Invasive Plants of California's Wildland

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Foreword >

Invasive Plants of California's Wildland

Foreword

The heart of this book is the species accounts, which provide detailed information about the biology and control of seventy-eight non-native plant species that are listed as Exotic Invasive Plants of Greatest Ecological Concern as of 1996 by the California Exotic Pest Plant Council (Cal-IPC). We decided to cover only the species on this list because it is the best effort to date1 to determine which of the non-native plants already growing wild in California cause or have the potential to cause serious damage in the state's parks, preserves, and other wildlands. We are convinced that non-native invasive plants pose one of worst threats, perhaps the worst of all, to the state's remaining populations and communities of native species. We hope the information on the pages that follow will be used to help promote the survival and growth of native plants and animals threatened by these invaders.

Cal-IPC was established in 1992 in response to growing concern about invasive non-native plants in the state's wildlands. In 1994 Cal-IPC canvassed its members and other land managers and researchers around the state for information about non-native plants that invade California's preserves, parks, and other wildlands. This information was used to develop a list of Exotic Invasive Plants of Greatest Ecological Concern in California. The species were grouped into several categories to indicate how severe and/or widespread they are. List A-1 includes the most invasive and damaging species that are widespread in the state. List A-2 includes highly damaging species that are invasive in fewer than five of the geographic subdivisions designated in The Jepson Manual: Higher Plants of California. List B includes less invasive species that move into and degrade wildlands. The Red Alert List includes species whose ranges in California currently are small but that are believed to have the potential to spread explosively and become major pests. Species for which there was insufficient information to determine their ability to invade and degrade natural areas were placed on a Need More Information list and only a few for whom strong evidence is mounting are included in this book. As the list was being compiled and categorized it was reviewed, re-reviewed, and finally approved by a group of respected researchers. In 1996 the Cal-IPC list was updated based on new information and expanded to include a total of seventy-eight species.

We begin this book with a brief overview of the impacts of invasive plants and what we know about the characteristics of plant species most likely to invade and the habitats and communities most likely to be invaded. This is followed by a discussion of strategies and methods appropriate for the control of invasive plants in parks, preserves, and other wildlands. The remainder of the book consists of species accounts for seventy-eight invasive non-native species. Each account helps readers to identify the species and understand important aspects of its biology and lists specific control methods that are regarded as relatively effective, as well as some found to be ineffective.

[1] We acknowledge that several non-native invaders that have caused severe damage to wildlands in California are not on the 1996 edition of the list, as does Cal-IPC. As we write this Cal-IPC is preparing an updated version of the list, but it will not be ready in time for us to include newly listed species.

Invasive Plants of California's Wildland

California Wildland Invasive Plants

John M. Randall and Marc C. Hoshovsky

The focus of this book is non-native plants that invade parks, preserves, and other wildlands in California, but our real concern is the survival and growth of the native plants and animals these invaders threaten. Unfortunately, some non-native invasive plant species inflict so much damage that, unless they are controlled, it will be impossible to preserve viable populations of many native species or many of the state's natural communities and ecosystems.

The good news is that many plant invasions can be halted or slowed, and, in certain situations, even badly infested areas can be restored to relatively healthy communities dominated by native species. Weed control and restoration are now widely regarded as necessary in many wildlands across the state and around the world. We hope this book will help land managers, volunteer stewards, and others to recognize some of California's most damaging wildland in vad ers, to better understand their impacts, and to minimize the damage they do to native biological diversity.

Invasive species are now widely recognized worldwide as posing threats to biological diversity second only to direct habitat loss and fragmentation (Pimm and Gilpin 1989, Scott and Wilcove 1998). In fact, when biological invasion by all types of organisms is considered as a single phenomenon, it is clear that to date it has had greater impacts on the world's biota than have more notorious aspects of global environmental change such as rising CO_2 concentrations, climate change, and decreasing stratospheric ozone levels (Vitousek et al. 1996). Compared to other threats to biological diversity, invasive non-native plants present a complex problem that is difficult to manage and has long-lasting effects. Even when exotics are no longer actively introduced, these plants continue to spread and invade new areas. Effective control will require awareness and active participation of the public as well as natural resource managers and specialists.

California's invasive plant problems are widespread and severe. The state's varied topography, geology, and climates have helped to give rise to the state's extraordinary native biological diversity and high levels of endemism. However, these varied conditions also provide suitable habitat for a wide variety of non-native plant species, many of which have readily established and rapidly spread in the state. Fewer than ten percent of the 1,045 non-native plant species that have established in California are recognized as serious threats (Randall et al. 1998), but these have dramatically changed California's ecological landscape. They alter ecosystem functions such as nutrient cycles, hydrology, and wildfire frequency, outcompete and exclude native plants and animals, harbor dangerous animal invaders, and hybridize with native species. Some spread into national parks, preserves, and other wildlands and reduce or eliminate the species and communities these sites were set aside to protect.

Rare species appear to be particularly vulnerable to the changes wrought by non-native invaders. For example, the California Natural Diversity Database indicates that 181 of the state's rare plant species are experiencing threats from invasive weeds (California Department of Fish and Game, Natural Heritage Division). Habitats for rare animals such as the San Clemente sage sparrow and the Palos Verde blue butterfly are also being invaded. Even more common species could be driven to rarity or near extinction by particularly disruptive invaders, as evidenced by the fate of the American chestnut (Castanea dentata) in the eastern hardwood forest following introduction of chestnut blight, Cryphonectria parasitica (National Academy of Science 1975).

IMPACTS OF INVASIVE PLANTS ON WILDLANDS

Non-native plant invasions can have a variety of effects on wildlands, including alteration of ecosystem processes; displacement of native species; support of non-na tive animals, fungi, or microbes; and alteration of gene pools through hybridization with native species.

Ecosystem Effects

The invasive species that cause the greatest damage are those that alter ecosystem processes such as nutrient cycling, intensity and frequency of fire, hydrological cycles, sediment deposition, and erosion (D'Antonio and Vitousek 1992, Vitousek 1986, Vitousek and Walker 1989, Vitousek et al. 1987, Whisenant 1990). These invaders change the rules of the game of survival and growth, placing many native species at a severe disadvantage (Vitousek et al. 1996). Cheat grass (Bromus tectorum) is a well studied example of an invader that has altered ecosystem processes. This annual grass has invaded millions of acres of rangeland in the Great Basin, leading to widespread increases in fire frequency from once every sixty to 110 years to once every three to five years (Billings 1990, Whisenant 1990). Native shrubs do not recover well from more frequent fires and have been eliminated or reduced to minor components in many of these areas (Mack 1981).

Some invaders alter soil chemistry, making it difficult for native species to survive and reproduce. For example, iceplant (Mesembryanthemum crystallinum) accumulates large quantities of salt, which is released after the plant dies. The increased salinity prevents native vegetation from reestablishing (Vivrette and Muller 1977, Kloot 1983). Scotch broom (Cytisus scoparius) and gorse (Ulex europaea) can increase the content of nitrogen in soil. Although this increases soil fertility and overall plant growth, it gives a competitive advantage to non-native species that thrive in nitrogen-rich soil. Researchers have found that the nitrogen-fixing firetree (Myrica faya) increases soil fertility and consequently alters succession in Hawaii (Vitousek and Walker 1989).

Wetland and riparian invaders can alter hydrology and sedimentation rates. Tamarisks (Tamarix chinensis, T. ramosissima, T. pentandra, T. parviflora) invade wetland and riparian areas in southern and central California and throughout the Southwest, and are believed to be responsible for lowering water tables at some sites. This may reduce or eliminate surface water habitats that native plants and animals need to survive (Brotherson and Field 1987, Neill 1983). For example, tamarisk invaded Eagle Borax Spring in Death Valley in the 1930s or 1940s. By the late 1960s the large marsh had dried up, with no visible surface water. When managers removed tamarisk from the site, surface water reappeared, and the spring and its associated plants and animals recovered (Neill 1983). Tamarisk infestations also can trap more sediment than stands of native vegetation and thus alter the shape, carrying capacity, and flooding cycle of rivers, streams, and washes (Blackburn et al. 1982). Interestingly, the only species of Tamarix established in California that is not generally regarded as invasive (athel, or T. aphylla) is regarded as a major riparian invader in arid central Australia.

Other wetland and riparian invaders and a variety of beach and dune invaders dramatically alter rates of sedimentation and erosion. One example is saltmarsh cordgrass (Spartina alterniflora), native to the Atlantic and Gulf coasts and introduced to the Pacific Coast, where it invades intertidal habitats. Sedimentation rates may increase dramatically in infested areas, while nearby mudflats deprived of sediment erode and become areas of open water (Sayce 1988). The net result is a sharp reduction in open intertidal areas where many migrant and resident waterfowl feed.

Coastal dunes along the Pacific Coast from central California to British Columbia have been invaded and altered by European beachgrass (Ammophila arenaria). Dunes in infested areas are generally steeper and oriented roughly parallel to the coast rather than nearly perpendicular to it as they are in areas dominated by Leymus mollis, L. pacificus, and other natives (Barbour and Johnson 1988). European beachgrass eliminates habitats for rare native species such as Antioch Dunes evening-primrose (Oenothera deltoides ssp. howellii) and Menzies' wallflower (Erysimum menziesii ssp. menziesii). Species richness on foredunes dominated by European beachgrass may be half that on adjacent dunes dominated by Leymus species (Barbour et al. 1976). Changes in the shape and orientation of the dunes also alter the hydrology and microclimate of the swales and other habitats behind the dunes, affecting species in these areas.

Some upland invaders also alter erosion rates. For example, runoff and sediment yield under simulated rainfall were fifty-six percent and 192 percent higher on plots in western Montana dominated by spotted knapweed (Centaurea maculosa) than on plots dominated by native bunchgrasses (Lacey et al 1989). This species is already established in northern California and the southern Peninsular Range and recently was found on an inholding within Yosemite National Park (Hrusa pers. comm.).

Some invasive plants completely alter the structure of the vegetation they invade. For example, the punk tree (Melaleuca quinquenervia) invades marshes in southern Florida's Everglades that are dominated by sedges, grasses, and other herbaceous species, rapidly converting them to swamp forest with little or no herbaceous understory (LaRoche 1994, Schmitz et al. 1997). Such wholesale changes in community structure may be expected to be followed by changes in ecosystem function.

HABITAT DOMINANCE AND DISPLACEMENT OF NATIVE SPECIES

Invaders that move into and dominate habitats without obviously altering ecosystem properties can nevertheless cause grave damage. They may outcompete native species, suppress native species recruitment, alter community structure, degrade or eliminate habitat for native animals, and provide food and cover for undesirable non-native animals. For example, edible fig (Ficus carica) is invading riparian forests in the Central Valley and surrounding foothills and can become a canopy dominant. Invasive vines are troublesome in forested areas across the continent. In California, cape ivy (Delairea odorata) blankets riparian forests along the coast from San Diego north to the Oregon border (Elliott 1994).

Non-native sub-canopy trees and shrubs invade forest understories, particularly in the Sierra Nevada and Coast Ranges. Scotch broom (Cytisus scoparius), French broom (Genista monspessulana), and gorse (Ulex europaea) are especially troublesome invaders of forests and adjacent openings and of coastal grasslands (Bossard 1991a, Mountjoy 1979). Herbaceous species can colonize and dominate grasslands or the ground layer in forests. Eupatory (Ageratina adenophora) invades and dominates riparian forest understories along California's southern and central coast. Impacts of these ground-layer invaders have not been well studied, but it is suspected that they displace native herbs and perhaps suppress recruitment of trees.

Annual grasses and forbs native to the Mediterranean region have replaced most of California's native grasslands. Invasion by these species was so rapid and complete that we do not know what the dominant native species were on vast areas of bunchgrasses in the Central Valley and other valleys and foothills around the state. The invasion continues today as medusa-head (Taeniatherum caput-medusae) and yellow starthistle (Centaurea solstitialis) spread to sites already dominated by other non-natives. Yellow starthistle is an annual that produces large numbers of seeds and grows rapidly as a seedling. It is favored by soil disturbance, but invades areas that show no sign of being disturbed by humans or livestock for years and has colonized several relatively pristine preserves in California, Oregon, and Idaho (Randall 1996b).

In some situations invasive, non-native weeds can prevent reestablishment of na tive species following natural or human-caused disturbance, altering natural suc ces sion. Ryegrass (Lolium multiflorum), which is used to reseed burned areas in southern California, interferes with herb establishment (Keeley et al. 1981) and, at least in the short term, with chaparral recovery (Schultz et al. 1955, Gautier 1982, Zedler et al. 1983).

Hybridization with Native Species

Some non-native plants hybridize with natives and could, in time, effectively eliminate native genotypes. The non-native Spartina alterniflora hybridizes with the native S. foliosa where they occur together. In some Spartina populations in salt marshes around south San Francisco Bay, all individual plants tested had non-native genes (Ayres et al. in press).

Promotion of Non-Native Animals

Many non-native plants facilitate invasions by non-native animals and vice versa. Myrica faya invasions of volcanic soils in Hawaii promote populations of non-native earthworms, which increase rates of nitrogen burial and accentuate the impacts these nitrogen-fixing trees have on soil nutrient cycles (Aplet 1990). M. faya is aided by the non-native bird, Japanese white-eye (Zosterops japonica), perhaps the most active of the many native and non-native species that consume its fruits and disperse its seeds to intact forest (Vitousek and Walker 1989).

EARLY INVASIONS BY NON-NATIVE PLANTS

The first recorded visit by European explorers to the territory now called California occurred in 1524, but people of Old World ancestry did not begin to settle here until 1769. Available evidence indicates that the vast majority of non-native plants now established in California were introduced after this time. There is compelling evidence that red-stem filaree (Erodium cicutarium), and perhaps a few other species, may have established even earlier, perhaps after being carried to the territory by roaming animals or by way of trading networks that connected Indian communities to Spanish settlements in Mexico (Hendry 1931, Hendry and Kelley 1925, Mensing and Byrne 1998). Once settlers began to arrive, they brought non-native plants accidentally in ship ballast and as contaminants of grain shipments and intentionally for food, fiber, medicine, and ornamental uses (Frenkel 1970, Gerlach 1998).

The number of non-native species established in California rose from sixteen during the period of Spanish colonization (1769-1824) to seventy-nine during the period of Mexican occupation (1825-1848) to 134 by 1860 following American pioneer settlement (Frenkel 1970). Jepson's A Manual of the Flowering Plants of California (1925), the first comprehensive flora covering the entire state, recognized 292 established non-native species. Rejmnek and Randall (1994) accounted for taxonomic inconsistencies between the 1993 Jepson Manual and earlier floras and found that Munz and Keck's 1959 A Flora of California included 725 non-native plants species and their 1968 A California Flora and Supplement included 975. The 1993 Jepson Manual recorded 1,023 non-natives, and subseqent reports in the literature have brought the number up to 1,045 (Randall et al. 1998). Rejmnek and Randall (1994) remarked that, although non-native species continue to establish in California, the rate of increase in their number appears to be slowing after roughly 150 years of rapid growth.

Most non-native plants introduced to California in earlier times first established at coastal sites near ports and around missions and other settlements. In recent times, first reports of new non-native species have come from every major geographic subdivision of the state (Rejmnek and Randall 1994). Apparently, the great speed and reach of modern transportation systems and the increasing global trade in plants and other commodities have enabled non-natives to spread to sites throughout the state. A variety of human activities continue to introduce new species to California and to spread those that have established populations in only a few areas. For example, land managers still introduce non-native species to control erosion or provide forage for livestock. New ornamental plants and seeds are imported and sold. Movement of bulk commodities such as gravel, roadfill, feed grain, straw, and mulch transport invasive plant propagules from infested to uninfested areas (OTA 1993). The rate of spread is often alarming. For example, within California, yellow starthistle has expanded its range at an exponential rate since the late 1950s, increasing from 1.2 to 7.9 million acres by 1991 (Maddox et al. 1996, Thomsen et al. 1993).

Problems caused by invasive plants in California were recognized by Frederick Law Olmsted in 1865 in a report he filed on the newly set-aside Yosemite Valley, noting that, unless actions were taken, its vegetation likely would be diminished by common weeds from Europe. The report pointed out that this had already happened in large districts of the Atlantic States. Botanists and other students of natural history noted the establishment of non-native species in the state in published papers, and by the 1930s natural area managers in Yosemite and scattered parks and preserves around the state began controlling invading non-native species that were recognized as agricultural pests (Randall 1991). The issue was brought into mainstream ecology in the late 1950s with the publication of Charles Elton's book, The Ecology of Invasions by Animals and Plants (1958). Concern and interest among both land managers and researchers have grown since that time, particularly since the mid-1980s.

SPECIES MOST LIKELY TO BE INVASIVE

Many people have wondered if certain traits distinguish species that become invasive. Despite a great deal of study, no single answer presents itself, and researchers have been surprised by the success of some species and the failure of others. Studies conducted in 1980 in central California on Peruvian pepper (Schinus molle) and its close relative Brazilian pepper (Schinus terebinthifolius) failed to determine why the former was spreading in California (Nilsen and Muller 1980a, 1980b). Instead the studies suggested Brazilian pepper was the more invasive species. Recently, Brazilian pepper has been found to be invasive in southern California, so perhaps studies of this type do have some predictive power.

Despite these puzzling cases, recent work has pointed to several factors that may help to predict which species are likely to be invasive. In two studies the best predictor was whether a species was invasive elsewhere (Panetta 1993, Reichard and Hamilton 1997). For example, if a species native to Spain is invasive in Western Australia, it is likely to be invasive in California and South Africa as well. Rejmnek and Richardson (1996) analyzed characteristics of twenty species of pines and found that the invasive species were those that produce many small seeds and that begin reproducing within their first few years. When they extended the analysis to a group of flowering trees, these same characters usually discriminated between invasive and non-invasive species. This study and several others also found plants with animal-dispersed seeds, such as bush honeysuckles or ligustrums, are much more likely to be invasive in forested communities (Reichard 1997, Reichard and Hamilton 1997). It has also been suggested that species capable of reproducing both by seed and by vegetative growth have a better chance of spreading in a new land (Reichard 1997).

Self-compatible species, with individuals that can fertilize themselves, have been thought more likely to invade, since a single plant of this type could initiate an invasion (Baker 1965). However, many self-incompatible species are successful invaders, including some with male and female flowers on separate plants. It is also thought that plants dependent on one or a few other species for pollination, fruit dispersal, or the uptake of nutrients from the soil are less likely to invade new areas unless these organisms are introduced at the same time. As a group, figs may be relatively poor invaders because, with few exceptions, each species is pollinated by a distinctive species of wasp that is in turn dependent on that species of fig. However, the edible fig's pollinator was introduced to promote fruit production, and now the species is invasive in parts of California. Other plant invasions may be promoted by introduced animals as well. For example, honeybees boost seed production of invaders whose flowers they favor (Barthell pers. comm.). In Hawaii feral pigs promote the spread of banana poka (Passiflora mollissima) and other species by feeding voraciously on their fruits and distributing them in their scat, often in soil they have disturbed while rooting for food.

It has also been suggested that species with relatively low DNA contents in their cell nuclei are more likely to be invasive in disturbed habitats (Rejmnek 1996). Under certain conditions, cells with low DNA contents can divide and multiply more quickly, and consequently these plants grow more rapidly than species with higher cellular DNA content. Plants that germinate and grow rapidly can quickly occupy such areas and exclude other plants following disturbance.

It is generally agreed that a species is most likely to invade an area with a climate similar to that of its native range, but some non-native species now thrive in novel conditions. An analysis of the distribution of non-native herbs of the sunflower and grass families in North America indicated that species with a larger native range in Europe and Asia are more likely to become established and to have a larger range here than species with small native ranges (Rejmnek 1995). It is thought that species with large native ranges are adapted to a variety of climate and soil conditions and are more likely to find suitable habitat in a new area. This ability to cope with different conditions can be attributed in part to genetic plasticity (genetic differences among individuals of a species) or to phenotypic plasticity (the ability of any given individual of some species to cope with a variety of conditions). Another factor that may help to determine whether a plant will invade a site is whether it is closely related to a native species (e.g., in the same genus). Plants without close relatives appear more likely to become established (Rejmnek 1996).

A species may be more likely to become established if many individuals are introduced at once or if they are introduced repeatedly. Introductions of many individuals may help to ensure that they will mate and produce offspring and that there will be sufficient genetic variability in the population for the species to cope with a wider variety of conditions. In addition, if sites where the species can successfully germinate and grow are limited in number, the chance that at least one seed scattered at random will land on an appropriate site increases with the number of seeds dispersed. Chance may be important in other ways. For example, species that happen to be introduced at the beginning of a drought may be doomed to fail, although they might easily establish following a return to normal rainfall. An early introduction may by chance include no individuals with the genetic makeup to thrive in an area, while a later introduction may include several.

There is often a time lag of many decades between the first introduction of a plant and its rapid spread. In fact, some species that rarely spread today may turn out to be troublesome forty, fifty, or more years from now. This makes it all the more urgent that we find some way of determining which species are most likely to become invasive so that we can control them while their populations are still small.

HABITATS AND COMMUNITIES MOST LIKELY TO BE INVADED

Another question that has long intrigued ecologists is why some areas appear more prone to invasion than others. Again, many hypotheses have been advanced, but we have few solid answers. There is even some question about which areas have suffered the highest numbers of invasions, since this may differ depending on the type of organism considered and which species are regarded as firmly established. A given area may be highly susceptible to invasion by one type of organism and highly resistant to another, while the situation might be reversed in other areas.

It is generally agreed that areas where the vegetation and soil have been disturbed by humans or domestic animals are more susceptible to invasion. In North America disturbed sites are commonly invaded by species native to the Mediterranean region and the fertile crescent of the Old World where the plants had millennia to adapt to agricultural disturbances. Changes in stream flows, the frequency of wildfires, or other environmental factors caused by dam building, firefighting, and other human activities may also hinder survival of native plants and promote invasion by non-natives. Nonetheless, reserves and protected areas are not safe from exotic species. In a 1996 poll, sixty-one percent of National Park Service supervisors throughout the United States reported that non-native plant invasions are moderate to major problems within their parks. In more than half (fifty-nine percent) of The Nature Conservancy's 1,500 preserves exotic plants are considered one of the most important management problems (TNC 1996a, 1997).

It is also safe to say that remote islands in temperate and tropical areas appear to be highly susceptible to invasions by non-native plants and animals. For example, nearly half (forty-nine percent) of the flowering plant species found in the wild in Hawaii are non-native as are twenty-five percent of plants on California's Santa Cruz Island (Junak et al. 1995). Most remote islands had no large native herbivores, so pigs, cattle, sheep, and other grazers introduced by humans found the native plants unprotected by spines or foul-tasting chemicals. Introduced grazers often denuded large areas of native vegetation, leaving them open to colonization by introduced species adapted to grazing. There is also speculation that islands, peninsulas such as southern Florida, and other areas with low numbers of native species or without any representative or distinctive groups are more prone to invasion. For example, there are no rapidly growing woody vines native to the Hawaiian Islands, where several introduced vines have become pests. Some researchers theorize that where such gaps exist, certain resources are used inefficiently if at all. Such open niches are vulnerable to invasion by non-native species capable of exploiting these resources. Other researchers reject this concept, maintaining that open niches are impossible to identify in advance and that when new species move in they do not slip into unoccupied slots but instead use resources that would have been used by organisms already present.

History likely also plays a large role in determining the susceptibility of a site to invasion. Busy seaports, railroad terminals, and military supply depots are exposed to multiple introductions. People from some cultures are more likely to introduce plants from their homelands when they migrate to new regions. In fact, colonization of much of the Americas, Australia, and other areas of the world by western Europeans and the plants and animals from their homelands may go hand in hand, the success of one species promoting the success of others. European colonists were followed, sometimes preceded, by animals and plants with which they were familiar and that they knew how to exploit. The plants and animals benefited in turn when these people cleared native vegetation and plowed the soil.

DEFINITIONS OF TERMS USED IN THIS BOOK

Native plants are those growing within their natural range and dispersal potential. They are species or subspecies that are within the range they could occupy without direct or indirect introduction and/or care by humans. Most species can be easily classed as either native or non-native using this definition, but there are some gray areas. Natural ranges should not be confused with political or administrative boundaries. Bush lupine (Lupinus arboreus), for example, may be thought of as a California native, but its native range is only along the central and southern coasts of the state. It is not native along the north coast, where it was intentionally planted outside its natural range (Miller 1988, Pickart this volume). All hybrids between introduced or domesticated species and native species are also non-native.

Non-native plants are those species growing beyond their natural range or natural zone of potential dispersal, including all domesticated and feral species and all hybrids involving at least one non-native parent species. Other terms that are often used as synonyms for non-native include alien, exotic, introduced, adventive, non-indigenous, non-aboriginal, and naturalized. With rare exceptions, conservation programs are dedicated to the preservation of native species and communities. The addition of non-native species rarely contributes positively to this unless these plants alter the environment in ways that favor native species as do some grazers and biological control agents.

Natural areas are lands and waters set aside specifically to protect and preserve undomesticated organisms, biological communities, and/or ecosystems. Examples include most national parks, state and federally designated wilderness areas, and preserves held by private organizations such as The Nature Conservancy and the National Audubon Society.

Wildlands include natural areas and other lands managed at least in part to promote game and/or non-game animals or populations of native plants and other organisms. Examples include federal wildlife refuges, some national and state forests, portions of Bureau of Land Management holdings, including some areas used for grazing, and some lands held by private landowners.

Pest plant and **weed** are used interchangeably in this book to refer to species, populations, and individual plants that are unwanted because they interfere with management goals and objectives. Plants regarded as pests in some wildlands may not be troublesome elsewhere. For example, the empress tree (Paulownia tomentosa) is a pest in deciduous forests of the eastern United States, particularly in the southern Appalachians, but it is not known to escape from cultivation in California, where it is used as an ornamental landscape tree. Some species that are troublesome in agricultural or urban areas rarely, if ever, become wildland weeds. The term environmental weeds is used by many Australians (Groves 1991, Humphries et al. 1991b) to refer to wildland weeds, but few North American land managers or researchers use this term.

Invasive species are those that spread into areas where they are not native, according to Rejmnek (1995), while other authors define as invasives only species that displace natives or bring about changes in species composition, community structure, or ecosystem function (Cronk and Fuller 1995, White et al. 1993). Most wildland weeds are both invasive and non-native, but not all non-native plants are invasive. In fact, only a small minority of the thousands of species introduced to California have escaped cultivation, and a minority of those that have escaped spread into wildlands.

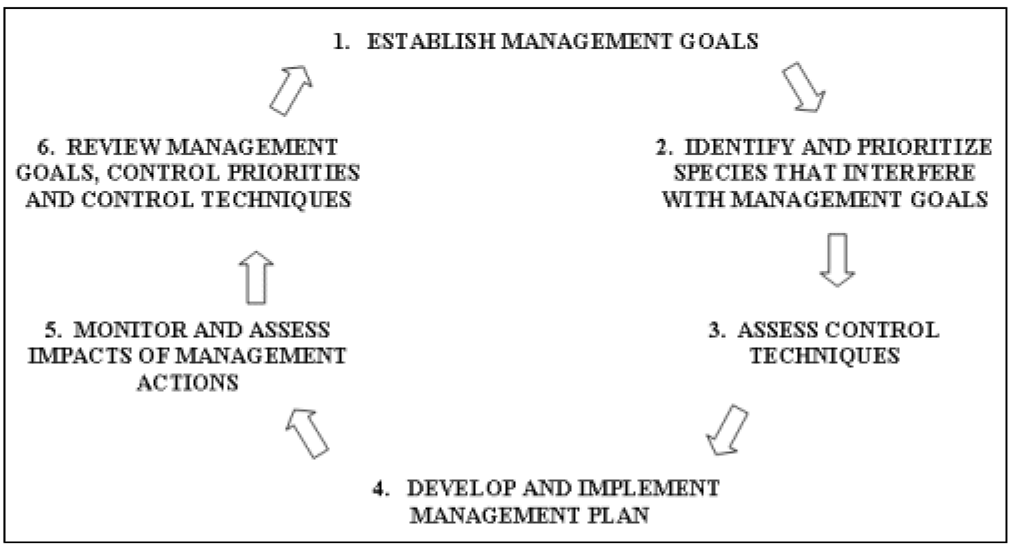
Management of Invasive Species >

Invasive Plants of California's Wildland

Management of Invasive Species

Marc C. Hoshovsk and John M. Randall

Before embarking on a weed management program, it is important to develop a straightfor-ward rationale for the actions you plan to take. We believe this is best accomplished using an adaptive management approach as follows: (1) establish management goals and objectives for the site; (2) determine which plant species or populations, if any, block or have potential to block attainment of management goals and objectives; (3) determine which methods are available to control the weed(s); (4) develop and implement a management plan designed to move conditions toward management goals and objectives; (5) monitor and assess the impacts of management actions in terms of effectiveness in moving toward goals and objectives; and (6) reevaluate, modify, and start the cycle again (Figure 1). Note that control activities are not begun until the first three steps have been taken.



