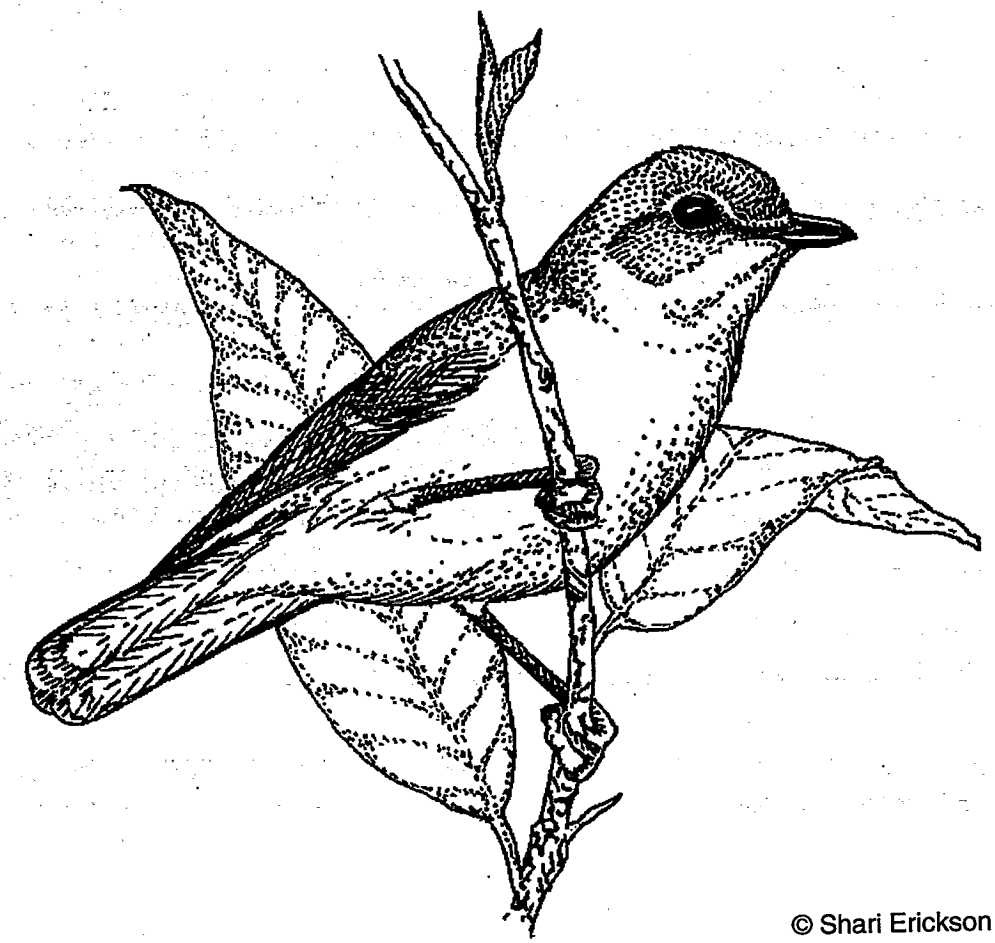
U.S. Fish and Wildlife Service

Draft Recovery Plan

For the Least Bell's Vireo
(Vireo bellii pusillus)



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DRAFT RECOVERY PLAN

for the

LEAST BELL'S VIREO

(*Vireo bellii pusillus*)

Prepared for

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: _____
Regional Director, U.S. Fish and Wildlife Service

Date: _____

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Literature citation should read as follows:

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Numerous individuals, organizations, jurisdictions, and agencies have contributed significantly to the development of the information contained in this recovery plan, as well as to the improved status of the least Bell's vireo from the time the species was federally listed as endangered. In addition to the individuals who over the years collected, analyzed, and disseminated data, further acknowledgments are extended to the United States Army Corps of Engineers (COE); United States Forest Service; United States Marine Corps, Camp Pendleton; Naval Facilities Engineering Command, Southwest Division; San Diego Association of Governments; California Department of Transportation, District 11; counties of San Diego, Orange, and Riverside; and Orange County Water District, for considerable financial assistance.

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EXECUTIVE SUMMARY
OF THE
RECOVERY PLAN FOR THE LEAST BELL'S VIREO
(Vireo bellii pusillus)

Current Species Status:

The breeding distribution of the least Bell's vireo (*Vireo bellii pusillus*) is currently restricted to eight southern counties in California and portions of northern Baja California, Mexico. Available census data indicate that the least Bell's vireo population in southern California increased from an estimated 300 pairs in 1986 to an estimated 1346 pairs in 1996. Least Bell's vireos winter in southern Baja California, Mexico. The least Bell's vireo was listed as endangered on May 2, 1986. Critical habitat for the species was designated on February 2, 1994.

Habitat Requirements and Limiting Factors:

The least Bell's vireo is an obligate riparian species during the breeding season and is characterized as preferring early successional habitat. This species typically inhabits structurally diverse woodlands along watercourses, including cottonwood-willow forests, oak woodlands, and mule fat scrub. Little is known about their winter habitat requirements, but they are not exclusively dependent on willow-dominated riparian woodland habitat on their wintering grounds. Most least Bell's vireos in winter occur in mesquite scrub vegetation in arroyos, but some also use palm groves and hedgerows associated with agricultural fields and rural residential areas.

Extensive breeding habitat loss and degradation and brood parasitism by the brown-headed cowbird (*Molothrus ater*) have resulted in a rangewide decline of the least Bell's vireo. These factors continue to be the most serious threats to the

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recovery of the least Bell's vireo. Populations occurring in the Owens Valley, Death Valley, Sacramento-San Joaquin Valleys and Sierra Nevada foothills, and Tehama County have been completely extirpated. Vast portions of these areas are no longer available for recolonization or expansion.

Recovery Objective:

The objective of this plan is the reclassification of the least Bell's vireo to threatened and, ultimately, delisting through recovery.

Downlisting Criterion:

Reclassification to threatened may be considered when criterion 1 has been met for a period of 5 consecutive years.

> Criterion 1: Stable or increasing least Bell's vireo populations/metapopulations, each consisting of several hundred or more breeding pairs, are protected and managed at the following sites: Tijuana River, Dalzura Creek/Jamul Creek/Otay River, Sweetwater River, San Diego River, San Luis Rey River, Camp Pendleton/Santa Margarita River, Santa Ana River, an Orange County/Los Angeles County metapopulation, Santa Clara River, Santa Ynez River, and an Anza Borrego Desert metapopulation.

Delisting Criteria:

Delisting may be considered when the species meets the criterion for downlisting and the following criteria have been met for 5 consecutive years.

> Criterion 2: Stable or increasing least Bell's vireo populations/metapopulations, each consisting of several hundred or more breeding pairs, have become established and are protected and managed at the

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following sites: Salinas River, a San Joaquin Valley metapopulation, and a Sacramento Valley metapopulation.

Criterion 3: Threats are reduced or eliminated so that least Bell's vireo populations/metapopulations listed above are capable of persisting without significant human intervention, or perpetual endowments are secured for cowbird trapping and exotic plant control in riparian habitat occupied by least Bell's vireos.

Actions Needed:

The plan describes a strategy for reclassification, recovery, and delisting. Instrumental to this strategy is securing and managing riparian habitat within the historical breeding range of the least Bell's vireo, annual monitoring and rangewide surveys, and research activities necessary to monitor and guide the recovery effort.

Recovery Costs:

Costs of specific recovery actions will be determined as information is obtained and/or final actions are undertaken. These items are designated as "to be determined" (TBD) in the Implementation Schedule.

Total ($1000)	1999	2000	2001	2002	2003
8402 + TBD	1037	2080	2065	1705	1515

Date of Recovery: A delisting target date cannot be projected at this time.

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I. INTRODUCTION

The Ecosystem Approach

This recovery plan for the least Bell's vireo (*Vireo bellii pusillus*), if successfully implemented, will lead not only to the recovery of this species, but also assist in the recovery of one of the most critically endangered ecosystems in the United States: southwestern riparian habitat. Recovery of this ecosystem, through preservation and restoration, will constitute a significant contribution to protection of native North American wildlife.

It is impossible to manage some species in isolation from other species. Species are components of complex ecosystems, influencing and influenced by biotic and abiotic features of their environments. The current emphasis on multiple species protection and management reflects a more accurate recognition of the way organisms interact with their environments, thus enhancing the ability to reverse species' declines and potentially preventing the need for future listings.

The least Bell's vireo was one of the first members of the riparian ecosystem to be recognized as declining to the brink of extinction, partially in response to the decimation of its habitat. The precipitous decline of the least Bell's vireo portends the probable fate of other riparian species in the absence of remedial action to change the status quo of land use in California. Although this recovery plan focuses on the least Bell's vireo, achievement of its recovery will ensure protection to a suite of sensitive species also dependent upon the riparian ecosystem.

The least Bell's vireo is a recoverable species. It has survived extensive modification, degradation, and loss of the habitat, demonstrating its ability to rebound after management preserves or restores the conditions under which the species evolved. It is the goal of this recovery plan to guide such management, leading to the ultimate delisting of the species.

The Riparian Ecosystem. A riparian habitat is a plant community that develops along the margins of freshwater streams, lakes, and rivers where soils are damp and sandy. The structure and composition of riparian plant communities are related to the physiography and hydrology of each watershed and consequently vary throughout the range of the least Bell's vireo. Community types such as southern willow scrub, and mule fat scrub (scrub habitat dominated by *Baccharis glutinosa*), sycamore alluvial woodland, coast live oak riparian forest, arroyo willow riparian forest, and cottonwood bottomland forest (Holland 1986, Faber *et al.* 1989), exemplify least Bell's vireo habitats in California.

Although riparian vegetation comprises a small proportion of the California landscape relative to various other habitat types, the value of this habitat to wildlife is disproportionately high. Riparian habitats support more species of birds than any other habitat type in California; more than 140 species occur in riparian habitat, and 88 of these are obligate riparian species (Faber *et al.* 1989). Birds use riparian habitats for nesting, wintering, or both. The mammalian community is also diverse and consists of several species that are dependent upon riparian woodlands for water, forage, and cover, such as the long-tailed weasel (*Mustela frenata*) and bobcat (*Felis rufus*). Insects are abundant and play important ecological roles as both predators and prey. Many species of fish, reptiles, and amphibians occupy riparian habitats and contribute to its immense diversity. According to the U.S. Council on Environmental Quality (1978, as cited in Faber *et al.* 1989), "no ecosystem is more essential than the riparian system to the survival of the nation's fish and wildlife."

Part of the reason for the high diversity of the riparian community lies in its structural complexity, which allows for "niche partitioning" in which different species seeking food, nest sites, and cover in the same habitat evolve behaviors to use different resources or the same resources in different ways (e.g., different times or space) to avoid competition. The presence of tall trees and a diverse understory creates a microclimate that differs from that of adjacent upland habitats

in its high humidity and cooler temperatures. Insects thrive in this environment and are an abundant and dependable food source for many insectivorous animals. Many animals in upland communities are attracted to riparian woodlands for access to water, shelter, and shade, particularly during the rainless southern California summers. The riparian zone also serves as a natural corridor, linking adjacent ecosystems and facilitating movement of animals between them. In these ways, the presence of riparian habitat significantly enriches regional biodiversity beyond what could otherwise be supported.

Not only are many riparian animals and plants listed as rare or endangered, the entire riparian community faces continual threats associated with human activities, including agriculture, flood control projects and channelization, livestock grazing, sand and gravel extraction, road construction, and residential and commercial development. Riparian habitat has been vanishing from the landscape of California at such a pace that today less than 10 percent of the riparian woodlands in existence at the time of the Gold Rush in the 1850's remain (Smith 1977), and those are but fragmented remnants. Faber *et al.* (1989) reported a 95–97 percent loss of naturally vegetated floodplains in southern California. Oberbauer (1990) reported a 61 percent loss of riparian habitat for San Diego County. The relatively higher proportion of riparian habitat remaining in San Diego County corresponds with the largest remaining least Bell's vireo populations, both at the time of listing and currently.

Fortunately, because of the dynamic aspect of riparian vegetation, riparian habitat is resilient and has high restoration potential, as long as the floodplain and fluvial processes (i.e., natural water flow and sedimentation regimes) are restored or intact. However, restoration ecology is in its infancy, and there is much yet to learn about how natural riparian ecosystems function. Until we perfect our ability to restore degraded environments to functioning, self-sustaining ecosystems, protection of existing habitat must be the conservation priority.

A. Brief Overview

The least Bell's vireo is a migratory songbird dependent upon riparian habitat for breeding. Historically, this species was widespread throughout riparian woodlands in the Central Valley and low elevation riverine valleys of California and northern Baja California (Figure 1). The least Bell's vireo was characterized by Grinnell as one of the most abundant birds in the state (Cooper 1861, Anthony 1893, 1895, Fisher 1893, Grinnell and Swarth 1913, Grinnell and Storer 1924, Grinnell and Miller 1944). In the last several decades, the species has undergone a precipitous decline in numbers, a decline attributable to the loss and degradation of riparian habitat throughout its range, as well as to the expansion in range of the brown-headed cowbird (*Molothrus ater*), a nest parasite (Garrett and Dunn 1981). Within California, least Bell's vireos are currently restricted in their distribution to eight southern counties (Figure 1), with the majority of birds occurring in San Diego County (RECON 1989, Appendix A).

In response to the dramatic reduction in numbers and range of the least Bell's vireo in California, the California Fish and Game Commission listed the species as endangered on June 27, 1980, under the California Endangered Species Act of 1970. The U.S. Fish and Wildlife Service proposed the least Bell's vireo for listing on May 3, 1985 (U.S. Fish and Wildlife Service 1985), and the species was subsequently federally listed as endangered on May 3, 1986 (U.S. Fish and Wildlife Service 1986), under the Endangered Species Act of 1973, as amended (Act). Critical habitat for the least Bell's vireo was designated on February 2, 1994 (U.S. Fish and Wildlife Service 1994). These designations afford a procedural process for protection of the least Bell's vireo under State and Federal laws. The species' recovery priority number is 3C, indicating it is a subspecies with a high degree of threat, has a high potential for recovery, and is in conflict with development activities.

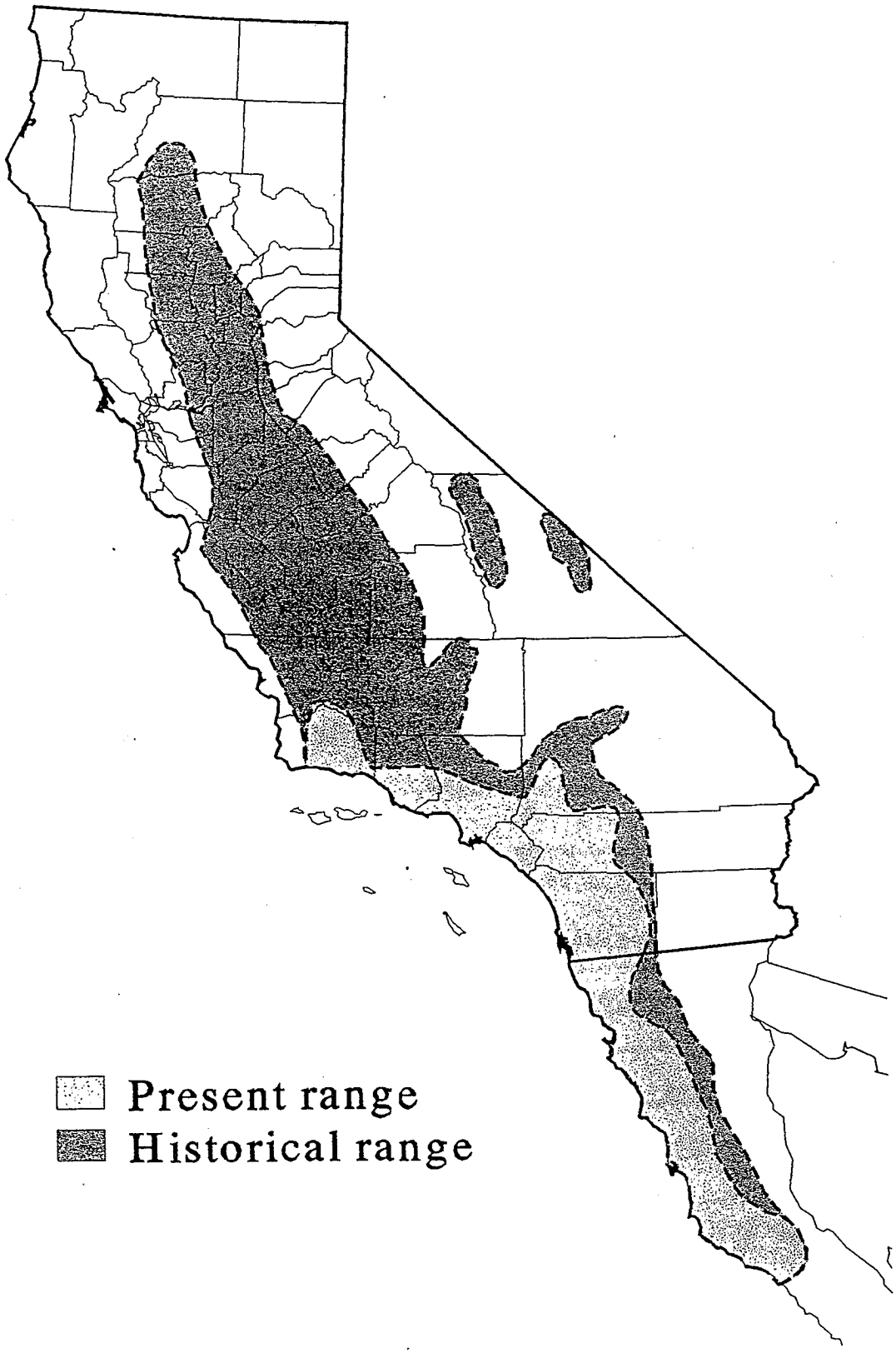

Figure 1. Historical and present ranges of least Bell's vireos.

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B. Species Description

Apparently the first account of the least Bell's vireo was written by J. G. Cooper and was based on two specimens he collected in 1861 along the Mojave River near Manix in San Bernardino County, California (Cooper 1861). The original description of the least Bell's vireo (Coues 1866) states:

> The color of the upper parts is a plain dull ashy gray on the head; tinged with grayish olivaceous on the rest of the upper parts. Above grayish ash, becoming more or less ashy olivaceous on the back; not more so on the rump than elsewhere. Below pure white, including under wing coverts; on the breast sometimes a faint suffusion of the lightest possible shade of brownish gray; sides under the wings moderately tinged with sulphur yellow. A narrow short superciliary streak; edges of eyelids, two bands on wings and narrow margins of outer border of wings and tail, dull white; on the latter tinged with olivaceous.

The least Bell's vireo is easily recognized on the breeding grounds by its distinctive song (Coues 1903), characterized by Peterson (1961) as "husky, unmusical phrases at short intervals: cheedle cheedle chee? - cheedle cheedle chew! First phrase ends in rising inflection; second phrase, given more frequently, has downward inflection and sounds as if bird were answering its own question."

Although indistinguishable to the human ear, the least Bell's vireo actually possesses a repertoire of songs, variants of the "question" and "answer" components, through which males rotate (Beck 1996). Males possess individually unique repertoires of from 5 to 15 songs, which are evidently fixed by the first breeding season, providing a "vocal fingerprint" for identifying individual birds. Beck (1996) hypothesizes that the possession of unique repertoires may function in neighbor and/or mate recognition.

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C. Taxonomy

Four subspecies of the Bell's vireo (American Ornithologists' Union 1957) have been recognized. Although all subspecies are similar in behavior and life history, they are isolated from one another on both the breeding and wintering grounds (Hamilton 1962) . The least Bell's vireo (*Vireo bellii pusillus*) breeds in California and northwestern Baja California, Mexico, and winters in southern Baja California (Howell and Webb 1995, Unitt 1984). The eastern Bell's vireo (*Vireo bellii bellii*) is found in the central United States from Colorado to Tennessee. The Texas vireo (*Vireo bellii medius*) is distributed in southwestern Texas and eastern Mexico, and the Arizona Bell's vireo (*Vireo bellii arizonae*) occurs in Arizona, Utah, Nevada, California (along the Colorado River), and Sonora, Mexico. The three latter species winter at different longitudes on mainland Mexico and thus, are apparently geographically segregated from one another on the wintering grounds.

D. Distribution

Historically, the least Bell's vireo was widespread and abundant, ranging from interior northern California near Red Bluff (Tehama County), south through the Sacramento-San Joaquin Valleys and Sierra Nevada foothills, and in the Coast Ranges from Santa Clara County south to approximately San Fernando, Baja California, Mexico. Populations also were found in the Owens Valley, Death Valley, and at scattered oases and canyons throughout the Mojave Desert.

No estimates of historical least Bell's vireo numbers were ever made, but workers in the early 19th century and even as late as the 1940's invariably described the subspecies as common to abundant and conspicuous (Cooper 1861, 1874, Anthony 1893 and 1895, Baird *et al.* 1874, Belding 1878, Fisher 1893, Grinnell and Swarth 1913, Grinnell and Storer 1924, Grinnell *et al.* 1930, Grinnell and Miller 1944). These historical accounts indicate that least Bell's vireos were present in considerable numbers wherever suitable habitat occurred.

In the decades following 1940, extensive habitat loss coupled with brood parasitism by the brown-headed cowbird decimated least Bell's vireo populations rangewide, and the decline has been well documented. In 1973, no least Bell's vireos were found during an intensive search in formerly occupied habitat between Red Bluff, Tehama County, and Stockton, San Joaquin County (Gaines 1974). By the early 1980's, the least Bell's vireo had been extirpated from the Sacramento and San Joaquin Valleys, once the center of its breeding range, and the species was restricted to two localities in the Salinas River Valley in Monterey and San Benito Counties (D. Roberson, pers. comm.), one locality along the Amargosa River (Inyo County), and numerous small populations in southern California south of the Tehachapi Mountains and in northwestern Baja California, Mexico (Gaines 1977, Goldwasser 1978, Goldwasser *et al.* 1980, Wilbur 1987, Unitt 1984). By the time the least Bell's vireo was federally listed in 1986, the statewide population was estimated at 300 pairs, with the majority concentrated in San Diego County (RECON 1989, Appendix A).

Breeding populations in northern Baja California apparently underwent similar declines during the same period. During a brief survey in 1980 of Baja California, Mexico, Wilbur (1981, 1987) found 40 pairs of least Bell's vireos distributed in six locations.. Although he believed more birds were present than his incomplete survey found, Wilbur observed that habitat was limited and susceptible to many of the same development pressures present in the U.S. Least Bell's vireos were found more recently at five of the eight historical Mexican locations: San Fernando Mission, Valladores, Rancho San Jose (Meling Ranch), Las Cabras, and El Gato. In addition, one new breeding location, Erendira, was described. Subsequent visits to northern Baja California since the late 1980's have revealed that a least Bell's vireo population of 20 to 30 pairs continues to exist at Rancho San Jose (Kus, unpubl. data), and a large (as high as 75 pairs) concentration occurs along the Santo Tomas River (J. and J. Griffith; Kus, unpubl. data). Other sites supporting least Bell's vireo include Catavina, San Telmo Valley, and La Misión. Recent observations suggest that, unlike Wilbur's (1980a) earlier assessment, cowbird parasitism is currently a serious threat to least Bell's vireo breeding populations in Baja California.

