet. Large watersheds are aggregations of smaller watersheds, producing a natural hierarchy. By conventional usage, the term watershed refers to a smaller drainage basin, while the term river basin refers to a larger one, but there are no specific definitions to separate the two. Watershed concepts are those analytic and management principles whose application relates directly to a geographic region defined by a drainage basin. Recent reviews of water-related resource management by the National Academy of Sciences (National Research Council 1999) and by a Presidential commission on western water (Western Water Policy Review Advisory Commission 1998) recommend watersheds as the spatial framework for planning and management of water and water-related resources.

Watershed boundaries are porous, in the sense that artificial transfers of water between watersheds are common, so that planning and management considerations may extend beyond the physical watershed boundaries. Examples include the export of water from the Lower Colorado River Basin to California, and the transfer of water from the Upper Colorado River Basin to the Rio Grande. Because of the importance of water and riparian environments to the recovery of the southwestern willow flycatcher population, planning and management for the opportunities and threats to the species should use watersheds as a geographic framework.

Definition of the watersheds and river basins of the Southwest is standardized among federal and state agencies by the National Water Resources Council and the U.S. Geological Survey who have created a series of watershed outlines (U.S. Water Resources Council 1978). It is therefore logical that a southwestern willow flycatcher recovery plan use the same definitions to facilitate interagency communication. This standard approach uses a hierarchical series of numbered hydrologic units, with each unit being a watershed or collection of watersheds (Seaber et al. 1987). The identification numbers, called hydrologic unit codes, use two digits for the largest divisions or regions, four digits for subdivisions, and six or eight digits for still finer subdivisions. The largest divisions in the classification system are 21 *water resource regions*, with each one containing either an entire river basin or a series of closely related basins, each identified with a two digit hydrologic code. The regions containing southwestern willow flycatcher habitat are the Rio Grande (region number 13), Upper Colorado River (14), Lower Colorado River (15), Great Basin (16), and California (18), with a total area of 1,738, 950 km^2 (671,410 mi^2). Table 1 summarizes the watershed regions, their hydrologic characteristics, dams, and human populations; Figure 3 provides a map of their extent. Although the California region extends into northern California areas not inhabited by the southwestern will flycatcher, the entire region is involved because of engineered water transfer facilities that connect the northern to the southern parts of the region.

The creators of the hydrologic unit code subdivided the water resource regions into *planning subregions*, designated with 4-digit code numbers; 6-digit code numbers identify the members of a still finer subdivision consisting of *accounting units*. The accounting units are aggregates of the smallest subdivisions, or *cataloging units*, identified by 8-digit code numbers. The 21 water resource regions of the nation contain 2,150 of these smallest units, which have an average drainage area of about 1,750 km^2 (700 mi^2). For the purposes of the southwestern willow flycatcher recovery plan, the most useful scale of analysis is the accounting unit, or 6-digit coded watersheds. In Arizona, for example, this implies that watersheds such as the Verde River Basin, Salt River Basin, and San Pedro River Basin represent the most convenient scale (Figure 3).

D. Stream Channels

Runoff within watersheds and drainage basins concentrates into channels and creates the distinctive streams and rivers of the Southwest with their associated willow flycatcher habitat. Streams begin flowing at higher elevations and flow to lower elevations. Generally, the gradients of watercourses are relatively high near the source areas and decline to nearly level at lower elevations. Variations in geology, artificial structures, and even beaver dams produce localized reaches of exceptionally steep or shallow gradient. The high elevation, steeper gradient regions are the primary source areas for water, but they are also the primary source area for alluvium (substrate particles that typify flowing waters). In addition to their roles in delivering water and alluvium to the channel, steeper areas tend to be transport zones where water and particles move quickly downstream. Because of their gradient and stream power, these rivers tend to flow through narrow, incised channels and valleys with little storage of alluvium. The lower elevation and lower gradient areas are usually storage zones for water and alluvium, as indicated by flood plains that typify the larger, low elevation systems.

The spatial distribution of southwestern willow flycatcher habitat is a reflection of these dynamics. Relative to upland areas, riparian areas are usually richer and of greater areal extent where the substrate is comprised largely of inorganic alluvium, subject to flooding, and with high soil moisture and shallow groundwater. Thus, southwestern willow flycatcher habitat was naturally very limited along high gradient, high elevation watercourses that flow through canyons. At higher elevations, the bird was probably reasonably common in topographic situations that resulted in low gradients such as mountain meadows. The bird was probably very abundant and optimal in low elevation zones with broad flood plains. In the low elevation areas, habitat quality probably was suboptimal where water levels remained stabile and the substrate was highly organic (including cattail or tule marshes) because of the anaerobic conditions within the shallow root zone.

In the low elevation, low gradient rivers of this region, the temporal and spatial variability of runoff results in three common types of river channels: single-thread, braided, and compound. Each channel type has particular dynamics and spatial arrangements, and each supports a different arrangement for willow flycatcher habitat. *Single-thread channels* contain their flows between well defined banks, and may have planimetric configurations ranging from relatively straight to meandering. They usually result from hydrologic regimes that have only modest fluctuations of flow. The channels conduct flows of low magnitude, but those flows that are so large that they occur only once every few years exceed the channel capacity, and spill onto the adjacent flood plain. Flood plains are relatively flat surfaces, located next to the channel and outside the channel banks, and consist of sediments that are active in the present regime of the river (that is, they are mobilized at least once every few years). Dense riparian forests occupy the flood plain when they are undisturbed by direct human activities. Relative to those of thee other channel types, the riparian forests although patchy are relatively continuous.. When composed of an appropriate assemblage of plant species and when located adjacent to open water, these forests can provide suitable willow flycatcher habitat. The flowing (lotic) water of the channel is sometimes augmented by slack (lentic) water in abandoned channels on the flood plain surface, usually the abandoned meanders (or oxbows) of the single-thread channel. Typical, large-scale examples of single-thread channels are the Lower Colorado River near Yuma and the Rio Grande downstream from Albuquerque, cases where controlled flows and levees have produced a single-thread channel. Natural examples of single thread channels include Aravaipa Creek in southern Arizona and many small coastal California streams.

Braided channels consist of a broad flow zone delimited at the edges by low but well defined banks. Between these banks are several channel threads intertwined among each other, with numerous mid-channel islands and bars. Occasionally, braided channels in the Southwest have flood plains which behave similarly to the flood plains of single-thread channels. In cases where braided streams occur without flood plains, their banks divide the channel from adjacent terraces, surfaces that do not experience flows during the present hydrologic regime of the river. Braided channels commonly result from highly variable flow regimes, channels with weakly consolidated bank materials, and/or watercourses with very heavy sediment loads. The islands and bars experience less overflow than other areas associated with many braided channels, and they tend to be the locations for willow flycatcher habitat, along with narrow ribbons of riparian vegetation on the banks. Unlike the flood plain forests, braided channels are unstable, and as floods rearrange the subchannels, islands, and bars, riparian forests change and are characterized by patchy vegetation with many inherent gaps.

Many lowland rivers of the Southwest were braided streams before human controls altered their flows, and under these conditions they hosted southwestern willow flycatcher populations. Historical accounts of streams ranging from the Los Angeles River to the San Juan River in southwestern Colorado describe such conditions for the pre-development era (*e.g*., Kino 1919, Griffin 1943). In the Los Angeles River and the general Los Angeles Basin, for example, the wide-spread existence of wetlands associated with the low-gradient coastal rivers produced substantial southwestern willow flycatcher habitat. Willett (1912) reported willow flycatchers in the Los Angeles and Pasadena areas, and indicated that they were common in riparian areas. Egg collections at the Western Foundation of Vertebrate Zoology include 44 clutches collected in the period 1901-1910 in Los Angeles County alone. The specific sites included water courses in Los Angeles, Pasadena, and along the San Gabriel River in Cerritos and Artesia. Unitt (1987) reported 67 egg sets were collected in the Los Angeles basin before 1940. Subsequent urbanization with its attending channelization and changes in riparian land use decimated the southwestern willow flycatcher habitat in the basin.

Although single-thread and braided channels are archetype morphologies for rivers, southwestern streams most commonly are of a third, hybrid type. The *compound channel* has the characteristics of both single- and multiple-thread arrangements (Gregory and Park 1974, Richards 1982, Graf 1988). At the lowest point of the cross section of a compound channel is the low flow channel, which conducts the usual low flow of the system either from natural sources or from low flows released by dams. Outside the banks of this low flow channel lie the braided channels, islands, and bars of the high flow system. This high flow portion is occupied by water only during the once in ten- or twenty- year flood under natural conditions, or by the rare spill or uncontrolled flow from dams. Beyond the banks of this high flow channel lies the terrace that is not active in the present regime of the river. There usually is no flood plain in the normal sense of the term in this compound system. Southwestern willow flycatcher habitat occurs in the form of threads of riparian vegetation along the banks of the low flow channel, and if the watertable is high enough, dense forests may also occur within the high flow, braided portion of the channel. With the physical processes that form the compound channel being intermediate between those that drive single-thread and braided channels, the riparian vegetation is similarly intermediate. It is arranged as somewhat patchy with moderate levels of connection. Compound channels are common in the Southwest under present conditions, exemplified by the Salt and Gila Rivers in Arizona and many southern California streams. The Hassayampa, Santa Cruz, and San Pedro rivers are smaller inland examples.

E. Flow Regimes: Water Quantity and Patterns of Water Flow

Six components of flow regimes, amplitude, magnitude, frequency, duration, timing, and rate of change of hydrologic conditions, strongly influence the structure and function of riparian ecosystems (Poff et al. 1997). With respect to magnitude, for example, the width of riparian vegetation communities and their biomass increases with mean and median annual flow volume and drainage size in alluvial river channels (Stromberg 1993). Low flows and peak flows are of particular importance to regeneration and maintenance of southwestern willow flycatcher habitat in the arid Southwest. With insufficient low flows or extended loss of surface flow in the summer dry season, alluvial ground water levels decline. These changes can result in mortality of the shallow-rooted native trees and shrubs in which the willow flycatchers nest and cause a narrowing or contraction of the riparian corridor. Extensive research on cottonwood species, and to a lesser extent on willows and tamarisk, has defined the threshold values for depth to water table and water level recession rates that seedling and adult plants can tolerate. Smaller reductions in stream flow or ground water levels can cause plants to undergo physiological stress and lose productivity, with possible adverse implications for the southwestern willow flycatcher habitat. Even short-term loss of surface flows may reduce bioproductivity and habitat quality by stressing those insects with aquatic larval forms, a portion of the southwestern willow flycatchers food base.

Flooding is characterized by amplitude (difference between minimum and maximum flows in a given period), timing, magnitude, frequency and duration. Floods are the primary natural disturbance in riparian ecosystems (Poff et al. 1997). Floods exert important physical and biological controls on riparian zones. They inundate and moisten flood plain soils, raise water tables and recharge aquifers, mobilize and deposit sediment of various textures on flood plains that creates a seed beds for riparian plants, flush salts and redistribute nutrients, cause river channels to relocate and/or meander, create abandoned channels and backwater depressions, disperse and scarify plant propagules, scour and relocate vegetation, and deposit organic materials that have higher water-holding capacity than the inorganic materials in the substrate. These flood-driven fluvial processes maintain high species diversity, bioproductivity, and habitat complexity in riparian ecosystems.

The forces controlling the timing of floods large enough to destroy southwestern willow flycatcher habitat operate at regional and local scales. At the regional scale, these destructive floods result from global and sub-global atmospheric circulation patterns that deliver moisture from warm ocean surfaces to the continental areas by way of decaying tropical storms and major frontal systems in mid- or late winter. Extensive regional flooding results in these cases, as happened in

1941, 1978, or 1993, with widespread lose of riparian habitat. In the intervening years, the habitat recovers and regrows. On the time scale of decades to a century, therefore, it is reasonable to expect regional changes in the amount of available riparian habitat for southwestern willow flycatchers regardless of human-induced changes. Local flooding results from conditions connected to local thunderstorms in summer months which affect a single or a few watersheds. In these instances, loss of riparian habitat is small compared to the large regional events, but at the end of the twentieth century there are so few active southwestern willow flycatcher sites that even these events affecting limited areas may be important for the bird population.

Many of the riparian plant species in the Southwest such as Goodding willow are pioneer species that depend on periodic winter and spring flood disturbance for regeneration. Other species in the plant community regenerate in response to periodic summer floods. With respect to magnitude, the infrequent but very large floods reset the successional clock and rejuvenate large stands of the riparian forests upon which southwestern willow flycatchers depend. Smaller floods that inundate but do not destroy the forests help to maintain a diversity of understory and herbaceous plant species that may play important roles in maintaining the food base of the flycatcher.

Most of the human population of the Southwest views the water flowing through the river systems as a commodity with specific legal and economic attributes. From a fluvial hydrology and geomorphology perspective, as well as from the standpoint of southwestern willow flycatcher habitat, the water is a vital landscape component, not a separate commodity. Any attempt to utilize water to improve conditions for the flycatcher population, however, must take into account the legal and economic aspects of water. River flows in the Southwest are appropriated, meaning that individuals, corporations, and government entities own the rights to withdraw and use the water within a specific set of allocations and priorities. These rights may be bought and sold, offering the opportunity in some cases for purchase of water for use by wildlife. However, purchase of water rights for the flycatcher population has been limited and will likely continue to be insufficient to maintain or recover southwestern willow flycatchers. Instead, they have and will likely continue to rely on the existing (or highly similar) arrangement of water flows and rights.

The restoration of habitat for the willow flycatcher along channels throughout much of the Southwest can introduce reclaimed riparian landscapes that will benefit the flycatcher population. However, this restored landscape will not be the original natural landscape that existed prior to the advent of modern technological river controls. Two types of changes altered that original landscape: 1) reduction of downstream flows caused the active part of the channel and its associated landforms to shrink in their overall areas, and 2) a variety of influences resulted in substantial simplification of the remaining landscapes and habitats. These influences include the storage of sediment behind upstream dams, channelization, dredging, construction on banks, levee building, and urbanization. Because it is unlikely that all of these forces will be removed, restoration of flycatcher habitat will produce a viable habitat area, but one that is smaller than the original habitat. Because it will be smaller than the original habitat, this restored habitat does not require a return to the original hydrologic regime, but rather needs only modest flood events. Complexity of the habitat also will be on a smaller scale, but landscape variety can be introduced within the limited restored area.

The cost of water varies throughout the region, depending on the value of the end use, the availability of water, and the expense of transporting it from source to use. Individual cases in limited areas have wide ranges in the value of water. Agricultural users in areas supplied by the Salt River Project in central Arizona, for example, may pay as little as $15 per acre foot, while some water used for fishing and whitewater boating in the Rio Grande has a value of $1,615 per acre foot (Frederick et al. 1995). In the Southwest, the highest single example for marginal values is $2,642 for fishing in the Lower Colorado Basin. Another indicator of economic value is marginal price, the cost to develop additional water supplies and deliver them to the user. Marginal costs are low where facilities are well developed and water is relatively plentiful, and high where water is scarce or where the available supply is fully developed. Marginal costs for the river basins of the Southwest include $191 per acre foot in the Rio Grande basin, the highest regional value in the nation. Marginal costs for other basins in the region are $122 in the Lower Colorado basin, $51 in California, $38 in the Great Basin, and $32 in the Upper Colorado basin.

Water rights, delivery contracts, legal commitments to power generation, and requirements for flood control are among the common constraints on making changes to the distribution of water in southwestern rivers and the management of dams and reservoirs. In the Colorado system, the “Law of the River” is the collection of international treaties, interstate compacts, court decrees, laws, rules, regulations and policies that govern the management, allocation and distribution of Colorado River water. Similar arrangements exist on all large rivers of the region that potentially provide southwestern willow flycatcher habitat, including coastal streams in California, the Rio Grande, and the Gila. However, there is some flexibility in these management systems, including the timing of some releases, storage locations, “bucket-for-bucket” transfers, and the handling and distribution of excess water, the amount that occasionally flows through the system in amounts greater than the allocations. Innovative use of this management flexibility and flood control releases can aid the recovery of the southwestern willow flycatcher without disrupting established legal commitments for water. In some cases, water purchases or modifications of legal arrangements might be negotiated.

F. Water-Related Activities that Impact Flycatcher Habitat

Human activities have introduced numerous modifications to the hydrography of southwestern rivers, so that the resulting hydrology and geomorphology are partly natural and partly artificial. These modifications included dams, diversion structures, canals, groundwater management, waste and tail water discharges, channelization, and levees.

1. Dams

Dams are the most pervasive and significant changes because they are ubiquitous and have radically altered the flows of water, energy, and sediment throughout the region. The five water resource regions of interest for the recovery of the southwestern willow flycatcher include 4,659 dams (U.S. Army Corps of Engineers 1996; structures are generally those 2 m or 6 ft high or higher, or those with reservoirs of 18,000 m^3 or 15 ac ft or more). Most of these structures are small but in the aggregate in local basins they are significant. A few very large ones exert substantial control with far-reaching consequences for hydrology and geomorphology of the region’s rivers (Graf, 1999). Dams in the Rio Grande Basin, for example, can store an amount of water equal to almost 4 times the mean annual runoff (Table 1). These structures provide societal benefits including urban water supply, irrigation, hydroelectric power, flood control, and recreation, but also cause environmentally costly changes in fluvial environments that include adjustments in potential habitat for the southwestern willow flycatcher. Important changes brought about by dams include upstream impacts related to reservoirs and downstream impacts related to controlled flows, sediment dynamics, water quality, and water temperature (Collier et al. 1997).

The impoundment of water and sediment upstream from dams causes changes in the fluvial hydrology and geomorphology because of inundation and the change in stream gradient as the streamflow enters the reservoir area. Those channels and near-channel surfaces that are in the reservoir area are drowned, either permanently or periodically, so that the habitat associated with them is lost. The shoreline of the newly formed reservoir may create new habitats where none existed previously. The headward-most portion of the reservoir, where the stream enters the lake formed by the dam, is a dynamic zone where deposition of sediment creates a delta because the lake area reduces the energy gradient of the flow. Flow velocity and stream power decline, with associated deposition of sediments that previously were carried by the stream. If the reservoir level fluctuates, the location of this delta building process also changes. If the reservoir level rises, the location of the deposition shifts upstream, and if the reservoir level declines, the location of deposition shifts downstream.

The delta surface is often the most important potential area for southwestern willow flycatcher habitat, because it offers moist sand deposits suitable for willow or tamarisk growth, and the associated lake surface offers slack water nearby. During the 1990s, southwestern willow flycatcher habitat of this type existed at the headwaters of Lake Mead behind Hoover Dam on the Colorado River; Lake Isabella on the Kern River in California; and Lake Roosevelt behind Roosevelt Dam on the Salt River, Arizona. This habitat situation is unstable, however, because it depends on a relatively unchanging lake level. Hydro-climatic variability that change inflow to the reservoir, and dam operations that change its outflow produce fluctuations in lake level, location of the delta deposition, and changes in the vegetation communities on the delta surfaces. If lake levels are stable for 3 to 5 years, substantial riparian vegetation may develop, only to be destroyed by changes in lake elevation. If the new levels remain relatively unchanging (that is, water levels do not fluctuate more than about 20 feet) for another 3 to 5 years, new deposition and vegetation growth will develop in the new location. Because of these adjustments, any specific southwestern willow flycatcher habitats at the headwaters areas of large reservoirs are temporary, but over a period of decades it is likely that some such habitat will be present temporarily at some location for many large reservoirs.

The downstream impacts of dams and their operations include depletion of sediment which is trapped in reservoirs, and several adjustments to fluvial hydrology including reduced total annual flow, reduced annual flood peaks, changes in low flows, changes in the timing of high and low flows, and altered short-term fluctuations (Figure 4). All these adjustments in river mechanics result in changes in the downstream geomorphology of channels and near-channel landforms, with accompanying changes in the potential to support vegetation communities favored by southwestern willow flycatchers. The changes in sediment flux downstream from dams is especially important because the relatively sediment-free water released by the dams erodes mid-channel bars, channel-side bars (or attachment bars), beaches, and flood plains, all important substrates for southwestern willow flycatcher habitat. Because sediment from upstream is trapped behind the dams, eroded features downstream are not replenished. At further distances downstream, where tributaries deliver sediment to the dammed watercourse. However, without a flood hydrology, the sediments may continue to accumulate to a point where the riparian vegetation potential is altered. The increase in sediment may convert a reach from a single-thread to a braided channel, and may lower the depth from the grounds surface to the water table.

The specific hydrologic changes downstream from a particular dam depend on the inflows to the reservoir, the engineering characteristics of the dam, and its operating rules (Figure 4). For example, if the dam is primarily a diversion structure, it will drastically reduce the normal flows downstream, and at some distance downstream often to the point of near desiccation and loss of most riparian vegetation. On the other hand, a dam that is primarily for hydroelectric power will pass through to downstream areas an amount of water that is similar to the pre-dam amount. However, the delivery will be in a highly altered schedule determined by power grid demands, often with substantial daily river flow fluctuations that previously did not exist and may approach the amplitude of flows only seen over annual cycles. Table 2 summarizes common hydrologic changes downstream from dams of various types. Very large dams on major rivers are multi-purpose, and their operating rules represent an optimization strategy (including storage of water, generation of electrical energy, enhancing recreation opportunities, and flood control) that produces mixed results for river flows downstream.

Uncontrolled flows from dams cause instability and changes in willow flycatcher habitat in the impacted streams of the Southwest when the channels shrunken by levees and/or a response to the damming cannot contain the large floods. Riparian forests developed in compound channels are often partially or completely destroyed by uncontrolled or exceptionally high flows, but the forests redevelop on the surfaces abandoned by flood waters when flows return to normal.

Dams also alter water quality. Salinity increases can be very high in the downstream reaches of dams or intensive agricultural areas, as in the lower Colorado River. Generally, according to the U. S. Environmental Protection Agency, the primary sources of salinity are irrigation water and reservoir evaporation (Briggs and Cornelius 1998). In the lower Colorado River, these sources contribute 50% of the salinity. Salinity increases can be biologically significant. Most native willows and cottonwoods are relatively intolerant of salt (Jackson et al. 1990, Shafroth et al. 1995). Germination rate of Goodding willow declines continuously with salt content, falling to less than 50% germination at values above 100 meq/l of sodium chloride (Siegel and Brock 1990). Tamarisk germination, in contrast, increases with salinity. Dams also eliminate the floods that otherwise would flush salts from flood plains.

Levels of nutrients can be reduced downstream from dams. Phosphorous typically adheres to clays and silts and thus tends to decline in below-dam systems as the fine sediments are deposited in the reservoir. Nitrogen levels can remain high if nitrogen-fixing plants such as mesquite remain abundant. Effects of nutrient reductions or changes in nitrogen-to-phosphorous ratios on quality of southwestern willow flycatcher habitat are unknown.

Water temperature regimes downstream from dams are often substantially modified from pre-dam conditions. Solar energy is stored in the surface waters of reservoirs and deeper waters remain cold. Most dams withdraw water from the hypolimnion, the cold, deep water below the thermocline, a sharp temperature boundary in the vertical stratification of many reservoirs. As long as storage is adequate to keep the withdrawal levels below the thermocline, the dam releases cold water. The distance downstream that the dam influences the water temperature varies based largely on water velocity, its turbulence, channel velocity, and air temperature. The cooler water temperature modifies microclimates in riparian zones and alters the aquatic invertebrate base which forms the flycatcher's food base. When a reservoir's withdrawal level coincides with the thermocline and the epilimnion (the warmer waters above the thermocline), downstream water temperature rapidly and dramatically increases. The result is severe stress on the aquatic communities.

Stratification of reservoirs poses other consequences to downstream river reaches. At depths, there is often intense biological oxygen demand that results from the decomposition of incoming organic material and the "rain" of surface-water algae. It is amplified by the lack of turnover with oxygenated waters. As a result, deep waters often are very anaerobic and of low pH and many ions are reduced to forms inhospitable to aquatic life. When water is discharged from that reservoir level, downstream impacts on the aquatic community can be severe until the flowing water oxygenates.

The hydrologic and geomorphologic effects of dams in the Southwest have only recently become apparent, partly because of increased interest in environmental quality and changes, but also partly because of the relative recency of dam closures in the region. The impacts of dams on southwestern willow flycatcher habitat is also relatively recent, becoming apparent only within the past two or three decades. The three major river basins in the region, however, have somewhat different histories in the development of their cumulative reservoir storage, a general measure of the impacts of dams on the regional hydrology (Figure 5). The greater the reservoir storage in a basin, the greater the impact on hydrologic systems, including those upon which the southwestern willow flycatcher depends. In the case of the Rio Grande, reservoir storage has increased gradually over the past century. Closure of flood control structures during the 1960s represented the most significant additions to the storage system. In the combined Upper and Lower Colorado River basins, the completion of two large structures, Hoover Dam in 1936 and Glen Canyon Dam in 1963, dominate the history of reservoir storage. After the early 1960s, dams had their most significant influence on the basin hydrology, geomorphology, and riparian ecology in the Lower Colorado River. Significantly, riparian bird populations appear to have begun their decline in the Lower Colorado in the 1960s and thereafter (Rosenberg et al. 1991). In California, rapid increases in storage associated with federal, state, and local water projects dramatically increased the total storage between about 1955 and the late 1960s. Therefore, taken together, the major basins of the Southwest experienced their most important increases in reservoir storage and artificial hydrologic adjustments in the decade of the 1960s.

The effects of dams on riparian ecosystems vary widely depending on many factors, including the nature of the dam management and the fluvial geomorphic setting. If accompanied by extensive water diversion that eliminate water from the channel, such as the Salt River below Granite Reef Diversion Dam near Phoenix or the Gila River below Ashurst-Hayden Dam near Florence, the downstream riparian vegetation inevitably is lost, reduced in area, or replaced by more xeric vegetation. In cases where base flows are unchanged or increased, and the magnitude and/or frequency of large scouring floods is decreased, the channel often narrows while riparian vegetation increases (Williams and Wolman 1984). This increase in vegetation is a result of high water tables and lack of destructive floods, and is particularly evident on braided rivers (Friedman et al. 1998) or in canyons downstream from dams. Moderation of peak flows may be responsible for increased vegetation cover on river sections such as the middle Gila below Coolidge Dam between Hayden and Kelvin (Graf 1982). Along the undiverted Bill Williams River, where summer base flows have increased and the natural cycle of flood scour and pioneer plant recolonization has been disrupted by Alamo Dam, the flood plain presently supports more extensive vegetation than it would were the dam not present (Shafroth, 1999).

Due to the many changes that accompany dam construction and management, the quality and structure of the post-dam vegetation often differs substantially from the pre-dam state. Compositional changes include a simplification of the flora, an increase in exotic species, a loss of native species, shifts from pioneer to later successional vegetation and older individuals, closing in towards the narrowing channel, and shifts from hydric to xeric species. Along the Bill Williams River, as well as along the Gila River and Upper Colorado, most of the 'added' vegetation is composed of exotic tamarisk. Tamarisk is reproductively opportunistic, has high water-use efficiency and deep roots, and is tolerant of drought and salinity (Busch and Smith 1995, Smith et al. 1998). Thus, tamarisk has a competitive advantage over cottonwoods and willows on regulated rivers subject to altered seasonal timing of regeneration floods, reduced stream flows and overbank floods, lowered water tables, and increased salinities. Increase in tamarisk abundance, together with a general increase in live and dead plant biomass, sets the river up for a shift from a flood-disturbance system to a fire-disturbance system, with implications for southwestern willow flycatcher habitat quality.

Dams have played a role in the decline of riparian cottonwood and willow forests throughout the western United States (Rood and Mahoney 1990). This decline is attributed to many factors: reduced rates of sediment deposition and increased rates of scour, reduced river meandering and channel realignment reduce availability of the "nursery bars" needed for seed germination, reduced frequency and size of winter and spring flooding reduces establishment rate of these spring-germinating species, more rapid declines in stream flows on the receding limbs of flood hydrographs cause seedlings to die, and reduced flows of water stresses and sometimes kills very young and very old trees in particular, as do increases in salinity (Braatne et al. 1997).

2. Diversion Structures

Diversion structures are low dams designed to divert river flows into the headings of canals and their distribution systems. Unlike other dams, diversion structures do not primarily store water. They are run-of-the-river dams; that is, they can not control the downstream discharge during medium or high flows and do not significantly reduce flood peaks. Neither do they redistribute downstream flows according to a release schedule. During low flow conditions, however, diversion works usually divert some or all of the flow from the river, so that downstream reaches of the river are desiccated. The result is the loss of riparian vegetation and potential southwestern willow flycatcher habitat downstream from such structures. The reaches upstream from diversion works may offer opportunities for southwestern willow flycatcher habitat because these are typically reaches with sedimentation and associated islands, bars, beaches, and banks suitable for willow or tamarisk and other riparian trees. There is usually also some slack water nearby created by ponding of water before it flows through canal headings at the diversion structure.

Perhaps the most dramatic case of diversion of surface flow, and ultimate restoration of flow to an arid region stream, involves Mono Lake and its tributary streams in the Sierra Nevada of California. While outside the range of the southwestern willow flycatcher, the case is nonetheless instructive in considering water management options for the recovery of the bird elsewhere. After a ramp-up in the rate of stream diversion by the City of Los Angeles, the riparian forests along some of the diverted tributary streams underwent a massive die-off and the level of Mono Lake declined. Invoking the Public Trust Doctrine, the California Supreme Court ultimately ruled that the ecosystems on federal lands had high value to the public and required the city of Los Angeles to restore flows to the diverted stream channels (Wiens et al. 1993). Flows are now being released from the diversion dam at sufficient quantity to maintain the base flows and shallow water tables required by the cottonwood-willow forests (Los Angeles Department of Water and Power 1995). Los Angeles since has been pursuing alternative and creative measures to attain municipal water. For example, in return for expending the money to increase the efficiency of agricultural irrigation techniques such as laser-leveled fields, the city obtains the water 'salvaged' as a result of the increased efficiency.

Stream diversions sometimes have more subtle ecological effects. In central Arizona, for example, mid-summer diversions for agricultural use sharply reduce the base flows in the free-flowing Verde River. Although the Verde River still supports cottonwood-willow forests, the seasonal dewatering may be exerting subtle effects on southwestern willow flycatcher habitat quality by causing physiological stress in the trees and variously reducing bioproductivity rates, plant cover and density, and age class diversity (Smith et al. 1991).

3. Canals

Once diversion works direct water out of river channels, canals and lateral distribution ditches conduct it to fields or urban treatment plants. These canals often offer the potential for southwestern willow flycatcher habitat because they have slow moving flows by design, and if their beds and banks are not completely sealed, seepage from them supports canal-side vegetation. These strips of vegetation and associated artificial water courses provide southwestern willow flycatcher habitat in the Upper Gila River Valley near Cliff, New Mexico. In many areas, managers remove the canal-side vegetation to improve flow efficiency or eliminate evapotranspirational water loss. Alternately, canals that are lined with impervious materials to prevent seepage and eliminate substrate for riparian vegetation growth. Removal or prevention of riparian shrubs and trees reduces the amount of potential flycatcher habitat. Where seepage from canals supports recharge to other water bodies, its control can diminish the amount or quality of potential habitat.

4. Wastewater and Tail Water Discharges

Stream reaches desiccated by diversions receive water inflows downstream from the diversion points through the return of some flow via wastewater or tail water discharges. Wastewater from urban treatment plants sustain continuous flows below the outfall points for the plants, often creating compound channels with enough water on and near the surface to provide for riparian forests potentially suitable for southwestern willow flycatcher habitat. An example of this arrangement is Las Vegas Wash, downstream from the city of Las Vegas, where wastewater discharges sustain an extensive area of tamarisk and other riparian species that host a southwestern willow flycatcher population. Along other rivers, cottonwood-willow forests have developed as an unintended consequence of return of treated municipal wastewater to dry river channels (Stromberg et al. 1993). If untreated or inadequately treated, urban return flows can be of reduced water quality, threatening to flycatcher food quality and quantity.

Two reaches of the Santa Cruz River in southern Arizona exemplify contrasting consequences of releasing effluent into channels where the flood-plain aquifers are deep relative to the channel. The Santa Cruz flows freely from it's headwaters in Arizona's desert grasslands, through northern Mexico, and back into the United States near Nogales. Some of the upper Santa Cruz River remains ephemeral and devegetated as a result of groundwater pumping to supply water to the border cities known as Ambos Nogales. In the reach below the Nogales International Wastewater Treatment Plant, release of effluent directly into the channel has caused stream flows and water tables to once again increase to levels that support cottonwood-willow forests. This hydrologic restoration, coupled with natural flood flows, has allowed for flood-plain wide recovery of cottonwood-willow forests along several miles of the river. Much farther downstream, release of similar amount of effluent from Tucson into a similarly sized channel but underlain by a heavily overdrawn groundwater basin has produced only a narrow, short stringer of riparian vegetation. The effluent rapidly percolates into the aquifer and falls below the zone available to riparian plant species, producing habitat of limited quality for species such as the flycatcher.

The example of the Santa Ynez River illustrates the changeable nature of habitat strongly influenced by human activities, including the release of urban wastewater. Suitable riparian habitat for the bird probably existed on a sporadic basis during relatively moist periods, but the release of urban waste water insured continuous maintenance of the habitat even during drought periods. During the middle 1990s, at least 3 territorial pairs used the riparian area of the river partly sustained by wastewater. However, the habitat eventually was lost as part of channel controls instituted by Santa Barbara County for flood protection (Holmgren and Collins 1995).

There is reticence on the part of some land and water managers to release effluent into river channels or constructed wetlands because of concerns over odor, human health risks from mosquito-borne diseases, or poor water quality. Along the Salt River downstream of Phoenix, managers are finding that some of these concerns can be alleviated by managing for, or allowing for habitat complexity. For example, complex habitats that support insect predators, such as topminnows, allow natural predation-prey interactions to keep the disease organisms at low levels.

Non-urban activities also create discharges of water into otherwise dry channels and provide for useful flycatcher habitat by supporting the appropriate vegetation communities. Agricultural irrigation usually returns some flows to the river that supplied the original withdrawals, and these tail waters occupy low flow channels bordered by dense growth of riparian vegetation. Tail waters are rarely able to sustain continuous flows of distances of many km, but in some cases downstream from large irrigation areas a semblance of dense riparian forest is possible. Such forests are not as extensive as the ones that existed in pre-development periods, but they may serve as the only available substitutes. Irrigation return flows to the Middle Rio Grande support extensive riparian vegetation that hosts some of the currently active southwestern willow flycatcher habitat in that system. Irrigation return flows typically are higher in dissolved solids and salts than are the irrigation inflows due to the tendency of irrigation to concentrate solutions through evapotranspiration and dissolution form the soils. Saltier water can shift the potential species mix of riparian vegetation from natives to salt cedar, and potentially beyond the tolerance limits of salt cedar. Pesticides and herbicides and their breakdown products can potentially alter the flycatcher’s food quantity and quality in discharge areas.

5. Groundwater Management

In many areas of southwestern agriculture, the return of irrigation tail waters to streams results in elevated groundwater levels. Saturated landscapes in and near river channels sustain extensive growth of phreatophytes in an arrangement that is determined partly by surface flows feeding water to the system and partly by groundwater pools whose influence extends far beyond the points of release of the surface waters. The extensive thickets and forests that survive on these groundwater pools cover thousands of km^2 along the large southwestern rivers with variable implications for flycatcher habitat. Along the middle and lower Gila River, some reaches have flycatcher habitat, such as those in the Safford Valley. On the other hand, flycatchers have not been recorded at seemingly similar reaches near the confluence with the Salt River and near Gila Bend.

River managers do not always view groundwater-supported phreatophyte forests positively. Water users suspect that the water transpired by the vegetation could be "salvaged" and used if they remove the phreatophytes, a concept that has given rise to phreatophyte removal programs beginning in the mid-1940s. Although extensive published research has indicated that water savings from phreatophyte removal would be very limited, such programs continue. Additional pressures to remove phreatophyte cover come from flood control interests who see phreatophyte growth in and near channels as reducing flow capacity and increasing the likelihood of flooding. Channel clearing efforts, followed by channel maintenance for phreatophyte control and flood conveyance reduce the forest and thicket coverage and are common in many parts of the southwest, including coastal California streams.

Groundwater pumping for municipal, agricultural, and/or mining activity has resulted in groundwater declines along many rivers in the southwest. Riparian water tables can decline if water is pumped directly from the alluvial aquifer or from the regional basin-fill aquifer. Along the San Pedro River in Arizona, aggressive pumping from the regional basin-fill aquifer has decreased flow into the local alluvial aquifer of the San Pedro River. The rate of groundwater flow from the regional aquifer to the alluvial aquifer has steadily declined in recent decades, as the nearby municipalities have pumped groundwater at a rate in excess of the recharge from runoff from the Huachuca Mountains. The net result has been a steady decline in base flows in the river. If the pumping and associated declines in river flow and water tables continue, the eventual loss of southwestern willow flycatcher habitat is inevitable. Remedial measures include recharging the aquifer with urban effluent, as in an experimental effort by the City of Sierra Vista and the U.S. Bureau of Reclamation.

On the other hand, Tucson and other cities, recharge groundwater through flow into streambeds, though all such efforts do not greatly benefit southwestern willow flycatchers. In some cases water is being recharged into small naturally ephemeral rivers, producing small patches of riparian vegetation that may not have appropriate nesting structure or may be distant from larger river networks. Planning efforts may be able to identify recharge sites that accommodate needs of water users and southwestern willow flycatchers.

The combination of ground water pumping and surface water diversion can be severe. Along the lower Gila River near Casa Grande, Arizona, groundwater was once within a shovel's reach of the flood-plain surface. But between loss of surface recharge following river diversion and pumping from agricultural wells, this water table has dropped by as much as 200 meters during this century (Judd et al. 1971). Riparian vegetation has been entirely replaced by upland vegetation along some stretches of the Gila River. Throughout the desert Southwest, practically all intermediate and large rivers are affected by surface flow diversion and/or groundwater mining. Lowered water tables have cause death of riparian vegetation and/or replacement of hydric vegetation types by more xeric types as along the Mojave River and Carmel River in California, and the Santa Cruz River in Arizona (Bryan 1928, Groeneveld and Griepentrog 1985).

There are ample opportunities to enhance or restore riparian vegetation by recharging ground water into appropriate sites. For example, the State of Arizona was allotted 3.4 x 10^9 m^3/yr (2.8 million acre-feet/year) of Colorado River water annually under the 1928 Boulder Canyon Project Act (45 Stat. 1057) and the 1964 decree in *Arizona vs. California*. Through water-banking, some of the Colorado River allocation of Arizona is recharged or "banked" in aquifers along the 530 km of the Central Arizona Project canal from Parker to Tucson, Arizona. In this arid region of the southwest, with open water evaporation rates greater than 2.7 m per year, aquifer recharge is considered to be a more viable and desirable method of water storage than storage in surface impoundments. Importantly for the southwestern willow flycatcher, it is feasible to accomplish the dual goals of ground water recharge and riparian restoration. A recent modeling study predicted that extensive riparian forests could be re-established in a dewatered reach of the Agua Fria River below the New Waddell Dam in central Arizona, if Central Arizona Project water was released from the dam. The river corridor could essentially be used as a conduit for water delivery to the recharge/recovery zone, with the key side benefit of providing water accessible to riparian vegetation (Springer et al. in review). The total amount of water transpired by the vegetation is predicted to be less than the amount that presently evaporates from the storage reservoir. If managed appropriately, such a project could produce southwestern willow flycatcher habitat along the Agua Fria analogous to that along the nearby Hassayampa River. However, it should be noted that during extreme drought periods, Central Arizona Project water may not flow to Arizona, so that a disruption of this recharge and restoration process is possible.

6. Channelization and Levees

The protection of near-channel properties often leads to the construction and maintenance of channelized rivers and levees along southwestern streams. Channelization consists of a variety of structures including jetties, bridge abutments, grade crossings, and pilot channels to impose a single--thread, relatively straight geometry on the previous meandering or braided system. Pilot channels are trapezoidal in cross section, are small compared to the natural braided channel they replace, and lead low flow channels through otherwise more complicated arrangements in simple straight lines. Levees provide further flood protection, and are usually situated at some distance away from the low flow channel. Because of the value of near-channel property, there has been a historical tendency to construct levees as close to the low flow channel as possible, restricting active channel width as much as possible, so that land outside the levee is available for use.

To gain a cross-sectional area adequate to pass flood flows while minimizing land allocated (channel width) for that purpose, high levees are required. During peak flows, high levees restrict water to a high level relative to the surrounding protected area. This arrangement creates a great pressure differential (or hydraulic head) that stresses levee systems and the ground upon which they are constructed. The high pressure differential results in a high risk of failure, mandating intense maintenance of the levees themselves. Little habitat for any species is allowed in these cases due to the fact that it, or some of the species it attracts, jeopardizes the levees integrity. Inside the levees, optimal flood control designs of waterways include allowances for only the most limited impedance to flow (roughness elements) such as riparian vegetation. To maintain its design flood capacity, management agencies are mandated to remove vegetation before it becomes limiting to flow. Deposition of sediment that was once spread across a broad cross section then becomes concentrated in a more narrow zone, and the bed of the channel between the levees gradually becomes elevated with respect to surrounding land. In some cases, the surrounding land subsides after being cut off from the hydrology of the river. The ironical result is that this situation reduces the hazard from moderate floods, but increases flood hazards in large floods because if the levee is accidentally breached in an uncontrolled situation, flows spilling from the elevated bed into surrounding lowlands are exceptionally damaging and difficult to control.

Flycatcher habitat is likely in some southwestern streams in the area between or within the levees. Such areas have slack water in low flow channels and have riparian forests and tickets if the vegetation is not mowed or removed. Active competing land uses are uncommon or within the levees because by definition such zones are high flow channels and subject to occasional inundation. Examples of these arrangements include extensive reaches of the Lower Colorado River, the Rio Grande in New Mexico (Figure 6), and some coastal California streams.

Southwestern willow flycatcher habitat can be restored or improved along some rivers by removing the physical barriers that separate a channel from its flood plain. Along the Colorado River, for example, there are opportunities to remove the dikes and levees and restore some degree of channel-flood plain connectivity. By allowing the water to periodically flow onto the flood plain, it is possible to provide the input of water, nutrients, sediments, and plant propagules to sustain the productivity and diversity of the riparian forest (Crawford et al. 1993).

G. History and Geography of Water-Related Impacts on Southwestern Willow Flycatcher Habitat

During the period after about 1880, significant changes in the fluvial hydrology and geomorphology of the Southwest resulted in the reduction, modification, and redistribution of willow flycatcher habitat. In most rivers of the region, human intervention in the flow of surface and groundwater as outlined above resulted in substantial reductions in the total length and width of flowing streams, and their riparian vegetation. In Arizona, for example, only about 15% of the original perennial flow remains. Throughout the region on small- to medium- scale rivers, dams and diversions have desiccated stream channels and changed them from moist corridors which supported southwestern willow flycatcher habitat in the nineteenth century to dryland conditions without suitable habitat. The Santa Cruz River in southern Arizona is an example.

Along small streams throughout the Southwest, marsh-like conditions existed on many alluvial valley floors which are likely to have been suitable willow flycatcher habitat similar to that now found in wet meadows of northeast Arizona. These valley-floor marshes, or cienegas, were reported by early Spanish, Mexican, and Anglo-American observers and were common up to the late 1800s. During the last two or three decades of the nineteenth century, intensive development that included road construction, railroad building, installation of drainage lines, and overgrazing lead to the destruction of almost all the cienagas of the southwest. The removal of their surface vegetation and the concentration of surface water flows led to their excavation by vertical erosion of stream channels, resulting in the arroyos commonly found in their former locations today (Cooke and Reeves 1976). The arroyo cutting in turn lowered groundwater levels, so that dense vegetation suitable for southwestern willow flycatcher habitat is now absent from these locations.

Large regional rivers have a more complex history. Photographs, drawings, and paintings made of the rivers during the 1800s show that potentially suitable southwestern willow flycatcher habitat was discontinuous along such rivers as the Lower Colorado, San Juan, and Gila rivers, probably because of the general instability of these systems resulting from occasional large floods (Figure 7). The streams had large expanses of bare sand in the late 1800s as shown by the photographs of major survey parties such as the Powell and Wheeler Surveys on the Colorado River, and by various other investigators on other streams of the region. Floods may have been especially common in the early twentieth century, temporarily reducing cover of riparian vegetation by destroying it, with vegetation recovering between floods. Research using ground and aerial photography of generally unregulated streams shows that the vegetation communities and channels on the Gila River gradually expanded after flood events, only to see channel widening and loss of riparian vegetation in the next flood event (Burkham 1976; Figure 8). Thus, under pre-development conditions, southwestern willow flycatcher habitat was likely to be highly changeable over a period of decades, with habitat being simultaneously gained and lost in various places throughout the southwest. A result of the flood cycle driving riparian vegetation distribution was likely a broken pattern of habitat that was somewhat naturally fire-proof.

When modern photographers have rephotographed these historic sites, they document inconsistent changes (Stevens and Shoemaker 1987). Some sites are now more heavily vegetated than they were more than a century ago because upstream dams have controlled destructive floods, but other sites appear similar to their nineteenth century barren conditions. In many cases, modern vegetation is more dense than in the views of the late nineteenth century because of the invasion of tamarisk (*Tamarix* sp.), an exotic species from the Middle East which was a rapid and effective colonizer of exposed moist sand accumulations. Tamarisk spread rapidly throughout southwestern rivers after about 1900 (Graf 1978), and it replaced much of the willow cover lost because of dams and diversions. Tamarisk, with its aggressive, deep tap roots effectively survived depleted surface flows in many areas, and it dominates the communities in many of the rephotographed locations.

Groundwater management has affected southwestern willow flycatcher habitat through an intricate series of connections with surface flows to produce a complicated history of changes. Under pre-development conditions, most of the medium and large rivers of the Southwest had flow almost continuously, with the channel water seeping into the groundwater system which had its upper surface connected to the channels from which it derived its water. This condition was common throughout the region until the early 1900s. When dams and diversions removed this surface flow and severed this nourishing connection, groundwater levels declined in those areas downstream from the diversions. Often, groundwater pumping further depressed the water table, so that phreatophyte vegetation (even the exotic tamarisk with its extensive tap root systems) could not survive in riparian environments. In many agricultural and urban areas, this groundwater depletion accelerated with the introduction of high capacity electric pumps beginning in the 1950s; from that time on, reductions in the coverage of riparian forests was common in many areas, including coastal California and the interior alluvial basins

(Figure 9). The replacement of riparian trees with barren surfaces is usual course of events in urban areas of the Southwest that produces no suitable habitat for the willow flycatcher without extensive restoration efforts (Figure 10).

The changes imposed upon the southwestern fluvial system through human activities take place against a backdrop of otherwise natural changes in the prevailing hydroclimatic system. The arrangement of the atmospheric circulation system, frequency of incursion of major storms and ordinary low pressure systems, sea surface temperatures, and teleconnections such as the El Niño and La Niña phenomena have caused some measurable adjustments in the frequency of storms and in regional flooding (Hirschboeck 1988). These changes are small compared to the local changes caused by human activities. It is unlikely that future local hydrologic responses from global climate change will be directly significant in the recovery of the southwestern willow flycatcher, because such changes will only be a maximum of about 15-20 percent of present flows (Intergovernmental Panel on Climate Change 1995). This change is small compared to the changes brought about by dams which have altered annual water yields by as much as 100% and have provided the opportunity to store several year's flow of the regional streams (Table 1; storage compared to annual runoff). If global climate change affects southwestern willow flycatcher recovery, it will be through minor changes in an already over-appropriated water economy, and by increasing the marginal cost of water that might purchased from other uses and applied for restoration.

