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Gap Analysis of the Southwestern California Region

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Report Summary

The Need for an Ecosystem Level Approach to Conservation of Biodiversity

Numerous efforts are underway by public and private groups to assess the status of biodiversity in the state. Most are being conducted at local to subregional scales, and many are focused on species or communities of special concern. Currently lacking is an overview of the protection status of species and communities both statewide and in the western U.S. as a whole. This report describes a geographic information system (GIS) based Gap Analysis of biodiversity in the Southwestern California Ecoregion. The project is part of an ongoing effort by many groups, including the USFWS, the California Department of Fish and Game (CDF&G), Department of Forestry and Fire Protection (CDF&FP), The Nature Conservancy (TNC) and others to provide this regional overview by mapping the distributions of plant community types and vertebrate species habitats and relating these distributions to existing patterns of land ownership and land management. The work at UCSB is supported by the National Fish and Wildlife Foundation, the Southern California Edison Company (SCE), and the IBM Environmental Research Program and is part of a national program of state and regional gap analyses being coordinated by the USFWS.

The term "Gap Analysis" refers to the evaluation of the protection status of plant communities, animal species and vertebrate species richness by GIS overlay of biological distribution data on a map of existing biological reserves. We are conducting a Gap Analysis of California in collaboration with a number of public and private groups. This entails preparing a statewide map of actual vegetation, supplemented with more detailed locality data for plant taxa of special concern. By compiling a statewide, albeit low resolution digital database, GIS capabilities can be used to identify and map landscapes in California that contain large numbers of potentially unprotected vegetation types and vertebrate species of interest. Such areas can then be studied in more detail as candidates for additional preservation and protection efforts to fill existing "gaps" in the protection network. This approach allows conservationists to be proactive rather than reactive in their efforts to preserve biodiversity. It should also result in fewer conflicts among developers and biologists.

The Southwestern California Region

Because of the significant differences between parts of California in the ecology, land uses, and data availability, we have chosen to perforrn GIS-based analyses on ecologically-defined subareas of the state. The subdivision we have chosen is the region as defined for the forthcoming revision of the Jepson Manual of California's flora (Hickman, 1993). The Manual delineates ten regions in the state that roughly correspond to the bioregions proposed for state conservation planning. This report is limited to the Southwestern California Region, within the California Floristic Province. The gap analyses of the remaining nine regions will be reported separately as each is completed. Ultimately, a statewide gap analysis will be conducted with the data from the ten regions.

The region includes 3,383,160 ha or roughly 8 percent of the area of California and is comprised of three subregions: South Coast, Transverse Ranges, and Peninsular Ranges. The region is bounded by the transition to the Sonoran and Mojave Desert regions on the east and the Santa Ynez Mountains on the north.

The Gap Analysis Process

Land Management: For the purposes of gap analysis, it is necessary to distinguish levels of management in order to determine the protection status of elements of biodiversity. Level 1 represents areas managed for the long-term protection of biodiversity, such as wilderness areas, research natural areas, National Wildlife Refuges, Areas of Critical Environmental Concern, state parks, ecological reserves, and private preserves and sanctuaries. Level 2 includes publicly-owned lands not specifically designated for Level 1 management, while Level 3 contains private lands with no formal management for biodiversity. A 1:100,000 scale management status map depicting these three levels and land ownership was compiled from many sources.

Vegetation: A map of actual vegetation was produced using summer 1990 Landsat Thematic Mapper (TM) satellite imagery, 1990 high altitude color infrared photography (1:58,000 scale), Vegetation Type Mapping maps based on field surveys conducted between 1928 and 1940, and miscellaneous recent vegetation maps and ground surveys. Landscape boundaries were mapped subjectively by photointerpretation of patterns in the satellite imagery and air photos. Final delineation of a landscape unit was an iterative process based on lines of converging evidence obtained from the various source data. The map was produced using a minimum mapping unit of 100 ha (1 km^2), and the region was mapped into some 2,100 landscape units. 230 polygons (excluding urban and agricultural areas) were checked in the field, primarily by roadside reconnaissance.

Based on our concept of landscape, we recorded a primary species complex, which was the most widespread vegetation type or land use/land cover type in the polygon, a secondary type, and the fraction of the landscape covered by each type. Each species complex was defined by up to three dominant species. Where possible, we also recorded the occurrence of minor overstory species of special conservation concern (e.g., *Juglans californica*, *Quercus engeltnanii*, *Cupressus forbesii*). Species composition was derived from field survey, air photos or from the VTM maps. VTM information was used for areas where air photos provided no evidence of recent disturbance, based on the assumption that canopy dominants observed by VTM field crews have not changed over the past 50-60 years. We also developed rules for assigning each species combination into Holland's classification of natural communities. We mapped 64 different communities (out of 89 recognized in the region).

The premise of Gap Analysis is that biological resources at risk can be identified by their ownership/management profile as generated by GIS overlay of 1: 100,000 scale maps. Based on the profiles of communities already known to be at risk, we adopted the following criteria for identifying communities or dominant plant species at-risk:

1. Less than 10% of the distribution is in Level 1 areas, *and* the species or community type is endemic to the region, *and* the mapped distribution covers more than 100 km^2

or

2. over 70% of the mapped distribution is in Level 3 areas.

Wildlife Distributions: Combining the California Wildlife Habitat Relationships (WHR) model with the vegetation map generated predicted distribution maps for native vertebrates. We used the WHR database to generate a set of presence/absence tables of species occurring within each of the major habitat types. Another component to the development of a set of predicted distribution maps is using a coarse-scale range map for general locality information. The maps used here are range outlines digitized from a state map at 1:3,500,000 scale and published as part of the VIM system (Zeiner et al. 1990). The vegetation map was translated into the major habitat types used in the WHR system. The coarse-scale range map was then combined with the medium-scale vegetation map to produce a predicted distribution map for every species. By overlaying the predicted distribution maps with land management status, the proportion of a species' range in various levels of habitat protection was determined.

The criteria for highest risk for breeding species whose habitats are rated either medium or high suitability or for migratory species with critical wintering habitat in the region are:

1. Less than 15% of the distribution is in Level I areas, and the species or a subspecies is endemic to the region, and the mapped distribution covers more than 100 km^2

and

2. The species does not find cropland, orchards/vineyards or urban habitats as either medium or high suitability, nor is it exclusively associated with wetlands. The species is not a marine mammal, shorebird, in the chiroptera order, introduced or intensively managed as either a harvest species or being translocated.

Results

Land Management: Level 1 areas total 324,773 ha or 9.6 percent of the region. Thirty percent is other public lands managed at Level 2, while the remaining 60 percent is Level 3. The area of level 1 managed areas is dominated by National Forest Wilderness Areas, with 226,185 hectares in 14 areas. State Parks, including Reserves and Wilderness Areas, are the second largest category of Level 1 areas, totaling 56,204 hectares. Lower elevations where most urban and agricultural development are located are predominately private land and therefore Level 3 management. Mid-elevations, between 1500 and 2500 meters are primarily public lands, with about 25 percent being Level 1 management, but most being Level 2. The majority of land above 2500 meters is in Level 1 management, and in fact more than 90 percent of the highest elevation zone is in Level I management (usually National Forest wilderness areas).

Vegetation: Based on the GAP criteria, communities restricted largely to the lower elevations , such as nonnative grasslands and the coastal sage scrub types, are at considerable risk (Table 2). Roughly 88% of areas below 500 rn are in Level 3 management (i.e. privately owned). A majority of the lands at these elevations have already been converted to agricultural or urban uses and most of the remaining lands are threatened with future urbanization.

Especially alarming is the condition of the California black walnut woodlands. The southern variety of this species is endemic to this region and its current distribution is highly fragmented and reduced compared with its original distribution. Sagebrush steppe shrublands, although widespread elsewhere in California, appear vulnerable in this region. A significant proportion of the sagebrush steppe habitat is on Level 2 lands, and conservation concern for these communities can probably be adequately addressed by the public land managing agencies. Species and communities at higher elevations, especially montane chaparral and coniferous forest types, are generally well represented in Level I protected areas. With the exception of canyon live oak and perhaps interior live oak, all other oak woodlands appear to be at risk now or over the next one or two decades. Most of the chaparral communities appear to be reasonably secure. They are generally found on steeper slopes, largely on public lands, and in areas with at least 10% and often >20% in Level 1 status. However there are a wide variety of chaparral types in this region, and we should not take the conservation of all for granted. A number of chaparral species/communities are endemic or largely restricted to this region and may be components of chaparral that may be at some risk. Individual dominant canopy species are also considered at-risk, even though the communities they are found in may be adequately represented in the existing reserve network.

Table 1. Area by Management Level in the Southwestern California Region. SNA's are Significant Natural Areas defined by the California Department of Fish & Game based on locations of rare and endangered species and communities.

Level	All Land Area (in ha)	Percent of Total Land Area	SNAs Area (in ha)	Percent of Total SNA Area
Level 1	330,655	9.8 %	57,008	12.1 %
Level 2	1,030,531	30.5 %	125,682	26.7 %
Level 3	2,021,197	59.7 %	287,212	61.1 %
Total	3,383,160	100 %	470,407	100 %

Table 2. Natural communities identified as at-risk using Gap Analysis criteria, ordered from highest to lowest relative extent on private lands. Asterisks indicate community types whose mapped distribution totals less than 50 km^2. Other communities identified by the Natural Heritage Division as threatened or endangered but not detected by the Gap Analysis method are listed separately in the full report.

Code	Natural Community Name
71130	Valley Oak Woodland *
42110	Valley Needlegrass Grassland *
71210	California Walnut Woodland
37G00	Coastal Sage-Chaparral Scrub
42200	Nonnative Grassland
32000	Coastal Sage Scrub
81310	Coast Live Oak Forest
71410	Digger Pine-Oak Woodland *
71160	Coast Live Oak Woodland
71182	Engelmann Oak Woodland
37120	Southern Mixed Chaparral
37300	Redshanks Chaparral
61310	Southern Coast Live Oak Riparian Forest *
35210	Big Sagebrush Scrub
37B00	Upper Sonoran Manzanita Chaparral
83330	Southern Interior Cypress Forest *
72110	Northern Juniper Woodland
72210	Mojavean Pinon Woodland *

From an ecosystem planning perspective, 7.5' quadrangles that contain high numbers of CNDDB communities of concern and where a large percentage is mapped by Gap Analysis as communities-at-risk would seem likely candidates for new, extensive biodiversity management areas. Such areas include the following quadrangles and areas:

• San Clemente, Canada Gobernadora and Oceanside quads (Santa Margarita River, Camp Pendleton)

• Beaumont quad (San Gorgonio Pass, foothills of San Bernardino and San Jacinto Mountains)

• Lake Mathews quad (Lake Mathews to Lake Elsinore)

• Piru, Simi, and Santa Susana quads (Santa Clara floodplain, Sespe and Piru Canyons, Oak Ridge to Santa Susana Mountains)

• Calabasas quad (Simi and Agoura Hills)

• Ventura quad (lower Ventura River floodplain and surrounding slopes)

• Lebec quad (15 corridor and slopes north of Castaic Lake to Grapevine (Tejon Pass)

Wildlife Distributions: Forty-two vertebrate species were identified by gap analysis as being at highest risk from lack of habitat protection (Table 3). The southern half of the region contains many quadrangles with at least 30 of the 42 species, with the highest being 37 in the Wildomar, Fallbrook, and Rodriguez Mountain quads. Eight other quads have 36 species, usually adjoining the three mentioned above. Two of these quads with 36 at-risk species, San Gorgonio Mountain and Cuyamaca Peak, are already mostly protected in Forest Service wilderness or state park and wilderness. Basically, the number of at-risk species is relatively uniform throughout San Bernardino, western Riverside, San Diego, and eastern Orange counties. The western half of the region in Los Angeles, Ventura, and Santa Barbara counties have fewer species at-risk per quad. Some of these species may only occur in the western half, however, so this area should not be dismissed as less critical to preserving biodiversity until a more detailed analysis can be performed.

Table 3. Wildlife species considered "at risk" based on Gap Analysis criteria.

Scientific Name	Common Name (WHR Code)
Amphibians	
Batrachoseps pacific	Pacific Slender Salamander (A016)
Batrachoseps stebbinsi	Tehachapi Slender Salamander (A018)
Bufo microscaphus	Southwestern Toad (A035)
Rana muscosa	Mountain Yellow-legged Frog (A044)
Birds	
Elanus caeruleus	Black-shouldered Kite (B111)
Haliaeetus leucocephalus	Bald Eagle (B113)
Aquila chrysaetos	Golden Eagle (B126)
Coccyzus americanus	Yellow-billed Cuckoo (B259)
Asio otus	Long-Eared Owl (B272)
Archilochus alexandri	Black-chinned Hummingbird (B286)
Calypte costae	Costa's Hummingbird (B288)
Empidonax difficilis	Western Flycatcher (B320)
Tachycineta thalassina	Violet-Green Swallow (B340)
Polioptila caerulea	Blue-Gray Gnatcatcher (B377)
Polioptila californica	California Gnatcatcher (B378)
Sialia mexicana	Western Bluebird (B380)
Lanius ludovicianus	Loggerhead Shrike (B410)
Vireo bellii	Bell's Vireo (B413)
Vireo vicinior	Gray's Vireo (B414)
Dendroica petechia	Yellow Warbler (B430)
Icteria virens	Yellow-breasted Chat (B467)
Guiraca caerulea	Blue Grosbeak (B476)
Aimophilia ruficeps	Rufous-crowned Sparrow (B487)
Amphispiza belli	Sage Sparrow (B497)
Passerculus sandwichensis	Savannah Sparrow (B499)
Ammodramus savannarum	Grasshopper Sparrow (B501)
Agelauis tricolor	Tricolored Blackbird (B520)
Mammals	
Tamias obscurus	California Chipmunk (M061)
Perognathus longimembris	Little Pocket Mouse (M086)
Perognathus alticola	White-eared Pocket Mouse (M089)
Perognathus fallax	San Diego Pocket Mouse (M094)
Dipodomys agilis	Pacific Kangaroo Rat (M103)
Dipodomys stephensi	Stephen's Kangaroo Rat (M108)
Dipodomys merriami	Merriam's Kangaroo Rat (M110)
Reptiles	
Clemmys marmorata	Western Pond Turtle (R004)
Sceloporus orcutti	Granite Spiny Lizard (R021)
Phrynosoma coronatum	Coast Horned Lizard (R029)
Xantusia henshawi	Granite Night Lizard (R033)
Cnemidophorus hyperythrus	Orange-throated Whiptail (R038)
Anniella pulchra	California Legless Lizard (R043)
Lichanura trivirgata	Rosy Boa (R047)
Crotalus ruber	Red Diamond Rattlesnake (R073)

Conclusions

One simple scheme for setting priority areas is to identify those that contain a large extent of at-risk plant communities AND large numbers of at-risk vertebrates AND large extent of unprotected Significant Natural Areas. Twelve quads meet this coarse screening of greater than 40 percent of their area in natural communities identified by GAP as at-risk, at least 25 of the 42 vertebrates considered at-risk, and more than 30 percent of their area in unprotected Significant Natural Areas: Lebec, Lake Mathews, Black Star Canyon, Canada Gobemadora, Laguna Beach, San Clemente, Morro Hill, Las Pulgas Canyon, San Onofre Bluff, Jamul Mountains, Tecate, and Otay Mountain. These quads, primarily in Orange and San Diego counties, deserve attention as sources of potential new nature reserves. The region southeast of San Jacinto Valley, including the Cahuilla Mountain, Bucksnort Mountain, Collins Valley, and Vail Lake quads, satisfy the first two criteria, but are below our threshold for SNA's.

Validation of the GAP database has consisted of simple comparisons with existing datasets for specific, well-known locations. A formal, statistically rigorous accuracy assessment was beyond the resources available to complete the analysis. The initial comparisons discussed in the report have been encouraging. While there may be minor corrections and updates required as better information becomes available, we do not expect the major findings of the analysis to change. Database users are encouraged to send us their feedback on any aspect of the database they feel needs to be revised.

Reserve selection and design will require additional levels of detail in both the mapped information and the sophistication of the analysis. Identification of priority areas presented in this report were based on a relatively simple observation of locations, generally 7.5' quadrangles, where the most at-risk species occur or the most land is comprised of at-risk plant communities. Protection of these "hot-spots" does not guarantee that all at-risk elements of biodiversity would be protected. More sophisticated methods have been used to identify optimal reserve networks on the basis selection of sites representing all elements. Selection of potential reserves is sensitive to the choice of criteria and algorithm used. As this is an active research area in conservation biology, we have not yet attempted to implement any of these prioritization schemes. We recommend that candidate reserve network selection be undertaken as an interagency planning effort involving UCSB, the California Department of Fish and Game, the U. S. Fish and Wildlife Service, The Nature Conservancy, and others.

We emphasize here that Gap Analysis, as a coarse-filter approach to conservation assessment, has the following limitations of which readers need to be aware:

- The vegetation map does not show explicit locations of habitats smaller than the minimum mapping unit (MMU) nor does it portray habitat stage, or stand age, except by distinguishing early seral stages.

- Species distribution maps are predictions only. Maps of predicted habitat distribution do not reflect habitat quality or species density.

- Gap Analysis is not a substitute for recovery efforts for species that are already threatened or endangered nor is it a substitute for a thorough national biological survey.

The gap analysis database has a wide potential set of applications for conservation planning, biogeographical research, and education. We have planned from the beginning of the project to make nonproprietary parts of the database accessible. We have recently established an "anonymous ftp" account for distribution of GIS coverages, text, and graphics over the internet network. Currently, this account contains the vegetation database (as an ARC/INFO export file), the 100 in digital elevation data, 3 band color composite Thematic Mapper image at 100 m resolution, and the wildlife species lists for each vegetation map unit.

The full report describing the methods and results for the Southwestern California Region Gap Analysis is also available through this internet access. For details on obtaining the files by ftp, send e-mail to biod(@horton.geog.ucsb.edu. The National Center for Geographic Information and Analysis (NCGIA) at UCSB will soon be printing copies of the full report as one of their technical report series. Please contact NCGIA directly by phone at (805) 893-8224 or by mail through the Department of Geography at UCSB for details on reproduction cost and ordering.

You are encouraged to contact us with comments on this report the database, or on the gap analysis process in general. For those with e-mail, contact fd@crseo.ucsb.edu. Otherwise, contact Dr. Frank Davis at the address on the cover letter.

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- The staff of the UCSB Map and Imagery Library (MIL) for generous assistance with MIL computing facilities, maps, imagery, aerial photos, and work space;
- Jesse Adams and Richard Johnson of UCSB for computer systems support in the Department of Geography;
- The Strategic Resource Planning Program of the California Department of Forestry and Fire Protection (CDF&FP) for supplying vegetation and wildlife data and imagery;
- The Natural Heritage Division of the Department of Fish & Game (CDF&G) for providing maps of many managed areas, Significant Natural Areas and the distribution of rare and endangered species and communities;
- The Teale Data Center for providing a map of land ownership;
- Barry Garrison of the California Department of Fish and Game for guidance on use of the California Wildlife-Habitat Relationships database;
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- Dr. James Quinn of the University of California, Davis, and his students for compiling species lists for managed areas that are being used in validation of the GAP database;
- Undergraduate researcher assistants Josh Graae, John Kealy, Mark McLean, and Keith Farnsworth contributed greatly to the compilation of the database for this region.

1. INTRODUCTION

1.1. Background

Numerous efforts are underway by public and private groups to assess the status of biodiversity in California. Most are being conducted at local to subregional scales, and many are focused on species or communities of special concern. Currently lacking is an overview of the protection status of species and communities both statewide and in the western U.S. as a whole. Our Geographic Information System (GIS) -based Gap Analysis of biodiversity in California is part of an ongoing effort by many groups, including the U. S. Fish and Wildlife Service (USFWS), the California Department of Fish and Game (CDF&G), Department of Forestry and Fire Protection (CDF&FP), The Nature Conservancy (TNC) and others to provide this overview in California by mapping the distributions of plant community types and vertebrate species habitats and relating these distributions to existing patterns of land ownership and land management. Our work is supported by the National Fish and Wildlife Foundation and the Southern California Edison Company (SCE), and is part of a national program of state and regional gap analyses being coordinated by the USFWS.

The term "Gap Analysis" refers to the evaluation of the protection status of plant communities, vertebrate species and vertebrate species richness by GIS overlay of biological distribution data on a map of existing biological reserves (Davis et al., 1990; Scott et al., 1993). Maps are produced at relatively low spatial detail (e.g., 1: 100,000 map scale) to provide a broad overview of the distribution of biota and their protection status, and to identify landscapes that contain large numbers of potentially unprotected vegetation types and vertebrate species. Such areas can then be studied in more detail as candidates for additional preservation and protection efforts to fill gaps in the protection network.

The biodiversity assessment for California uses existing digital geographical data sets on land ownership, topography, species ranges and locations of rare, threatened, and endangered (RTE) species. An up-to-date statewide vegetation map is being produced using digital Thematic Mapper (TM) satellite data. Image interpretation is being guided by vector overlays of existing vegetation maps, land use maps and forest inventory data. Upland types are being mapped with a minimum mapping unit (MMU) of 100 hectares (247 acres). Major wetland areas are mapped using a 40 hectare (99 acre) MMU, and smaller wetlands are encoded as attributes of larger upland polygons. The California Wildlife-Habitat Relationships System (WHR), in conjunction with digital species range maps, is applied to the vegetation map to predict the current distribution of potential habitat for each native terrestrial vertebrate species (570 species). Predicted vertebrate distributions are combined to map patterns of potential species richness in 7.5’ quadrangles.

1.2. Scope and Outline of the Report

Because of the state’s size and complexity, we are conducting our analysis on a bioregional basis, using the ten major subregions of the state as defined in *The Jepson Manual of Higher Plants of California* (Hickman, editor, 1993) (Figure 1 - 1). This report describes the database compilation, analysis, results, and recommendations for the Southwestern California Region. This region stretches from Point Conception in the north to the Mexican border, and from the coast inland across the Transverse and Peninsular Ranges to the edge of the deserts. This report summarizes the development and initial analysis of the Gap Analysis database. Actual conservation guidelines for the region as a whole may be forthcoming in a final report coauthored by appropriate state and federal agencies and non-governmental organizations. Similar reports will be prepared for the remaining bioregions in California. For bioregions that extend across other states, a corresponding analysis will be done in collaboration with neighboring Gap projects and reported separately.

The report is organized as a series of manuscripts for peer-reviewed journals describing the land ownership and management of the region, the analysis of vegetation, and the analysis of wildlife species distributions. The first section has been published in the Natural Areas Journal (Beardsley and Stoms, 1993); the vegetation section is being submitted to Madrono; the wildlife section will be submitted to a journal after further validation work is complete.

The report describes the compilation and analysis of biodiversity distribution data for the entire region. Natural communities and native plant and animal species that are not currently well-protected in nature reserves are identified as being "at-risk." This set of biological elements does not include previously listed threatened or endangered species and communities or those of special concern unless they meet the risk criteria used in this gap analysis. This highlights the fact that Gap Analysis is not a substitute for recovery efforts for species that are already threatened or endangered. Instead, our main objectives are to identify elements of biodiversity that are potentially at risk that have not already identified, and to locate priority areas where large numbers of at-risk species or area of at-risk communities are concentrated. We do not go so far as to recommend an new network of areas managed for biodiversity. That will require additional analyses incorporating more detailed land use/land cover information, socioeconomic data and political data.

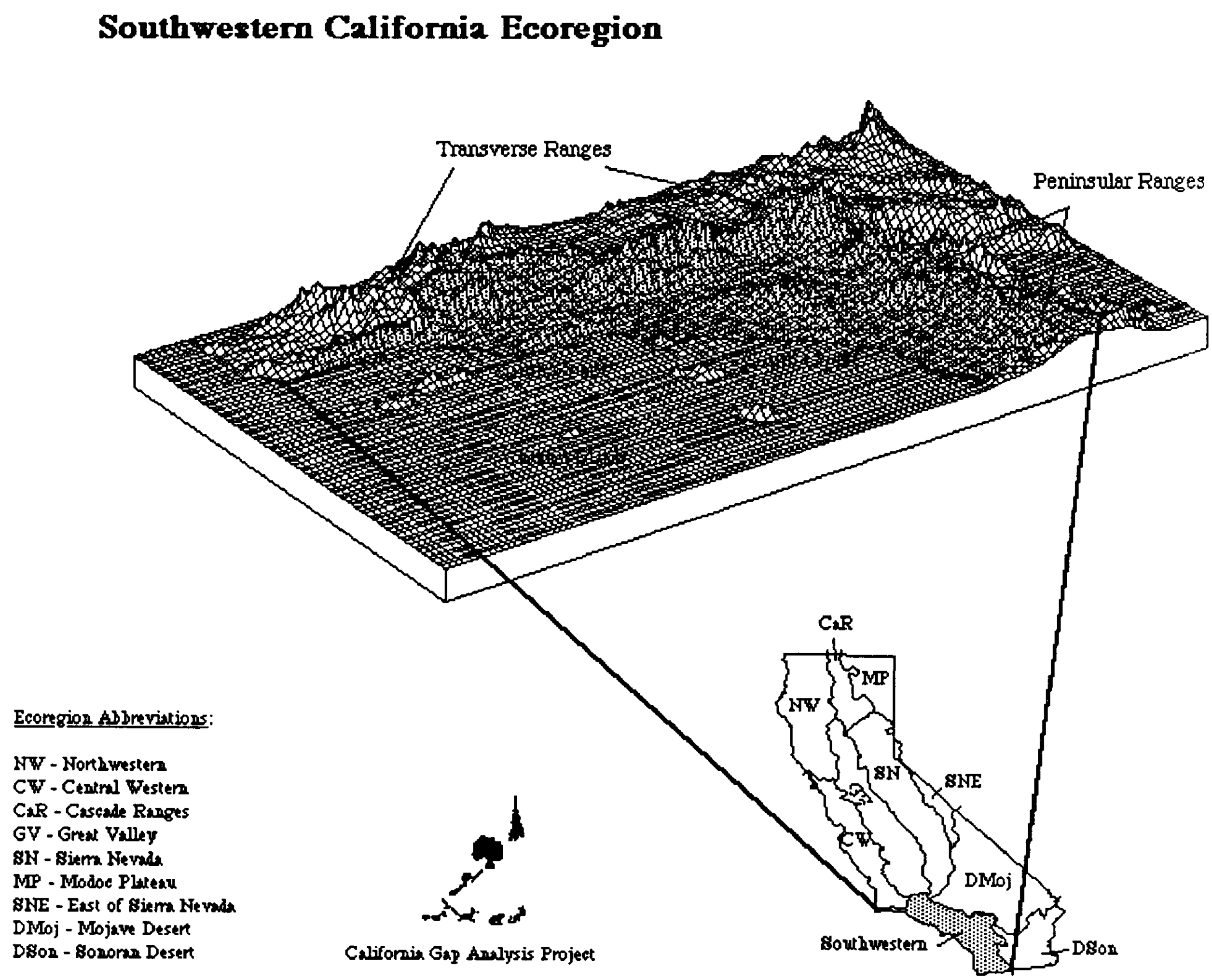

Figure 1-1. Three-dimensional view of Southwestern California Region and its relationship to the other nine regions in the state.

The GAP database has not been formally validated over the entire region. Several comparisons of GAP distribution data with observed data or information from more detailed mapping are discussed in the report. Further validation with existing datasets and new field sampling are planned in the near future.

1.3. Assumptions and Limitations of Gap Analysis

We think it is important to state explicitly the assumptions of gap analysis (Scott et al., 1993):

1. The vegetation types encoded in the vegetation cover type database occur uniformly throughout the mapping unit.

2. Discrete boundaries exist between vegetation polygons.

3. The vegetation map is geographically accurate.

4. A wildlife species may be present in suitable habitat within its distributional limits.

5. Appropriate microhabitats for a species occur within landscape-sized stands of vegetation types.

6. Species lists for the same habitat type within the distributional limits are independent of the size of habitat patch, in part because the mapping process has filtered out small patches where stochastic processes more strongly affect the probabilities of finding a species.

7. All polygons of a habitat type are of the same quality.

8. Wildlife habitats can be described in terms of plant communities.

9. Sufficient knowledge of the habitat affinities of animal species allowed the construction of an accurate habitat relationships database by the California Interagency Wildlife Task Force.

10. Areas rich in species are the best areas to manage for their biodiversity values.

11. Areas without legal or legislative mandates tied to specific land areas for long-term maintenance of self-sustaining natural ecosystems are at risk.

12. Accurate information exists on the occurrence of land ownership and areas managed for long-term maintenance of natural ecosystems.

We emphasize here that Gap Analysis, as a coarse-filter approach to conservation assessment, has the following limitations of which end-users need to be aware (Scott et al., 1993):

1. The vegetation map does not show habitats smaller than the minimum mapping unit (MMU). Important local habitat patches and plant communities still need to be identified by subsequent higher resolution assessment.

2. The vegetation map does not portray habitat stage, or stand age, except by distinguishing early seral stages following fire or logging from more mature stands. We assume that within the large landscape mosaics enclosed by our vegetation polygons, a mosaic of patches of varying age can be found at any given time. Thus, the vegetation map should have more durability over time at the expense of spatial and seral detail.

3. Boundaries between vegetation types along real environmental gradients are seldom as sharp as implied by the vegetation map. Ecotones must be identified by higher resolution analysis.

4. Species distribution maps are predictions only. Such maps, and subsequent species richness maps, are based on known distributional limits and known or inferred habitat relationships. Although comparisons of species lists from Gap Analysis data with those from well-studied nature reserves have shown reasonable agreement, presence of species should be confirmed in the field prior to site-specific reserve design and management planning.

5. Maps of predicted habitat distribution do not reflect habitat quality or species density. Gap Analysis predicts the presence or absence of a species, not whether it is rare or common in a particular area. Site-specific inventories are still needed to provide species abundance information.

6. Gap Analysis is not a substitute for recovery efforts for species that are already threatened or endangered. A primary argument in favor of Gap Analysis is that it is proactive in that it seeks to protect sites of high conservation value before individual species and vegetation cover types become critically rare. Thus, it should help to reduce the rate at which species require listing as threatened or endangered.

7. Gap Analysis is not a substitute for a thorough national biological survey. As a response to rapid habitat loss, Gap Analysis provides a quick look at the distribution of vegetation and associated species before they are lost and provides a focus and direction for a state and national program to protect biodiversity. The process of improving knowledge of systematics and taxonomy, and verifying species distributions, is lengthy and expensive. That process must be continued and expedited, however, in order to provide the detailed information needed for a comprehensive assessment of our nation's biodiversity.

2. GEOGRAPHY OF THE SOUTHWESTERN CALIFORNIA REGION

The Southwestern California region includes 3,383,160 ha, roughly 8 percent of the area of California (Figure 1-1). It lies within the California Floristic Province and is divided into four subregions and six districts. Subregions include the South Coast, the Channel Islands, the Transverse Ranges and the Peninsular Ranges. Districts of the Transverse Ranges include the San Bernardino

Mountains, the San Gabriel Mountains, and the Western Transverse Ranges. The San Jacinto Mountains are considered a separate district of the Peninsular Ranges.

The region is bounded by the Sonoran and Mojave Desert regions on the east and the crest of the Santa Ynez Mountains and the upper Cuyama Valley on the north. The boundary at the southern end of the region is defined as the Mexican border, although vegetation similar to that found in southwest San Diego County extends south into Baja California for roughly 300 km, where there is a steep transition to a more and adapted flora (Westman, 198 1).

Based on the 1990 census data, 16,539,858 people (56% of California's total population) reside in the region. This region has experienced extraordinarily rapid population growth in recent decades. Between 1980 and 1990, San Bernardino and Riverside Counties grew more than 50%, San Diego County grew 30 -39.9%, Orange and Ventura Counties expanded by 20 -29.9%, and Santa Barbara and Los Angeles Counties grew 5 - 19.9% (Goodenough, 1992). The population of some localities such as Vista and San Marcos in San Diego County grew by more than 100% over this ten year period (Griffin, 1992).

Sixty percent of the land area is in private ownership, much of it at lower elevations and dedicated to urban or agricultural uses. Only a small fraction of private land is managed for biodiversity protection, such as The Nature Conservancy preserves and National Audubon Society sanctuaries. Steeper, montane areas are largely managed by public agencies such as the U. S. Forest Service (29% of the region), U.S. Bureau of Land Management (3%), U.S. Bureau of Indian Affairs (2%), U.S. Department of Defense (2%), and the California Department of Parks and Recreation (2%). The four national forests in the region (the Cleveland, San Bernardino, Angeles, and Los Padres) are managed primarily for watershed and recreation resources and fire protection. Congressional legislation passed in 1964, 1968, 1984, and 1992 designated 14 wilderness areas on these national forests entirely or partially within the Southwestern California Region. Similarly, the Department of Parks and Recreation has designated all or parts of four wilderness areas within state park lands in the region. The U.S. National Park Service, California Department of Parks and Recreation, and private conservancy groups are actively purchasing land in the Santa Monica Mountains National Recreation Area to preserve recreational and natural values.

2.1. Physiography and Geology

Two geological provinces comprise the Southwestern California Region (Norris and Webb, 1990). The southern half of the region is dominated by the Peninsular Ranges. The northern portion of the region is part of the complex Transverse Ranges province. At least five main mountain ranges comprise the Peninsular Ranges of southern California: the San Jacinto Range (summit elevation 3,325 m), the Santa Rosa Range (2680 m); the Santa Ana Mountains (1755 m); the Agua Tibia Mountains (1880 m) and the Laguna Mountains (1940 m). The basement rock of the Peninsular Ranges is a granitic batholith, consisting mainly of quartz diorite dating from the lower Cretaceous period. Some older roof pendants remain, particularly in the western region, consisting of altered schist and gneiss, with some limestone. Major fault valleys include the Elsinore fault zone and the San Jacinto fault zone.

The major mountain ranges of the Transverse Range include the Santa Ynez Mountains (1325 m), the Topatopa Range (2060 m), the Santa Monica mountains (925 m), the San Gabriel Mountains (3080 m) and the San Bernardino Mountains (3385 m). Whereas the Santa Ynez and Topatopa Mountains are predominantly interbedded marine sandstones and shales, the Santa Monica Mountains are granitic and metamorphic rocks. The San Gabriels are a deeply dissected horst of about 70% Mesozoic granitic rock, fringed by more recent sedimentary formations. On the southern flank, deep contiguous alluvial fans are joined all the way from Pasadena to Cajon Pass. The San Bernardino Mountains are similar in most respects to the San Gabriels, but are slightly higher and less rugged. A frequency distribution of elevation derived from U.S. Geological Survey digital elevation data indicates that 46% of the region is lower than 500 m above mean sea level. Only 3.5% of the region is above 2000 m, and < 0. 1 % is above 3000 m.