It is vital to establish management goals before embarking on any management activities. What is it you want to protect or manage? Is your objective to protect or enhance a certain species or community, preserve a vignette of pre-Columbian America, preserve certain ecosystem attributes, or preserve a functioning ecosystem? A weed control program is best viewed as part of an overall restoration program, so focus on what you want in place of the weed, rather than simply eliminating the weed. Keep in mind that the ultimate purpose of a weed control program is to further the goal of preserving a species, community, or functioning ecosystem.

In many cases it will be easy to identify species that degrade the site or threaten to do so. If impacts of a species are not clear, you may need to monitor its abundance and effects on the natural community. Set priorities to minimize your total, long-term workload. This often means assigning highest priority to preventing new invasions and to quickly detecting and eliminating any new invasions that occur. High priority should also be assigned to the species with the most damaging impacts, to infestations that are expanding rapidly, and to infestations that affect highly valued areas of the site. Also consider the difficulty of control. It is of little use to spend time and resources to attack an infestation you have little hope of controlling.

Consider all control options available: manual, mechanical, encouraging competition from native plants, grazing, biocontrol, herbicides, prescribed fire, solarization, flooding, and other, more novel techniques. Each of these methods has advantages and disadvantages, and often the best approach is to use a combination of methods. Frequently, one or more methods will not be appropriate for a given situation because they do not work well, their use is objectionable to people in the area, or they are too costly. Herbicides may kill important non-target plants. Mechanical methods often disturb soil and destroy vegetation, providing ideal conditions for establishment of weedy species. It will often be best to employ two or more methods. For example, cutting and herbicides or prescribed fire and herbicides have been used successfully in combination in many weed control programs.

Biological control can be an extremely selective control tool, but there is some risk that control agents may attack desirable species. The best known example of a biocontrol agent attacking desirable species is that of Rhinocyllus conicus, a beetle first released to control non-native thistles in North America in the 1960s that was recently found attacking native thistles and reducing their populations at some sites (Louda et al. 1997).

Some native animals use invasive non-native species for food and cover and may have difficulty finding replacements if infestations are removed and not replaced with non-invasive native or introduced species. For example, huge numbers of monarch butterflies (Danaus plexippus) roost in some groves of Eucalyptus globulus in coastal California. In addition, elimination of plants in a natural area can be alarming to some people, particularly when herbicides are used, so it is important to explain the threats posed by the pest and the reasons why you chose the methods you did.

There is much room for improvement in control methods for many of the species described in this book. Readers may want to experiment with methods that may more effectively and efficiently control these invaders and promote native species.

The Bradley Method is a sensible approach to weed management (Bradley 1988, Fuller and Barbe 1985). In this approach, weed control is begun in portions of the site with the best stands of desirable native vegetation (those with few weeds) and proceeds slowly to areas with progressively worse weed infestations. This is similar to Moody and Mack's (1988) advice to attack outlying satellite weed populations first rather than larger, denser source populations. They based this advice on modeling work that indicated that the rate of spread of small satellite poplations is generally significantly higher than that of older, larger populations and that containing or eliminating the outliers saves time and effort in the long run. The Bradley Method dictates that the area under control should expand at a rate that allows previously treated areas to be monitored and kept in satisfactory condition. It also advocates the use of techniques that minimize damage to native plants and disturbance to the soil so that the natives can thrive and defend against reinvasion. This approach is particularly promising for small preserves or sites with access to large pools of volunteer labor. More detailed information on the Bradley Method is contained in Fuller and Barbe (1985).

PREVENTION

The most effective and efficient weed control strategies are preventing invasions by new plants species and quickly detecting invasions that occur so weeds can be eradicated or contained before they spread. The California Department of Food and Agriculture (CDFA) has long recognized this, and the state's Noxious Weed List gives highest priority to species that either are not yet established in the state or whose populations are not yet widespread. The state's native species will be better protected if new invaders are detected quickly and word of their discovery is communicated to those who can take action to prevent their spread, such as the staff at the CDFA Control and Eradication Branch or Plant Pest Diagnostics Branch.

There are already at least 1,045 non-native plant species established in California (Randall et al.1998), and more continue to arrive and become established. If allowed to spread, some of these new species could impact native species and communities as severely as yellow starthistle and tamarisk do now. Preventing or stopping just one new invasive weed would be of greater conservation benefit in the long run than far more costly and difficult efforts to control an already widespread pest.

Taking precautions in normal resource management activities can halt or slow the establishment and spread of weeds in a given area. Wise precautions include: removing seed sources from roads, trails, rights-of-way, watercourses, and other dispersal routes; closing unnecessary roads and trails where possible; planning work projects to minimize soil disturbance and reestablish vegetation as quickly as possible where disturbance does occur; limiting the use of construction materials such as gravel, fill, mulch, straw, and seed mixes that may carry weeds or buying from suppliers who guarantee their products are weed-free; washing vehicles and equipment to remove weed seeds and other propagules before they are used in another area; follow-up monitoring of work sites to detect new weed populations while they are still small and easily controlled; and public education and outreach regarding the importance of weed detection and prevention of invasion.

ERADICATION

Eradication is the complete elimination of a species from a given area. The great appeal of eradicating a weed is, of course, that once the project achieves success no more work is required and the species cannot spread unless it is re-introduced. Unfortunately, it is rarely possible to eradicate an established weed from a large area. In fact, the history of CDFA's eradication projects indicates that there is little likelihood of eradicating a species from California once it has spread to a few tens of acres in the state.

It may be possible to eradicate a weed from a given area, such as a preserve or national park if it has not yet become widespread there, but it is likely to re-invade from adjacent lands unless there is some barrier that will prevent it from doing so. Eradication is most likely when the species has just begun to establish in a new area, which underscores the importance of efforts to detect new invaders at national, state, and local levels.

PHYSICAL CONTROL

Physical methods of weed control generally are labor intensive and often are used for small populations or where other control methods are inappropriate, such as near sensitive water supplies. Nonetheless, physical methods have been used successfully by volunteer groups and paid workers to control weed infestations on several large sites in California (e.g., Pickart and Sawyer 1998). Physical methods can be highly selective, targeting only the pest species, but they can also disturb the soil or damage nearby vegetation, thereby promoting germination and establishment of weedy species. Physical control methods may also produce large amounts of debris, disposal of which is sometimes difficult.

Physical control methods range from manual hand pulling of weeds to the use of hand and power tools to uproot, girdle, or cut plants. Two companies produce tools specifically for pulling shrubs such as scotch broom, tamarisk, and Russian olive. The Weed Wrench (see Resources section) and the Root Jack (see Resources section) are lever arms with a pincher or clamp at the bottom that grips the plant stem. Once the stem is secured, the user leans back, tightening the clamp in the process. After a little rocking, the entire plant comes up, roots included (Hanson 1996). Other tools for weed control, including girdling knives, axes, machetes, loppers, clippers, chainsaws, and brush cutters, are available from hardware stores and gardening and forestry supply companies. Various attachments are available for bulldozers and tractors to clear and uproot woody plants. Brush rakes or blades may be mounted on the front of the bulldozer, and brushland disks or root plows may be pulled behind. Mowing can prevent seed formation on tall annual and perennial weeds and deplete food reserves of shoots and roots. Unfortunately, repeated mowing can favor low-growing weeds or damage desirable native species (Ashton and Monaco 1991).

Prescribed Fire

Fire can be an effective means of reducing weed infestations, particularly for shrub by weeds and in native communities that evolved with fire. Fire may sometimes be the only element necessary to give native species a chance to recover. Fire may also be used to eliminate old vegetation and litter in areas infested with perennial herbs such as fennel (Foeniculum vulgare) or leafy spurge (Euphorbia esula) prior to treating the area with herbicide. This allows more herbicide to reach the living leaves and stems of target plants, potentially enhancing its effectiveness. Fire can also be used to induce seeds of some species to germinate so the seedbank can be flushed and the resulting seedlings can then be killed with another fire or some other method (e.g., Bossard 1993).

Conducting a prescribed burn is not a simple or risk-free operation. Managers considering prescribed burning should be trained and certified and should work close ly with the local office of the California Department of Forestry and Fire Protection to ensure safe, effective, and legal burns. Good logistical planning, coordination of work teams, careful timing with respect to weather (winds, moisture conditions), co or di na tion with air quality agencies, and attention to other details are required to carry out an effective and safe burn. In most parts of California it is necessary to address air quality concerns and to obtain permission from the regional air quality board. Escaped fires are costly and can be disastrous.

Prescribed fires may promote certain invasive, non-native species, and so should be used with caution. Non-native annual and biennial species, such as cheat grass (Bromus tectorum) and bull thistle (Cirsium vulgare), are most likely to be favored in the years immediately following a burn and in repeatedly burned areas. Hot fires can also sterilize the soil, volatilizing important nutrients and killing microorganisms on which native plants rely. Removal of vegetation by fire can also increase soil erosion and stream sedimentation. Construction of firebreaks and associated soil disturbance can increase erosion and provide a seedbed for invasive weeds.

Blowtorches and flamethrowers can also be used to burn individual plants or small areas. This method has been used with some success on thistles in several areas. Flamethrowers have also been used to heat-girdle the lower stems of shrubs such as scotch broom (Cytisus scoparius). This technique has the advantages of being less costly than basal and stem herbicide treatments and suitable for use during wet weather. On the other hand, it is time-consuming and not viable in areas where wildfire is a danger.

Flooding and Draining

Prolonged flooding can kill plants that infest impoundments, irrigated pastures, or other areas where water levels can be controlled. This method may be even more effective if plants are mowed or burned before flooding. Spotted knapweed (Centaurea maculosa) is sensitive to flood ing, and its populations can be reduced by flood irrigation in pastures. Flooding may also help to control non-natives by promoting the growth and competitive ability of certain native species in some situations. Unfortunately, flood ing will not kill the seeds of many target species.

Draining water from ponds and irrigation canals may control aquatic weeds such as reed canary grass (Phalaris arundinacea) (Schlesselman et al. 1989). Drainage can be conducted in different ways, including seasonal, intermittent (within-season), or par tial draw downs (McNabb and Anderson 1989).

Mulching

Mulching excludes light from weeds and prevents them from photosynthesizing. Commonly used mulches are hay, manure, grass clippings, straw, sawdust, wood chips, rice hulls, black paper, and black plastic film. The most effective mulches are black paper or plastic because of their uni form coverage. Particle mulches cannot prevent all weeds from breaking through (Schlesselman et al. 1989). Mulch materials and application can be expensive and may be suitable only for small infestations. Particle mulches should be weed-free to avoid introduction of other weeds.

Soil Solarization

Soil solarization is a technique for killing weed seeds that have not yet germinated. A clear polyethylene plastic sheet is placed over moist soil and kept in place for a month or more. The incoming solar radiation creates a greenhouse effect under the plastic, increasing soil temperatures. High temperatures kill some seeds outright and weaken others, making them more susceptible to attack by pathogens (Schlesselman et al. 1989).

BIOLOGICAL CONTROL

Biological control, or biocontrol, involves the use of animals, fungi, or other mi crobes that prey upon, consume, or parasitize a target species. Target species are fre quent ly non-natives whose success in new environments may be due in part to the absence of their natural predators and pathogens.

Classical biological control involves careful selection and introduction of one or more natural enemies to the target species' new habitat to reduce target populations. Successful control programs of this kind result in permanent establishment of the control agent or agents and permanent reduction in target species populations. Such programs are not designed to eliminate the target species completely, and it may take repeated releases to ensure the establishment of an agent. It may take years or decades before their effects are obvious. Some of the greatest strengths of classical biological control are that once an agent is established it will last indefinitely and it may spread on its own to cover most or all of the area infested by the weed, generally without additional costs. On the other hand, these strengths can become liabilities if the agent begins to attack desirable species as well as the pest it was introduced to control. Biocontrol researchers take great pains to locate and use agents that are highly specific to the targeted weed. This contributes to the high cost and long time required for development and approval of new biological control agents. Several of the species covered in this book are the subjects of ongoing classical biological control programs.

As opposed to classical biocontrol, inundative or augmentative biocontrol involves mass releases of pathogens whose effects on the target are normally limited by their inability to reproduce and spread. Inundative biocontrol agents that are non-native and/or not target-specific may be sterilized or otherwise rendered incapable of establishing permanent populations before they are released. Because they do not become established, they must be reared and released again each time weed populations erupt. There have, however, been instances in which mistakes or back mutations allowed some of these species to establish permanent wild populations.

The USDA must approve biocontrol agents for use. Approved biological control agents have been studied, and their host specificity determined. Accidentally introduced species have unknown host species, are not permitted for distribution, and should not be redistributed. If you have questions about any potential biocontrol agents, contact the CDFA Biological Control Program (see Resources section).

Competition and Restoration

The use of native plants to outcompete alien weeds is a frequently overlooked but potentially powerful technique. Sometimes the natives must be planted into the habitat and given some care until they are well established. This may be appropriate where a native forest community is to be reestablished in an old field currently occupied by a thick cover of alien grasses and forbs. Reseeding with native species also works well in some grasslands. In other cases all that may be required is time; the native community may reestablish itself once human-caused disturbance ceases. Even in these cases, it may be important to locate and remove certain weeds capable of hindering succession. You can also enhance other weed control methods by encouraging competition from native species.

Ideally, seeds or cuttings used in restoration should be collected on the site or from adjacent properties. Unfortunately, in many cases the only available or affordable seeds and plants are from distant or unidentified populations. Potential impacts of using seeds and plants collected at distant sites include project failure if genotypes used are unable to survive conditions on the site, introduction of diseases, and loss of genetic diversity through overwhelming or contaminating locally adapted genotypes.

Grazing

Grazing animals may be used to selectively control or suppress weeds, but grazing is also known to promote certain invaders in some circumstances. Cattle, sheep, goats, geese, chickens, and grass carp have been used to graze undesirable species at sites around the nation. Often grazing must be continued until the weed's seedbank is gone, as the suppressed plants may otherwise quickly regain dominance. Another drawback to using grazing animals is that they sometimes spread weed seeds in their droppings.

CHEMICAL CONTROL

Herbicides are chemicals that kill or inhibit plant growth. They can be extremely effective tools when used to eliminate certain species. They can also be dangerous and should be used only after careful consideration of other options and only with extreme care. Each species treatment in this book provides specific information on the herbicides, rates, and times that have been found most effective against that species. However, the effectiveness of a given treatment may vary with climate and environmental conditions, and some populations of a given species may be more tolerant of, or even resistant to, a particular herbicide than other populations of the same species. It may be necessary to conduct trials to identify the most effective techniques for controlling a particular problem species.

The most important safety rule for herbicide use is to read the label and follow the directions. Applicators must wear all protective gear required on the label of the herbicide they are using. It is also important to adopt or develop protocols for storing, mixing, transporting, cleaning up, and disposing of herbicides and for dealing with medical emergencies and spills.

California's programs to regulate pesticides and pesticide applicators are regarded as the most stringent in the nation and as such are the standard against which many other states measure their programs. California's Department of Pesticide Regulation reviews health effects of pesticides independently of the federal Environmental Protection Agency and has more stringent registration requirements. California also has the most stringent pesticide use reporting requirements. Agricultural pesticide use is broadly defined and includes applications made in nature preserves, parks, golf courses, and cemeteries and along roadsides. Such applications are regulated by the CDFA, and county agricultural commissioners' offices enforce the regulations. Pest control businesses, agricultural pest control advisors, and pest control aircraft pilots must register in each county where they operate. Anyone who wants to buy a restricted pesticide must have a permit from the commissioner's office. All agricultural pesticide use must be reported monthly to the commissioner's office. Home-use pesticides (those purchased over-the-counter in small volumes) are exempt. There are also more detailed requirements for applicator training and protective gear. Inspectors from county commissioners' offices conduct thousands of compliance inspections every year and have the authority to halt pesticide applications if they believe an applicator's safety is in danger or the pesticide is likely to drift off-site. Contact your county agriculture commissioner's office for details on training and other regulations before purchasing or applying herbicides. County agricultural agents can answer questions about both wildland and agricultural uses of herbicides, as can certified herbicide applicators.

Environmental risks posed by herbicide use include drift, volatilization, persistence in the environment, groundwater contamination, and harmful effects on animals. Drift and resulting death or damage to non-target plants may occur when herbicides are applied as a spray; chances of drift increase with decreasing size of spray droplets and increase with increasing wind speeds. Volatilization and subsequent condensation on non-target plants resulting in their death or damage is another risk of herbicide use. Some herbicides are much more likely to volatilize than others, and likelihood of volatilization increases with increasing temperature. Some herbicides are more persistent in the environment and thus have a greater opportunity for harmful effects. Most herbicides will decompose more rapidly with increasing temperature and soil moisture, and some are decomposed by ultra-violet light. Chances of groundwater contamination generally increase with increasing solubility and persistence of the herbicide, increasing porosity of the soil, and decreasing depth to the water table. Herbicides with potential to cause direct harm to animals (e.g., diquat) are rarely used in natural areas. Animals may, however suffer from indirect impacts if, for example, their food plants are killed.

In order to minimize these environmental risks, look for compounds that can be used selectively (to kill one or a few species); that degrade rapidly under conditions found at the site; that are immobilized on soil particles and unlikely to reach groundwater; that are non-toxic to animals; and that are not easily volatilized.

Also choose an application method that minimizes risks of harming non-target plants and environmental damage. Possible application methods include: spraying on intact, green leaves (foliar spray); spot application (usually from backpack or handheld sprayer); wick application; boom application (from a boom mounted on a vehicle or aircraft); single spot or around the circumference of the trunk on intact bark (basal bark); cuts in the stem (frill or hack and squirt); injected into the inner bark; cut stems and stumps (cut stump); spread in pellet form at the plant's base; and sprayed on the soil before seeds germinate and emerge (pre-emergent).

Mix a dye with the herbicide so applicators can see which plants have been treated and if they have gotten any on themselves or their equipment. Some pre-mixed herbicides include a dye (e.g., Pathfinder II® includes the active ingredient triclopyr, a surfactant and a dye). Ester-based herbicides such as Garlon4® require oil-soluble dyes such as colorfast purple, colorfast red, and basoil red (for use in basal bark treatments), which are sold by agricultural chemical and forestry supply companies. Clothing dyes such as those produced by Rit® will work in water-soluble herbicides such as Garlon3A®, and they are inexpensive and available at most supermarkets and drugstores.

Detailed information on herbicides is available in the *Weed Science Society of America's Herbicide Handbook* (Ahrens 1994) and *Supplement* (Hatzios 1998). This publication gives information on nomenclature, chemical and physical properties, uses and modes of action, precautions, physiological and biochemical behavior, behavior in or on soils, and toxicological properties for several hundred chemicals (see Resources section). Critical reviews of several common herbicides are available at a small charge from the Northwest Coalition for Alternatives to Pesticides (see Resources section).

Beyond this book, additional information and training on weeds and their control can be found by contacting local universities, extension agents, county weed and pest supervisors, and the California Department of Food and Agriculture. The California Exotic Pest Plant Council can direct readers to other local experts on weeds. The Bureau of Land Management offers an Integrated Pest Management and Pesticide Certification course in Denver, Colorado, and the Western Society of Weed Science offers a Noxious Weed Management Short Course in Bozeman, Montana.

ENVIRONMENTAL ASSESSMENT
OF THE
SANTA ANA WATERSHED PROGRAM
2000-2002

U.S. ENVIRONMENTAL PROTECTION AGENCY

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INTRODUCTION

The Santa Ana River (SAR) watershed encompasses about 3,200 square miles, comprising the largest river system in coastal southern California (Figure 1). The river originates in the San Bernardino and San Gabriel Mountains, flowing over 75 miles through San Bernardino, Riverside, Orange, and a small portion of Los Angeles Counties to the Pacific Ocean between the cities of Newport Beach and Huntington Beach. Human development and activities in the watershed have greatly reduced the floodplain and associated habitats and deleteriously affected the river's natural function and processes. The purpose of the Santa Ana River Watershed Program is to gradually restore as much of the natural function of the river as possible, thereby maximizing the natural resources supported by this river system. The purpose of this document is disclosure of the proposed activities for 2000 – 2002 and their potential effects on the environment.

The Watershed Program involves a multitude of agencies and private citizens. The principal action agencies are the Resource Conservation Districts (RCD) and the Orange County Water District (OCWD). There are five RCDs in the watershed including East Valley RCD, Riverside-Corona RCD, Inland Empire West RCD, San Jacinto Basin RCD, and Elsinore-Murietta-Anza RCD. To plan and implement the necessary coordinated activities in the watershed, the five independent RCDs combined as the Santa Ana Watershed Association of RCDs (SAWA)(Appendix 1). Proposed activities are organized in an annual work plan, that is partly fashioned and finally approved by SAWA, OCWD, and the U.S. Fish and Wildlife Service (Service).

The Watershed Program relies upon many other participants, permitting agencies, and landowners. Most of the key agencies are as follows. The U.S. Army Corps of Engineers (Corps) has provided major funding through mitigation requirements and permits the wetland activities under Section 404 of the Clean Water Act. EPA receives, administers, and distributes Congressional funds earmarked for this program through the efforts of Congressman Calvert and others. The California Department of Fish and Game permits the wetland activities under Section 1601 of the Fish and Game Code and contributes its expertise to deal with some of the resource issues. The Service oversees and must approve activities that could affect wetland resources and endangered species. The Regional Water Quality Control Board approves activities that could affect water quality and provides oversight of the recognized beneficial uses of the wetland resources. OCWD is responsible for managing water resources and providing water to over two million Orange County residents; helps administer the Watershed Program; has provided major funding and manages an endowment that pays for some of the restoration activities; provides personnel to manage wetlands and endangered species; and manages 2,400 acres near the middle of the river in the Prado Basin in an attempt to maximize wildlife resources. The County flood control agencies maintain sections of the river for flood conveyance; cooperate toward achieving mutual goals; and issue entry permits.

The current foci of the Santa Ana River Watershed Program are the control of invasive weeds, restoration of wetland habitat, management of endangered species, and public education. The specific activities proposed for the workplan covering the years 2000 – 2002 (Appendix 2) include:

1. Complete an exotic plant management report for the SAR Watershed;
2. Complete mapping of all tributaries within the SAR Watershed;
3. Continue the development of a GIS database to track and monitor treatment project for the SAR Watershed;
4. Perform 55 acres of exotic plant treatment in the East Valley RCD;
5. Develop a watershed management plan and seek funding for the San Jacinto River in the Elsinore-Murietta-Anza RCD;
6. Perform 25 acres of exotic plant treatment in the Inland Empire West RCD;
7. Perform 30 acres of exotic plant treatment in the Riverside-Corona RCD;
8. Develop a Santa Ana Sucker, Arroyo Chub, and Speckled Dace Fish Recovery Program in the Riverside-Corona RCD;
9. Perform 16.65 acres of exotic plant treatment in the San Jacinto Basin RCD;
10. Continue the development of outreach materials and educational programs, and supply information on exotic plant control to private landowners within the watershed;
11. Continue to work on a watershed team structure that will coordinate and implement tasks and seek and manage funds for those tasks into the future;
12. Continue the first and implement a second SAWA Field Biologist position to coordinate and monitor invasive plant removal, habitat restoration and endangered bird management within the watershed; the first biologist to work out of East Valley RCD, focusing upon the San Timoteo Creek; the second biologist to work out of the Riverside-Corona RCD, focusing upon the Santa Ana River from Prado Basin to above Hidden Valley.

This Environmental Assessment examines the natural resources of the SAR watershed and how they could be affected by these proposed activities.

AQUATIC ENVIRONMENT

The Santa Ana River and its tributaries have been largely channelized and dammed to provide flood protection for the growing human population. There are many lakes, reservoirs, and dams on the tributaries including Santiago Dam, Villa Park Reservoir, Brea Dam, Fullerton Dam, Prado Dam, Carbon Canyon Dam, San Antonio Dam, Lake Hemet, Railroad Canyon Lake, Lake Elsinore, Lake Mathews, Big Bear

Lake, and Baldwin Lake. Seven Oaks Dam is situated on the mainstem, near its emergence from the San Bernardino Mountains and captures about 7.2% of the total watershed. Prado Dam is located near the middle of the mainstem, about 38.5 miles from the headwaters, capturing 52% of the watershed.

Flows in the upper Santa Ana River are perennial in an average year to the diversion for the Edison Power Plant near the canyon mouth. They are generally seasonal to the City of San Bernardino but become perennial again through the City of Riverside and below due to increased urbanization and runoff. Oceanic tidal influence extends about 1.5 miles up the river channel.

Water quality in the mountain portion of the watershed is excellent with low concentrations of total dissolved solids, nitrates, and other pollutants. Although elevated levels of total coliforms and silt have been identified with storm flows, water quality exceeds the state standards set for the identified beneficial uses of the water. The water quality generally decreases, and turbidity increases with distance from the mountains. Multiple water reuse becomes a more dominant factor. The river courses through a large dairy preserve. Treated municipal wastewater is discharged into the river at many points between Riverside and the Prado Basin.

Water from the upper tributaries contributes to municipal and domestic supplies, agriculture, groundwater recharge, hydropower generation, water-associated recreation, and wildlife resources. The primary human uses of the water along the entire course of the river are municipal and industrial. Flows that reach Prado Dam are used to recharge the groundwater basin and provide water to over two million residents along the 30 miles of river below the dam.

The combined average annual discharge in the mainstem at the canyon mouth below Seven Oaks Dam was 83.2 cubic feet per second (cfs), or 60,280 acre-feet for 86 years of record (excluding Warm Springs Canyon). The minimum and maximum records at this upper location were 7.4 cfs (1971) and 53,700 cfs (1891). River flows, near Riverside, were estimated by the U.S. Geological Survey (USGS) at 320,000 cfs during the 1862 flood. On the west side of the upper watershed, the flows in Lytle and Cajon Creeks are intermittent. The combined average discharge of the creek near Fontana (for 79 years of record) was 45 cfs, or 12,600 acre-feet per year. The maximum, recorded flow was 35,900 cfs (1969).

The base flow of the Santa Ana River continues to increase because of continuing urbanization. A minimum base flow of 42,000 acre-feet per year was adjudicated in 1969 as a result of litigation between OCWD and Chino. This flow rate is measured at Prado Dam and was based upon historical averages. However, rapid urbanization has resulted in increasing discharges of high quality tertiary treated water from the many treatment plants located along the river. In 1999, the base flow had increased to 140,000 acre-feet and is projected to rise to 230,000 acre-feet by 2020.

The Santa Ana River has an average gradient of about 240 ft/mile in the mountains, 20 ft/mile near Prado Dam, and 15 ft/mile downstream from Prado. The average gradient of the tributaries is about 700 ft/mile in the mountains and 30 ft/mile in the valleys. The upper river and tributaries course around large boulders and over sand and gravel bars. Riffles and shallow pools to about 6 ft deep occur regularly. The banks are generally vegetated in the upper, narrower portions of the waterways and intermittently so, in the wider, more active channels near the canyon mouths. Common bank cover and overhang in the canyons includes watercress (Rorippa nasturtium-aquaticum), bulrushes (Juncus spp.), nut-grasses (Cyperus spp.), white sweet clover (Melilotus alba), mule fat (Baccharis salicifolia), and occasional willows (Salix spp.), with local stands of white alder (Alnus rhombifolia) and cottonwood (both Fremont’s, Populus fremontii and black, P. balsamifera).

Where the waterways emerge from the mountains, the floodplains are broad, boulder-strewn, sand, and gravel washes. The low flow channels are well defined and the dominant vegetational cover is comprised of low to medium density shrubs. This specialized shrubland habitat, known as alluvial scrub was historically scoured by sheet flows during floods, once every 2 – 20 years. There is little bank or overhang cover for fish on these huge deposits of alluvium. The scouring action of water and winds kept soil nutrients low and weeds scarce. This unique habitat is home to three endangered species, the San Bernardino kangaroo rat (Dipodomys merriami parvus), the Santa Ana River woolly star (Eriastrum densifolium sanctorum), and slender-horned spine-flower (Dodecahema leptoceras).

The flow through the alluvial scrub is seasonal. Somewhere between the cities of San Bernardino and Riverside, the river picks up enough urban discharge to support perennial flow and productive riparian habitat dominated by willows. The quality of the fish habitat also increases greatly and there are recent records for the occurrence of native fishes including the Federally listed, threatened Santa Ana River sucker (Catostomus santaanae). The other native species recorded from several, scattered localities are the arroyo chub (Gila orcutti) and more rarely, the speckled dace (Rhinichthys osculus). The common fish of the river system are nonnative species.