Nevertheless, extremes of drought and flooding do influence southwestern willow flycatcher habitat, particularly if compounded by synergistic interactions with human activities. For example, the American Southwest experienced an "extreme" drought in the 1950s (Swetnam and Betancourt 1998). This contributed to the collapse of the cottonwood-willow communities and aquatic ecosystems along those portions of the Santa Cruz River that were subject to ground water pumping. The combined effects of drought and pumping from the small alluvial aquifer caused water tables in the 1950s and 1960s to decline below cottonwood and willow rooting depths (Arizona Department of Water Resources 1994). Since the mid-1970s, the Southwest has been in a wet cycle, allowing for expansion of riparian forests in some areas.

Seasonal changes in precipitation and flood patterns can influence southwestern willow flycatcher habitat, as well. After 1960, for example, climatic fluctuations tied to El Nino-southern oscillation weather patterns (Webb and Betancourt 1992) created a pattern of flood flows that was more favorable to cottonwood-willow establishment in parts of the southwest. Increased activity of Pacific frontal winter storms and of dissipating late summer and fall tropical cyclones resulted in increased magnitude of fall and winter floods (favoring the growth of willow and cottonwood seedlings by establishing enlarged potential seedbeds), while activity of convective summer thunderstorms decreased (favoring seedling survivorship). These flood patterns presumably facilitated the mid-century expansion of cottonwoods and willows over the length of the San Pedro River (Stromberg 1998) and possibly other rivers, as well. Of course, drought conditions and less favorable flood patterns may return at any time, underscoring the need for preservation of a variety of southwestern willow flycatcher river sites including the larger rivers and others with stable aquifers that are less subject to the vagaries of annual precipitation.

Several attempts have been made in western United States and Canada to restore riparian ecosystems by prescribing controlled flood flows (see Appendix K; habitat restoration). Some of these efforts have achieved notable success. To facilitate regeneration of cottonwoods, flood flows on the Oldman River tributaries (Canada) and Truckee

River (Nevada) were released at specific times in spring that coincided with the germination phenology of the target species, and with specific draw-down rates that were within the tolerance limits of the seedlings (Mahoney and Rood 1998). El Niño has assisted in the restoration of other rivers such as the lower Gila by filling reservoirs to levels that required spills from the reservoirs during spring and summer. With prior planning, water managers could be prepared to routinely release water in ways that facilitate riparian tree regeneration.

The case of the lower Gila River offers an object lesson in water management for habitat restoration for the flycatcher, and demonstrates the sorts of changes that would be needed in operating rules. Painted Rock Dam stores as much as 4 million acre feet of water, but is not designed to retain the entire amount. The dam is primarily a flood control structure, and present operating rules require that it be essentially empty by October 1 each year. If this requirement were relaxed to allow a minimal amount of storage, just enough to permit trickle flows downstream from the dam, habitat restoration would be greatly aided. The amount of flood storage thus reduced would be relatively small while at the same time improving sustainability of the flycatcher population.

Methods to manage flows on regulated rivers to favor native willows and cottonwoods over the tamarisk are being refined. Tamarisk overlaps with willows and cottonwoods in many of its ecological requirements. It is possible, however, to restore to regulated rivers some of the flow conditions under which the cottonwoods and willows are more competitive. For example, one can adjust the timing and duration of the spring floods to coincide with the desired needs of the desired species, or adjust the size and duration of the post-germination floods to levels that exceed seedling survivorship thresholds of the exotic species, but not the native species (Gladwin and Roelle, 1998).

H. Water-Related Recommendations for Flycatcher Recovery

Along with its population, the Southwest’s demand for municipal and agricultural water, hydropower, and aquatic recreation continues to grow. The time for management compromise has arrived. We need to adopt strategies that will both protect our natural resources and allow sustainable human use. There are creative ways to allow for continued flow-regulation on dammed rivers, while also allowing for the return of more natural flow regimes, including the flood flows that are paramount in the regenerative process of native riparian woodlands. Because there are pre-existing demands on water supply or power supply , we must find creative ways to work within the political and institutional constraints to rehabilitate, if not fully restore, the ecosystems.

Ultimately, we can manage our water resources to restore the conditions that favor a diversity of native riparian species. With appropriate planning, we can intermingle these habitat restoration efforts with direct human uses of the flood plain, such as agriculture. There are indirect benefits to undertaking such dual approaches. For example, native riparian forests in agricultural landscapes supply farmers with a wide variety of insects to pollinate crops and a variety of insectivorous birds to consume crop pests (Anderson et al. 1984). Such ecological services are critically important and ultimately economically cost-effective.

I. General Guiding Principles for Recovery

1. ***Reestablish and maintain physical integrity of rivers first, then proceed to biological integrity for flycatcher habitat.***

Physical integrity for rivers implies the restoration and maintenance of their primary functions of water and sediment dynamics, with some variability over time and space. The vegetation communities needed for flycatcher habitat require specific hydrologic and geomorphic conditions, the most basic of which are floods, sediments, and persistent water. Sediment supply is restricted below dams, and inflows from tributaries supply all that is readily available. Each case will need to be examined separately, but in some instances the reduced amount of sediment will coincide with reduced transport capacity, so that the imbalance is not as great as might be imagined.

2. ***Monitor physical integrity for rivers using simple indicator parameters such as stream flow and channel morphology, particularly width and channel pattern.***

Monitor physical conditions photographically using repeat ground station or aerial photography.

3. ***Set reasonable restoration and maintenance targets for physical integrity, recognizing the restored system will be a combination of natural and artificial processes.***

It is not possible to return the physical system to its pre-development condition, but it is possible to establish and maintain conditions that mimic those that existed before extensive development, although at a limited scale and at a limited number of sites.

4. Design flycatcher recovery strategies and objectives to accommodate rivers and lakes that change from time to time and place to place, rather than depending on a static, unchanging fluvial system.

Such an approach assumes that flood events and reservoir level changes will destroy some existing habitat, but that they will create opportunities for new habitat. Because of this changing nature of the fluvial system, target more of the fluvial system for recovery than will be needed at one time, because it is likely that at any one time, some of the system will not be useful.

J. Geographic Framework for Flycatcher Recovery

1. Focus recovery plans involving water-related resources locally on individual river reaches, but take into account the watershed areas upstream in planning and management.

Specific places for establishing or maintaining flycatcher habitat should be river reaches, stretches of channel and riparian zones that are a few km long and relatively similar geomorphologically throughout their extent. However, these localized efforts must take into account the entire drainage basin upstream, because activities (dam operations, tributaries, and other land-uses) in this larger framework influence water and sediment flows through individual reaches.

2. Manage and plan water-related resources in the southwestern willow flycatcher recovery effort on a watershed basis.

Use the six-digit coded hydrologic units as the basis of planning for water and water-related resources to facilitate communication among agencies and water users.

K. Opportunities in the Water-Related Resource System to Enhance Flycatcher Recovery

1. Modify dam operations to take advantage of system flexibility and water surpluses to create and maintain flycatcher habitat.

Although legal and economic considerations limit the flexibility of operations management, environmental restoration and maintenance are part of the operating strategies of many large, multi-purpose structures, and habitat considerations should be a part of decision-making for operating rules. Creative management offers many opportunities where water resource decisions can lead to important benefits to flycatcher habitat.

Use surplus / flood flows to increase or add water to marsh areas between levees and on flood plains where there are no conflicts with other land uses.

Experience on the Lower Colorado shows that occasionally flood flows are so large that water flows into the Sea of Cortez and it is not used. Rather than losing this water, it should be used through diversions onto flood plains behind levees (as discussed elsewhere) and stored as long as possible so that it may be used for restoration. Availability of the waters of flood flows and uncontrolled releases depends largely on climatic events. The use of the water in the Colorado River is presently regulated by laws and treaties; an Interim Surplus Criteria presently defines the use.

Maintain reservoir levels as constant as possible to allow the establishment of lake-fringe habitat.

Reservoir level fluctuations are inevitable, but when choices for change or stability are available, stability or slow change should be the objective. When changes are needed, seek a new level with the smallest changes possible to encourage the development of new vegetation at the new lake level on headwater deltas. Loss of habitat when one level is abandoned may provide the opportunity to establish replacement vegetation at a new reservoir level at a different delta location. Structurally create sub-impoundments at major and tributary inflows to settle sediments and remain moist environs to develop stable riparian deltas.

Keep daily ramping rates and absolute amplitude for dam releases as low as possible.

Ramping rates, the rates at which releases are increased or decreased, should be kept as gradual as possible to prevent bank erosion and loss of riparian vegetation through mechanical processes at the margins of downstream channels.

Maintain instream flow releases below dams at suitable levels to conserve or enhance instream values and public trust resources.

For those dams that are primarily flood control structures, release storage volumes to take advantage of both flood scouring processes and trickle flows over long periods to maximize groundwater recharge and small amounts of surface flow downstream from the structures.

Investigate multi-objective optimization methods for deciding best strategies for operating rules that explicitly take into account flycatcher habitat maintenance in addition to the other objectives for dam operations.

For those structures that have operating rules including environmental values, use the same analytic techniques for assessing options to maintain flycatcher habitat that are used for other water resource objectives. Operate dams systematically to attempt to mimic natural river processes at least occasionally. Distribute flood storage capacity differentially between dams in various years so the intervening watercourses will occasionally experience floods while the systems flood protection integrity is maintained. Release flows for purposes that will better simulate natural hydrology and/or specifically to enhance riparian systems – e.g., release water for recharge purposes along with peak flows to enhance the flood-like processes between the dam and point of diversion.

2. Focus some restoration efforts on river reaches that include outfall points for urban waste water and rural irrigation tail waters.

Such areas have the potential to support vegetation suitable for flycatcher habitat and often have open water surfaces. In the lower Colorado River flood plain, for example, irrigation of riparian trees and shrubs planted as part of revegetation / restoration efforts with agricultural return flows have increased the survivorship over plantings without irrigation (Briggs and Cornelius 1998). When utilizing return flows to support or create southwestern willow flycatcher habitat, it may be necessary to periodically flush the soils to reduce the concentrations of salts below the levels that are toxic to willows. Success also will be enhanced if water level fluctuations do not exceed tolerance ranges of the plant species (see Appendix K). Restoration efforts in waste-water systems need to monitor water quality and contaminant levels to minimize risks.

Investigate the feasibility of lining presently unlined canals and using the savings of previously lost water for habitat restoration purposes.

Substantial amounts of water are lost to the surface water system through the walls of unlined canals. Lining of these canals can result in savings of surface water that can then be redistributed to habitat restoration efforts. This same approach has been used by Southern California farmers whose canals were lined by cities who then have the use of the saved water. A similar arrangement should be explored for habitat, including identification of likely funding sources.

3. Manage ground water more effectively.

Integrated, watershed-based approaches to water management may suffice to reverse some of the changes resulting from ground water mining in some river reaches. All water users- be they municipal, agricultural, or industrial, need to work together and bear their share of water overdraft problems to achieve results. Approaches should focus on reducing withdrawals (e.g., xeriscaping, replacement of high-water-use crops by those with high water-use-efficiency) and increasing recharge (e.g., recharge of aquifers with effluent). In cases of extreme dewatering, restoration of water tables may require importation of water from other basins.

4. Increase the width of the flow zone between levees to expand flood conveyance potential and to foster wider areas likely to support flycatcher habitat.

If the distance between levees is increased, more space results for dense riparian vegetation outside the low flow channel. Flood conveyance channels should be designed to provide adequate flood-flow capacity with a large portion of the width in riparian vegetation. For example, doubling the width of channel dedicated to flood conveyance could free half the width from the necessity of channel clearing. Schedule channel clearing activities in such a way that riparian habitat is continuously available in the area –i.e., do not mow or grade entire flood control systems simultaneously. In some cases, levees may need to be rebuilt, with attending restrictions of space on flood plains outside them, but this loss is compensated by increased flood conveyance capacity, reduced maintenance costs, and reduced flood hazard. Sizing the channel width using the "meanderbelt" concept has potential for yielding both flood control and aquatic/riparian values. Discourage other land uses (e.g., cultivated agriculture) within flood conveyance facilities when they are inimical to riparian vegetation growth.

5. Breach levees temporarily during occasional high flows to reactivate flood plain areas in marsh conditions suitable for flycatcher support and not dedicated to other purposes.

Along some channels where the flood plain marshes can be maintained, construct additional levees around them to set them off from nearby flood plain areas used for other purposes, and install gates or valves to connect them through the main river levees to the channel to facilitate occasional diversions.

6. Reactivate abandoned channel segments now isolated on flood plains away from the active channel.

Abandoned channels and oxbows can be excavated to remove sediment and can be reconnected to the main river channel through artificial channels with gates or valves to supply temporary flows.

7. Use areas characterized by at least occasional standing water and the potential to support a dense understory of tamarisk or willow for restored or newly created flycatcher habitat, including:

a. Canals, laterals, and irrigation drains

b. Flood channels

c. Recharge basins

d. Minor lakes and reservoirs.

These activities can become multi-purpose projects including southwestern willow flycatchers if the areas are sized and maintained so that riparian vegetation is permitted. The basins should be lined only when water is lost to unusable sources. Managers should maintain water in unlined facilities beyond their original intended function so that they can act as recharge source areas where the aquifers are depleted. Along some streams, moving the point of diversion downstream as far as possible will ensure that a greater length of natural watercourse is watered.

8. Avoid creating a need to control riparian vegetation.

For example, size culverts and bridges so they are large enough to pass not only peak floods, but also the debris that the floods transport.

9. Land management agencies should assure through their activities and monitoring activities that all of their watercourses are rated as "properly functioning" (Bureau of Land Management 1995).

This basic management objective is the foundation upon which flycatcher habitat will result given adequate water, sediment, and rest from grazing.

10. Repatriate beaver in stream reaches devoid of flycatcher habitat to create still waters by impoundment and sediment storage.

L. Conclusions

The recovery of the southwestern willow flycatcher population depends on the restoration and maintenance of suitable riparian forests which the bird uses for nesting. The forests, in turn, depend on a physical substrate that includes functioning river channels and near-channel sediments and landforms. There is intense competition among users for the water and landscapes that constitute the region's functioning fluvial systems, and in many cases making provision for a recovering southwestern willow flycatcher population resolves itself into a conflict over space. If the flycatcher population is to survive, some space must be allotted for that purpose, and water which is in transit or that is being used for other purposes may also be used to aid in the recovery of the bird population. Many water-related resources of the Southwest serve multiple purposes. The key to using those resources to aid the southwestern willow flycatcher population is to extend this multi-purpose approach to sustaining the physical and biotic environments needed by the birds. Multi-purpose approaches ultimately reduce costs to other users of the water related resources, and reduce conflict among competing objectives. Creative and innovative use of existing water-related resources can make possible economic and environmental productivity without sacrificing one for the other.

L. Literature Cited

Please see Recovery Plan Section VI.

Table 1. Southwestern Water Resource Regions and Dams

Water Resource Region	Rio Grande	U. Colorado	L. Colorado	Great Basin	California
Region Identifier	***13***	***14***	***15***	***16***	***18***
Total Area (sq mi)	132,510	112,110	139,130	140,110	147,550
Total Number of Dams	716	1,164	446	803	1,530
Total Storage (ac ft)	21,013,562	46,364,999	48,373,154	5,979,380	74,161,688
Total Annual Runoff (ac ft)	5,487,880	15,063,670	18,982,714	6,596,655	72,910,402
Population	2,566,000	714,000	5,318,000	2,405,000	32,060,000
Area/Dams (sq mi/dam)	185	96	313	174	96
Storage/Area (ac ft/sq mi)	159	414	348	55	503
Storage/Runoff	3.83	3.08	2.55	0.91	1.02
1st Year Storage > Runoff	1935	1950	1936	NA	NA
Persons per Dam	3,584	613	11,924	2,995	20,954
Storage / Person (ac ft/pr)	8.19	64.94	9.10	2.49	2.31
Numbers of Dams by Size Classes					
Size = 10^x ac ft, where x =					
Unknown	2	4	19	16	7
0-0.99	0	0	0	0	0
1-1.99	134	221	80	214	209
2-2.99	406	620	171	314	693
3-3.99	119	212	108	186	345
4-4.99	37	82	45	60	182
5-5.99	13	21	16	11	69
6-6.99	5	3	6	2	25
7+	0	1	1	0	0
Storage of Reservoirs by Size Classes					
Size = 10^x ac ft, where x =					
0-0.99	0	0	0	0	0
1-1.99	8,142	12,523	4,339	9,804	11,479
2-2.99	126,532	214,674	58,020	112,704	242,597
3-3.99	416,734	646,016	362,490	529,651	1,118,433
4-4.99	961,056	2,357,803	1,303,178	1,535,752	7,476,134
5-5.99	5,072,502	7,195,673	4,519,487	3,091,140	21,633,085
6-6.99	14,428,596	7,117,310	11,888,640	2,452,894	43,679,960
7+	0	28821000	30237000	0	0

Table 2. Summary of Downstream Impacts of Dams

Dam Operations →	Hydrologic Changes →	Geomorphic Responses →	Willow Flycatcher Habitat Responses
General system-wide	Reduced annual water yield; dessication in cases of diversion of all normal flow	Shrinkage of high and low flow channels, expanded flood-plain areas with increased stability; falling water tables in the case of dessication	Expanded flood-plain forest areas; elimination of riparian forests if water tables decline below 10 m (33 ft)
Flood control	Reduced flood peaks	Shrinkage of high flow channel, change from braided to single-thread or compound patterns	Expansion of riparian forests given sufficient water table support
Irrigation and urban water supply delivery	Increased low flows	Expanded low flow channel, change from braided to single-thread or compound patterns	Maintenance of ribbon or gallery riparian forests along the low flow channel
Local diversions of flows	Decreased low flows, dessication	Shrinkage of low flow channel	Loss of most riparian vegetation
Spills, uncontrolled flows	Rare, very large flows	Destruction of the established low flow channel, occupation of the high flow channel of the compound system	Temporary loss of riparian vegetation, establishment of a new arrangement
Most operations	Decreased annual fluctuations in flow	Simplification of the channel system, loss of medium-level forms such as beaches, attachment bars, flood plains	Simplification of habitats, reduced variety of ecological niches, reduced area of riparian forest, conditions more conducive to tamarisk and other exotic species, less favorable for native species
Hydropower (run-of-river)	Little change	Little change	Little change
Hydropower (peaking)	Increased daily fluctuations	Creation of a scoured low flow channel, erosion and instability near the channel	Unsuitable for riparian forest within the zone of fluctuation

Table 3. Water Withdrawals and Uses in Southwestern Willow Flycatcher Water Resource Regions. Data from Solley and others, 1998.

Surface Water Withdrawals						
Region	**Public Supply**	**Irrigation**	**Livestock**	**Industrial**	**Mining**	**Thermal Power**
	acre feet per year					
Rio Grande	147	5150	39	11	62	2
Upper Colorado	119	7840	60	7	26	164
Lower Colorado	782	4710	45	53	17	19
Great Basin	285	4500	96	102	83	24
California	3230	20400	507	605	87	226

Surface Water Uses				
Region	**Pop Served**	**Acres**	**Thermal Power**	**Hydropower**
	thousand persons	thousand acre feet	millions kilowatt hours	millions kilowatt hours
Rio Grande	735	968	7780	464
Upper Colorado	407	1470	94000	7220
Lower Colorado	2510	938	62400	9740
Great Basin	1050	1060	16300	633
California	17400	7060	76000	47000

Appendix I. Figures

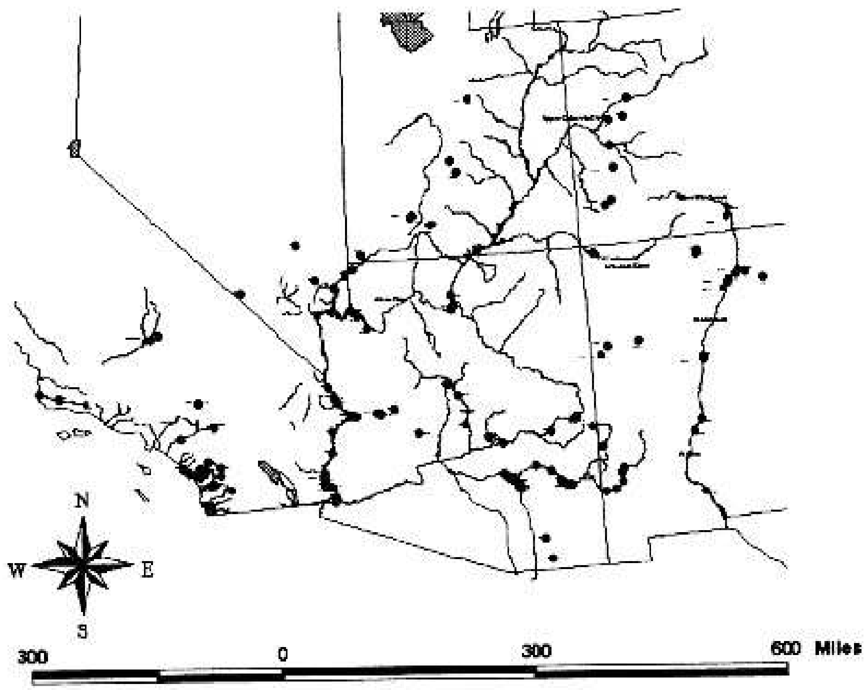


Figure 1. Map showing the present distribution of willow flycatcher nesting sites in the Southwestern United States.

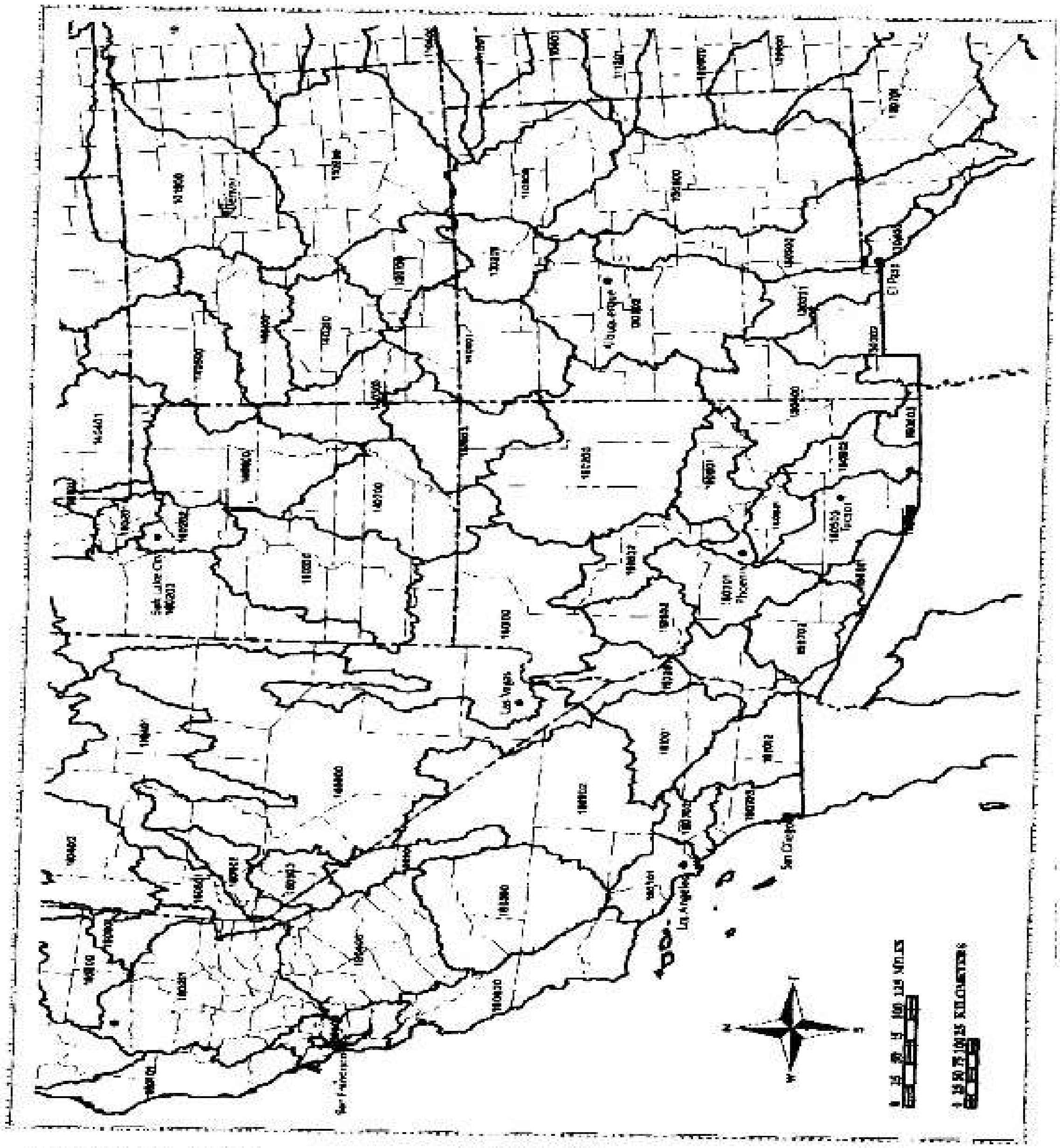


Figure 2. The watersheds and streams of the Southwest. Map created by William Cosgrove, U.S. Bureau of Reclamation, Phoenix.

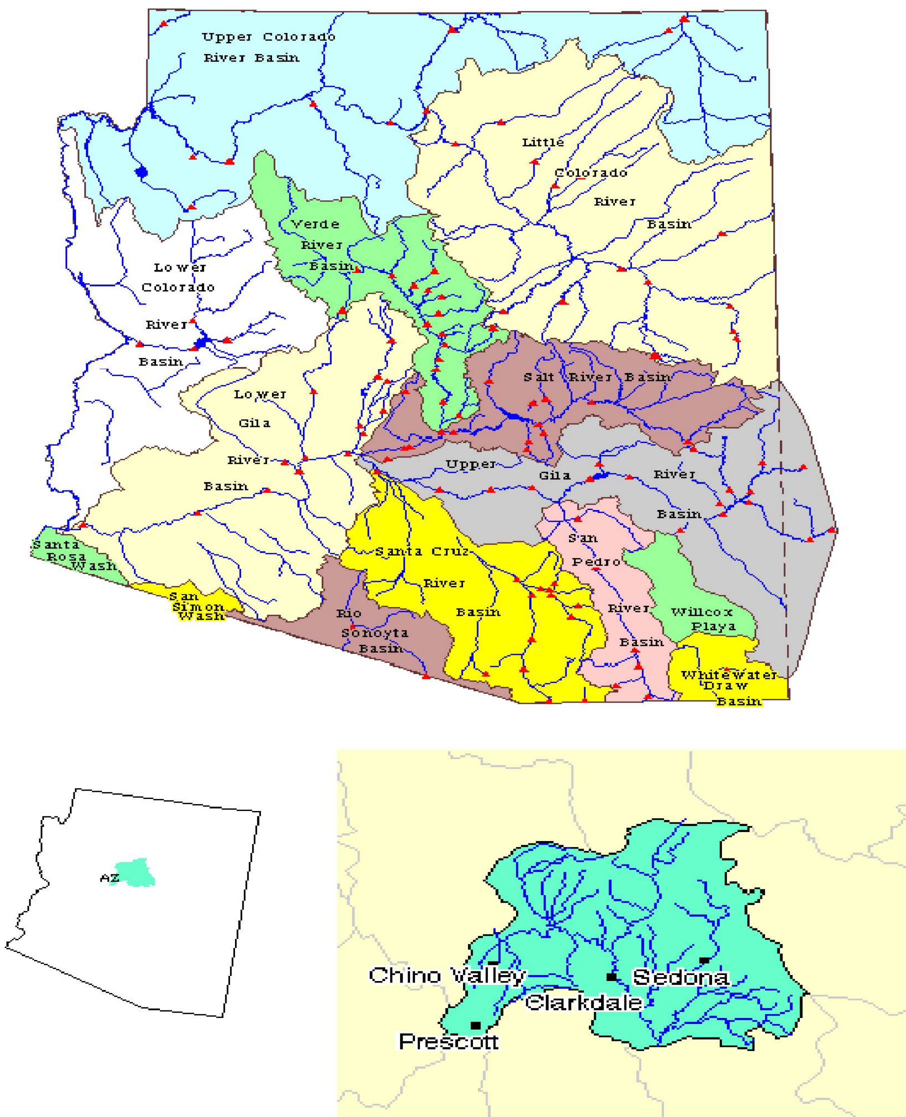


Figure 3. Varying scales of watersheds and river basins illustrated by watersheds in Arizona. Upper: the watersheds of the state outlined at using the 6-digit codes of the planning areas defined by the U.S. Geological Survey and the Water Resources Council. Small triangles are major stream gage sites (from the web site http://az.water.usgs.gov/rtaz/html /rtsw.html). Lower: the Upper Verde Watershed, an 8-digit code watershed, the smallest of the defined areas. It is 6,374 km^2 (2,461 mi^2) in extent. (From the web site http://www.epa.gov/surf2).

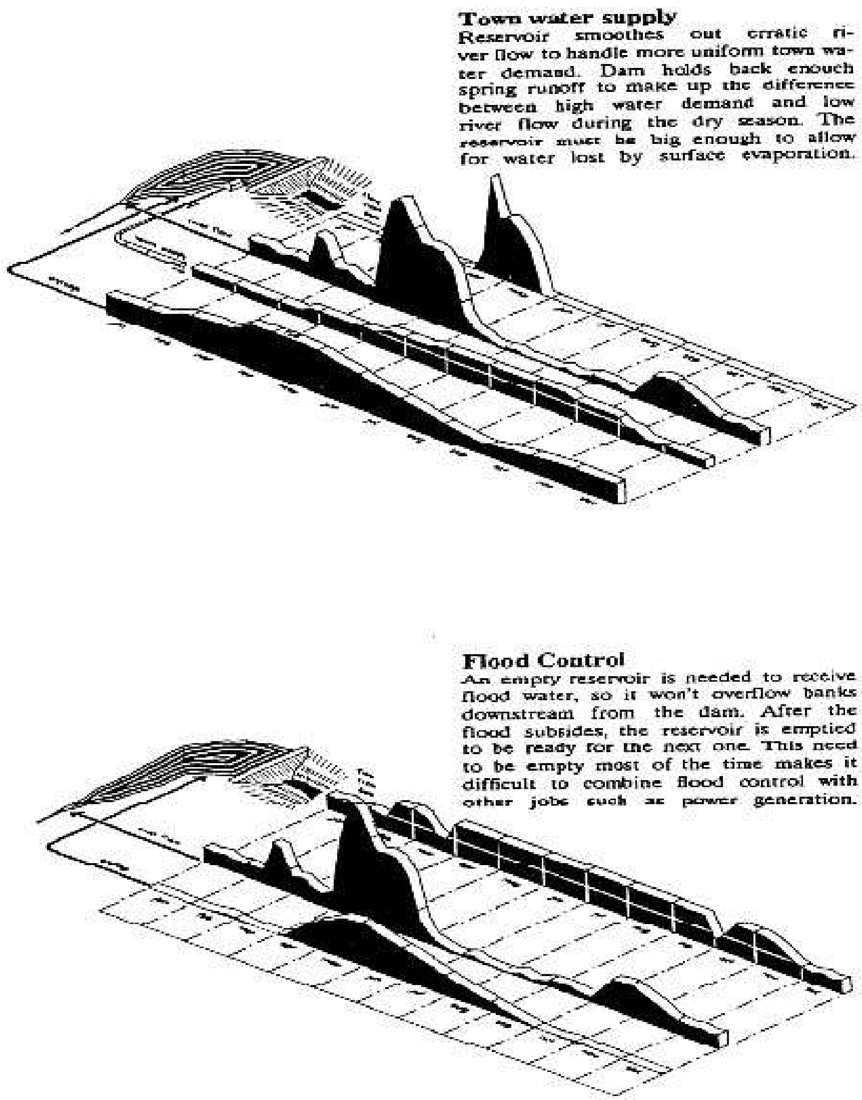
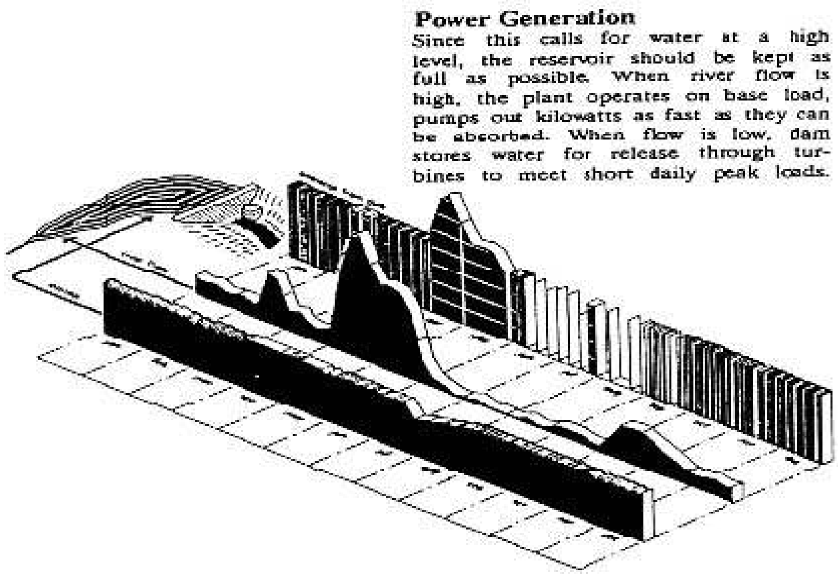


Figure 4. Effects of dams under varying operating rules in four hypothetical cases. (From Black, 1992).



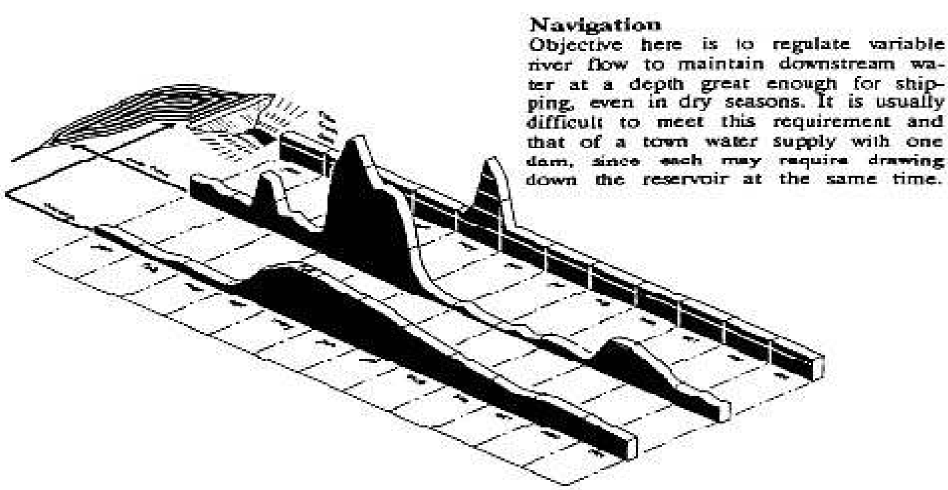


Figure 4 (continued). Effects of dams under varying operating rules in four hypothetical cases. (From Black, 1992).

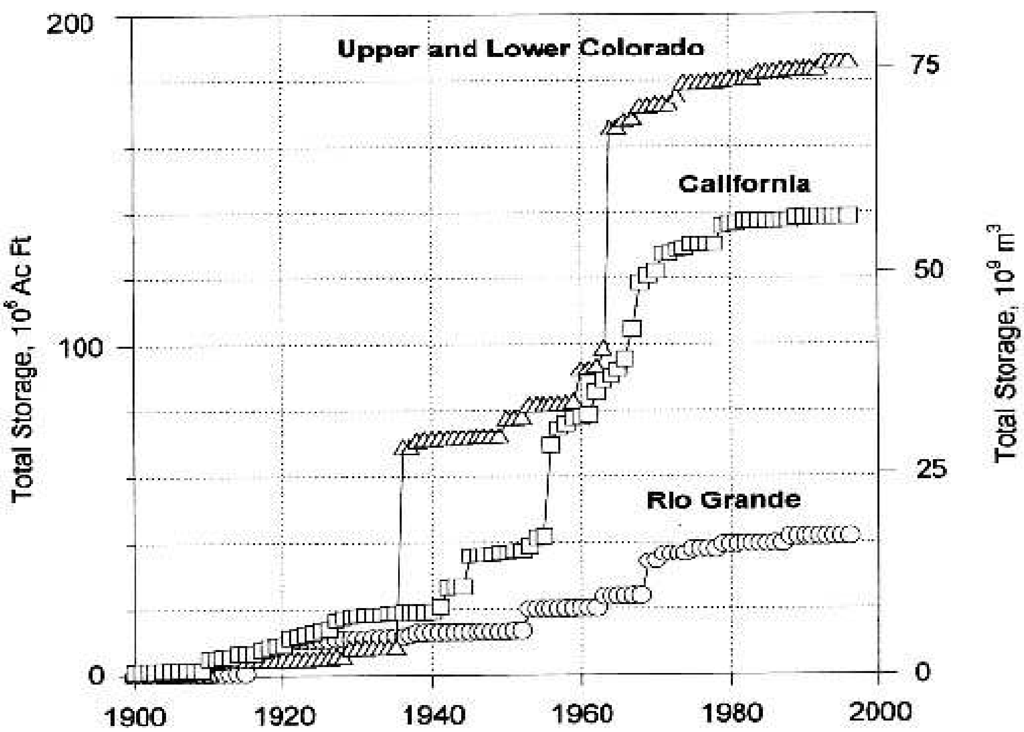


Figure 5. The history of increasing reservoir storage in Southwestern river basins. Data from U.S. Army Corps of Engineers, 1996; calculations from Graf, 1999.

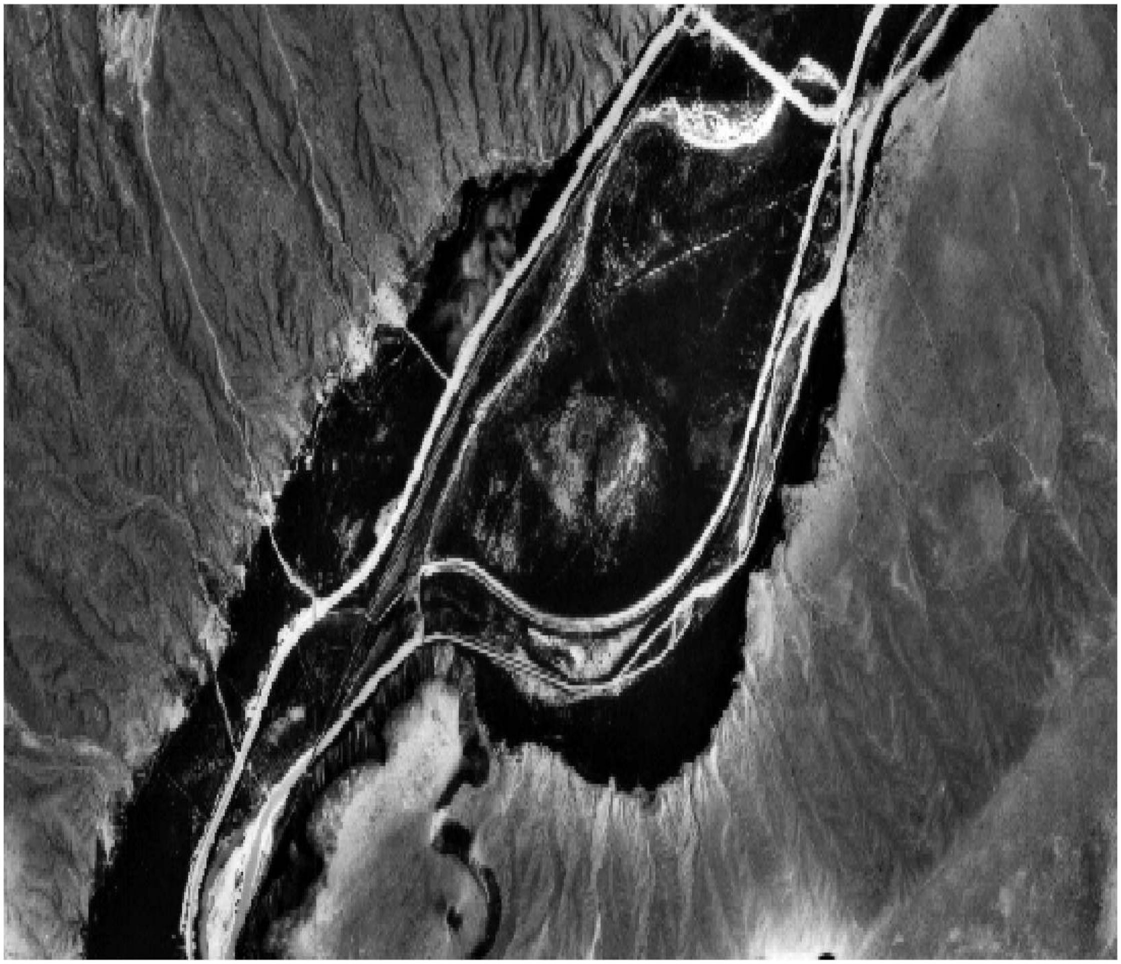


Figure 6. Aerial photograph of Rio Grande near San Marcial, New Mexico, in 1984 showing the density of riparian vegetation associated with a shrinking channel system and extensive diversions. The white lines are drains and canals with roads on their banks. U.S. Geological Survey mapping photograph from the EROS Data Center, Souix Falls, South Dakota.

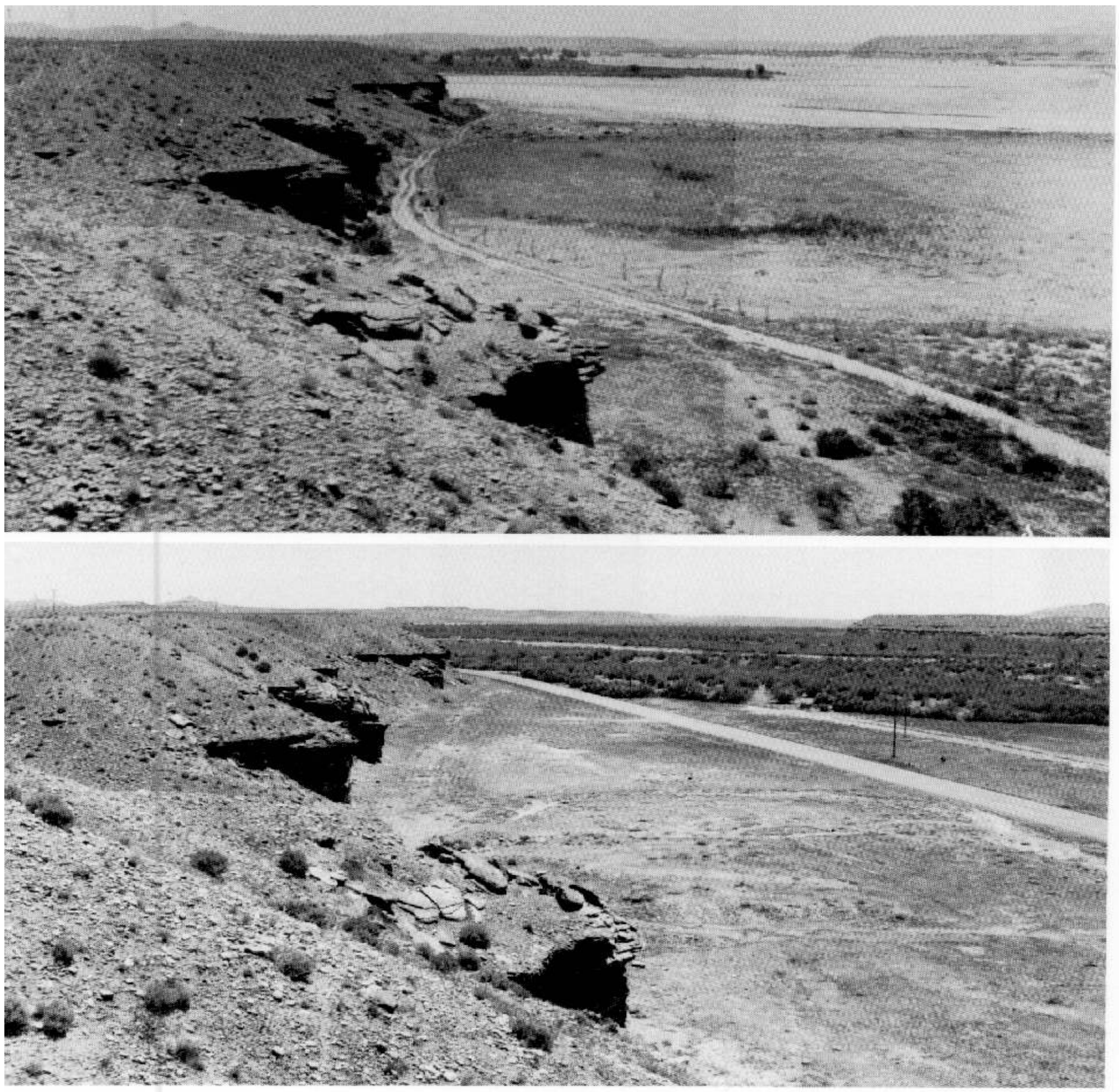


Figure 7. Repeat photographs of the San Juan River near Aneth, southeastern Utah, showing the change from a braided channel with little vegetation to a single thread channel with extensive phreatophyte cover. Navajo Dam substantially changed river flows in this reach after the completion of the structure in 1962. Above: 1928 photograph by H. E. Gregory. Below: 1982 photograph by W. L. Graf.

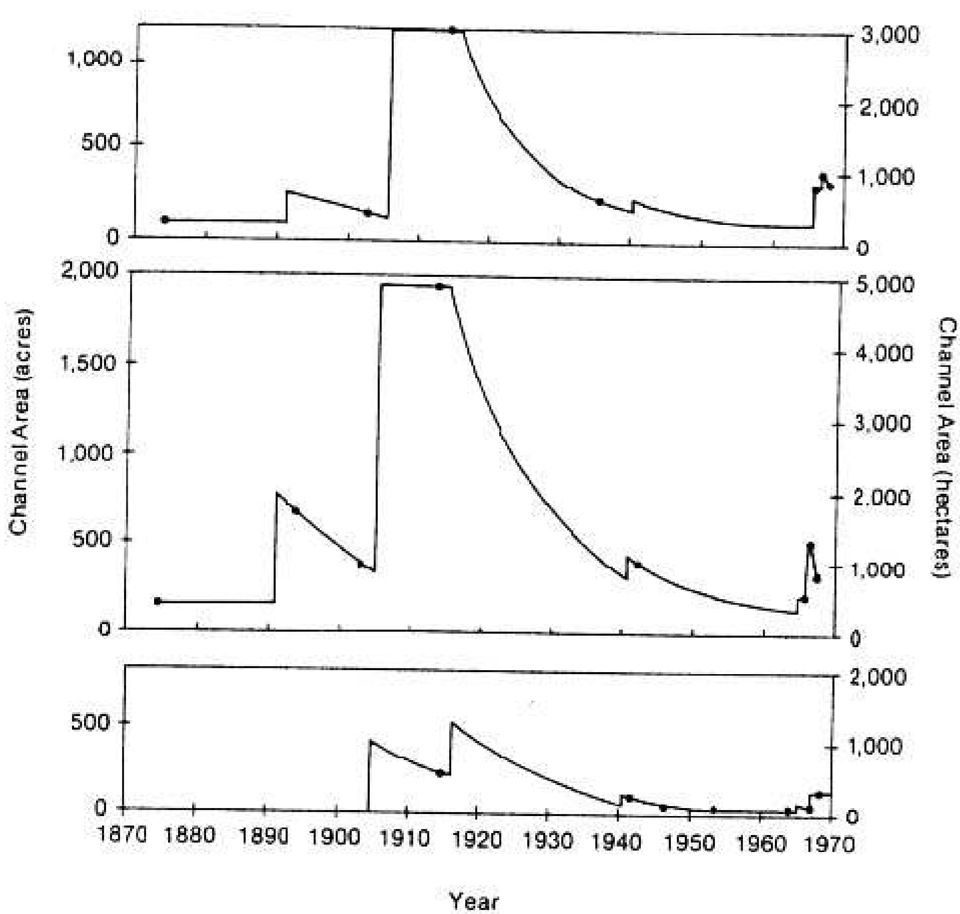


Figure 8. Channel and riparian vegetation area fluctuations on the Gila River in the Safford Valley, southeast Arizona. Each box represents a different river reach, with the total vertical extent of each box representing the total valley width. Within each box, the area below the plotted line is the channel, and the area above the plotted line is the riparian vegetation area. Rapid increases in channel width accompany the destruction of riparian vegetation in large flood events, followed by slow encroachment of vegetation on a gradually shrinking channel. There are no large dams upstream from these reaches. Data and design from Burkham, 1972.