Since the least Bell's vireo was federally listed in 1986 and intensive cowbird removal programs initiated, the species has undergone an increase almost as dramatic as its decline. While a few populations surviving the decline have generally stabilized in size (e.g., the Sweetwater, San Diego and Santa Ynez Rivers populations, Appendix A), most have undergone tremendous growth. For example, least Bell's vireos along the Santa Margarita River at Marine Corps Base Camp Pendleton (MCBCP) have increased in number from 15 males in 1980 (Salata 1980) to 523 males in 1996 (Griffith and Griffith 1997). Similar increases have occurred at the Prado Basin on the Santa Ana River, where the least Bell's vireo population grew from 12 males in 1985 (U.S. Fish and Wildlife Service 1986b) to 249 males in 1996 (Pike and Hays 1997) and at the Tijuana River, where the population expanded from 13 males in 1990 (Kus 1990c) to 142 males six years later (Kus 1996). A thorough rangewide survey has not been conducted since the 1986–1987 effort (RECON 1989), but available census data indicate that the least Bell's vireo population in southern California increased from an estimated 300 pairs in 1986 to an estimated 1346 pairs in 1996 (Appendix A).

In addition to population size increases, observations also indicate that least Bell's vireos are also expanding their range and recolonizing sites unoccupied for years or decades. Expansion is occurring both eastward in San Diego County as birds become reestablished in the more inland reaches of the coastal valleys and northward as birds disperse into Riverside and Ventura Counties. Observations of color-banded birds at these sites reveal that dispersal from the more southerly breeding populations is partially responsible for the recolonization (Greaves and Labinger 1997; L. Hays, U. S. Fish and Wildlife Service, pers. comm.; B. Kus, San Diego State University, unpubl. data). As populations continue to grow and least Bell's vireos disperse northward, it is anticipated they could reestablish in the central and northern portions of their historical breeding range.

E. Habitat Requirements

Least Bell's vireos are obligate riparian breeders, typically inhabiting structurally diverse woodlands along watercourses. They occur in a number of riparian habitat types, including cottonwood-willow woodlands/forests, oak woodlands, and mule fat scrub. Several investigators have attempted to identify the habitat requirements of the least Bell's vireo by comparing characteristics of occupied and unoccupied sites and have converged on two features that appear to be essential: (1) the presence of dense cover within 1–2 meters (3–6 feet) of the ground, where nests are typically placed and (2) a dense, stratified canopy for foraging (Goldwasser 1981, Gray and Greaves 1981, Salata 1981, 1983, RECON 1989). Although least Bell's vireos typically nest in willow-dominated areas, plant species composition does not appear to be as important a determinant of nesting site selection as habitat structure.

The selection of breeding sites by least Bell's vireos does not appear to be limited to riparian stands of a specific age, although least Bell's vireos are characterized as preferring early successional habitat. Again, vegetation structure more than simply age, appears to be the important determinant of site use. Early successional riparian habitat typically supports the dense shrub cover required for nesting and also a structurally diverse canopy for foraging. If permitted to persist, willows and other species form dense thickets in approximately 5–10 years and become suitable least Bell's vireo habitat (Goldwasser 1981, Kus in press). As stands mature, the tall canopy tends to shade out the shrub layer, making the sites less suitable for nesting. However, least Bell's vireos will continue to use such areas if patches of understory exist. In mature riparian habitat, the understory vegetation often consists of species such as California wild rose (*Rosa californica*), poison oak (*Toxicodendron diversiloba*), California blackberry (*Rubus ursinus*), grape (*Vitis californica*), and a variety of perennials that provide concealment for least Bell's vireo nests. In addition, least Bell's vireo nest placement tends to occur in openings and along the riparian edge, where exposure to sunlight allows the development of shrubs.

Within suitable riparian habitat, no features have been identified that distinguish least Bell's vireo nest sites from the remainder of the territory (RECON 1989, Hendricks and Rieger 1989, Olsen and Gray 1989). No significant differences have been found between habitat at the nest site and the surrounding habitat with regard to stem density, percent cover, percent open ground, and plant height and density (Hendricks and Rieger 1989). Nest site characteristics are highly variable, and nest success appears to be unrelated to nest height, host species, and amount and arrangement of foliage cover in the vicinity of the nest.

Although least Bell's vireos are tied to riparian habitat for nesting, they have been observed extending their activities into adjacent upland habitats. The arid nature of the southern California landscape typically results in the close proximity of riparian and nonriparian habitats, such as coastal sage scrub. Least Bell's vireos along the edges of riparian corridors maintain territories that incorporate both habitat types. Kus and Miner (1989) found that least Bell's vireos along the Sweetwater River in San Diego County traveled 3–61 meters (9–183 feet) from the riparian edge to reach upland areas. Upland habitat was used primarily by foraging adults and adults foraging with fledglings; however, 35 percent of the pairs whose territories included nonriparian habitat placed at least one nest there. Kus and Miner (1989) speculated that upland vegetation, in particular laurel sumac (*Malosma laurina*) and elderberry (*Sambucus mexicana*), may have provided important supplemental food resources for birds in marginal habitat. Use of upland vegetation has also been observed early in the spring when floodwaters inundate adjacent riparian habitat (J. Wells, TWB Consultants, pers. comm.; P. Ashfield, U.S. Fish and Wildlife Service, pers. comm.; J. and J. Griffith, Griffiths Wildlife Biology, pers. comm.). Under such conditions, least Bell's vireos may nest exclusively in the nonriparian habitat.

Little is known about the least Bell's vireo's wintering habitat requirements. It is known that least Bell's vireos are not exclusively dependent on riparian habitat on the wintering grounds (Kus, unpubl. data). Although wintering least Bell's vireos

do occur in willow-dominated riparian woodlands, a greater proportion of the population appears to occur in mesquite scrub vegetation within arroyos (Kus, unpubl. data). During winter, least Bell's vireos also occur in shrubby areas associated with palm groves and along hedgerows associated with agricultural fields and rural residential areas (Kus, unpubl. data). The winter habitat selection of least Bell's vireo in southern Baja California appears more similar to that of breeding Arizona Bell's vireos than to its own breeding-season habitat selection (Kus, unpubl. data).

F. Critical Habitat

Critical habitat was designated for the least Bell's vireo on February 2, 1994 (U.S. Fish and Wildlife Service 1994a). The Service designated critical habitat for the least Bell's vireo at 10 areas encompassing about 15,200 hectares (38,000 acres) in Santa Barbara, Ventura, Los Angeles, San Bernardino, Riverside, and San Diego Counties. About 49 percent of the least Bell's vireo population in the United States occurred within these 10 areas in 1994 (U.S. Fish and Wildlife Service 1994a).

The Endangered Species Act defines critical habitat as areas containing physical or biological factors "essential to the conservation of the species" and that "may require special management considerations or protection." The Department of the Interior regulations (50 CFR 424.12) describe these features as including areas important for population growth, food and water resources, shelter, breeding and recovery sites, and habitats that "are representative of the historic distribution of the species."

The features or elements of habitat that are essential to the conservation of the least Bell's vireo can be described as riparian woodland vegetation that generally contains both canopy and shrub layers and includes some associated upland habitats. General activities that could cause destruction or adverse modification

of least Bell's vireo habitat include the following: (1) removal or destruction of riparian vegetation; (2) thinning of riparian growth, especially near ground level; (3) removal or destruction of adjacent upland habitats used for foraging; and (4) increases in human-associated or human-induced disturbances. Specific actions that could adversely affect least Bell's vireo critical habitat include stream channelization, water impoundment or extraction, water diversion, intensive recreation, and development.

Because of the continued acceleration of these types of activities in remaining least Bell's vireo habitat, limited areas are available for expansion of the current distribution of least Bell's vireos. Nevertheless, these critical habitat areas are expected to support the core populations from which the least Bell's vireo will expand its distribution, particularly to the north. The core populations will have to increase in size to allow population expansion adequate for least Bell's vireo recovery to occur. These critical habitat areas are also expected to perform as refugia during periods of potential population declines following random naturally occurring events.

Protection provided by the critical habitat designation. Critical habitat identifies those areas essential for recovery, including areas currently unoccupied by the listed species. The designation of critical habitat serves to focus conservation activities by identifying areas that contain essential habitat features and may require special management consideration. Critical habitat as addressed under section 7 of the Endangered Species Act applies to actions by Federal agencies only. The Endangered Species Act does not provide any additional protection to lands designated as critical habitat: designating critical habitat does not create a management plan for the identified areas or prescribe specific management actions (inside or outside of critical habitat), establish numerical population goals, or have a direct effect on areas not designated as critical habitat. Specific management recommendations for critical habitat are addressed in recovery plans and management plans, as well as in section 7 consultations.

G. Life History and Ecology

Breeding Biology. Least Bell's vireo breeding biology has been well studied, and the following information summarizes the findings of many investigators, including Barlow (1962). Least Bell's vireos arrive on the southern California breeding grounds in mid-March to early April, with males arriving in advance of females by several days. Observations of banded birds suggest that returning adult breeders may arrive earlier than first-year birds by a few weeks (Kus, unpubl. data). Least Bell's vireos are generally present on the breeding grounds until late September, although they may begin departing by late July (Garrett and Dunn 1981, Salata 1983, Pike and Hays 1992). Stragglers have been noted in October and November (McCaskie and Pugh 1965; McCaskie 1969; K. Miner, California State Parks; J. Newman, U.S. Fish and Wildlife Service, pers. comm.), and occasionally individuals overwinter in California (McCaskie and Banks 1964; McCaskie 1970; L. Hays, pers. comm.).

Males establish and defend territories through counter-singing, chasing, and sometimes physically confronting neighboring males. Territory size ranges from 0.5 to 7.5 acres. Some average territory sizes are shown in Table 1. Newman (1992) investigated the relationship between territory size, vegetation characteristics, and reproductive success for populations of least Bell's vireos at the San Diego and Sweetwater Rivers, but found no significant factors that could account for the variability in territory size observed at his sites.

Spatial differences in riparian habitat structure, patch size, and numerous other factors result in differences in the density of territories within and between drainages such that males have varying numbers of neighbors against whom their territory must be defended. Embree (1992) hypothesized that, because singing is the primary form of territorial advertisement and defense in least Bell's vireos and singing may attract predators to nest sites, least Bell's vireos in dense concentrations might experience lower reproductive success than those with few

Table 1. Average sizes (acres) of least Bell's vireo territories.

Site	1987	1988	1991	1992	1993	Source
Prado Basin (Santa Ana River)	1.9±0.9	1.6±0.9				Hays 1987, 1988
San Diego River	2.1±1.0	1.7±0.9				Kus 1989a
Sweetwater River		1.4±0.8				Kus 1989b
Tijuana River			2.5 ±1.2	2.7 ±1.4	1.8 ±0.8	Kus 1991e, 1992c, 1993d

neighbors. Counter to the subjective impression of field investigators, least Bell's vireos with many (7–13) neighbors did not sing at statistically higher rates than did those with few (1–4) neighbors. Moreover, Embree (1992) did not find significant differences between the singing rates of successful and unsuccessful males. Embree concluded that patch size and crowding did not influence least Bell's vireo reproductive success, at least not through the mechanisms of singing rates and attraction of predators.

Nest building commences a few days after pair formation. The consistency of nest locations of color-banded females supports the supposition that the female selects the nest site (Pitelka and Koestner 1942, Barlow 1962). Both members of the pair construct the nest, a process that usually takes four to five days. The nest is cup-shaped and constructed of leaves, bark, willow catkins, spider webs, and other material (Bent 1950). It is typically constructed in the fork of a tree or shrub branch within 1 meter (3 feet) of the ground. Nests are placed in a wide variety of plant species including willows (*Salix* spp.), mule fat (*Baccharis glutinosa*), California wild rose, poison oak, grape, elderberry (*Sambucus mexicana*), Fremont's cottonwood (*Populus fremontii*), California sycamore (*Platanus*

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racemosa), coast live oak (*Quercus agrifolia*), and several herbaceous species. The majority of nests are placed in willows and mule fat.

Egg-laying begins one to two days after nest completion. Typically three to four eggs are laid, occasionally two, and rarely five. Average clutch sizes of nonparasitized nests observed with complete clutches have ranged from 3.1 to 3.9 during recent years. Long-term average clutch sizes have been determined at the best-studied populations (Table 2). Both parents share in incubation, which takes approximately 14 days. Upon hatching, nestlings are fed by both parents for 10–12 days until fledging.

Adults continue to care for the young for at least two weeks after fledging when territorial boundaries may be relaxed as family groups range over larger areas. Fledglings generally remain in the territory or its vicinity for most of the season, although the behavior of fledglings produced early in the year has not been well studied.

Predation is a major cause of nest failure in areas where brown-headed cowbird nest parasitism is infrequent or has been reduced by cowbird trapping programs (see "Brood Parasitism" under "H. Reasons for Decline"). Most predation occurs during the egg stage. Predators likely include western scrub-jays (*Aphelocoma californica*), Cooper's hawks (*Accipiter cooperii*), gopher snakes (*Pituophis melanoleucus*) and other snake species, raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*), coyotes (*Canis latrans*), long-tailed weasels, dusky-footed woodrats (*Neotoma fuscipes*), deer mice (*Peromyscus maniculatus*), rats (*Rattus* spp.), and domestic cats (*Felis domesticus*) (Franzreb 1989). Other sources of nest failure are human disturbance (trampling of nest or nest site; clearing of vegetation), ant infestations, rainstorms, and unknown factors.

Least Bell's vireo pairs may attempt as many as five nests in a breeding season (B. Kus, pers. comm.), although most fledge young from only one or two nests. The

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Table 2. Average reproductive success and productivity of least Bell's vireo.

Site	Average clutch size (# eggs)	Hatch Rate [a] (%)	Fledge Rate [b] (%)	Nests Successful (%)	Fledglings per Nest (#)	Fledglings per Pair (#)	Fledglings per egg (#)
Tijuana River	3.5	83	86	73	2.4	2.8	0.71
Sweetwater River	3.6	70	75	61	1.8	2.5	0.55
	3.7	66	74	51	1.6	2.8	0.49
San Luis Rey River	3.4	53	71	41	1.1	1.8	0.37
West San Luis Rey River	–	75	87	74	1.9	2.6	0.65
Santa Margarita River	3.4	83	91	66	2.1	2.7	0.75
Santa Ana River	3.7	–	–	46	1.8	2.4	–
Santa Ynez River	–	75	79	60	1.9	3.2	0.59

[a] Percent of eggs that hatch.
[b] Percent of nestlings that fledge.

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likelihood of renesting depends on the time of season, the pair's previous reproductive effort, the success of previous efforts, and other factors. Few nests are initiated after mid-July.

Reproductive success has been calculated using a variety of different measures. Annual rates of hatching success (the percentage of eggs laid that hatch) have ranged from 38 to 92 percent over the past several years at the major study populations; long-term averages for those sites range from 53 percent at the San Luis Rey River to 83 percent at the Santa Margarita River and Tijuana River (Table 2). Lower hatching rates are characteristic of sites with heavy parasitism and inadequate cowbird control and/or high rates of egg predation. Fledging success (the percentage of nestlings that fledge) is typically higher than hatching success, unless predation on nestlings is high. Annual rates of fledging success during recent years have ranged from 59 to 100 percent, with long-term averages for individual sites falling between 71 and 91 percent (Table 2).

Reproductive success can also be calculated using the nest as the unit of measure. The annual percentage of nests that fledge at least one vireo young has ranged from a low of 33 percent to a high of 89 percent; long-term averages for individual sites show a similarly high degree of variability, ranging from 41 to 74 percent (Table 2). Annual average numbers of young fledged per nest has ranged between 0.7 and 3.3, with long-term averages falling between 1.1 and 2.4 fledged young per nest.

Productivity is a measure of reproductive performance that represents the total production of offspring over all nesting attempts within a season, and is expressed on a per pair basis. The annual average number of fledglings produced per pair has ranged from 0.9 to 4.5, with long-term averages ranging between 1.8 and 3.2.

An even more encompassing measure of productivity is the number of fledglings produced per egg laid. This measure combines the effort of egg production with

the probability of hatching and fledging young from those eggs and hence incorporates the number of nesting attempts made by pairs. Annual averages have ranged from 0.31 to 0.85 fledglings per egg at the various sites with long-term averages of 0.37 to 0.75 fledglings per egg, reflecting the differential intensity of pressures such as egg predation, nestling predation, cowbird parasitism, and other sources of nest failure at those sites.

Diet and Foraging Behavior. Bell's vireos are insectivorous, preying on a wide variety of insects, including bugs, beetles, grasshoppers, moths, and particularly caterpillars (Chapin 1925, Bent 1950). They obtain prey primarily by foliage gleaning (picking prey from leaf or bark substrates) and hovering (removing prey from vegetation surfaces while fluttering in the air). Salata (1983) noted foliage gleaning during 93 percent and hovering during 30 percent of his observations of 131 foraging least Bell's vireos. In a study of least Bell's vireo foraging ecology at the Sweetwater River, Miner (1989) observed that 50.4 percent of 413 prey attacks consisted of foliage gleaning and 38.7 percent were hovering. Both Salata (1983) and Miner (1989) observed least Bell's vireos occasionally capturing prey by hawking (pursuit and capture of flying prey). Miner (1989) noted a behavior she called "clinging", which she described as hovering but with the feet in contact with the vegetation.

Foraging occurs at all levels of the canopy, but appears to be concentrated in the lower to mid-strata, particularly when pairs have active nests (Grinnell and Miller, 1944, Goldwasser 1981, Gray and Greaves 1981, Salata 1983, Miner 1989). Salata (1983) found that 69 percent of 131 foraging observations were within 4 meters (12 feet) of the ground. Miner (1989) found a similar peak in foraging activity in vegetation 3–6 meters (9–18 feet) in height. Moreover, she determined that the distribution of least Bell's vireo foraging time across all heights was not simply a function of the availability of vegetation at those heights, but rather represented an actual preference for the 3–6 meter zone.

Foraging occurs most frequently in willows (Salata 1983, Miner 1989). Miner (1989) observed that black willow (*Salix gooddingii*) was used preferentially relative to its cover within least Bell's vireo territories. Arroyo willow (*Salix lasiolepis*) was used preferentially in the 0–3 meter (0–12 feet) height range, possibly reflecting a tendency to forage close to nest sites. No other preferences were noted; other plant species were used proportionately to their availability. Insect sampling revealed that potential least Bell's vireo prey abundances were highest on black willow, arroyo willow, and mule fat.

Least Bell's vireos forage not only on a number of different riparian species, but also on nonriparian plants, particularly later in the season (Gray and Greaves 1981; Salata 1983; Kus and Miner 1989; Miner 1989; T. Keeney, U.S. Navy, pers. comm.). Miner (1989) found that insect abundance on one frequently used nonriparian species, laurel sumac, was lower than that on willows and mule fat. However, the proportion of large prey on this species was greater than on any other plant she studied, suggesting a high return per foraging effort.

Life History, Demography, and Dispersal. The least Bell's vireo is a sub-tropical migrant, traveling some two thousand miles annually between breeding and wintering grounds. Preliminary results of studies of color-banded birds (see Appendix C for sources) indicate that least Bell's vireos have a life span ranging to 7 years. A large proportion of the population dies before reaching the age of 1 year, as is typical of small migratory passerines. Banded bird returns suggest that between 5 and 29 percent of least Bell's vireos survive to their first breeding season, a wide range brought about by probable year-to-year differences in survivorship as well as differences in the effort devoted to reconnaissance for banded birds between sites, years, and observers. Moreover, reconnaissance is for the most part limited to a few well-studied populations; therefore, dispersers to other areas go undetected and are not factored into estimates of first-year survivorship. It is probable that, like other migratory passerines of similar size, roughly 25 percent of juveniles survive to their first breeding season. Resightings

of adults suggest that once birds reach the age of 1 year, they exhibit an average annual survivorship of approximately 47 percent (Salata 1983; Kus, unpubl. data).

The average female survivorship appears to be lower than the average documented for males (44 versus 49 percent, respectively [Kus, unpubl. data]), presumably because of the toll that egg production takes on longevity.
While most first-time breeders return to their natal sites to nest, an average of approximately 20 percent disperse to other drainages (Kus, unpubl. data). This figure may be even higher and will require more extensive rangewide surveys to determine. Birds show evidence of an ability to disperse long distances between drainages, moving as far as 130 miles from the natal site (J. Greaves, private consultant, pers. comm., regarding a disperser from the San Luis Rey River to the Santa Clara River in 1994). On average, a greater proportion of males (22 percent) than females (13 percent) disperse from their natal sites (Kus, unpubl. data).

The earliest studies of color-banded least Bell's vireos suggested that they were strongly site tenacious; once birds selected a breeding site, they returned to it year after year (Greaves 1989, Salata 1983). Not only do least Bell's vireos return to the same drainage, they return to the same territory and even the same nest tree or shrub, a remarkable feat considering the terrain covered during the course of migration. More recent data obtained at several additional breeding sites suggest that site tenacity in least Bell's vireos may not be as strong as previously believed. Many banded birds are seen for the first time as 2-year-olds and sometimes older, indicating that they have changed breeding locations during their first few years. The factors promoting a switch in breeding location are not known at this time. Habitat loss, lack of success in obtaining a mate, or even failure to return to the breeding grounds may be possible causes.

Preliminary data analysis of age-specific reproductive activity suggests that first-year females may lay smaller clutches and average fewer young fledged than older

females (Kus, unpubl. data). Generating the sample sizes of banded birds necessary for this type of analysis would require long-term effort and could be used for refinement of the population growth models presented in this plan. Expansion of the least Bell's vireo's range at the local and regional scale appears to be dependent on the existence of relatively large core populations that are producing sufficient numbers of juveniles that exploit previously unoccupied areas of their natal drainages or adjacent drainages with suitable habitat. As populations in these areas increase, further expansion occurs. Such expansion can be characterized as a "stepping stone" pattern. These core populations also serve to repopulate adjacent areas where small populations have been extirpated. A core population and the adjacent small populations with which it interacts forms a "metapopulation." This metapopulation concept must be considered in the development of a recovery strategy for the least Bell's vireo.

H. Reasons for Decline

Grinnell and Miller (1944) considered the least Bell's vireo still "common, even locally abundant under favorable conditions of habitat". However, they noted that in the "last fifteen years a noticeable decline has occurred in parts of southern California and in the Sacramento-San Joaquin Valley." That decline continued for four more decades, the combined result of habitat loss and degradation and nest parasitism by the brown-headed cowbird (Garrett and Dunn 1981).

Habitat Loss and Degradation. As human populations increased in California, riparian woodlands were cleared, primarily for agricultural purposes. Rivers were diked to prevent winter flooding of bottomlands. Dams were built to impound water for agricultural, industrial, and domestic use. As a result, large amounts of least Bell's vireo breeding habitat were inundated or removed. Impounding water upstream and diverting water to canals and cropland lowered water tables downstream so that dense vegetation could not grow or was reduced. Flood control projects and channelization of rivers further reduced available least Bell's

vireo habitat. Livestock grazing destroyed the choice lower strata of vegetation preferred by the least Bell's vireo (Overmire 1962) and provided foraging areas for brown-headed cowbirds. As the state's human population continues to increase, highway projects and urban, commercial, and recreational developments continue to encroach on what little riparian habitat remains. Similar activities are responsible for the decline of riparian habitat in Baja California (Short and Crossin 1967).

Riparian habitat loss in the Central Valley, estimated at 95 percent of that present during the Gold Rush of the 1850's (Smith 1977), has resulted in the loss of the least Bell's vireos from an area that at one time supported an estimated 60–80 percent of the statewide population based on potentially available habitat. Habitat loss and fragmentation continues to threaten the remaining least Bell's vireo populations in southern California and Baja California. Faber *et al.* (1989) reported a figure of 95–97 percent loss of naturally vegetated floodplains in southern California.