2.2. Climate

The is a strong climatic gradient from low coastal areas to high elevations of the interior, and a secondary gradient from north to south (Bailey, 1966). Mean temperatures along the coast range from around 10°C in winter to 2°C in the summer. In contrast, mid-elevations further east range from 5°C in winter to 22°C in summer. Annual precipitation averages 250-500 mm at lower elevations to greater than 1500 mm at high elevations in the Transverse Ranges. Total annual precipitation at coastal localities decreases from 400 mm in the north to 250 mm at San Diego. However, southern areas receive more summer precipitation associated with tropical hurricanes. Annual moisture balance ranges from a surplus of 100-200 mm in the mountains to deficits of 200-600 mm at lower elevations. In summary, topography and variable coastal influence combine to produce at least 5 general climatic types, including warm steppe, warm Mediterranean, cool Mediterranean, maritime Mediterranean and microthermal (montane).

2.3. Soils and Vegetation

Soil patterns are very complex, reflecting interactions among geology, topography, climate, geomorphology and vegetation. In general, mollisols predominate in the interior faulted valleys, while a diverse group of alfisols occur on the terraced coastal sediments. The mountain soils are not well characterized, but are likely to be comprised of poorly developed, excessively drained entisols.

The California Natural Diversity Data Base (NDDB) system currently recognizes 272 natural communities occurring in the state (Holland, 1986). Of these 272 community types, 89 (33%) occur within the southwestern region. A list of 87 widespread trees and shrubs that are frequent canopy dominants in upland vegetation of the region are provided in Appendix A. Appendix B lists 73 communities that we have mapped, as well as 11 other community types described by Holland.

Upland natural areas of this region are dominated by 24 major terrestrial community types. Annual grasslands and soft chaparral communities dominate lower elevations near the coast, giving way to hard chaparral at mid- elevations, and then to mixed evergreen forest and mixed conifer forest at the highest elevations. Slopes adjacent to the Mojave and Sonoran Deserts support drier shrubland types, as well as pinyon and juniper woodlands.

The California Natural Diversity Data Base lists 156 plants and 34 terrestrial plant communities of special concern within the region. As of 1990, 4,255/18,937 (25.5%) of all NDDB records fell within this area. High concentrations of threatened and endangered species occur near the coast in western San Diego County (Imperial Beach, Otay Mesa, Del Mar quads), near Cuyamaca Peak, in the Lake Mathews Basin, and near Big Bear Lake in the San Bernardino Mountains.

3. AREAS MANAGED FOR BIODIVERSITY

Gap analysis, a proactive method of conservation planning, involves comparing species distributions to the location of protected areas using a GIS (Scott et al., 1993). During gap analysis, a map of land ownership and management is needed to determine the management status of species and communities and to identify gaps in the nature reserve network. The managed areas map for California is being compiled as a necessary component of the California Gap Analysis project but is constrained by the cartographic standards and time and budgetary limitations of this project. We have attempted to design the digital map with a much broader perspective, however, anticipating that it will be useful for a wide variety of applications and analyses. For example, this map can be digitally overlaid with other data, such as species distributions and environmental factors, to determine their co-occurrence for regional analysis and planning.

As with any mapping project, careful consideration must be given to many cartographic questions. What classes of management will be mapped and how are they defined? What base map will data be compiled on and what map scale and projection should it be in? What is the smallest parcel of land that will be delineated on the map? How sensitive is the analysis to the choice of minimum mapping unit? What information should be collected for each area? Are there other potential applications of the information that might affect these decisions? These are some of the issues we have faced while compiling the management status map. The pragmatic choices made for the California managed areas map and the rationale for making them are presented here along with results for the Southwestern California Region (Hickman, 1993).

3.1. Methods

3.1.1. Definition and Classification of Managed Areas

Defining classes or levels of protection for land parcels is one of the most difficult steps in producing a managed areas map. Many different schemes exist, and criteria for "protected areas" inevitably differ. Even the terminology itself comes under scrutiny. To avoid categorizing areas as either protected or unprotected, we refer to them here as "managed areas".

The Natural Heritage Division within the California Department of Fish and Game describes a managed area as usually of public or institutional ownership, having the additional distinction of being maintained in a manner that will protect the significant elements of biodiversity and other features found within the area. Included in this definition is the presence of a professional manager or managing agency capable of protecting these important ecological attributes by adopting appropriate strategies for this purpose (The Nature Conservancy, 1988). The Natural Heritage Division groups managed areas into three categories of protected, semiprotected, and unprotected based on land ownership and management status of the property.

For the National Gap Analysis program, a managed area is one in which management goals include the long-term protection of biological diversity (Scott et al., 1993). The management level refers to the degree to which an area is managed to maintain its biodiversity. In this case management level is a combination of ownership status and management goals. The three levels of management that we use for the California Gap Analysis project (Table 3-1) are similar to those used by the California Natural Heritage Division. We have combined their protected and semiprotected categories into our Level 1 status because management of some types of areas varies between sites (e.g., Bureau of Land Management (BLM) Areas of Critical Environmental Concern (ACECs)), requiring a site-by-site classification which was beyond our means.

Klubnikin (1979) was one of the first to assemble a map of all preserved lands in California. She investigated the distribution of parks and preserves relative to Kuchler's potential natural vegetation types (Kuchler, 1977) by manually overlaying the two maps (both at a scale of 1:1,000,000). Crumpacker et al. (1988) carried out a similar analysis at a smaller map scale by performing a GIS overlay of the National Geographic Society's 1982 map of America's Federal Lands with Kuchler types. At the local level, Pryde (1988) inventoried and evaluated public and private preserved natural areas in San Diego County. He categorized each area indicating the level and efficacy of its protection.

3.1.2. Mapping Criteria

Several criteria were established to guide the compilation of the managed area map to facilitate objectives of gap analysis. Foremost among these criteria are the definition of management levels, map scale, and minimum mapping unit size.

Table 3-1. Biodiversity Management Levels and Examples.

Level 1 Management: An area with an active management plan in operation that is essentially maintained in its natural state and within which natural disturbance events are either allowed to proceed without interference or are mimicked through management. For mapping purposes, a further constraint is that the area be at least 200 ha for uplands or 80 ha for wetlands, or be contiguous with other Level 1 areas. (Natural Heritage Division categories of Protected and Semi-Protected.)

Nature Conservancy Preserves and Easements
Audubon Society Sanctuaries
Other conservancies and land trusts
University of California Natural Reserves
Other university reserves (Stanford, California State University system)
State Parks and Reserves, including state wilderness areas
State Fish & Game Ecological Reserves
State Fish & Game Wildlife Areas
USFS and BLM and FWS Research Natural Areas
USFS Wilderness Areas
USFS Special Interest Areas
Bureau of Land Management Areas of Critical Environmental Concern
National Parks and Monuments
National Recreation Areas and Seashores
National Wildlife Refuges
NOAA National Estuarine Research Reserves

Level 2 Management: Most non-designated public lands, including National Forests and BLM (and state park lands). Legal mandates prevent permanent conversion to anthropogenic habitat types (with some exceptions, such as tree plantations) and confer protection to populations of Federally listed and/or candidate species. Sites generally have a manager or managing agency capable of protecting elements of biodiversity. The same MMU constraint applies as for Level 1. (Natural Heritage Division category of Unprotected.)

National Forest and BLM lands not in 1 above
Indian Reservations
Bureau of Reclamation
Department of Defense land
State Forests
State Beaches, Historic Parks, Recreation Areas, Vehicular Recreation Areas
Other state, regional, county, city, and water district lands
City, county or regional parks

Level 3 Management: Private lands without existing easement or irrevocable management agreement that maintains native species and natural communities and which is managed primarily or exclusively for intensive human activity. (Natural Heritage Division does not define this category).

All lands are managed at some level with respect to the protection of natural ecosystems and processes. For the purposes of gap analysis, it is necessary to distinguish three levels of management in order to determine the protection status of elements of biodiversity. These levels, and the types of areas included in each, are defined in Table 3-1 (modified from Scott et al., 1993). The default category is Level 3, because parcels are not mapped explicitly unless they qualify for Level 1 or 2.

The management status map had to be compiled at a cartographic scale of 1: 100,000 to achieve the objectives of gap analysis. The base map is the USGS topographic map series at this scale but projected into the Albers Equal Area projection to be compatible with the other data layers in the California Gap Analysis database. Based on the regional scale of gap analysis and on the available resources for compiling data, a minimum size threshold or mapping unit (MMU) was established, such that only upland preserves at least 200 ha (500 acres) were mapped as Level 1 areas. An 80 ha (200 acre) MMU was established for wetland preserves, because in southern California these rare and diminishing habitats tend to be small. There are a large number of small protected areas for which adequate boundary maps are generally the most difficult to obtain. Smaller reserves may be critical for short-term protection of individual species, or as stepping stones in a nature reserve network, and would need to be mapped at a finer scale than required by gap analysis.

Our MMU of 200 ha was chosen to be consistent with the standard of the National Gap Analysis program (Mike Scott, personal communication). It is also an appropriate size for landscape-level analysis (not for more local analyses in which more detailed maps of land status must be obtained), and for combination with the vegetation map currently being produced at UCSB at a similar scale. Exceptions to the MMU criterion were allowed where digital maps were provided by public agencies or where small parcels are part of a complex of Level 1 parcels, such as within the Santa Monica Mountains NRA. A similar 200 ha MMU constraint was applied to Level 2 lands. Again, smaller parcels were compiled where digital maps were provided by public agencies (e.g., BLM parcels intermixed with private parcels throughout much of Riverside County).

3.1.3. Compiling Map Sources

An existing digital map of land ownership was obtained from the Teale Data Center in Sacramento. This map was derived from the 1:100,000 scale Bureau of Land Management (BLM) Surface Management Status maps published in the 1970's. It distinguishes ownership by private, state, and federal categories. Federal and state lands are further divided by managing agency. The most recent National Forests maps were used to update the base maps prior to digitizing. Teale Data Center registered the digitized map to the Public Land Survey System network. At UCSB, we further updated the ownership component of this map with current information in the Santa Monica Mountains National Recreational Area where land acquisition by several agencies and private conservancy groups has been very extensive. Large county parks were also digitized from 1:100,000 scale USGS topographic map base sheets if the park appeared to be relatively undeveloped and might contribute to long-term maintenance of biodiversity. Other semipublic lands (e.g., lands owned by water districts and public utilities) were included where digital maps were readily available, but it would have been too time-consuming to compile consistent information for the entire region. It is recognized, however, that water district lands are sometimes maintained in a natural condition for watershed protection, and thus may be valuable for preserving biodiversity.

To compile Level 1 managed areas, we obtained boundary maps for the types of areas listed in Table 3-2 from various agency and conservation group sources at scales approximately the same as the 1: 100,000 scale ownership map. The Natural Heritage Division of the California Department of Fish and Game provided a digital map of many of the Nature Conservancy preserves and easements and of Fish and Game Ecological Reserves and Wildlife Areas. Current land ownership of the Santa Monica Mountains NRA was supplied by the National Park Service. A digital map of ACEC's was provided by the BLM Riverside office. We drafted additional managed areas such as Federal wilderness areas, Audubon Society sanctuaries, and Forest Service Research Natural Areas (RNA) (Keeler-Wolf, 1990) onto 1: 100,000 scale topographic maps and digitized them. Most State Parks and National Wildlife Refuges were already part of the ownership coverage, but maps of recently acquired parks and refuges had to be located and digitized.

Table 3-2. Names and Area of Level 1 Lands Managed for Biodiversity by Land Ownership in the Southwestern California Region

(Source: California Gap Analysis Database)

Agency/Organization, Area Name	Date of Estab.	Area (in ha)	
PRIVATE			
The Nature Conservancy Preserves:			**3,267**
Dorland (adj. to Emerson Oaks UC Reserve and BLM land) *		111	
McGinty Mountain		304	
Santa Rosa Plateau	1984	2,852	
Audubon Society Sanctuaries:			**1,870**
Silverwood *	1965	287	
Starr Ranch *	1973	1,583	
Other Conservancies/Land Trusts:			**1,251**
Santa Monica Mtns	various	1,251	
Subtotal:			**6,388**
STATE OF CALIFORNIA			
Department of Parks and Recreation:			
State Parks, Reserves, and Wilderness			**56,206**
Anza-Borrego (incl. Wilderness) *	1933	18,946	
Border Field *	1972	283	
Chino Hills	1983	3,835	
Crystal Cove	1983	1,289	
Cuyamaca Rancho (incl. Wilderness) *	1933	9,921	
Gaviota *	1953	1,124	
Leo Carrillo	1953	884	
Malibu Creek *	1974	3,104	
Mount San Jacinto (incl. Wilderness) *	1930	5,512	
Palomar Mountain *	1932	746	
Point Mugu (incl. Boney Mtn. Wilderness) *	1966	5,611	
Santa Monica Mtns (misc. parcels)	various	892	
Topanga Canyon *		3,613	
Torrey Pines *	1952	446	
Department of Fish & Game:			
Ecological Reserves			**2,407**
Bolsa Chica Creek *	1973	161	
Buena Vista Lagoon *	1969	80	
Coldwater Canyon * (adj. Sespe Wild.)	1974	22	
Goleta Slough	1981	150	
Lake Mathews	1982	1,447	
San Elijo Lagoon	1977	344	
Upper Newport Bay *	1975	203	
Wildlife Areas			**2,672**
San Jacinto	1980	2,223	
Santa Rosa	1975	449	

Agency/Organization, Area Name	Date of Estab.		Area (in ha)
University of California:			
Natural Reserves			**673**
Carpinteria Salt Marsh *	1977	94	
Emerson Oaks (adj. to Dorland TNC Reserve and BLM land)	1991	103	
James (adj. to Black Mtn. FS Sp. Int. Area) *	1966	11	
Motte-Rimrock *	1975	465	
Subtotal:			**61,958**

FEDERAL

U. S. Forest Service:			
Wilderness Areas			**226,185**
Agua Tibia *	1964	6,414	
Chumash	1992	15,513	
Cucamonga *	1964	5,172	
Dick Smith	1984	6,168	
Hauser	1984	2,859	
Matilija	1992	11,047	
Pine Creek	1984	5,312	
San Gabriel *	1968	14,008	
San Gorgonio (incl. Millard Cyn. RNA) *	1964	22,213	
San Jacinto *	1964	12,257	
San Mateo Canyon	1984	15,585	
Santa Rosa	1984	3,783	
Sespe (incl. Condor Sanctuary)	1992	88,559	
Sheep Mountain	1984	17,295	
Research Natural Areas			**2,200**
Cahuilla Mountain	1989	357	
Falls Canyon	pending	579	
Fern Canyon *	1972	654	
King Creek	1992	353	
Organ Valley	1992	257	
Special Interest Areas			**2,701**
Black Mountain (incl. Hall Canyon RNA) *		2,701	
Bureau of Land Management:			
Areas of Critical Environmental Concern			**20,158**
Beauty Mountain	pending	2,584	
Cedar Creek	pending	400	
Inkopah	pending	3,011	
Johnson	pending	1,643	
Kuchumaa	pending	247	
Potrero	pending	5,238	
Santa Ana Wash	pending	301	
Santa Margarita	pending	1,523	
Whitewater Canyon	1982	5,211	

Agency/Organization, Area Name	Date of Estab.		Area (in ha)
National Park Service:			
National Recreation Area			**7,226**
Santa Monica Mtns (many parcels)	1978	7,226	
U. S. Fish and Wildlife Service:			
National Wildlife Refuge			**3,425**
Bitter Creek	1986	2,269	
Hopper Mountain *	1974	770	
Seal Beach *	1972	386	
NOAA:			
National Estuarine Research Reserve			**414**
Tijuana River	1981	414	
Subtotal:			**262,309**
TOTAL AREA:			**330,655**

* indicates area was included in Klubnikin's analysis, 1979.

3.1.4. GIS Database Attributes

One of the principal advantages of using a GIS linked to a relational database management system is the opportunity to add attributes to the information contained for each managed area polygon. The GIS automatically calculates the area and perimeter of each polygon. The base ownership map from the Teale Data Center included a code for the managing government agency (or private owner). The map was amended to include attributes for the agency or organization that manages the site, the site's name, the managed area code (from the California Natural Heritage Division), the management level as defined for the Gap Analysis Project, the source of the digital boundary lines, the date of establishment of the site, and a comment about the site's conservation significance. Through the managed area code, the map can be linked to the Natural Heritage Division's Managed Area File (The Nature Conservancy, 1988) which contains further information such as the area manager, address, and management considerations such as leasing or easement arrangements. Although the Managed Area File is useful for locating and identifying managed areas, there is by no means a one-to-one correspondence between this list and the areas we are mapping. The list contains many small parcels not appropriate for our uses, while at the same time our database includes many managed areas not yet included in the Managed Areas File. In cooperation with the Natural Heritage Division, we are assigning managed area codes to the areas we are adding so that their list may be updated with these additional sites.

Often an area of high interest within a larger managed or protected area receives special management designation (e.g., an RNA within a wilderness area within a national forest). The highest protection category (i.e., the lowest level number) for such nested managed areas takes priority in assigning the managed area code and management level.

3.1.5. Significant Natural Areas

Significant Natural Areas (SNAs) are a designation of the California Fish and Game's Land and Natural Areas Program (LNAP) for locations with concentrations of rare or endangered biota. An SNA must meet at least one of three criteria -- extremely rare elements of biodiversity, ensembles of three or more elements, or best examples of elements (Hoshovsky, 1988) -- as determined by querying the Natural Diversity Data Base (Ellison, 1991). Some SNAs are mapped as circles drawn around a point where a rare element occurs rather than as irregular polygons drawn along natural or ownership boundaries. The LNAP has produced a digital map of the 1992 version of the SNA inventory that was provided to the California Gap Analysis project. SNAs constitute only one variable in conservation planning. Management status of plant communities and wildlife species will be discussed in forthcoming papers.

3.1.6. Elevation Zones

Elevation data was obtained in the form of a digital elevation model (DEM) which is a grid of elevation values (U.S. Geological Survey, 1987). The grid size is 3 arc-seconds or roughly 75 by 90m at the latitude of the region. The DEM data was resampled to a 100-m-grid cell size and classed into 500-m elevation intervals or zones. This was overlaid with the managed areas map to derive summaries of the proportion of each zone in each management level.

3.2. Results

Figure 3-1 shows the managed areas in the Southwestern California Region. Table 3-3 summarizes the percent area in each management level, both for all lands in the region and for SNAs. Level I areas total 330,655 ha or 9.8 percent of the region. Thirty percent is other public lands managed at Level 2, while the remaining 60% is Level 3.

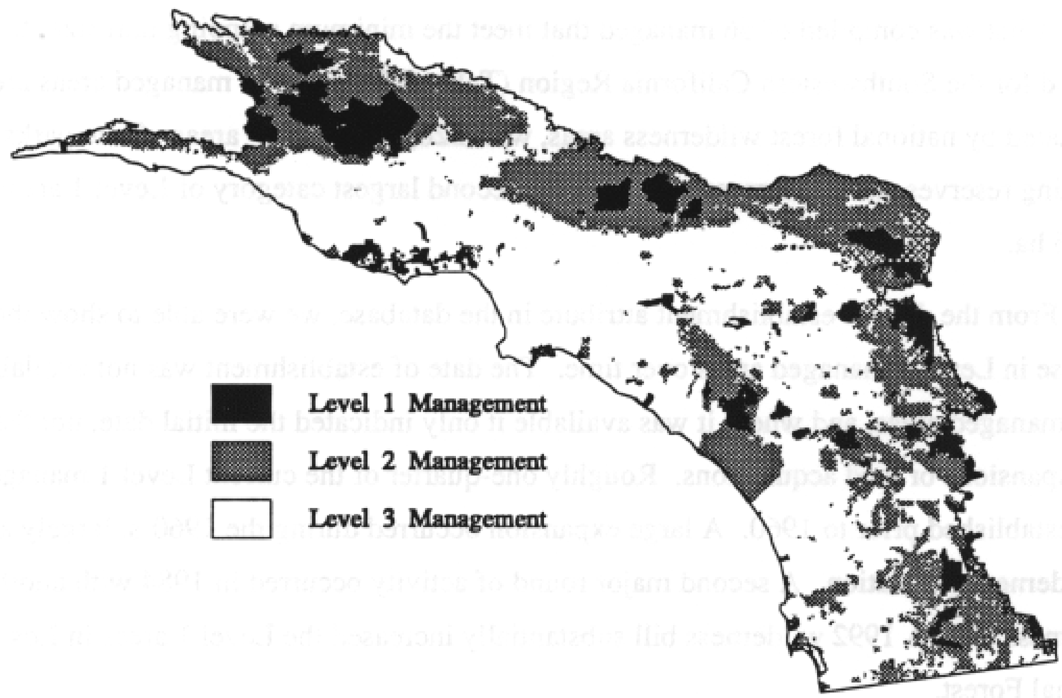

Figure 3-1. Map of management status of lands in the Southwestern California Region. See text for definitions of management levels.

Table 3-3. Area by Management Level in the Southwestern California Region

(Source: California Gap Analysis Database)

Level	All Land Area (in ha)	Percent of Total Land Area	SNAs Area (in ha)	Percent of Total SNA Area
Level 1	330,655	9.8 %	57,008	12.1 %
Level 2	1,030,531	30.5 %	125,682	26.7 %
Level 3	2,021,197	59.7 %	287,212	61.1 %
Total	3,383,160	100 %	470,407	100 %

Discrepancy in Total from the sum of Level 1 through 3 is due to small managed areas whose area is below the Minimum Mapping Unit (MMU) of 200 ha.

A list was compiled of 66 managed that meet the minimum mapping unit size; these were mapped for the Southwestern California Region (Table 3-2). Level 1 managed areas are dominated by national forest wilderness areas, with 226,185 ha in 14 areas. State parks, including reserves and wilderness areas, are the second largest category of Level 1 areas, totaling 56,206 ha.

From the date of establishment attribute in the database, we were able to show the increase in Level 1 managed areas over time. The date of establishment was not available for some managed areas, and where it was available it only indicated the initial date, not the date of any expansions or land acquisitions. Roughly one-quarter of the current Level 1 managed areas were established prior to 1960. A large expansion occurred during the 1960's, largely as a result of wilderness legislation. A second major round of activity occurred in 1984 with another wilderness bill. A 1992 wilderness bill substantially increased the Level 1 areas in Los Padres National Forest.

Overlaying the managed areas map with the SNA map produced an interesting distribution (Figure 3-2). As shown in Table 3-3, the percentage of SNAs in each level closely matches that of the region as a whole. This suggests that, with respect to SNAs, the distribution of managed areas is relatively random. That is, managed areas appear to have been established without specifically seeking the protection of SNAs. The primary opportunities for protecting SNAs on public lands are the national forests (14% of the total area in SNAs) and military bases (7.5% of SNA lands).

Figure 3-3 shows the proportion of each 500-m elevation zone in each of three management levels. Lower elevations where most urban and agricultural development is located are predominately private land and therefore Level 3 management. Middle elevations, between 1500 and 2500 m, are primarily public lands, with about 25 percent being Level 1 management but most being Level 2. Most land above 2500 m is in Level 1 management, and in fact more than 90% of the highest elevation zone is in Level 1 management (usually national forest wilderness areas). Clearly, natural communities and wildlife species characteristic of alpine environments are much better protected than those found in lowland and coastal landscapes. However, lands above 2500 m account for less than 1% of the total region, whereas lands below 1000 m cover 69% of the total region.

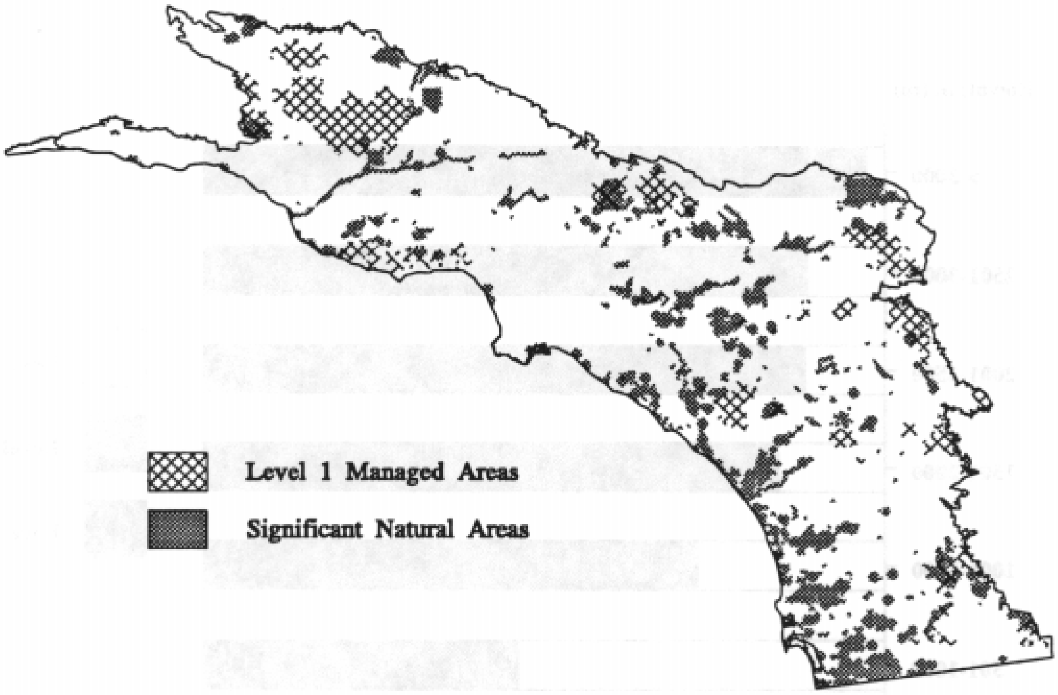

Figure 3-2. Map of the protection of Significant Natural Areas in the Southwestern California Region as defined by the California Department of Fish and Game in 1992.

3.3. Discussion

3.3.1. Comparison with Other Datasets

Analysis of management status within the SNAs indicates that about the same percentage of each management level occurs in the SNAs of the region as for the region as a whole. For instance, 9.8% of the region is in Level 1 areas, compared to 12.1% of SNAs. SNAs are identified based on information from the NDDB, which is a database of locations for rare and endangered species and natural communities (Ellison, 1991). The sightings are not based on a systematic survey of any kind and are somewhat biased with respect to where people happen to collect data and how accessible these areas are. Thus any conclusions made based on this information must be viewed with caution. Although virtually all the large public lands were established prior to the existence of NDDB, SNAs were identified irrespective of their level of protection so we can assume little bias. With this in mind, our overlay indicates that SNAs are no better protected than other land. The biological value of land, as evaluated from NDDB, does not appear to have been a factor in selecting areas to be managed for biodiversity protection. This implication reinforces the need for a gap analysis approach for planning and designing preserves in the future.

Klubnikin (1979) compiled a similar list of Level 1 parks and preserves over a decade ago. Many protected areas have been acquired since that survey. In a comparison to our list of protected areas, Klubnikin identified 22 sites (which also meet our MMU criterion), currently measuring 114,712 ha, or 3.4 percent of the region. Thus land managed for protection of biodiversity has nearly tripled since 1979. In fact, our estimate for Klubnikin's list is inflated because some areas have been expanded since her inventory. She did not include acreage figures in her thesis, so we have had to use current area as determined by the GIS as an approximation of management status in 1975.

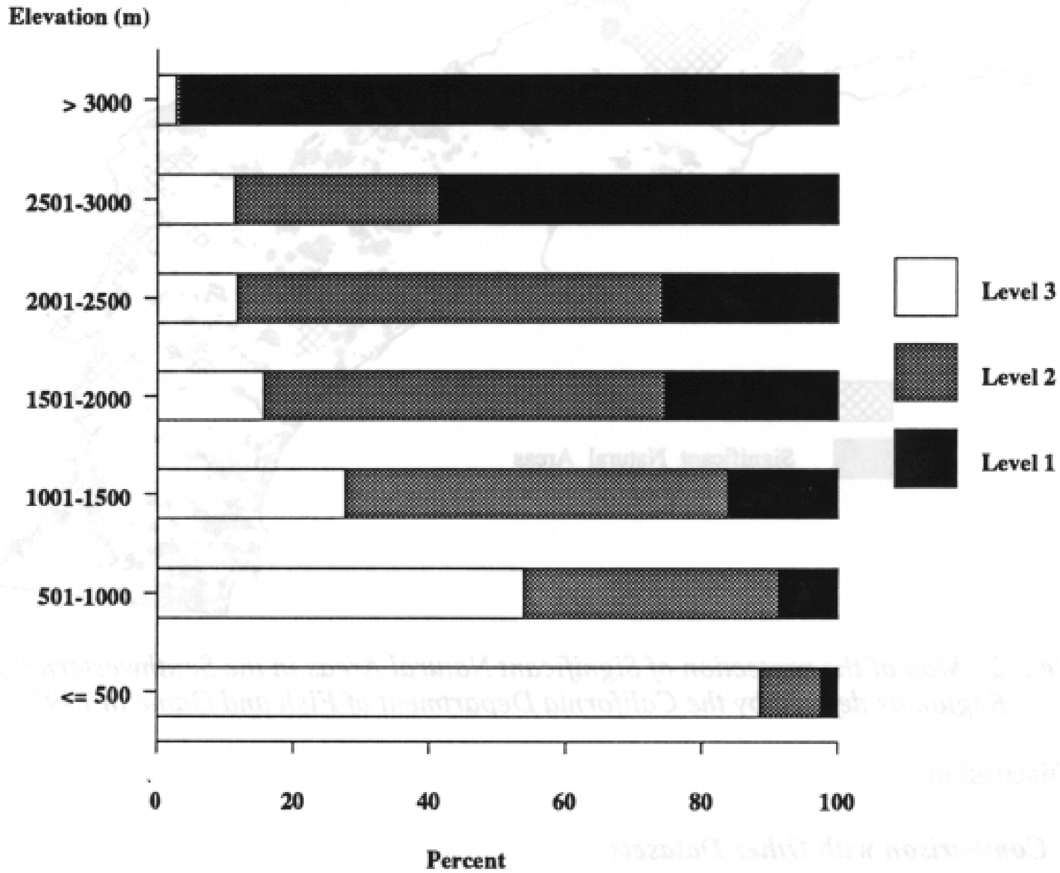

Figure 3-3. Proportion of elevation zones in the Southwestern California Region relative to management levels. Bars for each elevation zone are normalized to percent.

The relationship between elevation and management status was also compared. Level 1 areas are most often located at higher elevations (Figure 3-3). Similar patterns of distribution for the more highly protected areas were noted by Klubnikin (1979). From the standpoint of biodiversity protection, this means that certain native species and natural communities which occur at lower elevations are almost certainly under-represented in the protected area network.

3.3.2. Implications of Minimum Mapping Unit Selection

To determine how much Level 1 area was being omitted by our size threshold of 200 ha for uplands and 80 ha for wetlands, we compiled a size-frequency distribution of all Level 1 managed areas, irrespective of their size, in the region (Figure 3-4; area of unmapped sites obtained primarily from Kreissman, 1991). Of the 81 managed areas, 25 are less than 200 ha, and 45 are less than 1000 ha. By cumulative area, the managed areas under 200 ha account for only 0.6% of the total, and managed areas under 1000 ha account for only 3%. The nine sites greater than 10,000 ha (all are U.S. Forest Service wilderness areas except for Anza-Borrego State Park) account for two-thirds of the protected area in the region. One-quarter of the total area is contained in a single managed area, the Sespe Wilderness on Los Padres National Forest, designated in 1992.

The risk in setting a relatively large size threshold is that some biologically important areas will be overlooked, such as wetland preserves containing rare vegetation types; upland areas consisting of unusual natural communities or endangered species; or seemingly insignificant preserves that serve as corridors between larger, well-protected areas. In this ecoregion a large number of small sites make up a very small percentage of total protected land. Ideally it would be desirable to map all preserves, regardless of their size, but this has not proven practical since an inordinate amount of time and effort goes into searching for and acquiring map sources for these areas, relative to larger managed areas.

The MMU was based on the principle that very large reserves are required for the long-term maintenance of biodiversity (Shafer, 1990). However, the MMU is really an arbitrary threshold, and nothing in the literature prescribes a precise limit as to what makes a preserve effective for long-term biodiversity protection. As mentioned previously, boundaries of some small areas that would otherwise be classified as Level 1 under our criteria are included in the map if they were provided in digital form, but are not included in the analysis. A separate digital map with points representing the approximate centroids of these managed areas below the MMU is planned for the future. This point coverage could then be used for comparisons with other data layers (such as vegetation) to examine the conservation importance of these smaller sites.

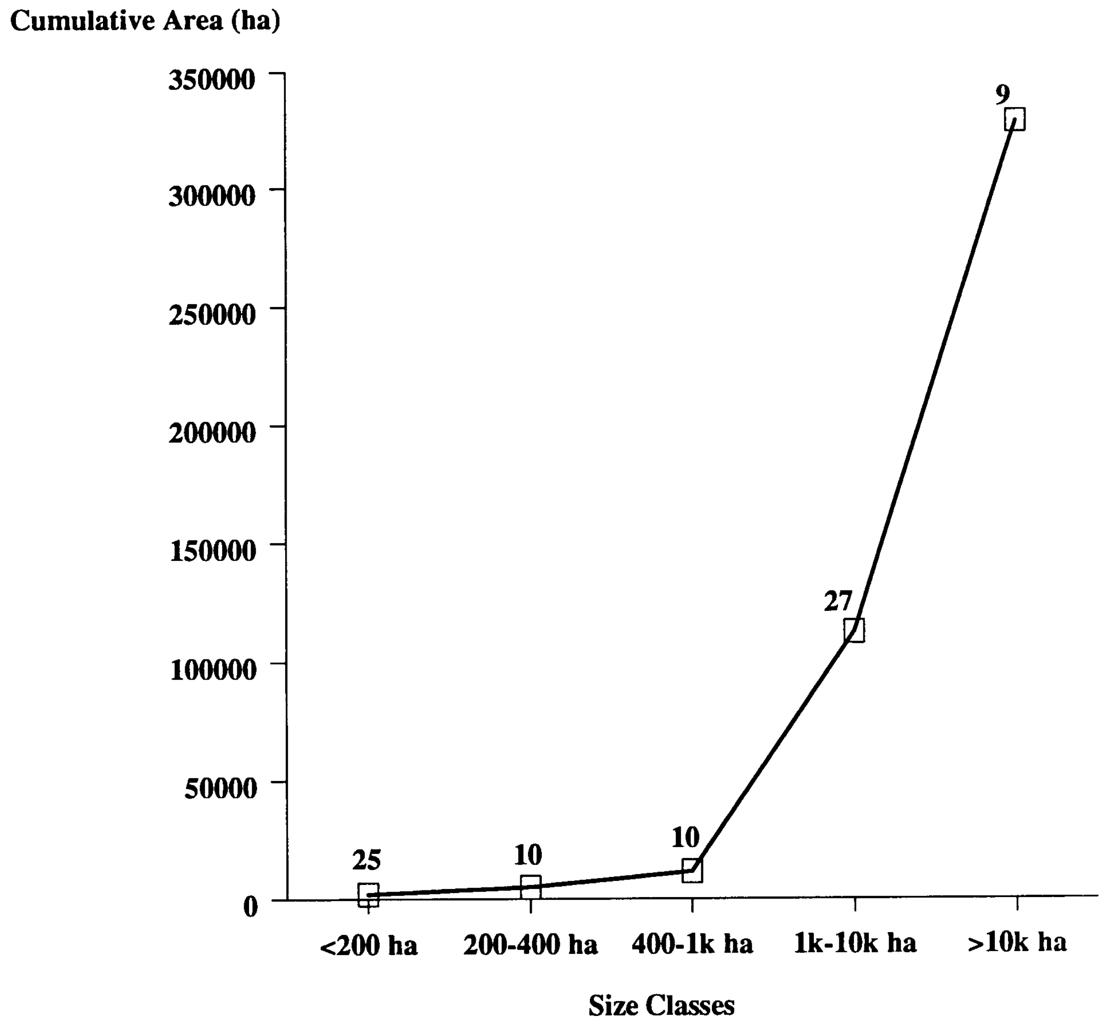

Figure 3-4. Graph of the cumulative area of Level 1 managed areas. Number above symbols indicates number of managed areas for that size class.