Figure 9. Repeat photographs of the Gila River west of Phoenix at the Cotton Lane Crossing, showing the effects of groundwater pumping. The dense cover of tamarisk, fed by surface flows and groundwater, has given way to a nearly barren river bed with some temporary standing water but little else. Depth to groundwater is greater than 15 m in the later view. Above: 1949 photograph by the U.S. Army Corps of Engineers, with an arrow added by the photographer to show the direction of surface flow. Below: 1980 photograph by W. L. Graf.

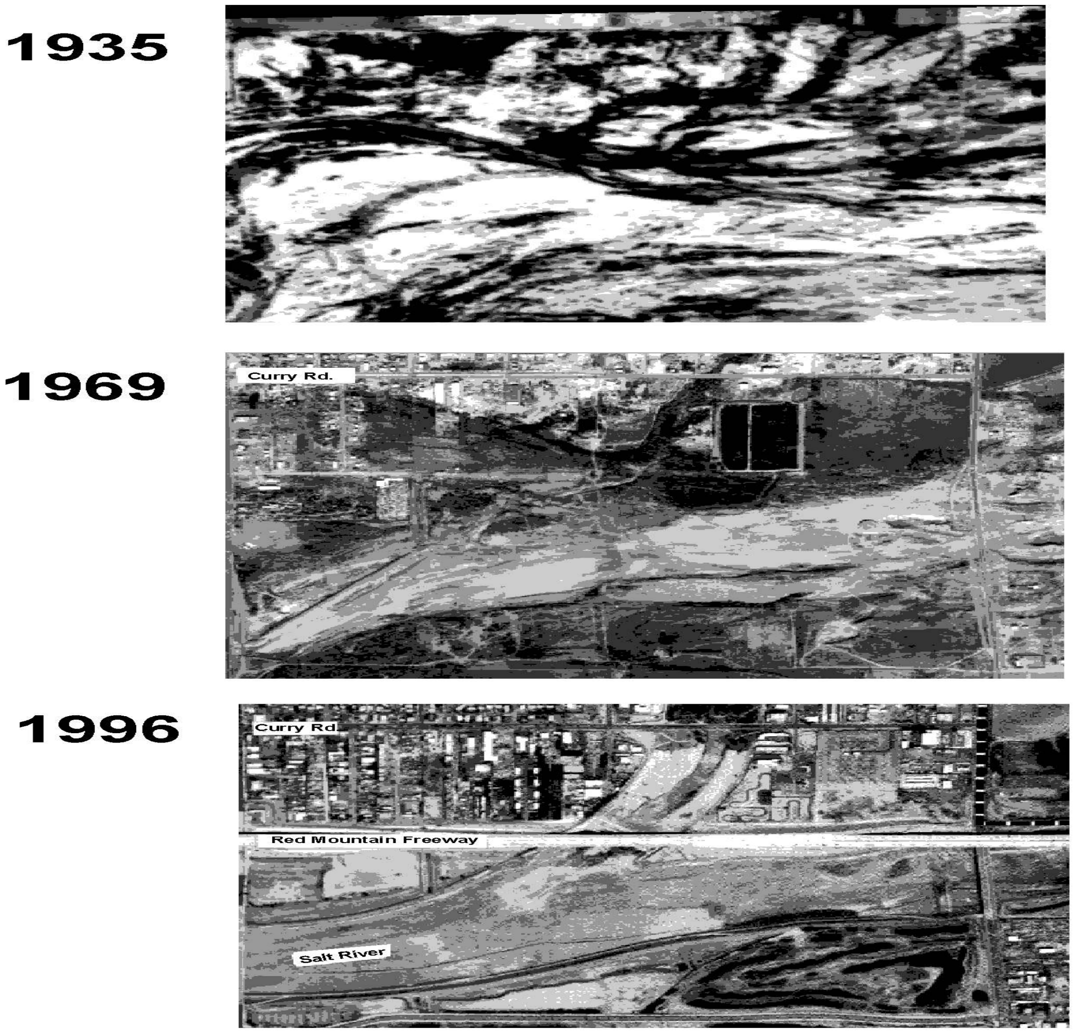


Figure 10. Series of aerial photographs showing the sequence of channel and riparian vegetation changes resulting from urbanization on the Salt River in Tempe, part of the Phoenix metropolitan area. All the photographs are registered to a common base using geographic information systems, and all show exactly the same one-mile reach of the river. 1935, prior to urbanization: Soil Conservation Service photograph showing a braided channel with a well-defined low flow channel, islands, bars, and ribbons of dark vegetation. 1969, urban fringe entering the area: Landis Aerial Survey, Inc., photograph showing the narrowed, simplified channel as a result of upstream dam closures, with building activities on the north bank and groundwater pumping that has lowered the water table. No riparian vegetation remains. 1996, urbanization complete: Landiscor, Inc., photograph showing a completely artificial channel, scheduled for some restoration, but none that is likely to reestablish the pre-development vegetation. Photographs from Nobel Science and Engineering Library, Map Collection, Arizona State University.

Appendix J.

Fluvial Hydrology of Regulated Rivers in the Range of the Southwestern Willow Flycatcher

A. Purpose

Dams, large and small, are important components of the economic infrastructure of the American Southwest. They were constructed with specific purposes and objectives designed to foster economic development through flood reduction, irrigation supply, urban supply, hydroelectric power generation, and provision of recreation. Dam management and administration during most of the twentieth century viewed rivers simply as sources of commodity water and electrical power, but changing social values have now expanded the roles of dams and the rivers they control. Rivers are now viewed by decision-makers and the public as complex landscapes and ecosystems that, in addition to providing commodities, are also the habitats of endangered wild species that our culture deems worth preserving. Part of this new mission for water managers is a rethinking of the role of dams, not as sources of problems for endangered species, but as opportunities for recovery. To use dams effectively in this effort, decision-makers require an understanding of the effects that dams and their operations have had on rivers and the hydrology, geomorphology, and riparian habitats.

Water is a key component of the natural, social, economic, and cultural fabric of the American Southwest (Table 1). The availability of water is highly variable through time and across space, but the construction and maintenance of an engineered water delivery system has permitted extensive economic development in the region. Early uses of water as a commodity focused on mining and agriculture, but subsequent uses broadened to include industrial, commercial, and livestock purposes. Cities in the region have always depended on diverted water from rivers (and later, groundwater), but explosive urban growth in the region in the latter half of the twentieth century has brought about new pressures on water resources. At the end of the twentieth century, however, agriculture still withdraws several times more water from Southwestern streams and groundwater sources than any other sector of the economy (Table 1). Dams, a portion of the critical infrastructure that supports the region’s society and economy, store water, dispense it in economically useful patterns, and provide for flood suppression. More than 20 million people in the region depend directly on water from the system dams and delivery structures, and as many as 50 million enjoy at least indirect benefits such as electricity from the regional power grid and recreation opportunities afforded by the rivers and reservoirs.

When most of the dams in the region were built, water was viewed by the public and decision makers as a commodity, and rivers were simply conduits for the movement of that commodity from one place to another. By 1996, the major water resource regions that include the willow flycatcher range contain 4,659 dams of all sizes, and 173 dams with storage capacity of greater than 100,000 ac ft (Table 1). In recent decades, however, ecosystem perspectives, recognition of the loss of valued species, and a change in social values has brought new emphasis to the undesirable changes associated with dams. While the upstream implications of reservoir development have often been clear, the unintended downstream consequences of river regulation are only now becoming obvious and of general interest. General works reviewing the downstream impacts of dams include a general review by Petts (1984), and a more ecologically oriented review by Brown (1988). Williams and Wolman (1984) provided a comprehensive evaluation of hydrologic and geomorphic changes by dams on selected American rivers, including some in the southwestern willow flycatcher range. The following report is more specific, and shows that the regulation of Southwestern rivers has had a detrimental effect on southwestern willow flycatcher habitat by changing the water and sediment flows, river landforms, and their associated vegetation communities important for flycatcher use.

The purpose of this appendix is to report the hydrologic characteristics of regulated rivers in the range of the endangered southwestern willow flycatcher of the southwestern United States. This exploration focuses on the apparent effects of dams and their operations on several major rivers that support riparian habitat for the bird by comparing the hydrologic behavior of the rivers as affected by dams with their behavior before dams or on reaches unaffected by them. Because one of the primary threats to the viability of the species is the loss of riparian habitat by means of stream flow altered by dams, restoration of the habitat depends on a clear understanding of the natural flow characteristics that have been lost through impoundment and regulation.

While it would be informative to review all the dams with reservoirs larger than some minimum threshold capacity (perhaps 100,000 ac ft) within the range of the southwestern willow flycatcher, the following detailed analysis is limited to the main stem of the Gila River, Verde River, Middle Rio Grande, and Lower Colorado River. These rivers and their dams receive emphasis here for three reasons. First, large amounts of stream flow data are readily available for them, while records for other streams with dams are less useful because they are discontinuous, or the measurement sites do not provide for highly informative comparisons between regulated and unregulated portions of the rivers. Second, general conclusions and lessons about the effects of dams on river hydrology are likely to emerge from these data rich sources that are widely applicable to other rivers in the American Southwest. Finally, these four main rivers are the region's largest, and they host important flycatcher nesting sites. California coastal rivers with dams that provide occupied habitat for the southwestern willow flycatcher and that offer restoration and population recovery potential include the San Luis Rey and Santa Clara systems, as well as the Santa Ynez downstream from Bradbury Dam. These regulated rivers have sediment and terrain characteristics that are somewhat different from the interior streams, but their hydrologic responses to dams and the consequences of those responses are similar to those of the inland rivers. Figure 1 shows the approximate location of the dams mentioned in the text below.

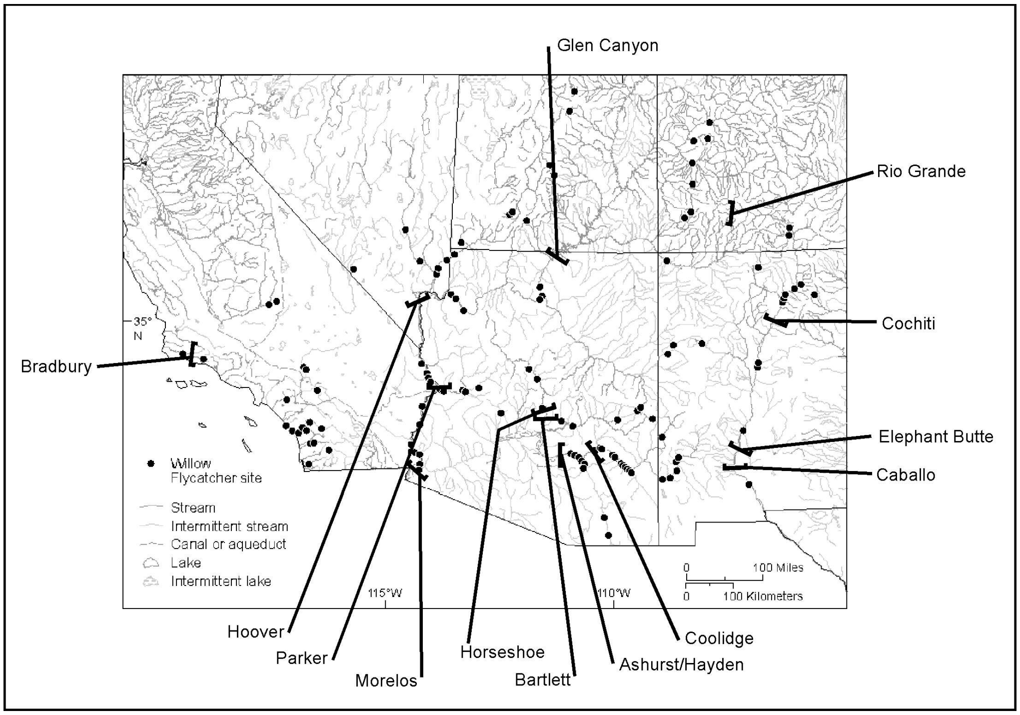


Figure 1. Approximate location of dams discussed in this appendix.

Extensive studies of the impacts of one dam on one river within the southwestern willow flycatcher range are available, and have resulted in changes in dam operations (National Research Council 1991). For over a decade, the Bureau of Reclamation, Glen Canyon Environmental Studies Program, analyzed the downstream effects of the operation of Glen Canyon Dam on the Colorado River (U.S. Bureau of Reclamation 1995). This effort, the most extensive ever undertaken for a regulated river, produced large amounts of data, information, and generalizations about the effects of the dam on the river (Carothers and Brown 1991), and resulted in a series of adjustments in the operation of the dam to partially reverse downstream changes brought about by the structure. Adjustments included the introduction of occasional moderate peak flows, maintenance of low flows that are larger than those released previously, and reduced ramping rates (that is, slowing the rate of change from one discharge level to another). Outside the range of the southwestern willow flycatcher, operators have adjusted the operations of many dams to mitigate downstream damages sustained through regulation (Collier et al. 1996).

The following paragraphs outline the parameters that describe important characteristics of river flows in the region, identify the sources of data, and report on the effects of dams on the Gila, Verde, Rio Grande, and Lower Colorado rivers. This appendix concludes by using these demonstrated effects of dams to make general recommendations for the recovery of the southwestern willow flycatcher population, generally by restoring a portion of the pre-dam flow characteristics of the rivers to support appropriate flycatcher habitat.

B. Flow Parameters

The construction and operation of dams have dramatically changed downstream flows, the channels they create and maintain, and the riparian vegetation that provides habitat for the southwestern willow flycatcher. Although a complete hydrologic analysis would include a myriad of flow parameters, the following investigation focuses on only a few measure that describe stream flow in simple terms:

- *Annual peak flow*: the largest daily flows found in each year of record for stream gages (the technical spelling for gauges); there is one annual peak flow for each year representing the largest flow for that particular year.
- *Mean annual peak flow*: the average annual peak flow for all the years of record; the average of the individual values for each year; there is one mean annual peak flow for each gage representing its entire record.
- *Annual mean flow*: the average of each of the mean daily flows for each year of record; the average of all the 365 (or 366 for leap years) single days of record for the year; there is one annual mean flow for each year.
- *Mean annual mean flow*: the average mean daily flow for all the years of record; the average of means for each year; there is one mean annual mean flow for each gage representing its entire record.
- *Annual low flow*: the lowest daily flow found in each year of the record; there is one annual low flow of each year, representing the lowest flow for that particular year; in the cases where the lowest flow is zero, the lowest flow may occur on more than one day.
- *Mean annual low flow*: the average annual low flow for all the years of record; the average of the individual values for each year; there is one mean annual low flow for each gage representing its entire record.

There are three reasons to emphasize investigation of the annual peak flows. First, the annual peak flows are the most important channel forming and maintaining flows because they shape channel and near-channel landforms, transport much of the sediment in the system, and directly influence biotic processes in the channel and on nearby flood plains. Second, data for annual peak flows are readily available in published records and are easily analyzed. Third, annual peak flows represent a parameter of the river discharge below dams that can be controlled through operating rules for the dams, and they are therefore subject to direct management.

There are three reasons to emphasize investigation of the annual mean flows. First, although the annual mean flow is not geomorphologically significant, it indicates the amount of water generally available for biotic systems in the river. Fluctuations from year to year give indications of drought or moist conditions. Second, the variability of the mean annual flows provides indications of the influence of dam operations which tend to dampen the variability. Third, the annual mean flow provides a method of standardizing the annual maximum flow when comparing one stream system with another of a different size. The annual maximum flow divided by the annual mean flow is a scale-free value that permits comparison among rivers.

There are two reasons for investigating annual low flows. The magnitude of these flows show the range of hydrologic conditions when they are compared to the mean and high flows, thus indicating the range of flow conditions to which the riparian vegetation must adjust. The mean annual low flows generally do not perform geomorphological work, but their magnitude also is significant for groundwater recharge and the maintenance of near-channel vegetation dependent on shallow groundwater. Streams with zero low flow conditions cease contributions to the groundwater system and contribute to falling water tables.

C. Sources of Data

The analysis of annual peak, mean, and low flows in the following paragraphs is simple and straight-forward. Although more sophisticated statistical analysis is possible, a fundamental and basic approach is best because the trends are most obvious. The major parameter not included in this analysis is the low flow information, which is more difficult to measure and analyze. The raw data for the annual peak flows are available from the U.S. Geological Survey in that agency's *Water-Supply Papers*, in its *Water Resource Investigation Reports*, or at its web site (http://water.usgs.gov). The analysis of data for stream gages in this investigation includes investigation of pairs, with one gage upstream and one downstream from a major dam on a single stream. Other analyses are of two sets of stream gages, with one set drawn from dammed rivers and the other drawn from free flowing streams.

Information on dams is from data bases collated by the U.S. Army Corps of Engineers and the Federal Emergency Management Agency. Individual state agencies created the original data and forwarded it to the federal agencies. The Corps and the Federal Emergency Management Agency made the data generally available in 1994, with an updated version in 1996, in the form of a CD-ROM disk. Although the data were temporarily available through the Corps' web site, this not presently the case. Data for this appendix are from the 1996 disk.

D. The Main Stem of the Gila River

Although a major concentration of southwestern willow flycatcher nesting sites occurs in the upper Gila River in New Mexico, the river is reasonably free flowing there except for local diversions. The middle Gila River in southeastern Arizona has many willow flycatcher nesting sites, but it is impacted by Coolidge Dam. The hydrology of the middle river provides a key to understanding and controlling the riparian habitat favored by the bird. From a hydrologic perspective, the main stem of the upper Gila River has two distinct parts: the segments upstream from Coolidge Dam and those downstream from the dam. The dam has a storage capacity that is very large with respect to the annual water yield of the river, because the reservoir can store 3.5 times the mean annual water yield of the stream. This figure implies that the dam has the potential to substantially alter downstream hydrology, as well as the downstream geomorphology and ecology dependent on the river flows. The basic descriptive information for Coolidge Dam are as follows:

Coolidge Dam
Dam closed: November 15, 1928
Reservoir: San Carlos Lake
Storage Capacity: 1,073,000 ac ft
Storage Capacity as a Function of the Mean Annual Water Yield: 3.5
Maximum Release Capacity: 120,000 cfs
Owner: U.S. Department of Interior, Bureau of Indian Affairs

The three gages for assessing the fluvial hydrologic effects of the dam are as follows:
Upstream from the dam: Gage 09448500, Gila River at head of Safford Valley, near Solomon, Arizona, period of record 1914-1991.
Downstream close to the dam: Gage 09469500, Gila Rive below Coolidge Dam, period of record 1921-1991.
Downstream distant from the dam: Gage 09474000, Gila River at Kelvin, Arizona, period of record 1913-1991.

Given these records, it is possible to explore the downstream effects of Coolidge Dam two ways. First, it is possible to compare the downstream impacted flows with those unaffected flows upstream from the dam for the period after the dam was completed. Second, it is possible to compare pre-dam and post-dam conditions at the same gage sites. The upstream gage is located above diversions of irrigation waters for Safford Valley. The downstream gage is directly affect by the operations of Coolidge Dam, and includes inflows from the San Pedro River. All three gages have records extending to 1999, but the data that are pre-processed and readily available for this analysis extend only to 1991. This limitation is unlikely to affect the conclusions of the following analysis.

1. Did Coolidge Dam reduce the magnitudes of the annual peak flows downstream?

Yes. In the pre-dam record, mean annual peak flows were larger at Kelvin downstream from the dam, but in the post-dam era they were larger at Safford, upstream from the dam (Table 2). The gage immediately downstream from Coolidge Dam dramatically indicates the magnitude of the effects of the dam. Before the dam was closed, the gage site near the dam location had peak flows that were 74% as large as those upstream near Safford. The remaining 26% (and minor tributary inflows) entered the groundwater system of Safford Valley between the two sites and was lost to direct surface flow. When Coolidge Dam was closed, the flows in the main stem were substantially reduced immediately downstream from the dam: mean annual peak flows were reduced to only 5% of the magnitude of the flood peaks upstream from the dam at Safford. Further downstream, the annual peaks at Kelvin consist of flows from the dam and from tributaries. Before the dam was closed, the peak flows at Kelvin were about one and a half times larger than the peak flows near Safford, because the inflows from the San Pedro River were added to flows in the main stem of the Gila. After the dam closure, peak flows at Kelvin were only 66%the magnitude of flows at Safford. In absolute terms, before the dam was closed, the mean annual peak flow at Safford was 21,900 cfs, and at Kelvin it was 33,500 cfs. After the dam closed, the average annual peak flow was 18,000 cfs at Safford, a modest decline probably related to climatic adjustments, but at Kelvin the mean plunged to 12,000 cfs because of storage in San Carlos Lake behind Coolidge Dam. The result of these substantial declines in annual peak flows has been considerable channel shrinkage and simplification downstream from the dam, with the greatest changes occurring between the dam and the confluence with the San Pedro River.

2. Did the closure of Coolidge Dam change the timing of the annual peak flows downstream?

Yes, the dam altered the timing of annual peak flows (Table 3). Exact date of the annual peak flows are readily available for the Gila River near Safford and at Kelvin. During the pre-dam era, 60% of the annual peak flows of the Gila River near Safford and at Kelvin occurred in the months of July, August, and September. After the closure of the dam, flows upstream occurred in July, August, and September in 49% of the years, a moderate decline in temporal concentration probably related to climatological changes over the watershed. These changes were not transmitted to the segments downstream, however, because the annual peak flows at Kelvin remained concentrated in July, August, and September, months that accounted for 64% of annual peak flows even after the closure of Coolidge Dam. Inflows from the San Pedro River probably account for the late-summer concentration in the river near Kelvin.

3. Did the closure of Coolidge Dam change the variability of the annual peak flows downstream?

Yes. Before the dam was closed, the standard deviations of the annual peak flows at all three gage sites were greater than the average peak flow, indicating great variability (Table 4). In the period after the closure of the dam, the standard variation remained similar for the annual peak flows at the unimpacted site near Safford, but at the gage just downstream from the dam, the standard deviation declined to only 3% of its former value. At Kelvin, further downstream, the introduction of flows from the San Pedro restored some of the variability, but the standard deviations were still only 42% of the pre-dam value. The importance of these changes to the geomorphology and riparian ecology is that the natural arrangements of the fluvial environment were dependent on highly variable annual peak flows. After the closure of the dam, that variability disappeared, resulting in high simplified channel configurations and much less spatial diversity in the riparian vegetation system.

4. Has Coolidge Dam changed the mean annual mean flows downstream?

No. The mean annual mean flow has declined at all three gage sites, partly as a result of upstream withdrawals and partly as a result of hydro-climatic changes (Table 2). The mean annual flow downstream from the dam is maintained by releases from the reservoir to supply downstream water users, so the structure does not have a significant impact on changing the annual mean flow.

5. Has the dam affected low flows downstream?

No. The annual low flows in the Gila River have approached zero throughout the record. At the gage near Safford, the change between pre-dam and post-dam conditions is statistically insignificant for the annual low flows, and downstream from the dam many years experienced no flow both before and after the dam.

6. What are the geomorphic and ecologic implications of the downstream impacts of Coolidge Dam?

The closure of Coolidge Dam signaled major changes in the geomorphology and riparian ecology of the Gila River downstream from the structure. The dam affected these changes largely be changing the magnitude and variability of the annual peak flows. The dam drastically reduced the size of the annual flood, which is the channel-forming discharge in the river. In continuously flowing streams the channel forming discharge is usually considered to be the bankfull discharge, which also often recurs approximately once per year over a decade or longer. Because the annual flood peaks were reduced by the dam, their channel forming power was also reduced, and the overall size of the channel declined downstream from the dam. The dam also substantially reduced the variability of the annual flood, so that the resulting channel was not only smaller than its predecessor, it was also much more simplified in its form and materials as shown in historical ground photographs. The highly variable floods that created and maintained a complex channel with islands, bars, subchannels, braids, and an active flood plain was replaced by a simple, single thread channel with almost no islands, bars, subchannels, or braids. The once active flood plain has converted (mainly through decreased flows with minor channel incision) to an inactive terrace, a change wherein the surface once had frequent interaction with the main channel by being overflowed and through sediment exchanges, but now it is isolated from the channel and no exchanges occur. Coolidge Dam stores all the fine sediment (sand and silt) than once moved downstream as part of the system. As a result, the only fine materials in the downstream river system are fine sands that make up the inactive terraces high above the active river.

The riparian vegetation developed on this geomorphic substrate is also simplified, because the constantly changing fluvial landscape has become geomorphologically frozen. Monotypical riparian forests, especially those dominated by tamarisk, became increasingly common in some reaches, while in other reaches the normal locations for cottonwood and willow became less common, so that forests of those types also became less common. The lack of fine materials restricts the available substrate for willow. The available natural habitat for southwestern willow flycatcher therefore has declined since the closure of the dam. As distance from the dam increases, tributary flows from the San Pedro River restore some natural characteristics to the river's flow, forms, and vegetation, but does not restore the biological component of the ecosystem in the sense that tamarisk dominates the native vegetation. Still further downstream, however, Ashurst-Hayden Dam diverts all the flow of the river except unusual floods, and from that point downstream the channel is little different from the surrounding desert

E. The Verde River

The Verde River hosts several nesting sites for the southwestern willow flycatcher, and offers potential for recovery of the bird. Major features of the river impacted by human activities are the dams and the hydrology they control. The Verde River has several distinct segments determined by human use of the stream. The upstream portion, above Clarkdale, experiences only minor diversions and no impacts from dams. A dam at Sullivan Lake, the starting point of the river, has completely filled with sediment, so that it functions as a run-of-the-river structure with few hydrologic effects. The middle portion of the river through the Verde Valley has significant diversions but no dams, while the lowest portion has flow controlled by Bartlett and Horseshoe Dams. The basic descriptive information for the dams are as follows (U.S. Army Corps of Engineers 1996):

Bartlett Dam

Dam closed: 1939

Reservoir: Bartlett Lake

Storage Capacity: 178,186 ac ft

Storage Capacity as a Function of the Mean Annual Water Yield: 0.44

Maximum Release Capacity: 175,000 cfs

Owner: U.S. Bureau of Reclamation and Salt River Project

Horseshoe Dam

Dam closed: 1945

Reservoir: Horseshoe Lake

Storage Capacity: 131,500 ac ft

Storage Capacity as a Function of the Mean Annual Water Yield: 0.33

Maximum Release Capacity: 250,000 cfs

Owner: U.S. Bureau of Reclamation and Salt River Project

In order to analyze the combined effects of Bartlett and Horseshoe dams, the investigation reported in the following paragraphs used the data from two gage sites.

Upstream from the dam: Gage 09508500, Verde River below Tangle Creek, above Horseshoe Dam, Arizona, period of record 1945-1991.

Downstream close to the dam: Gage 09510000, Verde River below Bartlett Dam, Arizona, period of record 1904-1991.

Given these records it is possible to explore the combined effects of Bartlett and Horseshoe dams by comparing the flow of the Verde River below Bartlett Dam after the dams were completed in 1945 with the flow near Tangle Creek upstream from the dams during the same post-dam period.

1. Did Bartlett and Horseshoe dams reduce the magnitudes of the downstream mean annual peak flows?

Yes. The mean annual peak flow downstream from Bartlett Dam declined by two thirds after the dams were built (Table 5). The annual peak flows below Bartlett Dam were also only about half the magnitude of the annual peak flows upstream from the dams near Tangle Creek. The resulting active channel downstream from the dams is smaller than it was previously. However, large releases from the spillway at Bartlett Dam in floods of 1978, 1980, and 1993 restored some of the high flow channel processes on a temporary basis. The largest flows in the post-dam period are similar to the largest ones in the pre-dam period, but these very large flows were much more common in the pre-dam era as opposed to the post-dam period. Because the *mean* annual peak is much lower in the later period, the original high-flow geometry is not now functionally maintained. It does not receive periodic infusions of water, sediment, and nutrients, so that it is now an unchanging, inactive part of the landscape.

2. Did the closure of Bartlett and Horseshoe dams affect the variability of the annual peak flows?

Yes, but not in the expected way (Table 6). Coolidge Dam reduced the variability of downstream annual peak flows because it has a large storage volume with respect to the mean annual flow and flood flows of the Gila River. Bartlett and Horseshoe dams, on the other hand, are smaller relative to the Verde River (their combined storage amounts to only 77% of the mean annual water yield of the watershed), and they have large spillways and outlet works. By reducing the mean annual peak flows through storage, but releasing large amounts of water in a few floods, Bartlett and Horseshoe increased the variability of peak flows downstream. The geomorphic and ecologic implications of this change are that the functional part of the channel is limited (as it is in the Gila River case), but there are geomorphic surfaces downstream from the dams that are like the previous natural high flow channels, but they are only remnants of unusual events and are not active.

3. Have Horseshoe and Bartlett dams affected mean annual mean flows downstream?

Probably not. The mean annual flows downstream from the dams were greater after the dams were completed, probably as a result of increased precipitation and runoff in the watershed during the post-1945 period. Because there are no records from the Verde River below Tangle Creek, this explanation cannot be directly tested. In any case, the dams did not reduce the mean annual mean flow, and their variation is similar in the pre- and post-dam period.

4. Have Horseshoe and Bartlett dams affected mean annual low flows downstream?

Yes. The mean annual low flows are lower after the dams were closed. Before the closure of the dams, the mean annual low flow values were all greater than about 50 cfs, but after the closing of Bartlett Dam in 1939, most years experienced low flows below 50 cfs, with many years recording some days with zero flow. The generalization that dams increase low flows in order to deliver water to downstream users does not apply to the dams on the Verde River. As a result, ecosystems downstream from the dams often experience no-flow conditions.

5. What are the geomorphic and ecologic implications of the closure of Horseshoe and Bartlett dams?

Because of the hydrologic changes introduced into the Verde River hydrology by Horseshoe and Bartlett dams, the channel downstream from the structures is smaller and less complex than the original pre-dam channel. Because flood discharges shape the channel, and because these flows have been significantly reduced by the dams, the downstream channel has a limited active component. Spills from the dams have scoured enlarged channel geometries, but these high-flow channels are not active. They were created and then immediately abandoned by the subsequent small discharges, whereas in the pre-dam conditions they would have been periodically reoccupied.

The ordinary low flows during the year must be somewhat higher than in pre-dam conditions because although the daily mean discharges are broadly the same in pre- and post-dam eras, the lack of large annual high flows means that the only way to achieve the observed means in the post-dam period is to have somewhat elevated low flows. These low flows do not influence the geomorphology of the channel, because they do not generate sufficient stream power to move the bed and bank materials. The ordinary low flows do provide ecological benefits in the form of increased groundwater recharge and more abundant surface water most of the time. The dams have created a new situation for the lowest flows each year (as opposed to ordinary low flow conditions). Before the dams, the Verde flowed continuously, but after the dams, many years experience one or more days of zero flow. The absence of water on the surface and the resulting dry channel clearly represents a radical departure from the ecological conditions that existed before the dams. If these non-flow conditions occur for several weeks during the months when the southwestern willow flycatcher is in the region, the lack of water in the channel would be a deterrent to use of the impacted river and its riparian habitat by the bird.

Horseshoe and Bartlett dams store fine sediments that prior to their construction would have continued to move downstream. With the dams in place, these fine sediments are now largely absent from the Verde River below the dams. The channel and its near-channel active landforms are dominated by cobbles and boulders which do not form suitable substrate for vegetation likely to be useful as willow flycatcher habitat. The remaining dense vegetation along the system is mostly confined by inactive terraces and consists mostly of mesquite bosques that are remnant populations. Cottonwood, willow, and tamarisk colonize only a few small and isolated locals.

F. The Middle Rio Grande

The middle Rio Grande is the location of several nesting sites of the southwestern willow flycatcher, and potentially offers more habitat for the recovery of the species than is presently available. A key to habitat management and restoration of the river is its hydrology and the effects of dams. The northern Rio Grande flows from its headwaters in the San Juan Mountains into the large basin of the San Luis Valley in southern and southwestern Colorado. After crossing the border with New Mexico, the stream flows generally southward through the Rio Grande Gorge, and then through a rift valley to the southern edge of the state near El Paso, Texas. Three dams along this main stem are of interest in considering impacts on southwestern willow flycatcher habitat. The Rio Grande Dam and Reservoir is located in the Rocky Mountains headwaters area, and does not impact flows in the lower elevation riparian areas used by the southwestern willow flycatcher. Cochiti Dam is a large flood control structure at Cochiti Pueblo, near Santa Fe, in the middle reaches of the stream, and is a potential consideration for flycatcher habitat. Elephant Butte Dam is near Truth or Consequences in southern New Mexico. The dam is one of the oldest large dams in the United States and serves as a flood control, water storage, and diversion structure that may also affect flycatcher habitat. Basic information about the dams follows:

Rio Grande Dam
Dam closed: 1916
Reservoir: Rio Grande Reservoir
Storage Capacity: 52,192 ac ft
Storage Capacity as a Function of the Mean Annual Water Yield: No Data
Maximum Release Capacity: 8,300 cfs
Owner: San Luis Valley Irrigation District

Cochiti Dam
Dam closed: 1975
Reservoir: Cochiti Lake
Storage Capacity: 722,000 ac ft
Storage Capacity as a Function of the Mean Annual Water Yield: 0.61
Maximum Release Capacity: 136,360 cfs
Owner: U.S. Army Corps of Engineers

Elephant Butte Dam
Dam closed: 1916
Reservoir: Elephant Butte Reservoir
Storage Capacity: 2,337,298 ac ft
Storage Capacity as a Function of the Mean Annual Water Yield: 2.03
Maximum Release Capacity: 47,500 cfs
Owner: Bureau of Reclamation

Stream gages with long records geographically bracket Cochiti and Elephant Butte dams, and are useful for assessing the dams' impacts on downstream hydrology, geomorphology, and ecology.

Upstream from Cochiti Dam: Gage 08313000, Rio Grande at Otowi Bridge, NM, 1895-1991
Downstream from Cochiti Dam and upstream from Elephant Butte Dam: Gage 08319000, Rio Grande at San Felipe, NM, 1927-1991

Downstream from Elephant Butte Dam: Gage 08361000, Rio Grande Below Elephant Butte Dam, 1916-1991

The lengths of these gaging records provides data for a before and after assessment of the hydrologic effects of Cochiti Dam, as well as upstream vs. downstream comparisons for both Cochiti and Elephant Butte dams.

1. Did Cochiti Dam affect the magnitude of the mean annual peak flows of the Rio Grande?

Yes, but not as much as might be expected. Annual peak flows were always less downstream from the site of the dam, because flows were dissipated across flood-plain surfaces downstream from the dam site (these flood plains are likely to have supported important willow flycatcher habitat). Annual peak flows declined downstream after the dam was closed, but they also declined upstream, so part of the change was produced by hydroclimatic controls and operations of dams in the Rio Chama, a major tributary upstream from Cochiti and the gage at the Otowi Bridge (Table 7). The mean annual peak declined about 20% upstream from the dam, and about 24% downstream, but the means are only part of the story. Cochiti Dam eliminated the extreme flows downstream, as evidenced by floods in 1979 and 1985. The dam reduced the downstream peak flows by one third to one half in these two events. As the record becomes longer (it is now only 24 years long for the dam) more instances of this type will likely affect the mean annual peak values more strongly.

When the annual peak flow is expressed as a function of the annual mean flow, the Rio Grande appears to have a hydrologic behavior that is different from the behavior of the Gila and Verde rivers described above. In those streams, the annual peak flows were 20 to 40 times greater than the annual mean flows, showing tremendous variability. In the middle Rio Grande, the annual peak flows are only 2 to 5 times greater than the annual mean, with or without Cochiti Dam. As a result, the downstream impacts of the dam are played out within a more narrow range of hydrologic conditions and a more restricted set of river landforms than was the case with the Gila and Verde rivers.

2. Did Cochiti Dam affect the variability of annual peak flows of the Rio Grande?

Yes, the dam reduced the variation, but that variation was already relatively small before the structure was closed (Table 8). The standard deviation of annual peak flows of the Rio Grande at San Felipe, downstream from Cochiti, declined by about a third after the closure of the dam. Some of that decline would have occurred in any case because of upstream controls on the Rio Chama and hydroclimatic changes. In the case of the Gila and Verde rivers, the standard deviation of annual peak flows was greater than the mean of those values in pre-dam periods and even in the post-dam periods. In other words, the peak flows may have been reduced in magnitude by the dams, but they retained some variability. In the middle Rio Grande, this variability is much less, with the standard deviation of annual peak flows generally less than the mean. In other words, the peaks flows are more consistent and produce a much less complex geomorphology and riparian ecology. The maintenance of levees, pilot channels, and other engineering efforts in the middle Rio Grande also promote this simplification of the geomorphology and riparian ecology.

3. Did Cochiti Dam alter the annual mean flows of the Rio Grande?

Partly. Although the dam is large with respect to the river, capable of storing 60% of the mean annual runoff upstream, its operation is predicated on passing normal flows of water through to downstream users in agricultural and urban areas (Tables 7 and 8). Upstream from the dam, moderate hydroclimatic changes caused mean flows to increase after the dam was closed, and the dam appears not to have a detrimental effect on this parameter downstream. On the other hand, the variation of mean flows declined about 20% downstream from Cochiti, indicating that the structure is modulating the variability of mean flows.

4. Did Cochiti Dam affect mean annual low flows in the Rio Grande?

Partially. The dam sustains low flow conditions that existed prior to its construction. The variation of low flows declined by about one third, meaning that low flows were less variable after the closure of the dam.

5. What are the likely downstream geomorphic and ecological effects of Cochiti Dam?

Reduced magnitudes for annual peak flows combined with decreased variation in annual peak, mean, and low flows all promote a geomorphic and riparian system downstream that is simplified from its original configuration. Engineering structures along the river downstream from Cochiti have designs that use this simplification to constrain the river and eliminate its processes from large areas of what were once active riparian zones along the course of the river. The river functions more like a canal than a natural river.

Cochiti Dam stores sediment in its reservoir, so that the reaches of the river immediately downstream from the structure are starved for material. Erosion of some river reaches has resulted along the stream for a distance of up to 150 miles, where infusions of sediment from the Rio Puerco and Rio Salado restore large amounts of sediment to the system. Some sediment augmentation is in order below the dam for restoration purposes, appropriately limited, however, to avoid excessive sedimentation in reaches of the channel where elevation of the bed poses tributary flooding problems in the Albuquerque area.

6. What have been the downstream effects of Elephant Butte Dam?

Elephant Butte Dam completes the conversion of the Rio Grande from a river to a canal. Mean annual peak flows downstream from the dam are less than one third their values in the middle river upstream, and the annual variability of the peak flows is tiny compared with other river reaches (Tables 7 and 8). Water diversions, and to a lesser degree evaporation and seepage losses, depreciate the flow, so that annual mean flows in the channel are also low. These mean flows are predicated on downstream water delivery requirements, and because the dam and reservoir are so large (able to store more than twice the mean annual inflow from upstream) the downstream system is highly consistent with respect to annual mean flows. Annual low flows show more variability, but in recent years they have been exceptionally low, with many years experiencing some days of zero flow.

7. What are the geomorphic and ecological effects of Elephant Butte Dam?

The Rio Grande downstream from Elephant Butte Dam is not a river in the normal sense of the word. It does not physically function in response to hydroclimatological forcing mechanisms, and is a simple conduit for water viewed as a commodity. The channel is highly simplified and relatively unvariable. Though the channel and near-channel landforms can support riparian habitats suitable for southwestern willow flycatchers, such arrangements are highly limited and artificial.

G. The Lower Colorado River

The lower Colorado River contains several southwestern willow flycatcher nesting sites, and prior to about 1950 numerous willow flycatcher specimens were observed and collected there. Because of the potential extent of riparian forest in the lower Colorado River, the hydrologic behavior of the river as influenced by upstream dams is critical for understanding environmental change and planning restoration of the river. Numerous large dams throughout the upstream basin exert some control on the flow of the Colorado River between Arizona and California, but the major controls on that segment of the river are three dams immediately upstream: Hoover, Davis, and Parker dams. These dams strongly influence the hydrology of the river, and thus also influence the geomorphology and riparian ecology of the stream, both of which are directly linked to habitat useful for the southwestern willow flycatcher. Basic information about the dams follows:

Hoover Dam
Dam closed: 1936
Reservoir: Lake Mead
Storage Capacity: 30,237,000 ac ft
Storage Capacity as a Function of the Mean Annual Water Yield: 2.24
Maximum Release Capacity: 200,000 cfs
Owner: U.S. Bureau of Reclamation

Davis Dam

Dam closed: 1953

Reservoir: Lake Mohave

Storage Capacity: 1,818,300 ac ft

Storage Capacity as a Function of the Mean Annual Water Yield: 0.13

Maximum Release Capacity: 216,000 cfs

Owner: U.S. Bureau of Reclamation

Parker Dam

Dam closed: 1938

Reservoir: Lake Havasu

Storage Capacity: 619,400 ac ft

Storage Capacity as a Function of the Mean Annual Water Yield: 0.05

Maximum Release Capacity: 314,000 cfs

Owner: U.S. Bureau of Reclamation

The most useful stream gage for assessing the hydrology of the river from Parker Dam to the United States/Mexican border is at Yuma: Gage: 09521000, Colorado River at Yuma, AZ, 1905-1984. The gage provides a data-based view of the hydrology of the river during three distinct periods: first, before any of the large dams was in place (1905-1936); second, when Hoover and Parker dams were the only influence on the lower river (1937-1953); and third, when all three structures were in place along with their associated withdrawal systems. Unfortunately the gage record ends too soon to assess the most recent history of the river after 1984.

1. Have the dams changed the mean annual peak flows on the Lower Colorado River?

Yes, dramatically. One of the primary reasons (in addition to water supply and hydropower) that the dams are in place is to provide flood control, and they excel at this mission (Table 9). Before the dams were in place, the Lower Colorado River had a large channel to accommodate annual peak flows that averaged almost 93,000 cfs. With Hoover and Parker dams in place, these annual peak flows declined to about 18,000 cfs, and with all three dams in place after 1953 the annual peak flows averaged only 5,500 cfs, a mere 6% of their former, pre-dam magnitude. The dams reduced the variability of these annual peaks in absolute terms as well (Table 10), so that the standard deviation of the annual peak flows declined from their natural value of 51,500 cfs to only 3,500 cfs. However, in terms of the prevailing means, the variability was roughly the same throughout the record, with the standard deviation always less than the mean.

2. Have the dams changed the mean annual mean flows on the Lower Colorado River?

Yes, the dams have substantially reduced annual mean flows for the Lower Colorado River (Table 9). Before the dams were in place, the mean annual mean flow in the Lower Colorado River was more than 21,000 cfs, but by the time all three dams were in place and water withdrawals from their reservoirs into canals became a feature of the system, the mean annual mean flow had dropped to only 2,100 cfs. This annual mean flow is now less that the annual lowest flows that existed prior to the construction of the dams. The variability of the mean annual mean flows also declined to a similar degree, so that the relative variability when assessed as a function of the mean remained little changed (Table 10). In other words, the entire hydrologic system has shrunken in response to dams and diversions.

3. Have the dams changed the mean annual low flow conditions on the Lower Colorado River?

Yes, to a degree similar to the other changes outlined above (Tables 9 and 10). Before the dams were in place, the mean annual low flow was 2,900 cfs, but now the mean annual low flows are a paltry 500 cfs, or a reduction to only 17% of the pre-dam values. Absolute variability has declined in a similar fashion, with standard deviations expressed as a function of the mean remaining less than one throughout the record.

4. What are the geomorphic and riparian ecological implications of the hydrologic effects of the dams?

The Lower Colorado River is a miniature ghost of its former self, with its entire hydrologic, geomorphic, and ecologic system shrunken to a fraction of its former size. Channelization and levees have aided the effects of major water withdrawals and successful flood control efforts centered on the major dams of the river. The channel has changed completely from a braided, multi-threaded system to one characterized by a narrow single thread. Where once there was a complex series of landforms and environments at each cross section of the stream, there now remains a highly simplified system that is more similar to a canal than a river. The flood plain outside the channel that once was active is now largely inactive. The diverse riparian habitat system, favorable for a variety of species including the southwestern willow flycatcher, has become a highly simplified system with limited diversity.

The timing of these impacts of dams is instructive. Biologists observed that the decline in many riparian bird species became significant in the 1950s. By that time, the effects of Hoover Dam had been seen in the fluvial system of the Lower Colorado River for a decade and a half. But they were then compounded by the closure of Davis Dam in 1953. From 1954 onward, the full impact of flow changes with associated geomorphic and ecologic changes became apparent. The accelerated decline of bird populations that had depended on the previously existing hydrologic, geomorphic, and vegetative system, simply reflected these dramatic changes in river processes and forms.

H. Recommendations

The foregoing review of the effects of dams on regulated rivers in the range of the endangered southwestern willow flycatcher leads to a set of logical recommendations for the recovery of the bird population. The purpose of these recommendations is to set out what is needed for the reestablishment of a functional hydrologic and geomorphic system, which serves as a physical substrate for an ecosystem likely to support suitable habitat for the bird in the Southwestern United States.

1. Dam Operating Rules and Rivers as Ecosystems and Commodities

Issue: Dam operating rules and decision-making are focused on obvious, direct economic goals, and treat rivers simply as commodity water and power resources, leaving little administrative space for endangered species. As a result, operating rules address commodity management rather than broader objectives.

Recommendation: Treat the rivers as landscapes and ecosystems, and as public trust resources rather than merely as commodity resources. Laws, regulations, and agreements governing the distribution of water are exceptionally difficult to change, but in the past these arrangements have evolved to meet new needs. The continued evolution of the arrangements benefits everyone and avoids a potential judicial clash between the laws of the river and the ESA. Generally, include these broadened objectives in revisions of the laws of the river as well as interstate water compacts and administrative rule decisions. Include recovery of endangered species as one of the multiple objectives in all dam operating rules so they are recognized as part of the multiple objective decision process, and to insure that tradeoffs and costs can be clearly understood. Apply this recommendation generally in the recovery plan, and specifically to all major dams in the range of the southwestern willow flycatcher.

2. Hydrodiversity, Geodiversity, and Biodiversity

Issue: Downstream geomorphic systems have become highly simplified because of dam operations, with the resulting loss of ecologic complexity needed for flycatcher habitat.

Recommendation: Allow occasionally complex flow regimes with a wide range of discharge levels within the shrunken channel system as well as flood or spike flows, all to reintroduce the complexity of hydrodiversity and geodiversity, which will lead to biodiversity. In many years, this new regime would not necessarily result in increased water releases, but rather releases on a schedule different from the present one. High or spike flows should be released in winter months to most benefit the native vegetation and should be avoided in summer months when they most benefit exotic vegetation. Examples where this recommendation should be explored in detail include Cochiti, Elephant Butte, Coolidge, Bartlett/Horseshoe, Stewart Mountain, and Hoover/Parker dams, as well as Bradbury Dam on the Santa Ynez River of California and other smaller California coastal streams.