From the vicinity of the City of Riverside to the Prado Basin, there is lush riparian growth, overhanging willows, occasional floating and emergent vegetation along the edges, and perennial flow in an often broad, flat, sandy-bottomed channel. There is fair habitat for warm-water fishes but the plethora of introduced species has taken a heavy toll on the natives. Additionally, holes, overhang, backwater, and riffle have been greatly reduced by sedimentation greatly accelerated by urbanization. Furthermore, an introduced grass, giant reed (Arundo donax) has taken over many hundreds of acres of riparian habitat, significantly diminishing bank quality for fish and reducing shade.

Water flows through the Prado Basin during the dry season but is regularly impounded for flood control and water conservation. Prado Dam was built in 1941 at the confluence of the river, Chino, Mill, and Temescal Creeks to provide flood protection for Orange County. Prado Dam is located about 31 miles from the Pacific Ocean and the mouth of the river. About half of the flow of the river is diverted into 465 acres of constructed wetlands in the Basin. The wetlands remove nitrates, sediment, and improve the quality of the water.

The river runs through the Santa Ana Canyon below Prado Dam. It is partially channelized but supports good riparian habitat for about 7.4 miles. Below this stretch, from about Wier Canyon Road, the river is channelized and heavily manipulated for flood control and to spread and percolate water. Floodplain and bank vegetation is largely herbaceous and ephemeral. Plant cover that develops on deposited sediments at the river mouth regularly includes elements of the coastal salt marsh because of the tidal influence. The higher tides move about 1.5 miles inland and there is at least one record of a marine fish, the striped mullet (Mugil cephalus) reaching as far inland as the lower canyon.

PLANTS AND VEGETATION

Upper Santa Ana River

The uppermost tributaries of the watershed cut through chaparral, southern oak woodland, and pine forest. At the higher elevations, the willows are shrubby. The common conifers include white fir (Abies concolor), Jeffrey (Pinus jeffreyi), sugar (P. lambertiana), and lodgepole (P. contorta) pines, along with incense cedar (Calocedrus decurrens) and bigcone spruce (Pseudotsuga macrocarpa). Most of the work associated with the Watershed Program will occur below the pine belt, in the floodplain proper, and within a few miles of the upper tributary canyon mouths to the ocean.

A total of 290 species of vascular plants were identified from the upper Santa Ana Canyon and environs during studies of the environmental effects of the Seven Oaks Dam (Feldmeth et al. 1985, Zembal and Kramer 1984 and Zembal 1985, 1989). Of these, four were cultivated species and 48 species, or 16.8% of the flora is non–native. A total of 77 species (26.9% of the flora) were observed in riparian habitat, 24 of which (31.1%) were non–natives; 164 species (57.3% of the flora) were found on the floodplain terraces, of which 35 species (21.3%) were non–natives; 164 species (57.3%) were also found in chaparral, 20 (12.2%) were introduced; 145 species (50.7%) were found in the coastal sage scrub, 35 (24.1%) were introduced; and 61 species (21.3%) were present in ruderal habitat, of which 24 species (39.3%) were non–natives.

Two species of rare plants were identified from the upper Santa Ana Canyon, Santa Ana River woolly star (Eriastrum densiflorum sanctorum) and round—leaved boykinia (Boykinia rotundifolia). The woolly star, a California endemic, is on the Federal list of endangered species. The current known distribution of Santa Ana River woolly star is along the Santa Ana River in the terrace shrublands of the floodplain in San Bernardino County (Zembal and Kramer 1984). Small stands occur in the Lytle/Cajon drainage area but most of the plants known to exist today occur between the Santa Ana River canyon mouth and the former Norton Air Force Base. This covers a linear distance of only about 7.5 river—miles. The stand nearest the dam was comprised of 25 plants and at 1,900 ft. represents the known upper elevational limit of the species' current distribution.

The round—leaved boykinia is also endemic to California, but is considered common enough now to be in no immediate threat of extinction (Smith 1984). A small stand of the boykinia was found in a seep near Powerhouse No. 2.

The floodplain of the Santa Ana Canyon is open and sandy with scattered boulders, the meandering stream course, and a narrow but almost unbroken belt of riparian habitat. Shrubs also grow in the floodplain, comprising an open scrub over much of the area, with vestiges of more densely vegetated shrublands that more closely resemble the slope vegetation on a few small terraces. The side slopes in the canyon are steep and near vertical rock walls are regularly interspersed. In the floodplain scrub, 65%—91% of the surface was open ground, of which 33%—42% consisted of sand and 30%—49% consisted of granitic boulders. Total shrub cover varied from 9.8% to 25% with an average cover of 18.2%. The common perennials included California buckwheat (Eriogonum fasciculatum), scale broom (Lepidospartum squamatum), and sweetbush (Bebbia juncea) with conspicuous local abundance of golden—aster (Heterotheca villosa), yerba santa (Eriodictyon trichocalyx), white everlasting (Gnaphalium canescens ssp. microcephalum), mullein (Verbascum thapsus), brickellia (Brickellia desertorum), and western ragweed (Ambrosia psilostachya) (vegetational analyses are from Feldmeth et al. 1985, Zembal 1985; plant names were updated from Hickman, ed. 1993). Frequently encountered annuals in the boulder—strewn wash included brome grasses (Bromus tectorum, B. madritensis, and B. diandrus), wild oats (Avena barbata), black mustard (Brassica nigra), schismus (Schismus barbatus), Vulpia myuros, pigmy weed (Crassula connata), filaree (Erodium cicutarium), peppergrass (Lepidium lasiocarpum), and several species of Camissonia (particularly Camissonia californica, C. bistorta, and C. hirtella).

Riparian thickets in the Santa Ana Canyon were comprised mostly of shrubby to subarborescent plants with widely spaced smaller stands of much taller old trees. The habitats varied from herbaceous to sub—shrubby species in and along the immediate watercourse to very small marshy patches and occasional stands of woodland along old side channels. The emergent and near–bank annuals included speedwell (Veronica anagallis–aguatica), watercress (Rorippa palustris var occidentalis), bentgrass (Agrostis viridis), rabbits foot grass (Polypogon australis), and white sweet clover; the perennial herbs include white everlasting, scarlet monkeyflower (Mimulus cardinalis), umbrella sedge (Cyperus eragrostis), rushes (particularly Juncus xiphioides and Juncus effusus var. pacificus), curly dock (Rumex crispus), and very locally, dense cattails (Typha latifolia). Overhead canopy was contributed by mulefat and young willows (Salix laevigata, S. lasiolepis, and S. gooddingii, in order of decreasing abundance) over much of the riparian belt. Particularly along old side channels, taller trees were intermixed and included individuals of the willows, scattered cottonwoods (mostly Populus fremottii with a few P. trichocarpa), white alder, infrequent sycamores (Platanus racemosa), and occasional tamarisk (Tamarix ramosissima). Total plant cover in the riparian belt varied from 78.5% to 108% with a mean of 95% (Feldmeth et al. 1985, and Zembal 1985). Quantified vegetational cover data are displayed in Tables 1 and 2 below.

The vegetation of the uplands along the Santa Ana River Canyon consisted of plant associations ascribable to coastal sage scrub and chaparral. Coastal sage scrub constitutes a more open shorter statured shrubland that occurred mostly on drier slopes, particularly those with a southern exposure. Common species of the open shrublands included coastal sagebrush (Artemisia californica), California buckwheat, brittlebush (Encelia farinosa), deerweed (Lotus scoparius), croton (Croton californicus), and white sage (Salvia apiana). Brittlebush occurred locally in nearby monotypic stands on the driest slopes. Where coastal sage scrub graded into chaparral on more mesic slopes, chaparral species, particularly chamise (Adenostoma fasciculatum) and chaparral lilac (Ceanothus crassifolius), intermixed in the coastal sage scrub. Total plant cover in coastal sage scrub varied from 40.8 to 95% and averages 64.8% (Feldmeth et al. 1985).

Much of the upland vegetation in the Santa Ana Canyon was chaparral. From the driest to the most moist conditions, the chaparral graded from a low shrubby form dominated by chamise through a lilac–dominated (locally either Ceanothus crassifolius or C. leucodermis) form to a dense, tall tangle dominated by scrub oak (Quercus dumosa) and flowering ash (Fraxinus dipetala). In the shadier draws and on more north–facing slopes the vegetation was particularly tall and scattered. Canyon oaks (Quercus chrysolepis) occurred and, locally in such situations, interior live oak (Quercus wislizenii var. frutescens) was dominant. The common perennials in the chaparral included chaparral lilac, chamise, flowering ash, scrub oak, holly-leaf redberry (Rhamnus ilicifolia), bush snapdragon (Keckiella cordifolia), honeysuckle (Lonicera subspicata var. denudata), toyon (Heteromeles arbutifolia), poison oak (Toxicodendron diversilobum), with local importance of sugar bush (Rhus ovata), holly–leaved cherry (Prunus ilicifolia), mountain mahogany (Cercocarpus betuloides), black

Table 1. Composition of perennial plants in the floodplain of the

upper Santa Ana River canyon.

Relative Abundance of General Habitats (%)

Riparian vegetation	42.2
Open water (overlapping riparian)	4.9
Boulder strewn floodplain/open shrublands	50.2
Terraced shrublands	7.6

Riparian Belt

	% Cover	Stem Count	Stems/acre
Baccharis salicifolia	34.8	556	7,979
Salix lasiolepis	28.5	172	2,468
Alnus rhombifolia	10.1	8	115
Salix gooddingii	9.3	28	402
Rorippa nasturtium—aquaticurn	2.8	-	-
Typha sp.	2.5	-	-
Populus fremontii	2.2	1	14
deadfall/dead shrub	1.8	1	14
Juncus effusus	1.2	-	-
Verbascum thapsus	0.9	-	-
Artemisia douglasiana	0.7	-	-
Cyperus alternifolius	0.7	-	-
mixed grasses	0.7	-	-
Juncus xiphioides	0.6	-	-
Rubus ursinus	0.5	-	-
Salix laevigata	0.5	1	14
Oryzopsis miliacea	0.5	-	-
Baccharis douglasii	0.4	117	1,679
Lepidospartum squamatum	0.4	1	14
Brickellia californica	0.4	1	14
Lotus heermannii	0.2	-	-
Mimulus guttatus	0.1	-	-
Sonchus oleraceus	0.1	-	-
Eriogouum fasciculatum	-	1	14
Nicotiana glauca	-	1	14
Galium nuttallii	-	1	14
Rhamnus sp.	-	1	14
Totals	99.9	890	12,772

Total Plant Cover (%) 57.8

Table 1. (continued)

Floodplain/Open Shrublands

	Relative Stems/ Cover (%)	Stem Count	Stems/ Acre
Bebbia juncea	27.3	19	229
deadfall	19.2		
dead shrub	3.1	1	12
Lepidospartum squamatum	17.0	26	313
Heterotheca villosa	10.0	145	1,746
Eriogonum fasciculatum	8.6	28	337
Brassica spp.	5.6		
Artemisia californica	2.8	2	24
Verbascum thapsus	1.4		
Yucca whipplei	1.1	2	24
Pennisetum setaceum	0.8		
Gnaphalium microcephalum	0.8		
Lotus scoparius	0.8	1	12
Nicotiana glauca	0.8		
Eriodictyon trichocalyx	0.6	10	120
Rhamnus sp.	0.1	1	12
Baccharis salicifolia		22	265
Lessingia filaginifolia		3	36
Baccharis douglasii		2	24
Melilotus albus		1	12
Ceanothus crassifolius		1	12
Totals	100	264	3,179
Total Plant Cover (%)		21.4	

Terraced Shrublands

	Relative Stems/ Cover (%)	Stem Count	Stems/Acre
Bebbia juncea	22.8	2	159
Salvia apiana	18.5	7	558
Lotus scoparius	16.3	3	239
Eriogonum fasciculatum	15.2	1	80
Croton californicus	9.8	15	1,195
Brassica spp.	6.5		
Artemisia californica	5.4	2	159
Eriodictyon trichocalyx	5.4	1	80
Lessingia filaginifolia		1	80
Adenostoma fasciculatum		1	80
Lepidospartuin squamatum		1	80
Totals	99.9	34	2,708
Total Plant Cover (%)		36.2	

[1]The data were taken from two transects run perpendicularly across the floodplain for a total length of 334.5m. Line intercept was used for cover estimates and a 2 m–wide belt totaling 669 square m was used for stem counts.

Table 2. Diameter at breast height (DBH) of trees encountered in the

upper Santa Ana River Canyon.

	0-1.5 in.	1.5-3 in.	3-6 in.	Total
Salix lasiolepis	67	4	-	71
Salix gooddingii	10	3	3	16
Alnus rhombifolia	5	1	1	7
Salix laevigata	1	-	-	1
Standing dead	1	-	-	1
Total	84	8	4	96

*Data are from 2 m wide belt transects totaling 669 square m. Sprouts lower than breast height were not included in counts.

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sage (*Salvia mellifera*), and yerba mansa (*Anemopsis californica*). A variety of annuals occurred in the chaparral understory and along edges. Total plant cover varied widely in the chaparral from about 83% to 130.5% with a mean of 98.4% (Feldmeth et al. 1985).

Disturbed areas, particularly the road margins, were inhabited by a weedy element dominated by annual grasses and including such species as brome grasses (four species), Vulpia, filaree, Russian thistle (*Salsola tragus*), black mustard, western ragweed, tree tobacco (*Nicotiana glauca*), tarragon (*Artemisia dracunculus*), and horehound (*Marrubium vulgare*).

Alluvial scrub dominated the floodplain from the canyon mouth to about the City of San Bernardino. The shrubs were openly spaced with total cover ranging from 26% to 52%, and averaging about 35%. Much of the cover was low-growing but there were regularly spaced, conspicuous stands and individuals of overstory species including California juniper (*Juniperus californica*), holly-leaved cherry, sumac (*Rhus* spp.), elderberry (*Sambucus mexicana*), scrub oak, and local sycamores. Another endangered plant, slender-horned spineflower (*Centrostegia leptoceras*) is known from a small number of sites along this reach of the river.

More complete descriptions of the vegetation and checklists of plants of the upper river system are available in Zembal and Kramer (1984); Feldmeth et al.(1985); and Zembal (1989).

Upper Lytle Creek

A total of 283 species of vascular plants was identified from the eastern side of the watershed along Lytle and Cajon Creeks. Of these, 13 species were cultivated, occurring only near home sites, and 58 species or 21.5% of the flora are non—native. A total of 117 species (43.3% of the flora) was detected in the wash, and 36 (30.8%) of these were non—natives; 132 species (48.8% of the flora) were observed in the terrace scrub and 19 (14.3%) of these were introduced species; 167

species (61.9%) were found in coastal sage scrub, of which 32 (19.2%) were non–native; 121 species (44.8%) were detected in chaparral, of which 17 (14%) were introduced species; 57 species (21.1%) were found in the slope woodlands, of which 9 (15.8%) were naturalized species; 135 species (50%) were observed in grassland, of which 30 (22.7%) were introduced; and 71 species (26.3%) were documented in disturbed areas, of which 27 (38%) were non–natives (Feldmeth et al. 1985).

Round–leaved boykinia was also observed in the Lytle Creek canyon, as was the Santa Ana River woolly star. Boykinia was observed in a few seeps along the canyon edge near its emergence from the mountains.

The Lytle Creek floodplain is open, sandy, and boulder–strewn. A few higher floodplain terraces supported shrublands with moderate to extremely dense plant cover, whereas most of the floodplain was quite open. The side slopes were steep and densely vegetated. The open floodplain is periodically disturbed by earth–moving equipment; dikes are maintained for flood control and the watercourse is kept to the west side of the floodplain by an artificially maintained low earthen berm. The plant cover that did occur on the open wash ranged from 1% to 5.5% with an average cover of about 3% (Feldmeth et al. 1985). From 95% to 99% of the ground along transects was unvegetated; 31% to 51% was sand, and 48% to 64% was rock. The common perennials in the broad wash included golden aster, white everlasting, California buckwheat, scale broom, mulefat, brickellia, and tarragon.

Scour has been infrequent enough to allow the persistence of terrace shrublands on the fringe of the creek. The shrubs on the terraces closest to the canyon mouth were more widely spaced and lower growing with local dominance of species such as California buckwheat, scale broom, yerba mansa, and goldenbush (Ericameria linearifolia). These open shrublands gradually transitioned into densely vegetated chaparral further up the canyon. Locally the terrace chaparral consisted of patches of dense chamise. Other dominants included scrub oak, interior live oak, holly–leaved cherry, honeysuckle, and manzanita (Arctostaphylos glauca). Silk tassel bush (Garrya veatchii) and flannel bush (Fremontodendron californicum) were locally conspicuous, as were stands and intermixed arborescent individuals of mountain mahogany. Plant cover in the terrace chaparral averaged 67.2%. Open areas occurred amidst the dense shrublands and were heavily vegetated with low–growing grasses and annuals including species of Bromus, Festuca (Vulpia), Avena, Camissonia, Chaenactis, Cryptantha, Clarkia, Lotus, Lupinus, and Phacelia.

The high winter flows on Lytle Creek keep the riparian habitat in fairly young successional stage. Habitat persists along side drainages, particularly along two that come into Lytle Creek from the west near the canyon mouth, and the toe of the slope. A white alder stand along 600 feet of the channel was composed of 198 live and 22 dead alders. A slope grove of 49 young sycamores occurred just above the alders. Other plants common in the side canyons included mulefat and willows with a locally dense understory of poison oak. There were a few local seeps on the slopes with dense tangles of wild grape (Vitis girdiana).

Disturbed areas, as along the edge of Lytle Creek Road, were characterized by grasslands dominated by introduced weeds, intermixed with native annuals. Common genera of weedy species included Bromus, Festuca (Vulpia), Avena, Erodium, Brassica, Hypochoeris, Centaurea, Salsola, and Picris. Natives included Lupinus, Lotus, Rafinesguia, Phacelia, Mentzelia, Cryptantha, Camissonia, Chaenactis, Clarkia, and Amsinckia.

Species typical of coastal sage scrub were not as abundantly dominant along the edge of Lytle Creek as they were near the mouth of the Santa Ana Canyon. Important species that were present included California buckwheat, California sagebrush, white sage, yerba mansa, and deerweed. Plant cover varied from 80% to 120% with an average value of 101.8%.

Most of the vegetation on the slopes of Lytle Creek was dominated by species typical of chaparral. The chaparral varied from less to most dense and tall, from a chamise–dominated type on drier sites, through a lilac–scrub oak type to an oak–dominated form on the most mesic sites. The chamise chaparral varied from nearly pure stands of chamise, to an association with species characteristic of coastal sage scrub, and the occurrence of other chaparral elements including honeysuckle, lilac, silk tassel bush, and poison oak. Total plant cover ranged from 83.5% to 94% with chamise contributing 33% to 62% of the cover. As the chaparral became woodier, species diversity increased greatly and local dominance by scrub oak and California lilac (both Ceanothus leucodermis and C. integerrimus) became apparent. Scrub oak and lilac associates included poison oak, bush snapdragon, interior live oak, elderberry, mountain mahogany, honeysuckle, buckthorn, coffeeberry (Rhamnus californica), bedstraw (Galium angustifolium), and wild cucumber (Marah macrocarpus). Plant cover in the scrub oak–lilac type chaparral varied from 68% to 127%. On the most mesic slopes, the chaparral graded to a type locally dominated by interior live oak, and there was an additional increase in species diversity. Common species included those mentioned above, as well as toyon, holly–leaved cherry, silk tassel bush, virgin’s bower (Clematis lasiantha), snowberry (Symphoricarpos mollis), California walnut (Juglans californica), sycamore, and ash trees (Fraxinus velutina). Plant cover in this most diverse of the chaparral types varied from 86.8% to 103.5%, and averages 98.6%.

Slope woodlands occurred along Lytle Creek on the most mesic of north–facing slopes. The two dominant species were canyon oak and big–cone spruce. Other associates included California bay (Umbellularia californica, a local dominant), big–leaf maple (Acer macrophyllum), poison oak, interior live oak, lilac, bush snapdragon, mountain mahogany, brickellia, toyon, holly–leaved cherry, gooseberry (Ribes amarum), and bush monkey–flower (Mimulus longiflorus). A variety of annuals occurred in the understory. Total plant cover varied only slightly from 105% to 105.8%.

Prado Basin

The riparian habitat along the Santa Ana River has been examined most intensively near mid-river, in the Prado Basin and environs including a 7.5-mile reach of the river through the lower canyon, below Prado Dam (Zembal et al. 1985).

About 4,400 acres of the 11,000 acres in the Prado Basin were comprised of various, vegetated riparian habitats, mostly willow woodland (Zembal et al. 1985). The quality, age, and coverage of the aerial photos available for analysis allowed only approximations of the extent of each habitat type. Of the approximately 1,800 acres in the canyon below Prado Dam, there was an estimated additional total of 340 acres of riparian habitat, assuming an average width of 400 feet of habitat for 7 miles. Most of the canyon riparian was willow and mixed woodland, with about 40% of the acreage in shrubby riparian and more scattered willows.

In examining the vegetation, a total of 311 species, belonging to 65 families of vascular plants, were identified from the project area. Species are listed along with annotations in the plant checklist in Zembal et al. (1985). Approximately 99 species, or 31.8% of the observed species, are most typically associated with floodplain and riparian habitats; 200 species, or 64.3%, are usually found on slopes and in upland habitats; and the remaining 12 species, or 3.9%, are often found in both upland and riparian situations. About 99 species, or 31.8% of the total, are introduced members of the flora and a small number of these are obvious escapes from cultivation.

Specimens of rare plants known from the general area (Smith et al. 1980) were examined from collection data at the herbaria at the University of California, Riverside, and the Rancho Santa Ana Botanic Garden. None of the 67 localities obtained from those specimens led to additional sightings of rare species in the project area. One rare species, many-stemmed dudleya (Dudleya multicaulis), had already been found in three small and widely separated stands. The first was comprised of about 25 plants, located on the rock and earthen wall just above and to the north of the west end of the dam—top road; the other totaled about 10 plants located on a vertical earthen bank along a foot trail just below the Raadhauge Pheasant Club. Many—stemmed dudleya is an endangered species and was most abundant on the northwest side of the spillway, where several hundred plants were found. The Santa Ana River woolly star was also looked for in the vicinity but was not found; neither was suitable habitat. The species was endemic to the Santa Ana River Canyon (Lathrop and Thorne 1978), but has apparently been extirpated there (Zembal and Kramer 1984).

The vegetated riparian habitat within the reservoir was mostly woodland and almost entirely willow woodland. Black willows (Salix gooddingii) were quite dominant with an occasional stand of arroyo willow (Salix lasiolepis) or an infrequent Fremont’s cottonwood, mostly along the past reservoir margins or on higher, less frequently inundated ground in the interior of the basin (Table 3). The data for the basin woodland are skewed toward a higher occurrence of arroyo willows because the sampling necessarily was accomplished near the basin edge. The percent of bare ground was relatively high for riparian habitat, and most of the low cover in the woodlands was from deadfall and litter. This and the local dominance of pure stands of cocklebur (Xanthium strumarium var. canadense) was apparently attributable to the periodically prolonged inundation of the habitat. There was only one small stand of sycamores found in the basin proper and but one general locality for coast live oaks (Quercus agrifolia). The sycamores, numbering about 30, were along the mid–south margin of the past reservoir and about 50 oaks grew in the draw bottoms above the west shore just north of the dam. The most extensive stand of cottonwoods observed in the basin was located near the oil pumping operation just south of the duck ponds. The low ground cover contributed by living plants increased in these higher elevation mixed woodlands (Table 4). Like the sycamores and cottonwoods, scattered patches of shrubby riparian growth were widely spaced only along higher ground along the nearshore band. The openings in the woodlands were devoid of vegetation, covered with open water, or densely vegetated with very low growing herbaceous species, particularly the fast growing and locally dominant cocklebur. This was in contrast with the habitat along the river and creeks at just slightly higher elevations, where shrubby riparian growth was a regular component. Some of this shrubby riparian habitat was artificially maintained by periodic mowing of certain areas along the river; giant reed was proliferating in such areas. The only other locally extensive habitats in the basin bottom were snag fields and fresh or brackish water marsh. The snag fields usually occurred in low sumps and are open areas of standing dead tree trunks that varied from one to several acres in extent. The marsh habitat was locally dominated by cattails (Typha spp.) or reeds (Scirpus spp.), with scattered willows that became increasingly abundant locally, toward the nearshore margins and closer to the creek mouths (Table 5).

The regularity of a diverse species composition in the woodlands increased away from the area of regular inundation along the watercourses, particularly along the Santa Ana River (Table 6). Similar woodlands can be found along Temescal and Chino Creeks (Table 7), although the area sampled on Temescal Creek was a uniformly, younger woodland (Table 8). In contrast, extremely heavy grazing and trampling along Mill Creek has kept species diversity, ground cover, and recruitment through establishment of young willows to a minimum (Table 9). A belt of eucalyptus groves occurred interruptedly along the shore of the reservoir. Many of the groves comprised the tallest tree stands around, with some individuals approaching 100 feet tall. Younger trees were often densely packed and live, so low ground cover was typically sparse, but the litter layer was dense (Table 10).

Table 3. Composition of willow woodland within Prado Basin.

Trees per acre

	Tree count per size class (dbh) in inches						
	0–1.5	1.5–3	3–6	6–9	9–15	15–21	Totals
Salix gooddingii	164	176	254	66	16	1	677
Salix lasiolepis	26	55	48	1	-	-	130
Populus fremontii	-	-	1	-	-	-	1
Ricinus communis	2	-	-	-	-	-	2
Standing snags	4	8	4	1	1	-	18
Totals	196	239	307	68	17	1	828

Low Ground Cover

	Cover contributions (%)
Litter	52.3
Deadfall	14.7
Plant cover	8.1
Total ground cover	75.1
Bare ground	24.9

Plant cover contributors (%)

Salix gooddingii	2.6	Scirpus spp.	0.1
Typha spp.	1.4	Cyperus spp.	0.1
Bidens spp.	1.3	Polygonum spp.	0.1
Helianthus annuus	0.7	Chenopodium ambrosioides	0.1
Sagittaria latifolia	0.6	Echinochloa crusgalli	0.1
Xanthium strumarium	0.4	Solanum douglasii	tr
Salix lasiolepis	0.3	Sonchus spp.	tr
Urtica holosericea	0.2	Ricinus communis	tr

Data are from 10 0.1–acre circular plots for tree counts and low cover estimations usually within 10 0.25m quadrats per plot. Tree stand height varied from 25 feet to 40 feet and canopy cover ranged from 35% to 80% (Zembal et al. 1985).

Table 4. Composition of woodland with dominant cottonwoods.

Tree density

	Tree count per size class (dbh) in inches					
	0–1.5	1.5–3	3–6	6–9	9–15	Trees/acre
Salix gooddingii	1	14	40	9	4	340
Populus fremontii	–	3	12	6	2	115
Salix lasiolepis	-	-	-	1	-	5
Standing snags	4	2	–	1	-	35
Totals	5	19	52	17	6	495

Table 4 (cont.)

Low ground cover

	Cover contributions (%)
Litter	34.7
Deadfall	-
Plant cover	48.2
Total low cover	82.9
Bare ground	17.1

Plant cover contributors (%)

Cyperus spp.	21.1	*Cynodon dactylon*	0.6
Bidens spp.	12.8	*Artemisia douglasiana*	0.2
Sonchus oleraceus	4.5	*Rorippa palustris*	0.2
Salix gooddingii	3.9	*Echinochloa crusgalli*	0.2
Baccharis salisifolia	3.9	*Chenopodium ambrosioides*	0.1
Rumex spp.	0.6	*Erodium cicutarium*	0.1

Data are from two 0.1—acre circular plots for tree counts and 10 - lm quadrats per plot for estimations of low cover. Tree stand heights varied from 40 feet to about 65 feet and canopy cover ranged from 45% to 85%.

Table 5. Plant composition in freshwater marsh along Temescal Creek.

Tree density

	Tree count per size class (dbh) in inches				
	0—1.5	1.5—3	3—6	Total	Trees/acre
Salix gooddingii	201	10	3	214	2,166
Salix lasiolepis	66	24	–	90	911
Standing snags	8	1	–	9	91
Totals	275	35	3	313	3,168

Low ground cover

	Cover contributions (%)
Litter	-
Deadfall	15.1
Plant cover	54.2
Total low cover	69.3
Mud and water	30.7

Plant cover contributors (%)

Baccharis salicifolia	24.2	*Venegasia carpesioides*	1.0
Typha spp.	17.7	*Polygonum lapathifolium*	0.8
Scirpus spp.	4.5	*Cynodon dactylon*	0.5
Artemisia dracunculus	3.5	*Cardaria draba*	0.1
Sprouting forbs	1.9		

Tree density data are from 2 - lOOm x 2m belt transects. Low ground cover and canopy cover estimates are from 20 - lm quadrats. Canopy cover ranged between 0% and 80% and averaged 17.3%.

