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Prioritizing Sites along the Santa Clara River for Conservation of Threatened and Endangered Species

A Group Project submitted in partial satisfaction of the requirements for the degree of Master's in Environmental Science and Management

for the

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Signature Page

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Abstract

The Santa Clara River is one of the few rivers in southern California where continuous stretches of riparian habitat persist. Although the expansion of agriculture and urban development has reduced the extent of riparian habitat, these areas continue to support a number of threatened and endangered species. As a result of a 1994 oil spill, a trustee council was formed to appropriate a $7.1 million settlement for the acquisition and future restoration of land along the Santa Clara River. The Trustee Council requested our assistance in determining which parcels of land would be most appropriate for acquisition.

Combining a Geographic Information System (GIS) with a computer-aided site selection model, we evaluated parcels for the conservation of potential habitat for eight threatened and endangered species. All the parcels were within the 500-year floodplain of the Santa Clara River. Criteria used to assess these sites included the amount and contiguity of habitat, as well as the cost of land.

Based upon an analysis of the model results, we recommended 38 parcels, clustered in two areas of the river, for purchase. The area of these parcels totaled approximately 2000 acres. It is hoped that our results and recommendations will not only provide guidelines for the conservation of riparian habitat along the Santa Clara River, but will also provide a framework for others faced with the challenge of prioritizing land for acquisition.

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Executive Summary

As a result of a 1994 oil spill, a $7.1 million settlement was agreed upon as compensation for damages to natural resources along the Santa Clara River. A Trustee Council was formed to disburse the funds for habitat protection and/or restoration of areas within the Santa Clara River watershed that would benefit threatened and endangered species. The trustee council requested our assistance in identifying ecologically significant sites for acquisition. Our goal is to provide assistance to the Trustee Council in the form of recommendations for the purchase of sites along the Santa Clara River for the purpose of riparian ecosystem conservation. We determined which parcels of land would be most appropriate for these purposes based on the amount of habitat provided for threatened and/or endangered species, the contiguity of the selected sites, the cost of the parcels, and the compatibility with the surrounding landscape.

Riparian habitats are among the most ecologically productive and diverse environments, and have undergone serious decline during the last several decades due to water diversions and increased development within the floodplain. The Santa Clara River is one of the last remaining free-flowing rivers in Southern California. It flows for approximately 100 miles from Pacifico Mountain in the San Gabriel Mountains to the Pacific Ocean, and drains a total area of about 1,630 miles. Its watershed contains various native habitat types including chaparral, coastal sage scrub, and oak woodlands in the uplands, cottonwood/willow riparian forests on the upper terraces above the streambed, and riparian scrubs on the lower terraces of the streambed.

The distribution of native habitat along the Santa Clara River has been altered as a result of human disturbance. Population growth has led directly to an increased use of the floodplain, as well as an ever-increasing demand for water. Urban and suburban development, agriculture, and invasion by exotic plants have reduced the extent of riparian vegetation and resulted in the fragmentation of remaining habitat areas. In these scattered patches, however, wildlife still flourishes. These habitats provide areas for nesting and foraging for a variety of sensitive, threatened and endangered animal species. Of the 35 sensitive species that inhabit the area, 14 are considered threatened or endangered by State and/or Federal agencies.

We defined our conservation goal as the maximization of potential habitat for eight threatened and endangered species: the least Bell's vireo, the southwestern willow flycatcher, the unarmored three-spine stickleback, the arroyo toad, the California red-legged frog, the tidewater goby, the western snowy plover, and the least tern. The cost of land was also considered since the amount of habitat to be purchased was limited by available funds. Thus, the distribution of species habitat and the cost of land parcels were combined in a Geographic Information System (GIS) and a computer-aided site selection model to prioritize parcels and highlight critical areas that should be protected.

We used land parcel boundaries as planning units for our analysis. The analysis was confined to parcels within the 500-year floodplain, where the distribution of riparian habitat is more abundant and the ecological value of the land for species conservation is greater. The study area was further limited by considering only those parcels in Ventura County.

We used the GIS database developed by the Santa Clara River Enhancement and Management Plan (SCREMP), which contained coverages such as parcel boundaries, floodplain boundaries, riparian habitat distribution and potential distribution for threatened and endangered species. The amount of species habitat in each parcel was quantified by overlapping the species distribution coverages with the parcel coverage. Aerial photos were used to interpret land use changes along the Santa Clara River. By overlaying the photos with the GIS coverages, we were able to assess the effects of increased agricultural development on riparian habitat over the past 50 years. To estimate the cost of each parcel, we collected data on the assessed value for each parcel and the year in which the parcel was assessed from the Ventura County Assessor's Office. For each of seven land uses, we ran a regression of assessed land value per square foot versus the year of assessment. These results were used to estimate the price of each parcel in the year 2000.

Due to our time constraints and funding limitations, we chose to use an existing site-selection model to represent our objectives, rather than develop our own. We chose SITES, a site-selection model written by Ian Ball and Hugh Possingham for The Nature Conservancy. SITES uses a heuristic procedure, known as "simulated annealing", for making selections that attempt to meet stated, quantitative conservation goals as efficiently as possible. "Simulated annealing" is an iterative process in which entire reserve systems are evaluated and compared to identify a good solution. In this process, each reserve system is evaluated based on the constraints and the goals defined by the user. In our analysis, the goals were amounts of habitat for eight species. The constraints were the costs of land and the contiguity of the selected sites. Thus, we entered the following data into the model: the amounts of different types of habitat within each parcel, the costs of each parcel, and the connectivity of each parcel to other parcels. We also specified a cost threshold, which limited the number of sites chosen, and a boundary modifier, which determined the importance of contiguity in the selection process. As a comparison to the SITES model, we set up a simple linear maximization of habitat in Microsoft Excel.

Of the 1,067 parcels in our study area, 282 contained endangered species' habitat. SITES selected 44 parcels for $8 million and an additional 37 parcels for $16 million.. These results were corroborated by the linear maximization. Eighty percent of the parcels chosen by SITES for $8 million were also chosen by the linear maximization, and 90% of the parcels chosen by SITES for $16 million were chosen by the linear maximization. Furthermore, 98% (44 out of 45) of the parcels chosen by the SITES $8 million scenario were also chosen by the linear maximization for $16 million. These results strongly support the selection of parcels made by SITES. Many of the selected parcels are adjacent to other selected parcels, creating a series of clusters. This natural clustering is driven by the distribution of habitat and cost values. Ten clusters and six lone parcels were identified. The parcels chosen using SITES provide a general picture of the possibilities for acquisition along the Santa Clara River. By using aerial photographs and the GIS database, the SITES results were further evaluated and verified within the context of surrounding land uses, levels of disturbance, and exotic species presence at both the parcel and landscape level. As a result, two areas were deemed priority sites for acquisition.

Of the 81 parcels identified by SITES, we recommended two areas for acquisition. The first area is located between the cities of Santa Paula and Fillmore and is significant for several reasons. Along this section of the river, agriculture is further back from the edge of the river and the presence of undeveloped upland areas allows for the formation of seasonal pools. It is the only cluster that contains habitat for five of the endangered species (stickleback, vireo, flycatcher, frog, and toad). Almost all (94%) of the red-legged frog habitat is in this cluster. Its proximity to the confluence of Sespe Creek offers an important connection to upland systems and a migration corridor for endangered species. The second area is located near the Ventura/ Los Angeles County line. It has a high percentage of riparian scrub and woodland habitats and low amounts of giant cane. The amount of potential endangered species' habitat is relatively high. The mountains to the south of this cluster are a source of ephemeral streams, which provide a connection to upland isolated environments.

The conservation of the recommended areas is only one step in what should be a multifaceted effort. If riparian conservation is to be effective, acquisition must be coupled with restoration, management, long-term monitoring, and public education. We hope that our project will serve as a foundation for riparian conservation along the Santa Clara River.

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I Project Objectives and Significance

History of Project

On January 17, 1994, a magnitude 6.8 earthquake in the Los Angeles area caused an oil pipeline owned by the ARCO Pipe Line Company (APL) to rupture in at least eight locations. The ruptures resulted in the discharge of crude oil onto nearby lands and water. The largest spill, approximately 190,000 gallons of crude oil, occurred at APL's Newhall Pump Station near the city of Santa Clarita, CA. A portion of the oil flowed down a roadway, into an open drainage ditch, and eventually into the Santa Clara River. The oil continued to flow approximately sixteen miles downstream to Piru where a dam was constructed to halt further spread of the oil (United States and State of California v. ARCO Pipe Line Company 1997).

As required under the Oil Pollution Act (33 U.S.C. §§ 2701 et seq.), a Natural Resource Damage Assessment was performed in order to assess the injuries to natural resources. Approximately 100 acres of woody and herbaceous vegetation, as well as 150 acres of river sediments, were impacted by the spill and its subsequent cleanup operations. Cleanup operations included removing oiled vegetation along the riparian corridor, excavating soil and sediment, backfilling, and grading the riverbed (Memorandum of Understanding Between CDFG and USFWS 1997; United States and State of California v. ARCO Pipe Line Company 1997). The spill and the cleanup operations resulted in injury to fish, including the arroyo chub (*Gila orcutti*) and the federally endangered unarmored three-spine stickleback (*Gasterosteus aculeatus williamsoni*), as well as injury to a number of wildlife species and riparian vegetation, including critical habitat for the federally endangered least Bell's vireo (*Vireo bellii pusillus*) (Memorandum of Understanding Between CDFG and USFWS 1997; United States and State of California v. ARCO Pipe Line Company 1997).

The natural resource damage was translated into a monetary value that reflected an amount reasonable and necessary to restore the injured resources. The California Department of Fish and Game (CDFG) and the U.S. Fish and Wildlife Service (USFWS) reached a settlement with the APL in lieu of a trial. APL was instructed to pay the sum of $7.1 million in compensatory damages for the "natural resource damages related to the earthquake-related oil spills" (United States and State of California v. ARCO Pipe Line Company 1997).

After the settlement, a Trustee Council was formed, composed of representatives from USFWS and CDFG. The Trustee Council was required to use the settlement funds for habitat rehabilitation, revegetation, and/or protection of areas within the Santa Clara River watershed, and wildlife projects that will benefit the endangered and threatened species in and along the Santa Clara River (United States and State of California v. ARCO Pipe Line Company 1997). One of the Trustee Council's original focuses was on the purchase of land along the river, either outright or through conservation easements.

Objectives of Project

The goal of this project was to provide assistance to the Trustee Council in the form of recommendations for the purchase of sites along the Santa Clara River. We determined which parcels of land would be most appropriate for these purposes based on the amount of habitat for threatened and/or endangered species, the contiguity of the selected sites, the cost of the parcels, and the surrounding landscape. Specifically, we provided lists of land parcels along the Santa Clara River that offer the greatest potential conservation value subject to the monetary constraint of the settlement. We also provided a list of parcels that are prioritized in terms of their conservation value, regardless of cost. This allowed us to identify parcels that have a great deal of habitat, but may have been overlooked because of their estimated cost.

Significance

Riparian habitats are among the most ecologically productive and diverse environments. The strong land-water ecotone creates moisture gradients that lead to a diversity of physical environments. Dynamic river changes create a mosaic of habitats and microhabitats. Riparian zones are especially important in semi-arid regions where the availability of moisture and the associated microclimate give these habitats an ecological importance disproportionate to their areal extent (Kondolf et al 1996; Zaleweski et al. 1998). Avian densities and species richness in riparian systems demonstrate the importance of these habitats to birds (Franzreb 1987).

Riparian habitat in the southwestern United States has undergone serious decline during the last several decades (Kus 1998). The Santa Clara River is one of the last remaining free-flowing rivers in Southern California (SCR Project Steering Committee 1996). Urban and suburban development, agriculture, and invasion by exotic plants have all reduced the extent of riparian vegetation and its accompanying wildlife. This project is an important step towards protecting some of this critical environment.

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II Environmental Setting

Natural History

The Santa Clara River, from its headwaters at Pacifico Mountain in the San Gabriel Mountains to its mouth at the Pacific Ocean, drains a total area of about 1,630 square miles (ACOE 1973). The river flows in an east-west direction for approximately 100 miles and is fed by several streams flowing south out of the San Rafael Mountains. The main tributary streams include Santa Paula Creek, Sespe Creek, Hopper Creek, and Piru Creek in Ventura County, and Castaic Creek, Bouquet Canyon Creek, and San Francisquito Creek in Los Angeles County. Its watershed contains various native habitat types. These include chaparral, coastal sage scrub, and oak woodlands in the uplands, cottonwood/willow riparian forests on upper terraces above the streambed, riparian scrubs on the lower terraces of the streambed, freshwater marsh on undisturbed depressions along the banks, and foredune and alkali marsh near the coastal regions (SCR Project Steering Committee 1996).

The distribution of native habitat along the Santa Clara River has been altered as a result of human disturbance. Introduction of non-native species and encroachment into the floodplain have resulted in the loss of habitat and the fragmentation of remaining habitat areas. For centuries, the indigenous Chumash and Tataviam people lived along the river with very little impact on the riparian system. In the 1800s, the Spaniards brought increased agricultural activity and large-scale cattle ranching to the area. Since then, the expansion of agriculture and the establishment of oil enterprises have further put demands on the river. Population growth has led directly to an increased use of the floodplain, as well as an ever-increasing demand for water (SCR Project Steering Committee 1996). A comparison of aerial photos of the lower part of the river from 1927, 1941, 1969 and 1979 shows that much of the middle and upper terrace zones had already been converted to agriculture by 1927 (Fairchild Aerial Photograph Collection, as cited in Faber et al. 1989). The distribution and extent of riparian woodlands have not diminished markedly over the last 50 years. However, activities such as off road vehicles, mining, floods and urban development have resulted in thinning and fragmentation of these woodlands.

The major difference in the nature of the river between 1927 and today is the current absence of riparian thickets on the floodplain. These thickets, consisting of mule fat *(Baccharis salicifolia*) and willow (*Salix* spp.) with a diverse understory of native vines such as poison oak (*Toxicodendron diversilobun*) and blackberry (*Rubus ursinus*), were once characteristic of the entire riverbed (Faber et al. 1989).

Flooding Characteristics and History

Three types of storms produce precipitation in the Santa Clara River watershed: general winter storms, thunderstorms, and tropical storms. The general winter storms usually occur from November through April and cause most of the major floods in the area. Thunderstorms can occur anytime and can cause high intensity precipitation within a short period of time (six hours or less). Tropical storms tend to occur in the late summer, but have not resulted in any major-recorded floods.

Streamflow in the Santa Clara River is negligible other than during and immediately after rains because climatic and basin characteristics are not conducive to continuous runoff (ACOE 1973). This is typical of the majority of southern California river basins. Additionally, streamflow is seasonal with the flow diminishing rapidly at the end of the winter rainy season.

Damaging floods have been recorded for the Santa Clara River for over 100 years. Records of river stage and discharge have been maintained since the U.S. Geological Survey began observations in 1911 by using a staff gage on Sespe Creek near the City of Fillmore (ACOE 1973). Based on stream-gage records, newspaper accounts, and field investigations, the majority of the large floods in the Santa Clara River basin resulted in washed out bridges, roads and orchards.

Biological Resources

Between 95 and 97 percent of riparian habitat within floodplain areas has been lost in southern California (Faber et al. 1989). This is mainly due to channelization or damming of these riparian systems in order to allow development on the floodplain. Although these activities are minimal along the Santa Clara River, agriculture and urban development have fragmented the existing riparian areas. In these scattered patches, however, wildlife still flourish (SCR Project Steering Committee 1996). The following section briefly describes the vegetation and wildlife that currently exist on the river.

Vegetation

The riparian zone along the Santa Clara River can be divided into several distinct habitat types based on the dominant species within each habitat. These plant community names follow those proposed by Holland (1986). Mule fat scrub, southern willow scrub, southern willow riparian woodland, southern cottonwood/willow forest, arrow weed scrub, alluvial scrub, and big sagebrush scrub are the dominant riparian communities located on the upper and lower terraces of the active channel. Areas that are saturated for prolonged periods of time support valley freshwater marshes and ponds. Near the mouth of the river are alkali marsh and foredune habitats. Nonriparian communities adjacent to the Santa Clara River include coastal sage scrub, chamise chaparral, and coast live oak woodland. These habitats provide areas for nesting and foraging for a variety of sensitive, threatened and endangered animal species. See Appendix A for a list of the habitat types and their associated plant species (SCR Project Steering Committee 1996) and Appendix B for a description of the habitat types.

Wildlife

Many sensitive, threatened and endangered species are supported by the previously mentioned native habitats. Whether migratory or year round residents, all of them depend on riparian habitat for survival. Thus, conservation of these habitat types would help prevent further declines in native populations of riparian-dependent plants and animals.

We developed a table of the Santa Clara River's sensitive species based upon information provided by the U.S. Fish and Wildlife service and the Santa Clara River Enhancement and Management Plan Study (SCR Project Steering Committee 1996), in addition to a database search in the Natural Diversity Data Base (NDDB). Sensitive, in this document, refers to those species that are listed as endangered or threatened by state or federal agencies, species that are proposed for listing by state or federal agencies and/or species considered rare or of special concern by other agencies or organizations. A total of 5 fish, 2 amphibians, 4 reptiles, 17 birds, 3 mammals, and 4 plants were identified as sensitive and occurring or having the potential to occur within the study area. Potential habitat that exists along the Santa Clara River was also identified for these species (SCR Project Steering Committee 1996). See Appendix C for the list of sensitive species and their potential habitat.

One of the tasks for this study was to identify riparian habitat associated with threatened and endangered species. Of the 35 species identified as sensitive, 14 are considered threatened or endangered by State and/or Federal agencies. For reasons discussed in the Methods Section, eight out of the 14 species were utilized in our analysis. A literature search was conducted for each species, and the information was compiled and summarized in Appendix D. The following are brief descriptions of the eight species.

Tidewater goby – *Eucyclogius newberryi*

The tidewater goby is federally endangered. This species is discontinuously distributed throughout California, from Del Norte County to San Diego County. Before 1900, the tidewater goby occurred in at least 87 of California's coastal lagoons. Since then, it has disappeared from approximately 50 percent of formerly occupied lagoons (Brewer et al. 1994).

The tidewater goby is benthic, and is restricted mostly to coastal lagoons and near stream mouths in the uppermost brackish portions of larger bays (Lee 1980, as cited in SCR Project Steering Committee 1996). Mollusks, insects, and crustaceans are food sources for the tidewater goby (Brewer et al 1994).

Poor water quality and loss of habitat due to urbanization are the major threats to tidewater goby populations (SCR Project Steering Committee 1996). Sightings were reported in 1984 in the Santa Clara River, from the mouth to 3 miles upstream (SCR Project Steering Committee 1996).

Unarmored threespine stickleback – *Gasterosteus aculeatus williamsoni*

The unarmored threespine stickleback is a federal and state listed endangered species. Historically, it is believed that this species occurred in the drainages of the Santa Clara River, the Los Angeles River, the San Gabriel River, and the Santa Ana River (Haglund 1989, as cited in SCR Project Steering Committee 1996). This species is now restricted to the Santa Clara River above the confluence of Piru Creek.

The threespine stickleback prefers calm water, often living in weedy pools and backwaters, or among emergent plants at stream edges, or over bottoms of sand and mud. It is usually never found in water with temperatures over 23° Celsius. The stickleback avoids cloudy waters because they are visual feeders preferring bottom organisms that live on aquatic plants (Tamagni 1995).

Populations of the stickleback are threatened by stream channelization, urbanization, agricultural development, water diversions, groundwater pumping, introduction of predators and competitors, off-highway vehicle use, and oil spills (State of California 1992, as cited in SCR Project Steering Committee 1996).

Several sightings of the unarmored threespine stickleback have been reported along the Santa Clara River (see Appendix D). Potential habitat occurs in appropriate portions of the low-flow channel from the confluence of the river with Piru Creek to the Los Angeles aqueduct crossing upstream from Bouquet Canyon Road (SCR Project Steering Committee 1996).

Arroyo Toad - *Bufo microscaphus californicus*

The arroyo toad is a federally listed endangered species. It lives in rivers that have shallow, gravelly pools adjacent to sandy terraces. Both juveniles and adults are insectivores (Sweet 1992).

The arroyo toad was formerly found on rivers with near-perennial flow throughout southern California from San Luis Obispo County to San Diego County. Today, populations persist in Santa Barbara, Ventura, Los Angeles, Riverside, and San Diego Counties. Both Sespe and Piru Creeks, which drain into the Santa Clara River, contain populations of arroyo toad (Sweet 1992).

Virtually all remaining populations are small and face a variety of immediate threats to their continued viability. These threats include: short- and long-term changes in river hydrology due to construction of dams and water diversions; alteration of riparian wetland habitats by agriculture and urbanization; construction of roads; site-specific damage by off-highway vehicle use; development of campgrounds and other recreational activities; over-grazing; and mining activities.

Potential habitat for the arroyo toad occurs in the Sespe and Piru Creeks, the active channel and riparian woodlands/forest from the Los Angeles County line east to Interstate 5, as well as the active channel and riparian woodlands/forest from the mouth of Soledad Canyon east to Acton (SCR Project Steering Committee 1996).

California red-legged frog – *Rana aurora draytonii*

The California red-legged frog is a federally threatened species. Its historical range extended from Marin and Shasta Counties in California, south to Baja California, Mexico. Today the red-legged frog has disappeared from over 90 percent of its original range (Jennings and Hayes 1994). It is known to occur in about 240 streams or drainages primarily in Monterey, Santa Barbara, and San Luis Obispo Counties.

Preferred habitat for adult frogs is characterized by dense, shrubby or emergent riparian vegetation closely associated with deep still- or slow-moving waters (Jennings and Hayes 1994). The most suitable habitat is commonly composed of arroyo willow, but cattails (*Typha* sp.) and bulrushes (*Scirpus* sp.) are also suitable (Jennings and Hayes, 1994).

The diet of California red-legged frogs is extremely variable. Adults eat invertebrates, small tree frogs and mammals, while larvae are thought to feed on algae (Jennings and Hayes 1994).

Current threats to red-legged frog survival include agriculture, urban development, reservoir construction, exotic predators, grazing, and drought. Clearing of creek-bed vegetation and the creation of concrete banks, as well as other forms of water-diversion associated with development, threaten the frog's breeding habitats.

Habitat for the red-legged frog along the Santa Clara River is scarce due to the lack of vegetation necessary to shade ponds and pools in the low flow channel. A few small freshwater marsh areas on the floodplain, as well as the river reach in

Soledad Canyon and east of Acton in Los Angeles County, may serve as potential habitat for the species (SCR Project Steering Committee 1996).

California Least Tern - *Sterna antillarum browni*

The California least tern is a federal and state listed endangered species. This species nests each spring and summer close to estuaries and coastal lagoons, and on sandy beaches and playas, from San Francisco Bay south into Baja California, Mexico (Palacios and Mellink 1996; Caffrey 1996). It winters along the coasts of western Mexico, south to northern South America (King 1981, as cited in García and Ceballos 1995). Least terns are opportunistic feeders known to capture more than 50 species of fish.

Numerous threats have affected the least tern populations. Predation is the major factor constraining the fledging of terns across California (Caffrey 1996). In addition, disturbance and degradation of nesting sites has led to its population decline (Palacios and Mellink 1996). Current conservation efforts should focus on the reduction of impacts from recreational activities and on the preservation of the coastal habitats on which the species depends (Palacios and Mellink 1996).

The Santa Clara River is an area in which terns have returned to breed after their absence for variable periods of time (Caffrey 1996). Potential habitat along the Santa Clara River occurs at the mouth.

Least Bell's Vireo – *Vireo bellii pusillus*

The least Bell's vireo, one of the four subspecies of Bell's vireo, is a federally and state listed endangered species and only occurs in coastal California. This subspecies arrives at its breeding grounds in southern California and northern Baja California, Mexico around mid-March to early-April, and departs by mid to late September to winter in southern Baja, California. Its preferred habitat is dense willow dominated riparian areas with a lush understory. The least Bell's vireo is insectivorous (Steinitz et al. 1997).

Loss of riparian habitat and increased parasitism by the brown-headed cowbird (*Molothrus ater*) are two main reasons for the decline in numbers of the least Bell's vireo. Protection of riparian habitat, habitat creation and enhancement projects, and brown-headed cowbird removal has resulted in significant increase in the region's least Bell's vireo population (USFWS 1995, as cited in SCR Project Steering Committee 1996).

Recorded occurrences of the least Bell's vireo on the Santa Clara River stretch from Saticoy east to Santa Clarita (SCR Project Steering Committee 1996). Potential habitat occurs in areas that support southern willow scrub and southern willow riparian woodland (SCR Project Steering Committee 1996).

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Southwestern Willow Flycatcher – *Empidonax trailii extimus*

The southwestern willow flycatcher is a federally and state listed endangered species. This species is present in its breeding range, which includes southern California, southern Utah, Arizona, New Mexico and western Texas, from late April until August or September. It then migrates to its wintering grounds, most likely in Mexico, Central America and perhaps northern South America (SCR Project Steering Committee 1996). Historically, the southwestern willow flycatcher was present in all lowland riparian areas of the southern third of California. Today, approximately 10 nesting groups exist in California, all of which consist of six or fewer nesting pairs.

Habitat requirements for the southwestern willow flycatcher include riparian areas along rivers, streams and wetlands where dense growths of willows, arrowweed, buttonbush, tamarisk, Russian olive and a scattered overstory of cottonwood are present (Federal Register 1995a). The willow flycatcher is an insectivorous bird that forages within and above dense riparian vegetation.

The decline of the southwestern willow flycatcher has resulted from the loss or degradation of riparian habitats due to urban and agricultural development, water diversion and impoundment, channelization, invasion by non-native species, and livestock grazing. This degradation attracts brown-headed cowbirds, which parasitize willow flycatcher nests (Sogge et al. 1997).