3. Water for Recovery

Issue: Many solutions for improving habitat for the southwestern willow flycatcher require increased availability of water in active channels or in near-channel areas. This issue is important throughout the range of the southwestern willow flycatcher.

Recommendation: Water purchases, other acquisition procedures, and other water management strategies are likely to be required in a comprehensive recovery of the species. Because agricultural withdrawals from rivers and groundwater are much larger than by any other economic sector, the agricultural community must be part of any long-term solution. Engage agricultural interests in all major watersheds in the range of the southwestern willow flycatcher to consult with agencies and other parties to take proactive measures to provide more water in rivers throughout the range of the southwestern willow flycatcher. Examples where this recommendation should be explored in detail include the Lower Colorado River near Yuma, lower San Pedro River, middle Gila River, and the Middle Rio Grande.

4. Instream Flows, Reactivated Channels, and Habitats

Issue: Flycatchers, Rio Grande silvery minnow, and many other endangered species require a continuous flow of water in the rivers they use, yet dams and diversions dessicate some channel reaches and completely eliminate flow.

Recommendation: Provide low level instream flows (enough merely to establish a wetted perimeter and a visible surface flow) during low flow periods downstream from dams and diversions as a general policy in the recovery plan applicable throughout the range of the southwestern willow flycatcher. Measure these flows at stream gages to assure the water is positively affecting the intended flycatcher habitat and at the appropriate times such as winter to sustain native vegetation and during the late spring to late summer breeding season of the bird. Procure water rights for delivery at desired times to hydrate flycatcher habitat.

Examples where this recommendation should be explored in detail include the Colorado River near Yuma, the Rio Grande downstream from San Acacia Dam, and the Gila River downstream from Ashurst/Hayden Dam.

*5. **Shrinkage of River Channels and Habitat***

Issue: Reservoir storage and diversions have caused river channels and their associated landscapes to become drastically more narrow through shrinkage because of water withdrawals. Levees with narrow spaces between them have stabilized the restricted widths. As a result, the original natural riparian forest and potential southwestern willow flycatcher habitat has also shrunk, becoming discontinuous along the alignment of channels.

Recommendation: Increase the width of the active channel zone and improve the along-channel connectivity of rivers by insuring continuous instream flows and allowing occasional minor floods with peak flows large enough to expand channel systems from their present shrunken dimensions. Make flows large enough to accomplish this expansion and increase the space between the levees (by moving them further apart, leaving a larger channel area) throughout the range of the southwestern willow flycatcher. Examples where this recommendation should be explored in detail include the Rio Grande, Lower Colorado River, coastal California streams, and streams in the Central Valley of California.

*6. **Reactivated Flood Plains and Habitats***

Issue: Flood plains, oxbows on single-thread channels, and secondary channels on braided streams have become inactive because of flood suppression by dams, entrenchment, and isolation by levees, and elimination of beaver, all of which have reduced the vitality of native riparian forests or completely eliminated them.

Recommendation: Permit overbank flows in selected locations to expand wetlands and riparian forests by larger releases from dams when excess water is available, or manage conveyance to include peak flows. Install gates temporarily (permanently where possible) in selected levees to reactivate flood plains and abandoned channels behind the structures. Pump, syphon, or divert water to flood plains abandoned by channel entrenchment. For these rivers (e.g., Colorado River), the flood plain refers to the flood plain of the existing river rather than the pre-dam historic flood plain. Reintroduce beaver on small and intermediate systems.

7. Sediment Augmentation and Habitat Restoration

Issue: Dams trap sediments and release erosive clear-water discharges, stripping downstream areas of sediment (mostly sand, silt, and clay in interior streams, mostly sand and coarse sediments in California streams) and eliminating the native vegetation and habitats that were developed on the deposits, including habitat areas for the southwestern willow flycatcher.

Recommendation: Augment the sediment supply of river reaches downstream from Coolidge, Bartlett, Stewart Mountain, Parker and smaller dams on Coastal California streams to replace the fine sediments artificially removed in upstream reservoirs, with due care to insure that sediments containing hazardous levels of heavy metals, pesticides, and herbicides are not re-mobilized, and that downstream fish habitats are not adversely affected. Augmentation may use sediments from the upstream reservoirs delivered through a slurry system, or from other sources using mechanical methods. A thorough assessment of anticipated consequences should precede such an effort to insure that there will be sufficient water discharges to move the sediment to desired locations on bars and flood plains.

8. Multi-Species Planning

Issue: Planning for recovery of the southwestern willow flycatcher is directly related to planning for other endangered riparian bird species and native fishes, because they all are dependent on the same hydrologic, geomorphic, and vegetation systems. Decisions that affect one species will inevitably affect all of them, yet recovery planning and implementation efforts are not formally connected.

Recommendation: Formally connect planning and decision making for the recovery of the southwestern willow flycatcher with the recovery of the Rio Grande silvery minnow on the Rio Grande, and with the native fishes in the Lower Colorado River. Determine likely interaction effects of implementing a plan for one species on the other endangered species.

I. Conclusions

Dams were structured to regulate flows to simplified regimes in order to deliver water to downstream users, generate hydroelectricity, enhance navigation, and provide recreation. The unintended and unforeseen effects of creating this artificial hydrology have included simplified fluvial geomorphology and riparian systems which reduce potential southwestern willow flycatcher habitat and restrict restoration. To increase habitat and provide restoration of riparian habitat and the physical systems on which it depends requires partially reversing some of the changes in hydrology produced by dams. Dams and their operations provide opportunities to resolve some of the habitat issues in recovering the southwestern willow flycatcher population. Existing theory and practice for the management of dams and the hydrology they produce, both downstream and upstream in their reservoirs, provide enough understanding to use the structures in recovery efforts.

The hydrology of the Gila, Verde, Rio Grande, and Lower Colorado rivers has been dramatically altered by dams, but all dams are not created equal (Table 11). Their effects vary from one river to another, depending on the original purpose of the structures, their architecture, their operating rules, and the original natural characteristics of the stream channels downstream. Despite these differences, however, dams generally cause the restriction of southwestern willow flycatcher habitat by reducing the extent and complexity of riparian ecosystems through two mechanisms: channel shrinkage and reduced hydro- and geocomplexity. Reduced peak flows and reduced variability of flows of all magnitudes and frequency leads to this channel shrinkage and simplification of the riparian system. These changes in scale and complexity have caused environmental changes unfavorable to the maintenance of willow flycatcher habitat. Restoration of such habitat depends in part on reversing the hydrologic changes brought about by dams to reintroduce larger and more variable flows downstream from dams. Dams and their operation represent opportunities to manage the hydrology, geomorphology, and vegetation that are indispensable components of the flycatcher's habitat. Dams have been major actors in the changes of southwestern rivers and their riparian habitats, and they represent tools for reversing the changes to more favorable conditions for the recovery of the willow flycatcher population.

J. Literature Cited

Please see Recovery Plan Section VI.

Table 1. General water and dam data for major water resource regions of the American Southwest.

Water Resource Region	Rio Grande	U. Colorado	L. Colorado	Great Basin	California
Dams and Storage Capacity, Runoff					
Total Number of Dams	716	1,164	446	803	1,530
Number of Dams Storing more than 100,000 ac ft.	18	25	23	13	94
Total Storage (ac ft)	21,013,562	46,364,999	48,373,154	5,979,380	74,161,688
Total Annual Runoff (ac ft) [1]	5,487,880	15,063,670	18,982,714	6,596,655	72,910,402
Storage/Runoff	3.83	3.08	2.55	0.91	1.02
Human Population [2]	2,566,000	714,000	5,318,000	2,405,000	32,060,000
Surface Fresh Water Withdrawals (ac ft per yr)					
Public Supply	146,720	118,720	781,760	284,480	3,225,600
Domestic	0	448	224	1,792	13,440
Commercial	2,240	784	8,400	16,800	357,280
Irrigation	5,152,000	7,828,800	4,704,000	4,502,400	20,384,000
Livestock	9,520	56,000	7,616	86,240	248,640
Industrial	112	4,480	6,160	34,720	21,280
Mining	2,240	4,480	29,120	2,240	69,440
Thermoelectric	2,240	163,520	243,040	23,520	226,240
Total	5,308,800	8,187,200	5,566,400	4,950,400	24,528,000
Ground Fresh Water Withdrawals (ac ft per yr)					
Public Supply	398,720	39,200	533,120	392,000	3,057,600
Domestic	28,000	12,320	49,280	14,560	125,440
Commercial	19040	6270	24,640	11,200	86,240
Irrigation	1,590,400	42,560	2,475,200	1,220,800	12,208,000
Livestock	30,240	4,480	36,960	10,304	258,720
Industrial	11,200	2,240	47,040	67,200	584,640
Mining	59,360	22,400	141,120	79,520	17,920
Thermoelectric	17,920	15,680	50,400	2,912	4,032
Total	2,161,600	129,920	3,360,000	1,803,200	16,352,000

[1] Total annual runoff is the USGS estimate from Solley et al. (1998) for the amount of water yielded from the watershed. The upper basin is that which passes Lee's Ferry, while the lower basin is that plus additions from the lower basin.

[2] For the Lower Colorado River, population data do not include those living outside the watershed but who use water from trans-basin diversions. In southern California, about 17 million depend in some degree on water from the Colorado River, and other diversions from the basin affect residents in New Mexico (and by connection Mexico and Texas) as well as Colorado. Note: Public Supply data for the Lower Colorado River do not account for 2.6-2.7 maf/yr diverted to southern California.

Sources: Dams and runoff data from Graf (1999), human population data from U.S. Census information 1990, surface and ground water data from Solley *et al*. 1998.

Notes: Figures may not add to totals because of independent rounding. Original published water use data were in millions of gallons per day, converted to ac ft per year by dividing by 3.259×10^5 to convert gallons to ac ft, and multiplying the result by 365 to convert from days to year.

Table 2. Mean annual peak, mean, and low flows for the Gila River upstream (near Safford), immediately downstream (below Coolidge Dam), and more distant downstream (at Kelvin) of Coolidge Dam. The notation "/m" indicates values expressed as divided by the mean annual mean flow.

Flow	Near Safford		Below Coolidge Dam		At Kelvin	
	cfs	(/m)	cfs	(/m)	cfs	(/m)
Mean Annual Peak Flow						
Pre-Dam	21,834	29.78	16,236	32.47	33,512	89.13
Post-Dam	18,015	42.79	902	2.81	12,076	28.08
Mean Annual Mean Flow						
Pre-Dam	733	1.00	500	1.00	376	1.00
Post-Dam	421	1.00	321	1.00	430	1.00
Mean Annual Low Flow						
Pre-Dam	53	0.07	4	0.01	9	0.02
Post-Dam	47	0.11	3	0.01	33	0.08

Table 3. Monthly frequency of annual peak flows, Gila River gages upstream and downstream from Coolidge Dam, before and after closure of the structure.

Safford				**Kelvin**		
Month Frequencies				**Month Frequencies**		
Pre-Dam				**Pre-Dam**		
Month	**Frequency**	**%**		**Month**	**Frequency**	**%**
1	1	7%		1	1	7%
2	0	0%		2	1	7%
3	0	0%		3	0	0%
4	1	7%		4	0	0%
5	0	0%		5	0	0%
6	0	0%		6	0	0%
7	1	7%		7	3	20%
8	6	40%		8	3	20%
9	2	13%		9	3	20%
10	1	7%		10	1	7%
11	0	0%		11	0	0%
12	3	20%		12	3	20%
Total =	15	100%		Total =	15	100%
Safford				**Kelvin**		
Month Frequencies				**Month Frequencies**		
Post-Dam				**Post-Dam**		
Month	**Frequency**	**%**		**Month**	**Frequency**	**%**
1	5	7%		1	4	6%
2	7	10%		2	4	6%
3	6	9%		3	4	6%
4	0	0%		4	0	0%
5	0	0%		5	0	0%
6	1	1%		6	0	0%
7	7	10%		7	9	13%
8	14	21%		8	28	41%
9	12	18%		9	7	10%
10	10	15%		10	5	7%
11	1	1%		11	0	0%
12	5	7%		12	7	10%
Total =	68	100%		Total =	68	100%

Table 4. Standard deviations (S.D.) for the annual peak, mean, and low flows for the Gila River upstream (near Safford), immediately downstream (below Coolidge Dam), and more distant downstream (at Kelvin) of Coolidge Dam. C.V. is the coefficient of variation, or the standard deviation divided by the mean, a way of standardizing comparisons across different magnitudes of discharge.

Flow	Near Safford		Below Coolidge Dam		At Kelvin	
	S.D., cfs	C.V.	S.D., cfs	C.V.	S.D., cfs	C.V.
Standard Deviation of Annual Peak Flow						
Pre-Dam	27,299	1.25	25,441	1.57	34,404	1.03
Post-Dam	23,194	1.28	787	0.87	14,468	1.20
Standard Deviation of Annual Mean Flow						
Pre-Dam	122	0.17	137	0.27	177	0.47
Post-Dam	281	0.67	204	0.64	254	0.59
Standard Deviation of Annual Low Flow						
Pre-Dam	2	0.04	1	0.25	3	0.33
Post-Dam	3	0.06	5	1.67	3	0.09

Table 5. Mean annual peak, mean, and low flows for the Verde River upstream from Bartlett and Horseshoe dams at Tangle Creek, and downstream from the structures, below Bartlett Dam. No data are available for the gage below Tangle Creek for the pre-dam period. The notation "/m flow" indicates values expressed as divided by the mean annual mean flow.

Flow	**Below Tangle Creek**		**Below Bartlett Dam**	
	cfs	**(/m)**	**cfs**	**(/m)**
Mean Annual Peak Flow				
Pre-Dam	--	--	22,231	26.9
Post-Dam	15,065	27.1	8,173	8.3
Mean Annual Mean Flow				
Pre-Dam	--	--	826	1.0
Post-Dam	555	1.0	991	1.0
Mean Annual Low Flow				
Pre-Dam	--	--	79	0.10
Post-Dam	94	0.17	14	0.01

Table 6. Standard deviations (S.D.) for the Verde River annual peak, mean, and low flows upstream from Bartlett and Horseshoe dams at Tangle Creek, and downstream from the structures, below Bartlett Dam. No data are available for the gage below Tangle Creek for the pre-dam period. C.V. is the coefficient of variation, or the standard deviation divided by the mean, a way of standardizing comparisons across different magnitudes of discharge.

Flow	Below Tangle Creek		Below Bartlett Dam	
	S.D., cfs	C.V.	S.D., cfs	C.V.
Standard Deviation of Annual Peak Flow				
Pre-Dam	--	--	18,734	0.83
Post-Dam	16,963	1.12	15,395	1.88
Standard Deviation of Annual Mean Flow				
Pre-Dam	--	--	465	0.56
Post-Dam	376	0.68	383	0.69
Standard Deviation of Annual Low Flow				
Pre-Dam	--	--	39	0.49
Post-Dam	23	0.25	20	1.43

Table 7. Mean annual peak, mean, and low flows for the Rio Grande upstream from Cochiti Dam (at Otowi Bridge), downstream from Cochiti Dam (at San Felipe), and downstream from Elephant Butte Dam. The notation "/m" indicates values expressed as divided by the mean annual mean flow.

Flow	At Otowi Bridge		At San Felipe		Below Elephant Butte	
	cfs	(/m)	cfs	(/m)	cfs	(/m)
Mean Annual Peak Flow						
Pre-Cochiti	7,633	5.16	6,342	4.80	2,324	2.40
Post-Cochiti	6,156	3.74	4,839	3.04	2,596	2.59
Mean Annual Mean Flow						
Pre-Cochiti	1,478	1.0	1,322	1.0	969	1.0
Post-Cochiti	1,646	1.0	1,591	1.0	1001	1.0
Mean Annual Low Flow						
Pre-Cochiti	261	0.18	208	0.16	75	0.08
Post-Cochiti	363	0.22	211	0.13	11	0.01

Table 8. Standard deviations (S.D.) for the mean annual peak, mean, and low flows for the Rio Grande upstream from Cochiti Dam (at Otowi Bridge), downstream from Cochiti Dam (at San Felipe), and downstream from Elephant Butte Dam. C.V. is the coefficient of variation, or the standard deviation divided by the mean.

Flow	At Otowi Bridge		At San Felipe		Below Elephant Butte	
	S.D., cfs	C.V.	S.D., cfs	C.V.	S.D., cfs	C.V.
Standard Deviation of the Annual Peak Flow						
Pre-Cochiti	5,099	3.45	4,358	0.69	902	0.39
Post-Cochiti	3,376	0.55	2,104	0.43	833	0.32
Standard Deviation of the Annual Mean Flow						
Pre-Cochiti	715	0.48	685	0.52	379	0.39
Post-Cochiti	696	0.42	663	0.41	407	0.41
Standard Deviation of the Annual Low Flow						
Pre-Cochiti	130	0.50	155	0.75	203	2.71
Post-Cochiti	155	0.43	99	0.47	27	2.45

Table 9. Mean annual peak, mean, and low flows for the Colorado River at Yuma, downstream from Hoover, Davis, and Parker dams. The notation "/m flow" indicates values expressed as divided by the mean annual mean flow.

Flow	**At Yuma**	
	cfs	**(/m)**
Mean Annual Peak Flow		
Pre-Dam	92,913	4.41
With Hoover and Parker	17,899	2.00
With all dams	5,479	2.55
Mean Annual Mean Flow		
Pre-Dam	21,067	1.00
With Hoover and Parker	8,949	1.00
With all dams	2,145	1.00
Mean Annual Low Flow		
Pre-Dam	2,901	0.14
With Hoover and Parker	2,568	0.29
With all dams	514	0.24

Table 10. Standard deviations (S.D.) for the Colorado River at Yuma, downstream from Hoover, Davis, and Parker dams. C.V. is the coefficient of variation, or the standard deviation divided by the mean, a way of standardizing comparisons across different magnitudes of discharge.

Flow	**At Yuma**	
	S.D., cfs	**C.V.**
Standard Deviation of the Annual Peak Flow		
Pre-Dam	51,471	0.55
With Hoover and Parker	7,004	0.39
With all dams	3,499	0.64
Standard Deviation of the Annual Mean Flow		
Pre-Dam	7,844	0.37
With Hoover and Parker	4,299	0.48
With all dams	1,338	0.62
Standard Deviation of the Annual Low Flow		
Pre-Dam	1,755	0.61
With Hoover and Parker	2,228	0.87
With all dams	253	0.49

Table 11. Summary of the most significant downstream effects of dams on river regulation for selected river segments in the southwestern willow flycatcher range.

River	Segment	Effects of Regulation
Gila River	Below Coolidge Dam	Loss of annual peak flows, loss of complex flows, sediment starvation (fine materials)
	Below Ashurst/Hayden Dam	No instream flows
Rio Grande	Below Cochiti Dam	Decreased flow variability at all discharges, loss of annual peak flows
	Below San Acacia Dam	No instream flows
	Below Elephant Butte Dam	Loss of peak flows and variability at all flows
	Below Caballo Dam	No instream flows
Lower Colorado River	Below Parker Dam	Reduced flows at Yuma
	Below Mexican Diversions	No instream flows
Verde River	Below Horseshoe and Bartlett Dams	Loss of annual peak flows, frequent loss of low flows, loss of flow variability at all levels, sediment starvation (fine materials)
California Coastal Rivers	Santa Ynez below Bradbury Dam	Loss of annual peak flows, frequent loss of low flows, sediment starvation (sand and coarse materials)

Appendix K.
Habitat Restoration

A. Introduction

Extensive loss and degradation of riparian habitat throughout the U.S. Southwest is considered to be the primary factor responsible for the decline of the southwestern willow flycatcher (*Empidonax traillii extimus*), as well as of other species dependent upon this habitat during part or all of their annual cycles (Unitt 1987, USFWS 1995). Consequently, recovery of the flycatcher will require increasing the availability of suitable habitat through the combined approaches of habitat protection and restoration. In this paper, we present an approach to habitat restoration, supported by examples, that we believe will provide the greatest long-term success in reversing the decades-long loss of riparian woodlands and thereby augment habitat for obligate riparian species such as the flycatcher. We use the term “restoration” in a broad sense to include enhancement of degraded habitat, and re-establishment of riparian vegetation to sites where it occurred historically but is currently absent as a result of reversible alterations of the conditions necessary for supporting it (Jackson et al. 1995). We also include the concept of "creation" of habitat in our restoration category, recognizing that ingrained changes in the infrastructure of flowing water in the U.S. Southwest may necessitate spatial shifts in habitat from historical sites to new areas that have greater potential for restoration success. There are different degrees of restoration that are achievable at any given site, ranging from full restoration to partial restoration, sometime referred to as rehabilitation or naturalization (Cairns 1995).

We begin by describing some of the causes of symptoms of habitat degradation, referring to other Appendices in this Recovery Plan that treat these topics more fully. We then describe methods for restoration, including restoration of physical elements and processes, restoration of animal populations and processes, and restoration of essential plants, fungi, and biotic interactions. We also address some of the factors to consider when selecting sites, to optimize restoration success. Finally, we address the topic of restoration as mitigation, and offer some recommendations regarding design, implementation, and evaluation of projects within this context.

1. Goal of Restoration: What Do We Want to Restore?

Our scope in this discussion includes river systems throughout the seven-state historic range of the southwestern willow flycatcher, recognizing that not all riparian habitat within this range was or can again become suitable for flycatchers. An implicit goal is to restore habitat to a level that is deemed *suitable* for flycatchers as evidenced by (1) the presence of breeding flycatchers (although even some of this habitat may benefit from enhancement) and (2) the presence of habitat attributes that characterize suitability for flycatchers. These attributes include dense shrubby and forested vegetation interspersed with small openings near surface water or saturated soil (see Appendix D for a complete description).

Although we offer guidelines for habitat restoration within the context of willow flycatcher recovery, our scope in this issue paper is a general one and not specific only to the flycatcher. Habitat loss has produced declines in many riparian species; thus, we strive for an approach that will restore entire plant and animal communities and the physical processes upon which they depend. To the degree possible, we seek to restore ecosystem integrity, defined as the "...state of ecosystem development that is optimized for its geographic location, including energy input, available water, nutrients and colonization history... It implies that ecosystem structures and functions are unimpaired by human-caused stresses and that native species are present at viable population levels" (Woodley 1993). We recognize that this developmental state is neither feasible nor desirable in all areas, given the large size of the human population. Thus, we also suggest compromises that allow rivers and riparian ecosystems to meet human needs and the needs of other riparian-dependent biota. This ecosystem-based approach is consistent with the goals of the Endangered Species Act, which include conserving the ecosystems upon which the endangered species' depend.

The approach we advocate is guided by the recognition that functional plant communities are necessary to support the large and diverse animal communities typical of native riparian habitat. With this perspective, restoring structure to the plant community means restoring a wide array of plant species and functional groups, restoring viable age structures for the dominant species, restoring vertical complexity, and restoring a mosaic of vegetation patches in the flood plain. Restoring function includes restoring bioproductivity, and restoring the ability of the plant communities to capture and store nutrients, build soils, stabilize stream banks, and create habitat for animals. Essential to ecosystem integrity is that the plant community be self-sustaining and resistant or resilient to various types of natural disturbances. Once structure, function, and self-sustainability have been restored to the plant community, the potential exists for establishment of viable animal populations through the provision of food, cover, shade, breeding sites, foraging sites, and other resources essential to survival and reproduction.

2. Causes and Symptoms of Habitat Degradation.

Before we attempt to restore an ecosystem, we need to understand the factors that have caused the degradation (Briggs 1996, Hobbs and Norton 1996, Goodwin et al. 1997). This step in the identification of root causes hinges upon an understanding of the ecological impacts of a lengthy list of human activities relating to water and land use, and species introductions and extirpations. Symptoms of degradation vary depending on the type and extent of anthropogenic stressors. Fluvial geomorphic changes such as reduced channel movement and channel incision can result from dams and diversions; channel widening can be symptomatic of overgrazing by livestock and/or stream dewatering and loss of streambank vegetation. Hydrologic indicators of degradation, including lowered ground water levels or stream flow regimes that deviate from climatic patterns, can be direct results of water management and/or indirect consequences of land use actions in the watershed that influence the water cycle (Richter et al. 1996). Plant communities may lose their capacity for self-repair or revegetation after flood disturbance, if subject to stressors such as dewatering or overgrazing. Replacement of species-rich communities by homogenous thickets of single species, be they native or exotic, can be symptomatic of dam-related reductions in fluvial disturbances and/or imposition of stressors such as grazing that select for a small number of tolerant species. Many factors, including landscape-level habitat fragmentation, can produce symptoms in the animal community such as declining diversity of bird species, or population declines of riparian specialist species such as southwestern willow flycatchers or yellow-billed cuckoos (*Coccyzus americanus*). A loss of biotic interactions, such as a loss of pollinators, a breakdown of plant-disperser interactions, or a loss of symbiotic relationships such as plant-fungi mycorrhizal relationships, are other indicators of degradation. Suites of symptoms, such as soil compaction, stream channel downcutting, lack of tree regeneration, and spread of unpalatable plant species together can be symptomatic of a particular stressor such as overgrazing (Prichard et al. 1998). Collectively, these and other symptoms provide a list of inter-related ecosystem components that form the basis for examination of root causes of degradation, and identification of appropriate strategies for restoration.

B. How Do We Restore Degraded Ecosystems?

1. Restoration of Physical Elements and Processes

Hydrologic regimes and fluvial geomorphic processes are prime determinants of riparian community structure (see Appendices I and J). To restore a diversity of plant species, growth forms, and age classes, we need to restore the diversity of fluvial processes, such as movement of channels, deposition of alluvial sediments, and erosion of aggraded flood plains, that allow a diverse assemblage of plants to co-exist. To restore bioproductivity and maintain plant species with shallow roots and high water needs, we have to ensure the presence of the necessary hydrogeomorphic elements; notably water flows, sediments and nutrients. We need to restore flows of water, sediment, and nutrients not only in sufficient quantities but with appropriate temporal patterns (Poff et al. 1997).

Hydrogeomorphic conditions have been altered and fluvial processes disrupted over much of the U.S. Southwest. There are over 400 dams that are managed for municipal or agricultural water supply, flood control, hydropower, or recreation (Graf 1999). Surface water is diverted from dammed and undammed rivers alike. Ground water is pumped from flood plain aquifers and regional aquifers. Dikes and berms constrain channels, reducing or eliminating river-flood plain connectivity. Throughout watersheds, livestock grazing, fire suppression, and urbanization reduce rates of water infiltration into soils and increase surface runoff. This, in turn, results in larger flood peaks, higher sedimentation rates, and reduced base flows.

Flood flows and river dynamism.

Full restoration of riparian ecosystems hinges on removing impediments to the natural flow regime (Schmidt et al. 1998). This type of approach, wherein one restores natural conditions and processes by removing stressors, and then allows the biotic communities to recover of their own accord, falls within the realm of passive restoration (Middleton 1999).

Dam removal is a passive restoration approach that allows for full ecosystem restoration. Dams are being removed throughout the U.S. for the purpose of restoring habitat, most often for endangered fish species. Working within drainage basins or at larger spatial scales, some groups have contrasted the relative costs and benefits of a suite of dams with respect to economics and ecology (Shuman 1995, Born et al. 1998). In some cases, removal of a dam can provide substantial ecological benefit, while causing minimal reduction in the production of 'goods': along the Elwha River in Washington State, removal of two dams is expected to cause a small loss of hydropower but a gain in fisheries productivity (Wunderlich et al. 1994). In Arizona, a recent decision was made to decommission the hydropower dam on Fossil Creek and restore full flows to the stream, because the benefits from restoring aquatic and riparian habitat outweigh the small loss of hydropower. Elsewhere in the arid Southwest, storage of water in ground water recharge basins may be a feasible alternative to reservoir storage, obviating the need for some dams.

Dam removal and decommissioning should be explored systematically throughout the range of the southwestern willow flycatcher. During this process, attention should be paid to effects of dam removal on the upstream as well as downstream riparian ecosystem, and an assessment should be made on a landscape or regional level of the overall net change in suitable habitat expected from dam removal. Many reservoir edges, because of the availability of water, fine sediments, and nutrients, support large patches of riparian habitat suitable for flycatchers and other wildlife. Much of this habitat is at risk or has been destroyed due to reservoir management for water supply or flood control, but additional losses could occur with dam removal. In other cases, flood-suppressing dams may stabilize habitat to some degree, perhaps locally buffering bird populations from the strong temporal fluctuations that may have characterized the pre-dam system. Assessments would be needed to determine whether habitat gains would compensate for habitat losses, were the dam to be removed.

If dams are to remain in place, there are ways to meet dual management goals of improving ecological integrity and maintaining the production of goods. Creative ways can be found to rehabilitate, if not fully restore below-dam ecosystems, while still allowing for municipal or agricultural water supply, hydropower, or flood control. Sediment and nutrients can be restored to some below-dam reaches by adding sediment bypass structures to dams (Schmidt et al. 1998). Riparian ecosystems on regulated rivers can be rehabilitated by naturalizing flows so as to mimic the natural hydrograph, or flow pattern, of the river. In arid parts of Australia and South Africa, there is growing recognition of the need to incorporate environmental flow requirements into river management plans (Arthington 1992). In Alberta, Canada, input from scientists and Environmental Advisory Committees has led to changes in the operation of dams (Rood et al. 1995, Rood et al. 1998, Mahoney and Rood 1998). The St. Mary and Oldman rivers, for example, are managed for delivery of summer irrigation water, and still flood fairly regularly during wet years. Rates of river meandering and channel realignment are relatively intact, and so too are the processes that create the "nursery bars" needed for germination of cottonwood (*Populus* spp.) seeds. Changes have been made, however, such that flood waters now recede slowly enough to allow for high survival of the seedlings; ecological models call for the stream stage to drop less than four cm per day, allowing the roots of cottonwood seedlings to keep in contact with moist soil. Another part of the agreement calls for an increase in summer base flow levels, thereby reducing the risk of tree death from drought. Operating agreements that address ecological concerns and restore 'environmental flows' should be incorporated into the management of dams that effect the habitat of the willow flycatcher throughout its range.

Large flows are released from many dams during occasional wet years, and the water often flows downstream in a fashion that does not optimize its environmental benefits. Sometimes, these releases fortuitously meet the regeneration needs of riparian plants. In 1992-93, for example, El Nino weather patterns assisted in the restoration of populations of cottonwood and willow (*Salix* spp.) trees along the lower Gila and Colorado, by filling reservoirs to levels that required large releases during winter and spring (Briggs and Cornelius 1998). With operating agreements in place, dam managers could be prepared in periodic wet years to intentionally release flows in ways that mimic the natural hydrograph and favor the establishment of native species adapted to the natural flow pattern. To keep the trees alive, 'maintenance' water sources would have to be secured. Certainly, the flood releases would not be essential every year. On unregulated rivers, cottonwood and willow recruitment flows occur only about once a decade or so (Mahoney and Rood 1998).

Along some dammed rivers, there are constraints on the degree to which the natural flood regime can be restored. The Bill Williams River in western Arizona is regulated by Alamo Dam, which was built to minimize flood pulses into the Colorado River. Over the past 25 years, the size and frequency of winter and summer flood peaks in the Bill Williams River have decreased, while base flows have increased. The U. S. Fish and Wildlife Service, Army Corps of Engineers, and university scientists have worked together to develop a flow-release plan that calls for high base flows and restoration of periodic flood (flushing) flows. The goals are to improve the quality of the riparian habitat in the below-dam wildlife refuge, while also maintaining recreational and wildlife benefits in Alamo Lake and flood control. However, there are constraints on the maximum flow release from the dam, that need to be addressed to allow for increased riparian restoration. Without the large scouring floods, rates of establishment of pioneering cottonwoods and willows are predicted to decline in the future, despite the release of appropriately timed spring flows (Shafroth 1999). Without the large floods to remove dead stems and woody debris, the dense post-dam vegetation (much of which is the exotic shrub tamarisk: *Tamarix ramosissima*) will remain susceptible to fire damage (see Appendix L).

There are other 'active' restoration measures that can mimic hydrogeomorphic processes and conditions at sites where these natural processes cannot be fully restored (Friedman et al. 1995). Flood pulses can be released through water control structures to small, cleared areas of the flood plain (Taylor and McDaniel 1998). Wet habitats can be created by excavating side channels or back-water depressions, and/or releasing water into off-channel sites, along rivers that no longer receive large, channel-moving floods (Ohmart et al. 1975, Schropp and Bakker 1998, Bays 1999). Low check dams can be constructed across channels, to locally concentrate sediments and nutrients and raise water tables to levels that support desired species. Such a structure (called a gradient restoration facility), with a fish apron, is planned to improve habitat for the willow flycatcher and endangered Rio Grande silvery minnow as part of the Bureau of Reclamation's Santa Ana project along the middle Rio Grande in New Mexico (Boelman et al. 1999). Additional research is needed to assess the efficacy of these and other rehabilitation approaches to restore desired conditions such as channel complexity, high water tables, or desired levels of fine sediments and nutrients in below-dam reaches.

Restoration efforts should strive to restore hydrogeomorphic conditions needed for more than just one or two of the many biotic elements in riparian ecosystems. It is impossible to manage directly for every single species in an ecosystem. We can, however, focus on a subset of species that we treat as indicators of intact physical processes (Lambeck 1997). We increase our odds of meeting the needs of more native species and providing sustainable ecosystem improvement if we take an ecosystem approach that accounts for natural cycles of disturbance, stream hydrology, and fluvial geomorphology (Bayley 1991, Stanford et al. 1996). This concept is exemplified in the case of the Truckee River in Nevada (Gourley 1997). Dams, channelization, and diversions of water from the Truckee have contributed to a loss of age class and structural diversity within the cottonwood forests and a collapse of native fish populations including the endangered cui-ui (*Chasmistes cujus*). To stimulate spawning of the fish populations , the U. S. Fish and Wildlife Service began managing Stampede Reservoir for spring flood release; an ancillary benefit was the establishment of cottonwood seedlings particularly in abandoned channels where the water table was close to the surface. The take-home message here is that "when restoring a basic ecosystem process, such as the natural flow regimes of the river, a whole array of ecosystem components may begin to recover" (Gourley 1997).

Water Quantities

Although stream water is fully-allocated and even over-allocated in parts of the arid Southwest, there are opportunities for restoring perennial flows and raising ground water levels in dewatered river reaches. Recycling of paper, plastic, and aluminum has become a way of life for many urbanites; if we approach municipal water the same way, we can create restoration opportunities by recycling treated municipal water back into river channels near to the point of initial diversion. Indeed, many cities are releasing their effluent directly into stream channels. At sites where the alluvial aquifer has not been depleted, the net result has been restoration or rehabilitation of large expanses of riparian vegetation. Below the 91st Avenue water treatment plant in Phoenix, Arizona, the channel of the Salt River is lined by herbaceous plants and young stands of cottonwoods, willows, and tamarisk trees. Vegetation extends across the wide flood plain, sustained by ground water that is recharged by effluent and agricultural return flows. Along the Santa Cruz River near Nogales, Arizona, cottonwood and willow forest ecosystems similarly have redeveloped as a consequence of the release of treated municipal wastewater to the dry river channel (Stromberg et al. 1993). Effluent also is released into the Tucson-reach of the Santa Cruz River. Due to long-term dewatering in the region, the stream flow is no longer hydraulically connected to the alluvial aquifer, thereby limiting the extent of the effluent-stimulated riparian corridor. Release of effluent from Lompoc, California into the mostly dewatered Santa Ynez River channel produced riparian habitat that was used by flycatchers for a number of years. There can be a short 'sacrifice zone' below the effluent-release point where poor water quality selects for a depauperate and pollution-tolerant aquatic biota, but the presence of a functional riparian and aquatic ecosystem can allow nutrient concentrations to return to ambient levels after a short distance (Stromberg et al. 1993).

Riparian vegetation also can be restored by recharging ground water into appropriate sites. Through water-banking, some of the Colorado River allocation of Arizona is recharged or “banked” in aquifers. In the arid Southwest, where open water evaporation rates exceed 2.7 m per year, aquifer recharge is a more viable and desirable method of water storage than storage in surface impoundments. At some sites, we can accomplish the dual goals of ground water recharge and riparian restoration. In a dewatered reach of the Agua Fria River below the New Waddell Dam in central Arizona, the shallow-bedrock layer would allow for re-establishment of extensive riparian forests, if Central Arizona Project water was released from the dam (Springer et al. 1999). The river corridor could be used as a conduit for water delivery to the recharge/ recovery zone, while also providing surface and ground water to sustain riparian vegetation. The total amount of water transpired by the vegetation would be less than the amount that presently evaporates from the reservoir. This and other such projects could restore diverse and productive riparian ecosystems to dry river reaches.

Agricultural return flows constitute another source of water for riparian restoration efforts. For example, agricultural return flows are being considered as a water source to maintain cottonwood-willow habitat in the Limnitrophe area of the Lower Colorado River, to allow for survivorship of plants that established after the 1992-93 winter floods (LCRBR 2000). Elsewhere in the lower Colorado River flood plain, agricultural return flows have been used to increase the survivorship of riparian trees and shrubs planted as part of revegetation efforts (Briggs and Cornelius 1998). Such efforts could be expanded. When using return flows to maintain or restore riparian habitat, it may be necessary to periodically flush the soils to reduce the concentrations of salts below the levels that are toxic to the desired species.

A recent decision in Pima County, Arizona allows the county to buy reclaimed water for riparian restoration projects. Projects that secure endorsement by the U.S. Fish and Wildlife Service will be eligible for a portion of a 5,000 acre-foot pool for each of the first five years of conservation efforts. A key question is, "where to utilize the water to maximize its habitat value?" Up-front regional planning efforts would be of great value in allowing Pima County and other groups to identify sites that would maximize the environmental benefits of reclaimed water. Planning efforts are needed throughout the flycatchers range to determine the best locations for effluent-based and groundwater-recharge-based riparian restoration efforts. Hydrogeologic studies can identify sites where shallow water tables exist or are likely to develop, and thus sites where phreatophytic riparian vegetation is likely to develop. Ecological studies can identify sites likely to have high wildlife value by virtue of traits such as proximity and connectivity to existing high quality patches of riparian vegetation. In some cases, it may make sense to release the reclaimed water closer to the aquifer-pumpage or stream-diversion sites, to reduce the length of the river that is dewatered.

Channel-Floodplain Connectivity

Riparian ecosystems can be restored or improved along some rivers by removing the physical barriers that separate a channel from its flood plain. Along the Colorado River, for example, there are opportunities to remove dikes and levees and restore some degree of channel-flood plain connectivity (LCRBR 2000). By allowing water to periodically flow onto the flood plain, one provides the input of water, and in some cases the nutrients, sediments, and plant propagules to sustain the productivity and diversity of the riparian forest. Small flood releases along the Rio Grande in New Mexico, although too small to serve as recruitment flows, have reconnected the floodplain vegetation with the river water and served to partially restore riverine functioning in cottonwood forests (Molles et al. 1998).

Integration of Natural and Managed Ecosystems

On flood plains managed for agriculture or as urban centers, there are some benefits to be had from restoring small patches of native riparian vegetation. Riparian forests restored to strips between agricultural fields, similar to the hedgerows used in Europe and elsewhere (Petit and Usher 1998), can provide services such as crop pollination and consumption of crop pests. We caution, however, that some of the restored riparian patches that are small and isolated might not be self-sustaining and might have adverse environmental effects on overall recovery efforts of the southwestern willow flycatcher or other riparian species. For example, riparian bird populations in small habitats might be populations sinks, producing a net-drain on an overall metapopulation. Such projects could draw water resources, funding and planning efforts from other project sites that have the potential for greater environmental benefit.

Watersheds

Full restoration of riparian ecosystems depends on restoration of hydrogeomorphic conditions and processes throughout the watershed. Long-term overgrazing and extensive urbanization have, in places, reduced plant cover and soil in the uplands. In many cases this has produced 'flashier' systems characterized by larger flood peaks and smaller base flows. In other areas, fire suppression has resulted in higher tree densities, higher transpiration rates, and smaller stream flows (Covington and Moore 1994, Covington et al. 1997). Watershed restoration will require a mix of passive measures, such as restoring natural fire regimes and grazing regimes, and active measures (see Appendices G and L). Controlled burns may be useful for restoring structure and function to upland forests. Check dams on tributaries may allow for more infiltration of water into the aquifers, thereby helping to sustain base flows year round while also reducing the frequency of catastrophic floods.

2. *Restoration of Animal Populations and Processes*

Ungulate Grazing

Just as it is important to restore the hydrogeomorphic regimes to which native riparian species are adapted, it also is important to maintain biotic interactions, such as herbivory, within evolved tolerance ranges. Herbivores exert strong selective pressure on plant species. Alteration of herbivore grazing patterns or grazing intensity selects for a different assemblage of plant species. In the past few centuries, cattle ranching has been a nearly ubiquitous influence, constituting a new and major stressor for riparian plant communities in the hot deserts of the U.S. Southwest. High intensities of grazing, from cattle or elk, similarly constitute a major stressor for riparian communities of higher elevations. Many adverse changes to riparian ecosystems have been documented as a result of overgrazing (GAO 1998, Belsky et al. 1999). Heavily grazed plant communities, more often than not, do not provide us with a wide range of desired functions and services (see Appendix G).

Will livestock exclusion restore riparian health? Natural recovery of some ecosystem elements after cattle exclusion can be slow and problematic, particularly on severely overgrazed sites or where there are ongoing stressors including improper livestock grazing elsewhere in the watershed (Kondolf 1993). For example, water tables that have been depressed as a result of livestock grazing may be slow to rise to desired levels (Dobkin et al. 1998). Sometimes, though, eliminating a stressor is all that is needed to enable natural recovery (Hobbs and Norton 1996). Removal of livestock or reductions of higher-than-typical populations of elk and deer can result in dramatic and rapid recovery of some elements of the riparian ecosystem, particularly where the ecosystem has not been degraded by other factors. Along the free-flowing upper San Pedro River in Arizona, exclusion of cattle (in tandem with other management restrictions) was followed by rapid channel narrowing and vegetative regrowth (Krueper 1992). New stands of cottonwood and willows and herbaceous plants developed in the wide, open stream banks, and songbird populations increased dramatically.

Elmore and Kauffman (1994) provide other examples of rapid recovery of riparian vegetation structure, diversity, or productivity after livestock exclusion. They indicate that recovery of stream features and woody and herbaceous vegetation is more rapid in response to livestock exclusion than to other types of riparian livestock management. If exclusion is accomplished through fences, the fences should be constructed to standards that allow for wildlife movement (Gutzwiller et al. 1997).

Can we manage for economically viable livestock grazing and riparian ecosystem health on the same parcel of land? There is some consensus that this compromise is best met by reducing the stocking rate rather than by imposing rest and rotation schemes (Holechek 1995). Restriction of grazing to certain seasons of the year can allow for recovery of certain components of the riparian ecosystem, but may not always provide for full recovery (Elmore and Kauffman 1994). Probabilities of achieving restoration success increased when there is coordination, communication, and goal-consensus among land managers throughout the watershed, such as has occurred in the Mary River watershed of Nevada (Gutzwiller et al. 1997).

Ungrazed reference allotments, located at a variety of elevations and in different geomorphic settings, can provide benchmark or reference sites against which to compare the condition or integrity of grazed allotments (Bock et al. 1993, Brinson and Rheinhardt 1996). Ideally, the ungrazed areas should encompass entire watersheds. Monitoring efforts in grazed and ungrazed sites should focus on a wide variety of measures of ecosystem integrity, such as herbaceous plant cover and composition, woody plant growth, establishment rate, and structure, and stream channel morphology, in addition to traditional range measures such as utilization rates (Ohmart 1986). Monitoring of the reference sites can help to identify factors responsible for riparian ecosystem changes, and to separate the effects of weather from land use. In the past few decades, for example the Sonoran Desert has been wetter-than-normal (Swetnam and Betancourt 1998), and conditions have been favorable for regeneration of many pioneer riparian trees including cottonwoods, willows, and sycamores (*Plantanus* spp.) (Stromberg 1998). Without ungrazed reference sites, it is difficult to determine if changes such as increased willow regeneration or increased bird populations are due to land use change or weather change.

Keystone Species

Reintroduction of missing or extirpated keystone species, such as beaver, can be an effective restoration tool in some areas. Beaver are considered to be a keystone species in riparian ecosystems because of the extent to which they modify local hydrology, stream geomorphology, and habitat conditions for plants and animals. Dams built by beavers serve to raise ground water levels, minimize seasonal variations in surface and ground water levels, and expand the areas of the flood plain and channel inundated by shallow water, all of which enhance habitat suitability for southwestern willow flycatchers (see Habitat Paper) and other wildlife. Because of the flashy, highly variable nature of stream flow in the arid Southwest, these changes increase habitat for hydrophytic, wetland vegetation and promote shifts in vegetative communities from facultative to obligate wetland species. Unlike large dams constructed by humans, the beaver dams tend to be short-lived and do not impede the flows of flood-borne sediments and propagules.

The combined effect of beaver activities serves to create a more heterogeneous flood plain. The felling of trees, building of dams and lodges, and impoundment of water create a diverse mosaic of habitat patches, such as open ponded water, marshland, and various types of forested swamps. Habitat can be created for the many threatened and endangered aquatic and wetland species that depend on slow-moving, nutrient-rich waters. There is a need, however, for additional scientific study of the effects of beaver on arid region riparian ecosystems (Naiman and Rogers 1997).

Prior to reintroducing beaver, one should assess site conditions to insure that the habitat and food supply are suitable. As with other natural forces such as floods, beavers can be problematic and cause further loss of quality at degraded sites. For example, if preferred food sources such as cattails (*Typha domingensis*) are sparse as a result of stream dewatering, beaver may be forced to feed heavily on cottonwoods and willows. The net effect can be further reduction in site quality. Restoration actions could be undertaken at degraded sites to improve them to a level that would enable beaver to exert positive effects.

3. *Restoration of Plants and Fungi*

Restoration Plantings

Opportunities exist to restore integrity to riparian ecosystems in the U.S. Southwest by re-establishing riparian vegetation, including cottonwood-willow forests and shrublands, to sites where it has been eliminated. Such sites include abandoned or retired agricultural fields, burned sites, or sites from which exotic plants have been removed. These efforts can augment the amount and structural complexity of habitat available to animal populations, and generally enhance ecological diversity. Before forging ahead with plantings, the potential restoration sites should be assessed for limiting factors including ground water depth, soil texture, and salinity; for the potential to alleviate intolerant conditions; and for the potential to manage the river to allow for natural plant establishment processes.

A decade or so ago in the U.S. Southwest, 'riparian restoration' was synonymous with 'cottonwood pole planting'. Not long after, the idea that riparian habitat could be created through plantings of native trees and shrubs took hold in southern California, where it has been used extensively to produce habitat for the endangered least Bell's vireo (*Vireo bellii pusillus*). While several sites have been successfully colonized by nesting vireos within 3-5 years of planting (Kus 1998), we have concerns regarding the self-sustainability and long-term value of planted sites to vireos and other riparian species. These concerns center on the fact that many planted sites are isolated from the river channel. They are not subject to the natural processes, such as flooding, which influence plant establishment as well as other ecosystem processes such as maintenance of bioproductivity of mature trees (Stromberg 2000).

Planted cottonwoods and willows often die, because water tables are too deep or too variable, or because the soils at the restoration site are too salty (Anderson 1998). In cases where the plantings are isolated from the ground water table, water is supplied through irrigation. Long-term watering commitments often are not met, and the increased water needs of the rapidly growing plants are not always taken into account, sometimes resulting in plant death. These experiences have taught us that planting is most successful as a restoration tool only if accompanied by other actions, i.e., if the root causes of the absence or scarcity of the native species are addressed (Briggs 1996). If the plants do survive, but we do not alter river management, the net effect often is the restoration of a single age class rather than restoration of a dynamic, multi-aged population. Nonetheless, such measures can constitute an important stop-gap measure to restore forest structure and bird communities as we also work towards longer-term and more sustainable solutions (Farley et al. 1994).