Table 6. Composition of willow woodland along the Santa Ana River.

Tree Density

Tree count per size class (dbh) in inches

	0–1.5	1.5–3	3–6	6–9	9–15	trees/acre
Salix gooddingii	39	80	94	39	11	526
Salix lasiolepis	45	30	75	8	-	316
Salix laevigata	3	2	1	4	-	20
Populus fremontii	1	–	1	-	1	6
Sambucus mexicana	3	-	-	-	-	6
Standing snags	87	40	22	2	-	302
Totals	178	152	193	53	12	1,176

Low Ground Cover

	Cover contributions (%)
Litter	46.3
Deadfall	13.1
Plant cover	34.4
Total low cover	93.8
Bare ground	6.2

Plant cover contributors (%)

Bidens spp.	10.5	*Sonchus* spp.	0.7
Baccharis salicifolia	4.4	*Typha* spp.	0.5
Urtica holosericea	3.2	*Bromus diandrus*	0.3
Salix gooddingii	2.9	*Marah macrocarpa*	0.3
Polygonum sp.	2.4	*Juncus* app.	0.1
Cyperus spp.	1.8	*Picris echioides*	0.1
Eleocharis sp.	1.6	*Urtica urens*	0.1
Artemisia douglasiana	1.5	*Epilobium* sp.	0.1
Vitis girdiana	1.3	*Conium maculatum*	0.1
Scirpus spp.	1.1	*Solanum douglasii*	tr
Arundo donax	0.9	*Heterotheca* sp.	tr

Data are from 5 0.1–acre circular plots for tree counts and low cover estimations were from 10 0.25m quadrats per plot. Tree stand heights varied from 25 feet to 50 feet and canopy cover ranged from 25% to 100%.

Table 7. Composition of willow woodland along Chino Creek.

Tree density

	Tree count per size class (dbh) in inches					
	0–1.5	1.5–3	3–6	6-9	9-15	trees/acre
Salix gooddingii	39	44	29	7	6	625
Salix lasiolepis	5	25	6	3	-	195
Salix laevigata	8	9	7	1	-	125
Standing snags	95	13	1	1	-	550
Totals	147	91	43	12	6	1,495

Table 7 (cont.)

Low Ground Cover

	Cover contributions (%)
Litter	3.8
Deadfall	12.8
Plant cover	77.7
Total low cover	94.3
Bare ground	5.7

Plant cover contributors (%)

Atriplex patula	34.8	*Polygonum lapathifolium*	1.5
Urtica holosericea	34.5	*Salix gooddingii*	0.2
Rumex crispus	6.7		

Data are from 2 0.1—acre circular plots for tree counts and 10 lm quadrats per plot for estimations of low cover. Tree stand heights varied from 50 feet to 70 feet and canopy cover ranged form 60% to 90%.

Table 8. Composition of willow woodland along Temescal Creek.

Tree density

	Tree count per size class (dbh) in inches			
	0—1.5	1.5—3	3—6	trees/acre
Salix gooddingii	47	34	33	570
Salix lasiolepis	65	22	6	465
Standing snags	-	1	-	5
Totals	112	57	39	1,040

Low ground cover

	Cover contributions (%)
Litter	16.5
Deadfall	24.7
Plant cover	41.3
Total low cover	82.5
Bare ground	17.5

Plant cover contributors (%)

Raphanus sativa	11.0	*Brassica geniculata*	3.2
Urtica holosericea	10.0	*Baccharis glutinosa*	2.3
Ambrosia psilostachya	8.8	*Rumex* spp.	0.5
Artemisia dracunculus	4.5		

Tree counts are from 2 0.1—acre circu~ar plots. *Low* ground and canopy cover estimates are from 10 lm quadrats (5 per plot) placed randomly in the plots. Canopy cover ranged between 40% and 60% and averaged 47.5%. Average tree height varied between 25 and 30 feet.

Table 9. Composition of willow woodland along Mill Creek.

Tree density

	Tree count per size class (dbh) in inches					
	0—1.5	1.5—3	3—6	6—9	9—15	Trees/acre
Salix goodingii	–	14	50	35	6	525
Standing snags	–	1	-	-	-	5
Totals	-	15	50	35	6	530

Low ground cover

	Cover contributions (%)
Litter	50.1
Dead fall	3.8
Plant cover	5.1
Total low cover	59.0
Bare ground	41.0

	Plant cover contributors (%)
Hordeum leporinum	3.3
Bromus diandrus	1.6
Cynodon dactylon	0.2

Data are from 2 - 0.1—acre circular plots for tree counts and 10 - lm quadrats per plot for estimations of low cover. Tree stand heights varied from 55 feet to 70 feet and canopy cover ranged from 35% to 80%.

Table 10. Composition of the woodland vegetation within the Prado Basin compared with that along the outlying watercourses.

Tees per acre

	Prado Basin	Santa Ana River	Chino Creek	Temescal Creek	Mill Creek
Salix gooddingii	677	526	625	570	525
Salix lasiolepis	130	316	195	465	-
Salix laevigata	-	20	125	-	-
Populus fremontii	1	6	-	-	-
Sambucus mexicana	-	6	-	-	-
Ricinus communis	2	-	-	-	-
Standing snags	18	302	550	5	5
Totals	828	1,176	1,495	1,040	530

Table 10 (cont.)

Low ground cover *(%)*

	Prado Basin	Santa Ana River	Chino Creek	Temescal Creek	Mill Creek
Litter	52.3	46.3	3.8	16.5	50.1
Deadfall	14.7	13.1	12.8	24.7	3.8
Plant cover	8.1	34.4	77.7	41.3	5.1
Total low cover	75.1	93.8	94.3	82.5	59.0
Bare ground	24.9	6.2	5.7	17.5	41.0

Interspersed with the eucalyptus groves and above them, on the slopes and undeveloped hills, were shrublands and grasslands that were mostly quite open and show the effects of heavy grazing. In a few, less accessible areas there were patches of less disturbed shrublands, varying locally by containing more elements of chaparral than coastal sage scrub. The chaparral influence was strongest above the western shoreline, a continuation of the vegetation on the eastern slope of the Chino Hills. The effects of grazing and trampling on the vegetation were apparent elsewhere (but not in the remnant shrublands) in the low species diversity, low shrub density, and the abundance of lower cover often comprised of weedy annual grasses.

MACROINVERTEBRATES

Two species of macroinvertebrates were conspicuous in the Prado Basin and environs. Individuals of one of these species, freshwater clams (Anodonta sp.), were observed in Temescal Creek. Remains of these clams were found near picnicing spots, evidence that some of the people recreating in the area are harvesting them. Freshwater clams probably form part of the diet of many organisms present in the project area.

Crayfish (Procambarus spp.) were found abundantly in the basin and all of the associated drainages. In one 22 square meter section, 186 individuals were counted and in a 36 square meter drying pond there were about 50 crayfish. Along banks where burrows were left dry for a time and could be seen, counts ranged between 2 and 8 burrows per meter. Procambarus spp. are detrital feeders and form a focal point in the food web of the project area. Aquatic and terrestrial species from several trophic levels feed on these invertebrates. Observed consumers included bullfrogs (Rana catesbeiana), red—shouldered hawks (Buteo lineatus) (Bloom 1983), herons, great egrets (Ardea albus), coyotes (Canis latrans), raccoons (Procyon lotor), and probably a variety of other species as well.

Crayfish are also heavily exploited by humans in the project area. Individuals were frequently seen carrying buckets and trash can liners containing hundreds of these animals. The level of exploitation appears high enough that competition with wildlife for this food resource is probably occurring. The crayfish “bloom” is highly seasonal and with the lowering of water levels in the reservoir, literally thousands were seen roaming away from drying areas. For wildlife and humans, the crayfish harvest appears to be a feast or famine situation. The "take" by humans is concentrated along the watercourses and probably reduces greatly the consistent availability of crayfish to wildlife. These people meticulously comb the creek banks and appear to greatly reduce local populations.

FISH

The common fishes of the watershed are nonnative (Table 11). This domination by introduced species is typical in areas that have been altered by human activities (Moyle 1976). Habitat alterations affecting the fish of the project area include streambed modifications (such as channel cutting, pond building, flood control near roads), oil drilling, and great water level fluctuations behind Prado Dam. Agriculture and other such adjacent land uses also affect fish habitat. Water is diverted from the Santa Ana River and then returned as agricultural "waste." This water has high concentrations of nitrates and other pollutants (Knepper 1984 pers. comm.). Mercury and lead have been detected in the water (USGS 1981), and PCB's are present in the fish (Zeiger 1982). Some of these chemicals can bio-accumulate.

Only certain species can cope with these kinds of habitat perturbations. The species that can, tend to be very prolific and capable of tolerating a wide range of environmental conditions. All of the species found in the project area are described by Moyle (1976) as being highly fecund. Goldfish (Corassius auratus), carp (Cyprinus carpio), mosquito fish (Gambusia affinis), bluegill (Lepomis macrochirus), and green sunfish (Lepomis cyanellus) are noted for living in altered habitats or tolerating extreme environmental conditions (Moyle 1976). Carp and goldfish, due to their feeding habits may contribute to the disturbed conditions of aquatic habitats. Many of these introduced species have been associated with the decline of native species.

The prickly sculpin (Table 11) is a saltwater species that has been collected many miles up the river from the ocean. There are 27 species of fish that have been collected at the river mouth (Reisch 1997).

The fish of the project area are an important part of this ecosystem. They form an integral part of the food web. For example, the remains of hundreds of threadfin shad (Dorosma petense) were found beneath heron nests. The abundance of belted kingfishers is also indicative of large populations of small forage fishes in the project area.

Table 11. Fish Recently Collected in the Santa Ana River Watershed.

Family & Scientific Name	Common Name	Native
Catostomidae		
Catostomus santaanae	Santa Ana sucker	yes
Centrarchidae		
Lepomis cyanellus	Green sunfish	
Lepomis macrochirus	Bluegill	
Micropterus salmoides	Largemouth bass	
Pomoxis nigromaculatus	Black crappie	
Cichlidae		
Tilapia mossambica	Mozambique tilapia	
Tilapia zillii	Redbelly tilapia	
Clupeidae		
Dorosoma petenense	Threadfin shad	
Cottidae		
Cottus asper	Prickly sculpin	yes*
Cyprinidae		
Carassius auratus	Goldfish	
Cyprinus carpio	Carp	
Gilia orcutti	Arroyo chub	yes
Pimephales promelas	Fathead minnow	
Rhinichthys osculus	Speckled dace	yes
Ictaluridae		
Ameiurus melas	Black bullhead	
Ameiurus natalis	Yellow bullhead	
Ictalurus punctatus	Channel catfish	
Poeciliidae		
Gambusia affinis	Mosquitofish	
Poecilia latipinna	Sailfin molly	
Salmonidae		
Oncorhynchus mykiss	Rainbow trout	
Salmo trutta	Brown trout	

In summary, the fish and macroinvertebrates of the project area, although largely comprised of non–native species, are ecologically important because of the amount of food they contribute to other wildlife, including terrestrial species. Additionally, the plight of the native species is of great concern. Habitat alteration and threats posed by the abundance of introduced species led to the listing of the Santa Ana sucker by the Federal government as threatened (see section on Threatened and Endangered Species). The sucker is one of the species targeted for management actions in the watershed.

REPTILES AND AMPHIBIANS

A minimum total of 10 species of amphibians and 34 species of reptiles have been recently observed in the watershed or have been found there historically and probably persist (Glaser 1970, Robertson and Shipman 1974, Stebbins 1966, Zembal 1985, Zembal et al. 1985). Four species, two frogs and two turtles, are non–native members of the fauna.

Pacific tree frogs (Hyla regilla) and bullfrogs were the most commonly observed amphibians on the river, although western toads (Bufo boreas) were plentiful as well (nomenclature from Collins et al. 1978). In the mountain canyons, the California tree frog (Hyla cadaverina) was the most abundant amphibian.

The sighting of a red–legged frog (Rana aurora) along the south shore of the Prado Basin in 1984 was the last report for that Federally threatened species in the watershed; it has probably been extirpated, in large part due to competition with, and predation by, bullfrogs (Rana catesbeiana). The Federally endangered arroyo southwestern toad (Bufo microscaphus californicus) was found along at least one tributary of the river (see section on Threatened and Endangered Species).

Near mid-river, western fence lizards (Sceloporus occidentalis) were the most frequently encountered reptiles in riparian woodlands and were quite common, whereas side–blotched lizards (Uta stansburiana) were probably more abundant in total numbers but were found mostly in the uplands. Western whiptails (Cnemidophorus tigris) were the most abundantly observed reptiles only very locally, in minimally disturbed open shrublands. Western skinks (Eumeces skiltonianus) were also observed only in the remnant shrublands and only in low numbers. The only snake that was regularly observed, the gopher snake (Pituophis melanoleucus), was sighted in uplands as well as in drier riparian habitats.

Western fence lizards and side–blotched lizards were the most commonly observed reptiles in the mountain canyons in the upper watershed, as well. Western whiptails were occasionally seen on the canyon slopes and in open shrublands. Less common were the sagebrush lizards (Sceloporus graciosus) and southern alligator lizards (Gerrhonotus multicarinatus).

The snakes observed in the upper watershed were the Rosy Boa (Lichanura trivirgata), striped racer (Masticophis lateralis), gopher snake, common kingsnake (Lampropeltis getulus), California mountain kingsnake (Lampropeltis zonata), two–striped garter snake (Thamnophis couchi hammondi), and pacific rattlesnake (Crotalus viridis). The most commonly observed snakes were pacific rattlesnakes, striped racers, and gopher snakes. The red rattlesnake (Crotalus ruber) and speckled rattlesnake (Crotalus mitchelli) were observed regularly in the upper Santa Ana Canyon.

The San Diego horned lizard (Phrynosoma coronatum blainvillei), was once considered for Federal listing but currently has no special legal status. Individuals were found occasionally on sandy substrate in the mountain canyons. Both individuals and droppings were regularly seen. They were found in scattered localities along the river to the drier fringes in the lower Santa Ana Canyon, below Prado Dam. McGurty (1980) considered this subspecies endangered.

Except with notable, local exception, the diversity of reptiles and amphibians in the river riparian appeared to be relatively low. This could be due to the secretive nature, and nocturnal and fossorial habits of many species; they often can go undetected during survey work that relies upon observations. Alternatively, the diversity may actually be low due to past alterations and current uses of much of the watershed, including extensive agricultural, flood control, grazing, mowing, and intermittently prolonged inundation. The highest observed diversities and abundances were along the least visited, most isolated tributaries or sections, particularly in the mountain canyons.

BIRDS

Two hundred and fifty-six species of birds have been observed recently along the river, or would most likely be present where suitable habitat persists. A checklist can be found at the end of this section.

Prado Basin

Of the 178 species observed in one study of the Prado Basin (Zembal 1985, 1990), 100 species were most closely associated with riparian and open–water habitats; 29 species were mostly observed in shrublands or other upland areas; and 49 species were regular in both riparian and upland areas. There were 92 species (52% of the total) documented as breeders, 4 species (2.3%) were probable breeders, 6 species (3.4%) were possible breeders, 7 species (3.9%) were known local breeders (that were observed using the project area but not breeding therein), 3 species (1.7%) were probably nonbreeding summer residents, 3 species (1.7%) were rare escapes of unknown status, and the remaining 63 species (35%) were nonbreeding visitants or transients.

Breeding Avifauna

The common breeding species in the basin woodlands included the house wren (Troglodytes aedon), American goldfinch (Carduelis tristis), black–headed grosbeak (Pheucticus melanocephalus), brown–headed cowbird (Molothrus ater), downy woodpecker (Picoides pubescens), spotted towhee (Pipilo maculatus), mourning dove (Zenaida macroura), Bullock’s oriole (Icterus bullockii), American crow (Corvus brachyrhynchos), Bewick’s wren (Thryomanes bewickii), bushtit (Psaltriparus minimus), and song sparrow (Melospiza melodia). Yellow warblers (Dendroica petechia) were regular in taller willow stands, and yellow–breasted chats (Icteria virens) were interspersed mostly along the edges of the basin and along the watercourses, wherever the mid– and understory was thick. There were regularly spaced pairs of black phoebes (Sayornis nigricans) and green herons (Butorides viresens), as well as lazuli buntings (Passerina amoena) and blue grosbeaks (Guiraca caerulea) along the riparian edge where shrubbier riparian habitat was prevalent. The great blue heron (Ardea herodias), double–crested cormorant (Phalacrocorax auritus), and black–crowned night–heron (Nycticorax nycticorax) were extremely conspicuous breeders but present in very local concentrations. Also conspicuous, was the significantly large population of nesting white-tailed kites (Elanus leucurus), red–shouldered hawks, and red–tailed hawks (Buteo jamaicensis). Nests of each of these raptors were regularly spaced along the past reservoir shoreline and the watercourses. Nesting tree swallows (Tachycineta bicolor) were very abundant locally, with concentrations in the snag fields. In one such field of about one acre in size, 12 pairs were observed visting nests.

Red–winged blackbirds (Agelaius phoeniceus) and marsh wrens (Cistothorus palustris) were locally abundant nesters in emergent willows, as well as freshwater marsh plants. Several additional species nested at the water line in emergent willows including a large population of pied–billed grebes (Podilymbus podiceps), American coots (Fulica americana), and ruddy ducks (Oxyura jamaicensis), with more widely spaced mallards (Anas platyrhynchos) and cinnamon teal (Anas cyanoptera). The waterfowl also nested on the dikes of the duck ponds, on isolated high ground within the ponds, and in marginal emergent reeds in the few ponds allowed to become overgrown. At least one pair of northern shovelers (Anas clypeata) nested along one pond and several northern pintail (Anas acuta) nested in the marsh along Temescal Creek. Other nesting species on dry open flats, isolated in the ponds, included the American avocet (Recurvirostra Americana), black–necked stilt (Himantopus mexicanus), killdeer (Charadrius vociferous), and at least one pair of spotted sandpipers (Actitis macularia). Additional conspicuous marsh–nesting birds were red–winged blackbirds, marsh wrens, common yellowthroats (Geothlypis trichas), song sparrows, tricolored blackbirds (Agelaius tricolor), American bitterns (Botaurus lentiginosus), Virginia rails (Rallus limicola), and common moorhens (Gallinula chloropus).

Inundated willow woodland in the basin provides nesting habitat for several species of water–associated birds, as long as the water level remains fairly constant during the breeding season. Periodic inundation, however, prohibits the widespread development of the thick lower ground cover and shrubby riparian growth that is a common component of the creek side habitat. Consequently, near ground and ground nesting species are very locally distributed within the basin, whereas they are widespread and much more common along the watercourses where they enter the basin and upstream. This affected species such as common yellowthroats, song sparrows, yellow–breasted chats, and least Bell's vireos (Vireo bellii pusillus), a Federally listed endangered species. The lowest known 1983 nesting location for a Bell's Vireo was near elevation 510 feet where Temescal Creek enters the basin.

Six species of hawks and five species of owls were documented as breeders. The six hawk species that bred on the river were the black-shouldered kite, Cooper's hawk (Accipiter cooperii), red–shouldered hawk, red–tailed hawk, golden eagle (Aguila chrysaetos), and American kestrel (Falco sparverius). The five breeding owl species were the common barn owl (Tyto alba), western screech–owl (Otus kennicottii), great horned owl (Bubo virginianus), burrowing owl and long–eared owl (Asio otus). Wintering raptors include the turkey vulture (Cathartes aura), osprey, northern harrier and sharp–shinned hawk.

Casual observations suggested other differences in the species diversity and abundance of nesting birds within the basin lowlands versus along even slightly higher ground, particularly along the river and creeks. The absence of low to mid–level foliage and presence of water obviously accounted for certain differences in the local presence or abundance of several species. Additionally, certain canopy nesters may not have nested as abundantly over water in the emergent woodlands as over drier vegetated ground along the watercourses and higher ground in the basin (nearshore and along berms). For other species, the opposite appeared to be the case. The red–shouldered hawks and white-tailed kites, for example, appeared to be more uniformly distributed along the near shore band of the past reservoir and along the watercourses. In contrast, the nests of certain species were found in local concentrations within the basin. Most obvious were the Bullock's oriole and hooded oriole (Icterus cucullatus) with 8 Bullock's and 4 hooded oriole nests spaced 50–lOOm between one another, and small area counts estimating densities of about 0.538 territorial individuals per acre. In one such area, several of the orioles were observed foraging well away from their nests on an adjacent, open grassy slope. House wrens totally dominated certain large willow groves in terms of numbers, with small area counts revealing densities of roughly 0.462 singing birds per acre. Casual observations suggested local concentrations of several other species as well, including the mourning dove, American crow, green heron, western kingbird (Tyrannus verticalis) and Cassin's kingbird (Tyrannus vociferans). The expansiveness of such an unusually large forest of woodlands in the Prado Basin has apparently led to the local occurrence of habitat blocks that are unusually well suited to certain species.

Whereas certain species, including the more water–oriented, were most abundant in, or nearly confined to areas holding impounded water, several others were more regularly encountered on the edge of the basin and/or outward along the watercourses. These included the acorn woodpecker (Melanerpes formicivorus), Nuttall's woodpecker (Picoides nuttallii), Pacific-slope flycatcher (Empidonax difficilis), ash–throated flycatcher (Myiarchus cinerascens), oak titmouse (Parus inornatus), wrentit (Chamaea fasciata), orange–crowned warbler (Vermivora celata), lesser goldfinch (Carduelis psaltria), California quail (Callipepla californica), and western wood–pewee (Contopus sordidulus). In the vicinity of the basin, belted kingfishers and northern rough–winged swallows (Stelgidopteryx serripennis) were encountered most regularly along the lower Santa Ana River, probably because vertical earthen banks and potential nest holes were most abundant there.

Along the edge of the reservoir, above the riparian habitat, were old fields and grazed grasslands, shrublands, and eucalyptus groves. Only two regular breeders were abundant in the old fields with almost no shrub cover, the western meadowlark (Sturnella neglecta) and the horned lark (Eremophila alpestris); burrowing owls (Athene cunicularia) also nested therein, but in much lower numbers. However, these open habitats also comprised the single most heavily used hunting areas for the large resident and wintering raptor population, and for loggerhead shrikes (Lanius ludovicianus) as well. The most frequently encountered nesting species in the shrublands included the California towhee (Pipilo crissalis), lesser goldfinch, bushtit, California thrasher (Toxostoma redivivum), spotted towhee, rufous–crowned sparrow (Aimophila ruficeps), Bewick's wren, California quail, wrentit, and lazuli bunting. Nests of several species were found in the eucalyptus groves including red–tailed hawk, red–shouldered hawk, house wren, western kingbird, Cassin's kingbird, loggerhead shrike, Bullock's oriole, hooded oriole, Anna's hummingbird (Calypte anna), and house finch (Carpodacus mexicanus). Other species that exhibited territoriality in the eucalyptus groves and probably nested therein included the European starling (Sturnus vulgaris), spotted towhee, blue grosbeak, song sparrow, ash–throated flycatcher, American crow, common yellowthroat, northern mockingbird (Mimus polyglottos), northern flicker (Colaptes auratus), and house sparrow (Passer domesticus). Nests of the red–tailed hawk and red–shouldered hawk were regularly located in eucalyptus trees because they were the tallest trees available. Oriole and kingbird nests were locally concentrated in eucalyptus trees.

Wintering Avifauna

The significantly large raptor population in the Prado Basin was augmented in winter, both in terms of number of individuals and number of species. A total of 19 raptor species have been detected wintering including rare sightings of the ferruginous hawk (Buteo regalis) and bald eagle (Haliaeetus leucocephalus). No observations of northern harriers (Circus cyaneus) were obtained during the breeding season but they were commonly seen hunting over the open fields in winter. Sharp–shinned hawks (Accipiter striatus) were present only in winter; sightings of osprey (Pandion haliaetus) and peregrine falcons (Falco peregrinus) were also most frequent in winter; and the numbers of nearly all of the known resident species of raptors were also higher in winter. The riparian forest, eucalyptus groves, and surrounding relatively open habitats appear to collectively provide excellent raptor habitat

The most commonly encountered winter visitants in riparian woodlands were yellow-rumped warblers (Dendroica coronata) and ruby–crowned kinglets (Regulus calendula). Where more understory growth was present, Lincoln's sparrows (Melospiza lincolnii) were abundant. White–crowned sparrow (Zonotrichia leucophrys) flocks of up to 50 or more birds were common along shrublands and the riparian fringe. In more open areas, American pipets (Anthus rubescens) and savannah sparrows (Passerculus sandwichensis) were commonly observed foraging along fields, sandbars, and ponds in flocks of 50–100 individuals or more. Say’s phoebes (Sayornis saya), western bluebirds (Sialia mexicana), and mountain bluebirds (Sialia currucoides) were conspicuous as they foraged along open areas in the woodlands and from fence posts in the open fields.

The egrets were apparent in the largest numbers in winter. Over 50 cattle egrets (Bubulcus ibis) were routinely observed in single small fields, foraging along behind cattle or amongst plantings. Up to 35 snowy egrets (Egretta thula) were seen foraging along the shallow water of single flooded fields or pond margins, with intermixed great egrets in lower numbers.

The European starlings built to incredible numbers in winter. In one small cattle feedlot, a hunter’s shot brought approximately 15,000 starlings into the air at once. Many shorebirds wintered in the basin and foraged along the open pond margins and edges of the reservoir. The largest numbers observed were of least sandpipers (Calidris minutilla) and long–billed dowitchers (Limnodromus scolopaceus). Far fewer numbers of western sandpipers (Calidris mauri) and greater yellowlegs (Tringa melanoleuca) were observed.

On the ponds, American coots, ruddy ducks and eared grebes (Podiceps nigricollis) became much more abundant. Examples of the densities of these three species were obtained on the Corona Sewage Ponds. The eight cells cover an area of about 45 acres. On single counts, there were 103 eared grebes, 541 American coots, and 764 ruddy ducks. Such concentrations were also observed on the ponds in the basin and there was an obvious exchange of flights and individuals between the basin and sewer ponds. The winter concentrations of waterfowl in the basin were at least as large as those on any of the southern California coastal lagoons and Prado may hold the largest wintering populations of some species. There was a significantly large concentration of Canada geese (Branta canadensis), for example, with a local population of about 5,000 birds. A few snow geese (Chen caerulescens) and greater white–fronted geese (Anser albifrons) were sometimes mixed in with the Canada geese. Early in one winter season, all 5,000 geese were observed in the area, grazing in the field between the women’s prison, the Prado Regional Park, Cucamonga Avenue, and the reservoir. The local population also heavily used the Hidden Valley Wildlife Refuge (located about 5 miles upstream along the river), although flight line directions suggested constant exchanges of birds between the basin and the refuge. At the close of the hunting season, many of the birds foraging in the study area began spending the night on the north ponds in the basin. During the season, flight direction and honking suggested that they roosted on the reservoir but deeper in, at some unknown locality.

Sixteen species of ducks were observed in the Prado area and many thousands of individuals wintered there. The most abundant of the waterfowl were green–winged teal (Anas crecca), mallard, cinnamon teal, northern shoveler, American widgeon (Anas Americana), ring–necked duck (Aythya collaris), and ruddy duck. There were many thousands of each of the commoner seven species. As many as 79 Green–winged Teal were counted on one 1–acre pond and the two hunting clubs reported shooting 1,208 individuals during one past season. A total of 972 mallards were reported shot by the two hunting clubs in the Prado Basin. A count of 132 cinnamon teal was made over 50 acres of ponded water and 679 individuals were reported shot by the two hunting clubs. About 1,500 northern shovelers were counted on the north part of the reservoir in late March 1984; 178 individuals were counted on about 25 acres of ponded water; and the two hunting clubs reported killing 462 individuals. The largest single count of American widgeon obtained was of 400 on the north ponds, although the reported duck club take was of 1,135 individuals. The largest concentration of ring–necked ducks was observed on the sewer ponds in early February, when 187 individuals were counted on the 45 acres of ponds. The ruddy duck appeared to be the commonest of the waterfowl wintering in the basin; 256 were counted on a 5–acre pond and 764 were present during one count of the sewage ponds.

The most outstanding feature of the Prado Basin and environs is its vast expanse of riparian habitat and associated avifauna. This area is extremely important to migratory bird species. In the spring, there is an influx of migratory passerines. In winter, there are great numbers of wintering waterfowl and raptors.