The widespread and precipitous decline of the species left small populations in scattered and widely separated remnants of riparian habitat. These conditions make least Bell's vireo populations particularly vulnerable to local and possibly rangewide extinction (Wilcox 1980). Small populations are susceptible to catastrophic extinction where the entire population could be adversely affected as a result of events such as flooding, as well as demographic failure when the population fails to produce any or enough offspring to survive into the future. Large interpopulation distances reduce the opportunity for dispersal and resultant genetic exchange among populations, thus heightening the risk of deleterious inbreeding (Soulé 1980, Conway 1980, Senner 1980). Lack of available habitat to serve as "refuges" during years when floods and other processes eliminate breeding sites poses a serious threat to the continued survival of the species.

In addition to outright destruction of habitat, riparian woodlands have been degraded in ways that reduce their suitability as least Bell's vireo nesting areas. Many riparian corridors are lined by roads and highways, which generate noise and pollutants and fragment habitats.

Habitat fragmentation results in four major consequences for ecosystems: (1) loss of area-sensitive species whose occurrence and successful reproduction are highly dependent on the size of the habitat patch in which they occur; (2) the larger species (e.g., bobcats) that move widely and occur at low densities are lost as they are more exposed to the dangers of associated with human environments; (3) fragmented and human-subsidized landscapes, providing artificial sources of food and shelter, become dominated by alien (e.g., European starlings) or already common species (e.g., skunks and racoons); (4) inbreeding depression (loss of genetic vigor) is a logical consequence of low densities and isolated populations (Harris and Gallagher 1989).

Habitat fragmentation and roadkills from highways and roads likely change predator-prey relationships in the ecosystems used by breeding least Bell's vireos. Larger predators, such as bobcats, may be lost from the ecosystem. The resulting changes in predator-prey relationships may include an increase in medium-sized predators, such as weasels, raccoons, possums, and foxes, which are nest predators.

Urbanization adjacent to habitat increases human presence in least Bell's vireo nesting sites, raising the potential for inadvertent destruction of nests and disturbance of breeding birds. Free-roaming and feral pets pose a risk of predation to nesting birds, as do increased densities of scrub-jays, racoons, and other predators typically associated with urban landscaping and development. Homeless people living in riparian areas threaten least Bell's vireos through clearing of vegetation for campsites, trampling of nest sites, and their continuous presence in the vicinity of least Bell's vireo territories. Many southern San Diego

County drainages receive enormous foot traffic by persons entering California across the U.S.-Mexico border and following rivers for the safety of their concealment afforded by riparian vegetation.

Loss or degradation of adjacent upland habitat reduces available foraging areas for least Bell's vireos and limits the upland/riparian ecotone (the overlapping of adjoining plant communities). This juxtaposition of different habitats provides increased biological function when compared with the same habitats occurring separately, which is likely important from an ecosystem perspective. Upland areas converted to livestock grazing and agriculture provide foraging areas for brown-headed cowbirds, a brood parasite of least Bell's vireos.

Brood Parasitism. Declines in the least Bell's vireo population brought about by extensive habitat loss and degradation have been exacerbated by parasitism by the brown-headed cowbird (cowbird) (Franzreb 1989, Goldwasser 1978, Goldwasser *et al.* 1980, Garrett and Dunn 1981, Mayfield 1977). Cowbirds are distinguished by their unusual reproductive strategy of laying their eggs in the nests of other species, leaving the "host" to raise the cowbird young, generally at the expense of the host's own young. Cowbirds have been documented using at least 130 avian species as hosts (Friedmann *et al.* 1977).

The least Bell's vireo is a common host (Hanna 1928, Dawson 1923, Rowley 1930, Grinnell and Miller 1944, Goldwasser *et al.* 1980, Salata 1981) and readily accepts cowbird eggs, although it is a relatively poor host and does not fledge many cowbirds (Friedmann 1963). The first reported cowbird eggs in least Bell's vireo nests were discovered in 1907 (Linton 1908). Soon it was difficult to find nests of this species that had not been parasitized (Dawson 1923, Hanna 1928, Rowley 1930). The immediate impact of cowbird parasitism was probably great because the least Bell's vireo population had not previously been exposed to nest parasitism and, therefore, had not evolved defenses as have other species with a long evolutionary history of co-occurrence with nest parasites. The tendency of

male least Bell's vireos to sing from the nest no doubt enhances vulnerability to parasitism, although cowbirds evidently locate most nests by observing the pair during nest construction.

At the time of laying, female cowbirds may remove a host egg and replace it with their own, and/or may damage host eggs by pecking them, although it is not known whether this behavior is intentional or coincidental to attempts to remove the egg from the nest. Cowbird eggs hatch sooner than host eggs, and the newly hatched chick may eject host eggs or young from the nest. Cowbird chicks grow more quickly and achieve a larger size than host young, effectively outcompeting them for parental attention and feeding. Few if any host young are fledged from parasitized nests.

Cowbird parasitism reduces least Bell's vireo productivity in several ways, even when nest monitoring is employed to remove cowbird eggs and young from least Bell's vireo nests. Removal of least Bell's vireo eggs from the nest by laying brown-headed cowbird females reduces least Bell's vireo clutch size, limiting potential productivity even if the nest is eventually successful. Some parasitized nests are abandoned outright, reducing overall nest success. The shorter incubation period of cowbird eggs means that some least Bell's vireo eggs may not receive adequate incubation and fail to hatch. Damage to eggs caused by cowbird females and/or chicks also reduces the hatch rate.

Collectively, these factors can lower nesting success (the proportion of nests with eggs that fledge at least one least Bell's vireo young) in heavily parasitized areas where up to four cowbird eggs may be found in least Bell's vireo nests (Salata 1983; B. Jones, Sweetwater Environmental Consultants, pers. comm.). For example, nest monitoring to remove cowbird eggs or young resulted in a 140 percent increase in the number of successful nests at the San Luis Rey site (RECON 1989). Rates of cowbird parasitism at the Santa Margarita and Santa Ynez Rivers during the early 1980's were documented to be between 20 and 47 percent of nests (Salata 1981, 1983, Gray and Greaves 1981). Rates as high as 80

percent of nests were reported for the San Luis Rey, Sweetwater, San Diego, and Santa Ana Rivers in 1984 (Jones 1985, U.S. Fish and Wildlife Service 1986b).

Cowbirds are native to the eastern U.S. and, with the exception of a few winter or vagrant records, were absent from most least Bell's vireo habitat prior to 1900. Subsequent increases in animal husbandry and irrigated agriculture in the West provided new foraging habitat for cowbirds and triggered an increase in cowbird range and numbers that has been described as "remarkable, in fact unparalleled by any of our native birds" (Willett 1933). Cowbirds have not only expanded generally into the western U.S., they achieve particularly high concentrations near least Bell's vireo breeding sites as a result of land-use practices. Dairies, livestock grazing, equestrian centers, and golf courses, all tending to be sited in rural areas along rivers, provide foraging areas for cowbirds in the vicinity of least Bell's vireo breeding habitat.

In one study of black-capped vireos (*Vireo atricapillus*) in Texas, cowbirds were feeding with cattle in 100 percent of the observations; cowbirds were not found in areas without cattle. Cowbird nest parasitism of black-capped vireos went from 35 percent in 1996 to 0 percent in 1997 when cattle were removed from the study area (Cook *et al.* 1997).

The distance to agriculture was the strongest predictor among all variables (landscape or habitat) in a study in Montana and Idaho. This study found landscape factors play a dominant role in predicting the distribution of cowbirds (Young and Hutto 1997). An Idaho study found cowbirds were often associated with horse herds, as well as game animals where salt blocks caused them to congregate. No cowbirds were detected in undeveloped (natural) habitat more than 20 kilometers from horse or mule herds (Wright 1997).

In a Michigan study, the probability that a cowbird would occur at any given site was 3–3.5 times greater when agricultural lands were present within 3 kilometers (2 miles) of the study site. This study found that where agriculture was lacking

cowbird occurrence was low, regardless of surrounding habitat characteristics (Stribley and Haufler 1997).

Cowbirds have been documented traveling at least 7 kilometers (4 miles) between foraging and breeding areas (Rothestein *et al.* 1984; E. Berryman, U.S. Fish and Wildlife Service, pers. comm. 1997). A study in New Mexico found cowbirds commuting at least 4 kilometers (2.5 miles) between foraging and breeding areas; female cowbirds were feeding nearly exclusively (more than 98 percent of the time) on grazed sites with livestock (Goguen and Mathews 1997).

I. Conservation Measures

Regulatory Protection

Endangered Species Act. On May 2, 1986, the least Bell's vireo was listed as endangered under the Act. Listing as a federally endangered species includes a prohibition against take and possession, prohibits Federal activities that are likely to jeopardize the continued existence of the species or adversely affect its critical habitat, authorizes land acquisition and other Federal preservation activities, and enables cooperative Federal-State programs for conservation and recovery of the species.

The Endangered Species Act requires the Fish and Wildlife Service to designate critical habitat, to the maximum extent prudent and determinable, concurrently with listing a species as endangered or threatened. Critical habitat was designated for the least Bell's vireo on February 2, 1994 (U.S. Fish and Wildlife Service 1994a) and is discussed previously under "F. Critical Habitat."

Section 9 prohibits the take of any species listed as endangered or threatened under provisions of section 4 of the Endangered Species Act, including the least Bell's vireo. The definition of "take" includes to harass, harm, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct.

"Harm", in the definition of "take", includes significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Sections 10(a)(1)(A) and 10(a)(1)(B) give the Fish and Wildlife Service the authority to issue permits to non-Federal and private entities for the take of least Bell's vireos, as long as such taking is incidental to, and not the purpose of, carrying out otherwise lawful activities.

Section 7(a)(2) requires all Federal agencies consult with the Fish and Wildlife Service on any action they authorize, fund, or carry out that may affect listed endangered or threatened species or critical habitat. Incidental take may also be permitted through the section 7 consultation process. Most take for least Bell's vireos is authorized through the section 7 process.

Section 4 of the Endangered Species Act requires the Department of the Interior and the Department of Commerce to develop and implement recovery plans for animal and plant species listed as endangered or threatened. In 1982, the Fish and Wildlife Service organized the Least Bell's Vireo Working Group, consisting of Federal, State, local government, and university representatives, as well as private individuals knowledgeable about the least Bell's vireo, to promote information exchange and interagency cooperation regarding conservation activities for the least Bell's vireo. While not a regulatory body, the Working Group was appointed to assist in development and implementation of recovery-oriented research and management plans. A draft recovery plan for the least Bell's vireo was prepared in 1988 but was never approved.

Habitat Conservation Plans. Most actions affecting least Bell's vireo habitat directly occur within waters of the U.S. and thus, require a permit from the U.S. Army Corps of Engineers under provisions of the Clean Water Act (discussed below). Activities and projects such as agriculture, dairy farming, flood damage reduction (including herbicidal spraying of riparian vegetation), groundwater pumping, sand and gravel mining, etc., occur with no obvious involvement of a

Federal agency. These actions should be performed in a manner consistent with the ecosystem (wetland and upland) needs of least Bell's vireos rangewide. Non-Federal (private and State) actions affecting least Bell's vireos may be subject to habitat conservation plan requirements of section 10(a)(1)(B) of the Endangered Species Act. Habitat conservation plans can and should effectively intermesh with the recovery goals of this recovery plan by conserving existing and restorable upland habitat, waters, and wetland habitat. Restorable habitat, such as in the Central Valley and along the Salinas River, should be conserved to allow reoccupation of former habitat by expanding least Bell's vireo populations.

Habitat conservation plans can address the problem of habitats that attract and support brown-headed cowbirds. The persistence of brown-headed cowbird foraging areas such as dairies, stables, and livestock grazing operations—and to a lesser extent, agriculture, turf parks and golf-courses, etc.—within 7 kilometers (4 miles) of existing and potential least Bell's vireo habitat reduces the capability of the species to recover and continues the need for cowbird control in perpetuity. Land use changes are needed to minimize the occurrence of cowbirds in riparian areas and allow least Bell's vireos the chance to be self-sustaining without cowbird trapping. Habitat conservation plans should address and, where possible, modify these land uses to reduce adverse effects of brown-headed cowbirds on least Bell's vireos. Draft habitat conservation plans for the least Bell's vireo were initiated on several drainages in San Diego County for the least Bell's vireo in the late 1980's but were later abandoned.

State Laws Protecting the Least Bell's Vireo. The least Bell's vireo is listed as an endangered species under the California Endangered Species Act of 1984. Similar to the Endangered Species Act, this legislation requires State agencies to consult with the California Department of Fish and Game (CDFG) on activities that may affect a State-listed species. The State law also requires State lead agencies as defined in the California Environmental Quality Act to consult with the California Department of Fish and Game regarding any project with potential

impacts on State-listed species. Compensation is required by the California Department of Fish and Game for projects that result in least Bell's vireo habitat loss.

Section 2080 of the California Fish and Game Code (Code) prohibits the import, export, take, possession, purchase, or sale of any endangered, threatened, or candidate species listed by the California Fish and Game Commission. As defined in the Code, take means to hunt, pursue, catch, capture, or kill or attempt the same. Exceptions to the take prohibition are as stated in sections 2081 and 2835.

Section 2081 of the Code allows the California Department of Fish and Game to "authorize individuals, public agencies, universities, zoological gardens, and scientific or educational institutions to import, export or possess a listed species for scientific, educational or management purposes," under terms specified in Memoranda of Understanding between any of these groups, agencies, institutions, or individuals and the California Department of Fish and Game.

Clean Water Act Protection. Congress passed the Federal Water Pollution Control Act Amendments of 1972 and the Clean Water Act of 1977 to provide for the restoration and maintenance of the chemical, physical, and biological integrity of the Nation's lakes, rivers, streams, and coastal waters. Section 404 of the Clean Water Act is the principal Federal program that regulates activities affecting the integrity of wetlands. Specifically, section 404 prohibits the discharge of dredged or fill material into jurisdictional waters of the United States, unless permitted by section 404(a) (individual permits), 404(e) (general permits), or unless the discharge is exempt from regulation as designated in 404(f).

In most circumstances, riparian habitat is considered to be in jurisdictional waters of the United States, and disturbance of riparian habitat would be regulated by the Army Corps of Engineers. Additionally, if the affected riparian habitat is occupied by least Bell's vireo, the Army Corps of Engineers would consult with

the Fish and Wildlife Service, pursuant to section 7 of the Endangered Species Act.

Migratory Bird Treaty Act. The Migratory Bird Treaty Act (MBTA) (16 U.S.C. 701–711) was implemented in 1918 between the governments of the U.S. and Great Britain (representing Canada) and subsequently Mexico in 1936, Japan in 1972, and in 1976 with the Union of Soviet Socialist Republics, which expanded the definition of migratory birds to include protection for virtually all birds found within the U. S., including the least Bell's vireo. The Migratory Bird Treaty Act establishes provisions regulating take, possession, transport, and import of migratory birds, including nests and eggs. This protection has been of limited importance because the species is not taken commercially or used for sport or food.

Other Regulatory Mechanisms. On July 9, 1986, a Memorandum of Understanding (MOU) was executed between the Fish and Wildlife Service and Marine Corps Base, Camp Pendleton for the purpose and objective of managing and perpetuating the least Bell's vireo on Camp Pendleton. On the basis of the special management considerations afforded the least Bell's vireo under this Memorandum of Understanding, the Fish and Wildlife Service determined that it was not necessary to designate critical habitat on the Base.

The Memorandum of Understanding specifically provides for removal of exotic plant species, annual cowbird trapping, research studies, annual least Bell's vireo censuses, and other management for the benefit of the species. The agreement does not remove the responsibilities of the Marine Corps Base, Camp Pendleton under the Endangered Species Act. The Base is required to consult on any and all activities that may affect the least Bell's vireo.

Conservation Efforts

Santa Clara River Enhancement and Management Plan. The Fish and Wildlife Service, the State Coastal Conservancy, and the counties of Ventura and Los Angeles are guiding the development of a long range conservation plan for the Santa Clara River, the largest unchannelized river in southern California. The plan emphasizes comprehensive planning to protect the substantial natural resources of the river and it will include high priority recovery actions for endangered species (least Bell's vireo and unarmored threespine stickleback) and prelisting recovery actions for numerous candidate species.

Brown-headed Cowbird Control. Probably the most effective management effort undertaken since the time of listing of the least Bell's vireo is cowbird control within least Bell's vireo breeding areas. Continuing cowbird removal programs have been funded by the California Department of Transportation, the Army Corps of Engineers, the International Boundary and Water Commission, the Marine Corps Base, Camp Pendleton, and the Fish and Wildlife Service. With the exception of the latter, most of the funding for cowbird control has been provided within the context of mitigation for projects adversely affecting least Bell's vireos.

Cowbird removal is accomplished through trapping birds in modified Australian crow traps. The traps have a slotted roof that allows birds to easily fly in, but flying out is difficult. These traps, which are large enough for a person to walk in and remove any trapped cowbirds, are baited with seed and live decoy birds and placed within and along the edges of riparian habitat. Traps are strategically placed in areas where cowbirds congregate for foraging, such as dairies and stables.

At Marine Corps Base, Camp Pendleton, the site of the longest continuously run cowbird removal program in the least Bell's vireo's range, nest parasitism dropped from a pretrapping rate of 47 percent of least Bell's vireo nests in the

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early 1980's to less than 1 percent by 1990 (Griffith and Griffith, in prep.). No cowbird parasitism of least Bell's vireo nests has been observed since 1990, although comprehensive nest monitoring ceased in 1992. As cowbird parasitism declined, least Bell's vireo productivity increased, resulting in the recruitment (increase in the numbers of birds) and expansion of the areas used by the least Bell's vireos observed at the Base since trapping was initiated. There are no cattle on the base, and only limited grazing of sheep and a very small number of bison are currently allowed. Cattle grazing occurs on the adjacent Fallbrook Naval Weapons Station.

Similarly dramatic reductions in the rate of nest parasitism coincidental with implementation of cowbird control programs, and associated increases in productivity, have been documented at the San Luis Rey River, San Diego River, Sweetwater River, and Santa Ana River. Modification and reduction of cowbird foraging areas near riparian zones, as noted above, will concomitantly reduce cowbird numbers (Stribley and Haufler 1997, Tewksbury *et al.* 1997, Young and Hutto 1997) and the need for cowbird trapping.

Monitoring and Research. In addition to cowbird removal, least Bell's vireo nest monitoring was one of the primary management actions called for by the Fish and Wildlife Service at the time of listing. Initially, the principal goal of the nest monitoring was to detect and remove cowbird eggs and/or young from least Bell's vireo nests, supplementing cowbird trapping and removal efforts. Nest monitoring has proven to be an effective backup to cowbird trapping, particularly in areas where trapping has been inadequate in scope and timing, and is useful in evaluating the effectiveness of trapping programs and providing guidance for their improvement. By itself, "rescue" of parasitized nests through removal of cowbird eggs has enhanced annual productivity by as much as 27 percent at the San Diego River (Kus 1992a) and as much as 44 percent at the San Luis Rey River (Kus 1991a,c, 1993b, 1995b).

In addition to its role in reducing nest parasitism, least Bell's vireo nest monitoring has provided an opportunity to collect long-term reproductive data. It has also facilitated color-banding of nestlings and adults for ongoing studies of demography, dispersal, and wintering site selection, which are summarized elsewhere in this plan.

Conservation-oriented research on least Bell's vireo breeding ecology has resulted in the completion of Master's theses describing foraging behavior (Miner 1989), the relationship between habitat patch size and reproductive success (Embree 1992), and the relationships of territory size, habitat quality, and reproductive success (Newman 1992). A fourth study investigated song type diversity and the function of song repertoires in least Bell's vireos (Beck 1996).

Habitat Creation and Restoration. Increasingly, habitat creation and restoration is being pursued as a means of mitigating the loss and degradation of riparian habitat. The majority of the restoration activity in southern California is driven by the requirement to mitigate losses of wetland habitat, which often support least Bell's vireos. Restoration may entail site preparation, including grading and soil amendment when necessary, and planting of either stem cuttings or nursery-grown container stock of a mix of native species selected to mimic the species composition of natural sites. The planted habitat is typically irrigated using overhead sprinklers or a drip system, weeded, and otherwise tended during the first few years of establishment. Other more experimental restoration attempts have used less intensive planting and irrigation efforts, but involved careful grading to restore/create proper hydrology for more passive restoration with an extensive exotics control component.

Considerable advances have occurred over the last ten years in the technical aspects of restoration site design and implementation (Baird 1989, Baird and Rieger 1989, Hendricks and Rieger 1989), and several restoration efforts in San Diego County have been successful both in producing riparian habitat with the

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structure of natural habitat and in attracting nesting least Bell's vireos (Kus, in press). In a long-term monitoring study of several sites in which restored habitat was quantitatively compared to natural reference habitat, Kus (in press) determined that the structural characteristics defining least Bell's vireo habitat can be achieved in 3–5 years with intensive effort, depending on site conditions and weather conditions, particularly the amount of winter rainfall and associated flooding. Vegetation development proceeds slowly during drought years, which are typical of the southern California climate, making it difficult to predict the time required to achieve certain structural conditions. Least Bell's vireos were observed using restored habitat within a year of planting, but this use was primarily foraging. Least Bell's vireos did not nest in restored habitat until it achieved certain structural conditions, including high cover in the nesting zone between the ground and 2 meters (6 feet) and a well-developed and stratified canopy where foraging is concentrated. Factors promoting the colonization of restoration sites included proximity to occupied natural habitat and adjacency of mature vegetation.

Despite these successes, many attempts at riparian restoration have failed, and there is a considerable need for increased scrutiny of mitigation/restoration plans, including increased monitoring of habitat restoration projects by regulatory agencies. Continued research is needed to develop techniques to improve site selection and site preparation, including grading. Planting techniques should be refined in terms of timing, stock, and subsequent care, including methods of irrigation and providing access to flooding. Other aspects of site maintenance, such as midterm protection from exotic plant invasion, vandalism, and control of pest outbreaks, should be addressed. Also needed is a comprehensive review of the "success" criteria used to evaluate restoration efforts, as well as of the methods used to generate data for such evaluations, particularly in projects where creation of least Bell's vireo nesting habitat is the goal.

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Population Viability Analysis

Population viability analyses are important tools for attempting to quantify both the threats to a species and the consequences of conservation actions. Properly used, a population viability analysis incorporates what is known about a species' population dynamics into a model that will facilitate examination and testing of various hypotheses about the viability of small populations. This analysis can help identify critical factors for study, management, and monitoring. The result of the analysis is the determination of a theoretical population number, the minimum viable population; however, the process is instructive only and is not meant to provide an absolute answer. The strengths and weaknesses of population viability analyses have been reviewed (Lacy, in press; U.S. Fish and Wildlife Service 1997a).

When evaluating the results of a population viability analysis, the following should be considered (Lacy, in press):

> Natural systems are too complex for any existing model to accurately predict population dynamics, and our understanding of the extinction process is inadequate.
>
> Most models assume that population changes occur at discrete time steps, which does not accurately reflect all wild populations.
>
> The time span over which data has been collected may not be sufficient to estimate the amplitude of environmental fluctuations and its impact; even less data is available on the frequency and impacts of catastrophes, such as epidemic diseases and severe weather or other environmental phenomena (e.g., fires, drought, El Niño).

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Population viability analysis is, by definition, the probability of persistence of a population over defined time frames; however, it may not accurately predict actual outcomes.

Population viability analysis is only as good as the parameter estimates and assumptions upon which it is built. Estimates of necessary parameters are usually incorporated into a population viability analysis; however small changes in these parameters can have profound changes in the estimated time to extinction.