As an illustration of the effort involved in collecting source data for managed areas, we sent inquiries to 85 land trusts and received replies from only 17 of them. Of these, only 6 own land that fit our mapping criteria and actually ended up as part of the managed areas map. Much of this delay is understandable. People often must ask permission to distribute digital information before releasing it, which increases the time involved in acquiring data. Once the data are approved for distribution, the information must be physically (magnetic tape or disk) or electronically transferred, imported into the GIS, transformed into the proper map projection, incorporated into the existing database (which involves resolving any discrepancies with existing boundaries), and finally labeled properly with all the attributes of the managed areas database (owner, source, managed area code, management level, etc.). When only paper maps are available, additional steps are required.

The managed areas GIS database was designed with flexibility in mind so that other users may add to it as they see fit for their needs. This is the reasoning behind including small managed areas (below the MMU) if they were already provided in digital form, and creating in the future a point coverage of the general locations of very small preserves. For instance, if another user of the managed areas database requires an MMU of 50 ha, the framework is in place for these smaller areas to be added and recoded as Level 1 to fit the objectives of the user's project.

3.3.3. Limitations of the Map

The digital map for the Southwestern California Region is spatially exhaustive and includes ownership and management level attributes for all land. It does not, however, include detailed records for individual privately owned parcels (i.e., Level 3). County agencies keep detailed maps and records that are beyond the scope of our needs for gap analysis. A closer look at land ownership will be required when reserve networks and corridors are designed.

Other limitations of this map derive from accuracy and currency of the source information. Some source maps were more detailed and assumed to be more accurate than others. It was not always clear which of two or more conflicting boundaries should be considered correct. The attribute included in the database that tracks the source of the boundary information will help in resolving some of these conflicts. The ownership layer that we used as a base map was compiled from maps produced in the 1970s, so it may be up to twenty years out of date. Land acquisition and management status are continually changing, and we are already aware of some changes for which maps are not yet available. Each area was assigned a single code despite multiple or nested classifications, and some information may be lost as a result. Finally, the scale of this map, although appropriate for certain levels of analysis, is not suitable for site-level planning.

Clearly a map of this sort is dynamic. Managed area boundaries are changing and new areas are frequently being added. Thus, this initial version of the map is not entirely complete nor accurate. A map of this nature should be periodically reviewed by knowledgeable representatives from different organizations. At this point it has not been determined who will be responsible for maintaining the map or where it will be ultimately housed. One possibility is for the creation of a biodiversity GIS center to manage, maintain, and distribute this type of digital data and function in a similar manner to the existing state Natural Heritage Division. It is also very likely that the Natural Heritage Division will take on the responsibility of updating and maintaining the managed areas database once it has been completed as part of the California Gap Analysis project. The issue of distributing proprietary data used in database development, or data that are sold in a cost-recovery GIS operation, must be considered if the map is to be shared among conservation partners.

4. DISTRIBUTION AND MANAGEMENT STATUS OF TERRESTRIAL PLANT COMMUNITIES

California's flora includes over 5,800 native vascular plant species, or roughly 25% of the flora of the continental U.S. (Mooney, 1988; Hickman 1993). 1416 species (24.2%) and 737 subspecies or varieties are endemic to the state. During the past century this remarkable native flora has been seriously diminished by agricultural, residential and industrial development and by the spread of naturalized, alien plant species. 600 plant taxa and 200 natural communities are now considered endangered or threatened with extinction, and some 200 natural plant communities have been significantly reduced from their original distribution (Jones & Stokes, 1987; Jensen et al., 1990).

Most conservation efforts in California focus on single species or site specific issues, particularly in response to federal and state endangered species legislation. This piecemeal approach to conserving California's flora cannot possibly succeed, first because the economic cost is ultimately higher than the public is willing to bear, and secondly because of the inevitable fragmentation and cumulative degradation of habitats that accompanies localized impact mitigation schemes.

Most conservation biologists agree that the best strategy for conserving biodiversity is to maintain native species in extensive, natural landscapes that are sufficiently linked to allow interaction and genetic exchange among disjunct populations (Noss, 1983). This requires a cohesive, representative system of areas managed for the maintenance of native biodiversity. (We avoid using the term "reserve" or "sanctuary" since management for maintenance of biodiversity does not necessarily preclude multiple-use land management strategies.) To implement such a system requires knowledge over regional to statewide extent of ecosystem patterns and dynamics, as well as species distributional status and trends, phylogeny, life history, and habitat requirements. It also requires more detailed, local information on population dynamics and genetics, as well as socioeconomic and political information. The broader-scale ecosystem assessment is sometimes referred to as the "coarse filter" approach to reserve design, as opposed to the fine filter" studies of individual species and localities.

This section summarizes our findings on the distribution of plant communities and dominant plant species in the Southwestern California Region, exclusive of the Channel Islands. We describe the development of the database and illustrate its application to biogeographic research and conservation assessments. Dominant woody species and plant communities are tabulated in terms of regional distribution patterns, management status and patterns of land ownership. We test the hypothesis that land ownership and management status can be used to identify plant communities at high risk of becoming threatened or endangered, and find strong support for the assertion. Based on criteria that we develop to identify at-risk communities and species, we identify a number of widespread, upland plant communities and dominant species that we believe deserve more attention in conservation planning efforts. Finally, we combine maps of communities at risk with information from the Natural Diversity Data Base and The Nature Conservancy of California to locate and highlight areas that emerge as high priority for conservation planning and management

4.1. Methods

4.1.1. Vegetation Classification and Mapping

The national Gap Analysis program is mapping actual vegetation to the subformation level based on the UNESCO classification system (Jennings, 1993), and to series within these subformations based on dominant or co-dominant overstory species.

For this study we identified vegetation types by one to three overstory species, each contributing greater than 20% of canopy cover. The 20% cover criterion, which we selected to be consistent with the California Vegetation Type Mapping (VTM) survey (Wieslander, 1946; see Colwell 1988, for overview), is lower than typically applied to define canopy dominance. For example, the CALVEG classification defines dominant as >50% (Parker and Matyas, 1981). Paysen et al. (1980) define Series based on a single dominant overstory species or genus. The ongoing California Native Plant Society Community Inventory is identifying series primarily based on a single, overstory dominant, although a few series are based on two co-dominant species, and others are defined by environment (e.g., Alpine Series) (Sawyer, 1993). For our purposes and at our 1: 100,000 mapping scale, we found that use of single canopy dominants to type vegetation produced an unacceptable simplification of vegetation composition and pattern. For example, much of the chaparral vegetation in the Southwestern California Region would be mapped as Charnise or Scrub oak chaparral, masking systematic, regional variation in community composition. By using the 20% cover threshold , we retained information on one to three, and rarely four, canopy species that are dominant or co-dominant over many hectares, that is over areas much larger than plot sizes used in traditional vegetation studies. To avoid confusing these vegetation types with Series or Associations as defined by other systems, we refer to these combinations as Species Complexes. In the field, species in a complex may be uniformly mixed or in a fine mosaic of single species patches, depending on the scale at which the pattern is observed. This means that in practice, species complexes in our database can be a series recognized by existing classification systems, a combination of two or three recognized series, or previously unrecognized species dominants and species combinations.

A map of actual vegetation was produced using summer 1990 Landsat Thematic Mapper (TM) satellite imagery, 1990 high altitude color infrared photography (1:58,000 scale), VTM maps based on field surveys conducted between 1928 and 1940, and miscellaneous recent vegetation maps and ground surveys. Details of the mapping process are provided in Davis et al. (1991), and are only summarized here.

We did not have the resources to map individual stands of homogeneous vegetation. Instead, we have attempted to delimit "landscapes," that is areas of one to many square kilometers in extent with uniform climate, physiography, substrate and disturbance regime, and covered by a single species complex or by a mosaic of a few species complexes associated with different sites (e.g., riparian zones, mesic slopes, xeric: slopes). Landscape boundaries were mapped subjectively by photointerpretation of patterns in the satellite imagery and air photos. Final delineation of a landscape unit was an iterative process based on evidence from the satellite imagery, 1990 air photos, existing vegetation maps and field reconnaissance. The map was produced using a minimum mapping unit of 100 ha (1 km^2), and the region was mapped into 2,014 landscape units, or polygons.

TM imagery was resampled to the Albers equal-area projection with 100 meter resolution (i.e. 1 hectare pixels), and a false color composite of red, near-infrared and mid-infrared reflectance images was displayed on a video monitor. Obvious landscape boundaries were digitally drafted over the imagery based on image tone and texture. Ancillary information, especially air photos and VTM maps, was used to capture additional compositional changes in vegetation that were not visually obvious in the TM imagery. VTM maps were used to position landscape boundaries on vegetation gradients where no obvious break was visible on either the satellite imagery or in air photos. 230 polygons (excluding urban and agricultural areas) were checked in the field, primarily by roadside reconnaissance.

Using these various sources, a large amount of information was collected for each landscape unit (Table 4- 1). Based on our concept of landscape, we recorded a primary species complex, which was the most widespread vegetation type or land use/land cover type in the polygon, a secondary type, and the fraction of the landscape covered by each type. We also recorded the most widespread wetland complex, which was usually riparian vegetation. Each species complex was defined by up to three don-dnant species. Where possible, we also recorded the occurrence of minor overstory species of special conservation concern (e.g., Juglans californica, Quercus engelmanii, Cupressus forbesii).

Species data were derived from field survey, air photos or from the VTM maps. VTM information was used for areas where air photos provided no evidence of recent disturbance, based on the assumption that canopy dominants observed by VTM field crews have not changed over the past 50-60 years. We realize this is a tenuous assumption. We have found during our field surveys that the assumption is usually valid for forest and hard chaparral types. Although the relative dominance of species may have changed over the interval, species that were mapped as co-dominants by VTM crews in the 1930's are still canopy dominants across the same landscape today. The composition of soft chaparral and grassland types is not as stable over the same interval, and we made special efforts to view these types in the field or to find more current maps. We should emphasize that our landscape units are many square kilometers in extent, and that canopy composition can vary greatly from site to site within a landscape. Thus the species complexes that we have mapped record those species that most frequently dominate most sites in that landscape.

We have tried to account for fire dynamics by recording recent burns and by retaining information on the pre-burn dominants (e.g., an area of recently burned chamise chaparral that is presently dominated by herbs would be recorded as sparse chamise canopy co-dominated by annual herbs).

Rather than a multi-colored vegetation map, the information we have developed is better treated as a vegetation database linked to a set of areas. One can retrieve distribution data on individual species, unique combinations of species, or vegetation types defined by physiognomy and/or composition (Stoms, et al., 1992).

Table 4-1. Data compiled for each vegetation map unit and used to derive maps of species' distributions, NDDB Plant Communities, and Gap Analysis Species Complexes.

- Polygon ID Number
- Primary Vegetation
    - Dominant Species 1
    - Codominant Species 2
    - Codominant Species 3
    - Canopy Closure (4 classes)
    - Fraction of polygon occupied by Type
- Secondary Vegetation
    - Dominant Species 1
    - Co-dominant Species 2
    - Codominant Species 3
    - Canopy Closure
    - Fraction of polygon occupied by Type
- Presence/Absence of 9 wetland habitat types (CA WHR types)
- Primary Wetland Vegetation
    - Dominant Species
    - Codominant Species 1
    - Codominant Species 2
- Presence of canopy species of special status (narrow endemics, RTE species)
- Evidence of Disturbance (5 categories)
- Source Map(s) used in Interpretation
- Air Photo ID Number
- Field Visit
- Disturbance
- Analyst

Although the database approach provides a more flexible framework for representing vegetational variation than the traditional vegetation map, it does not eliminate the need for classification in order to simplify and communicate results. We recorded 1,013 unique species (or species/landuse) combinations in 2,014 polygons. Many unusual species combinations occurred at the margins of the region in transitional environments. We reduced the 1,013 combinations to 189 species complexes based on a set of consistent, if somewhat subjective rules. Most combinations with two species in common were collapsed into a single complex, but this often resulted in ambiguities. To reduce these ambiguities we applied the following principals:

1. a species combination must occur several or more times and occupy more than 4 km^2 to qualify as a possible species complex;

2. geographically restricted species take precedence over widespread species;

3. tree species take precedence over hard chaparral species, which take precedence over soft chaparral species and herbaceous species

4. unusual combinations of species occurring in transitional environments should remain disaggregated from more widespread complexes.

We have not developed formal descriptions of each of the 189 species complexes, and we consider them tentative pending review by other botanists and ecologists. They were derived primarily from VTM maps, rather than by conventional plot sampling, and thus apply to overstory composition taken over a large area. Nevertheless, most combinations will be familiar to botanists in the region, and many of the same combinations have been documented by quantitative plot sampling at a finer scale (e.g., Sawyer, 1993)

We also developed rules for assigning each species combination into an existing classification of plant communities as defined in the California Natural Diversity Data Base (Holland, 1986). The criteria for class assignment in this classification system are qualitative and often not explicitly based on dominant overstory species. Where ambiguities existed, we assigned species combinations to more general types. For example, Holland (1986) identified 4 different Sage Scrub community types (Venturan, Diegan, Diablan and Riversidian) that we necessarily aggregated into a single type.

Analysis of the status of vegetation is thus approached from these three perspectives; 1) selected native, dominant species (Appendix A), 2) CNDDB Natural Communities (Appendix B), and Gap Analysis Species Complexes (Appendix Q. Each of these analyses provides a different view of the vegetation of the region. Also, different caveats must be applied to each of these analyses.

4.1.2. Identifying Species and Communities At-Risk

The premise of Gap Analysis is that biological resources at-risk can be identified by their ownership/management profile as generated by GIS overlay of 1: 100,000 scale maps. To test this premise, we compared the ownership profiles of plant communities that are considered at-risk by the Natural Heritage Division of the California Department of Fish and Game to the remaining communities. Using a look-up table to classify our map units into NDDB community types, we mapped 64 different communities (out of 89 recognized in the region), 61 of which occupied more than 2 square kilometers. The proportion of each community's distribution in Level 1 management versus private land is shown in Figure 4-1.

The mapped distribution of threatened upland types is significantly different than the types in general. All show less than 10% of the distribution in Level 1 Management, and 5/6 show at least two-thirds of their current extent on private lands. Six threatened wetland types are less distinctive, as would be expected given the scale of the vegetation map. Nevertheless, threatened wetland communities also show the same general pattern of being predominantly on private lands and with little representation in existing Level 1 managed areas.

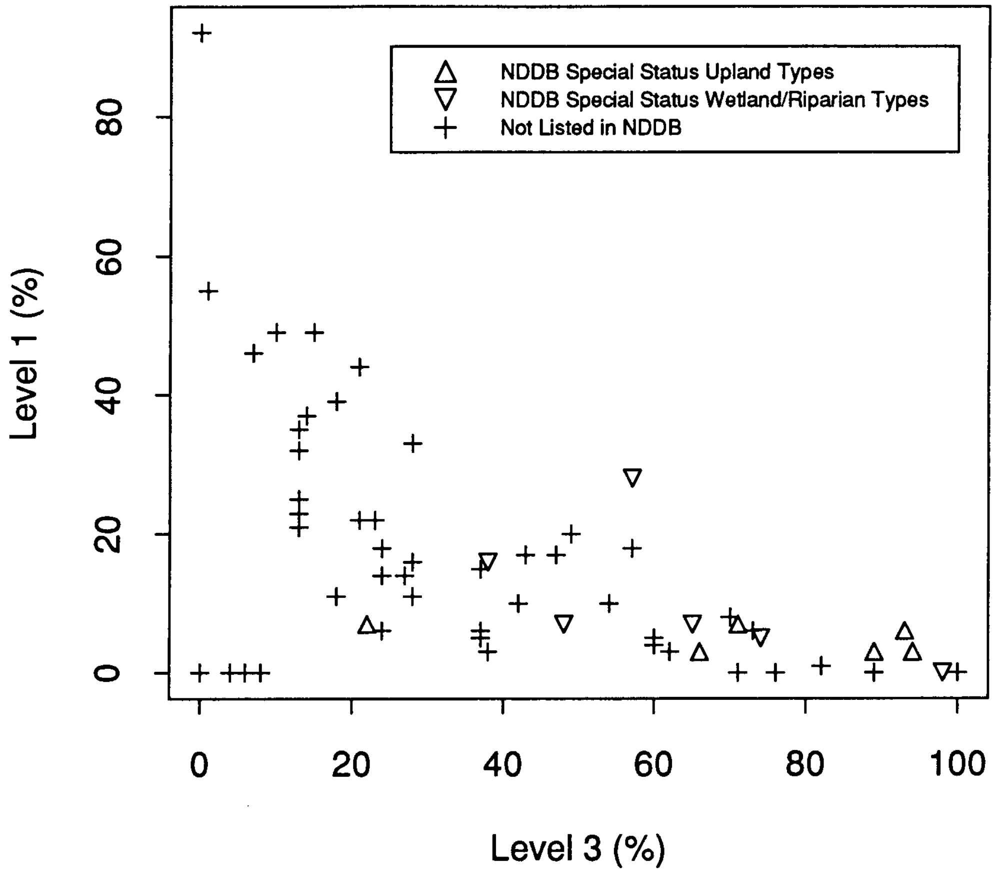

Figure 4-1. Ownership profiles of plant communities considered at risk by the state of California and other communities. Level 3 lands are privately owned, whereas Level 1 are areas managed for the preservation of biodiversity.

These results reinforce the caveat stated above that Gap Analysis data are not appropriate for assessing highly localized community types and widespread types that typically occur in small patches, such as many wetland types. However, Figure 4-1 supports our premise that the Gap Analysis approach can be used to identify more widespread upland plant communities at-risk. Guided by these results, we adopted the following criteria for identifying communities at risk:

1. Less than 10% of the distribution is in Level 1 areas, **and** the species or community type is endemic to the region, **and** the mapped distribution covers more than 100 km^2,

   or

2. over 70% of the mapped distribution is in Level 3 areas.

4.2. Results

4.2.1. Distribution and Management Status of Dominant Species and Communities

1) Herbaceous Vegetation - We were unable to distinguish herbaceous plant species and community types beyond very general classes. For example, we classified practically all grasslands as "Non-native" despite the fact that many of these areas contain sizeable populations of native grasses and forbs. Thus our estimate of the extent of the Valley Needlegrass community is undoubtedly too low (Appendix B). Keeley (1990) provides a much more detailed assessment of the distribution and conservation status of native

grasslands. However, we would call attention to the fact that nearly three-fourths of the non-native grassland in the region is privately held, and only 6% is in Level 1 areas. Although dominated by exotic species, these grasslands can be rich in native species and are habitat to many animal species. Recent efforts to preserve grassland habitats for the Stephens Kangaroo Rat (*Dipodomys stephensi*) in the Riverside Basin attest to the ecological significance of this community type. However, annual grasslands are generally not considered a conservation priority in the region. Our data suggest that from a regional perspective, non-native grasslands appear to be at risk.

2) Sagebrush steppe species and vegetation types - Plant communities dominated by *Artemisia tridentata*, *Chrysothamnus nauseousus* or C. parryi occur along northern and northeastern margins of the region, and are concentrated in the upper Cuyama Valley, Lockwood Valley, eastern San Bernardino Mountains and in small amounts in the Anza Valley and the extreme southeastern comer of the region (Figure 4-2). Roughly 60% of the area occupied by sagebrush steppe is multiple-use public land, and less than 5% occurs in Level 1 managed areas. It appears that nearly all sagebrush steppe in the region is subject to grazing. Some areas are already the focus of conservation efforts aimed at protecting threatened and endangered species, for example, the Pebble Plains in the northeastern San Bernardino mountains, which are habitat to a number of candidate endangered species such as *Castilleja cinerea* and *Astragalus leucolobus*. Based on current land ownership and management patterns, sagebrush steppe in this region appears to be at high risk and deserving of more conservation research and management.

3) Soft Chaparral - All soft chaparral species and communities occur predominantly on private lands. Soft chaparral in California is largely confined to this region, although variations with different species composition extend north along the coast to beyond the San Francisco Bay. Once very common and widespread, particularly in the south coast subregion, the type has been fragmented and its extent reduced severely by development of coastal habitats (O'Leary, 1990). Much conservation effort is focused on areas in Orange, Riverside, and San Diego Counties that are habitat for the threatened California *gnatcatcher (Polioptild californica*). Our analysis highlights the need to consider more northerly elements as well. For example, practically all landscapes dominated by *Salvia leucophylla* are in the western Transverse ranges, north of the current range of the gnatcatcher (Appendix A). 87.3% of the mapped distribution of this species is privately owned.

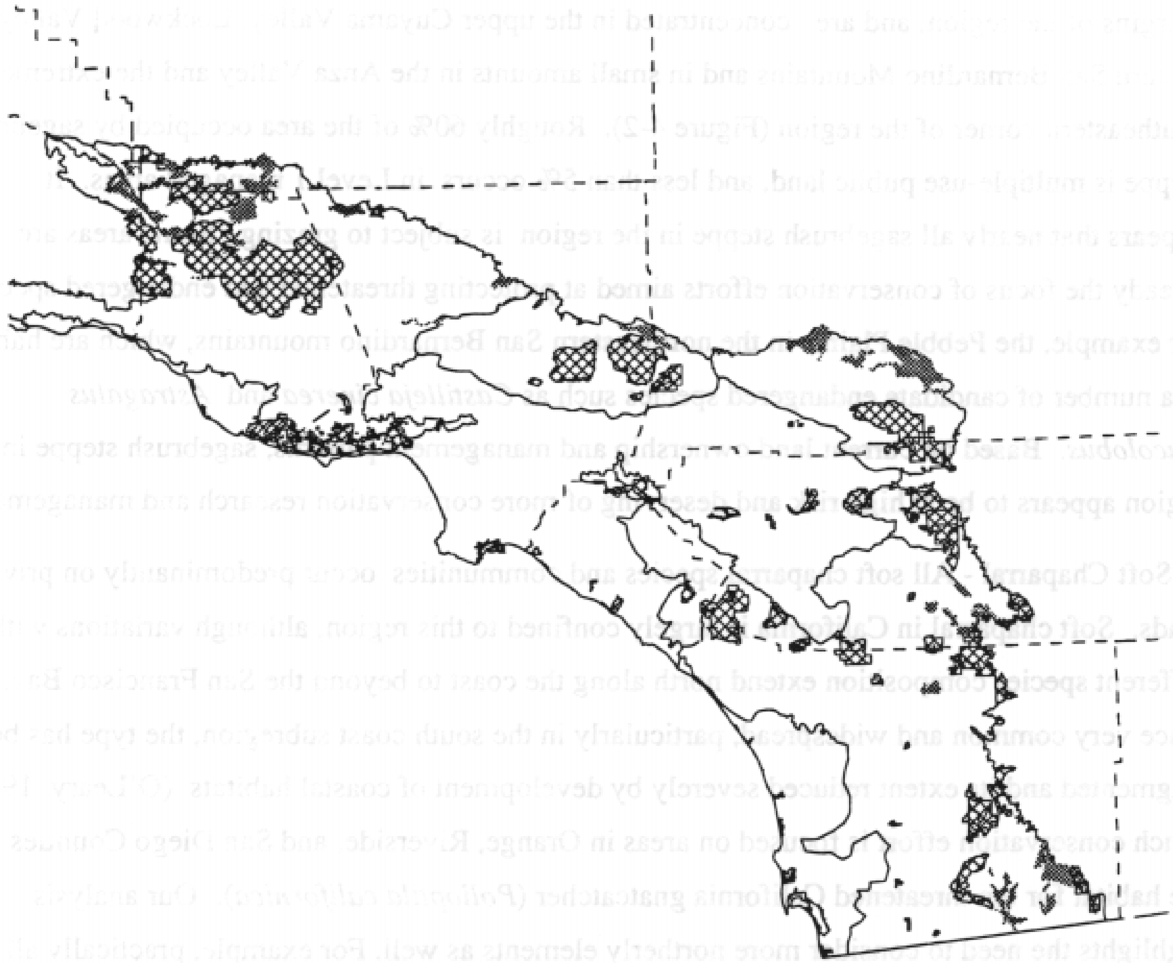

Figure 4-2. Mapped distribution of landscapes where the Big Sagebrush Scrub Community Type (#35210) is the primary (dark shading) or secondary (light shading) upland vegetation type. Also shown are county boundaries (broken lines), geographic subregions (solid lines) and Level 1 managed areas (hatched pattern).

The CNDDB coastal sage scrub community is widespread (3,90 8 km2), but 71 % is on Level 3 lands and only 7% are on Level 1 lands (Figure 4-3; Appendix B). We mapped 23 major coastal sage scrub species complexes (not shown) over about 10% of the region, perhaps less than 15% of their historical coverage (Westman, 1981). Soft chaparral dominated by *Artemisia californica* appears most at risk (Davis et al., 1993). Other coastal sage scrub types do not have much higher percent in protected status ; the highest percentage in Level 1 (excluding *Yucca whiplei*, which has a very small coverage) is 7. 1 % for Salvia *apiana*.

4) Chaparral - Chaparral is the dominant and characteristic vegetation of this region. Seventeen natural community types and 64 species complexes were identified covering over 12,057 km^2, about 36% of the current land cover of the region (including urban and agricultural lands). Many of these complexes are geographically restricted. *Adenostomafasciculatum* is the most widespread chaparral species in the region, occurring as a dominant or co-dominant on almost 8,000 km^2. It is associated with a number of different species, the most frequent being *Ceanothus crassifolius, C. greggii, Adenostoma sparsifolium,* and *Arctostaphylos glandulosa*. Many of these complexes show little overlap and are associated with specific subregions. For example, *A. fasciculatum/C. crassifolius* dominates mid-elevations of the San Bernardino, San Gabriel, and Santa Ana Mountains. *A. fasciculatum/C. greggii var. perplexans* is widespread in the Peninsular Ranges, and *A. fasciculatum/ A. sparsifolium* occurs extensively along the western slopes of the Santa Rosa Mountains and more locally in the Santa Monica Mountains.

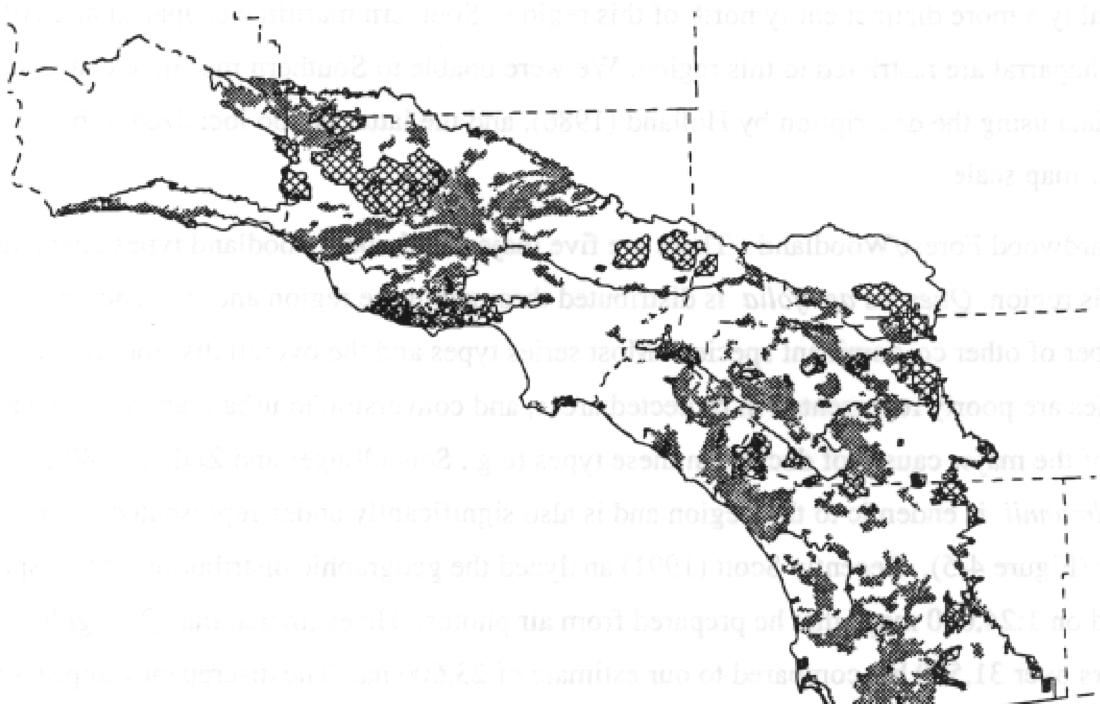

Figure 4-3. Mapped distribution of landscapes where the Coastal Scrub Community Type (#32000) is the primary (dark shading) or secondary (light shading) upland vegetation type. Also shown are county boundaries (broken lines), geographic subregions (solid lines) and Level 1 managed areas (hatched pattern).

The large majority of the chaparral species and communities appear to be either widespread and/or well represented (i.e., over 10%) in Level 1 areas. Some taxa are also relatively uncommon and underprotected in this region, but may be more widespread elsewhere in California (e.g. *Fraxinus dipetala* and *Ceanothus sorediatus = C. oliganthus var. sorediatus*). Several complexes are both uncommon and underprotected, notably those containing *Xyloccus bicolor* and *Ceanothus verrucosus*, which occur at the southern end of the region (Figure 4-4). The percent in Level 1 management for *X. bicolor* and *C. verrucosus* are 3.4% of 219 km^2 and <0-.01% of 16 km^2, respectively.

We mapped 17 CNDDB chaparral types out of 22 known to occur in this region. Of the 5 remaining community types, Tobacco brush and Bush chinquapin chaparral are localized at higher elevations in this region. Poison oak chaparral is currently not well defined, although it is probably a more distinct entity north of this region. Southern maritime chaparral and Alluvial fan chaparral are restricted to this region. We were unable to Southern maritime chaparral from our data using the description by Holland (1986), and the latter is too localized to be represented at our map scale.

5) Hardwood Forest/Woodland - There are five major hardwood woodland types characteristic of this region. *Quercus agrifolia* is distributed throughout the region and in association with a number of other co-dominant species. Most series types and the overall distribution of this species are poorly represented in protected areas, and conversion to urban land use appears to be one of the major causes of decline in these types (e.g., Scheidlinger and Zedler 1980). *Quercus engelmannii* is endemic to this region and is also significantly under-represented in Level 1 areas (Figure 4-5). Recently Scott (1991) analyzed the geographic distribution of this species based on 1:24,000 maps that he prepared from air photos. He estimated that *Q. engelmannii* occurs over 31,500 ha, compared to our estimate of 23,600 ha. The discrepancy appears mainly due to the differences in map scale rather than classification, given that his mapped stands fall almost entirely within our mapped landscapes. Scott called attention to the poor representation of the species in existing reserves, a pattern that we also observed (< 3.5% in Level 1 areas), despite the recent establishment of significant new reserves such as The Nature Conservancy's Santa Rosa Plateau Reserve.

The various riparian woodland types are usually found in patches too small to be detected with the techniques employed by the Gap project. Nevertheless these types appear to be poorly represented (0.2 to 7.2%) in Level 1 areas. *Quercus chrysolepis*, and to a lesser extent *Quercus kelloggii*, are widely distributed in the region and throughout California, and generally well represented in Level 1 protected areas.