Some Avian Species of Special Concern

Three species of birds listed by both the State and Federal governments occur in the project area, the bald eagle, least Bell's vireo, and southwestern willow flycatcher.

Generally, three or fewer of the State-listed endangered Yellow-billed Cuckoos (*Coccyzus americanus*) have been found near the Prado Basin annually. In 1984, there was a pair in the Prado Basin and two pairs just upstream along the Santa Ana River. One of these birds was seen carrying food, presumably for nestlings. Gaines (1977) detected three cuckoos in this general region. One individual was seen below Prado Dam at Featherly Park in 1976. These observations suggest the regular occurrence of cuckoos in the basin and environs. Cuckoos have large home ranges or territories of at least 10 ha, and possibly much larger (Laymon 1980). Furthermore, this species is secretive and fairly difficult to detect. The basin and environs appear to possess enough habitat for many more yellow–billed cuckoos than have been found. Indeed, this species illustrates the difficulties of working in the project area. The vast expanse of habitat, lack of access, and secretive nature of the cuckoo would make total assessment of the cuckoo's status in the basin exceedingly difficult.

The Blue List, List of Species of Special Concern, and the Sensitive Species List are all early warning devices or acknowledgements of the plight of several species of birds. Publication of these lists is an attempt to focus attention so that further declines can be arrested before legally binding recognition of these species rarity is necessary. All of these lists are warnings that unless current trends are reversed, it will be necessary to list these species in the future. The occurrence of so many rare and sensitive species in the

Prado Basin and environs is noteworthy (Zembal et al. 1985). Riparian habitat is dwindling away elsewhere in southern California and the Prado Basin is an extremely important refugia.

Threats by the Brown-Headed Cowbird

An unfortunate aspect of the avifauna of the project area is the large brown-headed cowbird population. This brood parasite lays its eggs into the nests of other species. The host species then raises a cowbird, often to the demise of its own young. Because the invasion of California by cowbirds is relatively recent, and unprecedentedly swift, due, in part, to large–scale land use changes, the impact on native species (for example, least Bell's vireos, yellow warblers, willow flycatcher, etc., Garrett and Dunn 1981) is high. Cowbirds seem to have an affinity for livestock, agriculture, and associated land uses; hence, the large population in the project area.

Avifauna of the Upper Watershed

One hundred and four species of birds were observed in the upper watershed and environs, mostly below the pine belt during earlier studies (Zembal and Kramer 1984). A total of 56 species of wintering birds was detected on wintering bird assessment plots. There were 42 species in the floodplain habitats along the Santa Ana River, 40 species in riparian habitat on Lytle Creek, and 38 species in the chaparral on a floodplain terrace on Lytle Creek. The most abundant wintering birds included the ruby–crowned kinglet, California towhee, hermit thrush (*Catharus guttatus*), black phoebe, rock wren (*Salpinctes obsoletus*), western scrub-jay (*Aphelocoma californica*), Bewick's wren, lesser goldfinch, wrentit, spotted towhee, golden–crowned sparrow (*Zonotrichia atricapilla*), and dark–eyed junco (*Junco hyemalis*).

The wintering raptors in the upper watershed include the golden eagle, sharp–shinned hawk, Cooper's hawk, red–tailed hawk, American kestrel, red–shouldered hawk, turkey vulture, barn owl, and western screech owl.

Table 12. Wintering Birds per 100 acres of the Upper Santa Ana River and Lytle Creek.

	Riparian		Chaparral
	Santa Ana Canyon	Lytle Creek	Lytle Creek
Ruby–crowned Kinglet	28	42	7
California Towhee	23	54	66
Hermit Thrush	18	25	11
American Goldfinch	18	-	-
Black Phoebe	13	4	+
Rock Wren	13	4	-
Western Scrub-Jay	10	29	21
Bewick’s Wren	10	8	3
Lesser Goldfinch	10	21	7
Northern Flicker	8	8	7
Wrentit	8	54	52
California Thrasher	8	8	17
Dark–eyed Junco	8	33	34
Mountain Quail	5	4	-
Bushtit	5	8	7
Spotted Towhee	5	46	55
Song Sparrow	5	17	+
Red–tailed Hawk	3	8	+
American Kestrel	3	+	+
Common Snipe	3	-	-
Anna’s Hummingbird	3	4	41
Nuttall’s Woodpecker	3	4	3
Canyon Wren	3	4	-
Loggerhead Shrike	3	-	+
Common Yellowthroat	3	-	-
Golden–crowned Sparrow	3	13	48
House Finch	3	-	11
Pine Siskin	3	62	+
Cooper’s Hawk	+	+	+
Red–shouldered Hawk	+	+	+
Spotted Owl	+	-	-
Vaux’s Swift	+	-	-
Belted Kingfisher	+	-	-
Say’s Phoebe	+	-	-
Common Raven	+	-	3
Oak Titmouse	+	4	17
American Dipper	+	-	-
California Gnatcatcher	+	-	-
Yellow-rumped Warbler	+	+	3
Rufous–crowned Sparrow	+	+	3
Fox Sparrow	+	+	-
Lincoln’s Sparrow	+	4	-
Steller’s Jay	-	29	+
Mountain Chickadee	-	8	+
Purple Finch	-	8	14

Table 12 (cont.)

	Riparian Santa Ana Canyon	Riparian Lytle Creek	Chaparral Lytle Creek
Band–tailed Pigeon	-	4	-
White–throated Swift	-	4	-
Western Bluebird	-	4	17
Sharp–shinned Hawk	-	+	-
Golden Eagle	-	+	-
American Crow	-	+	3
White–crowned Sparrow	-	+	14
California Quail	-	-	11
America Robin	-	-	3
Red–breasted Sapsucker	-	-	+
Golden–crowned Kinglet	-	-	+
Total Species	42	40	38
Total Count	218	527	479

*Numbers are birds per 100 acres and includes only those observed on the winter–bird plots.

A total of 61 species of breeding birds was detected on bird plots in the upper watershed (Table 13). There were 47 species detected in the floodplain habitats along the Santa Ana River, 39 species in riparian habitats on Lytle Creek, and 30 species in the chaparral on a floodplain terrace on Lytle Creek. The common breeding species included the song sparrow, lesser goldfinch, Costa’s hummingbird (Calypate costae), California towhee, rock wren, spotted towhee, black–headed grosbeak, lazuli bunting, Bullock’s oriole, house wren, black phoebe, ash–throated flycatcher, western scrub-jay, Anna’s hummingbird, and wrentit. Breeding raptors in the upper canyons and environs included the golden eagle, Cooper’s hawk, red–tailed hawk, American kestrel, barn owl, great horned owl, and western screech owl. (The winter counts and breeding bird censuses were published in American Birds.

During both Springs that the avifauna of the upper canyons was examined intensively, the endangered least Bell’s vireo was a visitor to the upper Santa Ana River Canyon. Two singing male Bell’s vireos were present briefly in the Santa Ana Canyon riparian thickets in the spring of 1984 and one in 1985. Breeding did not occur.

Table 13. Breeding birds of the Upper Santa Ana Canyon and Lytle Creek, 1985.

	Riparian		Chaparral
	Santa Ana Canyon	Lytle Creek	Lytle Creek
Song Sparrow	68	87	-
Lesser Goldfinch	46	54	28
Costa’s Hummingbird	32	27	24
California Towhee	26	50	36
Rock Wren	25	+	-
Spotted Towhee	24	50	45
Black—headed Grosbeak	19	21	4
Lazuli Bunting	17	17	4
Bullock’s Oriole	17	8	-
House Wren	15	50	+
Black Phoebe	13	-	-
Ash—throated Flycatcher	10	12	12
Western Scrub-Jay	10	12	11
Mourning Dove	8	-	7
Anna’s Hummingbird	8	27	14
Western Wood—Pewee	8	8	4
Violet—green Swallow	8	-	-
Wrentit	8	25	76
Brown—headed Cowbird	8	4	7
House Finch	8	8	7
White—throated Swift	5	-	-
Northern Flicker	5	4	4
Bushtit	5	8	4
Canyon Wren	5	-	-
Yellow Warbler	5	-	-
Black—chinned Hummingbird	2	12	4
Nuttall ‘s Woodpecker	2	2	2
Bewick’s Wren	2	6	17
California Thrasher	2	10	19
Wilson’s Warbler	2	8	-
Rufous—crowned Sparrow	2	4	2
Brewer’s Blackbird	2	-	-
Mountain Quail	1	-	-
Blue—gray Gnatcatcher	1	6	53
Orange—crowned Warbler	1	19	-
Mallard	+	-	-
Cooper’s Hawk	+	-	-
Red—tailed Hawk	+	-	-
American Kestrel	+	-	-
Greater Roadrunner	+	-	2
Pacific-slope Flycatcher	+	19	-
No. Rough—winged Swallow	+	-	-
Oak Titmouse	+	6	11
Warbling Vireo	+	4	-
Common Yellowthroat	+	-	-
Black—chinned Sparrow	+	+	+
Red—winged Blackbird	+	-	-
Common Raven	-	-	-

	Riparian Santa Ana Canyon	Riparian Lytle Creek	Chaparral Lytle Creek
Phainopepla	-	+	+
California Quail	-	-	7
Downy Woodpecker	-	-	-
American Dipper	-	-	-
Least Bell's Vireo	-	-	-
Yellow—breasted Chat	-	-	-
Steller's Jay	-	8	-
Swainson's Thrush	-	6	-
Lawrence's Goldfinch	-	6	+
Dark—eyed Junco	-	4	-
Purple Finch	-	4	14
Hutton's Vireo	-	+	-
Western Tanager	-	+	-
Total Species	47	39	30
Territories/100 acres	421	600	413

Birds at the Santa Ana River Mouth

Surveys of the marsh and river mouth habitats in 1995 revealed 94 species of birds (Kelsey and Collins 1995). Fifteen of these coastal species were not included on the earlier Prado checklist.

Avian Checklist of the Santa Ana River Watershed

Table 14 is a checklist of 256 species of birds observed in the watershed.

Table 14. AVIFAUNA OF THE SANTA ANA RIVER

Long-Legged Waders

Bitterns and Herons

American Bittern
Least Bittern
Great Blue Heron
Great Egret
Snowy Egret
Little Blue Heron
Cattle Egret
Green Heron
Black-crowned Night-Heron

Storks & Ibises

White-faced Ibis
Wood Stork
Red-throated Loon

Gull-like Birds

Gulls, Terns, and Jaegers

Parasitic Jaeger
Bonaparte's Gull
Ring-billed Gull
California Gull
Herring Gull
Western Gull
Elegant Tern
California Least Tern
Caspian Tern
Forester's Tern
Black Tern
Black Skimmer

Upright Perching Water Birds

Double-crested cormorant

Duck-like Birds

Swans, Geese, and Ducks

Snow Goose
Canada Goose
Wood Duck
Green-winged Teal
Mallard
Northern Pintail
Blue-winged Teal
Cinnamon Teal
Northern Shoveler
Gadwall
American Wigeon
Canvasback
Redhead
Ring-necked Duck
Greater Scaup
Lesser Scaup
Bufflehead
Hooded Merganser
Common Merganser
Red-breasted Merganser
Ruddy Duck
Greater White-fronted Goose
Common Goldeneye

Grebes

Pied-billed Grebe
Eared Grebe
Western Grebe
Clark's Grebe

Pelicans

American White Pelican
Brown Pelican

Sandpiper-like Birds

Sandpipers, Phalaropes, and Allies

Greater Yellowlegs
Lesser Yellowlegs
Solitary Sandpiper
Willet
Spotted Sandpiper
Whimbrel
Long-billed Curlew
Marbled Godwit
Western Sandpiper
Least Sandpiper
Baird's Sandpiper
Pectoral Sandpiper
Ruddy Turnstone
Dunlin
Ruff
Short-billed Dowitcher
Long-billed Dowitcher
Common Snipe
Wilson's Phalarope
Red-necked Phalarope

Plovers

Black-bellied Plover
Snowy Plover
Semipalmated Plover
Kildeer

Stilts and Avocets

Black-necked Stilt
American Avocet

Chicken-like Marsh Birds

Rails, Gallinules, Coots

Virginia Rail
Sora
Common Moorhen
American Coot

<u>Upland Ground Birds</u>

California Quail
Mountain Quail
Greater Roadrunner

Owls

Western Screech-Owl
Great Horned Owl
Burrowing Owl
Long-eared Owl
Short-eared Owl
Spotted Owl
Barn Owl

Nighthawks

Lesser Nighthawk

<u>Hawk-like Birds</u>

Kites, Hawks, and Eagles

Osprey
White-tailed Kite
Bald Eagle
Northern Harrier
Sharp-shinned Hawk
Cooper's Hawk
Red-shouldered Hawk
Swainson's Hawk
Red-tailed Hawk
Ferruginous Hawk
Golden Eagle

Vulture

Turkey Vulture

Caracaras and Falcons

American Kestrel
Merlin
Peregrine Falcon
Prairie Falcon

<u>Pigeon-like Birds</u>

Pigeons and Doves

Rock Dove
Spotted Dove
White-winged Dove
Mourning Dove
Common Ground-Dove
Band-tailed Pigeon

<u>Swallow-like Birds</u>

Swallows

Purple Martin
Tree Swallow
Violet-green Swallow
Northern Rough-winged Swallow
Bank Swallow
Cliff Swallow
Barn Swallow

Swifts

Black Swift
Chimney Swift
Vaux's Swift
White-throated Swift

<u>Tree-clinging Birds</u>

Woodpeckers and Allies

Acorn Woodpecker
Red-breasted Sapsucker
Nuttall's Woodpecker
Downy Woodpecker
Hairy Woodpecker
Northern Flicker
Willliamson's Sapsucker

Hummingbirds (HB)

Black-chinned HB
Anna's HB
Costa's HB
Rufous HB
Allen's HB

<u>Perching Birds</u>

Sparrows, Towees, Juncos, and Allies

Green-tailed Towhee
Spotted Towhee
California Towhee
Rufous-crowned Sparrow
Chipping Sparrow
Vesper Sparrow
Lark Sparrow
Black-chinned Sparrow
Sage Sparrow
Savannah Sparrow
Belding's Savannah Sparrow
Grasshopper Sparrow
Fox Sparrow
Song Sparrow
Lincoln's Sparrow
Swamp Sparrow
Golden-crowned Sparrow
White-crowned Sparrow
Dark-eyed Junco
Chestnut-collared Longspur
House Sparrow

Finches and Allies

Purple Finch
House Finch
Pink Siskin
Lesser Goldfinch
Lawrence's Goldfinch
American Goldfinch

Wood Warblers

Orange-crowned Warbler
Nashville Warbler
Northern Parula
Yellow Warbler
Black-throated Blue Warbler
Yellow-rumped Warbler

Black-throated Gray Warbler
Townsend's Warbler
Hermit Warbler
Palm Warbler
Black-and-White Warbler
American Redstart
Northern Waterthrush
Kentucky Warbler
MacGillivrays' Warbler
Common Yellowthroat
Wilson's Warbler
Yellow-breasted Chat

Old World Warblers
Ruby-crowned Kinglet
Golden-crowned Kinglet
California Gnatcatcher
Blue-gray Gnatcatcher

Tyrant Flycatchers
Olive-sided Flycatcher
Western Wood-Pewee
Southwestern Willow Flycatcher
Hammond's Flycatcher
Gray Flycatcher
Pacific-slope Flycatcher
Black Phoebe
Eastern Phoebe
Say's Phoebe
Vermillon flycatcher
Ash-throated Flycatcher
Cassin's Kingbird
Western Kingbird
Eastern Kingbird
Scissor-tailed Flycatcher

Titmice
Oak Titmouse
Mountain Chickadee
Bushitt

Pipits
American Pipit

Blackbirds and Orioles
Red-winged Blackbird
Tricolored Blackbird
Western Meadowlark
Yellow-headed Blackbird
Brewer's Blackbird
Great–tailed Grackle
Brown-headed Cowbird
Hooded Oriole
Bullock's Oriole

Tanagers, Grosbeaks, and Buntings
Western Tanager
Rose-headed Grosbeak
Black-headed Grosbeak
Blue Grosbeak
Lazuli Bunting
Indigo Bunting

Jays, Magpies, and Crows
Western Scrub Jay
Stellar Jay
American Crow
Common Raven

Wrens
Rock Wren
Bewick's Wren
House Wren
Marsh Wren
Canyon Wren
Catcus Wren

Dipper
American Dipper

Vireos
White-eyed Vireo
Least Bell's Vireo
Solitary Vireo
Hutton's Vireo
Warbling Vireo
Red-eyed Vireo

Thrushes
Western Bluebird
Mountain Bluebird
Swainson's Thrush
Hermit Thrush
American Robin
Wrentit

Mockingbird and Thrashers
Northern Mockingbird
California Thrasher
Sage Thrasher

Starling
European Starling
Waxwings
Cedar Waxwing
Shrikes
Loggerhead Shrike
Larks
Horned Lark
Cuckoo
Yellow-billed Cuckoo
Kingfisher
Belted Kingfisher
Phainopepla
Phainopepla

MAMMALS

Twenty-three species of mammals, including three that are nonnative, were observed along the middle river. These included one marsupial, one insectivore, two lagomorphs, 11 rodents, seven carnivores, and the mule deer. Chiropterans have not been surveyed well but there could be as many as 15 species in the watershed (Zembal 1984).

Six species of mammals found in the Prado Basin and environs are listed in the California Hunting Regulations with seasons and limits set by the State Fish and Game Commission. The mule deer (Odocoileus hemionus) is a big game animal; the Audubon cottontail (Sylvilagus audubonil) and jackrabbit (Lepus californicus) are resident small game animals; the gray fox (Urocyon cinereoargenteus) and the raccoon (Procyon lotor) are furbearing mammals; and the bobcat (Felis rufus) is a regulated nongame mammal. The mountain lion (Felis concolor) is protected under special State legislation and there are two listed small mammals, the endangered San Bernardino kangaroo rat (Dipodomys merriami parvus) (in the upper watershed only) and the threatened Stephen's kangaroo rat (Dipodomys stephensi) (in western Riverside County only).

The deer mouse (Peromyscus maniculatus) was by far the most commonly captured small mammal in previous studies of riparian habitat within the Santa Ana River Watershed. The species was captured most abundantly in the uplands, but animals were also trapped in riparian habitats. The high reproductive potential and mobility of cricetine mice may function to make them extremely efficient colonizers, able to take advantage of areas, such as floodplains and flood control basins that are suitable only on an intermittent basis (Whitford 1976). The abundance of local temporary disruption of habitat in the project area (inundation, plowing, and heavy grazing for a time that renders large areas unsuited to the presence or abundance of small mammals) may serve to foster the continued apparent dominance of deer mice in the small mammalian fauna of the Prado Basin and other floodplain areas. The other six species of rodents captured were taken in relatively low numbers. The introduced house mouse (Mus musculus) and black rat (Rattus rattus) were taken near current or abandoned dwellings, piles of human refuse, and in situations that were too wet for native small mammals.

The California Ground Squirrel (Spermophilus beecheyi) was the most abundantly encountered small mammal in the project area. The open uplands and heavily grazed fields provide ideal habitat for this species. Of the two lagomorphs found in the project area, the Audubon cottontail was the most common and was locally quite numerous. Animals were observed in grasslands, shrublands, in shrubby riparian growth, and along the margins of woodlands. Jackrabbits were locally very abundant in sparsely vegetated places. The coyote and raccoon were the most commonly encountered of the seven species of carnivores documented. Raccoon tracks were so abundant that we strongly suspect that they are the most abundant of the carnivores in terms of numbers of individuals. Both species are relatively omnivorous and appeared, through sign, to take full advantage of the incredible abundance of crayfish.

The next most commonly documented of the carnivores were the striped skunk (Mephitis mephitis) and long–tailed weasel (Mustela frenata). Bobcats were regular in occurrence throughout the Basin but in relatively low numbers. The feral cats (Fells domesticus) observed in the study area appeared to be entirely wild. Mule deer tracks were occasionally observed in the Prado Basin. The grazing lands and crops along with the dense cover of willow woodland provide support for small herds here and there along the middle river. The largest herds are probably associated with the upper river abutting the National Forest and the lower canyon and adjacent Chino Hills. The habitat breadth is more suitable in these areas and the deer sign was most regularly encountered.

A total of 13 kangaroo rats were captured in riparian habitat edges during 1,002 trap–nights in the Basin and all were pacific kangaroo rats (Dipodomys agilis).

Thirty species of mammals were detected in upper watershed, only one of which, the common opossum (Didelphis marsupialis), is an introduced species. These 30 species included one species of marsupial, two bats, three lagomorphs, 14 rodents, nine carnivores, and one ungulate. Annotations for these species are available in earlier reports (Zembal and Kramer 1984).

Ten species of these mammals are listed in the California Hunting Regulations, with seasons and bag limits set by the State Fish and Game Commission. Those additional to the species listed above for the Basin include the brush rabbit (Sylvilagus bachmani), a resident small game animal; the badger (Taxidea taxus), and beaver (Castor canadensis) are furbearing mammals; and the ringtail (Bassariscus astutus) is fully protected.

The most commonly observed small mammals during daylight hours were California ground squirrels and the rabbits. The ground squirrels were common along the dirt road margins, in boulder heaps, open disturbed areas, and open shrublands. The jack rabbits were most common on the open floodplain, whereas cottontails were prevalent on the floodplain margins where riparian thickets provided escape cover, and brush rabbits were very common in dense chaparral.

The most abundant small nocturnal mammals included deer mice, brush mice (Peromyscus boylii), cactus mice (P. eremicus) (in the Santa Ana River floodplain), the desert woodrat (Neotoma lepida), and the Pacific kangaroo rat. The diggings of pocket gophers (Thomomys bottae) were occasionally observed in open shrublands. The other rodents encountered in the project area were the San Diego pocket mouse (Perognathus fallax), California pocket mouse (P. californicus), western harvest mouse (Reithrodontomys megalotis), dusky–footed woodrat (Neotoma fuscipes), and California vole (Microtus californicus). Western gray squirrels (Sciurus griseus) were observed sporadically in the slope woodlands along Lytle Creek and in oak–dominated draws along the Santa Ana River. The sparse stick nests and droppings of the desert woodrat were common in the open floodplain amongst boulders, but on the slopes and in dense riparian growth, the more elaborate nests of the dusky–footed woodrat were abundant. Because of the similarity of the habitats, species composition of the small mammalian fauna was quite similar for the upper Lytle Creek and the Santa Ana River.

The bats of the project area have not been studied. Observations of several individuals in flight indicated the presence of the western pipistrelle (Pipistrellus hesperus) and at least two species of Myotis. There is an old report of hoary bats (Lasiurus cinereus) from the upper Santa Ana Canyon, as well (Ingles 1929).

Beaver dams were found on two side channels of the upper Santa Ana River, but they do not appear to be abundant anywhere along the river.

The coyote, raccoon, and striped skunk were the commonest of the carnivores detected in the upper watershed. Additional carnivores included the mountain lion, bobcat, ringtail, gray fox, badger, and long–tailed weasel.

The mule deer is the most economically important big game mammal in California and is found throughout the upper Santa Ana Canyon and Lytle Creek. Upper watershed areas provide key winter range for deer and receive heavy use by hunters (USFS 1985). In addition, the Santa Ana River Canyon provides an important corridor for movements during seasonal migration and appears to comprise an appropriate mosaic of habitats for some fawning.

ENDANGERED SPECIES

There are nine listed species in the watershed that could be affected by the proposed activities. Two are plants, the Santa Ana River woolly star and slender-horned spine flower; one fish, the Santa Ana River sucker; one amphibian, the southwestern arroyo toad; three birds, the southwestern willow flycatcher, least Bell's vireo, and bald eagle; and two mammals, the San Bernardino kangaroo rat and Stephen's kangaroo rat. It is the goal of the watershed program to benefit these species through management and habitat restoration and thereby to accommodate and benefit all native wildlife including additional rare species.

Santa Ana River Woolly Star

The Santa Ana River woolly star was listed as a federally endangered species on September 28, 1987. The woolly star is a short-lived, perennial, subshrub of the phlox family (Polemoniaceae). It has a basally branched, generally erect or spreading form, reaching 30 inches in height. The entire plant, including the inflorescence, is covered with woolly pubescence, giving it a silvery-white appearance. The inflorescence is dense and spiny-bracted with about 20 flowers. Flowers have blue to violet-blue, elongate, funnel-shaped corollas usually longer than 1.0 inch. The light gray-green leaves generally curve upward, are irregularly divided to the midrib into two to six narrow lobes, and are up to 2.0 inches long.

Four other subspecies of Eriastrum densifolium have been recognized. A key feature that distinguishes E. d. sanctorum from other subspecies is the length of its floral tube. Floral tube lengths in the other three subspecies do not exceed 0.8 inches. Eriastrum densifolium ssp. sanctorum occurs at elevations below 2,000 feet, lower than some of the other subspecies.

No critical habitat has been designated. Woolly star is a pioneer species that colonizes washed sand deposits created by sporadic stream flow action. Between major flood events, these deposits typically exist as terraces above the high water mark of the river and associated braided streams. Woolly star grows primarily in Riversidean alluvial fan sage scrub (RAFSS) in sandy soils from 1,240 to 1,900 feet in elevation. It thrives in nutrient poor sands of early phase RAFSS habitat that have more than 97% sand particles. The dominant species on young substrates include California buckwheat, scalebroom (Lepidospartum squamatum), fastigiate golden aster (Heterotheca fastigiata), and California croton (Croton californica). Woolly star also remains competitive on intermediate-aged substrates that have between 90% and 97% sand particles. The dominant species on intermediate substrates include California buckwheat, scalebroom, California juniper, valley cholla (Opuntia californica var. parkeri), and coastal prickly pear (Opuntia littoralis). In the few locations where woolly-star occurs in mature phase RAFSS, stands are relatively small and appear to be declining; probably because competition from shrubs and annual herbs limits the establishment of the subspecies. The dominant species on older substrates include sugar bush, holly-leaved cherry, and chamise. Total vegetative cover at sites supporting woolly-star ranges from 42% to 48% at younger sites and 66% to 88% at older sites.

Woolly star is a short-lived perennial species. The average life span of this perennial is 5 years, with a maximum life expectancy of 10 years. Woolly star begins reproduction in the second season of growth. The blooming period is from late May through mid-August with heaviest blooms occurring in June. Total seasonal rainfall and time of rainfall may have an effect on the time of flowering.

Woolly star is primarily an outcrosser, and depends on pollinators for dispersal because seeds typically fall within 4 inches of the parent plant. The flowers of woolly-star mature and release pollen prior to the maturation and receptivity of the stigma. Jones and Burk (1996) documented a “drastic reduction” in fruit and seed set in 1995, corresponding with a reduction in observed pollinator populations that year. Identified pollinators of woolly-star are the solitary digger bee (Micranthophora flavocinta), giant flower-loving fly (Rhaphiomidas acton acton), California bumblebee (Bombus californicus), white-lined sphinx moth (Hyles lineata), the black-chinned hummingbird (Arhilochus alexandri), and Anna's hummingbird (Calypte anna). The digger bee is an important pollinator in early phase RAFSS habitat, whereas hummingbirds and the giant flower-loving fly are important pollinators at intermediate stage sites. The California bumblebee and giant flower-loving fly may be the primary pollinators in both the Santa Ana River and Cajon Creek washes, although overall pollinator assemblages differed among sites.

When seeds of woolly star are wetted, the outer seed coat forms a mucilaginous mass that readily attaches the seed to the surrounding soil particles. Hence, it is unlikely that woolly star efficiently disperses into new habitats unless floods carry the seeds greater distances. The optimum temperature for germination is about sixty degrees Fahrenheit and no scarification or other treatment of any kind is necessary to stimulate germination. During demographic studies in the late 1980s, seedlings germinated simultaneously with the first major autumn storms. The median survival time of woolly star seedlings was determined to be significantly longer in early phase RAFSS than in older sites. Mortality in early phase RAFSS was not negatively correlated with seedling density, whereas at older sites mortality was density-dependent.

Historically, habitat for woolly star likely occurred in a mosaic pattern, shifting in time and space across alluvial floodplains. Woolly star habitat still exists in a mosaic pattern within remaining patches of alluvial fan scrub along the Santa Ana River and Lytle and Cajon Creeks. The pattern of distribution of sub-populations, combined with current knowledge of the genetic diversity and pollinator ecology, suggests that the subspecies functions as a meta-population. The woolly star has a standing seed bank. Those seeds not immediately shed from the fruits are stored within the capsules. During floods, long distance movement of encapsulated seeds down the floodplain is possible, facilitating some gene flow between sub-populations.