Least Bell's Vireo Population Viability Analysis. Since the early 1980's data has been collected on least Bell's vireo distribution and breeding biology. The database includes information reported by a number of investigators working at least Bell's vireo breeding sites from the U.S.-Mexico border to Santa Barbara County and represents 68 "site-years" of data.

A population viability analysis was performed using data from eight populations (Tijuana, Sweetwater, San Diego, San Luis Rey, West San Luis Rey, and Santa Margarita Rivers in San Diego County; the Santa Ana River in Riverside County, and the Santa Ynez River in Santa Barbara County). These sites were selected for analysis because (1) they supported the few remaining least Bell's vireo populations in 1986 when the species was listed as endangered; (2) they have been monitored and managed annually from 5 to 15 consecutive years; and (3) long-term color-banding studies provided a substantial database. These attributes allow analysis of least Bell's vireo population dynamics, demography, and dispersal over a wide geographic area and a relatively long period of time.

Population data were entered into a statistical model, RAMAS/Space (Akcakaya and Ferson 1992), that simulates the future of the populations given theoretical or empirical values for variables specifying rates of population growth and migration. Questions regarding future population growth and risk of extinction

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can be addressed with this model. Definitions of terms and a discussion of the population viability analysis are provided in Appendix B.

The results of the computer simulations indicated the least Bell's vireo populations used in the analysis exceeded the minimum viable population size, commonly defined as a population with a less than a five percent probability of extinction over a 100-year period (Soulé 1987), and had a probability of zero of going extinct during the next century assuming the same population growth and dispersal rates. With the exception of one remote population (at the Santa Ynez River), each of the individual populations had an extinction probability of zero during the next 100 years because of the sizes and growth rates of each population, as well as their interconnectedness through dispersal.

The data used for the least Bell's vireo population viability analysis was relatively substantial compared to data available for analysis for many species, but the analysis still required the use of estimates and assumptions. For example, an annual reproductive rate of 2.6 young per pair was assumed, but annual average number of fledglings produced per pair has ranged from 0.9 to 4.5, with long-term averages ranging between 1.8 and 3.2.

The analysis also assumed continued intensive brown-headed cowbird control. It must be stressed that the least Bell's vireo population viability results assume intensive cowbird control, which is inconsistent with the recovery goals of self-sustaining populations. No evidence exists that least Bell's vireos are capable of sustaining their current rate of growth without widespread cowbird trapping. Under current conditions, without land use changes to minimize brown-headed cowbirds, when human intervention is removed it is likely that least Bell's vireo populations will return to the low numbers documented when the species was listed.

RAMAS models logistic growth: populations increase to the limit, or carrying capacity, of their environments and then persist at some equilibrium population

size. However, prediction of these equilibrium sizes requires knowledge of the actual carrying capacity of each environment; information about the carrying capacities of least Bell's vireo habitats is not currently available.

Recovery of the least Bell's vireo extends beyond achieving a theoretical minimum viable population in each of the eight populations used in the population viability analysis. Recovery will require protection and management of 14 least Bell's vireo populations/metapopulations and restoration of least Bell's vireos to areas within the historical range. Protection and management actions must include the reduction and elimination of threats and assurances of long-term control of cowbirds, including assurances of modified land uses that contribute to cowbird foraging adjacent to least Bell's vireo breeding areas, and assurance of long-term control of exotic plants in riparian habitats. Completion of monitoring and research tasks will yield additional information regarding carrying capacity, dispersal patterns of birds away from their natal sites and the movements of adults, as well as other life history characteristics for use in refining the population viability analysis.

J. Conservation of Proposed and Candidate Species and Species of Concern

Least Bell's vireos occur with many sensitive species of amphibians, birds, fish, mammals, invertebrates, and plants (Table 3). Virtually all of these species are in peril as a result of the massive loss and degradation of the riparian habitat upon which they depend for survival. Declines in riparian songbirds, including many not listed in Table 3, have been exacerbated by cowbird parasitism. Although the number of sensitive species is, at first glance, intimidating when contemplating recovery of riparian fauna and flora, the fact that so many share the same threats suggests that management to reduce or eliminate those threats will benefit the entire suite of species and go far to restore ecosystem integrity. Cowbird control programs, for example, have already produced observable increases in southern California populations of yellow warblers (*Dendroica petechis*), yellow-breasted

Table 3. Sensitive species that may occur in Californian riparian habitats (California Department of Fish and Game 1996a, 1996b; U.S. Fish and Wildlife Service 1996).

Common Name	Scientific Name	Status [1]
AMPHIBIANS/REPTILES		
Arroyo toad	*Bufo microscaphus californicus*	FE, SC
California tiger salamander	*Ambystoma californiense*	C, SC
Mountain yellow-legged frog	*Rana mucosa*	SC
Yavapai (=lowland) leopard frog	*Rana yavapaiensis*	SC
Two-striped garter snake	*Thamnophis hammondii*	SC
Southwestern pond turtle	*Clemmys marmorata pallida*	SC
California red-legged frog	*Rana aurora draytonii*	FT, SC
BIRDS		
Least Bell's vireo	*Vireo bellii pusillus*	FE, SE
Southwestern willow flycatcher	*Empidonax traillii extimus*	FE, SE
Peregrine falcon	*Falco peregrinus*	FE, SE
Bald eagle	*Haliaeetus leucocephalus*	FT, SE
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	SE
Bank swallow	*Riparia riparia*	ST
Black-crowned night heron	*Nycticorax nycticorax*	SC
Great egret (rookery)	*Casmerodius albus*	SC
Snowy egret (rookery)	*Egretta thula*	SC
Great blue heron (rookery)	*Ardea herodias*	SC
White-faced ibis	*Plegadis chihi*	SC
Black-shouldered kite	*Elanus caeruleus*	SC
Cooper's hawk	*Accipiter cooperii*	SC

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Table 3. Sensitive species that may occur in Californian riparian habitats (California Department of Fish and Game 1996a, 1996b; U.S. Fish and Wildlife Service 1996).

Common Name	Scientific Name	Status [1]
Long-eared owl	*Asio otus*	SC
Yellow warbler	*Dendroica petechis brewsteri*	SC
Yellow-breasted chat	*Icteria virens*	SC
FISH		
Owens pupfish	*Cyprinodon radiosus*	FE
Owens tui chub	*Gila bicolor snyderi*	FE
Unarmored threespine stickleback	*Gasterosteus aculeatus williamsoni*	FE, SE
Tidewater goby	*Eucyclogobius newberryi*	FE
Santa Ana sucker	*Catastomus santaanae*	SC
Southern steelhead	*Oncorhynchus mykiss*	FT & FE[2], SC
INVERTEBRATES		
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	FT
MAMMALS		
Townsend's big-eared bat	*Plecotus townsendii townsendii*	SC
California leaf-nosed bat	*Macrotus californicus*	SC
Greater western mastiff bat	*Eumops perotis californicus*	SC
Occult little brown bat	*Myotis lucifugus occultus*	SC
Riparian brush rabbit	*Sylvilagus bachmani riparius*	SC

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Table 3. Sensitive species that may occur in Californian riparian habitats (U.S. Fish and Wildlife Service 1996).

Common Name	Scientific Name	Status [1]
PLANTS		
Fish slough milk-vetch	*Astragalus lentiginosus* var. *piscinensis*	PE
Nevin's barberry	*Berberis nevinii*	PE
La Graciosa thistle	*Cirsium loncholepis*	C
Surf thistle	*Cirsium rhothophilum*	C
Southern spikeweed	*Hemizonia parryi* ssp. *australis*	1B
Smooth spikeweed	*Hemizonia parryi* ssp. *laevis*	1B
San Diego marsh elder	*Iva hayesiana*	2
Gambel's watercress	*Rorippa gambellii*	FE
Owens Valley checkerbloom	*Sidalcea covillei*	SE
Valley sagittaria	*Sagittaria sandfordii*	1B

[1] FE = federally endangered; FT = federally threatened; PE = federally proposed endangered; SE = State endangered; SC = California species of special concern; C = Federal candidate for listing (taxa for which the Fish and Wildlife Service has substantial information to support listing as threatened or endangered); 1A = California Native Plant Society (CNPS) List (plants presumed extinct in California); 1B = CNPS List (plants rare, threatened, or endangered in California and elsewhere); 2 = CNPS List (plants rare, threatened, or endangered in California but more common elsewhere).

[2] Species was listed by "Evolutionarily Significant Units" (ESU); two ESUs were listed as endangered (including Southern California) and three were listed as threatened (including Central California Coast and South-Central California Coast) (National Marine Fisheries Services 1997).

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chats (*Icteria virens*), and southwestern willow flycatchers (*Empidonax trailli extimus*) in some areas. Modifications of land uses that create extensive foraging areas for cowbirds (e.g., minimization of available waste feed-seed and manure at dairies and livestock congregations) should benefit populations of riparian host-bird species in the long term.

K. Recovery Strategy

Recovery efforts will focus on addressing the two major causes of decline of the least Bell's vireo: (1) habitat loss and degradation and (2) brown-headed cowbird nest parasitism. Brown-headed cowbird removal programs, funded by several agencies and through mitigation for projects adversely affecting least Bell's vireos, have been the most effective short-term management effort since the species was listed as endangered. It is essential to continue, and expand where appropriate, brown-headed cowbird removal in least Bell's vireo habitat. Land uses that perpetuate cowbird foraging in the range of the least Bell's vireo should be modified for long-term benefits that reduce the need for human intervention. Establishing perpetual endowments to fund brown-headed cowbird removal, and possibly for exotic plant removal from riparian habitat, will be necessary if self-sustaining populations of least Bell's vireos are not possible without human intervention.

Nest monitoring programs will also be essential to determine levels of brown-headed cowbird parasitism and evaluate the effectiveness of brown-headed cowbird removal and management techniques. In addition to its role in reducing nest parasitism, least Bell's vireo nest monitoring will facilitate color-banding of nestlings and adults for ongoing studies of demography, dispersal, and wintering habitat selection.

The development of management plans for the 14 population/metapopulation units, and for any additional areas identified by completion of recovery tasks, will

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be supplemented with research on habitat needs and protection of habitat through conservation agreements, conservation easements, habitat conservation plans, and land acquisition. Protection and management of the 14 population/metapopulation units and stable or increasing populations are criteria for downlisting the least Bell's vireo to threatened status. Designation of each of the least Bell's vireo population/metapopulation units is based on drainages with available and restorable habitat within the present and historical ranges and will facilitate development of workable management plans. These population/metapopulation units are not the functional equivalents of recovery units as defined by current Service policy.

To ensure the recovery of the least Bell's vireo, a better understanding of the size, configuration, and location of habitat will be necessary. This information will be used to identify areas to be protected and managed for least Bell's vireos and will be useful in habitat restoration. This information will be particularly useful in identifying potential habitat to allow for recolonization within the historical range as least Bell's vireo populations recover; recolonization is one criterion for delisting least Bell's vireos. A statewide inventory of riparian habitat and rangewide surveys will identify additional and potential least Bell's vireo habitat within the species' historical range.

Although some natural expansion into suitable areas will occur in the least Bell's vireo's presently unoccupied historical range in southern California, it is unlikely that the species can return naturally to the Central Valley, which once supported the majority of the species' population and was the center of the breeding range (Franzreb 1989). The principal recovery strategy for restoring least Bell's vireos to historically occupied areas will focus on natural range expansion as habitat is restored and least Bell's vireo numbers increase under habitat management and restoration and threat management. However, because of the distances between current populations and the Central Valley, as well as the natural site tenacity of least Bell's vireos, reintroduction of the species using translocation of individuals

may be necessary to reestablish populations of least Bell's vireos in the Central Valley.

Research tasks will address developing better restoration techniques and monitoring the results as habitat is restored. Research, with international cooperation with Mexico, will determine the extent of the wintering range and identify threats on the wintering grounds that, through their impact on annual survivorship, could threaten the breeding population.

The progress of recovery will be assessed through ongoing evaluations of the success of each of these recovery efforts. As additional information becomes available, management plans will be revised.

Descriptions of the 14 Population/Metapopulation Units

Tijuana River. The Tijuana River originates in the mountains of Baja California, with three-fourths of its watershed in Mexico. The total watershed is 448,323 hectares (1,107,806 acres). Seventy-eight percent of the watershed is behind three dams, two of which are in the U.S. The major portion of the watershed is behind Rodriquez Dam in Mexico. Much of the remaining riparian habitats are on lands managed by the San Diego County Parks Department.

In 1996, the Tijuana River drainage represented 7 percent of the least Bell's vireo pairs recorded in California (Appendix A). Critical habitat for the least Bell's vireo extends approximately 5 kilometers (3 miles) along the Tijuana River, west of Interstate 5 and extending east and west of Dairy Mart Road (Fish and Wildlife Service 1994).

Riparian communities in the Tijuana River are threatened by unauthorized clearing activities and placement of fill materials, off-road vehicle use, exotic species, and flood control projects and channelization. Considerable human foot

and horse traffic traverses the riparian habitats of the Tijuana River, and equestrian corrals are common features within the surrounding floodplain and upland areas.

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Navy, U.S. Environmental Protection Agency, U.S. Department of Agriculture Forest Service, Bureau of Land Management, International Boundary and Water Commission, U.S. Department of Justice/Border Patrol, California Regional Water Quality Control Board, California State Water Resources Control Board, California Department of Transportation, California Department of Fish and Game, California State Lands Commission, California Coastal Commission, County of San Diego, San Diego County Parks and Recreation Department, San Diego County Vector Control, San Diego Association of Governments, City of San Diego, City of San Ysidro, San Diego Gas and Electric, and Tijuana Valley Water Board.

Dulzura Creek/Jamul Creek/Otay River. The Otay River watershed originates in the coastal foothills near the community of Dulzura and extends west approximately 38 kilometers (24 miles) to San Diego Bay near the community of Palm City. Surface flow is controlled by two dams. Additional flow is added by an aqueduct, which transfers water from Cottonwood Creek (Tijuana River watershed) to Dalzura Creek.

In 1996, the Dulzura Creek/Jamul Creek/Otay River population of least Bell's vireos represented approximately 2 percent of the pairs recorded in California (Appendix A). Critical habitat for the least Bell's vireo has been designated on Jamul-Dulzura Creeks along the drainages approximately 5.5 kilometers (3.5 miles) upstream of the upper end of Lower Otay Reservoir.

Riparian communities in the Otay River watershed are threatened by sand and gravel mining, water supply projects, unauthorized clearing activities and

placement of fill materials, exotic species, and flood control projects and channelization.

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Department of Agriculture Forest Service, Bureau of Land Management, California Regional Water Quality Control Board, California State Water Resources Control Board, California Department of Transportation, California Department of Fish and Game, California State Lands Commission, California Coastal Commission, County of San Diego, San Diego Association of Governments, San Diego County Parks and Recreation Department, San Diego County Vector Control, City of Chula Vista, San Diego County Water Authority, Otay Water District, and San Diego Gas and Electric.

Sweetwater River. The Sweetwater River watershed extends for about 64 kilometers (40 miles) from the headwaters of the river in Cuyamaca Rancho State Park to San Diego Bay in Chula Vista. Surface flow is controlled by two dams. Within the lower Sweetwater River (downstream of the Cleveland National Forest), San Diego Association of Governments (1991a) identified 371 hectares (917 acres) of existing riparian habitat and 566 hectares (1398 acres) of nonriparian land potentially reclaimable to riparian habitat. The surrounding areas are described as intense urbanization in the lower sections of the river to rapidly urbanizing areas in the middle sections to rural residential and large-scale open spaces in the upper sections of the river.

In 1996, the Sweetwater River population of least Bell's vireos represented approximately 3 percent of the pairs recorded in southern California (Appendix A). Critical habitat for the least Bell's vireo extends from about 1.6 kilometers (1 mile) upstream of Highway 94 downstream to Sweetwater Reservoir.

Threats to the riparian community include agriculture, flood control, sand and gravel mining, recreation, residential/commercial/industrial development, transportation, wastewater treatment, and water supply projects (San Diego Association of Governments 1991b). Equestrian facilities are adjacent to much of the lower Sweetwater River.

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Department of Agriculture Forest Service, Bureau of Indian Affairs, Sycuan Indian Reservation, California Regional Water Quality Control Board, California State Water Resources Control Board, California Department of Transportation, California Department of Fish and Game, California State Lands Commission, California Coastal Commission, County of San Diego, San Diego County Parks and Recreation Department, San Diego County Vector Control, San Diego Association of Governments, City of Chula Vista, City of National City, Sweetwater Authority, San Diego County Water Authority, Otay Water District, and San Diego Gas and Electric.

San Diego River. The San Diego River drains a watershed of approximately 1140 square kilometers (440 square miles). The watershed trends westward from the Laguna Mountains down to Mission Bay in San Diego, approximately 64 kilometers (40 miles) away. Five dams control surface flows in the watershed.

Downstream of the Cleveland National Forest and the upper end of El Capitan Reservoir, San Diego Association of Governments (1991b) identified 304 hectares (751 acres) of existing riparian habitat and 380 hectares (940 acres) of land with potential to support riparian habitat, if appropriately reclaimed. The surrounding areas are described as intense urbanization in the lower sections of the river to rapidly urbanizing areas in the middle sections to rural residential and large-scale open spaces in the upper sections (San Diego Association of Governments 1991b).

In 1996, the San Diego River population of least Bell's vireos represented approximately 3 percent of the pairs recorded in California (Appendix A). Critical habitat for the least Bell's vireo along the San Diego River near the City of Santee includes approximately 2.4 kilometers (1.5 miles) upstream and 5 kilometers downstream (3 miles) of the intersection of Big Rock Road and Mission Gorge Road.

Threats to the riparian community include agriculture, flood control, sand and gravel mining, recreation, residential/commercial/industrial development, transportation, wastewater treatment, and water supply projects (San Diego Association of Governments 1991b). Equestrian facilities are adjacent to portions of the San Diego River.

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Department of Agriculture Forest Service, Bureau of Land Management, Bureau of Indian Affairs, Capitan Grande Indian Reservation, California Regional Water Quality Control Board, California State Water Resources Control Board, California Department of Transportation, California Department of Fish and Game, California State Lands Commission, California Coastal Commission, San Diego Association of Governments, County of San Diego, San Diego County Parks and Recreation Department, San Diego County Vector Control, City of San Diego, City of Santee, City of Lakeside, City of San Diego Parks and Recreation Department, Metropolitan Transit Development Board, City of San Diego Water Utilities District, Helix Water District, Padre Dam Municipal Water District, San Diego County Water Authority, and San Diego Gas and Electric.

San Luis Rey River. The San Luis Rey River drains a watershed of approximately 1440 square kilometers (556 square miles). The watershed trends westward from the Laguna Mountains down to the Pacific Ocean in Oceanside,

approximately 80 kilometers (50 miles) away. One dam exists on the San Luis River at Lake Henshaw. Approximately 14 kilometers (9 miles) downstream of this dam, the Escondido Canal diverts runoff from the San Luis Rey River southwest to Lake Wolford. Under typical conditions, little or no surface flow passes this diversion point.

Eleven kilometers (7 miles) of the downstream end of the San Luis Rey River have been channelized with soft-bottom and concrete levees. West of Lake Henshaw, the San Luis Rey River flows through oak woodlands, chaparral, and coastal sage scrub canyons as it passes through three Indian reservations. The native plant communities have been (and continue to be) gradually replaced by citrus and avocado orchards, cattle and horse ranches, golf courses, and resort condominiums (Faber *et al.* 1989). Farther west and downstream, much of the natural San Luis Rey River floodplain has been turned into truck farms and wheat and barley fields, high- and medium-density residential areas, commercial zones, and industrial parks. Sand mining operations were frequent along the lower reaches of the river in the late 1980's (Faber *et al.* 1989), but most are now inactive. At least one dairy operation, row-crop agriculture, livestock grazing, and horse pasturage are active in the middle portion of the San Luis Rey watershed. However, the San Luis Rey River is considered to be one of the least modified and most easily restorable rivers in urbanized southern California, despite extensive conversion of floodplain riparian habitat to agricultural and other uses (U.S. Army Corps of Engineers 1981).

In 1996, the San Luis Rey River population of least Bell's vireos represented approximately 8 percent of the pairs recorded in California (Appendix A). Critical habitat for the least Bell's vireo extends along the San Luis Rey River from the community of Pala approximately 35 kilometers (22 miles) downstream to Interstate 5 near Oceanside.

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Threats to the riparian community include agriculture, flood control, water supply projects, sand and gravel mining, recreation, residential/commercial/industrial development, transportation, wastewater treatment projects (San Diego Association of Governments 1990), and unauthorized placement of fill materials, clearing, and herbiciding activities.

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Department of Agriculture Forest Service, U.S. Marine Corps, U.S. Navy, Bureau of Land Management, Bureau of Indian Affairs, California Regional Water Quality Control Board, California State Water Resources Control Board, California Department of Transportation, California Department of Fish and Game, California State Lands Commission, California Coastal Commission, San Diego Association of Governments, County of San Diego, San Diego County Parks and Recreation Department, San Diego County Vector Control, Pauma Indian Reservation, Rincon Indian Reservation, Pala Indian Reservation, La Jolla Indian Reservation, City of Oceanside, Pauma Mutual Water Company, Pauma Valley Community Services District, Rainbow Municipal Water District, San Diego County Water Authority, San Luis Rey Municipal Water District, Valley Center Municipal Water District, Escondido Municipal Water Company, Vista Irrigation District, and San Diego Gas and Electric.

Camp Pendleton/Santa Margarita River. The drainages on Camp Pendleton and Fallbrook Naval Weapons Station are varied and include the Santa Margarita River, Las Pulgas Creek, Fallbrook Creek, French Creek, Las Flores Creek, Pilgrim Creek, De Luz Creek, San Onofre Creek, San Mateo Creek, and others. These drainages have watersheds in Orange, Riverside, and San Diego Counties. Upstream of Camp Pendleton, the Santa Margarita River watershed includes Temecula Creek and Murrieta Creek, which drain from the Black Hills, Aqua Tibia Mountains, Santa Rosa Plateau, and Red Mountain through mostly private lands in Riverside County. Murrieta and Temecula Creeks join near Temecula

and form the main stem of the Santa Margarita River, which is bounded within the Santa Rosa Plateau and Santa Rosa Mountains. The western extension of the river flows through Camp Pendleton to the Pacific Ocean at the Santa Margarita estuary (Lee *et al.* 1997). San Mateo Creek, San Onofre Creek, and Las Pulgas Creek watersheds are almost wholly within public ownership on Camp Pendleton and the Cleveland National Forest. The watershed for the Santa Margarita River (including Temecula Creek and Murrieta Creek) is 1927 square kilometers (744 square miles) with a total of 1930 stream kilometers (1200 stream miles) (Lee *et al.* 1997). The Santa Margarita River is the only major water course in southern California south of the Santa Clara River that does not suffer from impoundment or restriction by one or more dams.

Much of the middle and lower elevation watershed on the Santa Margarita River has been adversely affected by either development or agriculture, including farming and grazing (Lee *et al.* 1997). Subdivision of property, fire prevention, land clearing, water management, and urban development are increasingly important land- use trends on the Santa Margarita River (Lee *et al.* 1997). Much of Temecula Creek has been channelized near Temecula. Riparian ecosystems on Camp Pendleton/Fallbrook Naval Weapons Station are adversely affected by fire and fire prevention activities, military training activities, groundwater pumping and wastewater treatment, agriculture, and flood/sediment control projects (J. Avery, U.S. Fish and Wildlife Service, pers. obser.). Exotic species threaten riparian communities throughout the Santa Margarita watershed.