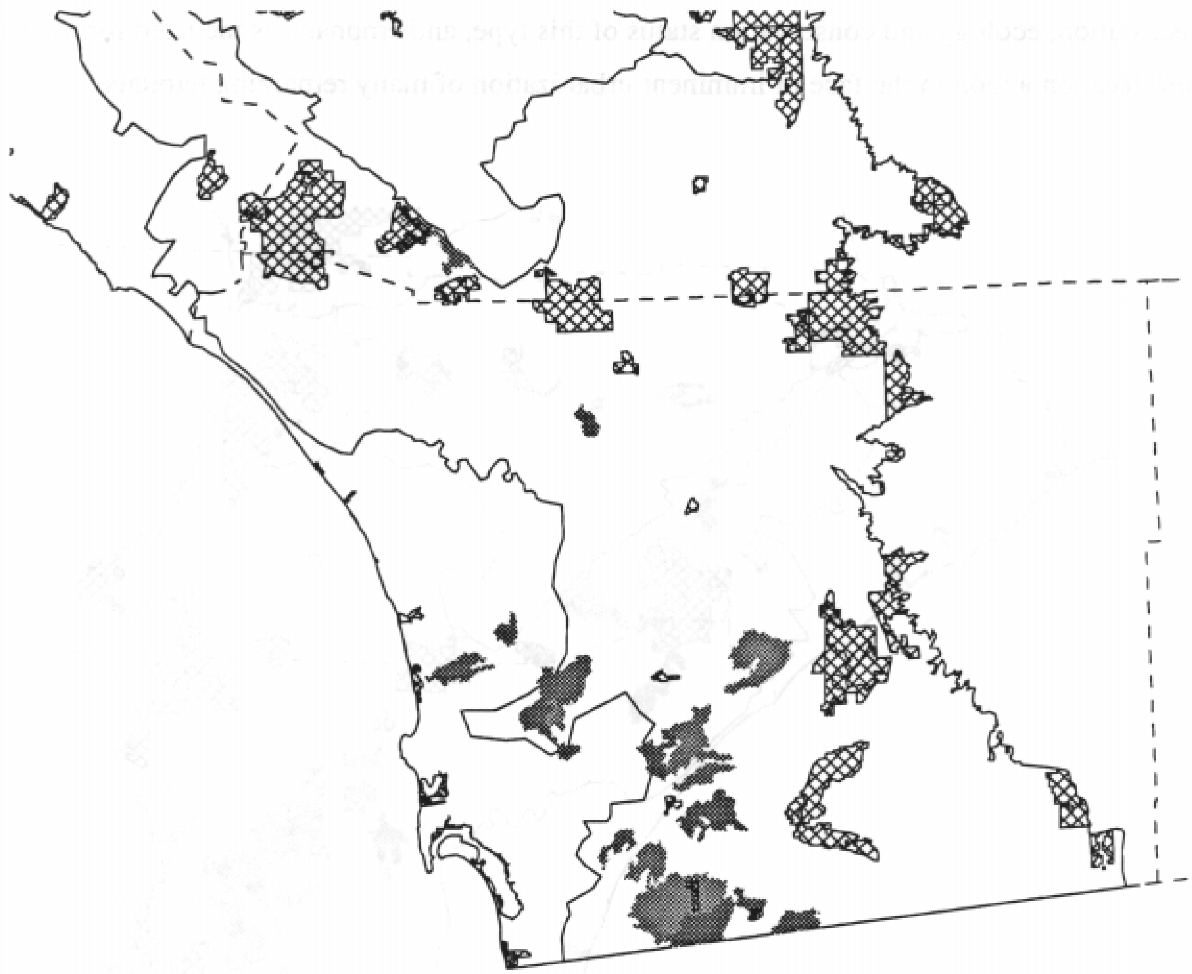

Figure 4-4. Mapped distribution of landscapes where either Xyloccus bicolor *or* Ceanothus verrucosus *is the primary (dark shading) or secondary (light shading) upland vegetation type. Also shown are county boundaries (broken lines), geographic subregions (solid lines) and Level 1 managed areas (hatched pattern).*

More localized woodland species include *Quercus lobata, Quercus douglasii, Quercus wislizenii, Arbutus menziesii*, and *Juglans californica*. While most of these species are more widely distributed in other regions of California, the southern California black walnut (*var. californica*) is almost entirely restricted to this region. The current distribution of this species is highly fragmented and almost entirely (89.3%) on private land, with remnant populations in the Santa Clara River drainage, Simi Hills, Santa Susana Mountains, Santa Monica Mountains, San Jose Hills, Puente Hills and Chino Hills. Quinn (1990) provides a detailed analysis of the distribution, ecology and conservation status of this type, and emphasizes the need for immediate conservation action in the face of imminent urbanization of many remaining habitats.

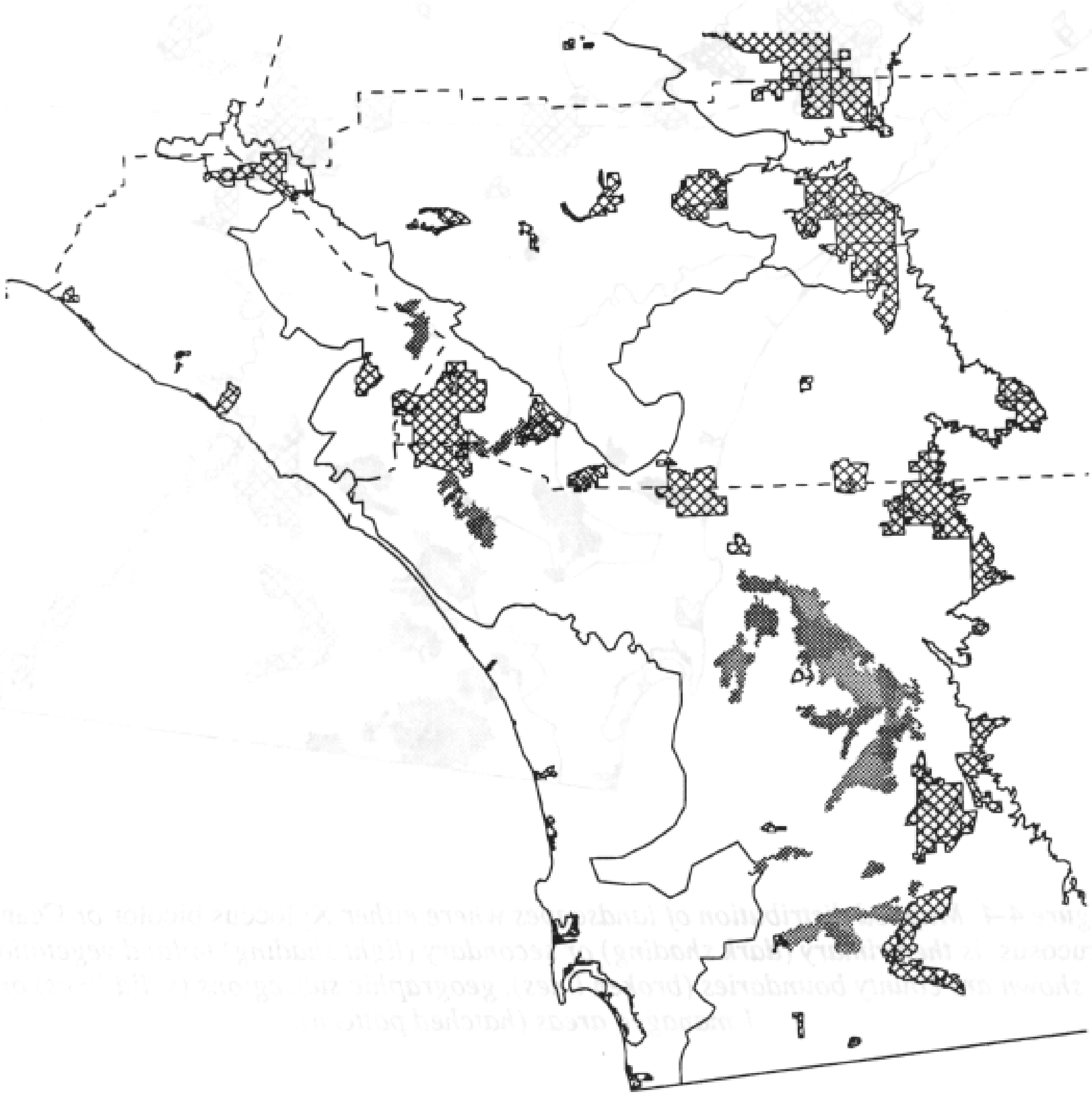

Figure 4-5. Mapped distribution of landscapes where Quercus engelmannii *occurs as a canopy dominant or co-dominant in the primary (dark shading) or secondary (light shading) upland vegetation type (usually Open or Dense Engelmann oak woodland or Coast live oak woodland). Also shown are county boundaries (broken lines), geographic subregions (solid lines) and Level 1 managed areas (hatched pattern).*

6) Conifer Forest/Woodland - The conifers *Pseudostuga macrocarpa* and, to a lesser extent, *Pinus coulteri* are largely restricted to and characteristic of this region. They occur between 500m and 1500m, but *P. macrocarpa* is concentrated in canyons and steep north-facing slopes, whereas *P. coulteri* occupies a range of topographic sites. 34% of the mapped distribution of *P. macrocarpa* is in Level 1 areas (Appendix A), and 40.7% of the widespread species complex, Bigcone spruce/canyon live oak, is in Level 1 areas. 22.2% of the mapped distribution of *P. coulteri* is on Level 1 lands. At slightly higher elevations, *Pinus ponderosa*, *P. lambertiana*, and *Libocedrus decurrens* are well represented in Level 1 areas (38.1%, 41.8%, and 13.3% respectively), with the vast majority of the remaining distribution on Level 2 lands. Highest elevations are dominated by *Abies concolor, Pinus jeffreyi, Pinus contorta var. murryana*, and *Pinus flexilis*. These vegetation types are among the best protected types in the region, with 22.2% to 91.1% of mapped distributions in Level 1 areas.

Pinus monophylla and *Juniperus californica* are prominent at the region boundaries adjoining the Desert and Central Valley regions. Both appear to be reasonably well represented in Level 1 areas at 14.2% and 15.6%, respectively (Appendix A). The Pinyon pine/California juniper complex is widespread in the upper Cuyama Valley and in other parts of the Transverse Ranges, and has 23.4% in Level 1 areas. Most other lands that include these two species are in Level 2 management.

Several other coniferous forest species are found only peripherally in this region. *Pinus attenuata*, *P. sabiniana*, and *J. occidentalis* are rare here and more widespread in adjoining regions. Two endemic conifers, *Cupressusforbesii*, and *Cupressus arizonica ssp. arizonica* are restricted to very localized sites and difficult to capture through out techniques. Both are worthy of conservation attention based on existing information (Oberbauer, 1990).

4.3. Discussion

4.3.1. Priority Environments/Types/Species

Tables 4-2 and 4-3 list plant communities and species that we consider to be at risk based on the criteria defined in Methods, above.

Based on these criteria, communities restricted largely to the lower elevations, such as non-native grasslands and the coastal sage scrub types, are clearly at considerable risk. Roughly 88% of areas below 500 m are in Level 3 management (i.e., privately owned). A majority of the lands at these elevations have already been converted to agricultural or urban uses and most of the remaining lands are threatened with future urbanization.

Table 4-2. Natural communities identified as at-risk using Gap Analysis criteria, ordered from highest to lowest relative extent on private lands. Asterisks indicate community types whose mapped distribution totals less than 50 km^2. Other communities identified by the Natural Heritage Division as threatened or endangered but not detected by the Gap Analysis method are listed separately.

Code	Natural Community Name
71130	Valley Oak Woodland *
42110	Valley Needlegrass Grassland *
71210	California Walnut Woodland
37G00	Coastal Sage-Chaparral Scrub
42200	Non-Native Grassland
32000	Coastal Sage Scrub
81310	Coast Live Oak Forest
71410	Digger Pine-Oak Woodland *
71160	Coast Live Oak Woodland
71182	Engelmann Oak Woodland
37120	Southern Mixed Chaparral
37300	Redshanks Chaparral
61310	Southern Coast Live Oak Riparian Forest *
35210	Big Sagebrush Scrub
37B00	Upper Sonoran Manzanita Chaparral
83330	Southern Interior Cypress Forest *
72110	Northern Juniper Woodland
72210	Mojavean Pinon Woodland *

Other Threatened or Endangered Plant Communities

21330	Southern Dune Scrub
32400	Maritime Succulent Scrub
32720	Riversidian Alluvial Fan Sage Scrub
37C30	Southern Maritime Chaparral
42300	Wildflower Field
44310	Southern Interior Basalt Flow Vernal Pool
44321	San Diego Mesa Hardpan Vernal Pool
44322	San Diego Mesa Claypan Vernal Pool
47000	Pebble Plains
52120	Southern Coastal Salt Marsh
52200	Coastal Brackish Marsh
52410	Coastal and Valley Freshwater Marsh
61330	Southern Cottonwood-Willow Riparian Forest
	Canyon Live Oak Ravine Forest
62100	Sycamore Alluvial Woodland
62400	Southern Sycamore-Alder Riparian Woodland
63320	Southern Willow Scrub
63300	Southern Riparian Scrub
81820	Mainland Cherry Forest
83140	Torrey Pine Forest

Table 4-3. Plant species considered "at-risk" based on gap analysis criteria.

Scientific Name	Common Name
Herbaceous	
	All forms of grasslands
Coastal Sage Scrub	
Eriogonum fasciculatum	California buckwheat
Salvia apiana	White sage
Salvia leucophylla	Purple sage
Salvia mellifera	Black sage
Malosma laurina	Laurel sumac
Artemisia californica	California sagebrush
Encelia californica	California encelia
Sagebrush Steppe Scrub	
Encelia farinosa	Brittlebush
Chrysothamnus nauseosus *	Rabbitbrush
Artemisia tridentata *	Great basin sage
Chaparral Shrubs	
Arctostaphylos gladulosa **	Eastwood manzanita
Xylococcus bicolor	
Prunus illicifolia *	Hollyleaf cherry
Ceanothus oliganthus var. sorediatus *	Jimbrush
Ceanothus tomentosus	Woolyleaf ceanothus
Ceanothus verrucosus ***	Wartystem ceanothus
Adenostoma sparsifolium ****	Redshanks
Hardwood Forest/Woodland	
Quercus agrifolia *	Coast live oak
Quercus engelmannii	Engelmann oak
Quercus kelloggii *	Black oak
Quercus lobata *	Valley oak
Juglans californica	California black walnut
	All riparian woodlands
Conifer Forest/Woodland	
Cupressus forbesii	Tecate cypress
Juniperus occidentalis *	Western juniper
Juniperus californica ****	California juniper
Pinus sabiniana *	Digger pine

* Fairly rare in this region but widespread in California, possibly rare associations in this region
** Widespread taxon in California, but possibly rare ecotypes in this region
*** Rare local endemic, difficult to map at this level of resolution
**** Some associations are significantly underrepresented on Level 1 lands

All extensive riparian communities, particularly those confined largely to low elevations such as mule fat scrub and southern arroyo willow, are already well known to be at risk (Bowler, 1990), as are coastal wetlands (Ferren, 1990). Conservation initiatives are already underway for most of these communities. Especially alarming is the condition of the California black walnut woodlands. The southern variety of this species is endemic to this region and its current distribution is highly fragmented and reduced compared with its original distribution.

Sagebrush steppe shrublands, although widespread elsewhere in California and other western states, appear vulnerable in this region. A significant proportion of the sagebrush steppe habitat is on Level 2 lands, and conservation concern for these communities can probably be adequately addressed by the public land managing agencies. Species and communities at higher elevations, especially montane chaparral and coniferous forest types, are generally well represented in Level 1 protected areas.

With the exception of canyon live oak and perhaps interior live oak, all other oak woodlands appear to be at-risk now or over the next one or two decades. In contrast, most of the chaparral communities appear to be reasonably secure. They are generally found on steeper slopes, largely on public lands, and in areas with at least 10% and often >20% in Level 1 status. However there are a wide variety of chaparral types in this region, and we should not take the conservation of all for granted. A number of chaparral species/communities are endemic or largely restricted to this region and may be components of chaparral that may be at some risk.

4.3.2. Priority Areas for Conservation Planning

Many different criteria have been used to prioritize areas for more detailed conservation planning and action, for example:

1. concentration of threatened and endangered taxa,
2. concentration of threatened and endangered communities,
3. concentration of narrowly endemic species,
4. high taxonomic richness,
5. high ecological diversity,
6. extensive and/or well connected natural areas containing one or more taxa and/or communities of concern,
7. areas that are environmentally or biotically distinctive or unique.

Experience shows that the geographic distribution of priority areas can vary significantly depending on the criteria, the spatial scale of the analysis (e.g., Stoms, 1992), and the taxonomic group(s) under consideration (Prendergast et al., 1993). Our Gap Analysis has identified relatively widespread upland plant species and communities that appear to be at-risk as a function of land ownership and management status (criterion 6, above). We have not focused on locally endemic taxa nor on species already recognized as threatened or endangered. Figure 4-6 maps the density of threatened or endangered communities or plant taxa in 7.5 minute quadrangles, as represented in the California Natural Diversity Data Base, as well as the percent of the quadrangle occupied by communities identified as at-risk by Gap Analysis. Patterns of the three criteria are quite distinctive, and only the Poway quad, which includes area between Poway and La Mesa in San Diego County, scores high on all three criteria. Western San Diego County, which has already undertaken an ambitious multi-species conservation planning effort, is striking for its concentration of threatened and endangered taxa and communities. The eastern edge of the region along the desert margin is distinctive for areas that contain concentrations of threatened taxa with low values for NDDB or Gap communities, while the northern region, notably the Santa Clara River Basin, contains many quads with large numbers of NDDB communities but low concentrations of NDDB plant taxa or Gap communities-at-risk.

From an ecosystem planning perspective, quads that contain high numbers of NDDB communities and where a large percentage is mapped by Gap Analysis as communities-at-risk would seem likely candidates for new, extensive biodiversity management areas. Areas appear as magenta in Figure 4-6 and include the following quadrangles and areas:

- San Clemente, Canada Gobernadora and Oceanside quads (Santa Margarita River, Camp Pendleton)
- Beaumont quad (San Gorgonio Pass, foothills of San Bernardino and San Jacinto Mountains)
- Lake Mathews quad (Lake Mathews to Lake Elsinore)

- Piru, Simi, and Santa Susana quads (Santa Clara floodplain, Sespe and Piru Canyons, Oak Ridge to Santa Susana Mountains)

- Calabasas quad (Simi and Agoura Hills)

- Ventura quad (lower Ventura River floodplain and surrounding slopes)

- Lebec quad (15 corridor and slopes north of Castaic Lake to Grapevine (Tejon Pass))

The Nature Conservancy of California (TNC) recently conducted a conservation analysis of the Southwest region and identified priority areas based on the occurrence of 1) highly endangered species, 2) rare, threatened or declining communities, 3) large-landscape wildlife species, and 4) ensembles of three or more globally endangered species (California Nature Conservancy, 1993). Using these criteria they identified 65 sites, 27 of which were considered critical for inclusion in a bioregional conservation strategy. Many of their sites fall within areas that are also of high priority based on the distribution of Gap communities-at-risk, especially in vicinity of Camp Pendleton, Otay Mesa in San Diego County, Lake Henshaw to Julian, and the western footslopes of the San Jacinto and Santa Rosa Mountains. TNC sites that are also identified based on both NDDB community occurrence data and Gap Analysis data include the Santa Margarita River, San Mateo Creek, Miramar Mesa, the Santa Clara floodplain near Fillmore, Sespe and Piru Canyons, and the Tejon Pass. The convergence of conservation priorities based on plant and animal species, threatened and endangered plant communities, and communities at risk, makes the case for immediate conservation action in these areas especially compelling.

4.3.3. Vegetation Map Validation

Map accuracy can be assessed in many different ways, most commonly by comparing the map to ground observations for a set of sample "points" (Congalton, 1991). This approach is not practical for small scale maps such as ours because it is difficult to determine the actual map class at a point on the ground when the minimum mapping unit is 1 km^2. The size and limited accessibility of the study area also pose considerable financial and logistical challenges. For these reasons, we have not conducted a formal assessment of the accuracy of the vegetation database. Instead, we have attempted to provide a qualitative measure of map accuracy through roadside reconnaissance and by comparing our map with recent, detailed vegetation maps that have been prepared for parts of the region. As noted above, 230 polygons were checked in the field (Figure 4-7). Less than 5% of the polygons that were visited needed replacement of the

We compared our vegetation data to large scale vegetation maps that had been extensively field checked and were not used in preparing the Gap Analysis map. For instance, we compared our Coastal Sage Scrub Series to a map prepared with a 1 ha MMU by Regional Environmental Consultants (RECON) for coastal San Diego County (Stine et al., 1993). The RECON map contained 1,625 polygons, compared to 105 for the same area in the Gap Analysis map. 99% of Coastal Scrub areas larger than 100 ha were represented in both maps. 1,383 RECON polygons fell outside landscapes that we had mapped as containing Coastal Sage Scrub. However, nearly all of these RECON polygons were small patches of coastal sage scrub in urban or agricultural landscapes, and 75% were smaller than 10 ha, thus falling well below the grain size of our analysis.

We have also compared our map to a very detailed vegetation map (MMU < .25 ha) prepared for southwestern San Diego County as part of the Multi-Species Conservation Planning (MSCP) program by OGDEN Environmental and Energy Services, Inc. A comparison of 138 random points on the two maps show 87% agreement (i.e., either Primary or Secondary designation of the GAP map agrees with the MSCP designation) and only 5% are larger polygons (i.e. > 10 ha) that disagree. By overlaying the two maps, we found 73% agreement (using the WHR habitat classification system) between the MSCP map units with the primary or secondary types of the GAP map. However, 83.9% of the area was contained in GAP map units in which the primary habitat class agreed with the most common MSCP classification. Most of the disagreement was due to small patches in the MSCP data that were not represented in the more generalized GAP database. Some disagreement was caused by interpretation differences in how the species data were classified into WHR types, even though the species data agreed. In general, however, each GAP map unit generally was labeled in agreement with the dominant type from the MSCP map.

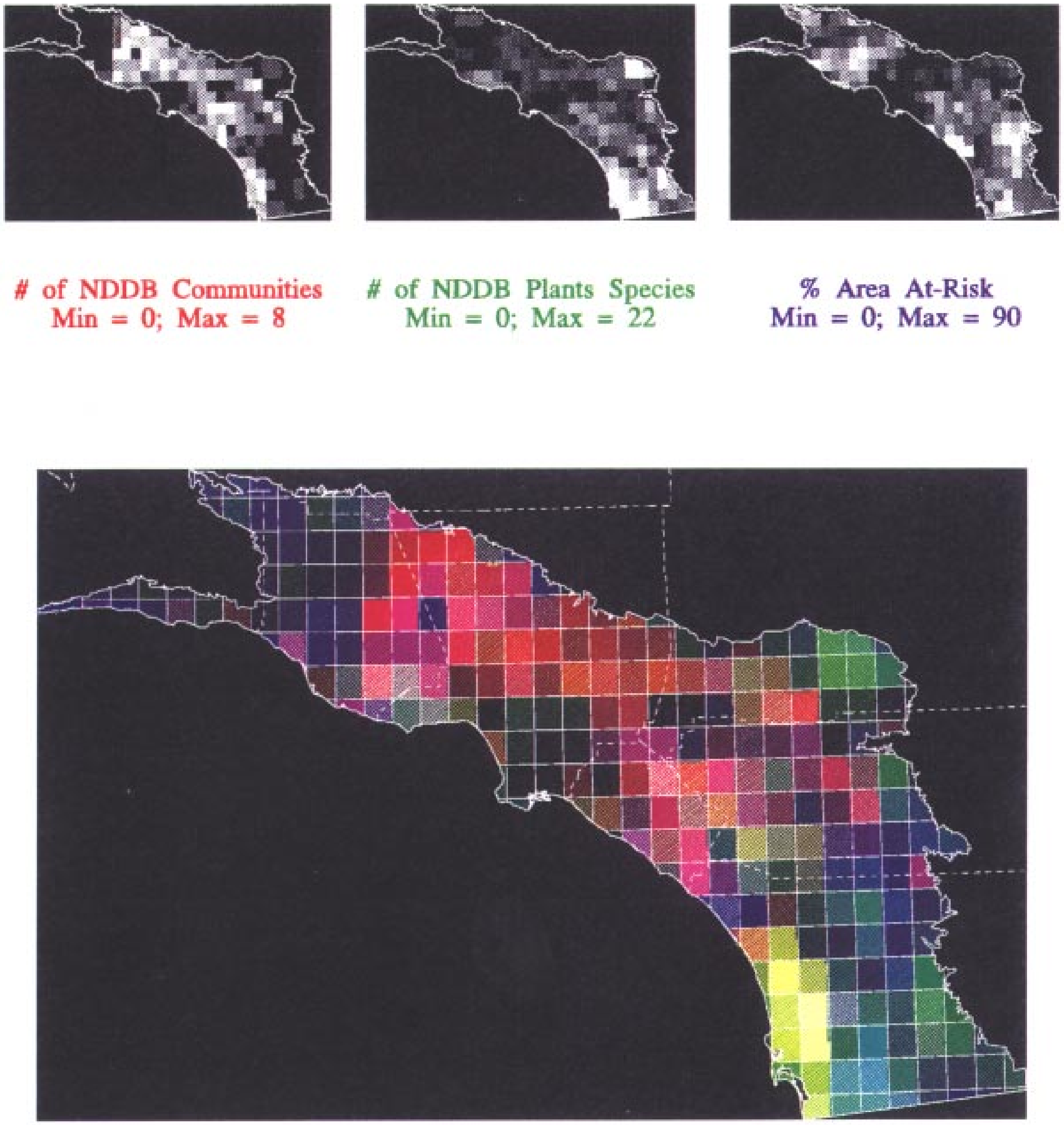

Figure 4-6. Map of the number of NDDB communities, NDDB plant species, and percentage of GAP at-risk natural communities in each 7.5 minute USGS quadrangle in the Southwestern California Region. The bottom figure shows the overlay of these three criteria, with the NDDB communities criterion shown as red, the NDDB plant species in green, and the GAP at-risk communities in blue. Brighter colors indicate higher values. Quadrangles closest to white are those with high values for all three criteria.

Ecological surveys have been conducted for 15 established and proposed Forest Service Research Natural Areas in the region (Figure 4-7; Keeler-Wolf, 1990). Each RNA contains one or more "target elements", either plant species or communities, that the area represents (Ann Dennis, personal communication). These managed areas are typically small watersheds, ranging in size from 198 to 1,542 ha, and thus are similar in size to the GAP landscape units. Often the target elements cover only a fraction of the RNA. The GAP vegetation map was compared to the set of 19 target elements for the 15 RNA's. The GAP map was consistent with 12 of these at the Holland community level. Three others showed the target element to be present in the GAP database as a co-dominant species. Four targets were not identified in GAP, but three of these targets are only found in scattered stands less than 20 ha, well below the

GAP MMU. However, these targets are species of special concern (Tecate cypress, Cuyamaca cypress, and Engelmann oak) that should have been recorded as such in the database. Primary or secondary types in the Holland classification in the GAP database were consistent with the chaparral types that are most abundant on these three sites, even though chaparral was not the target element. Thus, there was only one RNA target out of 19 that appeared to be completely missed, i.e., Coulter pine in the Fisherman's Camp RNA, which is the smallest site compared at 198 ha.

While such comparisons are more anecdotal than statistical, the vegetation database compares favorably with the more detailed information. Like all maps, however, it is a highly generalized abstraction of vegetation pattern that can only serve for broad regional assessments and inventories. We should add that the database is being distributed in both digital and analog form to local botanists and we fully anticipate that the map will undergo periodic revision based on feedback from local experts.

4.3.4. Limitations of the Methods

Gap Analysis provides a regional overview of the distribution and ownership profile of major, terrestrial plant species and communities. The method is not suited to the analysis of most wetland types, dune communities, or other communities that are restricted to very localized environments. The vegetation mapping technique is well suited to analysis of shrubs and trees, but provides little or no information on the distribution of herbaceous species.

Estimates of area made from maps are very sensitive to map scale and mapping methods. Our estimates of the extent of species and types are useful for comparing among types on our map, but should not be taken absolutely. Similarly, our maps of vegetation and land ownership were prepared commensurately for direct overlay and comparison, but ownership profiles of vegetation types would be different if either map was prepared using a different minimum mapping unit.

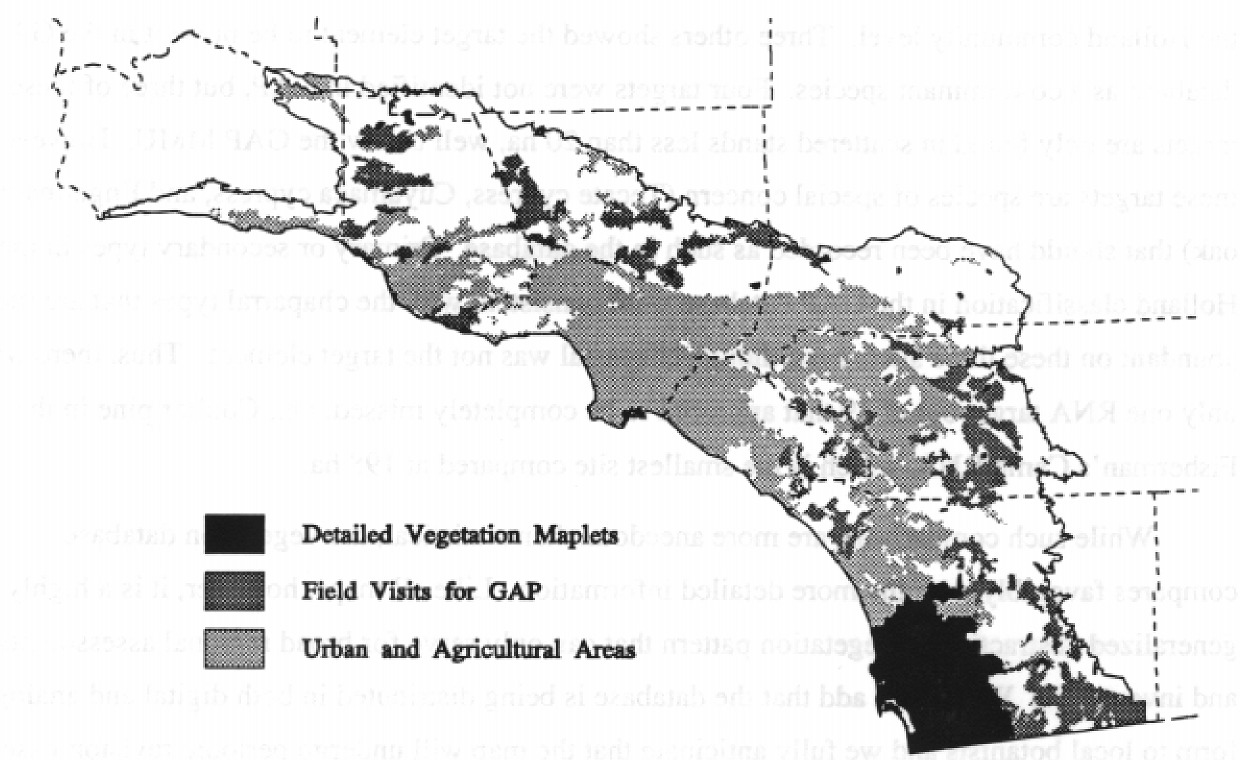

Figure 4-7. Map of the data used in validation of the GAP vegetation map. Maplets refer to sites where detailed vegetation mapping was compared to the GAP map (MSCP and RNA's). Most field visits were by roadside reconnaissance. Urban and agricultural types were easy to identify in 1990 TM imagery and are considered reliable. White areas therefore have unknown reliability at this time.

Land ownership profiles provide a crude measure of risk of development or resource over-exploitation. Species and communities can also be at risk due to climatic change, introduced competitors and pathogens, and many other ecological factors. For instance, subalpine forests may be extremely well protected in the region but at high risk due to global warming. Furthermore, there is wide variation in land management practices within each of the three categories. Some private lands are well managed for the maintenance of plant diversity, but some reserves may be managed in a way that threatens the persistence of selected species. Private land management also depends heavily on zoning status, and county zoning data are required to conduct a fuller analysis of present and possible future management of private lands. We are presently collaborating with the Southern California Association of Governments to conduct such an analysis. Similarly, land management on public lands ultimately should be analyzed within individual administrative units (e.g., individual national forests), and we are distributing our data to federal and state agencies to support these more detailed analyses.

The static nature of the Gap Analysis data also limit their utility in conservation risk assessment. Our database provides a snapshot of a region in which land cover and land ownership are both very dynamic and where trend data would be especially useful. VTM survey data collected a half century ago provide some opportunity for such trend analyses, and we intend to pursue such comparisons, which must remain qualitative given the nature of VTM and Gap Analysis data. For example, Figure 4-8 shows such a comparison for *Artemisia californica* in the southeastern portion of the region. The species is greatly reduced from the distribution mapped in the 1930's, especially in the San Diego metropolitan area, the area from Lake Elsinore to Temecula, and the Riverside Basin.

Figure 4-8. Map of the distribution of Artemisia californica mapped by the VTM survey of the 1930's and by the Gap Analysis project.

5. DISTRIBUTION AND MANAGEMENT STATUS OF TERRESTRIAL VERTEBRATES

5. 1. Methods

5.1.1. Species Distribution Modeling

Combining a wildlife habitat relationships model with the vegetation map allows us to generate predicted distribution maps for sets of species as well as deriving secondary products. The vegetation map thus serves as a filter applied over a coarse-scale species distribution map producing a predicted medium-scale map. These predicted maps can then be used to generate vertebrate species lists for polygons on the vegetation map, and create tabulations of the protection status of each species.

The habitat model used in this analysis is the California Wildlife Habitat Relationships (WHR) model, a tabular database giving information on habitat preferences for 646 species of terrestrial vertebrates resident within the state. This database breaks down wildlife habitat into 48 major vegetation types, which are in turn subdivided into two different vegetation structural categories of canopy size and cover. In each of these combinations of vegetation categories, the habitat quality is scored in terms of its suitability for feeding, resting, and reproduction for every species. This score is a qualitative rating of being unsuitable, or being of low, medium, or high suitability.

To work with this database, we have summarized the WHR database in three successive ways. First, we only used the major vegetation types; the suitability score for each of the major vegetation types is taken to be the highest score from the vegetation structural subcategories. Second, we collapsed the three categories of feeding, resting, and reproduction into suitability for non-breeding functions and breeding functions respectively. Third, we use these extracts to generate a set of presence/absence tables of species occurring within each of the major habitat types. We have translated the suitability rating into a presence/absence rating using a "conservative" model which considers a species to be present in a habitat if the suitability rating for breeding is medium or high at any season.

Another component to the development of a set of predicted distribution maps is using coarse-scale range maps for general locality information. The maps used here are range outlines digitized from a state map at 1:3,500,000 scale and published as part of the WHR system (Zeiner et al., 1990). Since working in the GIS context with large numbers of range outlines is problematic both in terms of storage management and overlay analysis, we resampled the range outlines to a hexagonal raster. This raster is an equal-area grid with each hexagon cell about 635 sq. km. in size, developed by the U. S. EPA for sampling purposes (White et al., 1992). A species was considered to be present in a hexagon cell if any part of the range outline overlapped it. The resampling also preserves the information concerning seasonality of occurrence contained in the original range outline.

This coarse-scale range map was then overlaid with the medium-scale GAP vegetation map to predict the distribution at medium scale for every species. The vegetation map describes plant cover in terms of three dominant species; we translated this list into the major vegetation type used in the WHR system first by recoding the list into the Holland classification scheme (Holland, 1986) and then by applying the published crosswalk between the Holland scheme and the WHR system (Mayer and Laudenslayer, 1988). As each polygon in the vegetation map is considered to be a landscape mosaic of several habitat types, two WHR habitat types can be assigned to each polygon as well as several WHR wetland types, the latter being coded in as attributes of each polygon during the original mapping.

A species can then be predicted to be present or absent in a landscape unit through the following method. If any part of the landscape unit overlaps a hexagonal cell where the species is coded as being present, and the landscape unit contains at least one of the WHR types that according to the presence/absence tables contains the particular species, the species is predicted as being in that particular landscape unit.

Once a list of species is ascribed to each landscape unit, several products are derived. One determined the area of the total range of a species by summing the area of all the landscape units where it occurs. Second the species distributions mapped on the polygons of the vegetation map were overlaid with the land ownership/management data and summarized by the proportion of each species' suitable habitat occurs in the three management levels: private land, public land not managed for the purposes of maintaining biodiversity, and public land that is managed for the purposes of maintaining biodiversity.