Woolly star was listed because the remaining 10% of its range was threatened by encroaching developments within the floodplain, sand and gravel mining, grazing by domestic animals, competition from exotic plants, and other factors. Historically, woolly star occupied about 60 miles of habitat along the Santa Ana River from an elevation of about 2,000 feet at the base of the San Bernardino Mountains, through Riverside County, to about 500 feet in the vicinity of Santa Ana Canyon in Orange County. Woolly star may have occupied alluvial habitats in Orange County as far downstream as Santiago Canyon. Today, the subspecies is known from one extended, fragmented population in San Bernardino County on alluvial terraces along the

Santa Ana River and its tributaries. No individuals have been located in Riverside or Orange Counties during recent decades.

Since its listing, the status of this woolly-star has been one of continuing decline, with land development responsible for a significant portion of the loss of habitat. Current threats include urban development, off-road vehicles, flood control activities, sand and gravel mining operations, and competition from non-native plants.

Slender-horned Spineflower

The slender-horned spineflower (Dodecahema leptoceras) was federally listed as endangered on September 28, 1987. A monospecific genus in the buckwheat family (Polygonaceae), the species is a small, ephemeral, low spreading annual that is difficult to detect from more than 15 feet away. The species is only readily detectable in the spring, when in flower or shortly thereafter. The leaves and bracts turn bright red by the time flower cluster appear.

No critical habitat has been designated for this plant. Dodecahema leptoceras is generally associated with old formation alluvial benches and floodplain terraces in washes and lower slopes of mountains below 2,000 feet in soft chaparral and alluvial scrub vegetation. The species generally inhabits openings in intermediate and mature Riversidean alluvial fan sage scrub, where disturbance from flooding is less frequent which is characterized by flood flows, scouring, and deposition of Entisol-type alluvium. Adequate alluvial scrub habitat and active fluvial processes are important to maintain habitat. The ideal habitat appears to be a terrace or bench that receives overbank deposits every 50 to 100 years (Prigge, et al., 1993).

The slender-horned spineflower is an herbaceous annual and a spring-bloomer, expected to germinate following winter precipitation. Germination often does not occur in years with inadequate rainfall. The normal life span is less than 4 months. The flowering period varies between April and June depending on the timing and the amount of winter rainfall. The species has white to pink flowers, 1.2 to 2 mm in length, which produce small brown or black single-seeded achenes, 1.7 to 2 mm long.

This spineflower is protandrous (anthers develop earlier than stigma), suggesting that the slender-horned spineflower is an obligate outcrosser; however, the species is apparently self-compatible (Reveal 1989, cited in Prigge *et al.* 1993). Small native bees, wasps and occasionally ants have been observed visiting D. leptoceras, however only a single wasp species, Plenoculus davisii, has been identified as a pollinator. The plant is probably pollinated by a variety of species.

After flowering, the plants die back, become brittle and may disintegrate. The involucre has six ascending and six descending awns, rendering it ideally suited for animal dispersal. Potential dispersal agents include coyotes, rabbits, rodents, and deer. Dispersal may also occur via flood water or wind.

Population size varies considerably from year to year depending on the amount and seasonality of rainfall, as well as seed set from previous years. Germination often does not occur in years with inadequate rainfall. Occurrences of Dodecahema leptoceras within individual drainage basins are best considered metapopulations. This term implies a fluidity in space and time where small groups of individuals of a species, with a naturally dissected range, grow in a localized site for a time then disappear.

The species is known from nine occurrences, ranging from Bee Canyon at the northeast limit of its known range, west to the Santa Ana River Wash in Redlands (supporting a cluster of several sub-populations), and south to Temescal Canyon, Bautista Canyon, and the Vail Lake area of Riverside County, California. Known occurrences on National Forest lands are at Bautista Canyon on the San Bernardino National Forest and south of Vail Lake on the Cleveland National Forest. Occurrences at Bee Canyon, Big Tujunga Canyon, Cajon Creek, Santa Ana River, Temescal Creek, San Jacinto River, and Dripping Springs are on alluvial outwashes downstream of National Forest lands.

Historically, this spineflower was reported to occur in many of the alluvial systems on the coastal side of the transverse range in Los Angeles and San Bernardino counties, and at the base of the interior slopes of the Agua Tibia mountains in Riverside County. Many of these alluvial fans coalesced into an extensive bajada to form a nearly continuous skirt along these mountains. Most historic collections of slender-horned spineflower were from stands that have been extirpated. At present, only about one-third of all known historic locations for this species are still extant. At least 15 previously known sites no longer support populations (California Natural Diversity Data Base (CNDDB) 1997, Michael Brandman Associates 1988).

This species was listed due to a dramatic reduction in range and immediate and tangible threats to many of its remaining known occurrences. The slender-horned spineflower is dependent upon washes and thus vulnerable to activities that would result in alterations of hydrology (e.g., channelization, restriction of active sediment transport, and removal of sandy substrate). The primary threats to Dodecahema leptoceras are loss of habitat through urbanization and flood control projects, and associated hydrological and fluvial geomorphological changes to the alluvial systems that maintain this characteristic habitat type. Off road vehicle activity and invasion of exotic species are also grave threats to some occurrences. Dispersed recreation can lead to trampling of plants.

Along with its alluvial scrub habitat, the slender-horned spineflower’s range has been significantly reduced and fragmented by the intense development within the greater Los Angeles area. Flood control structures such as debris dams and channelization have altered the natural flooding regimes or natural forces responsible for habitat renewal. Other impacts to this species' habitat include agriculture, sand and gravel mining, invasion of non-native plant species, off-road vehicle activity, and construction of various dams and debris basins upstream of and/or within habitat for this species, including the Seven Oaks Dam on the Santa Ana River.

Santa Ana Sucker

The Santa Ana sucker(<u>Catostomus</u> <u>santaanae</u>) is silvery below, darker along the back with irregular blotches, and the membranes connecting the rays of the tail are pigmented.

The Santa Ana sucker inhabits streams that are generally small and shallow, with currents ranging from swift (in canyons) to sluggish (in the bottomlands). All of the streams are subject to periodically severe flooding. Suckers appear to be most abundant where water is cool (less than 22 deg. Celsius), unpolluted, and clear; however, they can tolerate and survive in seasonally turbid water (Moyle 1976, Moyle and Yoshiyama 1992).

Suckers generally live no more than 3 years (Greenfield et al. 1970). Spawning occurs from early April to early July. Peak spawning activity occurs in late May and June. Females, ranging in size from 78 mm to 158 mm in length, produce approximately 4,000 to 16,000 eggs (Moyle 1976). Suckers feed mostly on algae, which they scrap off of rocks and other hard substrates. Larger fish generally feed more on insects than do smaller fish (Moyle 1976). The combination of early sexual maturity, protracted spawning period, and high fecundity potentially allows the sucker to quickly repopulate streams following periodic flood events that can decimate populations (Greenfield et al. 1970, Moyle 1976).

The Santa Ana sucker was federally listed as threatened on May 12, 2000. Critical habitat has not been proposed for the sucker. Within its native range, the species is now restricted to three noncontiguous populations: lower Big Tujunga Creek (Los Angeles River drainage), the East, West, and North Forks of the San Gabriel River (San Gabriel River drainage), and the lower and middle Santa Ana River (Santa Ana River drainage) (Moyle and Yoshiyama 1992). An introduced population also occurs in the Santa Clara River drainage system of Ventura and Los Angeles Counties (Smith 1966, Moyle 1976, Swift et al. 1993). Although the sucker was described as common in the 1970s, the species has experienced declines throughout most of its range (Swift et al. 1993).

Although historically present, the species may have been extirpated from the Los Angeles River (Swift et al. 1993). The portions of Big Tujunga Creek occupied by the sucker constitute approximately 25% of the total remaining native range of the species. Approximately 60% of the range of the sucker in the Los Angeles River basin occurs on private lands. The remaining 40% of the range in the Los Angeles River basin occurs on Angeles National Forest lands.

In the San Gabriel River, the sucker appears extant only upstream of the confluence of the East, West, and North Forks of the San Gabriel River. The portions of the San Gabriel River occupied by the sucker constitute approximately 15% of the total remaining native range of the species. Suckers were present in Piru Creek, a major Santa Clara tributary, by 1934 and in the Santa Clara River proper and its Sespe Creek tributary by 1940 (Buth and Crabtree 1982).

The sucker survives in the lower portions of the Santa Ana River, from the Imperial Highway (SR 90) to Rubidoux near the city of Riverside, but is now apparently absent from the upper reach of this river in the San Bernardino Mountains (Moyle and Yoshiyama 1992, Swift et al. 1993). The portions of the Santa Ana River occupied by the sucker constitute approximately 60% of the total remaining native range of the species. Approximately 95% of the range of the sucker in the Santa Ana River basin occurs on private lands. The balance is within state, county, city, and regional park lands, with a small portion, 3%, on military lands. Chadwick and Associates (1996) noted that length-frequency analysis indicates suckers are naturally reproducing in the Santa Ana River system. Evidence suggests suckers were using tributaries including Tequesquite Arroyo, Sunnyslope Channel, and Anaza Park Drain for spawning and nurseries.

Urbanization/development and associated habitat loss are potentially significant threats to the Santa Ana sucker. Urbanization/development may have caused the extirpation of Santa Ana suckers from lowland reaches of the Los Angeles and San Gabriel Rivers. Also, the elimination of Santa Ana suckers from the upper Santa Ana River in the San Bernardino Mountains may be partially caused by dewatering of the river by hydropower water rights users. As the Los Angeles urban area expanded, the Los Angeles, Santa Ana, and San Gabriel rivers were highly modified, channelized, or moved in an effort to either capture water runoff or protect property. All three river systems within the historic range of the sucker have dams that isolate and fragment fish populations. Dams likely have resulted in some populations being excluded from suitable spawning and rearing tributaries. Reservoirs also provide areas where introduced predators and competitors can live and reproduce. Seven Oaks Dam, now under construction upstream from the present range of Santa Ana sucker in the Santa Ana River, prevents future upstream movement of fish and further isolate the sucker populations from their native range in the headwaters of the system.

Water quality problems are a potential threat to the Santa Ana sucker. Although water quality tolerances of this species are unknown, in general, point and non-point source pollution (e.g., urban runoff, sedimentation, etc.) have significantly degraded the aquatic resources in most of the native range of the sucker. Based on available information, increased turbidity and associated deposition of fine particles and sand likely threaten the sucker population in the Santa Ana River by decreasing the availability of cobble and other hard substrates preferred by the species (Moyle and Yoshiyama 1992). Successive high flows threaten to eliminate the sucker population in the West Fork of the San Gabriel River by rapidly depleting the individuals soon after they migrate into the mainstem from tributaries. Proposals exist to sluice or otherwise remove sediment from the Cogswell, Morris, and San Gabriel reservoirs on the San Gabriel River system. The potential effects of these proposals, the deposition of large amounts of silt on the streambed and rapid increase in suspended sediments in the water column, threaten the Santa Ana sucker populations in the San Gabriel River. Many and various local inputs threaten Santa Ana River water quality, such as runoffs from light industry and surrounding farm lands (T. Haglund, in Sierra Club Legal Defense Fund 1994).

Predation may be a serious threat to the Santa Ana sucker. Moyle and Yoshiyama (1992) concluded that introduced brown trout (Salmo trutta) may have caused the extirpation of the sucker from the upper San Gabriel River in the San Bernardino Mountains. Centrachids (sunfishes) and bullheads are noted to prey on suckers; in the Los Angeles River such introduced predators aggregate in pools during droughts, presumably feeding on native fishes, including suckers (Sierra Club Legal Defense Fund 1994). Similar conditions exist in the Santa Ana River. Other nonnative predatory species that may cause serious problems for the sucker include bullfrogs, African clawed frog, crayfish, and other introduced species of fish.

Arroyo Toad

The arroyo toad is a small, dark-spotted toad of the family Bufonidae. The parotoid glands, located on the top of the head, are oval-shaped and widely separated. A pale area or stripe is usually present on these glands and on top of the eyes. The arroyo toad’s underside is buff-colored and usually without spots (Stebbins 1985). Recently metamorphosed individuals will easily blend in with the substrate and are usually found adjacent to water.

Arroyo toads use low gradient stream reaches with sand or gravel substrates. Stream order, elevation, and floodplain width are important factors in determining the size and long-term viability of a population of arroyo toads (Sweet 1992, Barto 1999, Griffin 1999). Streams with the greatest potential to support large, self-sustaining populations are typically of a high stream order (i.e., 3rd to 6th order), at low elevations (below 3,000 feet), with wide floodplains. Optimal habitat consists of low gradient portions of slow-moving streams with shallow pools that contain nearby sandbars and adjacent, undeveloped stream terraces. During the breeding season, arroyo toads require streams that have shallow pools with fine textured substrates (i.e., sand or gravel) in which to deposit their eggs. Outside of the breeding season arroyo toads are essentially terrestrial and are known to utilize a variety of upland habitats including, but not limited to, coastal sage scrub, chaparral, grassland, and oak woodland (Holland 1995, Griffin et al. 1999).

Critical habitat was proposed for the arroyo toad on June 8, 2000 (65 FR 36512). The proposal includes approximately 193,600 hectares (478,400 acres) of habitat in Monterey, San Luis Obispo, Santa Barbara, Ventura, Los Angeles, San Bernardino, Riverside, Orange, and San Diego Counties, California. The primary constituent elements of proposed critical habitat for the arroyo toad include: (1) rivers and streams with sufficient flowing water of suitable quality at the appropriate times to provide space, food, and cover needed to sustain eggs, tadpoles, metamorphosing juveniles, and adult breeding toads; (2) low-gradient stream segments (typically less than 4%) with sandy or fine gravel substrates which support the formation of shallow pools and sparsely vegetated sand and gravel bars for breeding and rearing of tadpoles and juveniles; (3) a natural flooding regime or one sufficiently corresponding to a natural regime such that adequate numbers and sizes of breeding pools and sufficient terrace habitats with appropriate vegetation are maintained to provide for the needs of all life stages of the toad; (4) upland habitats of sufficient width and quality (i.e., loose, sandy soil that allows burrowing) to provide foraging and living areas for sub-adult and adult arroyo toads; (5) few or no nonnative species that prey upon or compete with arroyo toads, or degrade their habitat; (6) stream channels and upland habitats where manmade barriers do not completely or substantially impede migration to overwintering sites, dispersal between populations, or recolonization of areas that contain suitable habitat; and (7) undisturbed habitats. Two units of critical habitat were proposed in the Santa Ana River watershed. Unit 8 is 1,200 ha (3,000 acres) and centered around the confluences of Santiago, Black Star, and Baker Creeks just above Irvine Lake. Unit 9 includes part of the San Jacinto River, Bautista Creek and adjacent uplands east of the town of Hemet in Riverside County. It encompasses 5,370 ha (13,300 acres).

Arroyo toad larvae feed on loose organic material such as interstitial algae, bacteria, and diatoms. They do not forage on macroscopic vegetation (Sweet 1992, Jennings and Hayes 1994). Juvenile toads rely on ants almost exclusively (U.S. Fish and Wildlife Service 1999). By the time they reach 17 to 23 mm in length, they take more beetles, along with the ants (Sweet 1992, U.S. Fish and Wildlife Service 1999). Adult toads probably consume a wide variety of insects and arthropods including ants, beetles, spiders, larvae, caterpillars, and others.

Breeding typically occurs from February to July in streams with persistent water (Griffin et al. 1999). Female arroyo toads must feed for a minimum of approximately two months to develop the fat reserves needed to produce a clutch of eggs (Sweet 1992). Eggs are deposited and larvae develop in shallow pools with minimal current and little or no emergent vegetation. The substrate in these pools is generally sand or fine gravel overlain with silt. Arroyo toad eggs hatch in 4 to 5 days and the larvae are essentially immobile for an additional 5 to 6 days (Sweet 1992). They then begin to disperse from the pool margin into the surrounding shallow water, where they spend an average of 10 weeks (Sweet 1992). After metamorphosis (June-July), the juvenile toads remain on the bordering gravel bars until the pool no longer persists (usually from eight to twelve weeks depending on site and yearly conditions) (Sweet 1992). Most individuals become sexually mature by the following spring (Sweet 1992).

This species has been observed moving approximately 1.6 kilometers (1 mile) within a stream reach and 1 kilometer (0.6 mile) away from the stream, into native upland habitats (Holland 1995, Sweet 1992) or agricultural areas (Griffin et al*.* 1999). Movement distances may be regulated by topography and channel morphology. Griffin (1999) reported a female arroyo toad traveling more than 300 meters (948 feet) perpendicular from a stream and Holland (1998) found arroyo toads 1.08 kilometers (0.7 miles) from a water course. Arroyo toads are critically dependent on upland terraces and the marginal zones between stream channels and upland terraces during the non-breeding season, especially during periods of inactivity, generally late fall and winter (Sweet 1992).

Arroyo toad population numbers and densities are not currently known because insufficient data is available on the species' normal population dynamics and on habitat characteristics that correlate with density. This species was historically found in at least 22 river basins in southern California from the upper Salinas River system in Monterey County to San Diego County and southward to the vicinity of San Quintin, Baja California, Mexico. They have been extirpated from an estimated 75 percent of their former range in the United States and they now occur primarily in small, isolated areas in the middle to upper reaches of streams.

The Service listed the arroyo toad as endangered on December 16, 1994 (59 FR 63264) and a recovery plan was published in July 1999 (U.S. Fish and Wildlife Service 1999). At the time of listing, the arroyo toad was described as the arroyo southwestern toad (Bufo microscaphus californicus). Gergus (1998) recently published genetic justification for the reclassification of the arroyo southwestern toad as a full species (i.e., arroyo toad [Bufo californicus]).

The current distribution of the arroyo toad in the United States is from the Salinas River Basin in Monterey County, south to the Tijuana River and Cottonwood Creek Basin along the Mexican Border. Arroyo toads are also known from a seemingly disjunct population in the Arroyo San Simeon River System, about 16 kilometers (10 miles) southeast of San Quintin, Baja California (Gergus et al*.* 1997). Although the arroyo toad occurs principally along coastal drainages, it also has been recorded at several locations on the desert slopes of the Transverse Range (Patten and Myers 1992, Jennings and Hayes 1994). The current elevational range for most arroyo toad populations in San Diego County is about 300 to 1,400 meters (1,000 to 4,600 feet), although they were historically known to extend into the lower portions of most river basins (U.S. Fish and Wildlife Service 1999).

Because arroyo toad habitats (i.e., broad, flat floodplains in southern California) are favored sites for flood control projects, agriculture, urbanization, and recreational facilities such as campgrounds and off-highway vehicle parks, many arroyo toad populations were reduced in size or extirpated due to extensive habitat loss from 1920 to 1980 (U.S. Fish and Wildlife Service 1999). The loss of habitat, coupled with habitat modifications due to the manipulation of water levels in many central and southern California streams and rivers, as well as predation from introduced aquatic species, caused arroyo toads to disappear from a large portion of their previously occupied habitat in California (Jennings and Hayes 1994). Currently, the major threats to arroyo toad populations are from stream alteration, introduction of exotic species, urban and rural development, mining, recreation, grazing, drought, wildfire, and large flood events.

Least Bell’s Vireo

The least Bell’s vireo, Vireo bellii pusillus), is a small, olive-gray neotropical migratory songbird that presently nests and forages almost exclusively in riparian woodland habitats in California and northern Baja California, Mexico (Garrett and Dunn 1981, Gray and Greaves 1981, Miner 1989; AOU 1998). Bell's vireos as a group are highly territorial (Barlow 1962, Fitch 1958, Salata 1983) and are almost exclusively insectivorous (Chapin 1925, Miner 1989).

Least Bell’s vireos generally begin to arrive from their wintering range in southern Baja California, and, possibly, mainland Mexico, and establish breeding territories by mid-March to late March (Garrett and Dunn 1981; Salata 1983, 1983; Hays 1989; Pike and Hays 1992). However, a singing vireo was on territory in the Prado Basin on March 2, 1994 (James Pike, pers. comm.). A large majority of the breeding vireos in the Prado Basin typically depart the breeding grounds by the third week of September and only a few Bell's vireos are found wintering in California or the United States as a whole (Barlow 1962, Nolan 1960, Ehrlich et al. 1988, Garrett and Dunn 1981, Salata 1983, 1983, Pike and Hays 1992).

Least Bell’s vireo nesting habitat typically consists of riparian woodlands with well-developed overstories, understories, and low densities of aquatic and herbaceous cover (Zembal 1984, Zembal et al. 1985, Hays 1986, Hays 1989, Salata 1983, RECON 1988). The understory frequently contains dense subshrub or shrub thickets. These thickets are often dominated by sandbar willow, mule fat, young individuals of other willow species, such as arroyo willow or black willow and one or more herbaceous species (Salata 1983, 1983, Zembal 1984, Zembal et al. 1985). Significant overstory species include mature arroyo willows and black willows. Occasional cottonwoods and western sycamore occur in some vireo habitats and there additionally may be locally important contributions to the overstory by coast live oak.

Although the least Bell’s vireo occupies home ranges that typically range in size from 0.5 to 4.5 acres (Regional Environmental Consultants 1988), a few may be as large as 10 acres (J. Greaves, pers. comm.). In general, areas that contain relatively high proportions of degraded habitat have lower productivity (hatching success) than areas that contain high quality riparian woodland (Jones 1985, RECON 1988, Pike and Hays 1992).

Because of a documented, drastic decline in numbers and continuing threats to the species and its riparian woodland habitats, the least Bell’s vireo was listed as an endangered species by the California Department of Fish and Game in 1980. Subsequently, the vireo was listed as endangered by the U.S. Fish & Wildlife Service on May 2, 1986 (51 FR 16474). Critical habitat was designated by the Service on February 3, 1994 (59 FR 4845), and includes all riverine and floodplain habitats with appurtenant riparian vegetation in the Prado Basin below the elevation of 543 feet.

The past, unparalleled decline of this California land bird (Salata 1986, U.S. Fish and Wildlife Service 1986) has been attributed, in part, to the combined, perhaps synergistic effects of the widespread and relentless destruction of riparian habitats, habitat fragmentation, and brood-parasitism by cowbirds (Garrett and Dunn 1981). The historic loss of wetlands (including riparian woodlands) in California has been estimated at 91% (Dahl 1990). Much of the remaining habitat is fragmented or infested with alien plants (e.g., giant reed) and exotic animals (e.g., cowbirds). Reductions in vireo numbers in southern California and the San Joaquin and Sacramento Valleys were evident by the 1930s and were “apparently coincident with increase of cowbirds which heavily parasitize this vireo” (Grinnell and Miller 1944).

During the 1999 breeding season, the least Bell’s vireo population in the Prado Basin and environs was studied and managed for the fourteenth consecutive year. Study areas included the Basin proper and contiguous reaches of the Santa Ana River and Chino Creek. The data necessary to determine vireo status and distribution, breeding chronology, reproductive success, and nest site preferences were obtained, when possible, during daily visits to appropriate riparian woodland habitats throughout the basin. In addition, brown-headed cowbirds present in vireo home ranges were routinely censused, and modified Australian crow traps were deployed throughout the basin and adjacent Santa Ana River in an attempt to control this brood-parasitic and rapidly expanding species.

Of the 336 territorial male vireos that were detected within the Prado Basin study area in 1999, 224 were paired (Pike et al. 1999). By contrast, 270 pairs were recorded in 1998, 195 pairs were detected in 1996, and 164 pairs were located in 1995 (Pike and Hays 1998). The reason for this substantial decrease in the number of breeding pairs remains unknown.

In 1999, a minimum of 489 known fledged young was produced by Prado Basin vireo breeding pairs, resulting in a 10 percent increase over the corresponding total recruitment (450) in 1998. Nesting success in 1999 was 57%, which exceeded the corresponding figures for 1998 (41% and 1997 (50%) (Pike et al. 1999). Although the average number of fledglings per breeding pair (2.2) in 1999 was the highest recorded since 1995, this average is substantially below the 1988-1991 fledglings-per-pair average of 3.1. In recent years, significantly fewer pairs have elected to renest after successfully fledging young on their first attempt (Pike et al. 1999).

By the end of the breeding season in 1998, 2,333 cowbirds had been trapped and removed from vireo and flycatcher habitats within the Prado Basin and an additional 105 cowbirds were removed from Hidden Valley Wildlife Refuge adjacent to the Santa Ana River in Norco. More than 1,314 cowbirds were removed from in or near vireo and flycatcher habitat in 1997. Correspondingly, the 13 percent parasitism rate in 1998 was the lowest recorded within the Prado Basin. Vireos continued to demonstrate a strong preference for nesting and foraging in willows and mule fat (Pike and Hays 1998). Of all nests in 1997 for which data were available (N=239), 54 percent were placed in various willow species and 40 percent were found in mule fat (The Nature Conservancy 1997).

The vireo was historically described by multiple observers as common to abundant in the appropriate riparian habitats from as far north as Tehama County, California, to northern Baja California, Mexico (Grinnell and Storer 1924, Willett 1933, Grinnell and Miller 1944, Wilbur 1980). Widespread habitat losses have fragmented most remaining populations into small, disjunct, and widely dispersed sub-populations. The remaining birds are concentrated in San Diego and Riverside counties (U. S. Fish and Wildlife Service 1998).

Although the species has begun to recover with approximately 2,000 vireos were on territories within California in 1998 (Service, unpublished data), preliminary data indicate that the United States breeding population in 1999 was almost certainly smaller. Population declines were noted at Marine Corps Base, Camp Pendleton, the Prado Basin, and at other locales throughout the range of the species in 1999 (Service, unpublished data). The reason for this apparent, recent population decline is unknown. Nevertheless, the Prado Basin population of vireos remained the second largest overall and the largest by far north of San Diego County. The largest population of vireos range-wide continues to be located on Marine Corps Base, Camp Pendleton in San Diego County. The recent Camp Pendleton and Prado vireo populations have represented approximately 60% or more of all known vireo territories.

Southwestern Willow Flycatcher

The southwestern willow flycatcher (Empidonax traillii extimus), a relatively small, insectivorous (passerine) songbird, is approximately 15 centimeters (5.75 inches) in length. Both sexes of southwestern willow flycatchers have grayish-green back and wings, whitish throats, light gray-olive breasts, and pale, yellowish bellies. The song is a sneezy “fitz-bew” or “fitz-a-bew” and the typical call is a breathy “whit” (e.g., Unitt 1987).

The southwestern willow flycatcher is a recognized subspecies of the willow flycatcher (Empidonax traillii). Although previously considered conspecific with the alder flycatcher (Empidonax alnorum), the willow flycatcher is distinguishable from that species by morphology (Aldrich 1951), song type, habitat use, structure and placement of nests (Aldrich 1953), eggs (Walkinshaw 1966), ecological separation (Barlow and MacGillivray 1983), and genetic distinctness (Seutin and Simon 1988).

The southwestern willow flycatcher is one of five subspecies of the willow flycatcher currently recognized (Hubbard 1987, Unitt 1987, Browning 1993). The willow flycatcher subspecies are distinguished primarily by differences in color and morphology. Although the subspecific differences in color have been termed “minor” (Unitt 1987), Lehman (pers. comm.) has indicated that the southwestern willow flycatcher in California is distinguishable in the field from other forms of willow flycatchers that might be present (in migration) within the breeding range of the former. Unitt (1987) and Browning (1993) concluded that the southwestern willow flycatcher is paler than other willow flycatcher subspecies. Preliminary data also suggest that the song dialect of the southwestern willow flycatcher is distinguishable from other willow flycatchers.

The breeding range of the southwestern willow flycatcher includes southern California, southern Nevada, Arizona, New Mexico, and western Texas (Hubbard 1987, Unitt 1987, Browning 1993). The species may also breed in southwestern Colorado, but nesting records are lacking. Records of breeding in Mexico are few and confined to extreme northern Baja California and Sonora (Unitt 1987, Howell and Webb 1995). Willow flycatchers winter in Mexico, Central America, and northern South America (Phillips 1948, Ridgely 1981, AOU 1983, Stiles and Skutch 1989, Ridgely and Tudor 1994, Howell and Webb 1995).

Breeding southwestern willow flycatchers are often present and singing on territories in mid-May (exceptionally in late April in southern California). Southwestern willow flycatchers are generally gone from breeding grounds in southern California by late August (The Nature Conservancy 1994) and are exceedingly scarce in the United States after mid-October (e.g., Garrett and Dunn 1981). The first southwestern willow flycatcher of the 1998 Prado Basin breeding season were detected on May 4 and the last was noted on August 9. In 1997, the first bird of the breeding season was detected on May 7 and the last (a juvenile) was noted on September 10.