To attain the greatest ecological benefits, we propose the following hierarchy, with respect to establishment of desired native plant species such as cottonwoods and willows: (1) Where possible, fully restore natural processes by removing the management stressors that restrict riparian plant establishment; (2) Next best, modify the management stressors, by naturalizing flow regimes or modifying grazing regimes to allow for natural plant establishment. If a water source can be manipulated on the flood plain, use techniques such as 'wet soil management' combined with seeding to allow for natural seedling establishment; (3) Plant nursery grown plants or cuttings (e.g., pole plantings) if the above options are not available, or if there is a need to achieve more rapid results.

In cases where the natural processes that allow for plant establishment can not be restored, care should be taken to monitor and document the success of the restoration plantings. Along the Sacramento River in California, where there are societal constraints on river flooding, various species of willow, cottonwood and other woody plants were planted on sites that were considered suitable based on criteria including depth to ground water and proximity to existing riparian forest (Alpert et al. 1999). Analysis of survivorship patterns provided information of use to future projects, such as finding greater plant survivorship on sites with fine-grained vs. coarse-grained soils.

Where local seed sources are sparse, seeding or planting is necessary to achieve restoration success or hasten recovery in response to removal of stressors. On the Owens River in California, physical integrity was restored when stream flows were released back into the river (Hill and Platts 1998). Few trees had survived the long-term dewatering, however, so seed sources were in short supply. Cottonwood seeds were collected from other river sites and released into the Owens River gorge at an appropriate time in spring. Such natural seeding is preferable to plantings of poles, cuttings, or nursery-grown seedlings, because it typically allows for greater genetic diversity within the plant population and allows for selection at the seedling-stage for plants adapted to the local conditions. Seeds collected for sowing should consist of a genetically diverse mix obtained from the local area.

We need to remind ourselves, periodically, of the biological complexity of riparian corridors. The lower Rio Grande Valley has about 1000 native vascular plant species (Vora 1992). Cottonwood-willow streams in Arizona support several hundred plant species, the relative abundance of which changes from year to year depending, in part, on rainfall and flooding patterns (Wolden and Stromberg 1997). These diverse plant communities have many functions, including sustaining a diverse insect community and thus a rich food base for insectivorous birds. There have been many efforts to plant the woody dominants of riparian forests, including Fremont cottonwood (*Populus fremontii*), Goodding willow (*Salix gooddingii*), mesquite (*Prosopis* spp.), and quailbush (*Atriplex lentiformis*), as well as efforts to plant herbaceous species. It is a daunting task to attempt to restore hundreds of species through direct plantings or seedings (Vora 1992). Donor seed banks is a technique that may serve to restore some of this biodiversity to degraded sites. A soil seed bank is defined as a soil's reserve of viable, ungerminated seeds. Donor soils have been obtained from high-integrity reference ecosystems to restore biodiversity to various types of degraded or newly created wetlands (Brown and Bedford 1997, Burke 1997). Seeds of woody riparian dominants generally are not present in the seed bank, but many of the annual plants and herbaceous perennials form persistent or at least transient seed banks. Before adopting the donor soil approach, additional studies are needed to identify which species, and how many species, are present in the seed bank of possible donor sites.

Exotic Plant Species

Exotic species (those that have been introduced accidentally or intentionally by humans to a new ecosystem) pose a definite challenge to riparian restorationists. There are hundreds of exotic plant species that have become naturalized in riparian corridors. A small percentage of these have become management issues due to their prevalence, negative influences on the ecosystem, or inability to completely mimic the functions of displaced natives (see Appendix H).

In many cases, removal of exotics is an effective restoration strategy only if part of a larger plan that includes restoration of processes and conditions (but see Barrows 1998). We need to ask, "is the exotic the cause of degradation, a symptom of degradation, or both"? Often, the abundance of riparian exotics is one symptom or facet of a complex, systemic resource allocation problem. If we don't address the root causes of degradation that led to the loss of the native species, there is a risk that traditional control measures, such as herbicides and biocontrol insects, could worsen the situation by resulting in replacement vegetation of lower quality (Anderson 1998). Additional studies are needed on a river by river basis, to identify the stressors on the native vegetation and assess the ability for re-establishment of natives, under scenarios of exotic-removal with and without active changes in river and land management.

Restoring natural processes and removing stressors, and then stepping back, can be an effective strategy for restoring native riparian species to some exotic-dominated sites. Theoretically, by restoring natural flow regimes and herbivory patterns, we can tip the ecological balance in favor of the native species (Poff et al. 1997). The middle San Pedro River provides an interesting case study of natural recovery (Stromberg 1998). Stream flows in the San Pedro vary from perennial to ephemeral depending on local geology, tributary inputs, and the extent of local and regional groundwater pumping. Tamarisks dominate in the reaches with ephemeral flow and deep water tables, but grow intermixed with cottonwoods in the wetter reaches. In these perennial reaches, cottonwoods have been increasing in abundance relative to tamarisk in the past decade. During this time period, livestock have been removed from the sites, groundwater pumping has been reduced immediately upstream, and spring flows have been high. Under these conditions, cottonwoods apparently can outcompete tamarisks. Also necessary to the recovery were several winter/spring floods that created opportunities for species replacement. Without suitable control sites, however, it is difficult to determine the relative influence of weather and management actions on the vegetation change. Again, we stress the need for additional studies that assess the potential for natural recovery of native species to exotic dominated sites, upon removal of stressors and/or removal of the exotic species.

Populations of some exotic species can persist for a long time after removal of the disturbance factor(s) that facilitated their invasion. They may produce self-favoring conditions (e.g., tamarisk promote fire cycles that they can withstand more easily than can many native species), or may simply have a long life span. In such cases, there is a need to manually remove the exotics before, coincidental with, or even after the implementation of other restoration measures. In some cases, removal of the exotic species may be all that is needed to allow for restoration of the native community. In others, it is important to obtain a firm commitment to naturalize processes before proceeding attempting to expedite recovery of the natives by mechanically removing the exotics.

At the Bosque del Apache Wildlife Refuge, as on much of New Mexico's highly regulated Rio Grande, tamarisk has become the dominant plant species. Lowered water tables, increased river salinity, and lack of winter/spring floods for several decades have all contributed to a declining cottonwood forest, while past flood plain clearing and at least one appropriately timed summer flood allowed for the influx of tamarisk (Everitt 1998). To restore the site, managers of the Refuge have mimicked the effects of large floods by using bulldozers, herbicides, and fire to clear the extensive stands of tamarisk at a cost of from $750 to $1,300 per hectare (Taylor and McDaniel 1998). They then released water onto the bare flood plains in spring with a seasonal timing that mimicked the natural flood hydrograph of the Rio Grande. This allowed for the establishment of a diverse assemblage of native and exotic plants. Long-term monitoring will be required to determine whether the multi-level canopy, diversity of vegetation structure, and diversity of insect life provided by the riparian assemblage provides superior wildlife habitat to the tamarisk thickets that existed before. Tamarisk clearing was essential, but it is the appropriate timing and quantity of water flows that will drive the system toward an increasingly native composition. This type of 'wet soil management' also can be used on other bare sites, such as abandoned agricultural fields.

Team Arundo in California (http://www.ceres.ca.gov/tadn/index.html) is another example of a program implementing mechanical means to remove exotics. In this case, they are removing giant reed (*Arundo donax*), from rivers into which it was introduced decades ago. Giant reed, an aggressive rhizomatous weed, spreads rapidly through drainages, and appears to thrive under a wide range of hydrologic conditions. It produces dense stands that are used by few native birds. Using a combination of herbicides, burning, and manual clearing, Team Arundo designs and coordinates efforts to eradicate giant reed while simultaneously promoting public awareness of the problem and the need to prevent future introductions stemming from the use of giant reed as a landscaping plant.

Fungi

Soil fungi are an important, but often overlooked, component of riparian ecosystems. Many human actions that affect soils, such as various agricultural practices, can deplete populations of mycorrhizal fungi. Re-introduction of mycorrhizal inoculum may improve the chances of restoration success on the many abandoned agricultural fields that line arid-region rivers. There is evidence that growth and survival of giant sacaton (*Sporobolus wrightii*), a plant that once dominated flood plains of many rivers in the U.S. Southwest, is improved on abandoned fields by the addition of mycorrhizal inoculum (Spakes, unpubl. data). Additional research is needed to determine the functional relationships between fungi and other riparian plant species, and to assess the need for restoration of mycorrhizal fungi in a variety of riparian settings.

C. Restoration as Mitigation

The resiliency of riparian vegetation and the relative ease with which the structural dominants can become established under proper conditions has prompted interest in the use of habitat restoration to mitigate the loss of endangered species habitat accompanying otherwise legal and permitted activities. For example, in southern California, habitat restoration is a typical form of mitigation for actions that adversely affect habitat of the least Bell’s vireo. The nature of the restoration varies from removing exotics from stands of native vegetation to the more commonly required creation of habitat through planting of cuttings or nursery stock. The success of created habitat in attracting nesting vireos (Kus 1998) and thus achieving mitigation goals, coupled with the fact that least Bell’s vireos and southwestern willow flycatchers share the same habitat where their ranges overlap, offers a tempting rationale for applying this approach to flycatcher recovery. We advise caution in yielding to this temptation too quickly. We have little confidence that efforts to enhance or create habitat in the absence of treating root causes and restoring proper physical conditions will be successful. Restoration ecology is a young science, and we do not know yet whether our attempts to create habitat will yield functioning, self-sustaining ecosystems that support the full complement of species we seek to protect (Williams 1993, Goodwin et al. 1997). Failure in either of these regards will result in a net loss of riparian habitat, and does not constitute mitigation.

Given this, we recommend that restoration performed within the context of mitigation be carefully designed, implemented, and monitored (Kondolf 1995, Michener 1997). Below, we list some considerations to maximize the potential for success of the mitigation, and minimize risks to the flycatcher:

1. "Up-front" mitigation (mitigation achieved prior to destruction/degradation of habitat) is preferable to mitigation concurrent with habitat loss because it avoids even a temporary net loss of habitat, and increases the probability that the mitigation has been successfully achieved.

2. Mitigation plans should include the following:

a) *Goal*: The goal of the restoration must be clearly stated, as it sets the stage for the other elements of the plan. Examples include 1) to provide suitable habitat for willow flycatchers, 2) to provide habitat supporting nesting willow flycatchers, 3) to remove exotics and restore dominance to native vegetation, 4) to restore a more natural flooding regime, 5) to achieve a self-sustaining ecosystem. There are many other potential goals that could be specified; the important point is that a goal must be explicitly identified in order to establish relevant criteria by which the success of the restoration can be measured.

b) *Model:* A model provides a picture of what the restored habitat should look like and how it should function, with little or no further human intervention. It should be based on a natural, functioning system that the restoration is attempting to mimic (White and Walker 1997). A model of the desired conditions is necessary to design appropriate restoration and to provide a basis from which quantitative performance criteria can be developed (Baird 1989, Baird and Rieger 1989, Kus 1998).

c) *Performance criteria*: These criteria constitute the yardstick by which success of the mitigation will be evaluated. They must be quantifiable, and pertinent to the overall goal (National Research Council 1992, Kentula et al. 1993, Hauer and Smith 1998). For example, success criteria for the above goals might include 1) production of habitat with the following habitat characteristics (e.g., vegetation volume >x, perennial water present), or, alternatively, the following bird community (enumerate), 2) the presence of x nesting pairs of flycatchers, 3) cover of natives between x and y percent, 4) the occurrence of winter and spring floods with the following characteristics (enumerate), and 5) vegetation or bird goals met with no human intervention required. It is imperative that these criteria not be subjective (e.g., based on "how the site looks"). In instances where some level of maintenance is involved in establishing the site or modifying conditions (e.g., irrigation of plantings, weeding, etc.), the maintenance should have ceased for a specified period prior to final site evaluation.

d) *Monitoring plan*: A detailed plan for collecting and analyzing data on the project's performance is necessary to ensure that it will adequately monitor progress towards success, and reveal the need for remedial action when appropriate. The period of time over which monitoring is required should be long enough to have a high probability of capturing temporal variability in the events or processes being monitored. Adaptive management should be built-in to the plan: mechanisms should be in place to trigger alternate restoration approaches or require restoration of additional habitat should the current effort fail to achieve its goals and/or be functioning at lower levels than reference sites (Hauer and Smith 1998).

3. The greatest potential for successful mitigation occurs when the physical processes required for long-term site maintenance are present or restored. Projects proposing short-term approaches, such as riparian vegetation dependent on irrigation, independent of attention to intrinsic factors related to habitat maintenance should receive low priority as candidates for mitigation.

D. Closing Words

Habitat restoration has the potential to greatly improve the suitability of existing willow flycatcher habitat, and provide additional habitat for population expansion. We encourage scientists, managers, and others interested and involved in restoration to be creative in developing new approaches, adopting an experimental framework and to share results, even if they include failures. Only from an extensive and shared knowledge base can we avoid repeating the mistakes of the past and move towards a more desirable future.

E. Specific Recommendations

To allow for full ecological restoration, we recommend these general guidelines:

(1) Restore the diversity of fluvial processes, such as movement of channels, deposition of alluvial sediments, and erosion of aggraded flood plains, that allow a diverse assemblage of native plants to co-exist.

(2) Restore necessary hydrogeomorphic elements, notably shallow water tables and flows of water, sediments, and nutrients, consistent with the natural flow regime.

(3) Restore biotic interactions, such as livestock herbivory, within evolved tolerance ranges of the native riparian plant species.

(4) Re-introduce extirpated, keystone animal species, such as beaver, to sites within their historic range.

We recognize that the potential for restoration success varies among sites with many physical, biological, and societal factors. Where possible:

(1) Fully restore these natural processes and elements by removing management stressors.

(2) Next best, modify the management stressors, by naturalizing flow regimes, modifying grazing regimes, removing exotic species, or removing barriers between channels and flood plains, for example, to allow for natural recovery.

(3) Take over processes such as plant establishment (e.g., nursery stock plantings) only if the above options are not available.

Some additional general recommendations:

(1) Focus restoration efforts at sites with the conditions necessary to support self-sustaining ecosystems, and at sites that are connected or near to existing high quality riparian sites.

(2) Develop restoration plans that encompass goals, models, performance criteria, and monitoring.

(3) If mitigation is required, call for "up-front" mitigation (mitigation achieved prior to destruction/degradation of habitat).

Some specific recommendations dealing with water and channel management:

(1) Conduct regional planning to identify sites most suitable for riparian restoration upon the release of reclaimed water (effluent), ground water recharge, or agricultural return flows.

(2) Conduct regional assessments to determine the merits of dam removal as a riparian ecosystem restoration strategy.

(3) Secure operating agreements for dams that incorporate environmental flows, for example to allow for tree and shrub regeneration flows during wet years and maintenance (survivorship) flows at other times.

(4) Pursue options for restoring sediment flows to below dam reaches.

(5) Secure operating agreements to manage reservoir drawdowns in such a way as to allow for regeneration of desired plant species.

(6) Develop water use management plans for river basins that will sustain or restore shallow ground water tables and perennial stream flows.

(7) At appropriate sites, remove barriers that reduce the connectivity between channels and floodplains.

Some specific recommendations dealing with land management:

(1) Within grazed watersheds, coordinate and communicate to establish goal-consensus among land managers and to achieve grazing levels compatible with riparian restoration.

(2) Establish a series of livestock exclosures that encompass riparian lands and/or watersheds, to provide benchmarks against which sites managed for livestock production can be compared.

(3) Monitor reference sites and grazed sites for a wide variety of measures of ecosystem integrity, including stream channel morphology and plant cover, composition, and structure, in addition to direct measures of plant utilization.

F. Literature Cited

Please see Recovery Plan Section VI.

Appendix L.
Riparian Ecology and Fire Management

A. Introduction: General Concepts of Disturbance

Disturbance has been defined as "any relatively discrete event that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment" (Pickett and White 1985). The size, intensity, frequency, and timing of a disturbance all influence ecosystem structure and function. Generally, natural disturbances maintain high diversity of habitat patches in the landscape and thus maintain species diversity. Many plant and animal species depend upon periodic disturbance.

Different types of disturbances - be they fire, flood, or landslide - produce different effects on ecosystems. Plant species have evolved suites of traits that adapt them to the particular types and patterns of disturbance that they routinely experience. “Novel” disturbances, new combinations of disturbances, or changes in the intensity, timing, duration, and/or scale of a disturbance all can alter ecosystem structure and function outside the range of conditions to which the species are adapted (Paine et al. 1998). For many of our Southwestern riparian ecosystems, due largely to land and water management practices, fires have replaced floods as the primary disturbance factor. This change has had adverse consequences for many native species.

B. Historical Fire Regimes in Southwestern Willow Flycatcher Habitats

Fires require an ignition source and adequate amounts of fine, dry fuel (McPherson 1995). Historically, fire was probably uncommon in southwestern willow flycatcher habitat. However, there is little quantitative information on the frequency, seasonality, intensity, and spatial extent of fire, all of which are components of the fire regime (Agee 1993). Turner (1974), for example, in a review of vegetation change over the past century along the Gila River (Arizona), stated that "the dense seasonally dry vegetation along the Gila River and other sites of the region periodically caught fire, but with what frequency cannot be determined."

The frequency of riparian fire probably varied temporally with drought cycles and the prevalence of lightning strikes, the primary natural ignition source for riparian fires. Spatially, riparian fire regimes probably varied with those in the surrounding uplands. Although riparian zones tend to burn less frequently than the uplands (Skinner and Chang 1996), fire probably was more frequent along rivers located in grassland and savanna biomes than along those in deserts, chaparral shrublands, and conifer forests. Other factors being equal, fires probably were more frequent in narrower, smaller riparian zones than in wide ones (Agee 1993).

In the following sections, we discuss in more detail the fire regimes in two broad vegetation types used by the willow flycatcher: 1) low to mid-elevation riparian forests, and 2) high elevation willow shrub lands.

1. Low to Mid-Elevation Riparian Forests

In this category, there are several types of biotic communities: Sonoran riparian cottonwood-willow gallery forests, dominated by Fremont cottonwood (*Populus fremontii)* and Goodding willow *(Salix gooddingii)* trees; Great Basin gallery forests vegetated by Rio Grande cottonwood (*P. deltoides* subsp. *wislizeni)* and peach leaf willow (*S. amygdaloides*); Interior riparian mixed broadleaf deciduous forests vegetated by Fremont cottonwood, Goodding willow, and other trees such as box elder (*Acer negundo*) and Arizona ash (*Fraxinus pennsylvanica* var *velutina*); and California Riparian Deciduous forests vegetated by Fremont cottonwood, Goodding willow, California sycamore (*Platanus racemosa*) and white alder (*Alnus rhombifolia*). Many shrubs including seep-willow (*Baccharis salicifolia*), coyote willow (*S. exigua*) and buttonbush *(Cepthalanthus occidentalis*) grow under or adjacent to the riparian trees.

Three lines of evidence suggest that fires historically were not a primary disturbance factor in these forest types. First, some of the dominant trees, notably Fremont cottonwood and Rio Grande cottonwood are not considered to be fire-adapted (Abrams 1986, Adams et al. 1982, Busch 1995). In general, plants are considered to be fire-adapted if they have traits that allow them to maintain their structure and not be altered by the fire, or that allow them to rapidly regenerate afterwards. Thick bark, for example, allows some trees to resist fire damage. Other traits allow for resilience, or the ability to rapidly return to the pre-disturbance condition. For example, some seeds germinate only in response to very high temperatures, allowing for post-fire regeneration. Cottonwoods show neither resistance nor resilience to fires. The cambium of Fremont cottonwood can be damaged by even light ground fire (Turner 1974), indicating low resistance. Burned cottonwood trees have a low probability of resprouting. Stuever (1997) reported that light burns completely killed about 50% of Rio Grande cottonwood trees, moderate burns about 75%, and highly severe burns killed all the cottonwoods in a stand (Figure 1). Higgins (1981) observed that Fremont cottonwood had high post-fire mortality and no recovery. Davis et al. (1989), however, observed that two of three burned Fremont cottonwoods vigorously sprouted three years after a fire. Summer burns tend to cause more mortality than winter burns, because less heat energy is required to raise plant tissue to lethal levels.

Several tree and shrub species in these biotic communities show some resilience to fires. White alder, buttonbush, Arizona ash, California sycamore, Goodding willow and coyote willow, for example, are readily top killed by fire, but can recover by resprouting (Barstad 1981, Barro et al. 1989, Davis et al. 1989). Resprouting provides some resilience to fire disturbance as well as to flood disturbance. Fires, however, generally do not create the opportunities for seed-based regeneration of these riparian tree and shrub species. The seeds of many species of willow and cottonwood are adapted to germinate at particular times of the year when flood disturbance is most likely -- a time that rarely coincides with high fire risk. This life-history strategy provides resilience to floods but not necessarily to fire.

Figure 1. This fire, called the Rio Grande Complex, occurred on April 18, 2000, and burned over 1,900 acres from La Joya to Los Lunas in the Rio Grande bosque. The intense fire burned the bark from the Rio Grande cottonwoods. Photo taken by Charlie Wicklund, April 20, 2000.

Another factor contributing to infrequent fires is the high water content of most riparian forests. Willows, cottonwoods, and many other obligate riparian trees and shrubs grow at sites with perennially available shallow ground water, enabling them to maintain high water content even during dry seasons. Additionally, the riparian forests are often associated with other vegetation types that had high moisture content. Large expanses of river flood plains in the Southwest were wet and marshy, and thus not very fire-prone (Hendrickson and Minckley 1984). Some parts of the flood plains are drier than others, however. Desert rivers carry high sediment loads, and flood plains can aggrade appreciably over time. The old cottonwood or willow forests that grow on the aggraded flood plains can develop a seasonally dry understory of non-phreatophytic grasses and forbs. These older stands were probably more likely to catch fire than were the younger forest stands along channel edges.

Fire was historically uncommon in many of the upland biomes that surround the low to mid-elevation riparian habitats. The rivers that support Sonoran riparian cottonwood-willow forests, which include segments of the Gila, Salt, Verde, Bill Williams, Santa Maria, Kern, Mojave, Virgin, San Pedro, and Colorado Rivers, were surrounded by Sonoran or Mojave Desert. The sparse vegetation in these deserts generally had insufficient fuel loads to carry fire (Brown and Minnich 1986). Portions of other rivers with riparian zones inhabited by flycatchers, such as the Rio Grande, San Pedro, and Gila, were surrounded by Chihuahuan Desert. Others, such as the San Juan, flowed through Great Basin Desert scrub vegetation. The drier portions of these deserts also had insufficient fuel loads to carry fire. Thus, there were few opportunities for fire to spread from uplands into riparian zones located along the desert rivers.

Some rivers were bordered by fire-prone upland vegetation. For example, the San Luis Rey River flowed through California Valley grasslands, the upper San Pedro River and upper Gila River flowed through semidesert grassland, and the upper Rio Grande flowed through Plains grasslands. All of these grasslands are fire-adapted and burned fairly frequently. Semidesert grasslands historically burned about once every ten years, started by lightning strikes in June or July that signaled the end of the summer dry season (McPherson 1995). In dry years, fires probably did occasionally spread from the grasslands into the riparian zones. Reports from explorers in the 1800s, for example, describe periodic riparian fires along the San Pedro River in the reach bordered by desert grasslands (Davis 1982). Generally, the riparian forests along such rivers were vegetated by mixed riparian broadleaf forests or other vegetation types rather than by 'pure' cottonwood-willow forests. Frequent fires probably allowed the fire-adapted riparian grass, giant sacaton (*Sporobolus wrightii*) to maintain its high abundance along the upper San Pedro River (Bock and Bock 1978). Cottonwoods and willows were historically present, but were less abundant than they were in the lower reaches of the San Pedro River that were bordered by desert vegetation. Other rivers, such as New Mexico's Rio Chama, flowed through Great Basin conifer woodland (pinyon-juniper savannahs). These pinyon-juniper savannahs historically had an abundance of grasses that carried frequent fire that probably occasionally spread into the riparian corridor.

Many of the coastal California rivers that support willow flycatchers flowed through California chaparral or California coastal sage scrub ('soft chaparral'). Both of these seasonally dry vegetation types are fire-adapted. Chaparral tends to burn with low frequency but high intensity. Chaparral fires have a recurrence interval of 30-65 years, for example, in the Santa Barbara area of California (Davis et al. 1989). Severe chaparral fires can spread into riparian zones in hot, dry years, such as occurred at the upper Santa Ynez River in July, 1985 (Barro et al. 1989).

2. High Elevation Willow Shrublands

At these high elevation riparian sites (which range to about 2600 m), shrub willows are a major component of the vegetation. The canopy generally is less than 7 m tall. Several species of willow may be present, including coyote willow (*Salix exigua*), Geyer willow (*S. geyeriana*), red willow (*S. laevigata*), arroyo willow *(S. lasiolepis*) and yellow willow (*S. lutea*). Peach-leaf willow (*S. amygdaloides*), a tree-like willow that grows to 9 m tall, also may be present. Sometimes, flycatcher nests are placed in or near other associated shrubs species such as Wood's rose (*Rosa woodsii*), twin-berry (*Lonicera involucrata*), or river hawthorn (*Crataegus rivularis*). The willow groves often are interspersed with wet meadow vegetation and open water.

The surrounding upland vegetation includes various types of montane conifer forests. Several of the flycatcher-inhabited riparian zones are bordered by ponderosa pine (*Pinus ponderosa*) forests. Historically, ponderosa pine stands were more park-like and open than they are today. Low intensity ground fires would sweep through the grassy undergrowth one or more times per decade (Covington et al. 1997). Stein et al. (1992) suggest that fires in the ponderosa pine stands of northern Arizona may have spread frequently into small, intermittently flowing creeks dominated by arroyo willow *(S. lasiolepis*). However, these small intermittent streams with narrow riparian zones typically do not provide suitable flycatcher habitat. Those with flycatcher habitat tend to have wet meadows, beaver ponds, and willow groves. Being along larger, perennial streams, these sites probably burned infrequently. During very dry years, if the vegetation was sufficiently stressed, the riparian meadows and willow stands may have burned. More often, fires would stop at the edge of the wet riparian zone as was observed by DeBenedetti and Parsons (1979) in the Sierra Nevada. Fire frequency data are lacking for shrub willow sites known to support southwestern willow flycatchers, but charcoal layering suggests a fire frequency of once every 250 to 300 years for some wet meadows in the Sierra Nevada (Chang 1996).

Most shrub willow species, including Geyer willow and arroyo willow, are able to resprout after low to moderate-intensity fires that kill only the aboveground plant parts. Low to moderate-intensity fires thus can maintain the willow patches in an early successional state, and also create habitat for particular animal species. The post-burn resprouts of many willows have a high growth rate and are preferentially foraged upon by elk (Stein et al. 1992; Leege 1979). Patchy fires may create mosaics of shrub stands with different canopy heights and stem densities. High-intensity fires, however, can burn deeply into the soils and kill the willow roots, thereby eliminating the possibility of basal sprouting. Stein et al. (1992) suggest that the vigorous post-fire resprouting ability of arroyo willow may be an adaptation to frequent fire; although it is equally plausible that resprout ability evolved as a response to flood damage.

Many willow species regenerate by seed after floods. Fires also can create seed beds for some willows, if they expose mineral soils at the appropriate time of the year (Zasada and Viereck 1975, Zedler and Scheid 1988, Uchytil 1989). Opportunities for seedling establishing after a fire decrease quickly as the mineral soils become vegetated by herbaceous species (Densmore and Zasada 1983). In some cases, fires or beavers may create the disturbance needed to allow the willows to encroach into areas dominated by perennial grasses, sedges, rushes, and other herbs (Cottrell 1995).

C. Recent Changes to Fire Regimes in Riparian Zones

1. Low and Mid-Elevation Habitats: Fire Increases.

There have been two distinct trends with respect to changes in riparian zone disturbance regimes. Foremost, there has been a shift from a flood-dominated to a fire-dominated disturbance regime on many of the cottonwood-willow rivers that historically supported large populations of southwestern willow flycatchers. Increases in fire size or frequency have been observed for the lower Colorado and Bill Williams rivers (Busch 1995), Rio Grande (Stuever 1997), Gila River (Turner 1974), and Owens River (Brothers 1984). Along the lower Colorado and Bill Williams, over a third of the riparian forests studied burned over a recent 12-year period (Busch 1995). The increased prevalence of fire on these rivers is due primarily to an increase in the abundance of dry, fine-fuels and secondarily to an increase in ignition sources.

Several interrelated factors have contributed to the increase in flammable fuel load. First, and perhaps foremost, is flood suppression. Flood flows are very large relative to base flows in unregulated rivers of the semi-arid Southwest. Large floods can scour extensive areas, clearing away live and dead vegetation and redistributing it in a patchy nature on the flood plain. Willows and other pioneer species quickly revegetate the scoured areas, replacing older, senescent stands with stands of young, 'green' wood. Small to moderate floods frequently remove litter and woody debris from the flood plain surfaces and disperse them into aquatic environments. Floods also increase the patchiness of the vegetation, thereby creating natural fire breaks between stands of riparian habitat. The net effect of this natural flood regime is to 'fire-proof' riparian habitats (Ellis et al. 1998). When floods are suppressed, litter cover and dead biomass accumulate; vegetation can increase in extent, density, senescence, and homogeneity; and fuels become more continuous. On the flood-suppressed Bill Williams River and portions of the Colorado River, riparian vegetation (most of which is fire-prone tamarisk; *Tamarix ramosissima*) has increased in density since dam construction (Turner and Karpiscak 1980, Shafroth 1999), setting the stage for frequent, intense, and large fires. Indeed, most of the rivers with documented fire increases are flow-regulated.

Dewatering of rivers also increases the frequency and intensity of fires by increasing the flammability of the vegetation. Reduced base flows, lowered water tables, and less frequent inundation all can cause plants to lose water content, and cause mortality of stems or whole plants. Stress-related accumulation of dead and senescent woody material is a primary factor contributing to the fire increase on the Lower Colorado (Busch 1995, Busch and Smith 1995). Dewatering also facilitates the replacement of broad-leaved riparian vegetation by more drought-tolerant, and often more flammable, vegetation such as tamarisk (Smith et al. 1998).

Loss of beavers has altered local hydrology, vegetation composition and possibly fire patterns. Beaver activities help to expand areas of shallow ground water and hydrophytic vegetation, and generally create a more heterogeneous flood plain (Apple 1985). This can create natural fire breaks and provide refugia from fire effects, especially where beaver activity results in extensive areas of marsh, wetland, and open water habitats. Beaver were extirpated from many Southwest rivers in the 1800s (Tellman et al. 1997), perhaps contributing to increased flammability of riparian vegetation.

Replacement of native vegetation by exotic plant species, many of which are highly flammable, also has contributed to riparian fire increase. Tamarisk, giant reed (*Arundo donax)*, and annual grasses such as red brome *(Bromus rubens)* all are highly flammable. The spread of many of these exotics is due partly to the same changes in stream flow regimes that render the riparian areas more flammable, making it difficult to disentangle the effects of the exotic species from the effects of management factors that have enhanced their spread (see Appendix H). Nevertheless, we will focus discussion on tamarisk because it is such a key factor in the flood-to-fire regime shift.

Tamarisk plants have many stems and high rates of stem mortality, resulting in an accumulation of dense, dry dead branches. Large amounts of litter - including dead branches and the small, needle-like leaves - are caught in the branches elevated above the ground surface, enhancing its flammability. Fallen leaves of the native broadleaf trees decay quickly relative to tamarisk, thus reducing the relative fuel loading. Based on studies conducted along the Rio Grande (Ellis et al. 1998), there is some evidence that tamarisks produce less litter than cottonwood stands, though this does not mean that tamarisk stands are therefore less fire prone.

When the fire-prone characteristics of tamarisk are coupled with conditions brought about by flood suppression, fires become inevitable in the tamarisk forests. Rosenberg et al. (1991) stated that "Saltcedar is deciduous and, without floods, large amounts of leaf litter accumulate. Therefore, after 10 or more years fires almost become a certainty, especially during the hot and dry summer months." Faber and Watson (1989) suggested that fires become a real hazard when the stands reach 15 to 20 years of age. Anderson et al. (1977) noted that 21 of the 25 tamarisk stands they studied along the lower Colorado River had burned in the prior 15 years. Weisenborn (1996) calculated a fire return interval of about once every 34 years for tamarisk stands along the Colorado River.

When dense tamarisk stands burn, the fires are often intense and fast moving, characteristics that have led to substantial acreages of burned riparian habitat along the Lower Colorado River (Table 1; note that Table 1 data are reported in acres, not hectares). During just three years, recent fires burned a total of 1,000 ha of the 6,200 ha of occupied or potentially suitable willow flycatcher habitat that existed along the Lower Colorado River in 1998 (U.S. Bureau of Reclamation 1999a). Altered fire regimes also have played a role in reducing the amount of cottonwood-willow vegetation on the Lower Colorado River from approximately 36,000 ha (based on 1938 aerial photography with appropriate adjustments: U.S. Bureau of Reclamation 1999a) to the current extent of less than 6,500 ha.

Although fire hazard is greatest with the combination of flood suppression, water stress, and tamarisk presence, tamarisk stands on free-flowing perennial rivers also can burn. Some of the tamarisk stands on the San Pedro River, for example, have large numbers of dead stems (Stromberg 1998) and occasionally ignite. In June 1996, a fire burned along the lower San Pedro River in a stand of cottonwood-willow with an understory of tamarisk (Paxton et al. 1996). The fire was primarily carried by the understory tamarisk, but almost all cottonwoods in the burned area were killed. The patchiness of the forest stands along the free-flowing San Pedro presumably results in smaller fire sizes than on flood-suppressed rivers.

Other human actions have increased the frequency of accidental and intentional fires. Turner (1974) describes the intentional setting of fires by ranchers to clear tamarisk thickets to allow access by cattle. More common, though, are accidental fires caused by campfires, cigarettes, automobile sparks, agricultural burning, and “kids-with-matches.” Riparian areas on military bases or ranges may also be at risk to frequent fires due to use of explosive ordinance, military vehicle traffic, or other ignition sources. Brothers (1984) attributed increased fire along the Owens River to increased use of the riparian zones by campers and fishermen in the past 30 years. Some managers recognize a '4th of July fire syndrome', due to the prevalence of riparian fires started by fireworks. According to Wiesenborn (1996), "Wildfires are an increasingly common occurrence in saltcedar along the lower Colorado River, partly the result of increasing population densities along the river's shorelines." In fact, John Swett (pers. comm.; U.S. Bureau of Reclamation, Boulder City, Nevada) reports that 95% of fires along the Lower Colorado River are human caused. Fires also can be started by homeless people or transients, especially along rivers near urban areas where dense riparian vegetation provides relatively attractive sheltering sites (see Appendix M).

Another factor that may be contributing to riparian fire increase is an increase in fires in the desert uplands. As is true for Sonoran riparian cottonwood-willow forests, fire has become a 'new' disturbance in the Sonoran and Mojave Desert during the past century (Brown and Minnich 1986). Dry, fine fuel-loads, as well as ignition rates, have increased in these deserts. Livestock grazing has contributed to the establishment of grazing-adapted, exotic annual plants which carry fire more readily than native annuals (Brooks 1995). The dense stands of exotic annuals that develop in wet, El-Nino years create opportunities for spread of fire in these non fire-adapted communities far in excess than would have been produced by native riparian plant species during similar El-Nino events. Fires also have become more frequent in other upland vegetation types, such as California chaparral. Extensive urban development in southern California has increased the ignition sources from cars, cigarettes, and other sources, thus providing more opportunities for upland fires to spread into riparian corridors.

2. Low and Mid-Elevation Habitats: Fire Decreases.

We speculate that fire has become less frequent along rivers that historically flowed through grassland or savannah habitats, given the documented declines in fire frequency in these upland habitats (MacPherson 1997). In addition to direct fire suppression, many of the grassland and savannah habitats have been replaced by less flammable vegetation types such as shrublands. There is some evidence that these changes have influenced the adjoining riparian cottonwood-willow-mixed broadleaf forests. For example, the upper reaches of the San Pedro River historically were vegetated primarily by marshland and sacaton grass, with fewer stands of riparian trees than today. Recurrent fire probably favored the herbaceous vegetation types. In the mid 1800s, for example, Leach (1858, in Davis 1982) describes a fire along the San Pedro River that destroyed "large quantities of Cottonwood, Ash, and willow timber with which the banks of the river were densely overgrown", but says that three weeks later "the Sacaton grass had grown up and covered the entire valley with a beautiful carpet of verdure". Only recently and only locally has fire returned as an ecological force to the San Pedro uplands, due to cessation of grazing and subsequent recovery of the grassy-fuel load (Krueper 1992). As a result, several fires have spread into the older riparian forests in the past decade. The fires are carried into the riparian corridor by the seasonally dry understory of perennial grasses and forbs, and have killed several patches of cottonwood and willow trees. In other areas throughout the range of the southwestern willow flycatcher, desert grasslands have been so degraded that they have reached a new stable state composed of shrublands and small trees; thus precluding the return of the historical upland fire regime.

There is other anecdotal evidence that fires have become less frequent at some mid-elevation sites. In some areas, fires may have decreased in frequency because Native Americans no longer set fires to improve hunting success. In others, ranchers no longer are setting fires to increase access and improve forage for cattle (Boukidis 1993). Part of the reason for the decline in prescribed burning is the difficulty in obtaining permission from the permitting agencies, as well as risks to the increasing number and distribution of rural homes.

3. High-Elevation Habitats.

There is little hard evidence that fire regimes of the high elevation wet meadows and willow shrublands have changed. In some of the adjacent upland conifer forests, including the *P. ponderosa* forests, fires have become less frequent but more intense. Heavy livestock grazing has eliminated the fine fuel load that historically contributed to frequent low-intensity fires in some of the forest types (Belsky and Blumenthal 1997). Active fire suppression has allowed for the accumulation of high fuel loads (i.e., very dense stands of young conifer trees) that results in very high fire intensities when the forest do burn (Covington et al. 1997). These changes may have altered fire patterns in the associated riparian zones. With higher intensity, the fires may be more likely to penetrate into the riparian corridor. Additionally, catastrophic fires can trigger catastrophic flooding events, which in turn can destroy wetlands or eliminate populations of some wetland plants (Hendrickson and Minckley 1984, Bowers and McLaughlin 1996); but at the same time create opportunities for establishment of disturbance-dependent species such as willows.

D. Impacts on Southwestern Willow Flycatcher

1. Low and Mid-Elevation Habitats: Fire Increases

The willow flycatcher is a bird that lives in a dynamic habitat. Suitable nesting patches historically underwent frequent loss and replacement due to flood disturbance. When assessing the impacts of fire regime change on the flycatcher, we must compare the population dynamics of the birds between flood-disturbance and fire-disturbance scenarios. Although there are some similarities, there also are substantial differences in the ways in which fires and floods influence the bird and its habitat. We stress the management implications of one similarity: because fires and floods both periodically cause localized habitat loss, the total numbers of individual flycatchers and of flycatcher populations need to be sufficiently large to buffer the species from these habitat losses. This requires that riparian habitat patches be sufficiently abundant and distributed appropriately throughout the birds' range to allow for post-disturbance recolonization.

Historically, most floods that were large enough to scour and remove nesting trees and shrubs from the Sonoran Desert rivers occurred in winter, spring, late summer or fall, but rarely in the early summer period coincident with the flycatcher breeding season. Thus, despite the floods, nest sites had a high probability of remaining intact throughout the breeding season. Riparian fires, however, tend to burn during the summer breeding season and thus can cause direct loss of nests and young. Some nesting flycatchers may move to other, unburned habitat to re-nest, but the resultant delayed breeding and use of alternative habitat may lower their overall seasonal breeding success. For example, the 13 willow flycatcher pairs breeding in the area burned by the San Pedro PZ Ranch fire in June 1996 abandoned the site (Paxton et al. 1996). Their subsequent reproductive success, if they had renested in the same year, probably would have been reduced because willow flycatcher clutch size is significantly reduced each time a flycatcher renests within a season (Holcomb 1974). Although some willow flycatchers returned to unburned portions of the PZ Ranch site during subsequent years, the population there continued to decline over time through 1999, when only a single unpaired male remained (Arizona Game and Fish Dept., unpubl.

data).

We do not know how many flycatchers are affected directly by burns in any given year. The number may be large given the dominance of tamarisk along rivers in the desert southwest and the prevalence of fires in this vegetation type. In 1998, for example, a major fire along the lower Colorado River destroyed large portions of dense tamarisk habitat at Topock Marsh. Approximately 100 ha of suitable flycatcher habitat was consumed in the blaze (of a total 1,200 ha burn), though effective fire suppression kept the fire out of known occupied habitat that supported over a dozen territories, and thus no known flycatcher nests were destroyed (U.S. Fish and Wildlife Service 1998). However, the potential for loss in such situations is high.

Fires at any time of the year can affect breeding success by causing changes in vegetation structure and composition. The structural characteristics of post-disturbance riparian vegetation and suitability as flycatcher habitat differ substantially between floods and fires. Floods, unlike fires, trigger primary succession along alluvial desert rivers. By scouring sediment from aggraded floodplains, creating new channels, redistributing sediment, recharging aquifers, and moistening sediments, floods create opportunities for seed-based regeneration of cottonwoods and willows, and create a mosaic of age classes in the flood plain. Natural flood regimes provide a mechanism for the continued development of habitat patches with suitable nesting structure. Fires, in contrast, do not cause these same geomorphic, hydrologic, and vegetational changes.

Fires cause directional change in the composition of the riparian stand, and trigger secondary successional processes. Along the lower Colorado and Bill Williams rivers, fires have contributed to the replacement of many native species including Fremont cottonwood, quail bush (*Atriplex lentiformis*), and salt bush (*Atriplex* spp.), by tamarisk (Anderson et al. 1977, Higgins 1981, Busch 1995, Shafroth 1999). Tamarisks can be killed by very hot or frequent fires, but generally resprout from the root crown in as little as a few days after the fire (Faber and Watson 1989, Hoddenbach 1990). Horton (1977) found that "fire burning through a saltcedar stand will not kill the shrubs, as they tend to sprout vigorously unless they are growing under stress. Then as many as half of the shrubs may not survive." Although some native species, including honey mesquite and Goodding willow, also resprout after fire, the development of a fire-cycle triggered by the dominance of tamarisk ultimately can result in the loss of these species. Anderson et al. (1977) noted that "with the initiation of a burn cycle, the dominance of an area by saltcedar becomes successively more complete." The native shrub arrow-weed *(Pluchea sericea*) also is favored by frequent fire, and thus tall forests of Fremont cottonwood, Goodding willow, and mesquite along the Colorado River have been replaced by short shrublands of arrowweed and tamarisk. Along the Owens River, fires may be favoring the shrubs narrowleaf-willow (also known as coyote willow; *Salix exigua*) and rabbitbrush (*Chrysothamnus nauseosus*) over Fremont cottonwood and Goodding willow trees (Brothers 1984).

Flycatcher breeding success can be impaired for several years after a fire. The extent and duration of the impairment varies with many factors including the size and severity of the fire, rate of vegetation regrowth, and post-fire changes in vegetation structure and insect community structure and productivity. Post-fire regrowth of tamarisk can be quite rapid if site conditions are favorable, with resprouts growing to 4 m high in a year after burning (Horton 1977). In other cases, over a decade may be required for the resprouted tamarisks and/or willows to attain the requisite structure for flycatcher breeding (Paxton et al. 1996).

The following case study illustrates the complexity of the post-fire response. In March 1997, an agricultural brush-pile fire on land adjacent to Escalante State Wildlife Area, Colorado escaped control and burned through the small patch of flycatcher habitat on the area (Owen and Sogge 1997). The habitat burned during the non-breeding season when flycatchers were not present, and approximately 95% of the known breeding area burned. Subsequently, the number of flycatchers present in 1997 (six territories) was lower than during 1996 (10 territories). Three territories within the burned area retained approximately 50-60% willow coverage and were occupied by breeding pairs. The other three territories were in completely burned habitat (much of which was previously tamarisk), and two of these three territories were only occupied by unpaired males. By 1998, resprouting willow and tamarisk vegetation provided dense habitat in the burned area, but only five territories were found (Sogge unpubl. data). Thus, although flycatchers occupied the site after the burn, it presumably reduced the local population size and lowered the overall breeding success.

Southwestern willow flycatchers breed in dense, tall, and typically older tamarisk patches at many sites in the Southwest (see Appendix D). We do not yet know if tamarisk patches can reach a state of maturity or decadence in which they would lose their suitability as flycatcher breeding habitat. This could theoretically occur if the tamarisk plants undergo senescence, become decadent, and lose vigor (and thus live-foliage density). This question has significant ramifications in terms of the sustainability of currently occupied sites, and for the future suitability, availability, and distribution of substantial amounts of flycatcher habitat. This important issue deserves future research attention.

If tamarisk stands can “age” beyond suitability for flycatchers, such conditions would require the absence of disturbance factors such as fire or floods. In these situations, small fires may be beneficial by allowing for development of younger stands. Fires may perpetuate a mosaic of size classes, in the absence of other disturbances. Thus, it is theoretically possible to use fire as a tool to manage for key structural types in saltcedar (Anderson et al. 1977) if research determines that older structural types are not suitable for flycatchers or that a mix of saltcedar successional stages is superior for flycatchers. However, older stands of dense tamarisk may be so fire-prone that it is impossible to keep a fire “small enough” to serve as an effective tool that does not destroy an entire riparian area.

Overall, many questions need to be answered regarding tamarisk and fire management. If fires are going to persist as the dominant disturbance factor on some rivers, we need to define more explicitly the tamarisk structural types and age ranges that are preferred by the flycatchers. More research is needed in general on relationships between riparian stand age and flycatcher habitat suitability (Farley et al. 1994). We also need to know the response of tamarisk to repeated burning. How long can tamarisk survive under a frequent-burn scenario? Will the resprouted plants die at the end of some fixed natural life span, or does burning reconfigure them to a juvenile state? More research also is needed to determine how post-fire forest stands differ from post-flood stands in terms of insect food base, or other habitat suitability factors.

2. Low and Mid-Elevation Habitats: Fire Decreases

As we noted earlier, fires have returned as an ecological force along some rivers, including the upper San Pedro, that are bordered in the uplands by fire-adapted vegetation types. We anticipate that the restoration of the fire regime in this reach will reduce the abundance of cottonwood-willow forests, particularly on the highest (and thus most surface-dry) flood plains. Fire-related losses of these habitat patches need to be countered by restoring riparian habitat to other sites throughout the flycatchers' range. Because there are other rare species that depend on the fire-adapted riparian vegetation types, we advocate a multi-species approach to riparian ecosystem management.

3. High-Elevation Habitats

We are not aware of published evidence that fire regime changes have had either positive or negative effects on the flycatcher in high elevation habitats. Mature stands of willows grow in some meadows in the Sierra Nevada. While fire may be a tool to rejuvenate willows in these situations, the ecological processes that lead to the stands natural presence and persistence are unknown (Valentine, pers. obs.). In some high-elevation willow habitats (e.g., the Alpine site in the White Mountains of Arizona), intentional removal of beavers dried the site substantially, contributing to reduced water ponding, conversion of perennial stream flow to intermittent, restriction of the flow to the narrow creek channel, and declines in the extent and density of willows (Langridge and Sogge 1997). Drier herbaceous and shrub vegetation, essentially pasture-like in nature, can surround the remaining willow patches where willow flycatchers still breed. These changes in vegetation and hydrology have the potential of increasing fire frequency, and are another topic that warrants research attention.