5.1.2. Species Richness Modeling

Species richness, or the number of species per unit area, is another product of the GAP database. The species lists of each habitat map unit are merged for each equal-area sampling unit (e.g., USGS 7.5 minute quadrangles), and the number of species can be summed to calculate richness. Richness for amphibians, breeding birds, mammals, and reptiles, were computed separately. Richness for all species at-risk was derived by the same method. 5.1.3. Identifying Species At-Risk

As seen in Figure 5- 1, it appears that known vertebrates at risk are defined more by percent of level 1 management and that level 3 has little predictive power. Therefore, the criteria for highest risk for breeding species whose habitats are rated either medium or high suitability or for migratory species with critical wintering habitat in the region are:

1. Less than 15% of the distribution is in Level 1 areas, *and* the species or a subspecies is endemic to the region, and the mapped distribution covers more than 100 km^2,

   and

2. The species does not find cropland, orchards/vineyards or urban habitats as either medium or high suitability, nor is it exclusively associated with wetlands.

   and

3. The species is not a marine mammal, shorebird, in the chiroptera order, introduced or intensively managed as either a harvest species or being translocated.

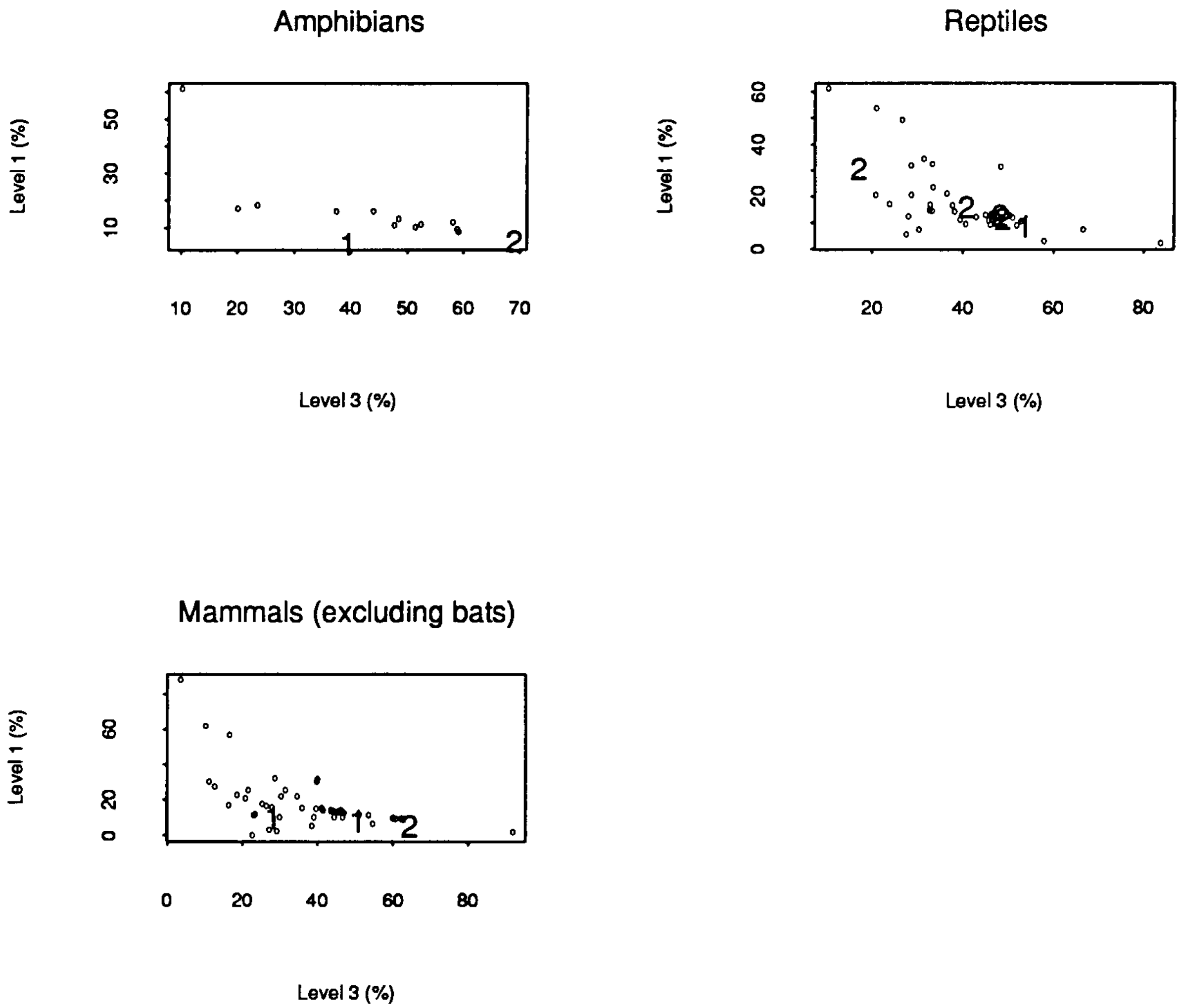

Figure 5-1. Protection status of amphibians, reptiles and mammals in the Southwestern California Region. 1 = Natural Diversity Data Base species; 2 = Natural Diversity Data Base subspecies.

5.2. Results

5.2.1. Distribution and Management Status of Vertebrates

The histogram below indicates the degree of endemism in the regional fauna (Figure 5-2). There appear to be two modes of distribution, with many species predicted to occur in most of the 2817.5' quadrangle sampling units but with a large number of species predicted in less than 60 quads. The more widely distributed species will tend to be close to the regional average in percent area in the three management levels, whereas those with restricted distributions will vary in the management profile based on where they occur. For instance, the Deer mouse and Botta's Pocket gopher occur in most quadrangles and both have 9.6% of their predicted distribution in Level 1 managed areas (see Appendix D), identical to the region as a whole. On the other hand, some of the most restricted species such as Bailey's Pocket mouse has over 50% of its range within this region in Level 1 areas. Other narrowly endemic species may have the opposite result if their limited habitat falls outside of existing managed areas. It should be noted that these narrowly endemic species are often the least successfully modeled by a species-habitat relationships approach at the scale of gap analysis, because small habitat patches may not be mapped at the level of generalization used.

5.2.2. Distribution of Species Richness

Richness was calculated for four taxonomic groups (amphibians, breeding birds, mammals, and reptiles) and for all native vertebrates combined. The histogram below indicates how uniform vertebrate richness is in the region (Figure 5-3). The histogram shows a statistically normal distribution of richness among the quadrangle sampling units. Of the 339 native vertebrates in the regional species pool, the mean richness is 180, or 53%. Lowest richness is 41 (12%), and the maximum is 274 (80%).

Amphibian richness is low throughout the region, with a maximum of only 10 species in several quadrangles near Interstate 5 in Ventura and Los Angeles counties, and near Glendora (Figure 5-4). Reptiles range from 0 in fully urbanized quadrangles to 52 along the eastern boundary of the region, particularly in the San Bernardino Mountains. The greatest numbers of breeding birds are consistently found in the montane quadrangles of the region, with the peak richness of 152 species occurring in the eastern end of the San Bernardino Mountains. Mammals are also most numerous in the San Bernardinos and Santa Rosas along the eastern boundary. These sites with the richest reptile, bird, and mammal faunas contain transitional habitats from montane forests to desert scrub, and therefore contain species from distinct faunistic provinces.

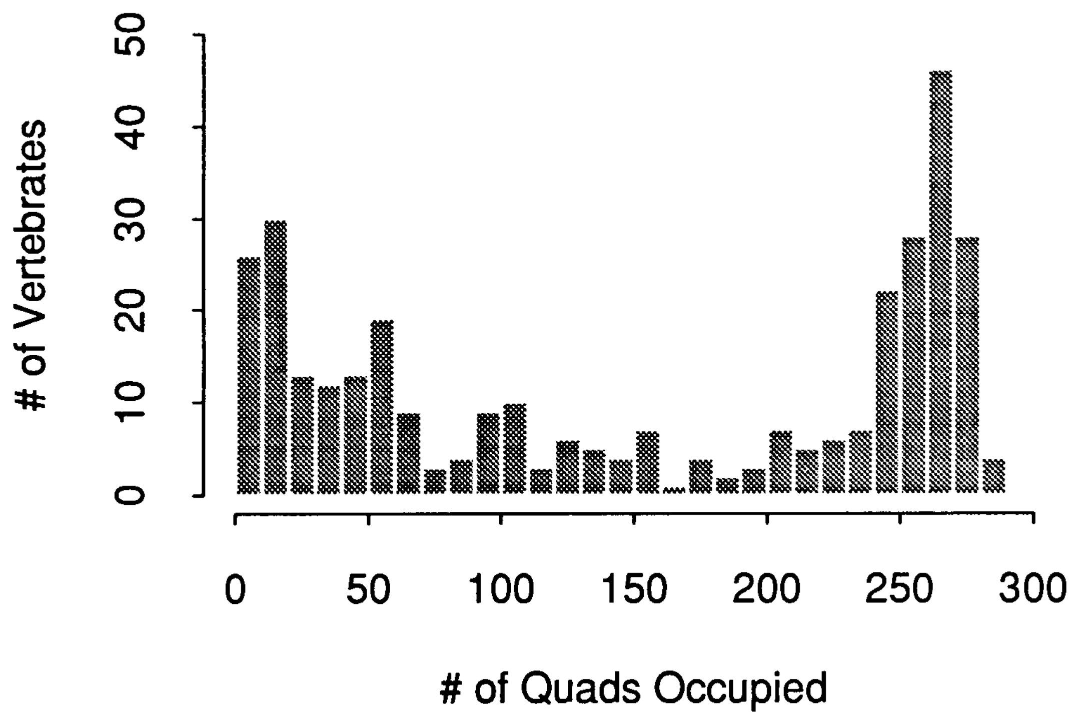

Figure 5-2. Histogram of number of 7.5 minute USGS quadrangles occupied by species in the Southwestern California Region. Some mammals were predicted to occur in all 281 quadrangles.

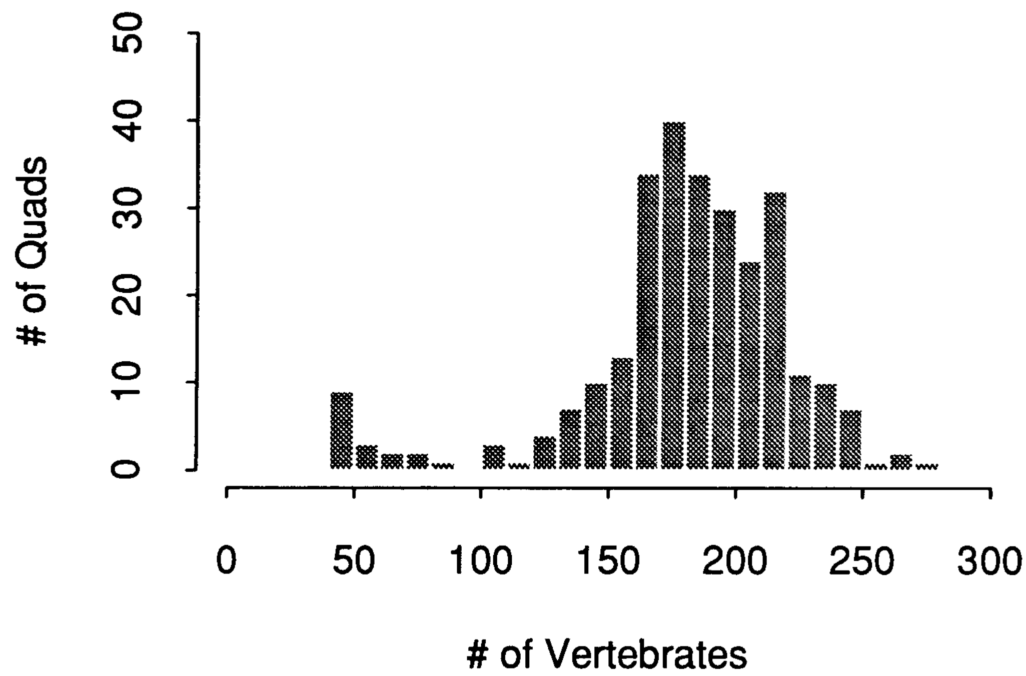

Figure 5-3. Histogram of number of species per 7.5 minute USGS quadrangle in the Southwestern California Region. The maximum number of species in a single quadrangle is 274 out of the 339 native species in the regional pool.

# of Amphibians
Min = 0; Max = 10

# of Reptiles
Min = 0; Max = 52

# of Breeding Birds
Min = 14; Max = 152

# of Mammals
Min = 13; Max = 67

Figure 5-4. Maps of the number of species per 7.5 minute USGS quadrangle in the Southwestern California Region by vertebrate class. Highest numbers of species are bright, lowest are dark.

5.3. Discussion

5.3.1. Priority Vertebrates

Table 5-1 lists the species that meet the gap analysis criteria for being at-risk. In some cases, at-risk species on the Gap Analysis list have previously been identified as species of concern through other reviews.

Table 5-1. Wildlife species considered "at risk" based on Gap Analysis criteria.

Scientific Name	Common Name (WHR Code)
Amphibians	
Batrachoseps pacific	Pacific Slender Salamander (A016)
Batrachoseps stebbinsi	Tehachapi Slender Salamander (A018)
Bufo microscaphus	Southwestern Toad (A035)
Rana muscosa	Mountain Yellow-legged Frog (A044)
Birds	
Elanus caeruleus	Black-shouldered Kite (B111)
Haliaeetus leucocephalus	Bald Eagle (B113)
Aquila chrysaetos	Golden Eagle (B126)
Coccyzus americanus	Yellow-billed Cuckoo (B259)
Asio otus	Long-Eared Owl (B272)
Archilochus alexandri	Black-chinned Hummingbird (B286)
Calypte costae	Costa's Hummingbird (B288)
Empidonax difficilis	Western Flycatcher (B320)
Tachycineta thalassina	Violet-Green Swallow (B340)
Polioptila caerulea	Blue-Gray Gnatcatcher (B377)
Polioptila californica	California Gnatcatcher (B378)
Sialia mexicana	Western Bluebird (B380)
Lanius ludovicianus	Loggerhead Shrike (B410)
Vireo bellii	Bell's Vireo (B413)
Vireo vicinior	Gray's Vireo (B414)
Dendroica petechia	Yellow Warbler (B430)
Icteria virens	Yellow-breasted Chat (B467)
Guiraca caerulea	Blue Grosbeak (B476)
Aimophilia ruficeps	Rufous-crowned Sparrow (B487)
Amphispiza belli	Sage Sparrow (B497)
Passerculus sandwichensis	Savannah Sparrow (B499)
Ammodramus_savannarum	Grasshopper Sparrow (B501)
Agelauis tricolor	Tricolored Blackbird (B520)

Mammals	
Tamias obscurus	California Chipmunk (M061)
Perognathus longimembris	Little Pocket Mouse (M086)
Perognathus alticola	White-eared Pocket Mouse (M089)
Perognathus fallax	San Diego Pocket Mouse (M094)
Dipodomys agilis	Pacific Kangaroo Rat (M103)
Dipodomys stephensi	Stephen's Kangaroo Rat (M108)
Dipodomys merriami	Merriam's Kangaroo Rat (M110)
Reptiles	
Clemmys marmorata	Western Pond Turtle (R004)
Sceloporus_orcutti	Granite Spiny Lizard (R021)
Phrynosoma coronatum	Coast Horned Lizard (R029)
Xantusia_henshawi	Granite Night Lizard (R033)
Cnemidophorus hyperythrus	Orange-throated Whiptail (R038)
Anniella pulchra	California Legless Lizard (R043)
Lichanura trivirgata	Rosy Boa (R047)
Crotalus ruber	Red Diamond Rattlesnake (R073)

Note that many other species are already of special concern or are on the Endangered Species list based on different criteria than used for Gap Analysis. Our list is in no way intended to divert attention away from these species nor to suggest that they are not also imperiled by habitat loss. Rather, it is meant to supplement the existing list with species who may become of concern if further management protection is not provided. Furthermore, several other species that did not meet all the criteria for being listed as at-risk but still warrant monitoring. For instance, some species were not listed here because they occur in many other regions of the state, but the genetic variations in the Southwestern California populations may require protection as well. Other species are declining in numbers despite being associated with human environments or having a substantial proportion of their range in Level 1 protection. Some of these other species include: Ensatina, Desert Slender Salamander, Red-Legged Frog, Cooper's Hawk, Swainson's Hawk, Greater Roadrunner, Burrowing Owl, Spotted Owl, Short-eared Owl, Willow Flycatcher, Heermann's Kangaroo Rat, Southern Grasshopper Mouse, Kit Fox, Badger, Mountain Sheep, Flat-tailed Homed Lizard, Rubber Boa, Glossy Snake, California Mountain Kingsnake, Long-nosed Snake, and Lyre Snake.

5.3.2. Priority Areas for Vertebrates At-Risk

Forty-two vertebrate species were identified by gap analysis as being at highest risk from lack of habitat protection. Figure 5-5 shows the relative number of these at-risk species in each 7.5' quadrangle in the region. The southern half of the region contains many quadrangles with at least 30 of the 42 species, with the highest being 37 in the Wildomar, Fallbrook, and Rodriguez Mountain quads. Eight other quads have 36 species, usually adjoining the three mentioned above. Two of these quads with 36 at-risk species, San Gorgonio Mountain and Cuyamaca Peak, are already mostly protected in Forest Service wilderness or state park and wilderness. Basically, the number of at-risk species is relatively uniform throughout San Bernardino, western Riverside, San Diego, and eastern Orange counties. The western half of the region in Los Angeles, Ventura, and Santa Barbara counties have fewer species at-risk/per quad. Some of these species may only occur in the western half, however, so this area should not be dismissed as less critical to preserving biodiversity until a more detailed analysis can be performed.

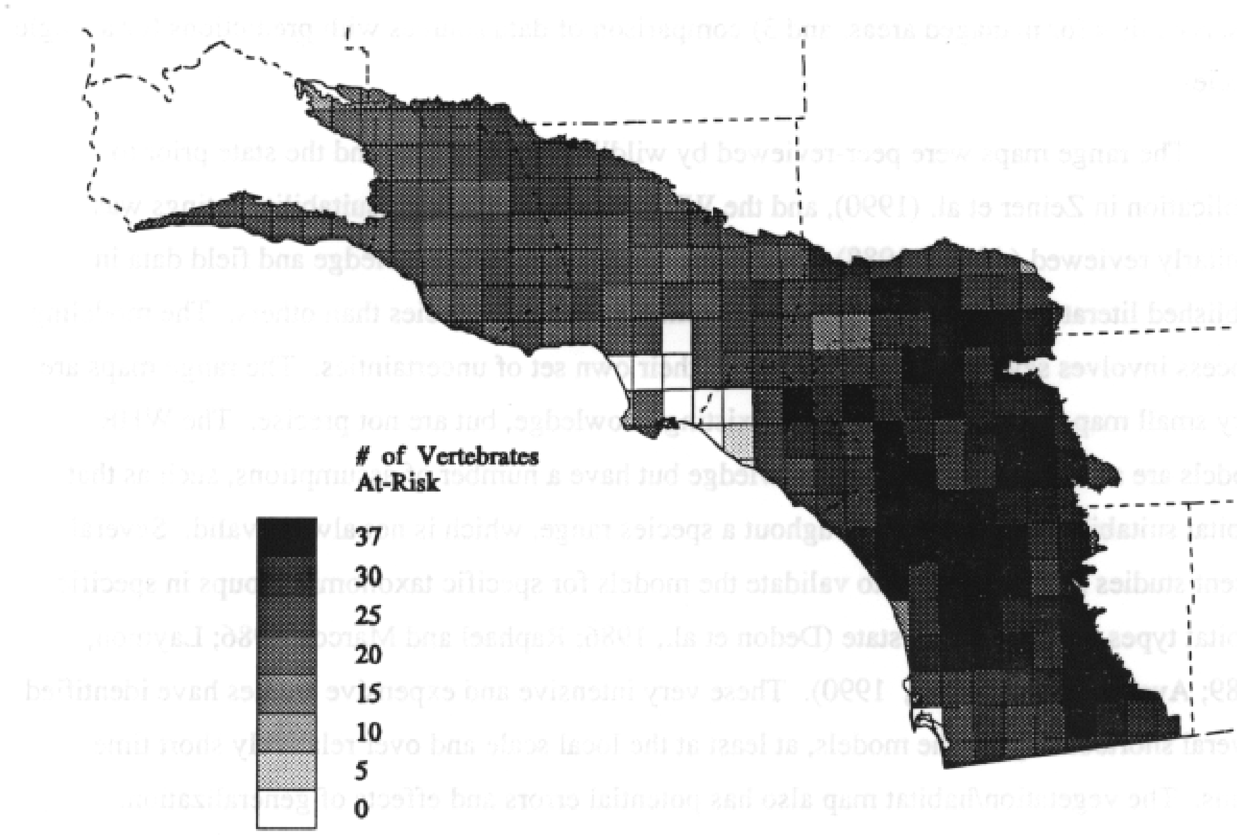

Figure 5-5. Map of the number of at-risk vertebrate species per 7.5 minute USGS quadrangle in the Southwestern California Region. The maximum number of species in a single quadrangle is 37 out of the 42 species in the regional pool.

5.3.3. Wildlife Distribution Validation

All distribution maps are predictions, and as such they must be validated. Validating regional-scale predictions of species distributions is a challenging enterprise. The most direct method of validation is based upon extensive field sampling. A new intensive field-sampling effort is impractical given the size of the sampling domain, the number of species to be observed (based on many different capture or observation techniques), and a practical limit to the duration of the validation task. The excessive time and money required for such sampling is one reason gap analysis resorted to modeling distributions by habitat modeling in the first place (Csuti et al., 1993). The validation reported here comes from several approaches: 1) validation efforts for the input data (range maps, suitability models, habitat map), 2) comparison of predicted with observed lists for managed areas, and 3) comparison of data sources with predictions for a single species.

The range maps were peer-reviewed by wildlife biologists around the state prior to publication in Zeiner et al. (1990), and the WHR database of habitat suitability ratings was similarly reviewed (Airola, 1988). Both were based on expert knowledge and field data in published literature, but certainly are more reliable for some species than others. The modeling process involves several datasets, each with their own set of uncertainties. The range maps are very small map scale and are based on existing knowledge, but are not precise. The WHR models are also based on existing knowledge but have a number of assumptions, such as that habitat suitability is the same throughout a species range, which is not always valid. Several recent studies have attempted to validate the models for specific taxonomic groups in specific habitat types throughout the state (Dedon et al., 1986; Raphael and Marcot, 1986; Laymon, 1989; Avery and Van Riper, 1990). These very intensive and expensive studies have identified several shortcomings in the models, at least at the local scale and over relatively short time spans. The vegetation/habitat map also has potential errors and effects of generalization. Because the uncertainties in each of these sources in the wildlife modeling are largely unknown, it is impractical to model error propagation from the inputs to the output product.

The only part of the data used in modeling not formally reviewed is the habitat map derived from the vegetation mapping for Gap Analysis, although it too has been tested in the field (see section 4), informally reviewed by botanists, and compared to detailed maps. Therefore, we believe the modeling is based on the best information available on distributions of all vertebrates at a common scale and habitat classification.

A more practical solution is to test the output database of species distributions against independent sets of data not used in compiling the original sources. Fortunately, there are two existing datasets for validating distribution models for Gap Analysis: well-documented species lists for existing managed areas, the Breeding Bird Survey (BBS) transect data.

Staff of some managed areas maintain lists of species observed within their jurisdictions. It is relatively straightforward to produce a predicted species list for these managed areas from the Gap Analysis database and compare the two lists for errors of commission and omission. In the Southwestern California Region, such lists for the Santa Monica National Recreation Area was provided by Dr. James Quinn of UC Davis (birds and mammals) and from DeLisle et al. (1986) for amphibians and reptiles; we compared these lists to predicted lists for this managed area generated from our vegetation map and the VMR model. (The list from WHR was created using the non-breeding/most-inclusive model as this would provide the best comparison to a species list compiled over a long period of time.)

Agreement between these sets of list turned out to be very good. The VMR database predicts 223 native species for the Santa Monica Mountains region. Data from observed sightings for this area total 233 native species. Most of the discrepancies of observed species that were not predicted can be attributed to listing of migrant or vagrant species. After correcting for these explainable differences, the total percent of true commission error is slightly more than 2% (5 species), total omission error is slightly more than 1% (3 species). The Jaccard's similarity coefficient for all vertebrates is 0.96, or 207 of 215 species. For the land birds, more species were actually seen than were predicted by WHR, but the margin was relatively small and almost all were occasional vagrants. Specifically, 150 species had been observed in the park, and 133 of these were on the WHR list. There was 1 species on the WHR list that was not on the actually-observed list, and 3 species that should have been predicted that were omitted. A Jaccard's similarity coefficient for these two lists thus is 0.97. For the mammals, more species were present on the WHR list than were actually observed. Of 53 species on the VMR list, 48 were actually observed in the park; two species were observed in the park but not on the VV'HR list. The Jaccard's similarity coefficient for mammals is 0.98. All 9 amphibians predicted have been observed within the Santa Monica Mountains, and only 3 reptiles were predicted incorrectly, giving coefficients of 1.0 and 0.88, respectively. Clearly for areas of this size, 63,780 hectares, species modeling provides a robust technique for predicting the occurrence of terrestrial vertebrates. This high agreement is due in part to the fact that the area being modeled was large enough that the species predicted mostly came from the range map component of the model rather than taking into account the habitats present in the area. We are continuing to conduct similar comparisons for other managed areas as species lists become available to us and as we complete our habitat mapping and modeling. It is our intent to publish an article on the results of these comparisons and discuss the success in relation to the size of managed area, because one would anticipate lower accuracies for smaller areas (Airola, 1988).

Another effort at validating the predicted wildlife distribution lists was to make a comparison to Breeding Bird Survey (BBS) data. The BBS is a roadside survey for birds carried out in June of each year along routes that do not change from year to year. The protocol for these transects is to make a three-minute stop every 0.5 miles along the 25-mile transect and record the identity and number of all species seen or heard at each stop (Robbins et al., 1989). After obtaining BBS data for the Southwestern California Region, we generated a predicted species list by combining the species lists for the vegetation polygons for all transects that could be accurately digitized. From the BBS data, we assembled a species list for each transect by combining the lists for every year the transect was run, typically 10- 15 years in duration. Agreement between these two lists was relatively poor. Using the breeding/most-inclusive WHR model, for 17 transects the value of the Jaccard's similarity coefficient between these two sets of lists ranged from 0.36 to 0.74, with an average of 0.58. In all cases the number of species predicted by WHR and not seen on the transects was substantially greater than the number seen on the transects and not predicted by WHR. Additionally, the BBS data was resolvable into five-mile sublengths along the 25-mile transect. The agreement for the comparison between the actual and predicted lists for each of the sublengths was even poorer: for 84 sublengths, the average value of the Jaccard's similarity coefficient comparing the two sets of lists was 0.43. This low level of agreement may be the result of inadequacies in the original WHR model, or a scale mismatch between using a species list collected over a short duration at a single point and a model meant to apply for predictions over a relatively larger area and time duration.

A recent analysis of the distribution data for the orange-throated whiptail (*Cnemidophorus hyperythrus*) provided an opportunity for validation of GAP distribution mapping (Hollander et al., 1993). This teiid lizard is a species of concern in an area threatened with urban development and ranges from coastal southern California west of the Peninsular Ranges to the southern end of Baja California. In this analysis, we were only concerned with the northern portion of the range that falls in California. Its habitat is sparsely vegetated slopes or washes with open, heterogeneous brush and friable soils for burrowing. The whiptail exhibits a range of diverse natural history characteristics. The mean home range is small, about 0. 1 acres. Three datasets are direct sources of whiptail distribution information for this study. The first dataset consists of locality information for 349 museum specimens of whiptails, compiled by Mark Jennings in a thorough survey of major museum collections. Since geocoding museum locality information presents many difficulties (McGranaghan and Wester, 1988), we positioned each of the locality records in the nearest U.S. Geological Survey 7.5' quadrangle. The second dataset consists of 61 point observations for the whiptail from the California Natural Diversity Database (CNDDB). The last dataset covers the planning area of the Multiple Species Conservation Plan (MSCP) in western San Diego County, and includes 432 sightings of orange-throated whiptails compiled by OGDEN Environmental and Energy Services, primarily from recent environmental impact assessments. These sources were compared to the distribution predicted for GAP.

The comparison of predicted and observed datasets for the orange-throated whiptail are shown in Figure 5-6. The dots and triangles indicate the two sets of field observations for MSCP and the CNDDB respectively. The diagonal hatching shows the quads containing museum specimens, although some of these are a century old. The gray shading is the suitable habitat modeled for gap analysis. Most of the observations match well with the modeled distribution, and areas such as the northwestern tip of the range contain neither suitable habitat nor any observations, indicating the range boundary could probably be adjusted here. It should be noted that the MSCP observations tend to occur along the urban fringe of San Diego communities, in keeping with the purpose of their collection for environmental impact assessment. Consequently, even an intensive field sampling program can generate a relatively biased sample for use in validation (Hollander et al., 1993). Absence of sightings is also not proof that a species does not occur at a location; it may only be that the location has not been sampled adequately. The other problem with such comparisons is temporal. The habitat information is based on 1990 data, whereas the observations for CNDDB and the museum specimens can predate the explosive urban development, and the suitable habitat they occupied then may no longer exist.

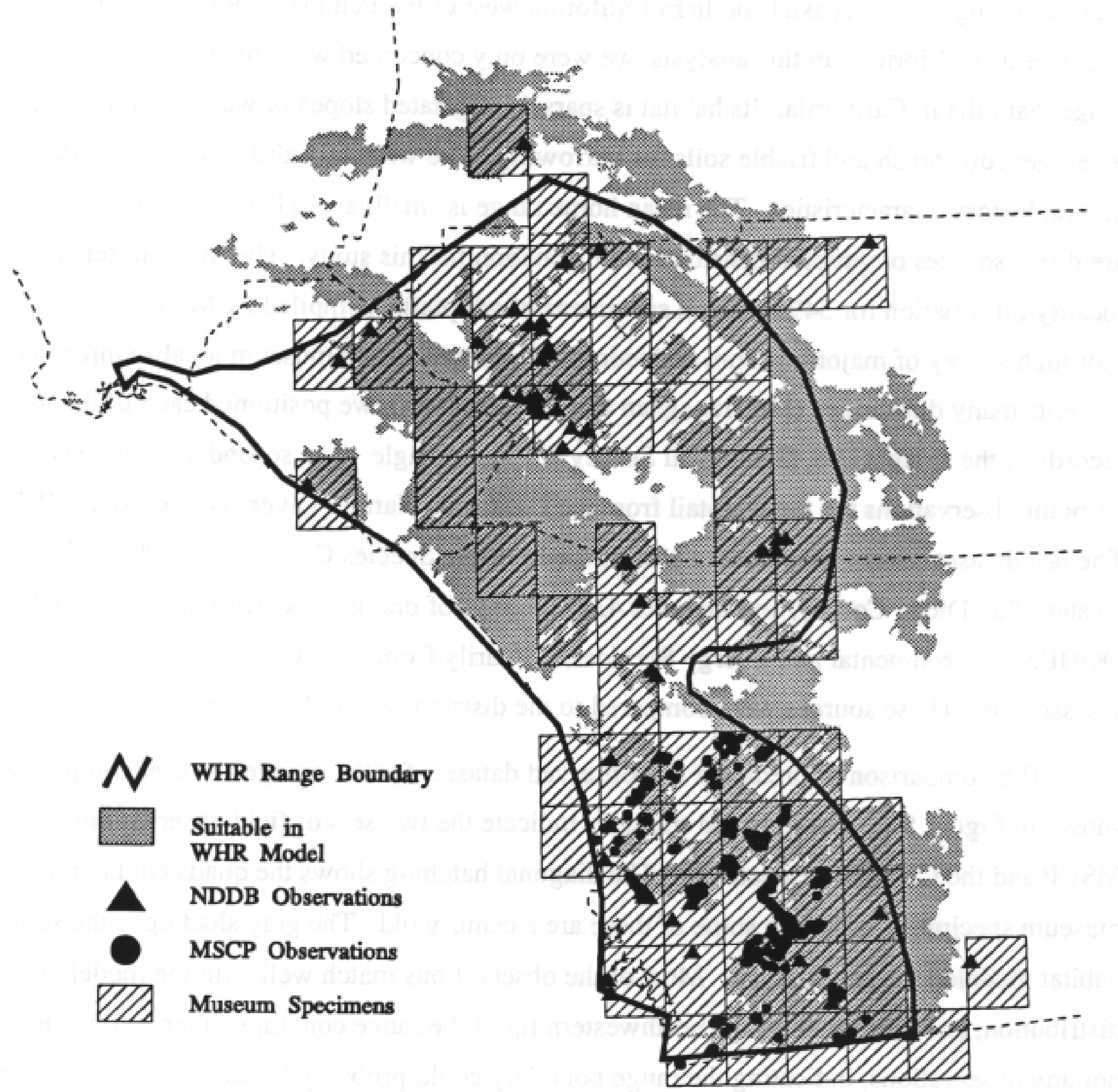

Figure 5-6. Map of various sources of data on the distribution of the orange-throated whiptail in the Southwestern California Region.

5.3.4. Limitations of the Methods

Gap Analysis provides a regional overview of the distribution and ownership profile of native vertebrate species. The utility of individual predicted distribution maps is related to the ecology and rarity of each species and to the size of the area of interest. In particular, species with relatively small home ranges (e.g., breeding passerine birds, many nonpasserines, salamanders, lizards, and non-volant small mammals) are best suited to WHR-type modeling (Csuti et al., 1993). It works less well for highly mobile species or those with specific microhabitat requirements such as caves or wetlands. Many of these species, such as bats, we have omitted from the analysis for this reason. Because of the scale of habitat mapping, it is not possible to include habitat structural information in the modeling, despite its known importance for many species (Hollander et al., unpublished manuscript). Our assumption has been that over large landscape units, dynamic natural processes will maintain a full range of size and density classes of habitats over time. As a corollary to that assumption, most species would be able to find suitable structural habitat within the landscape, even though the exact position of the best habitat may shift within the structural mosaic. The predictions for the 63,780 ha Santa Monica Mountains area described above were highly accurate, but accuracy declines as area becomes smaller. We anticipate that the predictions will not be useful for sites smaller than 100 ha.

Estimates of area made from maps are very sensitive to map scale and mapping methods. Our estimates of the extent of species distributions are useful for comparing among species, but should not be taken absolutely. Similarly, our maps of habitat and land ownership were prepared commensurately for direct overlay and comparison, but the ownership profiles of species distributions would be different if either map was prepared using a different minimum mapping unit.