The least Bell's vireo breeding population on Camp Pendleton and Fallbrook Naval Weapons Station is the largest rangewide. In 1996, the Santa Margarita River population of least Bell's vireos represented approximately 34 percent of the pairs recorded in California, and the Camp Pendleton population of least Bell's vireos represented 56 percent of the pairs recorded in California (Appendix A). Critical habitat for the least Bell's vireo on the Santa Margarita River extends approximately 8 kilometers (5 miles) downstream from the Riverside/San Diego

County line to the Camp Pendleton boundary (Santa Margarita y Las Flores Rancho grant boundary). Critical habitat for the least Bell's vireo was not designated on Camp Pendleton under the terms of a Memorandum of Understanding between the U.S. Fish and Wildlife Service and U.S. Marine Corps (see "Other Regulatory Mechanisms" under "I. Conservation Measures").

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Department of Agriculture Forest Service, U.S. Marine Corps, U.S. Navy, Bureau of Land Management, Bureau of Indian Affairs, California Regional Water Quality Control Board, California State Water Resources Control Board, California Department of Transportation, California Department of Fish and Game, California State Parks and Recreation, San Diego Association of Governments, California State Lands Commission, San Diego Association of Governments, County of San Diego, Riverside County, Orange County, Cahuilla Indian Reservation, City of Oceanside, City of San Clemente, City of Temecula, City of Murrieta, Southern California Edison, San Diego County Water Authority, Rainbow Municipal Water District, and Fallbrook Utilities District.

Santa Ana River. The watershed for the Santa Ana River is 6346 square kilometers (2,450 square miles) and comprises the single largest river system in southern California. The headwaters are in the San Bernardino National Forest. Two dams ultimately control surface flow; Seven Oaks Dam is currently under construction, and the Prado Dam is 63 kilometers (39 miles) downstream. The Santa Ana River has been straightened and channelized from Weir Canyon Road near Yorba Linda to the mouth at the Pacific Ocean near the city of Newport Beach.

The Prado Basin proper is actually a reservoir located behind Prado Dam, which was constructed as a flood control measure in 1941. It is located about 70 kilometers (43 miles) east of Los Angeles and 8 kilometers (5 miles) north of the City of Corona in the northwesternmost corner of Riverside County, California. It

is estimated that the Prado Basin encompasses some 4500 hectares (11,120 acres), which contains a maximum of 2400 hectares (5930 acres) having elements characteristic of wetland habitats (Zembal *et al.* 1985, Zembal 1986). The riparian woodland in Prado Basin is the largest in areal extent in southern California. Below Prado Dam only one large remnant of perennial stream riparian vegetation remains (Faber *et al.* 1989).

In 1996, the Santa Ana River population of least Bell's vireos represented approximately 15 percent of the pairs recorded in California (Appendix A). Critical habitat for the least Bell's vireo on the Santa Ana River extends from Rubidoux near Riverside downstream through Prado Basin. Much of the current habitat in the watershed for least Bell's vireo is found in Prado Basin.

Although willow woodlands and freshwater marshes and ponds comprise the majority of wetland habitats within the Prado Basin, a significant percentage of the woodland habitats are lacking or devoid of well-developed understories due to the expressed effects of plant community succession or the effects of prolonged inundation. In addition, large tracts of willow woodland habitat have been invaded (and therefore degraded or destroyed) by several nonnative plant species. Water conservation projects have substantially affected low elevation riparian communities within the Prado Basin; however, endowments and other mitigation measures have been established to ensure that revegetation and exotic plant control measures continue in perpetuity within the watershed.

Encroaching and potentially conflicting land uses within the Prado Basin include urban and suburban parks and developments, an airport, livestock grazing and dairy farming, agriculture, oil field operations, and industry. In addition, a large portion of the basin has been leased to hunting club operators and is used for waterfowl, pheasant, and dove hunting, shooting sports, sportsmen's fairs, and dog training.

Riparian communities on the Santa Ana River are threatened by water supply projects, exotic species, flood/sediment control and channelization projects, road projects, and sand and gravel mining. Riparian communities were once extensive along the Santa Ana River (Beattie and Beattie 1939). Because surface flows and ground water are currently heavily managed and diverted, much of the remaining riparian community remnants are now dependent upon wastewater flows and urban runoff.

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Department of Agriculture Forest Service, Bureau of Land Management, Federal Aeronautics Administration, State of California Department of Conservation Division of Oil, Gas, and Thermal Resources, California Regional Water Quality Control Board, California State Water Resources Control Board, California Department of Transportation, California Department of Fish and Game, California State Lands Commission, Riverside County, County of Riverside Parks and Open Space District, Riverside County Flood Control, Orange County, San Bernardino Association of Governments, San Bernardino County, San Bernardino County Flood Control, City of Corona, City of San Bernardino, City of Riverside, City of Redlands, City of Norco, Southern California Edison, Orange County Water District, Western Riverside County Regional Wastewater Authority, Western Municipal Water District, Santa Ana Water Project Authority, Northwest Mosquito Abatement District, West Valley Vector Control District, and Chino Basin Municipal Water District.

Orange County/Los Angeles County. As a direct or indirect result of urbanization, all of the drainages in these two counties have, to varying degrees, been impounded, channelized, or otherwise adversely affected. Most recently, preparations for anticipated El Niño-driven storm events in 1997–1998 have resulted in the clearing of hundreds of acres of stream course vegetation in Los Angeles County and, to a lesser extent, in Orange County. However, patches of suitable, important vireo habitat remain throughout the lower and middle

elevations of both counties. Notable among these patches are Arroyo Trabuco, Bonita Canyon/Creek, Canada Gobernadora, Carbon Canyon, Huntington Central Park, Laguna Reservoir, Mason Park/Sand Canyon Wash and Reservoir, Peters Canyon, Rattlesnake Reservoir, San Diego Creek, San Joaquin Marsh, Santa Ana River (task 1.117), and Santiago Creek/Villa Park Flood Control Basin in Orange County, and Big Tujunga Wash/Hansen Dam, Los Angeles River, Santa Fe Dam, San Francisquito, San Gabriel River drainage/Fish Canyon, Big Santa Anita Debris Basin, Santa Clara River drainage/Castaic Creek (task 1.119), Van Norman Dam, and Whittier Narrows in Los Angeles County.

Most or all of these habitat patches were almost certainly occupied historically by vireos (Coues 1903, Hoffman 1927, Grinnell and Miller 1944) prior to the precipitous decline of this once abundant species (Garrett and Dunn 1981). These habitat patches have been selectively and gradually reoccupied by vireos only recently, following sustained and relatively intensive management of the species within its current range. Vireos remain almost entirely absent from the large majority of comparatively expansive riparian habitats to the north within the historic range of the species, and over 95 percent of the entire vireo population is still confined to a small southern portion of the species' documented range despite the recent reoccupation of numerous (southerly) locales. Consequently, the closely spaced habitat patches in Orange and Los Angeles Counties are likely important "stepping stones" to the continuing (northward) expansion and full recovery of the species.

In 1996, the population of least Bell's vireos in Los Angeles and Orange Counties represented approximately 0.5 percent of the pairs recorded in California (Appendix A). Critical habitat includes a portion of the Santa Clara River in Los Angeles County (task 1.119).

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Department of Agriculture

Forest Service, U.S. Environmental Protection Agency, Bureau of Land Management, California Regional Water Quality Control Board, California State Water Resources Control Board, California Regional Water Quality Control Board, California Department of Transportation, California Department of Fish and Game, California State Lands Commission, California Coastal Commission, Los Angeles County, Los Angeles County Department of Public Works, Los Angeles Department of Water and Power, Los Angeles County Department of Health Services, County Sanitation Districts of Los Angeles County, Orange County, Orange County Water District, and Orange County Vector Control District.

Santa Clara River. The watershed of the Santa Clara River covers approximately 4,072 square kilometers (1,629 square miles) with headwaters in the Los Padres and Angeles National Forests. From headwaters in the San Gabriel Mountains, the main stem of the river flows approximately 135 kilometers (84 miles) to the Pacific Ocean. Flows on two principle tributaries of the river, Piru Creek and Castaic Creek, are controlled by dams that serve as both flood control and water supply reservoirs. Although there are no dams on the main stem of the Santa Clara, a large diversion structure on the main stem removes water for recharge of the aquifers underlying the Oxnard Plain. Approximately half of the main stem of the river is now constrained by engineered structures of various descriptions, primarily bank protection to prevent lateral migration of the river (Faber *et al.* 1989). Bank stabilization is particularly evident along the river in the rapidly urbanizing Santa Clarita area of Los Angeles County. The 23-million-liter-per-day (six million gallons) outfall from the Valencia Water Reclamation Plant augments surface flows along the river for several miles downstream of the Santa Clarita area.

Habitat for least Bell's vireos occurs in patches along much of the river, with location and quality varying from year to year as conditions in the river change following winter storm events. An exception is found in several areas along the

river where, regardless of rainfall events, extensive riparian habitats persist due to rising groundwater.

In 1996, the Santa Clara River population of least Bell's vireos represented approximately 3 percent of the pairs recorded in southern California (Appendix A). Surveys conducted in 1997 located 60 pairs of least Bell's vireos along this stretch of the river (Jim Greaves, pers. comm. 1997). Critical habitat for the least Bell's vireo extends along Santa Clara River from approximately 2.4 kilometers (1.5 miles) east of its junction with Piru Creek and eastward to the intersection of Old Road and Rye Canyon Road.

The primary threats to native habitats within the river are associated with engineered solutions to flooding of both urbanized and agricultural land, pressure to provide opportunities to mine sand and gravel from the river, and the spread of invasive exotic vegetation, particularly giant reed grass (*Arundo donax*).

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Department of Agriculture Forest Service, U.S. Environmental Protection Agency, Bureau of Land Management, California Department of Conservation Division of Oil, Gas, and Thermal Resources, California Department of Fish and Game, California State Lands Commission, California Department of Transportation, California Regional Water Quality Control Board, Ventura County Flood Control District, Los Angeles County, Los Angeles County Department of Health Services, Los Angeles County Department of Water and Power, Los Angeles County Department of Public Works, California State Water Resources Control Board, United Water Conservation District, County Sanitation Districts of Los Angeles County, and the cities of Santa Clarita, Santa Paula, and Fillmore.

Santa Ynez River. The watershed of the Santa Ynez River covers approximately 1,676 square kilometers (647 square miles) with its headwaters located in the Los

Padres National Forest. From its headwaters, and alternating between narrow canyons and broad valleys, the main stem of the river flows west approximately 158 kilometers (98 miles) between the Santa Ynez and San Rafael Mountain ranges. There are three dams on the main stem of the river: Jamison Dam, Gibralter Dam, and Bradury Dam. The Santa Ynez River empties into the Lompoc coastal plain through the Narrows into the Pacific Ocean

In 1996, the Santa Ynez River population of least Bell's vireos represented approximately 1.5 percent of the pairs recorded in southern California (Appendix A). Surveys conducted in 1997 located an estimated 20 pairs of least Bell's vireos on the river (Jim Greaves, pers. comm. 1997). Habitat for the least Bell's vireo occurs in scattered patches along most of the river, with quality varying from year to year as conditions in the river change following winter storms. Critical habitat for the least Bell's vireo exists along the Santa Ynez River from below Jamison Dam west to a point approximately 1.6 kilometers (1 mile) east of Gibralter Dam. The primary threats to native habitats within the river drainage are associated with dam construction, channelization, water diversions, agricultural and urban development, and wetland draining.

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Air Force, U.S. Department of Agriculture Forest Service, U.S. Environmental Protection Agency, Bureau of Land Management, Bureau of Reclamation, California Department of Transportation, California Department of Fish and Game, California Regional Water Quality Control Board, California State Water Resources Board, Santa Barbara County, Santa Barbara County Water Agency, California State Lands Commission, California Department of Water Resources, and the cities of Lompoc and Buelton.

Anza Borrego Desert. The Anza Borrego Desert region includes Coyote Creek, San Felipe Creek, Vallecito Creek, Bow Willow Creek, Carrizo Creek, San Felipe

Creek, Borrego Palm Canyon Wash, Carrizo Marsh, Sheep Canyon Wash, Sentenac Canyon Wash, Tamarisk Grove, Yaqui Well Wash, Aqua Caliente Creek, Windmill Creek, and others. This desert area is approximately 100 kilometers (60 miles) long north-south, and 40 kilometers (25 miles) wide east-west, mostly in eastern San Diego County. Riparian elements in this desert region are rare with considerable distances between sites.

In 1996, the Anza Borrego Desert population of least Bell's vireos represented 0.1 percent of the pairs recorded in California; however, the pairs were minimally surveyed for in this area in 1996 (Appendix A). The number of territorial males documented in the Anza Borrego Desert population, which is likely a better reflection of the current proportional occupation of this area, represented 4 percent of the territorial males recorded in California.

Critical habitat for the least Bell's vireo is designated in the Anza Borrego Desert on approximately 3 kilometers (1.9 miles) of Coyote Creek near the town of Borrego. The largest concentration of least Bell's vireos within this unit is found on private property (Vallecitos Creek). Threats to the riparian community include cattle grazing and equestrian facilities in adjacent areas, exotic species, off-road vehicles, and road projects.

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Department of Agriculture Forest Service, Bureau of Land Management, Bureau of Indian Affairs, California Regional Water Quality Control Board, Bureau of Land Management, California State Parks and Recreation, California Department of Transportation, California Department of Fish and Game, California State Lands Commission Riverside County, County of San Diego, Imperial County, Los Coyotes Indian Reservation, Santa Rosa Indian Reservation, San Diego and Arizona Eastern Railroad, and San Diego Gas and Electric.

Salinas River. The watershed of the Salinas River, with headwaters located in the coastal mountains of the Los Padres National Forest, drains approximately 11,396 square kilometers (4,400 square miles). From its headwaters the river flows in a northwesterly direction into the Salinas Lagoon and then into the Pacific Ocean at Monterey Bay. The major plant communities of the Salinas River include coniferous forest, oak and foothill (gray) pine woodlands, riparian scrub and woodlands, marshland, valley and foothill grasslands, chaparral, coastal scrub and coastal dunes. One thousand two hundred and ninety five square kilometers (500 square miles) of the watershed is the relatively flat Salinas River Valley. which is primarily agricultural land. Three major reservoirs regulate the flow of the Salinas River: the Nacimiento, San Antonio, and Santa Margarita Lakes.

Habitat for the least Bell's vireo occurs in scattered patches along most of the river; however, the best habitat exists in the upper Salinas Valley, specifically a 6-mile stretch from Bradley to Camp Roberts. The last record of a least Bell's vireo on the Salinas River was a singing male in July of 1993 (Roberson and Tenny 1993). The primary threats to native habitats within the river drainage are associated with dam construction, channelization, water diversions, agricultural development, and grazing.

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Forest Service, U.S. Environmental Protection Agency, California Department of Fish and Game, California State Water Resources Board, U.S. Bureau of Land Management, California State Lands Commission, Monterey County Water Resources Agency, U.S. Bureau of Reclamation, Monterey Peninsula Water Management District, Monterey County Parks Department, Northern Salinas Valley Mosquito Abatement District, California Regional Water Quality Control Board, Central Coast, King City, and City of Salinas.

San Joaquin Valley. The San Joaquin Valley watershed below the 152-meter (500-foot) contour encompasses approximately 3.4 million hectares (8.5 million acres) and extends about 415 kilometers (258 miles) north to south. The San Joaquin River basin is bounded on the west by the Coast Range, on the east by the Sierra Nevada, on the south by the Tehachapi Mountains, and in the north by the Sacramento/San Joaquin River Delta. The Tulare Lake basin to the south is often considered a separate drainage basin, but during wet years it has historically contributed occasional flood overflows and subsurface flows to the San Joaquin River. Numerous dams control surface flows in tributaries to the San Joaquin River, including the Merced, Tuolumne, Stanislaus, and Calaveras Rivers. Dams on the Kings, Kaweah, Kern and Tule Rivers control surface flows draining from the Sierras into the Tulare Lake basin. Agricultural activities and flood control projects are the primary threats to riparian habitats remaining within this basin.

Areas with potential least Bell's vireo habitat include the Kern River Preserve and Caswell Memorial State Park (Stanislaus River).

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Department of Agriculture, U.S. Forest Service, Bureau of Reclamation, Bureau of Land Management, Bureau of Indian Affairs, National Marine Fisheries Service, Natural Resources Conservation Service, Federal Energy Regulatory Commission, California Department of Water Resources, The Resources Agency, California Regional Water Quality Control Board, California State Water Resources Board, California Department of Transportation, California Department of Fish and Game, California Fish and Game Commission, California State Lands Commission, State Board of Forestry, California State Parks and Recreation, and numerous cities, counties, mosquito abatement districts, and water districts.

Sacramento Valley. The Sacramento Valley watershed below Shasta Dam encompasses approximately 3.2 million hectares (8 million acres) and extends about 310 kilometers (193 miles) north to south. The Sacramento River basin is bounded on the west by the Coast Range, on the east by the Sierra Nevada, on the north by the Cascade Range, and on the south by the Sacramento/San Joaquin River Delta. Shasta Dam controls flows in the Sacramento River. A number of dams control surface flows in tributaries to the Sacramento River, including the American River, Feather River, Bear River, and Stony Creek. Agricultural activities and flood control projects are the primary threats to riparian habitats remaining within this basin.

Areas of potential least Bell's vireo habitat include Cosumnes River Preserve, Bobelaine Sanctuary (Feather River), Butte Sink, Big Chico Creek to the mouth of Pine Creek, and the Sacramento River (Hanson Island to Parrot Landing, River Miles 170–181; Merrill's Landing at River Miles 212–215; Woodson Bridge-Kopta Slough at River Miles 218–220).

Land use, water, regulatory, and associated agencies include: U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Department of Agriculture, U.S. Forest Service, Bureau of Reclamation, Bureau of Land Management, Bureau of Indian Affairs, National Marine Fisheries Service, Natural Resources Conservation Service, Federal Energy Regulatory Commission, California Department of Water Resources, The Resources Agency, California Regional Water Quality Control Board, California State Water Resources Board, California Department of Transportation, California Department of Fish and Game, California Fish and Game Commission, California State Lands Commission, State Board of Forestry, California State Parks and Recreation, and numerous cities, counties, mosquito abatement districts, and water districts.

II. RECOVERY

A. Objective and Criteria

The objective of this recovery plan is to delist the least Bell's vireo when the five listing criteria no longer apply. Before delisting may occur, the Fish and Wildlife Service must determine that the following listing factors are no longer present or continue to adversely affect the least Bell's vireo: (1) the present or threatened destruction, modification, or curtailment of its habitat or range; (2) disease or predation; (3) the inadequacy of existing regulatory mechanisms; and (4) other natural or manmade factors affecting its continued existence (U.S. Fish and Wildlife Service 1985).

Downlisting Criterion:

Reclassification to threatened may be considered when criterion 1 has been met for a period of 5 consecutive years.

> Criterion 1: Stable or increasing least Bell's vireo populations/metapopulations, each consisting of several hundred or more breeding pairs, are protected and managed at the following sites: Tijuana River, Dulzura Creek/Jamul Creek/Otay River, Sweetwater River, San Diego River, San Luis Rey River, Camp Pendleton/Santa Margarita River, Santa Ana River, an Orange County/Los Angeles County metapopulation, Santa Clara River, Santa Ynez River, and an Anza Borrego Desert metapopulation.

Delisting Criteria:

Delisting may be considered when the species meets the criterion for downlisting and the following criteria have been met for 5 consecutive years.

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Criterion 2: Stable or increasing least Bell's vireo populations/metapopulations, each consisting of several hundred or more breeding pairs, have become established and are protected and managed at the following sites: Salinas River, a San Joaquin Valley metapopulation, and a Sacramento Valley metapopulation.

Criterion 3: Threats are reduced or eliminated so that least Bell's vireo populations/metapopulations listed above are capable of persisting without significant human intervention, or perpetual endowments are secured for cowbird trapping and exotic plant (*Arundo*) control in riparian habitat occupied by least Bell's vireos.

B. Narrative Outline for Recovery Actions

1. Protect and manage riparian and adjacent upland habitats within the least Bell's vireo's historical range.

Continued increases in least Bell's vireo populations and expansion throughout the historical range depend on the availability of suitable nesting habitat. Recent population trends indicate that overall habitat quality/function (predator/prey relationships, foraging and breeding areas, etc.), quantity, and management in southwestern United States portion of the least Bell's vireo's range have been sufficient to promote increases in the least Bell's vireo populations. As discussed in Part I ("D. Life History and Ecology"), expansion of the least Bell's vireo distribution has occurred in a "stepping stone" fashion (i.e., in response to increases in numbers in existing populations, least Bell's vireos expand their range by recolonizing sites that have been unoccupied for years or decades). Existing and restorable habitat within the least Bell's vireo's historic range should be protected. In order to continue progress towards recovery, not only must existing populations be protected and managed but the size, configuration, and location of habitat necessary to sustain new, self-perpetuating least Bell's vireo

populations must be determined. These areas must be protected and managed through conservation agreements, habitat conservation plans, multiple species conservation plans, land acquisition and management, conservation easements, and interagency consultations under section 7 of the Endangered Species Act.

1.1 Develop management plans for the 14 population/metapopulation units.

Management plans must be developed and implemented for each of the 14 population/metapopulation units described under the downlisting and delisting criteria. These management plans are essential to the continued viability of the species once the protection afforded by the Endangered Species Act is removed. Moreover, they provide excellent opportunities for multiple species protection, which could preclude the need for Federal listing of other sensitive riparian species. At a minimum, the plans should detail management responsibilities and funding sources to provide for continuing habitat protection, including maintenance of hydrologic regimes necessary to sustain habitat, cowbird control, cowbird foraging area reduction, and control of invasive exotic vegetation. Future proposed projects and activities within the management areas should be designed and regulated in ways compatible with the goals of the management plans.

For each unit, develop a management plan that defines (1) the geographical limits of the habitat unit, (2) the jurisdiction(s) with land-use authority over the unit, (3) what constitutes a viable vireo population for the unit, (4) what is needed to achieve a viable vireo population for the unit, and (5) jurisdictional responsibilities and costs for achieving this objective.

1.111 Tijuana River

Major threats to be addressed include unauthorized clearing activities and placement of fill materials, off-road vehicle use, exotic species, and

flood control projects and channelization. Considerable human foot and horse traffic traverses the riparian habitats of the Tijuana River, and equestrian corrals are common features within the surrounding floodplain and upland areas.

1.112 Dulzura Creek/Jamul Creek/Otay River

Major threats to be addressed include sand and gravel mining, water supply projects, unauthorized clearing activities and placement of fill materials, exotic species, and flood control projects and channelization.

1.113 Sweetwater River

Major threats to be addressed include agriculture, flood control, sand and gravel mining, recreation, residential/commercial/industrial development, transportation, wastewater treatment and water supply projects (San Diego Association of Governments 1991b) and equestrian facilities, adjacent to much of the lower Sweetwater River, and their attraction of brown-headed cowbirds.

1.114 San Diego River

Major threats to be addressed include agriculture, flood control, sand and gravel mining, recreation, residential/commercial/industrial development, transportation, wastewater treatment and water supply projects (San Diego Association of Governments 1991b), and equestrian facilities, which may attract brown-headed cowbirds, adjacent to the San Diego River.

1.115 San Luis Rey River

Major threats to be addressed include agriculture, flood control, water supply projects, sand and gravel mining, recreation, residential/commercial/industrial development, transportation, wastewater treatment projects (San Diego Association of Governments 1990), and unauthorized placement of fill materials, clearing, and herbiciding activities.