E. What Can Be Done

There are many actions that could be taken, and that are being undertaken at various riparian sites, to restore appropriate disturbance regimes. Some of these actions, such as restoring flood flows, fall in the category of “ecological restoration” approaches because the intent is to restore habitat by restoring desired physical processes. Others, such as clearing woody debris, fall in the “active intervention” category. Some actions focus on prevention of fires (e.g., reducing ignition sources, reducing the abundance of flammable fuel loads) while others focus on extinguishing fires once they have started. Some actions are long-term with regard to implementation and benefits. Others can be carried out more quickly, often at smaller scales, and result in relatively rapid reduction in fire risk and impacts. Some of the actions could be undertaken in adjacent uplands, where fires have become a new disturbance, to reduce probabilities of spread of upland fires to riparian corridors.

In this section, we discuss some of the caveats, constraints, and benefits of several action-items with respect to willow flycatcher habitat quality. Our primary focus is cottonwood-willow habitats (now cottonwood-willow-tamarisk), the type that has undergone the greatest change in disturbance regime.

1. Fire Risk Evaluation and Planning

* *Fire risk and management plans.* As a first step in reducing the risk and effects of fire, land owners or managers should develop a fire plan for all current flycatcher breeding sites, and for sites where flycatcher-related riparian restoration is planned. This can be accomplished quickly and with relatively little cost, and yet can yield great rewards in minimizing or avoiding loss of occupied habitat. This was the case for the 1998 fire that occurred at the Topock Marsh site along the Colorado River – advance risk-evaluation and response planning played a key role in preventing the destruction of active flycatcher nests and important breeding habitat. Fire control efforts involved on-the-ground "flycatcher advisors", working with the fire team to identify and protect occupied willow flycatcher habitat. The suppression tactics would have been different if fire crews were not aware that the flycatchers were present, and the fire would likely have burned occupied willow flycatcher habitat. This involvement of the willow flycatcher resource advisors was critical, and they will provide assistance on any future fires at the site.

Other fire-suppression planning for flycatchers has occurred. The Bureau of Reclamation distributed 10,000 brochures on the dangers of wildfire along the Lower Colorado River to local federal and state land management offices. Management agencies along the Lower Colorado River have developed cooperative strategies for fire response. In the BLM Lower Colorado Fire Management Plan, protection of riparian habitat is given suppression priority second only to human life and property. The BLM and USFWS prohibit campfires on their lands along the Colorado River from May 1 through September 30 from Davis Dam to Mexico.

A comprehensive fire evaluation and response plan (hereafter referred to as the fire plan) should have several components including:

(a) evaluation of the degree of fire threat for that particular site. This section of the fire plan involves consideration of vegetation composition and structure, hydrologic conditions, patch morphology/structure, historical and recent fire regime, assessment of the fire risks posed by land-use management (e.g., livestock grazing, fire suppression) on-site and adjacent to flycatcher habitat, and potential sources of ignition (especially with regard to intensive human use) as well as identifying entities that contribute to control of fireworks risks.

(b) identification of short-term preventative actions that will be taken to reduce the risk of fire. This section of the fire plan could include many of the recommendations made later in this appendix, such as reduction of ignition sources (e.g., recreational use management, signage), efforts to produce less flammable conditions (e.g., development of 'wet' fire breaks, periodic inundation to moisten the soils and litter, modifying grazing to achieve reduced flammability), encouraging fireworks regulating entities to eliminate or restrict sales and use areas, etc.

(c) direction for quick response for fire suppression. This section of the fire plan should be very detailed and identify flycatcher breeding locations, prioritize areas for protection, locate access points, provide important site contacts (including the management agency and the USFWS), etc. The plan should be developed in conjunction with local fire management agencies, and periodically updated (at least biennially). Updates should be reviewed with the associated fire management agencies so that firefighters know about the management plan *before* a fire actually threatens a site.

(d) post-fire remediation/restoration. This section of the fire plan should have a goal of enhancing the recovery of desired vegetation that is suitable for breeding flycatchers, and should take advantage of the vegetation-clearing role of the fire. Remediation plans will, of course, vary from site to site depending on site potentials and logistic considerations. For example, at some sites the flood plain surface could be cut and lowered closer to the water table, flood irrigated and seeded with desired species. At other sites, it may be possible to excavate channels and then revegetate their margins. Some areas may simply need planting of the desired species without undertaking any earth moving activities.

(e) identification of long-range efforts to reduce risk of fire. This section of the fire plan can include reducing ignition sources (e.g., educational efforts), producing less flammable conditions by restoring more natural hydrologic and ecologic conditions (e.g., release of flood pulses, increase of ground water levels, restoration of willow, cottonwoods and other native species; release of beavers), etc.

(f) development of long-term monitoring of conditions in the riparian zone and watershed that maintain flood regimes and reduce fire susceptibility. This section of the fire plan should consider efforts such as monitoring regional water use patterns; water level trends in the regional and flood plain aquifers; fire-related recreational activities; and fuels loading.

2. Ecological Approaches to Reducing Risk

**Restore flood flows.* Flood pulses can be restored by breaching dams or releasing prescribed flows from dams. Both approaches can serve to reduce fire frequency and size in the short-term by scouring flammable fuel loads and moistening the vegetation and in the long-term by selecting for less flammable vegetation types. This ecological approach has tremendous value in that it addresses the root causes behind the shift in the nature of the disturbance regime. To be most effective, flood pulse restoration should be part of an overall restoration plan that will allow for ongoing establishment and survivorship of the native tree and shrub species that constitute flycatcher habitat (see Appendices I, J, and K).

Ideally, floods should be released in a fashion that mimics the natural flow regime. Water or power demands, or physical characteristics of the dam structure itself, may constrain the size or frequency of flood releases. To reduce fire size and frequency, floods should be sufficiently large to scour and remove accumulated forest floor debris and moisten the surface soils and tree bases. Based on flood recurrence intervals calculated for free-flowing rivers (Stromberg et al. 1991), an approximate frequency for such floods is once every two to five years. Larger floods that remove dead branches and scour patches of forest should be released, at longer intervals, to further reduce fuel loads and allow for successional regeneration processes. Where river channels below dams have become entrenched, there may be a need to mechanically grade and lower the adjacent flood plains and/or to raise the channel, to allow the flood plain surfaces to be inundated by smaller flood flows. Site-specific hydrologic and ecologic studies should be conducted to determine specific flood frequencies and magnitudes. Hydrography information for the reach in question can be calculated from upstream gauging or other hydrological information to guide prescriptions on flood size, frequency, and timing (see Appendices I and J).

* *Restore ground water and base flows.* Restoration of water availability also is an ecologically-based approach that will aid willow flycatchers not only by reducing fire risks but by improving habitat quality in other ways. Depth to ground water should be sufficiently shallow to restore or maintain native cottonwood-willow forests in non-water stressed condition (i.e., no lower than 3 m below the flood plain surface for mature forests and within 0.5 to 1 m of the flood plain for younger forests measured during the peak water-demand periods). Hypothetically, shallow depth to ground water also might allow tamarisk stands to be more fire resistant than if water is deeper because they maintain higher internal water content. Such high water tables may also allow native cottonwoods and willows to outcompete tamarisk. If a stream has become intermittent, perennial surface flows should be restored. In lieu of restoring the natural hydrology (the preferable option), other actions to improve plant water content and raise water tables could be undertaken such as flood irrigation, sprinklers, or agricultural tail water.

* *Reintroduce beavers*. By locally raising water tables, creating ponds, and increasing the extent of marshy, wetland vegetation (Parker et al. 1985, Johnston and Naiman 1987, Naiman et al. 1988), beavers may reduce fire size or frequency at a site. By promoting these habitat conditions, beavers appear to generally enhance site quality for flycatchers (Albert 1999). Apple (1985) showed that introduction of beaver into deteriorated or deteriorating riparian habitats lead to substantial improvements in 3 years. Subirrigated meadows formed where the channel formerly was downcutting into a gully-cut channel and “full riparian recovery was underway.” Beavers have recolonized many riparian sites on their own, and they will likely spread (through natural dispersal or human intervention) into additional sites in the future.

There are several issues that must be considered before releasing beavers as a habitat restoration tool. The site should be assessed to ensure that there is an adequate food base of preferred foods, and to ensure that the natural successional dynamics are in place that will allow these plant species to regenerate over time. Otherwise, beaver foraging can reduce habitat quality by reducing densities of wetland herbs and riparian trees and shrubs below replacement levels. For example, in very small riparian patches, beaver might render the site unsuitable for breeding flycatchers by girdling or cutting down too many trees and shrubs. Arizona Game & Fish (unpubl. data) observed this event at the Tavasci Marsh flycatcher breeding site in the Verde Valley. There, beaver activity lead to a 50 percent loss of dominant large willows that dramatically reduced the live foliage. Subsequently, willow flycatchers did not nest at the site. However, these short-term losses in habitat quality may be offset by long-term improvements. Beaver habitat suitability analysis models (e.g., Allen 1982) should be consulted to determine if a site is likely to support beavers.

Another potential complication in using beavers for flycatcher habitat improvement is that beavers were not historically present in some parts of the Southwest (e.g., Southern California). There, introduction of beaver could violate proscriptions against introduction of new species. Furthermore, the hydrological conditions created by beaver activity (especially perennial ponds) could provide favorable conditions for unwanted species, such as the introduced bullfrog (*Rana catesbeiana*), at the expense of locally rare or endangered fish or amphibians. However, beavers are already so widespread in Southern California that it may be acceptable to consider them as vital agents in the functioning of riparian areas. In general, additional site- and context-specific research is needed about the role of beavers in creating and maintaining suitable willow flycatcher breeding habitat, and any ecological ramification or trade-offs of such actions.

* *Exclude livestock or follow proper utilization rates.* Livestock grazing is one of the factors that can cause drying of riparian sites and that can favor flammable exotic species such as tamarisk and red brome (see Appendices G and H). Many of these exotics are more flammable than the native species they replace. There is no guarantee that simple removal of livestock or reduction to more appropriate utilization rates will allow the native species to recover. Exotics can remain dominant for decades after a stressor, or factor that enabled their establishment, is removed. For example, Harris (1967 in Krebs 1972; 313) noted that the invasive cheatgrass (*Bromus tectorum*) is very resistant to displacement by native perennial grasses. In Washington, native wheatgrass (*Agropyron* sp) was not able to invade the *Bromus* stands even after 30-40 years of protection from fire and grazing. Further, some exotics may not even require the stressor to gain dominance in a community. Mensing and Byrne (1999) assert that red-stem filaree (*Erodium cicutarium*) was introduced to the West Coast of North America in the feed imported to support livestock of the first Spanish mission. However, its dispersal exceeded the spread of livestock from the mission, suggesting that the species was pre-adapted to the Mediterranean climates of the West coast. Therefore, simple removal of a stressor may not be adequate to recover native flora. However, removal of

the stressor, when coupled with other restoration measures such as seeding or soil manipulations (see Appendix H) may be necessary to hasten the recovery to a less flammable community type. Where the consequences of fire are high due to fine fuel loads, livestock grazing might be used as a tool to reduce the risks (Boukidis 1993, Chang 1996).

* *Use sustainable agricultural practices.* We need to address all of the factors that are causing riparian habitats to be more flammable. Some agricultural practices, for example, amplify the amount of salt and its delivery into rivers, in some cases favoring tamarisk and other exotics over willows and other native species. Increase in salinity is one subtle factor that can give tamarisks a competitive edge over willows (see Appendix H). Shifts towards more efficient use of water and less reliance on applications of fertilizers would help to reduce salt loads. Flood plains and watersheds should be managed in such a way as to keep salinity levels within the tolerance ranges of the native plant species.

3. Physical Manipulation of Fuel Loads

* *Manually/mechanically reduce fuel loads.* On heavily regulated rivers where natural flood regimes will not be restored, we must regularly intervene to actively manage the fire disturbance regime. One type of intervention involves clearing the 'fine woody debris' such as litter and dead branches, from dense stands of flammable vegetation, such as tamarisk. This also could entail clearing the duff of annual grasses from forest understories. These actions may reduce the intensity of fires and ease suppression, but are likely very time-intensive and could reduce site suitability. Such actions should be carefully planned, and adopted as part of a larger plan only after the benefits and costs are assessed to avoid causing more harm than good with respect to habitat quality. For example, it may be necessary to develop access roads to remove the fuel loads. The resulting fragmentation and opening of the vegetation may reduce quality of the flycatcher habitat or provide an avenue of ingress for threats to habitat or the species.

There has been little, if any, experimentation with fuel reduction in riparian habitats (especially tamarisk), and there are no standard guidelines on how best to accomplish this. Therefore, riparian fuel reduction actions should be considered as experimental, and initially conducted only in unoccupied habitats until the success and ramifications are better understood. Efficacy of these actions as a fire management tool, and effects on bird habitat quality, should be tested in a scientifically explicit, controlled fashion.

* *Dry fire breaks.* This approach, in some respects, is related to the one above. Here, the goal is to reduce the spread of fires by clearing all of the vegetation from swaths of land. Because of concerns over fragmentation of flycatcher breeding habitat, including the potential for providing increased human access to and into breeding sites,

fire breaks are not a preferred choice at most flycatcher sites. In addition, the effectiveness of firebreaks in dense willow and saltcedar willow flycatcher habitat is questionable. For example, the Topock Marsh fire of July 1998 jumped an existing firebreak. West (1996) indicated that fire breaks should be at least 100 feet (ca. 30 meters) wide, which would remove a substantial amount of habitat and greatly fragment a site. Furthermore, there is anecdotal evidence that flames from fires in dense tamarisk can travel across even 100 m wide bare strips, thus restricting the utility of fire breaks at tamarisk sites. In occupied or suitable flycatcher habitat, creation of wide fire breaks might render the habitat unsuitable. Situations where dry fire breaks may be effective include:

- along grass-edged roadways. Mowing or clearing dry vegetation along roadways may reduce fire ignition and spread from discarded matches and cigarettes.
- where large areas of fire-prone vegetation, unsuitable for flycatcher breeding, separate a breeding site from potential ignition sources or high-frequency fire areas. A wide fire break, far from the flycatcher breeding patch, could prevent or slow fire from spreading into the occupied patch.
- between agricultural "burn areas" and flycatcher sites, to prevent brush-pile fires from spreading into breeding sites.

Additional research is needed on the potential values, effectiveness, and ramifications of creating fire breaks in riparian habitats. Such research should first be conducted only in unoccupied sites.

* *Create wet fire breaks*. As an alternative to creating 'dry' fire breaks, 'wet' fire breaks could be created along heavily managed rivers by developing channels and restoring strips of less flammable vegetation along their margins. In dense, wide tamarisk stands, channels could be excavated to the level of the water table, or provide a water source directly into the channel. Site conditions adjacent to the channel would need to be assessed to determine what vegetation types could survive. If the soil is not too salty and if water tables are relatively stable, willows and cottonwoods could be restored (though this may require active establishment and maintenance). Another option is to plant marsh species such as cattails and bulrush. The channel and adjacent vegetation would have to be relatively wide (30 m to 100 m) to be an effective fire break. Potential ancillary benefits of this approach include increasing availability of flycatcher nest sites, enhancing the amount of water (an important habitat parameter) on-site, and increasing the productivity of the insect food base. Another benefit is that the presence of surface water can provide another source of water to be used for suppression purposes. However, even wet fire breaks have the potential to fragment habitat and provide increased access to flycatcher breeding sites, and should be approached with the same cautions noted for dry fire breaks (above).

* *Burning issues: Implement controlled burns*. There may be benefits to the use of prescribed fire in

riparian areas, from the perspective of flycatcher habitat. In older tamarisk stands, fire might create a mosaic of patches in different age classes and structural classes, which may provide for long-term maintenance of tamarisk at the site. It may also decrease the chance that an accidental fire will burn large areas and homogenize the landscape. However, these are theoretical benefits, and some fire experts consider dense tamarisk habitat a poor choice for controlled burns. Tamarisk is highly flammable (observers of some recent fires describe tamarisk plants as literally "exploding" in succession as the fire swept through stands) and there is a high risk of losing control of the burn (Kerpez and Smith 1987). In some cases, though, such as after rains or floods, managers were unable to ignite the tamarisk (Jorgensen 1996, West 1996). To better manage the controlled burns in tamarisk stands, one may wish to limit efforts to the rainy season, inundate the stand before burning, or reduce the fuel loads mechanically before burning. These possibilities warrant further research. Until then, however, controlled burns should be avoided in occupied habitat (or where the fire could spread to occupied sites), and considered only as experimental management techniques if dealing with suitable unoccupied habitat.

4. Public Education and People-Management

* *Reduce recreational fires.* In occupied habitat and in large buffer strips surrounding the occupied habitat, fires and fire-prone recreation uses should be prohibited during high fire-risk periods. In areas with suitable but unoccupied habitat, manage the numbers and/or distribution of recreationists to concentrate them into locations where fire suppression efforts can be more effectively deployed (and thus habitat loss minimized). Some areas may need to be closed to recreational use during high-risk periods, such as 4th of July weekends or drought periods. Additional patrolling by enforcement personnel would help to enforce restrictions.

* *Educate recreationists.* Brochures, signs, and other interpretive materials should be developed to educate river and riparian recreationists about the ecological roles of fires and floods, and the potential dangers of accidental fires. As noted above, such a program has been initiated by the U.S. Bureau of Reclamation along the Lower Colorado River. In the long-term, this should help to reduce accidental fires and garner public support for the implementation of ecological restoration approaches.

5. Reactive Measures: Fire Suppression

* *Suppress fires.* Fires in occupied habitat and adjacent buffer zones should be rapidly suppressed. As part of each breeding site's Fire Evaluation and Management Plan (described above), maps of occupied habitat and buffer zones should be updated at frequent intervals, and the maps made available to local fire commanders to aid in active suppression process. "Ok-to-burn" areas should be identified based on site-specific analysis of the size, structure and composition of the riparian habitat throughout the management area, the recent fire history in the area,

and the ease of extinguishing the fire once it has moved beyond the area targeted for burning.

F. When and Where to Apply Measures

Table 2 lists the suite of actions that should be taken to restore an appropriate disturbance regime for the southwestern willow flycatcher. We classify the actions based on the quality and occupancy of the habitat. The actions in Table 2 apply to low and middle-elevation riparian forests that have undergone shifts from flood to fire disturbance regimes.

For all riparian community types throughout the flycatcher's range, including those at low, middle and high elevations, we need more information on the fire regime and ecological effects of fire. As noted above, all occupied sites, even those at high elevations, should undergo a fire risk evaluation and development of a fire plan.

G. Literature Cited

Please see Recovery Plan Section VI.

Table 1. Recent fire history along the Lower Colorado River, Arizona and California (Source: U.S. Bureau of Reclamation 1997, 1998, and 1999).

Reporting period	Number of fires	Number of fires in known occupied willow flycatcher sites	Total acres burned (range/fire)	Total acres of potential or suitable willow flycatcher habitat burned
October 1996 - July 1997	8	2	431 (.1 - 158.0)	306*
October 1997 – August 1998	5	1	3238 (3.1 -2925.0)	2303
September 1998 – September 1999	27	0	1119 (.1 - 158.0)	7
October 1996 – September 1999	40	1	4776	2506

* best estimate, based on limited data

Table 2. Suggested actions for reducing and eliminating the risk and impacts of fire in southwestern willow flycatcher potential breeding habitat. These actions pertain primarily to low and middle elevation riparian forest types, which have undergone recent shifts from flood to fire disturbance regimes. Note, however, that fire risk and management plans should be developed for all occupied breeding sites.

Action	Occupancy and Condition Status of Habitat Patch		
	Occupied	Unoccupied but Suitable	Targeted for Restoration
Planning and Suppression			
Develop Fire Risk and Management Plan	Yes	Yes, if goal is occupancy	Yes
Develop Fire Remediation Plan	Yes	Yes, if goal is occupancy	Yes
Suppress Fire if it Occurs	Yes	Yes, if goal is occupancy	Possibly, if fire incompatible with restoration effort
Ecological Approaches			
Restore or maintain flood flows	Yes	Yes	Yes
Restore or maintain perennial surface flows and shallow ground water	Yes	Yes	Yes
Reintroduce Beaver	Yes, if site conditions are favorable	Yes, if site conditions are favorable	Yes, if site conditions are favorable
Manage livestock (exclude or proper utilization rates)	Yes	Yes	Yes
Use sustainable agricultural practices	Yes	Yes	Yes
Intervention: fuel load management			
Manually or mechanically reduce fuel loads	No	Experimentally	Experimentally
Create dry fire breaks	Not in habitat, possibly nearby	Not in habitat, possibly nearby	Not in habitat, possibly nearby
Create wet fire breaks	Not in habitat, possibly nearby	Experimentally	Possibly, as part of site design
Controlled burns	Not in habitat, possibly nearby	Experimentally	Experimentally
Education and People Management			
Public outreach and education	Yes	Yes	Yes
Manage activities or restrict access in high risk areas	Yes	Yes	Yes

Appendix M.

Potential Recreation Impacts on Southwestern Willow Flycatchers and Their Habitat

A. Introduction

When conservation ethics and outdoor recreation were evolving, they were initially thought of as mutually beneficial. Recreation activities were considered compatible with the environment, especially when compared to timber harvesting, mining, development, and grazing (Knight and Gutzwiller 1995). Recreation demands on riparian areas may have been the single most important factor in motivating management agencies to reduce consumptive use in flood plains (Johnson and Carothers 1982). However, as recreation activities increase and persist over time, the damage they sometimes cause can no longer be ignored. Conservation ethics and outdoor recreation are often in conflict, requiring recreation management (Flather and Cordell 1995). Some experts believe the primary natural resource management issue for this century will revolve around conflicts between recreation and wildlife (Knight and Gutzwiller 1995).

Some subspecies of the willow flycatcher *(Empidonax traillii*) are known to be suburban nesters, breeding along roads and freeways and in areas of low to moderate recreation use. Although the southwestern subspecies *(Empidonax traillii extimus*) does not occur as a suburban nester, it may be more likely to persist in suitable habitat adjacent to recreation than some other endangered species. For example, unlike a species like the bald eagle (*Haliaeetus leucocephalus*), which has a large home range and is often sensitive to human proximity during the breeding season, the flycatcher has a small home range and does not appear to be overly sensitive to low level human activity outside of its' breeding patch.

Although there is little evidence of direct impacts on southwestern willow flycatchers or their habitat, the projection of recreation use into the future is cause for concern. Increasing human populations, coupled with the attraction of limited riparian areas for recreation, make willow flycatcher habitat a vulnerable resource.

To truly understand the breadth of the potential impacts, we must first acknowledge that recreation is a growing and economically profitable business that produces outdoor experiences for the public. The recreation industry, which includes the government, caters to users by providing hiking trails, campgrounds, picnic areas, resorts, marinas, and stocked rivers. These amenities allow visitors diverse experiences such as hiking, camping, motorboating, whitewater rafting, kayaking, and sportfishing. Visitors patronize the recreation industry by purchasing equipment, food, fuel, lodging, permits, and commercial tours.

Despite the fact that their cumulative activities can degrade riparian habitat, recreationists are important advocates for riparian conservation. As individuals or organized groups, they support habitat acquisition, review management plans, and generate funds. Recognizing the unintentional negative impacts recreation can bring about, user groups provide stewardship by sponsoring riparian clean-up, trail maintenance, restoration, monitoring, and education programs. In other words, it is important to recognize that recreation users can have positive impacts.

B. Current and Future Recreation Use

As the Southwest becomes increasingly urbanized, there will be greater demand to escape to natural environments. Population growth during 2000 to 2025 is expected to increase from 48,161,345 to 68,692,000 people for Arizona, California, Colorado, Nevada, New Mexico, and Utah combined. This is an increase of an additional 30% (U.S. Census Bureau 2001). These trends clearly indicate impacts are likely to escalate in the absence of recreation planning.

The growth in recreation activity from 1983 to 1995 exceeded growth of population, based on National Recreation Surveys (Cordell et al. 1999). Birding, hiking, backpacking, downhill skiing, and primitive camping were the five fastest growing activities in the country in terms of percentage change in number of participants between 1983 and 1995. Outdoor recreation activities involve more than 25% of the country's population.

Based on analyses of public recreation visitor surveys (Table 1), significant increases in future recreation activities will likely result in increased use of formerly undisturbed or lightly disturbed areas. People will increasingly enter wildland areas in search of a more natural and less crowded experience (Flather and Cordell 1995).

Table 1. Projected indices of growth in recreation trips between years 2000 and 2040 in the United States. The baseline index for all activities was set at 100 for the year 1987. These projections assume that recent trends in facility development, access, and services for outdoor recreation will continue into the future. This table was adapted from Flather and Cordell (1995).

	Projected Participation Index by Year				
Activities	2000	2010	2020	2030	2040
Day hiking	123	144	168	198	229
Bicycling	124	146	170	197	218
Developed camping	120	138	158	178	195
Horseback riding	114	125	135	144	149
Primitive camping	108	115	122	130	134
Off-road vehicle use	104	108	112	118	121
Nature study	99	101	103	107	108
Rafting	123	151	182	229	267
Canoeing/ Kayaking	113	126	138	153	163
Swimming	108	118	128	140	152
Motorboating	107	114	122	131	138

C. Recreation Use in Riparian Areas

Riparian areas already receive disproportionately high recreation use in the arid Southwest, when compared with other habitats. Not surprisingly, riparian areas near cities receive greater use than those farther away from development (Turner 1983). The demand for recreation in riparian areas will continue to increase in proportion to increasing human populations.

Impacts can be even more devastating in the Southwest, where riparian habitat tends to be more linear, narrow, and dissimilar to adjacent habitat than in other parts of the country. Where there is no buffer between adjacent habitats, impacts are more significant.

1. Examples of High Use Recreation in Southwestern Riparian Habitat

To illustrate the magnitude of public demand for recreation, we provide two examples of intensive use currently challenging managers.

Typical holiday use on the Imperial National Wildlife Refuge, along the lower Colorado River in southern Arizona, was estimated for Memorial Day, 1999. A 30-mile stretch of river from Martinez Lake north to Cibola National Wildlife Refuge was estimated to be inhabited by at least 2,790 people and their 951 boats and personal watercraft (e.g., jetskis). More than half of this use was concentrated on a sandbar nicknamed "zoo island," with an estimated 1,550 users and their 523 boats and personal watercraft. Nearby Cibola National Wildlife Refuge receives less recreation pressure while Havasu National Wildlife Refuge has 2-3 times as many recreation users as Imperial National Wildlife Refuge (J. Record pers. comm.).

The 135-mile Lake Mead National Recreation Area, on the border of Arizona and Nevada, receives over 200,000 visitors on a summer holiday weekend. A summer holiday weekend day averages 5,385 boats and personal watercraft (J. Holland pers. comm.). Activities include swimming, camping, waterskiing, fishing, hiking, and use of personal watercraft. Almost half of the overnight visitors camp along the shoreline (Grafe and Holland 1997). Most recreation occurs on the lakes or along shoreline habitat, currently unsuitable for nesting willow flycatchers (J. Holland pers. comm., K. Turner pers. comm.).

D. Types of Recreation Impacts

1. Overview

Wildlife can be affected by recreation in a variety of ways: 1) direct mortality, 2) indirect mortality, 3) lowered productivity, 4) reduced use of habitat, 5) reduced use of preferred habitat, and 6) aberrant behavior/stress that in turn results in reduced reproductive or survival rates (Purdy et al. 1987). These impacts are not easily measured and different species may not react to them the same way. A review of nonconsumptive recreation impacts on wildlife was conducted, using results of 166 journal articles on the subject (Boyle and Samson 1985, DeLong and Schmidt in prep). Although this review did not quantify the type or intensity of impact, negative effects on birds were detected in 77 of these studies (Table 3). Table 4 lists the kinds of recreation impacts in riparian habitat in the southwestern United States.

Table 3. Number of citations in 166 journal articles on "nonconsumptive" outdoor recreation impacts on North American wildlife. Birds were the most common subject of study (61%), followed by mammals (42%), and herpetofauna (4%) respectively (Boyle and Samson 1985, DeLong and Schmidt in prep).

	Impact on birds			Impact on mammals			Impact on herpetofauna		
Type of recreation	+	-	0	+	-	0	+	-	0
Hiking and camping	4	17	6	5	24	4			
Boating		25	9		1	2		1	
Wildlife observation and photography		19	2	1	5	4			
Off-road wheeled vehicle use		7	2		5	2		7	1
Swimming and shore recreation		6	2						
Spelunking					8				
Rock climbing		2	3		1	1			
Snowmobiles		1	1	1	7	3			
Total	4	77	25	7	51	16	0	8	1

"+" = positive impact, "-" = negative impact, "0" = no impact or unknown impact

Table 4. Recreation impacts in riparian habitat in the southwestern United States. Adapted from Cole and Landres (1995).

Loss of surface soil horizons

Soil compaction

Altered soil moisture and temperature

Altered soil microbiota

Habitat fragmentation

Reduced dead woody debris (fuelwood gathering)

Altered plant species composition

Altered foliage height diversity

Reduced plant density/cover

Lack of plant regeneration

Erosion

Increased sedimentation/turbidity of water

Altered organic matter content of water

Altered water chemistry

Altered flow regimes

Pollution (air and water)

Increased risk of accidental fire

Increased trash

Increased human waste and diseases

Increased feral and pet dogs and cats (exotic predators)

Increased native predators, scavengers, brown-headed cowbirds (*Molothrus ater*)

Displacement of wildlife by facilities, roads and trails, human presence and noise disturbance

2. Fire Risk

As the number of recreation users increases, so does the probability of an accidental fire. Over 95% of fires on the lower Colorado River are caused by recreation users (J. Swett pers. comm.) (see Appendix L). This high cause-and-effect factor greatly increases the cumulative impacts of recreation on the environment. If recreation use is to persist, fire risk can be reduced by confining campfires to certain locations, using fire boxes, restricting campfires during high fire danger conditions, or prohibiting campfires. In some cases, fires may be fairly inevitable, but even in these cases, the amount of damage can still be reduced with proper planning. The risk of damage can be managed as much as possible with current fire response plans, operable equipment, and available personnel.

3. Frequency, Intensity, Location, and Type of Use

Although there are few cases where outdoor recreation caused direct major impacts, such as outright willow flycatcher habitat destruction, indirect effects should not be underestimated. Actions that affect the behavior, survival, reproduction, and distribution of wildlife may be as damaging as direct impacts (Cole and Landres 1995). Animals displaced by recreation are less likely to survive and reproduce where habitat is unfamiliar or inferior (Gutzwiller 1995).

The potential for the recreational activity to produce negative impacts depends on the frequency, intensity, location, and type of use. For example, a hiking trail placed outside of suitable habitat is less likely to impact willow flycatchers than a trail and campground placed within suitable habitat. A trail that receives daily use is likely to result in greater habitat damage and impacts to local wildlife than one that receives occasional use. As the frequency and intensity of use increase we can expect to see increases in multiple trailing, soil compaction, vegetation loss, erosion, trash and human waste, pollution, scavengers, predators, brown-headed cowbirds (*Molothrus ater*), noise disturbance, and development of physical facilities like parking lots (Boyle and Samson 1985, Tellman et al.1997, Monz 1998).

Infrequent, but unpredictable recreation without pattern can be just as or more damaging than frequent, predictable use. Activities with pattern, such as hiking on established trails, may cause birds to nest away from a frequently used area. Activities without pattern, such as target shooting, fishing, picnicking, or wildlife observation, can create more of an impact per event. Because these kinds of recreation are often conducted off established trails, they are more likely to startle nesting birds or damage habitat.

4. Habitat Impacts

Unlike direct recreation impacts on wildlife, impacts on soils and vegetation are easier to measure and are well documented. Changes in the structure, density, and composition of vegetation can occur from recreation induced soil compaction and erosion (Lutz 1945, Harper et al. 1965, Dotzenko et al. 1967, Hopkins and Patrick 1969, Merriam and Smith 1974, Snyder et al. 1976, Manning 1979, Webb 1983, Cole 1986, Hammitt and Cole 1987, Briggs 1992, Briggs 1996, Cole and Spildie 1998, Deluca et al. 1998, Monz 1998). Macroporosity, water infiltration rates, and available nutrients are reduced once soil is compacted (Harper et al. 1965, Frissell and Duncan 1965, Settergren and Cole 1970, Young and Gilmore 1976, Cole 1986). Activities contributing to these changes include hiking, horseback riding, off-road vehicle use, camping, recreational shooting, and day use (Willard and Marr 1970, Manning 1979, Briggs 1996, Cole and Spildie 1998). Off-road vehicles can produce noticeable changes in the environment after just one pass (Webb 1983) and can cause runoff to be nearly eight times greater than in an undisturbed area (Snyder et al. 1976).

Current recreation may be preventing suitable flycatcher breeding habitat from developing where trampling and soil compaction are impeding regeneration. Trails, campgrounds, and facilities can fragment habitat to the point where it cannot become suitable. Where vegetation is sparse, even light use can prevent further development of dense lower stratas which are important to willow flycatchers. Cottonwood and willow often establish on open, unvegetated sand or gravel bars, which are also attractive to off-road vehicle users (Turner 1983, Stromberg 1997).

Increased water turbidity, bank erosion, water pollution, noise disturbance, and overwater movement resulting from watersports like swimming, tubing, fishing, and boating reduce suitability of habitat (Tellman et al. 1997).

5. Increase in Predators, Scavengers, and Nest Parasites

Where humans appear, an entourage of other animals causing disturbance soon follow (Ward et al.1973, Aune 1981). Unleashed dogs chasing wildlife, barking, and digging up animal burrows can cause as much or more disturbance as their owners. Food and garbage left behind by recreation users attract scavengers, predators, and nest parasites including feral cats and dogs, jays, common ravens (*Corvus corax*), great-tailed grackles (*Quiscalus mexicanus*), brown-headed cowbirds, skunks, ringtails (*Bassariscus astutus*), lizards, rodents, and squirrels (Aitchison 1977, Foin et al.1977, Carothers et al. 1979).

Horses can attract brown-headed cowbirds and potential predators, especially if a stable or corral is near the riparian area. The combination of an increase in brown-headed cowbirds and predators can significantly reduce willow flycatcher nest success (see Appendix F).

6. Decline in Bird Species Diversity and Richness

Birds disturbed during the breeding season may abandon nests or young, especially if eggs have not yet hatched, resulting in reproductive failure. Recreation can also alter parental attentiveness that increases predation risk, disrupts feeding patterns, or exposes the young to adverse environmental stress (Speight 1973, Gotmark 1992, Knight and Cole 1995).

Recreation can reduce environmental structure and complexity, which causes a decline in species diversity and richness (Hammitt and Cole 1987). Vegetation changes in and near campgrounds can cause bird species diversity to shift to more common and generalist species, while rarer and specialist species such as the willow flycatcher decline (Aitchison 1977, Guth 1978). Reduced shrub and tree densities, woody debris, and litter depth in campgrounds cause ground, shrub, and small tree nesters to decline (Blakesley and Reese 1988). Changes in vegetation at or near campgrounds result in loss of lower vegetation strata and regeneration, both important components to willow flycatcher habitat.

Day use can reduce the density of breeding birds. Park visitor activities (primarily pedestrians and cyclists) negatively affected breeding bird densities for 8 of 13 species in a study in the Netherlands (van der Zande et al. 1984). In a different study on the effects of shoreline recreation (boaters, cyclists, walkers, moped riders), 11 of 12 bird species were less abundant in areas of high vs. low use. The lower abundances were associated with between 8 and 37 simultaneous visitors per hectare (van der Zande and Vos 1984, Knight and Cole 1995).

Passerine abundance was strongly positively correlated with the volume of willows in a study in Oregon (Taylor 1986). However, results at one site were contrary to this trend. It had a low relative abundance of birds compared to the amount of vegetation. A large number of campers extensively used the riverbanks during May. Willow flycatchers were absent from this campground site, but were present at a number of other noncampground sites in this study.

E. Examples of Effective Long-term Recreation Management on other Endangered Species

Where heavy recreation use occurs, intervention has proven to be successful in reducing negative impacts to some wildlife species. Although expensive and time consuming, this may be the only alternative enabling recreation to co-exist with some wildlife species. The bald eagle breeding population has persisted near the Phoenix metropolitan area for the last 22 years primarily through the efforts of an active management program. Seasonal closures near nest sites, combined with around-the-clock monitoring help reduce impacts. This multi-agency program provides funding for a coordinator and seasonal "nestwatchers." During two bald eagle breeding seasons, 13,999 human activities and nearly 4,000 gunshots were recorded within 3/4 mile of 13 nests along major rivers in central Arizona (Arizona Game and Fish Department in prep.). Season-long nestwatchers help increase bald eagle nesting success by educating the public and guiding activity away from nests. With the increasing growth of communities in central Arizona and accompanying recreation, the future of the bald eagle breeding population is dependent on intensive management.

In New Mexico, conflicts between recreational mountain climbers and nesting peregrine falcons were eliminated by educating climbers and enforcing strict seasonal closure of climbing routes at nesting cliffs (S. Williams pers. comm.).

F. Current Recreation Use in Occupied Willow Flycatcher Habitat

The impact of current recreation use on occupied willow flycatcher habitat can be evaluated from two perspectives: 1) displacement and 2) effects on the existing population. We focus on the latter and what we can do as managers to protect birds and habitat, recognizing that some displacement of willow flycatchers by recreation activities and associated facilities may have already occurred. We identify the recreation impacts and management challenges at these sites.

1. San Luis Rey River, California

Nesting willow flycatchers occur in a day use area on the Cleveland National Forest along the San Luis Rey River, California. As with many recreation use sites, some nesting habitat was probably physically displaced by the parking lot and foot bridge. This area receives light use during the week, but heavy use on summer weekends, usually after mid-morning. Fortunately, most of the human use occurs later in the morning than the peak period for willow flycatcher activity. Much of the habitat is protected from direct human contact because a large proportion of the nests are placed in the naturally thick and thorny shrub layer or higher in the trees (W. Haas pers. comm., K. Winter pers. comm., Kus et al. 1999). However, recreationists did impact this site. One of 13 nest failures in 1999 was caused by human disturbance. The branch supporting a nest was cut (Kus et al. 1999). Recreation use can also potentially impact this site through accidental fire, increased predation by predators and scavengers attracted to trash cans, and increased use by anglers after stocking trucks empty fish into the river (W. Haas pers. comm.).

2. Kern River, California

The South Fork Wildlife Area supports a significant willow flycatcher population that is patrolled by Sequoia National Forest staff. When Lake Isabella rises, boaters and users of personal watercraft have access adjacent to the nesting habitat. A five mile-per-hour speed limit is enforced on Lake Isabella to control disturbance to nesting birds. Willow flycatchers are also nesting along a trail near the Kern River Preserve headquarters office. California Audubon closes this trail during the breeding season (M. Whitfield pers. comm.).

3. Mill Creek, San Bernardino National Forest, California

Nesting willow flycatchers occur at the Thurman Flats picnic area along Mill Creek on the San Bernardino National Forest, California. The willow flycatchers nest in the blackberry (*Rubus ursinus*) understory and in white alder trees (*Alnus rhombifolia*). The primary impacts to these nests are 1) disturbance by blackberry pickers and 2) predation by common ravens (*Corvus corax*), western scrub-jays (*Aphelocoma californica*) and Steller's jays (*Cyanocitta stelleri*):

1) The lush tangle of blackberries that would ordinarily protect nests from off-trail hiking attracts fruit pickers. The San Bernardino National Forest provides a weekend employee to monitor activities at this site and educate users during the blackberry season. In addition, part of the site is closed during the nesting season. Flagging is used to mark the perimeter and closure signs are placed around the nesting habitat informing users that this is a sensitive wildlife area.

2) Ravens and jays may have increased at this site, attracted to the picnic area and adjacent communities of

Forest Falls and Mountain Home. Some nests at this site have failed because of predation from jays or ravens (S. Loe pers. comm.).

4. Grand Canyon, Arizona

The Colorado River in the Grand Canyon is a popular rafting destination for 20,000 people each year (R.V. Ward pers. comm.). The National Park Service closed access to beaches adjacent to habitat where willow flycatchers were found during the breeding season, in an attempt to minimize disturbance. Tour companies and private permit holders were informed of the closures prior to beginning their river trips. Some of these beaches had been regularly used by commercial rafting companies, private kayakers and rafters, and backpackers (Tibbitts and Johnson 1999). Although closing beaches has not yet resulted in an increase in willow flycatchers at these sites, it demonstrates a significant positive action an agency initiated to protect this bird. Within the last few years, that policy changed because willow flycatchers did not reoccupy some previously occupied sites. Beaches are now closed only after willow flycatchers are found. For example, the beach at river mile 50.5 was closed after surveyors found willow flycatchers at the beginning of the 1999 field season. All commercial and private groups are required to check in with the Lees Ferry Ranger Station at the beginning of each trip. Each group is given current information on the status of nesting willow flycatchers and beach closures prior to each trip (R.V. Ward pers. comm.).

5. Hassayampa River Preserve, Arizona

Willow flycatchers have nested near a popular hiking trail at The Arizona Nature Conservancy's Hassayampa River Preserve for several years. The Nature Conservancy closes the trail during the nesting season to minimize disturbance to the willow flycatchers. In 1999, this trail remained closed during the nesting season as a protective measure even though no willow flycatchers were documented from surveys. Nesting probably did occur locally, because juvenile willow flycatchers were caught in mist nets in late July (M. Rigney pers. comm.).

6. Roosevelt Lake, Tonto National Forest, Arizona

Two willow flycatcher breeding populations at the inflows to Roosevelt Lake are managed by the Tonto National Forest. Disturbance from boaters is minimal, because they primarily use the lake area away from the currently occupied breeding populations. However, this area is heavily used by visitors from nearby Phoenix and the potential for recreation conflicts is significant. The Forest Service maintains a vehicle and fire closure at these sites, with perimeter fencing and signs. These closures substantially reduce the potential disturbance caused by off-road vehicles, day use, and camping (C. Woods pers. comm.). One newly occupied area outside the current closure is threatened by impacts from anglers and campers, with increased trailing and fire risk from campfires. Additional measures may be taken to reduce risk in this new area.

7. San Pedro River Preserve, Arizona

The San Pedro River Preserve, managed by The Nature Conservancy, was established to protect southwestern willow flycatcher habitat. Patrolling and maintaining the perimeter fence to prevent off-road vehicle and cattle trespass have been the most effective ways of protecting habitat and promoting regeneration.

G. Management Recommendations

Managing recreation can be accomplished by altering visitor behavior to minimize impacts. Recreation user control ranges from complete restriction to some acceptable level of use (Moore 1989, Briggs 1996). This can be accomplished in a number of ways, including requiring permits, collecting user fees, limiting number of visitors, constraining visitor access or activities, instituting zoning or periodic closures, and limiting the frequency and duration of use (Cullen 1985, Purdy et al. 1987, Klein et al. 1995, DeLong and Schmidt in prep). We provide the following management guidelines to reduce recreation impacts on southwestern willow flycatchers and their habitat:

1. Provide protected areas.

Keep campsites and heavily used day use areas away from areas to be developed or maintained for flycatchers. Ensure protected areas are large enough to encompass breeding, foraging, and post-fledging habitat. Discourage unauthorized off-road vehicle use in riparian habitat with fencing or physical barriers.

Direct vehicles, boating, swimming, tubing, and fishing away from unoccupied and occupied suitable habitat, especially during the breeding season, where impacts are likely to negatively impact habitat or flycatcher behavior. Where potentially suitable habitat has been identified as future southwestern willow flycatcher habitat, these activities should be minimized to allow habitat to develop.

2. Reduce impacts from recreationists by promoting stewardship, educating users and maintenance workers, reducing unpredictable activities, reducing motorboat impacts, providing visual barriers, and reducing noise disturbance. Examples of how this can be accomplished are provided below:

Promote stewardship

Encourage individual recreationists and user groups to support riparian conservation, review management plans, and generate funds. Support their efforts to sponsor riparian clean-up, trail maintenance, field trips, on-site monitors, and development and distribution of interpretive materials.

Educate users and maintenance workers

Sponsor programs and post signs that educate users about the value of riparian habitat to sensitive species. Clearly mark trails, campgrounds, and revegetation areas. Educate equestrians, boaters, and tubers about the value of overhanging branches to nesting birds. Encourage them to avoid trimming overhanging branches. Discourage campers and day users from feeding birds, to prevent increases in jays, ravens, and cowbirds.

Reduce negative impacts of annual or periodic maintenance

Ensure all facilities and grounds workers conduct activities compatible with protecting riparian habitat and species. Conduct annual or periodic maintenance outside the breeding season.

Reduce unpredictable activities

Design wildlife recreation activities that are predictable for wildlife (DeLong and Schmidt in prep). For example, provide well-marked trails or boardwalks to a) encourage controlled and predictable use, and b) discourage off-trail hiking and creation of alternate routes.

Reduce motorboat impacts

Reduce rapid overwater movement and loud noise, such as wake and noise from motorboats through speed limits and designated use areas (DeLong and Schmidt in prep).

Provide visual barriers

Increase distance between disturbance and wildlife or provide visual barriers (DeLong and Schmidt in prep). Provide a natural vegetation buffer in day use areas and along trails.

Reduce noise disturbance

Minimize noise disturbance near southwestern willow flycatcher breeding habitat. Birds are sensitive to vibration, which occurs with low-frequency noise (Bowles 1995). Such efforts include rerouting trails and day use areas away from occupied habitat, controlling the number of visitors, relocating designated shooting areas, and discouraging the use of electronic equipment (radios, “boom boxes”) and off-road vehicles near breeding locations.

3. Confine camping areas.

Evaluate whether confining camping to a small concentrated number of campsites is less detrimental to wildlife and habitat than dispersal over a wide area. Institute fire bans when danger is high or where habitat is vulnerable, e.g., areas dominated by tamarisk (*Tamarix* spp.) See Appendix L for further guidelines. If campfires are authorized, confine them to fire boxes. Limit or prohibit fuel wood collecting in riparian areas.

4. Ensure fire plans are current, operable, and enforced.

Ensure fire fighting equipment and personnel are available.

5. Restore habitat impacted by recreation.

Where needed, post signs that explain the importance of habitat restoration, fence habitat, and/or temporarily close trails and use areas (Craig 1977). Because restoration of recovering habitat can be impeded by recreation, it is important to evaluate its potential for success before forging ahead with a project. For example, in a study of 27 riparian restoration projects, recreation was at least partly responsible for ecological deterioration of two sites and impeding recovery efforts at two other sites (Briggs 1992, Briggs 1996).

6. Place designated recreation shooting areas away from riparian areas.

Designated shooting areas used for target practice should be located away from riparian areas to minimize physical destruction of habitat and noise disturbance.

7. Minimize attractants to scavengers, predators, and brown-headed cowbirds.

Where recreation users congregate, provide adequate waste facilities (covered trash receptacles, restrooms) and regular collection service. Place horse stables away from suitable and occupied habitat. Avoid use of bird seed feeders that use cowbird preferred seeds such as millet.

8. Provide on-site monitors and enforcement where recreation conflicts exist.

Where potential recreation conflicts exist and total closure is not practical, provide on-site monitors to educate users and control use. Increase surveillance and/or impose fines for habitat disturbance or damage.

H. Personal Communication

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I. Literature Cited

Please see Recovery Plan Section VI.

Note: The Tribal Working Group of the Southwestern Willow Flycatcher Recovery Team developed the following issue paper for purposes of identifying issues relative to recovery of the flycatcher on Tribal lands, promoting a more thorough understanding of these issues and potential resolutions, and engaging the Service in a collaborative approach to recovery. As such, the ideas and opinions expressed herein are those of the Tribal Working Group, and are not necessarily representative of the views of the Service or the Department of the Interior.

Appendix N.