The land ownership profiles provide a crude measure of risk of development or resource over-exploitation. Species can also be at risk due to climatic change, introduced competitors and pathogens, and many other ecological factors. Furthermore, there is wide variation in land management practices within each of the three categories. Some private lands are well managed for the maintenance of plant diversity, some reserves may be managed in a way that threatens the persistence of selected species. County zoning data provide additional detail on present and possible future management of private lands. Land management on public lands ultimately should be analyzed within individual administrative units (e.g., individual national forests). We are distributing our data to federal and state agencies to foster these more detailed analyses.

The fundamental assumption of GAP that protecting all vertebrate species will likewise protect unmapped elements of biodiversity, such as invertebrates, has not yet been tested. We have plans to evaluate this assumption where floral and invertebrate species lists are available to see if the priority areas coincide between groups. This evaluation will be hampered by the lack of good data for even a modest sample of managed areas (which, of course, is why these taxa were not included in GAP in the first place).

6. PRELIMINARY CONCLUSIONS

6.1. Preliminary Recommendations

One simple scheme for setting priority areas is be to identify those that are contain a large extent of at-risk plant communities AND large numbers of at-risk vertebrates AND large extent of unprotected Significant Natural Areas. As seen in Figure 6- 1, some 7.5' quadrangles have very high values for at least one of the three criteria shown. Some quadrangles contain greater than 40 percent of their area in natural communities identified by GAP as at-risk. Similarly, many quadrangles contain at least 25 of the 42 vertebrates considered at-risk. And third, several quadrangles have more than 30 percent of their area in unprotected Significant Natural Areas. Twelve quads meet this coarse screening of all three criteria: Lebec, Lake Mathews, Black Star Canyon, Canada Gobernadora, Laguna Beach, San Clemente, Morro Hill, Las Pulgas Canyon, San Onofre Bluff, Jamul Mountains, Tecate, and Otay Mountain (Figure 6-2). These quads, primarily in Orange and San Diego counties, deserve attention as sources of potential new nature reserves. Of course, many other quads are nearly as high in all of the criteria. For instance, the region southeast of San Jacinto Valley, including the Cahuifla Mountain, Bucksnort Mountain, Collins Valley, and Vail Lake quads, satisfy the first two criteria, but are below the threshold set here for SNA's.

6.2. Validation and Database Revision

The GAP database validation to date has only consisted of simple comparisons with existing datasets for specific, well-known locations. A formal, statistically rigorous accuracy assessment was beyond the resources available to complete the analysis. The initial comparisons discussed in this report have been encouraging. While there may be minor corrections and updates required as better information becomes available, we do not expect the major results of the analysis to change. The GAP database should therefore be viewed as a draft product captured at a single point in time. Database users are encouraged to send us their feedback on any aspect of the database they feel needs to be revised.

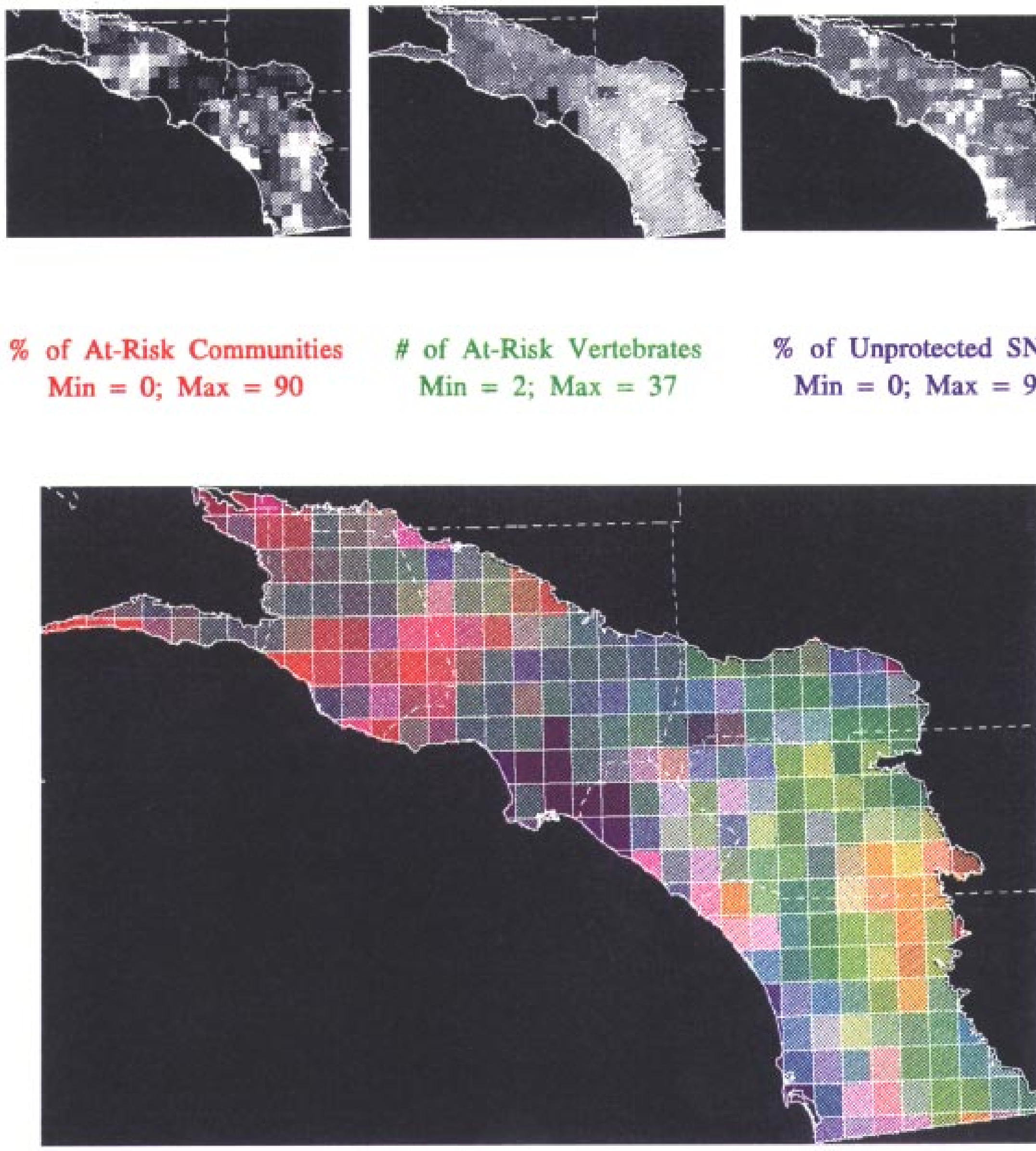

Figure 6-1. Map of the percentage of GAP at-risk natural communities, the number of at-risk vertebrate species, and the percentage of area in unprotected Significant Natural Areas in each 7.5 minute USGS quadrangle in the Southwestern California Region. The bottom figure shows the overlay of these three criteria, with the at-risk community criterion shown as red, the at-risk vertebrate richness in green, and the SNA's in blue. Brighter colors indicate higher values. Quadrangles closest to white are those with high values for all three criteria.

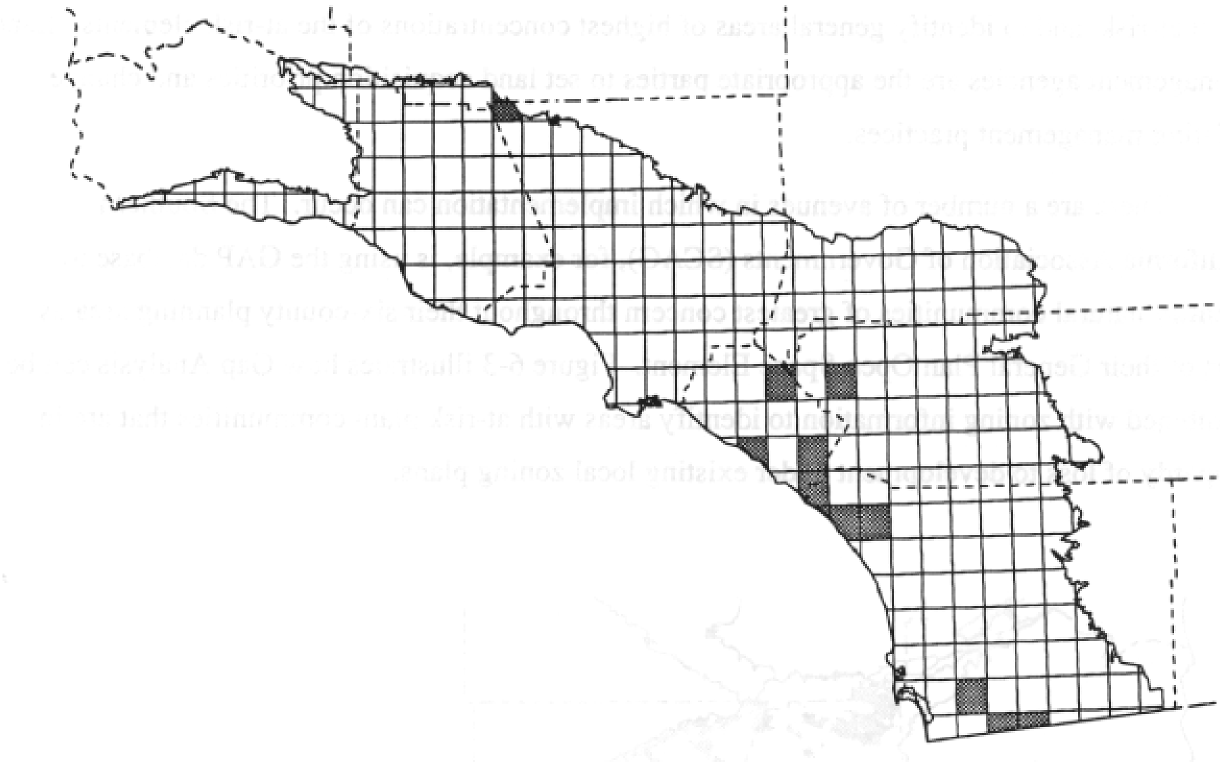

Figure 6-2. Map of the 12 quadrangles that contain greater than 40 percent of their area in GAP at-risk natural communities, at least 25 at-risk vertebrate species, and greater than 30 percent area in unprotected Significant Natural Areas.

6.3. Future Directions for Gap Analysis

Gap analysis databases are being compiled at the state level. Within California, we have divided the assessment into the ten regions of the Jepson Flora. This leaves two requirements for a more meaningful assessment of the management status of biodiversity. The first need is to complete the statewide assessment and to identify priority communities, species, and areas for statewide conservation planning. The second need is to compile databases over entire ecoregions (Bailey, 1976) without regard to artificial political boundaries. For the Southwestern California Region, this means collaborating with corresponding efforts in Baja California to complete the broader analysis. Many species and communities extend beyond the Mexican border (e.g., see the orange-throated whiptail discussion above).

6.3.1. Implementation Strategies

GAP is a research program that has no regulatory or management authority. GAP is designed to provide a coarse-filter screening of elements of biodiversity, to identify elements most at-risk, and to identify general areas of highest concentrations of the at-risk elements. Land management agencies are the appropriate parties to set land acquisition priorities and change existing management practices.

There are a number of avenues in which implementation can occur. The Southern California Association of Governments (SCAG), for example, is using the GAP database to identify natural communities of greatest concern throughout their six-county planning area as part of their General Plan Open Space Element. Figure 6-3 illustrates how Gap Analysis can be combined with zoning information to identify areas with at-risk plant communities that are in jeopardy of loss to development under existing local zoning plans.

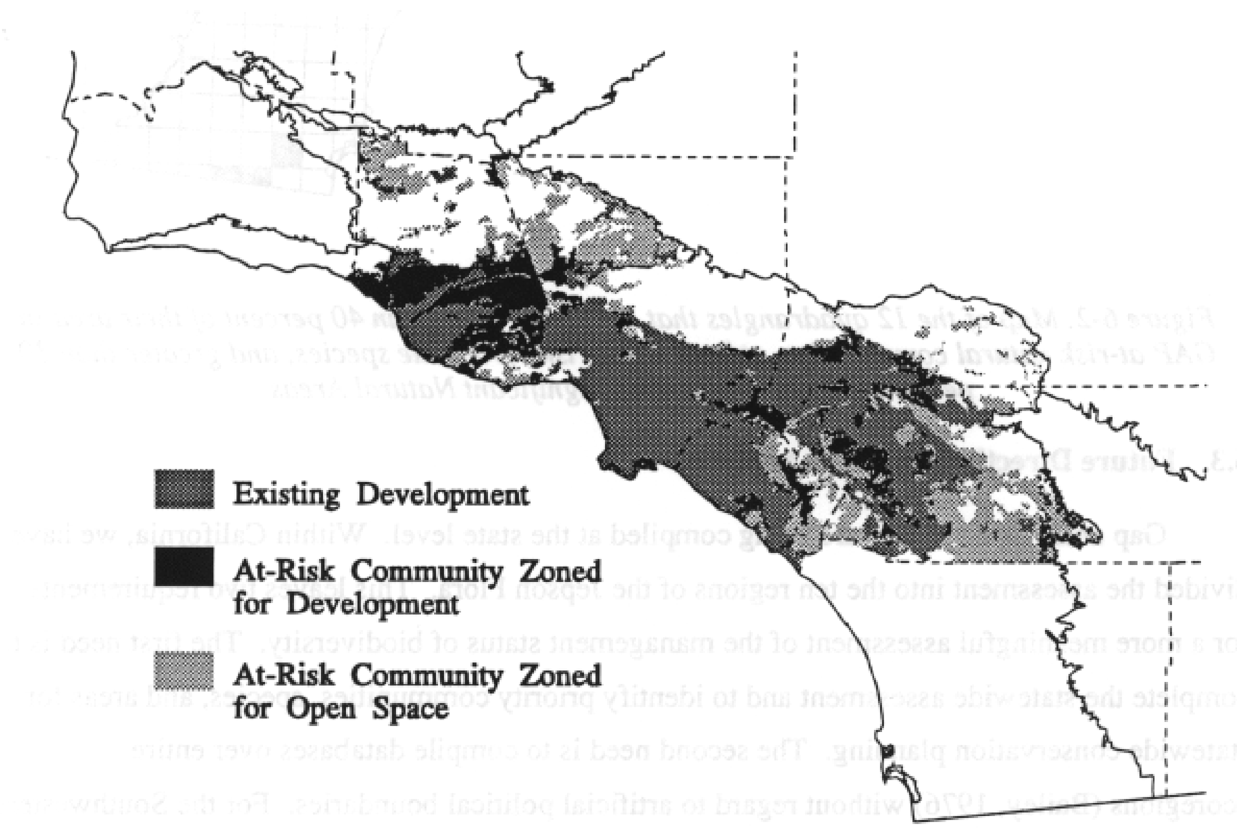

Figure 6-3. Map of the SCAG planning area within the Southwestern California Region, showing a relationship of at-risk plant communities from GAP and potential loss of these communities to potential development. Only Ventura, Los Angeles, San Bernardino, Orange, and Riverside Counties are included within SCAG in this region.

Reserve selection and design will require additional levels of detail in both the mapped information and the sophistication of the analysis. Identification of priority areas presented in this report were based on a relatively simple observation of locations, generally 7.5' quadrangles, where the most at-risk species occur or the most land is comprised of at-risk plant communities. Protection of these "hot-spots" does not guarantee that even all at-risk elements of biodiversity would be protected. More sophisticated methods have been used to identify optimal reserve networks on the basis selection of sites representing all elements (Bedward et al., 1992; Kiester et al., 1993; Nicholls and Margules, 1993). Selection of potential reserves is sensitive to the choice of criteria and algorithm used. As this is an active research area in conservation biology, we have not yet attempted to implement any of these prioritization schemes. We recommend that candidate reserve network selection be undertaken as an interagency planning effort involving UCSB, the California Department of Fish and Game, the U. S. Fish and Wildlife Service, and The Nature Conservancy as a minimum. In addition, more sophisticated modeling of long-term species persistence in specific habitat configurations, named "population viability analysis" (Hanski and Gilpin, 1991) will be required.

6.3.2. Database Availability

The gap analysis database has a wide potential set of applications for conservation planning, biogeographical research, and education. Further, because it is extremely rich in attributes that can only be hinted at in the graphics in this report, it will be much more valuable as a digital database than as a set of hardcopy products. We have planned from the beginning of the project to make nonproprietary parts of the database accessible. (The land management layer is based on ownership data distributed by California's Teale Data Center on a cost-recovery basis. At the present time, redistribution of this data layer requires written permission from the GIS director of Teale.) We have recently established an "anonymous ftp" account for distribution of GIS coverages, text, and graphics over the internet network. Currently, this account contains the vegetation database (as an ARC/INFO export file), its data dictionary, the 100 m digital elevation data, 3 band color composite TM image at 100 rn resolution, and the wildlife species lists for each vegetation map unit. The procedure for downloading other GAP data is as follows:

```
%ftp lorax.geog.ucsb.edu
Name: anonymous
Password: <user's e-mail address>
ftp> cd pub/gap/sweco                    # for southwestern region data
ftp> binary
ftp> get <filename>
ftp> quit
```

There is a file called 'Files' that describes the contents of the directory. For users not on the internet, we have also provided these data on a variety of magnetic media. Users are asked to contact us if they have transferred files so that we may notify them of updates and revisions. These data are provided "as is" and without any express or implied warranties, including, without limitation, the implied warranties of merchantability and fitness for a particular purpose. Preliminary discussions have also occurred regarding the permanent housing and maintenance of the GAP database at the California Department of Fish and Game's Natural Heritage Division.

Readers are encouraged to contact us with comments on this report, the database, or on the gap analysis process in general. For those with e-mail, contact fd@crseo.ucsb.edu. Otherwise, contact Dr. Frank Davis at the address on the cover of the report.

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APPENDIX A: Summary of the mapped distribution and management status of selected native, dominant species in California's Southwest Region. Statistics pertain to areas where the species was mapped as a canopy co-dominant (> 20% of overstory cover), not the entire range of the species. Nomenclature follows the Revised Jepson Manual of the Flora of California. Geographic subregions include the Western Transverse Ranges (WT), the South Coast (SC), the San Gabriel Mountains (SG), the San Bernardino Mountains (SB), the San Jacinto Mountains (SJ), and the Peninsular Ranges (PR). Land management status includes Level 1 (managed primarily for maintenance of biodiversity), Level 2 (public lands managed for multiple uses) and Level 3 (private lands not managed primarily for maintenance of biodiversity).

Appendix A. Distribution and Management of
Dominant Plant Species
in the Southwestern California Ecoregion

Species		Subregion (%)						Management (%)			Area
		WT	SC	SG	SB	SJ	PR	L 1	L 2	L 3	sq. km
STEPPE SHRUBS											
Antelope_bitterbush	*Purshia_tridentata*	82.4	0	0	0	0	17.6	0.3	55.9	43.8	38
Desert_bitterbrush	*Purshia_glandulosa*	0	0	0.4	99.6	0	0	0	94.7	5.3	68
Great_basin_sage	*Artemisia_tridentata*	45.8	0	6.2	28.2	0	19.8	8.5	61.7	29.8	597
Rabbitbrush	*Chrysothamnus_nauseosus*	87.6	0	12.4	0	0	0	2.7	42.4	54.8	130
Rabbitbrush	*Chrysothamnus_parryi*	0	0	0	100	0	0	0	93.4	6.6	78
Brittlebush	*Encelia_farinosa*	3.2	89.2	0	0	0.7	6.8	6.6	16.5	76.8	97
Narrowleaf_goldenbush	*Haplopappus_linearifolius*	68.1	0	2.7	0	0	29.2	0	17.8	82.2	100
SOFT_CHAPARRAL_SHRUBS											
California_buckwheat	*Eriogonum_fasciculatum*	30.9	19.7	4.5	2	0.4	42.6	6.5	30.9	62.4	3,610
White_sage	*Salvia_apiana*	11	19	3.1	3.4	0.6	62.8	7.1	32.5	60.3	1,200
Purple_sage	*Salvia_leucophylla*	98.5	1.1	0.4	0	0	0	7	5.7	87.3	853
Black_sage	*Salvia_mellifera*	55	24.4	1.9	0	0	18.7	5.8	22	72.2	1,188
Laurel_sumac	*Malosma_laurina*	29	4.7	1.4	0	0	64.9	2.1	40.2	57.6	393
California_sagebrush	*Artemisia_californica*	31.7	22.7	2.2	0.2	0.2	43	4.7	21.1	74.1	2,548
California_encelia	*Encelia_californica*	15.3	76.5	0.3	0	0	7.9	3.5	7.7	88.8	200
Chaparral_yucca	*Yucca_whipplei*	11	19	3.1	3.4	0.6	62.8	7.1	32.5	60.3	1,200
CHAPARRAL_SHRUBS											
Flannel_bush	*Fremontodendron_californicum*	0	0.3	67.2	32.5	0	0	11.7	82	6.3	74
Eastwood_manzanita	*Arctostaphylos_glandulosa*	8.7	0.2	1.2	22	13.5	54.2	8.9	64.7	26.4	608
Bigberry_manzanita	*Arctostaphylos_glauca*	35.1	3.5	19.7	4.3	3.5	33.9	10.5	61.4	27.9	1,358
Perry_manzanita	*Arctostaphylos_parryana*	100	0	0	0	0	0	41.2	38.2	20.5	12
Greenleaf_manzanita	*Arctostaphylos_patula*	5.3	0	5.8	86.1	1.2	1.7	37.7	52.4	10	121
Pink-bracted_manzanita	*Arctostaphylos_pringlei*	0	0	0	0	100	0	88.7	0.1	11.1	12
Mexican_manzanita	*Arctostaphylos_pungens*	0	0	0	0	0	100	14.8	22.2	62.9	90
Woollyleaf_manzanita	*Arctostaphylos_tomentosa*	22.2	0.3	37.8	4.2	1.6	34	14.2	63.7	22.1	494
Mission_manzanita	*Xylococcus_bicolor*	0	6.1	0	0	0	93.9	3.4	39.3	57.3	219

Appendix A. Distribution and Management of
Dominant Plant Species
in the Southwestern California Ecoregion

				Subregion (%)					Management (%)		Area
Species		WT	SC	SG	SB	SJ	PR	L 1	L 2	L 3	sq. km
Flowering_ash	*Fraxinus_dipetala*	0	0.4	0	0	0	99.6	0	87.5	12.5	28
Chamise	*Adenostoma_fasciculatum*	28.4	7.4	9.3	4.5	1.7	48.7	11.3	47	41.8	7,969
Redshanks	*Adenostoma_sparsifolium*	4	0	0.4	0	0.6	95	11.3	47	41.6	1,012
Mountain_mahogany	*Cercocarpus_betuloides*	38.1	0.5	16.9	10	3.2	31.4	20.3	61.5	18.3	2,945
Mountain_mahogany	*Cercocarpus_ledifolius*	0	0	20.3	18	0	61.7	7.2	85.8	7	24
Toyon	*Heteromeles_arbutifolia*	6	5.7	3.9	0	0	84.3	9.5	47.1	43.4	85
Hollyleaf_cherry	*Prunus_illicifolia*	87.9	0.5	11.6	0	0	0	3.1	68.6	28.4	132
Bush_chinquapin	*Castanopsis_sempervirens*	0	0	15.8	69.3	14.9	0	52.8	36.7	10.4	139
Scrub_oak	*Quercus dumosa (prev.)*	38.6	2.1	11.6	10.2	1.1	36.4	16.4	54.4	29.4	4,534
Canyon_live_oak(Shrub)	*Quercus_chrysolepis*	20.8	0.2	27.4	33.2	2.2	16.2	28	61.3	10.6	451
Interior_live_oak (Shrub)	*Quercus_wislizenii*	27	0.2	29.6	22.1	6.3	14.7	24.8	60.5	14.8	1,422
Mountain_whitethorn	*Ceanothus_cordulatus*	11	0	14.8	65.7	8.5	0	52.4	39	8.6	132
Hoaryleaf_ceanothus	*Ceanothus_crassifolius*	25	8.9	25.1	6.4	0	34.6	17.7	46.1	36.2	2,344
Buckbrush	*Ceanothus_cuneatus*	0	79.1	0	0	0	3.6	27.4	17.3	55.3	14
Desert_ceanothus	*Ceanothus_greggii*	8.1	0.6	6	14.8	9.7	60.8	14.4	60.4	25.2	1,379
Deerbrush	*Ceanothus_integerrimus*	0	0	40.7	59.3	0	0	36.1	40.2	23.7	43
Chaparral_whitethorn	*Ceanothus_leucodermis*	6.5	0.4	27.6	12.5	5.9	47.2	17.8	59.8	22.6	1,623
Bigseed_ceanothus	*Ceanothus_megacarpus*	94.9	2.4	0	0	0	2.7	17.4	23.8	58.7	616
Hairy_ceanothus	*Ceanothus_oliganthus*	18.7	1.3	27.9	0	0	52.2	20.2	49.7	30.1	549
Palmer_ceanothus	*Ceanothus_palmeri*	0	0	0	0	0	100	8.8	83.7	7.6	20
Jimbrush	*Ceanothus_sorediatus*	0	9.1	0	0	0	90.9	0.1	37.8	62.1	113
Greenbark_ceanothus	*Ceanothus_spinosus*	87.8	2.3	0	0	0.8	9.1	17	34.8	48.2	552
Woolyleaf_ceanothus	*Ceanothus_tomentosus*	0	0	0	0	0	100	1.8	44.1	54.1	130
Wartystem_ceanothus	*Ceanothus_verrucosus*	0	100	0	0	0	0	0	0	100	16
Lemonade_berry	*Rhus_integrifolia*	33.2	16.3	15	0	0	35.4	11.2	29.2	59.6	470
Sugarbush	*Rhus_ovata*	0	0.6	17.3	8.1	0	74	22.1	31.8	46.1	263
Snowberry	*Symphoricarpos_mollis*	91.6	0	8.4	0	0	0	38.2	47.5	14.4	12
BROADLEAF_TREES											
Madrone	*Arbutus_menziesii*	100	0	0	0	0	0	0	40.7	59.3	8
Coast_live_oak	*Quercus_agrifolia*	22	4.3	0.9	0.5	0.5	71.9	8.3	29.5	62.1	728
Canyon_live_oak	*Quercus_chrysolepis*	20.3	0.1	30.5	23.7	2.6	22.9	31	53	16	784

Appendix A. Distribution and Management of
Dominant Plant Species
in the Southwestern California Ecoregion

				Subregion (%)					Management (%)		Area
Species		WT	SC	SG	SB	SJ	PR	L 1	L 2	L 3	sq. km
Blue_oak	*Quercus_douglasii*	100	0	0	0	0	0	0	33	67	6
Engelmann_oak	*Quercus_engelmannii*	0	0.4	0	0	0	99.6	3.2	31.6	65.2	236
Black_oak	*Quercus_kelloggii*	1.9	0.2	5.2	30.5	7.2	55	9.4	49.8	40.8	457
Valley_oak	*Quercus_lobata*	99.5	0.5	0	0	0	0	2.4	7	90.7	50
Interior_live_oak	*Quercus_wislizenii*	0	0	100	0	0	0	0	99.6	0.4	53
California_walnut	*Juglans_californica*	59.5	9.1	0	0	0	31.4	2.8	7.9	89.3	60
Buckeye	*Aesculus_californica*	100	0	0	0	0	0	0	66.9	33.1	8
CONIFER_TREES											
White_fir	*Abies_concolor*	13	0	17	51.9	8.7	9.4	30.9	52.1	17	788
Knobcone_pine	*Pinus_attenuata*	0	0	41.5	58.5	0	0	0	89.7	10.3	15
Lodgepole_pine	*Pinus_contorta*	0	0	13.7	79.3	7	0	82.8	14.3	2.9	59
Coulter_pine	*Pinus_coulteri*	2	0.1	14.7	18.3	14.6	50.3	22.2	51.8	26.1	378
Limber_pine	*Pinus_flexilis*	0	0	0.8	88.3	11	0	91.1	8.9	0	45
Jeffrey_pine	*Pinus_jeffreyi*	21.6	0	14.6	49	1.8	13	25.3	63.1	11.6	958
Sugar_pine	*Pinus_lambertiana*	17.3	0	35.8	26.5	10.8	9.5	41.8	48.7	9.6	356
Single_leaf_pinyon	*Pinus_monophylla*	72.8	0	6.4	19.8	0	1	14.2	73.3	12.6	1,066
Ponderosa_pine	*Pinus_ponderosa*	12.2	0	30.8	28.7	19.1	9.1	38.1	39	22.8	361
Digger_pine	*Pinus_sabiniana*	100	0	0	0	0	0	0	16.4	83.6	15
Bigcone_spruce	*Pseudotsuga_macrocarpa*	24.5	0.1	42.5	23.5	0	9.4	34.9	53.8	11.4	43
Tecate_cypress	*Cupressus_forbesii*	0	0	0	0	0	100	7.2	70.3	22.4	18
California_juniper	*Juniperus_californica*	90	0	8.6	0	0	1.4	15.6	56.4	28	733
Western_juniper	*Juniperus_occidentalis*	0	0	0	100	0	0	0	96	4	96
Incense_cedar	*Libocedrus_decurrens*	0	0	3	63.8	14.4	18.9	13.3	72.7	14.1	140

APPENDIX B: Summary of the distribution and land ownership status of natural plant communities in California's Southwest Region. Communities are defined as in Holland (1985). Geographic subregions include the Western Transverse Ranges (WT), the South Coast (SC), the San Gabriel Mountains (SG), the San Bernardino Mountains (SB), the San Jacinto Mountains (SJ), and the Peninsular Range (PR). Land management status includes Level 1 (managed primarily for maintenance of biodiversity), Level 2 (public lands managed for multiple uses) and Level 3 (private lands not managed primarily for maintenance of biodiversity). The mapped area for each community type is provided in square kilometers.

Appendix B. Distribution and Management Status of
Natural Plant Communities
in the Southwestern California Ecoregion

COMMUNITY	Holland Code	Subregion (%) WT	SC	SG	SB	SJ	PR	Management(%) L 1	L 2	L 3	Area sq.km.
SCRUB											
Coastal_Scrub	32000	41	22	2	1	0	34	7	22	71	3,908
Mojave_Creosote_Scrub	34100	0	0	0	73	0	27	33	39	28	86
Big_Sagebrush_Scrub	35210	46	0	3	26	0	26	3	59	38	334
CHAPARRAL											
Northern_Mixed_Chaparral	37110	35	4	5	7	3	46	6	57	37	1,143
Southern_Mixed_Chaparral	37120	1	10	0	0	0	89	3	35	62	219
Chamise_chaparral	37200	35	12	2	4	0	46	10	36	54	1,407
Redshank_chaparral	37300	2	0	0	0	1	96	10	48	42	950
Semi-desert_chaparral	37400	5	0	8	8	9	70	18	59	24	1,025
Mixed_Montane_Chaparral	37510	19	0	28	45	4	4	49	41	10	187
Montane_Manzanita_Chaparral	37520	0	0	0	0	0	100	5	58	37	13
Deer_Brush_Chaparral	37531	0	0	22	78	0	0	20	31	49	17
Whitethorn_Chaparral	37532	7	0	26	2	0	64	11	62	28	337
Buck_Brush_Chaparral	37810	66	8	0	0	0	26	17	40	43	709
Ceanothus_crassifolius_Chaparral	37830	21	10	26	7	0	37	15	48	37	2,045
Ceanothus_megacarpus_Chaparral	37840	96	2	0	0	0	2	18	25	57	572
Scrub_oak_Chaparral	37900	32	1	14	10	1	41	22	56	23	1,644
Interior_Live_Oak_Chaparral	37A00	28	0	32	24	5	11	25	62	13	1,174
Upper_Sonoran_Manzanita_Chaparral	37B00	30	5	9	10	14	33	6	70	24	381
Southern_North_Slope_Chaparral	37EOO	66	0	12	11	0	12	55	44	1	14
Coastal_Sage-Chaparral_Scrub	37G00	7	27	4	0	0	61	1	17	82	64
HERBACEOUS											
Valley_Needlegrass	42110	0	0	0	0	0	100	6	1	93	3

Appendix B. Distribution and Management Status of
Natural Plant Communities
in the Southwestern California Ecoregion

	Holland	Subregion (%)						Management(%)			Area
COMMUNITY	**Code**	**WT**	**SC**	**SG**	**SB**	**SJ**	**PR**	**L 1**	**L 2**	**L 3**	**sq.km.**
Non-native_Grassland	42200	31	19	0	1	0	49	6	21	73	1,165
Southern_Coastal_Salt_Marsh	52120	0	82	0	0	0	0	28	14	57	13
Coastal_Brackish_Marsh	52200	0	100	0	0	0	0	0	0	100	1
Coastal/Valley_Freshwater_Marsh	52410	0	15	0	0	0	84	5	21	74	40
RIPARIAN_WOODLAND											
S._Coast_Live_Oak_Riparian	61310	63	9	0	0	3	25	16	46	38	26
S._Arroyo_Willow_Riparian	61320	12	49	0	11	0	28	4	36	60	37
S._Cottonwood-Willow_Riparian	61330	22	24	4	32	0	19	7	45	48	59
White_Alder_Riparian	61510	60	0	7	20	0	13	17	36	47	8
S._Sycamore-Alder_Riparian	62400	14	1	0	0	0	85	7	28	65	17
Mule_Fat_Scrub	63310	31	57	0	0	0	13	5	35	60	45
Southern_Willow_Scrub	63320	0	100	0	0	0	0	0	12	88	1
Southern_Alluvial_Fan_Scrub	63330	100	0	0	0	0	0	0	2	98	13
BROADLEAVED_WOODLAND											
Valley_Oak_Woodland	71130	99	1	0	0	0	0	3	3	94	36
Blue_Oak_Woodland	71140	100	0	0	0	0	0	0	11	89	4
Interior_Live_Oak_Woodland	71150	0	0	100	0	0	0	0	100	0	14
Coast_Live_Oak_Woodland	71160	29	1	4	0	0	67	0	29	71	60
Dense_Engelmann_Oak_Woodland	71182	0	0	0	0	0	100	3	30	66	226
California_Walnut_Woodland	71210	57	10	0	0	0	33	3	8	89	56
CONIFER_WOODLAND											
Non-Serpentine_Digger_Pine-Chaparral	71322	100	0	0	0	0	0	0	0	100	4
Digger_Pine-Oak_Woodland	71410	100	0	0	0	0	0	0	24	76	9
Northern_Juniper_Woodland	72110	0	0	0	100	0	0	0	96	4	95

Appendix B. Distribution and Management Status of
Natural Plant Communities
in the Southwestern California Ecoregion

	Holland	Subregion (%)						Management(%)			Area
COMMUNITY	**Code**	**WT**	**SC**	**SG**	**SB**	**SJ**	**PR**	**L 1**	**L 2**	**L 3**	**sq.km.**
Mohavean_Pinon_Woodland	72210	0	0	66	34	0	0	0	94	6	62
Peninsular_Pinon_Woodland	72310	68	0	8	22	0	3	11	71	18	346
Peninsular_Juniper_Woodland/Scrub	72320	58	0	0	0	0	43	39	43	18	23
Cuyaman_Pinyon_Woodland\u1\d	72500	87	0	10	4	0	0	14	62	24	939
BROADLEAVED_FOREST											
Mixed_Evergreen_Forest	81100	4	0	7	5	0	84	22	57	21	54
Coast_Live_Oak_Forest	81310	45	8	0	0	0	46	8	22	70	172
Canyon_Live_Oak_Forest	81320	32	0	27	11	10	21	37	49	14	121
Interior_Live_Oak_Forest	81330	0	0	100	0	0	0	0	100	0	38
Black_Oak_Forest	81340	2	1	0	23	7	67	16	56	28	202
CONIFER_FOREST											
Knobcone_Pine_Forest	83210	0	0	0	100	0	0	0	92	8	5
Southern_Interior_Cypress_Forest	83330	0	0	0	0	0	100	7	70	22	17
Coulter_Pine_Forest	84140	3	0	19	21	8	49	14	59	27	295
Bigcone_Spruce/Canyon_Live_Oak	84150	33	0	50	15	0	2	46	46	7	314
Westside_Ponderosa_Pine_Forest	84210	14	0	28	34	16	8	44	35	21	308
Sierran_Mixed_Conifer_Forest	84230	15	0	47	18	9	11	32	55	13	199
Jeffrey_Pine_Forest	85100	31	0	14	31	5	18	21	66	13	236
Jeffrey_Pine-Fir_Forest	85210	19	0	2	74	0	5	23	64	13	360
S._California_White_Fir_Forest	85320	4	0	10	51	36	0	35	53	13	38
Lodgepole_Pine_Forest	86100	0	0	58	42	0	0	49	36	15	4
S._California_Subalpine_Forest	86500	0	0	3	81	16	0	92	8	0	52
TOTAL		**25.0**	**31.4**	**6.9**	**6.5**	**1.3**	**28.8**	**9.6**	**30.5**	**59.9**	**33,832**

APPENDIX C. Summary of the ownership and management status of Species Complexes in the Southwest Region of California. Complexes are organized hierarchically within CALVEG Series, whose corresponding symbols are shown in parentheses (USDA Forest Service 1981). A Complex is defined by dominant overstory species, which are separated by slashes, with or without any of the associated species shown in brackets. Geographic subregions and land management levels are identical to those in APPENDIX A and APPENDIX B. See APPENDIX A for scientific names of species.