No recorded instances of breeding by the southwestern willow flycatcher have been documented along the Santa Clara River (SCR Project Steering Committee 1996). However, potential breeding habitat for the species occurs in the mature willow woodlands and cottonwood/willow riparian forests, particularly in Los Angeles County (SCR Project Steering Committee 1996).

Western Snowy Plover - *Charadrius alexandrinus nivosus*

The western snowy plover is a federally threatened species. Sand spits, dune-backed beaches, unvegetated beach strands, open areas around estuaries, and beaches at river mouths are the preferred coastal habitats for nesting and for wintering (SCR Project Steering Committee 1996). The snowy plover uses a variety of sites for foraging and loafing, including mudflats of San Diego Bay and other coastal lagoons, and sandy beaches associated with river mouths and lagoons. It feeds almost exclusively on insects and crustaceans gleaned from the sand surface (SCR Project Steering Committee 1996).

The snowy plover nests through mid-March to mid-September (Federal Register 1995b). Eight areas, including the Oxnard lowland, support 78 percent of the California coastal breeding population. Some of these birds winter in the same areas used for breeding (Warriner et al. 1986), while others migrate north or south to wintering areas. The majority of birds winter south of Bodega Bay, California.

Habitat loss, predation, and other human activities have threatened snowy plover populations. Sightings of the western snowy plover have been reported at Ormond Beach, approximately 1.5 miles southwest of Port Hueneme, McGrath

Beach State Park, Point Magu, and the Santa Clara River mouth (State of California 1995, as cited in SCR Project Steering Committee 1996). Potential habitat for this species is located on the beach and southern foredune areas near the mouth of the river (SCR Project Steering Committee 1996).

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III Framework for Analysis

One of the most important steps in protecting endangered species is establishing legally designated protected areas. While land acquisition will not by itself ensure habitat preservation, it represents an important starting point. There are many facets to consider in order to identify sites in the landscape that are most important to protect. When nature reserves constitute a small fraction of an area and there are limited funds available for their expansion, it is critical to utilize conservation resources efficiently (Csuti et al. 1997). Prioritization of sites is the key to this efficiency.

The challenges of site prioritization have been faced by many others. The Cantara Trustee Council developed a plan for the Upper Sacramento River that included habitat acquisition among its goals (Cantara Trustee Council 1998). More locally, the National Park Service (NPS) developed the Santa Monica Mountains National Recreation Area Land Protection Plan, which identified land parcels with the most significant natural, cultural and recreational resources (NPS 1998). Other projects we investigated included a plan written by The Nature Conservancy to protect land in the Mississippi River Alluvial Plain ecosystem (Llewellyn et al. 1996) and a project to identify and purchase a riparian buffer zone in North Carolina (Xiang 1996). Based on these projects and others (Davis et al. 1999, Holmgren et al. 1993, Schaefer and Brown 1992), we developed a four-step methodology: 1) define the conservation goal, 2) establish site-specific criteria, 3) identify a preliminary group of sites, and 4) apply landscape level criteria to make final recommendations.

Conservation goal

Our conservation goal was to protect habitat for threatened and endangered species in an effort to ensure their persistence. Other projects have had similar goals (Llewellyn et al. 1996, Schaefer and Brown 1992). More importantly, protecting endangered species habitat was one of the explicit requests of the Trustee Council.

Criteria

To move towards this goal, we established several criteria that could be applied to each planning unit. The most obvious criterion was the percentage of endangered species habitat in the planning unit; Schaefer and Brown (1992) used a similar criterion to select sites for protection. Because the amount of land to be purchased was limited by the available funds, the cost of each parcel was a second criterion. To obtain cost estimates, we followed an approach used in a project by Xiang (1996), who estimated land acquisition costs from the appraised land values at the County Tax Office. Our third criterion was the contiguity of the selected parcels. This is important because small, isolated habitats will not adequately protect species or processes (Schaefer and Brown 1992).

Preliminary Site Selection

To identify the sites that best met our criteria, we combined a Geographical Information System (GIS) with a computer-aided site selection model. The projects by the NPS for the Santa Monica Mountains (NPS 1998) and the Cantara Trustee Council for the Upper Sacramento River (Cantara Trustee Council 1998) have proven that a Geographic Information System (GIS) can be successful in accomplishing the task of prioritizing sites for resource protection. Both studies applied a set of criteria to the parcels in their study area and modeled each criterion as a layer in a GIS. Sites were prioritized based on how well they conformed to each criterion.

Final Recommendations

While criteria like amount of species habitat and cost apply to each individual planning unit, some aspects of the selected sites apply to the collection of sites as a whole. The configuration of the selected sites, for example, cannot be evaluated for each planning unit. There is a debate, known as "SLOSS" (single large or several small), whether species richness is maximized in one large nature reserve or several smaller ones (Diamond 1975; Simberloff and Abele 1982; Terborgh and Winter 1980). A single large reserve can support populations of big, wide-ranging species, encompass more species, minimize edge effects and contain greater habitat diversity (Schonewald-Cox 1983). On the other hand, a patchy distribution of reserves allows for recolonization, and offers protection from the negative effects of environmental stochasticity and catastrophes (Quinn and Harrison 1988). Both of these considerations were important for our final recommendations.

Besides the configuration of the selected sites, we also wanted to evaluate the surrounding land use (Cantara Trustee Council 1998) and any surrounding physical features that might enhance the value of the selected sites for endangered species protection.

These landscape level criteria were applied after the preliminary site selection. Thus, we used aerial photographs and the GIS to evaluate the results of the site-selection model. This evaluation led to our final recommendations. The implementation of this entire methodology is the subject of the next section.

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IV Methods

Based on the framework and goals discussed in the previous section, the methodology of the project was divided into six parts. First, we defined our study area. Next, we gathered current and historic information about the distribution of riparian habitat within the floodplain. We also gathered the necessary information to estimate the cost of land along the river. A computer model was then used to select the sites that offered the greatest potential habitat for a fixed cost. Next, the results of the models were verified using a linear maximization. Finally, the model results were analyzed critically in light of the historic riverine dynamics and landuses. The first five steps will be discussed in detail below, and the final step is discussed in Section VI.

Defining the Study Area

We confined our analysis to parcels within the 500-year floodplain, where the distribution of riparian habitat is more abundant and the ecological value of the land for species conservation is greater. The study area was further limited by considering only those parcels in Ventura County. The opportunities for conservation in Los Angeles County seemed to be fewer and more problematic.

We used parcel boundaries as the planning units for the analysis. Although these parcels do not generally reflect ecological realities, there were other compelling reasons for our decision to use them. Since the parcels were defined by the Ventura County Assessor's Office, we were able to estimate cost information from the assessed value of the land. More importantly, the parcels are the units in which land is bought and sold. Therefore, any acquisition of land will be done in terms of these divisions.

Biological and Landscape Information

The Santa Clara River Enhancement and Management Plan (SCREMP) developed a GIS describing the river and its associated natural resources. The mapping layers included flood control structures, land use, recreational areas, water resources and the distribution of flora and fauna. Kirk Waln, a wildlife biologist for the United States Forest Service and the primary contact for SCREMP, provided us with a copy of the GIS. Mapping layers, such as parcel boundaries, floodplain boundaries, riparian habitat distribution and potential distribution for threatened and endangered species, were the foundation for our analysis.

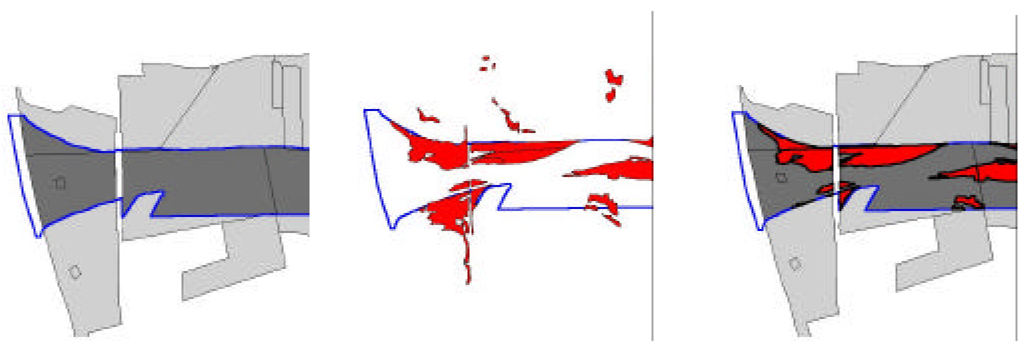
The information in the GIS was compiled by interacting subcommittees and groups. For example, the biological resources subcommittee of the Santa Clara River Enhancement and Management Plan generated data for the "bioreach", a layer which represented portions of the river within the 500-year floodplain that had similar habitat, channel and geomorphological characteristics. The consulting firm CH2MHill then used this information in conjunction with the vegetation layer to estimate the distribution of avifauna within several bioreaches. The most useful layers for our project were the habitat distributions, which were based on professional judgment using aerial photograph and field studies (Gautsch, pers. comm. 1999). A description of all of the coverages is provided in Appendix E.

Habitat Distribution

For our analysis we used eight threatened and endangered species: the least Bell's vireo, the southwestern willow flycatcher, the unarmored three-spine stickleback, the arroyo toad, the California red-legged frog, the tidewater goby, the western snowy plover, and the least tern. These eight species were chosen because their potential habitat was digitized and available to use in the GIS. Furthermore, the habitats used by these eight species are representative of most of the natural communities found along the Santa Clara River. Thus, conservation of these eight species will provide an umbrella of protection for the other listed species found in these communities.

The amount of habitat for each of these species in each parcel was calculated in the following manner. We began by creating separate coverages for each of the targeted species using the potential habitat distributions delineated by the GIS. The actual amount of species habitat in each parcel was then quantified by overlapping the species distribution coverages with the parcel coverage. The species distribution polygons were essentially "clipped" by the boundaries of the individual parcels. This process created a number of polygons fragmented by the boundary of each parcel; these polygons could later be summarized for total area (Figure 4.1).

Figure 4.1: Using GIS to Calculate the Amount of Habitat



(a) (b) (c)

Figure 4.1. The blue line is the 500-year floodplain. The dark gray areas are parcels that lie within the floodplain (a). Figure (b) shows the distribution of habitat used by the least Bell's vireo. By "clipping" the species distribution coverage with the parcel boundaries, we created a separate coverage of species habitat delineated by the boundary of each parcel. This final coverage (c) gave us the amount of least Bell's vireo habitat in each parcel. The same operation was performed for each species.

Contiguity

As a result of the largely reduced and fragmented nature of riparian habitat along the Santa Clara River, contiguity became an important consideration. We addressed the contiguity issue by minimizing the perimeter to area ratio of any combination of parcels that would later be evaluated for potential selection. We quantified the perimeter of each parcel and then used an AML (Arc Macro Language) to summarize the distances between them, allowing us to estimate the perimeter of any combination of parcels. The AML was written by David Stoms, manager of the Biogeography Lab at the University of California, Santa Barbara.

Historical Documentation

Aerial photos were used to interpret land use changes along the Santa Clara River after the early 1900s. We were primarily interested in the effects of land use changes on the distribution of riparian habitat over time. This information describing the historical extent of riparian vegetation was used to assess the restoration potential and the degree of anthropogenic disturbance to areas along the Santa Clara River. We also investigated the relationship between current and historic geomorphologic patterns and their effect on the landscape.

A series of aerial photos from 1947 and 1999 were provided by the Map and Imagery Lab at the University of California, Santa Barbara. The photos were geo-referenced using the ERDAS Imagine image registration software. By overlaying the photos with the GIS coverages, we were able to assess the effects of increased agricultural development on the extent of riparian habitat over the past 50 years. These data were gathered by comparing current land use activities with the 1947 image. The historic image provided a "snap shot" of the riparian vegetation that once existed along the banks of the river and in the upland areas of the floodplain. These previously existing patches were digitized and then compared to the current vegetation coverage. In order to assess the effects of flooding, we surveyed each photo for dramatic changes in the structure of the river and the distribution of riparian habitat.

Cost Data

An essential part of our analysis was a consideration of the costs of the parcels in the planning area. Ideally, we would have liked to know the price that the owners of the parcels were willing to accept for the purchase of their land, but political issues and physical impracticalities prevented us from gathering such information. So to estimate these prices, we collected data from the Ventura County Assessor's Office. We were able to get the assessed value and the year of assessment for 875 of the 1067 parcels in the planning area (See Appendix F).

Aside from the size of the parcel, the assessed value is also dependent on the year in which the assessment was made and the current land use status. A regression of the cost per area vs. time showed a steady increase until about 1990, after which there was no discernable trend. However, this ignored the different land uses along the river. Based on information in our GIS database, we divided the parcels into 7 land use types: residential, commercial, public, agricultural, mining/industrial, recreational, and vacant. For each of these 7 land uses, we ran a regression of assessed land value per square foot versus the year of assessment. The results (in Appendix G and summarized in Table 4.1) were only significant ($p<.01$) for some land use categories; these results were used to estimate the price of each parcel in the year 2000. When the p-value was not significant, the estimated costs for that land use were left equal to their assessed costs.

However, we could not do this for the 192 parcels for which we could not get information from the Assessor's Office. The costs of these remaining parcels were calculated based on the estimated prices of the other parcels for the year 2000. For each of the parcels without an assessed value, the cost per square foot was calculated as the average cost per square foot of all parcels of the same land use that were within two miles of the parcel. This approach was not practical for recreational parcels or industrial parcels because the study area only included eleven recreational parcels and nine industrial parcels. So in these cases, the missing costs were calculated as the average cost per square foot of all the parcels of the same land use type in the entire study area.

Table 4.1:Results of Linear Regression of Price Per Area vs. Year of Assessment

Land Use Type	All Parcels	Parcels with Assessed Values	Regression Results (increase in $/square foot/year)	P-value
Residential	252	233	.40	<.001
Commercial	104	78	.08	.002
Public/Transportation	115	92	.14	.001
Agricultural	346	293	.01	.003
Vacant	230	164	.01	.294
Recreational	11	8	.22	.475
Industrial	9	7	.33	.002
All Parcels	1067	875	.33	<.001

One final adjustment to the estimated costs was made. Because unreasonably cheap or unreasonably expensive land would bias our results, we wanted to put a limit on the range of estimated costs. The county assessor for agriculture and vacant land informed us that the range of assessed values for these types of land was generally between $8000/acre and $40,000/acre. Therefore, as very conservative limits on the cost of land, we chose .08$/square foot ($3500/acre) and 5$/square foot ($215,000/acre). Any agricultural or vacant land that was above this range was set equal to the upper limit, and any agricultural or vacant land that was below this range was set equal to the lower limit.

SITES Model

Due to our time constraints and funding limitations, we chose to use an existing model to represent our objectives, rather than develop our own. We chose SITES, a simulated annealing site selection model written by Ian Ball and Hugh Possingham (Andelman et al 1999). The model was originally developed for The Nature Conservancy (TNC), a non-profit organization which recently adopted a planning initiative with the aim of developing "portfolios" that would collectively conserve viable examples of all native species and plant communities within several eco-regions in the U.S., the Caribbean, and Latin America. SITES was developed as an iterative planning tool to assist TNC in identifying conservation areas.

SITES uses a heuristic procedure, known as "simulated annealing", for making selections that attempt to meet stated, quantitative conservation goals as efficiently (using as few sites) as possible. We will refer to a set of sites constituting a conservation area or potential reserve system as a "portfolio" in this report. The procedure begins with a random set. Then, at each iteration, the model swaps sites in and out of that set and measures the change in the function. If the change improves the set, the new set is carried forward to the next iteration. However, even changes that increase the function (that is, reduce the quality) of the set may be carried forward, so that one can examine a greater number of different site combinations to avoid getting stuck at a local minimum. The changes to the selected set can be large at first (even sites that contribute greatly to reducing cost can be removed) but then allowable changes are made progressively smaller as the function of the solution diminishes. Simulated annealing evaluates alternative complete reserve systems at each step, and compares a very large number of alternative reserve systems to identify a good solution.

In this process of comparing different portfolios, each reserve system is evaluated based on the constraints and the goals that the user has defined. For this project, the goals were amounts of habitat for the eight species in our analysis: the least Bell's vireo, the southwestern willow flycatcher, the three-spine stickleback, the arroyo toad, the California red-legged frog, the tidewater goby, the western snowy plover, and the least tern. The constraints were the costs of land and the contiguity of the selected sites. Thus, we entered the following data into the model: the amounts of different types of habitat in each parcel, the costs of each parcel, and the connectivity of each parcel to the other parcels. We also specified a cost threshold, which limited the number of sites chosen. Although the original settlement was for $7.1 million, that amount has grown as a result of accrued interest, to nearly $8 million. Thus, $8 million was a logical threshold. However, it is very likely that more money will be available for purchasing land; this money could come from private organizations, or from future settlements for natural resource damage. To address this possibility, we also used a cost threshold of $16 million. We also specified a boundary modifier parameter, which determined the importance of contiguity in the selection process. Selection of the boundary modifier required exploration by trial and error to obtain a reasonable solution. However, this weight had little effect because the distribution of habitat was already strongly clustered. Using all of this information, SITES performed its simulated annealing process to find a portfolio. The details of how the SITES model does this are in Appendix H.

In our multi-species approach, we initially considered all species habitat equally valuable. All eight species have limited distributions, and are all considered endangered. However, as our exploration process continued, we began to believe that the importance of a species in our analysis should be determined by assessing the degree of protection already afforded to them, and by the limits of their current distribution. As a result, species with extremely limited or extensive potential distributions were treated differently, as described below.

The potential habitats of the tidewater goby, the snowy plover and the least tern are predominantly concentrated in one parcel at the mouth of the Santa Clara River. This parcel, known as McGrath State Beach, is already protected as an endangered species habitat preserve. Although the amount of habitat preserved on the State Beach may or may not be adequate to support populations, recommending McGrath State Beach for acquisition is unnecessary. As a result, McGrath State Beach was "locked in" to our conservation portfolios for all scenarios. This means that McGrath State Beach is part of every portfolio, and cannot be removed. The habitat present at McGrath counts toward reaching our habitat goals, but the cost is set equal to zero to reflect the fact that it is, in a sense, already acquired.

We set the habitat goal for the unarmored three-spine stickleback equal to zero, as a result of its extensive potential distribution along the river. Its potential distribution spans the entire Santa Clara River, such that conservation of any endangered species' habitat would conserve stickleback habitat as well. Because of the nature of stickleback habitat, any clump of habitat anywhere adjacent to the river was contributing as much as any other clump to the preservation of stickleback habitat. In addition, the stickleback seems to be declining for reasons that are unrelated to parcel-scale activities. Thus, parcel level conservation would likely do little to speed its recovery. Setting the stickleback goal equal to zero means that SITES did not "try" to acquire stickleback habitat, but acquired it inadvertently while acquiring habitat for other species.

There are multiple parameters within these analyses that can be varied to represent different goals, and yield different results. We developed a series of scenarios by varying the boundary modifier, the species habitat goals, and the cost threshold. Scenario development was useful in exploring the role of the boundary modifier and the species habitat goals in our analysis. Often new scenarios were developed in response to information acquired through trial and error. However, the Results section refers only to the scenarios that provided insight into our research question. Scenarios whose purpose was related to parameterizing the SITES model are addressed in Appendix H.

Excel Models

As a comparison to the results of the SITES model, a simple linear maximization was performed using Microsoft Excel (Excel). Specifically, we maximized the total amount of habitat that could be purchased for $8 million and for $16 million. Unlike the SITES model, this model did not differentiate between the different types of potential species' habitat.

We also used Excel to create a biological ranking of the parcels that was independent of the estimated costs of the parcels. This model ranked all of the parcels based on the percentage of the parcel with habitat. We will refer to this as the biological ranking of the parcels.

V Results

SITES Model

Out of the 1,067 parcels in our study area, 282 contained endangered species' habitat. SITES selected 44 parcels for the $8 million scenario and an additional 37 parcels for the $16 million scenario. Refer to Appendix I for a list of the 81 parcels and the Map 1 for their location. In addition, for more detail, see the five maps (Maps 2-6) located in the pocket at the end of the document.

Many of the selected parcels are adjacent to another selected parcel, creating a series of clusters (Map 1). A "cluster" in our report will refer to a group of adjacent parcels. These clusters generally fall within a particular bio-reach that is defined by similar habitat, channel, and geomorphological characteristics. Because of these similarities, the bio-reaches were used to structure our analysis of the model results. Table 5.1 lists the clusters with their associated bio-reaches. Cluster area, the percentage of the cluster with species habitat and the percentage of potential habitat in each cluster are also reported in Table 5.1. Note that there are "sub-clusters" (e.g., G1 and G2) in the $8 million scenario that are connected with the additional parcels selected in the $16 million scenario.

Table 5.1: SITES Results

Bio-reach	**Cluster ID***	**16 million**				**8 million**			
		Total Cluster Area (acres)	**Species**	**% of Cluster with Potential Habitat**	**% of Potential Habitat in Cluster**	**Total Cluster Area (acres)**	**Species**	**% of Cluster with Potential Habitat**	**% of Potential Habitat in Cluster**
1	A	137	stickleback	43	2	85	stickleback	44	1
			flycatcher	30	6		flycatcher	33	4
			vireo	34	4		vireo	33	2
2	B	47	stickleback	21	0				
			vireo	25	1				
3	C	296	stickleback	48	4	181.45	stickleback	47	2
			flycatcher	16	7		flycatcher	25	7
			vireo	32	7		vireo	39	5

Bio-reach	Cluster ID*	16 million: Total Cluster Area (acres)	Species	% of Cluster with Potential Habitat	% of Potential Habitat in Cluster	8 million: Total Cluster Area (acres)	Species	% of Cluster with Potential Habitat	% of Potential Habitat in Cluster
			stickleback	24	1		stickleback	56	0
	D	98	flycatcher	15	2	34	flycatcher	23	1
			vireo	22	2		vireo	41	1
	E	14	stickleback	94	0	11	stickleback	98	0
3			vireo	36	0		vireo	37	0
			stickleback	35	9		stickleback	24	7
			flycatcher	18	32		flycatcher	42	29
	F	1215	vireo	25	23	820	vireo	28	17
			toad	35	17		toad	42	14
			frog	3	94		frog	4	94
							stickleback	72	2
			stickleback	55	6	G1=175	vireo	17	2
			flycatcher	1	0		toad	72	3
	G	384	vireo	13	4		stickleback	67	2
			toad	55	8	G2=24	vireo	7	0
							toad	67	3
							stickleback	74	2
4						H1=113	vireo	2	0.20
							toad	74	3
			stickleback	63	19		stickleback	74	7
			flycatcher	1	2	H2=350	flycatcher	2	1
	H	1145	vireo	5	5		vireo	9	2
			toad	63	29		toad	74	10
							stickleback	42	1
						H3=78	vireo	20	1
							toad	42	1
			vireo	23	8	J2=0.10	vireo	98	0.01
5	I		stickleback	85	0		stickleback	85	0
			toad	85	1		toad	85	1
			toad	11	2	J1=119	flycatcher	15	3
6	J	469	flycatcher	18	12		vireo	27	2
			vireo	23	8	J2=0.10	vireo	98	0.01

*Cluster ID: A cluster is defined by adjacency (see Map 1)

Excel Models

The linear maximization using Excel yielded results that were only slightly different from the SITES model. The $8 million and $16 million constraints led to the selection of 41 and 74 parcels, respectively. Table 5.2 shows the total percentage of habitat acquired for each species from both the SITES and Excel models.