1.116 Camp Pendleton/Santa Margarita River

Major threats to be addressed include agriculture, fire and fire prevention, land clearing, channelization, water management, urban development, military training activities, groundwater pumping and wastewater treatment, flood/sediment control projects, and exotic species.

1.117 Santa Ana River.

Major threats to be addressed include encroachment and potentially conflicting land uses such as urban and suburban parks, developments, an airport, livestock grazing and dairy farming, agriculture, oil field operations, industry, channelization projects, road projects, sand and gravel mining, and impacts of wastewater flows and urban runoff to riparian communities.

1.118 Orange County/Los Angeles County

Major threats include impoundments, channelization, and removal of stream bank vegetation. Management planning should address the need to maintain the remaining patches of suitable, important least Bell's

vireo habitat throughout the lower and middle elevations of both counties, and particulary, the closely spaced habitat patches that are likely important "stepping stones" to the continuing (northward) expansion and full recovery of the species.

1.119 Santa Clara River

Major threats to be addressed are associated with engineered solutions to flooding of both urbanized and agricultural land, pressure to provide opportunities to mine sand and gravel from the river, and the spread of invasive exotic vegetation, particularly giant reed grass (*Arundo donax*).

1.120 Santa Ynez River

Major threats to be addressed include dam construction, channelization, water diversions, agricultural and urban development, and wetland draining.

1.121 Anza Borrego Desert

Major threats to be addressed include cattle grazing and equestrian facilities in adjacent areas, exotic species, off-road vehicles, and road projects.

1.122 Salinas River

Major threats to be addressed include dam construction, channelization, water diversions, agricultural development, and grazing.

1.123 San Joaquin Valley

Major threats to be addressed include agricultural activities and flood control projects.

1.124 Sacramento Valley

Major threats to be addressed include agricultural activities and flood control projects.

1.2 Prepare management plans for least Bell's vireo habitats identified in Task 2.1.

As a result of a statewide inventory of riparian habitat (task 2.11) and statewide surveys (task 2.12) for least Bell's vireos, additional occupied or potential habitat may be found. Management plans should be developed and implemented for these areas to protect existing least Bell's vireos or to manage potential habitat (and adjacent land uses) that may be available for recolonization.

1.3 Establish a protocol for monitoring least Bell's vireo populations and habitat.

These data should provide estimates of population size and trends, demographic parameters, and habitat characteristics. Methods used should be standardized to ensure compatibility of data sets. Monitoring should be an intensive effort to obtain accurate information on population size, number of breeding pairs, nesting success and productivity, annual survivorship (of color-banded birds), dispersal (through resightings of color-banded birds), and rates of cowbird parasitism. Particular emphasis should be placed upon the detection and accurate identification of banded birds, as the linkage between least Bell's vireo populations produced by dispersal is one of the most

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important factors influencing metapopulation viability, and more data are needed to improve our estimates of this critical parameter. Standardized techniques for measuring vegetation and other habitat characteristics should be developed. Adjacent habitats and land uses should be described at each monitored site.

1.4 Conduct annual monitoring of the 14 population/metapopulation units.

Annual monitoring is needed to evaluate progress toward recovery and to identify any problems or threats that arise. Monitoring should follow the protocols established under Task 1.3.

1.411 Tijuana River
1.412 Dulzura Creek/Jamul Creek/Otay River
1.413 Sweetwater River
1.414 San Diego River
1.415 San Luis Rey River
1.416 Camp Pendleton/Santa Margarita River
1.417 Santa Ana River
1.418 Orange County/Los Angeles County
1.419 Santa Clara River
1.420 Santa Ynez River
1.421 Anza Borrego Desert
1.422 Salinas River
1.423 San Joaquin Valley
1.424 Sacramento Valley

1.5 Continue cowbird removal.

Nest parasitism by the brown-headed cowbird has been well-documented as a limiting factor on least Bell's vireo nesting success and productivity.

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Extensive and continuous cowbird removal from the least Bell's vireo management areas during the last decade is probably the single most important factor reversing population declines and producing the recent population increases in the southwestern United States portion of the least Bell's vireo range. The recovery criteria outlined in this plan are derived from analysis of the performance of least Bell's vireo populations under a regime of cowbird removal; consequently, it will be necessary to continue such programs until it is determined that active cowbird removal is no longer necessary to maintain current levels of least Bell's vireo productivity, or long-term control measures are assured (task 1.8).

1.6 Develop alternative means of controlling cowbird parasitism.

Presently, cowbird control takes the form of trapping adults and juveniles and monitoring least Bell's vireo nests to remove any cowbird eggs or young. While nest monitoring is limited to least Bell's vireo nests, trapping reduces parasitism of other riparian birds, including the endangered southwestern willow flycatcher and several sensitive species, but also results in losses to nontarget native bird species caught incidentally in traps. The benefits of reducing cowbird numbers, along with the interest of land managers working with endangered species threatened by parasitism elsewhere such as the golden-cheeked warbler (*Dendroica chrysoparia*) and the black-capped vireo (U.S. Fish and Wildlife Service 1991, 1992), justify the need to develop cowbird control measures that are long term, less costly and time intensive, multispecies oriented, and cover a broader geographic area.

Modification of land uses adjacent to least Bell's vireo breeding areas is likely the only long-term method available to reduce cowbird numbers without cowbird removal and nest monitoring. Modification of land uses would involve avoiding or modifying types of land use (e.g., dairies, livestock pens, equestrian centers, and other cowbird feeding areas) within flood plains and

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adjacent lands that result in concentrations of cowbirds. Additionally, land use management practices (e.g., seasonal alteration of grazing regimes and feed-seed/manure management) can be used to discourage concentrations of cowbirds near riparian habitat during the breeding season. Unless land uses are modified to eliminate or greatly reduce cowbird numbers, trapping may be required in perpetuity.

1.7 Control nonnative plant species.

Availability and suitability of riparian habitat for nesting least Bell's vireos and other species is threatened by the invasion of nonnative (exotic) vegetation, including castor bean (*Ricinus communis*), cocklebur (*Xanthium strumarium*), tamarisk (*Tamarix* sp.), and giant reed (*Arundo donax*). *Arundo* is particularly threatening because of its rapid rate of growth and establishment, its ability to be dispersed widely throughout drainages during flooding, and its propensity to spread over large areas, especially following natural or artificial disturbances when it competes effectively against native vegetation. Literally miles of monotypic stands of *Arundo* exist on some southern California drainages, preventing reestablishment of native riparian habitat in those areas and promoting fragmentation of native vegetation stands. Eradication of *Arundo* and other exotic plants is essential to maintain the suitability of riparian habitat for least Bell's vireos, as well as to restore native habitat in areas now dominated by nonnative vegetation.

Current management of nonnative vegetation requires a considerable commitment to thoroughly removing or killing all above- and below-ground parts of the target species and follow-up in subsequent years to control any exotics outbreaks. Eradication of most exotic species currently requires a combination of mechanical and chemical control. Coordination throughout drainages is required to prevent situations where downstream eradication sites are repeatedly colonized by upstream sources of exotic plants.

The Bureau of Reclamation funded biological control research for *Tamarisk* spp., which resulted in the release of *Tamarisk*-specific chrysomelid beetles in the summer of 1997 (Dr. Bernd Blossey, Professor of Biology, Cornell University, pers. comm.). The use of this biocontrol method for *Tamarisk* in California should be implemented, and other methods of biocontrol for *Arundo* and other nonnative plant species should be developed (task 2.5).

1.8 Establish perpetual endowments for brown-headed cowbird control and/or exotic plant control in least Bell's vireo habitat.

Threats must be reduced or eliminated so that least Bell's vireo breeding populations are capable of persisting without significant human intervention. Perpetual endowments must be secured for brown-headed cowbird trapping and/or exotic plant control in riparian habitat occupied by the least Bell's vireo where persistence of least Bell's vireo populations require continuous management of these threats.

2. Conduct research.

2.1 Identify additional and potential least Bell's vireo breeding habitat within its historical range.

The goal of the this recovery plan is to ensure that the 14 least Bell's vireo populations/metapopulations are capable not only of self-perpetuation, but also of producing colonizers that will reestablish viable populations within the historical range. As least Bell's vireo populations recover under protection and management, their increased reproductive success, survivorship, and recruitment of new individuals will require expansion into historically occupied, but currently unoccupied habitat (i.e., the Central Valley). Management plans should be prepared and implemented for protection of areas identified under this task (task 1.2).

2.11 Conduct a statewide inventory of riparian habitat.

Despite wide interest in the current status of California's riparian habitat and its associated wildlife, to date no comprehensive statewide inventory of riparian habitat acreage and distribution has been conducted. Such an effort is needed for effective least Bell's vireo management. Accurate maps, acreages, and habitat type delineations (e.g., cottonwood-willow, mule fat scrub, alder riparian, oak riparian, etc.) would allow projections of the size and geometry of least Bell's vireo populations likely to be established as recovery proceeds. Adjacent land uses should also be examined. Such information would also help to evaluate the contribution of individual sites to the overall habitat base available to the least Bell's vireo. Entry of inventory data into a computer-based Geographic Information System (GIS) would permit retrieval of maps useful for surveys and monitoring. These data would be useful in analyzing the impacts of natural factors, which may vary spatially, and human activities on least Bell's vireo population viability.

2.12 Conduct thorough rangewide surveys.

In addition to annual monitoring of the population/metapopulation units, rangewide surveys of all potential least Bell's vireo habitat are necessary to assess population size and distribution, habitat availability and condition, and to document dispersal. A Fish and Wildlife Service biologist or their designee should assemble, train, and supervise a qualified team large enough to complete an intensive survey. The initial coordinator should identify and delineate survey areas and develop maps, directions, and survey materials for participants. Special effort should be devoted to resighting color-banded birds and obtaining accurate band combinations for contribution to the database on

dispersal used in population viability analyses. Surveys should be conducted at least every five years and, preferably, every three years if funding is available.

2.2 Investigate the status of wintering habitat and identify current or potential threats.

A major factor contributing to population declines of neotropical migratory birds is loss of wintering habitat. Although least Bell's vireos are reported to winter throughout the Cape Region of Baja California, Mexico, investigators have had little success in locating specific wintering areas of color-banded least Bell's vireos that breed in California. Continued research is necessary to determine the actual location, extent, and function of the wintering range and to identify threats to birds on the wintering grounds that, through their impact on annual survivorship, could imperil the status of the breeding population.

2.21 Establish a cooperative agreement with Mexico to obtain information on vireo wintering grounds in Baja California, Mexico.

Such an agreement should be coordinated through the Fish and Wildlife Service's International Affairs Office and the Partners in Flight program.

2.3 Collect demographic data on least Bell's vireos.

2.31 Continue color-banding least Bell's vireos and collect data for demographic and dispersal analyses.

Color-banding of nestlings and adults, which has been essential to ongoing studies of demography, dispersal, and wintering site selection, must be continued to facilitate collection of data for additional analyses and to determine the effectiveness of management and recovery actions.

2.32 Determine the relationships between population density and reproductive characteristics.

Variation in demographic parameters as a function of population size is called density-dependent variation. As least Bell's vireos recover and approach the carrying capacity of their habitat, research is needed to determine whether any of their reproductive parameters (i.e., clutch size, hatching rate, fledging rate, predation and parasitism rates, and survival rates) change. Findings of such density-dependence would need to be incorporated into a population viability analysis to reflect its impact on population growth and persistence. Recovery criteria should be revised as necessary in light of any new data.

2.33 Determine the relationships between population density and dispersal.

Dispersal is another life history characteristic that may change as a function of population size, both natal (source) population and target population. As conditions in natal populations become more crowded, proportionately more birds may disperse to new areas. As target populations grow, they may become more attractive to dispersers than smaller populations. There are a number of scenarios possible, and each could produce a different effect on least Bell's vireo metapopulation dynamics. Research in this area will depend on continued intensive color-banding and resighting of color-banded least Bell's vireos.

2.4 Investigate the relationship between habitat characteristics and least Bell's vireo behaviors and access to necessary resources.

Least Bell's vireo habitat needs extend beyond defense of a territory, which can be readily measured in the field and used to quantify "occupied" habitat.

Many other least Bell's behaviors and access to necessary resources are influenced by habitat characteristics such as vegetation structure and species composition, size, age, adjacent land use, and proximity to other riparian habitat. Habitat characteristics can influence mate attraction, nesting and feeding of young, foraging, local post-breeding movements of juveniles, acquisition of territories by first-time breeders both within and outside of the natal drainage, and breeding site shifts prompted by natural disturbance processes. The relationships between these factors and the key components of least Bell's vireo population viability (productivity and dispersal) need to be better understood.

2.5 Develop biocontrol methods for *Arundo* and other nonnative plant species.

The development of biological control of *Arundo* and other nonnative plant species through U.S. Department of Agriculture, international, and university programs should be initiated. Biocontrol programs for some plant pest species have been developed, including the use of six insect species to control yellow-star thistle (*Centaurea* sp.), an exotic from southern Europe (Randall 1994); release of a *Tamarisk*-specific chrysomelid beetle in Texas (Dr. Bern Blossey, pers. comm.); and the release of European beetles in New York state for biological control of purple loosestrife (*Lythrum* sp.), an invasive exotic from Europe (U.S. Fish and Wildlife Service 1997). The International Institute of Biological Control headquartered in Switzerland has staff and facilities to perform the international research needed to perform the type of work needed for *Arundo* and other invasive species in the range of the least Bell's vireo (Dr. Bernd Blossey, pers. comm.). Biological control programs hold promise of long-term, self-sustaining, and very wide-range control of invasive plant species with relatively limited costs, but are not without the biological risks associated with releasing additional exotic species.

3. **Develop and evaluate least Bell's vireo habitat restoration techniques.**

Riparian habitat creation and restoration is becoming increasingly popular as a form of mitigation for the destruction or degradation of existing riparian habitat. Results are mixed as to whether suitable habitat is restored and subsequently occupied by nesting least Bell's vireos. While several San Diego County sites are promising examples of successfully colonized restored habitat, many other sites throughout southern California have failed. Long-term monitoring of restoration sites is essential. Existing habitat restoration techniques should be fully evaluated and new methods developed through cooperation between regulatory agencies and academic institutions.

3.1 **Implement long-term monitoring of restoration sites and their use by least Bell's vireos and other riparian species.**

Long-term monitoring of restoration sites and their use by least Bell's vireos and other riparian species is necessary to determine whether these sites can function as self-sufficient ecosystems and not simply human-tended native plant gardens. Monitoring of restoration sites established under mitigation agreements should be improved.

3.2 **Develop less costly methods of creating sites with the vegetation composition and structure required by nesting least Bell's vireos.**

Research is also needed on less costly methods of creating sites with the vegetation composition and structure required by nesting least Bell's vireos, such as the use of stem-cuttings rather than nursery stock. Research needs include finding ways to improve site selection and preparation, planting techniques (timing, stock, subsequent care, irrigation methods), and other aspects of site maintenance, such as protection from vandalism and controlling plant pests.

3.3 Evaluate restoration efforts and effectiveness of methods used.

Advances in restoration site design and implementation in the last 10 years have resulted in some successful restoration efforts. Riparian habitat with the structure of natural habitat and which attracts nesting least Bell's vireos has been produced. However, despite these successes, many attempts at habitat restoration have failed. The "success" criteria used to evaluate the effectiveness of past restoration efforts, as well as the methods used to generate the data for these evaluations, should be reviewed and revised.

3.4 Conduct habitat restoration.

Habitat restoration may be appropriate in areas of potential, or degraded, habitat identified as a result of the statewide inventory of riparian habitat (task 2.11) and rangewide surveys (task 2.12) for additional least Bell's vireos. As information is acquired through monitoring restored habitat and evaluating restoration efforts and techniques (tasks 3.1 and 3.3), and as restoration techniques are improved and costs reduced (task 3.2) habitat restoration should be conducted in such areas.

4. Reintroduce least Bell's vireos to unoccupied habitat in the historical range through translocation.

Translocation of least Bell's vireos may be necessary to reestablish populations in areas (i.e., Central Valley) that are too far from existing populations for natural reoccupation to occur. Evaluations of potential sites for reintroductions should include assessing habitat quality and suitability, assessing threats and determining methods of protecting and managing selected sites and reducing or eliminating threats, and assessing the likelihood of least Bell's vireo success in restored or managed areas. Habitat restoration should be completed before reintroductions are initiated, and all reintroduction sites should be protected and managed to

maximize long-term survival of least Bell's vireos. A thorough evaluation of reintroduction techniques should include determining the best sources of individuals while considering genetics contributions of selected individuals to a new population. Least Bell vireo behaviors (e.g. song recognition, site fidelity) will also influence selection of individuals. Capture and release of juveniles may be the most feasible approach with the best chance of success. Any translocation efforts should involve public outreach.

5. **Evaluate progress of recovery, effectiveness of management and recovery actions, and revise management plans.**

This adaptive management approach ensures that the best available scientific information is used to guide recovery efforts. As more information becomes available through the completion of recovery tasks, recovery strategies and criteria should be reassessed. Management plans will be updated as management strategies are evaluated and research provides the basis for developing more effective management strategies.

6. **Provide public information and education.**

Public understanding, support, and involvement in the least Bell's vireo recovery efforts are critical to successfully reaching the delisting objective of the recovery plan. An effective public outreach program should be developed and implemented to inform and update local governments and interested members of local communities. An effective outreach program will be particularly essential should translocation of least Bell's vireos become necessary. Outreach activities could include producing brochures about least Bell's vireos, the value of riparian habitat and undeveloped floodplains, wetland functions and values, the effects of channelization, and providing information on the negative impacts of nonnative species. Other outreach activities could include posting signs in public use areas in least Bell's vireo habitat and making presentations to schools and clubs. Outreach activities will benefit the recovery effort and increase public awareness of the reasons for the endangered status of the least Bell's vireo and the value of particular recovery activities.

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IV. IMPLEMENTATION SCHEDULE

A summary of scheduled actions and costs associated with this recovery program follows. The scheduling priority for each task and the responsible agency is indicated. Implementation of all tasks listed in the Implementation Schedule will lead to recovery of the least Bell's vireo. Initiation of these actions is subject to availability of funds.

Priorities in column one of the implementation schedule are assigned as follows:

1. **Priority 1:** An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

2. **Priority 2:** An action that must be taken to prevent a significant decline in population or habitat quality, or some other significant negative impact short of extinction.

3. **Priority 3:** All other actions necessary to meet the recovery objective.

Acronyms used in the Implementation Schedule

*	Lead Agency
ATSFRR	Atchison Topeka and Santa Fe Railroad
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BR	Bureau of Reclamation
BRD	Biological Resources Division, U.S. Geological Survey
BUEL	City of Buelton
CBMWD	Chino Basin Municipal Water District
CCC	California Coastal Commission
CDC	California Department of Conservation Division of Oil, Gas, and Thermal Resources
CDFG	California Department of Fish and Game
CDSP	California Department of State Parks
CGIR	Capitan Grande Indian Reservation
CIR	Cahuilla Indian Reservation
COE	Army Corps of Engineers
COR	City of Corona
CORNELL	Cornell University

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CRWQCB	California Regional Water Quality Control Board
CSDLA	County Sanitation Districts of Los Angeles County
CSLC	California State Lands Commission
CSPR	California State Parks and Recreation
CSWRCB	California State Water Resources Control Board
CV	City of Chula Vista
DOD	Department of Defense
DOJ	Department of Justice/Border Patrol
DOT	California Department of Transportation
DWR	California Department of Water Resources
EPA	Environmental Protection Agency
EMWC	Escondido Municipal Water Company
FAA	Federal Aeronautics Administration
FHWA	Federal Highway Administration
FIL	City of Fillmore
FUD	Fallbrook Utilities District
FWS	U.S. Fish and Wildlife Service
HWD	Helix Water District
IBWC	International Boundary and Water Commission
IIBC	International Institute of Biological Control
ICO	Imperial County
LADHS	Los Angeles County Department of Health Services
LADPW	Los Angeles County Department of Public Works
LACO	Los Angeles County
LADWP	Los Angeles Department of Water and Power
LAK	City of Lakeside
LCIR	Los Coyotes Indian Reservation
LJIR	La Jolla Indian Reservation
LOMPOC	City of Lompoc
MONCO	Monterey County
MTDB	Metropolitan Transit Development Board
MUR	City of Murrieta
NAVY	U.S. Navy
NC	City of National City
NMAD	Northwest Mosquito Abatement District
NORCO	City of Norco
OCO	Orange County
OCVCD	Orange County Vector Control District
OCWD	Orange County Water District

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OCN	City of Oceanside
OWD	Otay Water District
PAIR	Pauma Indian Reservation
PDMWD	Padre Dam Municipal Water District
PIR	Pala Indian Reservation
PMWC	Pauma Mutual Water Company
PVCSD	Pauma Valley Community Services District
RCD	Resource Conservation District of Greater San Diego County
RCFC	Riverside County Flood Control
RCP	Riverside County Parks and Open Space District
RED	City of Redlands
RIR	Rincon Indian Reservation
RIV	City of Riverside
RIVCO	Riverside County
RMWD	Rainbow Municipal Water District
SAL	City of Salinas
SANBAG	San Bernardino Association of Governments
SANDAG	San Diego Association of Governments
SANTEE	City of Santee
SAWPA	Santa Ana Water Project Authority
SBACO	Santa Barbara County
SBCO	San Bernardino County
SBCFC	San Bernardino County Flood Control
SBCWA	Santa Barbara County Water Agency
SBECO	San Benito County
SBR	City of San Bernardino
SCE	Southern California Edison
SCL	City of San Clemente
SCLR	City of Santa Clarita
SD	City of San Diego
SDAERR	San Diego and Arizona Eastern Railroad
SDCO	San Diego County
SDCPR	San Diego County Parks and Recreation Department
SDCVC	San Diego County Vector Control
SDCWA	San Diego County Water Authority
SDGE	San Diego Gas and Electric
SDPR	City of San Diego Parks and Recreation Department
SDWUD	City of San Diego Water Utilities District,
SIR	Sycuan Indian Reservation

SLOCO	San Luis Obispo County
SLRMWD	San Luis Rey Municipal Water District
SPA	City of Santa Paula
SPRR	Southern Pacific Railroad
SRIR	Santa Rosa Indian Reservation
SWA	Sweetwater Authority
SYS	City of San Ysidro
TBD	To Be Determined
TEM	City of Temecula
TVWB	Tijuana Valley Water Board
USAF	U.S. Air Force
USDA	U.S. Department of Agriculture-Agronomy and Range Science
USFS	U.S. Forest Service
USMC	U.S. Marine Corps
UWCD	United Water Conservation District
VCFCD	Ventura County Flood Control District
VCMWD	Valley Center Municipal Water District
VID	Vista Irrigation District
WMWD	Western Municipal Water District
WRCRWA	Western Riverside County Regional Wastewater Authority
WVVCD	West Valley Vector Control District

Recovery Plan Implementation Schedule for the Least Bell's Vireo.

Priority #	Task #	Task Description	Task Duration (Years)	Responsible or Associated Parties	Total Estimated Cost ($1000's)	Costs (1000s)					Comments
						FY 99	FY 00	FY 01	FY 02	FY 03	
1	1.5	Continue cowbird removal	Continuous	FWS*, NAVY, CDSP, USMC, DOD, DOT, FHWA, CDFG, USFS, COE, OCWD	500	100	100	100	100	100	Future costs to be determined if endowments are not established for the permanent monitoring and management of cowbirds
1	1.111	Prepare management plan for the Tijuana River population	1	FWS*, NAVY, COE, EPA, USFS, CSPR, BLM, BRD, IBWC, DOJ, CRWQCB, DOT, CDFG, CSLC, CCC, SDCO, SDCPR, SDCVC, SD, SANDAG, SYS, SDGE, TVWB	20	20					
1	1.112	Prepare management plan for the Dulzura Creek/Jamul Creek/Otay River population	1	FWS*, COE, EPA, USFS, BLM, BRD, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CCC, SDCO, SANDAG, SDCPR, SDCVC, CV, SDCWA, OWD, SDGE	20		20				

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Recovery Plan Implementation Schedule for the Least Bell's Vireo.