Appendix C. Distribution and Management Status of Species Complexes in the Southwestern California Ecoregion

	Subregion (%)						Management (%)			Area
SPECIES COMPLEX	WT	SC	SG	SB	SJ	PR	L 1	L 2	L 3	sq. km
HERBACEOUS										
Annual_Grass/Forbs_(HG)	33.8	20.4	0.4	1	0	44.5	6	17.5	76.7	1,119
Annual_Grassland/Perennial_Grassland_(HM)	0	0.3	0	13.2	0	86.5	6.8	67.2	26	92
Perennial_Grassland	0	0	0	0	0	100	10.9	0	89.1	1
Pickelweed_(HC)	0	77.2	0	0	0	3.9	21.3	18.8	35.8	13
Saltgrass_(HC)	0	100	0	0	0	0	0	0	99.9	1
Wet_Meadows_Grass/Sedge/Rush_(HJ)	1.7	4.9	0	1.4	0	92	2.4	10.9	86.6	176
DESERT_SHRUB										
Desert_scrub_(DL)	0	0	0	83.3	0	16.7	29.2	39.8	31	72
Narrow-leaved_goldenbush/Buckwheat_(DB)	71.3	0	0	0	0	28.7	0	17.7	82.3	64
Mesquite	0	0	100	0	0	0	0	91.6	8.4	41
Joshua_tree/Chamise	0	0	98	2	0	0	0	87.6	12.4	2
SAGEBRUSH_SHRUB										
Bitterbrush_(BB)										
Bitterbrush_(P_tridentata)/Great_basin_sage	100	0	0	0	0	0	0.1	61.7	38.2	27
Bitterbrush_(P_glandulosa)/Great_basin_sage	0	0	0.4	99.6	0	0	0	94.7	5.3	68
Rabbitbrush_(BR)										
Rabbitbrush	100	0	0	0	0	0	0	5	95	22
Rabbitbrush/Great_basin_sage	83.6	0	16.4	0	0	0	3.6	52.9	43.5	98
Parry_Rabbitbrush/Great_basin_sage	0	0	0	100	0	0	0	80.9	19.1	7
Great_Basin_Sage_(BS)										
Great_basin_sage/[Chamise,Scrub_oak]	15.9	0	0	0	0	84.1	0	66.4	33.6	23
Great_basin_sage/[Ags/Buckwheat]	33.2	0	3.3	13.4	0	50.1	6.1	46.9	47	125
SOFT_CHAPARRAL										

Appendix C. Distribution and Management Status of
Species Complexes in the
Southwestern California Ecoregion

			Subregion (%)					Management (%)		Area
SPECIES COMPLEX	**WT**	**SC**	**SG**	**SB**	**SJ**	**PR**	**L 1**	**L 2**	**L 3**	**sq. km**
Buckwheat_(SB)										
Buckwheat/Chap_yucca	95.7	3.1	1.1	0	0	0	12.1	53.9	34	120
Buckwheat/[Deerweed]	41.6	33.5	1.3	1.6	0.5	21.5	7.5	20.2	72.3	233
White_Sage_(SP)										
White_sage/[Deerweed,_Buckwheat,_Yerba_santa]	16.2	27.5	0.9	11.9	3.4	40.1	14.4	28.4	57.2	209
White_sage/CA_sage/[Buckwheat,Chap_yucca]	47.2	11.8	1.1	0.5	0	39.4	3.6	16.4	79.9	1,028
White_sage/Sugarbush/[Buckwheat]	0	0	0	0	0	100	1.7	12.2	86	40
White_sage/Lemonade_Berry	51.2	15.8	23.2	0	0	9.8	0	39.7	60.3	22
Purple_sage_(SP)										
Purple_sage/[Buckwheat,Deerweed,White_sage]	96.8	1.4	1.7	0	0	0	12.2	8.4	79.3	206
Black_sage_(SP)										
Black_sage/Hollylf_cherry	98.7	1.3	0	0	0	0	0	61.5	38.5	5
Black_sage/Purple_sage	98.5	1.5	0	0	0	0	8	4.6	87.5	129
Black_sage/Coastal_sage/[Deerweed,White_sage]	24.6	38.8	2.5	0	0.1	34	6.9	12.1	80.9	361
Black_sage/Buckwheat/[Deerweed]	55.2	36.4	1	0	0	7.4	0	36.3	63.6	52
Black_sage/Lemonade_berry/[CA_sage]	15.6	38.8	0	0	0	45.5	15.6	1.4	83	50
California_sagebrush_(SS)										
CA_sage/Buckwheat/[Deerweed]	16.2	18.8	0	0	0.6	64.4	3.4	31	65.6	310
CA_sage/[CA_coffeeberry,Heather_goldenbush]	34.2	30.9	0	0	1.8	33.1	1.6	29.3	69	122
CA_sage/Lemonade_berry/[Buckwheat]	0.7	24.6	0	0	0	74.7	6.3	66.9	26.8	43
Miscellaneous										
CA_encelia/[Buckwheat,CA_sage]	13.5	75.7	0.4	0	0	10.3	2	7.3	90.7	154
Laurel_sumac/[CA_sage,Buckwheat,_Ags]	0.1	8.1	1.6	0	0	90.2	0.3	35.8	63.7	168
Scale_broom/Deerweed	16.8	82.7	0	0.5	0	0	2.2	7.3	90.6	18
Coyote_bush/[Buckwheat,Annual_grassland]	17.1	46.3	0	0	0	36.6	0.8	37.8	60.6	36
Chap_yucca	98.5	0	1.5	0	0	0	32.3	5.4	62.3	11
Prickly_pear/Coastal_sage	26	29.6	2.4	0	0	42	0	41.2	58.9	44
Heather_Goldenbush/[Buckwheat,CA_sage]	1.9	80.6	0	0	1.4	16.1	9.7	15.9	74.2	40

Appendix C. Distribution and Management Status of
Species Complexes in the
Southwestern California Ecoregion

	Subregion (%)						Management (%)			Area
SPECIES COMPLEX	**WT**	**SC**	**SG**	**SB**	**SJ**	**PR**	**L 1**	**L 2**	**L 3**	**sq. km**
Laurel_sumac/Black_sage/[CA_sage]	1.4	4.7	0	0	0	94	0.7	97.8	1.4	24
Laurel_sumac/Narrowlf_goldenbush/[Buckwheat]	0	0	0	0	0	100	0	26.9	73.1	19
Mule_Fat	84.5	0	0	0	0	15.5	6.5	3.1	90.4	10
CHAPARRAL										
Semi-desert_Chaparral										
Flannelbush/Mtn_mahogany	0	0.8	98.9	0.3	0	0	22.4	69.8	7.8	28
Flannelbush/Great_basin_sage	0	0	69.2	30.8	0	0	1	90.2	8.8	28
Brittlebush/Chamise/[Buckwheat]	22.2	77.8	0	0	0	0	0	12.2	87.8	11
Buckwheat/CA_ephedra/Yucca	100	0	0	0	0	0	0	19.1	80.9	5
Desert_scrub_oak										
Desert_scrub_oak/[misc_shrubs]	17.5	0	1.6	0.5	4.9	75.5	18.7	55.6	25.7	432
Sumac_(CO)										
Lemonade_berry/[Chamise/scrub_oak/	0	100	0	0	0	0	0	0	99.9	16
Hoaryleaf ceanothus]										
Chamise_(CA)										
Chamise/CA_encelia	0	100	0	0	0	0	0	11.4	88.6	12
Chamise/CA_Sage/[Grassland]	14.6	33.2	28.6	0.1	0	23.6	3.8	23.4	72.8	118
Chamise/[Deerweed]	23.6	12	2.2	2	0	60.1	11.7	33.2	55	1,112
Chamise/Buckwheat/[Black_sage,_White_sage,	29.7	28.7	0.1	9.2	1	31.2	2.4	27	70.6	229
Chaparral_yucca]										
Chamise/Black_sage	89.1	6.4	0	0	0	4.5	1.8	31.4	66.5	168
Chamise/Mtn_mahogany	40.7	0	12	1.9	0	45.4	23.1	61.2	15.7	147
Chamise/Scrub_oak/Mtn_mahogany	76.8	2	3.7	7	0	10.6	16.8	64.3	19	346
Red_Shanks_(CR)										
Redshanks/[Buckwheat,_White_sage,	0	0	0	0	0	100	7.5	47.3	45.2	74
Antelope_bitterbrush]										
Redshanks/[Chamise,Scrub_oak,Mtn_mahogany]	1.7	0	0.7	0	0.7	96.9	12.8	48.2	38.9	549

Appendix C. Distribution and Management Status of
Species Complexes in the
Southwestern California Ecoregion

	Subregion (%)						Management (%)			Area
SPECIES COMPLEX	**WT**	**SC**	**SG**	**SB**	**SJ**	**PR**	**L 1**	**L 2**	**L 3**	**sq. km**
Redshanks/Hoarylf_ceanothus	38.1	0	0	0	0	61.9	18.5	14.4	67.1	32
Scrub_Oak_(CS)										
Scrub_oak/Chamise/[Lemonade_berry,_CA_sage]	29	15.5	7.9	6.3	0.1	41.2	14.7	36.9	48.5	151
Scrub_oak/Jim_brush	0	6.6	0	0	0	93.4	0.1	21.6	78.3	72
Scrub_oak/Buckwheat/[CA_sage, White_sage,	64.4	0	0	1.2	0	34.5	40.7	47.8	11.5	77
Black_sage, California_encelia]										
Scrub_oak/Laurel_sumac/[Chamise,	0	2.8	23.8	0	0	73.4	0	28	72	12
Mtn_mahogany]										
[Scrub_oak/Chamise/(Buckwheat,Black_sage]	57.6	0	0	3.6	0	38.8	0	11.5	88.6	8
[Scrub_oak/Chamise/Bigberry_manzanita	28.8	0	13.2	5	0	53	8.2	60.4	31.3	205
Scrub_Oak/[Mtn_mahogany,_Sugarbush]	14.1	3.3	1.1	5	0	76.5	16	47.7	36.4	150
Mountain_mahogany										
Mtn_mahogany/Buckwheat/[CA_sage,	82.7	0	17.3	0	0	0	25.3	73.6	1.1	32
White_sage, Black_sage]										
Desert_Ceanothus										
Desert_ceanothus/Chamise/[Scrub_oak,	4.2	0.9	7	21.5	12.3	54.2	9.7	62.4	27.9	841
Bigberry_manzanita]										
Bigseed_Ceanothus										
Bigseed_ceanothus/[CA_sage,Chamise,Redshanks]	88.7	3.5	0	0	0	7.8	18.5	29.4	51.8	215
Bigseed_ceanothus/Black_sage	98.7	1.3	0	0	0	0	18.9	10.4	70.8	73
Bigseed_ceanothus/Greenbark_ceanothus	99.2	0.8	0	0	0	0	18	25.5	56.6	282
Bigseed_ceanothus/Woollylf_manzanita	100	0	0	0	0	0	8.5	26.1	65.4	15
Hoaryleaf_ceanothus										
Hoarylf_ceanothus/[Buckwheat,White_sage]	14	52.3	17.1	14	0	2.6	1	32	67	55
Hoarylf_ceanothus/Chamise/	25	10.2	29.1	7.6	0	28.2	15.3	52.3	32.4	1,625
[Eastwood_manzanita, Bigberry manzanita]										
Hoarylf_ceanothus/Mtn_mahogany/	45.7	2.8	10.5	3.4	0	37.5	39.1	33.9	27	259
[Lemonade_berry, Interior_live_oak]										

Appendix C. Distribution and Management Status of
Species Complexes in the
Southwestern California Ecoregion

SPECIES COMPLEX	Subregion (%) WT	SC	SG	SB	SJ	PR	Management (%) L 1	L 2	L 3	Area sq. km
Greenbark_ceanothus										
Greenbark_ceanothus/[Chamise, Wedgeleaf_ceanothus, Scrub_oak]	80.8	5.2	0	0	0	14.1	11.1	52.5	36.5	201
Chaparral_whitethorn										
Chap_whitethorn/Woolylf_manzanita	19.2	0.1	69.5	0	2	9.2	18.6	75.4	6	171
Chap_whitethorn/Hoarylf_ceanothus	0	2.9	49.5	8.1	0	39.4	10	54.1	35.9	51
Chap_whitethorn/Desert_ceanothus	0	0	3.6	0	4.4	92	16.9	52.4	30.7	220
Chap_Whitethorn/[Chamise, Scrub_oak, Mtn_mahogany]	1.6	0.2	11	7.1	2.9	77.2	13.5	55.3	31.2	524
Chap_whitethorn/Bigberry_manzanita/ [Chamise, Scrub_oak]	0	1	20.9	6.2	33.3	38.6	6.9	53.8	39.3	51
Chap_whitethorn/Int_live_oak	6.3	0	23.2	54.4	16.2	0	6.2	83	10.3	51
Deerbrush	6.1	93.9	0	0	0	0	52.7	0.7	46.6	2
Mtn_whitethorn	15	0	6.2	77.9	0.9	0	56.1	34.8	9	89
Wedgelf_ceanothus/[Chamise,_Scrub_oak]	65.5	8.6	0	0	0.1	25.8	15.5	43.3	41.2	696
Woolylf_ceanothus/[Scrub_oak,Mexican manzanita, Chaparral_whitethorn]	0	0	0	0	0	100	6.9	33.5	59.5	50
Hairy_ceanothus										
Hairy_ceanothus/Scrub_oak/[Buckwheat, Hoaryleaf_ceanothus]	19.1	0.2	44.3	0	0	36.4	14.2	64.9	20.7	241
Hairy_ceanothus/[Chamise,Mtn_mahogany]	16.5	0.2	0.3	0	0	83.1	31.3	22.3	46.4	220
Manzanita_(CX)										
Xylococcus_bicolor/[Chamise]	0	6.3	0	0	0	93.7	3.1	36.3	59.8	212
Mexican_manzanita/[Chamise,Desert_Ceanothus]	0	0	0	0	0	100	12.1	23.8	64.2	71
Greenlf_manzanita/[Scrub_oak,_Mtn_mahogany]	0	0	0	100	0	0	6.1	77.8	16.1	8

Appendix C. Distribution and Management Status of
Species Complexes in the
Southwestern California Ecoregion

	Subregion (%)						Management (%)			Area
SPECIES COMPLEX	**WT**	**SC**	**SG**	**SB**	**SJ**	**PR**	**L 1**	**L 2**	**L 3**	**sq. km**
Eastwood_Manzanita/[Chap_Whitethorn/	0	0	0	18.3	4.5	77.2	21	55.8	23.2	24
Greenleaf_manzanita]										
Eastwood_Manzanita	0	0	0	0	0	100	5.1	57.8	37.1	14
Eastwood_manzanita/[Chamise,Scrub_oak,	12.3	0	0	15.6	4.9	67.2	2.3	65.9	31.8	129
Mtn_mahogany]										
Woollylf_manzanita/[Chamise,scrub_oak]	20.2	0	5.6	9.9	0	64.2	13.8	56.9	29.3	168
Bigberry_Manzanita/[Chamise,Mtn_mahogany,	44.7	4.2	11	3.6	4.7	31.7	13	65	21.9	550
Scrub_oak]										
Interior_Live_Oak_(Shrub_form)_(QW)										
Int_Live_Oak/Canyon_live_oak	27.6	0.1	27.4	36.9	2.2	6	27.3	60.1	12.6	265
Int_live_oak/[Chamise,Mtn_mahogany,Scrub_oak]	44.9	0.4	25.7	13.7	2.1	13.2	20.8	61.1	18.1	330
Int_live_oak/Desert_ceanothus	70.9	0	16	0	13.2	0	48	50.3	1.6	50
Int_live_oak/Woollylf_manzanita	68.9	0	31.1	0	0	0	65.9	34	0.1	15
Int_live_oak/Bigberry_manzanita	61.1	0	9.3	29.6	0	0	17.5	56	26.5	49
Int_live_oak/Eastwood_manzanita	5.4	0	11.9	32	8.2	42.5	11.4	70.9	17.8	61
Canyon_live_oak_(Shrub_form)_(QC)										
Canyon_Live_oak]	21.2	0.6	20.6	43.3	0.2	14.1	23.7	72.7	3.4	73
Canyon_Live_oak/Eastwood_Manzanita	0	0	0	5.6	0	94.4	33.2	55.9	10.9	19
Canyon_Live_oak/Chap_whitethorn/	0	1	28.2	53	16.7	1.1	23	60.7	16.3	17
Mtn_mahogany,Scrub_oak]										
Bush_chinquapin/[Greenlf_manzanita,_Mtn_whitethorn]	0	0	34.9	46.8	18.4	0	39	49.7	11.3	34
Curllf_mountain_mahogany	0	0	11.3	0	0	88.7	10.4	86.3	3.3	16
HARDWOOD_FOREST/WOODLAND										
CA_buckeye	100	0	0	0	0	0	0	66.9	33.1	8
Valley_Oak_(QL)										
Valley_Oak	99.5	0.5	0	0	0	0	0.8	3.8	95.3	27

Appendix C. Distribution and Management Status of
Species Complexes in the
Southwestern California Ecoregion

			Subregion (%)						Management (%)		Area
SPECIES COMPLEX	**WT**	**SC**	**SG**	**SB**	**SJ**	**PR**		**L 1**	**L 2**	**L 3**	**sq. km**
Valley_oak/CA_walnut	100	0	0	0	0	0		0	0	99.9	4
Valley_oak/Coast_live_oak	98.9	1.1	0	0	0	0		10.2	0	89.8	10
Blue_oak_(QD)											
Blue_oak	100	0	0	0	0	0		0	11	89	5
Engelmann_Oak_(QE)											
Engelman_oak	0	0	0	0	0	100		15.9	0	84.1	10
Engelman_oak/Coast_live_oak/Annual_grassland	0	0	0	0	0	100		0.7	35.8	63.6	66
Engelmann_oak/Chamise	0	0	0	0	0	100		0	29.8	70.2	10
Coast_Live_Oak_(QA)											
Coast_Live_Oak	39.8	8	1.4	0	0	50.8		6.2	21.4	72.5	177
Coast_Live_Oak/[CA_bay,Sycamore,White_alder]	55.2	13.7	0	0	0	31.2		14.4	33.8	51.8	44
Coast_live_oak/Willow	0	0	0	0	10.4	89.6		0	64.8	35.1	7
Coast_live_oak_[riparian]	45.3	0.9	0	0	0	53.8		1.6	29.3	69.2	38
Coast_Live_Oak/Engelman_Oak	0	0.6	0	0	0	99.4		4	33.7	62.3	139
Coast_live_oak/Engelman_oak/[Coulter_pine, Bigcone_spruce]	0	0	0	0	0	100		0	9.4	90.6	11
Coast_live_oak/Madrone	100	0	0	0	0	0		0	14.6	85.4	4
Coast_live_oak/CA_walnut	56.9	9.7	0	0	0	33.4		2.9	8.4	88.6	56
Canyon_live_oak_(QC)											
Canyon_live_oak/Int_live_oak	0	0	100	0	0	0		0	99.9	0	9
Canyon_live_oak/Coast_live_oak	4.2	0	7.1	5.2	0	83.6		22.3	57.2	20.5	55
Canyon_Live_Oak	34.5	0	28.8	11.4	3.3	22		36.6	51.7	11.5	113
Int_live_oak (tree)	0	0	100	0	0	0		0	99.6	0.4	44
Black_oak_(QK)											
Black_Oak	6.3	1.4	0	17.7	25.5	49		8.9	62.8	28.3	54
Black_oak/Canyon_live_oak	2.1	0	0	20.6	0	77.3		16.4	50.4	33.3	74
Black_oak/Coast_live_oak	0	0	0	0	0	100		22.3	2.5	75.1	13

Appendix C. Distribution and Management Status of
Species Complexes in the
Southwestern California Ecoregion

			Subregion (%)					Management (%)		Area
SPECIES COMPLEX	WT	SC	SG	SB	SJ	PR	L 1	L 2	L 3	sq. km
Black_oak/Incense_Cedar	0	0	0	13.2	0	86.8	15.7	20.7	63.5	5
Fremont_Cottonwood/[White_Alder,Willow]	23.5	25.8	3.7	27.3	0	19.7	7.2	46.2	46.7	56
White_Alder/[Willow,Sycamore]	5.7	0	7.8	73.1	0	13.4	0.2	89.9	9.9	8
Willow/[Mule_fat,_Tree_tabacco,_Giant_Reed]	14.6	68.3	0	0	0	17.1	2.1	38.8	57.9	60
CONIFER_FOREST/WOODLAND										
CA_Juniper	83.6	0	13.5	0	0	2.9	7.2	44	48.9	354
Pinyon_Pine_(PJ)										
Pinyon_pine	63	0	7.7	28.2	0	1.1	1.9	82.3	15.7	268
Pinyon_pine/Blue_oak	100	0	0	0	0	0	0	84.3	15.6	2
Pinyon_pine/Canyon_live_oak	72.1	0	0	27.9	0	0	0	80.7	19.2	23
Pinyon_pine/CA_juniper	96	0	4	0	0	0	23.4	68.3	8.4	378
Pinyon_pine/[Mtn_mahogany/Scrub_oak/	96.7	0	3.3	0	0	0	26.3	61.9	11.7	132
Bigberry_manzanita]										
Pinyon_pine/Great_basin_sage	66.9	0	10.2	22.9	0	0	9.1	72.5	18.4	72
Forbes_cypress/Mission_manzanita/Chamise	0	0	0	0	0	100	7.2	70.3	22.4	18
Knobcone_pine										
Knobcone_pine/Pinyon_pine	0	0	100	0	0	0	0	98.3	1.7	1
Knobcone_pine/Bigcone_spruce	0	0	0	100	0	0	0	91.8	8.2	5
Digger_Pine										
Digger_pine/Chamise	100	0	0	0	0	0	0	0	99.9	5
Digger_pine/Valley_oak	100	0	0	0	0	0	0	24.4	75.6	10
Coulter_Pine_(PC)										
Coulter_pine/Black_oak/Incense_Cedar	0	0	0	0	8.1	91.9	0	49.7	50.3	4
Coulter_pine	9.2	0	0	0	17.6	73.2	18.1	40.9	41.1	54
Coulter_pine/Bigcone_spruce/[Knobcone_pine]	0	0	8.8	54.9	0	36.3	5	79.1	15.9	34

Appendix C. Distribution and Management Status of Species Complexes in the Southwestern California Ecoregion

			Subregion (%)					Management (%)		Area
SPECIES COMPLEX	**WT**	**SC**	**SG**	**SB**	**SJ**	**PR**	**L 1**	**L 2**	**L 3**	**sq. km**
Coulter_pine/Black_oak/[Canyon_live_oak]	0	0.6	0	26.2	0	73.3	11.3	44.9	43.8	38
Coulter_pine/Canyon_live_oak	0	0	15.8	7.2	5.9	71.2	15.1	59.3	25.7	43
Coulter_pine/Bigcone_spruce/[White_fir,	0	0	15.4	0	0	84.6	0.1	32.4	67.5	15
Incense_cedar]										
Big-Cone_Douglas_Fir_(DF)										
Bigcone_Douglas_fir	28.3	0	40.5	23.8	0	7.4	70.1	22.8	7.1	40
Bigcone_Douglas_fir/Black_oak	12.5	0.2	0	53	0	34.3	0	63.2	36.9	29
Bigcone_Douglas_fir/Canyon_live_oak	30.3	0.1	54.8	14.8	0	0	40.7	53.4	5.8	290
Ponderosa_Pine_(PP)										
Ponderosa_Pine/Coulter_pine	0	0	49.5	0	0	50.5	3.2	49.5	47.3	11
Ponderosa_Pine_/[Single_lf_pinyon]	18.2	0	73.7	3.4	0	4.8	73.5	18.6	7.9	30
Ponderosa_pine/Black_oak/[Incense_cedar,	0	0	70.6	0	16.9	12.5	6.4	63	30.5	34
Canyon_live_oak]										
Ponderosa_pine,_Black_oak	0	0	0	100	0	0	0	36.7	63.3	1
Jeffrey_Pine_(JP)										
Jeffrey_pine	39.8	0	16.5	17.3	6.8	19.5	24.6	62.2	13.3	187
Jeffrey_Pine/Western_Juniper	0	0	0	100	0	0	0	96	4	96
Jeffrey_pine/Pinyon_pine	16.2	0	8	56.7	0	19.1	16.2	60.8	23.1	37
Jeffrey_Pine/Black_oak/[Incense_Cedar,	0	0	0	66	0	34	34	66	0	28
Coulter_pine]										
Jeffrey_pine/Coulter_pine/[Canyon_live_oak,	5.2	0	35.2	37.6	4.5	17.5	19.5	72.4	8.1	52
Coast_live_oak]										
Jeffrey_Pine/Ponderosa_Pine	0	0	26.6	58.9	14.5	0	10.5	56.1	33.4	44
Jeffrey_pine/[Coast_live_oak,_Black_oak,	0	0	0	39.7	0	60.3	13.9	68.7	17.4	55
Canyon_live_oak]										
White_Fir_(WF)										
White_fir	0	0	4.2	0	95.2	0.6	84.1	2.7	13.3	11
White_fir/Ponderosa_Pine/Coulter_pine	0	0	0	0	83.5	16.5	70.2	26.6	3.3	33
White_fir/Ponderosa_pine/[Black_oak,	0	0	0	100	0	0	0	21.8	78.2	40

Appendix C. Distribution and Management Status of
Species Complexes in the
Southwestern California Ecoregion

			Subregion (%)					Management (%)		Area
SPECIES COMPLEX	**WT**	**SC**	**SG**	**SB**	**SJ**	**PR**	**L 1**	**L 2**	**L 3**	**sq. km**
Canyon_live_oak]										
White_fir/Sugar_pine	11.3	0	52.3	18.6	9.3	8.5	41.7	51.2	7.1	235
White_fir/Jeffrey_pine/[Incense_cedar,	7.4	0	0	78.8	0	13.8	9.8	78.2	12	85
Ponderosa_pine, Pinyon_pine]										
White_fir/Jeffrey_pine	27.1	0	3.2	66.9	0	2.8	20.1	66.8	13.2	248
White_fir/Incense_cedar/Canyon_live_oak	1.3	0	0	95.2	3.5	0	55	28.5	16.4	65
White_fir/Canyon_live_oak	100	0	0	0	0	0	99.9	0	0	1
White_fir/Deerbrush	0	0	0	0	0	100	91.2	8.8	0	5
Sugar_Pine										
Sugar_pine/Ponderosa_pine,_Black_oak	0	0	0	100	0	0	0	78.8	21.2	30
Sugar_pine/Ponderosa_pine	90.3	0	9.7	0	0	0	89.9	9.7	0.4	10
Sugar_pine/Ponderosa_pine/[Jeffrey_pine,	76.5	0	0	0	0	23.5	80.8	12.8	6.4	30
Counter_pine]										
Sugar_pine/Bigcone_spruce	37.5	0	26.2	36.3	0	0	30.3	64.8	4.9	8
Sugar_pine/Incense_cedar	0	0	0	0	100	0	55.1	15.7	29.2	14
Sugar_pine/Canyon_live_oak	100	0	0	0	0	0	11.7	87.6	0.7	1
Sugar_pine/Incense_cedar/[Jeffrey_pine,	0	0	8.6	58.6	0	32.8	19.9	67.6	12.5	21
Coulter_pine]										
Lodgepole_Pine_(LP)										
Lodgepole_Pine	0	0	32.5	23.4	44.1	0	71.4	20.2	8.3	8
Lodgepole_pine/White_fir	0	0	26.9	73.1	0	0	99.3	0.7	0	4
Lodgepole_Pine/Limber_Pine	0	0	0.8	97.4	1.7	0	90.2	9.8	0	41
Limber_pine	0	0	0	0	100	0	99.9	0	0	4
Other_land_cover	10.6	76.6	0.5	0.6	0	11.7	0.7	4.1	95	11,312
REGIONAL TOTAL	**25**	**31.4**	**6.9**	**6.5**	**1.3**	**28.8**	**9.6**	**30.5**	**59.9**	**33,832**

APPENDIX D: Summary of the mapped distribution and management status of native, vertebrate species in the Southwestern California Region. Statistics pertain to areas where the habitat was mapped as "suitable" or "optimal" for breeding within the range for each species. Nomenclature follows the California Wildlife Habitat Relationships system except where more recent nomenclature has superceded it. The list excludes bats, shorebirds, and marine mammals whose habitats are not suited to gap analysis modeling, and introduced species which are not of conservation interest. Land management status includes Level 1 (managed primarily for maintenance of biodiversity), Level 2 (public lands managed for multiple uses) and Level 3 (private lands not managed primarily for maintenance of biodiversity).