Table 5.2: Total Potential Species' Habitat Acquired by SITES and Excel Models

	SITES				*Excel*			
	$8 Million Scenario		**$16 Million Scenario**		**$8 Million Scenario**		**$16 Million Scenario**	
Species	**% Habitat**	**Total Area (acres)**	**% Habitat**	**Total Area (acres)**	**% Habitat**	**Total Area (acres)**	**% Habitat**	**Total Area (acres)**
Least Bell's Vireo	40	529	59	789	31	410	51	674
Willow Flycatcher	50	337	69	462	43	290	63	425
Stickleback	30	1144	47	1782	33	1258	53	2020
Arroyo Toad	37	917	59	1464	47	1165	74	1834
Red-Legged Frog	94	34	94	34	94	34	94	34

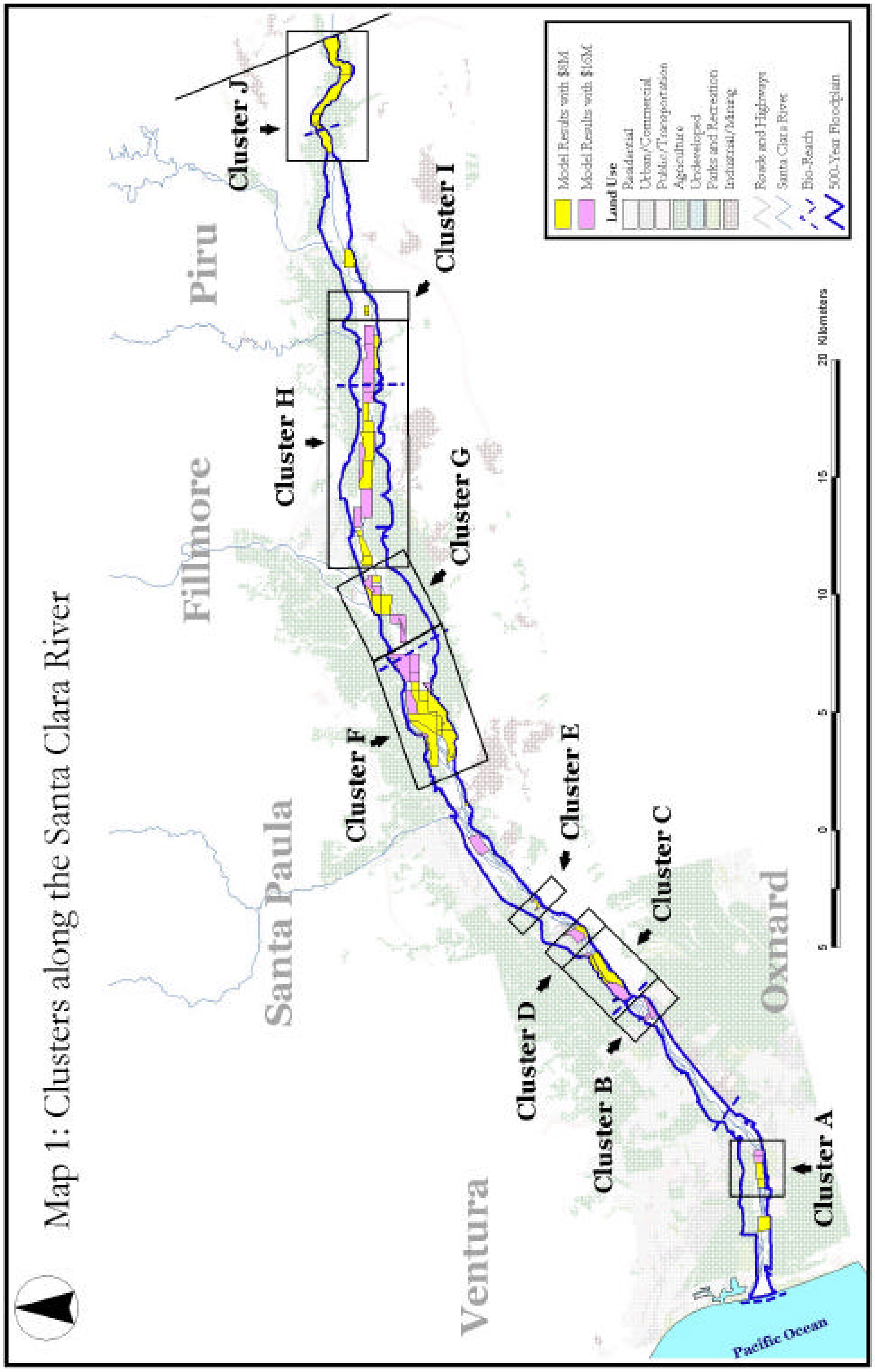
The second Excel model created a biological ranking of the parcels that was independent of the estimated costs. Table 5.3 lists the 20 parcels that scored the highest and that were also greater than 10 acres. The complete results are in Appendix J.

Table 5.3: Biological Ranks of Some Parcels with Areas > 10 Acres

Biological Rank	**APN**	**% Habitat**	**Area (Acres)**	**Estimated Cost/Acre**	**Land Use**	**SITES 8**	**SITES 16**
7	McGrath	174	91.7	0	3		
9	138005011	155	23.4	53735	1		
11	046023022	144	121.0	40182	2		
18	046023020	110	178.8	3485	4	Y	Y
19	046023008	107	100.3	3485	4	Y	Y
21	046023015	103	97.4	3485	5	Y	Y
22	046023025	101	23.3	3485	4	Y	Y
25	(no APN)	100	11.8	58313	7		
28	107001064	100	31.7	84950	2		
29	055026017	99	44.8	3485	4	Y	Y
33	046009002	97	83.5	3485	4	Y	Y
35	138019028	96	25.1	38264	4		
36	090018008	95	43.8	6787	5	Y	Y
38	055026005	95	125.3	3485	5	Y	Y

Biological Rank	APN	% Habitat	Area (Acres)	Estimated Cost/Acre	Land Use	SITES 8	SITES 16
40	055027028	94	31.9	3485	4	Y	Y
41	046023013	94	29.1	3485	5	Y	Y
42	179005004	93	24.7	12616	1		Y
45	107014037	91	39.3	46706	3		
46	046023009	90	38.9	3485	4	Y	Y
50	046023021	89	148.9	3485	5	Y	Y

***% Habitat** refers to the percentage of endangered species' habitat in the parcel. It can be greater than one hundred because the habitat of all the species is added together (i.e. if a parcel were entirely covered with habitat for all 8 species, the % Habitat would be 800).*
***Land Use** codes are as follows: 1=residential, 2=commercial, 3=public/transportation, 4=agriculture, 5=vacant/undeveloped, 6=parks and recreation, 7=industrial/mining.*
***SITES 8** and **SITES 16** refer to whether that parcel was chosen by either of the SITES scenarios.*



Map 1: Clusters along the Santa Clara River
Ventura
Santa Paula
Fillmore
Piru
Oxnard
Pacific Ocean
Cluster A
Cluster B
Cluster C
Cluster D
Cluster E
Cluster F
Cluster G
Cluster H
Cluster I
Cluster J
Model Results with $8M
Model Results with $16M
Land Use
Residential
Urban/Commercial
Public/Transportation
Agriculture
Undeveloped
Parks and Recreation
Industrial/Mining
Roads and Highways
Santa Clara River
Bio-Reach
500-Year Floodplain
5 0 5 10 15 20 Kilometers

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VI Discussion

This section is divided into three parts. First, we will discuss the results of the SITES model. Then, we will compare these results to the Excel model results. Finally, some limitations of our analysis will be evaluated.

SITES Results

The SITES model selected 44 parcels in the $8 million solution and 81 parcels in the $16 million solution. These parcels provide a general picture of the possibilities for acquisition along the Santa Clara River. The conservation portfolios that SITES selected were an attempt to represent a certain amount of habitat for each endangered species without spending more than a fixed amount of money. SITES did not evaluate solutions based on factors such as surrounding land uses, structure of vegetation, or level of disturbance. In the following section, the SITES results were evaluated and verified within the context of these attributes of the Santa Clara River at both the parcel and landscape level. This evaluation was based on our interpretation of the aerial photographs and the GIS database.

As shown in Maps 1 and 2, the areas chosen by SITES tend to be groups of parcels. That is, many of the selected parcels are adjacent to other selected parcels, creating a series of clusters. This natural clustering is driven by the distribution of habitat area.

Given the clumped nature of our solution, we have organized the discussion around clusters of parcels, located within unique bio-reaches of the river. Discussion of the attributes of clusters, which contain parcels with similar characteristics, is more practical than a discussion of each parcel individually. More importantly, groups of adjacent parcels containing endangered species' habitat foster more successful conservation because larger habitat areas support larger populations and contribute to the functioning of landscape level processes.

In addition, management of adjacent parcels is easier than management of parcels separated by land devoted to incompatible uses.

The bio-reach coverage, which was created by the SCREMP biological subcommittee, allowed us to segregate the selected parcels based on similarities in habitat and geomorphology within the 500-year floodplain (See Appendix E). Clusters were identified based on adjacency to other parcels within the solution and were given a letter as an identifier.

Table 5.1 and Map 1 identify ten clusters and six lone parcels. Of the clusters selected in the $16 million scenario, six contained more than 5% of the habitat of at least one species. Our discussion will focus on these clusters. These clusters were cluster A in bio-reach 1, cluster C in bio-reach 3, cluster F in bio-reach 3, cluster G in bio-reach 4, cluster H in bio-reach 4, and cluster J in bio-reach 6.

Cluster A

Sites within the first bio-reach are likely to be influenced by the coastal environment, as a result of their proximity to the Pacific Ocean. Unlike more upstream portions of the river, this stretch is supplemented by moisture moving off the coast during the dry seasons. Historically, these areas contained southern willow and mule fat scrub. However, agriculture now occupies the upland areas, and dense patches of giant cane often dominate remaining riparian habitats. The sites selected in this stretch are located within the active channel between two golf courses. Buena Ventura Golf Course is to the north and River Ridge Golf Course is to the south. Aerial photos from 1947 show that the golf courses were likely prone to large-scale flood events. In fact, it appears that the Santa Clara River once flowed through the site that is now River Ridge. In 1947, the floodplain extended to the south for an additional 0.5-km and contained at least 1.5 km^2 of additional riparian habitat. Flooding may currently occur at outer edges of Buena Ventura, but a series of groins on the southern bank of the river has likely minimized the effects on River Ridge. Cluster A, located approximately 5 kilometers from the mouth of the Santa Clara River, is the only cluster of selected parcels within the first bio-reach.

Cluster A includes four parcels (See Map 3), three of which contain a significant amount of flycatcher habitat. Together, these parcels contain 6% of the flycatcher's habitat. Some vireo habitat (1.27%) is present in one of the parcels. The stickleback also exists in this cluster, although none of the parcels contain a significant percentage of its habitat. The current land use is vacant/undeveloped.

Clusters C and F

Two clusters were identified in the third bio-reach of the river, where a significant amount of riparian habitat remains in the upland and wetland portions of the braided channel (See Maps 3 and 4). In the cluster located between the city of Ventura and Santa Paula (Cluster C), the density of giant cane generally does not exceed more than 50% of the total area of each selected parcel. Most of the giant cane appears to be growing on the terraces of adjacent agricultural fields. Row crops and open fields appear to be more prevalent on the northern bank since the southern bank is largely protected by an undeveloped hillside.

Cluster C consists of five parcels. A significant percentage of vireo habitat is present in three of the five parcels in this cluster, two of which also contain a significant percentage of flycatcher habitat. This cluster contains about 7% of vireo habitat and 8% of flycatcher habitat. Two of the five parcels contain a significant percentage of stickleback habitat. Four of the parcels in cluster C are vacant/undeveloped, while the remaining parcel is in agricultural use (see Table 6.1).

A second cluster in the third bio-reach, Cluster F, lies approximately 2 miles east of Santa Paula. Within this section of the reach, agriculture is set further back from the river and more than 2.5 km^2 of riparian habitat persists on the gradually sloping terraces. These gradients are likely to allow for frequent flooding and the subsequent formation of palustrine environments. Aerial photos provide evidence of recurring flooding and the formation of pools in upland areas adjacent to the selected sites. The dynamic landscape has also led to a braided channel where riparian vegetation dominates in several close patches.

Cluster F, with 25 parcels, contains a significant proportion of red-legged frog, arroyo toad, vireo and flycatcher habitat. Approximately 64% of frog habitat is present in one of these parcels (APN 046023023). The entire cluster contains 94% of frog habitat.

Clusters G and H

Two clusters, G and H, are located within the fourth bio-reach surrounding the City of Fillmore and are important for conservation purposes as a result of the large amounts of alluvial scrub within and adjacent to each parcel (See Map 5). The proximity to Sespe Creek also increases its significance, since Sespe Creek is one of the last wild rivers in southern California and could act as a migration corridor for endangered species such as the arroyo toad. The area directly upstream of the Sespe confluence is heavily used for agriculture and residential development. Agricultural activities have been present in Fillmore since the 1920s and flood control facilities have also been built at the northern edge of the channel. Such long-term disturbances have led to the removal of much of the riparian habitat in this stretch of the river. However, increased scouring of the riverbed has also decreased the distribution of giant cane in this area. In many of the selected sites, the density of giant cane is relatively low. Cluster H is located in the area east of Fillmore within bio-reach 4. Compared to many parts of the river, this area has small proportions of riparian habitat (less than 10% of the total area of the selected parcels in this cluster have riparian or alluvial scrub habitat).

The larger cluster, Cluster H, consists of 17 parcels. The cluster contains 29% of toad habitat, 5% of vireo habitat, 19% of stickleback habitat and 2% of flycatcher habitat. Cluster G is considerably smaller than H but contains a comparable amount of vireo habitat (4%). It also contains 8% of toad habitat and 6% of stickleback habitat. The current land use designation for the parcels in both these clusters is agriculture or vacant/undeveloped.

Cluster J

The last cluster is located within the sixth bio-reach near the Ventura/Los Angeles County line. Mountains rise at each side of the river and limit the spread and intensity of agriculture. A number of canyons filled with plunge pools and ephemeral streams empty into the Santa Clara River and could act as migration corridors for several aquatic species (Sweet, pers. comm. 2000). Riparian scrub and riparian woodland dominate the cluster, and the density of giant cane is low. Palustrine environments exist in the upland habitats of both sides of the river and likely occur from the dynamic structure and processes within this reach. Historic air photos reveal similar physical patterns as seen in the river today.

Cluster J contains five parcels, three of which have significant proportions of vireo, flycatcher and/or toad habitat. Together, these parcels contain 8% of vireo habitat, 12 % of flycatcher habitat, and 2% of toad habitat. Agriculture is the main land use on these parcels.

Excel Results

Linear Maximization

As a comparison to the results of the SITES model, a simple linear maximization was performed using Microsoft Excel (see Table 6.1). This table shows that 80% of the parcels chosen by SITES for $8 million were also chosen by the linear maximization, and 90% of the parcels chosen by SITES for $16 million were chosen by the linear maximization. Furthermore, 98% (44 out of 45) of the parcels chosen by the SITES $8 million scenario were also chosen by the linear maximization for $16 million. These results strongly support the selection of parcels made by SITES.

Table 6.1: Comparison of SITES to Linear Maximization

	Number of Parcels Chosen		
Constraint	**SITES Model**	**Linear Maximization**	**Common Parcels**
$8 million	45	41	36
$16 million	82	74	64

Biological Ranking

The biological ranking created in Excel was useful because the results were independent of the estimated costs. The estimated costs of the parcels selected by SITES are fairly uniform. Under the constraint of $8 million, all 45 of the parcels had estimated costs between $3,500 per acre and $7,000 per acre. Only 5 of these 45 parcels had estimated costs over $5,000 per acre. Under the constraint of $16 million, 78 of the 82 parcels selected had estimated costs between $3,500 per acre and $7,000 per acre. Of the 4 parcels that were not in this range, only one of them (APN # 179005004) had an area greater than 2 acres, and its estimated cost was about $12,500 per acre. Thus, the cost estimations do not favor any of the clusters over other ones.

Since SITES selected less expensive parcels, it may have overlooked parcels that are superior from a conservation viewpoint because they were more expensive. The biological ranking that we created tested this hypothesis. This ranking was based solely on the amount of habitat and not on the cost of the parcel. This model ranked all of the parcels based on the percentage of the parcel with habitat. The results are in Appendix J. Of the first 100 parcels in the biological ranking, 40 of them were larger than 30 acres. Of these 40 parcels, 33 were chosen by the SITES $16 million scenario. So, with only a few exceptions, SITES has selected those large parcels that contain greater amounts of habitat. This further supports the results of the SITES model. However, it also identifies other parcels that should be considered.

In particular, the biological ranking identified parcels that had a great deal of habitat but were not chosen by the SITES model because they were too expensive. Given the uncertainty of the cost estimates, these parcels may be reasonable selections for purchase. They are listed in Table 6.2.

Table 6.2: Habitat-Rich Parcels not selected by SITES

APN	Biological Rank	Acres	Estimated Cost/acre	Location (Cluster)
046023022	11	121	$40,182	Adjacent to F
107001064	28	32	$84,950	near F
107014037	45	39	$46,706	Between E and F
055029016	52	266	$6562	Between I and J
107001076	63	82	$102,057	Between E and F
138006055	94	142	$93,754	Adjacent to A
099009009	95	81	$39,451	Between D and E

Limitations

Both of the Excel models support the results of the SITES model. Thus, our results seem to be fairly robust. However, the data used to reach these results, both the species' habitat areas and the cost estimates, have some uncertainty associated with them. Another possible limitation is the fact that the clusters identified in our results only contain habitat for 5 of the 8 species that we used for our analysis. We will discuss each of these concerns below.

GIS data

We acquired our GIS database from the USFWS, who contracted several consulting firms to develop it. This data is at least 8 years old, and we are relying on the judgement of others for the habitat information that is the basis of our analysis. Although we believe the quality of this information is good, our results might improve if this information was updated and verified.

Cost Data

Our cost data was obtained from the Ventura County Assessor's Office, which keeps a list of land value statistics for each parcel. The value estimates from the Assessor may or may not reflect the actual selling prices. Also, Proposition 13, which states that property may only be assessed at its purchase value, not at its current market value, meant that many of the land values from the Assessor were over a few decades old. Although regressions were run to try to correct for this, a regression is still a fairly crude tool. Even some of the recently assessed parcels have cost per area values that seem ridiculously high or ridiculously low. Finally, some of the Assessor's parcel numbers did not have values associated with them. As a result of all of these factors, the cost data required a high level of manipulation, and the numbers we arrived at are fairly uncertain. This does not, however, threaten the integrity of our results because the biological ranking (Appendix J) that was created independent of the cost estimates, verified the results of the SITES model.

Coastal Species

None of the clusters we have discussed contain habitat for the western snowy plover, the least tern or the tidewater goby. These coastal species occur significantly in only two parcels near the mouth of the river. One of these is McGrath State Beach and the other is 23 acres of Assessor's Parcel # 31960735. We are not recommending either of these parcels for purchase because the first one already offers some degree of habitat protection and the second one has an estimated cost of about $1,000,000. However, a conservation strategy for these species should consider the activities in both of these parcels, and the possible acquisition of the second one.

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VII Recommendations for Acquisition

Based on the model results and in light of the limitations, we will now conclude with a discussion of our recommendations and some ideas about how to implement them. Of the six clusters discussed earlier, two clusters deserve special attention because of their amounts of potential habitat, diversity of habitats and possibilities for management and conservation (See Map 7). Cluster F, between Santa Paula and Fillmore, is unique for several reasons. Along this section of the river, agriculture is further back from the edge of the river and the presence of undeveloped upland areas allows for the formation of seasonal pools. It is the only cluster that contains habitat for five of the endangered species (stickleback, vireo, flycatcher, frog, and toad). Almost all (94%) of the red-legged frog habitat is in this cluster. Its proximity to cluster G is also an advantage because the confluence of Sespe Creek in cluster G offers an important connection to upland systems and a migration corridor for endangered species.

The other cluster that stands out is cluster J. It has a high percentage of riparian scrub and woodland habitats and low amounts of giant cane. The amount of potential endangered species' habitat is relatively high. The mountains to the south of this cluster are a source of ephemeral streams, which provide a connection to upland isolated environments.

Clusters A, C, and H are all less advantageous for several reasons. Clusters A and C are both smaller clusters and contain less potential habitat than the others. Additionally, cluster A, surrounded by golf courses, is in a more urbanized and less natural part of the river. Because of long-term agricultural use of the surrounding area, cluster H has less riparian habitat than some other parts of the river.

Given all of the above considerations, acquisition should focus on parcels in cluster F (with a possible connection to cluster G) and cluster J. Photos of these areas appear in Appendix K. One objective of our analysis was to recommend parcels to be purchased for $8 million. If all of the parcels in these three clusters were purchased, the estimated cost is remarkably close to $8 million (See Table 7.1). Is this too good to be true? Probably. The estimated costs are clearly uncertain. However, there are several ways to proceed in the face of this uncertainty.

Table 7.1: Our Recommendations

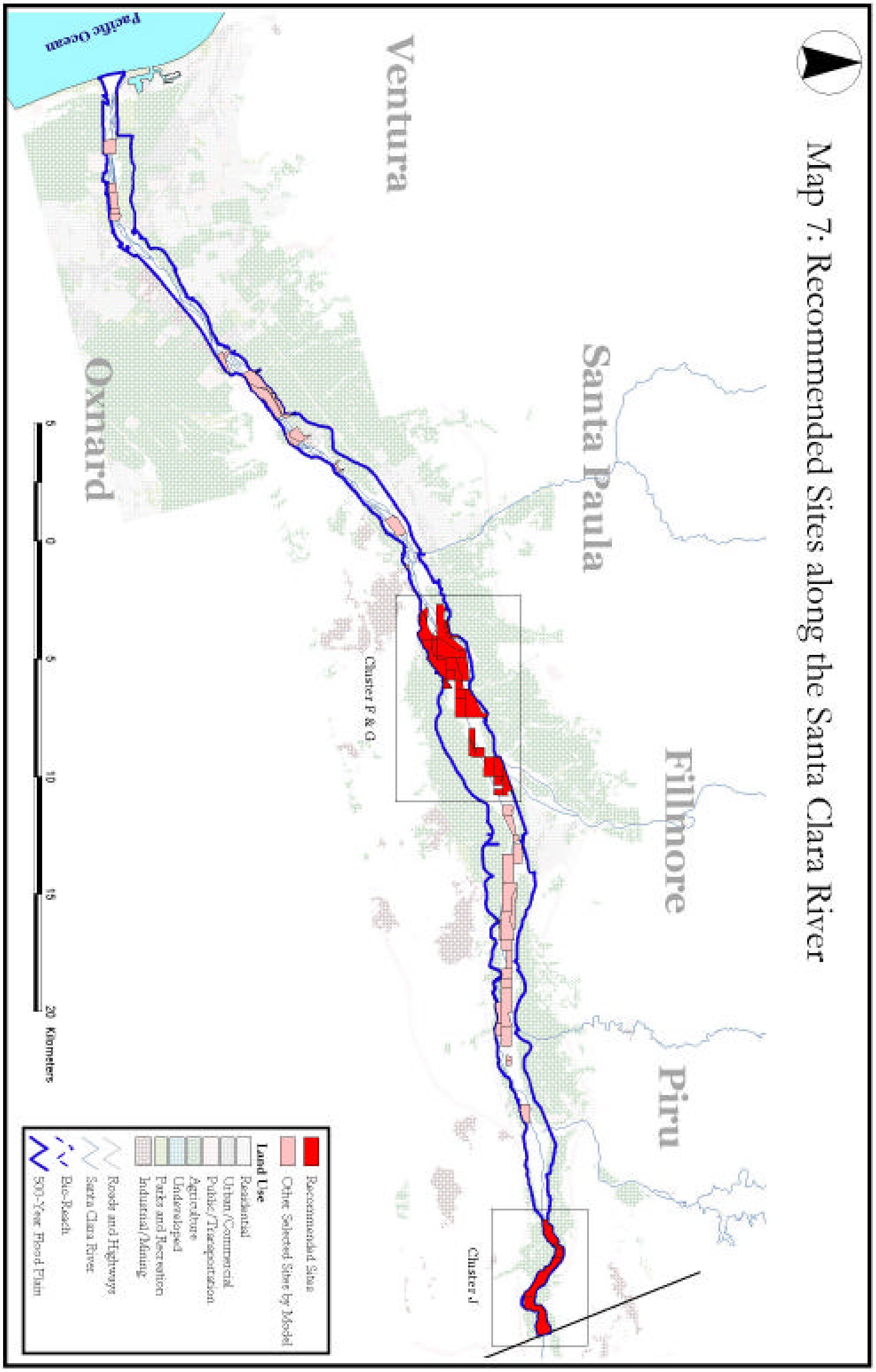
Cluster	Number of Parcels	Total Area	Estimated Cost
F	25	1215	$4.5 Million
G	8	384	$1.4 Million
J	5	469	$1.9 Million
Totals:	38	2068	$7.8 Million

The purchase of any of these parcels presents the difficulties of whether the owner is willing to sell the parcel and, if so, at what price. The price may or may not be close to our estimate. One solution to these problems would be to focus acquisition activities on more parcels than will be bought so that there will be some flexibility in what is purchased. Our results offer this flexibility.

Another solution would be to hold a type of land auction. The Trustee Council could solicit bids from different landowners for the part of their land that is within the 500-year floodplain. Any landowner who was interested could offer her land for sale at any price. These bids could be ranked based on our biological ranking (in Appendix J) and the amount of the bid. A simple way to do this for each parcel would be to take our '% habitat' score multiplied by the area of the parcel, divided by the amount of the bid. The highest scoring bids could then be purchased until the $8 million was used up. This, in theory, would lead to the most efficient use of the money. A similar ranking system is used by the Department of Agriculture for their Conservation Reserve Program.

An alternative to acquisition is the purchase of conservation easements. A conservation easement is a legal agreement between a landowner and a qualified conservation organization (e.g., land trust) or government agency that permanently limits a property's use in order to protect its conservation values. The easement, a legal document, guides future uses of a property regardless of ownership. While the land's conservation values are protected by the organization, the landowner retains title to the property and can live on it, use it, sell it, or pass it on to heirs. For example, it might be that that the landowner retains the right to create future building lots, but, with the easement, limits the number allowed to be built under local zoning. One of the benefits of an easement is that it can provide income tax and property tax reductions by eliminating unwanted development value (Natural Lands Trust 1997). Some landowners who are unwilling to sell their land may be interested in the advantages of putting their land in a conservation easement.

Regardless of how the land is acquired, the conservation of the recommended areas is only one step in what should be a multifaceted effort. If riparian conservation is to be effective, acquisition must be coupled with restoration, management, long-term monitoring, and public education. We hope that our project will serve as a foundation for riparian conservation along the Santa Clara River.


Map 7: Recommended Sites along the Santa Clara River
Pacific Ocean
Ventura
Oxnard
Santa Paula
Fillmore
Piru
Cluster F & G
Cluster J
5 0 5 10 15 20 Kilometers
Recommended Sites
Other Selected Sites by Model
Land Use
Residential
Urban/Commercial
Public/Transportation
Agriculture
Undeveloped
Parks and Recreation
Industrial/Mining
Roads and Highways
Santa Clara River
Bio-Reach
500-Year Flood Plain

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Appendix A

Dominant Plant Species of the Santa Clara River

The following table lists the dominant plant species for each habitat type (as defined by Holland 1986) found along the Santa Clara River. This information was taken from the *Santa Clara River Enhancement and Management Plan Study, Biological Resources, Volume I* (Santa Clara River Project Steering Committee, June, 1996).