Priority #	Task #	Task Description	Task Duration (Years)	Responsible or Associated Parties	Total Estimated Cost ($1000's)	Costs (1000s)					Comments
						FY 99	FY 00	FY 01	FY 02	FY 03	
1	1.113	Prepare management plan for Sweetwater River population	1	FWS*, BLM, COE, EPA, USFS, BRD, BIA, SIR, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CCC, SDCO, SDCPR, SDCVC, SANDAG, CV, NC, SWA, SDCWA, OWD, SDGE	20	20					
1	1.114	Prepare management plan for the San Diego River population	1	FWS*, FHWA, COE, EPA, USFS, BLM, BRD, BIA, CGIR, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CCC, SANDAG, SDCO, SDCPR, SDCVC, SD, SANTEE, LAK, SDPR, MTDB, SDWUD, HWD, PDMWD, SDCWA, SDGE	20		20				

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Recovery Plan Implementation Schedule for the Least Bell's Vireo.

Priority #	Task #	Task Description	Task Duration (Years)	Responsible or Associated Parties	Total Estimated Cost ($1000's)	Costs (1000s)					Comments
						FY 99	FY 00	FY 01	FY 02	FY 03	
1	1.115	Prepare management plan for the San Luis Rey River population	1	FWS*, COE, EPA, FHWA, USFS, USMC, NAVY, BLM, BIA, BRD, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CCC, SANDAG, SDCO, SDCPR, SDCVC, PAIR, RIR, PAL, LJIR, OCN, PMWC, SDCWA, SLRMWD, VCMWD, EMWC, VID, FUD, SDGE	20		20				
1	1.116	Prepare management plan for the Camp Pendleton/Santa Margarita population	1	FWS*, USMC, NAVY, DOD, FAA, BRD, CSPR, COE, FHWA, EPA, USFS, BLM, BIA, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CCC, SANDAG, SDCO, RIVCO, OCO, CIR, OCN, SCL, TEM, MUR, SCE, SDCWA, RMWD, FUD, ATSFRR	20		20				

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Recovery Plan Implementation Schedule for the Least Bell's Vireo.

Priority #	Task #	Task Description	Task Duration (Years)	Responsible or Associated Parties	Total Estimated Cost ($1000's)	Costs (1000s)					Comments
						FY 99	FY 00	FY 01	FY 02	FY 03	
1	1.117	Prepare management plan for Santa Ana River population	1	FWS*, COE, EPA, USFS, BLM, FAA, BRD, CDC, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CSPR, OCWD, RIVCO, RCP, RCFC, OCO, SANBAG, SBCO, SBCFC, COR, SB, RIV, RED, NORCO, SCE, WRCRWA, WMWD, SAWPA, NMAD, WVVCD, CBMWD, ATSFRR, SPRR	20		20				
1	1.118	Prepare management plan for the Orange County/Los Angeles County metapopulation	1	FWS*, COE, EPA, USFS, DOD, BLM, BRD, CDC, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CSPR, OCO, OCWD, OCVCD, LACO, LADPW, LADWP, LADHS, CSDLA, SCE, SPRR	25		25				

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Recovery Plan Implementation Schedule for the Least Bell's Vireo.

Priority #	Task #	Task Description	Task Duration (Years)	Responsible or Associated Parties	Total Estimated Cost ($1000's)	Costs (1000s)					Comments
						FY 99	FY 00	FY 01	FY 02	FY 03	
1	1.119	Prepare management plan for the Santa Clara River population	1	FWS*, DOD, COE, FHWA, EPA, USFS, BLM, BRD, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CCC, CDC, CSPR, DWR, VCFCD, LACO, LADHS, LADWP, LADPW, UWCD, CSDLA, SCLR, SPA, FIL, SPRR	20		20				
1	1.120	Prepare management plan for the Santa Ynez River population	1	FWS*, DOD, COE, USAF, USFS, FHWA, EPA, BLM, BRD, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CCC, CDC, CSPR, DWR, SBACO, SBCWA, LOMPOC, BUEL, SPRR	20			20			
1	1.121	Prepare management plan for the Anza Borrego Desert metapopulation	1	FWS*, DOD, COE, NAVY, USFS, FHWA, EPA, BLM, BRD, BIA, CSPR, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CCC, CDC, RIVCO, SDCO, ICO, LCIR, SRIR, SDAERR, SDGE	30			30			

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Recovery Plan Implementation Schedule for the Least Bell's Vireo.

Priority #	Task #	Task Description	Task Duration (Years)	Responsible or Associated Parties	Total Estimated Cost ($1000's)	Costs (1000s)					Comments
						FY 99	FY 00	FY 01	FY 02	FY 03	
2	1.122	Prepare management plan for the Salinas River population	1	FWS*, DOD, COE, USFS, FHWA, EPA, BLM, BRD, CSPR, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CCC, CDC, SBECO, MONCO, SLOCO, SAL, SPRR	20			20			
2	1.123	Prepare management plan for the San Joaquin Valley population	1	FWS*, DOD, COE, USFS, FHWA, EPA, BLM, BRD, CSPR, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CCC, CDC	20			20			
2	1.124	Prepare management plan for the Sacramento Valley population	1	FWS*, DOD, COE, USFS, FHWA, EPA, BLM, BRD, CSPR, CRWQCB, CSWRCB, DOT, CDFG, CSLC, CCC, CDC	20			20			
2	1.3	Establish monitoring protocol	1	FWS	2	2					
2	1.411	Conduct annual monitoring in the Tijuana River population	5	FWS*, COE, DOJ	250	50	50	50	50	50	monitoring will be required annually and 5 years beyond delisting

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Recovery Plan Implementation Schedule for the Least Bell's Vireo.

Priority #	Task #	Task Description	Task Duration (Years)	Responsible or Associated Parties	Total Estimated Cost ($1000's)	Costs (1000s)					Comments
						FY 99	FY 00	FY 01	FY 02	FY 03	
2	1.412	Conduct annual monitoring in the Dulzura Creek/Jamul Creek/Otay River population	5	FWS*, FHWA, COE, BLM	250	50	50	50	50	50	
2	1.413	Conduct annual monitoring the Sweetwater River population	5	FWS*, FHWA, COE, BLM	250	50	50	50	50	50	
2	1.414	Conduct annual monitoring in the San Diego River population	5	FWS*, FHWA, COE	250	50	50	50	50	50	
2	1.415	Conduct annual monitoring in the San Luis Rey River population	5	FWS*, FHWA, COE, EPA, USFS	250	50	50	50	50	50	
2	1.416	Conduct annual monitoring in the Camp Pendleton/Santa Margarita River population	5	FWS*, DOD, EPA, COE, USFS	375	75	75	75	75	75	

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Recovery Plan Implementation Schedule for the Least Bell's Vireo.

Priority #	Task #	Task Description	Task Duration (Years)	Responsible or Associated Parties	Total Estimated Cost ($1000's)	Costs (1000s)					Comments
						FY 99	FY 00	FY 01	FY 02	FY 03	
2	1.417	Conduct annual monitoring in the Santa Ana River population	5	FWS*, COE, EPA, FHWA, OCWD, DOT	250	50	50	50	50	50	
2	1.418	Conduct annual monitoring in the Orange County/Los Angeles County population	5	FWS, COE, EPA, DOT							
2	1.419	Conduct annual monitoring in the Santa Clara River population	5	FWS*, COE, USFS, EPA	250	50	50	50	50	50	
2	1.420	Conduct annual monitoring in the Santa Ynez River population	5	FWS, DOD, USFS, USAF	100	20	20	20	20	20	
2	1.421	Conduct annual monitoring in the Anza Borrego Desert metapopulation	5	FWS, CSPR, BLM, DOD	250	50	50	50	50	50	
2	1.422	Conduct annual monitoring in the Salinas River population	Continuous	FWS, DOD, BLM, DOT	250	50	50	50	50	50	

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Recovery Plan Implementation Schedule for the Least Bell's Vireo.

Priority #	Task #	Task Description	Task Duration (Years)	Responsible or Associated Parties	Total Estimated Cost ($1000's)	Costs (1000s)					Comments
						FY 99	FY 00	FY 01	FY 02	FY 03	
2	1.423	Conduct annual monitoring in the San Joaquin Valley population	Continuous	FWS, BLM, DOT, COE,	250	50	50	50	50	50	
2	1.424	Conduct annual monitoring in the Sacramento Valley population	Continuous	FWS, BLM, DOT, COE, USAF	250	50	50	50	50	50	
2	1.6	Develop alternative means of controlling cowbird parasitism	3	FWS*, USDA, BLM, USFS, USMC, NAVY, DOT, COE, OCWD, SDCO, SD, RIVCO, SBCO	TBD						
2	2.1	Identify additional and potential habitat in historical range	3	FWS*, COE, CDFG, FHWA, BLM, CDSP, DOD	TBD			TBD	TBD	TBD	
2	1.2	Prepare management plans for areas identified in 2.1	1	TBD	TBD					TBD	
2	1.7	Control nonnative plant species	5	FWS*, USDA, FHWA, USMC, NAVY, COE, CDFG, USFS, CDSP DOT, OCWD, SDCO, RIVCO, RCP	500	100	100	100	100	100	Future costs to be determined if endowments are not established for the permanent monitoring and management of nonnative species

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Recovery Plan Implementation Schedule for the Least Bell's Vireo.

Priority #	Task #	Task Description	Task Duration (Years)	Responsible or Associated Parties	Total Estimated Cost ($1000's)	Costs (1000s)					Comments
						FY 99	FY 00	FY 01	FY 02	FY 03	
2	2.5	Develop biocontrol methods for *Arundo* and other nonnative plant species	4	FWS*, USDA, COE, CORNELL, IIBC, USMC, BR, OCWD	1200		500	300	200	200	
3	1.8	Establish perpetual endowments for cowbird and exotic plant control	Continuous	FWS	TBD						
3	2.11	Conduct a statewide inventory of riparian habitat	2	FWS*, BRD, EPA, COE, USFS, DOD	300		150	150			
3	2.12	Conduct rangewide surveys	5	FWS*, BRD	250	50	50	50	50	50	
3	2.2	Investigate the status of wintering habitat and identify current or potential threats	2	FWS*, BRD	630		30	200	200	200	
3	2.31	Continue color-banding to provide demographic and dispersal data	5	FWS*, BRD	50	10	10	10	10	10	

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Recovery Plan Implementation Schedule for the Least Bell's Vireo.

Priority #	Task #	Task Description	Task Duration (Years)	Responsible or Associated Parties	Total Estimated Cost ($1000's)	Costs (1000s)					Comments
						FY 99	FY 00	FY 01	FY 02	FY 03	
3	2.32	Determine relationships between population density and reproductive characteristics	3	FWS*, BRD	225		75	75	75		
3	2.33	Determine relationships between population density and dispersal	3	FWS*, BRD	225		75	75	75		
3	2.4	Investigate relationship between habitat characteristics and least Bell's vireos behaviors and access to necessary resources	3	FWS*, BRD	120		40	40	40		
3	3.1	Implement long-term monitoring of restored sites	Continuous	FWS, COE, DOD	80		20	20	20	20	
3	3.2	Develop improved restoration techniques	4	FWS, COE, BRD, USFS, BR	200		50	50	50	50	

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Recovery Plan Implementation Schedule for the Least Bell's Vireo.

Priority #	Task #	Task Description	Task Duration (Years)	Responsible or Associated Parties	Total Estimated Cost ($1000's)	Costs (1000s)					Comments
						FY 99	FY 00	FY 01	FY 02	FY 03	
3	3.3	Evaluate restoration efforts and effectiveness of methods used	3	FWS*, BRD, CDSP, USFS COE	150			50	50	50	
3	3.4	Conduct habitat restoration	Continuous	FWS, COE, BRD, USFS, BLM, DOD, USMC, NAVY	TBD	TBD	TBD	TBD	TBD	TBD	
3	5	Evaluate progress of recovery, management and recovery actions, and revise management plans	Continuous	FWS	150	30	30	30	30	30	
3	6	Provide public information and education	Continuous	FWS*, BRD, BLM, USFS	50	10	10	10	10	10	

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V. APPENDICES

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APPENDIX A. Numbers and Distribution of Least Bell's Vireos, 1986-1996: Number of Pairs (Territorial Males)

Site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
San Diego County											
Agua Caliente County Park	--	--	--	--	--	--	--	--	- (1)	--	- (2)
Agua Hedionda Creek	1 (1)	0 (0)	--	--	--	--	1 (2)	--	--	--	--
Alder Canyon	0 (0)	--	--	--	--	--	--	--	--	--	--
Aliso Creek	--	--	--	--	--	2 (2)	2 (2)	2 (5)[b]	- (9)[b]	6 (12)	10 (24)
Angelina Spring	--	--	--	--	--	--	--	--	--	- (0)	--
Borderfield	--	--	--	--	--	--	0 (1)	--	--	--	--
Borrego Palm Canyon	5 (7)	1 (2)	3 (6)	2 (4)	2 (4)	4 (4)	0+ (5)	? (5)	? (2)	? (3)	? (1)
Campbell Grade	--	--	--	--	--	--	--	? (18)	? (12)	? (12)	? (19)
Campo Creek	--	4 (5)	--	--	--	--	--	--	--	--	--
Canebrake Canyon	--	--	--	--	--	--	--	--	--	--	? (1)
Carmel Valley	0 (0)	0 (0)	--	--	--	--	--	--	--	--	--
Carrizo Creek	--	--	--	--	--	--	0 (3)	? (1)	0 (0)	--	? (1)
Carrizo Marsh	--	--	--	--	--	--	--	--	--	? (1)	? (1)
Cockleburr Canyon	--	--	--	--	--	--	--	--	--	--	0 (0)
Cottonwood Creek	0 (0)	--	--	--	3 (8)	--	--	--	--	--	--
Cougar Canyon	0 (0)	--	--	--	0 (0)	--	--	0 (0)	0 (0)	--	--
Coyote Creek	8 (9)	2 (8)	0+ (8)	10 (11)	7 (10)	12 (13)	? (17)	5 (18)	? (22)	? (14)	? (20)

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APPENDIX A. Numbers and Distribution of Least Bell's Vireos, 1986-1996: Number of Pairs (Territorial Males)

Site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Cristianitos Creek	--	--	--	--	--	--	--	--	0 (0)	0 (1)	4 (5)
Culp Valley	--	--	--	--	--	--	--	--	--	? (0)	? (0)
DeLuz Creek	1 (2)	0 (3)	2 (2)	1 (2)	0 (0)	1 (3)	2 (2)	? (3)	? (9)	17 (24)	24 (26)
Encinitas Creek	0 (0)	0 (0)	--	--	--	--	--	--	--	--	--
Fallbrook Creek	--	--	--	--	--	--	1 (1)	4 (10)[b]	- (28)	9 (11)	12 (16)
French Creek	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	- (1)[b]	? (4)	4 (7)	4 (10)
Hauser Creek	--	--	--	--	2 (3)	--	--	--	--	--	--
Hellhole Canyon	4 (5)	0 (1)	- (1)	1 (1)	2 (2)	0 (0)	0 (0)	--	--	? (0)	? (2)
Hidden Canyon	--	--	--	--	--	--	--	--	--	--	7 (10)
Horno Creek	--	--	--	--	--	--	--	--	0 (0)	0 (0)	0 (0)
Horse Canyon	--	--	--	--	--	--	--	0 (0)	? (1)	? (1)	? (0)
Indian Canyon	1 (1)	--	--	--	0 (0)	--	--	0 (0)	? (2)	--	--
Jamul/Dulzura Creeks	2 (8)	6 (11)	--	6 (10)	--	6 (9)	? (2)	7 (11)	4 (12)	--	23 (24)
Key's Creek	0 (0)	0 (0)	--	--	--	--	--	--	--	--	--
Kilo 1/Kilo 2 areas Camp Pendleton	--	--	--	--	--	--	--	--	--	--	2 (3)
Las Flores Creek	0 (0)	2 (4)	2 (3)	3 (4)	8 (8)	15 (19)	5 (9)	9 (59)[b]	? (50)	111 (125)	132 (148)
Lima/Mike/November areas Camp Pendleton	--	--	--	--	--	--	--	--	--	--	6 (6)

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APPENDIX A. Numbers and Distribution of Least Bell's Vireos, 1986-1996: Number of Pairs (Territorial Males)

Site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Live Oak Creek	0 (0)	--	--	--	--	--	--	--	--	--	--
Los Penasquitos	0 (0)	0 (0)	--	--	--	--	--	--	--	--	--
Moosa Creek	0 (0)	0 (0)	--	--	--	--	--	--	--	--	--
Newton Canyon	--	--	--	--	--	--	--	--	--	--	0 (3)
Otay River	--	--	--	--	--	--	1 (3)	1 (1)	4 (4)	--	--
Peterson Creek	0 (0)	--	--	--	--	--	--	--	--	--	--
Piedra de Lumbre Canyon	--	--	--	--	--	--	--	--	0 (0)	0 (1)	1 (1)
Pilgrim Creek	2 (5)	1 (4)	3 (3)	3 (8)	6 (10)	9 (14)	13 (13)	5 (20)[b]	? (28)	35 (44)	62 (69)[g]
Proctor Valley	--	--	--	--	--	--	--	--	1 (1)	--	--
Pueblitos Canyon	--	--	--	--	--	--	--	? (1)	--	? (1)	2 (2)
Roblar Creek	--	--	--	--	--	--	--	--	--	0 (0)	--
San Diego River											
MissionValley	0 (0)	0 (0)	? (1)	--	--	? (1)	2 (2)	--	--	3 (4)	10 (11)
Mission Trails-Padre Dam	0 (0)	? (2)	1 (1)	--	--	4+ (5)	1+ (5)	--	--	--	--
Padre Dam-Carlton Hills Blvd	19 (21)	21 (27)	28 (31)	25 (26)	24 (28)	27 (29)	24 (32)	28 (32)	32 (36)	37 (42)	30 (33+)[h]
Carlton Hills Blvd-Lakeside	? (6)	4 (5)	? (2)	0 (1)	0 (0)[c]	? (1)[c]	? (1)[c]	--	--	--	--
El Capitan	8 (8)	--	--	--	--	0 (0)	0 (0)	--	--	--	--

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APPENDIX A. Numbers and Distribution of Least Bell's Vireos, 1986-1996: Number of Pairs (Territorial Males)

Site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
San Felipe Creek	0 (1)	--	0+ (2+)	1+ (3)	--	--	2 (2)	2 (3)	--	4 (?)	--
San Luis Rey River											
Interstate 5-College	7 (9)	7 (9)	--	4 (6)	7 (11)	7 (9)	21 (26)	25 (31)	40 (54)	41 (52)	42 (50)
College-Gird Rd.	19 (19)	26 (32)[d]	38 (44)	25 (32)	27 (43)	35 (39)	54 (59)	62 (76)	68 (89)	75 (104)	70 (90)
Upstream of Gird Rd.	--	--	--	--	--	--	--	--	1 (10)	6 (10)	--
San Marcos Creek	0 (0)	0 (0)	--	--	--	--	--	--	--	--	--
San Mateo Creek	0 (0)	2 (3)	1 (1)	0 (0)	1 (1)	1 (1)	1 (2)	1 (4)[b]	? (5)[b]	11 (17)	44 (48)
San Onofre Creek	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (3)[b]	? (7)	7 (15)	22 (27)
Santa Margarita River											
Camp Pendleton	68 (98)	97 (127)	167 (81)	122 (142)	168 (186)	138+ (212)	? (194)	132 (319)[b]	84 (336)[b]	352 (426)	456 (523)
Fallbrook	--	--	--	--	--	--	--	--	--	--	2 -
Santa Ysabel/ San Dieguito River	3 (13)	5 (18)	--	4 (6)	10 (11)	9 (13)	17 (25)	21 (48)	31 (47)	--	--
Santa Ysabel/ Forest Service	--	--	--	--	--	--	4 (4)	--	--	--	--
Sentenac Canyon	4 (5)	1 (2)	--	1 (2)	0 (2)	2 (2)	? (5)	4 (8)	? (4)	? (12)	? (13)
Sheep Canyon	0 (0)	0 (1)	--	--	0 (1)	--	--	0 (0)	? (1)	--	--
Stage Coach Canyon	--	--	--	--	--	--	--	--	0 (0)	0 (0)	--

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APPENDIX A. Numbers and Distribution of Least Bell's Vireos, 1986-1996: Number of Pairs (Territorial Males)

Site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Sweetwater River											
Downstream of Reservoir	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	1 (1)	1 (1)	--	0 (0)
Reservoir-Rancho S. D. Golfcourse	48 (51)	60 (82)	54 (69)	40 (49)	41 (50)	36 (51)	49 (53)	50 (61)	29 + (41)[c]	29 (40)	33+ (51)
Upstream of Golfcourse	(1)	?(5)	--	--	--	--	? (4+)	--	--	--	3+ (3+)
Talone Lake	--	--	--	1 (2)	--	1 (1)	1 (3)	--	--	--	3 -
Tamarisk Grove	--	--	--	--	--	--	--	--	--	? (1)	? (0)
Tecolote Canyon	2 (3)	0 (0)	--	--	--	--	--	--	--	--	--
Tijuana River											
West of Dairymart Rd.	3 (5)	0+ (8)	0+ (3+)	3+ (5)	9 (13)	15 (22)	26 (27)	41 (49)	63 (79)	80 (112)	87 (134)
East of Dairymart Rd.	0 (0)	0 (0)	--	--	--	? (2)	--	--	--	2 (2)	2 (5)
Goat Canyon	--	--	--	--	--	--	2 (3)	2 (3)	1 (1)	0 (0)	1 (3)
Tecate Creek (Marron Valley)	--	--	--	--	--	--	0 (1)	--	--	--	--
Vallecito Creek	0+ (6)	0+ (7)	--	10 (10)	3+ (10)	3+ (9)	? (18)	? (8)	? (14)	? (23)	? (33)
Windmill Canyon	--	--	--	--	--	--	--	--	0 (0)	0 (0)	2 (2)
Yaqui Well	--	--	--	--	--	--	--	--	--	? (1)	? (1)
Orange County											

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APPENDIX A. Numbers and Distribution of Least Bell's Vireos, 1986-1996: Number of Pairs (Territorial Males)

Site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Anaheim Wetlands	--	--	--	--	--	--	--	--	--	--	- (1)
Aliso Creek	0 (1)	0 (0)	--	--	--	--	--	--	--	0 (1)	--
Arroyo Trabuco	--	--	--	--	--	0 (0)	--	--	--	--	--
Bonita Canyon/Creek	--	--	--	--	0+ (1)	1 (1)	1 (2)	1 (2)	3 (3)	1 (1)	0 (3)
Brea Dam	--	--	--	--	--	--	--	--	--	--	0 (1)
Canada Gobernadora	0 (0)	--	--	--	--	0 (0)	0 (0)	0 (2)	0 (0)	--	--
Carbon Canyon	--	--	--	--	--	--	--	--	--	--	1 (2)
Featherly Park	--	--	--	--	--	--	--	--	--	--	- (0)
Green River	--	--	--	--	--	--	--	--	--	--	- (0)
Huntington Beach Central Park	0 (1)[e]	--	--	--	0 (2)[e]	0 (0)	0 (0)	0 (0)	0 (1)	0 (1)[g]	0 (0)
Sand Canyon Wash Mason Park/Upstream of Reservoir	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	1 (1)	1 (1)	1 (1)	0 (4)	2 (7)
Peters Canyon Res.	--	--	--	--	--	0 (1)	0 (0)	--	1 (2)	1 (2)	1 (3)
Rattlesnake Res.	--	--	--	--	--	0 (1)	0 (0)	--	--	--	1 (2)
San Diego Creek	--	--	--	--	--	--	--	- (1)	1 (3)	0 (1)	0 (4)
San Joaquin Marsh	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	1 (2)	0 (2)
San Juan Creek	0 (0)	--	0 (0)	0 (0)	0 (0)	--	--	--	--	0 (1)	--