Tribal Perspectives on Southwestern Willow Flycatcher Management and the Endangered Species Act

A. Introduction

To speak with one voice for all the Indian Tribes in the Southwest Region that have a stake in willow flycatcher management and the recovery of endangered species is not possible. There are probably as many approaches to this issue as there are Tribes. It is possible that many Tribes, beyond disagreeing with the notion of acceptance of and cooperation with the Endangered Species Act (ESA), would be hesitant to even participate in this dialogue. Therefore, this paper in no way intends to speak for every Tribe in the United States or even the Southwest Region. Instead, the ideas presented here represent a consensus among some Tribes that believe there is room for dialogue with the U.S. Fish and Wildlife Service on ways of improving the Federal/Tribal relationship as it relates to endangered species management. While many of the problems surrounding this issue remain extremely sensitive and contentious, some Tribes have established the basis for a new type of relationship with the Service, based on mutual respect for each other's goals, and the desire to move beyond a structured legal relationship to a more problem-solving approach.

B. Background

Before we explore aspects of willow flycatcher recovery, it is important to provide some background on the Endangered Species Act as it relates to Tribal interests. Before this is possible, however, some history of the Federal/Tribal affiliation is necessary. This relationship is built on the foundations of several principles which have been refined through many court decisions and the directives of several Presidential administrations. By far, the most important and pervasive of these are concepts are Tribal Sovereignty and Trust Responsibility.

Tribal Sovereignty

The inherent sovereignty of Indian Tribes and nations has long been recognized by the United States Government and has been reiterated extensively in recent years within the context of natural resource management. As sovereign nations, Tribes and Tribal lands are not subject to the same public laws which govern other lands within the United States, either public or private. It has been legally well-established that inherent in the establishment of a reservation is the right of Indians to hunt and fish on reservation lands free from state regulation. Cases such as the Menominee Tribe v. The United States (1968), Washington v. Passenger Vessel Association (1979), New Mexico v. Mescalero Apache Tribe (1983), Arapahoe Tribe v. Hodel (1990), and Minnesota v. Mille Lacs Band of Chippewa Indians (1999), have cemented this precept. Some of these rights are based on treaty rights, but many follow from the mere establishment of a reservation and the rights inherent therein. Congress can, if it specifies, deny a hunting or fishing treaty right, as it did when it prohibited Indians from hunting eagles under the Eagle Protection Act. Absent this clear congressional intent, however, hunting and fishing rights are not extinguished and may even be upheld for off-reservation lands (including both public and private land) where a Tribe has a strong enough treaty claim. This concept was established by United States v. Winans (1905). In general, however, Congress has not used its authority extensively to regulate Indian hunting and fishing and the matter has been left to Tribal regulation.

Although Congress does have authority to restrict some Tribal wildlife practices, it is unclear whether or not the U.S. Fish and Wildlife Service and the National Marine Fisheries Service (the two agencies responsible for enforcing the Act) have authority to enforce the ESA on Tribal land, as there has never been a court case which has specifically tested the issue. At the heart of the matter is the question of what was Congress' intent when it established the ESA. The ESA does not specifically mention Tribes, and other court cases have upheld the concept that, unless Tribal treaty and other rights are specifically abnegated by an act of Congress or a particular piece of legislation, that they remain in force. In the case that came the closest to testing this question, United States v. Dion, a Tribal member was convicted of taking a bald eagle for ceremonial use. The statute under which the case was prosecuted, however, was not the ESA, but the Eagle Protection Act. The ESA question was left unanswered.

Given this ambiguity (not to mention the potential for costly and lengthy litigation), many Tribal leaders and natural resource managers would just as soon work out these conflicts with cooperative agreements with Federal and State officials, rather than in the courts.

All of the above is not to imply that Indian Tribes are unwilling to work with the ESA or even see it as a burden. In fact, some Tribes would like the ESA to apply on Tribal land, and application of the Act has brought benefit to some Tribes, especially in regard to protection of dwindling fish stocks in the Pacific Northwest and the Great Lakes region. For example, the Pyramid Lake Paiute Tribe in Nevada and other entities used the ESA to achieve listing of the cui-ui fish in Pyramid Lake, and to protect water resources and reduce diversions from the Truckee River. In the Pacific Northwest off-reservation treaty fishing rights are often protected by mandatory conservation measures which are backed with the strong arm of the ESA.

All this legal maneuvering, of course, does little to help endangered species themselves. Consequently, a dialogue has arisen between some Tribes and the Fish and Wildlife Service about whether it is possible to set aside differences over interpretation of the ESA and other laws and instead concentrate on cooperative policies that can be adopted to help endangered species and their habitat.

Trust Responsibility

While it has been well-established that Indian Tribes in the United States are sovereign nations, the U.S. is legally required to act as caretaker for Indian interests, including the protection of the health, welfare, and land resources of Indian people. In other words, Indian land and resources are held "in trust" by the U.S. Government, a policy known as the government's trust responsibility. In managing trust lands or assisting Tribes to do so the Government must act for the exclusive benefit of Tribes, and ensure that Indian reservations are protected and used for the purposes for which they are intended: to provide for the physical, economic, social, and spiritual well-being of Tribes. Reservations were not set aside as parks, critical habitat for endangered species, or even, for that matter, for protection of wildlife, except as this will directly benefit the Tribe for which the reservation was created. Tribal lands do harbor some of the most wild and scenic places on the continent and Tribal lands in many cases harbor far greater biological diversity than the surrounding public or private land. Nevertheless, reservation lands are primarily the ***home*** to the people who live and work there and were created for the safe haven, ecological, social, and economic benefit of the Indian people.

The interaction of the concepts and practices of Tribal sovereignty and trust responsibility are often complex and occasionally contradictory as Tribes and the government struggle to protect Indian interests while at the same time allowing Tribes as much leeway as possible to manage their own affairs.

In the matter of natural resource or wildlife law several other Executive Branch administrative directives also bear directly on the relationship of the U.S. Fish and Wildlife Service and other Interior Department Agencies to Tribes:

Secretarial Order 3175 (November 8, 1993) and Interior Departmental Manual 512 DM 2.

These documents require all Interior Department agencies to identify potential effects from their activities on Indian trust resources and to have meaningful consultation with Tribes where Department activities effect Tribal resources, either directly or indirectly. This Order also directs Interior Agencies to remove procedural impediments to working effectively with Tribal governments, to consult with Tribes on a government-to-government basis where trust resources are affected, and to identify potential effects on Indian trust resources of Department plans, projects, programs, and activities.

Presidential Memorandum of April 29, 1994.

This document reminds all Executive Branch Departments and Agencies of the government-to-government relationship between Indian Tribes and the United States and requires these Departments to consult with Tribal governments to the greatest extent practicable prior to taking actions that affect Tribal governments; to assess the impact of Federal activities on Tribal trust resources; and to ensure Tribal rights and concerns are taken into account during plan development and program implementation.

<u>The Native American Policy of the U.S. Fish and Wildlife Service, June 28, 1994</u>.

This policy reiterates the government-to-government relationship and establishes a framework for joint projects and formal agreements. It also directs the Service to assist Tribes in identifying Federal and non-Federal funding sources for wildlife management activities, and provides a framework for the Service to give technical assistance to Tribes, where requested. While the Service has been helpful to Tribes from a technical standpoint, many Tribes feel that funding has been hard to get. The "Partners for Fish and Wildlife" program has provided some funds, but these are often for small-scale projects.

<u>Secretarial Order 3206, June 5, 1997</u>.

This is perhaps the most far-reaching of the Executive Branch Directives and has been very well-received by most Tribes. It also has potentially the greatest impact on how Tribes and the Federal government manage endangered species. While some have suggested that the Secretarial Order gives Tribes the rights to manage endangered species on their own land, this is far from true. The Order specifically states that it "shall not be construed to grant, expand, create, or diminish any legally enforceable rights, benefits, or trust responsibilities . . . under existing law." and it "does not preempt or modify the [Service's] statutory authorities." It actually re-acknowledges the trust and treaty responsibilities of the U.S. Government and instructs Federal agencies to "be sensitive to Indian culture, religion, and spirituality", the basis for which often relies on the use of natural resources. It also reminds Interior Departments that Indian lands are not subject to the same controls as Federal public lands; instructs them to recognize that Tribes are the appropriate governmental entities to manage their lands and resources; and instructs them to support Tribal measures that preclude the need for conservation restrictions. At the same time, the Order strives to harmonize Tribal concerns and interests about the ESA with Federal mandates to enforce it; and it allows for Tribes to develop their own conservation plans for listed species that are more responsive to Tribal needs.

<u>Executive Order No. 13084, May 14, 1998</u>.

This Presidential Order instructs all executive branch agencies to establish a process whereby elected officials and other representatives of Indian Tribal governments may provide meaningful and timely input in the development of regulatory policies on matters that significantly or uniquely affect their communities. Interestingly, it also instructs agencies, to the extent practicable and permitted by law, to consider any application by a Tribal government for a waiver of statutory or regulatory requirements with a general view toward increasing opportunities for flexible policy approaches. This opportunity for administrative flexibility has the potential to play a key role in how the Service implements endangered species recovery on Tribal land.

C. Tribal Concerns About the Endangered Species Act

Because Indian Tribes as Federal trustees are so dependent on Federal funding, a wide array of activities on Indian lands can trigger Section 7 consultation -- many more so than on private land where the Federal presence and the connection to Federal activities is not so extensive. Approvals for nearly every type of development project require Federal procedure or consultation of one sort or another. While the intent of these regulations is to protect Indian resources, the occasional side effect can be an excessive bureaucracy which slows even the most benign types of projects.

In recent years many Indian Tribes in the United States have become wary of the intent of the Endangered Species Act and the manner in which it is applied on Tribal lands. Many Tribes feel that they have been far better land stewards than the vast majority of private land owners and even some Federal land management agencies, and consequently have a higher proportion of endangered species on their land. In addition, most Indian reservations are far less "developed" (i.e., have a higher proportion of rangelands, forests, or de facto wilderness) than surrounding private or public land. This means that Tribal lands have the potential to act as a safe haven for some endangered or rare species which are driven off surrounding private land as it is developed. Tribes feel that they have been penalized for this good stewardship by having restrictions placed on development activities, and being told what they can and cannot do on their own land, which is viewed as a direct affront to Tribal sovereignty. While Tribes want to keep vast areas of resource use on their reservations, they don't want to be penalized for not having "urbanized" yet.

A more far-reaching concern of Tribes is the use of some species for religious, cultural, or ceremonial purposes. Considerable conflict has arisen in the past about Indian use of eagles and eagle feathers. Some of the cases have ended up in Federal courts and even the U.S. Supreme Court. Nearly all Indian Tribes in the United States revere bald and golden eagles and use the birds' feathers or other parts in ceremonies or dances. The fact that this bird has become endangered has led to severe restrictions on its take. Currently individual Tribal members must apply to the Service through the National Eagle Repository to obtain eagle carcasses and feathers, a process which can take as long as 3-4 years. While many Tribal members understand the need for this process, many view it as a direct affront to religious freedom and feel frustrated by the delays entailed in applying for an eagle.

While some latitude has in the past been given to Tribes to take such species, any take may be considered a violation of the ESA, The Migratory Bird Treaty Act, The Lacey Act, or other Federal or state wildlife laws. Again, court cases have led to conflicting interpretations about under what circumstances a Tribe or an individual Tribal member can "take" a species for cultural or religious purposes, and what types of permits are needed. Some Tribes are working cooperatively with the Service to permit some of these activities.

Within the context of the ESA, previous endangered species recovery plans have done a poor job of integrating Tribal concerns. While some Tribes were included at the level of "stakeholders" or "interested parties", their participation, comments, or suggestions carried no more weight than if they were a large private land owner in the region. For example, the Tulalip Tribes of the Northwest have charged that they were largely ignored in the Section 7 consultation during a major Habitat Conservation Plan. Several other Tribes in the Southwest were shocked to find that critical habitat for the Mexican Spotted Owl had been designated on Tribal land without prior consultation. Tribal leaders and land managers from one Tribe found out by reading about it in the Federal Register. Critical habitat for the Rio Grande silvery minnow was also declared on Pueblo Indian land in New Mexico, over the objections of Tribal leaders. Many other instances exist where Tribes were inadequately brought into the process of Section 7 consultation, despite the fact that species recovery plans had the potential for major impacts to Tribal resources, particularly water rights. For example, recovery plans for endangered San Juan River and Colorado River fishes were driven by court-ordered deadlines which did not leave time for adequate consultation with Tribes. Many instances such as these could easily have been better handled simply through better communication, and many Tribes hope to alleviate some of these misunderstandings through increased cooperation.

1. Endangered Species and Tribal Water Rights

Tribes are watching closely to determine whether or not species recovery means a change in the status of water rights, water availability, and water use. Like many private land owners, Tribes make active use of the region's critical water supplies for farming, ranching, drinking water, and recreation. In a region where water is depended upon by so many entities, battles over who controls how much water are inevitable. Many Tribes along the Rio Grande are already involved in issues surrounding another endangered species, the Rio Grande silvery minnow, and while they are generally supportive of protection for the minnow, they are wary of shouldering a large share of the burden for this species' recovery.

For Tribes, the issue of recovery of many riparian species and talk of protection of riparian habitat is inextricably linked to water rights. In all but a few instances in the Southwest, Indian water rights are senior to those of nearly all other users, dating back at least to the date of the establishment or U.S. Government recognition of a Tribe's reservation (many Tribes justifiably believe that their water rights extend much further back than this). These water rights are generally "Federal reserve water rights" meaning when Indian reservations were created, although water rights were not specifically addressed, it was clearly the intent to include them, because any establishment of a reservation without concurrent rights to its water would have been ridiculously unfair, since the reservations were created for the "beneficial use" of the Indian people. This concept is referred to as the "Winters

Doctrine" and is one of the cornerstones of Indian Water Law. Recently, this doctrine has been affirmed to apply to both surface and ground water.

In some cases due to lack of funding or the very slow water rights process, the rights in a basin or a river have been adjudicated or otherwise fully determined. Despite this, water development has gone on apace, with dams, diversions, and other uses. When the water rights in an area are finally determined, it is quite likely in most cases that Tribes will have rights senior to all other users. In other cases the water rights have already been adjudicated, though Tribes for whatever reason (normally lack of capital) have not made full use of their water rights.

In addition -- and this is the key point -- these water rights are not subject to forfeiture due to non-use, and thus may be exercised at any time in the future, while still retaining their senior priority. This becomes problematic, however, when a watercourse is already fully appropriated and further water use has been deemed to jeopardize a listed species. This is a very difficult question: how to protect species while at the same time preserving water rights. The issue is especially nettlesome to Tribes since, in most cases, it was not Indian appropriation of water that has led to loss of habitat and listed species jeopardy. Now that the species are declining and restrictions are being put on water use, Tribes are wary of not being able to fully exercise their water rights. Tribes become very uncomfortable with the assumption that, by exercising a Federal reserve water right, they are going to jeopardize a threatened or endangered species.

2. Federal/Tribal Cooperation on Endangered Species

The diversity of opinion about Federal/Tribal relations has led to a contentious history of differing interpretations over Federal/Tribal resource jurisdiction. Nevertheless, the Service and many Tribes have expressed a willingness to work together on endangered species issues. Some Tribes in the Southwest region are optimistic that, beginning with this willow flycatcher recovery plan, the Service and affected Tribes can begin to move in a new direction. Within the last few years, many Tribes have gained considerable natural resource management expertise and this experience is being recognized by the Service and other Federal agencies. Doors are being opened for Tribal participation on a broader level among agencies such as the Bureau of Reclamation and the Environmental Protection Agency, and many Federal agencies are hiring Native American Liaisons or offering entire Tribal programs. The intent of the above-listed Federal directives is to establish policies whereby input from concerned Tribes can become a regular and critical part of resource planning initiatives, and to cement the process for Tribal participation. Tribes welcome these changes and are beginning to take full advantage of them.

Some Tribes have moved forward in an effort to establish new parameters to the way Indian Tribes and the Service interact. The White Mountain Apache Tribe and the Pueblo of Zuni have established "Statements of Relationship" (SORs) with the Service. These documents set up a framework by which the Service and the Tribe could, while recognizing differences of opinion or interpretation, work through problems toward a common goal of promoting biodiversity and healthy ecosystems. The SORs reaffirm Tribal sovereignty, while recognizing the Service's technical expertise and the ability to assist the Tribe with complex management issues. This has become possible in part because Tribes have increased their technical capabilities and infrastructure, but also because a new framework for open dialogue has been developing whereby Tribes feel that many of the issues they have been long advocating are being taken seriously. Central to this approach is the Service's use of some of its administrative flexibility to work with Tribes to come up with mutually satisfactory solutions to seemingly intransigent wildlife and resource issues.

One example is the Pueblo of Zuni's recent initiative to alleviate the wait for eagle feathers for Tribal members by constructing the only Native American-owned eagle aviary in the country. With the close cooperation and assistance of the Service and several private foundations, Zuni has received permits and constructed a facility to care for non-releasable (e.g., from permanent injuries or due to human imprinting) bald and golden eagles. The molted feathers from these birds are distributed to Tribal members, and the Tribe is looking into expanding the facility to include a captive breeding facility. This is a good example of how the Service used some of its administrative flexibility to assist the Tribe in adopting a unique and innovative solution to a vexing problem.

Tribes have also been lobbying for more of a voice in endangered species recovery. When the initial steps were taken toward a recovery plan of the southwestern willow flycatcher, some Tribes expressed dismay at the relatively low level of Tribal involvement. Initially, Tribes were grouped with other "stakeholders" (numbering in the many hundreds). Tribes believed that their voices were being unduly diluted, given the large amount of flycatcher habitat on Tribal land. Under Secretarial Order 3206, Tribes have considerable authority to begin to manage endangered species on Indian land. Under the auspices of Tribal sovereignty, each individual Tribe had more endangered species management authority than, say, the individual states that were involved in the process. If a Tribe is unhappy with the process, it can opt not to participate and develop its own plan. In deciding whether or not to sign on to this process, most Tribes need to ask what benefits it could provide them.

Given the tentative nature with which Tribal leaders and land managers have approached endangered species issues, there were several reasons why the southwestern willow flycatcher recovery gives us cause for optimism. The goal of the recovery process, of course, is not only higher populations of this particular bird, but improved riparian areas in general. For many Tribes in the Southwest, the rivers and streams that cross their land provide critical areas for plant and animal collection, recreation, and cultural and religious use. Tribes see riparian protection as an excellent long-term goal. In only a few generations Tribes have seen these areas severely degraded, mainly from human induced changes, some of these changes have unquestionably provided benefits to Tribes, but many of which Tribes had no say in implementing. To restore riparian and wetland habitat and to improve these critical ecosystems is a goal that all Tribes in the region can support.

D. Where Do We Go From Here?

The current climate presents opportunities for significant improvement over what has been a contentious history. The Service and other Interior agencies have considerable administrative flexibility to work cooperatively with Tribes and more actively seek their input and guidance when dealing with endangered species and other region-wide initiatives. Some of the Executive Directives instruct agencies to use this flexibility. It should be remembered that even if a project or consultation may not appear to affect a Tribe's resources, there may be aspects of the situation which are not immediately apparent (such as off-reservation treaty rights, water rights, or the presence of traditional cultural properties that may give a Tribe a stake in the management of certain resources).

The Service has taken great strides to achieve concrete results. Tribes applaud the appointment of several Tribal members to serve as "Native American Liaisons" within the Service, and the creation of Interior Department directives which are favorable to a more cooperative environment. Tribes have also been offered more meaningful participation on regional planning initiatives all over the country, from the operations of the Glen Canyon Dam, to recovery of Northwest salmon stocks and dozens of other issues.

1. Suggestions for Meaningful Tribal Participation

In order to further the blossoming cooperation between Tribes and the Service, the following suggestions are offered:

1. Increased Communication. Many of the past problems outlined in this paper could be avoided with open, honest communication, which may necessitate a massive re-structuring in which way consultation is carried out. Tribes must be kept involved at a meaningful level and treated as equal partners. This does not mean informing Tribes post-facto about management or listing plans that have already been developed. Tribes need to be involved in the earliest stages of planning. Differences in the capabilities of Tribes present challenges to this type of cooperation. Some Tribes already have well-developed natural resource departments but many do not; the rates of communication within a Tribe may work at a different rate than in the Federal government, and adequate time for full consultation must be planned. This is already being done by some Interior Agencies which have used their administrative flexibility to allow Tribes to participate at a higher level than in previous years.

2. Remove Disincentives for Conservation. Vast areas of Tribal land have remained deliberately undeveloped and provide considerable habitat for both endangered and common species. Tribes and other land owners should not be penalized for having maintained good habitat, which might harbor a listed species, or providing improved habitat which brings willow flycatchers or other listed species onto their land. On June 17, 1999 the Fish and Wildlife Service issued its "Safe Harbors" policy, which is gaining

recognition within the Service as a way to encourage private land owners and Indian Tribes to restore and protect wildlife habitat without fearing the repercussions of having endangered species use that habitat. "Safe Harbors" works with Tribes (or other non-Federal land owner) to develop a "time zero baseline" which determines (1) the current population level of a listed species on a particular piece of property; and (2) how long it might take to improve the habitat to provide a net conservation benefit to the species. The Service assures the land owner that, at the end of that time they can, if they wish, return the land to the state in which it was at time zero (the baseline) without worrying that they may be altering habitat for a listed species that may have since moved onto their land. In other words, they will not be penalized under the ESA for any habitat destruction as long as it is at least as good as it was at time zero.

3. Protect Tribal Water Rights. Any discussion of water resources and any recovery plans which dictate or imply a change in water use should be done taking full account of Tribal water rights and water resources. Specifically, when developing an "environmental baseline" by which to gauge the status or trends in a species' population, Tribal reserved water rights (even those not yet developed) need to be factored in. Where a species is affected by a Federal water project, the courts have held that the projects must be consistent with the protection of senior Indian water rights. Before Indian water rights are affected, junior users should bear the brunt of the restrictions. Before *any* users are affected, however, detailed and thorough consideration should be given to water conservation measures which would make more water available to all users. However, given the lengthy and complicated nature of water rights negotiations or adjudication, parties should not let unresolved water rights issues hold up conservation planning.

4. Do Not Declare Critical Habitat on Tribal Land Without Consent. Even with consent, before critical habitat is declared, the impacts of this designation on Tribal economies and natural resource management operations should be evaluated. If an alternative to critical habitat designation would be equally effective in preserving and recovering a species, this alternative should be implemented in lieu of critical habitat designation on Tribal lands.

Where designations of critical habitat are essential and where Tribes want to fully participate in the recovery process, one approach might be for the Service, in cooperation with Tribal biologists, to designate a target of a certain amount of habitat which should be maintained in a certain condition, and then let the Tribe decide which areas to protect. In other words, the Service and a Tribe could agree on a "big circle" of potential range or habitat for a species, and within this big circle, identify a set amount of habitat targeted for a certain condition. For example, for a riparian species, the Service and the Tribe might agree that 2 miles of stream on a reach of 8 miles needs to have stable banks, vegetation at ***x*** feet high, and an average canopy cover of ***y*** percent. It would then be up to the Tribe to identify the areas it wishes to manage towards these conditions.

5. Provide Funding. Some Tribes have well-developed natural resource management departments which have made considerable strides in rehabilitating riparian areas and wetlands. Some of these projects have received national recognition and praise. However, this work is technically complex and very expensive. The Fish and Wildlife Service should, through every mechanism available, seek funding for Tribal initiatives which foster the recovery of the willow flycatcher. Recovery is a Federal responsibility and the Federal government has an obligation, since it is they who list species, to assist Tribal and State governments seek funding and assistance for recovery. Both Secretarial Order 3206 and the U.S. Fish and Wildlife Service's Native American Policy direct the Service to seek funding for Indian projects. Tribes, of course, should also seek their own sources of funding which will complement Federal sources.

6. Continue implementing Secretarial Order 3206. This directive was very positive in defining the Tribal/Federal relationship over endangered and sensitive species and should be upheld and referred to as a positive model for open dialogue.

7. Respect for Cultural Values. Many Tribal religious, social, and cultural beliefs are based on the concept of reverence for the earth and all its creatures. In conducting business with Tribes and in dealing with Tribes, land managers from Federal and State agencies should be aware of and sensitive to these values. In addition, many Tribal cultural practices use wildlife in a way to which the Service may not be accustomed. Where they impact wildlife, either endangered or common, care must be taken in discussing alterations of any cultural practices. These values may often be at odds with Federal concepts of conservation.

8. Manage for multiple uses. While caring for and protecting the environment is paramount to Tribal land managers, most Tribes want control over the way they use their own land, and this often means more than one use for the land. Woven into the culture are activities such as hunting, fishing, ranching, farming, and collecting which are just as much a part of the value systems and way of life as environmental protection. As stated above, many Tribes feel that they have been unfairly treated by laws such as the ESA which have allowed extensive development on non-Indian lands, leaving Tribal lands as a refuge for rare and endangered species, which are now illegal to make economic use of. Tribes are not in favor of developing land which will lead to the loss of species or the depaupering of the biological diversity on their lands; yet

some development is necessary in order for Tribes to maintain sovereignty and a level of economic independence which even begins to approach that of the non-Indian society in the United States.

9. Confidentiality of Tribal information. All Tribes have serious concerns about what will happen with any information that is gathered concerning the location and numbers of endangered species, habitat, or water quantities. Unfortunately, this often acts as a large stumbling block which inhibits Federal-Tribal cooperation. Tribes need to be assured that information collected during the course of research, inventories, or other management activities will not be subject to disclosure to the general public. This is definitely true for information which the Tribe gathers on its own, but also includes information which may be gathered when public employees and resources are involved. The issue goes far beyond natural resource management, and the confidentiality of information is a cornerstone of a Tribe's sovereignty, self-governance, and spiritual and religious power. This will no doubt be a very difficult precept to implement. Recent case law, such as a 9th Circuit Court decision involving the Klamath Tribes (1999) have held that if any Federal employees, such as Fish and Wildlife Service personnel, were involved in a project, the public has a right to petition for disclosure of information. Ultimately the Tribes had to turn over sensitive information for public review despite initial assurances from the Service that would not have to do so. The Service, apparently, did not have the power on its own to provide that assurance.

2. Specific Recommendations for Implementing Willow Flycatcher Recovery

While the above recommendations speak to implementing the ESA on Tribal lands in general, we have several more specific recommendations for implementing willow flycatcher recovery.

1. A Tribal representative should be placed on the willow flycatcher technical team as a liaison or voting member. While the technical team at present represents the best ecologists in the fields of willow flycatcher ecology, riparian systems, grazing, and other biological aspects of recovery, there may be some points of view or aspects of the physical recovery process that are not represented on the team. Many Tribes working with flycatchers on their land have natural resource specialists who can be brought up to speed on many of the crucial issues concerning the recovery process, and can add significantly to the recovery discussion. Having a representative with Tribal interests in the forefront will also alleviate some of the discomfort Tribes feel in dealing directly with the Service. Thereafter Tribes can work directly with the Technical Subgroup as an extension of the Regional Director.

2. Tribal natural resource personnel should be fully trained in the willow flycatcher survey protocol and

should devote significant personnel to planning and implementing surveys. This may present a significant change in direction for some Tribal wildlife departments, and some Tribes may not have sufficient resources to carry out surveys. In that case, Tribes should seek the assistance of either the Bureau of Indian Affairs or the Fish and Wildlife Service in carrying out surveys. Like states, many Tribes rely on big game as a source of revenue to fund their operations. A shift toward non-game wildlife management might mean allocating resources toward species which will raise no revenue for the Tribe. Nevertheless, if Tribes want to be viewed as equal partners in this process, they need to allocate technical and financial resources to non-game programs, including willow flycatcher monitoring and management.

3. Information collected by Tribes should remain in the custody of Tribes, but Tribes will share summaries of the information, or provide Service or Technical Team personnel access to files on Tribal land with the understanding that the files or photocopies will not be released. This may be difficult in cases where Tribes need to have outside agencies such as the Service perform the surveys. This is a very sensitive issue and potentially one which could lead Tribes away from cooperating in flycatcher surveys, which would work against the conservation of the resource and recovery of the flycatcher. Written agreements should be made with the Service concerning the collection and storage of data.

4. If a Tribe has a riparian restoration plan or is thinking about developing one, it should strongly consider implementing a Safe Harbors Agreement with the Service.

5. The Service, at the request of Tribes, should offer to do an assessment of Tribal riparian habitat, to delineate which areas are likely to provide the best habitat. Perhaps an even better approach would be to provide direct funding to Tribes to enable them to carry out this type of evaluation on their own (under the technical guidance of the Service). Tribes realize that the Service, like many Federal agencies, is under a tight budget. However, Tribes cannot reasonably be expected to take on the additional burden of endangered species management or willow flycatcher habitat assessments without additional funds.

6. Include suggestions for region-wide water conservation in any recovery plan. Protection of endangered species does not always automatically mean a total abandonment of all forms of development or severe impacts to Tribal and non-Tribal water rights. If species can be protected through conservation measures, this is always preferable to other alternatives and there may be relatively little change in the way sustainable development is carried out. In the case of riparian obligate species such as the flycatcher, water conservation could play a big role in assuring that Tribes and other private land owners can continue to use

water to their advantage while still offering a means of protection to listed species.

7. For their part, Tribes should be as open as possible and as committed as practicable to the recovery process. This may mean divulging information or allowing Federal land managers onto Tribal land so an evaluation of populations or habitat can be conducted.

We believe that if the above recommendations are implemented, they will go a long way toward alleviating Tribal concerns, and will allow Tribes to willingly participate at a level which has heretofore not been achieved. Given the positive atmosphere that is emerging in the Service and among many Tribal leaders and resource managers, now is the time to form the foundations of a solid cooperative working relationship. This will only serve to foster increased conservation, a healthier environment, and more harmonious Federal/Tribal relationships.

Appendix O.

Summary of Comments on the Draft Recovery Plan

On June 6, 2001, the USFWS published in the Federal Register (66 FR 30477) an announcement of the availability of the draft Southwestern Willow Flycatcher Recovery Plan, and opened a 120-day comment period. The comment period was subsequently reopened for a period of 60 days extending through December 10, 2001 (66 FR 51683). More than 500 copies of the Recovery Plan were directly distributed to Federal and State agencies, private interests, and Congressional members in New Mexico, Arizona, California, Utah, Colorado, Nevada, and Texas, as well as more than 200 Implementation Subgroup members. The draft Recovery Plan was also available on a USFWS Southwest Region website.

Responses to 87 significant issues identified in comments received by the USFWS are included in this appendix. The USFWS appreciates the interest expressed and the information shared by the commenting parties; many comments led to changes in the draft Recovery Plan. The USFWS hopes that the final Recovery Plan reflects the high degree of collaboration and cooperation that has shaped this planning effort over the last five years.

Issue #1

Comment: The Services policy states a recovery plan delineates, justifies, and schedules the research and management actions necessary to support recovery of the species. Much of the rationale in the draft Recovery Plan fails to show a clear relationship between the task and flycatcher recovery. Some tasks are derived from appendices that acknowledge that many recommended actions may not be appropriate for all situations, but this is not adequately reflected in the Recovery Plan portion of the draft Plan, where tasks are described as universal goals.

Response: The Recovery Plan has been revised in response to this comment.

The approach of the “issue papers” provided in the Plan’s appendices is described on pages 2 and 3 of the Introduction. The appendices provide a broad background of information, full analysis of the threat or management issues, and in some cases, specific justification for the recovery strategy/action used in the body of the Plan. In some cases, an appendix contains information that is useful for understanding the context of a threat to flycatcher recovery, but may not be directly applicable to management recommendations.

The Plan has been revised to bring forward important information from the appendices into the Recovery Plan in order to describe the rationale for specific recovery actions/tasks. A summary of the nine categories of Recovery Actions is provided in the Executive Summary (page vi). The details of the Recovery Actions are presented in the Stepdown Outline of Recovery Actions (Section IV.D.) and Narrative Outline for Recovery Actions Chapter IV Recovery (Section IV.E.). These two sections have been revised in response to this comment to include better descriptions, examples, and more specific information. Also, Section IV.F., “Minimization of Threats to the Southwestern Willow Flycatcher Through Implementation of Recovery Actions”, has been added to specifically associate recovery actions with the factors which led to the flycatcher being listed.

Issue #2

Comment: In order to use the best scientific and commercial data available, consider reports completed by Jones and Stokes in 2000 and 2001 on operation of Isabella Dam along the Kern River in California before completing the final Recovery Plan.

Response: The Plan has been revised in response to this comment.

The reports on the operation of Isabella Dam completed by Jones and Stokes have been reviewed by the Technical Team and included in the list of literature used to formulate the final Recovery Plan.

Issue #3

Comment: The draft Plan has only briefly addressed the introduction of biological control for salt cedar.

Response: Yes, while biological control of salt cedar is only briefly addressed in the Recovery Plan, strategies for management of exotic plant species are provided in detail. Biological control of saltcedar is addressed in Appendix H, "Exotic Plant Species in Riparian Ecosystems of the U.S. Southwest" (page H-17). Appendix H explains that biological control is a complex form of management that is being tested as a method to reduce tamarisk (saltcedar). Widespread biological control is not recommended due to the potential for unfavorable results as described in Appendix H, page H-17, and the Recovery Plan provides recovery actions in the Sections IV.D. and IV.E. for the management of exotic plant species (recovery action 1.1.3.2.). The Recovery Plan specifies that biological control be considered on a site-specific basis only if significant information on impacts is known and if it can be factored into an overall management scheme that addresses underlying reasons for the decline of riparian vegetation. Future revisions to the Recovery Plan will reflect new findings concerning this type of management.

Issue #4

Comment: The Implementation Schedule in the draft Plan does not adequately reflect costs for any changes in water or livestock management, or other recovery actions such as development of habitat for delisting, sediment augmentation, modification of dam rules, etc., nor does it provide any description for how costs were derived.

Response: See revised Implementation Schedule, Section V., page 144.

Issue #5

Comment: The manner displaying costs in the Implementation Schedule is inconsistent with requirements of the ESA which requires recovery plans to show the costs of recovery. The implementation schedule needs to be expanded to show the full cost of recovery through 2030.

Response: See revised Implementation Schedule, Section V., page 144.

Issue #6

Comment: Establish a single target parasitism percentage for when cowbird trapping should be initiated, rather than a range (20 to 30%). A range of percentages makes it more difficult for managers to make a decision on when to trap and regulatory agencies to remain consistent. We realize that there will always be exceptions to every target number, but those should be dealt with in the text, not by giving managers a range of numbers.

Response: The Recovery Plan has been revised in response to this comment. In Sections IV.D. and IV.E., Stepdown and Narrative Outline item 3.1.1.3. has been changed to provide additional clarity. Also, new text has been added to Appendix F, "Cowbird Management and the Southwestern Willow Flycatcher: Impacts and Recommendations for Management", which provides justification for maintaining a range. The USFWS emphasizes that recommendations in a Recovery Plan that provide the roadmap for recovery of an entire subspecies may differ from the determination that a project may adversely affect a breeding pair of flycatchers, or the need to reduce and minimize effects associated with a project evaluated under the Endangered Species Act.

Issue #7

Comment: Because cowbird parasitism has inhibited the reproductive success of the flycatcher, reduced population levels, and contributed to the endangerment of the species, the statement that cowbird parasitism does not necessarily have critical or even significant effects on a given flycatcher population appears to be contradictory. In any case, recently reported cowbird parasitism rates ranging up to 66 percent at several important nesting locales suggest significant, if not critical, parasitism impacts at those locales.

Response: There is no contradiction here. Cowbird parasitism has contributed to the endangerment of the flycatcher and caused adverse effects to individual breeding attempts, but depending on a variety of factors, the presence of cowbird parasitism may not always have an effect on local flycatcher populations(see Section II., page 28, 39 to 41, and also Appendix F). The Recovery Plan recognizes that some flycatcher populations are heavily impacted by cowbird parasitism and advocates control in these cases. But the Plan also advocates an adaptive management approach in order to avoid a one size fits all strategy that dictates inflexible policies to managers and potentially waste recovery funds and efforts that would be more efficacious if directed to other actions. The text in Section II. has been modified to more clearly explain that cowbird parasitism is a potential impediment to recovery, and depending on many factors, the effects of parasitism to the overall population can (but not always) be slight.

<u>Issue #8</u>

Comment: What is the basis for the statement that cowbird parasitism rates of 20 to 30 percent have barely detectable levels on host recruitment (presumably of flycatchers)? How would it be possible that flycatchers would be unaffected (from recruitment and fitness standpoints) if they produced no or reduced numbers of young from up to 30 percent of all nests?

Response: As summarized in Appendix F in the subsection titled "Host Defenses Against Cowbird Parasitism", there is a consensus among recent researchers that the traditional practice of assessing avian productivity on a per nest basis is misleading because it inflates the apparent impacts of factors such as brood parasitism and nest predation. Instead, it is now widely accepted that impacts on avian productivity need to be assessed from a per female breeder perspective. Once this is done, it becomes evident that something like a 30% parasitism rate is likely to translate to a 15% or less reduction in host reproductive output due to desertion or depredation of a nest followed by renesting. However, any measurable reduction in nest productivity should not be construed as one that is insignificant or discountable. For further information, please consult the references listed in Appendix F. In terms of fitness effects other than reduced numbers of young, such as effects of parasitism on adult viability, Sedgewick and Iko's (1999) exceptionally detailed and data rich study found that parasitism had no clear detrimental effects on flycatcher viability, as discussed in Appendix F.

<u>Issue #9</u>

Comment: The statement says that cowbird control should be considered only after impacts exceed certain levels. What are those levels? Given the precarious status of the flycatcher and our incomplete understanding of the means and measures necessary to recover individual populations or the species as a whole, we suggest that there currently is no acceptable level of impacts to the species. In contrast to the recommendations in the draft plan, we contend the available information strongly suggest that the breeding productivity of the species should be maximized wherever possible and not compromised during and after studies that will almost invariably reveal, if cowbirds are present, that brood parasitism by cowbirds has reduced the breeding success of the test population of flycatchers.

Response: Section IV.E., Narrative Outline of Recovery Actions in the Recovery Plan has a detailed explanation of the levels that should trigger consideration of cowbird control efforts for overall recovery of the flycatcher, as does Appendix F. In agreement with the comment, the Recovery Plan argues that maximizing flycatcher breeding success needs to be a major goal, but it also acknowledges the need for adaptive management, which means that actions other than, or in addition to, cowbird control, will often be most effective in achieving recovery. The Recovery

Plan acknowledges that cowbird control is a useful tool because it is a threat that is easily remedied (unlike nest predation and habitat loss). When considering overall recovery of the flycatcher, relative ease of a recovery action should not be the primary reason for taking action.

Issue #10

Comment: The draft Plan recommends that cowbird control should be stopped after a local willow flycatcher population reaches a large size. Please define a large size.

Response: The Recovery Plan has been revised to provide clarification of this issue. The Recovery Plan now states that cowbird control should be discontinued when the flycatcher population has doubled to tripled in size from when cowbird control began, as long as the absolute number of pairs is equal to or exceeding 25 (page F-31). Research (test cases) are needed to determine the extent to which enlarged populations experience significantly reduced rates of parasitism.

Issue #11

Comment: It is the understanding that critical habitat for the flycatcher will be reassessed based on recent court decisions. The critical habitat section should remove opinions on the designation of critical habitat, update the facts surrounding recent court cases, and include the Technical Teams recommendations for critical habitat designation.

Response: The Recovery Plan has been revised in response to this comment. It should be recognized that although the Technical Subgroup has developed a roadmap for recovery by delineating recovery and management units and recognizing important areas within those units for conservation of the species, it is not the Technical Subgroup's responsibility to designate critical habitat.

Issue #12

Comment: On page 43 of the draft Plan, the statement that in recent years, several of the few larger populations have been impacted...by inundation by impounded water (Lake Mead and Lake Isabella) is incomplete and inaccurate. The statement is not supported by any reference to any scientific data. A review of the entire record indicates that any site specific adverse impacts of short duration are counter-balanced by positive impacts of increased riparian acreage and maintenance of existing habitat within the reservoir. The Plan should consider the entire record of data when discussing impacts of routine reservoir operations.

Response: The USFWS recognizes these reservoirs have contained habitat that flycatchers use. In fact, many large populations of flycatchers exist within the water storage space at Lake Isabella, Lake Mead, and Roosevelt Lake. However, dam operations can, have, or will result in reduced suitability and/or complete loss of habitat through inundation or dessication. The broader perspective on dam operations is that dams can alter hydrological regimes and impede transport of sediment, impacting downstream riparian vegetation quality, quantity, and species. This change in vegetation results in conditions that often do not favor development, maintenance, and recycling of native flycatcher habitat (Section II, page 34 and Appendices H and I). Rather, downstream habitat quality is changed to contain more exotic vegetation, which also increases the frequency of fires. Therefore, while dams and the operations of dams can create flycatcher habitat within the area where water is stored, these situations are more vulnerable to inundation and dessication, less persistent, and tend to decrease the amount and quality of available flycatcher habitat downstream. In fact, dams and dam operations can help create the undesirable condition where the only available flycatcher habitat on a stream is contained within the storage space of the reservoir (e.g., Salt River/Roosevelt Lake; however, note that Roosevelt Lake is not the only area where flycatcher habitat can develop within the Roosevelt Management Unit). Although large flycatcher populations do occupy habitat within the storage space of reservoirs, they may not be as numerous or as persistent as those that occupied miles of pre-dammed rivers with fewer anthropogenic stressors.

Issue #13

Comment: The draft Plan treats dams and reservoirs generically, which results in over generalizations that need to be replaced with specifics or deleted. These generalization imply that if these measures are not carried out, there will not be favorable results for recovery of the flycatcher.

Response: The Recovery Plan does not give dam/reservoir-specific information due to the large number and diversity of dams and reservoirs within the range of the southwestern willow flycatcher. Management for dams will differ according to dam size and structure, flow levels, operating rules, and other considerations. In recognition of the comment, the water-related recovery actions in the Section V., Implementation Schedule, have been revised (actions 1.1.2.1.1–1.1.2.1.9.). Based on the new schedule, location-specific information will be obtained during the next five years. This information will help target dams and reservoir operations that may be modified to benefit flycatcher habitat within the legal and economic constraints under which they operate.

Issue #14

Comment: The statement that dam operating rules should be changed to treat rivers as landscapes and ecosystems should be revised to reflect what is meant. Existing dam operations do treat rivers as landscapes and ecosystems.

Response: The Plan has been revised and Stepdown and Narrative Outline item 1.1.2.1.1. has been described in more detail in response to this comment.

Issue #15

Comment: The Plan discusses major changes to river operations in order to accomplish its goals. There is no discussion of how such changes are to be accomplished within existing laws of the Colorado River and treaties with Mexico. It is not appropriate to include these recommendations in the Plan unless the Service has determined how such changes can be accomplished.

Response: The Recovery Plan has been revised in response to this comment. In order to investigate feasibility of modifying dam operations for the benefit of the flycatcher and its habitat, the Recovery Tasks/Actions, Stepdown and Narrative Outline, and Implementation Schedule have been restructured. The current scheme recommends that the responsible entities investigate and identify those dams and reservoirs where it is legally, economically, and logistically feasible to modify operational changes for the benefit of the flycatcher. Furthermore, those who participate in the Recovery Plan and Recovery Tasks/Actions are never expected, nor required, to violate laws or international treaties. Note that this Recovery Plan is intended to provide guidance for the recovery of the flycatcher, and is not a regulatory document.

Issue #16

Comment: The Plan references the Law of the River regarding the Colorado River. This is the only specific reference in the Plan to the legal framework within which dams are operated. However, even this information is not well integrated into the narrative discussion of dam operations. Further, there is not discussion of the influence of state law, flood control criteria, energy production considerations or surface water rights on the operation of other reservoirs within the Plan area like those located on the Salt and Verde rivers. We suggest that you investigate more fully the specific discretionary authority of the operating entity if you intend to include a description of truly feasible site-specific management actions.

Response: The Recovery Plan has been revised in response to this comment. See response to Issues 13, 14, and 15.

Issue #17

Comment: Because of channelization and channel incisement on the lower Colorado River, even very large releases above downstream demand cannot achieve overbank flooding and inundation of even portions of the historic floodplain. While conceptually, it may be possible to remove/relocate bankline and high levees along discrete portions of the lower Colorado River, the greater challenge is channel incisement due to earlier channelization projects, construction of training structures, banklines and levees. It is physically impossible (short of extremely large flood control releases) to facilitate overbank flooding naturally. It will require significant and costly structural modifications and water diversion in order to wet the floodplain periodically.

Response: The Recovery Plan has been revised to address this issue, see Section IV.E., actions 1.1.2.1.1.-1.1.2.1.9.

Issue #18

Comment: In the draft Plan, modifying dam operations to have spike flows in winter time (page 99, line 7) to benefit flycatcher habitat is in conflict with page 108 section 1.1.3.2.2.2 and recovery of endangered native fish species.

Response: The Recovery Plan has been revised in response to this comment. The draft Plan mistakenly recommended spike flows in the winter, when it should have indicated flows that are consistent with the natural hydrograph.

Issue #19

Comment: The boundary line for southwestern willow flycatcher subspecies bisects the southern portion of the state of California, Nevada, Utah, and Colorado. The boundary represents an integrated area where both species may co-exist. It appears that there is a question as to a definitive boundary for the southwestern willow flycatcher. The draft Plan proposes to impose restrictions on this birds habitat without having scientifically sound data of the actual boundaries.

Response: A precise boundary between subspecies is not currently known, given (a) potential integradation between subspecies, and (b) limited survey effort in much of boundary area. However, the boundaries as drawn in the Plan are based on the best available published and unpublished data (Section II, B). Recent studies have helped refine the northern boundary of the southwestern willow flycatcher's range through the collection of blood from breeding willow flycatchers and subsequent genetic comparison and analysis (Paxton 2000). As a result of this information, two Management Units in Utah and Colorado described in the draft Plan (Dolores and Sevier) were removed from the breeding range of southwestern willow flycatcher. Findings from future research may continue to modify the boundary.

Issue #20

Comment: Identify cut-off dates for historical versus contemporary records. This is crucial to determining, and defending, recovery goals and objectives.

Response: The Plan has been revised to now explain that "contemporary investigations" of flycatcher territories in Arizona are post-1990 (Section II, page 8). Note that recovery goals for the southwestern willow flycatcher are not dependent on historical records, historical abundance of habitat, or historical populations. Rather, they are based upon the current potential of habitat, and an abundance and distribution that assures long-term persistence throughout its range. In other words, the recovery goals are not established to maximize the number of birds or achieve historical pre-European settlement population levels.

Issue #21

Comment: A recommendation on page 109 in the draft Plan states that tamarisk in occupied flycatcher habitat not be removed. However, tamarisk is an exotic species. Tom Dudley, University of California, indicated in a personal conversation that tamarisk habitat as producing 0.82 fledgling per nest and therefore was not producing a sustaining population. It would seem the position of managing tamarisk should be rethought to allow removal of the tamarisk and replace it with the more productive native willows and cottonwood vegetation where the water regime permits such conversion.

Response: The Recovery Plan discusses exotic vegetation management in Section IV.E., actions 1.1.2.2 and 1.1.3.2, and also in Appendix H. The Recovery Plan describes methods and conditions for removal of tamarisk and restoration of native vegetation. Specifically, item 1.1.3.2 discusses and recommends use of native plants for revegetation, developing exotic vegetation management plans, and most importantly, advocates reducing the conditions that allow exotic plants to thrive.

The Plan is very explicit by recommending against removal of tamarisk if underlying factors are not understood and management across landscapes is not coordinated, as the probability that re-establishment of exotic plants will occur is high. The Plan describes the fact that flycatchers can and often do nest successfully in tamarisk (Section II, page 13 and14) and recommends that tamarisk be retained in areas where flycatchers are breeding (Section IV.E., action 1.1.3.2.5.1., page 119).