Habitat Type	Plant Species	Native/ Introduced
Alkali Marsh	alkali heath (*Frankenia salina*)	N
	jaumea (*Jaumea carnosa*)	N
	pickleweed (*Salicornia virginica*)	N
	salt grass (*Distichlis spicata*)	N
Southern Foredune	sand verbena (*Abronia maritima*)	N
	beach-bur (*Ambrosia chamissonis*)	N
	Beach evening-primrose(*Camissonia cheiranthifolia*)	N
	salt grass (*Distichlis spicata*)	N
	sea rocket (*Cakile maritima*)	I
Mule Fat Scrub	mule fat (*Baccharis salicifolia*)	N
	narrow-leaved willow (*Salix exigua*)	N
Southern Willow Scrub	arroyo willow (*Salix lasiolepis*)	N
	red willow (*Salix laevigata*)	N
	mule fat (*Baccharis salicifolia*)	N
	narrow-leaved willow (*Salix exigua*)	N
Southern Willow Riparian Woodland	arroyo willow (*Salix lasiolepis*)	N

Habitat Type	Plant Species	Native/ Introduced
Southern Willow Riparian Woodland	red willow (*Salix laevigata*)	N
	fremont cottonwood (*Populus fremontii*)	N
	black cottonwood (*P. balsamifera* ssp. *trichocarpa*)	N
	mule fat (*Baccharis salicifolia*)	N
	narrow-leaved willow (*Salix exigua)*	N
	western sycamore (*Platanus racemosa*)	N
Southern Cottonwood-willow Riparian Forest	fremont cottonwood (*Populus fremontii*)	N
	black cottonwood (*P. balsamifera* ssp. *trichocarpa*)	N
	red willow (*Salix laevigata*)	N
	mule fat (*Baccharis salicifolia*)	N
	arroyo willow (*Salix lasiolepis*)	N
	arrow weed (*Pluchea sericea*)	N
	wild grape (*Vitis girdiana*)	N
	blackberry (*Rubus ursinus)*	N
	California bay (*Umbellularia californica*)	N
	hoary nettle (*Urtica dioica ssp. holosericea*)	N
	mugwort (*Artemisia douglasiana*)	N
Arrow Weed Scrub	arrow weed (*Pluchea sericea*)	N
	big saltbush (*Atriplex lentiformis*)	N
	mule fat (*Baccharis salicifolia*)	N
Alluvial Scrub	scalebroom (*Lepidospartum squamatum*)	N
	big sagebrush (*Artemisia tridentata*)	N
	California buckwheat (*Eriogonum fasciculatum*)	N

Habitat Type	**Plant Species**	**Native/ Introduced**
Alluvial Scrub	chaparral broom (*Baccharis sarathroides*)	N
	interior goldenbush (*Ericameria linearifolia*)	N
Big Sagebrush Scrub	big sagebrush (*Artemisia tridentata*)	N
	fourwing saltbrush (*Atriplex canescens*)	N
	hairy yerba santa (*Eriodictyon trichocalyx*)	N
	Palmer's goldenbush (*Ericameria palmeri*)	N
	California buckwheat (*Eriogonum fasciculatum*)	N
Valley Freshwater Marsh	broad-leaved cattail (*Typha latifolia*)	N
	bulrush (*Scirpus* sp.)	N
	sedge (*Carex* sp.)	N
	rush (*Juncus* sp.)	N
	yerba mansa (*Anemopsis californica*)	N
	dwarf and hoary nettle (*Urtica urens; U. dioica* ssp. *Holosericea*)	I;N
	cocklebur (*Xanthium strumarium*)	N
	celery (*Apium graveolens*)	I
Coastal Sage Scrub	California sagebrush (*Artemisia californica)*	N
	California buckwheat (*Eriogonum fasciculatum*)	N
	purple sage (*Salvia leucophylla*)	N
	black sage (*Salvia mellifera*)	N
	common encelia (*Encelia californica)*	N
	California broom (*Lotus scoparius*)	N
Chamise Chaparral	chamise (*Adenostoma fasciculatum*)	N
Coast Live Oak Woodland	coast live oak (*Quercus agrifolia)*	N
Disturbed Areas	giant cane (*Arundo donax*)	I

Habitat Type	**Plant Species**	**Native/ Introduced**
	castor bean (*Ricinus communis)*	I
	tamarisk (*Tamarix sp.)*	I
Disturbed Areas	tree tobacco (*Nicotiana glauca*)	I
	black mustard (*Brassica nigra*)	I
	Russian thistle (*Salsola tragus*)	I

Appendix B

Vegetation Descriptions

The following is a description of the plant community types located along the Santa Clara River. The plant community names follow those proposed by Holland (1986). The plant species nomenclature follows the Jepson Manual (Hickman 1993).

Mule Fat Scrub

Mule fat (*Baccharis salicifolia*) is commonly the sole or dominant canopy species in the mule fat scrub plant community, forming a continuous canopy with sparse ground layer. It occupies habitats that are seasonally flooded or saturated, usually along canyon bottoms, irrigation ditches, or stream channels (Sawyer and Keeler-Wolf 1995). This habitat type can be found along the Santa Clara River within the active channel following floods, along the banks, and on the low floodplain terraces (SCR Project Steering Committee 1996). Mule fat scrub is an early stage of the successional development of riparian woodlands often maintained by moderate to high frequency disturbance (Warner and Hendrix 1984, as cited in SCR Project Steering Committee 1996). Because this community occupies seasonally flooded or saturated areas, the mule fat shrubs tend to be relatively young and do not reach the typical height of 5 to 8 feet for mature stands. Many birds, including the least Bell's vireo (*Vireo bellii pusillus*), may utilize mule fat scrub for foraging.

Southern Willow Scrub

Southern willow scrub habitat is characterized by dense, broadleaf, winter-deciduous riparian thickets that are dominated by several willow species (*Salix* spp.) (Holland 1986). Understory development tends to be sparse due to thick vegetation cover. Southern willow scrub is found along the Santa Clara River on first and second terraces of the floodplain (SCR Project Steering Committee 1996). Moderate flooding frequency in these areas prevents the community from developing into a riparian woodland. Thus the willow scrub is the middle stage of riparian woodland succession. This habitat supports a variety of birds, including least Bell's vireo and southwestern willow flycatcher (*Empidonax trailii extimus*), which tend to nest in dense willow-dominated thickets. Foraging raptors and small mammals are also found in these habitats.

Southern Willow Riparian Woodland

Southern willow riparian woodland is characterized by a dense to open stand of broadleaf, winter-deciduous trees that are dominated by several willow species (Holland 1986). This habitat type represents a mature riparian habitat. The understory is composed of shrubby willows and mule fat with a limited herbaceous layer. Scattered cottonwoods and sycamore trees (*Platanus* spp.) may also be present. Red willow (*Salix laevigata*) and arroyo willow (*Salix lasiolepis*) dominate this habitat along the Santa Clara River. Willow riparian woodland provides habitat for a variety of small birds (e.g., least Bell's vireo and southwestern willow flycatcher), small foraging mammals, and amphibians, including the red-legged frog (*Rana aurora draytonii*) and the arroyo toad (*Bufo microscaphus californicus*).

Southern Cottonwood/Willow Riparian Forest

Southern cottonwood/willow riparian forest habitat consist of a tall, open, broadleafed winter-deciduous riparian forest dominated by cottonwoods (*Populus* spp.) and various tree willow species (Holland 1986). The understory is composed of shrubby willows and mule fat with an herbaceous layer. Because this habitat type is best represented on the mid to outer floodplain, disturbance from floods is less frequent and mature riparian forest is allowed to develop. Many birds, including the southwestern willow flycatcher, the least Bell's vireo, and the western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), may utilize this habitat for nesting and foraging. This habitat supports foraging raptors and small mammals as well.

Arrow Weed Scrub

Arrow weed scrub is characterized by moderate to dense streamside thickets strongly dominated by arrow weed shrubs *(Pluchea sericea)* (Holland 1986). It occurs in streambanks, ditches, and washes with gravelly or sandy channels. Along the Santa Clara River, this plant community is located on the upper floodplain and terraces at the edges of woodlands, forests, and along the manufactured slopes of Highway 126 (SCR Project Steering Committee 1996). This disturbance-maintained community appears to be increasing in extent at the expense of willow, cottonwood, and cotton-sycamore riparian forest types as a result of grazing and groundwater pumping (Holland 1986). Birds and insects are the primary users of this habitat type, but reptiles may also forage in these areas. The southwestern willow flycatcher has been noted to occur where arrow weed is present.

Alluvial Scrub

Alluvial scrub habitat is characterized by a mixture of shrubs that colonize alluvial materials within intermittent creeks, arroyos, and the drier terraces within large washes (Holland 1986). The widely scattered shrubs are intermixed with grasses and herbs as understory. Reptiles, including the silvery legless lizard *(Anniella pulchra pulchra)* and the San Diego horned lizard *(Phrynosoma coronatum blainvillii)*, utilize this habitat for foraging or burrowing. Plant species such as the endangered slender-horned spineflower *(Dodecahema leptoceras)* and the endangered Nevin's barberry *(Berberis nevinii)* are found in this habitat as well. Alluvial scrub is also utilized by foraging birds, small mammals, and insects.

Big Sagebrush Scrub

Big sagebrush scrub is characterized by soft-woody shrubs, 0.5 to 2 meters tall, usually with bare ground underneath and between shrubs (Holland 1986). Big sagebrush (*Artemisia tridentata*) is the dominant species in this community. It can occur on a wide variety of soils and terrain, from rocky, well-drained slopes to fine-textured valley soils with a high water table. This habitat occurs on the drier floodplain terraces adjacent to the Santa Clara River, especially in the eastern portion of the river in Los Angeles County (SCR Project Steering Committee 1996). Flooding frequency is low to moderate. This habitat is similar to alluvial scrub in that it provides habitat for birds, small mammals, insects, and reptiles on the drier portions of the riparian system.

Valley Freshwater Marshes and Ponds

Valley freshwater marshes and ponds are wetland habitats characterized by prolonged inundation which allows for the accumulation of deep, peaty soils (Holland 1986). These areas are dominated by perennial, emergent monocots four to five meters tall (e.g. broad-leaved cattail (*Typha latifolia*) and bulrush (*Scirpus sp*.)). Freshwater marsh is found in portions of the Santa Clara River channel where water accumulates and along small tributary streams, or in depressions in the scrubs, woodlands, and forests of the floodplain terraces (SCR Project Steering Committee 1996). This habitat supports amphibians such as the red-legged frog, reptiles such as the southwestern pond turtle *(Clemmys marmorata pallida)*, and foraging and/or nesting birds.

Southern Foredunes

Southern foredunes are areas of sand accumulation along the coast (Holland 1986). Vegetation is sparse due to winds, salt spray and shifting sand. Fordune habitat is utilized by coastal birds like the snowy plover *(Charadrius alexandrinus nivosus)* and the California least tern *(Sterna antillarum browni)*, and by small mammals. Insects like the sandy beach tiger beetle *(Cicindela hirticollis gravida)* also utilize this habitat.

Alkali Marsh

Small pockets of alkali marsh habitat have formed adjacent to the mouth of the river beyond the foredune habitat (SCR Project Steering Committee 1996). These low-lying marsh areas are saturated for long periods during the wet season but are dry during the summer. The frequency of flooding is moderate to high (i.e., floods one or more times a year). This community provides habitat for many coastal birds including the California least tern, the Belding's savannah sparrow *(Ammodramus sandwichensis beldingi)*, and the western least bittern *(Ixobrychus exilis hesperis)*. Salt marsh bird's beak *(Cordylanthus maritimus* ssp. *maritimus)* and ventura marsh milkvetch *(Astragalus pycnostachyus* var. *lanosissimus)* are two plant species also found in this habitat.

Non-Native Vegetation

Many of the native communities described above have been disturbed by urbanization, mining, agriculture and other human activities. This disturbance allows for the development of a suite of non-native weeds. These species (particularly giant cane (*Arundo donax)*) will compete with native vegetation for water and nutrients and can ultimately dominate the native communities and reduce the habitat quality for native wildlife species. See Appendix A for a list of non-native species along the Santa Clara River.

Appendix C

Sensitive Plant and Animal Species

The following table identifies the sensitive species that occur or have the potential to occur on the Santa Clara River (primarily within the 500-year floodplain). Sensitive species, as used in this report, refers to those taxa that belong to one of the following categories: taxa listed as endangered or threatened by state or federal resource agencies; taxa that are proposed for listing by state or federal agencies (including former federal category 2 candidate species); taxa considered rare or species of special concern by other local public and private resource agencies. The following list was generated from information provided by the USFWS, the Santa Clara River Enhancement and Management Plan Study, in addition to a database search using the California Natural Diversity Data Base (NDDB).

Given the known habitat requirements of each of the species listed below, potential habitat occurring on the Santa Clara River that could support these species was also identified (SCR Project Steering Committee 1996).

Code Designations

FT = Federally listed Threatened
FE = Federally listed Endangered
ST = State listed Threatened
SE = State listed Endangered
FPD= Federally proposed (Delisting)
sc = State species of special concern
C1 = Federal category 1 candidate for listing
C2 (former) = Federal category 2 candidate for listing (category eliminated in 1995)
CNPS 1B = California Native Plant Society listing
CFP = California fully protected

*Distribution of potential habitat was utilized in the site selection analysis.

Species	Status	Habitat Requirements	Potential Habitat on SCR
Insects			
Sandy beach tiger beetle *(Cicindela hirticollis gravida)*	Former C2	clean, dry, light-colored sand: occur in bright sunlight in open sandy areas on sandy beaches and on open paths or lanes	southern foredune, alluvial scrub

Species	Status	Habitat Requirements	Potential Habitat on SCR
Fish			
Tidewater goby* (*Eucyclogius newberryi)*	FE (94) FPD (99) sc	benthic, restricted mostly to shallow water (< 1meter) in small coastal lagoons and near stream mouths in the uppermost brackish portions of larger bays	active channel near mouth of river
Unarmored threespine stickleback* *(Gasterosteus aculeatus williamsoni)*	FE (70) SE (71)	weedy pools and backwaters or among emergent plants along the edges of streams where the water stays below 23 degrees Centigrade; prefer bottoms of sand or mud	active channel from east of the confluence of Piru Creek and the Santa Clara River to Los Angeles County aqueduct crossing
Southern steelhead trout *(Oncorhynchus mykiss iridius)*	FE (97)	salt water; spawning occurs in fall/winter in the headwaters of freshwater coastal streams with gravel bottoms	active channel from mouth of river to Piru Creek (including Sespe and Santa Paula creeks)
Santa Ana sucker *(Catostomus santaanae)*	Former C2 sc	clear, cool, rocky, and gravely streams	active channel from Santa Paula east to Acton
Arroyo chub *(gila orcuttii)*	Former C2 sc	sand and mud bottomed flowing pools and runs of headwaters, creeks, and small to medium rivers; it occasionally can be found in intermittent streams	active channel from mouth of river to Los Angeles County aqueduct crossing
Amphibians and Reptiles			
California red-legged frog* *(Rana aurora draytonii)*	FT (96) sc	dense, shrubby or emergent riparian vegetation closely associated with deep still or slow moving waters; prefers areas with arroyo willow, cattails, and rushes which cover a large portion of the water's surface; water at least 0.7 m deep required	freshwater marsh; active channel and riparian scrubs, woodlands, and forests from mouth of Soledad Canyon east to Acton
Arroyo toad* *(Bufo microscaphus californicus)*	FE (95) sc	Restricted to rivers with shallow, gravelly pools adjacent to sandy terraces	active channel in Sespe and Piru creeks; active channel and riparian woodlands and forests from LA county line east to I-5 and from mouth of Soledad Canyon to Acton

Species	Status	Habitat Requirements	Potential Habitat on SCR
San Diego horned lizard *(Phrynosoma coronatum blainvillii)*	Former C2 sc	Associated with coastal sage scrub and riparian woodlands, especially areas of level to gently sloping ground with well-drained, loose or sandy soil	alluvial scrub, coastal sage scrub, riparian woodlands and forests
Two-striped garter snake *(Thamnophis hammondii hammondii)*	Former C2	highly aquatic; most commonly found in or near permanent water; occasionally found in small and intermittent streams with rocky beds	riparian scrubs, woodlands, forests; freshwater marsh
Southwestern pond turtle *(Clemmys marmorata pallida)*	Former C2 sc	ponds, small lakes, reservoirs, and slow-moving streams, where it may be seen basking on logs or mud banks	active channel, freshwater marsh, and in man-made ponds (e.g., water cress ponds, duck ponds) within the floodplain of the river
Silvery legless lizard *(Anniella pulchra pulchra)*	Former C2 sc	Herbaceous layers with loose soil in coastal scrub, chaparral, and open riparian habitats; sand of washes and beach dunes are preferred for burrowing , and logs and leaf litter are used for cover and feeding	southern foredune, alluvial scrub, cottonwood/willow forest
Birds			
Least Bell's vireo* *(Vireo bellii pusillus)*	FE (86) SE (80)	dense willow dominated riparian areas with a lush understory in a 5-10 year old succession stage; dense, low growing thickets of willows, mule fat, blackberry and mugwort are an essential part of habitat; often with an overstory of tall willows, cottonwoods and sycamores	mule fat scrub, willow scrub, willow riparian woodlands from near river mouth to Bouquet Canyon Road
Southwestern willow flycatcher* *(Empidonax trailii extimus)*	FE (95) SE (88)	riparian habitats along river, streams, or other wetlands where stands of willows, mule fat, arrow weed, tamarisk, or other riparian plants are present; often with an overstory of cottonwood	willow riparian woodland, cottonwood/willow riparian forest

Species	Status	Habitat Requirements	Potential Habitat on SCR
Western snowy plover* *(Charadrius alexandrinus nivosus)*	FT (93) sc	sand spits, dune-backed beaches, mud flats, unvegetated beach strands, open areas around estuaries, and beaches at river mouths are the preferred	beach, southern foredune
California least tern* *(Sterna antillarum browni)*	FE (70) SE (71)	barren to sparsely vegetated sandbars along rivers, sand and gravel pits, or lake and reservoir shoreline; nests only in open sandy places or mud flats with little or no vegetation	beach, southern foredune, alkali marsh, active channel areas near the river mouth
Western yellow-billed cuckoo *(Coccyzus americanus occidentalis)*	SE (88)	restricted to dense riparian woodland during breeding	willow riparian woodland, cottonwood/willow riparian forest
Bank swallow *(Riparia riparia)*	ST (89)	riparian areas with vertical cliffs and banks with fine-textured or sandy soil	vertical banks; cliffs adjacent to the river
Belding's savannah sparrow *(Ammodramus sandwichensis beldingi)*	SE (74)	mud flats, beaches, rocks, and low tide coastal strand vegetation; nests low to the ground under a pickleweed canopy; build their nest in the upper littoral zone	alkali marsh near mouth of river
Western least bittern *(Ixobrychus exilis hesperis)*	Former C2 sc	nest in dense emergent wetland vegetation of cattails and tules	Alkali marsh, freshwater marsh
Elegant tern *(Sterna elegans)*	Former C2 sc	inshore coastal waters, bays, estuaries, and harbors	beach, southern foredune, alkali marsh, active channel areas near the river mouth
Long-billed curlew *(Numenius americanus)*	Former C2 sc	large coastal estuaries, salt marshes, tidal flats, upland herbaceous areas, and croplands	active channel near river mouth
White-faced ibis *(Plegadis chihi)*	Former C2 sc	fresh emergent wetland vegetation, shallow lacustrine waters, and the muddy ground of wet meadows and irrigated, or flooded pastures/croplands	alkali marsh, active channel near river mouth
Yellow warbler *(Dendroica petechia brewsteri)*	sc	require riparian woodland for breeding; utilize various trees during migration	riparian scrubs, woodlands, and forests

Species	Status	Habitat Requirements	Potential Habitat on SCR
Yellow-breasted chat *(Icteria virens)*	sc	dense riparian woodlands in the coastal lowlands	riparian scrubs, woodlands, and forests
Loggerhead shrike *(Lanius ludovicianus)*	sc	inhabits grasslands, agriculture, chaparral, and desert scrub	riparian scrubs, woodlands, and forests
Cooper's hawk *(Accipiter cooperii)*	sc	breeds in oak woodland habitats and southern cottonwood-willow riparian woodland	riparian scrubs, woodlands, and forests
Black-shouldered kite *(Elanus caeruleus)*	CFP sc	nests in riparian woodlands, particularly those comprised of live oaks and sycamores, and forage over open areas and grasslands	riparian scrubs, woodlands, and forests
Northern harrier (Circus cyaneus)	sc	prairie, wet meadow, and marsh habitats; hunts over grassland, agricultural fields, and coastal and freshwater marshes	riparian scrubs, woodlands, and forests up to mouth of Soledad Canyon
Mammals			
Mountain lion *(Felis concolor)*	CFP	riparian and brushland habitat	riverwide, except areas of urban development
Townsend's big-eared bat *(Plecotus townsendii)*	sc	mesic habitats; roost in caves, mines, tunnels, and buildings	may forage in riparian woodlands and scrubs along entire river
Western mastiff bat *(Eumops perotis)*	sc	riparian and brushland habitats; roosts in crevices in cliff faces, high buildings, trees, and tunnels	may forage in riparian woodlands and scrubs along entire river
Plants			
Slender-horned spineflower *(Dodecahema leptoceras)*	FE (87) SE CNPS 1B	restricted to older, stable sandy river terraces and washes in alluvial scrub and chaparral; at elevations between 200-700 meters.	alluvial scrub from Santa Paula east to Soledad Canyon
Salt marsh bird's beak *(Cordylanthus maritimus* ssp. *maritimus)*	FE (78) SE (79)	higher reaches of salt marshes where inundation with salt water occurs only at the higher tides	alkali marsh near mouth of river
Nevin's barberry *(Berberis nevinii)*	C1 CNPS 1B	sandy and gravelly places in chaparral, cismontane woodlands, coastal sage scrub, and riparian scrub	alluvial scrub from Santa Paula east to Bouquet Canyon Road
Ventura marsh milkvetch *(Astragalus pycnostachyus* var. *lanosissimus)*	T	coastal salt marshes and coastal seeps below 100 feet elevation	alkali marsh near mouth of river

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Appendix D

Species Descriptions

The following text describes in detail the distribution, habitat requirements, life history, and current threats to the eight species utilized in our analysis.

Tidewater goby – *Eucyclogius newberryi*

The tidewater goby is federally endangered. This species is discontinuously distributed throughout California, ranging from Tillas Slough (mouth of the Smith River) in Del Norte County south to Agua Hedionda Lagoon in San Diego County. The goby is apparently absent from three sections of the coast between: 1) Humboldt Bay and Ten Mile River, 2) Point Arena and Salmon Creek, and 3) Monterey Bay and Arroyo del Oso (Brewer et al. 1994).

Before 1900, the tidewater goby occurred in at least 87 of California's coastal lagoons. Since then, it has disappeared from approximately 50 percent of formerly occupied lagoons. A rangewide status survey conducted in 1984 found that 22 historic populations of tidewater goby had been extirpated. Only 5 years later, a status survey documented the disappearance of an additional 21 populations. In the San Francisco Bay area, 9 of 10 previously identified populations have disappeared. Losses in the southern part of the state have been the greatest, including 74 percent of the coastal lagoons south of Morro Bay. Three populations currently remain south of Ventura County (Brewer et al. 1994). Water quality and degradation, as well as the loss of habitat due to urbanization, are the major threats to tidewater goby populations (SCR Project Steering Committee 1996).

The tidewater goby occurs in loose aggregations of a few to several hundred individuals in shallow water less than 1 meter deep. All life stages of the tidewater goby are found at the upper end of lagoons in salinities less than 10 parts per thousand (ppt). Although its closest relatives are marine species, the tidewater goby does not have a marine life history phase (Brewer et al. 1994).

Nesting activities commence in late April and early May, when male gobies dig a vertical nesting burrow 10 to 20 centimeters (4 to 8 inches) deep in clean, coarse sand. Suitable water temperatures for nesting are 18 to 22 °C (75.6 to 79.6 °F) with salinities of 5 to 10 ppt (Brewer et al. 1994). Mollusks, insects, and crustaceans are food sources for the tidewater goby (Wang 1986).

Sightings of the tidewater goby were reported in 1984 in the Santa Clara River, from the mouth to 3 miles upstream (SCR Project Steering Committee 1996). This area coincides with potential habitat for this species (SCR Project Steering Committee 1996).

Unarmored threespine stickleback – *Gasterosteus aculeatus williamsoni*

The unarmored threespine stickleback is a federal and state listed endangered species. Historically, it is believed that the unarmored threespine stickleback occurred in the Santa Clara River, the Los Angeles River, the San Gabriel River, and the Santa Ana River drainages (Haglund 1989, as cited in SCR Project Steering Committee 1996). This species is now restricted to the Santa Clara River above the confluence of Piru Creek. Three zones have been proposed for critical habitat by the USFWS along the Santa Clara River drainage system: San Francisquito, Soledad Canyon, and Del Valle zones. The threespine stickleback prefers quiet water, often living in weedy pools and backwaters, or among emergent plants at stream edges, or over bottoms of sand and mud. It is usually never found in temperatures over 23 °C or in cloudy waters because they are primarily visual feeders evidenced by their large eyes (Tamagni 1995).

Spawning takes place in fresh water during the warm summer months, usually in June or July, but the breeding season varies with locality from April to September.

This species of stickleback feeds primarily on bottom organisms that live on aquatic plants (Moyle 1976, as cited in SCR Project Steering Committee 1996). The unarmored threespine stickleback may compete with another more common subspecies of threespine stickleback (*Gasterosteus aculeatus microcephalus*) for food.

Populations of this species are threatened by stream channelization, urbanization, agricultural development, water diversions, groundwater pumping, introduction of predators and competitors, off-highway vehicle use, and oil spills (State of California 1992, as cited in SCR Project Steering Committee 1996).