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APPENDIX A. Numbers and Distribution of Least Bell's Vireos, 1986-1996: Number of Pairs (Territorial Males)

Site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Santa Ana River (Gypsum Canyon)	0 (0)	0 (1)	0 (0)	0 (0)	--	--	--	0 (2)	--	0 (1)	1 (4)
Santiago Creek/Villa Park FCB/above Loma Street	0 (0)	--	--	0 (0)	0 (0)	1 (2)	0 (3)	1 (2)	0 (3)	0 (1)	1 (2)
Upper Newport Bay	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	0 (1)	0 (1)	0 (1)
Riverside County											
Andreas	2 (2)	3 (3)	--	--	0 (2)	--	--	--	--	--	--
Auld Valley	0 (0)	--	--	--	--	--	--	--	--	--	--
Bautista Creek	0 (0)	0 (0)	--	--	--	--	--	--	--	--	--
Chino Canyon	4 (4)	--	--	--	--	--	--	--	--	--	--
March Air Force Base (unnamed tributary west of Interstate-215)	--	--	--	--	--	--	--	1 (1)	0 (1)	--	--
Murrietta Creek	--	--	--	--	--	--	0 (1)	--	--	--	--
Murray Canyon	1 (2)	--	--	--	--	--	--	--	--	--	--
Oasis de los Osos	0 (0)	--	--	--	--	--	--	--	--	--	--
Palm Canyon	1 (1)	0 (1)	--	--	--	--	--	--	--	--	--
Potero Creek? (Beumont/Lockheed)	--	--	--	--	--	--	--	--	--	0 (0)	--
San Jacinto Creek	0 (0)	0 (0)	--	--	--	--	--	--	--	--	--
San Jacinto River (Route 74)	--	--	--	--	--	--	--	--	--	? (0)	--

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APPENDIX A. Numbers and Distribution of Least Bell's Vireos, 1986-1996: Number of Pairs (Territorial Males)

Site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Saint John's Canyon	0 (0)	0 (0)	--	--	--	--	--	--	--	--	--
San Timoteo	1 (3)	0 (1)	--	--	--	--	--	--	--	--	--
Santa Ana River											
Prado Basin[a]	19 (21)	20 (26)	30 (37)	31 (36)	42 (47)	64 (70)	99 (112)	123 (138)	149 (188)	164 (217)	195 (249)
Below Prado Dam	--	--	--	--	--	--	--	--	--	? (2+)	1 (4)
Temescal Wash	2 (3)	2 (3)	--	--	1 (1)	2 (3)	--	--	--	--	--
Hidden Valley	--	--	--	--	--	--	--	--	? (2)	1 (3)	2 (4)
Tonner Canyon	--	--	--	--	--	--	--	--	--	0 (0)	--
Warm Springs Valley (unnamed tributaries Lake Elsinore)	--	--	--	--	--	--	--	--	--	1 (1)	--
Whitewater Hole	0 (0)	0 (0)	--	--	--	--	--	--	--	--	--
Willow Hole	0 (0)	0 (1)	--	--	--	--	--	--	--	--	--
Wilson Creek	--	--	0 (1)	0 (1)	--	--	--	--	--	--	--
San Bernardino County											
Cajon Creek	--	--	--	--	0 (1)	--	--	--	--	--	--
Chino Creek	--	--	--	--	--	--	--	--	--	0 (1)	--
City Creek	--	--	--	--	--	--	--	--	--	0 (0)	--

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APPENDIX A. Numbers and Distribution of Least Bell's Vireos, 1986-1996: Number of Pairs (Territorial Males)

Site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
East Etiwanda Creek	--	--	--	--	--	--	1 (2)	--	--	--	--
Fort Paiute Creek	1 (1)	--	--	--	--	--	--	- (3)	0 (0)	--	--
Horsethief Creek	--	--	--	--	--	--	--	--	--	0 (0)	--
Los Serranos Channel	--	--	--	--	--	--	--	--	--	0 (1)	--
Mill Creek	--	--	--	--	--	--	--	--	--	0 (0)	--
Mojave River	0 (0)	--	--	0 (1)	--	--	--	--	--	0 (0)	0 (1)
Morongo Creek[f]	0 (1)	0 (1)	0 (1)	0 (1)	--	--	--	--	--	--	--
San Jacinto River	--	--	--	--	--	--	--	--	--	0 (0)	--
Santa Ana River	--	--	--	--	--	--	--	--	0 (1)	1 (1)	1 (1)
Wildhorse Canyon	--	--	--	--	--	--	--	? (2)	--	--	--
Los Angeles County											
Amargosa Creek (W of Palmdale)	--	--	--	--	--	--	--	--	- (1)	- (1)	--
Big Tujunga	--	--	--	--	--	--	0 (1)	--	--	0 (2)	--
Fish Canyon	0 (0)	--	--	--	--	--	--	--	--	--	--
Las Brisas Ranch	--	--	--	--	--	--	--	--	? (1)	--	--
San Francisquito	0 (1)	0 (1)	--	--	--	--	--	--	1 (1)	--	--
San Gabriel River	0 (0)	0 (0)	--	--	--	--	--	--	--	- (1)	- (1)
Santa Clara River	--	--	--	--	--	--	--	--	--	--	2 (4)

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APPENDIX A. Numbers and Distribution of Least Bell's Vireos, 1986-1996: Number of Pairs (Territorial Males)

Site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Van Norman Dam	0 (0)	0 (0)	--	--	--	--	--	--	--	--	--
Ventura County											
Arroyo Simi	0 (0)	0 (0)	--	--	--	--	1 (3)	1 (2)	- (1)	--	--
La Jolla Canyon	--	--	--	--	--	--	--	--	--	--	--
Piru Creek	0 (0)	0 (0)	--	--	--	--	--	--	--	--	--
San Antonio Creek	0 (0)	--	--	--	--	--	--	--	--	--	--
Santa Clara River	0+ (8)	0 (1)	--	--	--	12 (17)	14 (20)	22 (26)	25 (27)	30+ (34+)	40+ (44+)
Santa Paula	--	--	--	--	--	--	--	--	--	--	--
Ventura River	0 (0)	--	--	--	--	--	--	1 (2)	1 (2)	1 (1)	--
Santa Barbara County											
Cuyama River	0 (0)	--	--	--	--	--	--	- (1)	--	--	--

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APPENDIX A. Numbers and Distribution of Least Bell's Vireos, 1986-1996: Number of Pairs (Territorial Males)

Site	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Santa Ynez River											
Upper (Gibralter Res./Mono Creek/Agua Caliente Creek.)	~30 (57)	19 (32)	21 (23)	14 (20)	17 (22)	17 (20)	16 (20)	29 (31)	20+ (20+)	1+ -	2 + -
Lower (Buellton/Lompoc)	--	--	--	--	--	--	--	--	--	--	0 (2)
Inyo County											
Amargosa River	0 (0)	--	--	--	--	--	--	--	--	--	--
China Ranch Wash	1 (2)	2 (2)	--	--	--	--	--	--	? (1)	--	--
Scotty's Castle	--	--	--	--	--	--	--	--	? (1)	--	--
Tecopa	1 (2)	2 (2)	--	--	--	--	--	--	? (3)	--	--
Kern County											
South Fork Kern River	--	--	--	--	--	--	- (1)	--	- (1)	--	--
Monterey County											
Salinas River	2 (3)	0 (0)	--	--	--	--	--	--	--	--	--

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Legend:

- No data.
+ Indicates that actual number could have been higher (field surveys were incomplete or noncomprehensive).
? Number of pairs unknown.
~ Approximately.
a Prado Basin includes a small portion of San Bernardino County. See Riverside County data. 1970 to 1986 data include areas upstream and downstream from Prado Basin.
b Territorial male data include the following numbers of males reported as "status unknown."

Year	Site	Number
1993	Aliso Creek	1
1993	Fallbrook Creek	4
1993	French Creek	1
1993	Las Flores Creek	19
1993	Pilgrim Creek	6
1993	San Mateo Creek	2
1993	San Onofre Creek	1
1993	Santa Margarita River	80
1994	Aliso Creek	3
1994	San Mateo Creek	1
1994	Santa Margarita	101

c Indicates partial survey.
d College-Gird Rd. and Upstream of Gird data combined in 1987.
e Because of excellent coverage at this site, birds were known to be either migrants or wintering (winter of 1985-1986). Numbers not included in territorial male totals.
f Data for Big Morongo Creek and Little Morongo Creek combined after 1986.
g This data is for on and off Camp Pendleton, whereas most or all data for previous years is for on-base.
h This survey area is from Padre Dam to Mast Blvd, a smaller survey area then in previous years.

APPENDIX B: POPULATION VIABILITY ANALYSIS FOR THE LEAST BELL'S VIREO

The following discussion uses several terms from population ecology, which are defined here:

Population: a group of interbreeding organisms of a single species in a particular geographical area.

Metapopulation: "a collection of interacting populations of the same species" (Akcakaya and Ferson 1992).

Viable population: a population that "maintains its vigor and its potential for evolutionary adaptation" (Soulé 1987) and that "is self-sustaining with minimal demographic or genetic intervention over the long term" (Wilcox *et al.*1986). Within the context of modeling, a viable population is one that has some probability of surviving (avoiding extinction) over some period of time, where the probability of extinction and the time span are specified. In this plan, "viable population" refers to one with a probability of 5 percent or less of going extinct during a 100-year period.

Minimum viable population size: the minimum size that a population must achieve to avoid extinction and thus remain viable, as defined above.

Recruitment: addition of new members into a breeding population through production of offspring.

Productivity: production of offspring; usually expressed as the number of young produced per pair.

Predicting the future of an endangered species such as the least Bell's vireo requires considerable information on its life history, demography, and current abundance and distribution. At the core of population ecology, the discipline upon which such an exercise draws, are fundamental principles which describe how populations behave over time. Put simply, individuals are added to a population through the production of offspring and immigration into the population from outside, and are lost from the population as a result of mortality (death) and emigration out of the population. The net effect of these processes determines whether populations grow or decline in size over time. Central to any recovery plan is a determination of the population size trend for the species of interest, accompanied by an analysis of which of these processes has been altered to produce the trend. While the first determination is comparatively straightforward, the second is not.

The processes of birth, death, and migration, and consequently population size trends, are influenced by many factors. These have been condensed into four general categories which

describe the nature of factors creating a risk of extinction for endangered species (Shaffer 1981). Three of these are applicable to least Bell's vireos (the fourth pertains to species with mating systems not exhibited by the least Bell's vireo). ***Extrinsic forces*** include forces in the environment with which the species cannot contend. With regard to least Bell's vireos these include interactions with other organisms, such as exposure to brood parasitism by brown-headed cowbirds, a species with which the least Bell's vireo has not evolved, and possibly heightened rates of predation by native and non-native predators; random catastrophic events such as floods and droughts; and human-induced habitat loss and degradation. ***Demographic stochasticity*** refers to random events in the survival and reproduction of individuals in small populations, resulting in such problems as a skewed sex ratio leading to difficulty in finding a mate; total reproductive failure one year; death of the entire population, etc. ***Genetic deterioration*** can be both short-and long-term. Short-term genetic deterioration includes inbreeding depression, leading to reduced survival, skewed sex ratios and other problems, particularly in small populations. Long-term deterioration refers to the reduced ability of a population to adapt to environmental changes because of a loss of genetic variability. Both of these processes are linked to the amount of dispersal among populations of a species.

Increasingly, conservation biologists are using a tool called Population Viability Analysis (PVA) to project the future of populations or species. A PVA simulates the population's future given a set of current parameters describing birth, death, and migration, incorporating the complexities of the factors influencing these parameters. With this tool, investigators can ask questions such as "What is the probability that this population will go extinct within 20 years?", or "How long will it take for this population to reach 1000 individuals?", or "What effect on population growth rate would doubling the birth rate have?" A common goal of a PVA is to determine the conditions necessary for maintaining a viable population. A "viable population" is one capable of surviving (avoiding extinction) with some probability over some extended period of time. The term "viability" does not have universal meaning with regard to the time period involved or the acceptable probability of extinction; these must be specified based on the biology of the species of concern, and the context within which the PVA is being used.

Recovery plans are concerned with the management of species, and most species in nature occur in multiple populations. From the perspective of a recovery plan, then, a PVA must address not just the dynamics of individual populations, but the complex interactions among the populations as well. This is achieved by incorporating into the PVA information on the number of different populations, their geographic configuration, and the rate of migration between them.

A PVA was performed for the least Bell's vireo using RAMAS/Space (Akcakaya and Ferson 1992), a widely used modeling environment that allows the user to simulate population performance by inputting empirical and/or theoretical values for demographic parameters. Output of the simulations includes projections for each individual population as well as the network of populations, referred to as the metapopulation. Here, the term "metapopulation" is used for consistency with the terminology of the model, and is not meant to imply anything

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more than "a collection of interacting populations of the same species" (Akcakaya and Ferson 1992).

Empirical data used in the PVA were obtained from the results of long-term population monitoring conducted at eight major breeding sites in southern California, located at (from south to north) the Tijuana, Sweetwater, San Diego, San Luis Rey, West San Luis Rey, and Santa Margarita Rivers in San Diego County; the Santa Ana River in Riverside County, and the Santa Ynez River in Santa Barbara County (see Appendix C for site descriptions and sources of information). The sites were selected for analysis because (1) they supported the few remaining least Bell's vireo populations by the time the species was listed in 1986 and intensive monitoring and management initiated, (2) they have been monitored annually for from 5-15 consecutive years, and (3) long-term color-banding and resighting studies are being pursued at most sites. These attributes allow for analysis of least Bell's vireo population dynamics, demography and dispersal over a wide geographic area and a relatively long period of time. In 1994, these eight sites supported approximately 70 percent of the known least Bell's vireo population.

Empirical values were entered into the model parameters "R" (average population growth rate), standard deviation of R, density dependence, and migration rates between populations. These are discussed in turn below.

R: R symbolizes the average growth rate of a population, and is the proportion by which the population size changes each year. It is calculated as population size at time t+1/population size at time t. An R equal to 1.0 represents a stable population (neither growing nor declining). R greater than 1.0 represents a growing population, and less than 1.0 a declining population. Populations in which R is chronically less than 1.0 will eventually go extinct.

Most modeling exercises involving endangered species attempt to identify the conditions necessary to achieve an R of 1.0 or greater; that is, the model is used to specify values for demographic parameters needed to reverse an extinction-bound trend and achieve at a minimum a stable population. In simulating the least Bell's vireo metapopulation, this was not done. Analysis of the long-term data available for the eight core populations revealed average R's of greater than 1.0, indicating that reproductive output is currently adequate to maintain at least stable populations (Table 1).

Standard Deviation of R: The standard deviation of R is used to model fluctuations in the population growth rate from year to year, simulating the variability found in nature.

Density Dependence: Density dependence refers to the relationship between population growth and population size, and whether or not population growth is limited by any factors as a function of size. Populations that are density independent grow exponentially and are not limited by resources. Populations such as the least Bell's vireo, however, are eventually

limited by habitat availability and resources critical to survival and reproduction. A logistic model of density dependent growth was used in the simulations. By this model, as populations grow and approach the limit, or carrying capacity, of their environment, their rate of growth slows and approximates 1.0. At this point, the population is in a stable equilibrium unless disrupted by a change in the environment or some demographic parameter.

Simulation of density dependent growth requires specification of K, the carrying capacity, for each population. The value of K is not known for least Bell's vireo populations. A crude estimate can be obtained by dividing the total habitat base by the average least Bell's vireo territory size, but this assumes the habitat to be homogenous in quality and considers only one potentially limiting resource (space). Moreover, average territory size at the breeding areas it has been studied at has declined over the years as least Bell's vireo abundance has increased, indicating that the minimum threshold in territory size has not yet been achieved. As a conservative estimate, the population sizes at each site in 1994 were used as values for K to simulate density dependent growth. This allowed an assessment of the metapopulation's future under the assumption that all suitable habitat is currently occupied and no further population growth at these sites is possible (a worst case scenario). These values were then increased by 50 percent in a separate simulation to determine the sensitivity of the results to K.

Migration Rates: Migration, which includes dispersal of birds away from their natal sites and movement between populations by adults, was modeled using data from color-banded birds of known origin. Return rates to the natal site, as well as observations of birds at sites other than their natal sites, allowed calculation of the proportion a given population that migrated to each of the other populations in the metapopulation, and vice versa. Migration between populations was not symmetrical; that is, the migration rate from Population A to Population B was not equivalent to the migration rate from Population B to Population A. Rather, a northward bias was detected, with birds more likely to change drainages by moving north than by moving south.

Migration rates are probably underestimated, because they rely on thorough examination of all individuals in a population to detect banded birds, and then depend on accurate determination of the band combination of any banded birds located. Canvassing an entire population for banded birds is more feasible in small populations than in large ones, and even then, obtaining clear views of females can be challenging. The opportunity for resighting banded birds was beyond the scope of some projects, given the person-power and funding available for such an effort.

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Table 1. Empirical values used in least Bell's vireo PVA

Site	Average Growth Rate (R)	Standard Deviation of R	1994 Population Size (# males)
Tijuana River	1.60	0.33	80
Sweetwater River	1.05	0.25	61
San Diego River	1.08	0.13	36
San Luis Rey River	1.16	0.29	89
West San Luis Rey River	1.68	0.91	31[a]
Santa Margarita River	1.29	0.32	348
Santa Ana River	1.37	0.19	188
Santa Ynez River	1.02	0.27	31[a]

[a] *1993 data most recent available.*

To initiate the simulations, geographic coordinates are input for each site to establish spatial relationships, and initial population sizes specified. Population sizes during the first year of monitoring were used for these values, creating an opportunity to compare the results of the simulations with the past ten or so years of history. One hundred replications of each simulation were run, using a time frame of 100 years. Three questions were asked of the model:

1. What is the probability of extinction of the least Bell's vireo during the next 100 years?

The results of the simulations predict that the least Bell's vireo metapopulation as defined by the eight core sites has an extinction probability of zero during the next 100 years. Moreover, seven of the eight individual populations have extinction probabilities of zero over the same time period, indicating that they are unlikely to "blink out" and require re-colonization by migrants from another population. One population (at the Santa Ynez River), is at risk of extinction, however, as a result of small population size, a low rate of growth, and isolation from dispersers from other of the core populations, at least to the extent that such migration could be

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detected by observations of color-banded birds. The Santa Ynez population may in fact persist longer than predicted if it is experiencing immigration from other unknown or unbanded populations.

2. How long will it take for the least Bell's vireo population to reach carrying capacity?

The time required to reach carrying capacity, at which time the population becomes stable (R = 1.0) depended on the value of K input into the model. The metapopulation reached equilibrium within approximately 20 years when 1994 population sizes were used to estimate K; note that nearly half of this time has actually passed since the starting point of the simulations reflected population conditions during the mid-1980's. The time to achieve equilibrium for each of the seven individual populations that grew to carrying capacity ranged between 15 and 30 years, with a modal time of 20 years. One population, the Santa Margarita River, failed to reach the carrying capacity input into the model (348 pairs) and instead leveled off at approximately 220 pairs. This may be the result of overestimating migration away from the Santa Margarita by failing to detect birds remaining at their natal site, and of underestimating migration into the Santa Margarita population by a similar failure to detect color-banded immigrants.

When K is increased by 50 percent, the time to achieve equilibrium for the metapopulation increased from 20 years to 28 years, or by 40 percent (Figure 2). The differences for the individual populations ranged from zero to 30 percent (Figure 2).

3. What is the effect of migration rate on the time required to reach carrying capacity?

Migration rate was varied holding K constant at the larger of the two estimates, producing the result that time to achieve equilibrium under higher migration was virtually unchanged for those populations currently experiencing low migration rates, and increased for those with high rates, particularly those with emigration (migration out of the population) rates higher than immigration (migration into the populations), such as the San Diego and San Luis Rey Rivers (Figure 3). An exception to this was the Santa Margarita River, for which the simulations predicted a reduction in the time to achieve stability. This may be because the simulations also predicted a lower equilibrium population size at the Santa Margarita under conditions of higher migration.

Conclusions

The following conclusions are drawn from this modeling exercise:

1. Under current conditions, the least Bell's vireo is not at risk of extinction.

2. One population at the Santa Ynez River is at risk of extinction as a result of a low reproductive rate and no detectable migration into the population. However, this population should continue to be managed to preserve it as a "stepping stone" for future colonization to the north, and because establishment of breeding populations in the vicinity of the Santa Ynez River, such as those at the Ventura and Santa Clara Rivers, may facilitate migration into the population and provide a "rescue effect" from local extinction.

3. Although carrying capacity and hence potential maximum population size for the least Bell's vireo is not known at this time, at current rates of growth, least Bell's vireo populations have the capacity to achieve conservative estimates of carrying capacity within 20 years. In fact, least Bell's vireo at some sites, such as the Santa Margarita River, appear to be "out-performing" the simulations in actual population growth, achieving the predicted maxima rather than the averages.

4. Migration rates among populations influence the time required to achieve carrying capacity for those populations with a comparatively high rate of emigration. However, for a 50 percent increase in migration rate, time to reach equilibrium increases by less than ten years, a remarkably short period of time within the context of endangered species management. Further study is needed to improve estimates of migration among the eight core populations as well as other populations throughout the range of the least Bell's vireo.

APPENDIX C: SOURCES OF INFORMATION FOR THE POPULATION VIABILITY MODEL

Tijuana River:	RECON 1989; Kus 1990c; 1991e; 1992c,d; 1993d;1994b.
Sweetwater River:	Jones 1985b; Collier and Jones 1989; Kus and Collier 1988; Kus 1989b;Kus 1990b; Kus 1992b; Kus 1993b.
San Diego River:	Jones 1985; RECON 1989; Kus 1989a; Kus 1990a,b; Kus 1992a; Kus 1994a; Kus 1995a.
San Luis Rey River:	Jones 1985; RECON 1989; Kus 1989c,d; Kus 1991a; Kus 1993b; Kus 1995b.
West San Luis Rey River:	Jones 1985; RECON 1989; Kus 1989e; Kus 1991b,d; Kus 1992e; Kus 1993c; Griffith and Griffith 1995.
Santa Margarita River:	Salata 1980; Salata 1981; Salata 1982; Salata 1983; Salata 1984; Salata 1986; Salata 1987; Jones 1989a; Griffith and Griffith 1990a,b; Griffith and Griffith 1991; Sweetwater Environmental Biologists 1992a; USFWS 1994; USFWS 1995.
Santa Ana River:	USFWS 1986; Hays 1986; Hays 1987; Hays 1988; Hays 1989; Hays and Corey 1991; Pike and Hays 1992a,b; Pike and Hays 1993; Pike 1994.
Santa Ynez River:	RECON 1989; Greaves 1991; Greaves 1992; Greaves 1993; Greaves 1994.