The southwestern willow flycatcher breeds in riparian habitats along rivers, streams, and other wetland habitats where dense growths of willows (*Salix* spp.), coyote-bush (*Baccharis* spp.), arrowweed (*Pluchea sericea*), buttonbush (*Cephalanthus occidentalis*) [not found in southern California], or other plants of similar structure and configuration are present. The flycatcher nests in thickets of trees and shrubs approximately 4 to 7 meters (13 to 23 feet) or more in height with dense foliages from approximately 0 to 4 meters (0 to 13 feet) above ground. Overstories are often present in occupied habitats and composed of willows or cottonwoods or, in some portions of the species' range, tamarisks (*Tamarix*, spp.) (e.g., Phillips 1948, Grinnell and Miller 1944, Whitmore 1977, Hubbard 1987, Unitt 1987, Whitfield 1990, Brown 1991, U.S. Fish and Wildlife Service 1993, 1995). Although nesting willow flycatchers of all subspecies generally prefer areas with surface water nearby (Bent 1960, Stafford and Valentine 1985, Harris et al. 1986), the southwestern willow flycatchers in the Prado Basin virtually always nest near surface water or saturated soil (e.g., The Nature Conservancy 1994).

All known southwestern willow flycatcher territories within the Prado Basin have been situated in relatively close proximity to water-filled creeks or channels. In addition, territories have usually consisted of overgrown clearings containing varying amounts of nettles and with, at least, a few moderately tall, often dense, willows. Among the five nests found in 1996, two were placed in arroyo willow, one was found in a red willow (*Salix laevigata*), one was placed in a sandbar willow, and one was placed in a tamarisk. During the 1997 season, both nests that were discovered had been placed in arroyo willow. Nests have been placed as low as 0.61 meters above ground level.

All three resident subspecies of the willow flycatcher (*E. t. extimus*, *E. t. brewsteri*, and *E. t. adastus*) were once considered widely distributed and common within California wherever suitable habitat existed (e.g., Grinnell and Miller 1944). The historic range of *E. t. extimus* in California apparently included all lowland riparian areas of the southern third of the state. Nest and egg collections indicate the bird was a common breeder along the lower Colorado River near Yuma in 1902. Willett (1933) considered the bird to be a common breeder in coastal southern California. Most recently, Unitt (1987) concluded that the southwestern willow flycatcher was once fairly common in the Los Angeles basin, the San Bernardino/Riverside area, and San Diego County.

The southwestern willow flycatcher is apparently vulnerable to the same factors that have caused the decline of the vireo within those species' shared ranged in the Californias and thus has almost been extirpated as a breeding species throughout much of southern California (e.g., Garrett and Dunn 1981, Unitt 1987). Because range-wide, recent surveys have essentially corroborated these assumptions, the current status of E. t. extimus is likely much more precarious than that of the vireo, which has begun to recover in southern California.

On July 23, 1993, the Service proposed the southwestern willow flycatcher as an endangered species throughout its range (58 FR 39495) and simultaneously proposed critical habitat for the species. Although deferring a decision on the designation of critical habitat, the Service listed the flycatcher as endangered on February 27, 1995 (59 FR 10693). Critical habitat for the flycatcher, including much of the Prado Basin, was designated by the Service on August 20, 1997 (62 FR 39129 and 62 FR 44228). Breeding willow flycatchers are listed as endangered by the States of California and Arizona.

The Prado Basin southwestern willow flycatcher population was studied and managed for the 14th consecutive year within the Prado Basin, adjacent Santa Ana River, and environs during the 1999 breeding season. The data necessary to determine southwestern willow flycatcher status and distribution, breeding chronology, reproductive success, and nest site preferences were obtained whenever and wherever possible during daily visits to appropriate riparian woodland habitats throughout the basin. In addition, cowbirds present in southwestern willow flycatcher home ranges were routinely censused, and modified Australian crow traps were once deployed throughout the basin and adjacent Santa Ana River in an attempt control this brood-parasitic species and thus maximize the local breeding success of the vireo, flycatcher, and a large number of other sensitive passerine bird species.

Despite 14 consecutive years of cowbird management and habitat conservation efforts within the Prado Basin, a total of only five flycatcher home ranges was detected within the Prado Basin during the 1999 breeding season. Four of the five territorial flycatchers were likely returning to home ranges that were occupied during the previous season. Pairs were eventually found in only three of these home ranges. Two of the three pairings resulted in successful breeding, producing a total of five fledglings (Pike et al. 1999).

Although flycatcher home ranges have been detected nearly throughout the surveyed portions of the Basin, successful breeding prior to 1996 had been detected only in North Basin and West Basin (Chino Creek). From 1996 to 1998, however, the only successful breeding occurred in two adjacent home ranges in South Basin. Given that only three breeding pairs of southwestern willow flycatchers were present within the survey area during the 1999 breeding season, southwestern willow flycatchers likely are in danger of disappearing from the Prado Basin and environs.

The available information suggests that all three willow flycatcher subspecies breeding in California have declined substantially, with declines most critical in E. t. extimus, the southwestern willow flycatcher, which remains only in small, disjunct nesting groups (e.g., Unitt 1987, U.S. Fish and Wildlife Service 1995), like those found in the Prado Basin. Status reviews or analyses conducted before the listing of the southwestern willow flycatcher considered extirpation from California to be possible, even likely, in the foreseeable future (e.g., Garrett and Dunn 1981, Harris et al. 1986).

The Prado Basin population is one of only six permanent breeding sites that now exist in California, and only three southwestern willow flycatcher populations in California contain 20 or more nesting pairs. Despite the virtual elimination of impacts from livestock grazing to the large and important flycatcher population on the South Fork of the Kern River (Harris et al. 1986, Whitfield 1990), numerical declines in the population levels were observed in 1991 and 1992. Fortunately, increases in nesting success were realized in 1992 and 1993; these increases were attributed to removing cowbird eggs or nestlings found in southwestern willow flycatcher nests, and cowbird trapping (Whitfield and Laymon, Kern River Research Center, in litt., 1993). The Kern River population consisted of 29 pairs in 1996 (M. Whitfield, pers. comm., 1996). Another large, and relatively stable, nesting population is along the Santa Margarita River on Marine Corps Base Camp Pendleton, where cowbird numbers have also been reduced by trapping. Approximately 20 pairs were detected on Camp Pendleton in 1996. The third and last “large” population persists on the Upper San Luis River, where 25 pairs were detected in 1996 (Bill Haas, pers comm., 1996).

Although five other nesting groups were known in southern California in 1996, all but one of these consisted of four or fewer nesting pairs in recent years (Service, unpublished data). A total of 104 pairs of southwestern willow flycatchers was recorded in California in 1996 and preliminary data indicate that 100 pairs were present in the state in 1998 (Service, unpublished data).

Unitt (1987) reviewed historical and contemporary records of the southwestern willow flycatcher throughout its range and determined that the species had declined precipitously during the last 50 years. Unitt (1987) argued convincingly that the southwestern willow flycatcher is faring poorly throughout much of its breeding range (see also Monson and Phillips 1981, Garrett and Dunn 1981, U.S. Fish and Wildlife Service 1995). Unitt (1987) has postulated that the “total population of the subspecies is well under 1,000 pairs; I suspect that 500 is more likely.” Recent range-wide surveys have corroborated Unitt’s hypothesis.

Throughout the known range of the flycatcher, occupied riparian habitats have been, and remain, widely separated by vast expanses of relatively arid lands. However, the southwestern willow flycatcher has suffered the extensive loss and modification of these cottonwood-willow riparian habitats due to grazing, flood control projects, and other water or land development projects (e.g., Klebenow and Oakleaf 1984, Taylor and Littlefield 1986, Unitt 1987, Dahl 1990; U.S. Fish and Wildlife Service 1995). Estimated losses of wetlands between 1780 and the 1980's in the American southwest are; California (91 percent), Nevada (52 percent), Utah (30 percent), Arizona (36 percent), New Mexico (33 percent), and Texas (52 percent) (Dahl 1990). Changes in riparian plant communities have resulted in the reduction, degradation, and elimination of nesting habitat for the willow flycatcher, curtailing the ranges, distributions, and numbers of western subspecies, including *E. t. extimus* (e.g., Klebenow and Oakleaf 1984, Taylor and Littlefield 1986, Unitt 1987, Ehrlich et al. 1992).

The species is also impacted by a variety of other factors, including brood parasitism by cowbirds (Unitt 1987; Ehrlich et al. 1992; U.S. Fish and Wildlife Service 1993, 1995). Parasitism rates of flycatcher nests have recently ranged from 50 to 80 percent in California (Whitfield 1990; M. Whitfield and S. Laymon, unpublished data) to 100 percent in the Grand Canyon in 1993 (U.S. Fish and Wildlife Service 1993). Mayfield (1977) concluded that a species or population might be able to survive a 24 percent parasitism rate, but that much higher losses “would be alarming.” In any case, a composite of all current information indicates continuing declines, poor reproductive performance, and continued threats to most of the extant populations of flycatchers (e.g., Brown 1991; Whitfield and Laymon (Kern River Research Center, in litt., 1993); U.S. Fish and Wildlife Service 1993, 1995; Service, unpublished data).

Bald Eagle

In 1978 the bald eagle was listed as endangered in the lower 48 states except for Michigan, Minnesota, Wisconsin, Washington, and Oregon where it was considered threatened (64 FR 36453). In 1995 the bald eagle was reclassified to threatened within the lower 48 states (64 FR 36453), and on July 4, 1999, the eagle was proposed for delisting. The bald eagle is a large, mostly dark-brown raptor. Adult bald eagles have a white heads and tails, which are developed at about four to six years of age. Juvenile bald eagles are mostly brown and can be confused with golden eagles. Females can weigh from 8 to 14 pounds, and males from 8 to 10 pounds. Bald eagles usually have a wingspan of six to seven feet. The bald eagle is the second largest raptor in California; the California condor is slightly larger.

Rangewide, bald eagles occur primarily near seacoasts, rivers, swamps, and large lakes (AOU 1998). Within southern California, although birds are found in these same habitats, they are most often recorded at large inland bodies of water with mixed conifer (Garrett and Dunn 1981). However, some use chaparral and oak/sycamore. Day roost sites often are snags. Night roosting often occurs within 0.5 miles of water on steep north or northwest facing slopes with green trees. Bald eagles feed on fish, coots, waterfowl, seagulls, and carrion (Stephenson and Calcarone 1999, 64 FR 36453). Nesting most often occurs in large trees near water, but occasionally nests occur on cliffs or the ground. Eagles usually need areas free from disturbance (64 FR 36453).

Bald Eagles breed from Alaska eastward to Newfoundland southward to Baja California, Sonora, Texas, and Florida (64 FR 36453). The species winters in the large majority of the breeding range, but generally withdraws from central Alaska and the central and the northern portions of Canada (AOU 1998).

Documentation of pair bonding behavior is limited. Southern nesting eagles can potentially start courtship in September, approximately one month before laying eggs. The nesting season will last about 6 months. Incubation lasts about 35 days. Eagles fledge at about 11-12 weeks, but parental care may extend for another 4-11 weeks. Upon leaving the nesting site, most juvenile eagles migrate a few hundred miles to wintering areas (64 FR 36453). Wintering eagles gather around sites with water and good roosting areas. In southern California, eagles are mainly wintering, with a few exceptions (Stephenson and Calcarone 1999). Eagles will take 4-5 years to reach maturity (64 FR 36453).

Bald eagle populations have increased dramatically since the implementation of the five regional recovery plans. Most population goals have been met or exceeded. In 1994 there were 4,450 breeding areas with 1.16 young each. This indicates a 462% increase over 1974 estimates. From 1990-1994, the population increased 47%. The positive results have continued and in 1998 there were 5,748 breeding areas with all but 2 states having nesting pairs. An eagle population needs about a 0.7 young/pair rate to be sustainable (Sprunt et al. 1973). Since the rate averaged 1 in the Pacific region (64 FR 36453), the population should grow.

While the bald eagle recovery is impressive, not all goals have been reached. In the Pacific Region of Idaho, Nevada, California, Oregon, Washington, Montana, and Wyoming 28 of 37 (76%) management zones have met population goals (64 FR 36453). Eleven of the 28 zones have more than doubled their goals, but the Pacific Region recovery plan states that the goal is for 80% of management zones to meet population goals. This goal may not be reached since not all management zones have preferred habitat. The success rate for all breeding areas, combined has exceeded 65% for years (64 FR 36453).

Habitat loss, the effects of some pesticides on reproductive success, and persecution necessitated the listing of bald eagles. Certain areas still have difficulties with contamination including along the Great

Lakes, Maine, the Columbia River, and in southern California (64 FR 36453). In addition, power line construction and human caused disturbances can be a problem. Disease and predation are generally not thought to be significant problems for the population. Overall, successful captive breeding efforts, the banning of certain organochlorine pesticides, and other recovery efforts have resulted in significant increases in eagle numbers on the continent (64 FR 36453).

The bald eagle has been found breeding in the southern Los Padres and Santa Lucia mountain ranges. Specifically, breeding has occurred at Nacimiento Lake, San Antonio Lake, and Cachuma Lake.

Wintering populations occur in both the San Jacinto and San Bernardino Mountains. A large wintering population occurs at Big Bear Lake in the San Bernardino Mountains. About 20-30 eagles congregated here from November to March annually from 1978-2000. The eagles begin to appear in the 3rd week of October, peak in January or February and are gone sometime in April.

Average monthly winter bald eagle counts for the years 1978 to 2000 for the Big Bear Valley, including Big Bear and Baldwin Lakes, were as follows: December, 12, January, 17, February, 15, March, 10, and, April 0. The high count average was 20.3.

Other large reservoirs may support 2-10 wintering eagles annually. Breeding/potential breeding activity has occurred with the following results:

Upper Miller Canyon 1990: 2 eggs, unsuccessful 1991: nest building, no known egg-laying

Lake Hemet (also on private land): adult pair through July in multiple years

Potential threats include increased urban development on private lands around Big Bear, Silverwood, and Baldwin Lakes. The removal of perching trees on public and private sites due to safety concerns has occurred. Not only may roosting areas be subject to loss, but disturbance levels may increase due to higher shoreline visitation.

Another concern for eagles is the power lines in the Big Bear area. Two electrocutions have occurred since 1988. One on the east side of Baldwin Lake and one on the north side of Stanfield Marsh by Big Bear Lake.

A boardwalk in Stanfield Marsh developed by the Municipal Water District has seemed to cause the abandonment of the area by eagles for day use. An additional factor in the abandonment is the lack of enforcement of the Castle Glen conservation easement. The easement, which is under the Nature Conservancy's jurisdication, is to prevent the public from entry and from stopping along Big Bear Boulevard. Several hundred people may use the area for sledding/snow on some weekends. Currently, the Forest Service generally imposes a December 1 to April 1 restriction on permitted activities in eagle habitat.

Wintering populations occur in the San Diego Ranges. Only transient eagles occur in the Santa Ana Mountains. Large reservoirs may support between 2-10 wintering eagles annually. In the San Gabriel Mountains and Castaic ranges, large reservoirs may support between 2-10 wintering eagles annually.

San Bernardino Kangaroo Rat

The San Bernardino kangaroo rat (Dipodomys merriami parvus) is one of 19 recognized subspecies of Merriam's kangaroo rat (D. merriami), a widespread species distributed throughout arid regions of the western United States and northwestern Mexico (Hall and Kelson 1959, Williams 1993). In coastal southern California, Merriam's kangaroo rat is the only species of kangaroo rat with four toes on each of its hind feet. The San Bernardino kangaroo rat has a body length of about 95 mm (3.7 in) and a total length of 230 to 235 mm (9 to 9.3 in). The hind foot measures less than 36 mm (1.4 in) in length. The body color is pale yellow with a heavy overwash of dusky brown. The tail stripes are medium to dark brown and the foot pads and tail hairs are dark brown. The flanks and cheeks of the subspecies are dusky (Lidicker 1960). The San Bernardino kangaroo rat is considerably darker and smaller than either of the other two subspecies of Merriam's kangaroo rat that occur in southern California, D. merriami merriami and D. merriami collinus. The San Bernardino kangaroo rat, endemic to southern California, is one of the most highly differentiated subspecies of Merriam's kangaroo rat and, according to Lidicker (1960), “it seems likely that it has achieved nearly species rank”.

The historical range of this species extended from the San Bernardino Valley in San Bernardino County to the Menifee Valley in Riverside County (Hall and Kelson 1959, Lidicker 1960). Within this range, the San Bernardino kangaroo rat was known from more than 25 localities (McKernan 1993). From the early 1880s to the early 1930s, the San Bernardino kangaroo rat was a common resident of the San Bernardino and San Jacinto Valleys of southern California (Lidicker 1960). At the time of listing, based on the distribution of suitable soils and data from museum collections, the historical range was estimated to encompass approximately 130,587 ha (326,467 ac) (U.S. Fish and Wildlife Service unpubl. GIS maps, 1998 in 63 FR 51005). Recent studies indicate that the species occupies a wider range of soil and vegetation types than previously thought (McKernan 2000 pers. comm.), which suggests that the species' historical range may have been larger than previously estimated.

Although the entire historical range would not have been occupied at any given time due to hydrological processes and resultant variability in habitat suitability, the San Bernardino kangaroo rat was widely distributed across the San Bernardino and San Jacinto valleys. By the 1930s, suitable habitat was probably reduced to approximately 11,200 ha (28,000 ac) (McKernan 1997). Habitat destruction continued and in 1997 the San Bernardino kangaroo rat was thought to occupy only 1,299 ha (3,247 ac) of suitable habitat at seven locations (McKernan 1997). At the time of listing, it was estimated that an additional 5,277 ha (13,193 ac) of habitat was probably occupied by the San Bernardino kangaroo rats within the Santa Ana River, Lytle and Cajon Creeks, and the San Jacinto River. There were also smaller remnant populations at City Creek, Etiwanda alluvial fan and wash, Reiche Canyon, and South Bloomington (including Jurupa Hills). At the time of listing, approximately 1,358 ha (3,396 ac) of the 5,277 ha (13,193 ac) of additional habitat was too mature or degraded to support San Bernardino kangaroo rats. Additional research has indicated that San Bernardino kangaroo rats occupy mature alluvial scrub, coastal sage scrub, and even chaparral vegetation types (McKernan 2000 pers comm.). Thus, a minimum of approximately 6,576 ha (16,440 ac) of habitat was likely occupied at the time of listing.

Critical habitat has been proposed for the Santa Ana River (including City, Plunge, and San Timoteo Creeks), Lytle and Cajon Creeks, San Jacinto River and Bautista Creek, Etiwanda alluvial fan (including the Etiwanda Wash), Reche Canyon, and Jurupa Hills-South Bloomington (McKernan 1997; California Natural Diversity Data Base (CNDDB) 2000; University of California, Riverside species database 2000; database for the San Bernardino Valley-Wide Multiple Species Habitat Conservation Plan (MSHCP) 2000; and section 10(a)(1)(A) survey reports 1998-2000). The areas proposed as critical habitat are an expansion of the known locations of the San Bernardino kangaroo rat identified in the final listing rule and are within the known geographical range of this species. Areas with small, scattered populations or habitats that were highly fragmented, or were no longer subject to natural processes were not proposed as critical habitat.

Habitat for the San Bernardino kangaroo rat has been severely reduced and fragmented by development in the San Bernardino and San Jacinto Valleys. As noted by Andren (1994) in a discussion of highly fragmented landscapes, reduced habitat patch size and isolation exacerbate the effects of habitat loss on a species' persistence and may preclude recolonization of suitable habitat following local extinction.

Past and ongoing causes of fragmentation of San Bernardino kangaroo rat habitat include conversion of lands to urban, industrial, agricultural, and recreational uses; construction of roads and freeways; and development of flood control structures such as dams, levees, and channels. The effect of these human-caused disturbances is two-fold: (1) they reduce the amount of suitable habitat for the San Bernardino kangaroo rat, breaking large areas into smaller patches, and (2) they act as barriers to movement between the remaining suitable habitat patches.

San Bernardino kangaroo rats are typically found on alluvial fans, flood plains, along washes, in adjacent upland areas containing appropriate physical and vegetative characteristics (McKernan 1997), and in areas with historic braided channels (McKernan in litt. 1999). These areas consist of sand, loam, sandy loam, or gravelly soils (McKernan 1993) that are associated with alluvial processes. San Bernardino kangaroo rats also occupy areas where sandy soils are at least partially deposited by winds (e.g., northwest of the Jurupa Hills) (McKernan 1997). These soils allow kangaroo rats to dig simple, shallow burrow systems (McKernan 1997) and typically support alluvial sage scrub and chaparral vegetation.

Alluvial sage scrub, or Riversidean Alluvial Fan Scrub (Holland 1986) is considered a distinct and rare plant community found primarily on alluvial fans and flood plains along the southern bases of the Transverse Ranges and portions of the Peninsular Ranges in southern California (CNDDB 1996). This relatively open vegetation type is adapted to periodic flooding and erosion (Hanes et al. 1989) and is comprised of an assortment of drought-deciduous shrubs and larger evergreen woody shrubs characteristic of both coastal sage scrub and chaparral communities (Smith 1980).

Three phases of alluvial sage scrub have been described: pioneer, intermediate, and mature. The phases are thought to correspond to factors such as flood scour, distance from flood channel, time since last catastrophic flood, and substrate features (Smith 1980, Hanes et al. 1989). The vegetation of early and intermediate stages is relatively open, and supports the highest densities of the San Bernardino kangaroo rat (McKernan 1997).

The latest, or mature, phase of alluvial sage scrub is rarely affected by flooding and supports the highest plant density (Smith 1980). The mature terraces and upland areas adjacent to them supporting the oldest phase of sage scrub provide an important refugia for San Bernardino kangaroo rats during flood events.

Similar to other subspecies of Merriam's kangaroo rat, the San Bernardino kangaroo rat prefers moderately open habitats characterized by low shrub canopy cover (McKernan 1997). However, the species uses areas of denser vegetation, and McKernan (pers. comm. 2000) stated that such areas are essential to San Bernardino kangaroo rat conservation. Research conducted by Braden and McKernan (2000) during 1998 and 1999 demonstrated that areas with late phases of the flood plain vegetation, including some areas of moderate to dense vegetation, are at least periodically occupied by the species.

Little is known about home range size, dispersal distances, or other spatial requirements of the San Bernardino kangaroo rat. However, home ranges for the Merriam's kangaroo rat in the Palm Springs, California, area average 0.33 ha (0.8 ac) for males and 0.31 ha (0.8 ac) for females (Behrends et al. 1986). Furthermore, Blair (1943) reported much larger home ranges for Merriam's kangaroo rats in New Mexico, where home ranges averaged 1.7 ha (4.1 ac) for males and 1.6 ha (3.8 ac) for females. Space requirements for the San Bernardino kangaroo rat likely vary according to season, age and sex of animal, food availability, and other factors. Although outlying areas of their home ranges may overlap, Dipodomys adults actively defend small core areas near their burrows (Jones 1993). Home range overlap between males and between males and females is extensive, but female-female overlap is slight (Jones 1993). The degree of competition between San Bernardino kangaroo rats and sympatric species of kangaroo rats for food and other resources is not presently known.

Similar to other kangaroo rats, the Merriam's kangaroo rat is generally granivorous (feeds on seeds and grains) and often stores large quantities of seeds in surface caches (Reichman and Price 1993). Green vegetation and insects are also important seasonal food sources. Insects, when available, have been documented to constitute as much as 50% of a kangaroo rat's diet (Reichman and Price 1993).

Wilson et al. (1985) reported that compared to other rodents, Merriam's kangaroo rat, and heteromyids in general, have relatively low reproductive output. Rainfall and the availability of food have been cited as factors affecting kangaroo rat populations. Droughts lasting more than a year can cause rapid declines in population numbers after seed caches are depleted (Goldingay et al. 1997).

Little information exists on the specific types and local abundances of predators that feed on the San Bernardino kangaroo rat. Potential native predators include the common barn owl, great horned owl, long-eared owl, gray fox, coyote, long-tailed weasel, bobcat, badger, San Diego gopher snake, California king snake, red diamond rattlesnake, and southern Pacific rattlesnake, among others. Domestic cats (Felis cattus) are known to be predators of native rodents (Hubbs 1951, George 1974) and have the ability to reduce population sizes of rodents (Crooks and Soule 1999). Predation of San Bernardino kangaroo rats by domestic cats has been documented (McKernan, pers. comm., 1994).

A limited amount of data exists pertaining to population dynamics of the San Bernardino kangaroo rat. Braden and McKernan (2000) documented substantial annual variation on a trapping grid in San Bernardino County, where densities ranged from 2 to 26 animals per hectare (2.47 acre). The reasons for these greatly disparate values are unknown. These fluctuations bring to light several important aspects of the species' distribution and life history which should be considered when identifying areas essential for the conservation of the species: (1) A low population density observed in an area at one point in time does not mean the area is occupied at the same low density any other month, season, or year; (2) a low population density is not an indicator of low habitat quality or low overall value of the land for the conservation of the species; (3) an abundance of San Bernardino kangaroo rats can decrease rapidly; and (4) one or more factors (e.g., food availability, fecundity, disease, predation, genetics, environment) are strongly influencing the species' population dynamics in one or more areas. High-amplitude, high-frequency fluctuations in small, isolated populations make them extremely susceptible to local extinction.

Stephens' Kangaroo Rat

The Stephens' kangaroo rat was federally listed as endangered on March 31, 1988. Stephens' kangaroo rats are 2.7-3.0 cm long, with long hind legs, small front legs and feet, and a white belly. This species is dark brown with a long black and white tail (CDFG 2000). It is distinguished from the Panamint kangaroo rat (*Dipodomys panamintinus*) by being smaller (Whitaker 1989).

Today, the Stephens' kangaroo rat is found almost exclusively in open, often disturbed, nonnative grasslands or in sparse shrublands with areal cover of less than approximately 30% (Hogan 1981). The Stephens' kangaroo rat has been found on 36 types of well-drained soils, and more than 125 soils are thought to be potentially suitable. These soils include those capable of supporting annual grasses mixed with forbs and shrubs. Additionally, soils must exhibit compaction characteristics suitable for the establishment of burrows. Soils not considered suitable for Stephens' kangaroo rat include heavily alkaline or clay soils, highly rocky soils, shallow soils less than 50 centimeters, soils in areas exceeding 25% slope, and soils above approximately 3,000 feet in elevation. Stephens' kangaroo rats feed on green vegetation, seeds, and, to a limited extent, insects. These animals will create their own burrow system in areas with sandy soils and use existing burrow systems of gophers and ground squirrels in areas of compacted soils.

The spring growing season and increased availability of food usually coincide with the reproductive peak of Stephens' kangaroo rat. The breeding season generally occurs between April and June with a litter of two to three by late spring. These animals emerge at night to forage in areas around their burrows. They return to the burrow to store the foods gathered into their cheek pouches (CDFG 2000). Population studies have indicated seasonal and annual variations in the number of animals occupying a given area. These variations have been linked to the amount of rainfall and subsequent seed production. A positive linear relationship exists between precipitation and population levels of Stephens' kangaroo rat. Observations of Stephens' kangaroo rat populations by Price and Endo (1989) at locations separated by approximately 12 miles, indicate that populations in western Riverside County can show more than a tenfold temporal density fluctuation in response to regional rainfall patterns.

The patchy distribution of Stephens' kangaroo rat appears to be defined by soil type, vegetative stage, and slope (O'Farrell and Uptain 1989). This species appears to be adapted for existence in intermediate vegetative seral stages. Fallow farmland is invaded by weedy species, and rodents such as the Botta's gopher (Thomomys umbrinus) that facilitate colonization by the Stephens' kangaroo rats. Absent successional setbacks that maintain relatively open grass or forb lands, eventual maturation of vegetative communities renders habitat unsuitable for the Stephens' kangaroo rat.

Stephens' kangaroo rats occur in arid grassland habitat in northern San Diego, western Riverside County, and on the southwestern edge of San Bernardino Counties. Specific populations occur at Camp Pendleton Marine Corps Base, the adjacent Fallbrook Naval Weapons Station, around Lake Henshaw/Warner Springs, and the Guejito and Santa Maria Valleys.

Reported densities of Stephens' kangaroo rats range from 3 to 23.7 individuals per acre during the summer months (Bleich 1973, Thomas 1975). Fall and winter densities range from 2 to 6 individuals per acre (Price and Endo 1989). According to O'Farrell and Uptain (1989), most of the currently occupied habitat contains populations of low (less than 2 individuals per acre) or medium density (2 to 4 individuals per acre), and only a few areas contain a high population density (greater than 4 individuals per acre).