Sightings of the unarmored threespine stickleback in the Santa Clara River have been reported from the junction of San Martinez Grande Canyon east to Interstate 5, in San Francisquito Creek from its confluence to approximately 10 kilometers upstream, the downstream portion of the Santa Clara River from McBean Parkway through the proposed Del Valle critical habitat area (State of California 1995, as cited in SCR Project Steering Committee 1996), and the easternmost segment of the river in Aliso Canyon (Bautista, pers. comm. 1996, as cited in SCR Project Steering Committee 1996).

Potential habitat occurs in appropriate portions of the low-flow channel east of the confluence of the river with Piru Creek, east to the Los Angeles aqueduct crossing upstream from Bouquet Canyon Road (SCR Project Steering Committee 1996).

Arroyo Toad - *Bufo microscaphus californicus*

The arroyo toad is a federally listed endangered species. Its habitat requirements include rivers that have shallow, gravelly pools adjacent to sandy terraces. Breeding occurs in large streams with persistent water from late March until mid-June (Sweet 1992). Eggs are deposited and larvae develop in shallow pools with minimal current and little or no emergent vegetation. After metamorphosis (June or July), the juvenile toads remain on the bordering gravel bars until the pool no longer persists (3 to 8 weeks, depending on site and year) (Sweet 1992). Juveniles and adults forage for insects on sandy stream terraces that have nearly complete closure of cottonwoods, oaks, or willows, and almost no grass and herbaceous cover at ground level. Adult toads excavate shallow burrows on the terraces where they shelter during the day when the surface is damp or during longer intervals in the dry season (Sweet 1992).

The arroyo toad was formerly found on rivers with near-perennial flow throughout southern California from San Luis Obispo County to San Diego County. It is believed to be extirpated in San Luis Obispo County (Sweet, pers. comm. 1998), however, populations still persist in Santa Barbara, Ventura, Los Angeles, Riverside, and San Diego Counties. The majority of the remaining populations in Santa Barbara and Ventura Counties are located on the Los Padres National Forest. Both Sespe and Piru Creeks which drain into the Santa Clara River contain populations of arroyo toad (Sweet 1992). The Sespe Creek population is the largest known within the current range.

Due to the isolation and the small sizes, almost all populations are at great risk of extinction. Virtually all remaining populations are small and face a variety of immediate threats to their continued viability. These threats include: short- and long-term changes in river hydrology due to construction of dams and water diversions; alteration of riparian wetland habitats by agriculture and urbanization; construction of roads; site-specific damage by off-highway vehicle use; development of campgrounds and other recreational activities; over-grazing; and mining activities.

Potential habitat for the arroyo toad occurs in the Sespe and Piru Creeks, the active channel and riparian woodlands/forest from the Los Angeles County line east to Interstate 5, as well as the active channel and riparian woodlands/forest from the mouth of Soledad Canyon east to Acton (SCR Project Steering Committee 1996).

California red-legged frog – *Rana aurora draytonii*

The California red-legged frog is a federally threatened species. Its historical range extended from Point Reyes National Seashore, Marin County, California, and from Redding, Shasta County, California, south to northwestern Baja California, Mexico. Today the red-legged frog has disappeared from over 90 percent of its original range, and many of the remaining populations appear to be declining rapidly (Jennings and Hayes 1994). It is known to occur in about 240 streams or drainages primarily in the central coastal area of California, mostly in Monterey, Santa Barbara, and San Luis Obispo Counties.

Preferred habitat for adult frogs is characterized by dense, shrubby or emergent riparian vegetation closely associated with deep still- or slow-moving waters (Jennings and Hayes 1994). During winter, well-vegetated areas along these river corridors are needed for shelter. The red-legged frog disappears for some parts of the year when the creeks dry up, hiding in dense vegetation and small animal burrows as far as 300 feet from the creek, only to emerge when the creek is replenished (Defenders of Wildlife 1999). The most suitable habitat is commonly composed of arroyo willow, but cattails (*Typha* sp.) and bulrushes (*Scirpus* sp.) are also suitable (Jennings and Hayes, 1994).

The California red-legged frog breeds early in the year, from late November to late April. Males appear at breeding sites typically 2 to 4 weeks ahead of females, and call in small mobile groups of between 3 and 7 to attract females (Jennings and Hayes, 1994). Egg masses containing between 2,000 and 5,000 small (0.1 inches in diameter), dark, reddish-brown eggs are attached to vegetation, such as bulrushes or cattails, in or near the water. Biologists call this kind of plant "emergent vegetation". Emergent vegetation and streamside shrubs such as willows that root in creeks are so important to red-legged frogs that the frogs will usually disappear from an area when these plants are cleared (Defenders of Wildlife 1999).

The diet of California red-legged frogs is extremely variable. Adults eat invertebrates, small tree frogs, and mammals, while larvae are thought to feed on algae (Jennings and Hayes 1994).

The California red-legged frog was harvested for food in the San Francisco Bay area and the Central Valley during the late 1800s and early 1900s. About 80,000 frogs were harvested annually between 1890 and 1900 (Jennings and Hayes 1994). The market eventually dwindled as red-legged frogs became more rare, but the species continued to decline as agricultural and urban development eliminated its habitat. It has disappeared from over 99 percent of its former range in the Central Valley (Jennings and Hayes 1994). Remaining populations in the Sierra foothills were fragmented and later eliminated by reservoir construction, exotic predators, grazing, and drought. Bullfrogs have also had substantial negative impacts on red-legged frog populations. Introduced to supply frog legs for restaurants in the face of declining numbers of the California red-legged frog, bullfrogs eat red-legged frog eggs, and replace them in their habitat. Clearing of creek-bed vegetation and the creation of concrete banks threaten the frog's breeding habitats, as well as other forms of water-diversion associated with development. The results have been fragmented habitat, isolated populations, and degraded streams.

Habitat for the red-legged frog is scarce due to the lack of vegetation necessary to shade ponds and pools in the low flow channel. Although the likelihood is low, a few small freshwater marsh areas on the floodplain may serve as potential habitat for the species as well as the river reach in Soledad Canyon and east of Acton in Los Angeles County (SCR Project Steering Committee 1996).

California Least Tern - *Sterna antillarum browni*

The California least tern is a federal and state listed endangered species. This species nests each spring and summer close to estuaries and coastal lagoons, and on sandy beaches and playas, from San Francisco Bay south into Baja California, Mexico (Palacios and Mellink 1996; Caffrey 1996). It winters along the coasts of western Mexico, south to northern South America (King 1981, as cited in García and Ceballos 1995). Habitat requirements during the nesting season include barren to sparsely vegetated sandbars along rivers, sand and gravel pits, or lake and reservoir shoreline.

There were approximately 4,017 pairs nested at 38 sites along the coast of California in 1997. This represented a 19 percent increase from 1996 pair estimates and 55 percent increase from 1995 pair estimates (Keane 1997). The birds usually live in colonies of 30-50 nesting pairs. The California Least Tern has evolved an ability to rapidly colonize new and appropriate nesting areas (García and Ceballos 1995). Some sites are actually clusters of alternative nesting sites, and the selection and use of a particular site of the cluster depends on its suitability during that particular breeding season (Massey and Fancher 1989, as cited in Palacios and Mellink 1996). Nests are usually in a shallow hole scraped in an open sandy area, gravelly patch, or exposed flat (Caffrey 1996). These birds have been found nesting on artificial islands and other areas created by construction activities (e.g., dredged sand and construction pads). Thus creation of new sites may aid in the management of these species (SCR Project Steering Committee 1996).

Least Terns are opportunistic feeders known to capture more than 50 species of fish. The terns hover over and dive into relatively shallow, near shore waters and coastal freshwater ponds, channels, and lakes to catch the fish (Thelander 1994).

Numerous threats have affected the least tern populations. Predation is the major factor constraining the fledging of terns across California (Caffrey 1996). In addition, disturbance and degradation of nesting sites has led to its population decline (Palacios and Mellink 1996). Current conservation efforts should focus on the reduction of impacts from recreational activities and on the preservation of the coastal habitats on which the species depends (Palacios and Mellink 1996). Protection of nesting sites with fencing and signage has effectively limited human disturbance at most nesting sites (Keane 1997). Enhancement of well-established, incipient, and potential sites remains a priority.

The Santa Clara River is an area in which terns have returned to breed after not being used for variable periods of time (Caffrey 1996). Potential habitat along the Santa Clara River occurs at the mouth.

Least Bell's Vireo – *Vireo bellii pusillus*

A federally and state listed endangered species, the least Bell's vireo, one of the four subspecies of Bell's vireo, only occurs in coastal California. This subspecies arrives on its breeding grounds in Southern California and northern Baja California, Mexico around mid-March to early-April, and departs by mid to late September to winter in southern Baja California. Its preferred habitat is dense willow dominated riparian areas with a lush understory in a 5-10 year old succession stage (Steinitz et al. 1997). Dense, low growing thickets of willows, mule fat, blackberry and mugwort are an essential part of its habitat, as well as an overstory composed of tall willows, cottonwoods and sycamores. Few vireos are found where open ground or low amounts of aquatic or herbaceous cover are present.

Nesting territories range in size from about one to four acres, and are defended by the males. These territories are established in riparian habitat, usually in dense willow-dominated thickets. A low growing dense shrub layer and a large degree of vertical stratification are preferred. Most nest sites are located near the edge of thickets (Steinitz et al. 1997) and the average nest height is approximately 3 feet from the ground (USFWS 1996).

The least Bell's vireo is insectivorous. Most foraging takes place below twelve feet (USFWS 1996) in the vicinity of the nest site in predominantly willow habitat (Steinitz et al. 1997). The vireo will travel up to 15 meters to forage in both high and low shrub layers.

Loss of riparian habitat and increased parasitism by the brown-headed cowbird (*Molothrus ater*) are two main reasons for the decline in numbers of the least Bell's vireo. Over the past century riparian habitat has decreased dramatically in California. Estimations show that more than 90 percent of riparian woodland habitat in the Central Valley has been cleared for development (Katibah 1984, as cited in SCR Project Steering Committee 1996). Nest parasitism by brown-headed cowbirds has also negatively impacted vireo populations. Development of agricultural and livestock activities near riparian habitats, where cowbirds tend to thrive, has increased nest parasitism by brown-headed cowbirds in southern California. Protection of riparian habitat, habitat creation and enhancement projects, and brown-headed cowbird removal has resulted in significant increase in the region's least Bell's vireo population (USFWS 1995, as cited in SCR Project Steering Committee 1996).

Recorded occurrences of the least Bell's vireo on the Santa Clara River stretch from Saticoy east to Santa Clarita (SCR Project Steering Committee 1996). Potential habitat occurs in these areas as well as the areas that support southern willow scrub and southern willow riparian woodland (SCR Project Steering Committee 1996).

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Southwestern Willow Flycatcher – *Empidonax trailii extimus*

The Southwestern willow flycatcher is a federal and state listed endangered species. From late April until August or September, this species is present in its breeding range including southern California, southern Utah, Arizona, New Mexico and western Texas. It then migrates to its wintering grounds, most likely in Mexico, Central America and perhaps northern South America (SCR Project Steering Committee 1996). Historically, the southwestern willow flycatcher was present in all lowland riparian areas of the southern third of California. Today, approximately 10 nesting groups exist in California, all of which consist of six or fewer nesting pairs. The total population is estimated to be 70 pairs and 8 singles in California (Federal Register 1995a).

The southwestern willow flycatcher occurs in riparian habitats along rivers, streams and wetlands where dense growths of willows, arrowweed, buttonbush, tamarisk, Russian Olive and a scattered overstory of cottonwood are present (Federal Register 1995a). Coyote willow, seepwillow (Johnson et al. 1999), cattail, horsetail (Sogge et al. 1997) and dogwoods (Harris 1991) are also suitable. An abundance of willow flycatchers is correlated with willow abundance, density and coverage. This species is most abundant in structurally complex, willow-dominated areas close to surface water, and are intolerant of changes in vegetation structure (Sanders and Edge 1998). A new hypothesis states that they may not attempt to breed in the absence of flowing water, especially in May and June (Johnson et al. 1999).

The willow flycatcher is an insectivorous bird that forages within and above dense riparian vegetation. It also forages in adjacent areas which may be more open (Federal Register 1995a).

The decline in the populations of the southwestern willow flycatcher has resulted from the loss or degradation of riparian habitats due to urban and agricultural development, water diversion and impoundment, channelization, invasion by non-native species, and livestock grazing. This degradation can attract brown-headed cowbirds, which parasitize willow flycatcher nests. Studies have shown that the cowbirds, which feed in heavily grazed pastures and stubblefields, parasitize nests that are located closer to the edge of the flycatcher habitat. To reach the nests, cowbirds can travel up to 20 km from where they feed (Sogge et al. 1997). Fragmentation and disturbance are associated with higher parasitism rates. Loss of wintering grounds to tropical deforestation is another factor affecting the abundance of the southwestern willow flycatcher.

No recorded instances of breeding by the southwestern willow flycatcher have been documented along the Santa Clara River (SCR Project Steering Committee 1996). However, potential breeding habitat for the species occurs in the mature willow woodlands and cottonwood/willow riparian forests, particularly in Los Angeles County (SCR Project Steering Committee 1996).

Western Snowy Plover - *Charadrius alexandrinus nivosus*

The western snowy plover is a federally threatened species. Sand spits, dune-backed beaches, unvegetated beach strands, open areas around estuaries, and beaches at river mouths are the preferred coastal habitats for nesting and for wintering (SCR Project Steering Committee 1996). The snowy plover nests through mid-March to mid-September (Federal Register 1995b). It builds its nests in shallow depressions in sand lined with small pieces of shell (SCR Project Steering Committee 1996). The Pacific coast population breeds in loose colonies primarily on coastal beaches from southern Washington to southern Baja California, Mexico (Federal Register 1995b). Based on the most recent surveys, a total of 28 snowy plover breeding sites or areas currently occur on the Pacific Coast of the United States. A total of 20 plover breeding areas currently occur in coastal California (Page et al. 1991). Eight areas support 78 percent of the California coastal breeding population including the Oxnard lowland. Some birds winter in the same areas used for breeding (Warriner et al. 1986). Other birds migrate north or south to wintering areas. The majority of birds winter south of Bodega Bay, California. Wintering plovers occur in widely scattered locations on both coasts of Baja California and significant numbers have been observed on the mainland coast of Mexico. Many interior birds west of the Rocky Mountains winter on the pacific coast (Page et al. 1986).

The snowy plover uses a variety of sites for foraging and loafing, including mudflats of San Diego Bay and other coastal lagoons, and sandy beaches associated with river mouths and lagoons. It feeds almost exclusively on insects and crustaceans gleaned from the sand surface (SCR Project Steering Committee 1996).

Habitat loss, predation and other human activities have threatened snowy plover populations. The most important form of habitat loss to coastal breeding snowy plovers has been encroachment of European beachgrass (*Ammophila arenaria*) (Federal Register 1995b). This non-native plant was introduced to the west coast around 1898 to stabilize dunes. Cost effective methods to control or eradicate European beachgrass have not been found. Human activity (e.g. walking, jogging, running pets, horseback riding, off-road vehicle use, and beach raking) is also a key factor in the ongoing decline in snowy plover coastal breeding sites and breeding populations in California. Predation by birds and mammals (especially American crows (*Corvus brachyrhynchos*), common ravens (*Corvus corax*), and red fox (*Vulpes vulpes*)) predators is a major concern at a number of nesting sites (Federal Register 1995b). Accumulation of trash at beaches attracts these as well as other predators.

Sightings of the western snowy plover have been reported at Ormond Beach, approximately 1.5 miles southwest of Port Hueneme, McGrath Beach State Park, Point Magu, and the Santa Clara River mouth (State of California 1995, as cited in SCR Project Steering Committee 1996). Potential habitat for this species is located on the beach and southern foredune areas near the mouth of the river (SCR Project Steering Committee 1996).

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Appendix E

Metadata

The Santa Clara River Enhancement and Management Plan (SCREMP) developed the GIS database utilized by this project. The Ventura County Flood Control Department and the consulting firms of CH2MHill, Psomas & Associates, and RECON provided the following coverage information.

Coverage Name	Data Source*	Coverage Description
agg	Unknown	Aggregate mining areas for Ventura and Los Angeles (L.A.) Counties
agrilu	SCAG	Agricultural Land Use
agrilud	SCAG	Agricultural Land Use
arundo	BSC	Areas containing *Arundo donax (Giant Reed)*
bioreach	BSC	Biological Segments: This layer represents the 500-year floodplain with upstream and downstream reach boundaries. The reaches indicate portions of the river with similar habitat, channel, and geomorphological characteristics. They were used to make generalized recommendations as to the conservation priorities along the river.
countyln	unknown	Boundary between L.A. and Ventura Counties
dsfpb	LAC	L.A. County flood plain boundary
dsfwb	LAC	L.A. County floodway boundary
dvrsns	WRSC	Public and private water diversion locations
enhance	BSC	Areas of Vegetation Enhancement: This layer is indicative of some level of *Arundo donax* mixed in with native vegetation. Removal of *Arundo donax* in these areas would enhance the habitat value for native vegetation and wildlife.
excav	VCFCD	Streambed Excavation Areas: These areas, mapped by CH2MHill, contain large amounts of sediment deposition (Proposal to allow removal of these materials by aggregate minors)
fcfacl	LAC	L.A. County flood control facilities (levees, groins, dikes, etc.)
fcfacv	VCFCD	Ventura County flood control facilities (levees, groins, dikes, etc.)
fcplain2	VCFCD/LA	Flood Plain Boundaries: Coverage which outlines the boundaries for the floodway, 100-yr and 500-yr flood plains
floodway	VCFCD	Floodway for Ventura County
fp100	VCFCD	100 Year Flood Plain
fp500	VCFCD	500 Year Flood Plain
gwbasin	WRSC	Groundwater Basins for Ventura and L.A. Counties

Coverage Name	Data Source*	Coverage Description
if25	VCFCD	25 Year Interim Flood Plain (Proposed 25 year protection and encroachment limits in which property owners have the ability to protect their property up to this boundary)
landuse	SCAG	Landuse: SCAG landuse data from 1993 for Los Angeles and Ventura Counties (see code descriptions below)
map_ndx	CH2MHill	Map index boundary coverage for map series.
mrz	ASC	Aggregate Mineral Resource Zones: Derived from State of California mineral resource zone maps.
mrz2	ASC	Aggregate Mineral Resource Zone 2
ocean	unknown	Pacific Ocean
ospace	SCAG	Designated openspace areas
parcell	LAC	Los Angeles County Parcels
parcelv	VCFCD	Ventura County Parcels
prkreclu	RSC	Parks and recreation land use
prks_rec	RSC	Parks and recreation areas for Ventura and L.A. Counties
rail	unknown	Rail roads
reach	VCFCD	River reaches: Reach boundaries based on various factors including landmarks, flood control facilities, ground water basins and/or biology
restore	BSC	Vegetation Restoration Areas: This layer indicates pure stands of *Arundo donax*, agricultural areas within the floodplain, or disturbed areas within the floodplain but not the active channel. These areas have the potential to be restored to native riparian habitats.
risewat	WRSC	Areas of rising groundwater
scriver	unknown	The entire Santa Clara River system (including tributaries) for Ventura and L.A. Counties
species	BSC	Threatened and Endangered Species: This layer contains value fields of potential habitat for a selected set of threatened and endangered species based on the vegetation polygons as well as the "best professional judgment" of biologists based on aerial photo interpretation and field assessment.
sprdbsn	UWCD	Spreading basins (e.g., Saticoy spreading, Piru spreading grounds)
tiger	unknown	?
topo_l	LAC	Elevation contours for L.A. County
topo_v	VCFCD	Elevation contours for Ventura County
trails	RSC	Existing and proposed trails for Ventura and L.A. Counties
transcor	WRSC	Transportation corridor for water release from reservoirs
translin	WRSC	Transportation corridor to Freeman Diversion
Valu	BSC	Biological Habitat Valuation

Coverage Name	Data Source*	Coverage Description
Veg	BSC	Existing Vegetation: The distribution of the riparian habitat types along the Santa Clara River in the 500-year floodplain was mapped using topographic maps, color aerial photographs (flown in 1993), and field surveys conducted in March and April, 1995.
Vegera	BSC	Vegetation Eradication
Vegerac	BSC	Vegetation Eradication Class
wwtp	WRSC	Wastewater reclamation plants

***Data Source Descriptions:**

ASC = Aggregate Subcommittee
BSC = Biological Subcommittee
LAC = Los Angeles County
RSC = Recreation Subcommittee
SCAG = Southern California Association of Governments
UWCD = United Water Conservation District
VCFCD = Ventura County Flood Control District
WRSC = Water Resources Subcommittee

Land Use Code(LUCODE)	LUCODE Description
1000	Urban or Built-Up
1100	Residential
1110	Single Family Residential
1111	High Density Single Family Residential
1112	Low Density Single Family Residential
1120	Multi-Family Residential
1121	Mixed Multi-Family Residential
1122	Duplexes and Triplexes
1123	Low-Rise Apartments; Condominiums; & Townhouses
1124	Medium-Rise Apartments and Condominiums
1125	High-Rise Apartments and Condominiums
1130	Mobile Homes and Trailer Parks
1131	Trailer Parks and Mobile Home Courts; High Density
1132	Mobile Home Courts and Subdivisions; Low Density
1140	Mixed Residential
1150	Rural Residential
1151	Rural Residential High Density
1152	Rural Residential Low Density
1200	Commercial and Services
1210	General Office Use
1211	Low and Medium-Rise Major Office Use
1212	High-Rise Major Office Use
1213	Skyscrapers
1220	Retail Stores and Commercial Services
1221	Regional Shopping Mall
1222	Retail Centers (Non-Strip With Contiguous Interconnected Off-Street Parking)
1223	Modern Strip Development
1224	Older Strip Development
1230	Other Commercial
1231	Commercial Storage
1232	Commercial Recreation
1233	Hotels and Motels

Land Use Code(LUCODE)	LUCODE Description
1234	Attended Pay Public Parking Facilities
1240	Public Facilities
1241	Government Offices
1242	Police and Sheriff Stations
1243	Fire Stations
1244	Major Medical Health Care Facilities
1245	Religious Facilities
1246	Other Public Facilities
1247	Non-Attended Public Parking Facilities
1250	Special Use Facilities
1251	Correctional Facilities
1252	Special Care Facilities
1253	Other Special Use Facilities
1260	Educational Institutions
1261	Pre-Schools/Day Care Centers
1262	Elementary Schools
1263	Junior or Intermediate High Schools
1264	Senior High Schools
1265	Colleges and Universities
1266	Trade Schools
1270	Military Installations
1271	Base (Built-up Area)
1272	Vacant Area
1273	Air Field
1300	Industrial
1310	Light Industrial
1311	Manufacturing and Assembly
1312	Motion Picture
1313	Packing Houses and Grain Elevators
1314	Research and Development
1315	Winery
1320	Heavy Industrial
1321	Manufacturing
1322	Petroleum Refining and Processing
1323	Open Storage
1324	Major Metal Processing
1325	Chemical Processing
1330	Extraction
1331	Mineral Extraction - Other Than Oil and Gas
1332	Mineral Extraction - Oil and Gas
1340	Wholesaling and Warehousing
1400	Transportation; Communications; and Utilities
1410	Transportation
1411	Airports
1412	Railroads
1413	Freeways and Major Roads
1414	Park and Ride Lots
1415	Bus Terminals and Yards
1416	Truck Terminals
1417	Harbor Facilities
1418	Navigation Aids
1420	Communication Facilities
1430	Utility Facilities
1431	Electrical Power Facilities
1432	Solid Waste Disposal Facilities
1433	Liquid Waste Disposal Facilities
1434	Water Storage Facilities
1435	Natural Gas and Petroleum Facilities
1436	Water Transfer Facilities

Land Use Code(LUCODE)	LUCODE Description
1437	Improved Flood Waterways and Structures
1438	Mixed Wind Energy Generation and Percolation Basin
1439	Caretaker Residence for Water Transfer Facility
1440	Maintenance Yards
1450	Mixed Transportation
1460	Mixed Transportation and Utility
1500	Mixed Commercial and Industrial
1600	Mixed Urban
1700	Under Construction
1800	Open Space and Recreation
1810	Golf Courses
1820	Local Parks and Recreation
1830	Regional Parks and Recreation
1840	Cemeteries
1850	Wildlife Preserves and Sanctuaries
1860	Specimen Gardens and Arboreta
1870	Beach Parks
1880	Other Open Space and Recreation
1900	Urban Vacant
2000	Agriculture
2100	Cropland and Improved Pasture Land
2110	Irrigated Cropland and Improved Pasture Land
2120	Non-Irrigated Cropland and Improved Pasture Land
2200	Orchards and Vineyards
2300	Nurseries
2400	Dairy and Intensive Livestock; and Associated Facilities
2500	Poultry Operations
2600	Other Agriculture
2700	Horse Ranches
3000	Vacant
3100	Vacant Undifferentiated
3200	Abandoned Orchards and Vineyards
3300	Vacant With Limited Improvements
4000	Water
4100	Water; Undifferentiated
4200	Harbor Water Facilities
4300	Marina Water Facilities
4400	Water Within a Military Installation
4500	Area of Inundation

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Appendix F

Assessor's Information

The following information was collected from the Ventura County Assessor's Office.