There are as yet, no firm data that southwestern willow flycatchers nesting in tamarisk produce less young than those in native habitats, or that populations breeding in tamarisk are less self-sustaining than those in natives (Section II, pages 11-15). Sferra et al. (2000) compiled the nesting success of 84% of the 2008 nests documented primarily between 1993 and 1999, and some from 2000. Nest productivity in tamarisk-dominated sites is 23% to 54%, which is similar to native willow-dominated sites. Tamarisk nest success averaged 45% in New Mexico and 54% in Arizona, indicating that tamarisk nests are at least as successful as nests in other substrates. Therefore, until such data are available, the Plan's approach to tamarisk/saltcedar removal is reasonable.

Issue #22

Comment: What is the definition of potential and occupied flycatcher habitat and the difference between potential and suitable willow flycatcher habitat?

Response: The Recovery Plan has been revised to clarify the definitions, differences, and importance of these stages of flycatcher habitat to its survival and recovery in Section II, pages 15 to 19 and Appendix D, Southwestern Willow Flycatcher Habitat.

Issue #23

Comment: Little emphasis is placed on suitable and potential, restorable and/or recovering southwestern willow flycatcher habitat. Also, little emphasis is placed on tributaries or drainages outside the rivers main stem. The document is almost entirely focused on existing occupied flycatcher habitat and makes little or no effort to deal with managing other areas for recovery of the species.

Response: The primary recovery task is to increase and improve currently suitable and potentially suitable habitat (Stepdown and Narrative Outline item 1, page 96 and 106). Every item underneath this heading is directed toward protecting, enhancing, restoring, managing, and cooperating in the management of these habitats.

A section to the Recovery Plan was added on describing the importance of unoccupied suitable habitat and potentially suitable habitat (Section II, page 17). Here, the Plan describes that these different stages of flycatcher habitat are essential for flycatcher survival and recovery because flycatcher habitat is dynamic and ephemeral in nature. As a result, all flycatcher breeding habitat begins as potential habitat, grows into suitability, and then becomes occupied by nesting flycatchers.

Additionally, as directed by the Endangered Species Act, the purpose of this Plan is to conserve the ecosystems upon which the southwestern willow flycatcher depends. The flycatcher depends upon one of the most critically endangered habitats in North America: southwestern riparian ecosystems. As a result, this Plan takes an Ecosystem and Watershed Approach to flycatcher recovery (Section I, page 2).

The Plan discusses that the health of riparian ecosystems and development, maintenance, and regeneration of flycatcher nesting habitat depends on appropriate management of uplands, headwaters, and tributaries, as well as the main stem of river reaches. All of these landscape components are inter-related. As a result, nesting habitat is only a small portion of the larger landscape that needs to be considered when developing management plans, recovery actions, biological assessments for section 7 consultations with the USFWS, or other documents defining management areas or goals for flycatcher recovery (Section II, page 16). Also note that discussion and separate guidance is developed for upland grazing in Appendix G.

Issue #24

Comment: The definition of potential southwestern willow flycatcher habitat used in the draft recovery plan may be too broad to be practical. Using this definition, almost all riparian areas would be considered potential habitat. We suggest using the definition from the Forest Service Region 3 Grazing Criteria, August 1998, page 50, as something more useful [see comments for full definition]. Further discussion of potential habitat on page 16 of the draft recovery plan would dovetail with this definition. The Forest Service definition should be reworded to make it more palatable, definable, and useable for the biologists.

Response: The Recovery Plan has been revised to clarify the definition of potential habitat, and while the description is not identical to that of the National Forests in the Southwest, it retains a similar concept (Section II, pages 15 to 19 and Appendix D, Southwestern Willow Flycatcher Habitat).

Issue #25

Comment: Nesting habitat size requirements must be defined in more specific terms. There seems to be a definite width and length combination providing the seclusion, security, and territory protection needed for successfully breeding flycatchers. Mojave County states that “many biologists in the Grand Canyon National Park no longer classify the long narrow strips of riverbank vegetation as nesting habitat although an occasional nest will be found there” but that BLM wildlife biologists “identify willow strip vegetation along a dry wash as nesting habitat.” BLM’s decision has serious ramifications upon surrounding land management with the restrictive practices required.

Response: The Plan has been revised to respond to this comment (Section II., page 17, Patch Size and Shape, Section II., page 80 and 81, and Appendix D). The riparian patches used by breeding flycatchers vary in size and shape. They may be relatively dense, linear, contiguous stands or irregularly-shaped mosaics of dense vegetation with open areas. Southwestern willow flycatchers nest in patches as small as 0.1 ha (0.25 ac) along the Rio Grande, and as large as 70 (175 ac) in the upper Gila River in New Mexico. Based upon patch size values given in publications and agency reports, mean size of flycatcher breeding sites supporting 10 or more flycatcher territories is 24.9 ha (61.5 ac) (SE =5.7 ha; range =1.4 to 72 ha; 95% confidence interval for mean=12.9 to 37.1; n= 17 patches).

Issue #26

Comment: The position on saltcedar removal needs to be perfectly clear to managers. Removing it, even when it may not be appropriate, is still the prevalent action in S. Nevada among land managers.

Response: The plan has been revised in response to this comment. Recovery tasks listed under Stepdown and Narrative Outline item 1.1.3.2 provides explicit direction for managing and/or removing saltcedar and other types of exotic vegetation. Appendix H discusses the current understanding of exotics in riparian areas specific to the flycatcher. Condition B (page H-19) presents pertinent assessment questions, actions, and case studies to be used by managers. In addition, the Service acknowledges that there may be reasons unrelated to the flycatcher for removing exotics.

Stepdown and Narrative Outline item 1.1.3.2.5.1 is clear in its recommendation to not remove tamarisk in occupied flycatcher habitat and where appropriate, in suitable but unoccupied habitat. Item 1.1.3.2.6 recommends only removing suitable exotic vegetation if: 1) underlying causes for dominance of exotics have been addressed; 2) there is evidence that the exotic species will be replaced be vegetation of higher functional value; and 3) the action is part of an overall restoration plan.

Issue #27

Comment: If parasitism rates of 20-30% have barely detectable effects, how does it make a difference if it is exceeded in more than one year? What rates are needed to create a detectable effect on the species? And how are these rates derived? More study is definitely needed in this area before a true trapping program is developed.

Response: Despite the lack of evidence for increases in flycatcher breeding populations after cowbird trapping, there are cogent reasons to continue this management approach because 1) control does increase the numbers of flycatchers being produced and these increased numbers may result in emigrants to other populations; 2) one can not invalidate the hypothesis that populations that have not increased after cowbird control would have been extirpated without control; 3) whether cowbird control increases local flycatcher populations may vary geographically so it is worth continuing the program to fully assess the efficacy of this approach. The 20-30% range reflects the best judgement of the technical team members familiar with passerine breeding biology. Because many flycatcher populations are small and subject to stochasticity, even moderate rates of parasitism such as 30% could have large effects, by for example, affecting all individuals, within a population that are left unaffected by other threats such as nest predation. Therefore, such rates could lead to local extirpations and affect, metapopulation dynamics. The presentation of the 20-30% range is followed by an extensive discussion of additional factors that managers and regulators should read. This discussion stresses that each site needs to be treated individually and explicit wording to that effect has been added.

Issue #28

Comment: There is inherent conflict between the current state of riparian areas and the proposed management of exotic species. Many riparian areas are populated by thick stands of tamarisk. The Service, in previous publications, has called for removal of tamarisk, but now, because the flycatcher uses it, implies that some plants should not be removed. There is no clear directive and land managers are hard pressed to know what to do.

Response: The USFWS supports restoration of riparian areas to native vegetation (see section IV.E; action 1.1.3.2.3.). In the particular case of the flycatcher, a species that uses tamarisk for breeding habitat, consideration of where and how restoration occurs is needed. As a consequence, this Recovery Plan calls for a coordinated, temporally-staged approach to removal of tamarisk (see section IV.E.; action 1.1.3.2.6.). The endangered status of the flycatcher necessitates maintaining current structure of occupied breeding habitats and suitable unoccupied habitats, regardless of species composition (see section IV.E.; action 1.1.3.2.5.).

Issue #29

Comment: The Recovery Plan needs to better address the overall perception by the general public that tamarisk is good for the flycatcher and be upfront in explaining this dilemma to agencies and the general public.

Response: The Recovery Plan has been adapted in response to this comment (refer to expanded discussion in Section II.C., page 13, *Habitats Dominated by Exotic Plants*, and Section II.J., page 33, ***Reasons for Listing and Current Threats***).

Issue #30

Comment: The Habitat Restoration Appendix describes 5 mitigation goals. Numbers 3 through 5 (remove exotics and restore natives, restore a more natural flood regime, and attaining a self sustaining ecosystem) may be appropriate for a white paper, but turning suggested guidelines and goals into explicit recovery tasks for the flycatcher is not authorized under the ESA.

Response: This Recovery Plan is intended to provide guidance for the recovery of the flycatcher, and is not a regulatory document. The mitigation goals listed in the Habitat Restoration Appendix are intended to guide mitigation projects that involve the flycatcher. Numbers 3-5 are based on the current understanding of significant threats to the species, and are significant issues that are addressed throughout the plan.

Issue #31

Comment: The fundamental and pervasive defect of the Plan is the failure to distinguish between species recovery as properly within the scope of section 4 (f), and maximum ecosystem protection, a goal of section 2 but not the focus of recovery plans. By asserting that the purpose of the Plan is to conserve flycatcher ecosystems, rather than the species itself, the Service concedes the legal deficiency of the document and reveals the fundamental reasons that the measures it calls for are too broad and burdensome and outside the scope of ESA.

Response: Conserving flycatcher ecosystems to the extent that the southwestern willow flycatcher is considered recovered may or may not result in maximum ecosystem protection. The Recovery Plan has been revised in response to this comment to further clarify the focus on riparian systems relevant to the southwestern willow flycatcher (see Section I.B).

Issue #32

Comment: Will 40 percent use by cattle of current years growth ever allow a willow to attain a height great enough for quality flycatcher habitat?

Response: As Appendix G discusses at length the fact that percent utilization of woody vegetation has important consequences for flycatcher habitat quality. Although some willow species may be able to survive with high utilization rates (Lammon 1994/pg. G-7), this does not ensure that woody vegetation is able to attain a structure that is suitable for flycatchers. With appropriate monitoring, as called for in the grazing guidance detailed in Section IV.E., actions 1.1.3.1.1.1.-1.1.3.1.1.4., and 6.4.1., and in Appendix G, Table 2 and page G-28, woody vegetation utilization should not approach, let alone exceed, 40% percent, because livestock would be moved when herbaceous utilization reached 35%. The 40% woody vegetation utilization figure is based on the best science currently available – but this may change in the future as this level is evaluated based on monitoring.

Issue #33

Comment: The Plan states there should be no livestock grazing in occupied flycatcher habitat until research in comparable unoccupied habitats demonstrates no adverse impacts from grazing. Sufficient information exists to identify acceptable use levels in most, if not all, currently-grazed areas such that flycatcher needs can be met while not entirely disrupting the grazing industry. Moreover, where research into impacts of grazing is needed, the grazing pressure in the experimental area should be managed to yield results that will be useful in structuring acceptable use levels on the control site. The text as written provides no such guidance.

Response: The Recovery Plan allows for conservative grazing in the non-growing season in occupied habitats, as long as average utilization does not exceed 35% of palatable, perennial grasses and grass-like plants in uplands and riparian habitats, the extent of alterable stream banks showing damage from livestock use do not exceed 10%, and woody utilization does not exceed 40% on average (Appendix G, Table 2, page G-27). The Recovery Plan supports documentation of grazing practices and further research on grazing schemes (Section IV.E., actions 1.1.3.1.1.2–1.1.3.1.1.4., and 6.4, and Appendix G, page G-23), and advocates an adaptive management approach. The Recovery Plan will be revised with new information on compatible grazing schemes as it becomes available, assuming the additional data and analyses exist in 5 years.

Issue #34

Comment: The Plan is inadequate because the Service did not meet the statutory requirements of Congress nor the regulatory requirements of the Agency, due to not basing the plan on adequately sound data on grazing. The Plan admits that information linking management of livestock grazing effects to the flycatcher remain to be researched. The Plan also goes against statute, by elevating single use over multiple use, which is required by statute.

Response: The Recovery Plan is based upon the best available science and information. The Recovery Plan emphasizes multiple use, as it includes recommendations for a variety of activities, including grazing, recreation, and water use. The Plan is based on the best available data on grazing (see Appendix G). The Recovery Plan allows for conservative grazing, and acknowledges the need for flexibility interpreting the grazing guidelines based on location-specific conditions. If a particular grazing system coincides with improved southwestern willow flycatcher habitat (e.g., the grazing system is not preventing regeneration of woody and herbaceous riparian vegetation), then that particular grazing system should be allowed to continue provided it is appropriately monitored and documented (Appendix G, page G-25). Additionally, the Plan recommends studies on grazing so that information can be gained and used to assess the compatibility of grazing with flycatcher recovery. Also see previous response.

Issue #35

Comment: The livestock grazing discussion and management would benefit from the addition, development, and implementation of watershed wide management plans. Poor conditions on the adjacent and upstream uplands could exacerbate catastrophic floods and wipe out local gains in riparian habitat recovery.

Response: The Recovery Plan has been revised in response to this comment to incorporate upland areas in the grazing recommendations given in Appendix G, Table 2. The Recovery Plan does not preclude Management Units from working together to craft watershed-scale management plans.

Issue #36

Comment: After much discussion in the issue paper and the beginning of this document, why are upland conditions ignored? Upland conditions and utilization by livestock should have guidelines similar to riparian areas. The proposed utilization standards for occupied habitat seem more appropriate for upland areas than for riparian areas.

Response: The plan has been revised in response to this comment. Upland conditions have been incorporated into the grazing guidelines given in Appendix G, Table 2, as well as in the text of Section IV.E., Narrative Outline of Recovery Actions. Beyond conservative grazing, sufficient scientific information on upland habitat does not exist from which to develop more specific guidelines relevant to flycatchers. Due to the significant variability in upland habitats, guidelines are difficult to recommend and will need to be assessed on a site by site basis.

Issue #37

Comment: Average utilization levels of 35% on herbaceous vegetation and 40% on woody vegetation is not conservative grazing, particularly when dealing with listed species habitat and recovery. Instead, it may rank as moderate to high levels based on the type of vegetation present. If you are grazing in the dormant season, there should be almost no use on woody vegetation; 40% use during the dormant season would seem to represent unexpectedly high use during the nongrowing season. Grazing at these levels are likely to significantly alter overall cover density at lower levels of the canopy.

Response: Available science supports the grazing guidelines given in the Recovery Plan as “conservative” over the variety of riparian systems across the range of flycatcher habitat. Wetter and drier areas will be differentially impacted by grazing. One area (i.e., Tonto National Forest) cannot be the basis for all guidelines. However, data from the Tonto has been assessed and is discussed in Appendix G, and the plan calls for new science/research to further our knowledge base. In addition, the Recovery Plan also recommends vegetation/habitat monitoring. Areas of poor habitat quality (= low forage availability) should not be grazed (Appendix G, pages 23, 28). If 35% utilization of herbaceous vegetation is reached, livestock should be removed from the area and the 40% woody utilization level will likely not be attained. The guidelines will be revised if new information suggests that this strategy is in error. Other relevant changes to the Recovery Plan include establishing maximum bank alteration levels, and clarification of “dormant” season (see Appendix G).

Issue #38

Comment: Livestock use in the riparian areas at the recommended levels, even in dormant season, can affect understory density of vegetation. Allowing these levels in warm, dry winters, will cause extremely high use and are likely to result in bank damage (stream channel alteration) and expose channels to alteration or loss during the peak spring runoff season. More conservative use levels are needed and bank alteration limits should also be established.

Response: The Recovery Plan has been revised in response to this comment. The USFWS reviewed additional data and the published literature on range management and incorporated a threshold for stream bank condition into the grazing guidelines (Fleming et al. 2001; see Appendix G, Table 2).

Issue #39

Comment: What constitutes the dormant season (leaf drop to bud break)? Dormant season means a lot of things to a lot of people.

Response: Definitions of growing season and non-growing season have been added to Appendix G, Table 2 (page G-27). Growing season is defined as bud break to leaf drop for cottonwood and willow species. The non-growing (i.e., dormant) season is defined as leaf drop to bud break for cottonwood and willow species.

Issue #40

Comment: Standards for stubble height should be an option for measuring riparian use. Determining percent use is often difficult for various riparian grasses/grass-like plants because of variability in plant height, site productivity and other factors.

Response: The plan has been revised to discuss stubble height for measuring riparian use (Appendix G). Unfortunately, sufficient available science in riparian areas of flycatcher habitat does not exist upon which to base stubble height recommendations in this Recovery Plan. What we do know is that Mosley et al. (1997) suggested the following guidelines for stubble heights in riparian systems in Idaho: 1) stubble height of 3 to 4 inches for sedges, tufted hairgrass, and similar species following the growing season; 2) two inches for Kentucky bluegrass; 3) four to 6 inches for large bunchgrasses; and 4) utilization of riparian shrubs should not exceed 50 to 60% during the growing season. However, some researchers caution against recommendations that call for a uniform level of utilization or stubble height to maintain riparian attributes because these recommendations ignore the inherent complexity of riparian systems (Green and Kauffman 1995).

Issue #41

Comment: The use of the word habitat appears in several different forms. Mixing the different definitions leads to confusion. Consistent definitions of habitat are important since downlisting criteria calls for protection of double the amount of habitat required to support the target number of flycatchers. Until the term habitat is scientifically defined and consistently used, it will be impossible to implement the Plan.

Response: The Recovery Plan has been revised in response to this comment to clarify the definitions of habitat used in the plan (see Section II.C.). Habitat requirements/characteristics are discussed in Section II.C., Habitat Characteristics. The Recovery Plan States (page 11): "...general unifying characteristics of flycatcher habitat can be identified. Regardless of the plant species composition or height, occupied sites usually consist of dense vegetation in the patch interior, or an aggregate of dense patches interspersed with openings. In most cases this dense vegetation occurs within the first 3-4 m (10-13 ft) above ground. These dense patches are often interspersed with small openings, open water, or shorter/sparser vegetation, creating a mosaic that is not uniformly dense. In almost all cases, slow-moving or still surface water and /or saturated soil is present at or near breeding sites during wet or non-drought years."

Issue #42

Comment: Agricultural lands with suitable flycatcher habitat and future potential habitat are somewhat overlooked in the Recovery Plan. In southern Nevada, irrigation practices are many times conducive to creating habitats for flycatchers and this resource has been undervalued. The document needs to better assess the value of agricultural lands as breeding flycatcher habitat and relate this to the overall recovery of the flycatcher. Agricultural lands operated for their traditional uses under certain constraints may provide significant benefits to adjacent flycatcher habitats as well.

Response: See section IV.E.; action 1.1.2.2.1.

Issue #43

Comment: The Recovery Plan needs to emphasize opportunities for creation of additional breeding habitat over a short period of time. For example, there are willow habitats in Nevada which have recently become established over a 5 year period and have successful nesting flycatchers within that 5 year period. The ability of southwestern river systems to provide a matrix of individually small and short-lived habitat patches which contribute to a larger habitat complex that has both connectivity and appropriate overall structural availability should not be overlooked.

Response: The Recovery Plan (pg. 17) recognizes that potential habitats that are not currently suitable will be essential for flycatcher recovery, because they are the areas from which new suitable habitat develops as existing suitable sites are lost or degraded; in a dynamic riparian system, all suitable habitat starts as potential habitat. Furthermore, potential habitats are the areas where changes in management practices are most likely to create suitable habitat. Not only must suitable habitat always be present for long-term survival of the flycatcher, but additional acreage of suitable habitat must develop to achieve full recovery. See also Section IV.A.; page 75.

Issue #44

Comment: The Recovery Team should consider using existing technology and information to develop a habitat-predictor model for the range of the flycatcher to estimate the amount of current available habitat, help direct survey efforts, and possibly identify areas needing habitat rehabilitation. A model of this type had been developed by the Mexican spotted owl Recovery Team and GIS experts, as has undergone field-testing and several revisions.

Response: Basic research to identify and predict flycatcher habitat at a variety of spatial and ecological scales, using standard vegetative measurement techniques as well as remote sensing and GIS, is recommended in the Recovery Plan. Such projects have been initiated by the AGFD, which developed and successively tested a predictive model for flycatcher breeding territory at low-elevation reservoir inflows in Arizona. The next step is to adapt the AGFD modeling approach to other parts of the flycatcher's range, recognizing that the variability in flycatcher breeding habitats (e.g., native and exotic vegetation; differing plant species; low and high elevation; large and small patches) may require a series of related but somewhat differing habitat models. The Recovery Plan supports and encourages the continuation and expansion of such habitat modeling efforts, as part of the tasks described in Section IV.E.; actions 6.1.1. and 6.1.2.

Issue #45

Comment: The minimum list of responsible entities shown in the Implementation Schedule has no reasonable basis. The assignment of specific tasks that have not agreed to undertake those tasks and have no responsibility to do so is a clear indication that the Plan is arbitrary and capricious and should not be used unless binding agreements exist. The minimum list of responsible entities includes entities who have made no commitments to perform or fund any of the tasks contemplated by the draft plan. The ESA does not authorize the Service to use Recovery Plans to enlist non-federal parties to a species recovery program. Recovery is the responsibility of the federal government, not stakeholders.

Response: Recovery tasks were developed by the Recovery Team with input from stakeholders, including Federal and State agencies, industry groups, conservation organizations, academic institutions, and others. As recovery plans are not regulatory documents, parties on the "Minimum List of Potential Partners"in Section V., Implementation Schedule, are not committed by law to undertake recommended recovery actions. These partners are identified due to their potential to implement recovery actions, if they so choose. Federal agencies do have general responsibilities to listed species.

Issue #46

Comment: Unless recovery actions are made site-specific it is highly questionable that many of the actions listed, such as modify dam operating rules should be given a priority 1 status. Priority 1's are those that MUST be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future. Any priority 1 must be justified in the narrative outline as necessary to prevent extinction. As currently written, most of the tasks in 1.1.2 and 1.1.3 are not justified.

Response: The Recovery Plan has been revised to allow managers to identify site-specific opportunities (see Section IV.E.; 1.2.1.1.-- 1.1.2.1.9.); priority numbers have also been revised (see Section V., Implementation Schedule).

Issue #47

Comment: The 3:1 ratio of acquired habitat to lost habitat needs some additional supporting rationale that agencies/groups can use.

Response: See response to following comment.

Issue #48

Comment: The Plan indicates that potential habitat should be replaced at a 3:1 ratio. Potential habitat is neither occupied nor suitable for use by flycatchers because it lacks in some critical component. This is not habitat. We do not believe the Service has the authority to regulate potential habitat.

Response: Recovery plans are non-regulatory documents; therefore the USFWS is not regulating potential habitat for the southwestern willow flycatcher with the Recovery Plan. The discussion of potential habitat and its importance to the flycatcher has been expanded within the Recovery Plan (see section II.C.2.; page 15). Regarding the suggested habitat replacement ratio, refer to the expanded discussion under "Measures to Minimize Take and Offset Impacts" on page 83.

Issue #49

Comment: Research and removal of exotic species should be maintained as items that should be used to offset the loss of flycatcher habitat.

Response: Research and removal of exotic species are potentially significant recovery actions (see Section IV.E.; 1.1.3.2.6., and 6.1-6.12.3.), but do not compensate for loss of habitat. As the Recovery Plan states (see Section II.J.; page 33), loss and modification of habitat is one of the primary causes for the endangered status of the southwestern willow flycatcher.

Issue #50

Comment: Habitat should be replaced or permanently protected within the same Management Unit. Allowing replacement or protection of habitat that cannot be used by the affected population will lead to a decline of that metapopulation.

Response: The USFWS agrees that habitat should be replaced or permanently protected within the same Management Unit (see Section IV.B.; page 83); however, to increase flexibility in plan implementation, the downlisting criteria allow for small departures within Management Units (see Section IV.B.; page 78-79).

Issue #51

Comment: The Service should ensure that the Plan includes a description of the actual factors which led to the flycatcher being listed as endangered, as described in section 4(a)(1) of the ESA. The objective measurable criteria in a recovery plan are intended to establish goals which, when met, address each of the factors which led to the listing and can lead to the de-listing of the species.

Response: The plan has been revised in response to this comment. See Section II.J.; page 33, "Reasons for Listing and Current Threats", and also Section IV.F.; page 138, "Minimization of Threats to the Southwestern Willow Flycatcher Through Implementation of Recovery Actions".

Issue #52

Comment: In some cases, the discussion of recovery of riparian habitats, found in the appendices, has been substituted for flycatcher recovery. The Plan correctly states the purpose is to conserve the ecosystems on which flycatchers depend. However, the purpose appears to have been modified to that of conserving riparian habitat in the Southwest regardless of the probability of benefitting flycatchers. On page 2 of the Plan it is stated, the Plan ..seeks in part to protect, re-establish, mimic, and/or mitigate for the loss of natural processes that establish, maintain, and recycle riparian ecosystems. In many cases this goal may be necessary for recovery, but it is highly questionable that this should be a goal in itself.

Response: The purpose of the Recovery Plan is to recommend actions that can be implemented in riparian habitats relevant to the flycatcher. The Recovery Plan has been revised to clarify this intent (see Section I.B; page 2).

Issue # 53

Comment: The Population Viability Analysis (PVA) is speculative and should be deleted. Caveats in the PVA itself indicate that it should not be used to determine number of territories per site for target goals, or other such statements. If the PVA is to be included, then full disclosure of its faults at the beginning of the PVA section is necessary, and followed throughout. Also, replace the summary of the PVA in the appendices with the author=s actual literature so that other people can interpret the results for themselves.

Response: The Recovery Plan has been revised in response to this comment (see Section IV.A.4.; page 73). The Recovery Plan explicitly recognizes that the demographic analysis might not be applicable across the entire range of the flycatcher. The incidence function analysis, based on data from 143 sites, was helpful in formulating the Recovery Plan's strategy (e.g., reclassification and delisting criteria) for achieving a population level and an amount and distribution of habitat sufficient to provide for the long-term persistence of metapopulations.

Issue #54

Comment: An appropriate Plan addresses each of the factors that served as the basis for listing and discusses 1) site-specific management and 2) objective and measurable criteria under which the species can be removed from protection of the ESA. The Plan fails to satisfy these items.

Response: Section II.J.; page 33 addresses each of the factors that served as the basis for listing. This Recovery Plan provides a strategy to characterize flycatcher populations, structure recovery goals, and facilitate effective recovery actions that should closely parallel the physical, biological, and logistical realities on the ground. Recommendations for specific sites where recovery actions should be focused is provided in Section IV., Table 10. The down- and delisting criteria provided in the Recovery Plan are both objective and measurable, and provide for a population level and an amount and distribution of habitat sufficient to provide for the long-term persistence of metapopulations. Flexibility provided by the downlisting criteria is intended to allow local managers opportunities to apply their knowledge to meet goals, possibly in areas the USFWS cannot identify or may not foresee.

Issue #55

Comment: Values for existing number of territories were based on survey data for all breeding sites known to have been occupied for at least one year between 1993 and 1999. Why is it not also the criteria for determining the number of territories for reclassification; occupancy at least once over a five year period?

Response: The Recovery Plan has been updated to include 2000 and 2001 survey data. Values for current number of known territories are based on the most recent available survey data for all breeding sites known to be occupied for at least one year between 1993 and 2001 (see Section IV., Table 9). The recovery strategy outlined in Section IV.A. and B. builds on this number of territories to attain a population level and an amount and distribution of habitat sufficient to provide for the long-term persistence of metapopulations. An effective monitoring protocol has yet to be developed for determining when down- and delisting criteria have been met. We do not yet know how and to what extent populations fluctuate, or how often monitoring must take place to satisfactorily estimate population size. This is one reason the USFWS intends to amend the Recovery Plan in 5 years, and proposes recovery action 6.7.4. "Develop methodologies, which can be site-specific if necessary, for determining year-to-year trends in population sizes at breeding sites".

Issue #56

Comment: Using cumulative total for estimate of known territories overestimates the number of known territories. It needs to be made clear that recovery goals are not based on cumulative totals.

Response: The estimates for known number of territories and minimum number of territories for reclassification (see Section IV.B., Table 9) are not cumulative estimates. Values for current number of known territories are based on the most recent available survey data for all breeding sites known to be occupied for at least one year between 1993 and 2001.

Issue #57

Comment: The narrative at the top of Table 12 should be restated in the main text of the document and highlighted as a recovery action, i.e. recovery efforts need not focus only on reaches identified. In addition to focusing on occupied habitat, there should be substantial effort to promote the protection of watersheds, such as tributaries to main stems, and to move potential, restorable and/or recovering riparian areas toward suitability.

Response: Table 12 is now Table 10 in the Recovery Plan. Refer to Section II.C.2., pages 15-17, and Section IV.B.2., page 80.

Issue #58

Comment: Additionally, the list of reaches for recovery efforts presented in Table 12 seems woefully incomplete. The table should include rivers or reaches with small populations, existing populations, or no populations. We see no reason why this list should not be as comprehensive as possible.

Response: Table 12 is now Table 10 in the Recovery Plan, and has been revised in response to this comment. Table 10 now includes a more extensive list of suggested reaches.

Issue #59

Comment: It is not clear whether recovery goals include breeding flycatchers on Tribal Lands. The document needs to clarify whether the population targets for down- or delisting include or exclude Tribal lands.

Response: Some Tribes are currently participating with the USFWS in assessing flycatcher numbers on Tribal lands. In these instances, the Tribal information is included in the numbers of existing territories in a Management Unit; continued participation of these Tribes is factored into the numbers needed for reclassification (see Section IV.B.2., Table 9). If additional Tribes choose to participate in the flycatcher recovery effort, data from survey and monitoring efforts will also likely count towards achieving the numeric recovery goals.

Issue #60

Comment: Research shows that flycatchers are much more mobile than previously thought, which is relevant to whether satisfying population goals for Management Units should be a prerequisite to downlist or delist the species. The population goals should be more geographically flexible to take into account greater movement from season to season, while still allowing for genetic diversity rangewide.

Response: The down- and delisting criteria provide sufficient flexibility by allowing an individual Management Unit to meet 80% (criteria set A), or 50% (criteria set B), of its minimum population target, as long as the Recovery Unit attains the overall population goal.

Issue #61

Comment: No specific information in the Plan describes how population goals were set other than using a 25 territory minimum, and feasible management actions. No supporting data or rationale other than according to model results are provided for the 25 territory target or the 15 km distance between sites.

Response: The Recovery Plan has been revised in response to this comment. Refer to Section IV.A.4., page 73.

Issue #62

Comment: Dispersal of flycatchers have been documented in excess of 200 km. The Plan also describes that flycatchers in excess of the minimum required for each management unit are considered potential colonizers to other units, implying the birds can move from one unit to another and sometimes significant distances. Moving from one unit to another, considering the birds great migration distance, must be considered not only possible, but probable. In light of this new information on flycatcher movements, we question the feasibility of and need for maintaining minimum populations in each unit simultaneously.

Response: See response to Issue #64.

Issue #63

Comment: There has been no demonstration that 3900 individuals are necessary to allow a proper functioning metapopulation. There has been no appropriate discussion on metapopulations or numbers of individuals required to establish each (or any) metapopulation of flycatchers.

Response: See expanded discussion in Section IV.A.4. and IV.A.5.

Issue #64

Comment: The little Colorado River is placed with the Lower Colorado Recovery Unit, while the lower Gila River is situated in the Gila Recovery Unit. Consider switching these streams into different Recovery Units. Although the Little Colorado River does eventually flow into the mainstem Colorado in the Grand Canyon, it is much closer both in distance and in ecology to some of the Gila River Management Units, especially the San Francisco Management Unit. The lower Gila is separated from the rest of the Gila by a long stretch of dry riverbed whereas it's a short distance to its confluence with the mainstem Colorado near Yuma in the Lower Colorado Recovery Unit.

Response: In response to this comment and information provided by the Lower Colorado River Implementation Subgroup, the lower Gila River near its confluence with the Lower Colorado River has been assigned to the Lower Colorado River Recovery Unit (see Section IV.A.1.). No change in the Little Colorado's inclusion in the Lower Colorado River Recovery Unit was made at this time.

Issue #65

Comment: Most if not all of the existing flycatchers and flycatcher habitat is found within the conservation space at Roosevelt. The Team should recognize there is little or no compensation habitat within the Roosevelt Management Unit. Given the lack of available flycatcher habitat, the population goals should be drastically reduced or not be a prerequisite for reclassification or delisting. The Service should specify where and how there is habitat for 40 to 50 pairs in the Roosevelt Management Unit.

Response: Given our current level of understanding, the USFWS believes that a target of 50 territories in the Roosevelt Management Unit is achievable, and necessary to attain a population level and an amount and distribution of habitat sufficient to provide for the long-term persistence of the metapopulation within the Gila Recovery Unit. If this proves to be in error, the USFWS will modify the target, as appropriate, in future revisions of the Recovery Plan. Within the Roosevelt Management Unit, the USFWS believes there is enough potentially suitable habitat outside of the conservation space of Roosevelt Lake to achieve the population target of 50 territories.

Issue #66

Comment: The Roosevelt Management Unit numbers should be increased. There is much more potential for habitat restoration at Roosevelt Lake than the current goal indicates. Even if the lake reached capacity, there would be enough fringe habitat to contain as many as 50 territories. The current goal does nothing to encourage habitat improvement projects above the lakes new conservation pool. Such suggestions are in line with the Plan's conclusions to maintain existing populations as the highest priority.

Response: The Recovery Plan does not seek to maximize flycatcher numbers in habitats. The strategy used in the Plan calls for increasing population numbers that will serve the metapopulation in that recovery unit. See also response to Issue #69.

Issue #67

Comment: There are concerns that the Plan singles out the Roosevelt Management Unit for additional review of recovery goals in another 5 years. Because the Roosevelt Unit is singled out as a moving target, it creates a climate of uncertainty in the regulated community. We urge this to be removed from the Plan.

Response: The Roosevelt Management Unit was not singled out as a moving target, but rather was assessed, as all Management Units were, for potential habitat that could provide for metapopulation stability and persistence in the future. The USFWS believes there is enough potentially suitable habitat outside of the conservation space of Roosevelt Lake to achieve the population target of 50 territories.

Issue #68

Comment: Camp Pendleton hosts 25% of the flycatcher territories in the San Diego Management Unit. The population's stability is evidence of effective Marine Corps stewardship. On the other hand, the lack of expansion into available habitat on the Base suggests that the population targets for the San Diego Management Unit are not realistic.

Response: The USFWS believes that the amount of potentially suitable habitat within the San Diego Management Unit will support the minimum population target of 125. The known number of territories for this Management Unit is 101 (see Section IV.B., Table 9, page 84).

Issue #69

Comment: The plan fails to acknowledge numerous documented observations and breeding information for willow flycatcher (now being considered southwestern) in the San Luis Valley Management Unit. Recent blood chemistry and DNA work done on birds from the Alamosa National Wildlife Refuge concluded that the birds in the Upper Rio Grande most closely resemble southwestern willow flycatcher and should be treated as such (Paxton 2000). Paxton (2000) presents many locations of the southwestern willow flycatcher in the San Luis Valley Management Unit that have heretofore been discounted or overlooked. The literature search done by Owen and Sogge (1997) for the San Luis Valley Management Unit was inadequate and failed to do a thorough examination of all the existing data in the San Luis Valley Management Unit. There is considerable evidence by numerous observations by amateur and professional birders/biologists that cannot be discounted nor overlooked.

Response: The Recovery Plan references the results of Paxton 2000 (indicating that the San Luis Valley flycatchers show the genetic characteristics of *extimus)* as justification for inclusion of these birds within the range of *extimus*. The current southwestern willow flycatcher population data for the San Luis Valley is not based on Owen and Sogge (1997); rather, it is from Sogge et al. (2002) , which reports current (1993 - 2001) breeding sites as recognized by the USFWS and/or the wildlife agency of the state in which they occur. This is necessary because detections of other species of willow flycatchers (e.g., *E.t. adastus* and *brewsteri*) are common and widely distributed throughout the southwest as they migrate northward during the early portions of the breeding season. Sogge et al. (2002) coordinated closely with Federal and State wildlife agencies during data compilation efforts in order to avoid erroneously reporting migrant detections as breeding individuals, which would inaccurately inflate abundance estimates for *E.t. extimus*. Furthermore, during 2002, the authors of Sogge et al. (2002) met with amateur and professional biologists in the San Luis Valley to review existing information on the current status and distribution of the flycatcher, and trained over 20 biologists to conduct additional flycatcher surveys in that region; any new information arising from these surveys will be included in future Recovery Plan updates.

Issue #70

Comment: Recovery goals for the flycatcher in the middle Rio Grande are unrealistic because they appear to be inconsistent with current management practices for protection and enhancement of habitat for the silvery minnow, land management agencies are actively engaged in removing exotic saltcedar and Russian Olive to save water for the minnow.

Response: The recovery goals for the flycatcher are consistent with current management for the silvery minnow, as the plan provides for removal of exotics in certain circumstances. Continued coordination between and within agencies is vital.

The most extensive project ever undertaken to investigate water savings by tamarisk removal is the U.S. Geological Survey's multi-year, multi-million dollar project on the Gila River below Safford. The results of that project are the most closely controlled scientific investigation in the literature. The results are available in U.S. Geological Survey Professional Papers 655A through 655J. The project extended over a 10-year period, and included precipitation, groundwater well, surface water discharge, and individual plant data to produce a highly detailed water budget that showed the amount of water saved was within the error envelop of the measurements and no more. The savings of removing tamarisk are lost because of the replacement surface (i.e., a bare surface loses a great deal of water through evaporation, and other plants use high amounts of water as well). The USGS project was designed to address this issue – to conduct a rigid controlled experiment where as many variables as possible could be accounted for.

Issue #71

Comment: The Virgin Management Unit could be managed to increase flycatcher territories to a minimum of 100 territories. The Virgin River flows approximately 80 km from Littlefield, Arizona, to its confluence with Lake Mead. This entire stretch of the Virgin River is an active floodplain that creates and alters habitat on an annual basis. A land or water rights acquisition program could ensure ample in-stream flows to accomplish this goal.

Response: The Recovery Plan has been revised in response to these comments (see Section IV.B., Table 9).

Issue #72

Comment: The Bill Williams Management Unit includes areas below and above Alamo Dam. Current known territories are listed at 25, with the majority of them found above Alamo Dam. Increased survey efforts have found additional pairs below Alamo Dam on the Bill Williams River National Wildlife Refuge. The minimum number of territories listed for reclassification is 75. However, reaching this number will depend on the potential acquisition of Planet Ranch from the City of Scottsdale. If this acquisition goes through, then the minimum territories may increase to 100.

Response: The Recovery Plan has been revised in response to this comment (see Section IV.B., Table 9).

Issue #73

Comment: The Pahranagat Valley has the potential to increase the number of flycatcher territories to a minimum of 50 territories. Past survey efforts were limited to mainly native plant dominated habitat on Pahranagat National Wildlife Refuge. Surveys were not conducted within exotic plant dominated habitats on the refuge and limited surveys were conducted on privately owned parcels within the valley. The opportunity for habitat acquisition is limited within the Pahranagat Valley due to political restraints; however, some opportunity for purchase of conservation easements or habitat restoration on private and state lands does exist. The potential for habitat restoration exists on Pahranagat National Wildlife Refuge.

Response: The Recovery Plan has been revised in response to this comment (see Section IV.B., Table 9).

Issue #74

Comment: The minimum number of territories for reclassification should be adjusted slightly for the Lower Colorado Recovery Unit. Specifically, the Hoover to Parker Management Unit has much less potential habitat (based on floodplain characteristics) than the Parker to Mexico Management Unit. Opportunities for habitat expansion are much more limited geographically in the Hoover to Parker reach than from Parker to Mexico. The Hoover to Parker reach is dominated by canyons that have been flooded to form lakes; the Mohave Valley represents the main opportunity for habitat expansion. Much of the Mohave Valley is within the Havasu National Wildlife Refuge, dominated by Topock Marsh. The Colorado River is heavily channelized through the Mohave Valley and groundwater is deep below the land surface, limiting opportunities for habitat management. Based on the proportions of floodplain in the two reaches, target numbers of territories for reclassification should be redistributed.

Response: The Recovery Plan has been revised in response to this comment (see Section IV.B., Table 9). After careful consideration of information provided by the Lower Colorado River Implementation Subgroup, no changes to the population goal for the Parker to Southerly International Border Management Unit were made at this time. The USFWS believes there is enough potentially suitable habitat within the Management Unit to support the minimum population target.

Issue #75

Comment: If the target 150 territories is met from Parker to Mexico Management Unit, it can only happen through a large-scale land acquisition and restoration program. Several sites within this reach could be used for habitat restoration. The Cibola Valley Irrigation and Drainage District, Palo Verde Irrigation District, and over 2000 acres of BLM administered agricultural leases offer the best opportunities for land acquisition and restoration. The Colorado River Indian Tribes have partnered on riparian restoration projects in the past and may want to be involved in this effort. Cibola NWR and Imperial NWR are located within this reach and the Service should participate in habitat restoration; however, funding opportunities will be limited. It may be possible to meet this ambitious goal but only through large-scale active restoration projects.

Response: The USFWS agrees that the goal is ambitious, but achievable. See also the response to Issue #78 which pertains to this Management Unit.

Issue #76

Comment: Along the Rio Grande in Texas, two management units (Pecos and Texas Rio Grande) have a question mark regarding minimum number of territories for reclassification. Does this mean no territories are expected? If territories are expected, will they be added to the Rio Grande's total, or subtracted from other units?

Response: After further assessment of these two Management Units, the minimum population targets were set at zero (see Section IV.B., Table 9, page 84).

Issue #77

Comment: To meet overall recovery objectives in the Plan, it is not necessary to have viable populations of flycatchers in every Recovery Unit, rangewide. Long-term persistence can be attained by the presence of functioning metapopulations in only some of the Recovery Units. Relaxing the standards for down and de-listing to either a portion of the target population, or preferably, to only a fraction of the Recovery Units would make recovery more achievable without significantly decreasing the probability of long-term persistence.

Response: The plan has been revised to include a criteria set B for downlisting (see Section IV.B., page 78), to provide further flexibility for plan implementation.

Issue #78

Comment: It is not clear whether the Service is requiring that all Management Units meet their respective minimum numbers before reclassification can occur or whether reclassification is being proposed on a unit by unit basis.

Response: Each Recovery Unit must meet its respective minimum population goal, with flexibility provided for Management Units contained therein. Downlisting and delisting will occur when all Recovery Units meet and maintain their population and habitat targets.

Issue #79

Comment: The goal that all management units must achieve and continuously maintain their minimum population goals wrongly assumes that the condition and quantity of flycatcher habitat will remain static over time. Riparian habitats are subject to cyclical and sudden declines and increases. Populations within management units can and are quite likely to vary significantly. Management and development pressures will vary in management units, hydrology of a management unit may impede recovery.

Response: The Recovery Plan takes into account the fact that habitat condition and quality will change over time (see Section II.C.2., page 17, "The Importance of Unoccupied Suitable Habitat and Potentially Suitable Habitat"). Flexibility has been built into the plan to allow for the dynamic nature of riparian habitat (see Section IV.B.).

Issue #80

Comment: The downlisting criteria require achieving 80 percent of the population objectives, and maintaining them for five consecutive years, in all six Recovery Units before downlisting is triggered. Conservation partners vary widely from one unit to another, those in one or more units who failed to act or to achieve success would penalize those in another who aggressively and successfully pursued recovery.

Response: The Recovery Plan has been revised in response to this comment. A second downlisting criterion has been added to increase the implementation flexibility of the plan (see Section IV.B.2.).

Issue #81

Comment: An insufficient case has been made to warrant treating Recovery Units as isolated populations that are separate, unique metapopulations with non-linked objectives. Thus, we believe the Service must offer another objective that would enable downlisting if 80 percent of the overall objective were accomplished in a lesser number of Recovery Units. We believe that achieving 80 percent of the rangewide objective in 3, or perhaps 4, of the units would be an appropriate trigger for downlisting.

Response: The Recovery Plan has been revised in response to this comment. A new downlisting criterion has been developed as a way to increase the flexibility plan implementation (see Section IV.B.2.).

Issue #82

Comment: The concept that de-listing criteria should focus on security of protected and created/restored habitats to accommodate and support target population numbers achieved in downlisting is a good one and represents a valid approach to accomplishing overall recovery. While certain recovery units may present challenges in meeting the projected habitat conservation targets, other units may actually be quite conservative. We would be most supportive of a recovery objective that is population-based (i.e., breeding pair based), when it is demonstrable that the species is clear of jeopardy because enough pairs are breeding to support a healthy metapopulation. We would support that approach more readily than one that unduly focuses on achievement of projected targets in all units before recovery is declarable.

Response: The recovery strategy recommended in the Recovery Plan is population based (i.e., recovery criteria of 1,950 territories) and habitat based (i.e., spatial distribution). The population targets establish a distribution and abundance of flycatchers that minimizes the distance between populations, connects isolated sites to other breeding populations, and increases population sizes to achieve metapopulation stability (see Section IV.A.4., page 73).

Issue #83

Comment: The general criteria for management agreements necessary for delisting are poorly defined, highly subjective, and thus probably impossible to achieve. No definition is provided for the word protected or how much area must be protected. No criteria is provided to indicate which areas are critical to metapopulation stability, or what a network of conservation areas is that would support recovery.

Response: The Recovery Plan has been revised in response to these comments. Examples of management agreements may be found in Section IV.B.2., page 79; Table 10 has been expanded to identify areas where recovery efforts should be focused; and the delisting criteria in Section IV.B.2., pages 81-82, “Removal from the Federal Endangered Species List”, provide a measurable context for how much area must be protected for the benefit of breeding flycatchers.

Issue #84

Comment: We are unable to find the scientific justification or rationale for the delisting criterion that the amount of suitable breeding habitat be double that necessary to support the target number of flycatchers within each Management Unit under the criteria for threatened status. Do we know how much habitat this will require in each Management Unit? If so, is it feasible to restore enough habitat to accomplish recovery? If these parameters are not currently known, is it possible to determine how much habitat is necessary to accomplish recovery and how much habitat needs to be created? If the answers to any of the above questions are not known, we recommend that focused research directed at providing said answers should be a high-priority recovery action. Such research may be a prerequisite for the establishment of realistic recovery criteria.

Response: The Recovery Plan has been revised to address these comments (see Section IV.B.2., page 80). The USFWS believes it is feasible to restore enough habitat to accomplish the recovery goal.

Issue #85

Comment: The recovery objectives and criteria do not even mention the statutory listing factors which must be addressed.

Response: The Recovery Plan has been revised in response to this comment (see Section IV.F., page 138).

Issue #86

Comment: The Plan fails to set forth management actions on a site-specific basis as is required by the ESA. A recovery plan must, to the maximum extent practicable incorporate site specific management actions necessary for the conservation and survival of the flycatcher. The Service already has extensive documentation on operation of dams on the lower Colorado River and Salt River. We believe that each dam and river system is unique in terms of what actions the Service may be able to implement to aid in recovery of the flycatcher. Any proposed modifications to dam operating rules or dam operations should be accurately described and separately identified.

Response: The Recovery Plan has been revised in response to this comment. To obtain information on site-specific management actions that will aid the flycatcher, the plan now calls for the development of feasibility plans for the modification of dam and reservoir operations in flycatcher habitat. These studies will identify site-specific management actions that are legally, economically, and logistically feasible to implement (refer to Section V., page 143, actions 1.1.2.1.1.– 1.1.2.1.9.).

Issue #87

Comment: The Service should include in the Plan suggestions for meaningful Tribal participation offered by the Tribal Working Group in fulfilling the Federal Governments trust responsibility to Indian Tribes as outlined in Secretarial Order 3206.

Response: The Recovery Plan has been revised in response to this comment (see Section IV.E., Narrative Outline for Recovery Actions, actions 1.3.1. – 1.3.6., and Section V., actions 1.3.1.– 1.3.6.).