Much of the habitat in the range of the species was historically converted to agriculture. In addition, urban expansion has increased dramatically since 1984. These two land use changes have contributed to the decline and fragmentation of Stephens' kangaroo rat populations and remain the primary threat to the continued existence of the species.

THE ECOLOGY AND CONTROL OF GIANT REED

Introduction

The riparian forests of Southern California have become infested with many non-native species; two are particularly problematic, giant reed (Arundo donax) and saltcedar *(*Tamarix spp.). Public and private agencies with ownership and management responsibilities share a common concern dealing with wild fires, loss of habitat, excessive transpiration of water and obstruction of the floodway caused by these invasives.

More than *95%* of the historic riparian habitat in the southern part of the state has been lost to agriculture, development, flood control, and other human-caused impacts. The greatest threat today to the remaining riparian corridors is the invasion of exotic plant species, primarily giant reed*.* Giant reed readily invades riparian channels, especially in disturbed areas, is very competitive, difficult to control, and does not provide significant food or nesting habitat for native animals. The reed competes with native species such as willows, mulefat, and cottonwoods that do provide nesting habitat for species such as least Bell’s vireo, willow flycatcher, and countless other native organisms.

Giant reed replaces native riparian forests by invading after floods and fires, and by growing faster than the native species. Spreading mainly by stolons and other vegetative parts, giant reed invades riparian communities at any stage of succession. It grows very quickly, up to 2 inches per day, is highly flammable, and re-sprouts rapidly after a fire. Because of these characteristics, once giant reed invades a riparian area it redirects the succession of the community towards pure stands of reed, often involving increasingly frequent and catastrophic fires.

Giant reed was introduced into southern California more than 100 years ago by Spanish settlers who used it for erosion control on ditches. It was also planted to serve as a food source for pigs and goats, and as thatch roofing for homes. Saltcedar was similarly introduced in the early 1800’s as an ornamental and as a windbreak. These weeds have since infested nearly every drainage system in the southwestern United States (Brotherson and Field 1987) including tens of thousands of acres of riparian habitat in California.

These large weeds out-compete the native plants for space and other resources, and can cause significant disruption of entire ecosystems. Their presence inhibits seedling recruitment of native riparian species (Duncan and Carrigan 1992). Both species crowd out natives and use massive amounts of water making it unavailable to natives and potentially lowering the water table. Saltcedar exudes salt from its leaves in the course of transpiration (Thomson et al. 1969), creating saline soils that inhibit germination of native plants. In addition, both species are highly flammable and so can alter the fire regime of riparian and adjacent habitats. Giant reed, by far the greatest threat of the two weeds in coastal Southern California river systems because of its aggressive and invasive nature (Hoshovsky 1988), ongoing management is necessary to prevent total habitat conversion. Periodic fires in river floodplains have favored the fast growing giant reed over native riparian vegetation. Today, thousands of acres are infested with the plant. This acreage increases each year in response to flood events, fires, and other disturbances.

To return an aquatic community to its native character, giant reed and saltcedar should be removed through biomass reduction and the application of herbicides. The biomass of extensive stands of these weeds must be removed mechanically or through the application of prescribed fire. In some cases, the treated plants may be left to die and decay. Physical removal of treated reeds should not be done until at least four to six weeks following application of herbicide to ensure that rootstocks are killed. The initiation of treatment should allow enough time for plants to die prior to flood season to prevent viable propagules from spreading downstream with storm flows. Similarly, material should not be stockpiled close to flowing water and should be removed from the floodplain prior to flood season. Stalks removed in the Santa Ana River Watershed have been run through a chipper. The chips are too small to sprout in wet soil and can be left onsite.

Treated sites on the Santa Ana River are left to reseed naturally with willow and cottonwood; natural regeneration plays the dominant role in the maintenance of native riparian vegetation where natural flood processes still operate. Individual willows cast thousands of wind and water borne seeds, and the river deposits enough of them in suitable growing sites to keep this dynamic habitat in constant regeneration. Furthermore, in most areas where Arundo has been removed, it has been intermixed with native trees and shrubs that grow expansively with the reduced competition, eventually filling in the voids. In few cases, it could be desirable to plant cuttings or rooted material. Selective planting may help reduce re-infestation of giant reed and saltcedar by helping native plants establish and outcompete the non-native plants. However, in such a large, dynamic riparian community as the Santa Ana River Watershed, extensive replanting should not be necessary with but few exceptions. In fact, re-vegetation efforts on the Santa Ana River over the past 20 years have been largely problematic and unsuccessful in the long term. The river has removed them through scour and sediment deposition, or the planted trees have been replaced by giant reed.

Benefits of Removal of Invasive Plants

Removal of these weeds offers a number of benefits to landowners, land managers, and public agencies:

1. Fire Protection: Giant reed is extremely flammable, increasing both fire risk and fire intensity. In areas where extensive stands of giant reed have developed, there is a risk to natural resources, homes, bridges, and other infrastructure. Public fire agencies must deal with an ever-increasing threat as giant reed expands in the watershed. Removing large areas of giant reed will greatly reduce the fire risk.

The pervasion of giant reed greatly increases the risk of catastrophic fire. It is extremely flammable, and once established within a riparian area, it redirects the natural function of the site by increasing the probability and intensity of wildfires. Giant reed can effectively change riparian forests from a flood-defined to a fire-defined community.

In addition to the ecological implications of this change in fire regime, the increasingly frequent and intense wildfires associated with stands of Arundo are a major risk to human life and property, especially within urban centers. Without measures to eliminate large stands of giant reed, and to remove giant reed and tamarisk from the system, intense fires, with extreme risk to life and property, will continue and accelerate in these communities.

2. Floodway Protection: Heavy rains can wash debris dams of giant reed and saltcedar down river, pushing mats of dense roots and stalks against bridge abutments, clogging channels, and re-directing the river to flood adjacent lands. The River Road Bridge has been damaged severely twice by water pushing reed stalks and debris against the abutments. In eliminating stands of giant reed, the material is removed that causes the congestion and impedes flood flows.

By virtue of its great biomass, rapid growth, and dense, interconnected root masses, giant reed poses a substantial flood management problem. Floodwaters strip portions of the standing crop of canes and root masses from the substrate and these mats combine with trash to form substantial debris dams. In contrast, native riparian species are more adapted to bend than to break during high flows greatly reducing the amount of vegetative debris that is washed downstream.

The fate of large quantities of Arundo debris is to be washed up on the beaches near the mouth of the Santa Ana River. The annual clean up of this debris costs the public many millions of dollars.

Additionally, vegetation control activities of flood management agencies contribute to the spread of giant reed throughout the river system. Annual mowing of managed flood channels results in numerous cut stem and root pieces, which are available to wash downstream and infect new areas of the river. Channel maintenance activities need to be coordinated with other giant reed management goals on the river to eliminate this source of downstream contamination. Complete control and eradication of giant reed, rather than annual maintenance mowing, should result in substantial annual savings to the flood management agencies.

3. Protection of Endangered Species and Native Wildlife: Riparian vegetation serves as critical habitat for many state and federally listed threatened and endangered species such as the least Bell’s vireo. Additionally, riparian habitat is one of our most productive habitats for wildlife with unique, unparalleled diversity and abundance. Critical Habitat for these species has

been reduced by development by about 95% and giant reed has replaced over 50% of what is left on the Santa Ana River. This exotic weed out-competes the native willows and cottonwood that native wildlife depends upon. Infestation by giant reed increases the probability and intensity of wildfire, redirecting succession towards pure stands of reed at the expense of native riparian habitat. Preventing the spread of giant reed and saltcedar will prevent the further deterioration of habitat for many of the sensitive, threatened, and endangered riparian species. As areas of giant reed and saltcedar are removed and converted back to native riparian habitat, rare species will be able to expand their populations.

4. Water Quality: Extensive stands of giant reed along rivers lack the dense foliage canopy of native riparian forest. As a result, near-shore stream habitats lack the shade offered by the vegetational canopy, and water temperatures are thus several degrees higher than under natural conditions. Higher water temperatures have a direct negative impact on native stream fishes such as the arroyo chub and Santa Ana sucker. Higher temperatures also increase algal growth and lower water oxygen, resulting in lower water quality. Replacing these stands of exotics with native riparian forest will, in time, result in sufficient overhanging foliage to provide the necessary cooler water temperatures, bank cover, and improved water quality needed to protect populations of native fish species.

The lack of streamside canopy structure may degrade water quality in other ways. Studies have shown that, in the shallower sections of the river, high levels of algal photosynthetic activity can increase pH levels which facilitate the conversion of total ammonia to the toxic unionized ammonia form (Bell 1993). An additional water quality threat is the salinization of sites invaded by saltcedar.

Water quality and quantity are very important to downstream users of the river system, as well. In addition to human uses, the river supplies water to diverse wildlife habitats along its path. Ensuring adequate water supply to these habitats nurtures and protects native wildlife, including the endangered least Bell’s vireo.

5. Water Conservation: Giant reed has three times the water uptake of native riparian species. For example, researchers at the University of California, Riverside estimate that clearing 10,000 acres of Arundo from the Santa Ana River would result in a water savings of approximately 37,000 acre-feet per year. In addition, removing these exotics would result in more in-stream water, benefiting the native aquatic organisms.

The removal of every 1,000 acres of giant reed and subsequent recovery of native vegetation will yield a water savings of approximately 3,800 acre-feet per year. This is enough to supply almost 20,000 residents with water. The cost of providing imported water to residents is high and increasing. The savings to the water suppliers, and ultimately to the residents, would be enormous. Furthermore, reducing the demand for water will ultimately reduce the need for future water projects and their environmental costs.

Control of Invasive Plants

The pervasion of giant reed on the Santa Ana River is counter-indicated if Federal, state, and local agency, and societal goals for uses of the river resources and environs are to be met. Giant reed must be controlled but will not be without great cost and a major shift from the traditional approach to wetland mitigation and resource management. Mitigation will have to start upstream, not necessarily next to the impact and the rarest species must be managed to greater productivity to offset unavoidable impacts of the weed control activities. Impacts could include some loss of short term habitat values at specific locales and disturbance of rare species. In the long term, however, the function of the river will be restored, there will be a major gain in wetland acreage, resources will be maximized, and rare species recovered.

The focus of non-native plant control should be maintenance of a system with a minimum percent coverage (i.e. less than *5%* relative coverage) of giant reed and saltcedar. Control efforts should start from the upper reaches of a river and its major tributaries, with a goal of managing the river corridor, minimizing the expansion and invasion of non-native plant populations into pristine or previously cleared areas, and coordinating these actions with parallel projects and flood control activities to maximize effectiveness. Other objectives include managing endangered species and other wildlife resources to counteract any impacts of the control program while the native vegetation recovers. Also, in a few instances, re-vegetation could be employed in key areas where aesthetics necessitate it.

The following are important considerations for exotic plant control programs that are integrated into the watershed program:

- Work should be conducted from the most upstream location within a watershed. This is important particularly for control of exotic species that spread by vegetative stalks such as the giant reed.

- Active maintenance including ongoing removal and re-treatment of exotic plants must be of longer duration than what has been traditionally accepted. A minimum of 20 years should be the standard to prevent re-infestation.

- Work should be conducted during a time that avoids the breeding season for birds and ensures maximum uptake of herbicide by the exotic plants. This period has been determined to be post-flowering, September through mid-November, for giant reed. During the breeding season, biological monitoring must accompany the removal efforts to avoid untoward impacts.

- Green cane and roots of the giant reed must be kept away from the water to prevent downstream re-infestation.

The optimal time for treatment of giant reed with herbicides is between September 1 and November 15. If using herbicides in stands containing a mixture of exotic and native vegetation between April 15 and September l5, the U.S. Fish and Wildlife Service should be contacted regarding potential impacts to migratory birds and endangered species. For all activities, the conditions in the Regional General Permit No. 41 issued by the Army Corps of Engineers for work on exotics, shall be followed.

A suite of methods is needed to control giant reed, saltcedar, and other system-level weeds depending upon the species being treated, the presence or absence of native plants, the density of the stand, the amount of biomass that must be dealt with, the terrain, and the season.

The key to effective treatment of established phreatophytes is killing of the root masses. This requires treatment of the plant with systemic herbicide at appropriate times of the year to ensure translocation to the roots. Only one herbicide is currently labeled for wetlands use by the EPA, Rodeo, produced by Monsanto Corp. Rodeo is a broad-spectrum herbicide that can be used on giant reed, saltcedar, and most other monocots and dicots. It has proven very effective against giant reed. Garlon 3A, produced by Dow Chemical Corp., is a dicot-specific herbicide which has been proven effective against saltcedar in the desert. Dow has made application to the EPA for approval for use in wetlands, but that process has not been completed. Other herbicides might also be used as labels and conditions allow. Candidates include Fusilade-DX (fluazapop-butyl) and Post (Sethoxidan), which are monocot-specific herbicides. Neither is currently labeled for wetlands use.

The most effective treatment of giant reed is the foliar application of a solution of Rodeo post-flowering and pre-dormancy. During this period of time, usually late-August to early November, the plants are actively translocating nutrients to the root masses in preparation for winter dormancy. This timing of application results in effective translocation of herbicide to the roots. Two to three weeks after treatment, the leaves and stalks turn brown and soften, creating an additional advantage in dealing with the biomass; cut green stems might take root if left on damp soil and are very difficult to cut and chip. Treated stems have little or no potential for rooting and are brittle. They may be left intact on the ground or chipped on site and left for mulch.

Cut-stem, or cut-stump treatment requires more time and labor than foliar spraying, and requires careful timing. Cut stems must be treated within one to two minutes in order to ensure uptake of herbicide into the tissues. This treatment is also best done post-flowering. The chief advantage of cut-stem treatment is that it requires less herbicide, surgically applied to the stem. Because of the labor required it is rarely cheaper than foliar spraying except on very small, isolated patches or individual plants.

The approach usually taken by the Watershed Program has been to cut the stalks by hand and remove the biomass, wait three to six weeks for the plants to grow to three or four feet tall, then apply a foliar spray of Rodeo solution. The chief advantage of this approach is that less herbicide must be applied to treat the fresh growth compared with tall, established plants, and that coverage is often better because of the shorter and uniform-height plants. However, cutting of the stems results in the plants returning to growth phase, drawing nutrients from the root mass. As a result there is less translocation of herbicide to the roots and less root-kill. However, follow-up treatments are usually required, anyway. Root kill is almost never achieved with a single application of herbicide except on very young stands.

Other exotic species are treated with appropriate herbicides after consultation with a licensed Pest Control Advisor. Rodeo is the most effective material for the treatment of pampas grass, while Rodeo or Garlon-3A is effective against castor bean, cocklebur, and other dicots.

Pure stands of giant reed can be efficiently treated by aerial application of an herbicide concentrate, usually by helicopter. Helicopter application can deal with at least 100 acres per day. Special spray apparatus produces extremely fine droplets of concentrated herbicide, which actually reduces herbicide use, minimizes over-spray, and results in greater kill. Heavy machinery can also be used where little or no native material is at risk.

In areas where helicopter access is impossible, where giant reed makes up the understory, where patches are too small to make aerial application financially efficient, or where weeds are mixed with native plants, herbicides must be applied by hand. Street-vehicles with 100 gallon spray tanks are a good alternative where road access is available, but small four wheel drive vehicles equipped with 15 gallon sprayers are the preferred approach where the streambed is not so rocky as to prevent access. Four or five gallon backpack sprayers are the final alternative where the vegetation is too dense, or the landscape too rugged for vehicles to be effective.

Methods for vegetation removal include use of prescribed fire, heavy machinery (e.g. bulldozers), hand-cutting by chainsaw or brushcutter, hydro-axe, shredder, chipper, or biomass burning or removal by vehicle. Prescribed fire, or burning piles of stacked biomass, is the most cost-effective way of removing biomass as long as it does not threaten native vegetation or other resources. Prescribed burning should be conducted between September and February to avoid impacts to breeding birds. Chipping is more costly in terms of equipment and labor, but cut, dried chips pose no threat for regeneration or for forming debris dams. Hauling of biomass by vehicle is extremely expensive and should only be done as a last resort. Most landfills will not accept giant reed and those that do will only accept if cut into short lengths and bagged into plastic trash bags, making the labor costs very high. The use of heavy machinery such as the hydro-ax is extremely expensive. The machines are slow; a hydro-ax can only cut between one and three acres per day. Cutting by hand and chipping have been used almost exclusively, so far in the upper Santa Ana Watershed.

One of the most important considerations when undertaking an exotic plant control program is a long-term maintenance and monitoring period. The purpose of this is to ensure that satisfactory results are being achieved through the weed control project. The management goal is to remove these weeds so that native species will naturally re-establish themselves. As the native riparian vegetation matures and the upstream sources of exotic vegetation is removed, maintenance efforts will be considerably decreased. By the third year, monitoring and maintenance efforts would be considerably lower than the first two years. Adequate funding for the long-term monitoring and maintenance must be considered during the initial planning efforts.

Arundo control and endangered species management are the top priorities of the Watershed Program. These tasks are so extensive and expensive that re-vegetation efforts have been minimal. Furthermore, natural re-vegetation has filled in the removal sites quite quickly in most cases. In special cases, plantings will be necessary and the following guidelines will be followed.

1. Site analysis: Once planting sites have been identified, field investigations of the existing environmental conditions must be made. Soil texture and depth to groundwater need to be measured.

Consideration of the hydrologic regime is critical to successful re-vegetation; without appropriate hydrology, planting efforts will likely fail.

2. Site preparation: This includes initial weed control treatments and appropriate soil tillage prior to planting. Initial weed control treatments are addressed above. Tillage is important to break up soil aggregation and compaction in areas where planting is planned. There appears to be a direct correlation between volume of soil tilled and tree growth (Anderson 1991). If a thick root mass or Arundo rhizome network remains on site, it may act as a physical barrier for establishment of riparian seedlings or pole cuttings. It addition, a thick rootmass (2-4 feet) may increase the depth to groundwater enough to hinder or preclude growth of native riparian plants. Therefore, when practical, root masses should be removed.

3. Irrigation and water source: In situations where riparian vegetation is planted on terraces above the water table, a reliable water source and irrigation are necessary. Plantings of pole cuttings is adequate in low terrace areas where plants will have ready access to groundwater. Short–term irrigation may be used to enhance and promote seedling establishment during the first year or two. Extensive or prolonged irrigation is counter-productive since the goal is self-sustaining vegetation.

4. Planting: The planting design will be based on local vegetational cover in adjacent riparian habitat. Emphasis is given to understory and shrubby elements and establishing them in places where they will not be replaced quickly by trees. Mulefat planting is a priority, since it is used for vireo nest placement and is in far lower supply than desirable in many locations.

Species that may be planted locally include: S. lasiolepis, S. gooddinggii, S. hindsiana and P. fremontii, at a density of about 2,400 cuttings/acre (6’ x 6’). Mulefat is typically planted in monotypic blocks at a density of 4840/acre (3’ x 3’); however, individual plants can be clumped to mimic natural establishment. Block location and size must be determined by assessing soil and groundwater conditions.

Fresh cuttings are used, measuring 2 ft long and at least .25 in diameter, taken as close to the project site as is feasible. Cuttings should be taken from as many different individuals as is feasible to ensure genetic diversity within the population. Cuttings should be taken while the tree is dormant, and cuttings taken later in dormancy have a better survival than those taken earlier. In southern California, riparian species start to break dormancy soon after the winter rains have started, usually February to March. Ideally then, cuttings should be taken and planted in December and January. If the winter rains have not started by planting, the entire site should be thoroughly saturated by irrigation to ensure that the cuttings have adequate moisture. If planting starts after the trees have flushed, and late enough in the year that temperatures will desiccate the cuttings, buds can be stripped off and the cuttings soaked for up to 4 days to increase moisture content. Cuttings should not be taken or planted after May, as fresh cuttings in a field situation have poor survival.

5. Weed control: Controlling annual weeds in the first year of growth increases the growth, and survival rate, of the natives used in riparian restoration. A combination of mowing, weeding by hand, and treatment with herbicides is used on an as-needed basis. Mowing should be performed when a visual assessment of the site indicates that weeds are inhibiting site access or are having a negative impact on planted stock due to light or water competition. Straw mulch can be used to control weeds at the base of the plantings and should be applied immediately after planting.

There is a great need for community support in a watershed-wide exotic plant control program. Unless weed problems on privately owned upstream land are addressed with the rest of the watershed there will be long-term and financially costly annual monitoring and treatment required to maintain treated areas in a weed-free state. One of the goals for a good long-range management plan is strong community support. Getting the public interested in helping with exotic plant control, promoting awareness of the impacts from exotics, and empowering individuals to maintain an exotics-free environment are important strategies for success on the Santa Ana River.

Once community members have been provided educational materials, attended meetings, and helped with local programs, they become project leaders. This strengthens the program in several ways. First, less outside resources will be necessary due to community participation. The community will direct their government to support these programs through letters, *etc.* Many community members live their entire lives in the area, whereas we tend to come and go with our jobs. It will be these individuals that will keep the program going. Finally, an educated community is one that can make sound decisions regarding maintaining the biological integrity of their community.

The Resource Conservation Districts work extremely well with the public. They have employed many techniques in successfully engaging and vesting the public in the Watershed Program including: flyers, brochures, door-to–door campaign, community meetings, and social group meetings.

ENVIRONMENTAL EFFECTS OF THE ACTIVITIES OF THE WATERSHED PROGRAM

The long-term goal of the Watershed Program is to restore the natural functions of the Santa Ana River. The current associated activities include: removal, control, and eradication of invasive species, particularly giant reed and cowbirds, which interfere with river function and resource abundance; increasing wetlands and open space; managing endangered species toward recovery; and involving the public.

Significant management efforts for endangered species, including the control of cowbirds and their effects on nesting birds, began in 1986. There were observer encroachments into the habitat, disturbance to nesting least Bell’s vireos, and incursions into nests. These activities continue today and are proposed for subsequent years under permit with the U. S. Fish and Wildlife Service and authorization for the harm or harassment of the potentially affected endangered species. Approximately 650 hours were spent in the field in, and adjacent to, vireo-occupied habitat in 1986. There were 19 pairs of vireos detected in the Basin during that initial year of intensive monitoring; 20 fledged youngsters were observed; but there was a 39% rate of cowbird parasitism. There were also 858 cowbirds removed from the riparian habitat in the Basin in 1986.

The management activities have been conducted annually since 1986 and the negative effects of these activities have been minor incidental habitat damage and disturbance of endangered birds in the riparian habitat. Approximately 3,000 hours were spent in the field in, and adjacent to vireo-occupied habitat, potentially disturbing vireos during the nesting season in 2000. The positive effects are best portrayed through the results on the vireo population in the Prado Basin. During the 2000 breeding season, 357 territorial males and 281 breeding pairs were detected. This is a 1,479% increase in the vireo breeding population. A total of 2,595 cowbirds were removed from the Basin and as a result, cowbird parasitism was down to 8%. As a direct result of the increasing vireo population and decreased nest parasitism, 649 fledglings were observed (Pike et al. 2000).

The most significant environmental effect of the management activities has been the recovery of the vireo in the Prado Basin. However, other native nesting birds are equally as affected by cowbird parasitism and should be benefited as well by cowbird control. This has been qualitatively observed in the richness of the nesting avifauna in the Basin, compared to unmanaged riparian areas in the watershed.

The proposed management activities for the year 2000 and in subsequent years expand the areas to be managed beyond the Basin. The results should be similar. There will be human encroachment, some minor disturbance of nesting birds, and minimal habitat damage, mostly associated with the incidental breakage or crushing of vegetation. These effects are to be kept to an absolute minimum but they do occur at an incidental and insignificant level.

Beginning in the year 2000, the bird management activities began on San Timoteo Creek in the upper watershed and along the river above Prado Basin to the Hidden Valley Preserve. If the funding is available beginning in 2001, the management activities will be expanded above Hidden Valley and into the lower canyon, below Prado Basin. Initially, 2 – 3 miles of the river above Hidden Valley will be added and the 7.5 miles of the lower canyon. Eventually, these activities will be conducted in all of the riparian habitat in the watershed. The effects over time are likely to be similar to those observed in the Basin.

The willow flycatcher has probably benefited from these same management activities but has only held its own in the Basin. It has not responded with the dramatic increase in population observed of the vireo. Consequently, it will be a future focus of the management and study activities. The attempt will be made to focus on the flycatchers needs through study first, then management, to understand and try to provide for this species' specific needs. The overall goal is to increase the flycatcher population to a more viable level.

Similarly, other listed species will be subject to monitoring, study, and management when the needed funding levels are obtained. The Watershed Program is currently partnering with efforts for the Santa Ana sucker, for example. Studies have been ongoing for two years and this program will focus on habitat management and restoration. A 300-foot stream has been created at the Riverside-Corona RCD. Once permits are obtained, sucker fry from the river will be raised in the predator-free environment of the artificial stream. When they have obtained a size more capable of dealing with the many exotic predators of the river, they will be re-introduced to sites that have been restored.

River restoration will involve the cleanup of trash and debris; control of exotic predators; structure placement to deny access by exotic predators; placement of logs, trees, rocks, or other appropriate objects to enhance habitat through shading, providing cobbled surfaces, eddies, and pools. These activities will have minor negative effects associated with momentary potential increases in turbidity and other results of human incursion into the aquatic environment. There will also be local population reductions in the exotic fish populations, frogs, and crayfish. However, the long-term benefit will be restoration of diversity in the habitat structure of the aquatic environment, reduction in exotic predator population levels, and increased habitat for native fishes. Several of these activities may require permits from the Corps, Department, and RWQCB. The overall goal will be the eventual recovery of native fish populations in the river and tributaries.

Endangered species management and recovery will be integrated into the annual work plan for other listed species in the watershed as need, opportunity, and wherewithal develop. Fully operational, the Watershed Program would engage in annual activities expending $ 2.5 – 5 million. At the point where this level of activity appears sustainable, each of the 9 listed target species would receive the benefit of specific and adaptive management. The adaptive nature of the program would extend to the inclusion of other rare species, where modifications of intended implementation measures would reap benefits disproportionate to the effort required.

Habitat restoration has been largely accomplished with the removal of giant reed and expansion of adjacent native riparian habitat. In many areas, removal of the reeds has exposed diminutive willows, barely vegetated, that grow expansively with the reduced competition for light, nutrients, and moisture. On San Timoteo Creek in the upper watershed, over 60% of 209 recently treated acres already support riparian habitat (Figure 2). Plantings have been, and will be done locally where the need is greatest for short-term cover. These will be pole plantings done where ground water is available.

In the Prado Basin, approximately 200 acres have been treated for Arundo. About 75% of this acreage is still relatively free of giant reed but this has taken major annual effort and the remainder has been heavily re-infested. Giant reed removal was done in the Basin along with plantings as part of efforts to restore habitat for the vireo. There is such a significant concentration of vireos in the Basin today, that restoration is ongoing, although costly. The Basin is heavily infested with giant reed and there are 8,000 – 10,000 acres of it upstream, ready to break off in high flows and replant downstream.

Consequently, giant reed removal is being concentrated upon in the upper watershed and along isolated tributaries. Approximately 305 acres of Arundo have been removed from the upper watershed and isolated tributaries since 1997 (Figure 3). This not only results in the redevelopment and expansion of native habitat on treated sites, it reduces source material for continued expansion of Arundo downstream.

Treatment will continue in future phases of the program along the tributaries and mainstem down to the San Bernardino County line and into Riverside. The initial treatment of San Timoteo Creek including Live Oak Canyon will be completed in 2001. Cajon Creek and most of Lytle Creek will also be completed.

The environmental effects of the activities associated with removal include temporary disturbance of native wildlife, crushing or trimming of native plants, including willows and mulefat. The disturbance with noise and human activity is kept to the minimum level possible and is monitored in areas where listed species could be affected. The ultimate goal of the monitoring is to avoid effects on the reproductive activities of rare riparian species. Crushed and cut plants usually resprout and provide low nesting cover by the following spring.

The negative impacts associated with giant reed removal are short term and insignificant. Monitoring and resulting cessation or modification of work are built into the methodologies, as contained in the Regional General Permit No. 41 issued by the Corps and the recently obtained Streambed Alteration Agreement for the watershed efforts. The watershed activities are also conducted in conjunction with stipulations contained in the Section 401 permit issued by the California Regional Water Quality Control Board for the program activities in the Santa Ana River Watershed.

The longer-term benefits of the program activities begin to be realized within one growing season following initial treatment and removal of giant reed with the spread of native vegetation onto and over removal sites. Downstream of the removal areas, dozens of acres of additional infestation by giant reed and subsequent loss of habitat and wildlife values are avoided. Additional benefits are realized and include: reduction in water consumption; reduction in the threat of intense fires; reduction in water flow blockage; reduction in storm-swept debris; and increased ability of the riverine habitats to recover naturally.

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