APN Number	Land Value	Year Assessed
041026001	100000	91
041026012	107695	75
041026016	11652	86
041026017	1392865	75
041026019	36085	75
041026021	75874	75
041026025	4676	75
041026028	12175	75
041026029	10796	99
041026030	274681	85
041026032	417426	99
041026038	3033	83
041026039	368721	81
041026041	305133	86
041026042	338433	83
041026043	86196	75
041026045	5137	78
041026046	9555	76
041026047	12510	78
041026050	327	83
041026051	327	83
041026053	362796	90
041026055	206524	85
041029001	112079	87
041029003	17181	75
041029004	194512	89
041029005	62642	75
041029006	624	75
041029007	38850	82
041029011	16013	75
041029012	768	75
041029013	1242	75
041029015	7871	75
041029019	221171	84
041029023	43683	77

APN Number	Land Value	Year Assessed
041029024	452	75
041029025	15473	75
041029026	503315	80
041029028	181969	75
041029029	87950	75
041029034	260	75
041029035	524807	81
041029038	254624	95
041029039	250931	96
041029040	402679	86
041029041	375000	89
041029042	401556	78
041029043	662315	97
041029046	13355	77
041029047	57782	75
041029049	20304	75
041029050	281	76
041029051	87870	83
041029057	480000	87
041029058	14213	82
041030007	64674	99
046005001	82530	89
046005002	294000	99
046005007	219996	99
046006005	71000	87
046006010	168942	86
046006011	140532	81
046006012	8679	86
046007012	3880	75
046007013	10707	86
046008002	635000	93
046008007	443609	98
046008007	450464	98
046008011	176031	94
046008012	338786	94

APN Number	Land Value	Year Assessed
046009001	100087	89
046009002	26772	89
046010001	21972	89
046010007	232361	92
046010009	9519	86
046010010	7170	75
046010011	226059	75
046010012	4756	86
046010013	72254	75
046010014	1260	75
046010015	48589	77
046010017	36020	76
046011001	714533	98
046011003	306987	97
046011004	96947	75
046011006	245021	86
046011008	84512	99
046011009	97985	78
046011012	48468	75
046011013	47680	75
046011017	31001	75
046011018	95379	76
046011021	156994	98
046011027	73526	75
046011028	708545	98
046012202	80850	75
046012205	88335	75
046012206	6247	75
046012208	99616	75
046012209	102608	80
046013201	243179	75
046013203	406209	97
046013204	169076	97
046014203	427723	91
046014204	113112	89
046014205	55057	89
046014206	414741	91
046014207	406636	91
046014208	513363	93
046015009	635934	75
046015014	271618	93
046015017	398930	81
046015018	366322	81

APN Number	Land Value	Year Assessed
046015019	291	75
046015020	3714	75
046015021	16988	80
046015022	62429	80
046015027	149395	75
046015032	248005	94
046015033	2660	94
046015034	695654	97
046015037	532960	91
046015039	543124	92
046015040	481764	98
046015041	549340	91
046016002	292987	79
046016003	230389	77
046016007	11427	98
046016009	10502	93
046016023	36989	75
046016024	371926	98
046016030	1342861	75
046016033	1362	87
046016035	210795	75
046016037	98793	84
046016039	357749	95
046016041	436991	82
046016045	482994	90
046016046	646077	90
046017101	169547	75
046017102	90283	75
046017108	361979	75
046017109	249089	75
046017110	42609	75
046017201	120864	75
046017202	180098	85
046017203	61757	75
046017204	765	75
046017205	13240	77
046018101	454354	75
046018102	103547	75
046018103	39243	75
046018104	76872	81
046018202	69368	81
046018207	86353	75
046018208	48521	75

APN Number	Land Value	Year Assessed
046018302	23500	91
046018303	73332	81
046018304	111014	75
046018308	79288	85
046018309	166500	91
046018310	150174	88
046018401	108299	77
046019103	79592	75
046019104	795	75
046019201	168835	83
046019202	26781	75
046019203	180021	93
046019204	523947	92
046019205	123509	80
046019301	195806	80
046019303	122091	88
046019304	317995	96
046019306	80000	99
046019307	165000	99
046019308	46361	79
046019401	113485	75
046019402	59885	75
046019403	170000	94
046019405	161524	95
046019406	459	79
046019502	9359	75
046019503	153445	98
046019506	170375	85
046019509	19590	75
046019510	20373	75
046019512	36373	75
046019601	66450	75
046020101	97878	75
046023001	10737	81
046023002	76131	75
046023003	12812	75
046023004	1541	75
046023005	237	75
046023007	175421	80
046023008	117650	75
046023009	6234	75
046023013	36142	89
046023015	168612	75

APN Number	Land Value	Year Assessed
046023016	22640	95
046023020	174162	89
046023021	225036	89
046023022	223839	89
046023023	41891	89
046023025	9065	75
046025002	82868	75
046025005	109507	95
046025007	470	75
046025008	493062	75
046027001	205278	77
046027002	128271	75
046027003	21879	75
046027004	70361	75
046027009	163	75
046027010	442	75
052017001	29307	75
052017012	56800	99
052017013	33562	86
052017014	33562	86
052017015	38227	86
052017016	52400	98
052017017	53000	96
052017018	38227	86
052017019	52400	88
052017020	52400	88
052017021	38227	86
052017031	52400	89
052017032	38227	86
052017033	49200	91
052017034	33562	86
052017035	38227	86
052017036	52400	89
052017037	48532	96
052017038	33562	86
052017039	38227	86
052017052	49200	87
052017053	52400	92
052017054	40311	87
052017055	52400	97
052017056	52400	92
052017057	49200	94
052017058	43999	99

APN Number	Land Value	Year Assessed
052017071	28562	88
052017072	25968	88
052017073	47600	90
052017074	44904	96
052017075	25968	86
052017076	47600	97
052017077	47600	93
052017078	47600	92
052017079	47600	96
052017080	47600	93
052017081	47600	93
052018006	298887	87
052018035	43582	87
052018036	70000	91
052018044	63236	84
052019001	70948	75
052019002	70948	75
052020001	11711	75
052020002	22089	77
052020003	8641	75
052020005	73676	77
052020006	35571	75
052020009	40007	87
052021007	15626	75
052021009	9359	75
052021010	143605	79
052021011	7797	75
052021012	13881	79
052021013	7797	75
052021014	420000	99
052021015	1540000	99
053014002	26019	76
053014015	441916	89
055016027	154	98
055016028	1170402	98
055018007	83331	79
055018008	53820	79
055018009	25559	92
055018016	153765	80
055018017	244966	75
055018018	296	79
055018023	165671	79
055018028	277173	99

APN Number	Land Value	Year Assessed
055018029	200000	90
055018030	165671	79
055018034	243680	84
055021013	1440397	75
055024002	69256	93
055024006	111421	85
055024007	2135237	75
055025002	99761	85
055025003	737622	75
055026003	156548	90
055026004	129559	90
055026005	17633	75
055026006	14848	75
055026013	136715	90
055026014	75324	84
055026015	17372	75
055026017	26422	84
055026018	68714	84
055026020	139477	87
055026021	6234	75
055026022	6234	75
055026023	112543	81
055026024	146922	77
055026025	241423	82
055026026	3725	75
055026031	100434	84
055026033	434883	75
055026033	523241	75
055026039	54177	84
055026044	30555	98
055026047	223345	84
055026051	200608	75
055026053	197039	81
055026054	193005	99
055026057	399502	87
055026059	175748	80
055027009	1292	79
055027010	31354	75
055027012	1554	75
055027018	6763	93
055027019	1554	75
055027026	193000	99
055027028	52698	98

APN Number	Land Value	Year Assessed
055027029	233647	76
055027032	98670	98
055027038	105421	75
055027039	629000	99
055029013	1559500	90
055029014	54880	88
055029015	950000	90
055030002	319951	75
055031001	200185	75
057001014	113603	75
057002009	104575	75
057002010	684532	93
057002011	67813	75
057003011	302563	84
057003012	118712	75
057003013	301069	83
057003014	394899	84
057003016	287151	97
057004001	217233	96
057004003	136743	88
057004004	342309	95
057004006	31101	75
057004010	111421	85
057004011	162215	85
057005005	8825	75
057005008	6242	75
057005010	275979	85
057006001	316973	92
057006003	120227	92
057006003	123675	92
057007013	172741	75
057007015	429779	76
057007018	151695	77
057007019	62193	91
057008007	436338	91
057008009	514000	91
090011003	513422	98
090011004	1919	75
090011021	311853	84
090016004	634512	87
090017205	31338	86
090018007	34424	86
090018008	3071495	86

APN Number	Land Value	Year Assessed
090019014	87190	75
090019016	440825	96
090019020	7210	79
090019024	249000	99
090019026	22054	75
090019028	363615	97
090019029	39178	75
090019031	370169	75
090019032	152253	78
090019033	171648	75
090019035	4667	75
090019044	4856	75
090019049	87561	75
090019051	7985	75
090019053	7985	75
090019054	6220	89
090019058	4446	75
099003034	241137	88
099003056	56276	75
099003057	120477	75
099003063	31334	79
099003064	75606	75
099004053	180145	97
099004054	40511	75
099004055	39072	75
099004057	30933	78
099004058	87615	83
099004060	28129	75
099004061	15626	75
099004063	115579	79
099005006	440187	75
099005007	26455	74
099005011	4085	74
099005022	23434	75
099006004	6718	94
099006009	122457	75
099006016	1276355	90
099006017	22006	94
099006025	110585	75
099006026	218161	75
099006027	738	75
099006029	86731	94
099006033	254000	99

APN Number	Land Value	Year Assessed
099006034	332872	82
099006038	225000	90
099006039	140000	95
099006040	220000	84
099006044	229276	75
099006046	62428	75
099006047	58	75
099007004	247037	80
099007005	78171	75
099007006	7176	89
099007008	110664	75
099007009	77000	99
099007010	10106	94
099007012	31652	82
099007014	397015	75
099007016	218548	88
099007018	1192	89
099007020	473884	82
099007022	1551	75
099007023	150000	92
099007024	71135	75
099008003	240062	80
099008010	77726	80
099008011	141017	88
099008012	425	75
099008014	10577	87
099008015	300	75
099008016	20123	81
099008018	211935	97
099008019	209218	87
099008020	69335	79
099008021	143387	75
099008023	602562	97
099009004	809382	93
099009009	201094	89
099011001	328499	96
099011004	587626	99
099011005	17342	94
099011006	32739	94
099011007	149	75
099011008	602500	99
099011009	780007	95
099011010	148371	75

APN Number	Land Value	Year Assessed
104006114	30000	90
104006115	10143	75
104006116	7803	75
104006139	32386	85
104006140	9364	75
104006145	51945	97
104006148	21000	90
104006149	54000	90
104006505	65829	89
104006506	54139	92
104006507	8533	75
104006508	9364	75
104006509	73320	92
104006510	81480	99
104006511	4710	75
104006512	9364	77
104006513	42386	97
104007101	13609	82
104007102	45832	99
104007103	8582	75
104007104	8238	77
104007105	55000	90
104007106	21557	83
104007112	66214	99
104007116	35000	90
104007117	35000	90
104007118	36000	96
104007119	35647	99
104007120	37497	95
104007121	35000	90
104007122	83112	97
104007123	35000	91
104007124	35000	91
104007125	35648	98
104007126	35000	99
104007127	35000	99
104007128	101728	97
104008009	71297	98
104008010	45832	99
104008011	15626	75
104008033	7498	77
104008034	12490	75
104008035	10927	75

APN Number	Land Value	Year Assessed
104008036	10927	75
104008049	20612	76
104008056	55000	95
104008059	41984	78
104008061	8576	75
104008063	54452	82
104008064	64285	95
104008065	61069	95
104009106	70000	99
104009107	21236	80
104009118	11862	78
104009119	34314	75
104009120	7803	76
104009121	7803	75
104009221	26952	83
104009223	9574	75
104010503	8582	75
104010504	3134	75
104010505	8582	75
104010506	8582	75
104010508	3138	75
104010509	25904	86
104010510	8582	75
104010511	26422	85
104010512	54452	82
104010514	39639	84
104010516	8582	75
104010704	10921	75
104010705	68567	98
104010706	6234	75
104010707	6472	85
104010708	28321	80
104010709	676792	92
104010710	29946	82
104010713	7803	75
104010714	7803	75
104010715	7803	75
104010716	4775	80
104014308	203329	93
104014309	24257	77
104014312	83112	98
104014313	57156	86
104014314	81482	98

APN Number	Land Value	Year Assessed
104014315	90072	97
104014317	12490	75
104014318	77735	86
104014320	103890	98
104014321	68878	97
104014322	46249	84
104014504	47940	87
104014505	55200	98
104014506	10084	75
104014507	14724	78
104014508	10001	77
104014509	54800	91
104014510	52770	97
104014511	10138	75
104014512	56800	97
104014513	10138	75
104014514	10138	75
104014515	33654	86
104014516	39447	85
104014517	11474	76
104014518	50925	99
104014520	390953	75
104014521	84773	96
104014522	162130	96
104014523	100000	99
104014524	86731	94
104014525	13276	75
104014526	11706	75
104014527	10943	75
104014528	10143	75
104014529	28321	80
104014530	10143	75
104014535	64285	95
104014536	99623	87
104014542	64200	91
104014543	10138	75
104014545	28400	91
104014545	71000	91
104014546	28400	91
104014547	28400	91
104014548	32400	91
104014549	28400	91
104014550	28400	91

APN Number	Land Value	Year Assessed
104014551	32400	91
104014552	190741	96
104014601	234182	94
104014603	180000	90
104014604	92156	95
104014606	168052	99
104015101	55600	92
104015102	63200	99
104015103	28298	83
104015104	54800	90
104015105	55600	88
104015106	10138	75
104015107	38845	84
104015108	54800	95
104015109	14724	78
104015110	54800	95
104015111	54800	97
104015112	54800	93
104015113	55600	96
104015114	10138	75
104015115	54800	98
104015123	59226	95
104015206	10153	75
104015207	10138	75
104015208	54800	98
104015209	10218	75
104015210	39770	85
104015211	55600	89
104015212	14724	78
104015213	10157	75
104015214	23707	80
104015215	47898	87
104015216	45563	86
104015217	14724	78
104015218	55600	89
104015219	11491	76
104015220	62200	98
104015221	55600	89
104015222	10138	75
104015223	54800	94
104015224	10138	75
104015225	10218	75
104015226	10138	75

APN Number	Land Value	Year Assessed
104015227	54800	91
104015228	10138	75
104015229	56400	97
104015230	55600	88
104015231	47940	87
104015232	56000	99
104015233	10138	75
104015238	10138	75
104015241	11491	75
104015305	10138	75
104015306	54800	97
104015307	56017	99
104015308	37459	84
104015309	10138	75
104015310	54800	98
104015311	54641	95
104015312	15020	77
104015313	54800	96
104015314	10138	75
104015315	55600	94
104015316	15020	77
104015317	10153	75
104015318	14844	78
104015319	10138	75
104015320	55200	95
104015321	55200	98
104015322	55200	90
104015323	52963	88
104015324	10227	75
104015325	55200	97
104015326	18908	79
104015327	53200	97
104015328	44452	87
104015329	36998	84
104015330	58400	93
104015331	14724	78
104015332	10138	75
104015337	53600	92
104015338	61411	90
104015401	48832	88
104015402	43582	87
104015403	67528	98
104015405	10227	75

APN Number	Land Value	Year Assessed
104015406	10138	79
104015407	58200	88
104015408	56800	87
104015409	59000	96
104017024	24257	79
104017025	364	79
104017032	1728168	80
104017033	186805	87
104017037	187817	79
104017039	158951	96
104017040	84307	75
104017041	175101	75
104017042	91943	79
104017043	152478	82
104017044	51728	82
104017045	254051	87
104017046	768786	98
104017047	46900	75
104017048	47938	93
104017049	1294	75
104018101	331005	75
104018102	107053	92
104019301	3956	80
104019306	57174	82
104019401	31931	81
104019402	24901	88
104020020	2473	90
104022001	296	75
104022002	31262	75
104022003	245779	96
104022005	68878	96
104022006	9120	76
104022008	1869	98
104022009	149	75
104022019	56942	99
104022020	164081	99
104022021	441477	99
104023002	11024	84
104023003	11024	84
104023004	11008	84
104023005	11008	84
104023006	11056	93
104023007	11008	84

APN Number	Land Value	Year Assessed
104023008	42000	99
104023009	11008	84
104023010	11008	84
104023011	40000	91
104023012	42777	99
104023013	11008	84
104023014	11008	84
104023015	39027	94
104023016	11024	84
104023017	11008	84
104023018	11024	84
104023019	43633	98
104023020	11024	84
104023021	11008	84
104023022	11008	84
104023023	11008	84
104023024	43633	98
104023025	11008	84
104023026	11008	84
104023027	11008	84
104023028	11008	84
104023029	11008	84
104023030	11008	84
104023033	14438	79
104023034	14438	79
107001114	100426	84
107004303	945248	75
107004304	609	75
107004305	18804	75
107004307	439903	89
107005002	870	77
107005042	265958	97
107006201	73332	99
107006204	20241	83
107006213	66450	79
107008001	183752	89
107008003	179037	93
107012001	254380	86
107014015	31725	94
107014032	760	75
107014033	340922	75
107014037	55640	92
107014037	55640	92

APN Number	Land Value	Year Assessed
107014038	1462	75
107014039	22581	88
107014040	311228	88
107015002	17098	75
107015004	168393	94
107015008	149	75
107015009	30933	75
107015010	162625	94
107016001	2185	75
107016003	208034	83
107016005	37125	75
107016006	2185	75
107016007	391	92
107021020	245000	89
107021026	105646	79
107021027	297224	79
107021028	89883	79
107021029	71521	79
107021033	157253	98
107021041	107056	79
107021042	245000	92
107021048	420000	90
107021049	225000	89
108001008	30539	75
108001014	2190	75
109001020	21065	75
128003012	193916	79
128004020	29831	75
128004021	288670	91
129001101	1721	91
129001103	38279	75
129001106	37272	75
129001133	63449	75
129001135	9844	75
129002001	7871	77
129002006	49731	77
130006005	344429	90
130007002	1233534	86
130007003	304843	79
132001007	672151	86
132001008	70350	79
132001016	244	84
132001018	1172118	77

APN Number	Land Value	Year Assessed
132002034	31076	75
132002039	4350000	88
132008027	3000000	88
132009005	5217388	99
132009006	519450	98
132009008	89628	99
132009009	98285	99
132010004	630000	91
132010005	1125000	91
132010008	350000	91
132010009	800000	92
132010014	32500	91
132010015	9681065	91
133001003	39115	91
138006006	749296	97
138006010	93524	98
138006036	1318452	96
138006041	521000	99
138006047	296314	82
138006054	93830	75
138006055	1121086	75
138006056	3293048	88
138006057	477880	99
138006058	458558	97
138008002	147	75
138009018	572746	75
138009020	458600	99
138009023	222262	84
138009024	222577	84
138019022	3937	86
138019027	1231477	80
138021102	129128	75
138021103	4835	98
138021104	511843	87
138021201	22826	75
138021202	9960	98
138021203	76052	98
138021204	14990	75
138021206	12846	98
138021207	64476	75
138023013	2224716	85
138023016	2877419	88
138023021	1199999	75

APN Number	Land Value	Year Assessed
138023026	1375000	75
138023027	1149604	75
138023029	333345	75
138023048	945195	98
138023050	889792	91
139001022	20595	77
139001027	582	90
139001036	736	75
139002201	30000	75
139002212	1219784	75
139015010	130	75
139015011	6251571	96
139015013	529	96
140004525	227500	99
140004526	229000	93
140005101	215418	97
140005102	212000	93
140005103	229000	93
140005104	212000	94
140005105	232000	99
140005106	229000	93
140005107	260999	99
140005108	225000	93
140005109	243420	99
179005001	1363325	87
179005002	127000	87
179005003	1701	75
179005004	311670	98
179005005	4044	75
179007007	28705	82
500001001	50824	77
500001002	391916	75
500001003	682891	91
500001011	227308	84

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Appendix G

Regression Results for the Estimated Costs

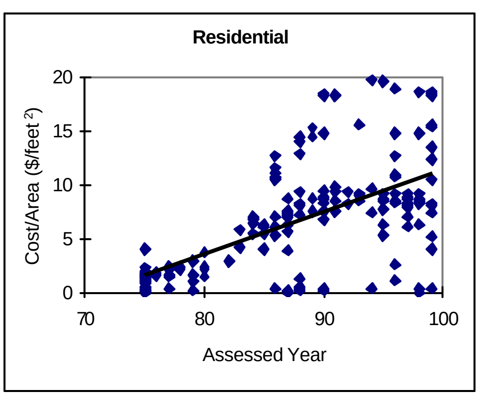
The following tables and graphs shows the regression results and statistics for the estimated costs of the seven land uses.

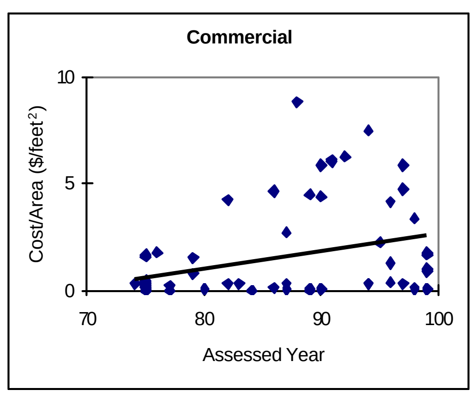
Residential Parcels:

Regression Statistics						
Multiple R	0.67382063					
R Square	0.45403425					
Adjusted R Square	0.45149487					
Standard Error	3.82822069					
Observations	217					
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-28.3286294	2.57671848	-10.994	1.3E-22	-33.4074882	-23.249771
X Variable 1	0.39899885	0.029839449	13.372	4.5E-30	0.340183594	0.4578141

Commercial Parcels:

Regression Statistics						
Multiple R	0.350012939					
R Square	0.122509057					
Adjusted R Square	0.11015003					
Standard Error	2.022284005					
Observations	73					
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-5.412549262	2.211255456	-2.449	0.01685	-9.82166959	-1.0034289
X Variable 1	0.080900175	0.025695526	3.1484	0.00240	0.029664726	0.13213562



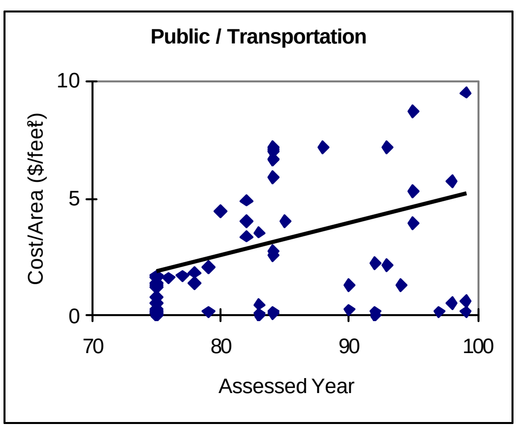


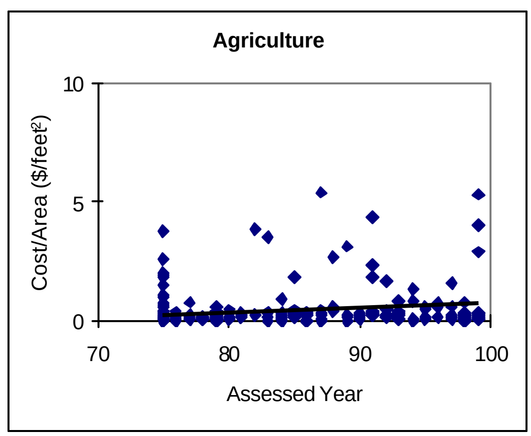
Public/Transportation Parcels

Regression Statistics						
Multiple R	0.35104603					
R Square	0.123233315					
Adjusted R Square	0.112135003					
Standard Error	2.757112663					
Observations	81					
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-8.392737802	3.452751883	-2.430	0.01733	-15.26527432	-1.52020128
X Variable 1	0.137867274	0.041373818	3.3322	0.00131	0.05551468	0.22021986

Agriculture Parcels

Regression Statistics						
Multiple R	0.177550375					
R Square	0.031524136					
Adjusted R Square	0.02786951					
Standard Error	0.688599718					
Observations	267					
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.88891156	0.435194291	-2.04	0.04208	-1.745789966	-0.032033
X Variable 1	0.015442758	0.00525805	2.936	0.00360	0.005089888	0.0257956



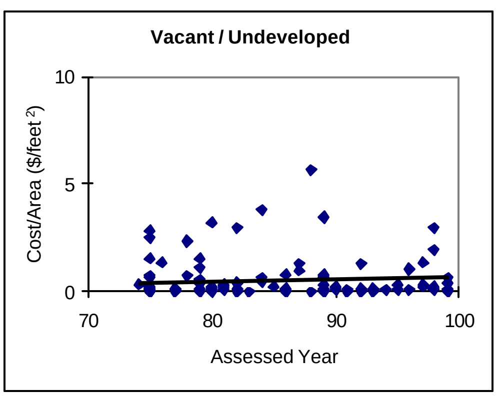


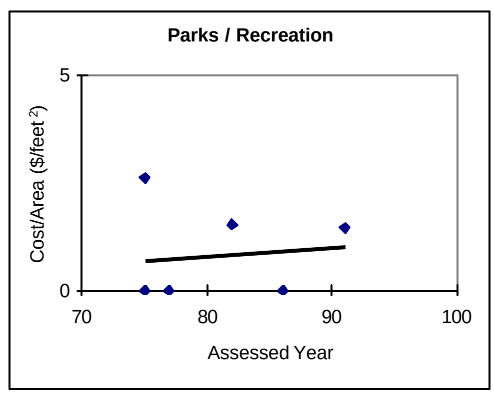
Vacant, Undeveloped Parcels

Regression Statistics						
Multiple R	0.087501065					
R Square	0.007656436					
Adjusted R Square	0.000765162					
Standard Error	0.880976406					
Observations	146					
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.322882904	0.741944073	-0.435	0.66407	-1.789392902	1.14362709
X Variable 1	0.009381334	0.008900226	1.0540	0.29362	-0.008210653	0.02697332

Parks, Recreation

Regression Statistics						
Multiple R	0.297083					
R Square	0.088258					
Adjusted R Square	-0.0637					
Standard Error	4.633686					
Observations	8					
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-15.148	23.0218	-0.657	0.53496	-71.4804	41.18432
X Variable 1	0.216726	0.284377	0.7621	0.47487	-0.47912	0.912572



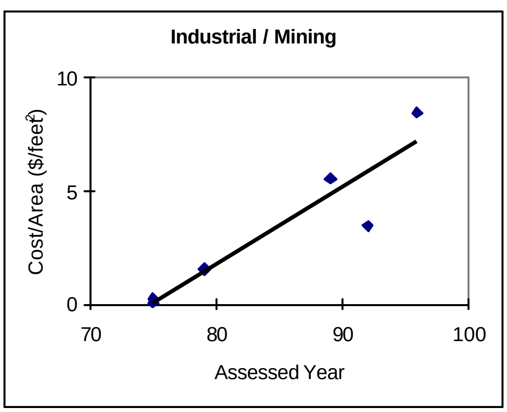


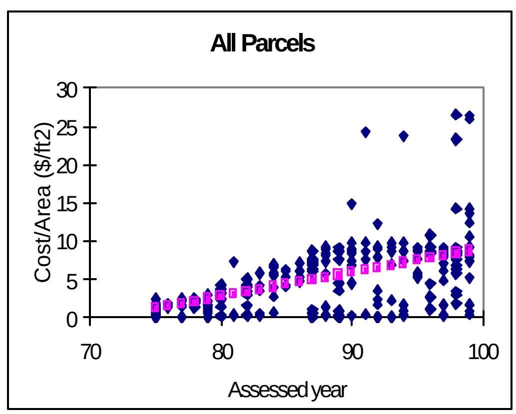
Industrial Parcels

Regression Statistics						
Multiple R	0.93707					
R Square	0.878101					
Adjusted R Square	0.853721					
Standard Error	1.241608					
Observations	7					
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-25.0369	4.660283	-5.372	0.00300	-37.0165	-13.0573
X Variable 1	0.335257	0.055863	6.0014	0.00184	0.191658	0.478856

All Parcels

Regression Statistics						
Multiple R	0.429772					
R Square	0.184704					
Adjusted R Square	0.18377					
Standard Error	5.914464					
Observations	875					
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-23.9958	1.977472	-12.13	2E-31	-27.8769	-20.1146
X Variable 1	0.327306	0.023274	14.063	1.22E-40	0.281627	0.372985





Appendix H

The SITES Model

SITES is a simulated annealing site selection model written by Ian Ball and Hugh Possingham for The Nature Conservancy (TNC), a non-profit organization. TNC recently adopted a planning initiative with the aim of developing “portfolios” that would collectively conserve viable examples of all native species and plant communities within several ecoregions in the U.S., the Caribbean, and Latin America. SITES was developed as an iterative planning tool to assist TNC in identifying conservation areas. SITES has two components: a site selection module (SSM) and an ArcView interface.