Appendix D. Distribution and Management Status of Native Vertebrates in the Southwestern California Ecoregion

Species Code	Common Name	Scientific Name	L1%	L2%	L3%	Area (sq km)
	AMPHIBIANS					
A007	CALIFORNIA_NEWT	Taricha_torosa	13.1	38.4	48.5	17,980
A013	DESERT_SLENDER_SALAMANDER	Batrachoseps_aridus	61.2	28.7	10.1	40
A015	BLACK-BELLIED_SLENDER_SALAMANDER	Batrachoseps_nigriventris	15.7	40.3	44.0	11,167
A016	PACIFIC_SLENDER_SALAMANDER	Batrachoseps_pacificus	10.0	38.6	51.4	12,438
A018	TEHACHAPI_SLENDER_SALAMANDER	Batrachoseps_stebbinsi	4.0	56.6	39.4	418
A022	ARBOREAL_SALAMANDER	Aneides_lugubris	11.8	30.1	58.1	1,445
A032	WESTERN_TOAD	Bufo_boreas	8.2	32.7	59.1	1,562
A035	SOUTHWESTERN_TOAD	Bufo_microscaphus	4.9	26.3	68.9	931
A036	RED-SPOTTED_TOAD	Bufo_punctatus	11.2	36.3	52.4	255
A038	CALIFORNIA_TREEFROG	Hyla_cadaverina	15.8	46.7	37.4	234
A039	PACIFIC_TREEFROG	Hyla_regilla	9.1	32.1	58.8	722
A040	RED-LEGGED_FROG	Rana_aurora	15.8	46.7	37.4	234
A043	FOOTHILL_YELLOW-LEGGED_FROG	Rana_boylii	16.9	63.1	19.9	91
A044	MOUNTAIN_YELLOW-LEGGED_FROG	Rana_muscosa	10.6	41.9	47.6	230
A045	NORTHERN_LEOPARD_FROG	Rana_pipiens	18.2	58.2	23.5	87
	BIRDS					
B108	TURKEY_VULTURE	Cathartes_aura	13.1	40.9	45.9	24,333
B109	CALIFORNIA_CONDOR	Gymnogyps_californianus	30.8	48.4	20.8	2,967
B110	OSPREY	Pandion_haliaetus	30.9	53.8	15.3	3,367
B111	BLACK-SHOULDERED_KITE	Elanus_caeruleus	11.9	38.8	49.3	18,432
B113	BALD_EAGLE	Haliaeetus_leucocephalus	11.8	40.2	48.0	17,643
B114	NORTHERN_HARRIER	Circus_cyaneus	3.0	18.0	79.0	8,279
B115	SHARP-SHINNED_HAWK	Accipiter_striatus	24.4	58.2	17.4	6,763
B116	COOPER'S_HAWK	Accipiter_cooperii	9.7	30.4	59.9	29,814
B117	NORTHERN_GOSHAWK	Accipiter_gentilis	34.0	53.6	12.3	2,846
B119	RED-SHOULDERED_HAWK	Buteo_lineatus	8.9	36.5	54.6	17,580
B121	SWAINSON'S_HAWK	Buteo_swainsoni	0.0	95.1	4.9	354
B123	RED-TAILED_HAWK	Buteo_jamaicensis	9.8	30.9	59.3	30,402
B126	GOLDEN_EAGLE	Aquila_chrysaetos	12.6	42.2	45.2	20,278
B127	AMERICAN_KESTREL	Falco_sparverius	9.8	30.3	59.9	31,897
B129	PEREGRINE_FALCON	Falco_peregrinus	9.4	29.5	61.1	32,128
B131	PRAIRIE_FALCON	Falco_mexicanus	20.7	56.9	22.4	6,800
B134	BLUE_GROUSE	Dendragapus_obscurus	53.2	39.6	7.2	620
B139	GAMBEL'S_QUAIL	Callipepla_gambelii	23.1	43.8	33.2	265
B140	CALIFORNIA_QUAIL	Callipepla_californica	11.8	37.2	51.0	27,136
B141	MOUNTAIN_QUAIL	Oreortyx_pictus	13.5	42.2	44.3	22,758
B251	BAND-TAILED_PIGEON	Columba_fasciata	14.2	41.2	44.6	18,808
B254	WHITE-WINGED_DOVE	Zenaida_asiatica	16.4	39.9	43.8	250
B255	MOURNING_DOVE	Zenaida_macroura	8.7	28.6	62.7	28,159
B257	COMMON_GROUND-DOVE	Columbina_passerina	0.7	3.9	95.3	9,594
B259	YELLOW-BILLED_CUCKOO	Coccyzus_americanus	3.6	25.1	71.3	1,876
B260	GREATER_ROADRUNNER	Geococcyx_californianus	11.1	49.6	39.4	782
B262	COMMON_BARN_OWL	Tyto_alba	8.9	29.8	61.4	32,629
B263	FLAMMULATED_OWL	Otus_flammeolus	15.1	55.6	29.3	7,544
B264	WESTERN_SCREECH_OWL	Otus_kennicottii	9.1	30.6	60.3	28,526
B265	GREAT_HORNED_OWL	Bubo_virginianus	9.8	30.9	59.3	30,391
B267	NORTHERN_PYGMY_OWL	Glaucidium_gnoma	13.0	41.0	46.0	20,536
B269	BURROWING_OWL	Athene_cunicularia	11.6	35.8	52.6	24,750
B270	SPOTTED_OWL	Strix_occidentalis	18.3	35.6	46.1	7,697
B272	LONG-EARED_OWL	Asio_otus	14.7	49.6	35.7	7,330
B273	SHORT-EARED_OWL	Asio_flammeus	1.1	6.2	92.7	11,553
B274	NORTHERN_SAW-WHET_OWL	Aegolius_acadicus	18.2	53.2	28.6	6,667
B275	LESSER_NIGHTHAWK	Chordeiles_acutipennis	18.3	48.8	32.9	365

Appendix D. Distribution and Management Status of Native Vertebrates in the Southwestern California Ecoregion

Species Code	Common Name	Scientific Name	L1%	L2%	L3%	Area (sq km)
B276	COMMON_NIGHTHAWK	Chordeiles_minor	3.1	78.5	18.4	831
B277	COMMON_POORWILL	Phalaenoptilus_nuttallii	13.3	42.1	44.6	23,113
B278	WHIP-POOR-WILL	Caprimulgus_vociferus	25.5	60.2	14.2	1,030
B279	BLACK_SWIFT	Cypseloides_niger	21.3	48.6	30.0	99
B282	WHITE-THROATED_SWIFT	Aeronautes_saxatalis	29.9	26.8	43.2	259
B286	BLACK-CHINNED_HUMMINGBIRD	Archilochus_alexandri	9.4	37.3	53.3	15,668
B287	ANNA'S_HUMMINGBIRD	Calypte_anna	8.8	29.4	61.8	31,302
B288	COSTA'S_HUMMINGBIRD	Calypte_costae	11.8	40.3	47.9	21,656
B289	CALLIOPE_HUMMINGBIRD	Stellula_calliope	35.7	52.7	11.6	2,815
B292	ALLEN'S_HUMMINGBIRD	Selasphorus_sasin	9.6	16.2	74.3	3,648
B293	BELTED_KINGFISHER	Ceryle_alcyon	13.4	41.1	45.5	18,213
B294	LEWIS'_WOODPECKER	Melanerpes_lewis	15.3	46.8	37.9	15,840
B296	ACORN_WOODPECKER	Melanerpes_formicivorus	14.2	42.1	43.7	18,501
B298	YELLOW-BELLIED_SAPSUCKER	Sphyrapicus_varius	22.2	56.3	21.6	2,543
B299	RED-BREASTED_SAPSUCKER	Sphyrapicus_ruber	30.7	55.5	13.8	3,733
B300	WILLIAMSON'S_SAPSUCKER	Sphyrapicus_thyroideus	34.4	54.8	10.9	2,215
B301	LADDER-BACKED_WOODPECKER	Picoides_scalaris	11.3	57.7	31.0	365
B302	NUTTALL'S_WOODPECKER	Picoides_nuttallii	13.5	40.9	45.5	19,548
B303	DOWNY_WOODPECKER	Picoides_pubescens	15.3	40.8	43.9	14,831
B304	HAIRY_WOODPECKER	Picoides_villosus	23.7	48.8	27.5	5,666
B305	WHITE-HEADED_WOODPECKER	Picoides_albolarvatus	30.5	53.4	16.2	2,198
B307	NORTHERN_FLICKER	Colaptes_auratus	13.9	42.6	43.6	21,359
B309	OLIVE-SIDED_FLYCATCHER	Contopus_borealis	32.5	54.4	13.1	3,721
B311	WESTERN_WOOD-PEWEE	Contopus_sordidulus	13.9	42.0	44.0	20,670
B315	WILLOW_FLYCATCHER	Empidonax_traillii	0.0	40.0	60.0	18
B318	DUSKY_FLYCATCHER	Empidonax_oberholseri	30.9	56.0	13.1	3,848
B319	GRAY_FLYCATCHER	Empidonax_wrightii	2.8	72.2	25.0	202
B320	WESTERN_FLYCATCHER (Pacific Slope)	Empidonax_difficillis	13.7	40.5	45.8	17,961
B321	BLACK_PHOEBE	Sayornis_nigricans	11.5	35.8	52.7	21,661
B323	SAY'S_PHOEBE	Sayornis_saya	12.4	58.0	29.6	3,481
B324	VERMILION_FLYCATCHER	Pyrocephalus_rubinus	16.2	44.3	39.5	143
B326	ASH-THROATED_FLYCATCHER	Myiarchus_cinerascens	12.1	41.7	46.2	21,836
B328	BROWN-CRESTED_FLYCATCHER	Myiarchus_tyrannulus	9.6	48.4	42.0	135
B331	CASSIN'S_KINGBIRD	Tyrannus_vociferans	13.1	41.0	46.0	24,186
B333	WESTERN_KINGBIRD	Tyrannus_verticalis	11.3	39.7	49.0	17,672
B337	HORNED_LARK	Eremophila_alpestris	3.7	18.0	78.3	9,235
B338	PURPLE_MARTIN	Progne_subis	6.4	21.9	71.7	13,461
B339	TREE_SWALLOW	Tachycineta_bicolor	9.7	25.2	65.1	4,658
B340	VIOLET-GREEN_SWALLOW	Tachycineta_thalassina	13.3	40.8	45.9	16,923
B341	NORTHERN_ROUGH-WINGED_SWALLOW	Stelgidopteryx_serripennis	13.5	40.8	45.7	17,996
B343	CLIFF_SWALLOW	Hirundo_pyrrhonota	9.0	28.9	62.1	28,151
B344	BARN_SWALLOW	Hirundo_rustica	6.3	21.4	72.3	6,217
B346	STELLER'S_JAY	Cyanocitta_stelleri	28.0	50.1	21.9	5,050
B348	SCRUB_JAY	Aphelocoma_coerulescens	8.9	30.5	60.6	32,181
B349	PINYON_JAY	Gymnorhinus_cyanocephalus	21.6	61.3	17.1	2,502
B350	CLARK'S_NUTCRACKER	Nucifraga_columbiana	17.8	68.5	13.7	2,365
B352	YELLOW-BILLED_MAGPIE	Pica_nuttalli	0.2	40.3	59.5	527
B353	AMERICAN_CROW	Corvus_brachyrhynchos	6.3	25.3	68.4	22,250
B354	COMMON_RAVEN	Corvus_corax	22.5	65.4	12.0	938
B356	MOUNTAIN_CHICKADEE	Parus_gambeli	10.4	25.6	64.0	16,124
B358	PLAIN_TITMOUSE	Parus_inornatus	8.0	30.0	62.0	27,173
B359	VERDIN	Auriparus_flaviceps	16.0	56.9	27.1	381
B360	BUSHTIT	Psaltriparus_minimus	8.4	29.9	61.6	31,357
B361	RED-BREASTED_NUTHATCH	Sitta_canadensis	33.0	52.5	14.5	1,785
B362	WHITE-BREASTED_NUTHATCH	Sitta_carolinensis	14.0	42.6	43.4	20,952

Appendix D. Distribution and Management Status
of Native Vertebrates in
the Southwestern California Ecoregion

Species Code	Common Name	Scientific Name	L1%	L2%	L3%	Area (sq km)
B363	PYGMY_NUTHATCH	Sitta_pygmaea	26.7	57.8	15.4	1,509
B364	BROWN_CREEPER	Certhia_americana	31.9	54.1	14.0	4,237
B366	ROCK_WREN	Salpinctes_obsoletus	10.5	35.2	54.3	13,118
B367	CANYON_WREN	Catherpes_mexicanus	29.9	26.8	43.2	259
B368	BEWICK'S_WREN	Thryomanes_bewickii	13.7	42.4	44.0	22,689
B369	HOUSE_WREN	Troglodytes_aedon	13.8	40.5	45.7	18,831
B370	WINTER_WREN	Troglodytes_troglodytes	19.2	41.7	39.1	8,322
B372	MARSH_WREN	Cistothorus_palustris	8.9	32.1	59.0	757
B373	AMERICAN_DIPPER	Cinclus_mexicanus	18.8	44.9	36.3	8,241
B375	GOLDEN-CROWNED_KINGLET	Regulus_satrapa	29.9	56.2	14.0	4,530
B376	RUBY-CROWNED_KINGLET	Regulus_calendula	33.0	52.5	14.5	1,785
B377	BLUE-GRAY_GNATCATCHER	Polioptila_caerulea	14.5	48.4	37.1	16,394
B378	CALIFORNIA_GNATCATCHER	Polioptila_californica	5.3	28.6	66.1	3,924
B380	WESTERN_BLUEBIRD	Sialia_mexicana	14.1	41.1	44.8	19,507
B381	MOUNTAIN_BLUEBIRD	Sialia_currucoides	88.7	8.8	2.5	75
B382	TOWNSEND'S_SOLITAIRE	Myadestes_townsendi	29.8	56.2	14.0	3,997
B385	SWAINSON'S_THRUSH	Catharus_ustulatus	14.2	40.5	45.3	14,750
B386	HERMIT_THRUSH	Catharus_guttatus	28.3	57.6	14.1	4,651
B389	AMERICAN_ROBIN	Turdus_migratorius	9.8	29.1	61.2	28,651
B391	WRENTIT	Chamaea_fasciata	12.5	41.0	46.5	19,940
B393	NORTHERN_MOCKINGBIRD	Mimus_polyglottos	9.4	29.9	60.7	31,894
B394	SAGE_THRASHER	Oreoscoptes_montanus	0.0	90.9	9.1	27
B398	CALIFORNIA_THRASHER	Toxostoma_redivivum	12.4	39.7	47.9	22,279
B400	LE_CONTE'S_THRASHER	Toxostoma_lecontei	31.6	40.0	28.4	119
B407	CEDAR_WAXWING	Bombycilla_cedrorum	6.0	24.6	69.4	24,198
B408	PHAINOPEPLA	Phainopepla_nitens	9.5	37.8	52.7	16,019
B410	LOGGERHEAD_SHRIKE	Lanius_ludovicianus	11.8	40.5	47.7	23,011
B413	BELL'S_VIREO	Vireo_bellii	9.7	36.4	53.9	9,668
B414	GRAY_VIREO	Vireo_vicinior	4.2	70.2	25.6	475
B415	SOLITARY_VIREO	Vireo_solitarius	17.0	51.6	31.4	13,357
B417	HUTTON'S_VIREO	Vireo_huttoni	12.7	39.1	48.2	18,472
B418	WARBLING_VIREO	Vireo_gilvus	17.7	43.1	39.2	9,739
B425	ORANGE-CROWNED_WARBLER	Vermivora_celata	11.6	39.4	49.0	21,338
B426	NASHVILLE_WARBLER	Vermivora_ruficapilla	31.1	58.7	10.3	2,195
B427	VIRGINIA'S_WARBLER	Vermivora_virginiae	19.7	68.1	12.2	806
B428	LUCY'S_WARBLER	Vermivora_luciae	20.3	44.9	34.7	197
B430	YELLOW_WARBLER	Dendroica_petechia	13.8	40.8	45.4	18,197
B435	YELLOW-RUMPED_WARBLER	Dendroica_coronata	29.8	56.2	14.0	3,999
B436	BLACK-THROATED_GRAY_WARBLER	Dendroica_nigrescens	21.3	60.7	18.0	4,607
B438	HERMIT_WARBLER	Dendroica_occidentalis	26.6	60.4	13.0	1,810
B460	MACGILLIVRAY'S_WARBLER	Oporornis_tolmiei	22.4	66.2	11.5	1,849
B461	COMMON_YELLOWTHROAT	Geothlypis_trichas	12.8	40.2	47.0	17,884
B463	WILSON'S_WARBLER	Wilsonia_pusilla	15.6	36.4	48.0	10,432
B467	YELLOW-BREASTED_CHAT	Icteria_virens	9.6	38.4	52.1	15,584
B469	SUMMER_TANAGER	Piranga_rubra	13.5	44.2	42.3	173
B471	WESTERN_TANAGER	Piranga_ludoviciana	25.5	59.0	15.4	6,229
B475	BLACK-HEADED_GROSBEAK	Pheucticus_melanocephalus	13.9	42.4	43.7	20,847
B476	BLUE_GROSBEAK	Guiraca_caerulea	9.5	37.6	52.9	14,165
B477	LAZULI_BUNTING	Passerina_amoena	13.5	42.4	44.1	22,155
B482	GREEN-TAILED_TOWHEE	Pipilo_chlorurus	21.8	62.3	15.9	3,555
B483	RUFOUS-SIDED_TOWHEE	Pipilo_erythrophthalmus	13.1	41.0	45.9	24,117
B484	BROWN_TOWHEE	Pipilo_fuscus	8.3	28.9	62.8	30,602
B487	RUFOUS-CROWNED_SPARROW	Aimophila_ruficeps	12.6	41.7	45.6	19,464
B489	CHIPPING_SPARROW	Spizella_passerina	13.9	42.7	43.4	21,041
B491	BREWER'S_SPARROW	Spizella_breweri	11.9	62.0	26.1	2,599

Appendix D. Distribution and Management Status of Native Vertebrates in the Southwestern California Ecoregion

Species Code	Common Name	Scientific Name	L1%	L2%	L3%	Area (sq km)
B493	BLACK-CHINNED_SPARROW	Spizella_atrogularis	14.3	48.9	36.8	16,824
B494	VESPER_SPARROW	Pooecetes_gramineus	1.4	67.6	31.0	523
B495	LARK_SPARROW	Chondestes_grammacus	14.2	46.1	39.7	19,098
B496	BLACK-THROATED_SPARROW	Amphispiza_bilineata	7.5	63.9	28.6	725
B497	SAGE_SPARROW	Amphispiza_belli	12.7	43.9	43.3	20,414
B499	SAVANNAH_SPARROW	Passerculus_sandwichensis	7.0	28.9	64.2	9,627
B501	GRASSHOPPER_SPARROW	Ammodramus_savannarum	6.4	26.9	66.7	1,045
B504	FOX_SPARROW	Passerella_iliaca	24.2	57.7	18.1	7,005
B505	SONG_SPARROW	Melospiza_melodia	9.0	28.9	62.1	30,772
B506	LINCOLN'S_SPARROW	Melospiza_lincolnii	26.8	53.8	19.4	3,883
B510	WHITE-CROWNED_SPARROW	Zonotrichia_leucophrys	13.7	35.2	51.0	11,512
B512	DARK-EYED_JUNCO	Junco_hyemalis	14.0	42.4	43.6	20,902
B519	RED-WINGED_BLACKBIRD	Agelaius_phoeniceus	9.1	36.7	54.3	18,021
B520	TRICOLORED_BLACKBIRD	Agelaius_tricolor	9.0	31.5	59.5	786
B521	WESTERN_MEADOWLARK	Sturnella_neglecta	5.0	21.4	73.6	14,213
B522	YELLOW-HEADED_BLACKBIRD	Xanthocephalus_xanthocepha	1.0	10.7	88.3	2,390
B524	BREWER'S_BLACKBIRD	Euphagus_cyanocephalus	9.7	30.7	59.6	30,850
B528	BROWN-HEADED_COWBIRD	Molothrus_ater	9.4	30.0	60.7	32,833
B530	HOODED_ORIOLE	Icterus_cucullatus	0.8	5.4	93.8	10,917
B532	NORTHERN_ORIOLE	Icterus_galbula	9.4	29.3	61.3	28,896
B533	SCOTT'S_ORIOLE	Icterus_parisorum	1.9	66.9	31.3	983
B536	PURPLE_FINCH	Carpodacus_purpureus	14.7	41.8	43.4	18,473
B537	CASSIN'S_FINCH	Carpodacus_cassinii	30.5	58.3	11.1	1,240
B538	HOUSE_FINCH	Carpodacus_mexicanus	8.2	29.7	62.1	28,566
B539	RED_CROSSBILL	Loxia_curvirostra	56.9	27.1	16.0	12
B542	PINE_SISKIN	Carduelis_pinus	43.0	49.1	7.9	515
B543	LESSER_GOLDFINCH	Carduelis_psaltria	13.1	41.0	45.9	23,959
B544	LAWRENCE'S_GOLDFINCH	Carduelis_lawrencei	13.9	43.1	43.0	20,293
B545	AMERICAN_GOLDFINCH	Carduelis_tristis	9.8	37.6	52.7	14,540
B546	EVENING_GROSBEAK	Coccothraustes_vespertinus	34.3	53.3	12.4	324
	MAMMALS					
M004	DUSKY_SHREW	Sorex_monticolus	27.3	60.1	12.6	1,429
M006	ORNATE_SHREW	Sorex_ornatus	13.8	40.2	46.0	19,857
M012	TROWBRIDGE'S_SHREW	Sorex_trowbridgii	87.8	8.8	3.4	29
M014	DESERT_SHREW	Notiosorex_crawfordi	14.9	49.5	35.6	13,288
M018	BROAD-FOOTED_MOLE	Scapanus_latimanus	11.3	35.4	53.3	21,995
M019	CALIFORNIA_LEAF-NOSED_BAT	Macrotus_californicus	98.6	0.0	1.4	17
M021	LITTLE_BROWN_MYOTIS	Myotis_lucifugus	51.4	30.8	17.8	35
M023	YUMA_MYOTIS	Myotis_yumanensis	0.4	3.6	96.0	10,510
M025	LONG-EARED_MYOTIS	Myotis_evotis	14.0	42.6	43.4	21,113
M026	FRINGED_MYOTIS	Myotis_thysanodes	29.9	26.8	43.2	259
M027	LONG-LEGGED_MYOTIS	Myotis_volans	14.0	42.6	43.4	21,115
M028	CALIFORNIA_MYOTIS	Myotis_californicus	9.7	30.8	59.4	33,075
M029	SMALL-FOOTED_MYOTIS	Myotis_leibii	1.6	6.6	91.8	12,122
M031	WESTERN_PIPISTRELLE	Pipistrellus_hesperus	29.9	26.8	43.2	259
M032	BIG_BROWN_BAT	Eptesicus_fuscus	9.7	30.9	59.5	33,095
M033	RED_BAT	Lasiurus_borealis	9.8	30.5	59.7	29,912
M034	HOARY_BAT	Lasiurus_cinereus	14.1	41.1	44.8	19,508
M037	TOWNSEND'S_BIG-EARED_BAT	Plecotus_townsendii	29.9	26.8	43.2	259
M038	PALLID_BAT	Antrozous_pallidus	8.6	28.9	62.5	29,429
M039	BRAZILIAN_FREE-TAILED_BAT	Tadarida_brasiliensis	1.1	4.1	94.8	10,769
M040	POCKETED_FREE-TAILED_BAT	Tadarida_femorosacca	40.6	24.6	34.9	86
M041	BIG_FREE-TAILED_BAT	Tadarida_macrotis	0.1	6.0	94.0	880
M045	BRUSH_RABBIT	Sylvilagus_bachmani	9.2	28.2	62.6	31,607

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Species Code	Common Name	Scientific Name	L1%	L2%	L3%	Area (sq km)
M047	DESERT_COTTONTAIL	Sylvilagus_audubonii	9.1	30.1	60.8	33,024
M051	BLACK-TAILED_HARE	Lepus_californicus	11.8	37.3	50.9	27,130
M060	MERRIAM'S_CHIPMUNK	Tamias_merriami	14.5	46.1	39.4	18,660
M061	CALIFORNIA_CHIPMUNK	Tamias_obscurus	9.9	60.3	29.8	3,206
M063	LODGEPOLE_CHIPMUNK	Tamias_speciosus	29.7	59.4	11.0	355
M067	WHITE-TAILED_ANTELOPE_SQUIRREL	Ammospermophilus_leucurus	5.5	56.3	38.3	1,313
M068	SAN_JOAQUIN_ANTELOPE_SQUIRREL	Ammospermophilus_nelsoni	29.8	30.4	39.7	52
M072	CALIFORNIA_GROUND_SQUIRREL	Spermophilus_beecheyi	9.6	30.5	59.9	33,676
M074	ROUND-TAILED_GROUND_SQUIRREL	Spermophilus_tereticaudus	31.6	40.0	28.4	119
M075	GOLDEN-MANTLED_GROUND_SQUIRREL	Spermophilus_lateralis	11.7	65.0	23.3	2,260
M077	WESTERN_GRAY_SQUIRREL	Sciurus_griseus	14.9	44.2	40.9	14,391
M080	NORTHERN_FLYING_SQUIRREL	Glaucomys_sabrinus	20.7	58.8	20.6	3,338
M081	BOTTA'S_POCKET_GOPHER	Thomomys_bottae	9.6	30.5	59.9	33,743
M086	LITTLE_POCKET_MOUSE	Perognathus_longimembris	5.2	30.3	64.5	6,538
M087	SAN_JOAQUIN_POCKET_MOUSE	Perognathus_inornatus	25.2	53.4	21.4	2,529
M089	WHITE-EARED_POCKET_MOUSE	Perognathus_alticola	3.0	69.9	27.1	1,508
M091	LONG-TAILED_POCKET_MOUSE	Perognathus_formosus	11.2	65.9	22.9	385
M092	BAILEY'S_POCKET_MOUSE	Perognathus_baileyi	61.2	28.7	10.1	40
M093	DESERT_POCKET_MOUSE	Perognatus_penicillatus	17.2	57.7	25.1	356
M094	SAN_DIEGO_POCKET_MOUSE	Perognathus_fallax	9.8	43.6	46.6	12,786
M095	CALIFORNIA_POCKET_MOUSE	Perognathus_californicus	13.1	41.6	45.3	22,180
M096	SPINY_POCKET_MOUSE	Perognathus_spinatus	56.6	27.1	16.4	65
M100	CHISEL-TOOTHED_KANGAROO_RAT	Dipodomys_microps	15.5	56.6	27.8	373
M103	PACIFIC_KANGAROO_RAT	Dipodomys_agilis	12.5	40.5	47.0	23,491
M104	HEERMANN'S_KANGAROO_RAT	Dipodomys_heermanni	6.5	39.0	54.6	663
M106	GIANT_KANGAROO_RAT	Dipodomys_ingens	31.3	28.6	40.0	49
M107	PANAMINT_KANGAROO_RAT	Dipodomys_panamintinus	2.2	68.6	29.2	2,242
M108	STEPHENS'_KANGAROO_RAT	Dipodomys_stephensi	8.0	41.4	50.6	360
M109	DESERT_KANGAROO_RAT	Dipodomys_deserti	21.6	43.8	34.5	283
M110	MERRIAM'S_KANGAROO_RAT	Dipodomys_merriami	10.1	51.1	38.8	7,417
M112	BEAVER	Castor_canadensis	9.7	25.5	64.7	571
M113	WESTERN_HARVEST_MOUSE	Reithrodontomys_megalotis	11.8	37.1	51.0	27,253
M115	CACTUS_MOUSE	Peromyscus_eremicus	13.3	42.5	44.3	19,287
M116	CALIFORNIA_MOUSE	Peromyscus_californicus	13.9	42.6	43.5	22,666
M117	DEER_MOUSE	Peromyscus_maniculatus	9.6	30.5	59.9	33,792
M118	CANYON_MOUSE	Peromyscus_crinitus	16.0	57.7	26.3	3,004
M119	BRUSH_MOUSE	Peromyscus_boylii	13.1	41.0	45.9	24,321
M120	PINYON_MOUSE	Peromyscus_truei	14.0	44.7	41.3	19,374
M122	SOUTHERN_GRASSHOPPER_MOUSE	Onychomys_torridus	10.1	45.5	44.4	15,756
M125	WHITE-THROATED_WOODRAT	Neotoma_albigula	25.3	43.4	31.3	102
M126	DESERT_WOODRAT	Neotoma_lepida	13.4	43.2	43.4	21,559
M127	DUSKY-FOOTED_WOODRAT	Neotoma_fuscipes	13.2	40.3	46.4	23,353
M134	CALIFORNIA_VOLE	Microtus_californicus	8.9	28.9	62.2	31,732
M136	LONG-TAILED_VOLE	Microtus_longicaudus	16.4	67.2	16.3	1,128
M139	MUSKRAT	Ondatra_zibethicus	0.0	77.4	22.6	574
M145	PORCUPINE	Erethizon_dorsatum	21.7	48.1	30.2	7,425
M146	COYOTE	Canis_latrans	13.2	41.0	45.8	24,390
M147	RED_FOX	Vulpes_vulpes	31.0	28.3	40.6	2,943
M148	KIT_FOX	Vulpes_macrotis	9.8	62.4	27.9	2,272
M149	GRAY_FOX	Urocyon_cinereoargenteus	13.1	41.0	45.9	24,353
M151	BLACK_BEAR	Ursus_americanus	22.4	59.0	18.6	5,236
M152	RINGTAIL	Bassariscus_astutus	13.1	41.0	45.9	24,304
M153	RACCOON	Procyon_lotor	13.2	41.0	45.8	24,225
M157	LONG-TAILED_WEASEL	Mustela_frenata	13.1	40.9	45.9	24,312
M160	BADGER	Taxidea_taxus	13.7	42.3	44.0	23,482

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Species Code	Common Name	Scientific Name	L1%	L2%	L3%	Area (sq km)
M161	WESTERN_SPOTTED_SKUNK	Spilogale_gracilis	13.1	41.0	45.9	24,304
M162	STRIPED_SKUNK	Mephitis_mephitis	11.8	37.2	51.1	27,212
M165	MOUNTAIN_LION	Felis_concolor	13.3	41.1	45.6	23,935
M166	BOBCAT	Lynx_rufus	13.2	41.0	45.8	24,390
M177	ELK	Cervus_elaphus	4.7	59.2	36.2	397
M181	MULE_DEER	Odocoileus_hemionus	13.2	41.1	45.8	24,217
M182	PRONGHORN	Antilocapra_americana	0.6	52.8	46.6	561
M183	MOUNTAIN_SHEEP	Ovis_canadensis	31.6	40.0	28.4	119
	REPTILES					
R004	WESTERN_POND_TURTLE	Clemmys_marmorata	12.7	39.1	48.2	21,931
R005	DESERT_TORTOISE	Gopherus_agassizi	16.6	45.7	37.7	79
R007	BAREFOOT_BANDED_GECKO	Coleonyx_swaitaki	2.8	39.3	57.9	33
R008	BANDED_GECKO	Coleonyx_variegatus	31.6	40.0	28.4	119
R009	LEAF-TOED_GECKO	Phyllodactylus_xanti	16.7	50.5	32.7	3,311
R010	DESERT_IGUANA	Dipsosaurus_dorsalis	16.6	45.7	37.7	79
R011	CHUCKWALLA	Sauromalus_obesus	32.3	34.5	33.2	149
R012	ZEBRA-TAILED_LIZARD	Callisaurus_draconoides	31.6	40.0	28.4	119
R013	COLORADO_DESERT_FRINGE-TOED_LIZARD	Uma_notata	61.2	28.7	10.1	40
R014	COACHELLA_VALLEY_FRINGE-TOED_LIZAR	Uma_inornata	49.1	24.5	26.5	25
R017	BLACK-COLLARED_LIZARD	Crotaphytus_insularis	5.5	67.0	27.4	944
R018	LONG-NOSED_LEOPARD_LIZARD	Gambelia_wislizenii	7.2	62.6	30.2	613
R019	BLUNT-NOSED_LEOPARD_LIZARD	Gambelia_silus	17.1	59.1	23.8	619
R021	GRANITE_SPINY_LIZARD	Sceloporus_orcutti	12.0	45.1	42.9	4,929
R022	WESTERN_FENCE_LIZARD	Sceloporus_occidentalis	13.0	40.9	46.1	24,396
R023	SAGEBRUSH_LIZARD	Sceloporus_graciosus	20.4	58.9	20.7	6,767
R024	SIDE-BLOTCHED_LIZARD	Uta_stansburiana	11.8	40.5	47.7	23,064
R025	LONG-TAILED_BRUSH_LIZARD	Urosaurus_graciosus	14.3	52.4	33.2	432
R027	SMALL-SCALED_LIZARD	Urosaurus_microscutatus	21.1	42.5	36.4	85
R028	BANDED_ROCK_LIZARD	Petrosaurus_mearnsi	31.3	20.4	48.3	53
R029	COAST_HORNED_LIZARD	Phrynosoma_coronatum	11.6	39.8	48.7	22,023
R030	DESERT_HORNED_LIZARD	Phrynosoma_platyrhinos	12.3	59.8	27.8	506
R032	FLAT-TAILED_HORNED_LIZARD	Phrynosoma_mcalli	53.5	25.7	20.8	69
R033	GRANITE_NIGHT_LIZARD	Xantusia_henshawi	11.2	42.4	46.3	5,756
R034	DESERT_NIGHT_LIZARD	Xantusia_vigilis	31.6	40.0	28.4	119
R036	WESTERN_SKINK	Eumeces_skiltonianus	12.6	40.9	46.4	23,911
R037	GILBERT'S_SKINK	Eumeces_gilberti	12.7	42.5	44.9	18,896
R038	ORANGE-THROATED_WHIPTAIL	Cnemidophorus_hyperythrus	8.5	37.9	53.6	8,926
R039	WESTERN_WHIPTAIL	Cnemidophorus_tigris	14.0	47.8	38.1	17,776
R040	SOUTHERN_ALLIGATOR_LIZARD	Gerrhonotus_multicarinatus	12.4	39.7	47.8	22,346
R043	CALIFORNIA_LEGLESS_LIZARD	Anniella_pulchra	11.7	40.0	48.3	21,350
R045	WESTERN_BLIND_SNAKE	Leptotyphlops_humilis	11.9	39.3	48.8	21,417
R046	RUBBER_BOA	Charina_bottae	30.8	52.4	16.9	1,469
R047	ROSY_BOA	Lichanura_trivirgata	9.1	45.1	45.9	14,189
R048	RINGNECK_SNAKE	Diadophis_punctatus	11.6	39.6	48.8	21,652
R050	SPOTTED_LEAF-NOSED_SNAKE	Phyllorhynchus_decurtatus	14.7	52.7	32.6	421
R051	RACER	Coluber_constrictor	12.6	41.0	46.5	24,164
R052	COACHWHIP	Masticophis_flagellum	11.1	49.6	39.4	782
R053	CALIFORNIA_WHIPSNAKE	Masticophis_lateralis	12.3	40.9	46.8	19,984
R055	WESTERN_PATCH-NOSED_SNAKE	Salvadora_hexalepis	11.7	39.9	48.4	21,929
R056	GLOSSY_SNAKE	Arizona_elegans	2.2	14.1	83.7	4,495
R057	GOPHER_SNAKE	Pituophis_melanoleucus	11.8	37.2	51.0	27,214
R058	COMMON_KINGSNAKE	Lampropeltis_getulus	10.5	36.7	52.8	25,957
R059	CALIFORNIA_MOUNTAIN_KINGSNAKE	Lampropeltis_zonata	16.0	43.2	40.8	16,787
R060	LONG-NOSED_SNAKE	Rhinocheilus_lecontei	8.8	39.3	51.8	6,343

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Species Code	Common Name	Scientific Name	L1%	L2%	L3%	Area (sq km)
R061	COMMON_GARTER_SNAKE	Thamnophis_sirtalis	12.5	37.2	50.3	19,931
R062	WESTERN_TERRESTRIAL_GARTER_SNAKE	Thamnophis_elegans	9.6	49.7	40.6	3,562
R063	WESTERN_AQUATIC_GARTER_SNAKE	Thamnophis_couchi	13.2	40.2	46.6	23,493
R067	WESTERN_SHOVEL-NOSED_SNAKE	Chionactis_occipitalis	34.2	34.5	31.2	164
R068	WESTERN_BLACK-HEADED_SNAKE	Tantilla_planiceps	12.3	41.3	46.4	21,620
R070	LYRE_SNAKE	Trimorphodon_biscutatus	7.3	26.2	66.5	7,504
R071	NIGHT_SNAKE	Hypsiglena_torquata	11.9	40.6	47.5	21,634
R072	WESTERN_DIAMONDBACK_RATTLESNAKE	Crotalus_atrox	23.3	43.3	33.3	262
R073	RED_DIAMOND_RATTLESNAKE	Crotalus_ruber	10.9	43.5	45.6	8,592
R074	SPECKLED_RATTLESNAKE	Crotalus_mitchelli	20.4	51.2	28.4	1,198
R075	SIDEWINDER	Crotalus_cerastes	31.6	40.0	28.4	119
R076	WESTERN_RATTLESNAKE	Crotalus_viridis	12.9	41.0	46.1	24,359

APPENDIX E: List of vegetation mapping for the Southwestern California Region, including map coverage, source agency, date of source material, sources used, intended scale of use, classification system, minimum mapping unit or pixel resolution. Most are digital maps, except for the VTM maps of the Forest Service.

Vegetation Mapping Sources
for the Southwestern California Ecoregion

Map Coverage	Source Agency	Source	Source Date	Intended Scale of Use	Classification System	MMU (ha)
CALVEG	US Forest Service	Landsat MSS	1976	250,000	CALVEG	320
Hardwoods	Pillsbury, Cal Poly, SLO (CDF)	b/w and color IR aeria	1981	100,000	species/density	16
MSCP planning area	OGDEN, Inc. (SANDAG)	color IR aerial photos	1990	24,000	Holland	<1
SD Pipeline #6 Study Area	Pacific SW Biological (MWD)	color aerial photos	1989-90	24,000	Holland	<1
FIA photo points	US Forest Service	aerial photos	1985	24,000	formation	~2
Vegetation Type Mapping	USFS--Wieslander	field mapping	1928-45	62,500	dominant spp.	~50
Coastal Sage Scrub--west SD Co.	RECON, Inc.	color aerial photos	1989	48,000	Holland	4