Site Selection Module (SSM)

SSM provides a heuristic procedure, known as “simulated annealing”, for selecting a conservation portfolio that attempts to meet stated, quantitative conservation goals as efficiently (using as few sites) as possible. The procedure begins with a random set, then swaps sites in and out of the set, measuring the change in cost at each iteration. If the change improves the set, the new set is carried forward to the next iteration. However, even changes that increase the cost (that is, reduce the quality) of the set may be carried forward, so that one may examine a number of different site combinations to avoid getting stuck at a local minimum. The changes to the selected set can be large at first, allowing sites that contribute greatly to reducing cost and improving the portfolio to be removed. Allowable changes are made progressively smaller as the total cost of the solution diminishes. Simulated annealing evaluates alternative complete reserve systems at each step, and compares them to identify a good solution. This procedure is not guaranteed to find the optimal solution, in the mathematical sense, but is believed to come very close as a result of the high number of iterations performed.

SITES Objective Function

The overall objective of SITES is to minimize the objective cost function of the portfolio while ensuring that all conservation goals have been met. The conservation goals include representation goals and goals for spatial configuration. Spatial configuration goals specify the relative importance of contiguity to achieve spatial compactness and connectivity of the final portfolio. The SSM represents this set of objectives as an “Objective Cost function:”

Objective Function = (cost of selected sites) + (penalty cost for not meeting the stated conservation goals for each element) + (cost of spatial dispersion of the selected sites as measured by the total boundary length of the portfolio).

The algorithm seeks to minimize Objective Function by selecting a set of sites that covers as many elements as possible as cheaply as possible in as compact a set as possible. The actual solutions depend on how cost is measured, on the target levels (or representation desired) and the penalty cost for each element, and on how heavily one weighs boundary length (using the boundary modifier, w_b) as an additional cost factor.

Cost

Cost in the objective function is the sum of the acquisition costs for each parcel within a conservation portfolio. The user supplies cost data for each planning unit in an input file.

Penalty

The “penalty” is the sum of the cost of acquiring enough sites to meet the specified conservation “targets”. The “targets” or conservation goals in this case are areas of potential endangered species’ habitat measured in square feet. “Targets” represent the desired amount of habitat that will be contained within each portfolio. The “penalty” is calculated using a heuristic known as the Greedy Heuristic. It is a stepwise, iterative procedure that accumulates one site at a time, choosing the best site at each step, until the goals have been met. “Best”, in this case, means cheapest. SITES looks for the cheapest way to meet the “targets”, calculates the cost for acquiring these sites, and adds it to the objective function as a penalty for not reaching the specified its goals. This is intended to encourage acquisition of sites until conservation goals are met.

Boundary Length

It is generally desirable for nature reserves in a portfolio to be both compact and comprised of adjacent planning units. For a conservation portfolio of a given size, the shorter the total boundary length around selected planning units, the more compact the portfolio. One objective of the SSM, therefore, is to minimize the total length of the boundary of the portfolio. Boundary lengths between planning units are supplied by the user. The boundary modifier (or w_b), which is applied to every boundary value, is a scalar that gives relatively greater importance to boundary costs as it is increased. This is intended to encourage “clumping” of solutions, is set by the user, and is entirely data dependent.

ArcView Interface

SITES also provides an ArcView interface that allows the analyst to run the SSM, enter parameters, and display solutions from ArcView. Parameters that are set from the ArcView interface include the cost threshold, and the threshold penalty strength. This feature acts like a budget constraint by setting an optional maximum cost threshold and a penalty for exceeding it. If the cost for a portfolio goes above this threshold at any iteration, then an additional penalty is applied to increase the Objective Function, making the site less desirable. The additional penalty is the amount by which the cost threshold was exceeded, multiplied by the penalty strength factor. This feature allows the user to apply a budget constraint on the “cost” of a portfolio, and allows the user to decide on the absoluteness of that constraint. Increasing the penalty strength by orders of magnitude ensures that the cost threshold will not be exceeded.

Input data

Our data were contained in a GIS database, and had to be manipulated into the format required by SITES 1.0. SITES uses six text files, describing the attributes of each planning unit. We provided files describing the cost, habitat, and boundary length associated with each parcel.

Varying Boundary Modifier (BM)

The boundary modifier is entirely data dependent, so its role was explored by trial and error. It was explored by keeping all other parameters constant and varying the BM slightly, then noting changes, visually, in the amount of clumping achieved. We also looked at the Boundary Length statistic given in the SITES output files, and compared its length for different scenarios. In addition, we noted the changes in results like the cost of the portfolio and the number of parcels included in the portfolio to assess the affect of increasing “clumpiness” on the values of other components of the objective function.

We hypothesized that setting the boundary modifier to 1000 would increase the magnitude of the boundary length portion of the objective equation such that SITES would notably increase the “clumpiness” of the conservation solution. However, this proved to be wrong as we varied the boundary modifier from 0 to 1,000,000 and saw very little change in clumpiness. As a result of increasing the boundary modifier by many orders of magnitude, SITES began to acquire an increased number of expensive parcels that increased the cost of the portfolio, while adding very little biological value. The nature of the distribution of parcels and potential endangered species habitat is inherently clumped. We decided to set the boundary modifier to zero for every scenario, essentially removing contiguity from our analysis, as imposing an artificial clumping parameter did not yield very different results.

Scenario development

We developed a series of scenarios by varying the cost threshold and the species targets.

Cost threshold

The cost threshold is a constraint that was imposed because of the financial limitations of the Trustee Council and the ARCO settlement. The Trustee Council currently has approximately $8 million to spend on riparian conservation. This is our most specific and straightforward constraint. However, we also realize that one of the limitations of our analysis is that we were not able to get information on willing sellers, or even accurate cost data. As a result, we varied the cost threshold to provide more flexibility for the Trustee Council in deciding which parcels to purchase. We varied the cost threshold from $8 million to $16 million, and included scenarios with no cost threshold. We set the cost threshold penalty to 1,000,000 to ensure that the cost of the portfolio did not exceed the stated threshold.

Targets

Because the Trustee Council did not have specific representation goals, we decided to develop “scenarios”, in which targets were systematically increased. The target designations are arbitrary in our analysis because we do not have specific goals we are trying to achieve in terms of area representation. We want our conservation solutions to contain as much potential habitat as possible, subject to a cost constraint. As a result, the role of the target in our analysis became unclear, and had to be explored by trial and error. We ran a series of scenarios that explored the relationship between cost of acquiring a portfolio and the proportion of potential species habitat represented in the portfolio. Our exploratory results guided our decisions regarding target levels in our final analysis. It would seem that the targets should always be set to 100% of the species distribution, as our goal is to represent as much habitat is possible. However, this imposes a large penalty, as the target is not feasible given the budget constraint, which causes the algorithm to perform poorly. We found that the algorithm would most likely reach an optimal solution when the targets were set to levels just above what could be obtained given the budget constraint. This would not artificially inflate the penalty cost as a result of unrealistic goals, and in this way, the cost threshold is always the constraint.

Targets or conservation goals were set as the number of square feet of potential species habitat that should be contained in the resulting conservation portfolio. We set the targets for each species to a proportion of the total square footage of potential species habitat available within the study region. This information came from manipulation of the spatial data contained in our GIS database. We provided a file summarizing the amount in square feet of each element within each parcel. SITES used this information to assess whether a portfolio met the conservation goals. Targets were set at 50% and 75% for the $8 million and the $16 million scenarios, respectively.

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Appendix I

SITES Results for $8 Million and $16 Million Scenarios

The following table lists all the parcels selected in the $8 million and $16 million scenarios. Note that the shaded areas are the additional parcels selected in the $16 million scenario.

*Cluster ID: A cluster is defined by adjacency (see Map 1)
**n/a: Selected parcels that did not occur in a cluster
***Land Use: agr =agriculture; v/u = vacant/undeveloped; res = residential; i/n = industrial/mining

Bio-reach	Cluster ID*	Assessors Parcel Number (APN)	Parcel Cost ($US)	Land Use***	Parcel Area (acres)	Species Present	% of Parcel with Species Habitat	% of Potential Habitat in Parcel
1	n/a**	138006047	8928	v/u	1	vireo flycatcher	70 70	0.04 0.09
1	n/a	138009024	263353	agr	76	vireo stickleback flycatcher	33 28 21	1.90 0.56 2.39
1	A	179007007	189938	v/u	55	vireo stickleback flycatcher	31 48 30	1.27 0.70 2.46
1	A	138019022	107698	v/u	31	vireo stickleback flycatcher	37 37 37	0.87 0.31 1.68
1	A	179005005	93104	v/u	27	vireo stickleback flycatcher	22 43 9	0.44 0.31 0.37
1	A	179005004	311670	v/u	25	vireo stickleback flycatcher	50 38 43	0.93 0.25 1.58
2	B	090011004	41270	v/u	12	vireo stickleback	26 49	0.23 0.16
2	B	109001020	124218	v/u	36	vireo stickleback	25 12	0.66 0.11
3	C	090018008	297072	agr	44	vireo stickleback flycatcher	51 3 44	1.68 0.03 2.89
3	C	090019049	479790	v/u	138	vireo stickleback flycatcher	35 61 19	3.65 2.25 3.93

Bio-reach	Cluster ID*	Assessors Parcel Number (APN)	Parcel Cost ($US)	Land Use***	Parcel Area (acres)	Species Present	% of Parcel with Species Habitat	% of Potential Habitat in Parcel
3	C	090019053	33439	v/u	10	vireo stickleback	16 16	0.11 0.04
		090019054	41845	v/u	12	vireo stickleback flycatcher	23 33 2	0.21 0.10 0.04
		090018007	324667	v/u	93	vireo stickleback flycatcher	20 55 0	1.41 1.36 0.05
	D	090019051	102058	v/u	29	vireo stickleback flycatcher	35 64 26	0.78 0.50 1.11
		107012001	15422	v/u	4	vireo flycatcher	82 4	0.27 0.02
		090019024	248925	i/m	64	vireo stickleback flycatcher	13 7 11	0.61 0.12 1.09
	n/a	099007022	5250	res	2	vireo stickleback	16 12	0.02 0.00
	E	099008015	788	v/u	0.23	vireo	87	0.01
		099007006	36459	v/u	10	vireo stickleback	36 100	0.29 0.28
		099008014	10676	v/u	0.47	vireo stickleback	89 9	0.03 0.00
		099008012	10107	v/u	3	vireo stickleback	24 95	0.05 0.07
	n/a	104018102	336877	v/u	97	vireo stickleback flycatcher	16 48 8	1.17 1.23 1.13
	n/a	107005002	15813	v/u	5	vireo	31	0.10
	F	046023021	518860	v/u	149	frog vireo stickleback flycatcher toad	0 12 64 12 64	0.75 1.38 2.51 2.74 3.82
		046023020	623138	v/u	179	vireo stickleback flycatcher toad	55 19 37 19	7.34 0.91 9.74 1.39
		046013201	28256	agr	6	vireo flycatcher	68 68	0.30 0.60
		046015020	102664	v/u	29	vireo stickleback flycatcher toad	7 72 3 72	0.16 0.56 0.12 0.85

Bio-reach	Cluster ID*	Assessors Parcel Number (APN)	Parcel Cost ($US)	Land Use***	Parcel Area (acres)	Species Present	% of Parcel with Species Habitat	% of Potential Habitat in Parcel
3	F	046023008	349402	v/u	100	frog	1	3.71
						vireo	18	1.33
						stickleback	71	1.89
						flycatcher	18	2.63
						toad	71	2.87
		046023009	135557	v/u	39	vireo	13	0.38
						stickleback	64	0.67
						flycatcher	13	0.75
						toad	64	1.01
		046015019	6351	v/u	2	vireo	94	0.13
						flycatcher	94	0.25
		046023004	11811	v/u	3	vireo	91	0.23
						flycatcher	93	0.47
		046023005	5480	v/u	2	vireo	100	0.12
						flycatcher	100	0.23
		046025008	522022	agr	150	frog	15	63.94
						vireo	31	3.54
						flycatcher	32	7.02
		046027009	4355	v/u	1	vireo	97	0.09
						flycatcher	94	0.17
		046023013	101302	agr	29	frog	17	13.67
						vireo	22	0.48
						stickleback	33	0.25
						flycatcher	22	0.94
						toad	33	0.38
		046023023	41891	v/u	9	vireo	16	0.11
						stickleback	97	0.24
						flycatcher	16	0.22
						toad	97	0.36
		046025007	4400	agr	1	vireo	68	0.06
						flycatcher	65	0.12
		046023015	339436	v/u	97	frog	4	11.50
						vireo	24	1.74
						stickleback	55	1.43
						flycatcher	20	2.92
						toad	55	2.17
		46023025	81292	v/u	23	vireo	4	0.07
						stickleback	97	0.60
						flycatcher	1	0.03
						toad	97	0.91

Bio-reach	Cluster ID*	Assessors Parcel Number (APN)	Parcel Cost ($US)	Land Use***	Parcel Area (acres)	Species Present	% of Parcel with Species Habitat	% of Potential Habitat in Parcel
3	F	046015034	613432	agr	151	vireo stickleback toad	19 23 23	2.20 0.92 1.40
		046023007	298498	agr	86	vireo stickleback flycatcher toad	13 7 13 7	0.83 0.16 1.64 0.25
		046015021	134392	v/u	39	vireo stickleback toad	1 58 58	0.04 0.59 0.90
		046015005	385141	v/u	80	vireo stickleback toad	30 22 22	1.78 0.47 0.71
		046013204	83218	agr	14	vireo flycatcher	32 26	0.33 0.52
		046012205	7727	agr	1	vireo flycatcher	22 20	0.02 0.03
		046027010	11369	v/u	3	vireo flycatcher	21 21	0.05 0.10
		046027004	64821	agr	19	vireo flycatcher	22 23	0.31 0.63
		046023003	12436	v/u	2	vireo flycatcher	47 47	0.07 0.14
4	G	046005001	75690	v/u	22	vireo stickleback toad	48 34 34	0.78 0.20 0.30
		046009001	244094	v/u	70	vireo stickleback toad	23 60 60	1.23 1.11 1.70
		046009002	291006	v/u	84	vireo stickleback toad	4 93 93	0.12 0.41 0.63
		046010012	81200	v/u	23	vireo stickleback toad	7 67 67	0.26 2.06 3.13

Bio-reach	Cluster ID*	Assessors Parcel Number (APN)	Parcel Cost ($US)	Land Use***	Parcel Area (acres)	Species Present	% of Parcel with Species Habitat	% of Potential Habitat in Parcel
4	G	046005007	200070	agr	41	vireo	27	0.83
						stickleback	1	0.01
						toad	1	0.02
		046010001	118596	v/u	34	vireo	9	0.23
						stickleback	41	0.37
						toad	41	0.57
		046016039	357749	v/u	100	vireo	1	0.10
						stickleback	49	1.29
						flycatcher	1	0.20
						toad	49	1.96
		046016040	42281	v/u	11	vireo	10	0.08
						stickleback	47	0.13
						flycatcher	10	0.16
						toad	47	0.20
	H	046007012	59057	v/u	17	vireo	1	0.02
						stickleback	77	0.35
						toad	77	0.53
		046007013	188895	v/u	54	vireo	1	0.05
						stickleback	81	1.17
						toad	81	1.78
		046006012	144385	v/u	41	vireo	5	0.14
						stickleback	62	0.68
						toad	62	1.03
		041029049	478775	v/u	137	vireo	4	0.39
						stickleback	67	2.43
						flycatcher	0	0.09
						toad	67	3.69
		055026005	436701	v/u	125	vireo	19	1.81
						stickleback	71	2.38
						flycatcher	4	0.74
						toad	71	3.61
		055026006	147676	v/u	42	vireo	2	0.06
						stickleback	77	0.87
						toad	77	1.32
		055026017	156192	v/u	45	stickleback	99	1.18
						toad	99	1.80
		055027029	158894	agr	46	vireo	18	0.63
						stickleback	22	0.26
						toad	22	0.40
		055027028	111332	v/u	32	vireo	22	0.53
						stickleback	72	0.61
						toad	72	0.93
		041029007	239536	v/u	69	stickleback	60	1.09
						toad	60	1.66

Bio-reach	Cluster ID*	Assessors Parcel Number (APN)	Parcel Cost ($US)	Land Use***	Parcel Area (acres)	Species Present	% of Parcel with Species Habitat	% of Potential Habitat in Parcel
4	H	041026028	231220	agr	66	vireo	12	0.59
						stickleback	7	0.12
						flycatcher	12	1.17
						toad	7	0.18
		041029011	461336	v/u	132	stickleback	65	2.27
						toad	65	3.46
		055026020	146052	v/u	42	stickleback	61	0.68
						toad	61	1.04
		055026021	146942	v/u	42	stickleback	56	0.62
						toad	56	0.95
		055027026	533365	v/u	153	stickleback	77	3.15
						toad	77	4.79
		55027010	288159	v/u	83	stickleback	60	1.31
						toad	60	1.99
		055026026	62887	v/u	18	vireo	26	0.36
5	I	055027019	36371	v/u	10	stickleback	87	0.24
						toad	87	0.37
		055027012	36331	v/u	10	stickleback	83	0.23
						toad	83	0.35
	n/a	057008009	366369	v/u	70	vireo	26	1.37
						stickleback	60	1.11
						toad	60	1.69
6	J	55024007	470107	agr	119	vireo	27	2.39
						flycatcher	15	2.68
		055025002	99761	agr	0.10	vireo	98	0.01
		55024002	45597	v/u	11	vireo	30	0.26
		55024008	613753	agr	155	vireo	17	1.95
						flycatcher	19	4.42
						toad	10	0.65
		055025003	638886	agr	183	vireo	26	3.57
						flycatcher	19	5.16
						toad	18	1.36

Appendix J

Biological Ranking of Parcels

The biological ranking is based on the '% Habitat'. This percentage was calculated by summing the total acres of habitat in a parcel and dividing by the area of the parcel. (Thus, a parcel that was completely covered with habitat for all eight species would have a % Habitat of 800.) The land use codes are as follows: 1=residential, 2=commercial, 3=public/transportation, 4=agriculture, 5=vacant/undeveloped, 6=parks and recreation, 7=industrial/mining. A 'Y' in the SITES 8 or SITES 16 column indicates that that parcel was selected by the SITES model with a cost constraint of $8 million or $16 million.

Biological Rank	APN	% Habitat	Area(Acres)	Cost/Acre (Dollars)	Land Use	SITES 8	SITES 16
1	046023005	200	1.6	3485	4	Y	Y
2	108001008	200	0.1	146476	7		
3	046027009	191	1.2	3485	4	Y	Y
4	046015019	188	1.8	3485	4	Y	Y
5	046023004	184	3.4	3485	4	Y	Y
6	138008002	176	1.4	57325			
7	McGrath	174	91.7	0	3	Y	Y
8	108001014	160	0.7	87353	2		
9	138005011	155	23.4	53735	1		
10	138005005	151	1.5	87261	4		
11	046023022	144	121.0	40182	2		
12	138006047	140	0.9	10490	4		Y
13	046013201	137	5.9	4796	4	Y	Y
14	046025007	133	1.3	3485	5	Y	Y
15	107015009	131	0.2	145095	3		
16	046023023	129	9.3	4510	5	Y	Y
17	138006056	122	0.8	114765	4		
18	046023020	110	178.8	3485	4	Y	Y
19	046023008	107	100.3	3485	4	Y	Y
20	138019027	105	8.1	87376			
21	046023015	103	97.4	3485	5	Y	Y
22	046023025	101	23.3	3485	4	Y	Y
23	107001032	100	3.7	113216	1		
24	107001077	100	0.2	113216	1		
25		100	11.8	58313	7		
26	041026054	100	0.3	74546	3		
27	046023022	100	0.9	304973	7		
28	107001064	100	31.7	84950	2		
29	055026017	99	44.8	3485	4	Y	Y
30	107001072	99	1.1	105648	1		
31	055025002	98	0.1	6718	4	Y	Y
32	107010013	98	1.4	82559	5		
33	046009002	97	83.5	3485	4	Y	Y
34	107006213	96	6.8	125825	3		

Biological Rank	APN	% Habitat	Area(Acres)	Cost/Acre (Dollars)	Land Use	SITES 8	SITES 16
35	138019028	96	25.1	38264	4		
36	090018008	95	43.8	6787	5	Y	Y
37	046023018	95	1.7	58313	2		
38	055026005	95	125.3	3485	5	Y	Y
39	046023003	94	2.0	6326	4		Y
40	055027028	94	31.9	3485	4	Y	Y
41	046023013	94	29.1	3485	5	Y	Y
42	179005004	93	24.7	12616	1		Y
43	138009020	92	0.3	29885			
44	107001069	92	5.4	70710	2		
45	107014037	91	39.3	46706	3		
46	046023009	90	38.9	3485	4	Y	Y
47	107015010	90	2.5	88621	3		
48	055031001	89	8.9	294344	1		
49	099008014	89	0.5	22715	4		Y
50	046023021	89	148.9	3485	5	Y	Y
51	138019030	88	25.0	59057	3		
52	055029016	87	266.4	6562	5		
53	099008015	87	0.2	3485	5	Y	Y
54	055027019	87	10.4	3485	4	Y	Y
55	057008009	86	69.9	5242	5	Y	Y
56	107012001	86	4.4	3485	5	Y	Y
57	046009001	83	70.0	3485	4	Y	Y
58	055027012	83	10.4	3485	4	Y	Y
59	046007013	83	54.2	3485	4	Y	Y
60	046005001	82	21.7	3485	5	Y	Y
61	046015020	81	29.5	3485	4	Y	Y
62	055026006	79	42.4	3485	5	Y	Y
63	107001076	78	82.2	102057	2		
64	046025008	78	149.8	3485	4	Y	Y
65	179007008	78	9.2	50640			
66	104020011	78	1.1	25183	2		
67	046007012	78	16.9	3485	4	Y	Y
68	055027026	77	153.1	3485	5		Y
69	138019017	77	25.4	61213	4		
70	138019022	74	30.9	3485	6	Y	Y
71	057006003	74	14.4	8345	5		
72	046010012	74	23.3	3485	5	Y	Y
73	041029049	71	137.4	3485	5	Y	Y
74	041029009	68	1.7	12979	5		
75	132008005	67	1.9	44798	4		
76	046016040	67	10.7	3946	4		Y
77	046006012	66	41.4	3485	5	Y	Y
78	041029011	65	132.4	3485	5		Y
79	107015008	64	0.5	141825	3		
80	055025003	63	183.3	3485	4		Y
81	107001061	62	0.4	25183	4		
82	179007007	61	54.5	3485	5	Y	Y
83	055026020	61	41.9	3485	4		Y
84	090019051	61	29.3	3485	5	Y	Y
85	041029007	60	68.7	3485	5		Y
86	055027010	60	82.7	3485	5		Y
87	046015021	59	38.6	3485	5		Y

Biological Rank	APN	% Habitat	Area(Acres)	Cost/Acre (Dollars)	Land Use	SITES 8	SITES 16
88	046013204	58	13.6	6129	4		Y
89	055026021	56	42.2	3485	5		Y
90	138009024	55	75.6	3485	4	Y	Y
91	138019029	54	9.1	87376			
92	090019049	54	137.7	3485	4	Y	Y
93	138006001	53	1.1	54131	2		
94	138006055	52	142.0	93754	2		
95	099009009	52	81.4	39451	2		
96	046015005	52	80.0	4814	4		Y
97	046016039	51	100.0	3578	4		Y
98	046010001	50	34.0	3485	4		Y
99	057007019	50	5.2	11927	4		
100	179005012	49	4.8	44798			
101	104019405	49	0.8	90082	2		
102	055030002	48	0.3	294532	1		
103	057007018	47	59.4	3485	5		
104	090019042	47	14.4	16012	5		
105	055024008	46	155.0	3960	4		Y
106	107014037	46	9.2	51372	3		
107	057002010	45	52.2	13123	4		
108	107001083	45	147.3	12225	5		
109	046027004	45	18.6	3485	5		Y
110	104017051	45	52.6	83977	5		
111	090011021	44	10.1	20057	5		
112	046016033	44	10.7	3485	4		
113	057006003	43	24.7	4865	5		
114	046027010	43	3.3	3485	4		Y
115	046012205	42	1.1	7166	4		Y
116	046015022	42	28.3	3485	4		
117	046015034	42	151.5	4050	4		Y
118	041029033	42	41.1	32840	5		
119	055027018	42	62.2	3485	5		
120	055024007	42	119.1	3946	4	Y	Y
121	046006005	41	41.6	3485	4		
122	090011003	41	4.0	34373	3		
123	055027029	40	45.6	3485	4	Y	Y
124	055026014	40	9.8	97439	3		
125	041029058	39	27.5	3485	5		
126	107001078	39	18.7	105648	5		
127	041029006	38	6.9	3485	5		
128	138009018	37	173.4	144220	3		
129	104019308	37	1.9	90082	2		
130	099007006	36	10.5	3485	4	Y	Y
131	057006001	36	41.0	7728	4		
132	107001079	35	0.2	105648	1		
133	055026025	35	5.2	18777	5		
134	055026003	35	10.3	12175	4		
135	139015012	35	16.6	44798	2		
136	055026022	34	40.3	3485	4		
137	046013203	34	21.2	11189	5		
138	055027032	33	46.8	3485	4		
139	046023007	33	85.7	3485	5		Y
140	055026004	32	9.5	67311	3		

Biological Rank	APN	% Habitat	Area(Acres)	Cost/Acre (Dollars)	Land Use	SITES 8	SITES 16
141	055021013	32	279.0	3485	4		
142	179005005	31	26.7	3485	4		Y
143	099011008	31	112.9	10942	3		
144	046017108	31	64.2	5636	4		
145	055027038	31	81.7	3485	5		
146	107005002	31	4.5	3485	5	Y	Y
147	055024002	30	11.4	3995	5		Y
148	041026028	30	66.4	3485	5		Y
149	055026013	30	11.0	10316	5		
150	046010011	29	84.9	3485	4		
151	107001114	29	0.2	490199	2		
152	138009023	29	77.8	92725	3		
153	057008007	28	5.6	12255	4		
154	046005007	28	41.1	4874	5		Y
155	046007014	28	11.8	13392	5		
156	055029015	28	68.0	4667	4		
157	139001030	28	50.1	44798	1		
158	104020018	28	4.5	25183	5		
159	139001048	27	4.4	44798	4		
160	046010009	27	41.1	3485	4		
161	055026026	26	18.0	3485	4		Y
162	046006013	26	1.8	12983	5		
163	090011004	26	11.8	3485	6		Y
164	107001084	26	9.3	15338	4		
165	107005042	26	25.7	24580	3		
166	046016024	26	152.2	3485	4		
167	090019054	25	12.0	3485	4		Y
168	109001020	25	35.6	3485	6		Y
169	099008012	24	2.9	3485	4		Y
170	104018102	24	96.7	3485	5		Y
171	090019024	24	64.4	3866	5		Y
172	057007015	23	69.2	3485	4		
173	090019055	23	1.6	13536	5		
174	057003016	23	20.8	6994	4		
175	107001066	23	65.0	77478	5		
176	055022004	22	180.1	9613	4		
177	090019006	21	5.4	14800	5		
178	104020019	21	2.2	146376	2		
179	090018007	21	93.2	3485	5		Y
180	046016034	20	4.3	3969	4		
181	041026053	20	4.6	112659	3		
182	055026015	20	23.8	142195	3		
183	055026024	20	11.9	8122	5		
184	099007022	16	1.5	3485	4		Y
185	041029051	16	30.2	99178	3		
186	090019053	16	9.6	3485	5		Y
187	179005002	15	25.8	50220	2		
188	133001002	15	32.2	55469	5		
189	041029059	15	3.2	13916	5		
190	138019033	13	6.0	61213			
191	041026050	13	0.5	3485	5		
192	099008023	13	45.5	13235	5		
193	046007015	13	34.6	33174	5		

Biological Rank	APN	% Habitat	Area(Acres)	Cost/Acre (Dollars)	Land Use	SITES 8	SITES 16
194	132002034	12	94.1	87450	2		
195	104017041	12	23.6	301438	1		
196	104017040	12	13.6	300196	1		
197	099008019	12	28.2	160302	1		
198	041029029	12	32.9	3485	4		
199	104017045	11	5.9	43046	5		
200	046015033	11	68.0	3485	4		
201	099007009	11	43.7	3485	4		
202	132002003	11	18.8	44175	4		
203	046016041	11	81.1	5391	5		
204	057003013	11	8.7	15292	4		
205	055026023	10	17.2	5808	4		
206	138019031	10	6.8	87376			
207	099008016	10	1.4	14395	5		
208	104017046	10	5.9	130115	5		
209	104017039	9	3.2	49582	1		
210	046014204	8	13.1	8662	5		
211	099007016	7	3.9	197687	1		
212	099008003	7	53.3	74199	2		
213	041026038	7	2.9	3485	4		
214	104020020	7	0.7	38308	2		
215	090016004	7	153.0	48003	2		
216	138006010	7	21.5	11200	2		
217	104018061	7	1.1	83142	1		
218	099009004	7	34.0	4804	5		
219	046027003	7	1.2	3485	5		
220	104017033	6	61.9	155908	1		
221	046023002	6	17.1	4406	4		
222	099007005	5	27.3	3485	5		
223	057005009	5	10.6	4669	5		
224	129002006	5	147.6	3485	6		
225	057007013	5	45.1	3485	4		
226	041026042	4	42.6	7948	4		
227	046015014	4	16.0	6384	5		
228	057003012	4	7.3	6128	4		
229	099008021	4	44.4	3485	4		
230	104018101	4	45.3	148873	3		
231	107001067	4	19.0	92167	2		
232	179005010	4	32.0	44798	5		
233	090019058	3	27.4	3485	5		
234	104018103	3	22.8	88449	5		
235	055029014	3	63.2	3485	5		
236	138006058	3	38.1	11878	5		
237	055027027	3	9.3	10201	5		
238	104017037	3	30.7	253098	1		
239	107015004	2	3.0	15431	1		
240	129002003	2	18.6	29800	4		
241	046016032	2	1.4	24263	4		
242	041026012	2	29.8	3485	4		
243	055027009	2	30.8	3485	5		
244	128004005	2	19.0	19743	6		
245	128004020	2	95.2	3485	5		
246	130006005	1	120.9	3485	5		

Biological Rank	APN	% Habitat	Area(Acres)	Cost/Acre (Dollars)	Land Use	SITES 8	SITES 16
247	055018023	1	49.4	3485	4		
248	046015017	1	22.7	11996	5		
249	104017049	1	8.1	294191	1		
250	090019059	1	0.7	13536	5		
251	130007002	1	148.3	57018	2		
252	055026051	1	58.8	3485	5		
253	107016003	1	10.5	73634	2		
254	104017024	1	17.7	3485	4		
255	132001007	1	58.7	10928	4		
256	046007009	1	40.6	33759	5		
257	090019057	<1	8.6	13536	5		
258	052022003	<1	11.0	74546	5		
259	055016028	<1	106.3	3935	5		
260	046008012	<1	50.8	4784	5		
261	055029013	<1	46.1	7696	4		
262	133001003	<1	76.5	3485	5		
263	104017038	<1	1.7	67971	4		
264	090019027	<1	51.6	80290	5		
265	090019002	<1	41.5	83267	5		
266	128003031	<1	3.8	45347	5		
267	129002001	<1	23.3	80487	2		
268	107008003	<1	12.9	3485	4		
269	129001101	<1	1.0	3485	5		
270	129001110	<1	0.2	25012	5		
271	090019040	<1	4.1	14134	5		
272	090019041	<1	1.6	14134	5		
273	129002007	<1	1.5	4835	5		
274	104017025	<1	13.8	3485	4		
275	129001133	<1	3.1	8236	5		
276	129001103	<1	1.6	6185	4		
277	129015604	<1	0.9	4835	4		
278	129015603	<1	0.2	4835	5		
279	129001135	<1	0.9	5672	5		
280	129001106	<1	1.6	5577	4		
281	090017205	<1	0.1	5474	5		
282	099007018	<1	1.0	3485	4		

Appendix K

Photographs of Recommendations

Cluster F

a)

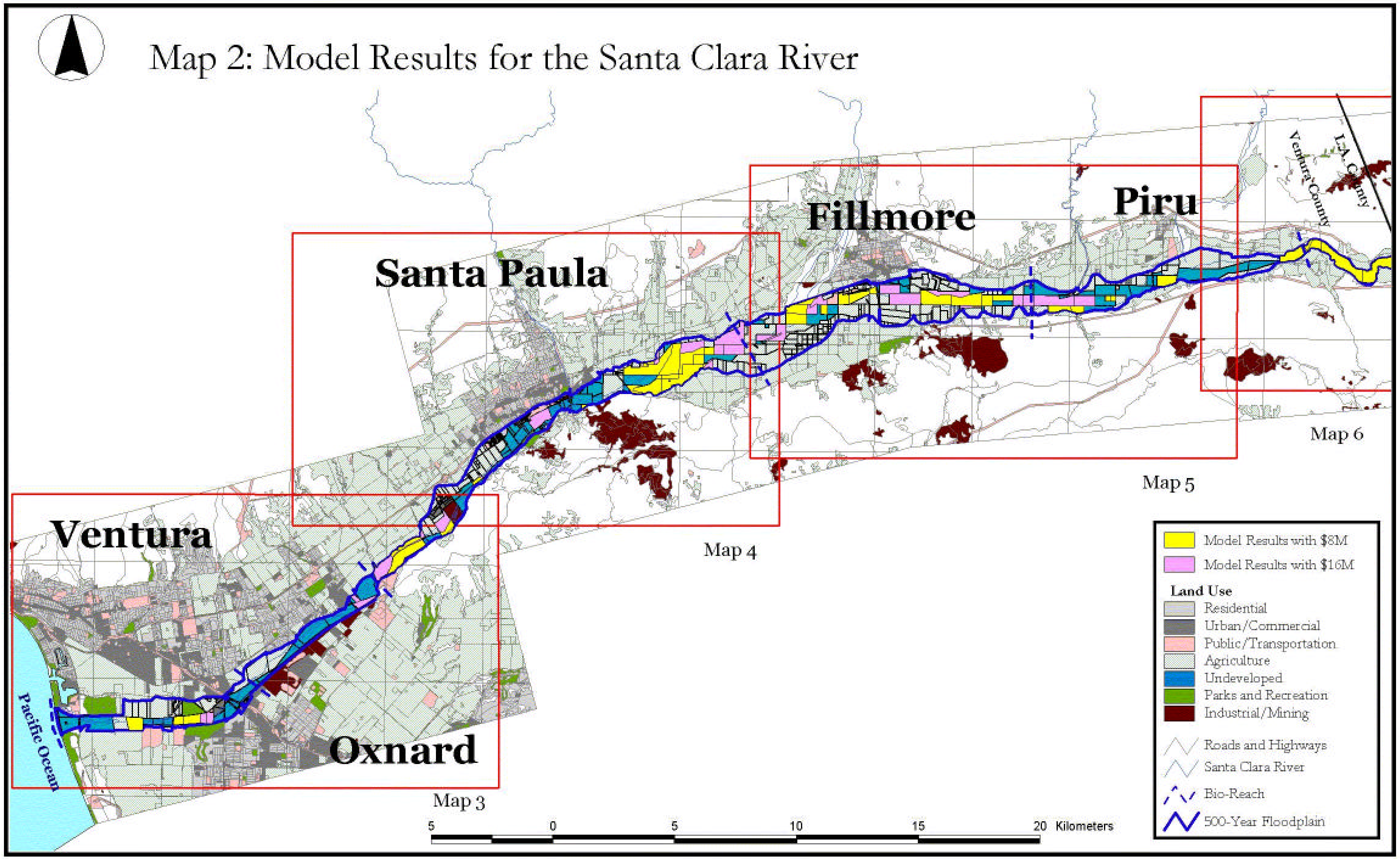
b)

Cluster J

a)

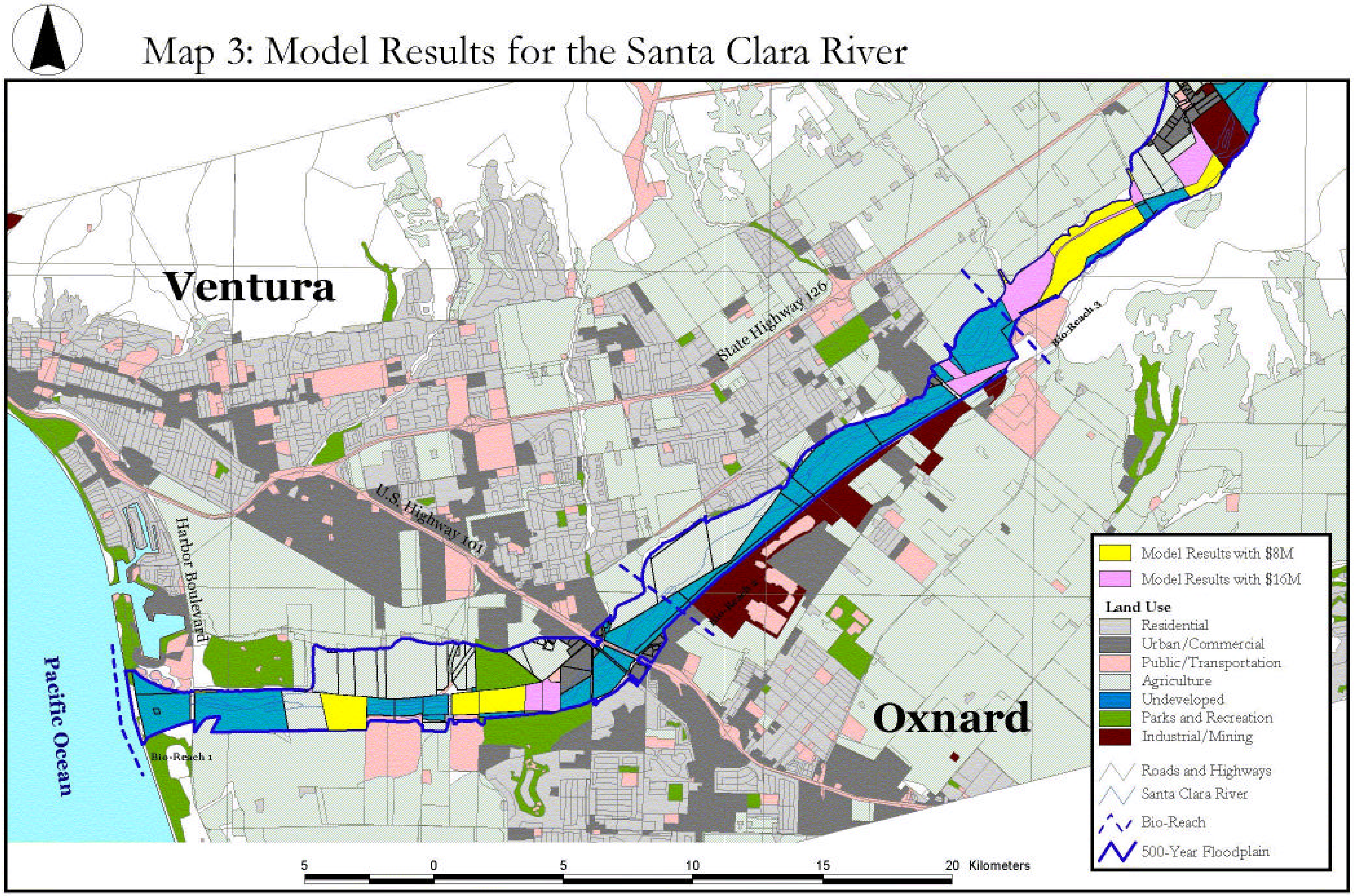
b)

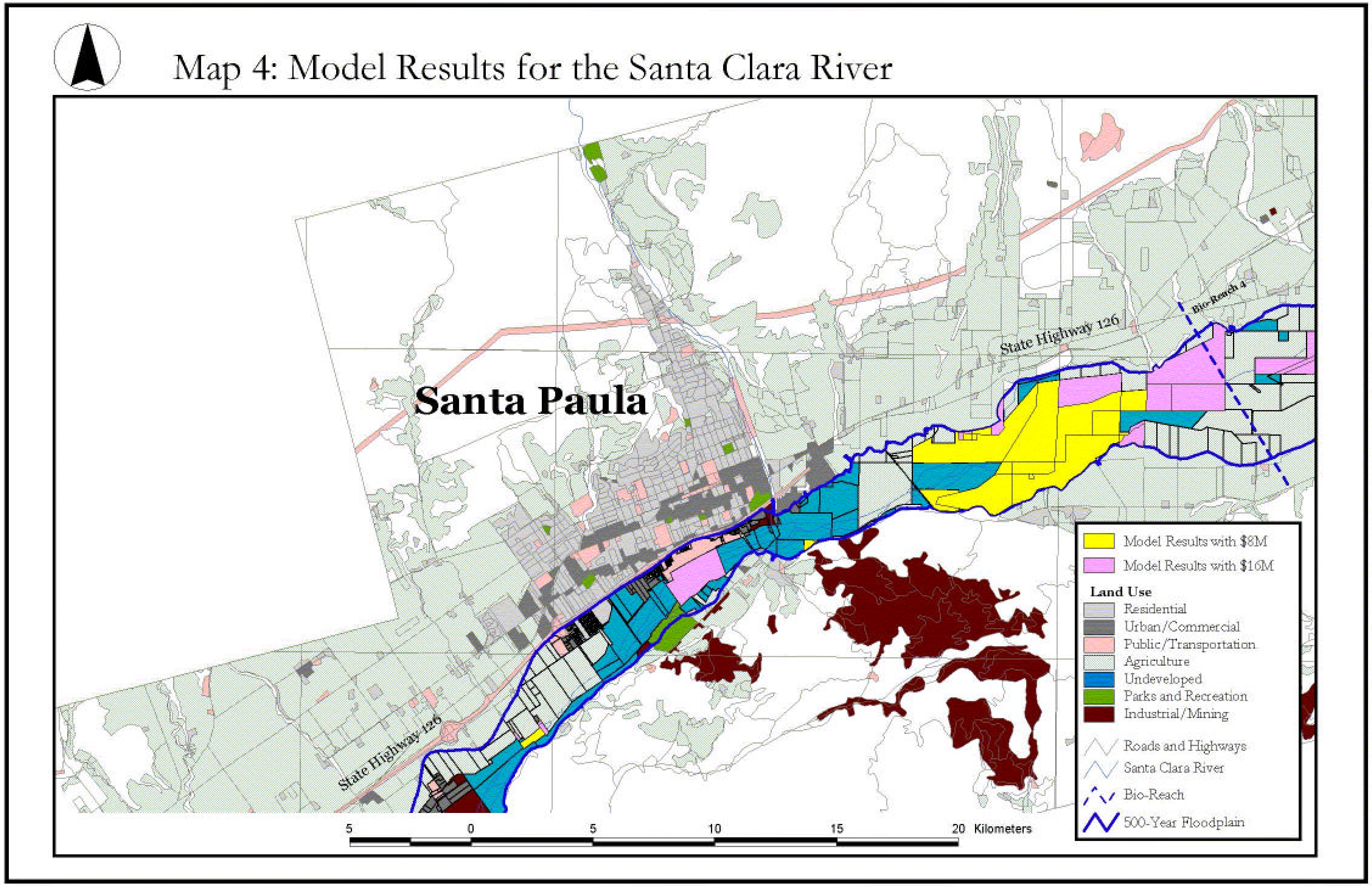
End of Document.



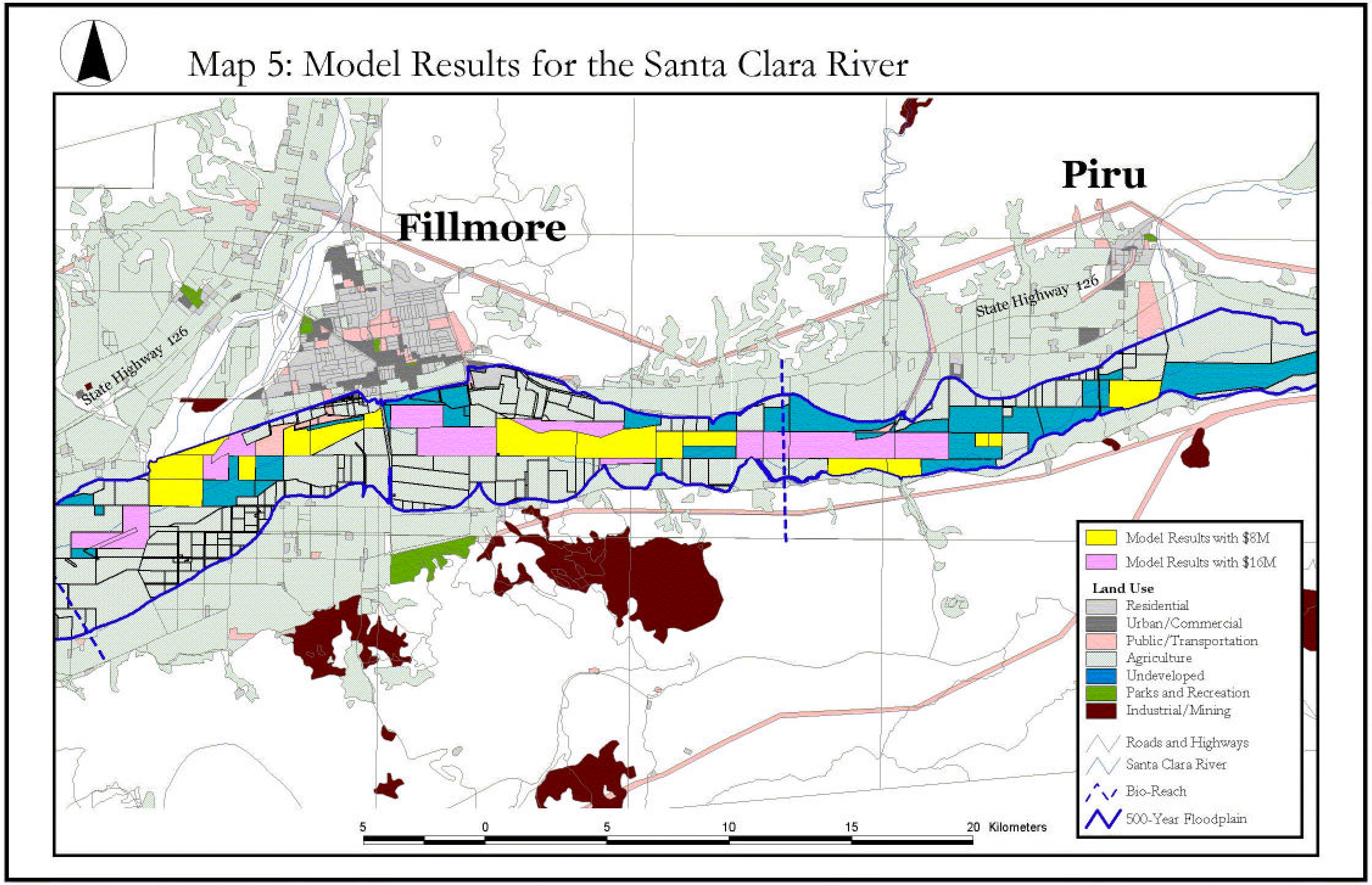
Map 2: Model Results for the Santa Clara River
Santa Paula
Fillmore
Piru
Ventura County
L.A. County
Ventura
Oxnard
Pacific Ocean
Map 3
Map 4
Map 5
Map 6
5
0
5
10
15
20 Kilometers
Model Results with $8M
Model Results with $16M
Land Use
Residential
Urban/Commercial
Public/Transportation
Agriculture
Undeveloped
Parks and Recreation
Industrial/Mining
Roads and Highways
Santa Clara River
Bio-Reach
500-Year Floodplain

Map 3: Model Results for the Santa Clara River





Map 4: Model Results for the Santa Clara River
Santa Paula
State Highway 126
State Highway 126
Bio-Reach 4
Model Results with $8M
Model Results with $16M
Land Use
Residential
Urban/Commercial
Public/Transportation
Agriculture
Undeveloped
Parks and Recreation
Industrial/Mining
Roads and Highways
Santa Clara River
Bio-Reach
500-Year Floodplain
5 0 5 10 15 20 Kilometers


Map 5: Model Results for the Santa Clara River
Fillmore
Piru
State Highway 126
State Highway 126
5
0
5
10
15
20 Kilometers
Model Results with $8M
Model Results with $16M
Land Use
Residential
Urban/Commercial
Public/Transportation
Agriculture
Undeveloped
Parks and Recreation
Industrial/Mining
Roads and Highways
Santa Clara River
Bio-Reach
500-Year Floodplain

Map 6: Model Results for the Santa Clara River